

**DRAFT**

**REVIEW OF SLOPE STABILITY  
AND INFRASTRUCTURE CONDITIONS**

**SHORELINE DRIVE, BAYSHORE DRIVE  
AND MACKWORTH POINT BRIDGE  
TO BROWN STREET**

**for the  
TOWN OF FALMOUTH, MAINE**

**October 2009**

# REVIEW OF SLOPE STABILITY AND INFRASTRUCTURE CONDITIONS

## TOWN OF FALMOUTH, MAINE

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## **BACKGROUND - PROJECT PURPOSE**

The report is intended to provide a concise but informative summary of the results of our investigations into the nature and extent of slope stability problems, as well as recommendations with respect to mitigation of current and impending problems along Bayshore and Shoreline Drives and northerly to the end of Brown Street. It also includes a discussion of the present state of sewer, storm drainage and street infrastructure within the project area, with recommendations relative to improvements in those systems.

## **SUMMARY OF TASKS COMPLETED**

Following the Town's decision to proceed with the evaluation, the initial tasks related to assimilation of mapping and preparing maps of the study area using the following information:

- Digital Orthoquad Aerial Photography (DOQ's).
- Municipal tax mapping (for approximate lot lines and ownership).
- GIS data layers corresponding to the Town's sewer and stormwater systems.
- USGS elevation data
- FEMA data relative to flood hazard issues

Since visual observations of both slope stability and infrastructure conditions would be key to the assessment effort, and since portions of the slope areas and sewer and drainage infrastructure fall within privately-owned parcel boundaries, it was determined that a formal notification to area landowners was appropriate. Following identification of the subject parcels and owners, letters were sent during the last week in July. In addition to advising the landowners about the assessment effort, it indicated that they should contact either Wright-Pierce or the Town with comments or questions. Several responses were received.

It should be noted that the mapping exhibits within this report document show approximate limits of public rights-of-way and parcel boundaries. This information is based on the Tax Parcel Data included within the Town's Geographic Information System and is subject to refinement based on actual boundary or right-of-way survey data.

***FIGURE 1 - PROJECT LOCATION MAP***

## **SITE SCREENING/FIELD OBSERVATIONS REGARDING STABILITY**

During August, staff from S.W. Cole Engineering (a firm specializing in geotechnical investigations and design) conducted site visits to the project area to visually assess the following:

- Areas of existing slope failures;
- Areas in which man-made activities and land use (such as cutting of vegetation, established walking paths, tree clearing, dumping of yard waste, etc.) are impacting or have the potential to impact the stability of the slopes;
- Areas where drainage patterns seem to elevate the risk of erosion/slope failure; and
- Other areas which can be identified as being at elevated risk for potential slope failure.

In addition, the geotechnical assessment effort included a review of soil types and other conditions to support conclusions relative to the mechanism and causes of past and current slope failures.

### ***Infrastructure Assessment***

In parallel with the site screening associated with slope instability, engineering staff from Wright-Pierce conducted site visits to review elements of municipal infrastructure. The assessment included the following components:

- Visual inspection of all storm drain outfalls which have been identified by the Town to identify erosion issues, problems with physical condition and evidence of illicit discharges (consistent with the Town's Phase II MEPDES Stormwater permit).
- Visual inspection of the sanitary sewer system, with a focus on the interior and exterior of manhole structures and visible portions of the piping.
- Assessment of the street/roadway infrastructure using standard record-keeping forms associated with the RSMS Pavement Management Systems. Where appropriate, the forms were supplemented by additional notes regarding surficial stormwater issues of concern.

### ***Summary of Findings***

Following completion of the field assessments into slope stability and infrastructure condition, the engineering staff compiled their observations into a framework that would support analysis and conclusions and would be convenient for reference by Town officials. The results are as follows:

### ***General Slope Stability Issues***

Based on surficial geologic soils mapping and our site reconnaissance, the profile of soils along the shoreline generally consists of outwash sands overlying glaciomarine clays with sand seams. The glaciomarine clays extend out into the natural reed marsh fronting most of the shoreline and then to the mudflats. Both predominant soil types are highly erodible particularly when disturbed from wave action or when denuded of vegetation. It is anticipated that groundwater seeps exiting the face of the shoreline also contribute to erosion of these soils and the gradual blocking failure that can be observed along the shoreline.

A number of studies have looked at the issue of coastal erosion over the years to determine the rate of soil loss and project issues that may relate to anticipated increases in sea levels. Because the rate of soil loss is highly dependent on both the nature of soil deposits and the extent the area is subject to tidal/current/wave factors, it is difficult to draw conclusions from studies based on other locations. In the present instance, the most relevant past evaluation appears to have been performed by Barry Timson and published in 1977. Timson's effort was focused on the area of the Gilsland Farm, which appears to offer similar geology, although wave and current factors may differ. Timson's evaluation suggested that the long-term rate of soil loss from the bluff was on the order of 0.15 meters/year.

Since future activities within the project area may be dictated to some extent by limitations imposed through both local flood hazard permitting and NEPA constraints on infrastructure projects using federally-originating funding, it is worth considering the likely ramifications of FEMA's ongoing program to update Flood Insurance Rate Maps. According to the Floodplain Management Program at the Maine State Planning Office, "Scoping to determine the extent of mapping needs was completed in March of 2006. Since then work has continued in developing new ortho photo base maps and acquiring LiDAR (Link to description of LiDAR) topographic data for the coastal sections of the county of all communities from Scarborough to Harpswell and including some of Bath". It is our understanding that new floodplain mapping is expected to be formally adopted in 2010. The Floodplain Management Program also reports that "The Maine Geological Survey has been doing coastal erosion studies in southern Maine that provide provocative and interesting analysis of potential flooding changes based on rising sea levels predicted to occur as a result of global warming."

### ***Observed Failure Scenario(s)***

The predominant failure scenario along the shoreline appears to be related to block failures triggered by wave erosion and groundwater seepage. The cohesive characteristics of the glaciomarine clays permit these soils to stand at relatively steep slopes for a period of time before blocks break off and deposit at the toe of the slope. The deposited soil at the base of the slope creates a stabilizing berm which is subsequently eroded by wave action thereby restarting the cycle. The contribution from groundwater seepage lubricated that base of the slope and stabilizing berm allowing a gradual creep to the ocean. Segments of shoreline partially protected from wave action, such as along Bayshore Drive between US Route 1 and the Mackworth Island Causeway, appear more stable, with flatter slopes and receding at a slower rate than those exposed to more harsh wave attack, such as east of the Mackworth Island Causeway. The storm drain outfalls further accelerate erosion of the stabilizing reed marsh front slope.

See Figure 2B - Slope Stability Issues (end of this section). The clouded area represents one problem area that needs immediate attention (i.e., within the next 12 months) and two "model" repair areas that approximate the recommended solution. Photos are also included in Appendix A. The shoreline area along Shoreline Drive appeared most at risk. We recommend monitoring this area at least bi-annually and after severe storm events. Monitoring would be best performed

in the Spring prior to foliage being established. When the head of the bluff becomes less than the height of the bluff, the need for mitigation should be considered imminent.

### ***Mitigation Options***

The principal mitigation option is to create stabilizing berms at the base of the slope that replicate those of the natural block failure mechanism, but are comprised of rip-rap that is resistant to erosion and keyed into the existing substrate to resist creep toward the ocean. The height of the stabilizing berms should be at least 2 feet above the design flood tide. Above the rip-rap stabilizing berms, the slope could be flattened using a granular fill material faced with rip-rap or a vegetated mat with salt resistant plantings. Non-woven geotextile fabrics should be installed against the existing substrate prior to installing the stabilizing berm rip-rap and slope repair materials (see attached typical section).

Simple rip-rap facing repairs, approximating the solution discussed above, have been installed along the shoreline at several properties. The most stable use larger rip-rap at the base, which somewhat replicates a stabilizing berm, with smaller rip-rap working up the slope. The stabilization projects that were previously completed in the vicinity of the ends of Hammond Road and McKinley Road appear relatively well constructed.

The shoreline could be stabilized one area/property at a time or altogether. Since the properties are private, it is likely that stabilization would occur one property at a time, which is feasible so long as the repairs use the same scheme so they will eventually integrate the entire shoreline. In our opinion, the conditions in the field seem to favor a piecemeal repair as areas are determined to be "at risk" over a period of years, rather than a global repair. In certain cases it may be possible to realize some economy of scale, where the costs could be proportioned based upon length of shoreline stabilized and surface area of slope repaired.

### Cost Implications

For planning purposes, we suggest budgeting approximately \$30,000 - \$40,000 for a section of approximately 100 feet in length.

### Permitting Implications

Work within 75 feet of the mean high water mark is typically regulated by the Maine Department of Environmental Protection (MeDEP) under the Natural Resources Protection Act (NRPA). Based on the repairs done to date, it appears that Permit-By-Rule would apply for repairs done by each individual property owner. If the repairs are done altogether, it is likely more rigorous permitting may apply. While the Corps of Engineers has jurisdiction over work performed below the high water mark, the need for a separate Corp review is generally waived for projects which are deemed eligible by the state for Permit-By-Rule.

***FIGURE 2A - CONCEPTUAL RIP RAP SLOPE DETAIL***

***FIGURE 2B - SLOPE STABILITY ISSUES***

***FIGURE 3 - FEMA FLOOD ZONE***

## STORM DRAINAGE SYSTEM - SYSTEM DESCRIPTION

- Runs of catch basin and drain manholes that discharge to Casco Bay via outfalls. Some outfalls serve only a small drainage area (only one or two catch basins), whereas others serve a much larger drainage area.

### Outfalls (inspected 17, could not locate 3)

- Outfalls vary in size and material from 8" PVC to 15" (inside dia.) RCP.
- Located on the slope adjacent to Bayshore and Shoreline Drive.

### Catch basins (27 inspected)

- Catch basins vary in size from 2' diameter to 4' diameter as well as "F" type (2' x 2').
- Catch basins also vary in cover type (some round with slots, cascade, square (non-cascade), etc).
- Risers were made of brick, block, precast, and at least one made of CMP, others had no risers. The majority were made of brick.
- Walls were precast concrete; however there a few were made of brick.

### Drain Manholes (5 inspected, 1 could not get cover off)

- There was one drain manhole that had a sewer cover, all others read drain manhole.
- One drain manhole was buried - we unburied the cover, inspected it, and left it unburied.
- Drain manholes were 4' diameter.
- Risers were made of brick or precast, at least one drain manhole did not have a riser.
- Walls were precast concrete.
- Two drain manholes were flowing during the inspections.

## ***Observed Issues of Concern***

### Outfalls

- All outfalls experience slope erosion to some extent.
- Significant number of outfalls having a hanging discharge.
- Erosion occurring under pipe.
- Pipe condition - one outfall (OF-014) in poor condition (rusted); another outfall completely plugged (OF-011).

### Catch Basins

- Overall the catch basins are in good condition; however some of the risers were in poor condition.
- Some catch basins had grit in bottom; one had as much as 12" of silt on bottom (others less than 4").
- A few had poor wall condition with cracks and poorly sealed joints. At least one had observed water seepage.
- Several catch basins did not have mortar around inverts.
- Oil sheen in sump and algae on the walls was observed in CB-017.
- One had noticeable cigarette butts in it (CB-024).
- CB-003 did not have a rim/frame. The cover was set directly on brick riser (of which grass was growing out of).

### Drain Manholes

- Overall the drain manholes are in good condition.
- One showed evidence of silt on the frame which is indicative of leakage in the cover or frame.

### ***Interconnections with MS4 Efforts***

- Inspections of the drainage system fall within the Town's second highest priority watershed: Casco Bay/Foreside.
- The outfalls were not inspected during dry weather; therefore "dry weather outfall inspections" were not completed; however no signs of illicit discharges were observed, except for CB-017 which had an oil sheen in the sump. This catch basin discharges to OF-014 (this outfall is bent and rusted back and in very poor condition with noticeable erosion).
- The Town can likely get credit in their PY2 AR for these inspections.
- The Town conducts dry weather outfall inspections at the closest upstream catch basin to the outfall, as noted in the Town's Stormwater Annual Report, and conducts the inspection during catch basin cleaning. It is not clear whether the Town conducted inspections on the same catch basins that we did.
- The outfalls were hard to find/access and were very overgrown - typically these types of inspections should be conducted in spring or fall when there is less vegetation.

At least one outfall was completely plugged - this should be added to a work order to be unplugged. The majority of the outfalls had very little stabilization and should be maintained.

- Any maintenance or upgrades to the stormwater infrastructure as a result of these inspections or this study should be added to the prioritized schedule that the Town needs to begin to develop/implement.
- One YardScaping sign was observed on Shoreline Drive, which could be noted in the PY2 Annual Report under Public Education and Outreach.
- Several instances, some rather significant, of grass clippings/lawn waste were observed dumped on the slope. Additionally, grass clippings were observed on some catch basin grates, in outfalls, and along the road. The discouragement of this behavior can be approached from several angles (i.e. YardScaping/healthy lawn, no dumping, slope stabilization, etc.).
- This behavior is indirectly being targeted in the ISWG BMP Adoption Plan. The BMP for behavior change in the Plan is the reduction of lawn fertilizers and pesticides. One of the BMPs for adoption includes mow high or mow better, which encourages homeowners to leave the clippings on the lawn after mowing. Information on public education and outreach efforts and YardScaping is available at: <http://www.cumberlandswcd.org/yardscape/index.htm>
- Catch basins on Shoreline Drive were recently stenciled, which was reported in the PY1 Annual Report.
- Public hearings and/or presentations related to this project can likely be woven into the PY2 report because of efforts to include the public in stormwater education/issues.

See attached Table 1 - Outfall Inspection Summary and photos included in Appendix B.

INSERT TABLE 1 - OUTFALL INSPECTION SUMMARY PAGE 1



## ***Mitigation Options***

Recommended mitigation measures associated with the storm drainage system can be summarized as follows:

### Outfalls

- Address "hanging" outfalls and slope erosion through the placement of stone riprap aprons (note that some pipes may need to be cut back);
- Replace piping at one outfall (OF-014). It is probably appropriate to consider excavating the pipe to determine the extent of the deterioration at the time of the rehabilitation; and
- Remove material plugging one outfall (OF-011).

### Catch Basins

- Clean sumps (selected locations - most appeared to have been well maintained in this regard);
- Consider replacing mortar around the pipe inverts in some catch basins; and
- Review potential for installing a flanged frame to accommodate the grate on CB-003 (the cover was set directly on brick riser). Note that this may dictate some alteration to the structure to accommodate the height of the frame without impacting the ability of the basin to collect drainage.

### Cost Implications

For planning purposes, we suggest budgeting approximately \$35,000 - \$45,000 to address the areas of concern identified above. While the remediation activities are straightforward in their own right, the issues associated with access to the outfall pipes can be expected to result in higher-than-usual costs.

### Permitting Implications

Work within 75 feet of the mean high water mark is typically regulated by the Maine Department of Environmental Protection (MeDEP) under the Natural Resources Protection Act (NRPA). Section 480-Q of the DEP rules discusses activities for which a permit is not required: they include

**Maintenance and repair.** Maintenance and repair of a structure in, on, over or adjacent to a protected natural resource and maintenance and repair of a private crossing of a river, stream or brook if:

- A. Erosion control measures are taken to prevent sedimentation of the water;
- B. Crossings do not block fish passages in water courses;
- C. There is no additional intrusion into the protected natural resource; and
- D. The dimensions of the repaired structure do not exceed the dimensions of the structure as it existed 24 months prior to the repair, or if the structure has been officially included in or is considered by the Maine Historical Preservation Commission eligible for listing in the National Register of Historic Places, the dimensions of the repaired structure do not exceed the dimensions of the historic structure.

This subsection does not apply to: the repair of more than 50% of a structure located in a coastal sand dune system; the repair of more than 50% of a dam, unless that repair has been approved by a representative of the United States Natural Resources Conservation Service; or the repair of more than 50% of any other structure, unless the municipality in which the proposed activity is located requires a permit for the activity through an ordinance adopted pursuant to the mandatory shoreland zoning laws and the application for a permit is approved by the municipality;

**2-A. Existing road culverts.** In any protected natural resource area, a permit is not required for the repair and maintenance of an existing road culvert or for the replacement of an existing culvert, as long as the replacement culvert is:

- A. Repealed. Laws 1993, ch. 315, § 2.8
- B. Not more than 25% longer than the culvert being replaced; and
- C. Not longer than 75 feet.

Ancillary culverting activities, including excavation and filling, are included in this exemption. A person repairing, replacing or maintaining an existing culvert under this subsection shall ensure that erosion control measures are taken to prevent sedimentation of the water and that the crossing does not block fish passage in the water course.

On this basis, it appears that rehabilitation of the pipe outlets can be accomplished without permitting with the MeDEP if the work consists of minor adjustments of the piping and replacement of dislodged armoring. More comprehensive efforts are likely to require more formal permitting under NRPA.

**FIGURE 4 - STORMWATER MAP**

***FIGURE 5 - STORMWATER MAP***

**FIGURE 6 - STORMWATER MAP**

## **SANITARY SEWER SYSTEM - SYSTEM DESCRIPTION**

The sanitary sewer collection system within the project area consists of an interceptor sewer laid along the shoreline which receives flows from collector sewers running along the streets within the project area (see attached map). Both the interceptor and collector sewers were constructed during the late 1960's and consist of asbestos cement pipe (ACP) with precast concrete manhole structures. The diameter of this section of the interceptor varies between 12 and 16-inches.

### ***Observed Issues of Concern***

Our assessment of the system was focused on the condition of the existing interceptor sewer and the associated manholes. Due to past and ongoing erosion of the slope area, some soil cover in the vicinity of the pipe arrears to have been lost, however, the area which was constructed with the minimum amount of cover does not appear to have been impacted as much due to it's relatively sheltered location between the Route 1 bridge to Portland and the causeway to Mackworth Island. Of greater concern is the fact that much of the riprap armoring that originally existed as protection around the manhole structures has been lost. In many cases, as much as 3- to 5-feet of the manhole structure is exposed.

It is worth noting that the Falmouth Sewer Department is presently engaged on a separate initiative to assess infiltration and inflow (I/I) within the sewers in this portion of the community. While several minor sources of infiltration were observed in the context of this evaluation, measures to address I/I are expected to be implemented in the context of this larger I/I study.

The attached map identifies problem areas. Reference photos in Appendix C for additional detail relative to observed problems.

### ***Mitigation Options***

Recommended mitigation measures associated with the sanitary sewer system are expected to consist of renewing the exterior waterproofing coating and replacement of stabilization (riprap) in the vicinity of the sewer manholes. Among the products available for sealing the exposed joints of the interceptor manholes is riser wrap <http://www.riserwrap.com/>. It is a shrink wrap product with a 5 year shelf life to protect the joints of the exposed man hole from infiltration. Several products are available to protect the precast concrete from salt (and the effects of chlorides on the embedded reinforcement), however most have limited projected effective lives (typically 5 years) and application may be complicated by limited vehicular access.

### **Cost Implications**

For planning purposes, we suggest budgeting approximately \$4,000 - \$6,000 per manhole location to address the placement of riprap. While the remediation activities are straightforward in their own right, the issues associated with access to the manholes can be expected to result in higher-than-usual costs. To the extent this work can be completed concurrently with slope stabilization or stabilization of outfalls the unit cost for the work may be reduced.

### Flood Mapping and Sea Level Rise

Earlier this year, the Federal Emergency Management Agency (FEMA) issued new draft flood hazard mapping for coastal areas in this part of the state. While Falmouth and other communities have challenged the new mapping, most parties agree that design criteria for high water elevations along our coastline are higher than they were four decades ago when the interceptor sewer was designed and constructed.

### Permitting Implications

Work within 75 feet of the mean high water mark is typically regulated by the Maine Department of Environmental Protection (MeDEP) under the Natural Resources Protection Act (NRPA). Section 480-Q of the DEP rules discusses activities for which a permit is not required. They include:

**Maintenance and repair.** Maintenance and repair of a structure in, on, over or adjacent to a protected natural resource and maintenance and repair of a private crossing of a river, stream or brook if:

- A. Erosion control measures are taken to prevent sedimentation of the water;
- B. Crossings do not block fish passages in water courses;
- C. There is no additional intrusion into the protected natural resource; and
- D. The dimensions of the repaired structure do not exceed the dimensions of the structure as it existed 24 months prior to the repair, or if the structure has been officially included in or is considered by the Maine Historical Preservation Commission eligible for listing in the National Register of Historic Places, the dimensions of the repaired structure do not exceed the dimensions of the historic structure.

This subsection does not apply to: the repair of more than 50% of a structure located in a coastal sand dune system; the repair of more than 50% of a dam, unless that repair has been approved by a representative of the United States Natural Resources Conservation Service; or the repair of more than 50% of any other structure, unless the municipality in which the proposed activity is located requires a permit for the activity through an ordinance adopted pursuant to the mandatory shoreland zoning laws and the application for a permit is approved by the municipality;

We suggest a discussion with MeDEP staff to gauge whether the re-stabilization of the interceptor manholes can be accomplished without permitting with the MeDEP. Because the work would be completed below the high water mark, it will also be necessary to coordinate with the Corps of Engineers, as they have jurisdiction over this area via section 404 of the Clean Water Act.

**FIGURE 7 - SEWER MAP**

**FIGURE 8 - SEWER MAP**

**FIGURE 9 - SEWER MAP**

## **ROADWAYS - DESCRIPTION**

The system of roadways within the project area consists in most cases of a paved street along the shoreline with connections to residential streets which run generally perpendicular to the shoreline (see attached plan). The streets along the shoreline are surfaced with bituminous pavement to a width of approximately XX feet. Due to the low speeds and low volumes of traffic within the area the streets are not striped to delineate the lanes for bi-directional traffic.

### ***Observed Issues of Concern***

Our assessment of the street system was focused on the condition of the existing pavement, conditions of the storm drainage system and evidence of present or future degradation associated with predicted erosion or slope failure. As presented above, there is one segment of Shoreline Drive, between Avon and McKinley Roads, where the head of the slope is within 10 feet of the roadway where repair of the slope is recommended within the next 12 months.

The attached map identifies problem areas. Reference photos in Appendix E for additional detail relative to observed problems, as well as Appendix F, forms documenting our observations relative to factors pertaining to pavement condition.

### ***Mitigation Options***

Based on the relatively good condition associated with pavement in the project area, we are not recommending any improvements at this time. Rather, the subject sections of roadway should be included within the Town's overall strategy for prioritization of crack sealing, hot bituminous overlays and related elements of roadway surface management.

### **Permitting Implications**

Since work within 75 feet of the mean high water mark is typically regulated by the Maine Department of Environmental Protection (MeDEP) under the Natural Resources Protection Act (NRPA) any roadway reconstruction effort that involves soil disturbance within this buffer zone must be accompanied by erosion protection measures and should reviewed to gauge whether permitting actions are warranted.

***FIGURE 10 - ROADWAY MAP***

**FIGURE 11 - SEWER MAP**

**FIGURE 12 - SEWER MAP**

