DINGLEY ISLAND SEDIMENTATION ASSESSMENT

Prepared for:
MAINE CORPORATE WETLAND RESTORATION PARTNERSHIP

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ATTACHMENTS ***[not included here]***

ATTACHMENT 1 – FIGURES
ATTACHMENT 2 – SITE PHOTOGRAPHS
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Section 1

Introduction

The Dingley Island Causeway links Harpswell to Dingley Island along the west side of the New Meadows River Estuary as shown on Figure 1 (Attachment 1).

Several years ago a group of motivated residents of Dingley Island began efforts to explore the possibility of restoring the tidal flow through the Dingley Island Causeway. Their goal was to restore the causeway to historical conditions in order to preserve and improve the habitat conditions on the clam flats and stem the potential transformation of the clam flats into a salt marsh.

As donors to the ME-CWRP, Duke Engineering & Services, Inc. (DE&S) met with Ms. Elsa N. Martz of Harpswell on August 24, 2001 to tour the site and review information accumulated by Ms. Martz and the Island Residents.

Information for the original causeway construction was obtained from review of a photograph (circa 1890) provided by Ms. Martz (See Figure 2). The original causeway was built sometime after 1870 and was constructed of stone and fill, with a timber decked bridge over a small tidal opening. The causeway appears to be constructed out of fill framed by large laid-up stone masonry walls (with a batter) on the north and south sides of the causeway. The causeway appeared to be narrow, between approximately 9 and 12 feet wide across the top, based on estimations from the photograph. The elevation of the top of the causeway was reported to be lower than existing, as Ms. Martz recounted tales from residents of the Island of frequent inundation during astronomical high tides and storm events. This is supported by the photograph, where the top of causeway is estimated at 5 to 5.5 feet above mudline. The opening in the causeway was reported to be approximately 12 feet in width.

The existing causeway was reported to have been constructed on top of the original causeway, where the elevation was raised and widened to the current conditions.

DE&S performed a preliminary topographic survey of the existing causeway on October 16, 2001. The existing causeway is approximately 32 feet wide, with a 15-foot-wide paved travel surface and is approximately 9 feet above existing mud line. The width of the causeway at the mudline is approximately 63 feet. The causeway is protected from erosion by a thick layer of large diameter riprap on the north and south slopes. The existing mud line is slightly higher on the south side of the causeway averaging approximately 0.7 feet higher, with a maximum of 0.9 feet higher.

Section 2
Soils

There have been no soil tests performed to determine engineering properties of the soils at the site. DE&S was not provided any records of the materials used for the construction of the causeway, and it is doubtful that any exist. The causeway was most likely constructed from local available material filled directly on the original causeway and marine sediments.

A seismic survey was performed by Mr. Alex Mann in 1998 to determine the amount of overburden and the depth to bedrock along the toe of slope of the causeway embankment. The results of the seismic survey showed that there was approximately 20 feet of overburden above bedrock along the southerly toe of the causeway. No description of the materials were made.

As no soil tests have been performed, a characterization of the materials will be based upon visual observations of soils conditions and observations of DE&S biologists during an October clam study. The material of the clam flats is variable, but generally is one half (½) to one and one half (1½) feet of unconsolidated silts, organics, and clays (muds) underlain by consolidated silts, clays, organics and sands. The upper layer of the consolidated material is stiff and contains shell fragments. The overburden material beneath the causeway will most likely be similar materials and will have been consolidated by the surcharge loading over the years. The causeway materials are most likely sands and gravels with cobbles and boulders.

An interesting observation from the DE&S clam survey was that the south side of the causeway had less unconsolidated sediment and generally had more coarse material.

Section 3

Existing Tidal Dynamics

The tidal cycle at the site ranges between fluctuations of 9-foot average tide to a 12-foot average spring tide. The average monthly mean tide for the Portland tidal gage is 9.1 feet. The average extreme monthly tide for the period 1950 to 2001 for the Portland NOAA National Ocean Service gage is 13.4 feet. The elevation of the flats near the causeway are approximately at mid tide elevation, so that at full normal tide, the depth of water is approximately 5 feet. Spring tides would create water depths at the causeway of approximately 6 feet or more. Ms. Martz was not aware of any tide or storm event that has overtopped the existing causeway.

Section 4

Proposed Modification

The proposed modification has been conceptually planned as a precast concrete arch bridge, founded on a reinforced cast-in-place concrete foundation (pile cap) supported on piles driven to bedrock as shown on the conceptual sketch provided to DE&S (Figure 3). The opening had been conceptually chosen as 12 feet, which is based upon estimates of the original causeway bridge width. Fill would be placed over the concrete arch to form the subgrade for the Dingley Island Road. The bridge pile caps and precast walls will retain the causeway embankment material. A layer of riprap will be placed along the invert of the opening just below the existing mudline to protect the foundation from any erosive forces. Wing walls will extend from the causeway at diverging angles along the fill slopes to the toe of the existing causeway.

The opening width and bridge type will be revisited during the final design process and will be selected based upon economics and constructability. For example, if foundation soil conditions permit, a 12-foot by 12-foot precast concrete box culvert could be used, which would eliminate the requirements for piles and cast-in-place concrete, speeding up construction and potentially reducing costs.

Section 5

Impacts to Tidal Conditions

The proposed construction of a span in the causeway will open the two basins, north and south, to tidal flow once again. Local residents who harvest clams are concerned about the potential impacts that any erosion and sediment transport might have on the existing clam flats.

The tidal dynamics of the project area are complicated and do not lend to computational hydrodynamic modeling, without modeling the entire New Meadows River Estuary. This would be a large undertaking requiring three-dimensional modeling of the Estuary and tidal cycles, with extensive data collection and model calibration.

With an opening in the causeway, the Dingley Island tidal flats will once again be essentially an open system. An open system subject to the same tidal cycles and timing with flood and ebb tides approaching and retreating with equal tidal stage from the Estuary to both the north and south basins. The tidal cycle itself will not create appreciable tidal flow through the proposed causeway opening, as both basins will experience the same tidal influences and range of tides. Flow through the proposed causeway opening will be more influenced by climactic events, such as from storms and winds. The causeway opening will not affect the rate the tide floods or recedes, nor the velocity of the tidal currents along the mud flats. As a result, any erosion of materials will be localized at the causeway crossing itself and be temporary and short term. Proper construction of the causeway invert would address this issue and would provide protection from localized erosion.

This is essentially the same conclusion as made by Mr. Steve Dickson of the Maine Geologic Survey in his review of the project in a November 9, 2000 memorandum (See attached).

Section 6

Erosion Potential and Sediment Transport Assessment

Unconsolidated and consolidated marine silts, clays and sands are susceptible to erosion from waves and currents. Flowing water exerts a shear stress on the soils due to fluid viscosity and turbulence. Soils material can be eroded when the restraining forces (gravitational, interparticle friction, and cohesion forces) on a soil particle are exceeded by the shear stresses imposed by moving water. The stress that will move a particle is referred to as the critical shear stress for erosion. The critical shear stress for soil types varies with the soil characteristics, such as particle size, density, particle shape and behavior. Fine silts and clays, once eroded, tend to stay in fluid suspension until tranquil conditions exist. In the marine environment this means that they will stay in solution until carried out to deeper water in the estuary where they will eventually settle out.

The north and south basins on the west side of Dingley Island have approximately a one mile direct fetch distance each. A full gale force wind of 60 mph from the South-south east or from the North-northeast will produce a wind set-up (or wind “tide”) of approximately 0.5 feet, and a wave height (significant wave height) of slightly less than three feet. This climactic condition will drive a flow through the causeway opening equal to slightly less than 300 cubic feet per second, with an average velocity within the 12-foot-wide opening of 4.7 feet per second. This velocity is enough to cause erosion and transport of unconsolidated sediment within the bridge section, if the sediment were exposed to the velocity. The invert of the bridge section will be protected from erosion by a blanket of riprap. The design of the causeway opening will also feature a transition section of headwalls that will accelerate and decelerate the water velocity through the opening. The velocity of the wind tide induced flow a short distance away from the causeway will be less than 0.5 feet per second.

Due to the localized and limited extent of exposed soils, there may be some short term limited erosion of materials near the causeway during construction, resulting in turbid water. These events will be short lived as the sources of sediment are small and the duration of exposure is short.

Section 7

Recommendations for Further Study

Soils investigations should be performed as a part of future engineering studies to determine the limitations or potential uses of the soils on the site. The soils investigations should address the composition of the existing causeway fill and underlying soils. The potential for "heaving" (soil shear failure due to surcharge) into the open span should be addressed for any pile solution not involving sheeting. The soils investigation will should collect samples along and through the causeway.

The causeway elevation should be established based upon a field survey tie to the National Geodetic Vertical Datum of 1929, so that the elevations of the causeway can be compared to the tidal datum. This will also enable a review and comparison of flood elevations for the 100 and 500-year coastal storm surge.

The final design process should revisit the determination of the causeway opening considering final consultation with the town and state. The economics of openings greater than 12 and less than 20-feet should be evaluated. The Maine Department of Transportation has jurisdiction for spans equal to and exceeding 20 feet in length.

The construction methods and sequence should be selected to minimize or eliminate transportation interruptions to residents of the islands. The use of temporary roads or fill should be incorporated so that emergency access or egress is not interrupted.

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