State of New Hampshire

GENERAL COURT
CONCORD

Final Report of the Commission to Study the Causes, Effects, and Remediation of Siltation in the Great Bay Estuary

(HB 216, Chapter 31:1, Laws of 2007)

May 2010

Final Report of the Great Bay Siltation Commission
(HB 216, Chapter 31, Laws of 2007)

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INTRODUCTION

This report fulfills the requirements of Chapter 31, Laws of 2007 for "establishing a commission to study the causes, effects, and remediation of siltation in the Great Bay Estuary".

The duties of the commission were:

I. Seek the assistance of the Environmental Protection Agency, the National Oceanic and Atmospheric Administration, the United States Fish and Wildlife Service, the National Marine Fisheries Service, the United States Army Corps of Engineers, and the United States Geological Survey, as appropriate.

II. Study the historic and current sources of siltation in the estuary.

III. Study the impacts upon the aquatic and riparian ecosystem.

IV. Study the recreational, social, and commercial uses of estuarine waters.

V. Study methods of minimizing additional siltation.

VI. Evaluate the desirability of remediation.

VII. Study optimal means of remediation considering economic, ecological, and other relevant factors.

A list of Commission members is provided in Appendix A

Background

The issue of siltation (synonymous with sedimentation) of Great Bay Estuary and its tributaries arose from both scientific research on the estuarine ecology and from anecdotal reports of users of the Estuary's water bodies that the rate and extent of sedimentation was problematic. For the purposes of its work, the Commission defined the process of sedimentation as the erosion, transport and deposition of material from the water column. Scientists at the University of New Hampshire and its Jackson Estuarine Laboratory have documented impacts of sediment on shellfish and eelgrass beds. Engineering studies have shown a decrease in flow in the Oyster River related to shallowing. Recreational and commercial interests on tributaries cite decreased access for navigation. Dredging has occurred on three tributaries, and there has been mounting public pressure for extending it to others. The Town of Durham's 2000 Master Plan recommends: "The Town should seek to have its water access points evaluated and reviewed by the State for placement on the list of future coastal dredging needs."

Beginning in August 2007, the Commission was educated on various dimensions of the sedimentation problem through a series of informational sessions. The Commission's work commenced with presentations on the degree of land conversion to impervious surfaces in the Estuary, geomorphology of rivers entering Great Bay and its impact on erosion and sedimentation, the sedimentation study conducted on the Oyster River, the state's coastal dredging program and ecological health trends of the Estuary.

Existing information on various topics was also assembled, including effects of suspended sediment on aquatic life, declines in shellfish and eelgrass beds, results of water quality sampling in Great Bay Estuary watershed tributaries, sediment loading by tributary, and studies done elsewhere on the eastern seaboard regarding the relationship between various types of land use and rates of export of sediment from them.

In addition, the Commission initiated research on the historic bathymetry of the Estuary (Dr. Larry Ward of the University of New Hampshire). A coastal recreation survey was conducted by Commission members working with Chris Williams of the New Hampshire Department of Environmental Services' Coastal Program to establish the degree to which sedimentation has affected recreational use of estuarine waters.

The 2009 State of the Estuary Report was released in the fall of 2009, providing additional information about factors relating to the topic of sedimentation in the Estuary.

Commission members then considered the information gathered over the preceding two-year effort to develop a set of recommendations for remediation, and identification of further research that needs to be done to address the issue of estuarine sedimentation.

Two subcommittees were formed to engage Commission members in a more focused discussion. The Causes subcommittee worked to identify the sources of sedimentation while the Effects subcommittee endeavored to uncover evidence of the impacts the problem. Most of the work of the Commission occurred within these two subcommittees. The final recommendations and conclusions were written by the Commission through a series of in-depth discussions and weighing of the evidence presented by the subcommittees. This report is the result of that deliberation, and is organized to reflect that process.

The Commission's Conclusions:

1) There is a problem of increasing sediment deposition into Great Bay Estuary which results from human changes to the watershed. Increasing impervious surfaces within the watershed, along with uncontrolled run-off and inadequately managed stormwater are creating an ecological crisis in the Estuary.

2) The trend of increasing sedimentation must be reversed in order to restore the ecological functions and values of the Estuary. Steps must be taken throughout the watershed to decrease sediment loading and runoff into the tributaries. Best management practices (BMPs) for stormwater discharge need to be made a high priority within all cities and towns of the watershed. Prevention must start where the problem starts,

throughout the watersheds of the Estuary's various tributaries, with storm water control and good land management.

3) In order to fully address the issue of sedimentation, data must be gathered to develop a "sediment budget" to establish where sediment is coming from, going to, and in what quantities. An increased understanding of sediment dynamics and long-term trends in Great Bay Estuary are crucial for effective intervention and management.

4) Remediation of excess sedimentation must include establishing functional geomorphology to support productive ecosystems in the Estuary and its tributaries, including regulation of flood flows, bank stabilization, and consideration of dam removal. Sediment removal through dredging should occur only through a comprehensive dredge management plan that establishes the highest priority parts of the Estuary and places a premium on dredging that combines ecological benefits with navigation and other benefits.

I. CAUSES OF SEDIMENTATION IN THE GREAT BAY ESTUARY

The Commission's Causes subcommittee examined whether there is evidence that sediment accumulation in Great Bay Estuary exceeds what would occur under natural conditions. There is significant evidence in the scientific literature that indicates human activities can increase sediment levels in receiving waters. For example, runoff from urban impervious surfaces and other land uses is known to increase, in some cases by significant amounts, the discharge of sediments to receiving waters. This relationship between land uses and the potential for discharge of sediments has been well documented.

The Causes subcommittee initially hoped to apply sediment models that had been developed in other watersheds, such as the Chesapeake Bay region, to develop an estimate of the volume of sediments produced by human activity within the Great Bay watershed based on land-use data. Unfortunately, there are significant challenges to developing a model to produce a valuable estimate of sediment loading that would be expected based on existing land uses. Thus, what initially appeared to be a relatively straightforward task of applying research conducted in other watersheds to Great Bay Estuary would either require a great number of assumptions that would undermine the validity of the results, or, would require technical and financial resources well beyond the means and time available for this Commission.

Some of the challenges to develop a land-use based model of the sediment loads to Great Bay Estuary include the following:

- Studies and models developed for other watersheds contain specific assumptions concerning soils, geology, hydrology, climate and other environmental conditions that would need to be adjusted to reflect conditions present in Great Bay Estuary; and

- Land uses from other watersheds reflect local practices that may differ significantly in Great Bay Estuary. For example, a model developed for agricultural runoff in the Chesapeake Bay region would need to be adjusted to reflect practices in the Great Bay watershed. The same is also true for other land-use practices such as forestry, and residential, commercial and industrial development.

These uncertainties are made even more complicated due to the effect of tides and movement of sediments within Great Bay Estuary itself, and the fact that not all sediments discharged into Great Bay Estuary can be expected to behave uniformly. For example, coarse sediments discharged into the Estuary during storm events may be deposited close to their source waters, while other finer materials could remain in suspension for longer periods and potentially carried farther into the Bay, or remain in suspension and leave the Estuary via the Piscataqua River. Coarse-grained sediments can also be transported in channels creating shoaling problems, as demonstrated by researchers with the University of New Hampshire Center for Ocean Engineering and Dartmouth College. Bilgili et al. (1996) and Bilgili et al. (2003) described bedload transport rates and the processes leading to the development of sand waves and shoals in the lower Piscataqua River that requires dredging indicating rapid sedimentation in that region. The Commission members with research or other experience working in the Estuary indicated that storm events frequently redistribute sediments within the Estuary (Ward and Bub, 2005).

The Commission feels that developing an estimate of the sediments produced by different land uses in Great Bay Estuary is an important goal and will help develop a better understanding of the extent of sediment accumulation in Great Bay Estuary and management implications. The Commission does not feel that sufficient research has been completed that would allow the contribution of each potential source of siltation to be quantified or modeled with any reliability. As a result, the discussion returned to the fundamental question: whether there are any empirical data that suggest or provide evidence as to the rate at which siltation in Great Bay Estuary may be occurring, either under natural conditions or due to human alteration of the watershed landscape.

Many sources may contribute to siltation in Great Bay Estuary. These include both man-made sources and natural sources such as the natural erosion of soils and their redistribution within Great Bay Estuary due to storm events.

The sources discussed below included the following:

- Natural causes
- Runoff from developed areas, especially impervious surfaces
- Construction sites
- Agricultural land uses
- Forestry operations
- Transportation corridors
- Wastewater treatment facilities

- Dams and undersized culverts

Natural Causes of Sedimentation

Even in undisturbed areas, there will always be sedimentation caused by runoff and shoreline erosion. Both the current and historic natural inputs of sediment into Great Bay Estuary and the outputs to the Gulf of Maine are incompletely understood. The Commission recommends the completion of additional studies on the historic rate of sediment accumulation, such as a thorough examination of sediment cores. This would provide information on Great Bay Estuary's natural rate of sedimentation, and could provide data to determine the rate of sedimentation as the land surrounding the Estuary has been developed over the last few centuries.

Stormwater Runoff from Developed Areas

Surface runoff (stormwater) carries sediments and other pollutants into the Estuary. The amount of sediment depends, in part, on the land use, and the amount of treatment the water receives before it flows offsite. BMPs including the use of appropriate stormwater treatment practices have been shown to significantly decrease sediments in runoff. Impervious surfaces increase both the volume and rate of surface runoff, resulting in more erosion of soils or stream banks. Land uses that are known to contribute high sediment loads include construction, agriculture, and transportation related infrastructure.

Stormwater runoff from urbanized (i.e. paved) areas is the leading source of non-point pollution in New Hampshire (NHDES 1999). Stormwater causes pollutants and particulate matter containing heavy metals, hydrocarbons (oil and grease) and organic waste to flow directly to surface waters with little or no treatment. It also increases temperature, nutrient, turbidity and bacteria levels, and reduces dissolved oxygen. Studies conducted in New Hampshire indicated that surface water quality declines sharply when *as little as 10 percent* of a watershed is covered by impervious surfaces (Deacon et al. 2005) In sections of some watersheds' commercial and industrial zones, such as in the Paul's Brook Watershed in Newington, imperviousness already exceeds 40 percent.

Watershed-wide development has created new impervious surfaces at an average rate of nearly 1,500 acres per year. In 2005, there were 50,351 acres of impervious surfaces in the Great Bay Estuary watershed, which is 7.5 percent of the watershed's land area. Nine of the 40 subwatersheds contained over 10 percent impervious cover, indicating the potential for degraded water quality and altered stormwater flow. Land consumption per person, a measure of sprawling growth patterns, continues to increase (PREP 2009), as has more commercial development that includes large parking lots.

Construction Sites

Improperly managed construction sites may be a significant source of sediments (Figure 1). Appropriate construction controls include silt fencing, runoff reduction, and stormwater treatment. BMPs designed to control surface flows, such as ponds or constructed wetlands, will decrease the erosion potential of stormwater**.** The Natural Resources Conservation Service (NRCS) estimates erosion from land clearing for development in New Hampshire at 30 to 40 tons per acre per year. Where the problem is severe, losses may be as high as several hundred tons per acre per year. By contrast erosion from undeveloped land is typically less than 1 ton per acre per year (NHDES 1999). Requirements for erosion and sedimentation control measures at construction sites depend on the size of disturbance. Smaller projects that do not fall under the NHDES Alteration of Terrain Program are subject to requirements imposed by municipalities. However, there is much variability from town to town with regard to BMPs required for construction site erosion and sedimentation control measures as part of a site's stormwater management plan. Enforcement and monitoring for effectiveness of the BMP can be erratic. An ongoing study by the Piscataqua Region Estuaries Partnership (PREP) is attempting to quantify the extent of construction activity in the seacoast region that was covered by federal, state, or local regulatory or permit requirements.

Figure 1: Run-off from highway and construction sites can be a major source of sediments. The above photographs were taken on July 11, 2006 in Newington, New Hampshire several hours after a rain storm. Sediments from a nearby construction site washed on to the surface of the road and into the storm drain system which discharged into Little Bay (Source: Newington Conservation Commission).

Agricultural Land Uses

Agriculture can also be a significant source of sediments (Figure 2), but conservation and the use of BMPs have significantly reduced agricultural runoff in New Hampshire. The NRCS estimates that in 1982 half of the state's cropland was eroding at annual rates of at least 3 tons per acre per year. By 1992, erosion rates had dropped in half due to conservation practices. BMPs for agricultural land include buffer areas, cover crops, and rotation of pasture land. Agricultural BMPs are largely voluntary and their implementation varies widely.

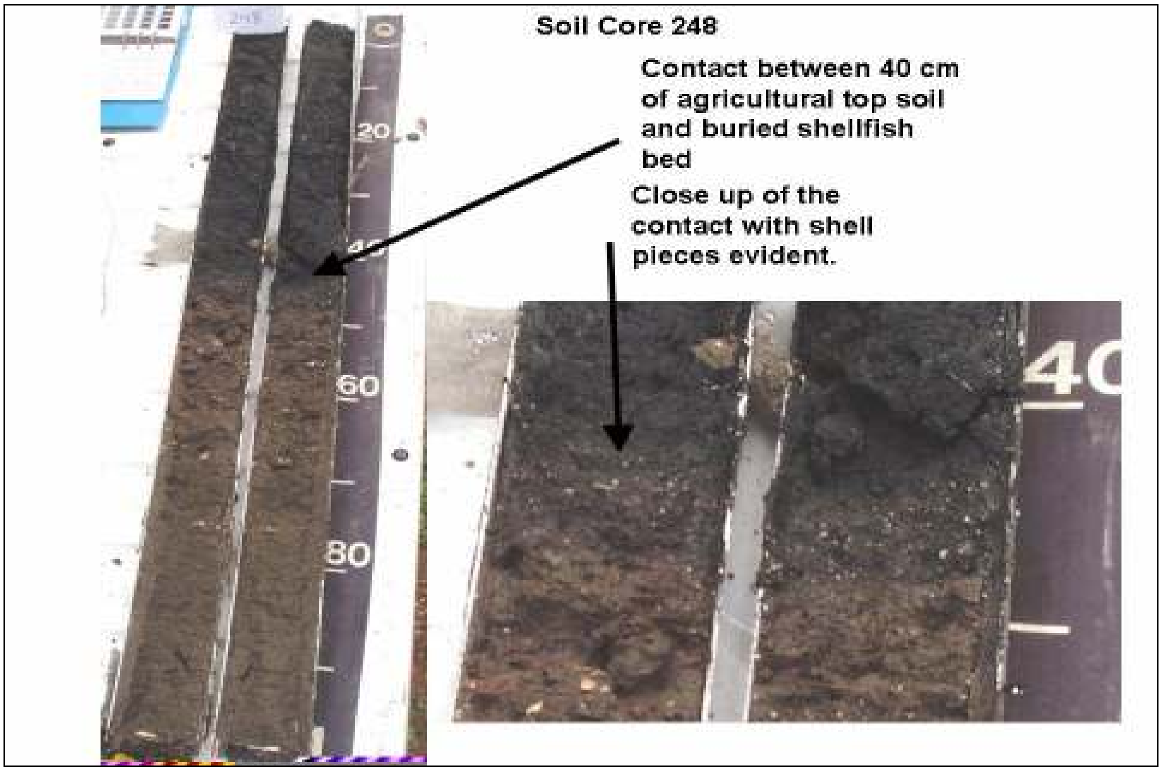

Figure 2: Photo of sediment core taken from the Bellamy River showing agricultural soil deposits over historic oyster reefs (Source: NRCS).

Forestry Operations

Active forest management or harvest can result in sedimentation. Forestry management guidelines have been developed to limit the impacts of forestry operations to water resources, largely by minimizing erosion (New Hampshire Division of Forests and Lands, and the Society for the Protection of New Hampshire Forests, 1997). Forest management and timber harvesting activities within Great Bay watershed are not inconsequential. During the period from 2000 through 2004, the New Hampshire Department of Environmental Services Wetlands Bureau received 279 notifications for crossings of wetlands or surface waters associated with forest management or timber harvesting activities. The number of notifications increased to 324 for the period from 2005 through 2009.

Transportation

Runoff from roads and parking areas contains high concentration of sediments from eroded soils, from sand used in winter maintenance, and from roadway dirt and debris. Unpaved roads, in particular, are prone to erosion. According to the Office of Energy and Planning, there were approximately 4,464 miles of roads in the Piscataqua River and coastal watersheds in 2005.

Wastewater Treatment

After initial discussions, the Commission did not further evaluate wastewater treatment facilities as a source, since it was believed they did not contribute significantly to the deposition of sediments in Great Bay Estuary compared to the sediment loads delivered by the major rivers.

Dams and Culverts

Disrupted natural flows associated with undersized or poorly placed culverts, and dams, result in altered hydrologic processes that contribute to sediment pulses under high-flow storm conditions. Culverts that constrict natural stream banks cause accelerated flow velocities that may suspend additional sediments. While impacts of dams on freshwater river systems are well documented, the role of dams in the tidal environment is less studied. In general, sediments accumulate behind dams. This accumulation, however, is not enough to significantly reduce the flows of sediment downstream, especially as these dams age and their impoundments fill up and become shallower. In addition, during spring runoff and large storms, sediments are resuspended and migrate downstream.

The tidal portion of a river can also be impacted by upstream dams. Tidal flows bring sediment upstream to the base of the dam. When the tide slows, especially under low upstream river flow conditions, sediments may drop out. This process has been well-documented in the Canadian portion of the Gulf of Maine.

Dam or barrier removal can reverse some of these impacts. High rivers flows return to an unmoderated condition. The river is then able to flush sediments in a more normal manner. Similarly, the return to normal tidal flows can reduce the amount of sediment that drops out at the base of dams. The initial removal of a dam requires a sediment control plan since it can create a large pulse of sediment that may contribute to siltation. This pulse needs to be weighed against the long term benefit of a return to normal flow regimes. Over time, a naturally flowing river system will find its equilibrium and a normal rate of sedimentation.

II. EVIDENCE OF SEDIMENTATION IN GREAT BAY ESTUARY

Whenever the load in an aquatic system exceeds the sediment carrying capacity, the excess sediment is deposited, typically in lower energy/velocity areas such as mudflats or sand bars. As sedimentation increases, the water becomes shallower, potentially impacting the ecology of the estuary and affecting navigation.

Sediments that are not deposited can be removed from Great Bay Estuary by flushing through the Portsmouth Harbor into the Gulf of Maine. Sediments that are deposited in the Estuary can be re-suspended during storm events and by tidal action.

Sediment is also removed from the system by dredging. With the exception of recent maintenance dredging activities in the Cocheco and Squamscott Rivers, minimal dredging has occurred within the tributaries to Great Bay Estuary in the past 100 years. In the Piscataqua River, however, significant large-scale dredging projects by the United States Army Corps of Engineers have occurred to improve deep draft navigation for shipping.

There have been several studies in the past that assessed longer-term (decades to approximately a century) sedimentation rates in the Estuary (i.e., Capuzzo and Anderson 1973, Leavitt 1980, Ward 1995). Although important insights into sedimentation rates at specific locations are given by these studies, they do not provide adequate coverage to understand the high variability in rates throughout the Estuary.

The Commission examined in detail the four recent studies discussed below to quantify the sedimentation in Great Bay Estuary, two of which were created specifically for the Commission.

A. Recent Evidence Concerning Increases in Sediment Loads in Tributary Rivers

On October 22, 2009, the New Hampshire Department of Environmental Services (NHDES) published a report entitled *Sediment Loads from the Great Bay Estuary Watershed: A Report to the Siltation Commission* (the "Sediment Loads Report"). The Sediment Loads Report was prepared by Philip Trowbridge, P.E., an engineer in NHDES' Watershed Management Bureau and Coastal Scientist for the Piscataqua Region Estuaries Partnership (PREP) who has worked extensively on water quality issues in Great Bay Estuary and other waters of the State. The Sediment Loads Report is contained in Appendix B.

The Sediment Loads Report evaluated existing data collected by the NHDES and the University of New Hampshire (UNH) regarding stream flow volumes and suspended sediment concentrations in tributaries to Great Bay Estuary measured at the tidal dams during three periods: 1993-1996, 2002-2005, and 2006-2008. Software developed by the United States Geological Survey (LOADEST) was used to estimate actual sediment loads to Great Bay.

The following trends were noted in the Sediment Loads Report:

- The largest sediment loads were from the Exeter, Lamprey, Cocheco, and Salmon Falls rivers (Figure 3);

- The loads from Great Bay Estuary watersheds were relatively constant across the three study periods. The exception to this statement is the Lamprey River, for which the loads nearly doubled in 2006-2008 from the previous years. The cause of this increase in unknown.

- The overall sediment yield (i.e., sum of loads divided by sum of drainage areas) from Great Bay Estuary watersheds (Figure 4) was 7.1 tons per year per square mile in 2002-2005 and 9.1 tons per year per square mile in 2006-2008.

- The Oyster River has a sediment yield which is disproportionately large for its size, compared to other rivers that drain into Great Bay Estuary.

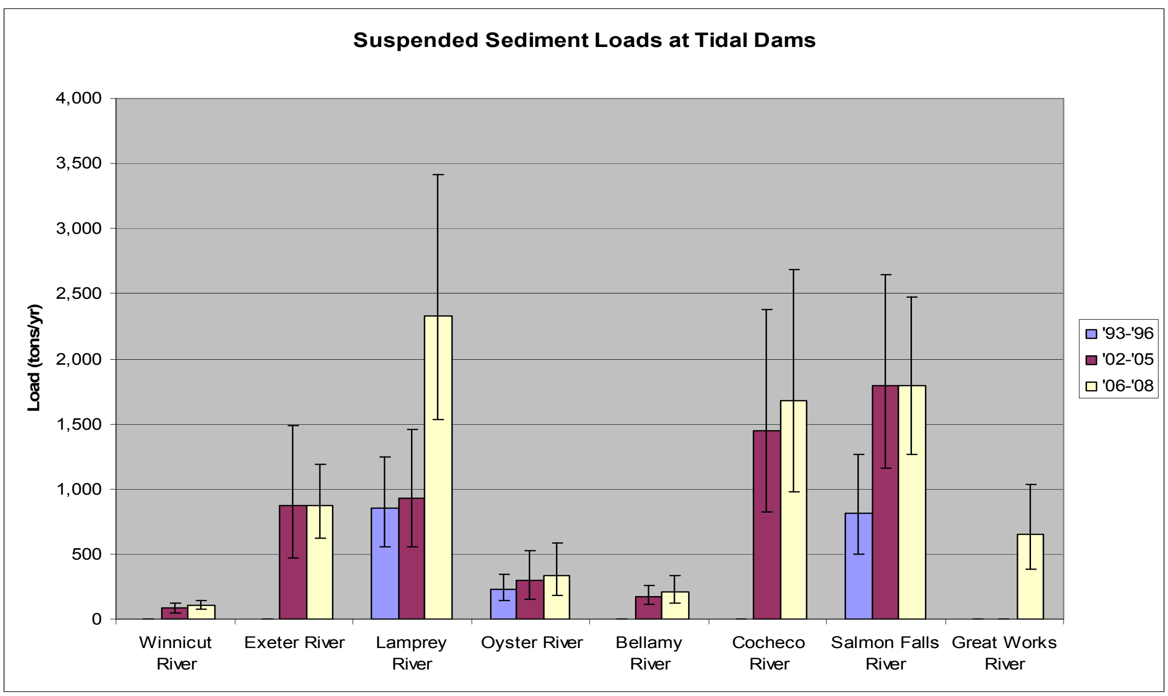

Figure 3: Average Loads of Suspended Sediments from Great Bay Estuary Watersheds (Trowbridge 2009).

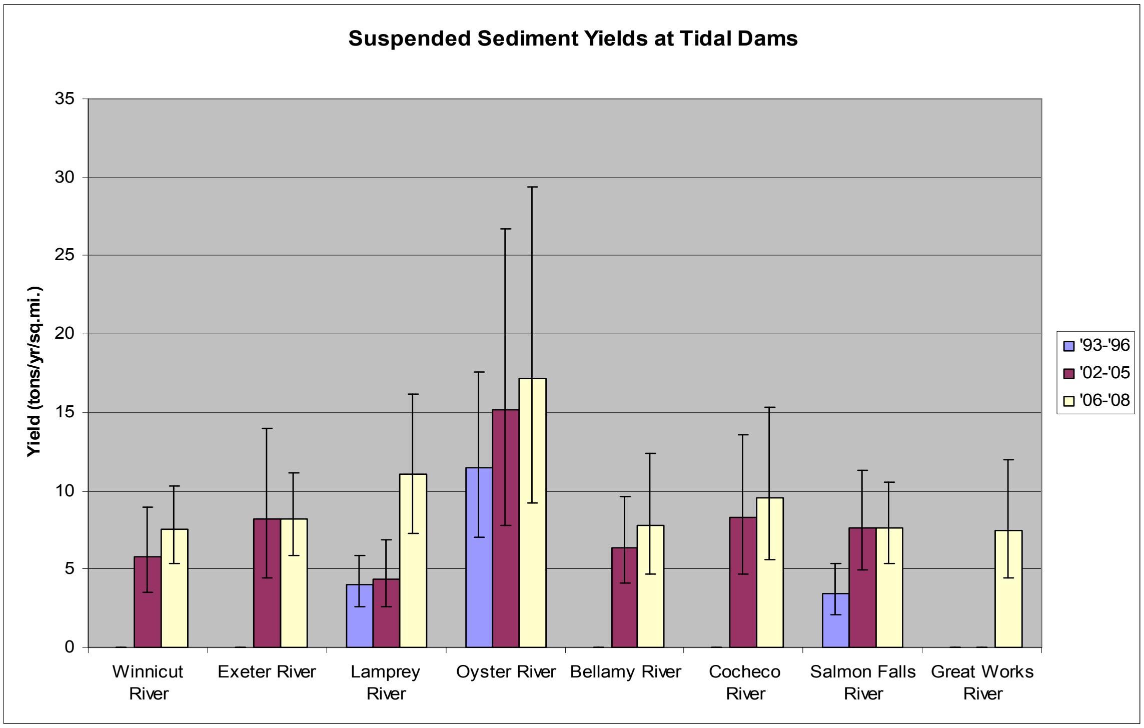

Figure 4: Average Yields of Suspended Sediments from Great Bay Estuary Watersheds (Trowbridge 2009).

The NHDES reviewed and compared its result with other published reports concerning sediment yields. Their analysis indicates that sediment yields for Great Bay Estuary watersheds are at the low end of the range observed in other watersheds. However, the Sediment Loads Report and NHDES staff indicated that estimates of actual sediment yields may be biased to produce lower than expected results due to a number of factors, including the analytical and sampling methods used, which do not accurately measure fine sediment particles, and may miss high flow events.

The results are significant, however, in that they indicate that in recent years the sediment loads have increased from 7.1 tons per year per square mile for the period 2002 to 2005, to 9.1 tons per year per square mile for the period 2006 to 2008.

B. Analysis Concerning Changes to the Bathymetry of Great Bay Estuary

Bathymetric surveys have been conducted in Great Bay Estuary for more than a century, largely for navigation purposes, using a variety of technologies for soundings (i.e., lead lines, single beam and multibeam acoustics) and positioning (i.e., sextant, RTK GPS). Dr. Larry Ward at the UNH Center for Coastal and Ocean Mapping conducted a study directed at examining these bathymetric surveys entitled “Development and Analysis of a Bathymetric Database for Great Bay Estuary, New Hampshire”(Appendix C) .
A digital bathymetric database was built using existing surveys conducted in Great Bay Estuary in order to assess changes that have occurred in the estuary in the past and to create a baseline for the future. To date, a total of sixteen bathymetric surveys have been acquired that occurred from 1898 to 2007. Two of the surveys (1898 and 1903) were not

previously available in digital form, and were digitized as part of this project. The addition of these early bathymetric surveys from Portsmouth Harbor and the Piscataqua River extended the period of coverage for Great Bay Estuary. Following the compilation of the bathymetric database, all surveys were converted to a common coordinate system (UTM 19N WGS84) and units and were brought into a GIS (ArcGIS). The database will continue to grow as more surveys occur. At present, the surveys group into three time periods: 1898 to 1913; 1953 to 1955; and 2001 to 2007.

A comparison of the 1913 and the 1953-1955 National Ocean Service (NOS) bathymetric surveys of upper Great Bay Estuary was done in order to assess changes in depths using a modification of a method developed by Jakobsson et al. 2005. The 1913 and the 1953-1955 NOS surveys were used for comparison, rather than the more recent surveys, due to their wider spatial coverage.

Quantifying depth changes between the 1913 and the 1953-1955 surveys was problematic due to inherent limitations of the data sets that were discovered when examined in detail during the study. The problems are related to the fact that the historical surveys used during this study measured the level of the tides (necessary to establish a common vertical reference or datum) at very different locations and thus quantitative comparisons between the historical surveys are limited. Nevertheless, qualitative assessments of morphologic changes can be done. Comparison of the 1913 and 1953-1955 NOS surveys of the eastern third of Great Bay indicate that reaches of the northern channel became shallower over the 40-year period indicating shoaling occurred.

Results of the bathymetric comparisons in upper Great Bay Estuary demonstrate the need for modern high resolution surveys that include coverage in shallow regions with a common referencing system (horizontal and vertical). Development of high resolution bathymetric maps in critical areas will provide a baseline for future comparisons. During summer 2009, the UNH Center for Coastal and Ocean Mapping – NOAA Joint Hydrographic Survey conducted a single beam bathymetric survey of Great Bay in an effort to begin to address this gap. The data from this survey is presently being processed and will be made available upon completion.

C. Assessment of Sediment Accumulation and Erosion in Great Bay Estuary Using Sediment Elevation Tables

The continual input of soil and organic particles into Great Bay Estuary from upland runoff and the surrounding rivers has resulted in a net increase in sediment in Great Bay Estuary. The amount of fine-grained sediment has increased significantly in Great Bay Estuary over the past 13 years (Felch and Short 2009). Use of SET (Sediment Elevation Tables) to measure sedimentation at several locations in the estuary since 1996 has shown rates of accumulation of approximately 1 cm/yr within the eelgrass beds of the Estuary, a high accumulation rate for a coastal estuary. Large inputs of sediment to the Estuary that occur during storm events, which flush materials from the rivers into the Estuary, have been seen to bury eelgrass beds near river mouths over the past decade.

D. Feasibility Study for Reestablishing a Navigation Channel in the Oyster River

Comparison of historic charts with 2002 hydrographic studies show changes in Oyster River channel morphology over time, with heavy deposition of silt in the upper third of the river and at the mouth of Johnson Creek. Due to filling of the Mill Pond in Durham by upstream sediment, it may no longer serve as an effective silt trap. Sediments are now carried over the dam. A recent bathymetric survey of the Mill Pond showed that a well-defined channel now exists through the pond. The sediments in slower moving parts of the pond are now becoming consolidated and vegetated (Oyster River Channel Restoration Task Group 2002).

III. EFFECTS OF EXCESSIVE SEDIMENTATION ON GREAT BAY ESTUARY

The Commission assessed the negative impacts of excessive sedimentation on the ecological and human uses of Great Bay Estuary. The Effects subcommittee developed a matrix to show the primary ecological, recreational, social, and commercial impacts of excess siltation in Great Bay Estuary. The matrix is included in the Appendix D, with key areas summarized below. Gaps in knowledge are also identified in the table.

A. Ecological Impacts

The following sections describe the primary ecological threats to estuarine habitats (eelgrass beds, oyster reefs, subtidal bottom, mudflats) and species (estuarine fish).

Eelgrass and the Eelgrass Habitat

"Eelgrass (*Zostera marina*) is essential to estuarine ecology because it filters nutrients and suspended particles from water, stabilizes sediments, provides food for wintering waterfowl, and provides habitat for juvenile fish and shellfish, as well as being the basis of an important estuarine food web. Healthy eelgrass both depends on and contributes to good water quality. Excess nitrogen contributes to eelgrass loss by increasing phytoplankton blooms which decrease water clarity and by promoting the proliferation of macroalgae." (PREP 2009).

Siltation causes suspended sediments in the water column, which reduce light reaching the bottom and thereby reduce the productivity of eelgrass in the estuary. It has been shown that less light reaching eelgrass directly decreases its productivity (Short et al. 1995). Decreased water clarity and decreased light conditions from increased sediment and nutrient loading have eliminated <u>all</u> eelgrass from the waters of the Piscataqua River (north of Portsmouth Harbor) and from Little Bay (Beem and Short 2009) and caused a reduction in eelgrass production and biomass in Great Bay proper (Figure 5). Particularly in Great Bay, resuspension of silt particles affects water clarity, further increasing the impact of siltation on eelgrass health. Excess sediments and the nutrients that accompany them are the two main risk factors affecting eelgrass and its survival in Great Bay

Estuary. Eelgrass is the main filter of sediment from the waters of Great Bay and is also the basis of an estuarine food web critical to the ecology of the estuary. Continued losses of eelgrass reduce the health of the Estuary.

In the most recent 303(d) list that NHDES submits through the Environmental Protection Agency (EPA) to Congress, many areas were added because of degradation of eelgrass beds. This report analyzed data from both new surveys and historic sources, and concluded the following:

> "The analyses determined that there has been significant eelgrass loss in most of the assessment zones of the Great Bay Estuary. Due to the importance of eelgrass for the ecosystem of the estuary, the loss of this habitat constitutes a violation of the Biological Aquatic Community Integrity water quality criteria (Env-Wq 1703.19). Based on the numeric nutrient criteria, many of the assessment units were found to be impaired for nitrogen. In the Cocheco River and the Salmon Falls River, the nitrogen impairment is related to violations of the dissolved oxygen criteria. In all the other impaired assessment zones, the nitrogen impairment is related to significant eelgrass loss." (NHDES 2009).

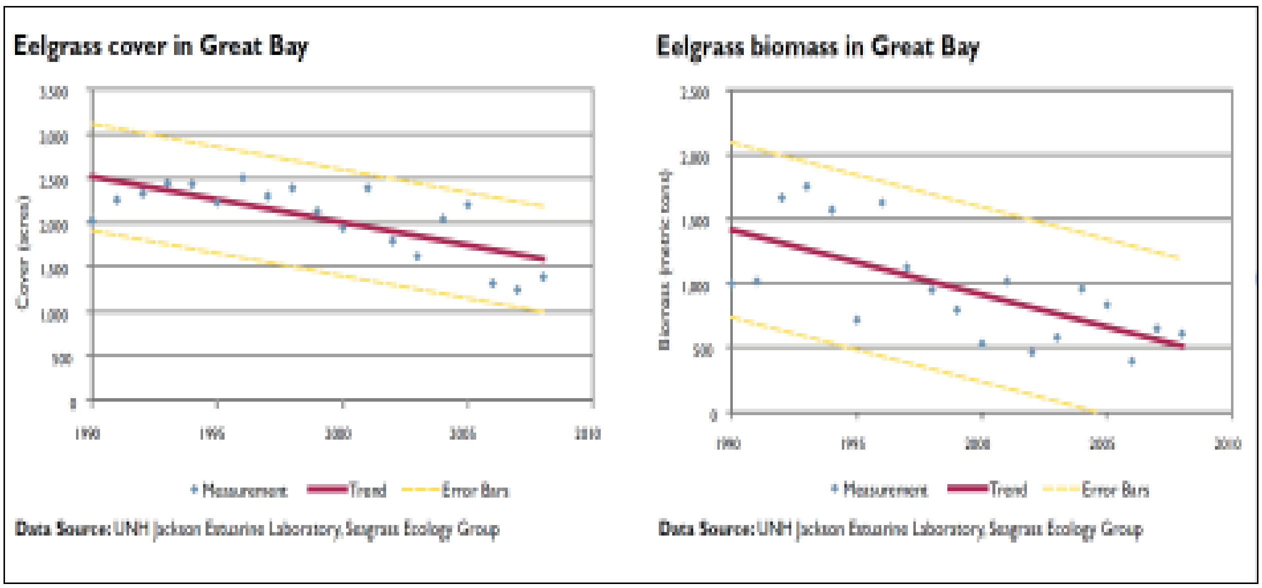

Figure 5. Eelgrass cover and biomass in Great Bay (PREP 2009).

Oyster Reefs and Shellfish Beds

"Oysters are the keystone species in the estuarine ecosystem. They are relatively long-lived, stationary filter feeders that play important roles in nutrient cycling and water quality. They also provide food and habitat for other species in the estuary. They are economically important because they support valuable recreational fisheries and have potential as an aquaculture species." (PREP 2009).

Although oyster and clam beds provide important filtration services that improve water quality for eelgrass and other organisms, population recovery is limited by excessive sediment and siltation events. Historically, hundreds of acres of oyster reefs have been lost in Great Bay Estuary (Odell et al. 2006) due to a combination of over-harvest, disease, and sediment/nutrient pollution. From 1993 to 2002, populations of adult oysters in Great Bay Estuary were reduced by more than 90% primarily due to disease. (PREP 2009). However, in recent years there has been a modest increase in oyster populations following three strong recruitment years (2003, 2006 and 2007).

High levels of siltation directly impact Great Bay Estuary oysters through these pathways:

- Filter feeding is disrupted by excess suspended solids (Loosanoff 1948);
- Reproductive success is reduced by elimination of hard-bottom substrate needed for larval settlement and by direct damage to larvae (Loosanoff 1962); and
- Organisms are directly buried in large deposition events following storms (as observed in the Bellamy River, personal communication, R. Grizzle, UNH Jackson Estuarine Laboratory).

Subtidal Bottom and Intertidal Mudflat Communities

Silt from tributaries contributes directly to the amount of fine-grain sediments suspended in the water column and eventually deposited on subtidal bottom and mudflats. In the Feasibility Study for Reestablishing a Navigation Channel in the Oyster River, Dr. Steve Jones, UNH Jackson Estuarine Laboratory analyzed the composition of estuary bottom sediments at ten locations and found very high percentages of fine-grain sediments (50-97%). The highest amounts were all found at the mouths of small tributary creeks, indicating the land-based runoff source of these particulates (Oyster River Channel Restoration Task Group 2002).

Fine-grain sediments are associated with increased levels of toxic contaminants and nutrients due to the chemical binding characteristics of particulates. In Great Bay Estuary, approximately 24% of the estuarine sediments tested in 2002-2005 had at least one contaminant at a concentration greater than a screening value (PREP 2009).

Estuarine Fish

Excessive siltation directly impacts estuarine fish through three primary pathways:

- Health suffers through clogged or damaged gills (Wilber and Clark 2001);
- Feeding opportunities are lost due to poor visibility and/or limited food supplies (Bruton 1985); and
- Fertilization and overall reproductive success is reduced (Galbraith et al. 2006).

Although there are no studies specific to silt impacts on estuarine fish in Great Bay Estuary, Auld and Shubel (1978) studied migratory species and showed that excess silt reduces the success of larval egg development for river herring and shad, and may also limit availability of substrates needed for egg development of rainbow smelt. A literature review of the effects of suspended solids on estuarine fish and shellfish was done by the New Hampshire Fish and Game Department and provided to the Commission (Fischer 2008, Appendix E). Populations of rainbow smelt in Great Bay Estuary have been decreasing for decades (New Hampshire Fish and Game Department 2009).

B. Recreational and Social Impacts

Survey of Human Uses

One of the duties the legislature assigned to the Commission was to "Study the recreational, social, and commercial uses of estuarine waters." To help fulfill this obligation, the Commission developed a Recreational Use Survey to ascertain how and where users recreate in Great Bay Estuary, the quality of their recreational experience, and their level of concern with various recreational and navigational issues.

The survey was developed using a web-based survey tool. Participants in the survey were not randomly selected rather the general composition of the audience was determined by the Commission. For example, participants included those individuals and groups identified as stakeholders and interested parties in the organizations represented by the members comprising the Commission. Many of these stakeholders and interested parties were notified electronically with a direct link to the survey, while others were notified via mail. For example, in its newsletter to current mooring holders and those on its mooring waitlist mailed in early September 2009, the Pease Development Authority-Division of Ports and Harbors provided a description of the survey with information detailing how to access the survey. Additionally, links to the survey were posted on the Commission's web site (hosted by the NHDES Coastal Program), and on the web sites and in the newsletters of Commission members, including the Piscataqua Region Estuaries Partnership and the Strafford Regional Planning Commission.

The survey ran for 36 days from late August to late September 2009. During that time period 198 people responded to the survey, approximately 70% of whom live in municipalities bordering the Great Bay Estuary. Select survey results are depicted in Figure 6 and results of the full survey can be found in Appendix F.

As can be seen in Figure 6, nearly 40% of respondents indicated that water depths are shallower today than they used to be and that there are areas within Great Bay Estuary that are no longer accessible due to shallow water. This compares to less than 10% of respondents who indicated that waters are not shallower today than they used to be. The relatively large percentage of "don't know" responses to questions regarding water depths within the Estuary may be a reflection of the large number of kayakers and canoers who responded to the survey. Because kayaks and canoes enable access to shallow waters, those using these types of watercraft would likely not be affected by or perhaps even aware of shallow water within the Estuary.

The results also indicate that respondents were supportive of potential fish, shellfish and wildlife habitat restoration efforts within the Estuary. As depicted in Figure 6, more than 85% of respondents agreed that the state should pay for efforts to restore fish, shellfish, and wildlife habitat, and greater than 70% of respondents indicated that they'd be willing to pay fees for such restoration efforts.

Finally, when asked about the overall recreational experience within Great Bay Estuary, results were less clear. Approximately 23% of respondents believe their overall recreational experience is better now than it used to be, while nearly 31% believe it is not. It should be noted that nearly 46% of respondents did not know (or were neutral on this question).

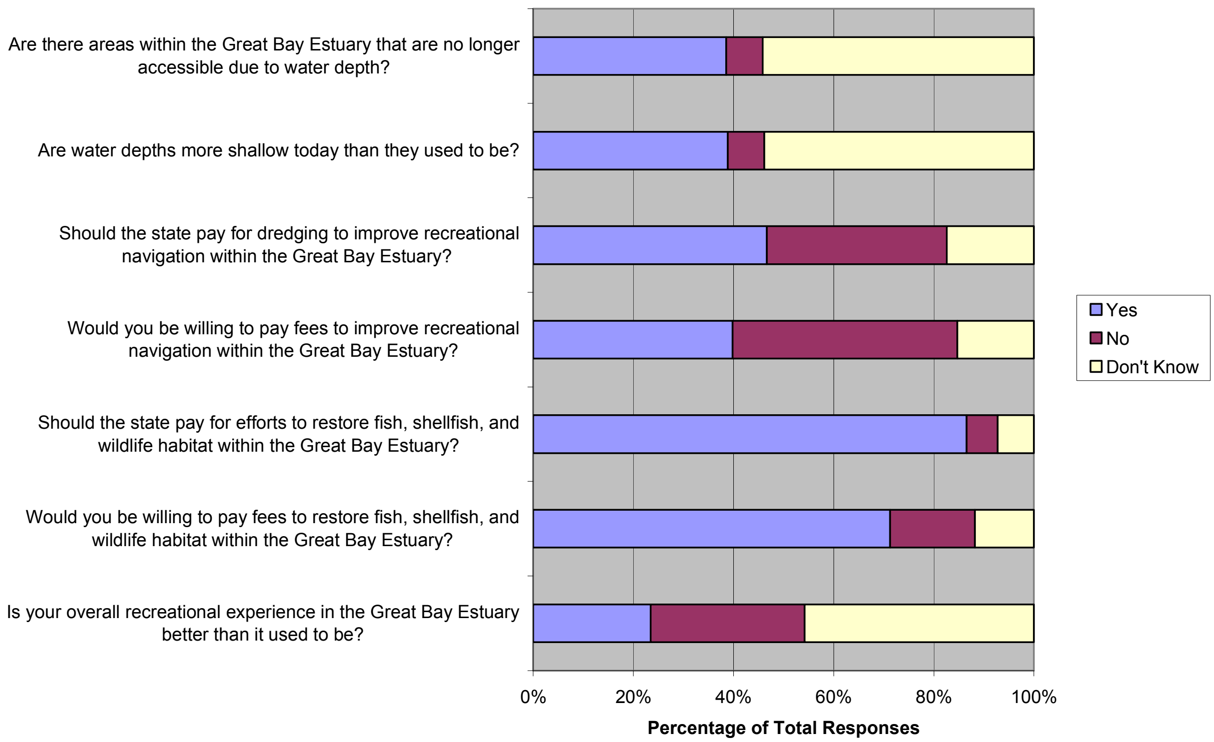

Figure 6: Selected results of recreational use survey

Rowing Programs

There are currently three rowing programs operating on the Oyster River: The University of New Hampshire (UNH) men's and women's crew teams; the Great Bay Rowing club with approximately 75 high school youth and adult men and women; and the Durham Boat Club, which trains high-level competitive rowers. Together, these represent over 150 people impacted by the sedimentation of the Oyster River.

Rowers attest that in the 1980s, the Oyster River could be used any time of the day. By the 1990s, the river had become so shallow that it could only be used for three hours on either side of the high tide. This has severely impacted the practice schedule and training of the UNH teams, causing them to resort to rowing on the very limited Mendums Pond on occasion. UNH is also exploring an ancillary facility on the Cocheco River to which students would have to be bussed. The Great Bay Rowing Club must suspend its program every other week to accommodate the times when the river is too shallow. Summer rowing camps are also limited by this low-water schedule.

Other Recreational Boat Use

Recreational sail and motor boat use of several Great Bay Estuary tributaries is limited during the hours around low tide by the narrow tidal channels and soft sediments which impede navigation and restrict access to docks and moorings. The responses to the recreational survey appear to indicate a growing number of kayakers in the Estuary.

Moorings, Docks and Marinas

Theoretically, as channels fill in, people along the shore need longer docks to reach navigable waters. Operators of mooring areas must relocate into deeper areas, leading to crowding of mooring fields and increasing demand for new areas. This leads to even greater dock and mooring impacts to eelgrass and salt marsh habitats. The Commission was unable to document any specific instance of this in New Hampshire waters. Largely this lack of documentation is related to the way records are kept for docks and moorings.

C. Commercial Impacts

Great Bay Estuary once served as the economic heart of its communities, with timber shipped to the King of England for his ships, large vessels being built along the Lamprey River in Newmarket and Oyster River in Durham, clay for bricks dredged up from the Oyster River and shipped to build Back Bay homes in Boston, and freight being transported to and from ports as far up the rivers as Rochester.

Only limited commercial navigation-dependent activities are possible in today's Great Bay Estuary without extensive dredging of silted channels in the Bay and every tributary. The marina in Dover could receive larger boats and be less dependent on the tidal schedule once the dredging of the Cocheco River is complete. The marina on the Lamprey River in Newmarket now serves smaller vessels than in the past. Tourists explore the Great Bay Estuary on tour boats from Portsmouth, but schedules are limited to high tide hours, and they are unable to reach into the commercial centers of towns to boost their economies. The City of Dover has embarked upon a major dredging project to enhance navigation on the Cocheco River, thereby opening up their revitalized waterfront areas downtown to increase commercial opportunities.

In a less direct way, the adverse effect of sedimentation on the Estuary's ecology also has economic ramifications. Anecdotal evidence points to a decline in lobster harvests in the

Estuary and-there are no other commercial fishing activities except for sport fish charters. Lobsters and finfish -- and accordingly those who harvest them in both the Estuary and the Gulf of Maine-- depend upon clear water and healthy eelgrass "nurseries."

It is thus evident that limiting and remediating sedimentation of Great Bay Estuary has the potential to enhance commercial activities in the Estuary in tandem with ecological and recreational benefits.

Sanitation Facilities

Sedimentation in the Lamprey and Oyster Rivers has current or potential impacts on the functioning of the towns' wastewater treatment facilities (WWTFs). Regarding the Town of Newmarket's WWTF, although the Town is currently in compliance with the terms of their Environmental Protection Agency (EPA) National Pollutant Discharge Elimination System permit, diffusers have had to be put in place because of sedimentation which the facility operator attributed to the most recent storm events in 2006 and 2007 (Sean Grieg, Newmarket Wastewater Treatment Facility and Water Treatment operator, personal communication to Cynthia Copeland, Stafford Regional Planning Commission).

Regarding Durham's WWTF located on the Oyster River, a study conducted in 2004 found that the sedimentation of the river since 1972 had decreased the volume of tidal flow available for dilution, and that to meet EPA requirements for ammonia, copper and zinc, this would have to be addressed. In the proximity of the Oyster River outfall, sediment deposits have led to reductions in channel depth and lowered dilution rates (Oyster River Channel Restoration Task Group 2002). The results of reduced outfall dilution is an increase of nutrients, fine particles and contaminants in the river and greater residence time of these wastewater products in the Estuary, increasing the eutrophic condition of the Estuary. These conditions may also be occurring at other tributary outfalls not specifically measured (e.g., Lamprey River outfall).

Potential solutions include dredging the river at the location of the outfall pipe; extending the outfall pipe downstream to a location where the river was deeper and flow greater; or improving the facility to remove regulated pollutants. Durham Town Engineer David Cedarholm reported that facility improvements, including better operation of the WWTF, had mitigated the situation to the extent that for the present time no remediation was required. However, this could change in the future.

IV. REMEDIATION OF CAUSES OF SEDIMENTATION AND EXISTING SEDIMENT PROBLEMS

The Commission did not recommend specific remediation measures in specific locations. It did, however, identify a number of options and potential pilot projects for remediation.

A. Sediment Removal (dredging)

The traditional and most obvious solution to excessive sediment accumulation is removal by dredging. Dredging can have a single objective, most commonly for commercial interests, or for multiple objectives such as recreation and habitat improvement. There is an active dredging program in New Hampshire's seacoast area, primarily related to the maintenance of navigation in federal channels. The U.S. Army Corps of Engineers (ACOE) maintains eight such projects in New Hampshire, five of which are located in Great Bay Estuary: the Bellamy, the Cocheco, the Lamprey and the Squamscott Rivers, as well as in the Piscataqua River/Portsmouth Harbor. Current ACOE policy favors maintaining navigation as opposed to multi-objective projects that include ecological restoration and recreation.

While maintenance dredging within the Cocheco River last occurred in 2007, the federal channels of the Bellamy, Lamprey and Squamscott Rivers have not been dredged in approximately 100 years. A small portion of the Squamscott River was dredged in 2004 by Phillips Exeter Academy to restore water depths for its crew program, and small scale dredging has occurred at several marinas, but overall dredging to support recreation in Great Bay Estuary has been limited.

The ideal dredging project is one that serves multiple purposes such as navigation and habitat restoration. Dredging presently underway on the Cocheco River in Dover is an example of multi-objective dredging. This project was designed to enhance recreational boating access to revitalize the riverfront, improve marina access at the head of this tidal river and remove contaminated sediments. However, care must be taken in such circumstances, because dredging can also negatively impact the environment by resuspending sediments. This is especially true of metals (PCBs and PAHs). Limited data on the Cocheco River suggests that dredging in the Dover area increased PAH concentrations in Dover Point and Portsmouth Harbor (PREP 2009).

The Commission discussed the pros and cons of a state-owned dredge (see Appendix G), but no conclusion was reached.

Need for Pilot Project on Restoration Dredging

To remediate the impacts of long-term sediment loading and the increasing inputs of sediment entering the Estuary, it will be necessary to restore displaced habitats. To reestablish these lost habitats, re-engineering of the bottom topography (dredging) will be necessary in many cases. Areas of the Estuary that used to have eelgrass and oyster habitat have filled with sediments to the point that eelgrass and oysters can no longer exist, nor could they be successfully restored without deepening and re-contouring the bottom sediments. A pilot project is recommended in one of the tidal rivers to deepen the bottom through dredging, planting eelgrass and seeding oysters in designed habitat areas. This should enhance the overall productivity and ecological health of the Estuary, while also creating a base of information and techniques necessary for revitalization of larger degraded portions of Great Bay Estuary.

B. Streambank Remediation

Streambank remediation is the act of limiting erosion and subsequent sedimentation by fixing eroding areas along rivers and bays in such a way that future erosion is better controlled. As a potential estuary-wide solution, the following aspects would need to be addressed:

- A spatial inventory to identify erosion 'hot spot' areas for priority remediation (e.g., Wagon Hill Farm shore along the Oyster River in Durham);
- Funding for remediation efforts;
- Site-specific buffer protection and restoration design planning for select shoreline areas; and
- Use of subtidal features associated with a 'living shoreline', like oyster reefs and eelgrass beds that dissipate wave energy and current intensity.

C. Habitat Restoration and Geomorphic Modification

In New Hampshire, we have recognized for some time now that active restoration is needed for systems that are too impacted to recover on their own. Habitat restoration is often thought of as a single act that "fixes" a place back to the way it was at some previous time, but we now know that restoration is an adaptive process rather than a single act. Restoration of an estuarine area degraded by excessive sediments and altered hydrology might therefore have the following multiple components:

- Removal of sediments to recreate channel morphology that simulates the structure of a natural systems;
- Restoration of oyster reef and eelgrass beds as structural components that trap and control sediment transport;
- Erosion control of adjacent shorelines through stabilization and natural vegetation; and
- Monitoring of restored systems to evaluate restoration success and adapt methods as needed.

Together, these actions will set the system back on a trajectory toward a more sustainable and healthy ecosystem. Success would be further enhanced if accompanied by other measures such as restoring natural hydrology and improving water quality.

D. Restoring Natural Hydrology

Restoring the natural hydrology of a system means providing for water flow through a watershed that minimizes the impact of alteration by humans. It does NOT mean that human activity needs to be eliminated but rather mimic the native system as much as possible. Stormwater, for example, is infiltrated rather than channeled in such systems. Similarly, culverts must be appropriately sized to handle larger volumes of water resulting from recent changes in weather patterns for current and future storm flows, and dams must be continually evaluated for their utility. Targeted dam removal can also help to restore natural hydrology. Many sub-watersheds around Great Bay Estuary are currently being analyzed for their fluvial erosion hazard (FEH) potential. This is a method to determine the natural movement of rivers and protect corridors to allow for those natural processes.

Stormwater management is a large component of restoring natural hydrology, especially in sub-watersheds that are highly developed. Improved stormwater management and implementation of retrofits for existing developments will be needed to limit sediment loads in high priority areas.

V. CONCLUSIONS / RECOMMENDATIONS

From September 2007 to November of 2009, the Commission examined the issues surrounding causes, effects and possible remediation measures for sedimentation in Great Bay Estuary and its tributaries. The Commission focused in large part on identifying the causes of sedimentation, and the nature and extent of its impact on the Estuary's aquatic life and human use of its waters. The study found both anecdotal and quantitative evidence that sedimentation in the Great Bay Estuary is problematic and will continue to worsen if steps are not taken to remediate it.

The Evidence

- Increased loading of sediments based on measures of suspended solids in the tributary rivers to Great Bay Estuary – sediment yield from Great Bay Estuary watersheds was 7.1 tons per year per square mile from 2002-2005 and increased to 9.1 tons per year per square mile from 2006-2008;
- The Oyster River report on the feasibility of reestablishing a navigation channel showed that the upstream portion of the channel is much shallower than in 1972 and navigation is difficult for much of the tidal reach of the river;
- Eelgrass and shellfish beds have been smothered. Even newly planted shellfish reefs have been covered in silt following large storms;
- Sediment elevation table (SET) data from Great Bay show a sediment accumulation rate of approximately 1 centimeter per year, a high rate for a coastal estuary;
- Results of the bathymetry study (Appendix C) indicate that the northern channel in the eastern part of Great Bay has become shallower;
- The recreational survey results showed that many respondents felt that water depths were more shallow today than they used to be; and
- Periodic maintenance dredging is needed in several of the tributaries to Great Bay Estuary.

This evidence led the Commission to conclude that excessive sedimentation of Great Bay Estuary is occurring to an extent that calls for remediation. The Commission also found that the occurrence of sedimentation is causing a number of problems including the following:

- Decreased shellfish and eelgrass, due in part to increased suspended solids in the water;
- Navigation is no longer possible in the tidal reach of the Oyster River except at high tide;
- Unhealthy impacts of excessive silt on the gills of resident and transient fish;

- Fine-grain sediments act as transport agents for nutrients and contaminants from the watershed into the Estuary ;
- Diminished dilution capacity for waste water treatment plant effluent as water depths become shallower in the proximity of outfalls; and
- Continued need for dredging for navigation purposes.

The Recommendations

The Commission developed three categories of recommendations, as follows:

A. Increase research on sedimentation processes in Great Bay Estuary ;

B. Reduce sediment loading to the Estuary; and

C. Remediate problems resulting from excess sedimentation.

A. Research Needs

A major factor that limited the Commission's analyses was the lack of information on current and long-term rates of sedimentation in all parts of the Estuary and its tributary rivers. More research is needed in order to understand sedimentation rates, sources, transport processes, and the most effective ways to reduce sediment loading to Great Bay Estuary.

To address this issue, the New Hampshire Coastal Program at NHDES contracted with Dr. Larry Ward at UNH to conduct an investigation of the bathymetry of Great Bay Estuary (Appendix C). The Commission hoped that this study might shed some light on the rates of sedimentation by comparing the bathymetric data over different time periods. However, that was not possible with the existing historical data. Therefore, in order to determine rates of sedimentation, further studies are necessary. A comprehensive "sediment budget" is also needed to understand the inputs and outputs of the Estuary.

Other knowledge gaps include:

- High resolution bathymetric surveys of shallow areas as a baseline for monitoring change over time;
- Relationship between land-use practices and sediment loads;
- Movement and deposition of sediments within the Estuary;
- Spatial distribution of sedimentation "hot spots", such as Varney Brook in Dover, including both the largest sources of sediment and areas where the heaviest deposition occurs;
- Direct measurements of impacts to biota, especially eelgrass, shellfish and fish;

- Impact of climate change, including the frequency and intensity of storms, on sedimentation;
- Data on changing configurations of docks and the number, location and availability of moorings attributable to shallowing of the Estuary and tributaries;
- Effects of dams and dam removal on the sediment dynamics of tributaries; and
- Frequency, purposes and costs of dredging.

B. Reducing Sediment Loading to the Estuary

As the data from the Piscataqua Region Estuaries Partnership (PREP) demonstrate, sediment input from the tributary rivers is increasing. In some places, like the Lamprey River, this increase has been twofold over 10 years. We also know that the amount of impervious surfaces (pavement and buildings) in the watershed has been increasing over the years such that, according to the most recent regional data in 2005, 7.5 percent of the watershed was impervious. Imperviousness leads directly to increased stormwater runoff, carrying sand and silt to water bodies. It increases the storm flows because less stormwater soaks into the ground. Changing hydrology due to more stormwater causes erosion and stream bank collapse. Finally, poor construction, agricultural and forestry practices can cause huge loads of sediment to run downstream. When these conditions occur in close proximity to tributary shoreline buffers, it is especially difficult to control sediment inputs to the estuary.

Many suggestions have been made in the PREP Management Plan, interim report of the Stormwater Commission, NHDES Water Primer, NHDES Innovative Land Use Guide, and various natural resource agency printed materials about how to reduce stormwater and erosion. Overall, these sources suggest the following ways to reduce sediment inputs:

- Mandate and enforce the use of best management practices for construction, agriculture and forestry;

- Reduce erosion by protecting buffers, limiting alteration of vegetated slopes, properly managing agricultural fields, and properly constructing and maintaining roadways and parking lots;

- Improve stormwater management throughout Great Bay Estuary watershed, including impacts from impervious surfaces, by enhancing stormwater infrastructure; and

- Maintain natural hydrology wherever possible throughout the watershed, through stream bank restoration, land use decisions, proper sizing of culverts, and re-evaluation of existing dams to identify possibilities for their removal.

C. Remediation of Causes of Sedimentation and Existing Sediment Problems

The Commission identified four areas of potential remediation including:

- **Sediment removal by dredging.** Decisions about dredging should be premised on a dredge management plan, which should include: consideration of rates of sedimentation and required frequency of dredging; water quality implications; environmental impacts; ecological, navigational and recreational need; cost-benefit analysis; funding alternatives; disposal alternatives, etc.;

- **Stream bank remediation.** Erosion of streambanks is a direct source of sediment. Areas of high erosion should be mapped and targeted for restoration along with the buffer areas along rivers that help protect against erosion;

- **Habitat restoration and geomorphic modification.** Restoration of certain types of habitat, such as eelgrass and shellfish beds, and salt marshes can help improve water quality by removing suspended material from the water column. Salt marshes, eelgrass beds and oyster reefs often create low energy/velocity environments where sediment and organic particles drop out of suspension. Additionally, shellfish actively filter the water column; and

- **Restoring natural hydrology.** Dams and culverts can dramatically alter the timing and volume of flows which can lead to excessive erosion and accumulation of sediments. Removal of barriers to flow can allow for natural flushing and restore native fish populations.

VI. LEGISLATIVE AND REGULATORY NEEDS

A. Funding

The Commission found that a basic funding need across research, pilot projects and full remediation is for non-federal matching dollars. There are numerous federal and private funding opportunities for research and restoration, however, nearly all of them require some sort of non-federal match. Often, especially when working with U.S. Geological Survey or the U.S. Army Corps of Engineers, that match must take the form of cash rather than in-kind services. The State should create a mechanism for making cash match available to research and restoration projects as a way of leveraging federal investment in our state waters.

The priority research that should be funded by the state or, at least, to assist with non-federal match are as follows (not prioritized):

- Sediment budget – spatially explicit around priority areas

- Baseline bathymetry, including shallow estuarine areas

- Fluvial Erosion Hazard (FEH) studies and assistance to communities and Regional Planning Commissions for FEH ordinances

- Pilot project combining dredging and restoration

- Stormwater Best Management Practices – aid to communities to help comply with Clean Water Act requirements.

- Aging stormwater and sewer systems – NHDES should identify and prioritize failing infrastructure in coastal watersheds, with restored state aid as well as help for community bonding and stormwater utilities

B. Legislation

The Commission urges the legislature to enact recommendations of existing land use and stormwater management commissions which will address many of the problems of sedimentation of Great Bay Estuary.

- Apply NHDES Alteration of Terrain requirements to lower threshold developments (e.g., 50,000 square foot projects in all shore land areas, not just Comprehensive Shore land Protection Act areas) in watersheds that have been identified as priorities for reducing sediment sources.

- Create standard best management practice requirements for land use activities in subwatersheds in the Great Bay Estuary watershed

- A federal legislative priority should be to refocus U.S. Army Corps of Engineers (ACOE) priorities for dredging more on multi-objective projects versus the current "value to nation" approach for navigational projects. This approach focuses primarily on commercial usage and cost benefit analysis.

C. Administrative/Regulatory

The Commission believes that certain regulatory actions would be beneficial to the control and mitigation of excessive sedimentation in the Estuary, namely:

- Streamline permitting for ecological restoration activities, including shoreline restoration and dredging projects.

- Direct state agencies to work with local governments to increase enforcement of erosion and sediment control regulations.

- Allow for region specific land use management regulations for nutrient and sediment improvement through implementation of model ordinance based on state mandated minimums.

- Direct state agencies and local partners like PREP and SeaGrant to increase public education on the links between land use and sedimentation.

- Encourage the Southeast Watershed Alliance (SWA) to address sediment issues along with nutrients reduction.

- Increase education and technical assistance for implementing BMPs (DES stormwater manual, forestry guidelines, agriculture guidelines, etc.).

- Streamline dam removal and culvert replacement regulations and permitting (including historic review).

D. How to Move Forward

The most important action to address the issue of sedimentation is broad recognition of the problem. The Commission has concluded through a weight of evidence approach that sedimentation in Great Bay Estuary is a problem that needs to be addressed. However, solving the problem will require the concerted actions of many people and communities. Educating the public about the issue and its relationship to other environmental and social ills is paramount to making improvements. In accepting this report, the Commission requests that the Legislature acknowledge and affirm the findings herein.

This report identified that a major gap is the lack of knowledge about sedimentation rates and sediment budgets. We may have enough information to identify some of the 'hot spot' areas for remediation even though a more systematic approach is needed. For those known areas, we suggest prioritized sediment budget work as initial studies of inputs, outputs, and processes. This could be done as joint project between DES and UNH.

The state is currently building many partnerships to deal with nutrient enrichment issues in Great Bay Estuary. All of these partnerships, including the Southeast Watershed Alliance should integrate sediment issues into their work, especially as it relates to stormwater management.

Finally, the state should encourage a pilot project to test the feasibility of integrating sediment removal in problem areas with the proactive restoration of eelgrass and shellfish habitat.

In closing, it is our collective belief that the level of sediment pollution now present in Great Bay Estuary reflects a serious problem that will only worsen without intervention. The call for this Commission is a timely and important step toward hopes of reversing this trend. It is now the time to take action while Great Bay Estuary is still capable of recovery, and we strongly urge those in a position of authority to support the recommendations of this Commission going forward.

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