Deer Isle Causeways Feasibility Study Final Report

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Prepared for:

Maine Department of Transportation

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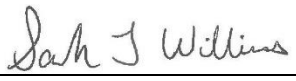
Prepared by 
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ACKNOWLEDGEMENTS

The Study Team would like to acknowledge several contributors for their efforts during the Deer Isle Causeways Feasibility Study. Collaboration and communication were paramount to the success of the Study and the progress that has been made during this initial project phase. More than 100 residents, stakeholders and elected officials participated throughout the Study to provide local knowledge, and history and to offer opinions on alternatives throughout the public involvement process. The Study Team extends their gratitude to:

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EXECUTIVE SUMMARY

The Maine Department of Transportation (MaineDOT) conducted the Deer Isle Causeways Feasibility Study to improve Route 15 and to be responsive to the Communities desires for reliable and resilient causeways. The Towns of Deer Isle and Stonington have only one land connection between the islands and the mainland, creating a vital economic and social link for residents, businesses, and visitors. It is important to quickly move the project forward to the extent practicable before further deterioration of the causeways requires major maintenance efforts.

Study Area

The study area includes Route 15 over the small causeway connecting the Deer-Isle-Sedgwick Bridge to Little Deer Isle (the 'little causeway'), and a second causeway between Little Deer Isle and Deer Isle (the 'main causeway'), referred to as causeways. The Deer-Isle-Sedgewick Bridge is not part of the Study area.

The study documents existing conditions and evaluates alternatives that address transportation reliability and resiliency. Alternatives were evaluated based on constructability, Maintenance of Traffic (MOT) during construction, traffic impacts, cost, and minimizing environmental impacts.

Purpose and Need

The purpose of this study is to achieve transportation resiliency based on the Maine Climate Council's recommendations for predicted sea level rise (SLR) to prevent damage to MaineDOT infrastructure, maintain emergency services access, and avoid stranding residents, businesses and visitors on Deer Isle and Stonington; and to prevent future flooding impacts associated with sea level rise.

Public Involvement

Coordination and public engagement is a key element to the Study. The Towns of Deer Isle and Stonington were the primary stakeholders for the Study as the causeways are a top concern for local officials, residents, and businesses. Three public meetings were held for the study, an initial public meeting in Deer Isle in August 2023, a second virtual public meeting with a storymap website in April 2024 and a third final public meeting held in Deer Isle in June 2024. The feedback from the public engagement was supportive of modifications to the causeways. There is balanced support for the reconstruction alternatives without an obvious preference.

Existing Conditions and Flooding

The existing little causeway is approximately 1,000 feet long and the main causeway is approximately 3,500 feet long and carry 3,328 vehicles per day. The existing roadway cross-section is two 12-foot lanes and two 2-foot shoulders for a total rail-to-rail width of 28 feet.

The causeways currently experience over topping and are vulnerable to increasing deterioration from frequent severe storm events, erosion, and rising sea levels. Recent severe storm events in the region resulted in the causeways being closed for several hours, most recently on December 18, 2023, January 10, January 13, and March 10, 2024.

Alternatives

The following Alternatives were considered for the main and little causeways:

Main Causeway

- *Alternative 1:* No Build – Carried for comparison of alternatives.
- *Alternative 2:* Erosion Control and Stability Improvements – No increases to causeway elevation or width.
- *Alternative 3:* Reconstruction on Alignment- Increase roadway elevation and widen.
- *Alternative 4 & 4a:* Reconstruction Partially Off Alignment- Increase roadway elevation and widen (4a includes a single span bridge or culvert within the causeway).
- *Alternative 5 & 5a*: Reconstruction Off Alignment- Increase roadway elevation and widen (5a includes a single span bridge or culvert within the causeway).

Little Causeway

- *No Build:* Carried for comparison.
- *Reconstruction:* Reconstruction on Alignment- Increase roadway elevation and widen.

University of Maine Study

Addressing the reliability and resilience of the causeways is the primary goal of this study, however agency partners requested that MaineDOT consider an opening in the main causeway that could potentially improve circulation in the region to provide new sources of larval supply of sea scallops, American lobster, soft-shell clams, and other commercially important species. Based on the work done by the University of Maine and Maine Center for Coastal Fisheries there is no clear benefit to the target fisheries expected with an opening in the main causeway between Penobscot and Eggemoggin Reach. The location of the causeway in relation to the surrounding islands, the complex geomorphology in the area, combined with the strong currents indicate particle transfer is unlikely through an opening.

Although the University of Maine study concluded that an opening would not significantly change the circulation in the region, additional feedback from the public meetings suggested there may be ecological benefits to the habitat immediately adjacent to the main causeway. As such, a culvert or series of culverts will continue to be evaluated.

Causeway Width and Height

For the little causeway build alternative and main causeway reconstruction alternatives the roadway is widened to increase the paved shoulder width to 5’-0” in both travel ways. The resulting overall roadway width is 32 feet, an increase of 4-feet from the existing roadway width.

The most frequent comment and concern the Study Team received during this process was related to the height of recommended causeway improvements. This issue can become confusing and complicated due to related but different factors such as Sea Level Rise, and storm and tidal surges. Another source of confusion has to do with different scales of measurement (datum) used to report tidal heights. In general, publicly available daily tide charts are provided in Mean Lower Low Water (MLLW) datum while agencies such as MaineDOT use North American Vertical Datum of 1988 (NAVD88) datum. This study recommends increasing the causeway height from 9 feet to 13.3 feet NAVD88. In MLLW, this is an increase from 14.8 feet to 19.1 feet which exceeds the 12-foot-high tides fishermen and others expressed concerns about during this study. It is also several feet above the highest water level that occurred during the January 10, 2024 storm, anecdotally the highest to date, which was estimated at approximately 10 feet NAVD88, or 15.8 feet MLLW.

The proposed height is responsive for the next 75+ years and provides protection against reasonable combinations of SLR and storm surge events. The causeway will be constructed such that it may be raised again in the future, should conditions warrant.

Traffic Impacts

Reconstruction of the causeways will involve delays and impact travel time. Since there is no viable detour route for the islands, traffic will be maintained through the work zone for all alternatives. The goal is to maintain at least one lane of traffic during construction and ensure that emergency vehicles are disrupted as little as possible. While some preliminary analysis has been done during this Study to evaluate relative differences between alternatives, impacts will be refined as the design progresses. MaineDOT is committed to proactive communication during design and monitoring during construction to minimize disruptions.

Environmental Impacts

Environmental impacts for the reconstruction of the causeways could be substantial. As the causeways connect the islands to the mainland through a body of water, any change to the footprint of the causeway will cause an impact to wetlands and/or the waterbody and associated habitats. In general, the wetland impacts increase as the alignment shifts further from the existing little and main causeway footprint. Navigating the permitting process for alternatives with larger environmental impacts is challenging. Causeway improvements that meet the purpose and need while minimizing environmental impacts is preferred.

Cost

Planning level cost estimates were developed for the build alternatives for the little and main causeways. The cost estimates include construction cost, preliminary engineering, right-of-way, construction engineering and permitting costs and were projected to the anticipated construction start in 2027. The little causeway project cost ranges from $4 to 5 million. The reconstruction alternatives for the main causeway range from $17 to $20 million for the lowest project cost (Alternative 3) to $23 to $26 million for the highest project cost (Alternative 5a).

Alternative Selection and Recommendation

Alternatives were evaluated by developing preliminary engineering drawings, cross-sections and calculations to develop relative environmental impacts, maintenance of traffic schemes, project cost estimates and preliminary construction schedules. Recommendations for an alternative to be progressed in preliminary design consider the study purpose and need, secondary study goals and feedback from public meetings and municipal coordination.

There is currently a single alternative for the little causeway. Given the location of Bridge End Park and the building immediately to the west of the little causeway, the only feasible option to meet the study's purpose and need is to raise and widen the little causeway to the east.

For the main causeway, Alternative 3 meets the project purpose and need, limits the environmental impacts to the extent practicable and is the lowest cost compared to the other reconstruction alternatives (Alternatives 4, 4a, 5 and 5a). The proposed causeway height and width is responsive to storm events and Maine Climate Council recommendations and meets current highway design standards. A bridge will not be considered for the main causeway, but a culvert or series of culverts will continue to be evaluated.

It is recommended that Alternative 3, on alignment construction, with a proposed roadway elevation of 13.3 feet and a roadway width of 32 feet (11-foot lanes with 5-foot shoulders) and continued evaluation of a culvert opening be advanced to preliminary design.

1.0 BACKGROUND

The Maine Department of Transportation (MaineDOT) is administering the Deer Isle Causeways Feasibility Study to be responsive to the Community's desire for reliable and resilient causeways and to quickly move the project forward to the extent practicable. The Study Team consists of planners, highway engineers, water resource engineers, geotechnical engineers and environmental scientists from MaineDOT, Stantec and Haley and Aldrich (H&A).

The Towns of Deer Isle and Stonington have only one land connection between the islands and the mainland, creating a vital economic and social link for residents, businesses, and visitors. This connection follows Route 15 across the Deer-Isle-Sedgwick Bridge connecting to Little Deer Isle, across a small causeway on Little Deer Isle (the 'little causeway'), and then across a second causeway between Little Deer Isle and Deer Isle (the 'main causeway'), referred to as 'causeways' herein.

The causeways currently experience over topping leaving debris on the roadway. They are vulnerable to increasing deterioration from frequent severe storm events, erosion, and rising sea levels. This study identifies deficiencies for all modes of transportation and evaluates alternatives to provide practical recommendations for the future of the causeways. Guidelines from the Maine Climate Council and concurrent work by University of Maine School of Marine Sciences, with input from the Maine Center for Coastal Fisheries, helped inform the alternatives evaluation. Work specific to the Deer-Isle-Sedgewick Bridge is not included as a part of this study.

2.0 PURPOSE AND NEED

The purpose of this study is to achieve transportation resiliency based on the Maine Climate Council's recommendations for predicted sea level rise (SLR) to prevent damage to MaineDOT infrastructure, maintain emergency services access, and avoid stranding residents, businesses and visitors on Deer Isle and Stonington; and to prevent future flooding impacts associated with sea level rise.

MaineDOT identified the causeways as a low-lying coastal roadway susceptible to flooding impacts. Additionally, Route 15 at this location is closed during highest tide and storm surge events, and MaineDOT has prioritized it for the development of adaptation scenarios and analysis. As part of the study, the following secondary goals are identified:

- Provide reliable mainland connectivity during all project planning, design and construction.
- Maintain competitiveness for federal discretionary funds.
- Consider related efforts for improving circulation (tidal flow) between Penobscot Bay and Eggemoggin Reach sides of the main causeway.

3.0 COORDINATION & PUBLIC ENGAGEMENT

Coordination and public engagement is a key element to the Study. The Towns of Deer Isle and Stonington were the primary stakeholders for the Study as the causeways are a top concern for local officials, residents, and businesses. Coordination was prioritized with a public meeting held at the very beginning of the Study before any technical work was started by the Study Team.

3.1 PUBLIC MEETINGS

3.1.1 Initial Public Meeting

The first public meeting was held on August 1, 2023, in Deer Isle. The goal for the meeting was to introduce the study objectives and purpose, identify the scope of work and provide baseline alternatives for the Study. The meeting was attended by more than 80 people with a short presentation (included in Appendix C) followed by a question-and-answer session. Feedback from the initial public meeting was generally in favor of the project and noted urgency for construction.

3.1.2 Second Virtual Public Meeting

A second, virtual, public meeting and StoryMap was released on the MaineDOT website on April 1, 2024, and was open for public comment through the end of April 2024. This meeting introduced the alternatives analysis and evaluation criteria for the study to the Public. The virtual on-demand meeting format was deliberate, as it allows users to watch on their own schedule and spend time as much time as desired with the content and graphics. It also allows participants to submit comments or questions via the website who may not be able to or comfortable doing so in an in-person public meeting setting.

The virtual public meeting received a mix of comments with no clear alternative preference. The following is an overview of the comments:

1. Summary: Most comments supported modifications to the causeway, with varying levels of enthusiasm for specific alternatives.
2. Common Themes:
    a. Height and Width: Many comments expressed concerns that the proposed elevation may not be sufficient to handle future sea level rise and storm surges. Suggestions included raising the causeway higher than currently planned.
    b. Environmental Impact: Several comments focused on the ecological effects of the causeway, advocating for designs that improve water flow and support marine life.
    c. Safety and Accessibility: There was strong support for ensuring the causeway accommodates bikes and pedestrians safely. Concerns about speeding and traffic safety were also prevalent.

d. Economic Considerations: Many recognized the causeway as vital for local commerce, particularly for industries like fishing and tourism.

e. Construction Impact: There was considerable concern about the construction phase, particularly how it will affect emergency services and general traffic flow. Options that minimize disruption were generally favored.

3. Responses from MaineDOT:

a. MaineDOT generally thanked commenters for their input and indicated that all feedback will be considered in ongoing studies and future planning.

b. Specific issues raised by commenters, like construction impacts and environmental considerations, are noted, and MaineDOT committed to providing more detailed plans and considering all input as the project progresses.

A full record of submitted public comment and responses is included in Appendix C. The virtual public meeting and associated graphics is located at the following web address: https://storymaps.arcgis.com/stories/47a69b3829294707bf8095cfd7de2421.

3.1.3 Final Public Meeting

A third, final public meeting was held in Deer Isle on June 5, 2024. The final public meeting timing was coordinated through the Towns to optimize attendance when considering summer populations and the local school year calendar. At this meeting Alternative 3 (Reconstruction On Alignment) for the main causeway was presented to the public as the recommended alternative to progress to preliminary design along with preliminary cost information, construction duration and project next steps.

Feedback from the meeting focused on the causeway height, traffic impacts during construction and the possibility of an opening within the main causeway. As a result of public input during the final meeting and comments received on the draft report, the Study Team investigated the additional cost and impacts associated with an additional foot of raise for the causeways. Additional clarification discussion regarding the vertical datum referenced in this report and graphics presented to the public during the final public meeting was added to the report. See Appendix C for the presentation and public comments submitted through the project website.

3.2 STUDY COORDINATION

An initial Study Team meeting was held on September 11, 2023, to review study objectives, identify technical leads and communicate the schedule. Coordination with the Town of Deer Isle and Stonington was ongoing throughout the Study. Monthly meetings were held to provide updates, share up to date information and solicit feedback on alternatives. Coordination meetings were held on the following dates:

- October 10, 2023
- November 14, 2023
- December 12, 2023

- January 9, 2024
- February 13, 2024
- March 12, 2024
- April 9, 2024
- May 14, 2024
- May 30, 2024
- June 11, 2024

The Study Team presented the draft alternatives information as the engineering work progressed and provided the Towns with the public information graphics and presentations for review and comment ahead of public meetings. The collaborative process allowed the Towns to inform the Study Team of any local feedback and raise concerns prior to selecting a recommended alternative.

4.0 EXISTING CONDITIONS

4.1 Route 15 Causeways

The Deer Isle causeways were originally constructed in the 1930's and the main causeway was widened in 1947. The existing little causeway is approximately 1,000 feet long and the main causeway is approximately 3,500 feet long, carries 3,328 vehicles per day and is classified as a corridor priority 3 roadway. The existing roadway cross-section is two 12-foot lanes and two 2-foot shoulders for a total rail-to-rail width of 28 feet. The sideslopes are protected with stacked stones and riprap. There are aerial utilities across both causeways and no known buried utilities.

There is a small overflow pond to the west of the little causeway, connected with a 4-foot diameter culvert with granite stacked stone headwalls. The tides cover the culvert and headwall at higher tides. There are no existing openings within the main causeway.

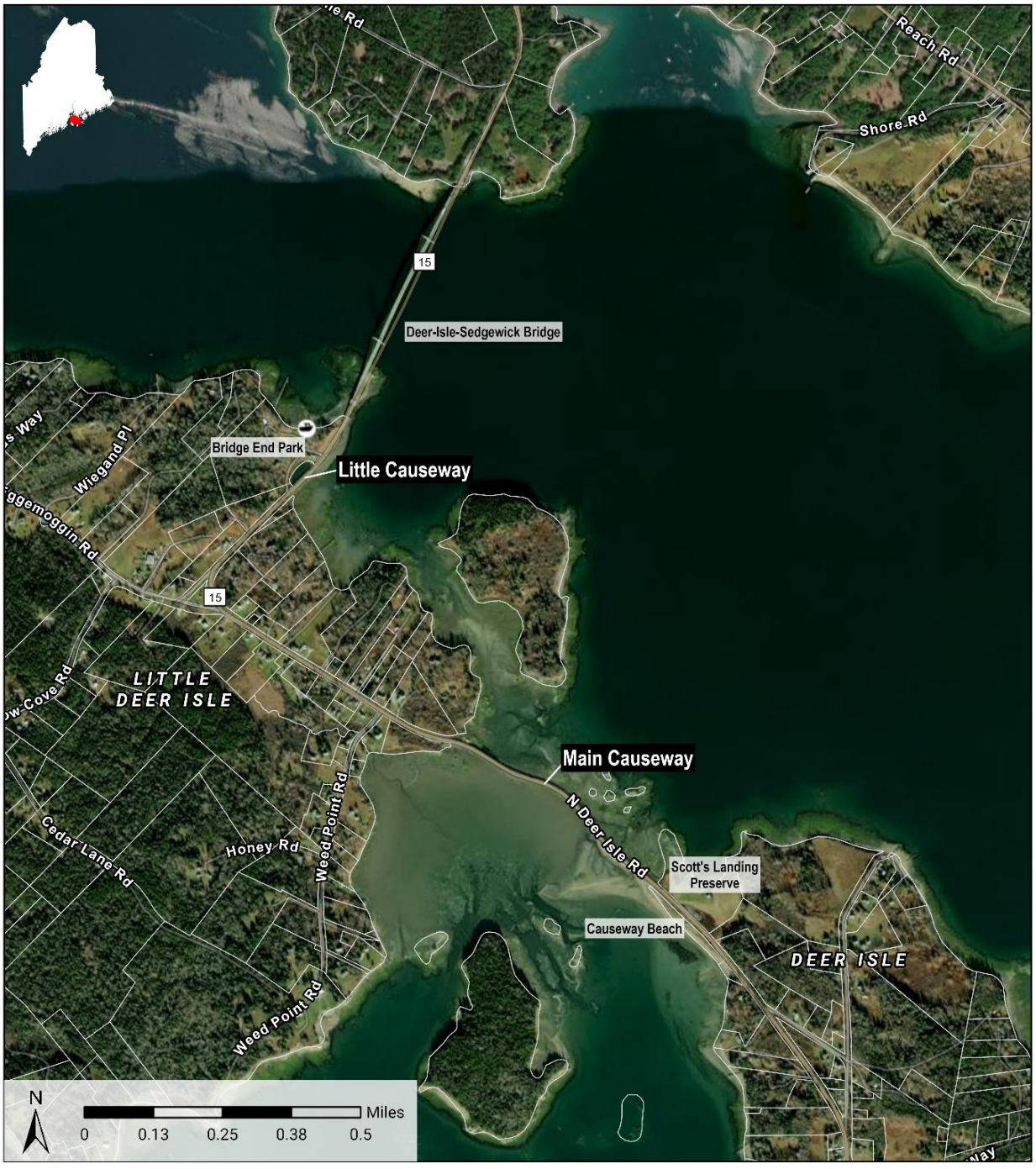

Figure 1 – Location Map

The Study Team visited the causeways on October 16, 2023, to observe the existing conditions, identify project constraints and document typical areas of damage. The following observations were noted in the field at the main causeway between Little Deer Isle and Deer Isle:

- The majority of the damage to the sideslopes is on the North/Eggemoggin Reach side of the causeway.
- The riprap sideslopes showed signs of storm damage and newer riprap had been added to prevent further deterioration.
- At low tides, the western portion (near Little Deer Isle) of the causeway is the only location with water adjacent to the causeway on both sides.
- Water levels were measured to be about the same on both sides of the causeway at the time of the site visit as the tide was rising (flood tide). Measurements were taken near the eastern end of the main causeway (Deer Isle side) near the beach.

Photo 1 – Main Causeway looking east from Little Deer Isle towards Deer Isle

The following observations were noted in the field at the little causeway between the Deer Isle – Sedgewick Bridge and Little Deer Isle:

- The riprap sideslopes showed signs of storm damage and newer riprap had been added to prevent further deterioration.
- Undermined pavement from erosion was present along the shoulder/berm.
- The culvert in the small pond west of the causeway is in satisfactory condition with no distortion noted.

- Bridge End Park and an associated building are immediately west of the little causeway, making widening in this direction less practical.

Photo 2 – Little Causeway looking north from Little Deer Isle towards the Deer Isle – Sedgwick Bridge.

Documentation from the site visit and additional photos are in included in Appendix A.

4.2 HISTORIC RESOURCES & PUBLIC PARKS

The main causeway is considered eligible for listing on the National Register of Historic places under Section 106 of the National Historic Preservation Act. Section 106 requires federal agencies to consult with the State Historic Preservation Office (SHPO) to identify historic properties in the study area, consider the effect of their projects on historic properties and seek ways to avoid or reduce adverse effects to historic properties. Coordination with SHPO will be ongoing throughout design. Causeway beach is located on the south side at the eastern end and Scott's landing preserve is located on the north side of the eastern end of the main causeway.

Bridge End Park is located on the west side of the little causeway at the north end and is a 4(f) property (public parks and recreational areas).

4.3 TRANSPORTATION MODES & ACCIDENT HISTORY

The existing causeways accommodate vehicular traffic with sufficient minimum lane and shoulder widths at 12 feet and 2 feet respectively. However, with guardrail located along both sides of the roadway the

current shoulder widths are too narrow to meet current Department standards, and do not safely accommodate cyclists and pedestrians. The deterioration of the shoulder pavement further reduces the available width.

The posted speed is 45 and 40 miles per hour (mph) at the main and little causeways respectively. There is no reported accident history at either causeway. The existing causeways alignments and roadway curves meet current highway design criteria.

4.4 SEA LEVEL RISE & STORM EVENTS

The sea level has risen in Maine over the last century and is expected to continue rising along Maine's coastline. In addition to rising sea levels, there have been frequent severe storm events in the region that resulted in the causeways being closed for several hours, most recently on December 18, 2023, January 10, January 13, and March 10, 2024. The closures have resulted in emergency maintenance projects to repair erosion and sideslope damage.

The causeway roadway elevation varies from left to right along its width, most noticeably within the roadway curves, as is typical in highway roadway and drainage design. The roadway elevation is relatively constant along the length of the causeways. The average roadway elevation of the causeway is 9 feet and 10 feet (North American Vertical Datum 1988 or NAVD88), for the main and little causeways respectively.

4.5 NATURAL RESOURCES

On September 27, 2023, Stantec completed a reconnaissance level field survey of coastal wetland habitats and marine resources at the main and little causeways. The coastal wetland habitats were classified in accordance with the Maine Department of Environmental Protection coastal wetland assessment guidelines[1]. The survey characterized benthic habitat present along the length of causeways and included an inventory of substrate types and dominant marine species present within each tidal zone.

The intertidal habitat is predominantly riprap immediately adjacent to the causeways with coarse sandy beach, sand and mud flats with ledge outcroppings beyond the rip rap slopes. There is a small area of high salt marsh on the east and west ends of the main causeway. Some soft-shell clams were observed in the mudflat areas with some evidence of commercial and/or recreational clam digging. The baseline marine data was used to evaluate construction alternatives for the causeways and potential corresponding impacts to marine resources. See Coastal habitat and substrate characterization memo in Appendix A.

[1] Ward, A.E. 1999. Maine's Coastal Wetlands: Recommended Functional Assessment Guidelines, Volume II. Maine Department of Environmental Protection, Bureau of Land & Water Quality, Division of Environmental Assessment. Augusta, Maine

5.0 ALTERNATIVES

5.1 DESCRIPTION OF MAIN CAUSEWAY ALTERNATIVES

The alternatives, described below, represent a range of proposed work from repair and maintenance to new causeway construction adjacent to the existing for the main causeway. The various alternatives prioritize different project considerations, such as constructability, Maintenance of Traffic (MOT) during construction, material volume, cost, and minimizing environmental impacts. Additionally, all transportation users are considered in the alternative design and MOT evaluation, including vehicular traffic, cyclists, pedestrians, emergency response, school busing, specialized or permit vehicles (e.g. boat on trailer), and delivery trucks. Conceptual plans for Alternatives 3, 4, 5 are included in Appendix D.

5.1.1 Alternative 1 – No Build

The No Build alternative is the baseline condition for evaluation of the build alternatives. The existing conditions and the current function of transportation modes along the causeway is deficient with several closures due to flooding and limited width for cyclists or pedestrians. The long history of the existing causeways includes frequent maintenance needs and several emergency repairs for erosion protection and to maintain stability of the existing causeways. The No-Build alternative highlights the need for addressing the integrity and stability of the existing causeways, transportation resiliency due to SLR, and the narrow width of the existing roadways.

5.1.2 Alternative 2 – Erosion Control and Stability Improvements

Alternative 2 evaluates erosion control and stability improvements of the existing causeway. This consists of a large-scale maintenance project, including adding riprap on the existing side slopes, repairing deteriorated pavement, and replacing guardrail sections in undermined areas. This alternative does not include raising the causeway or increasing the paved shoulder width. A small future increase of the roadway elevation is possible within the larger footprint from the added rip-rap side slope work. Alternative 2 does not accommodate an opening.

5.1.3 Alternative 3 – Reconstruction On Alignment

Alternative 3 increases the causeway elevation and widens the roadway while maintaining the existing causeway alignment and roadway curves. The existing causeway embankment material will remain in place and be re-used for the reconstruction. Embankment material will be added to the existing causeway to achieve the proposed roadway elevation and width.

The project would avoid impacts to Causeway Beach and widen to the north side of the existing causeway, toward Eggemoggin Reach. The initial widening earthwork is anticipated to be constructed while maintaining two lanes of traffic on the existing causeway and the remaining work above the existing causeway elevation, is to be constructed with incremental layering in 800-foot sections with alternating one-way traffic maintained throughout construction. Alternative 3 does not accommodate an at-grade

single span bridge as it complicates maintenance of traffic during construction. It may be feasible to incorporate a smaller culvert or series of culverts into the on-alignment alternative.

5.1.4 Alternative 4 – Reconstruction Partially Off-Alignment

Alternative 4 increases the causeway elevation and widens the roadway. Part of the causeway alignment is shifted further to the north, which flattens some of the roadway curves. The existing causeway embankment material will remain in place for the reconstruction. In areas of the proposed causeway that are off-alignment, the existing causeway would be abandoned in place and the material is not anticipated to be removed.

The project would avoid impacts to Causeway Beach and design the widening on the north side of the existing causeway, toward Eggemoggin Reach. The roadway alignment is partially shifted away from the existing to allow some of the causeway to be constructed while maintaining two-way traffic on the existing causeway. The ends and one middle section of the causeway would require a similar approach to Alternative 3, with alternating one-way traffic and incremental layering to achieve finished grade in 800-foot sections.

5.1.5 Alternative 4a – Reconstruction Partially Off-Alignment with Opening

Alternative 4a is identical to the Alternative 4 horizontal alignment except that it includes a single span bridge or a series of culverts to provide an opening in the western portion of the causeway that is off alignment. To accommodate an opening, the vertical roadway grade could potentially increase, beyond the 6-foot raise, in the opening vicinity and would be dependent on the structure type. The maintenance of traffic described for Alternative 4 is the same for Alternative 4a.

5.1.6 Alternative 5 – Reconstruction Off-Alignment

Alternative 5 increases the causeway elevation and widens the roadway. The majority of the causeway is shifted off-alignment to build an independent roadway. The tie-in locations at either end of the causeway will be the same as the existing causeway tie-in locations. Except for the tie-in locations at either end, the existing causeway would be abandoned in place and the material is not anticipated to be removed.

The project would avoid impacts to Causeway Beach and design the widening on the north side of the existing causeway, toward Eggemoggin Reach. . The roadway alignment shifts fully to the north and away from the existing causeway enough to allow the majority of the causeway to be constructed while maintaining two-way traffic on the existing causeway. The shift results in the largest overall project footprint and associated wetland impacts. The approach sections where the new causeway would tie into the existing roadway would require a phased, incremental construction approach similar to Alternatives 3 and 4.

5.1.7 Alternative 5a – Reconstruction Off-Alignment with Opening

Alternative 5a is identical to Alternative 5 horizontal alignment except that it includes a single span bridge or a series of culverts to provide an opening in the western portion of the causeway that is off alignment.

To accommodate an opening, the vertical roadway grade could potentially increase, beyond the 6-foot raise, in the opening vicinity and would be dependent on the structure type. The maintenance of traffic described for Alternative 5 is the same for Alternative 5a.

5.2 DESCRIPTION OF LITTLE CAUSEWAY ALTERNATIVES

There is currently a single alternative for the little causeway. Given the location of Bridge End Park and the associated building immediately to the west of the little causeway, the only feasible option to meet the study's purpose and need is to raise and widen the little causeway to the east. Conceptual plans for the little causeway build alternative are included in Appendix D.

5.2.1 No-Build Alternative

The No Build alternative is the baseline condition for evaluation of the build alternative. The existing conditions and the current function of transportation modes along the little causeway is deficient with several closures due to flooding and limited width for cyclists or pedestrians. The long history of the causeway includes frequent maintenance needs and several emergency repairs for erosion protection and to maintain stability of the existing causeways. The No-Build alternative highlights the need for addressing the integrity and stability of the existing causeways, transportation resiliency due to SLR, and the narrow width of the existing roadways.

5.2.2 Build Alternative

The Build alternative increases the causeway elevation and widens the roadway. The existing causeway embankment material will remain in place and be re-used for the reconstruction. Embankment material will be added to the existing causeway to achieve the proposed roadway elevation and width.

The roadway will be widened to the East to limit impacts to an existing building and Bridge End Park located to the west (a Section 4(f) resource). Similar to Alternative 3 for the main causeway, the initial widening earthwork is anticipated to be constructed while maintaining two lanes of traffic on the existing causeway and the remaining work above the existing causeway elevation is to be constructed with incremental layering with alternating one-way traffic maintained throughout construction with temporary traffic signals. The length of the work zone includes the Deer Isle Sedgewick Bridge. Traffic analysis and queuing will be investigated further in the next phase during preliminary design. No additional openings are anticipated at the little causeway and the small existing culvert will be extended and maintained.

5.3 GEOTECHNICAL CONSIDERATIONS

5.3.1 Subsurface Conditions

Subsurface information and as-built drawings for the existing causeways are not available. Planning level recommendations and construction considerations are based on anticipated, assumed subsurface conditions developed from review of published geologic map information. The following assumptions were made to assess the stability of the causeway alternatives during the planning study:

- A marine clay layer is present below and adjacent to the existing causeways.
- Soil properties were assumed based on typical values obtained at other sites with similar subsurface conditions.
- The same soil properties were assumed for all alternatives.
- The minimum required factor of safety specified by AASHTO LRFD for embankments under static conditions regardless of whether they support structures is 1.3.

The depth of the clay layer was varied to determine the sensitivity of the stability analysis and to assess any significant difference between the alternatives. Due to the raise in profile, causeway widening, and potential for a clay layer, preliminary assumptions indicate that some global stability issues could occur for the raise alternatives (3, 4 and 5) at the main causeway and the build alternative at the little causeway. The analysis assumed 2 (horizontal) to 1 (vertical) side slopes. Steeper side slopes are possible when using heavy rip rap, however, it reduces the overall global stability factor of safety, which is marginal based on assumptions to date. Global stability and settlement analysis could result in the potential need for ground improvement strategies at the causeways. If settlement and slope stabilization mitigation are required, the following approaches may be considered:

- Lightweight fill: the use of expanded shale aggregate is likely the only lightweight material appropriate in this application.
- Preload/Surcharge with prefabricated vertical drains (PVDs): a common solution to improve embankment stability, however there are constructability challenges to install at this site while maintaining traffic.
- Ground Improvement or pile supported embankment: Likely consist of rigid inclusions (stone columns) that would extend through the clay and into naturally deposited glacial soils.
- Over-excavation: If bedrock is shallow, it may be feasible to over-excavate the clay and replace with stone fill or plain riprap. There may be environmental impacts associated with this approach.

It is anticipated that a subsurface exploration program, including borings, will be completed early in the next phase of design to aid in the stability analysis and investigation of geotechnical solutions. See Appendix E for additional geotechnical information.

5.3.2 Proposed Causeway Selection

Causeway construction is an important consideration for the study as the proposed reconstruction will be subject to erosional forces from wave and tidal action. Due to limited subsurface information, a preliminary typical construction section was developed based on engineering experience from previous projects and causeways constructed at similar sites. The assumed causeway section consists of a plain rip rap base below the HAT of 7.3 ft to be placed in the wet, a choke stone layer, heavy rip rap and stone ditch protection side slopes and typical roadway base and pavement layers. The section will be refined as the design progresses. The typical section was used to develop preliminary cost estimates, construction

schedules and was assumed to be the same for all alternatives. See Figure 2 for preliminary typical causeway construction section.

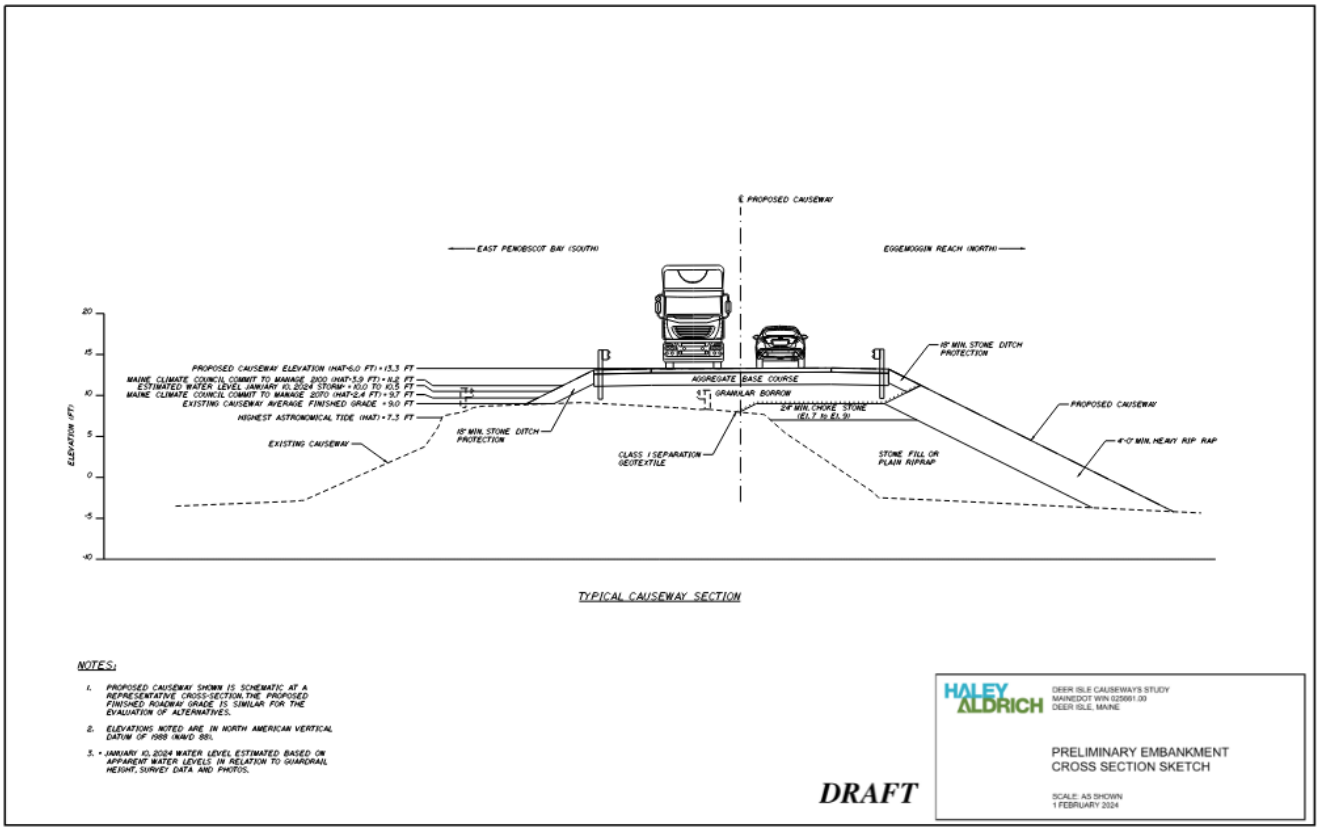

Figure 2 – Causeway Construction Section

5.4 CAUSEWAY WIDTH & HEIGHT

5.4.1 Width

For the little causeway build alternative and main causeway reconstruction alternatives the roadway is widened to increase the paved shoulder width to 5'-0" in both travel ways. The resulting overall roadway width is 32 feet, an increase of 4-feet from the existing roadway width. The increase in roadway shoulder width will accommodate cyclists and pedestrians in addition to vehicular traffic and will not be separated by a barrier. The reconstruction alternatives will have new guardrail and meet current design standards.

5.4.2 Height

The height of the little causeway build alternative and main causeway reconstruction alternatives considers information from the Maine Climate Council (MCC), recent storm events in the region and public feedback.

In December 2020 Maine Climate Council published *Maine Won't Wait*, a four-year plan for climate action. The Maine Climate Council — an assembly of scientists, industry leaders, bipartisan local and state officials, and engaged citizens — was charged with developing this four-year Climate Action Plan to put Maine on a trajectory to decrease greenhouse gas emissions by 45% by 2030 and 80% by 2050 and achieve carbon neutrality by 2045. As part of its report, The Maine Climate Council recommends that the state consider committing to manage for 1.5 feet of relative sea-level rise by 2050, 2.4 feet by year 2070 and 3.9 feet by the year 2100.

In developing alternatives, SLR considerations are added to the published Highest Astronomical Tide (HAT). According to the National Oceanic and Atmospheric Administration (NOAA), the HAT is the elevation of the highest predicted astronomical tide expected to occur at a specific tide station of the National Tidal Datum Epoch (NTDE) and does not include storm surge. For the Deer Isle causeways, the published HAT is 7.3 feet (NAVD88). The existing roadway grade at the causeways averages approximately 9.0 feet NAVD88. The finished roadway grade elevation assumed for the alternatives is the HAT plus 6 feet, resulting in a finished roadway grade of 13.3 feet (NAVD88), to provide additional protection beyond the Maine Climate Council guidelines for year 2100 (HAT + 3.9 feet = 11.2 feet NAVD88). For comparison, the water level during the January 10, 2024 storm was estimated at approximately 10 to 10.5 feet (NAVD88). Anecdotally, the January 10th storm event was the highest water level at the causeway to date. The HAT, existing causeway roadway grade, Maine Climate Council recommended elevations and proposed roadway elevation are shown graphically in Figure 3.

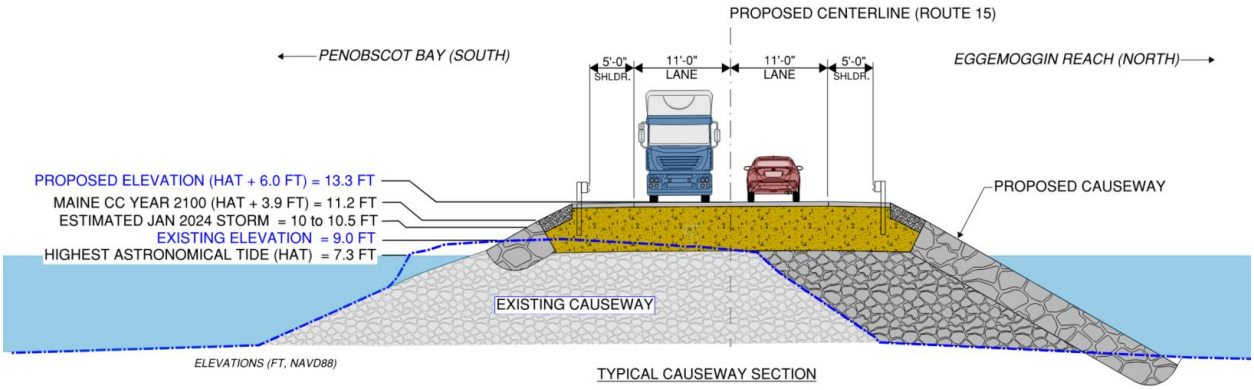

Figure 3 – Causeway Elevation

Elevations noted throughout this feasibility report and presented in graphics during public meetings and on the MaineDOT project website are referenced in North American Vertical Datum of 1988 (NAVD88). NAVD88 is the most commonly used vertical datum in the United States. It is a geodetic datum that serves as a reference surface for measuring elevations above sea level and allows for the consistent measurement and comparison of elevations across maps and surveys. Many federal, state and local agencies use NAVD88 including US Army Corps of Engineers, Federal Emergency Management Agency, and United States Geological Survey.

In contrast, Mean Lower Low Water (MLLW) is a tidal datum, used to track local water levels as measured by nearby tidal gauging stations. MLLW is the average of the lowest low tide of each day over a 19-year period, called the National Tidal Datum Epoch. MLLW is a common reference datum for NOAA nautical charts, and tidal predictions. NAVD88 and MLLW are not directly comparable as they have different starting (zero) points. The conversion between the datums depends on geographic location and oceanographic characteristics and will vary from site to site. In order to convert from NAVD88 to MLLW at the Deer Isle Causeways, add 5.78 feet to the elevation. The following table summarizes the points of interest presented during the Study in NAVD88 and MLLW datums.

Table 1 – Reference Datum Summary

Point of Interest	North American Vertical Datum (NAVD88) (ft)	Mean Lower Low Water Datum (MLLW) (ft)
Conversion	0.0	5.8
Highest Astronomical Tide (HAT)	7.3	13.1
Average Existing Causeway Height	9.0	14.8
Maine Climate Council Commit to Manage Year 2070 (HAT + 2.4 ft)	9.7	15.5
Estimated Water Surface Elevation January 10, 2024 Storm	10.0	15.8
Maine Climate Council Commit to Manage Year 2100 (HAT + 3.9 ft)	11.2	17.0
Proposed Causeway Elevation (HAT + 6.0 ft)	13.3	19.1
Public Input Additional Foot (HAT + 7.0 ft)	14.3	20.1

The proposed roadway elevation of 13.3 feet NAVD88 is practical, feasible and responsive for the next 75+ years. It provides protection against reasonable combinations of SLR and storm surge over the expected project life. Additionally, the proposed causeways will be constructed such that they may be raised again in the future, should conditions warrant.

5.5 UNIVERSITY OF MAINE CIRCULATION STUDY

Addressing the reliability and resilience of the causeways is the primary goal of this study, however agency partners requested that MaineDOT consider whether an opening in the main causeway could potentially improve circulation in the region and provide new sources of larval supply of sea scallops, American lobster, soft-shell clams, and other commercially important species. As such, MaineDOT contracted with The University of Maine School of Marine Sciences to build a model to study the potential implications of allowing circulation between East Penobscot Bay and Eggemoggin Reach. The modeling work included collaboration with the Maine Department of Marine Resources (DMR) to establish locations of likely source populations and Maine Center for Coastal Fisheries (MCCF) to validate the model output using an Acoustic Doppler Current Profiler (ADCP) in the region. The MaineDOT Study Team met with the University of Maine Scientists several times throughout the study to establish goals, discuss methodology, and review outcomes. The primary coordination meetings were held on September 8, 2023, February 2, 2024, and March 12, 2024.

The circulation study evaluated an opening in the causeway by releasing particles in the model and tracking them over several tidal cycles, see Figure 4. The results indicated a strong pattern of self-recruitment in the vicinity of the causeway (i.e. particles in this area tended to stay nearby) while particles released at locations near dense broodstock, as identified by DMR, were likely to be exported to offshore areas.

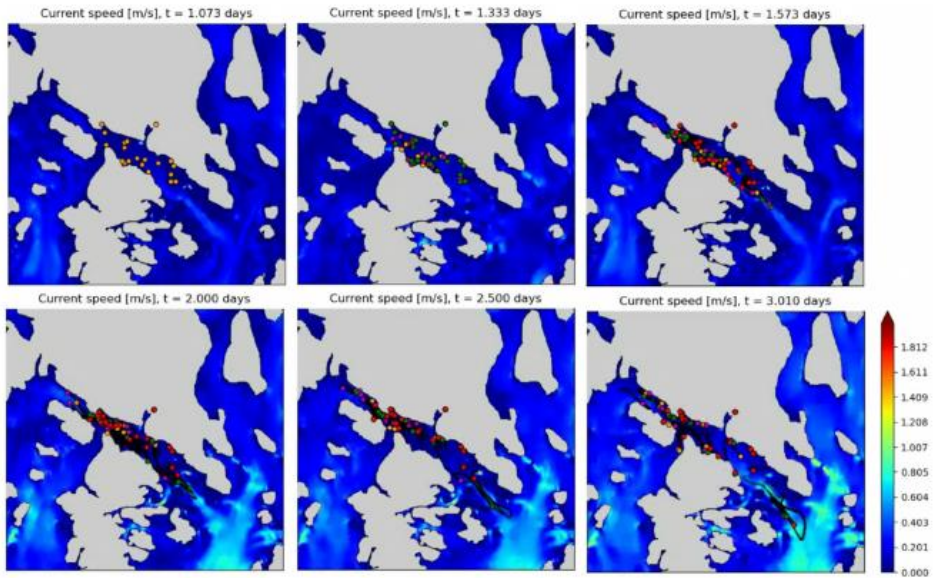

Figure 4 – Evolution of particles released in the Eggemoggin Reach area east of Blue Hill. (From University of Maine Memo)

From a circulation perspective, an opening in the causeway is unlikely to change the population of target species (sea scallops, American lobster, soft-shell clams, and other commercially important species), as the causeway is in an area of complex geomorphology, where the islands and currents have more effect on circulation and flow than the causeway itself. See Appendix B for the University of Maine Memo.

No additional, more complex coastal modeling is anticipated as part of this study. However, feedback from the second public meeting indicated that there may be some ecological benefits from an opening within the main causeway. While there is no apparent benefit to an opening for commercially important species in Eggemoggin Reach, there could be potential opportunity for sediment and nutrient transport in the causeway vicinity. An opening within the causeway may benefit natural habitats immediately adjacent to the causeway. A culvert or series of culverts will continue to be evaluated in preliminary design.

5.6 CONSTRUCTABILITY

The causeways provide the only roadway link from Little Deer Isle, Deer Isle and Stonington to the mainland. There is no ferry service on the islands. The causeways present a unique challenge in constructing the causeways while also maintaining traffic. It is anticipated that the earthwork associated with widening and raising the causeways would be done in the wet. Areas of exposed and presumably

shallow bedrock, in conjunction with the tides, limits the viability of cofferdams and de-watering to complete the work in the dry.

In water work is also restricted certain times of the year depending on the species and habitat located within the project area. Environmental consultation is not underway during this study phase, however, a preliminary in-water work window of August 15 to March 15 is assumed and based on other MaineDOT projects in the general area and previous projects with similar habitats. The Contractor is typically allowed to work on either side of low tide if not within the work window but restrictions on the work will be finalized during subsequent design phases.

5.7 TRAFFIC IMPACTS & MAINTENANCE OF TRAFFIC

Maintenance of Traffic (MOT) during construction is critical to the success of any transportation project. The improvement to the causeways includes balancing MOT schemes with the roadway profile raise. Since there is no viable detour route for the islands, traffic will be maintained through the work zone for all alternatives. Reconstruction of the causeways will involve delays and impact travel time. The goal is to maintain at least one lane of traffic during construction and ensure that emergency vehicles are disrupted as little as possible.

The little causeway reconstruction begins immediately adjacent to the south approach of the Deer Isle – Sedgwick Bridge. As such, the work zone will include the Bridge, with one of the temporary traffic signals on the mainland to avoid traffic queuing on the load-posted bridge. The additional length in the work zone will increase the traffic impacts and delays through the little causeway area during construction. The work at the little causeway is anticipated to be a single lane of alternating traffic throughout construction as the area is constrained by maintaining access to Bridge End Park and accommodating the tie-in locations at either end of the causeway.

The main causeway alternatives will impact traffic to varying degrees. For all reconstruction alternatives, the initial phase of work includes widening the causeway base while traffic is maintained on the existing causeway. There may be some intermittent disruptions for access to the work zone within the initial phase, but a single lane of alternating traffic occurs during subsequent construction phases when the causeway is being raised. Alternative 3 maintains a single lane of alternating traffic while the causeway is incrementally raised and results in the longest impact to traffic. Alternative 5 maintains two lanes of traffic on the existing causeway while the off-alignment construction occurs for most of the causeway, however, the tie-in locations at either end of the main causeway will require a section of single lane of alternating traffic and will impact traffic. Alternative 4 is partially off-alignment, which results in alternating one-way traffic at the tie-in locations at either end of the causeway and in the middle portion of the causeway. As such, the traffic impacts for Alternative 4 are expected to be greater than Alternative 5 but less than Alternative 3.

While some preliminary analysis has been done during this Study to evaluate relative differences between alternatives, impacts will be refined as the design progresses. Due to in-water work windows and paving season windows, construction may not occur year-round. The construction sequence and whether the little and main causeway construction occurs at the same time will be investigated during design. Working on both causeways simultaneously could lead to the greater traffic impacts and delays

through both work zones as there is potential for work zone overlap. Completing one of the causeways prior to the start of the other would increase the overall construction duration. Table 2 summarizes the traffic impacts for both causeways and overall estimated construction duration.

Table 2 – Main Causeway Traffic Impact Summary

Causeway Alternatives		Single Lane of Alternating Traffic Duration	Overall Construction Duration
Main Causeway	Alternative 3 – Reconstruction On Alignment	10 to 12 months	2 to 2.5 Years
	Alternative 4 – Reconstruction Partially Off-Alignment	6 to 8 months	3 to 3.5 Years
	Alternative 4a – Reconstruction Partially Off-Alignment with Opening	6 to 8 months	4+ Years
	Alternative 5 – Reconstruction Off-Alignment	4 to 6 months	3 to 3.5 Years
	Alternative 5a – Reconstruction Partially Off-Alignment with Opening	4 to 6 months	4+ Years
Little Causeway	Build Alternative	10 to 12 months	10 to 12 months

Impacts to traffic will continue to be evaluated during design and into construction. MaineDOT is committed to being proactive in communication and anticipates using technology to measure and respond to impacts during construction in real time. Preliminary MOT concepts have been developed for the little causeway and the main causeway primary alternatives, see Appendix D.

5.8 ENVIRONMENTAL IMPACTS & PERMITTING

Transportation projects are required to consider the natural environment and impacts as part of the National Environmental Policy Act (NEPA). NEPA provides a framework for environmental planning and decision-making for projects that receive federal funds or require federal approvals, this project is expected to have both. MaineDOT coordinates with State and Federal resource agencies to consider the potential impacts on the environment by their proposed actions and supports identification of project alternatives. A matrix summarizing the NEPA topics considered at this phase of project planning is included in Appendix G.

Environmental impacts for the reconstruction of the causeways are anticipated to be substantial. As the causeways connect the islands to the mainland through a body of water, any change to the footprint of the causeway will impact coastal wetlands and associated in-water habitats. Wetlands adjacent to the causeways were delineated within the study area and used to estimate the wetland impacts for each of the primary alternatives. In general, the wetland impacts increase as the alignment shifts further from the existing causeway footprint. Alternative 3 has the least amount of wetland impacts as it re-uses the existing causeway and alignment while Alternative 5 has the largest amount of wetland impacts as it is furthest from the existing causeway.

Navigating the permitting process for alternatives with larger environmental impacts is challenging. Causeway improvements that meet the purpose and need while minimizing environmental impacts is preferred. Alternative 4, 4a, 5 and 5a would need to demonstrate that there is a need for the additional environmental impacts and that there is no other viable alternative for the project. Temporary traffic impacts during construction would likely not be considered sufficient justification as the sole reason for the associated increase in environmental impacts. A summary of preliminary anticipated wetland impacts is provided in Table 3. The estimate does not include temporary wetland impacts, which will be determined during design.

Table 3 – Preliminary Estimated Wetland Impacts

Causeway Alternatives		Wetland Impacts (Square Feet)
Main Causeway	Alternative 3 – Reconstruction On Alignment	137,000
	Alternative 3 – Additional Foot of Raise	143,000
	Alternative 4 – Reconstruction Partially Off-Alignment	197,000
	Alternative 4a – Reconstruction Partially Off-Alignment with Opening	
	Alternative 5 – Reconstruction Off-Alignment	202,000
	Alternative 5a – Reconstruction Partially Off-Alignment with Opening	
Little Causeway	Build Alternative	32,000
	Build Alternative - Additional Foot of Raise	34,000

5.9 PLANNING LEVEL COST ESTIMATES

Planning level cost estimates were developed for the build alternatives for the little and main causeways. The cost estimates include construction cost, preliminary engineering, right-of-way, construction engineering and permitting costs.

Construction costs are generated based on recent bid histories for similar projects for all items. These costs only include the initial cost to construct the project and do not consider future improvements or maintenance. Factors affecting bid prices for individual components of a project include location, constructability, and market conditions. This project site is unique due to its tidal location and load restricted bridge to access the project site. Construction estimates are adjusted based on professional engineering judgement.

Preliminary engineering, right-of-way and construction engineering costs are estimated as a percentage of the total construction cost. Preliminary permitting costs were based on the wetland impacts generated for the alternatives as discussed in section 5.6. At the planning level, the permitting costs were estimated using the Maine Department of Environmental Protection (Maine DEP) in-lieu fee structure to provide a relative cost difference between alternatives. It is important to note that wetlands and habitat within the project vicinity will be reviewed as the design progresses and could affect the permitting cost associated with the causeway reconstruction.

Each of the cost estimates for the causeways includes a contingency cost. This is to recognize variation in estimates and recognize the preliminary nature of the estimate during the planning phase. The cost of

materials can also fluctuate over time, which can affect the accuracy of estimates. The estimates currently include inflation to project the construction costs to the anticipated Contract bid date in a few years in 2027. The cost estimates do not include any geotechnical ground improvements that may be required pending a subsurface investigation program during the next design phase. Alternatives 4, 4a, 5 and 5a do not include cost for removing the portion of the existing causeway that is not re-used as part of the reconstruction of the main causeway which would increase the overall project cost for those alternatives. The existing causeway is reused for Alternative 3. As a result of the public involvement process, cost estimates were developed for an additional foot of raise for Alternative 3 and the little causeway Build Alternative. Planning cost estimates are summarized for each primary alternative in Table 4.

Table 4 – Preliminary Planning Level Cost Estimates

Causeway Alternatives		Project Cost	Notes
Main Causeway	Alternative 3 – Reconstruction On Alignment	$17,000,000 to $20,000,000	Includes Culverts
	Alternative 3 – Reconstruction On Alignment Additional Foot of Raise	$20,100,000 to $22,100,000	Includes Culverts
	Alternative 4 – Reconstruction Partially Off-Alignment	$20,000,000 to $22,000,000	
	Alternative 4a – Reconstruction Partially Off-Alignment with Opening	$22,000,000 to $25,000,000	Opening could range from large culverts to single span bridge
	Alternative 5 – Reconstruction Off-Alignment	$20,500,000 to $22,500,000	
	Alternative 5a – Reconstruction Partially Off-Alignment with Opening	$23,000,000 to $26,000,000	Opening could range from large culverts to single span bridge
Little Causeway	Build Alternative	$4,000,000 to $5,000,000	
	Build Alternative – Additional Foot	$4,500,000 to $5,500,000	

Detailed preliminary cost summaries for the primary alternatives and the little causeway are included in Appendix F.

6.0 ALTERNATIVES ANALYSIS

Alternatives were evaluated by developing preliminary engineering drawings, cross-sections and calculations to develop relative environmental impacts, maintenance of traffic schemes, project cost estimates and preliminary construction schedules.

6.1 MAIN CAUSEWAY ALTERNATIVES EVALUATION MATRIX

An alternative evaluation matrix was developed to summarize and compare relative similarities and differences between alternatives. The evaluation criteria include study purpose and need, goals, impacts and cost. The impacts criteria include geotechnical considerations, maintenance of traffic, construction duration, environmental impacts, historic/public properties and right of way and utilities.

Each alternative was evaluated for all criteria in the matrix; however, some require additional investigation during the next phase during preliminary design. Study purpose and need along with any goals are evaluated on a yes or no basis, as the alternative either meets the goal or it does not. For any evaluation criteria that involved preliminary engineering calculations, such as traffic impact duration, construction duration, environmental impacts and project cost estimates, numbers are provided in the matrix to support the alternatives analysis and recommendation. The detailed matrix is included in Appendix G.

2023-2024 Planning Study

ALTERNATIVE		ALTERNATIVE EVALUATION											PROJECT COST
		PURPOSE AND NEED		SECONDARY	OTHER GOALS		IMPACTS						
		Improve Causeway Safety & Reliability	Resiliency & Sea-Level Rise (SLR)	Consider related studies & Natural Resources	Municipal & Public Input	Transportation Modes	Geotechnical	Maintainance of Traffic	Construction & Project Duration	Environmental Permitting	Historic Properties & Public Parks	Right-of Way & Utilities	Construction cost, Prelim. Eng., ROW, Constr. Eng., & Permitting
Number	Title	Address impacts from severe storms and erosion	Consistent w/Maine State Climate Council guidance and adapt to future SLR	Improves tidal flow between Penobscot and Eggemoggin Reach	Consistent with Town planning efforts and preferences	Accommodates Cyclists & Pedestrians	Settlement Mitigation	Single lane, two-lane (Traffic Impact Duration)	Construction Duration	Permanent Fill & Wetland Impacts (Square Feet)	Section 106 and Section 4(f) Evaluation	Number of parcels impacted	Does not include cost for potential geotechnical ground improvements.
Alternative 1	No Build	No	No	No	No	No Improvement (11 ft lanes & ~2 ft shoulders)	No	N/A	N/A	No Impact	None	0	N/A
Alternative 2	Erosion Control and Stability Improvements	Yes	No	No	No	No Improvement (11 ft lanes & ~2 ft shoulders)	No	Single-Lane Alternating Traffic (4 to 6 months)	1 Year	76,700 SF	None	0	To be determined
Alternative 3	Reconstruction On Alignment	Yes	Yes	Culverts considered in final design	Yes	Improvement (11 ft lanes & 5 ft shoulders)	More investigation needed	Single-Lane Alternating Traffic (10 to 12 months)	2 to 2.5 Years	137,000 SF	Possible	Up to 5	$17 to $20 million (Main) $4 to $5 million (Little) $21 to $25 million (Total)
Alternative 4	Reconstruction Partially Off-Alignment	Yes	Yes	No	Yes	Improvement (11 ft lanes & 5 ft shoulders)	More investigation needed	Two lanes on exist and (1) section w/single lane alt (6 to 8 months)	3 to 3.5 Years	197,000 SF	Possible	Up to 5	$20 to $22 million (Main) $4 to $5 million (Little) $24 to $27 million (Total)
Alternative 4a	Reconstruction Partially Off-Alignment with Opening	Yes	Yes	Yes	Yes	Improvement (11 ft lanes & 5 ft shoulders)	More investigation needed	Two lanes on exist and (1) section w/single lane alt (6 to 8 months)	4+ Years	197,000 SF	Possible	Up to 5	$22 to $25 million (Main) $4 to $5 million (Little) $26 to $30 million (Total)
Alternative 5	Reconstruction Off - Alignment	Yes	Yes	No	Yes	Improvement (11 ft lanes & 5 ft shoulders)	More investigation needed	Two-Lanes on existing (4 to 6 months)	3 to 3.5 Years	202,000 SF	Possible	Up to 5	$20.5 to $22.5 million (Main) $4 to $5 million (Little) $24.5 to $27.5 million (Total)
Alternative 5a	Reconstruction Off - Alignment with Opening	Yes	Yes	Yes	Yes	Improvement (11 ft lanes & 5 ft shoulders)	More investigation needed	Two-Lanes on existing (4 to 6 months)	4+ Years	202,000 SF	Possible	Up to 5	$23 to $26 million (Main) $4 to $5 million (Little) $27 to $31 million (Total)

Figure 5 – Main Causeway Alternatives Evaluation Matrix

6.2 MAIN CAUSEWAY DISMISSED ALTERNATIVES

Several alternatives can be eliminated from further analysis and consideration based on the study purpose and need, goals and objectives. Alternative 1 and 2 do not meet the study purpose and need of improving causeway reliability and resiliency for SLR and were therefore dismissed from further consideration. As such, the remaining alternatives that meet the study purpose and need for the main causeway are Alternatives 3, 4, 4a, 5 and 5a.

There is no clear benefit to the target fisheries expected with an opening in the main causeway between Penobscot Bay and Eggemoggin Reach based on the work done by the University of Maine and Maine Center for Coastal Fisheries. The location of the causeway in relation to the surrounding islands, the complex geomorphology in the area, combined with the strong currents indicate particle transfer is unlikely through an opening and does not warrant an additional more complex coastal modeling effort. Alternatives with openings (4a and 5a) are not recommended to be carried to preliminary design on the basis of improving target fisheries populations.

6.3 MAIN CAUSEWAY ALTERNATIVE ANALYSIS

The suitability of the remaining reconstruction alternatives is analyzed based on traffic impacts during construction, project cost, constructability, construction duration, traffic impacts, utility relocation timeframes, right-of-way, and environmental impacts.

6.3.1 Alternative 3 – On Alignment

Alternative 3 meets the study purpose and need by improving causeway reliability and SLR resiliency. It accommodates cyclists and pedestrians and reuses the existing causeway embankment in its entirety. A single span bridge opening on-alignment would be complicated due to the MOT impacts during construction, but a culvert or series of culverts could be considered.

Advantages:

- Requires less material for embankment construction than Alternatives 4 & 5.
- Fewer impacts to natural resources than Alternatives 4 & 5.
- Construction cost is less than Alternatives 4&5.
- Shortest overall construction duration.
- Could be further raised in the future by steepening the sideslopes.

Disadvantages:

- Most impact to traffic. Once widened, the embankment is constructed on top of the existing causeway and all remaining. construction will require alternating one-way traffic.
- Least flexibility for aerial utility relocation. Will require relocation of all poles on northbound side prior to moving to Phase 2 of construction.

6.3.2 Alternative 4 – Partially Off-Alignment

Alternative 4 meets the study purpose and need by improving causeway reliability and SLR resiliency. It accommodates cyclists and pedestrians but does not include an opening in the main causeway.

Advantages:

- Fewer impacts to traffic than Alternative 3 because significant sections would maintain two-way traffic.
- Requires less fill than Alternative 5.
- Allows for flexibility in timing of utility relocation.
- Could be raised in the future by steepening the sideslopes.

Disadvantages:

- Includes sections of alternating one-way traffic.
- Requires more material for embankment construction than Alternative 3.
- More impacts to natural resources than Alternative 3.
- Longer construction duration than Alternative 3.
- Construction cost is more than Alternative 3.
- Potential impacts/adverse effect to the National Historic Register Eligible causeway by changing the character and layout.

6.3.3 Alternative 5 – Off-Alignment

Alternative 5 meets the study purpose and need by improving causeway reliability and SLR resiliency. It accommodates cyclists and pedestrians but does not include an opening in the main causeway.

Advantages:

- Can be constructed largely without impacting existing traffic.
- The lack of need for layered/incremental construction will reduce the overall construction duration.
- Allows for flexibility in timing of utility relocation.
- Could be raised in the future by steepening the sideslopes.

Disadvantages:

- Requires the most amount of material for embankment construction.
- Has the most impacts to natural resources.
- Highest construction cost of all alternatives.
- Adverse effect to the National Historic Register Eligible causeway by changing the character and layout.

6.4 LITTLE CAUSEWAY ALTERNATIVE ANALYSIS

The suitability of the alternatives is analyzed based on traffic impacts during construction, project cost, constructability, construction duration, traffic impacts, utility relocation timeframes, right-of-way, and environmental impacts.

6.4.1 Build Alternative

There is only one alternative being investigated. The Build alternative meets the study purpose and need by widening the roadway to the east to limit impacts to an existing building and Bridge End Park located to the west. The shift of the roadway will be a function of achieving the proposed finished grade elevation of the roadway without impacting resources to the east by maintaining the existing toe of slope. There is a small culvert that will need to be extended due to the widening of the little causeway.

Advantages:

- Does not impact resources to the west of the causeway.
- Minimizes environmental impacts as much as possible while raising the roadway elevation.

Disadvantages:

- The length of the work zone includes the Deer Isle-Sedgwick Bridge to limit traffic queuing on the posted bridge.

7.0 PRELIMINARY RECOMMENDATIONS

Recommendations for an alternative to be progressed in preliminary design consider the study purpose and need, secondary study goals and feedback from public meetings and municipal coordination.

7.1 ALTERNATIVE SELECTIONS

Alternatives 3, 4 and 5 all increase the roadway elevation and accommodate cyclists and pedestrians. The primary difference between the alternatives for the main causeway is how traffic is maintained during construction, and as a result, the environmental impacts, construction duration, and costs vary accordingly. Alternative 3 re-uses the existing causeway in its entirety, limiting environmental impacts as much as practical to achieve the proposed roadway elevation and width, however, it has the greatest impact to traffic during construction. Single lane of alternating traffic will require several work zones and incremental layering of material to complete the work. Conversely, Alternatives 4 and 5 shift the proposed causeway to limit impacts to traffic during construction, but significantly increase environmental impacts, material needed for the embankment construction, and construction costs. Due to the long length of the causeway and the volume of material required to construct the causeway while also considering in-water work restrictions, Alternatives 4 and 5 would take longer to construct than Alternative 3. The permitting effort for Alternative 4 and 5 would need to demonstrate there is no other viable alternative for the project and that the increase in environmental impacts when compared to Alternative 3 is warranted. Solely considering traffic impacts, especially when the impacts are temporary, is unlikely to be successful with the permitting agencies.

Since it is important to complete capital improvements as quickly as practicable before further deterioration of the causeways requires major maintenance efforts, Alternative 3 best meets the study purpose and need while minimizing environmental impacts, construction duration, and construction costs. Public feedback indicated there may be some benefit to an opening as it relates to sediment deposits adjacent to the causeway. A single span bridge is not warranted within the main causeway; however, a culvert or series of culverts will continue to be evaluated in design. The additional foot of raise for the causeways will be evaluated as the design progresses and the impacts, costs and permitting effort are evaluated. It is recommended that Alternative 3, on alignment construction, with a proposed roadway elevation of 13.3 feet and a roadway width of 32 feet (11-foot lanes with 5-foot shoulders) and continued evaluation of a culvert opening be advanced to preliminary design.