Upper North Shore Dredge Purchase Feasibility Study

Evaluating alternatives to support the need for dredging services on the upper North Shore of Massachusetts

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1.0 INTRODUCTION AND SCOPE OF WORK

The Need for Dredging on the Upper North Shore of Massachusetts

The upper North Shore of Massachusetts is home to a diverse coastline of rocky intertidal outcroppings, extensive estuarine systems, salt marshes, and dynamic barrier beaches. These coastal resource areas serve as the gateway to busy commercial fishing ports, recreational boating facilities, and working waterfronts which support a variety of marine industries. Each year, thousands of tourists and vacationers travel to the North Shore, where they join year-round residents recreating along the shore. The diverse recreational and commercial opportunities supported by the region's coastal waterways and resource areas have solidified the link between local environmental features and the regional economy. The Merrimack Valley Planning Commission (MVPC), which assists a total of 15 member communities proactively plan for a sustainable economic and environmental future acknowledges this connection by formally recognizing the importance of environmental assets to the overall character, economic vitality, and quality of life on the North Shore.

Over the past several years, frequent coastal storms and associated climate impacts have resulted in increased rates of erosion along the upper North Shore while exacerbating shoaling in local harbors and waterways. Impacts to coastal and barrier beaches along the upper North Shore have put residential communities and municipal infrastructure at risk and have increased the need for a reliable source of sediment to complete beach nourishment and dune enhancement projects designed to increase resilience (Figure 1). Shoaling has restricted safe navigation by commercial and recreational vessels, creating a very real public safety concern. Outer bars in the Merrimack River, Plum Island Sound, and Essex Bay have become tidally restricted, limiting safe passage to the hours preceding and following the high tide (Figure 2). Shoaling in estuarine systems and internal navigation channels has restricted boat traffic and reduced passing distances, bringing mariners into conflict. Deteriorating conditions have forced emergency personnel to respond to an increased number of incidents, often with little water to safely maneuver response vessels, putting first responders and boaters at risk. Without safe and navigable waterways, commercial operations may choose to relocate to more accessible harbors and recreational boaters may choose to depart from alternative ports, impacting the local and regional economies.

Municipal Engagement and Action to Address Dredging Need

The North East Coastal Coalition (NECC) has met regularly over the past few years to discuss channel infilling and the need for dredging in the waters of the upper North Shore. At the same time, the Merrimack River Beach Alliance (MRBA) has been actively addressing erosion and subsequent beach nourishment along sections of Plum Island and Salisbury Beach and has identified the beneficial reuse of dredged materials as a source of sediment for future projects (Figure 3). Both organizations agree that that beach erosion and sedimentation of navigation channels is a persistent problem on the upper North Shore, prompting the 10 coastal municipalities of Salisbury, Amesbury, Newburyport, Newbury, Rowley, Ipswich, Essex, Rockport, Gloucester, and Manchester-by-the-Sea to investigate alternatives for localized dredging and options for the beneficial reuse of dredged materials.

Figures 1, 2 – Waves break along the shore of Plum Island, MA during winter storm event (left) http://www.surf-forecast.com/breaks/Plum-Island/photos/9677**. Extensive shoaling at the mouth of the Ipswich River, MA, a constant impediment to navigation (2018 Google Earth Imagery).**

Within the 10 coastal municipalities on the upper North Shore, there are a total of 9 existing Federal Navigation Projects (FNPs): the Merrimack River, Newburyport Harbor, Ipswich River, Essex River, Annisquam River, Gloucester Harbor, Rockport Harbor, Pigeon Cove, and Manchester Harbor. There are also many non-Federal estuarine channels, tidal creeks, mooring fields, and marinas that reportedly require dredging. Federal funding for dredging FNP channels used to be dependable. However, in recent years, Federal funding and the availability of dredging equipment have become more sporadic, leaving North Shore Towns and communities on their own to maintain safe and navigable depths in their channels, harbors, and mooring fields. The upper North Shore Towns recognize the importance of maintaining a working relationship with the United States Army Corps of Engineers (USACE) so they can take advantage of funding when it becomes available. At the same time, municipalities want to be prepared to maintain their own waterways, avoid significant delays, and re-establish navigable depths in non-Federal areas including marinas, estuarine channel, tidal creeks, and mooring fields.

Acknowledgement of State Funding Mechanism

Based on the significant need for dredging identified by the NRCC and MRBA as well as the lack of Federal funding to address those needs, Massachusetts Senator Bruce Tarr, Representative Brad Hill, and Representative Lenny Mirra met with Coastal Scientists from the Woods Hole Group, Inc. in January 2018 to discuss possible dredging alternatives for the 10 upper North Shore municipalities of Salisbury, Amesbury, Newburyport, Newbury, Rowley, Ipswich, Essex, Rockport, Gloucester, and Manchester-by-the-Sea. This initial conversation led to a State budget request facilitated by Senator Tarr, Representative Hill and Representative Mirra to conduct a regional dredge purchase feasibility study for the upper North Shore. Budget line item funds for the dredging assessment study were allocated to Executive Office of Energy and Environmental Affairs and administered by the Merrimack Valley Planning Commission (MVPC). After considering multiple proposals, the MVPC awarded the contract to the Woods Hole Group, Inc. based on a combination of factors including cost and experience.

Figure 3 – Massachusetts State Representatives Lenny Mirra, Jim Kelcourse, Brad Hill, Senators Bruce Tarr and Kathleen O'Connor Ives, and local officials attend Northeast Coastal Coalition meeting alongside Secretary of Housing and Economic Development Jay Ash, June 2018. https://lennymirra.com/northeast-coastal-coalition-meeting/

The Question Being Addressed

Project partners on the upper North Shore understand the importance of maintaining safe and navigable entrance and internal navigation channels to support a vibrant commercial fishing fleet, recreational boating community, and to ensure first-responders are able to respond to on-water incidents quickly and safely. Additionally, public and private mooring fields and marinas depend on dredging to maintain safe depths at their docks and moorings, a significant economic driver in the region. This project aims to address whether a regionally owned, operated, and managed dredge is a cost effective and efficient alternative for meeting the upper North Shore's dredging needs or whether more cost effective and/or efficient alternatives exist.

Tasks Assigned to the Woods Hole Group

Woods Hole Group, an international environmental services and products organization headquartered in Bourne Massachusetts, was selected by the MVPC to investigate dredging alternatives for the upper North Shore. Woods Hole Group offers a range of Coastal, Ecological, and Oceanographic consulting services, along with products for collecting ocean measurements, ocean forecasting, tracking wildlife with satellite communications, and vessel monitoring systems (VMS) for fisheries management. Working closely with regional stakeholders, Woods Hole Group completed the following Tasks, which are documented in Chapters 2-8 of the Technical Report. Please refer to Appendix A for a copy of the full, written proposal.

Task 1. Meetings and Stakeholder Engagement

- Facilitated kick-off conference call with MVPC and regional stakeholders (municipal officials, NRCC, MRBA) to review the geographic scope of the project and better understand how stakeholder goals and objectives differ throughout the region.
- Participated in NECC meeting in February 2019 to kick-off project and review scope of work with regional stakeholders.
- Hosted update meeting at Woods Hole Group facility in April 2019 to keep regional stakeholders informed of project deliverables. Facilitated discussion between regional stakeholders, legislators, Barnstable County Regional Dredge personnel, and regional dredge stakeholders. Toured Barnstable County Regional Dredging site to view equipment and dewatering operations.
- Attended wrap-up meeting in July 2019 to review findings, recommendations, and next steps.

Task 2. Data Collection

- Developed standard Preliminary Data Collection Survey questionnaire and record request, distributed Survey to municipal stakeholders, reviewed and catalogued responses.
- Researched historic dredge databases and developed inventory of documented historic dredging events in upper North Shore waterways.
- Documented historic dredge quantities and quality data, and designed dredge depth for each documented historic dredging event.
- Estimated quantities of material that could reasonably be dredged from select upper North Shore waterways based on take-off estimates from the most current hydrographic survey data for each waterway.
- Reviewed alternatives for beneficial reuse of dredged material (offshore, beach nourishment, TLD, etc.) in the upper North Shore Region.

Task 3. Identification of Dredging Alternatives

- Identified 3 possible Alternatives for maintaining navigation channels within the specified region and beneficially reusing and/or disposing of dredged material.
- Researched costs for each alternative and associated dredging equipment (if applicable).
- Researched private dredge contracting costs.

Task 4. Feasibility Assessment - Cost Forecast

- Developed cost estimates for the implementation of each alternatives.
- Conducted a cost analysis of dredge ownership v. using a commercial dredge contractor to complete projects within the specified region.
- Established financial model of 3 regional dredging Alternatives.
- Developed regional sediment budget(s) based on historic dredge records and Woods Hole Group engineering take-offs.
- Factored the sediment budget(s) against the cost forecast for each dredging alternative.
- Identified most cost-effective alternative(s).

Task 5. Final Report

- Drafted final technical report documenting Tasks 1 through 5.

Task 6. Project Management

- Coordinated and communicated with upper North Shore Stakeholders.

2.0 MUNICIPAL OUTREACH CAMPAIGN

Geographic Scope

The Woods Hole Group worked with the Merrimack Valley Planning Commission (MVPC) to identify 10 municipalities on the upper North Shore of Massachusetts with an interest in maintaining safe and navigable waterways and resilient coastal resource areas to participate in the Dredge Purchase Feasibility Assessment. The 10 municipalities extended along the upper North Shore of Massachusetts to the New Hampshire border and included the coastal Towns and Cities of Salisbury, Amesbury, Newburyport, Newbury, Rowley, Ipswich, Essex, Rockport, Gloucester, and Manchester-by-the-Sea. Within the 10 coastal Towns and Cities on the upper North Shore, there are a total of 9 existing Federal Navigation Projects (FNPs) including the Merrimack River, Newburyport Harbor, Ipswich River, Essex River, Annisquam River, Gloucester Harbor, Rockport Harbor, Pigeon Cove, and Manchester Harbor. There are also many non-Federal estuarine channels, tidal creeks, mooring fields, and marinas located within and adjacent to Plum Island Sound, Ipswich Bay, and Essex Bay that reportedly require dredging. A summary of participating municipalities and their associated FNPs and non-Federal channels is provided in Table 1, which has been reviewed for consistency by the New England District of the Army Corps of Engineers (USACE). Figure 4 provides a locus map of all municipalities and associated FNPs located in the study region. Figure 5 provides a locus map of all municipalities and associated non-Federal waterways in the study region.

Project Kick-Off and Preliminary Data Collection Survey

On February 6, 2019 a conference call with representatives from the MVPC, regional stakeholders, and State Representatives was held to kick-off the project, review the scope of work, and take the first steps towards better understanding the need for dredging on the upper North Shore. An agenda for the initial kick-off conference call is included in Appendix B. On March 1, 2019, a Woods Hole Group Coastal Scientist attended the joint Merrimack River Beach Alliance (MRBA) and Northeast Coastal Coalition (NECC) in Essex, MA to discuss the project scope, expected deliverables, field questions, and solicit feedback from project stakeholders, State Representatives, State Senators, and State and Federal regulators. At the joint meeting, each municipality designated an individual or individual(s) (primarily harbormasters, public safety officers, and elected officials) to represent the community and act as the first point of contact throughout the project. A copy of the presentation given by the Woods Hole Group at the joint MRBA and NECC meeting is included in Appendix C.

Immediately following the joint MRBA and NECC meeting in Essex, the Woods Hole Group worked with the MVPC to develop a Preliminary Data Collection Survey which was distributed to the 10 participating municipalities. The goal of the Survey was to establish solicit feedback regarding the current navigability, need for dredging, and specific public safety concerns associated with waterways located within each municipality. The Survey also included questions regarding historic dredging events, future dredging plans, existing permits, sediment characteristics and preferred disposal method(s), waterway features (mooring fields, marinas, etc.), and statistics regarding commercial and recreational boat traffic. Survey questions were standardized across municipalities for consistency and were distributed to each Town on March 18, 2019.

A total of 7 Survey responses were received from Salisbury, Newburyport, Ipswich, Essex, Rockport, Gloucester, and Manchester-by-the-Sea. Once received, survey results were compiled, archived, and utilized to help inform data collection Tasks. A summary of Survey results for each Town is presented below. A brief description of waterways is included for Towns that did not submit a completed Survey. Copies of completed Preliminary Data Collection Surveys are included in Appendix D.

Table 1. Summary of Municipalities and associated FNPs and non-Federal waterways.

Municipality	Navigation Channel	Designation
Salisbury	Newburyport Harbor	FNP
	Town Creek, Black Rock Creek	Non-Federal
	Blackwater River	Non-Federal
Amesbury	Merrimack River (upstream)	FNP
	Powwow River	Non-Federal (De-Authorized)
Newburyport	Newburyport Harbor	FNP
	Merrimack River (upstream)	FNP
	Salisbury Jetty	Non-Federal
	Commercial Fish Piers	Non-Federal
Newbury	Parker River	Non-Federal
	Plum Island River	Non-Federal
	Plum Island Sound	Non-Federal
	Plumbush Creek	Non-Federal
Rowley	Plum Island Sound	Non-Federal
	Rowley River	Non-Federal
Ipswich	Ipswich River	FNP
	Ipswich Bay	Non-Federal
	Eagle Hill, Castle Neck Creek	Non-Federal
Essex	Essex River	FNP
	Essex Bay	Non-Federal
	Town Landing Rt. 133	Non-Federal
Gloucester	Annisquam River (all sections)	FNP
	Gloucester Harbor	FNP
	Lanes Cove	Non-Federal
	Hodgkins Cove	Non-Federal
	Little River	Non-Federal
Rockport	Rockport Harbor	FNP
	Pigeon Cove Harbor	FNP
	Old Harbor	Non-Federal
	Granite Pier	Non-Federal
Manchester-by-the-Sea	Manchester Harbor (all sections)	FNP
	Magnolia Cove	Non-Federal

Figure 4 – Locus map of Federal waterways within the study region.

Figure 5 – Locus map of non-Federal waterways within the study region.

Town of Salisbury

The Town of Salisbury Harbormaster, Ray Pike, provided feedback regarding the status of Newburyport Harbor (FNP), Black Rock Creek, Town Creek and Blackwater River (non-Federal). A base map of waterways described in this section is included in Figure 6.

Current Navigability: Newburyport Harbor is currently navigable, but some shoaling exists and requires dredging. Black Rock Creek, Town Creek, and Blackwater River are only navigable to small craft, kayaks, and canoes due to overhanging bridge and/or depth limitations.

Specific Dredging Needs: The mouth of the Merrimack River (approach to Newburyport Harbor) requires dredging and poses a significant hazard to navigation. Dredging Black Rock Creek, Town Creek, and Blackwater River would open waterways to larger vessels and possibly generate material for beneficial reuse.

Public Safety Concerns: Significant public safety risk reported at the mouth of the Merrimack River. No significant public safety risk within Black Rock Creek or Town Creek. Public safety concerns exist in Blackwater River are due to the remote nature of the site.

Historic Dredging: Newburyport Harbor and the Merrimack River were dredged by the USACE in 2010. Black Rock Creek, Town Creek, and Blackwater River have not been dredged.

Future Dredging: Dredging will be required in Newburyport Harbor over the next several years. An USACE project is currently in the planning stages to restore depths to 9.0’ at mean low water. No dredging is planned in Black Rock Creek, Town Creek, or Blackwater River.

Existing Permits: The Town of Salisbury does not currently hold permits for dredging in Newburyport Harbor, Black Rock Creek, Town Creek, or Blackwater River.

Beneficial Reuse of Dredged Material: The Town of Salisbury reported primarily sandy sediments in Newburyport Harbor. Ray Pike expressed a preference for beach nourishment and / or nearshore disposal alternatives. Black Rock Creek, Town Creek, and Blackwater River contained muddier sediments. Ray Pike expressed a preference for thin layer deposition (TLD) or nearshore disposal alternatives (if appropriate).

Moorings and Marinas: The Salisbury shore of Newburyport Harbor contains 180-200 public moorings, 14 private moorings, 3 private marinas, and 1 public Town pier. Black Rock Creek, Town Creek, and Blackwater river contain no moorings or marinas.

Commercial and Recreational Boat Traffic: An average of 15-20 commercial fishermen, 25 charter boats, and 450 recreational vessels utilize the navigation channel within Newburyport Harbor daily during peak season. A limited number of kayaks, jet skis, and canoes utilize Black Rock Creek, Town Creek, and Blackwater River during peak season.

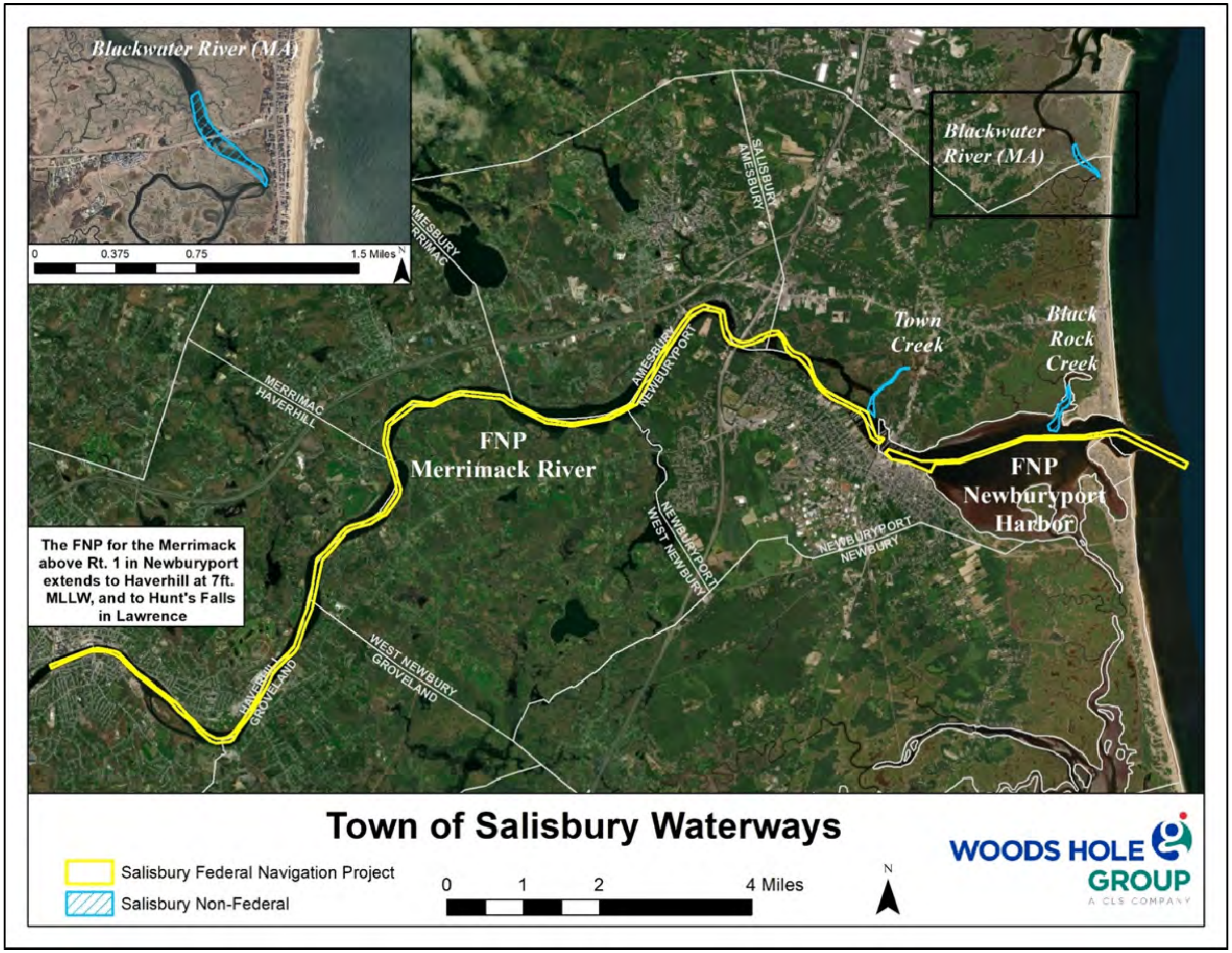

Figure 6 - Federal and non-Federal waterways located within the Town of Salisbury.

City of Amesbury

The City of Amesbury did not submit a Survey response. The Merrimack River flows through the City of Amesbury, allowing access to the Atlantic Ocean. Currently, the City supports 4 marinas, one public boat ramp, and several boat shops (UHI, 2015). The Merrimack River FNP (upstream) reports no previous public or private dredging events within city boundaries. The Powwow River, a small non-Federal tributary leading into the Merrimack River reports no previous dredging events. Although bathymetric survey data was collected from the Merrimack River FNP in 2018, it does not appear as though dredging events have been planned or scheduled within the City of Amesbury. Imagery of Federal and non-Federal waterways in the City of Amesbury is included in Figure 7.

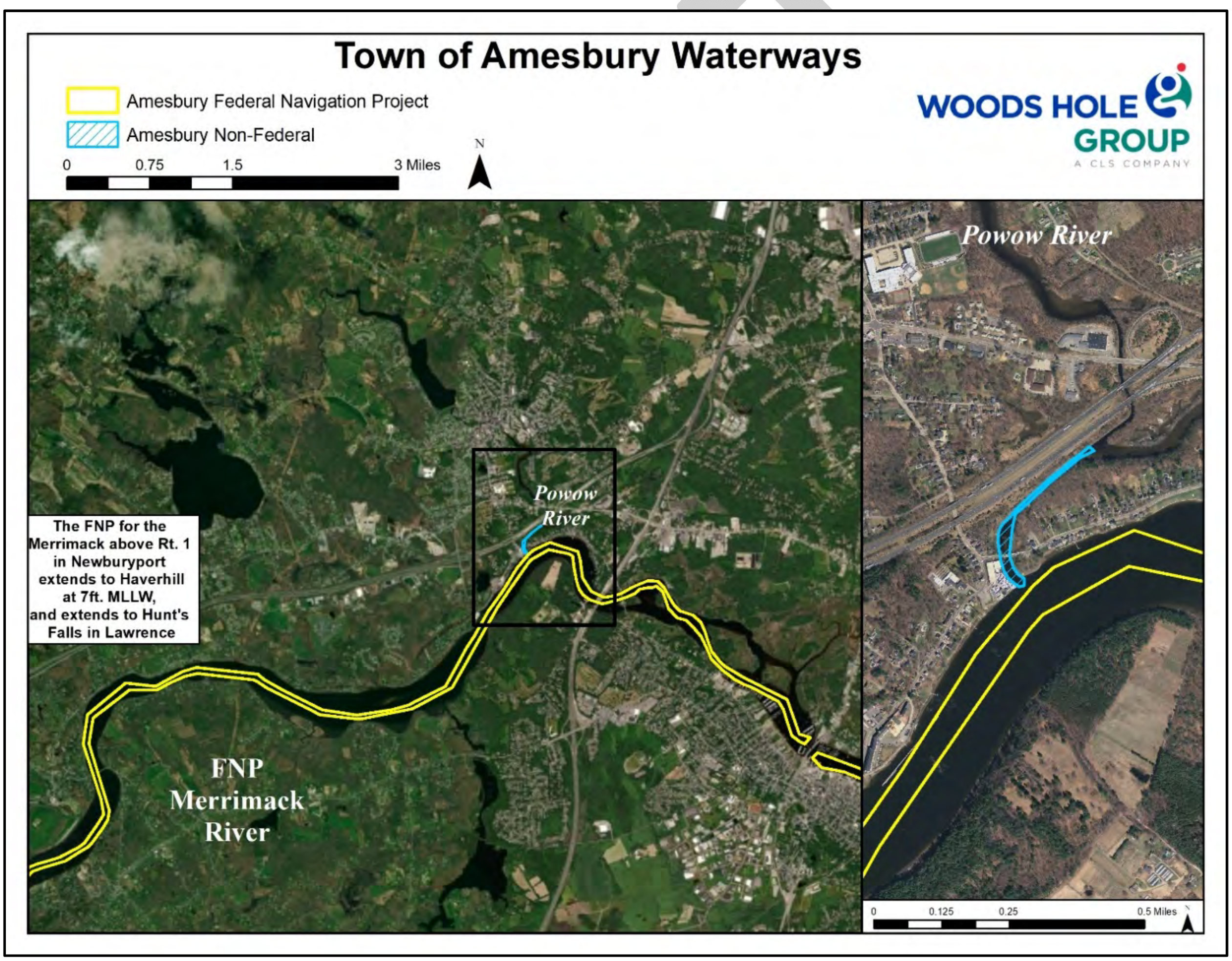

Figure 7 - Federal and non-Federal waterways located within the Town of Amesbury.

City of Newburyport

Newburyport Harbormaster Paul Hogg provided feedback regarding the current status of the Merrimack River (FNP), Newburyport Harbor (FNP), 2 commercial fish piers and the Salisbury Jetty (non-Federal). Imagery of Newburyport waterways is included in Figure 8.

Current Navigability, Specific Dredging Need, and Public Safety Concerns: The City of Newburyport reported that the mouth of the Merrimack River has an immediate need for dredging. The mouth of the Merrimack has become extremely dangerous and is having a large impact on the commercial fishing community and on transient boaters. Both of these factors are a constant economic and public safety concern for the City of Newburyport.

Historic Dredging: Newburyport reported historic USACE dredging events in 2010-2011 (mouth of the Merrimack) and the upper portions of the river in 1939. The most recent dredging of the mouth of the Merrimack also included select locations adjacent the Salisbury Jetty. No dredging of Newburyport Harbor's 2 commercial fish piers was reported.

Future Dredging: Newburyport reported that historic dredging events have not kept navigation channels safe and navigable to boat traffic and that no dredging events are currently scheduled.

Existing Permits: Local and State permits are maintained by the City for Newburyport Harbor (including the 2 commercial fish piers). The Town did not report any existing permits for the Merrimack River or for the Salisbury Jetty.

Beneficial Reuse of Dredged Material: Variable sediment was reported within the Merrimack River and adjacent the Salisbury Jetty. Beach nourishment was listed as the preferred disposal alternative. Newburyport Harbor reportedly contains mixed sandy and variable sediment. Areas adjacent the commercial fish pier may be unsuitable for beach nourishment. Offshore disposal was listed as the preferred disposal method for this material.

Moorings and Marinas: A total of 200 public moorings were reported in the Merrimack River within the City of Newburyport. An additional 11 private marinas were also reported.

Commercial and Recreational Boat Traffic: During peak season, Newburyport and the Merrimack River support 1,500 registered recreational boaters and an additional 100 transient recreational boaters, 200 commercial fishermen, and 50 charter boats. Up to 2,000 recreational craft may utilize Newburyport's waterways during a typical, peak season day.

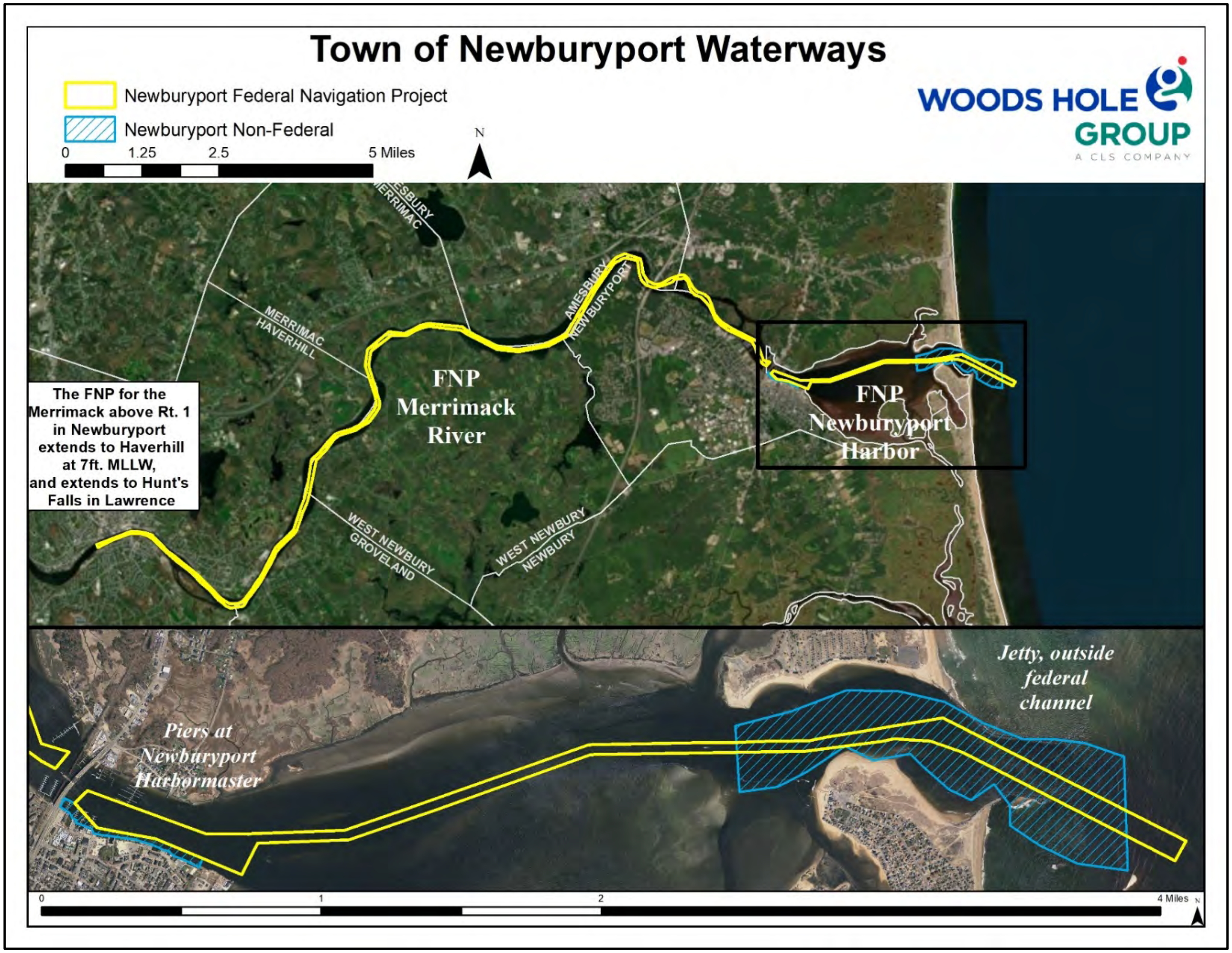

Figure 8 - Federal and non-Federal waterways located within the Town of Newburyport.

Town of Newbury

The Town of Newbury did not submit a Survey response. Plumbush Creek (non-Federal), a small tidal reach of the Merrimack River extends south into the Town of Newbury. Plumbush Creek retains no water at low tide, and floods to allow shallow draft boat access at high tide. Portions of Plumbush Creek are used to moor small boats and to support recreational sailing, wind surfing, water skiing, and access to the Merrimack River (UHI, 2015).

Parker River and Plum Island River (non-Federal) are tributaries of Plum Island Sound that pass through the Town of Newbury. The shallow, brackish rivers can be accessed by the Town boat ramp, but due to shallow drafts and the fixed structure of the Route 1A bridge, access is limited to small boats and recreational crafts (UHI, 2015). Parker River and Plum Island River are within the Great Marsh, a Massachusetts-designated Area of Critical Environmental Concern (ACEC). To date, no dredging events have been reported in Plumbush Creek, Parker River, or Plum Island River. Imagery of Newbury waterways is included in Figure 9.

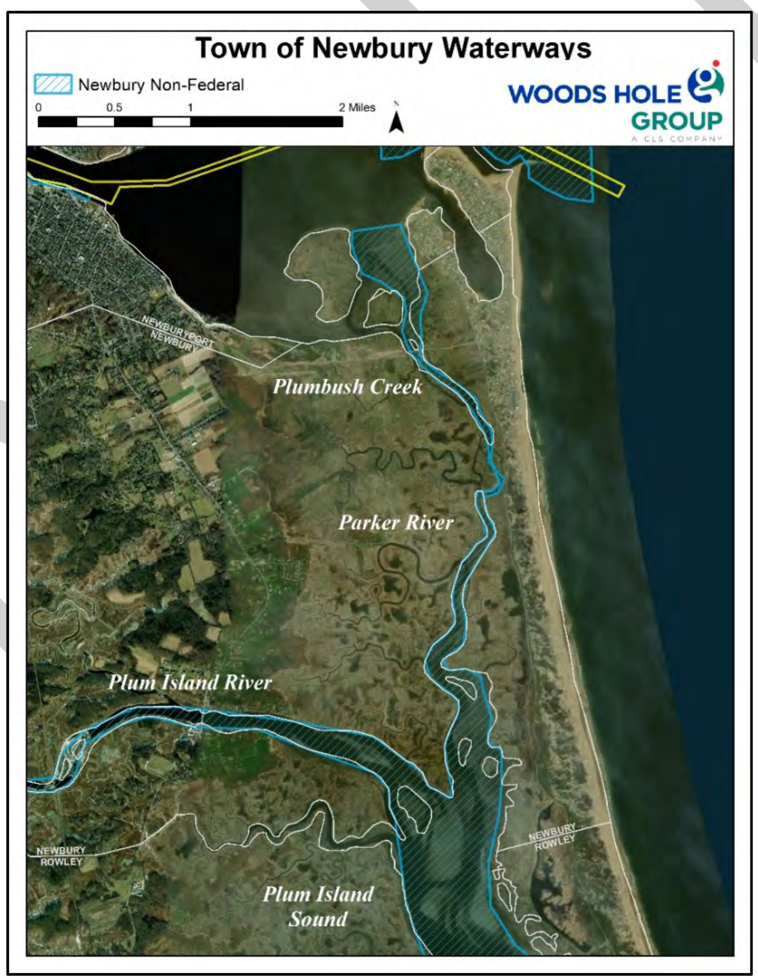

Figure 9 - Federal and non-Federal waterways located within the Town of Newbury.

Town of Rowley

The Town of Rowley did not submit a survey response. The Rowley River, a tributary to Plum Island Sound forms a portion of the border between the Towns of Rowley and Ipswich. The Rowley River is primarily used by recreational small boaters, fishermen, and kayakers. Recreation in the Rowley River is supported by a private marina, Town moorings, and Town boat launch (UHI, 2015). The Rowley River and Plum Island Sound are within the Great Marsh, a Massachusetts-designated Area of Critical Environmental Concern (ACEC). To date, no dredging events have been reported in the Rowley River or within Plum Island Sound. Imagery of Rowley waterways is included in Figure 10.

Figure 10 - Federal and non-Federal waterways located within the Town of Rowley.

Town of Ipswich

The Town of Ipswich Survey response was provided by Chief Paul Nikas, Harbormaster. Ipswich waterways include the Ipswich River (FNP), which flows downtown to Ipswich Bay, part of Plum Island Sound (non-Federal). Ipswich supports a $4-million-dollar shellfish industry, including soft shell clam (*M. arenaria*) harvesting (30% of total landings in Massachusetts), seafood processing, and restaurant sales (UHI, 2015). Waterways in the Town of Ipswich also include Eagle Hill River and Castle Neck Creek (non-Federal). Imagery of Ipswich waterways is provided in Figure 11.

Current Navigability: From Ipswich Town Warf to the mouth of the Ipswich River, navigation is only possible during the 3 hours either side of high tide. Numerous spots within the channel have less than 1.0' depth at low tide. Significant shoaling was reported in Ipswich Bay from the mouth of the Ipswich River to the bell buoy. Eagle Hill River and Castle Neck Creek were only reported to be navigable 3 hours before and after high tide. The Town of Ipswich also commented on conditions at the mouth of the Essex River, where the channel has become increasingly shallow and narrow.

Specific Dredging Needs: Chief Nikas reported that the Ipswich River requires dredging from Town Warf to the mouth of the river. Ipswich Bay requires the establishment and maintenance of a safe channel for passage to and from the Atlantic Ocean. Eagle Hill River and Castle Neck Creek require dredging to create a safe and navigable channel for boaters.

Public Safety Concerns: Chief Nikas reported the Ipswich River is currently non-navigable for police patrol boats. Numerous boats reportedly run aground due to the shallow, narrow, and hazardous nature of the existing channel. Within Ipswich Bay, the primary channel has narrowed and shoaling has created high wave conditions. Conditions within Eagle Hill River and Castle Neck Creek prevent emergency personnel from responding to incidents at low tide (Eagle Hill River contains a marina and boat yard; Castle Neck Creek often contains multiple vessels at anchorage and high boat traffic).

Historic Dredging: The Ipswich River was last dredged using Federal funds in 1887. No dredging has previously occurred in Ipswich Bay, Eagle Hill River, or Castle Neck Creek, which lie within the Great Marsh, a Massachusetts-designated Area of Critical Environmental Concern (ACEC).

Future Dredging: No dredging is currently planned for Ipswich River, Ipswich Bay, Eagle Hill River, or Castle Neck Creek.

Existing Permits: The Town does not maintain permits for dredging the Ipswich River, Ipswich Bay, Eagle Hill River, or Castle Neck Creek.

Beneficial Reuse of Dredged Material: The Town of Ipswich reported variable sediment, sand, and mud in the Ipswich River, Ipswich Bay, Eagle Hill River, and Castle Neck Creek. The Town stated a preference for beach nourishment and / or TLD beneficial reuse alternatives.

Moorings and Marinas: Numerous public mooring fields were reported in the Ipswich River, Eagle Hill, and Castle Neck Creek, with a total of 300 moorings dependent on dredging. The Ipswich River contains a public Town Warf and Eagle Hill River contains a private boat yard.

Commercial and Recreational Boat Traffic: During peak season, as many as 400 boats utilize Ipswich River, 1,000 boats utilize Ipswich Bay, and 200 boats utilize Eagle Hill River and / or Castle Neck Creek during a given day. An additional 135-140 commercial fishermen utilize Ipswich River and 130 commercial fishermen utilize Eagle Hill River and / or Castle Neck Creek.

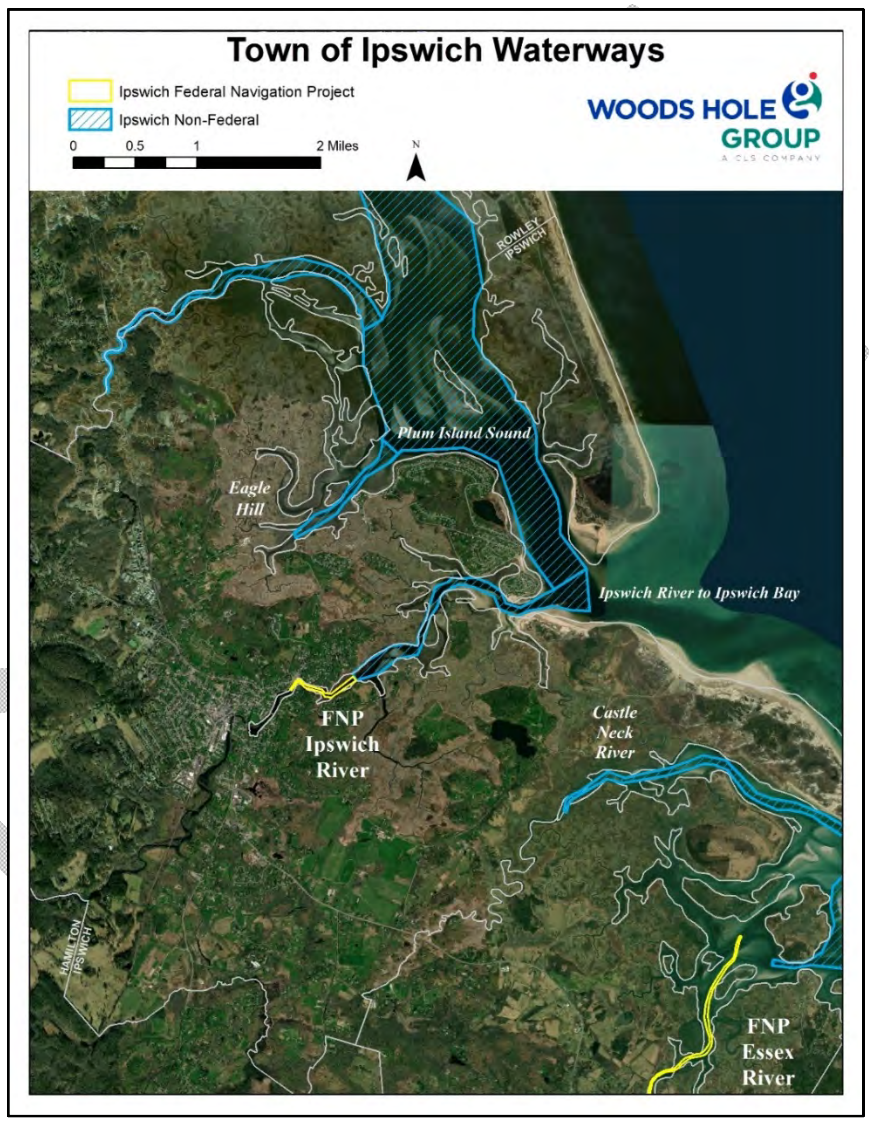

Figure 11 - Federal and non-Federal waterways located within the Town of Ipswich.

The Town of Essex

Andrew C. Spinney, Selectmen, provided a Survey response on behalf of the Town of Essex. The Essex River FNP was re-designated in 2016 to avoid encroachments from existing structures (docks, piers, etc.), so as to free the channel for unimpeded future dredging as part of the Federal Water Resource Development Act of 2016. Additional waterways in the Town of Essex include Essex Bay and the Town Landing located up the Ipswich River at Rt. 133 and Main Street (non-Federal). Imagery of Essex waterways is provided in Figure 12.

Current Navigability: All waterways in the Town of Essex were reported to be extremely tidally dependent. Reportedly, safe navigation is only possible 3 hours before and after high tide.

Specific Dredging Needs: The Town reported that an established navigation channel is required to facilitate safe passage during all phases of the tide.

Public Safety Concerns: For 3 hours before and after low tide, it is not possible for emergency personnel to safely respond to an incident within the Essex River or Essex Bay. Exigency to remediate existing conditions for the purposes of public safety is currently required.

Historic Dredging: State and private funds were mobilized to dredge the Essex River and the Rt. 133 landing in 1992. No previous dredging is reported to have occurred in Essex Bay.

Future Dredging: Dredging is not currently scheduled within any waterway located in the Town of Essex.

Existing Permits: The Town does not currently hold permits for dredging.

Beneficial Reuse of Dredged Material: Variable sediment types (mud and sand) were reported in Essex River and Essex Bay. The Town would like to consider any and all disposal methods including but not limited to beach nourishment, dune enhancement, offshore, upland, TLD, marsh restoration, etc. Sediment closer to the Rt. 133 landing is primarily mud, which may require offshore disposal at an approved location.

Moorings and Marinas: There are a total of 4 Town mooring fields within the Essex River and Essex Bay. It was reported that all mooring fields in Essex currently require dredging. In addition, there are a total of 5 private marinas adjacent the Rt. 133 landing.

Commercial and Recreational Boat Traffic: Combined, Essex River, Essex Bay, and the Rt. 133 landing support approximately 100 commercial fishermen, 20 charter boats, and upwards of 1,500 recreational craft daily during peak season.

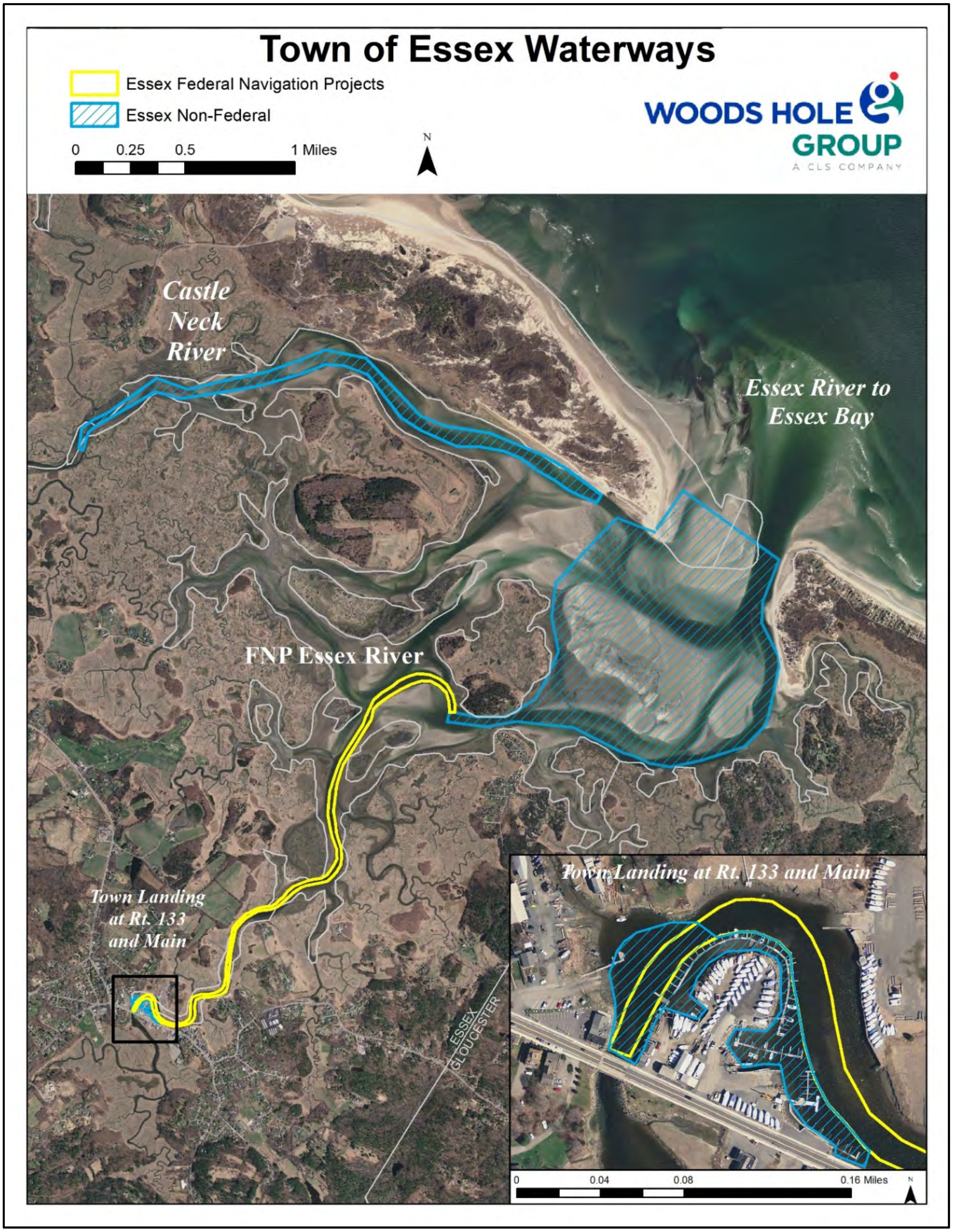

Figure 12 - Federal and non-Federal waterways located within the Town of Essex.

The Town of Rockport

Feedback for the Town of Rockport was provided by Harbormasters Rosemary Lesch and Scott Story. Waterways within the Town of Rockport include Rockport Harbor and Pigeon Cove (FNP), as well as Old Harbor and Granite Pier (non-Federal). Imagery of Rockport waterways is included in Figure 13.

Current Navigability, **Specific Dredging Needs, Public Safety Concerns**: At present, Old Harbor is reportedly not navigable at low tide and requires immediate dredging. Old Harbor was identified by the Seaport Advisory Council, which has invested time and funding in the form of a Seaport Improvement Grant for engineering services. Improving the safety and navigability of Old Harbor is the top priority of the Town of Rockport Harbormaster's office.

Historic Dredging: Rockport Harbor and Pigeon Cove were historically dredged by the USACE using Federal funds in the mid 1980's. Old Harbor was dredged in the 1960's-1970's using private funds. Granite Pier has not been dredged in recent history.

Future Dredging: Rockport Harbor and Pigeon Cove will require future dredging, but projects are not currently scheduled. Old Harbor requires immediate action. There are no current plans to dredge Granite Pier.

Existing Permits: The Town does not currently hold permits to dredge Rockport Harbor, Pigeon Cove, Old Harbor, or Granite Pier. The Town is actively working to secure funding to permit dredging in Old Harbor. Permits will be secured for Rockport Harbor and Pigeon Cove when dredging becomes necessary (likely less than 5 years' time).

Beneficial Reuse of Dredged Material: Given the variability of material (mud, mud and cobble) in Rockport Harbor, Pigeon Cove, Old Harbor, and Granite Pier, as well as the lack of suitable dewatering and disposal areas for beneficial reuse, the Town reported a preference for offshore disposal alternatives.

Moorings and Marinas: Rockport Harbor, Pigeon Cove, Old Harbor, and Granite Pier each have public mooring fields, containing a total of 350+ individual moorings. Rockport Harbor contains a single private marina and Old Harbor contains a total of 30 public boat slips. Granite Pier and Pigeon Cove do not contain any marina facilities.

Commercial and Recreational Boat Traffic: All Rockport waterways contain heavy recreational boat traffic during peak season and provide safe harbor to a total of 68 commercial fishing vessels and 4 charter boat operators.

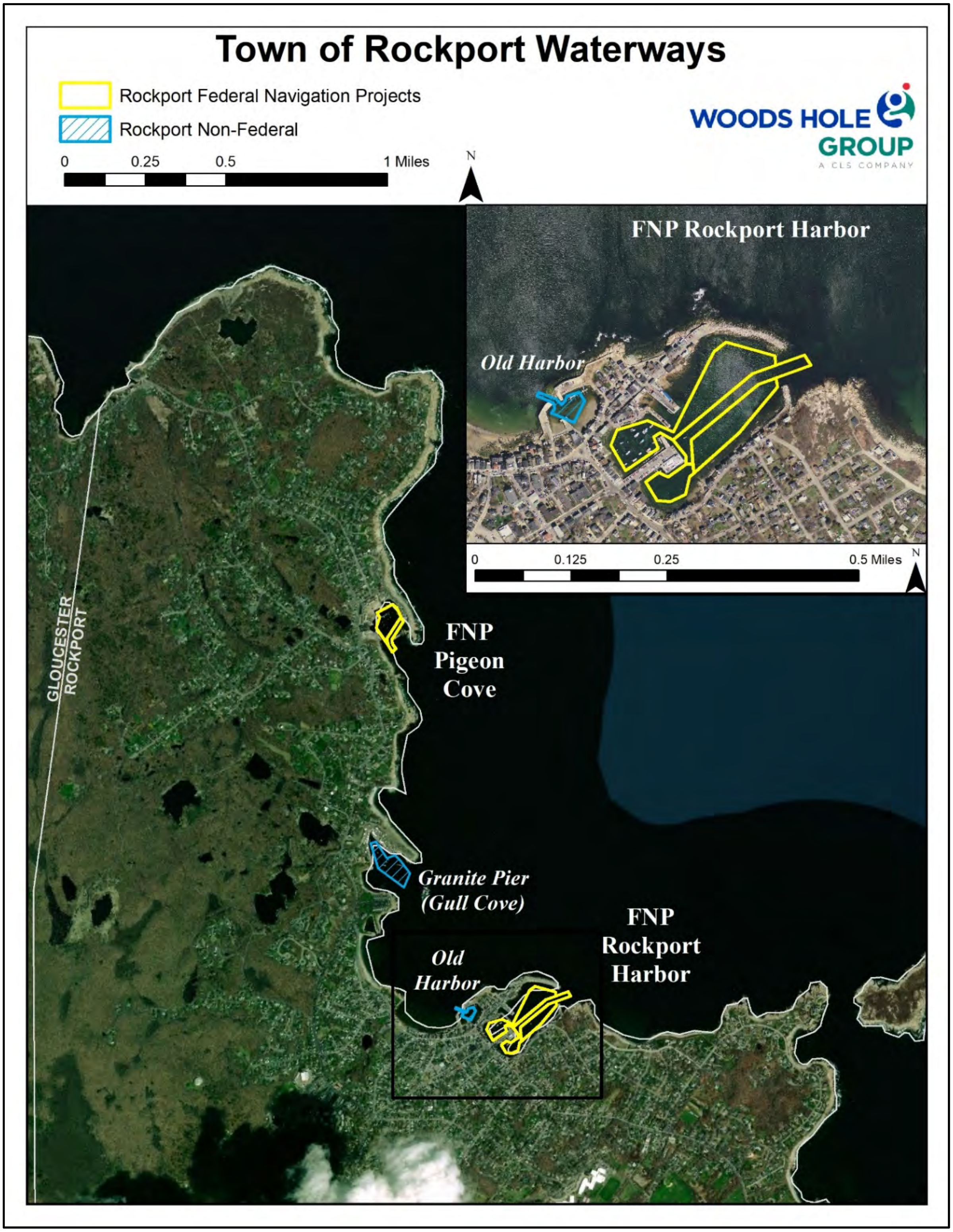

Figure 13 - Federal and non-Federal waterways located within the Town of Rockport.

City of Gloucester

Harbormaster Thomas Ciarametaro provided a Survey response on behalf of the City of Gloucester. The City contains the Annisquam River and Gloucester Harbor (FNPs) as well as Lane's Cove, Hodgkins Cove, and Little River (non-Federal). Imagery of Federal and non-Federal waterways in the City of Gloucester are included in Figure 14.

Current Navigability; Specific Dredging Needs; and Public Safety Concerns: Harbormaster Ciarametaro reports that the Annisquam River FNP (including Blyman's Canal and Lobster Cove sections) is currently scheduled to be dredged by the USACE, beginning Fall 2019. Certain tides currently limit navigability within sections of the Annisquam River. Lane's Cove has an immediate dredging need to support the commercial fishing fleet. Navigation into and out of Lane's Cove and Little River is limited and there is an immediate need for dredging.

Historic Dredging: The Annisquam River (all sections) was last dredged by the USACE in 1968. Gloucester Harbor was last dredged by the USACE in 1972. Little River was last dredged using State and local funds in 1968. Lane's Cove and Hodgkins Cove have not been historically dredged.

Future Dredging: The Annisquam River (including Blyman's Canal and Lobster Cove) is currently scheduled to be dredged by the USACE in 2019. No dredging is scheduled for Gloucester Harbor, Lane's Cove, Little River, or Hodgkins Cove. Hodgkins Cove is heavily vegetated with eelgrass and not a strong candidate for future dredging.

Existing Permits: The City of Gloucester does not currently hold permits to dredge Federal or non-Federal waterways.

Beneficial Reuse of Dredged Material: Sediments in Gloucester waterways were reported to be comprised of sand and silt. Harbormaster Ciarametaro reported a preference for near shore beneficial reuse alternatives for dredged material.

Moorings and Marinas: The Annisquam River (including Lobster Cove) contains over 475 commercial and recreational moorings. Additional moorings exist within Gloucester Harbor, Lane's Cove, and Little River. The Annisquam River is served by a private marina, Lobster Cove is served by a private Yacht Club, Gloucester Harbor contains multiple private marinas, and Little River contains a private marina. There are an additional 435 public and private boat slips across all waterways in the City of Gloucester.

Commercial and Recreational Boat Traffic: Not reported.

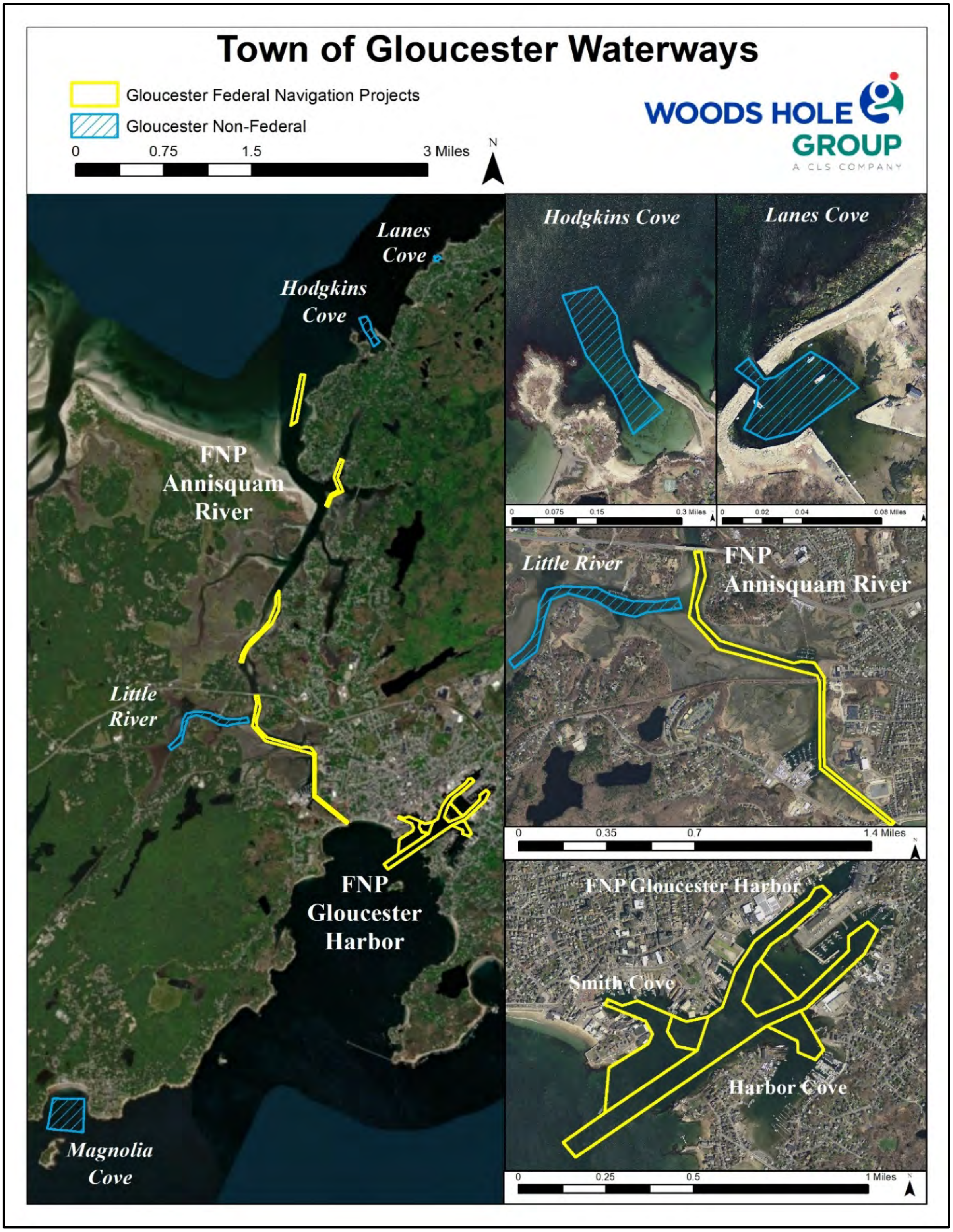

Figure 14 - Federal and non-Federal waterways located within the City of Gloucester.

The Town of Manchester-by-the-Sea

Harbormaster Bion Pike provided feedback on behalf of Manchester-by-the-Sea. Waterways in the Town of Manchester-by-the-Sea include Manchester Harbor (historic FNP, now State-managed) and Magnolia Cove. Imagery of Manchester-by-the-Sea waterways is included in Figure 15.

Current Navigability; Specific Dredging Needs; and Public Safety Concerns: Harbormaster Pike reported that sections of Manchester Harbor were dredged in 2018. Additional dredging is still required in Whittier's Cove, which is limiting boat traffic to shallow-draft vessels only in an effort to delay dredging; in Proctor Cove, where dredging is planned and pre-dredge surveys were completed in 2018; and in the inner harbor below the drawbridge. Dredging is also planned adjacent the Yacht Club, where shoaling has encroached on the existing navigation channel. Harbormaster Pike acknowledged that Manchester-by-the-Sea is a destination harbor on the North Shore and that dredging is currently needed in multiple locations to ensure safe and navigable passage. Magnolia Cove is not dredged or maintained by the Town, although Pike stated that Magnolia Cove is an exposed harbor that would benefit from a breakwater or coastal engineering structure.

Historic Dredging: Sections of Manchester Harbor (primary Channel, innermost harbor) were dredged in 2018. Yacht Club adjacent Proctor Cove last dredged c. 2000.

Future Dredging: No dredging is currently scheduled within Manchester Harbor or Magnolia Cove, although there are active plans to dredge sections of Proctor Cove and adjacent the Yacht Club.

Existing Permits: The Town of Manchester-by-the-Sea does not hold current dredging permits for Manchester Harbor or Magnolia Cove.

Beneficial Reuse of Dredged Material: Given the variable, muddy material reported in Manchester-by-the-Sea waterways, the Town stated a preference for offshore disposal options.

Moorings and Marinas: Public mooring fields exist throughout Manchester harbor, totaling over 400 individual moorings and an additional 134 boat slips. Manchester Harbor is served by multiple commercial marinas as well as a private Yacht Club. Magnolia Cove has no established mooring fields or marinas.

Commercial and Recreational Boat Traffic: Manchester Harbor serves up to 400 transient commercial and recreational boats daily during peak season, plus an additional 28 commercial fishermen and 6 charter boat operators.

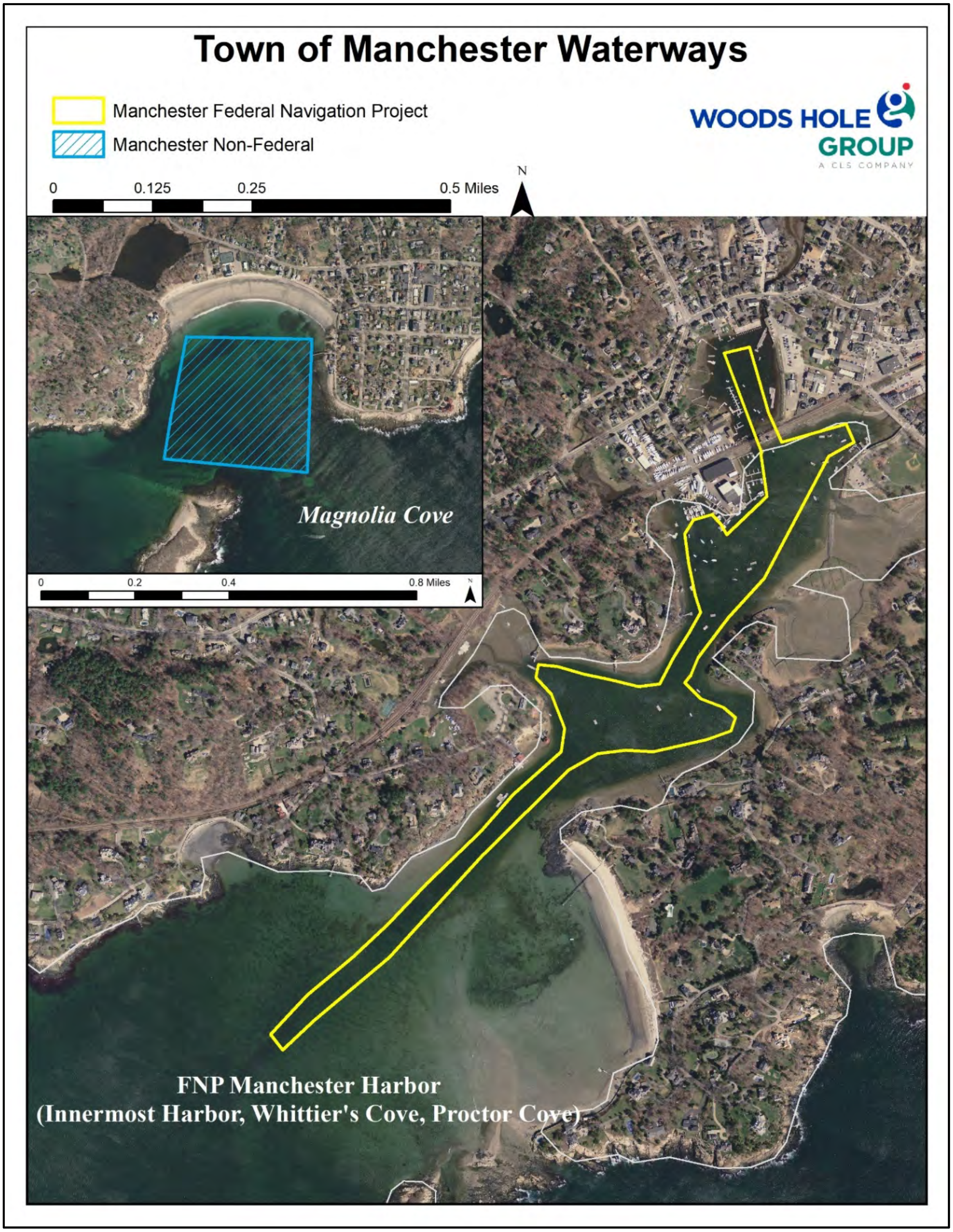

Figure 15 - Federal and non-Federal waterways located within the Town of Manchester-by-the-Sea.

Preliminary Data Collection Summary

All 7 municipalities responding to the Preliminary Data Collection Survey reported an immediate need for dredging in one or more Federal and/or non-Federal waterways on the upper North Shore of Massachusetts. All FNPs located within the 7 municipalities responding to the Preliminary Data Collection Survey have been previously dredged. The length of time since the last dredging event varies considerably from a single year (2018) in Manchester Harbor to 125 years (1894) in the Ipswich River. As such, five out of the 7 municipalities (Newburyport, Essex, Ipswich, Rockport, and Gloucester) reported that previous dredging events have not kept Federal and/or non-Federal waterways on the upper North Shore safe and navigable to commercial and recreational boat traffic and/or first responders. Despite the stated need for dredging on the upper North Shore, only the City of Gloucester reported that dredging was currently scheduled to occur in 2019 (Annisquam River (FNP), all sections). Salisbury and Rockport reported that they are currently in the planning stages for future dredging in Newburyport Harbor (FNP) and Old Harbor (non-Federal), respectively.

Reported Immediate Need for Dredging:

- **Salisbury:** The mouth of the Merrimack River (FNP) requires dredging and poses a significant hazard to navigation.
- **Newburyport**: The mouth of the Merrimack River (FNP) has an immediate need for dredging, has become dangerous, and is having a large impact on the commercial and recreational boaters.
- **Ipswich:** Ipswich River (FNP) is currently non-navigable for police patrol boats and requires dredging from Town Warf to the mouth of the river (beyond the existing FNP).
- **Essex:** For 3 hours before and after low tide, it is not possible for emergency personnel to safely respond to an incident within the Essex River or Essex Bay. Exigency to remediate existing conditions for the purposes of public safety is currently required.
- **Rockport:** Old Harbor is not navigable at low tide and requires immediate dredging.
- **Gloucester:** Certain tides currently limit navigability within sections of the Annisquam River (FNP). Lane's Cove (non-Federal) has an immediate dredging need to support the commercial fishing fleet. Navigation into and out of Lane's Cove and Little River (non-Federal) is limited and there is an immediate need for dredging.
- **Manchester-by-the-Sea:** Manchester Harbor is a destination on the North Shore and dredging is currently needed in multiple locations to ensure safe and navigable passage.

Based on feedback received from municipal stakeholders, sediment type varied considerably across waterways on the upper North Shore (Table 2). Based on the variable characteristics of the sediment, preferred alternatives for beneficial reuse and/or disposal of dredged material also varied.

Table 2. Reported sediment type(s) and preferred alternative for beneficial reuse and/or disposal of dredged material within upper North Shore municipalities.

Municipality	Sediment Type Reported	Preferred Alternative for Beneficial Reuse / Disposal
Salisbury	Sand	Beach Nourishment, Near-Shore
Newburyport	Variable	Beach Nourishment, Offshore
Ipswich	Variable, Sand, Mud	Beach Nourishment, Thin Layer Deposition
Essex	Variable, Sand, Mud	Considering All Available
Rockport	Variable	Offshore
Gloucester	Variable, Sand, Silt	Near-Shore
Manchester	Variable, Mud	Offshore

All municipalities submitting Survey responses reported busy working waterfronts and heavy commercial and recreational boat traffic during the summer season. A summary of the total number of moorings, boat slips, marinas and boatyards, commercial fishing vessels and charter boat operators utilizing Federal and non-Federal waterways on the upper North Shore is included in Table 3.

Table 3. Reported moorings, slips, marinas, commercial and recreational usage of Federal and non-Federal waterways on the upper North Shore of Massachusetts.

Municipality	Moorings	Slips	Marinas	Commercial Vessels*	Charter Vessels*	Recreational Vessels*
Salisbury	214	-	4	20	25	450
Newburyport	200	-	11	200	50	2,000
Ipswich	300	-	2	140	-	1,000
Essex	4 mooring fields	-	5	100	20	1,500
Rockport	350+	30	1	68	4	Heavy Use
Gloucester	475+	435	Multiple	-	-	-
Manchester	400+	134	Multiple	28	6	400
Total	**1,939+**	**599+**	**23+**	**556+**	**105+**	**5,455+**

*Total number of vessels, peak season conditions; (-) denotes unreported data

The Preliminary Data Collection Survey focused on qualitative and quantitative information provided by municipal officials. This study acknowledges the countless private entities operating independently along each waterway, though it was beyond the scope of this study to gauge the impact of a safe and navigable waterway on day-to-day operations. Chapters 3 builds upon the Preliminary Data Collection Survey by summarizing the quantity and quality of material historically dredged from Federal and non-Federal waterways on the upper North Shore from 1887 to 2018.

3.0 DATA COLLECTION

Data Collection and Methodology

An extensive data collection effort was conducted to generate a database of historic dredge events, dredged material volumes, and sediment types in upper North Shore waterways. Primary datasets used to complete data collection Tasks included:

- The United States Army Corps of Engineers Annual Dredge Statistics (2019)
- The United States Army Corps of Engineers Ocean Dredged Material Disposal Site Database (2016)
- The United States Army Corps of Engineers Annual Waterways Reports
- The United States Army Corps of Engineers Hydrographic Surveys
- Urban Harbors Institute, State of Our Harbors Report (2015)
- The United States Geological Survey East Coast Sediment Texture Database (Poppe et al., 2004)

Woods Hole Group also submitted a data request to representatives from the United States Army Corps of Engineers New England District and solicited feedback from stakeholders through the municipal Preliminary Data Collection Survey. Historic press releases, news publications, peer-reviewed academic papers, and USACE Environmental Impact Statements were also reviewed.

The data collection effort allowed Woods Hole Group to identify historic:

- Project Proponents
- Type of Dredging Event (initial improvement, improvement, maintenance)
- Volume of Material Dredged (in cubic yards, cy)
- Dredged Channel Depth (feet relative to Mean Lower Low Water tidal datum, ft, MLLW)
- Characteristics of the Material Dredged
- Protocol for the Disposal of Dredged Material

Each of the datasets were cross-referenced to ensure replicate events were only counted once. When available, actual volumes of dredged material were used in place of USACE estimated quantities to be dredged. Anecdotal and unconfirmed dredging events were excluded from the final database. The final historic dredge database forms the basis of the estimates of historic annual dredge volumes, the percentage of dredged material suitable for beneficial reuse, estimated dredge frequency, and current, estimate dredge take-off volumes presented in Chapter 6.0. A summary of the data available for each waterway are presented in the following Sections and summary tables. Despite a comprehensive review of the available data, gaps still remained in many fields. Data gaps are symbolized by a (-) in the following tables.

Town of Salisbury

The Town of Salisbury contains the Merrimack River FNP, which borders the Newburyport Harbor FNP. The historic dredging events in Newburyport Harbor FNP are summarized in the Newburyport section, as the project is supported by both the Towns of Salisbury and Newburyport.

The Merrimack River FNP was established in 1907, and consists of a 7-feet deep and 150-feet wide channel extending 16.5 miles upstream of the Route 1 Bridge in Newburyport to the railroad bridge in the Town of Haverhill (USACE, 1909). The FNP passes through the Towns of Salisbury, Amesbury, West Newbury, Merrimac and Groveland. One recorded dredge event has occurred in this reach, a total of 4,000 cy dredged in 1945 (Table 4; UHI, 2015).

Three waterways have been identified by municipal stakeholders as potential new, improvement dredging sites:

- Black Rock Creek
- Blackwater River
- Town Creek

None of the above referenced waterways have been dredged historically. Black Rock Creek and Town Creek are derived from small tidal rivers that drain wetlands to the Merrimack River. The sediments are muddy sand, though no extensive surveys or sampling have been conducted in recent record. Blackwater River is a small tidal river that crosses the State border in New Hampshire and is part of the Hampton River inlet system.

Table 4. Merrimack River Historic Dredging Events

Year	Proponent	Type	Volume (cy)	Depth (ft, MLLW)	Material	Disposal
1945	ACOE	Improvement	4,000	-7	-	-
		Total	**4,000**			

City of Amesbury

The City of Amesbury lies along the Merrimack River, which allows direct Atlantic Ocean access. The Merrimack River 7-foot FNP channel passes through Amesbury, though no dredging events have been recorded within Town boundaries.

The Powwow River is a small, tidal freshwater river that stretches 1.5 miles from downtown Amesbury to the Merrimack River. The Powwow River was previously de-authorized by the USACE. No dredging events or sediment quality data have been recorded in the Powwow River.

City of Newburyport

The City of Newburyport contains one FNP and several non-Federal waterways. The existing FNP in Newburyport Harbor was established in 1880 and extends 3 miles from the mouth of the Merrimack River to the Route 1 Bridge. From the Atlantic Ocean to the harbor entrance, the channel is 15-feet deep and 400-feet wide, which then narrows to 200-feet in width and 9-feet deep from the harbor entrance to the Route 1 Bridge. Two jetties protect the entrance to the harbor extending 4,118 feet and 2,445 feet from the north and south shores, respectively.

The channel was first dredged in 1961 and maintenance dredging has occurred periodically since (Table 5). Historically, the dredged material from Newburyport Harbor was disposed of at an offshore disposal site, just over two miles off the shore of Newburyport (Hubbard, 1987). The 1977 event was disposed at the USACE Massachusetts Bay Designated Offshore Disposal Site (MBDS). Since 1983, the dredged material has been beneficially placed in the near shore, following a directive from the Commonwealth of Massachusetts (Hubbard, 1987). A 2009 agreement between the USACE and the Commonwealth of Massachusetts specified that any material dredged from Newburyport Harbor considered suitable for beneficial reuse would be divided between Salisbury Beach (25%) and Plum Island Beach (75%). The existing Environmental Assessment (EA) concluded that 50,000 – 200,000 cy of clean sand should be removed every three to four years from the Newburyport Harbor FNP (USACE, 2008).

Municipal stakeholders in the City of Newburyport identified the piers at the Harbormaster office downstream of the Route 1 Bridge and areas adjacent the Salisbury Jetty as areas in need of new, improvement dredging. The area adjacent to the commercial piers likely contains fine grained sediment mixed with sand, while the Salisbury Jetty likely contains sandy material more suitable for beneficial reuse (Hartwell, 1970; Li et al., 2018).

In summary:

- Newburyport Harbor has been dredged 18 times in the 58 years, removing a total of 2.09 million cy of sediment.
- Dredging in Newburyport Harbor has occurred approximately every four years.
- Newburyport Harbor was last dredged in 2010 by the USACE.
- The channel consists mainly of clean sand and gravel.

Table 5. Newburyport Harbor Historic Dredging Events

Year	Proponent	Type	Volume (cy)	Depth (ft, MLLW)	Material	Disposal
1961	ACOE	Maintenance	250,000	-	Sand and gravel	Offshore
1964	ACOE	Maintenance	131,100	-	Sand and gravel	Offshore
1966	ACOE	Maintenance	50,000	-	Sand and gravel	Offshore
1968	ACOE	Maintenance	86,000	-	Sand and gravel	Offshore
1970	ACOE	Maintenance	106,190	-	Sand and gravel	Offshore
1970	ACOE	Maintenance	183,230	-	Sand and gravel	Offshore
1973	ACOE	Maintenance	93,650	-	Sand and gravel	Offshore
1973	ACOE	Maintenance	8,970	-	Sand and gravel	Offshore
1977	ACOE	Maintenance	54,000	-	Sand and gravel	MBDS*
1981	ACOE	Maintenance	102,600	-	Sand and gravel	Offshore
1983	ACOE	Maintenance	123,500	-	Sand and gravel	Nearshore
1983	ACOE	Maintenance	154,000	-	Sand and gravel	Nearshore
1990	ACOE	Maintenance	62,458	-	Sand and gravel	Nearshore
1991	ACOE	Maintenance	135,290	-	Sand and gravel	Nearshore
1993	ACOE	Maintenance	125,040	-	Sand and gravel	Nearshore
1996	ACOE	Maintenance	125,386	-	Sand and gravel	Nearshore
1999	ACOE	Maintenance	145,017	-	Sand and gravel	Nearshore
2010	ACOE	Maintenance	160,000	-	Sand	Bch. Nourishment
		Total	**2,096,431**			

*Massachusetts Bay Offshore Disposal Site

Town of Newbury

The Town of Newbury is located within the Great Marsh system, a Massachusetts-designated ACEC on Plum Island Sound. Three non-Federal waterways in Town drain to Plum Island Sound, facilitating access to the Atlantic Ocean:

- Parker River
- Plum Island River
- Plumbush Creek

These rivers are tidal, saltwater rivers with predominantly sandy sediments (Hubbard, 1970). Plumbush Creek has mud flats along its banks, and Plum Island River has muddy sand located in the southern reaches. All three waterways are part of the Great Marsh ACEC.

No historic dredging events were recorded in the Parker River, Plum Island River, or within Plumbush Creek.

Town of Rowley

The Town of Rowley contains one non-Federal waterway, the Rowley River, a 5-mile long tidal river that flows into Plum Island Sound. The river bed is likely sandy, although no historic dredging events have been recorded in the River. The Rowley River is located within the Great Marsh ACEC.

Town of Ipswich

The Town of Ipswich has one FNP, the Ipswich River, initiated in 1887 and maintained once, in 1894. The FNP consists of a 4-foot-deep channel, 3,000 linear feet long and 60 feet wide, that cuts through documented shoals in the River referred to throughout USACE Annual Reports as 'The Shoals' and 'Labor in Vain'. No federally-sponsored maintenance has occurred since 1894 (Table 6). The FNP channel is predominantly comprised of sandy material.

Municipal stakeholders in the Town of Ipswich identified that there is an immediate need for new improvement dredging in the Ipswich River (particularly at the mouth of Ipswich Bay), Eagle Hill Creek, and Castle Neck River. No historic dredging events have been recorded outside the Ipswich River FNP.

Table 6. Ipswich River Historic Dredging Events

Year	Proponent	Type	Volume (cy)	Depth (ft, MLLW)	Material	Disposal
1887	ACOE	Improvement	4,665	-4	Sand	-
1894	ACOE	Maintenance	7,266	-4	Sand	-
		Total	**11,931**			

Town of Essex

The Town of Essex has one FNP, the Essex River, first established in 1895 and completed in 1901. The Federal channel is 4-feet deep, 60-feet wide, and extends from Essex Bay to the Route 133 bridge in Essex. Eight maintenance dredging events have occurred since the initial improvement, the last maintenance project was completed in 1994 (Table 7). The most recent dredging events were sponsored by the Town and dredged material was disposed of offshore. In 2016, the Essex River FNP channel was re-designated to avoid encroachments from existing structures (docks, piers, etc.), and to free the channel for unimpeded future dredging as part of the Federal Water Resource Development Act of 2016.

Municipal stakeholders in the town of Essex identified the piers at the Town Landing at Route 133 and Main Street as potential areas in need of improvement dredging. Castle Neck River is part of the Great Marsh ACEC.

In summary:

- The Essex River has been dredged 9 times since 1895, totaling 193,000 cy of material.
- The channel is predominantly comprised of sand. The upstream extent of the FNP near the Town Landing contains higher concentrations of silt and mud.

Table 7. Essex River Historic Dredging Events

Year	Proponent	Type	Volume (cy)	Depth (ft, MLLW)	Material	Disposal
1895	ACOE	Improvement	47,008	-4	Sand	-
1897	ACOE	Maintenance	14,000	-4	Sand	-
1900	ACOE	Maintenance	14,094	-4	Sand	-
1909	ACOE	Maintenance	10,355	-4	Sand	-
1909	ACOE	Maintenance	15,904	-4	Sand and Mud	-
1909	ACOE	Maintenance	30,187	-	Rock	-
1912	ACOE	Maintenance	6,014	-4	Sand	-
1947	ACOE	Maintenance	27,735	-4	Sand	-
1993	Town of Essex	Maintenance	23,702	-	Cohesive	MBDS*
1994	Town of Essex	Maintenance	4,103	-	Cohesive	MBDS*
		Total	**193,102**			

*Massachusetts Bay Offshore Disposal Site

Town of Rockport

The Town of Rockport contains 2 FNPs, Rockport Harbor and Pigeon Cove, completed in 1987. The work in both Rockport Harbor and Pigeon Cove were constructed under Section 107 of the ACOE Continuing Authorities Program (ACOE, 2019). The Rockport Harbor FNP consists of a 1,100-foot-long, 10-foot deep, 80-foot wide channel leading from deep water in Sandy Bay to the Town wharf in the center of the harbor. Two 8-foot deep anchorage basins are located north and south of the main channel. Two dredging events have been recorded, both Federally sponsored and totaling 50,000 cy of material (Table 8). The quality of the material in the Harbor is not well constrained, with reports of sand, mud and rock (ACOE 1989).

Pigeon Cove, located 1.5 miles north of Rockport Harbor, was designated and completed at the same time as Rockport Harbor FNP, and the total dredge volumes reflect the events spanning both harbors. The Pigeon Cove FNP consists of a 10-foot deep, 75-foot wide channel extending 550 feet from the deep water beyond the breakwater to the southern corner of the inner harbor. An 8-foot anchorage is located in the inner harbor. Pigeon Cove is used primarily by commercial vessels.

Old Harbor and Granite Pier are two non-Federal harbors included in this assessment. Both are small, armored harbors used for both recreation and commercial vessels. Neither waterway has documented historic dredging events, though stakeholders cited an unconfirmed event in the 1960s in Old Harbor. Old Harbor has been identified by the Town as an area in need of new improvement dredging.

Table 8. Rockport Harbor and Pigeon Cove Historic Dredging Events

Year	Proponent	Type	Volume (cy)	Depth (ft, MLLW)	Material	Disposal
1986	ACOE	Improvement	12,800	-10	-	MBDS*
1987	ACOE	Improvement	38,000	-10	-	MBDS*
		Total	**50,800**			

*Massachusetts Bay Offshore Disposal Site

City of Gloucester

The City of Gloucester has 2 FNPs, the Annisquam River and Gloucester Harbor, as well as several non-Federal coves and waterways. The Annisquam River is a highly-trafficked narrow tidal waterway extending from Ipswich Bay, 4 miles south to Gloucester Harbor. The southern reach of the river from Gloucester Harbor to the Boston and Maine railroad bridge is known as the Blyman Canal. The Annisquam River FNP was initially authorized in 1932 and was dredged to completion in 1965 (USACE, 1935; Table 9). From Ipswich Bay to the railroad bridge, the FNP is 8-feet deep and 200 feet wide. The channel narrows to 100 feet wide south of the bridge.

Gloucester Harbor FNP, which was initially authorized in 1872 and completed in 1965, consists of an outer and inner harbor (USACE, 1872; Table 10). The 20-foot deep outer harbor entrance channel separates into two channels in the inner harbor. The inner harbor contains two anchorages, with Harbor Cove to the east and Smith Cove to the west. The sediment is mixed and variable throughout Gloucester Harbor, with records of sand, silt, mud, and contamination. Since the last major Federal event in 1965 that removed over 150,000 cy of material, all dredging events have been City, State, or privately sponsored.

The Little River, a tributary of the Annisquam River though not a part of the FNP, was identified by municipal stakeholders as an area in need of improvement dredging. Stakeholders reported that the Little River was last dredged using State and local funds in 1968, though this event and volume was unconfirmed. Hodgkin's Cove, located a mile northeast of the Annisquam River mouth, contains substantial eelgrass habitat, thus limiting the possibility of dredging. A mile further northeast lies Lane's Cove, a small, non-Federal protected harbor with documented commercial moorings. No prior dredging events have been identified in Lane's Cove.

In summary:

- The Annisquam River has been dredged 14 times over 123 years, totaling nearly 600,000 cy of material. Excluding the initial improvement project, the 13 dredge events occurred over the past 83 years.
- The last dredging event in the Annisquam River was in 2007.
- Material is primarily sandy, with finer grained material located in Lobster Cove and at the junction with the Little River.
- Approximate dredging rate of once every 6-9 years.
- The Annisquam River is scheduled for Federally-sponsored dredging fall 2019.
- Gloucester Harbor has been dredged 7 times in 54 years, totaling 254,000 cy of material.
- Dredging events have been Federal, State and City-sponsored. The last Federally-sponsored event was in 1965.
- Material is mixed sand, silt, and mud. Areas of the harbor may contain contaminated material.
- Contamination has been identified in Gloucester Harbor, limiting options for beneficial reuse.

Table 9. Annisquam River (all sections) Historic Dredging Events

Year	Proponent	Type	Volume (cy)	Depth (ft, MLLW)	Material	Disposal
1936	ACOE	Improvement	91,773	-8	-	-
1940	ACOE	Maintenance	53,104	-8	-	-
1940	ACOE	Maintenance	50,446	-8	-	-
1949	ACOE	Maintenance	33,302	-8	-	-
1958	ACOE	Maintenance	51,500	-8	-	-
1958	ACOE	Maintenance	184,120	-8	Sand with mud	-
1961	ACOE	Maintenance	28,000	-8	-	-
1965	ACOE	Maintenance	19,536	-8	Sand	-
1970	ACOE	Maintenance	7,500	-8	-	-
1972	ACOE	Maintenance	65,000	-8	-	-
1976	ACOE	Maintenance	2,690	-8	-	-
2006	Cape Ann Marina	Maintenance	8,933	-8	Sand	MBDS*
2007	MA DCR	Maintenance	1,000	-8	-	IBNDS**
		Total	**596,904**			

*Massachusetts Bay Offshore Disposal Site
**Ipswich Bay Nearshore Disposal Site

Table 10. Gloucester Harbor Historic Dredging Events

Year	Proponent	Type	Volume (cy)	Depth (ft, MLLW)	Material	Disposal
1896	ACOE	Improvement	2,206	-20	-	-
1965	ACOE	Improvement	152,498	-20	-	-
1982	Gloucester Redevelopment Authority	Maintenance	42,200	-	Mixed	MBDS*
1984	City of Gloucester	Maintenance	4,900	-	Sand	MBDS*
1985	City of Gloucester	Maintenance	11,000	-	Mixed	MBDS*
1992	MA Govt Land Bank	Maintenance	33,700	-	Mixed	MBDS*
1994	City of Gloucester	Maintenance	2,700	-	Mixed	MBDS*
2002	Heron Way Coop. Assoc.	Maintenance	5,000	-	Mixed	MBDS*
		Total	**254,204**			

*Massachusetts Bay Offshore Disposal Site

Town of Manchester-by-the-Sea

The Town of Manchester-by-the-Sea has one FNP, Manchester Harbor. Following its initial Federal improvement in 1903, Manchester Harbor has been managed by the Town, with the subsequent 7 dredge events sponsored by the Town, State or Private entities (Table 11). The FNP consists of an outer harbor, with 10-foot main channel extending 200 feet to the 8-foot Innermost Harbor upstream of the drawbridge, and Whittier's Cove and Proctor's Cove east and west of the channel respectively.

In summary:

- Over 105,000 cy of material has been removed over 115 years.
- Material is sand with silt and mud.
- Although Manchester Harbor is a designated FNP, the harbor is currently managed by the State and Town.

Magnolia Cove, initially included in this assessment, is an exposed, unmaintained harbor south of Manchester Harbor. It is neither maintained or dredged historically, thus was excluded from this final assessment.

Table 11. Manchester Harbor Historic Dredging Events

Year	Proponent	Type	Volume (cy)	Depth (ft, MLLW)	Material	Disposal
1903	ACOE	Improvement	10,500		Sand and mud	-
1970	Private	Maintenance	1,344	-	-	-
1981	MADEQE	Maintenance	3,500	-	Sand	MBDS*
1987	MADEM	Maintenance	52,500	-	Sand	MBDS*
1991	Town of Manchester	Maintenance	21,200	-	Silt	MBDS*
2001	Town of Manchester	Maintenance	9,749	-	Silt	MBDS*
2001	David McCue	Maintenance	2,400	-	Silt	MBDS*
2018	Town of Manchester	Maintenance	4,676	-	Silt	MBDS*
		Total	**105,869**			

*Massachusetts Bay Offshore Disposal Site

Summary of Historic Dredging Events, Volumes, and Sediments

A total of 65 dredging events were recorded since 1887 in 9 waterways within the study region on the upper North Shore of Massachusetts (Table 12). The 65 dredging events resulted in the removal of 3,300,000 cy of material (Figure 16). Newburyport Harbor and the Annisquam River are the two most actively managed waterways, with 18 and 13 total dredging events respectively, which accounts for over 80% of all material removed from the study region (Figure 17). The majority of dredging events occurred in FNPs and were Federally sponsored, with Manchester Harbor and Gloucester Harbor the two main exceptions, which have had State, Municipal and privately sponsored dredging events.

Records in Non-Federal Waterways

There was a total of 16 waterways identified in the study region during the Preliminary Data Collection Survey that could benefit from maintenance dredging, but had no confirmed historical dredging data available. It is possible that several privately sponsored dredge events recorded within existing FNPs extend into non-Federal waterways, but existing records were inconclusive. As a result, the non-federal waterways were not included in the final assessment of sediment quantity and quality. The waterways that were excluded from the summary dataset include: Black Rock Creek, Blackwater River, Powwow River, Parker River, Plum Island River, Plum Island Sound, Plumbush Creek, Rowley River, Eagle Hill River, Essex Bay, Lanes Cove, Hodgkins Cove, Little River, Old Harbor, Granite Pier and Magnolia Cove.

Table 12. Summary of Historic Dredging Event Data

Waterway	No. of Dredging Events	Volume (cy)	Sediment Quality
Newburyport Harbor (Merrimack River)	18	2,096,431	Gravel and Sand
Merrimack River (Upstream Reaches)	1	4,000	Sand / Mud
Ipswich River	2	11,931	Sand / Mud (Upstream)
Essex River	10	193,102	Sand / Mud (Upstream)
Annisquam River	13	596,904	Sand
Gloucester Harbor	9	254,204	Silt / Contamination
Rockport Harbor	2	50,800	Sand / Gravel / Mud
Manchester Harbor	8	105,869	Sand / Mud / Silt (Variable)
TOTAL	**65**	**3,313,241**	**-**

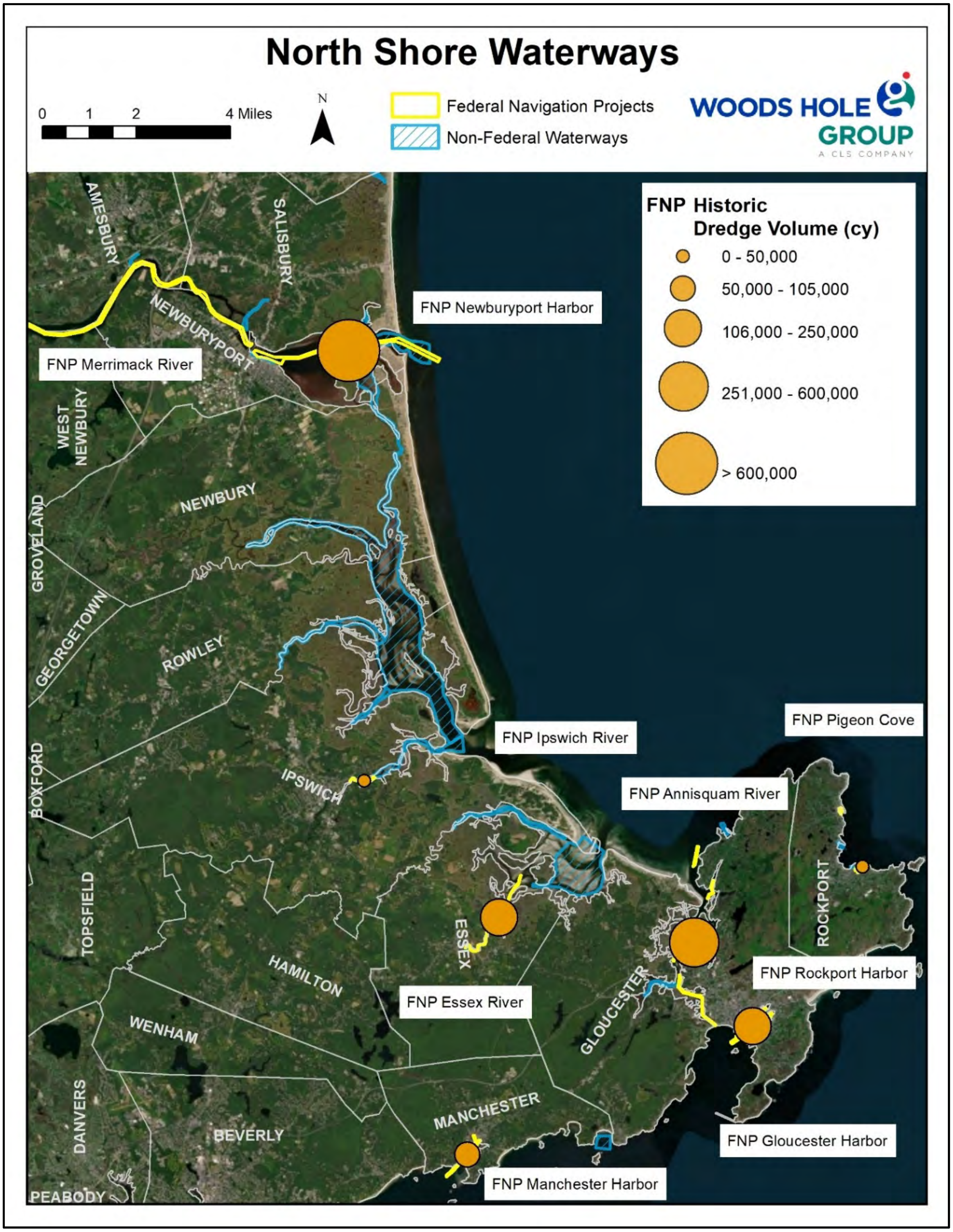

Figure 16 – Total volume of material removed from FNPs in the North Shore study region from earliest record to present.

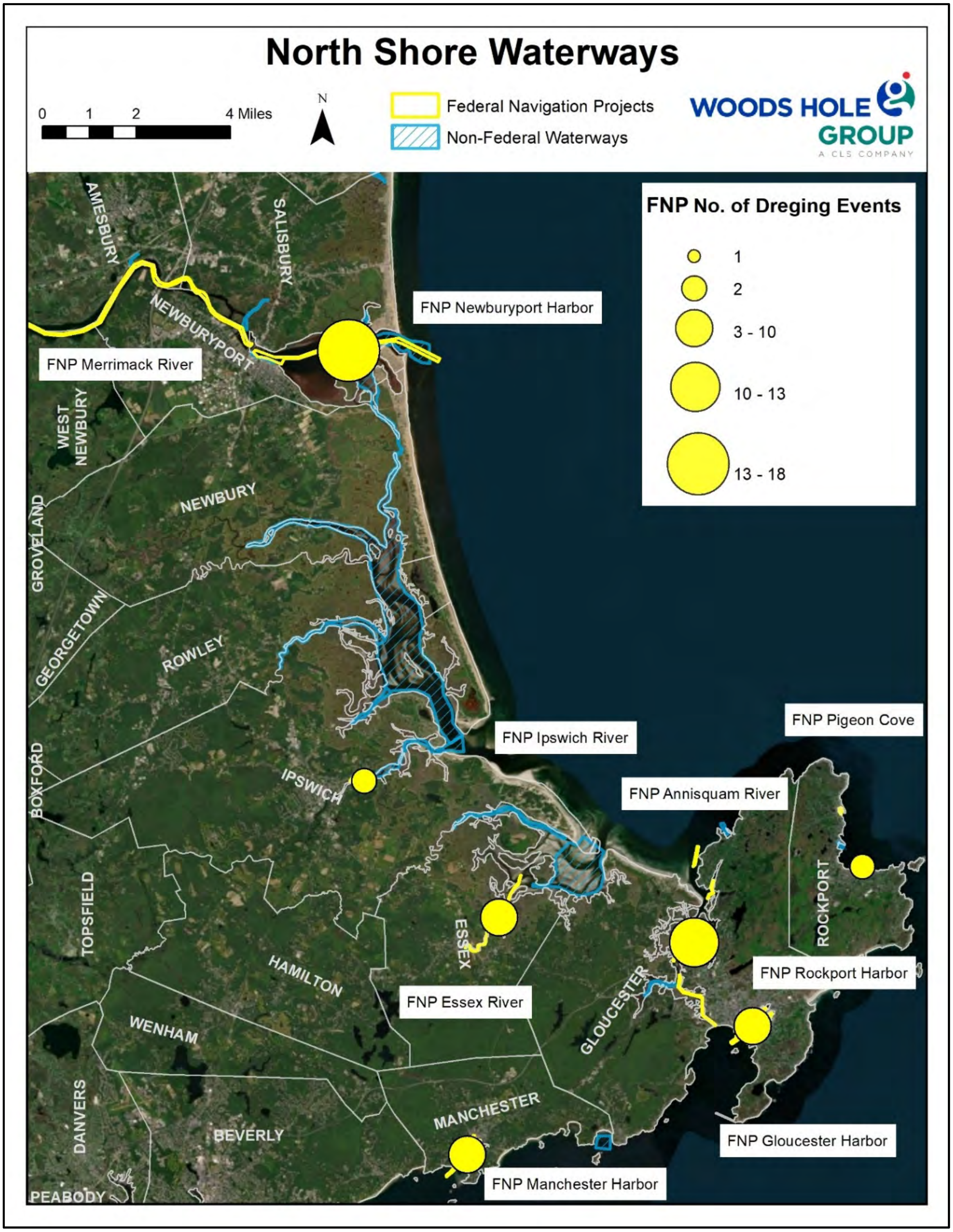

Figure 17 – Total number of historic dredging events that occurred in FNPs in the North Shore study region from earliest record to present.

Alternatives for Beneficial Reuse and/or Disposal of Dredged Material

An important consideration for municipalities investigating regional dredging alternatives is how best to manage and beneficially reuse and/or dispose of material once it has been dredged. Woods Hole Group researched possible alternatives for the beneficial reuse and/or disposal of dredged material from waterways on the upper North Shore (Table 13). For the purposes of this preliminary study, Woods Hole Group based the list of possible alternatives for each waterway on the available sediment quality data (summarized above), the proximity of possible dewatering sites within each waterway, and previous experience working with private dredge contractors and municipal dredge programs.

Considerations and Limitations

Given the inherent variability of the sediment found in each waterway, it was expected that only some of the material found in each waterway would be suitable for the specified alternative(s). The preliminary list of alternatives did not take into consideration the presence of any contaminants not reported in the above-referenced datasets. Woods Hole Group emphasizes the importance of developing robust sediment coring data, conducting chemical testing, considering environmental and water quality standards, and identifying any existing prohibitions on the placement of dredged material while developing a dredging project. Further, Woods Hole Group emphasizes the importance of assessing the feasibility of permitting various alternatives for beneficial reuse and working in close collaboration with local and regional partners when developing a dredging project.

Based on the feedback received during the Preliminary Data Collection Survey and during the Kick-Off Meeting, upper North Shore municipalities have an interest in considering a variety of alternatives for beneficial reuse including but not limited to beach nourishment and dune enhancement, near-shore placement, thin layer deposition (TLD), salt marsh enhancement (restoration, ditch-filling), offshore disposal, and upland disposal. Woods Hole Group has provided the following list of alternatives to act as a point of further discussion. Assessing the feasibility of implementing any of the proposed alternatives was beyond the scope of this initial study.

Table 13. Conceptual Alternatives for Beneficial Reuse of Dredged Material in upper North Shore Waterways.

Municipality	Navigation Channel	Sediment Quality	Possible Alternatives for Future Beneficial Reuse
Salisbury	Newburyport Harbor	Sand, Gravel	• Beach Nourishment and Dune Enhancement (25% Salisbury Beach, 75% Plum Island Beach)
	Black Rock Creek/ Town Creek	Mud, Sand	• Beach Nourishment and Dune Enhancement (Black Rock Creek, pump to Salisbury Beach) • Salt Marsh Enhancement • TLD (Town Creek, Black Rock Creek)
	Blackwater River	Mud, Sand	• Beach Nourishment and Dune Enhancement (Pump to Salisbury Beach)

			• Salt Marsh Enhancement • TLD
Amesbury	Merrimack River (upstream)	Sand, Mud	• Near-Shore Placement • Upland Disposal • Offshore Disposal
	Powwow River	Mud, Silt, Sand	• Upland Disposal • Offshore Disposal
Newburyport	Newburyport Harbor	Sand, Gravel	• Beach Nourishment and Dune Enhancement (25% Salisbury Beach, 75% Plum Island Beach)
	Merrimack River (upstream)	Sand, Mud	• Near-Shore Placement • Upland Disposal • Offshore Disposal
	Salisbury Jetty	Sand	• Beach Nourishment and Dune Enhancement (25% Salisbury Beach, 75% Plum Island Beach)
	Commercial Fish Piers	Sand, Mud	• Upland Disposal (if contamination present) • Offshore Disposal
Newbury	Parker River	Sand, Mud	• Beach Nourishment and Dune Enhancement (to Plum Island) • Salt Marsh Enhancement • TLD
	Plum Island River	Gravel, Sand, Mud	• Beach Nourishment and Dune Enhancement (to Plum Island) • Salt Marsh Enhancement • TLD
	Plum Island Sound	Sand	• Beach Nourishment and Dune Enhancement (to Plum Island)
	Plumbush Creek	Sand, Mud	• Beach Nourishment and Dune Enhancement (25% Salisbury Beach, 75% Plum Island Beach)
Rowley	Plum Island Sound	Sand	• Beach Nourishment and Dune Enhancement (Plum Island) • Near-Shore
	Rowley River	Sand, Mud	• Beach Nourishment and Dune Enhancement (Plum Island) • Salt Marsh Enhancement • TLD
Ipswich	Ipswich River	Sand, Mud	• Beach Nourishment and Dune Enhancement (Plum Island) • TLD (in upper River) • Upland Disposal (in upper River, if contamination present) • Offshore Disposal (in upper River)
	Ipswich Bay	Sand	• Beach Nourishment and Dune Enhancement (Plum Island) • Near-Shore
	Eagle Hill, Castle Neck	Sand, Mud	• Beach Nourishment and Dune Enhancement (Plum Island) • Salt Marsh Enhancement

			• TLD
Essex	Essex River	Variable, Sand	• Beach Nourishment and Dune Enhancement (to Crane Beach) • Near-Shore • Salt Marsh Enhancement (upper River) • TLD (upper River)
	Essex Bay	Variable, Sand	• Beach Nourishment and Dune Enhancement (Crane Beach) • Near-Shore
	Town Landing Rt. 133	Mud	• Upland Disposal (if contamination present) • Offshore Disposal
Gloucester	Annisquam River (Inc. Blyman's Canal and Lobster Cove)	Sand, Silt	• Beach Nourishment and Dune Enhancement (mouth of the Annisquam) • Near-Shore • Salt Marsh Enhancement (mid-River) • TLD (mid-River) • Offshore Disposal (Lobster Cove)
	Gloucester Harbor	Sand, Silt	• Offshore Disposal • Upland Disposal (if contamination present)
	Lanes Cove	Sand, Silt, Rock	• Near-Shore Disposal • Offshore Disposal
	Hodgkins Cove	Sand, Silt	• Near-Shore Disposal • Offshore Disposal
	Little River	Sand, Mud	• Near-Shore Disposal • Offshore Disposal
Rockport	Rockport Harbor	Mud	• Offshore Disposal
	Pigeon Cove Harbor	Mud	• Offshore Disposal
	Old Harbor	Cobble, Gravel, Mud	• Offshore Disposal
	Granite Pier	Cobble, Gravel, Mud	• Offshore Disposal
Manchester-by-the-Sea	Manchester Harbor (Inc. Whittier's Cove; Proctor's Cove; Innermost Harbor; and Yacht Club)	Sand, Mud, Gravel	• Beach Nourishment and Dune Enhancement (outside Harbor entrance) • Offshore Disposal • Upland Disposal (if contamination present)
	Magnolia Cove	Sand	• Beach Nourishment and Dune Enhancement (on adjacent beach)

4.0 DREDGING 101

Prior to evaluating dredging alternatives for the upper North Shore, it is important to understand the inherent complexities of dredging, steps in the development of a dredging project, and the equipment required to complete the proposed work. Careful selection of dredging equipment, employment and retention of a skilled and experienced crew, budgeting for down time and maintenance, and the establishment of an effective management structure are all important considerations. The following sections describe the basic steps, equipment, and personnel necessary to develop and complete a dredging project.

Project Development, Permitting, Pre and Post-Dredge Surveys

New, improvement dredging projects involve removal of previously undisturbed bottom sediments. Maintenance dredging projects involve the repetitive removal of naturally recurring deposited bottom sediment. Prior to construction of any dredge project, the project proponents must develop design-engineering plans clearly identifying the proposed project footprint. An important first step in this process is the completion of a pre-dredge bathymetric survey and sediment sampling program (Figure 18). This allows the engineering team to estimate the type of material to be dredged, identify and contaminants, and calculate the volume of material that must be removed from the project site to achieve designed depths. Once the quantity and quality of the material have been determined, alternatives for beneficial reuse of the material must be developed and an appropriate dewatering and/or disposal site identified. Prior to construction, the project proponent must secure all necessary local, State, and Federal permits and abide by all stated time-of-yea-restrictions (TOYs). Collaboration with local, State, and Federal regulatory and advisory Agencies while developing dredging projects can help save significant time and resources during the permitting process. Once the project has been constructed, a second bathymetric survey is conducted to confirm that designed depths have been established throughout the project footprint.

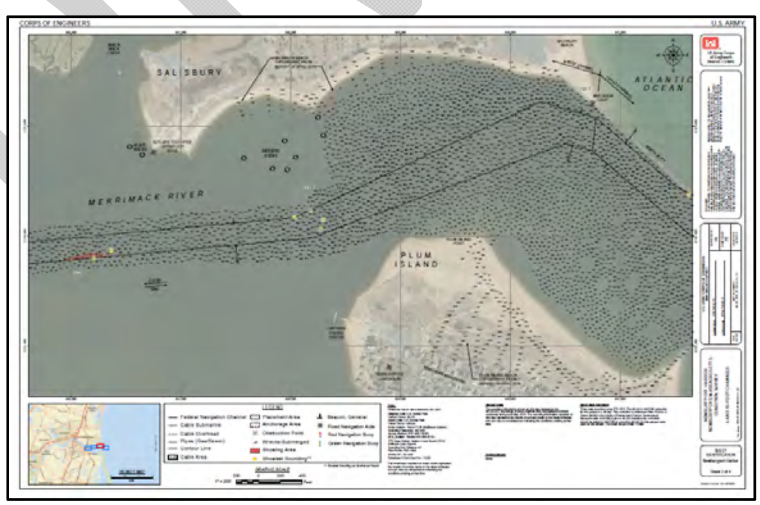

Figure 18 - USACE Project Footprint and Pre-Dredge Survey results for the mouth of the Merrimack River, MA.

Dredge Superstructure

Three main types of dredging equipment, hydraulic cutter suction, hopper, and mechanical are described below. Each type of dredging equipment relies on a central dredge superstructure, a large, barge-like vessel to support equipment and personnel.

Hydraulic Cutter Suction Pump Dredge

A hydraulic cutter suction dredge uses a rotating cutter head attached to the end of a suction pipe to agitate material on the seafloor which creates a slurry of water, sand, and fine-grained material. Long hydraulic spuds anchor the dredge as it works its way through the project footprint. The suction pipe draws the slurry into a large, diesel-powered centrifugal pump located on the dredge superstructure (Figure 19). The centrifugal pump pushes the slurry of seawater and dredged material through a dredge pipeline, which extends from the dredging site to a dewatering site located nearby. At the dewatering site, the slurry of sediment and seawater exits the dredge pipe (Figure 20). Dredged material falls out of solution, accumulates, and must be managed by ancillary excavation and / or loading equipment. An effluent of seawater and fine-grained material flows from the dewatering site back into the adjacent waterbody. Beach compatible sediment (sand) can be used to nourish beaches located near the dewatering site or can be trucked to an approved upland stockpile for later use. Dredging higher concentrations of fine-grained materials (mud, silt) may require more complex dewatering equipment to avoid impacts to adjacent water bodies.

Figure 19 - Components of Barnstable County Dredge "Cod Fish", a Hydraulic Cutter Suction Dredge at rest in Saquatucket Harbor, Harwich, MA, May 2019.

Figure 20 - Barnstable County Dredge Pipe discharges dredged material at dewatering site. Dewatered material is then stockpiled for beneficial reuse, May 2019.

Small-scale hydraulic cutter suction dredges (Ellicott 670 Dragon, or similar) can pump sandy sediments up to 4,000 linear feet (lf) of discharge pipe at an average of 1,000-2,000 cy per day. Pumping distances greater than 4,000 lf require the use of an in-line booster pump. Hydraulic cutter suction dredges area limited by the availability of suitable dewatering sites located within close proximity of the dredge site and the type of material being dredged. Sandy material, suitable for beach nourishment is easily pumped, dewatered, and placed. Muddy material may require more elaborate dewatering structures to prevent fine-grained material still in solution from flowing back into adjacent waterways. Upland disposal of muddy material may be required if the material is found to be unsuitable for beach nourishment. Significant amounts of gravel and cobble cannot be dredged using a hydraulic cutter suction dredge because of the risk of damage to internal components of the centrifugal pump and cutter head and limitations on pumping distance.

Hopper

Hopper dredges utilize 1-2 cutter heads attached to suction pipes to agitate material on the seafloor (Figure 21). The material is then drawn through the suction pipe and into a holding cell on the dredge superstructure (Figure 22). Sediment in the holding cell is retained and water is able to exit the superstructure. Once the holding cell has been filled to capacity, the dredge relocates to the beneficial reuse / disposal site. The hull of the dredge superstructure is designed to split open, allowing the material to be dumped on the ocean floor at a designated disposal site, or alternatively, the material can be re-suspended and side cast into the near-shore, or pumped to a nearby beach for beneficial reuse (Figure 23, 24).

Figure 21 - The USACE Hopper Dredge Currituck. Cutter heads extend from the base of the dredge superstructure to agitate material on the seafloor. 28 June 2019.
https://www.nao.usace.army.mil/Media/Images/igphoto/2000751381/

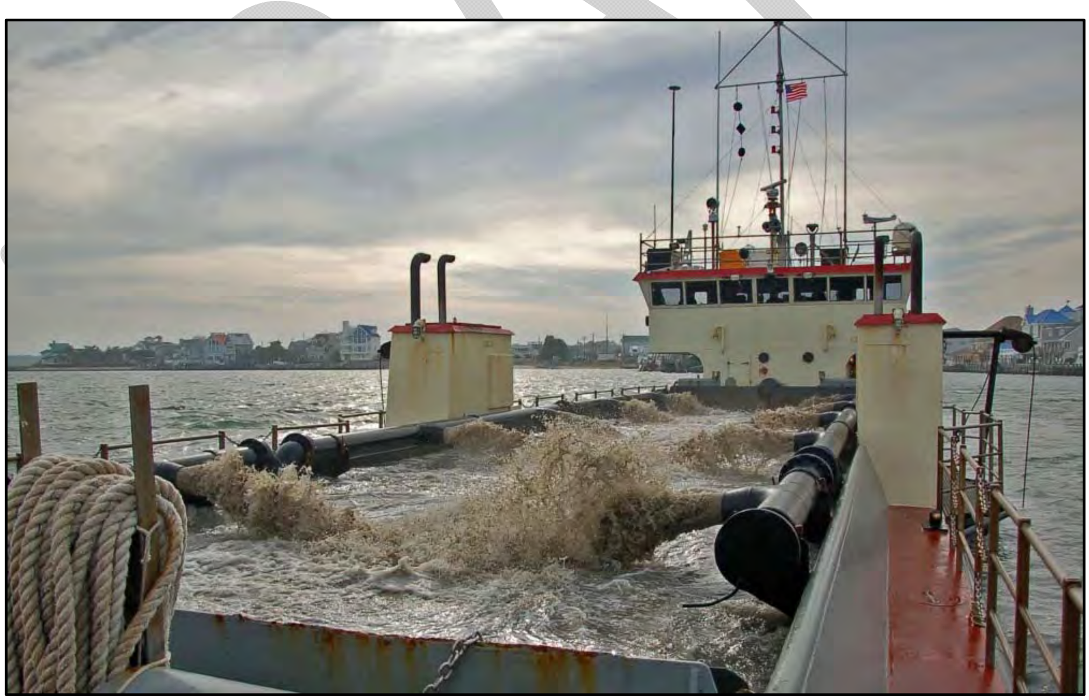

Figure 22 - USACE Hopper Dredge Currituck. Suction pumps draw a slurry of water and dredged sediment into the onboard holding cell. 28 June 2019.
https://www.dvidshub.net/image/968960/hopper-dredge-currituck-indispensable-vessel-safely-removes-hazards-navigation

Figure 23 - USACE Dredge Currituck dumping dredged material in the near-shore of Assateague Island National Seashore. 28 June 2019. https://www.dvidshub.net/image/968962/hopper-dredge-currituck-indispensable-vessel-safely-removes-hazards-navigation

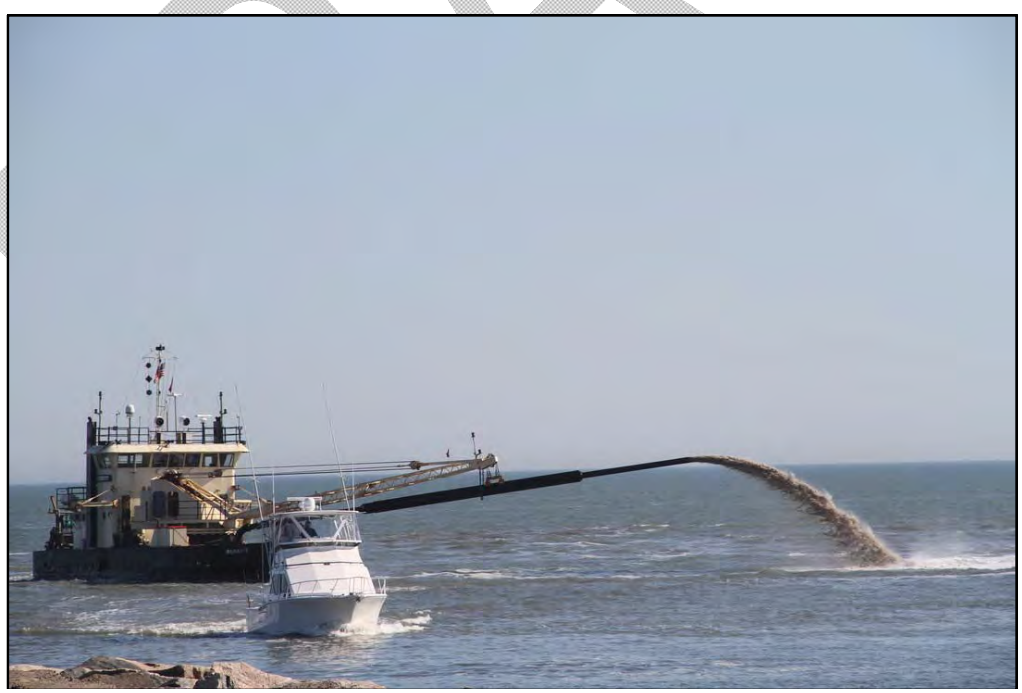

Figure 24 - USACE Dredge Merritt side casting material from Virginia Beach, VA navigation channel following Hurricane Sandy. 28 June 2019. https://www.nao.usace.army.mil/Media/Images.aspx?igphoto=2000751508

Small-scale hopper dredges (USACE Currituck, or similar) can safely remove 1,000-2,000 cy of sandy and fine-grained material per day. Depending on the characteristics of the sediment, hopper dredges then have the flexibility of dumping material at designated near-shore and /or offshore disposal sites, side casting the material, or pumping the material to nearby beaches for beneficial reuse. Hopper dredges are not limited by the availability of suitable dewatering sites located within close proximity of the dredge site because they can mobilize to suitable dewatering sites based on the type of material being dredged. Significant amounts of gravel and cobble cannot be dredged using a hydraulic cutter suction dredge because of the risk of damage to internal components of the centrifugal pump and cutter head and limitations on pumping distance.

Mechanical

A mechanical, or bucket dredge operates using a clamshell bucket attached to a crane on the dredge superstructure to excavate material from the seafloor and load it into an adjacent barge (Figure 25). Production rates vary based on the size of the superstructure, capacity of the bucket, and capacity of the barge. Once the barge has been filled, the material can then be transported to a suitable dewatering or disposal site.

Figure 25 - Cashman Dredge F.J. Belesimo at work loading barge. 28 June 2019.
http://www.cashmandredging.com/assets/pdf/FJBelesimo.pdf

Mechanical dredging equipment can safely dredge sand, cobble, and contaminated material without risk of damage. Placement of the material can prove challenging, as most barges do not have the ability to pump out or side cast the material for beneficial reuse. Rather, the material must be excavated out of the barge onto a beach for beneficial reuse, or loaded into trucks for upland stockpiling or disposal.

Ancillary Equipment

In addition to the primary dredge superstructure, the following marine-based and land-based ancillary equipment is required to support dredging and dewatering operations.

Primary Push Boat

Cutter suction dredge superstructures that do not have the capacity to navigate under their own power rely on push boats. Generally, hopper and mechanical dredged operate under their own power, eliminating the need for a push boat. Push boats are generally fastened to the stern of the cutter suction dredge superstructure where they provide the necessary power to mobilize the dredge from one project location to another and help position the dredge at the project site (Figure 26).

Figure 26 - Barnstable County Dredge Push Boat, M/V "J.W. Doane" at the stern of the Barnstable County Dredge "Cod Fish", January 2018.

Support Boat

A secondary support boat is necessary to mobilize discharge pipe and ancillary dredging equipment to the project site. The support boat may also assist the primary push boat in positioning the dredge in heavy current or navigating tightly restricted coastal waterways (Figure 27).

Figure 27. Typical marine support craft. 29 June 2018, https://www.joshuapreston.co.uk/workboats/

Support Skiff

A small support skiff is used to transport dredge personnel from shore to the dredge superstructure and between the dredging site and the dewatering site (Figure 28).

Figure 28. Typical support skiff. 29 June 2018, http://www.carolinaskiff.com/boats/carolina-skiff/jv-th-series/17-jv-th

Discharge Pipe

Discharge pipe is used to transport material that has been hydraulically dredge from the dredge site to the dewatering site (Figure 29). It is also used by hopper dredges to facilitate pump out and side casting of dredged material. Dredge pipe is generally made from HDPE plastic or steel. Lengths of dredge pipe are connected to one another using steel fasteners. A variety of diffusers can be attached to the end of the dredge pipe to regulate the discharge of dredged material. During dredging operations, the discharge pipe is filled with water and sinks to the bottom of the water column, avoiding impacts to navigation in and around the dredge site.

Figure 29. Length of HPDE discharge pipe coming ashore at local dewatering area, Yarmouth, MA, May, 2019.

Booster Pump

Booster pumps can be placed along dredge discharge pipelines to extend the maximum pumping distance of hydraulic cutter suction and hopper dredges (Figure 30). Booster pumps are diesel centrifugal pumps similar to those found on the dredge superstructure.

Wheeled Front-End Loader

Front-end loaders are used to manage dredged material at the dewatering site, transport dredged material along adjacent beaches, and place dredge material at permitted beach nourishment and dune enhancement sites (Figure 31).

Figure 30. Typical skid-mounted booster pump. 29 June 2018,
https://www.westerndredge.com/product/10in-cat-booster-pump/

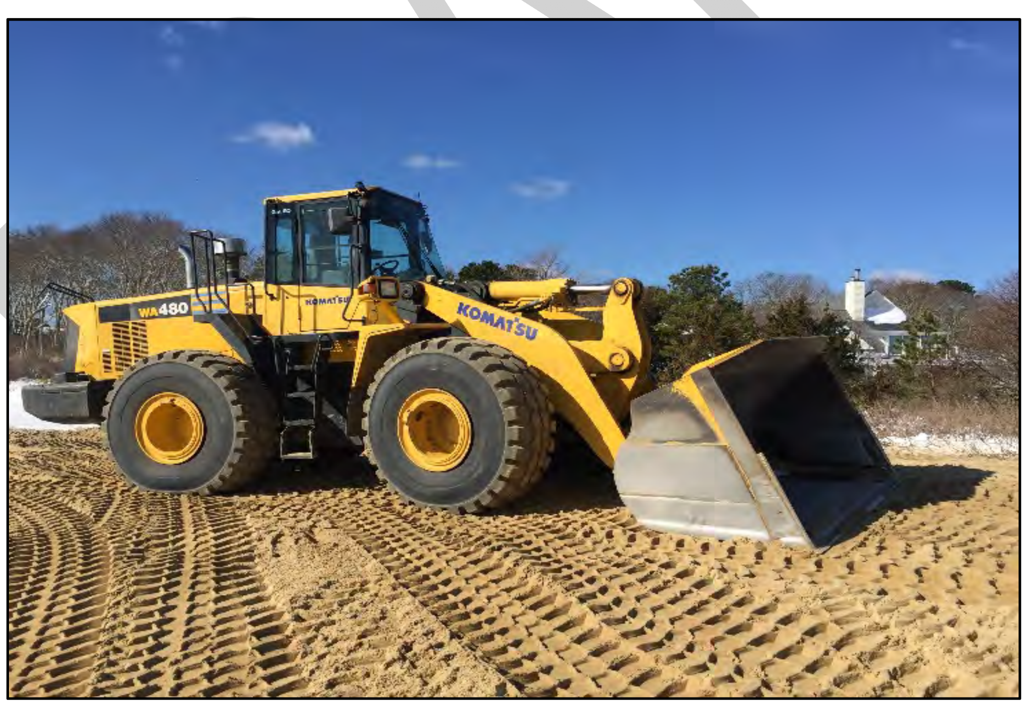

Figure 31. Typical wheeled front-end loader supporting dredge operations, Mashpee, MA, March 2018.

Truck Fleet

A fleet of one-ton trucks (GMC Duramax 3500 HD, or similar) are generally used to support land-based operations at the dewatering site, haul equipment, and transport the dredge crew.

Heavy Equipment Trailers

Heavy equipment trailers are used to haul lengths of dredge pipe to the dewatering site and to storage locations when not in use. Trailers are also used to haul heavy equipment and equipment attachments to and from the dewatering site.

Heavy Equipment Attachments

Heavy equipment attachments including forks, buckets, and grapples are used to support land-based operations at the dewatering site, the placement and repositioning of dredge pipe, and the placement of dredged materials at approved locations.

Diesel Fuel

Dredging is a fossil fuel intensive industry requiring between 300 and 500 gallons of diesel fuel per day to power the dredge superstructure under normal conditions.

Personnel

At a minimum, the following personnel are required to support dredging operations:

- Dredge Superintendent – supervises dredging operations, manages dredge crew.
- Dredge Captain – operates primary push boat and ensures safety of dredge crew.
- Dredge Maintenance Engineer – maintains and repairs dredging equipment.
- Dredge Leverman – operates hydraulic dredging equipment on-board dredge.
- Dredge Deckhand(s) – assist in all dredging, dewatering, and ancillary tasks.

5.0 REGIONAL CASE STUDY

Barnstable County Dredge Program

The Barnstable County Dredge Program (BCD) serves municipalities on Cape Cod, Martha's Vineyard, and Nantucket and provides an interesting case study for upper North Shore municipalities interested in owning and operating regional dredging equipment. Prior to the establishment of the BCD, local municipalities often relied on private dredge contractors to maintain Federal and non-Federal waterways, mooring fields, and marinas. Individual municipalities were responsible for funding 25% of the cost of municipal dredge projects and the State of Massachusetts was responsible for funding the remaining 75%. Given the high cost private dredge contracting and fluctuations in State funding, municipal dredging projects in Barnstable County were routinely delayed, if ever completed.

In 1993, a needs assessment and cost-benefit analysis conducted by Barnstable County determined that a County dredging program would benefit local municipalities and be cost-effective to operate. Barnstable County then requesting a $1 million-dollar capital grant from the Massachusetts Department of Environmental Management (now Department of Environmental Protection (DEP)) for the purchase of a dredge and ancillary equipment. The $1 million-dollar capital grant awarded to the County was intended to serve as a replacement for any future State funding for municipal dredging projects on Cape Cod. Over time, the capital grant provided the State with significant cost savings while improving the municipalities' ability to manage their own waterways. Shortly after the grant was awarded, Barnstable County took delivery of a hydraulic cutter suction dredge, which was named the "Cod Fish" (Figure 32).

Figure 32. Barnstable County Dredge "Cod Fish" at rest in Popponessett Bay, Massachusetts, March 2018.

Barnstable County Dredge Advisory Committee

The Barnstable County Dredge Advisory Committee was established in 1994 to provide operational and financial oversight of the BCD. The Advisory Committee is made up of representatives from all Cape Cod Towns, with the exception of Brewster, which has no navigable waterways, DEP and County officials and is responsible for developing and maintaining an equitable dredge schedule and setting the municipal dredge rate. Each municipality is required to maintain their own environmental permits – with several municipalities opting for consolidated, comprehensive permits which cover multiple dredging and dewatering locations. This permitting structure gives Towns the flexibility to adaptively manage waterways from year to year based on need. Municipalities are required to have all required permits in-hand prior to scheduling a project with the BCD. Each municipality pays a flat rate per cy for BCD services, which includes pre and post-dredge surveys, mobilization, dredging, and basic dewatering.

Barnstable County Dredging Equipment

The BCD "Cod Fish" is a hydraulic cutter suction pump dredge that can efficiently pump sandy and muddy sediments through up to 4,000 lf of pipe to the dewatering site. Production rates of up to 1,000 cy per day can be expected depending on the pumping distance. For distances over 4,000 lf, a secondary, in-line booster pump is required. Use of the BCD is limited by 2 important factors: suitable, nearby dewatering sites and the type of material being dredged. Sandy material, suitable for beach nourishment is easily pumped, dewatered, and beneficially reused. Muddy material requires a more elaborate dewatering structure, but can also be pumped, dewatered, and beneficially reused or trucked for upland disposal. Significant amounts of coarse gravel and cobble cannot be dredged using a hydraulic cutter suction pump dredge because of the risk of damage to the cutter head and internal components of the pump. Dredging operations are supported by a fleet of support boats and land-based equipment to position the dredge pipe, manage the dewatering site, and relocate dredge spoils.

Reserve Fund and Purchase of Replacement Dredging Equipment

The State of Massachusetts capital grant to purchase BCD dredging equipment allowed Barnstable County to quickly establish a reserve fund to account for unexpected breakdowns, variable dredge volumes, annual maintenance, and to save for the future replacement of aging equipment. In 2017, 24 years after the establishment of the Barnstable County Dredge Advisory Committee, the County invested $1.8 million in the construction of a new, larger Ellicott 670 Dragon Cutterhead Dredge. The County expected that the Ellicott 670, named the "Sand-Shifter" would be responsible for larger-scale dredging projects, or those requiring pumping distances in excess of 8,000 lf, and that the "Cod Fish" would continue to operate on smaller scale projects. However, a series of unexpected mechanical breakdowns, which require a significant retrofit have limited the use of the "Sand-Shifter".

Barnstable County Dredge Completed Projects and Cost Savings

Since 1994, the BCD has dredged over 1.8 million cy of material from waterways in 16 municipalities on the Cape and Islands at 38% to 68% below market rates. With rare exceptions, nearly all dredged material is sand, which is beneficially reused on nearby beaches. The all- inclusive, flat rate per cy allows municipalities to avoid the added costs associated with mobilizing and demobilizing private dredging equipment and conducting pre and post-dredge surveys required by dredge contractors and regulatory agencies, an added savings of nearly $6,000 per project. Pre and post-dredge surveys conducted by the BCD crew are an effective means of determining the net volume (total cy) dredged and subsequently, the net cost of the project to the municipality.

Over an 18-year period from 2000 – 2017, the County completed an average of 10 projects, annually, pumped an average of 92,633 cy of material annually, and saved taxpayers an estimated $13,939,255 (based on the State paying 75% of the cost of private municipal dredging projects at market rate). Barnstable County Dredge Operations from 2000 – 2017 are summarized in Table 14. The fiscal status of the Barnstable County Dredge from 2000 – 2017 is summarized in Table 15. Please refer to Appendix E for a copy of the most recent Report of the BCD, which includes a summary of completed dredging projects, quantities dredged, and fiscal status of the dredge in FY 2017.

Table 14. Barnstable County Dredge Operations from FY 2000 – FY 2017.

Year	Cubic Yards Dredged	Total Projects
2000	123,281	4
2001	113,339	6
2002	75,385	15
2003	84,973	9
2004	N/A	10
2005	52,000	12
2006	94,070	11
2007	82,928	10
2008	60,553	11
2009	91,731	8
2010	104,782	8
2011	170,835	6
2012	102,827	11
2013	72,331	13
2014	106,774	15
2015	102,418	10
2016	58,874	9
2017	77,658	7
Total	**1,574,759**	**175**
Average	**92,633 cy / year**	**10 projects / year**

Table 15. Fiscal Summary of the Barnstable County Dredge 2000 – 2017.

Year	Cost per CY	Market Rate per CY	Cost Below Market Rate	Operating Revenue	Cost Savings to Taxpayers*
2000	$4.55	$12.00	38%	$468,914	$1,082,529
2001	$4.55	$12.00	38%	$588,240	$1,047,051
2002	$4.55	$12.00	38%	$444,725	$678,465
2003	$4.55	$12.00	38%	$554,780	$764,757
2004	$4.55	$12.00	38%	$409,622	N/A
2005	$5.55	$12.00	46%	$524,703	$468,000
2006	$6.45	$14.00	46%	$558,167	$856,037
2007	$6.45	$14.00	46%	$631,698	$870,744
2008	$6.45	$16.00	40%	$611,094	$726,636
2009	$7.00	$16.00	44%	$628,671	$1,100,772
2010	$7.00	$16.00	44%	$635,817	$943,038
2011	$7.00	$16.00	44%	$660,228	$1,537,515
2012	$7.00	$16.00	44%	$798,440	$411,308
2013	$11.00	$16.00	68%	$835,284	$867,972
2014	$11.00	$16.00	68%	$929,859	$830,701
2015	$11.00	$18.00	61%	$737,742	$716,926
2016	$11.00	$18.00	61%	$631,289	$506,202
2017	$11.00	$18.00	61%	$867,242	$530,602
-	-	**Total**	**N/A**	**$11,516,515**	**$13,939,255**
-	-	**Average**	**47%**	**$639,806**	**$819,956**

*Based on the State paying 75% of the market rate of private municipal dredging projects
**Established to finance the purchase of replacement dredging equipment

BCD Consultation with upper North Shore Stakeholders

To allow upper North Shore regional stakeholders to better understand the operational and financial structure of an existing regional dredge program, Woods Hole Group hosted a project update meeting and facilitated a round table discussion between the following individuals:

- State Representative Lenny Mirra
- State Representative Brad Hill
- Massachusetts CZM State Dredging Coordinator, Robert Boeri
- MVPC Coastal Resources Coordinator, Peter Phippen
- Barnstable County Administrator, Jack Yunits
- Town of Chatham Coastal Resources Director, Theodore Keon
- Woods Hole Group Coastal Scientists and Engineers
- Upper North Shore Municipal officials and project stakeholders (via telephone)

The group reviewed historic dredge data from the North Shore and conceptual alternatives for beneficial reuse identified by the Woods Hole Group. Mr. Jack Yunits then offered a review of the Barnstable County Dredge program, lessons learned over 25 years of BCD ownership, and the advantages and disadvantages of the regional dredge program. Mr. Theodore Keon, who also serves on the BCD Advisory Committee, then offered the municipal perspective of BCD services. Following the round table discussion, Peter Phippen accompanied Woods Hole Group staff for a visit to a regional dredging site to view BCD equipment and dewatering operations at an active site. Meeting minutes for the update meeting and round table discussion are included in Appendix F.

6.0 DREDGE VOLUME ESTIMATES

Means and Methods

Dredging operations rely on the availability of sediment accretion in navigation channels, mooring basins, etc. to ensure that dredging equipment remains occupied throughout the dredging season. A high degree of occupancy (working days) during the dredging season is required in order for operations to remain financially solvent. To determine how much sediment might be available to be dredged from upper North Shore waterways, Woods Hole Group developed two estimates based on historic dredging events and on the most recent bathymetric survey data.

- **Volume Estimate 1**: Historic dredging records allowed Woods Hole Group to estimate the average volume of material dredged on an annual basis from waterways on the upper North Shore since the first documented dredging event.
- **Volume Estimate 2**: Recent bathymetric survey data available from the USACE allowed Woods Hole Group to estimate the volume of material immediately available to be dredged from waterways on the upper North Shore.

Both methods used sediment quality data (summarized in Chapter 3.0) to estimate the percentage of each volume that might be suitable for beneficial reuse as beach nourishment and dune enhancement. Based on the available data, Woods Hole Group utilized a tiered-approach to estimate the percentage of material presumed to be free of contamination and primarily comprised of sand within each waterway:

- If clear descriptions of sediment samples and sediment lithology existed in the literature and were indicative of predominantly sandy material, 100% of the annual estimated volume for the respective waterway was counted towards the scaled annual total.
- In waterways where less than 100% of the material was sandy, an estimate of the percentage of sandy material was developed based on a composite of all historic sediment samples or sediment descriptions within the waterway and counted towards the scaled annual total.
- In waterways where the literature indicated that very little sandy material existed and high percentages of mud, fines or a high probability of contamination were present, 0% of the annual volume was counted towards the scaled annual total.

Importance of Beach and Dune Compatible Dredged Material

Identifying sources of sandy sediment to support beach nourishment and dune enhancement is an important consideration from both a coastal resilience perspective and a permitting perspective. Beach nourishment and dune enhancement provide shoreline protection by adding compatible sediment to an existing beach or dune profile, thereby increasing the resilience of adjacent upland infrastructure. If the material from a dredging project is found to be suitable for use as beach and dune nourishment, and if there is an appropriate site for beneficial reuse located close to the dredging site, the material may provide a significant cost savings to a community by avoiding the need to truck in nourishment sand from an upland source.

From a regulatory perspective, beach nourishment and dune enhancement are accepted practices for the beneficial reuse of beach compatible dredged material and are currently permittable in the State of Massachusetts. The Massachusetts Office Coastal Zone Management (CZM) outlines specific permitting and regulatory standards required to advance beach nourishment and dune enhancement projects, sediment compatibility guidelines, revegetation guidelines, preferred design standards, and alternatives to minimize impacts to habitat and wildlife in Storm Smart Properties Fact Sheet 1: Artificial Dunes and Dune Nourishment (CZM, 2018). Remaining volumes of material unsuitable for beach nourishment may still be beneficially reused in the near-shore, along the edges of salt marshes, or as thin layer deposition however, these practices may require more complex dewatering practices and more complicated permitting procedures.

Limitations

Given the variability in the quality of the sediment in waterways on the upper North Shore, Woods Hole Group recognizes that the percentage material suitable for beneficial reuse as beach nourishment and dune enhancement is difficult to quantify. Also, it is rare for dredged material to exactly match native sand located at a beach nourishment project site, requiring evaluation on a case-by-case basis. Therefore, an important next step for communities on the upper North Shore will be to complete comprehensive sediment sampling (grab and/or core samples) within all established and proposed dredge project footprints to refine volume estimates and better understand the feasibility of alternatives for beneficial reuse based on sediment type. It will also be important for upper North Shore communities to consider regional rates of sediment transport. For instance, more material may be able to be dredged from dynamic areas near estuary mouths than from more quiescent areas located further inland. Analyzing rates of sediment transport to refine dredge frequency estimates was beyond the scope of this preliminary study.

With few exceptions, dredging events have either not occurred or have not been documented in non-Federal waterways on the upper North Shore. Further, bathymetric datasets for non-Federal waterways either did not exist, or were not readily available. Therefore, it was not possible to develop estimated dredge volumes for non-Federal waterways.

Volume Estimate 1: Annual Rate based on Historic Dredging Records

Table 16 summarizes the results of Volume Estimate 1 for each FNP. Appendix G includes a summary of sediment quality data that was used to estimate the percentage of sandy, beach compatible material within each FNP. Total dredged volumes from the initial dredging event to present were used to calculate an annual dredging rate in cubic yards per year (cy/year). The dredging rate in (cy/year) was then multiplied by the estimated percentage of material that may be suitable for beneficial reuse as beach nourishment and dune enhancement resulting in an adjusted volume of sandy material that may be able to be dredged from each FNP on an annual basis.

Table 16. Summary of Historic Dredge Volumes and Annual Dredge Rate Estimates for FNPs on the upper North Shore.

Federal Navigation Project	No. Historic Dredging Events	Total Volume Dredged (cy)	Annual Rate* (cy/year)	Sediment Quality	Estimated % Suitable for Reuse**	Adjusted Total for Reuse (cy)
Newburyport Harbor	18	2,096,431	36,145	Sand / Gravel	100	36,145
Merrimack River (Upstream)	1	4,000	54	Sand / Mud	0	0
Ipswich River	2	11,931	90	Sand / Mud	75	68
Essex River	10	193,102	1,557	Sand / Mud	75	1,168
Annisquam River	13	596,904	4,557	Sand	100	4,557
Gloucester Harbor	9	254,204	4,707	Silt / Possible Contamination	0	0
Rockport Harbor	2	50,800	1,539	Sand / Gravel / Mud	50	770
Manchester Harbor	8	105,869	913	Sand / Mud / Silt	75	684
TOTAL	**65**	**3,313,241**	**49,562**	**-**	**-**	**43,391**

*Since first documented dredging event in the waterway
**As beach nourishment and dune enhancement

Volume Estimate 2: Immediate Need

To calculate Volume Estimate 2, data were collected from recent USACE hydrographic surveys. The USACE conducts extensive surveying and mapping services to support the management of federal navigation channels and ports throughout the United States. A database of hydrographic surveys that have been processed and uploaded by USACE districts is freely accessible online through the eHydro database of USACE hydrographic surveys. The available datasets include bathymetric sounding (depth) data, survey areas, shoal areas, and Survey Channel Condition Reports, which include formal engineering drawings of the channel extents, design depths, survey methods and metadata. At least one hydrographic survey was conducted in each of the 9 FNPs in the study region between 2013 and 2018, with the exception of Manchester Harbor. Excluding Rockport Harbor, all surveys were completed between 2016 – 2018.

Take-off volumes for the existing conditions of study-region FNPs defined by the most recent ACOE survey were calculated by the Woods Hole Group by calculating the area and average depth of the shoals mapped by the USACE, which are defined as areas within the FNP that were shallower than the controlling depth. Any soundings taken within or intersecting the mapped shoal areas were averaged to provide a mean shoal depth. The take-off volume was then calculated by multiplying the area of the shoal by the depth of sediment that would need to be removed to restore the channel to the controlling depth:

Take-off Volume = (Controlling Depth - Average Shoal Depth) x Shoal Area

This method assumes that only shoal areas within the designated FNP channel would be dredged and does not account for over-dredge volumes (dredging deeper than the controlling depth), and assumes that the survey conditions are representative of existing conditions. In hydrodynamically active environments, such as the mouths of sandy rivers like the Merrimack, Essex and Annisquam, it is fair to assume that existing conditions change on a regular basis. These estimates are based on the best publicly available data and do not replace the necessity of conducting pre-dredge hydrographic surveys.

Additionally, in areas where the USACE survey extended beyond limits of the FNP, for example at the mouth of the Essex River and the upstream extent at the Essex Town Landing, it was possible to derive take-off estimates for limited areas outside the bounds of the FNP. Appendix H provides the full metadata and inputs that were used to calculate Volume Estimate 2. Net volume estimates for each FNP were converted to annual total by dividing the estimated total volume by the estimated dredge frequency derived from USACE estimates and Preliminary Data Collection feedback received from local municipalities. Results for each FNP are presented in Table 17.

Table 17. Take-off Volume Estimates for FNPs Based on most recent USACE Hydrographic Survey data.

Federal Navigation Project	Estimated Total Volume (cy)	Expected Annual Total*	Sediment Quality	Estimated % for Beneficial Reuse	Adjusted Total for Reuse (cy)	Estimated Dredge Frequency
Newburyport Harbor & Merrimack River	139,898	27,980	Sand	100	27,980	5-year
Ipswich River	31,302	3,130	Sand / Mud (Upstream)	75	2,348	10-year
Essex River	53,108	5,311	Sand / Mud	75	3,983	10-year
Annisquam River & Gloucester Harbor	126,422	6,321	Silt / Contamination	60	3,793	20-year
Rockport Harbor	257	13	Sand / Gravel / Mud	50	7	20-year
Manchester Harbor**	-	-	Sand / Mud / Silt	-	-	20-year
TOTAL	**350,987**	**42,755**	-	**-**	**38,109**	**-**

*Estimated total volume / dredge frequency
**No ACOE survey data is available for Manchester Harbor.

Volume Estimate 1 Summary:

- Based on documented historic dredging events, an estimated 49,562 cy of material could potentially be dredged from the 9 FNPs in the North Shore study region annually.
- Based on the estimated percentage of sandy material in each FNP on the upper North Shore, an estimated 43,391 cy of sandy material may be suitable for beach nourishment and dune enhancement on an annual basis.
- Estimated percent sandy material ranged from 0% in Manchester Harbor and Gloucester Harbor (primarily silt and mud), to 100% in the Merrimack River, Newburyport Harbor, the Essex River and the Annisquam River (primarily sand).

Volume Estimate 2 Summary:

- Based on recent USACE hydrographic surveys and bathymetric datasets, the Woods Hole Group estimates that a total of 350,987 cy of material could be removed from 8 FNPs within the study region.
- Estimated dredge volumes were calculated to project depth and did not include advance maintenance dredging (over depth dredging) beyond the designed project depth.
- This estimate is based on the mean shoal elevations and areas calculated using the most recent USACE bathymetric survey data from 2013 – 2018.
- Based on take-off estimates factored against estimated dredge frequency for each waterway, an estimated 42,755 cy of material could potentially be dredged from the 8 FNPs in the North Shore study region with current bathymetric survey data on an annual basis.
- Based on the estimated percentage of sandy material in each FNP with current bathymetric data, an estimated 38,109 cy of sandy material may be suitable for beach nourishment and dune enhancement on an annual basis.

7.0 FEASIBILITY ASSESSMENT

Dredging Alternatives for the Upper North Shore

Based on the sediment quantity and quality data collected and analyzed in Chapters 3 and 5, the Woods Hole Group has identified 3 specific alternatives to address the current and future dredging needs of the municipalities on the upper North Shore.

- **Alternative 1** – Purchase and Operation of Hydraulic Cutter Suction Pump Dredge
- **Alternative 2** – Purchase and Operation of Hopper Dredging Equipment
- **Alternative 3** – Retention of a Private Dredge Contractor

Hydraulic and hopper dredging equipment were considered based on their mobility, versatility, and ability to dredge and beneficially reuse the variable sediment types found on the upper North Shore. Woods Hole Group researched costs associated with owning and operating regional dredging equipment and spoke with multiple private dredge contractors about the feasibility of drafting an intermunicipal agreement to retain a private dredge contractor to complete multiple projects over a 3-to-5-year time span. A description and overview of the costs associated with each Alternative included below:

Alternative 1: Ownership and Operation of Hydraulic Cutter Suction Dredging Equipment

Alternative 1 considers the purchase and operation of a hydraulic cutter suction dredging equipment to complete small scale, high frequency dredging events on the upper North Shore over a 30-year period. Alternative 1 is based on the BCD model, which allows member municipalities to complete dredging projects across the Cape and Islands and beneficially re-use dredged sandy sediments as beach nourishment and dune enhancement. One-time equipment costs for the purchase of the dredge superstructure, marine-based support craft, and land-based vehicular support are outlined in Table 18. In addition to up-front equipment costs, Alternative 1 considers the annual cost of staffing, maintaining, insuring, and fueling dredging equipment over an assumed 168-day dredging season (assuming a 6 day per week, 7 month per year occupancy schedule). Total personnel and overhead costs are summarized in Table 19.

Alternative 1 does not take into consideration the added annual cost per cy of pumping material from the dredging site to the dewatering site. Rather, Alternative 1 provides an estimate of the total number of cy of material the dredge would need to pump at an assumed, subsidized dredge rate of $15 per cy inclusive of mobilization, demobilization, pre and post-dredge surveys in order to meet expenses during year 1 following the purchase of dredging equipment. Typically, this cost-per-cy is paid directly by the municipalities benefiting from the services of the dredge. Alternative 1 does not include costs associated with establishing and maintaining a regulatory body to govern dredging operations, set the dredge schedule, and manage the finances of the dredge program. Financial model data for Alternative 1, summarizing total annual operating costs and depreciation expenses over a 30-year period are included in Appendix I.

Table 18. Alternative 1: Total Equipment Costs

Dredge Superstructure	Estimated Cost
Ellicott 670 Dragon	$1,800,000
Total Superstructure Costs	**$1,800,000**

Marine-Based Support Craft	Estimated Cost
Primary Push Boat	$250,000
Support Boat (to haul pipe)	$75,000
Support Skiff (to haul personnel)	$20,000
Booster Pump	$350,000
Dredge Pipe (11,000 linear feet (12-14"))	$418,000
Total Equipment Costs	**$1,113,000**

Land-Based Vehicular Support	Estimated Cost
3x GMC Sierra 2500HD Duramax Pickups	$180,000
2x Heavy-Duty Equipment Trailers	$15,000
CAT 928 Wheeled Loader	$125,000
Loader Attachments	$10,000
Land-Based Support Costs	**$330,000**

Total Equipment Costs (One-Time)	**$3,243,000**

Table 19. Alternative 1: Total Personnel and Overhead Costs

Personnel	Estimated Cost
Dredge Superintendent	$100,000
Dredge Captain	$75,000
Dredge Leverman	$65,000
Dredge Deckhand	$65,000
Dredge Deckhand	$50,000
Dredge Deckhand	$50,000
Total Personnel Cost (Annual)	**$405,000**

Overhead Cost	Estimated Cost
Maintenance	$100,000
Insurance	$25,000
Diesel Fuel	$164,000
Total Overhead Cost (Annual)	**$289,000**

Total Ancillary Cost (Annual)	**$694,000**

Alternative 2: Ownership and Operation of Hopper Dredging Equipment

Alternative 2 considers the purchase and operation of hopper dredging equipment to complete dredging events on the upper North Shore over a 30-year period. Alternative 2 requires a significantly higher initial investment in dredging equipment than Alternative 1, but allows for more diverse options (bottom dump, pump-out, side-cast) alternatives for beneficial reuse of dredged material. One-time equipment costs for the purchase of the hopper dredge, marine-based support craft, and land-based vehicular support are outlined in Table 20. In addition to up-front equipment costs, Alternative 2 considers the annual cost of staffing, maintaining, insuring, and fueling dredging equipment over an assumed 168-day dredging season (6 day per week, 7 month per year occupancy schedule). Given the increased size and scale of hopper dredging operations, Alternative 2 requires a greater investment in staffing, maintaining, insuring, and fueling than Alternative 1. Total personnel and overhead costs are summarized in Table 21.

Alternative 2 does not take into consideration the added annual cost per cy of pumping material from the dredging site to the dewatering site. Rather, Alternative 2 estimates the total number of cy of material the dredge would need to pump at an assumed, subsidized dredge rate of $15 per cy inclusive of mobilization, demobilization, pre and post-dredge surveys in order to meet expenses during year 1 following the purchase of dredging equipment. Typically, this cost-per-cy is paid directly by the municipalities benefiting from the services of the dredge. Alternative 2 does not include costs associated with establishing and maintaining a regulatory body to govern dredging operations, set the dredge schedule, and manage the finances of the dredge program. Financial model data for Alternative 2, summarizing total annual operating costs and depreciation expenses over a 30-year period are included in Appendix J.

Table 20. Alternative 2: Total Equipment Costs

Dredge Superstructure	Estimated Cost
Custom Hopper (pump-out, side-cast, bottom-dump capable)	$10,000,000
Total Superstructure Costs	**$10,000,000**

Marine-Based Support Craft	Estimated Cost
Support Boat (to haul pipe)	$75,000
Support Skiff (to haul personnel)	$20,000
Dredge Pipe (5,500 linear feet (12-14"))	$209,000
Total Equipment Costs	**$304,000**

Land-Based Vehicular Support	Estimated Cost
3x GMC Sierra 2500HD Duramax Pickups	$180,000
2x Heavy-Duty Equipment Trailers	$15,000
CAT 928 Wheeled Loader	$125,000
Loader Attachments	$10,000
Land-Based Support Costs	**$330,000**

Total Equipment Costs (One-Time)	**$10,634,000**

Table 21. Alternative 2: Total Personnel and Overhead Costs

Personnel	Estimated Cost
Dredge Superintendent	$150,000
Dredge Captain	$95,000
Dredge Leverman	$75,000
Dredge Deckhand	$65,000
Dredge Deckhand	$50,000
Dredge Deckhand	$50,000
Total Personnel Cost (Annual)	**$485,000**

Overhead Cost	Estimated Cost
Maintenance	$250,000
Insurance	$100,000
Diesel Fuel	$273,000
Total Overhead Cost (Annual)	**$623,000**

Total Ancillary Cost (Annual)	**$ 1,108,000.00**

Alternative 3: Retention of a Private Dredge Contractor

Alternative 3 considers the possibility of establishing an intermunicipal agreement between upper North Shore communities to solicit and retain a private dredging contractor to complete multiple dredging projects. Alternative 3 assumes that the private dredge contractor would complete, at a minimum, a total of 5 projects per year on an annual basis for the duration of a 3-year contract. It is assumed that the multi-year contract would go out to bid 3 times over a 30-year period, assuming a 3-year-on, 7-year-off schedule. Mobilization, demobilization, and pre and post-dredge survey costs for Alternative 3 are summarized in Table 22.

Based on the Woods Hole Group estimate of immediately available sediment in upper North Shore waterways (350,987 cy) identified in Chapter 5, Alternative 3 assumes that the private dredge contractor would dredge one third of the estimated total available sediment annually, or an average of 116,996 cy during each year of the 3-year contract and that approximately 350,987 cy of material would be available to be dredged during subsequent 3-year contract periods. It is assumed that the dredging rate would vary from $10 per cy for basic projects (dredge and bottom-dump) to $40 per cy for more complex projects (dredge and dewater, side-cast, pump-out, etc.). These costs are typically paid by the project proponent. The final dredging rate would be developed by the selected contractor and would be based on multiple factors including the proposed schedule, total number of projects, total quantity to be dredged, the quality of the material to be dredged, and the preferred alternative for beneficial reuse. The low ($10 per cy) and high ($40 per cy) cost scenarios are summarized in Table 23.

Alternative 3 does not include costs associated with establishing and maintaining a regulatory body to govern dredging operations, set the dredge schedule, and manage the finances of the dredge program. Financial model data for Alternative 3, summarizing total annual operating costs over a 30-year period are included in Appendix K.

Table 22. Alternative 3: Mobilization, Demobilization, and Survey Costs

Mobilization, Demobilization, and Survey Costs	Estimated Cost
Initial Mobilization	$350,000
Subsequent Mobilizations (4x)	$200,000
Pre and Post-Dredge Surveys (5x)	$30,000
Total Costs	**$580,000**

Table 23. Alternative 3: Variable Pumping Costs

Annual Dredging Costs*	Min. Cost/CY	Max. Cost/CY
Dredging Cost per CY	$10	$40
Total Cost	$1,169,960	$4,679,840

*Assuming 116,996 CY dredged annually

Alternative Cost Summary

- Based on the financial model, Alternative 1 would cost an estimated $859,287 during the first year of dredging operations, covering all personnel, ancillary/overhead, and depreciation expenses. Lifetime costs over a 30-year period would total $28,343,072. The total estimated annual and lifetime expenditure does not include the cost of dredging a minimum volume of material (57,286 cy during year 1) at an assumed rate of $15 per cy (inclusive of mobilization, demobilization, pre and post-dredge survey) to offset annual expenses.

- Based on the financial model, Alternative 2 would cost an estimated $1,568,927, covering all personnel, ancillary/overhead, and depreciation expenses during the first year of dredging operations. Lifetime costs over a 30-year period would total $48,999,518. The total estimated annual and lifetime expenditure does not include the cost of dredging a minimum volume of material (an estimated 104,595 cy during year 1) at an assumed rate of $15 per cy (inclusive of mobilization, demobilization, pre and post-dredge survey) to offset annual expenses.

- Based on the financial model, Alternative 3 ($10 per cy dredge rate scenario) would cost an estimated $1,749,960 during the first year of dredging operations, or a total of $5,249,880 over the first 3-year contract period including mobilization, demobilization, pre and post-dredge survey, pumping, and basic dewatering disposal costs. Lifetime costs over a 30-year period would total $15,749,640 (a total of (3) 3-year contract periods).

- Based on the financial model, Alternative 3 ($40 per cy dredge rate scenario) would cost an estimated $5,259,840 during the first year of dredging operations, or $15,779,520 over the first 3-year contract period, including mobilization, demobilization, pre and post-dredge survey, pumping, and basic dewatering disposal costs. Lifetime costs over a 30-year period would total $47,338,560 (a total of (3) 3-year contract periods).

Single-year costs are illustrated in Figure 33. Cumulative annual costs for Alternatives 1 and 2 (excluding pumping costs at $15/cy) and Alternative 3 are illustrated in Figure 34. Lifetime (30-year) costs for Alternatives 1 and 2 are summarized in Table 24. Lifetime (30-year) costs for Alternative 3 are summarized in Table 25.

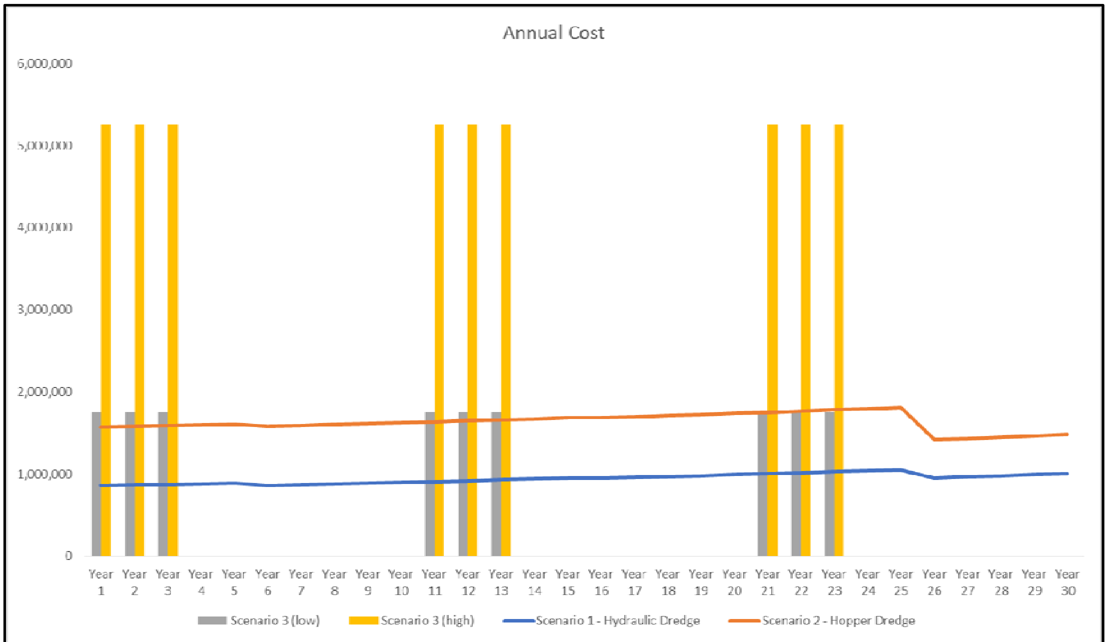

Figure 33. Cumulative Annual Costs of Alternatives 1, 2, 3.

* Estimated cost of owning & operating each asset. Does not include assumed pumping rate of $15/cy for Alt. 1, 2.
**Complete estimated cost of outsourced private dredge contractor on a 3-year-on / 7-year-off schedule.

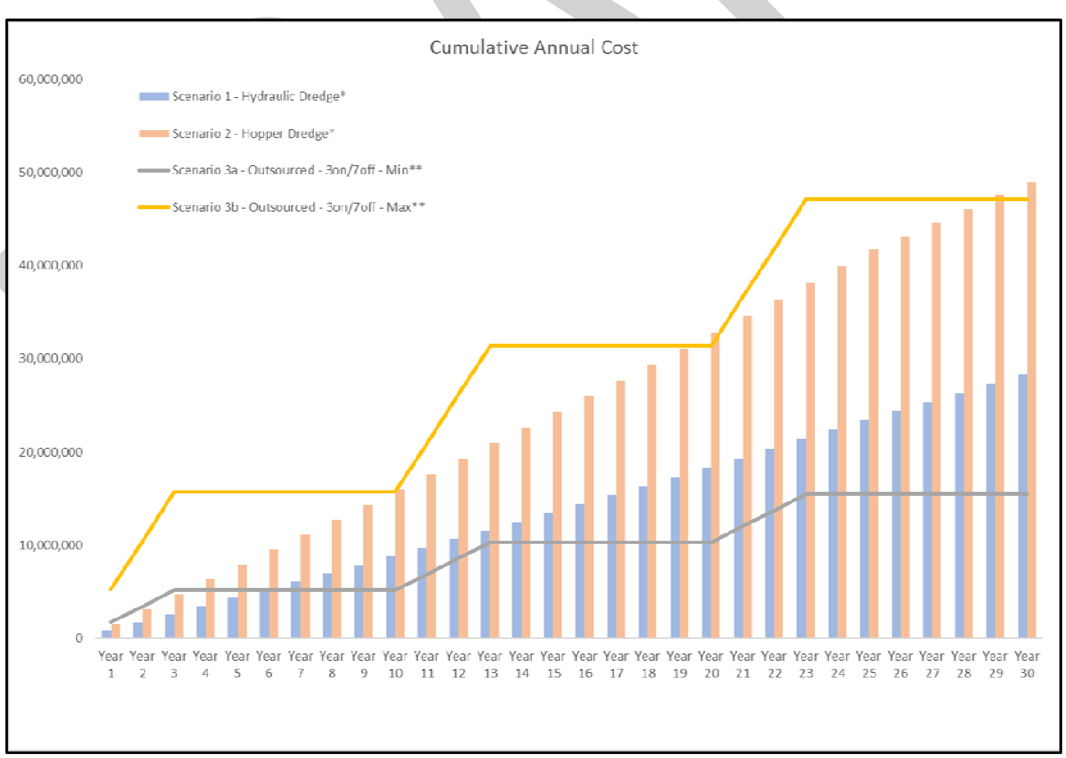

Figure 34. Cumulative Annual Costs of Alternatives 1, 2, 3.

* Estimated cost of owning & operating each asset. Does not include assumed pumping rate of $15/cy for Alt. 1, 2.
**Complete estimated cost of outsourced private dredge contractor on a 3-year-on / 7-year-off schedule.

Table 24. Alternatives 1, 2; 30-year Cost Summary

	Alternative 1 Hydraulic Dredge Purchase	Alternative 2 Hopper Dredge Purchase
Total cubic yards*	1,889,538	3,266,633
Total estimated cost**	$28,343,072	$48,999,518
Average cost / cubic yard	$15.00	$15.00

*Minimum total cy dredged to offset expenses over 30-year time horizon.
**Personnel, ancillary/overhead, and depreciation expenses. Excludes pumping cost of $15 cy.

Table 25. Alternatives 3 (Min, Max); 30-year Cost Summary

	Alternative 3 (Min) Contractor @ $10/CY	Alternative 3 (Max) Contractor @ $40/CY
Total cubic yards (yd^3)*	1,052,964	1,052,964
Total estimated cost**	$15,749,640	$47,338,560
Average cost per yd^3	$14.96	$44.96

*Assuming 350,987 cy of material dredged during each 3-year contract period.
**Scenario 3 (Min) & (Max) include all estimated mobilization, survey, pumping, and dewatering/disposal costs.

Assumptions of the Financial Model

Alternatives 1, 2, and 3 were considered over a 30-year time horizon. All estimated expenses are derived from a combination of factual data and direct consultations with private dredge contractors, coupled with what we believe to be appropriate and realistic financial assumptions. To ensure full disclosure, the following section will provide details on the financial assumptions taken to complete this feasibility study.

Alternatives 1 and 2: Owning and operating regional dredging equipment

- All staff and labor costs associated with Alternatives 1 and 2 are derived from current BCD salary rates and include the cost of all relevant benefits (Appendix L). Woods Hole Group assumes, at minimum, a 2% increase in these costs for each year along the 30-year time horizon.
- All overhead costs associated with Alternative 1 and 2 are based on conversations with BCD officials and private dredge contractors. Total diesel fuel expense is calculated assuming 168 days of operation at 300 gallons per day (hydraulic dredge) and at 500 gallons per day (hopper dredge) assuming a cost of $3.25 per gallon.
- Depreciation expenses are calculated using the straight-line method and incorporate a useful life that we believe to be appropriate for each individual asset listed in Table 26.

Table 26. Expected useful life of dredging and ancillary equipment.

Asset	Useful Life (Years)
Dredge Superstructure (both models)	25
Booster Pump (Hydraulic Dredge only)	25
Primary Push Boat (Hydraulic Dredge only)	25
CAT 928 Wheeled Loader Attachments	25
Dredge Pipe	15
Support Boat (haul pipe)	15
Support Boat (haul personnel)	15
CAT 928 Wheeled Loader	15
Heavy Duty Equipment Trailers	10
GMC Sierra 2500HD Duramax Pickup Truck	5

- Total annual expenses for Alternative 1 and 2 are derived by adding operating expenses (personnel & overhead) along with each year's depreciation expenses (cost of owning the assets).
- For the purposes of this study, Woods Hole Group assumes a repayment method to the Commonwealth of Massachusetts matching the amount of each year's depreciation expense (assume a 0% APR on the life of the loan).
- All costs listed represent what we believe to be the likely cash outflows for owning and operating each type of dredge. It is important to note that these costs do not include the subsidized cost of pumping all extracted sediment at an estimated rate of $15 per cy.
- In order to remain solvent, and at the pumping rate of $15 per cy, we have provided annual calculations of the minimum annual cy that would need to be dredged. Alternative 1, year 1 estimate: 57,268 cy to remain solvent. Alternative 2, year 1 estimate: 104,595 cy to remain solvent.
- Finally, based on a series of six DCR-funded dune sand placement projects occurring between the years 2013 and 2018, a total 35,490 cy of sediment were placed and graded at a total cost of $1,098,274 (including mobilization fees). Therefore, a reuse value of $30.95 cy can be assumed for extracted sandy sediments suitable for beneficial reuse as beach nourishment and dune enhancement.

Alternative 3: Outsourcing dredging projects to a private dredge contractor

- Woods Hole Group assumes a 3 year on / 7 year off cycle of dredging activity.
- Woods Hole Group has estimated 350,986 cy of known sediment to be extracted within the first three years (based on calculated estimates summarized in Chapter 5).
- Woods Hole Group assumes that over a 30-year time horizon, at least 350,986 cy of sediment will need to be dredged during each subsequent 3-year dredging cycle.
- Based on pumping costs ranging from $10 - $40 per cy (which are dependent on the type of sediment dredged, pumping distance, preferred dewatering alternative, etc.) Woods Hole Group has split Scenario 3 into two sub-scenarios: Alternative 3 (Min) and

Alternative 3 (Max) to highlight the range of total annual and cumulative costs of hiring a private dredge contractor.

8.0 FINDINGS AND RECOMMENDATIONS

Initial upper North Shore Dredge Feasibility Study Findings

Based on the preliminary findings of the feasibility study, there appears to be a significant need and a sufficient quantity of material within the Federal waterways of the 10 upper North shore municipalities included in the study region to continue evaluating alternatives for a regional dredge purchase or the retention of a private dredge contractor to complete multiple dredging projects.

Preliminary Data Collection Survey

- Of the 10 municipalities identified in the study region, 7 (Salisbury, Newburyport, Essex, Ipswich, Rockport, Gloucester, and Manchester-by-the-Sea) submitted formal responses to the Preliminary Data Collection Survey.

- Each of the 7 municipalities responding to the Preliminary Data Collection Survey reported an immediate need for dredging for the purposes of navigation and public safety in one or more Federal Navigation Project (FNP) and/or non-Federal waterway on the upper North Shore.

- Five out of the 7 municipalities responding to the Survey reported that previous dredging events have not kept Federal and/or non-Federal waterways safe and navigable to commercial and recreational boat traffic and emergency first responders.

- Despite the documented need for dredging on the upper North Shore, only the City of Gloucester reported that dredging was currently scheduled to be completed by the USACOE in 2019 (Annisquam River (FNP), all sections).

- The Towns of Salisbury and Rockport reported that they are actively moving through the planning stages to advance future dredging projects in Newburyport Harbor (FNP) and Old Harbor (non-Federal), respectively.

- Based on feedback from the Preliminary Data Collection Survey, sediment type and preferred alternative for beneficial reuse and/or disposal of dredged material varied considerably across waterways on the north shore.

- The Preliminary Data Collection Survey identified at a minimum, a total of 1,939 public and private moorings, 599 boat slips, 23 marinas, 556 Commercial Fishing Vessels, 105 Charter Fishing Vessels, and 5,455 Recreational Vessels within the 7 upper North Shore municipalities responding to the Survey that are reliant on safe and navigable waterways.

Historic Dredging Events

- A total of 65 historic dredging events were document and recorded in upper North Shore waterways from 1887 to the present.

- Since 1887, a reported total of 3,313,241 cy of material has been dredged from the 9 FNPs identified in the study region.

- No confirmed, documented historic dredging records were found in any of the 16 non-Federal waterways identified in the study region.

- Newburyport Harbor (FNP) and the Annisquam River (FNP) account for over 80% of the material historically dredged from the study region. Based on historic records, both waterways contained sandy material, the primary source of sediment for beneficial reuse. With easements now authorized in the Essex River and the potential to extend the length of the FNP in the Ipswich River, this fractional share could begin to shift.

- Woods Hole Group summarized possible alternatives for beneficial reuse of dredged material from each FNP and non-Federal waterway in the study region based on sediment type.

Dredging 101 and Regional Case Studies

- Dredging is an inherently complex industry. A thorough understanding of the required steps to develop a dredge project and the required equipment and personnel required to implement the project are key considerations for any municipality interested in investing in regional dredging equipment.

- The Barnstable County Dredge Program serves as an important Case Study for upper North Shore municipalities interested in regional dredging alternatives. The Barnstable County Dredge is governed by the Barnstable County Dredge Advisory Committee, which monitors dredging operations, establishes the dredge schedule, and sets the dredge rate.

- Since the year 2000 the Barnstable County Dredge, which was used as a model for this feasibility study, has dredged a total of 175 projects and pumped 1,574,759 cy of sandy, beach compatible material, an average of 92,633 cy annually.

- The Barnstable County Dredge Program has consistently dredged sandy, beach compatible material at 38-68% below the market rate.

- The quick establishment of a reserve fund allowed the Barnstable County Dredge program to invest in replacement dredging equipment in 2017, 25 years after the initial dredge purchase.

Estimated Dredge Volumes

- Based on available historic dredge records, an estimated 49,562 cy of material has been dredged from the 9 FNPs in the study region on an annual basis since the first documented dredging event. Of the 49,562 cy of material historically dredged on an annual basis, 43,391 cy of the material is assumed to be sandy in nature and potentially suitable for beneficial reuse as beach nourishment and dune enhancement.

- Based on the most recent USACE hydrographic survey data, Woods Hole Group estimated that a total of 350,987 cy of material is currently available to be dredged from 8 FNPs in the study region. This most likely represents a one-time removal of material. It is assumed that sediment will continue to accrete in upper North Shore waterways, but projecting future accretion rates is beyond the scope of this preliminary study.

- If the total number of cy available to be dredged is factored against the assumed dredge frequency in each waterway, 42,755 cy of material may be able to be dredged from north shore waterways on an annual basis until the 350,987 cy threshold has been reached. Of the 42,754 cy of material that may be able to be dredged, 38,109 were estimated to be sandy in nature and potentially suitable for beneficial reuse as beach nourishment and dune enhancement.

- Despite the general estimates listed above, the infrequency of historic dredging events recorded in the study region, the lack of dredging records outside FNP boundaries, and the absence of consistent hydrographic surveys data and sediment quality data make it difficult to forecast the expected annual volume of material available for dredging on an annual basis.

- Based on data provided by the Massachusetts Department of Conservation and Recreation, costs for 6 beach nourishment projects in the Town of Salisbury have exceeded $1M from 2013-2018 with the cost of beach compatible upland sand exceeding $30.95 per cy (inclusive of mobilization and rough grading). Given these data, dredging and beneficially reusing sandy sediments for beach nourishment and dune enhancement may provide a cost savings over importing upland sand for beach nourishment and dune enhancement projects.

Dredging Alternatives

- The Woods Hole Group identified 3 Dredging Alternatives for municipalities on the upper North Shore of Massachusetts:

- <u>Alternative 1</u> – Purchase and Operation of Hydraulic Cutter Suction Dredge
  - Estimated Year-1 Costs: $859,287
  - Estimated Lifetime Costs over a 30-year period: $28,343,072.
  - Costs for Alternative 1 do not include the cost of dredging a minimum volume of material at an assumed rate of $15 per cy (inclusive of mobilization, demobilization, pre and post-dredge survey) to offset annual expenses.
  - Estimated dredge volume required to cover Year-1 expenses: 57,286 cy

- <u>Alternative 2</u> – Purchase and Operation of Hopper Dredging Equipment
  - Estimated Year-1 Costs: $1,568,927
  - Estimated Lifetime Costs: $48,999,518
  - Costs for Alternative 1 do not include the cost of dredging a minimum volume of material at an assumed rate of $15 per cy (inclusive of mobilization, demobilization, pre and post-dredge survey) to offset annual expenses.
  - Estimated dredge volume required to cover Year-1 expenses: 104,595 cy

- <u>Alternative 3 (low)</u> – Retention of a Private Dredge Contractor
  - Estimated Year-1 Costs: $1,749,960
  - Estimated 3-Year Contract Costs: $5,249,880
  - Estimated Lifetime Costs: $15,749,640
  - Costs for Alternative 1 (low) assume a basic dredge rate of $10 per cy, simple alternative for beneficial reuse and/or disposal.

- <u>Alternative 3 (high)</u> – Retention of a Private Dredge Contractor
  - Estimated Year-1 Costs: $5,529,840
  - Estimated 3-Year Contract Costs: $15,779,520
  - Estimated Lifetime Costs: $47,338,560
  - Costs for Alternative 1 (high) assume a basic dredge rate of $40 per cy, complex alternative for beneficial reuse and/or disposal.

- The volume required to cover expenses for Alternatives 1 and 2 (57,268 and 104,595 cy, respectively) exceeds the estimated annual volume available to be dredged from upper North Shore FNPs (49,562 cy (historic annual rate), and 42,755 cy (current estimated volume / estimated dredge frequency)).

- It is possible that sufficient volume exists in non-Federal waterways to exceed the annual volume threshold to maintain financial solvency under Alternative 1 and Alternative 2, however, dredge records and hydrographic survey data for non-Federal waterways on the upper North Shore do not currently exist. In order to ensure the solvency of dredging operations under Alternative 1 and Alternative 2, additional data collection would be required to refine annual volume estimates. If sufficient volumes are found in non-Federal waterways to increase the solvency of dredging operations, new improvement dredging permits would be need to be secured.

- Based on the results of this study, the most cost-effective alternative for dredging on the upper North Shore of Massachusetts is Alternative 3 (low) Retention of a Private Dredge Contractor assuming a low rate of $10 per cy inclusive of simple dewatering and disposal / beneficial reuse. It is possible that the rate per cy could increase substantially with pumping / barging distance, if a more elaborate dewatering structure were required (contaminated material, mud, etc.) or if a more elaborate alternative for beneficial reuse (TLD, Salt Marsh Enhancement, etc.) were selected.

Limitations of this Study

As previously stated, one of the largest limitations of this study was the availability of historic dredge records and hydrographic survey data for FNPs and non-Federal waterways on the upper North Shore. Estimated annual dredge quantities were calculated based on average historic rates of removal and on the take-off estimates calculated from available hydrographic surveys of FNPs in the study region. Additional dredge records and associated hydrographic survey data from non-Federal waterways were not readily available. Only confirmed, quantifiable events were included in the final dredge volume estimates, excluding subjective or qualitative reports. It is possible that more material could be dredged from non-Federal waterways within the study area, or by extending the bounds of FNPs to include larger portions of highly dynamic waterways, but data to support this claim was not readily available.

The analysis was also limited by the availability of reliable sediment quality data. Although the upper North Shore of Massachusetts has a significant need for beach nourishment, it is unclear from the available sediment quality data whether the material identified in the study region would meet the specific guidelines for beach nourishment and dune enhancement set forth in the State of Massachusetts regarding the beneficial reuse of dredged material. Woods Hole Group provided a basic estimate of the percentage of material that may be suitable for beach nourishment and dune enhancement based on the best available information. The estimate focused on material for beach nourishment and dune enhancement because dredged sandy material has an assumed value (+/- $30 per cy) that when beneficially reused, could potentially offset dredging costs. However, a more robust sediment quality dataset is required to further refine this general estimate. Lastly, Woods Hole Group identified possible conceptual alternatives for the beneficial reuse of dredged material. Assessing the feasibility of each conceptual alternative for the beneficial reuse of dredge material was beyond the scope of this initial study.

This assessment assumed that State grant funding could be secured to purchase regional dredging equipment, establish a dredge crew, and/or secure the services of a private dredge contractor. Under either scenario, it was also assumed that a Regional Dredge Advisory Council would be established to ensure equitable access to dredging services, prioritize projects of greatest need, and develop an annual schedule that would maximize the productivity and efficiency of dredging equipment and/or the preferred dredge contractor within the study region.

Regarding Improvement Dredging Projects within Areas of Critical Environmental Concern

Areas of Critical Environmental Concern (ACECs) are defined by the Commonwealth of Massachusetts as:

"a place in Massachusetts that receives special recognition because of the quality, uniqueness, and significance of its natural and cultural resources. Such an area is identified and nominated at the community level and is reviewed and designated by the state's Secretary of Energy and Environmental Affairs. The Department of Conservation and Recreation (DCR) administers the ACEC program on behalf of the Secretary"

At present, new improvement dredging projects (projects in areas that have no history of previous dredging having occurred) are not permittable in ACECs in the State of Massachusetts until the project is "*incorporated into a Resource Management Plan approved by participating municipalities and the Secretary of Environmental Affairs"* (CZM, 2003). Improvement dredging and dredge material disposal to support fishery and wildlife enhancement is permissible and recurring maintenance dredging projects (projects in areas where previous dredging projects have occurred) are allowed (CZM, 2003).

Limited exceptions to this rule have been made elsewhere in the State of Massachusetts, most notably within the Pleasant Bay ACEC, where *"limited improvement dredging to maintain or restore historical navigable access"* was approved by Town meeting vote in 2012 and incorporated into the Pleasant Bay Resource Management Plan (Pleasant Bay Resource Management Alliance, 2018). For additional information please refer to the Pleasant Bay Resource Management Plan 2018 Update.

Regarding Thin Layer Deposition as an Alternative for Beneficial Reuse

The Massachusetts Wetland Protection Act 310 CMR 10.32 defines salt marsh as: "*a coastal wetland that extends landward up to the highest high tide line, that is, the highest spring tide of the year, and is characterized by plants that are well adapted to or prefer living in, saline soils. Dominant plants within salt marshes are salt meadow cord grass (Spartina patens) and/or salt marsh cord grass (Spartina alterniflora). A salt marsh may contain tidal creeks, ditches and pools".* General Provision 5(f) of 310 CMR 10.53 states that: *"there shall nor be any filling or dredging of a salt marsh".*

At present, TLD is not considered to be a widely accepted practice for the beneficial reuse of dredged material in the State of Massachusetts, as any filling of salt marsh is not currently permitted. Thin layer deposition is currently being studied and employed by the USACE in other districts around the country to improve the resilience of salt marsh to projected sea level rise. However, it should not be relied upon as the preferred alternative for beneficial reuse of dredged material on the upper North Shore of Massachusetts without careful consultation with State regulatory agencies. For additional information regarding TLD, including case studies and state of the practice, please refer to the USACE Dredging Operations Technical Support Program (https://tlp.el.erdc.dren.mil/).

Regarding Permitting

Prior to the construction of any dredging project, the project proponent must secure all necessary local, State, and Federal permits which may include but not be limited to:

- Notice of Intent (NOI) Application (local)
- Massachusetts Environmental Policy Act (MEPA) Review (State)
- Chapter 91 License (State)
- Water Quality Certificate (State)
- Massachusetts Coastal Zone Management Federal Consistency (State)
- Army Corps of Engineers General Permit (Federal)

Dredging projects are also subject to review and imposed time-of-yea-restrictions (TOYs) by, at a minimum, the State of Massachusetts Natural Heritage and Endangered Species Program (NHESP), Massachusetts Division of Marine Fisheries (DMF), and National Marine Fisheries (NMFS).

Pros and Cons of a Municipal Dredge Purchase

Purchasing and operating regional dredging equipment presents a significant opportunity for municipalities to take responsibility for the management of their own waterways. However, owning and operating hydraulic dredging equipment is not without risk.

Pros

- Purchasing a dredge reduces uncertainty and prevents scheduled projects from being delayed due to a lack of State, Federal, or private dredging resources.
- Purchasing a dredge allows individual municipalities to exercise a high degree of autonomy in managing waterways and prioritizing projects outside FNP boundaries.
- Purchasing a dredge allows projects to be implemented at a rate that is generally well below the market average, saving taxpayers money in the long-term.
- Purchasing a dredge would allow municipalities, if approved, to beneficially reuse dredged material as beach nourishment, reducing beach management costs while increasing coastal resilience.

Cons

- Purchasing and operating regional dredging equipment is a significant long-term investment.
- Purchasing and operating regional dredging equipment in a cost-effective manner is contingent on identifying, permitting, and dredging a sufficient volume of material annually to cover expenses, debts, and to establish a reserve fund. This level of production would be required annually for the lifetime of the dredging equipment.
- Purchasing hydraulic cutter suction pump dredging equipment or hopper dredging equipment would be limit dredging operations to sandy, muddy, and fine-grained material. Projects with significant amounts of gravel or cobble could not be completed using a hydraulic or hopper dredging equipment and may require supplemental mechanical dredging services.
- Purchasing and operating a regional dredge would expose the owners to liability and risk.
- Ensuring equitable access to dredging equipment and equitable scheduling of projects throughout the region may prove challenging.
- Identifying and recruiting a qualified dredge superintendent and skilled laborers with industry experience into a municipal role may prove challenging.

Pros and Cons of Soliciting Private Dredge Contractor

Pros

- Soliciting a dredge contractor allows individual municipalities to exercise a high degree of autonomy in managing waterways and prioritizing projects outside FNP boundaries.
- Soliciting a dredge contractor would allow municipalities, if approved, to beneficially reuse dredged material as beach nourishment, reducing beach management costs while increasing coastal resilience.
- Soliciting a dredge contractor would allow municipalities to utilize the best available dredging technology and equipment for the project at hand.
- Equipment provided by a private dredge contractor could manage variable sediments (sand, mud, cobble, etc.) found in upper North Shore waterways.
- Soliciting a dredge contractor would allow municipalities to reduce liability and risk of owning and operating dredging equipment.
- Soliciting a dredge contractor would allow municipalities to avoid the need to recruit, train, and retain a skilled dredge crew.
- Sufficient dredge volumes (to ensure a cost-effective dredge rate) would only be required during 3-year contracted dredge cycles, not for the lifetime of dredging equipment.

Cons

- Soliciting a dredge contractor would not allow municipalities to retain fully depreciated assets (at the end of the 30-year project lifecycle), which may retain residual value.
- Soliciting a dredge contractor is contingent on identifying, permitting, and dredging a sufficient volume of material annually to ensure a cost-effective dredge rate.
- Ensuring equitable access to private dredge contracting services may prove challenging.
- Contracted dredge rates are not subsidized or fixed, and may fluctuate considerably based on available volume of material to be dredged and preferred alternative(s) for beneficial reuse.

Recommendations and Next Steps

If municipalities on the upper North Shore were to continue evaluating a regional purchase of hydraulic cutter suction dredging equipment, the following recommendations would need to be considered prior to selecting a preferred Alternative:

- Establish Regional Dredge Steering Committee to evaluate alternatives, facilitate next steps, and collaborate with local, State, and Federal stakeholders to identify appropriate pathway towards improved management of upper North Shore waterways.
- Develop a conceptual design for any future Regional Dredge Advisory Committee and administrative structure that would ensure equitable access to dredging resources (municipal dredging equipment or private dredge contractor).
- Collect additional sediment cores, conduct additional geochemical testing, and consider regional rates of sediment transport within existing and proposed FNPs and non-Federal dredging sites on the upper North Shore to refine forecasted annual dredge quantities and sediment quality data.
- Based on updated sediment quality data, conduct a thorough evaluation of the feasibility of various alternatives for the beneficial reuse of dredged material.
- For material found to be unsuitable for beneficial reuse:
    - Identify suitable upland disposal site(s);
    - Consider costs for hauling sediment to an approved offshore disposal site;
    - Consider costs for dewatering, trucking, and disposing of contaminated sediment at a secure landfill.
- For each waterway, research permitting requirements for preferred dredging footprint, preferred dewatering site, and preferred alternative for the beneficial reuse of dredged material.
- Work to secure consolidated, comprehensive dredging and disposal permits for each municipality to allow for better adaptive management of waterways from year to year, based on need.

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1.0 Appendix A

October 19, 2018

Mr. Peter Phippen
Coastal Resources Coordinator
Merrimack Valley Planning Commission
160 Main Street
Haverhill, MA 01830

Re: Proposal for Upper North Shore Coastal Massachusetts Dredge Purchase Feasibility Study

Dear Mr. Phippen:

The following is a proposal to assess the feasibility of purchasing and operating a dredge and associated equipment within shallow-draft boat harbors along the upper North Shore of Massachusetts. We understand the importance of maintaining safe and navigable entrance and internal channels to support a vibrant commercial fishing and recreational boating community. Additionally, public and private mooring fields and marinas depend on dredging to maintain safe depths at their docks and moorings. Federal funding for dredging Federal navigation channels used to be dependable. However, in recent years, Federal funding has become more sporadic and undependable, leaving North Shore Towns and communities on their own to maintain safe and navigable depths in their channels, harbors, and mooring fields. The North Shore recognizes the importance of maintaining a working relationship with the United States Army Corps of Engineers (USACE) so they can take advantage of funding when it becomes available. However, the same Towns and communities want to be prepared to maintain their own waterways and assist in maintaining navigable depths in non-Federal areas such as marinas, private channels, and mooring areas.

The Woods Hole Group has experience working with communities in Southern Maine interested in pursuing a similar dredge purchase. Through our work in Maine, we developed expertise researching historic dredging events, evaluating sediment characteristics within historic dredge channels, and synthesizing the available data to analyze the costs and benefits of a regional dredge purchase. We also articulated the importance of evaluating alternatives for cost-effective, beneficial reuse of dredged material (beach nourishment, dewatering and stockpiling, thin layer deposition, etc.), a critical component of any dredge purchase feasibility study. Additionally, we identified the importance of obtaining regional or municipal comprehensive permits for dredging and disposal, which provide a long-term cost savings to Towns and communities with active navigation channels. The project also included the development of comprehensive recommendations and next steps for municipal project partners.

The Woods Hole Group Coastal Scientists and Coastal Geologists also have extensive experience working with the Barnstable County Regional Dredge Program and the Edgartown Municipal Dredge Program on the Cape and Islands designing municipal dredging projects, identifying suitable locations for the beneficial reuse of dredged material, and developing and implementing resilient designs for large-scale beach nourishment and dune enhancement projects using dredged material. Our in-house Permitting Specialists are often responsible for securing the necessary local, State, and Federal permits required to facilitate the implementation of such projects.

A summary of relevant projects includes:

- Southern Maine Planning and Development Commission: Examining the Feasibility of Purchasing and Operating Hydraulic Dredging Equipment in Southern Maine. Saco, ME.
- Beneficial Reuse of Dredged Material: 2013 American Shore and Beach Preservation Association Best Restored Beaches - Cow Bay Beach Nourishment and Dune Enhancement Project. Edgartown, MA
- Beneficial Reuse of Dredged Material: 2017 American Shore and Beach Preservation Association Best Restored Beaches – Popponesset Spit Beach Nourishment and Dune Enhancement Project. Mashpee, MA
- Beneficial Reuse of Dredged Material: Thin Layer Deposition Pilot Project. Ninigret Marsh, RI
- Dredged Material Management: Dewatering and Upland Disposal of Fine-Grained Sediment from Centerville River. Centerville, MA
- Dredged Material Management: Long Island Dredge Material Management and Disposal Study. Long Island, NY.

It is our understanding that the Merrimack Valley Planning Commission (MVPC) and North Shore municipal stakeholders are interested in pursuing this feasibility study because many of the shallow-draft boat harbors on the North Shore have not been maintained by the US Army Corps of Engineers (USACE) and are interested in exploring opportunities to manage their own waterways. To address this question, Woods Hole Group proposes the following Tasks:

Task 1. Meetings and Stakeholder Engagement

This Task includes a kick-off meeting with MVPC and municipal stakeholders to review the geographic scope of the project (a total of 9 communities and their associated coastal waterways from Salisbury, MA to Manchester, MA), discuss the proposed scope of work, and understand how stakeholder goals and objectives differ throughout the region. It is anticipated that this meeting will take place at the MVPC offices or at one of the municipal stakeholders' offices. At the kick-off meeting, Woods Hole Group will request that each municipality nominate an individual to represent the Town at all future Dredge Purchase Feasibility Working Group Meetings.

The Dredge Purchase Feasibility Working Group will meet three times over the course of the project. Meeting objectives are defined below:

- Meeting 1 – To include municipal harbor personnel and/or members of municipal waterways advisory boards to identify site-specific goals and objectives. Meeting to include site visits to municipal waterways within the study region.

- Meeting 2 – To take place on Cape Cod and update the Working Group on project deliverables, tour Barnstable County Regional Dredging equipment and/or meet with Barnstable County Dredge personnel and regional dredge stakeholders[1].

- Meeting 3 – Wrap-up meeting with Working Group to review findings, recommendations, and next steps.

Task 2. Regional Sediment Characterization and Analysis

It is anticipated that regional stakeholders will provide information from their records regarding: historic permits obtained, exiting permits, historic quantities dredged, historic dredging location(s), historic dredged sediment types, historic disposal locations, etc. The Woods Hole Group will develop a standard questionnaire and permit record request that will help ensure that the data received from each stakeholder will be similar in nature. Once received, the data will be compiled. Impediments to dredging within designated Areas of Critical Environmental Concern (ACEC) will also be identified and summarized.

Woods Hole Group will research historic databases to amend data received from regional stakeholders. From the data obtained in the records search, the Woods Hole Group will identify and characterize grain size, type of material, potential volume, and presence of any pollutants for selected navigation channels and specific nearshore/offshore borrow sites within the North Shore region. These data will be used to forecast the quantities that a municipal dredge may be expected to dredge in a year. In conjunction with members of the Working Group, the Woods Hole Group will research suitable disposal sites (offshore, beach nourishment, TLD, etc.) based on the characteristics of the material to be dredged. This Task also includes the development of GIS imagery to accompany the data. GIS imagery will be incorporated into the Final Report (Task 6).

Task 3. Identification of Suitable Dredging Equipment

Once regional sediment characteristics and historic dredging events have been analyzed, Woods Hole Group will research and identify the most suitable dredging equipment for maintaining navigation channels within the specified region and beneficially reusing and/or disposing of dredged material. The data collected for this Task will include but not be limited to initial costs for the purchase of

---

[1] Costs for regional stakeholder participation in this meeting (on Cape Cod) have not been included in our proposal.

recommended equipment (dredge superstructure (hydraulic dredge, hopper, etc.), support boats, pipe, booster pump, etc.) labor costs, fuel costs, pumping rates, maintenance costs, etc.

Task 4. Operational Costs Forecast

The data collected in Tasks 3 will be compiled and used to estimate costs associated with dredge operation and ownership. Task 4 will also include a cost analysis of dredge ownership v. using a commercial dredge contractor to complete projects within the specified region.

Task 5. Feasibility Assessment

The data obtained in Tasks 1 through 4 will be used to develop a regional sediment budget (the amount of material that could be expected to be dredged on an annual basis) for waterways in the specified region. The sediment budget will be factored against the operational cost forecast for owning and operating regional dredging equipment within the specified region, generating a cost per cubic yard of material dredged. This unit cost will help to determine the capital outlay that will be required to obtain the dredge and how quickly the initial investment can be recovered. Additionally, a return on investment curve will be developed to show revenue generated by the dredge balanced against initial investment cost; annual operating costs; and maintenance and repair costs.

Task 6. Final Report

A report will be generated that documents the data obtained in Tasks 1 through 5. The final report will provide an outline of the assumptions that were made in generating these data and will provide a comprehensive list of recommendations and next steps for future work.

Task 7. Project Management

This task provides time for the Woods Hole Group project team to communicate with the SMPDC and the stake holders. This task will help the Woods Hole Group keep the project team up-to-date on the project and to complete administrative tasks.

Acceptance and Authorization to Proceed

This proposal was assembled under the guidelines for a "Fixed Fee" contract. Prior to the work being started, Woods Hole Group requires receipt of the signed and dated "Acceptance and Authorization to Proceed" form at the end of this proposal. Invoices for services rendered will be submitted monthly based upon percent complete. Unless otherwise agreed to in writing, payment is due within 30 days following the date of our invoice. In the event of payments that are significantly or routinely late, Woods Hole Group retains the right to stop work until payment issues are redressed. In case of refusal to address payment issues, Woods Hole Group retains the right to use legal measures to obtain rightful payment.

Respectfully Submitted,

Adam Finkle, M.S.; PWS
Coastal Scientist

Lee Weishar, PhD; PWS
Senior Scientist

Acceptance and Authorization to Proceed:

"I authorize Woods Hole Group, Inc. to proceed with the above scope of work and budget of **$45,000** for Tasks 1-7."

Client Name **Date**

Woods Hole Group Representative **Date**

2.0 Appendix B

WOODS HOLE GROUP
FOR EARTH, FROM SPACE
A CLS COMPANY

North Shore Dredge Purchase Feasibility Study
Kick-Off Meeting
Wednesday, February 6th, 2019
2:00-3:00pm

Dial-In Access: 508-495-6299
Bridge: 601
PIN: 147258

- **Introductions**
  - Merrimack Valley Planning Commission;
  - State Officials;
  - Municipal Stakeholders;
  - Woods Hole Group

- **Project Outline and Timeline**

  Task 1. Meetings and Stakeholder Engagement

  Task 2. Regional Sediment Characterization

  Task 3. Identification of Suitable Equipment

  Task 4. Operational Cost Forecast

  Task 5. Feasibility Assessment

  Task 6. Final Report

  Task 7. Project Management

- **Barnstable County Case Study**

- **Review Geographic Extent and Included Waterways**
  - Public / private waterways that are actively being dredged, or have been dredged historically

- **Questions / Next Steps**
  - Assign Municipal point(s)-of-contact

3.0 Appendix C

WOODS HOLE GROUP
FOR EARTH, FROM SPACE
A CLS COMPANY

North Shore Dredge Purchase Feasibility Study

Kick-Off Meeting
Town Hall, Essex, Massachusetts
March 1, 2019

Adam Finkle
Coastal Scientist
afinkle@whgrp.com
Direct: 508-495-6272

Lee Wieshar
Senior Scientist
lweishar@whgrp.com
Direct: 508-459-6221

Merrimack Valley Planning Commission
plan • develop • promote

Presentation Outline

- Project Partners
- Project Tasks and Timeline
- Regional Case Studies
- Work Completed to Date
- Questions / Next Steps

Project Goals and Objectives

- Assess the feasibility of purchasing and operating a dredge and associated equipment within shallow-draft boat harbors along the upper North Shore of Massachusetts
    - Driven by importance of maintaining safe and navigable entrance and internal navigation channels

- The North Shore recognizes the importance of maintaining a working relationship with the United States Army Corps of Engineers (USACE) so they can take advantage of funding when it becomes available. However, the same Towns and communities want to be prepared to maintain their own waterways and assist in maintaining navigable depths in non-Federal areas such as marinas, private channels, and mooring areas.

Project Partners

- Merrimack Valley Planning Commission
- State Officials
  - Senator Bruce Tarr
  - Representative Leonard Mirra
  - Representative Brad Hill
- Municipal Stakeholders
  - Towns of Salisbury, Newburyport, Newbury, Amesbury, Rowley, Ipswich, Essex, Rockport, Gloucester, Manchester-by-the-Sea
- Woods Hole Group

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Merrimack Valley Planning Commission
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Project Outline and Timeline

- **Task 1. Meetings and Stakeholder Engagement**
  - **Kick off Meeting** – Establish Regional Working Group
    - **Meeting 1** – To include site visits to select waterways in study region, clarify site-specific goals and objectives.
    - **Meeting 2** – To be conducted on Cape Cod. Meet with local municipal leaders and Barnstable County Dredge personnel.
    - **Meeting 3** – Wrap-up meeting with Regional Working Group

Project Outline and Timeline

- **Task 2. Regional Sediment Characterization**
  - Expected that regional stakeholders will provide information from Town records regarding:
    - historic permits obtained,
    - exiting permits,
    - historic quantities dredged,
    - historic dredging location(s),
    - historic dredged sediment types,
    - historic disposal locations, etc.
  - Woods Hole Group will research historic databases to amend data received from regional stakeholders.
    - USACOE public data requests, Mass Bay Disposal Site Database, NOAA, USGS
  - Data obtained will be used to identify and characterize grain size, type of material, potential volume, and presence of any pollutants for selected navigation channels and specific nearshore/offshore borrow sites within the North Shore region.

Project Outline and Timeline

- **Task 3. Identification of Suitable Equipment**
  - Once regional sediment characteristics and historic dredging events have been analyzed, Woods Hole Group will research and identify the most suitable dredging equipment for maintaining navigation channels within the specified region and beneficially reusing and/or disposing of dredged material.
    - **Hydraulic Cutter Suction Pump Dredge?**
    - **Hopper Dredge?**
    - **Mechanical Dredge?**
  - Initial costs for the purchase of recommended equipment (dredge superstructure (hydraulic dredge, hopper, etc.), support boats, pipe, booster pump, etc.) labor costs, fuel costs, pumping rates, maintenance costs, etc.

Project Outline and Timeline

- **Task 4. Operational Cost Forecast**
  - Task 4 will also include a cost analysis of dredge ownership v. using a commercial dredge contractor to complete projects within the specified region.
- **Task 5. Feasibility Assessment**
  - Develop a regional sediment budget (the amount of material that could be expected to be dredged on an annual basis) for waterways in the specified region.
  - The sediment budget will be factored against the operational cost forecast for owning and operating regional dredging equipment within the specified region, generating a cost per cubic yard of material dredged.
  - This unit cost will help to determine the capital outlay that will be required to obtain the dredge and how quickly the initial investment can be recovered.
- **Task 6. Final Report**
  - The final report will provide an outline of the assumptions that were made in generating these data and will provide a comprehensive list of recommendations and next steps for future work.

Project Outline and Timeline

Project Outline and Timeline

Task 1. Meetings and Stakeholder Engagement – 4/1; 5/1; 6/30

Task 2. Regional Sediment Characterization – April 2019

Task 3. Identification of Suitable Equipment – April 2019

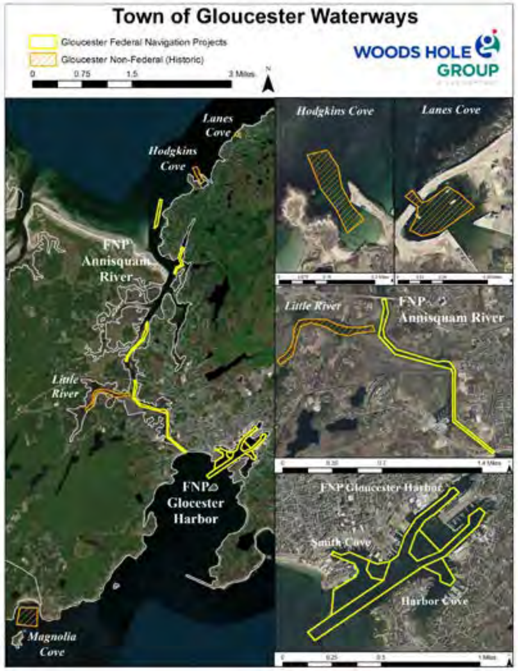
Task 4. Operational Cost Forecast – May 2019

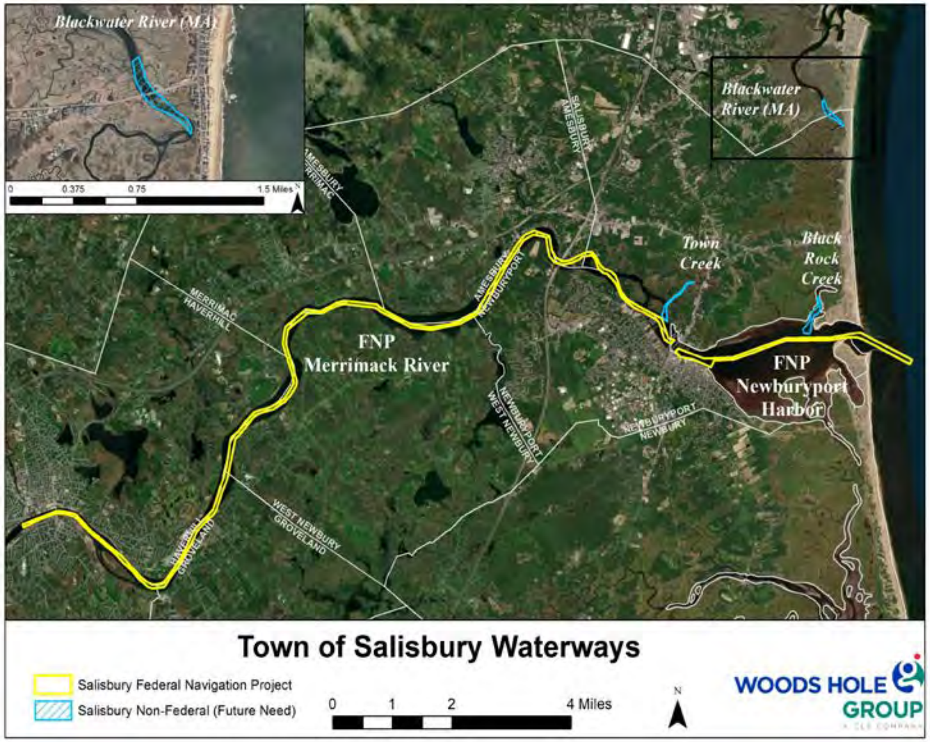
Task 5. Feasibility Assessment – May 2019

Task 6. Final Report – June 2019

Work Completed to Date

- USACOE Outreach – Accommodating data requests and will be sending along electronic copies of historic reports to supplement initial data collection.
- USACOE has provided comments on the expanded list of waterways / classifications that were identified by the Harbormasters.
- Woods Hole Group has begun assimilating historic sediment quantity and quality data for identified waterways on the North Shore.
- Woods Hole Group has begin developing GIS imagery of all waterways
- Finalizing questionnaire to Harbormasters





Questions? / Next Steps

- Finalize Imagery
- Municipal outreach - questionnaire forthcoming
- Scheduling Working Group Meetings 1, 2
- Continued data collection / queries

4.0 Appendix D

North Shore Dredge Purchase Feasibility Study

Preliminary Data Collection - Town of Salisbury, MA

Name: Ray Pike

Position: Harbormaster

Contact Information: (978)420-7834

Navigation Channel(s)*

- Newburyport Harbor
  1. The current navigability of the waterway is good in the channel, but in some areas there is some shoaling and needs to be dredged.
  2. The areas that pose a significant safety risk are closer to the mouth of the river.

- Black Rock Creek / Town Creek
  1. These creeks are navigable by small craft such as kayaks, canoes and jetskis.
  2. Dredging these creeks would open them up to larger vessels and possibly provide some material for beneficial use, but that has yet to be determined.
  3. There is no significant public safety risk at this time.

- Blackwater River (NH Border)
  1. Only navigable to small craft such as kayaks and canoes due to Rte 286 bridge and depth limitations.
  2. Dredging would open up the waterway, offer a source of material for either beach nourishment or TLD.
  3. Public safety concerns include the isolated nature of the area, only one access into the area from Seabrook/Hampton Harbor. This area is not patrolled due to remoteness and limited access.

*For each of the navigation channel(s) listed above, please provide a brief narrative describing:

1) The current navigability of the waterway;

2) Specific dredging needs within the waterway;

3) Public safety concerns within the waterway.

Historic Dredging:

	Newburyport Harbor	Black Rock Creek	Blackwater River
Has channel been dredged (Y/N)?	y	n	n
Project funding source (Fed, State, Private)?	Fed	n/a	n/a
Date of last dredging?	2010	n/a	n/a

Future Dredging:

	Newburyport Harbor	Black Rock Creek	Blackwater River
Has dredging kept the channel safe and navigable (Y/N)?	y	n/a	n/a
If "Yes", how many years before it is needed again?	Approx 2		
Is channel scheduled to be dredged (Y/N)?	In planning stages	n	n
If "Yes" project funding source (Fed, State, Private)?	Fed		
Date dredging is scheduled to occur?			
What depth is required for safe passage at MLW?	9'	Unsure, but approx 3'	Unsure, but approx 3'

Existing Permits:

	Newburyport Harbor	Black Rock Creek	Blackwater River
Does the Town currently hold Federal, State, and/or Local permits to dredge the waterway?	n	n	n
Are permits current and regularly renewed?	n	n	n
Town official responsible for furnishing Permits?	Harbormaster	Harbormaster	Harbormaster

Beneficial Reuse of Dredged Material:

	Newburyport Harbor	Black Rock Creek	Blackwater River
What type of sediment does the channel contain (cobble / sand / mud, variable)?	Mostly sand	Unsure, mostly mud	Unsure, mostly mud and some sand
Preferred method of disposal (beach nourishment / offshore / upland / thin layer deposition	Beach nourishment or nearshore disposal	TLD if appropriate	TLD or nearshore disposal if appropriate

(TLD))?			

Channel Features – Mooring Fields:

	Newburyport Harbor	Black Rock Creek	Blackwater River
Please describe existing mooring fields:	180-200 on Salisbury side of river	none	none
Mooring Field Ownership (public / private)?	All public except for 14 private		
Does mooring field require dredging (Y/N)?	n		
Number of moorings dependent on dredging?	none		

Channel Features – Marinas:

	Newburyport Harbor	Black Rock Creek	Blackwater River
Please describe existing marinas:	3 Marinas, 1 Town Pier	none	none
Marina Ownership (public / private)?	3 Private, Town Pier is public		
Does the marina require dredging (Y/ N)?	n		
Number of slips in harbor dependent on dredging?	none		

Commercial and Recreational Boat Traffic:

	Newburyport Harbor	Black Rock Creek	Blackwater River
Please describe typical, peak season boat traffic:		Kayaks, canoes and jetski	Kayaks, canoes and jetski
Number of commercial fishermen?	15-20	0	0
Number of charter boats?	25	0	0
Number of recreational crafts (peak season)?	450	50/mo	50/mo
Average LOA vessel?	28’	12’	12’
Average draft vessel?	4’	1’	1’
Maximum LOA and draft vessel allowed?	LOA = no limit Draft = 9’	LOA = 16’ Draft = 4’	LOA = 16’ Draft = 4’

Additional Comments / Feedback / Notes:

North Shore Dredge Purchase Feasibility Study

Preliminary Data Collection - Town of Newburyport, MA

Name: Paul Hogg

Position: Harbormaster

Contact Information: phogg@cityofnewburyport.com Cell (978-360-6963)

Navigation Channel(s)*

- Merrimack River

- Newburyport Harbor (Including 2 Commercial Fish Piers)

- Salisbury Jetty

*For each of the navigation channel(s) listed above, please provide a brief narrative describing:

1) The current navigability of the waterway;
2) Specific dredging needs within the waterway;
3) Public safety concerns within the waterway.

Historic Dredging:

	Merrimack River	Newburyport Harbor (Inc. 2 Comm. Fish Piers)	Salisbury Jetty
Has channel been dredged (Y/N)?	Y	N	Y
Project funding source (Fed, State, Private)?	FED	N	FED
Date of last dredging?	2011 Mouth /Inside river 1939	N/A	2011

Future Dredging:

	Merrimack River	Newburyport Harbor (Inc. 2 Comm. Fish Piers)	Salisbury Jetty
Has dredging kept the channel safe and navigable (Y/N)?	N	N	N
If "Yes", how many years before it is needed again?			
Is channel scheduled to be dredged (Y/N)?	N	N	N
If "Yes" project			

funding source (Fed, State, Private)?			
Date dredging is scheduled to occur?	N/A	N/A	N/A
What depth is required for safe passage at MLW?	22 Ft	22 Ft	22 Ft

Existing Permits:

	Merrimack River	Newburyport Harbor (Inc. 2 Comm. Fish Piers)	Salisbury Jetty
Does the Town currently hold Federal, State, and/or Local permits to dredge the waterway?		Local and State	
Are permits current and regularly renewed?			
Town official responsible for furnishing Permits?	Geordie Vining/Paul Hogg		

Beneficial Reuse of Dredged Material:

	Merrimack River	Newburyport Harbor (Inc. 2 Comm. Fish Piers)	Salisbury Jetty
What type of sediment does the channel contain (cobble / sand / mud, variable)?	Variable	Ledge/Variable	Variable
Preferred method of disposal (beach nourishment / offshore / upland / thin layer deposition (TLD))?	Beach	Off Shore	Beach

Channel Features – Mooring Fields:

	Merrimack River	Newburyport Harbor (Inc. 2 Comm. Fish Piers)	Salisbury Jetty
Please describe existing mooring fields:	200 Moorings		
Mooring Field Ownership (public / private)?	Public		
Does mooring field require dredging (Y/N)?	N		
Number of moorings dependent on dredging?	None		

Channel Features – Marinas:

	Merrimack River	Newburyport Harbor (Inc. 2 Comm. Fish Piers)	Salisbury Jetty
Please describe existing marinas:	11 Private Marinas		
Marina Ownership (public / private)?	Private		
Does the marina require dredging (Y/ N)?	N		
Number of slips in harbor dependent on dredging?	All , they transit the River		

Commercial and Recreational Boat Traffic:

	Merrimack River	Newburyport Harbor (Inc. 2 Comm. Fish Piers)	Salisbury Jetty
Please describe typical, peak season boat traffic:	1500 boats registered 200 Boats Cashman 100 Transient		
Number of commercial fishermen?	200		
Number of charter boats?	50		
Number of recreational crafts (peak season)?	2000		
Average LOA vessel?	30		
Average draft vessel?	6 ft		
Maximum LOA and	200 Ft		

draft vessel allowed?	13 Ft		

<u>Additional Comments / Feedback / Notes:</u>

<u>The Mouth of the Merrimack River needs to be dredged ASAP. It has become extremely dangerous and has a large impact for commercial fisherman and transient boating. These factors are both a huge economic impact and safety concern.</u>

North Shore Dredge Purchase Feasibility Study

Preliminary Data Collection - Town of Ipswich, MA

Name: Chief Paul A. Nikas

Position: Harbormaster

Contact Information: p2nikas@ipswichpolice.org 978-356-4343

Navigation Channel(s)*

- Ipswich River-

1. From Ipswich Town Warf to the mouth of the Ipswich River-Safe navigation 3 hours before to three hours after low tide. Numerous spots at low tide with less than 1 foot of water in channel.
2. Create a channel with consistent depth the length of the river from Town Warf to the mouth of the river. Remove sand from mooring fields.
3. The river is non-navigable for our police patrol boats. Numerous boats run aground within the channel. Channel is very narrow and creates hazardous passing conditions.

- Ipswich Bay-From the mouth of the Ipswich river seaward to the bell buoy through the channel

1. Shoaling occurring in the channel from the mouth of the Ipswich River to the green can and bell buoy. Inconsistent depths in the channel.
2. Create a safe channel for safe passage of vessels heading to and from Open Ocean.
3. Shoaling creates high wave conditions in channel. Channel has shrunk in size and is very narrow for large boats to pass.

- Essex River-Mouth of Essex River

1. Mouth of Essex River has become shallow and narrow
2. Create a safe boating channel
3. Shoaling of sandbars in the mouth creates large swells during wind and tide exchange creating hazardous condition.

- Eagle Hill River-Mouth to the Greens Point Marinna

1. No water for navigation three hours before or after tide.
2. Create a safe and navigable channel for boats.
3. Our vessels cannot respond in this area during lower parts of the tide. There is a large marina/boat yard at the end of the river.

- Castle Neck-From Essex River along the backside of Crane Beach to Fox Creek

1. No water for navigation three hours before or after tide.
2. Create a safe and navigable channel for boats.
3. This area is known for large vessel traffic and people spending long periods of time on mooring or anchorage. At low tide we cannot respond to emergencies in this area due to no water.

*For each of the navigation channel(s) listed above, please provide a brief narrative describing:

1) The current navigability of the waterway;

2) Specific dredging needs within the waterway;

3) Public safety concerns within the waterway.

Historic Dredging:

	Ipswich River	Ipswich Bay	Eagle Hill, Castle Neck, Essex R.
Has channel been dredged (Y/N)?	Yes	No	No
Project funding source (Fed, State, Private)?	Fed		
Date of last dredging?	1887		

Future Dredging:

	Ipswich River	Ipswich Bay	Eagle Hill, Castle Neck, Essex R.
Has dredging kept the channel safe and navigable (Y/N)?	NO	NO	NO
If "Yes", how many years before it is needed again?			
Is channel scheduled to be dredged (Y/N)?	NO	NO	NO
If "Yes" project funding source (Fed, State, Private)?			
Date dredging is scheduled to occur?			
What depth is required for safe passage at MLW?	5 FEET	6 FEET	5 FEET

Existing Permits:

	Ipswich River	Ipswich Bay	Eagle Hill, Castle Neck, Essex R.
Does the Town currently hold Federal, State, and/or Local permits to dredge the waterway?	NO	NO	NO
Are permits current and regularly renewed?			
Town official responsible for furnishing Permits?	Harbormaster/Conservation	Harbormaster/Conservation	Harbormaster/Conservation

Beneficial Reuse of Dredged Material:

	Ipswich River	Ipswich Bay	Eagle Hill, Castle Neck, Essex R.
What type of sediment does the channel contain (cobble / sand / mud, variable)?	SAND/MUD	SAND	SAND/MUD
Preferred method of disposal (beach nourishment / offshore / upland / thin layer	BEACH NOURISHMENT/THIN LAYER DEPOSITION	BEACH NOURISHMENT/THIN LAYER DEPOSITION	BEACH NOURISHMENT/THIN LAYER DEPOSITION

deposition (TLD))?			

Channel Features – Mooring Fields:

	Ipswich River	Ipswich Bay	Eagle Hill, Castle Neck, Essex R.
Please describe existing mooring fields:	NUMEROUS Can provide map	NONE	NUMEROUS Can provide map
Mooring Field Ownership (public / private)?	PUBLIC		PUBLIC
Does mooring field require dredging (Y/N)?	Yes		Yes
Number of moorings dependent on dredging?	250		50

Channel Features – Marinas:

	Ipswich River	Ipswich Bay	Eagle Hill, Castle Neck, Essex R.
Please describe existing marinas:	Town Warf – Public Access	None	Boat yard
Marina Ownership (public / private)?	Public		private
Does the marina require dredging (Y/ N)?	Yes		No
Number of slips in harbor dependent on dredging?	8		0

Commercial and Recreational Boat Traffic:

	Ipswich River	Ipswich Bay	Eagle Hill, Castle Neck, Essex R.
Please describe typical, peak season boat traffic:	400	1000	200
Number of commercial fishermen?	135-140		130
Number of charter boats?			
Number of recreational crafts (peak season)?	1500	2000	300
Average LOA vessel?	22	32	40

Average draft vessel?	3	4	4
Maximum LOA and draft vessel allowed?	NONE	NONE	NONE

Additional Comments / Feedback / Notes:

North Shore Dredge Purchase Feasibility Study

Preliminary Data Collection - Town of Essex, MA

Name: Andrew C. Spinney

Position: Selectman

Contact Information: anchorseal@me.com

Navigation Channel(s)*:

The following answers apply to each of these three areas:

- Essex River
- Essex Bay
- Town Landing Rt. 133 and Main

1) The current navigability of the waterways: Extremely tidal-dependent.

2) Specific dredging needs within the waterways: A good channel at all tides.

3) Public safety concerns within the waterways: No access at ½ tide to low for public safety. Rescue and emergency response throughout entire River. Exigency to remediate for public safety.

Historic Dredging:

	Essex River	Essex Bay	Rt. 133 and Main
Has channel been dredged (Y/N)?	Y	N	Y
Project funding source (Fed, State, Private)?	State.	N/A	State & Private.
Date of last dredging?	1992.	N/A	1992.

Future Dredging:

	Essex River	Essex Bay	Rt. 133 and Main
Has dredging kept the channel safe and navigable (Y/N)?	N	N	N
If "Yes", how many years before it is needed again?	Every	10 Years	Needed.

Is channel scheduled to be dredged (Y/N)?	N	N	N
If "Yes" project funding source (Fed, State, Private)?	N/A	N/A	N/A
Date dredging is scheduled to occur?	N/A	N/A	N/A
What depth is required for safe passage at MLW?	4 to 5 feet deep	And	60 feet wide.

Existing Permits:

	Essex River	Essex Bay	Rt. 133 and Main
Does the Town currently hold Federal, State, and/or Local permits to dredge the waterway?	N	N	N
Are permits current and regularly renewed?	N	N	N
Town official responsible for furnishing Permits?	Brendhan Zubricki.	Brendhan Zubricki.	Brendhan Zubricki.

Beneficial Reuse of Dredged Material:

	Essex River	Essex Bay	Rt. 133 and Main
What type of sediment does the channel contain (cobble / sand / mud, variable)?	Variable.	Variable.	Mud.
Preferred method of disposal (beach nourishment / offshore / upland / thin layer deposition (TLD))?	Would like to keep all options on the table.	Would like to keep all options on the table.	"A" buoy MA Dump Area.

Channel Features – Mooring Fields:

	Essex River	Essex Bay	Rt. 133 and Main
Please describe existing mooring fields:	Basin, Water Street, & Conomo Point.	Conomo Point.	Basin.

Mooring Field Ownership (public / private)?	Town owned.	Town owned.	Town owned.
Does mooring field require dredging (Y/N)?	Y	Yes, partly.	Y
Number of moorings dependent on dredging?	All.	All.	All.

Channel Features – Marinas:

	Essex River	Essex Bay	Rt. 133 and Main
Please describe existing marinas:	None.	None.	Total 5.
Marina Ownership (public / private)?	None.	None.	Private
Does the marina require dredging (Y/ N)?	None.	None.	Y
Number of slips in harbor dependent on dredging?	None.	None.	All.

Commercial and Recreational Boat Traffic:

	Essex River	Essex Bay	Rt. 133 and Main
Please describe typical, peak season boat traffic:	Busy.	Busy.	Busy.
Number of commercial fishermen?	100.	100.	100.
Number of charter boats?	20.	20.	20.
Number of recreational crafts (peak season)?	1500 +	1500 +	1500 +
Average LOA vessel?	25 feet.	25 feet.	25 feet.
Average draft vessel?	3 feet.	3 feet.	3 feet.
Maximum LOA and draft vessel allowed?	80 ft. LOA	And	10 ft. draft.

Additional Comments / Feedback / Notes: None.

North Shore Dredge Purchase Feasibility Study

Preliminary Data Collection - Town of Rockport, MA

Name: Rockport Harbormasters Scott Story/Rosemary Lesch

Position: Harbormasters

Contact Information: email: rockportharbormasters@rockportma.gov

978-546-9589

Mailing address: 34 Broadway, Rockport, Ma 01966

Navigation Channel(s)*

- Rockport Harbor
- Old Harbor
- Granite Pier
- Pigeon Cove

*For each of the navigation channel(s) listed above, please provide a brief narrative describing:

1) The current navigability of the waterway;
2) Specific dredging needs within the waterway;
3) Public safety concerns within the waterway.

Historic Dredging:

	Rockport Harbor	Old Harbor	Granite Pier	Pigeon Cove
Has channel been dredged (Y/N)?	Y	Y	?	Y
Project funding source (Fed, State, Private)?	Fed	Private	Not in recent history	Fed
Date of last dredging?	Mid 1980's	1960/1970's ?	n/a	Mid 1980's

Future Dredging:

	Rockport Harbor	Old Harbor	Granite Pier	Pigeon Cove
Has dredging kept the channel safe and navigable (Y/N)?	Y	N	n/a	Y
If "Yes", how many years before	5 years	Need immediate Attention	n/a	5 years

it is needed again?				
Is channel scheduled to be dredged (Y/N)?	N	N	n/a	N
If "Yes" project funding source (Fed, State, Private)?				
Date dredging is scheduled to occur?				
What depth is required for safe passage at MLW?	10'	8'	8'	10'

Existing Permits:

	Rockport Harbor	Old Harbor	Granite Pier	Pigeon Cove
Does the Town currently hold Federal, State, and/or Local permits to dredge the waterway?	N	N	N	N
Are permits current and regularly renewed?	When necessary	When necessary & funds	N	When necessary
Town official responsible for furnishing Permits?	DPW director & BOS, harbormasters	DPW & BOS, harbormasters	DPW, BOS, harbormasters	DPW, BOS, harbormasters

Beneficial Reuse of Dredged Material:

	Rockport Harbor	Old Harbor	Granite Pier	Pigeon Cove
What type of sediment does the channel contain (cobble / sand / mud, variable)?	Mud	Mud and cobble	Variable	Mud
Preferred method of disposal (beach nourishment / offshore / upland / thin layer deposition (TLD))?	Off shore	Off shore	TBD	Off shore

Channel Features – Mooring Fields:

	Rockport Harbor	Old Harbor	Granite Pier	Pigeon Cove
Please describe existing mooring fields:	150 fore/aft moorings & 50	30 Slips	60 fore & aft	60 fore & aft

	small boat swing moorings-			
Mooring Field Ownership (public / private)?	Public	Public	Public	Public
Does mooring field require dredging (Y/N)?	Y-5 yrs.	Y	Y-5 yrs.	Y-5 yrs.
Number of moorings dependent on dredging?	200 boats	30 boats	20 boats	60 boats

<u>Channel Features – Marinas</u>:

	Rockport Harbor	Old Harbor	Granite Pier	Pigeon Cove
Please describe existing marinas:	Sandy Bay Yacht Club 12 club boats-private	30 slips	n/a	n/a
Marina Ownership (public / private)?	Private	Public	n/a	n/a
Does the marina require dredging (Y/ N)?	N	YES	n/a	n/a
Number of slips in harbor dependent on dredging?	30 slips Town owned slips	30 slips Town owned slips	n/a	n/a

<u>Commercial and Recreational Boat Traffic</u>:

	Rockport Harbor	Old Harbor	Granite Pier	Pigeon Cove
Please describe typical, peak season boat traffic:	Heavy boating traffic in season	30 boats, small area needs dredging	Heavy boating traffic in season	Heavy boating traffic in season
Number of commercial fishermen?	31	2	11	24
Number of charter boats?	3	1	0	0
Number of recreational crafts (peak season)?	50-60 per days	No access needs dredging	40-50 per day	20-30 more a commercial harbor
Average LOA vessel?	30’	20’	22’	22’
Average draft vessel?	4’	2’	3’	4’
Maximum LOA and draft vessel allowed?	50’ 6’ draft	20’ 3’	30’ 4’	35’ 4’

Additional Comments / Feedback / Notes:
We answered the questions as best as possible per our unique circumstances.

The mooring fields are publicly owned but the mooring gear is provided by the boat owner. All moorings are assigned by the Harbormasters from a public Mooring Waiting list except for the 12 slips at the Sandy Bay Yacht Club.
At the present time Old Harbor is not navigable at low tide, it is in desperate need of dredging. Old Harbor is a project that the Seaport Advisory Council had invested time and money in for engineering in the form of a Seaport Improvement Grant and the material approved for offshore disposal. As we stated "Old Harbor is in desperate need of dredging" and our top priority.

The Rockport Harbormasters look forward to working with the other communities in the area and the Woods Hole Group, North Shore Dredge program to make it feasible for all cities and towns north of Boston to get small navigational/dredge projects accomplished.

Rockport Harbormasters Scott Story/Rosemary Lesch

North Shore Dredge Purchase Feasibility Study

Preliminary Data Collection - Town of Gloucester, MA

Name: Thomas Ciarametaro

Position: Gloucester Harbormaster

Contact Information: 978-325-5757

Navigation Channel(s)*

- Annisquam River Federal Channel in the process of dredging starting fall of 2019.

- Blyman's Canal Part of the Annisquam River part of the fall USACOE Dredge plan.

- Lobster Cove Part of a Federal navigation project will also be dredge fall of 19.

- Gloucester Harbor Is mainly broken into two channels north and south both Federal channels.

- Lane's Cove Is a small cove with 25 moorings protected by a seawall. This area housed mostly commercial boats and needs to be dredged.

- Hodgkin's Cove Should be removed from the study it is all eelgrass and would never be allowed to be dredged.

- Little River This area is home to over 100 moorings private docks and a marina. This tributary is in desperate need of dredging.

*For each of the navigation channel(s) listed above, please provide a brief narrative describing:

1) The current navigability of the waterway;
2) Specific dredging needs within the waterway;
3) Public safety concerns within the waterway.

Historic Dredging:

	Annisquam R.	Blyman's Canal	Lobster Cove	Gloucester H.	Lane's Cove	Hodgkin's C.	Little River
Has channel been dredged (Y/N)?	Fall of 2019	Fall of 2019	Fall of 2019	Yes	Never	NA	Parts
Project funding source (Fed, State, Private)?	Federal	Federal	Federal	Should be Federal	State/Local	NA	State Local
Date of last dredging?	1968	1968	1968	1972	NA	NA	1968

Future Dredging:

	Annisquam R.	Blyman's Canal	Lobster Cove	Gloucester H.	Lane's Cove	Hodgkin's C.	Little River
Has dredging kept the channel safe and navigable (Y/N)?	It will current conditions are un navigable certain tides	It will current conditions are un navigable certain tides	It will current conditions are un navigable certain tides	Yes	NA	NA	NO
If "Yes", how many years before it is needed again?	Should be done every 10-15 years	Should be done every 10-15 years	Should be done every 10-15 years	25 years	10 years	NA	10-15
Is channel scheduled to be dredged (Y/N)?	Yes Fall of 2019	Yes Fall of 2019	Yes Fall of 2019	NO	NO	NA	NO
If "Yes" project funding source (Fed, State, Private)?							
Date dredging is scheduled to occur?	October 2019	October 2019	October 2019	NA	NA	NA	NA
What depth is required for safe passage at MLW?	8ft	8ft	8ft	20ft	8Ft	NA	8Ft

Existing Permits:

	Annisquam R.	Blyman's Canal	Lobster Cove	Gloucester H.	Lane's Cove	Hodgkin's C.	Little River
Does the Town currently hold Federal, State, and/or Local permits to dredge the waterway?	NO on all						
Are permits current and regularly renewed?							
Town official responsible for furnishing Permits?							

Beneficial Reuse of Dredged Material:

	Annisquam R.	Blyman's Canal	Lobster Cove	Gloucester H.	Lane's Cove	Hodgkin's C.	Little River
What type of sediment does the channel contain (cobble / sand / mud, variable)?	Sand / Silt	Sand / Silt	Sand / Silt	Sand / Silt	Sand / Silt/Rock	NA	Sand/ MUD
Preferred method of disposal (beach nourishment / offshore / upland / thin layer deposition (TLD))?	Near Shore disposal.	Near Shore disposal.	Near Shore disposal.	Near Shore disposal.	Near Shore disposal.	Near Shore disposal.	Near Shore disposal.

Channel Features – Mooring Fields:

	Annisquam R.	Blyman's Canal	Lobster Cove	Gloucester H.	Lane's Cove	Hodgkin's C.	Little River
Please describe existing mooring fields:	Houses over 300 Moorings	None	175 Moorings	Moorings marinas private piers.	Moorings	NA	Moorings
Mooring Field Ownership (public / private)?	Private	NA	Private	Public Private	Private	NA	Private
Does mooring field require dredging (Y/N)?	Yes	NA	Yes	NO	Yes	NA	Yes
Number of moorings dependent on dredging?	300	NA	175	150	25-30	NA	100 Plus

Channel Features – Marinas:

	Annisquam R.	Blyman's Canal	Lobster Cove	Gloucester H.	Lane's Cove	Hodgkin's C.	Little River
Please describe existing marinas:	Cape Ann Marine	NA	Private docks, Annisquam Yacht Club and Marina	Multiple Marinas	NA	NA	1 Marina
Marina Ownership (public / private)?	Private		Private	Private	NA	NA	Private
Does the marina require dredging (Y/ N)?	Yes		Yes	Some	NA	NA	Yes
Number of slips in harbor dependent on dredging?	250		55	Over 100	NA	NA	30

Additional Comments / Feedback / Notes:

North Shore Dredge Purchase Feasibility Study

Preliminary Data Collection - Town of Manchester-by-the-Sea, MA

Name: Bion Pike

Position: Harbormaster

Contact Information: cell# 978-473-2520/ email harbormaster@manchester.ma.us

Navigation Channel(s)*

- Magnolia Cove: Not dredged or maintained. This is an exposed harbor that would benefit from a breakwater from Magnolia Pt. to Kettle Island.
- Manchester Harbor/Area 2: Dredged in 2018. Not part of the planned next round of dredging
- Manchester Harbor/Area 3: Partially dredged in 2018. Not part of the planned next round of dredging.
- Whittier's Cove/Area 4: To be converted to shallow draft vessels on double point moorings in an effort to delay dredging.
- Proctor Cove/Area5: To be dredged in the next round. Hydro survey completed by Foth/ CLE in October of 2018.
- Innermost Harbor (Inside Draw Bridge)/Area 1: Adjacent to town dock and below the drawbridge are in need of dredging.
- Yacht Club adjacent Proctor's Cove/ Channel: The channel is shoaling rapidly at Glass Head. To be dredged in the next round.

*For each of the navigation channel(s) listed above, please provide a brief narrative describing:

1) The current navigability of the waterway;
2) Specific dredging needs within the waterway;
3) Public safety concerns within the waterway.

Historic Dredging:

	Magnolia Cove	Manchester Harbor	Whittier's Cove	Proctor Cove	Innermost	Yacht Club

Has channel been dredged (Y/N)?	No	Yes	Yes	Yes	Yes	Yes
Project funding source (Fed, State, Private)?	No	State, Local Private	Federal, State	Federal, State	Federal, State Private	Federal, State
Date of last dredging?	N/A	2018	N/A	N/A	2018	2000?

<u>Future Dredging</u>:

	Magnolia Cove	Manchester Harbor	Whittier's Cove	Proctor Cove	Innermost	Yacht Club
Has dredging kept the channel safe and navigable (Y/N)?	N/A	Yes	Yes	Yes	Yes	Yes
If "Yes", how many years before it is needed again?	N/A	10	10	Now	10	Now
Is channel scheduled to be dredged (Y/N)?	N/A	No	No	No	No	No
If "Yes" project funding source (Fed, State, Private)?	N/A					
Date dredging is scheduled to occur?	N/A					
What depth is required for safe passage at MLW?	N/A	8' at Mean Low	6' at Mean Low	8' at Mean Low	8' at Mean Low	8' at Mean Low

<u>Existing Permits:</u>

	Magnolia Cove	Manchester Harbor	Whittier's Cove	Proctor Cove	Innermost	Yacht Club

Does the Town currently hold Federal, State, and/or Local permits to dredge the waterway?	N/A	No	No	Mo	No	No
Are permits current and regularly renewed?	N/A	Not yet	Not yet	Not yet	Not yet	Not yet
Town official responsible for furnishing Permits?	N/A	Harbormaster	Harbormaster	Harbormaster	Harbormaster	Harbormaster

Beneficial Reuse of Dredged Material:

	Magnolia Cove	Manchester Harbor	Whittier's Cove	Proctor Cove	Innermost	Yacht Club
What type of sediment does the channel contain (cobble / sand / mud, variable)?		Mud/Till	mud	mud	mud	variable
Preferred method of disposal (beach nourishment / offshore / upland / thin layer deposition (TLD))?		offshore	offshore	offshore	offshore	N/A

Channel Features – Mooring Fields:

	Magnolia Cove	Manchester Harbor	Whittier's Cove	Proctor Cove	Innermost	Yacht Club
Please describe existing mooring fields:	Exposed/S/SW	Harbor of Refuge	Harbor of Refuge	Harbor of Refuge	Harbor of Refuge	Harbor of Refuge

Mooring Field Ownership (public / private)?	public	public	public	public	public	public
Does mooring field require dredging (Y/N)?	Yes	Yes	Yes	Yes	Yes	Yes
Number of moorings dependent on dredging?	N/A	127	73	95	62	55

<u>Channel Features – Marinas</u>:

	Magnolia Cove	Manchester Harbor	Whittier's Cove	Proctor Cove	Innermost	Yacht Club
Please describe existing marinas:	N/A	Commercial & Property Owner	Property Owner	Property Owner	Commercial & Property Owner	Property Owner & yacht club
Marina Ownership (public / private)?	N/A	private	private	private	private	private
Does the marina require dredging (Y/ N)?	N/A	Yes	Yes	Yes	Yes	Yes
Number of slips in harbor dependent on dredging?	N/A	52	2	2	73	5

<u>Commercial and Recreational Boat Traffic</u>:

	Magnolia Cove	Manchester Harbor	Whittier's Cove	Proctor Cove	Innermost	Yacht Club
Please describe typical, peak season boat traffic:	N/A	Up to 400/day visiting day transient vessels	Up to 400/day visiting day transient vessels	Up to 400/day visiting day transient vessels	Up to 400/day visiting day transient vessels	Up to 400/day visiting day transient vessels

Number of commercial fishermen?	N/A	28	N/A	N/A	N/A	N/A
Number of charter boats?	N/A	2	N/A	2	N/A	2
Number of recreational crafts (peak season)?	N/A	Up to 400/day visiting day transient vessels	Up to 400/day visiting day transient vessels	Up to 400/day visiting day transient vessels	Up to 400/day visiting day transient vessels	Up to 400/day visiting day transient vessels
Average LOA vessel?	N/A	26’	26’	26’	26’	26’
Average draft vessel?	N/A	4’	4’	4’	4’	4’
Maximum LOA and draft vessel allowed?	N/A	45’LOA / on a mooring	45’LOA / on a mooring	45’LOA / on a mooring	45’LOA / on a mooring	45’LOA / on a mooring

Additional Comments / Feedback / Notes:

____________No draft restrictions. Manchester is a destination Harbor for the region similar to Cranes and Wingersheek Beaches____

____

____

5.0 Appendix E

Report of the Barnstable County DREDGE

THE CODFISH

Barnstable County Dredge
The Codfish

Superior Court House
P.O. Box 427
Barnstable, MA 02630

M/V "J.W. Doane" with dredge "Cod Fish" passing through the Cape Cod Canal.

Administration

Wayne Jaedtke, Superintendent
508-375-6634 | wjaedtke@barnstablecounty.org

Staff

Stephen Bradbury, Captain
Christopher E. Armstrong, Leverman
Jason Bevis, Deckhand
Cory Fleming, Deckhand

INTRODUCTION

In 1993 Barnstable County conducted a needs assessment and cost benefit analysis of operating a municipal dredge program on behalf of the towns. This report documented that a County operated maintenance-dredging program would be both beneficial to the towns and cost effective to operate.

The County and its legislative delegation approached the Massachusetts Department of Environmental Management (DEM) and requested financial assistance in the form of a $1 million capital grant for the purchase of a dredge and ancillary equipment. Prior to this grant, the state was responsible for funding 75% of the cost of municipal dredge projects and the town was responsible for the remaining 25%. However, funding constraints at the state level meant that much of the dredge work was not completed on a timely basis or was never accomplished. As stipulated in the grant Agreement, the provision of a capital grant replaces the state funding for municipal dredge projects here on the Cape.

The Barnstable County Dredge Advisory Committee was established in October of 1994. The Committee has representation from all of the Cape towns, except Brewster, which has no navigable harbors, DEM and County staff. The Advisory Committee is responsible for developing the dredge schedule and recommending the dredge rate each fiscal year.

COMPLETED DREDGE PROJECTS:

To date the County has dredged 1,856,254 cubic yards of material from the waterways in 16 Cape and Island towns over 21 years. Barnstable County dredged these waterways at a rate approximately 65% below the market rate. The cost per cubic yard to dredge this material ranged between $3.33 and $13.00 per cubic yard. The average market rate for dredge services is over $18.00 per cubic yard.

If there were no Barnstable County dredge program, it would have cost the tax payers an additional $530,602 to complete the dredge projects that the County has completed on behalf of the towns on the Cape and Islands in FY 2017. This amount is based on the state paying 75% of the cost of town dredge projects at $18.00 per cubic yard.

The following projects were completed this fiscal year totaling 77,658 cubic yards of material to nourish the beaches:

- Allen Harbor Approach Channel
- Chatham, Aunt Lydia's Cove
- Dennis, Bass River
- Falmouth Green & Great Pond Inlets
- Harwich, Allen Harbor Inlet
- Mashpee, Popponesset Bay Channels
- Yarmouth, Parkers River Channel

In addition to a reduced rate for dredging services, the County conducts before and after dredge surveys at a savings of approximately $6,000 per project to the towns. These surveys are invaluable records in the event of a major hurricane for submission to the Federal Emergency Management Agency as documentation of storm damage.

FISCAL STATUS

The operating revenue for FY 2017 was $867,242.

Chatham's south coast shoreline dredging project at Mill Creek Mill Creek.

6.0 Appendix F

North Shore Dredge Purchase Feasibility Study
Update Meeting #2 – Meeting Minutes
29 April 2019

Progress to Date:

Meetings and Stakeholder Engagement 4/1, 5/1
Regional Sediment Characterization – April 2019
ID Suitable Dredging Equipment – April 2019 (pending)

- **Survey Results**
  - Responses Received – 7 municipalities provided written responses
    - Emphasis on public safety / response time
    - Shallow depths, narrow channels, tidal restrictions
    - Urgent need for dredging as you approach inlets
  - Overview of Dredging Need

- **Sediment Quantity and Quality Manchester – Salisbury, MA**
  - Sediment Characteristics
  - Sediment Quantity
    - The following sources were referenced when developing sediment quantity and quality estimates:
    - Sediment Quantity Data Sources
      - ACOE Dredge Records
      - ACOE Annual Reports
      - Massachusetts Bay Disposal Site Records
    - Sediment Quality Data Sources
      - USGS East Coast Sediment Texture Database
      - MASS CZM Dredge Materials Management Plans
      - ACOE Dredge Records
      - ACOE Annual Reports
    - Peer-reviewed research papers
      - Estimated Dredge Quantities
      - ACOE Hydrographic Surveys
    - Estimated dredge volumes using most recent ACOE Hydrographic Surveys

- **General Comments:**
    - 220k yards material estimated from mouth of Merrimack River (R. Boeri)
    - Dredging mouth of Merrimack requires alternating 75/25 split of dredge spoils btn. Salisbury / Newburyport (R. Boeri)
    - Plum Island River – usage increasing with shoaling at mouth of Merrimack
    - MA State of the Harbors Report to inform dredge quantity estimates (R. Boeri)

- Sandy Point State Reservation is accreting – DCR-funded Sediment Tx. Study pending (R. Boeri)
- Sandy Point State Reservation Mgmt. Plan discourages placement of dredged material on Reservation property (R. Boeri)
- Granite Pier site may also have eelgrass present

- **Alternatives for Beneficial Reuse (by Town)**
  - Beach Nourishment – Dune Enhancement
  - Marsh Enhancement – Marsh Restoration
  - Thin Layer Deposition
  - Upland / Offshore Disposal

- **General Comments:**
  - Client looking at full suite of alternatives for beneficial reuse and disposal of dredged material – beach nourishment, dune enhancement, upland, offshore, marsh creation, TLD, ditch-filling, etc. (A. Finkle)
  - Emphasis should be placed on alternatives for beneficial reuse and disposal that are currently permittable in the state of Massachusetts (R. Boeri)

- **Data Gaps**
  - Dredging events in non-federal waterways difficult to identify
  - Feasibility of alternatives
  - Historic permit records (municipal)
  - Required dredge frequency

Regional Dredging Perspectives – Round Table Discussion:

- **Operational Perspective – Jack Yunits, County Administrator, Barnstable County**
  - **Overview** of Barnstable County Regional Dredge Program
  - **Funding** – Capital Outlay – Subsequent Dredge Purchase(s)
  - **Scheduling** – Prioritizing Projects – # Projects per Year
  - **Financial Considerations** – Funding, Staffing
    - Towns pay rate / cubic yard $9-13 all inclusive (J. Yunits)
    - County pays salaries, benefits, operational costs (J. Yunits)
    - Organization is key – County is restructuring dredge program (J. Yunits)
    - County seeking consultant to develop dredge database, guide permitting, guide scheduling (J. Yunits)
    - Depreciation / emergency accounts are key consideration (J. Yunits)
    - Inter-municipal agreement would be required on north shore (J. Yunits)
    - County looking into dredges that can handle variable material (J. Yunits)
    - $1.8M annual operating budget (J. Yunits)
    - Costs ~1/3 of private dredge contractor (J. Yunits)

- **Municipal Perspective – Ted Keon, Director of Coastal Resources, Chatham, MA**
    - **Benefits** of Regional Dredge Program
    - **Drawbacks** of Regional Dredge Program
    - Balancing ACOE (FNP) Projects with Regional Dredge Projects
    - **Permitting** Considerations
    - **Financial** Considerations
        - Dredge Material is important sand source (T. Keon)
        - Accessibility an issue for hydraulic dredge (T. Keon)
        - Important to ID viable alternatives for disposal (T. Keon)
        - Difficult to get private dredge rates – there may be push back from private dredge industry (T. Keon)
        - Challenges with dredge frequency / demand (T. Keon)
        - Issues with storage of equipment and re-mobilization (T. Keon)
        - Need home-base for equipment (T. Keon)
        - Disposal an issue with permitting – needs to be nailed down prior to dredge purchase (T. Keon)
        - TLD – special equipment would be required (T. Keon)
        - Dredge Advisory Group – reviews rates and sets schedule (T. Keon)
        - Comprehensive permit strategy complicated, but Chatham has exemplified BMPs in the dredge / permitting arena (T. Keon)
        - Municipal dredging is open to liability – be prepared! (T. Keon)

- **Closing Comments:**
    - Annual need on N. shore may not be enough to drive municipal dredge program
    - Make sure to ID the right equipment for the job
    - Towns on Cape looking at municipal (Town by Town) dredge purchases – not easy to implement – many hurdles!
    - Important next steps (beyond scope of report) is to ID required dredge frequency – pending DCR Report should help inform this data gap

Site Visit – Parker's River, Yarmouth, MA

- **Active Dredge Site**
    - Dredge Superstructure
    - Pipeline
    - Dewatering / Disposal Site

(See site photographs on subsequent pages)

Figure 1 – Locus map showing location of (2) typical Barnstable County Dredge project sites.

Figure 2 – Parkers River inlet, Yarmouth, MA

Figure 3 – Barnstable County Dredge “Codfish” superstructure at work in approach channel to Parkers River, Yarmouth, MA.

Figure 4 – Barnstable County Dredge “Codfish” superstructure.

Figure 5 – Barnstable County Dredge dewatering site. As project continues, dredge spoils will accrete on beach.

Figure 6 – Barnstable County Dredge discharge pipe – dredge superstructure visible in background, dredge pipeline sits on bottom of Nantucket Sound to minimize impacts to navigation.

7.0 Appendix G

Waterway	Date	Title	Sheet ID	File ID	Controlling Depth (ft, MLLW)	Mean Shoal Elevation (ft, MLLW)	Shoal Area (sq. ft)	Estimated Take Off Volume (cy)
Merrimack River	5/29/2018	Merrimack River, Newburyport, Salisbury, Amesbury, West Newbury, Merrimac, Groveland, and Haverill, MA Obstruction Survey	Merrimack River 16/30	MA_02_MER_20180529_CS_2018_024	7	6.31	29,193	745
						Salisbury	**TOTAL**	**745**
Newburyport Harbor	4/20/2016	Newburyport Harbor, Newburyport, MA Condition Survey 9 and 15-Foot Channels	Newburyport Harbor 1-2/4	MA_01_NEB_20160420_CS_40	15	10.38	756,524	129,320
Newburyport Harbor	4/20/2016	Newburyport Harbor, Newburyport, MA Condition Survey 9 and 15-Foot Channels	Newburyport Harbor 3-4/4	MA_01_NEB_20160420_CS_40	9	7.99	258,809	9,672
Newburyport Harbor	5/3/2018	Newburyport Harbor, Newburyport, MA Condition Survey 9 and 15-Foot Channels	Newburyport Harbor 1/4	MA_01_NEB_20180503_CS_2018_020	15	10.66	480,870	77,218
Newburyport Harbor	5/24/2018	Newburyport Harbor, Newburyport, MA Condition Survey 9 and 15-Foot Channels	Newburyport Harbor 1-2/4	MA_01_NEB_20180524_CS_2018_020	15	11.07	359,417	52,263
						Newburyport	**TOTAL**	**139,153**
Annisquam River	1/4/2017	Annisquam River, Gloucester, MA Condition Survey 8-Foot Channel And Anchorage	Annisquam River and Lobster Cove 1-20	MA_08_GLO_20170104_CS_10	8	5.66	428,333	37,085
Annisquam River - Reach 3-4	12/18/2018	Annisquam River, Gloucester, MA Condition Survey 8-Foot Channel And Anchorage	Annisquam River and Lobster Cove 5-7/20	MA_08_GLO_20181218_CS_2018_077	8	4.8	194,292	23,004
Annisquam River - Lobster Cove & Reach 7	12/19/2018	Annisquam River, Gloucester, MA Condition Survey 8-Foot Channel And Anchorage	Annisquam River and Lobster Cove 13-16,19-20/20	MA_08_GLO_20181219_CS_2018_077	8	5.66	617,507	53,464
Gloucester Harbor - Anchorage	1/4/2017	Gloucester Harbor, Gloucester, MA Condition Survey 16, 18 and 20-Foot Channels 15 and 16-Foot Anchorages	Gloucester Harbor 2/4	MA_07_GLO_20170104_CS_20	15	14.65	763	10
Gloucester Harbor - Smith Cove	1/4/2017	Gloucester Harbor, Gloucester, MA Condition Survey 16, 18 and 20-Foot Channels 15 and 16-Foot Anchorages	Gloucester Harbor 4/4	MA_07_GLO_20170104_CS_20	16	15.28	43,659	1,163
Gloucester Harbor - Harbor Cove	1/4/2017	Gloucester Harbor, Gloucester, MA Condition Survey 16, 18 and 20-Foot Channels 15 and 16-Foot Anchorages	Gloucester Harbor 1-2/4	MA_07_GLO_20170104_CS_20	18	17.12	57,403	1,869
Gloucester Harbor - North and South Channel	1/4/2017	Gloucester Harbor, Gloucester, MA Condition Survey 16, 18 and 20-Foot Channels 15 and 16-Foot Anchorages	Gloucester Harbor 2-3/4	MA_07_GLO_20170104_CS_20	20	18.99	262,976	9,827
						Gloucester	**TOTAL**	**126,422**
Ipswich River	12/8/2015	Ipswich River, Ipswich, MA Condition Survey 4-Foot Channel	V-113	MA_03_IPS_20151208_CS_10	4	-0.87	16,833	3,033
					4	-0.7	180,000	31,302
					4	-1.03	870,000	161,916
						Ipswich	**TOTAL**	**31,302**
Essex River	7/13/2015	Essex River, Essex, MA Condition Survey 4-Foot Channel	V-101 - V-110	MA_04_ESS_20150713_CS_10	4	1.91	345,902	26,749
Essex River Town Landing					4	1.56	113,038	10,205
Essex River Mouth					4	2.24	132,000	8,596
Essex River - Reach 1	12/11/2015	Essex River, Essex, MA Report of Channel Conditions 100 to 400 Feet Wide		MA_04_ESS_20151211_CS_10	4	2.04	104,220	7,558
						Essex	**TOTAL**	**53,108**
Rockport Harbor	4/9/2013	Rockport Harbor, Rockport, MA, Condition Survey 10-Foot Channel, 6-Foot North & South Outer Anchorages	V-101	MA_05_RKM_20130409_CS_10	10	7.76	2,841	235
Rockport Harbor - Anchorages	4/9/2013	Rockport Harbor, Rockport, MA, Condition Survey 10-Foot Channel, 6-Foot North & South Outer Anchorages	V-101	MA_05_RKM_20130409_CS_10	8	7.76	2,402	21
						Rockport	**TOTAL**	**257**
						ALL WATERWAYS	**TOTAL**	**350,987**

8.0 Appendix H

Sediment Quality Data

Waterbody	Lithology	% Sand (Average)	Database	Source	Date	No. Samples	Notes
Salisbury							
Merrimack River	Gravel and sand	88.21	USGSECSTDB	USGS Open Report 03-001	1994	3	Mouth of Merrimack
	Sand	93.76	USGSECSTDB	USGS Open Report 03-001	1994	34	Main Channel, east of Rt 1 bridge
	Gravel and sand		NOSGOM	USGS Open Report 03-001	1954	16	Main Channel, east of Rt 1 bridge
	Gravel		NOSGOM	USGS Open Report 03-001	1954	2	Immediately east of Rt 1 bridge
	Sand and gravel	91.93	USGSECSTDB	USGS Open Report 03-001	1994	8	Immediately east of Rt 1 bridge
	Sand and gravel		NOSGOM	USGS Open Report 03-001	1954	6	Main Channel, between I95 bridge and Rt 1 bridge
	Sand	97.51	USGSECSTDB	USGS Open Report 03-001	1994	22	Main Channel, between I95 bridge and Rt 1 bridge
	Sand and gravel		NOSGOM	USGS Open Report 03-001	1954	3	Main Channel, upstream of I95 bridge
	Sand and gravel	84.65	USGSECSTDB	USGS Open Report 03-001	1994	4	Main Channel, upstream of I95 bridge
Black Rock Creek	Muddy sand			Hartwell, 1970	1970		
Blackwater River							
Town Creek	Muddy sand to sandy mud			Hartwell, 1970	1970		
Amesbury							
Powow River							
Newburyport							
Newburyport Harbor	Gravel and sand	88.21	USGSECSTDB	USGS Open Report 03-001	1994	3	Mouth of Merrimack; 88% sand because of higher percentage of gravel
	Sand	93.76	USGSECSTDB	USGS Open Report 03-001	1994	34	Main Channel, east of Rt 1 bridge
	Gravel and sand		NOSGOM	USGS Open Report 03-001	1954	16	Main Channel, east of Rt 1 bridge
	Silt and mud			Hartwell, 1970	1970		Joppa Flats, south of channel
Merrimack River							Newburyport to Haverhill and Lawrence
Newbury							
Parker River							
Plum Island River	Gravel and sand; muddy sand in			Hartwell, 1970	1970		
Plum Island Sound	Sand		NOSGOM	USGS Open Report 03-001	1954	2	Mouth of Parker River
Plumbush Creek	Sand and Mud		NOSGOM	USGS Open Report 03-001	1954	15	Sand in channel, mud on flats/banks
Rowley							
Plum Island Sound	Sand		NOSGOM	USGS Open Report 03-001	1954	6	Rowley section of Plum Island Sound, fine to coarse sand
Rowley River							
Ispwich							
Plum Island Sound							
Ipswich River	Sand		NOSGOM	USGS Open Report 03-001	1954	23	Ipswich section of Plum Island Sound, sand with several mud samples along channel edges
Ipswich Bay	Sand		Anan71	USGS Open Report 03-001	1971	3	Mouth of sound
Eagle Hill, Castle Neck River, Essex River							
Essex							
Essex River	Sand		Anan71	USGS Open Report 03-001	1971	22	Sand, with 5 samples of muddy sand
Essex Bay	Sand			Smith and Fitzgerald 1994	1989		Fine to medium sand at the inlet mouth **not inner bay
Town Landing at Rt 133							
Gloucester							
Annisquam River	Sand			MA CZM DMMP DEIR	2001		Primarily sand; Lobster Cove and upstream of Boston Maine Railroad Bridge area higher silt content
Lobster Cove	Silt			MA CZM DMMP DEIR	2001		
Gloucester Harbor	Silt			MA CZM DMMP DEIR	2001		Data from Normandeau Assoc. 1999 benthic survey
Hodgkins Cove	Sand and Rock		Smithsonian	USGS Open Report 03-001	1969	4	Mouth of harbor, rocky with sand and kelp
Little River							
Rockport							
Rockport Harbor							
Old Harbor							
Granite Pier				Rockport Harbor Plan, 2003	2003		Eel grass - not likely to be dredged
Pigeon Cove	Gravel and sand			ACOE, Water Resources Improver	1983	2	Northwest corner of harbor
	Sandy silt			ACOE, Water Resources Improver	1983	3	Northeast and southern edges of harbor
Manchester by the Sea							
Manchester Harbor	Sand with gravel and	77.78	USGSECSTDB	USGS Open Report 03-001	1999	4	Transect northeast of Loblolly Cove, sand with gravel and some silt
Whittier's Cove							
Proctor Cove	Mud		Smithsonian	USGS Open Report 03-001	1969	6	Inner harbor, not in coves
Magnolia Cove							
Manchester Bay	Sand		Smithsonian	USGS Open Report 03-001	1969	4	Shells, grass, one sample with gravel
	Muddy Sand		Smithsonian	USGS Open Report 03-001	1969	5	Outer/Southern Manchester Bay
	Sand and Mud			ACOE AR 1903	1903		

9.0 Appendix I

Alternative 1

Item	MU/UL/SL	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15
Operating Costs	MU															
Staff/Labor																
Dredge Superintendent	1.02	$100,000	$102,000	$104,040	$106,121	$108,243	$110,408	$112,616	$114,869	$117,166	$119,509	$121,899	$124,337	$126,824	$129,361	$131,948
Dredge Captain	1.02	75,000	76,500	78,030	79,591	81,182	82,806	84,462	86,151	87,874	89,632	91,425	93,253	95,118	97,020	98,961
Dredge Leverman	1.02	65,000	66,300	67,626	68,979	70,358	71,765	73,201	74,665	76,158	77,681	79,235	80,819	82,436	84,084	85,766
Dredge Deckhand	1.02	65,000	66,300	67,626	68,979	70,358	71,765	73,201	74,665	76,158	77,681	79,235	80,819	82,436	84,084	85,766
Dredge Deckhand	1.02	50,000	51,000	52,020	53,060	54,122	55,204	56,308	57,434	58,583	59,755	60,950	62,169	63,412	64,680	65,974
Dredge Deckhand	1.02	50,000	51,000	52,020	53,060	54,122	55,204	56,308	57,434	58,583	59,755	60,950	62,169	63,412	64,680	65,974
Total Staff/Labor Costs		405,000	413,100	421,362	429,789	438,385	447,153	456,096	465,218	474,522	484,012	493,693	503,567	513,638	523,911	534,389
Ancillary/Overhead																
Maintainence	1.00	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000
Insurance	1.00	25,000	25,000	25,000	25,000	25,000	25,000	25,000	25,000	25,000	25,000	25,000	25,000	25,000	25,000	25,000
Diesel Fuel	1.00	164,000	164,000	164,000	164,000	164,000	164,000	164,000	164,000	164,000	164,000	164,000	164,000	164,000	164,000	164,000
Total Ancillary/Overhead Costs		289,000	289,000	289,000	289,000	289,000	289,000	289,000	289,000	289,000	289,000	289,000	289,000	289,000	289,000	289,000
Total Annual Operating Costs		694,000	702,100	710,362	718,789	727,385	736,153	745,096	754,218	763,522	773,012	782,693	792,567	802,638	812,911	823,389
Depreciation Expense	UL/SL															
Dredge/Superstructure																
Ellicott 670 Dragon	25.00	72,000	72,000	72,000	72,000	72,000	72,000	72,000	72,000	72,000	72,000	72,000	72,000	72,000	72,000	72,000
Total Dredge/Superstructure		72,000	72,000	72,000	72,000	72,000	72,000	72,000	72,000	72,000	72,000	72,000	72,000	72,000	72,000	72,000
Marine Support Equipment																
Primary Push Boat	25.00	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000
Support Boat (to haul pipe)	15.00	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000
Support Skiff (to haul personnel)	15.00	1,333	1,333	1,333	1,333	1,333	1,333	1,333	1,333	1,333	1,333	1,333	1,333	1,333	1,333	1,333
Booster Pump	25.00	14,000	14,000	14,000	14,000	14,000	14,000	14,000	14,000	14,000	14,000	14,000	14,000	14,000	14,000	14,000
Dredge Pipe (11,000 linear feet (12-14"))	25.00	16,720	16,720	16,720	16,720	16,720	16,720	16,720	16,720	16,720	16,720	16,720	16,720	16,720	16,720	16,720
Total Marine Support/Equipment		47,053	47,053	47,053	47,053	47,053	47,053	47,053	47,053	47,053	47,053	47,053	47,053	47,053	47,053	47,053
Land Support Equipment																
3x GMC Sierra 2500HD Duramax Pickups	5.00	36,000	36,000	36,000	36,000	36,000	0	0	0	0	0	0	0	0	0	0
2x Heavy-Duty Equipment Trailers	10.00	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	0	0	0	0	0
CAT 928 Wheeled Loader	15.00	8,333	8,333	8,333	8,333	8,333	8,333	8,333	8,333	8,333	8,333	8,333	8,333	8,333	8,333	8,333
Loader Attachments	25.00	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400
Total Land Support Equipment		46,233	46,233	46,233	46,233	46,233	10,233	10,233	10,233	10,233	10,233	8,733	8,733	8,733	8,733	8,733
Total Annual Depreciation Expense		165,287	165,287	165,287	165,287	165,287	129,287	129,287	129,287	129,287	129,287	127,787	127,787	127,787	127,787	127,787
Total Annual Cost		859,287	867,387	875,649	884,076	892,672	865,439	874,382	883,504	892,809	902,299	910,479	920,353	930,425	940,697	951,176
Total Cumulative Cost (30 year)		859,287	1,726,673	2,602,322	3,486,398	4,379,070	5,244,509	6,118,891	7,002,396	7,895,205	8,797,504	9,707,983	10,628,336	11,558,761	12,499,458	13,450,634
CY to be extracted to remain solvent		57286	57826	58377	58938	59511	57696	58292	58900	59521	60153	60699	61357	62028	62713	63412

Item	Year 16	Year 17	Year 18	Year 19	Year 20	Year 21	Year 22	Year 23	Year 24	Year 25	Year 26	Year 27	Year 28	Year 29	Year 30
Operating Costs															
Staff/Labor															
Dredge Superintendent	$134,587	$137,279	$140,024	$142,825	$145,681	$148,595	$151,567	$154,598	$157,690	$160,844	$164,061	$167,342	$170,689	$174,102	$177,584
Dredge Captain	100,940	102,959	105,018	107,118	109,261	111,446	113,675	115,948	118,267	120,633	123,045	125,506	128,016	130,577	133,188
Dredge Leverman	87,481	89,231	91,016	92,836	94,693	96,587	98,518	100,489	102,498	104,548	106,639	108,772	110,948	113,167	115,430
Dredge Deckhand	87,481	89,231	91,016	92,836	94,693	96,587	98,518	100,489	102,498	104,548	106,639	108,772	110,948	113,167	115,430
Dredge Deckhand	67,293	68,639	70,012	71,412	72,841	74,297	75,783	77,299	78,845	80,422	82,030	83,671	85,344	87,051	88,792
Dredge Deckhand	67,293	68,639	70,012	71,412	72,841	74,297	75,783	77,299	78,845	80,422	82,030	83,671	85,344	87,051	88,792
Total Staff/Labor Costs	545,077	555,978	567,098	578,440	590,009	601,809	613,845	626,122	638,644	651,417	664,445	677,734	691,289	705,115	719,217
Ancillary/Overhead															
Maintainence	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000
Insurance	25,000	25,000	25,000	25,000	25,000	25,000	25,000	25,000	25,000	25,000	25,000	25,000	25,000	25,000	25,000
Diesel Fuel	164,000	164,000	164,000	164,000	164,000	164,000	164,000	164,000	164,000	164,000	164,000	164,000	164,000	164,000	164,000
Total Ancillary/Overhead Costs	289,000	289,000	289,000	289,000	289,000	289,000	289,000	289,000	289,000	289,000	289,000	289,000	289,000	289,000	289,000
Total Annual Operating Costs	834,077	844,978	856,098	867,440	879,009	890,809	902,845	915,122	927,644	940,417	953,445	966,734	980,289	994,115	1,008,217
Depreciation Expense															
Dredge/Superstructure															
Ellicott 670 Dragon	72,000	72,000	72,000	72,000	72,000	72,000	72,000	72,000	72,000	72,000	0	0	0	0	0
Total Dredge/Superstructure	72,000	72,000	72,000	72,000	72,000	72,000	72,000	72,000	72,000	72,000	0	0	0	0	0
Marine Support Equipment															
Primary Push Boat	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	0	0	0	0	0
Support Boat (to haul pipe)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Support Skiff (to haul personnel)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Booster Pump	14,000	14,000	14,000	14,000	14,000	14,000	14,000	14,000	14,000	14,000	0	0	0	0	0
Dredge Pipe (11,000 linear feet (12-14"))	16,720	16,720	16,720	16,720	16,720	16,720	16,720	16,720	16,720	16,720	0	0	0	0	0
Total Marine Support/Equipment	40,720	40,720	40,720	40,720	40,720	40,720	40,720	40,720	40,720	40,720	0	0	0	0	0
Land Support Equipment															
3x GMC Sierra 2500HD Duramax Pickups	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2x Heavy-Duty Equipment Trailers	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CAT 928 Wheeled Loader	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Loader Attachments	400	400	400	400	400	400	400	400	400	400	0	0	0	0	0
Total Land Support Equipment	400	400	400	400	400	400	400	400	400	400	0	0	0	0	0
Total Annual Depreciation Expense	113,120	113,120	113,120	113,120	113,120	113,120	113,120	113,120	113,120	113,120	0	0	0	0	0
Total Annual Cost	947,197	958,098	969,218	980,560	992,129	1,003,929	1,015,965	1,028,242	1,040,764	1,053,537	953,445	966,734	980,289	994,115	1,008,217
Total Cumulative Cost (30 year)	14,397,831	15,355,929	16,325,147	17,305,706	18,297,835	19,301,763	20,317,728	21,345,970	22,386,734	23,440,271	24,393,717	25,360,451	26,340,740	27,334,855	28,343,072
CY to be extracted to remain solvent	63146	63873	64615	65371	66142	66929	67731	68549	69384	70236	63563	64449	65353	66274	67214

10.0 Appendix J

Alternative 2

Item	MU/UL/SL	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15
Operating Costs	MU															
Staff/Labor																
Dredge Superintendent	1.02	$150,000	$153,000	$156,060	$159,181	$162,365	$165,612	$168,924	$172,303	$175,749	$179,264	$182,849	$186,506	$190,236	$194,041	$197,922
Dredge Captain	1.02	$95,000	96,900	98,838	100,815	102,831	104,888	106,985	109,125	111,308	113,534	115,804	118,121	120,483	122,893	125,350
Dredge Leverman	1.02	75,000	76,500	78,030	79,591	81,182	82,806	84,462	86,151	87,874	89,632	91,425	93,253	95,118	97,020	98,961
Dredge Deckhand	1.02	65,000	66,300	67,626	68,979	70,358	71,765	73,201	74,665	76,158	77,681	79,235	80,819	82,436	84,084	85,766
Dredge Deckhand	1.02	50,000	51,000	52,020	53,060	54,122	55,204	56,308	57,434	58,583	59,755	60,950	62,169	63,412	64,680	65,974
Dredge Deckhand	1.02	50,000	51,000	52,020	53,060	54,122	55,204	56,308	57,434	58,583	59,755	60,950	62,169	63,412	64,680	65,974
Total Staff/Labor Costs		485,000	494,700	504,594	514,686	524,980	535,479	546,189	557,113	568,255	579,620	591,212	603,037	615,097	627,399	639,947
Ancillary/Overhead																
Maintainence	1.00	250,000	250,000	250,000	250,000	250,000	250,000	250,000	250,000	250,000	250,000	250,000	250,000	250,000	250,000	250,000
Insurance	1.00	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000
Diesel Fuel	1.00	273,000	273,000	273,000	273,000	273,000	273,000	273,000	273,000	273,000	273,000	273,000	273,000	273,000	273,000	273,000
Total Ancillary/Overhead Costs		623,000	623,000	623,000	623,000	623,000	623,000	623,000	623,000	623,000	623,000	623,000	623,000	623,000	623,000	623,000
Total Annual Operating Costs		1,108,000	1,117,700	1,127,594	1,137,686	1,147,980	1,158,479	1,169,189	1,180,113	1,191,255	1,202,620	1,214,212	1,226,037	1,238,097	1,250,399	1,262,947
Depreciation Expense	UL/SL															
Dredge/Superstructure																
Custom Hopper (pump-out, side-cast, bottom-dump ca	25.00	400,000	400,000	400,000	400,000	400,000	400,000	400,000	400,000	400,000	400,000	400,000	400,000	400,000	400,000	400,000
Total Dredge/Superstructure		400,000	400,000	400,000	400,000	400,000	400,000	400,000	400,000	400,000	400,000	400,000	400,000	400,000	400,000	400,000
Marine Support Equipment																
Support Boat (to haul pipe)	15.00	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000
Support Skiff (to haul personnel)	15.00	1,333	1,333	1,333	1,333	1,333	1,333	1,333	1,333	1,333	1,333	1,333	1,333	1,333	1,333	1,333
Dredge Pipe (5,500 linear feet (12-14"))	25.00	8,360	8,360	8,360	8,360	8,360	8,360	8,360	8,360	8,360	8,360	8,360	8,360	8,360	8,360	8,360
Total Marine Support/Equipment	104595.00	14,693	14,693	14,693	14,693	14,693	14,693	14,693	14,693	14,693	14,693	14,693	14,693	14,693	14,693	14,693
Land Support Equipment																
3x GMC Sierra 2500HD Duramax Pickups	5.00	36,000	36,000	36,000	36,000	36,000	0	0	0	0	0	0	0	0	0	0
2x Heavy-Duty Equipment Trailers	10.00	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	0	0	0	0	0
CAT 928 Wheeled Loader	15.00	8,333	8,333	8,333	8,333	8,333	8,333	8,333	8,333	8,333	8,333	8,333	8,333	8,333	8,333	8,333
Loader Attachments	25.00	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400
Total Land Support Equipment		46,233	46,233	46,233	46,233	46,233	10,233	10,233	10,233	10,233	10,233	8,733	8,733	8,733	8,733	8,733
Total Annual Depreciation Expense		460,927	460,927	460,927	460,927	460,927	424,927	424,927	424,927	424,927	424,927	423,427	423,427	423,427	423,427	423,427
Total Annual Cost		1,568,927	1,578,627	1,588,521	1,598,613	1,608,906	1,583,406	1,594,115	1,605,039	1,616,181	1,627,547	1,637,639	1,649,463	1,661,524	1,673,826	1,686,374
Total Cumulative Cost (30 year)		1,568,927	3,147,553	4,736,074	6,334,687	7,943,593	9,526,999	11,121,114	12,726,153	14,342,335	15,969,881	17,607,520	19,256,984	20,918,507	22,592,333	24,278,707
CY to be extracted to remain solvent		104595	105242	105901	106574	107260	105560	106274	107003	107745	108503	109176	109964	110768	111588	112425

Item	Year 16	Year 17	Year 18	Year 19	Year 20	Year 21	Year 22	Year 23	Year 24	Year 25	Year 26	Year 27	Year 28	Year 29	Year 30
Operating Costs															
Staff/Labor															
Dredge Superintendent	$201,880	$205,918	$210,036	$214,237	$218,522	$222,892	$227,350	$231,897	$236,535	$241,266	$246,091	$251,013	$256,033	$261,154	$266,377
Dredge Captain	127,857	130,415	133,023	135,683	138,397	141,165	143,988	146,868	149,805	152,802	155,858	158,975	162,154	165,397	168,705
Dredge Leverman	100,940	102,959	105,018	107,118	109,261	111,446	113,675	115,948	118,267	120,633	123,045	125,506	128,016	130,577	133,188
Dredge Deckhand	87,481	89,231	91,016	92,836	94,693	96,587	98,518	100,489	102,498	104,548	106,639	108,772	110,948	113,167	115,430
Dredge Deckhand	67,293	68,639	70,012	71,412	72,841	74,297	75,783	77,299	78,845	80,422	82,030	83,671	85,344	87,051	88,792
Dredge Deckhand	67,293	68,639	70,012	71,412	72,841	74,297	75,783	77,299	78,845	80,422	82,030	83,671	85,344	87,051	88,792
Total Staff/Labor Costs	652,746	665,801	679,117	692,699	706,553	720,684	735,098	749,800	764,796	780,092	795,694	811,608	827,840	844,397	861,285
Ancillary/Overhead															
Maintainence	250,000	250,000	250,000	250,000	250,000	250,000	250,000	250,000	250,000	250,000	250,000	250,000	250,000	250,000	250,000
Insurance	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000
Diesel Fuel	273,000	273,000	273,000	273,000	273,000	273,000	273,000	273,000	273,000	273,000	273,000	273,000	273,000	273,000	273,000
Total Ancillary/Overhead Costs	623,000	623,000	623,000	623,000	623,000	623,000	623,000	623,000	623,000	623,000	623,000	623,000	623,000	623,000	623,000
Total Annual Operating Costs	1,275,746	1,288,801	1,302,117	1,315,699	1,329,553	1,343,684	1,358,098	1,372,800	1,387,796	1,403,092	1,418,694	1,434,608	1,450,840	1,467,397	1,484,285
Depreciation Expense															
Dredge/Superstructure															
Custom Hopper (pump-out, side-cast, bottom-dump ca	400,000	400,000	400,000	400,000	400,000	400,000	400,000	400,000	400,000	400,000	0	0	0	0	0
Total Dredge/Superstructure	400,000	400,000	400,000	400,000	400,000	400,000	400,000	400,000	400,000	400,000	0	0	0	0	0
Marine Support Equipment															
Support Boat (to haul pipe)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Support Skiff (to haul personnel)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dredge Pipe (5,500 linear feet (12-14"))	8,360	8,360	8,360	8,360	8,360	8,360	8,360	8,360	8,360	8,360	0	0	0	0	0
Total Marine Support/Equipment	8,360	8,360	8,360	8,360	8,360	8,360	8,360	8,360	8,360	8,360	0	0	0	0	0
Land Support Equipment															
3x GMC Sierra 2500HD Duramax Pickups	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2x Heavy-Duty Equipment Trailers	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CAT 928 Wheeled Loader	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Loader Attachments	400	400	400	400	400	400	400	400	400	400	0	0	0	0	0
Total Land Support Equipment	400	400	400	400	400	400	400	400	400	400	0	0	0	0	0
Total Annual Depreciation Expense	408,760	408,760	408,760	408,760	408,760	408,760	408,760	408,760	408,760	408,760	0	0	0	0	0
Total Annual Cost	1,684,506	1,697,561	1,710,877	1,724,459	1,738,313	1,752,444	1,766,858	1,781,560	1,796,556	1,811,852	1,418,694	1,434,608	1,450,840	1,467,397	1,484,285
Total Cumulative Cost (30 year)	25,963,213	27,660,774	29,371,652	31,096,111	32,834,424	34,586,869	36,353,727	38,135,287	39,931,843	41,743,695	43,162,389	44,596,997	46,047,837	47,515,234	48,999,518
CY to be extracted to remain solvent	112300	113171	114058	114964	115888	116830	117791	118771	119770	120790	94580	95641	96723	97826	98952

11.0 Appendix K

Alternative 3 (low) @ $10/cy

Item	Markup	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20	Year 21	Year 22	Year 23	Year 24	Year 25	Year 26	Year 27	Year 28	Year 29	Year 30
Operating Costs																															
Mobilization Costs																															
Mobilization	1.00	356,000	356,000	356,000	0	0	0	0	0	0	0	356,000	356,000	356,000	0	0	0	0	0	0	0	356,000	356,000	356,000	0	0	0	0	0	0	0
Subsequent Mobilization, Demobilization (4x)	1.00	224,000	224,000	224,000	0	0	0	0	0	0	0	224,000	224,000	224,000	0	0	0	0	0	0	0	224,000	224,000	224,000	0	0	0	0	0	0	0
Total Mobilization Costs		580,000	580,000	580,000	0	0	0	0	0	0	0	580,000	580,000	580,000	0	0	0	0	0	0	0	580,000	580,000	580,000	0	0	0	0	0	0	0
Annual Dredging Costs																															
Pump & Bottom Dump @ $10/$40/C.Y.	1.00	1,169,960	1,169,960	1,169,960	0	0	0	0	0	0	0	1,169,960	1,169,960	1,169,960	0	0	0	0	0	0	0	1,169,960	1,169,960	1,169,960	0	0	0	0	0	0	0
Total Annual Dredging Costs		1,169,960	1,169,960	1,169,960	0	0	0	0	0	0	0	1,169,960	1,169,960	1,169,960	0	0	0	0	0	0	0	1,169,960	1,169,960	1,169,960	0	0	0	0	0	0	0
Total Annual Cost		1,749,960	1,749,960	1,749,960	0	0	0	0	0	0	0	1,749,960	1,749,960	1,749,960	0	0	0	0	0	0	0	1,749,960	1,749,960	1,749,960	0	0	0	0	0	0	0
Total Cumulative Cost (30 year)		1,749,960	3,499,920	5,249,880	5,249,880	5,249,880	5,249,880	5,249,880	5,249,880	5,249,880	5,249,880	6,999,840	8,749,800	10,499,760	10,499,760	10,499,760	10,499,760	10,499,760	10,499,760	10,499,760	10,499,760	12,249,720	13,999,680	15,749,640	15,749,640	15,749,640	15,749,640	15,749,640	15,749,640	15,749,640	15,749,640

Alternative 3 (high) @ $40/cy

Item	Markup	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20	Year 21	Year 22	Year 23	Year 24	Year 25	Year 26	Year 27	Year 28	Year 29	Year 30
Operating Costs																															
Mobilization Costs																															
Mobilization	1.00	356,000	356,000	356,000	0	0	0	0	0	0	0	356,000	356,000	356,000	0	0	0	0	0	0	0	356,000	356,000	356,000	0	0	0	0	0	0	0
Subsequent Mobilization, Demobilization (4x)	1.00	224,000	224,000	224,000	0	0	0	0	0	0	0	224,000	224,000	224,000	0	0	0	0	0	0	0	224,000	224,000	224,000	0	0	0	0	0	0	0
Total Mobilization Costs		580,000	580,000	580,000	0	0	0	0	0	0	0	580,000	580,000	580,000	0	0	0	0	0	0	0	580,000	580,000	580,000	0	0	0	0	0	0	0
Annual Dredging Costs																															
Pump & Bottom Dump @ $10/$40/C.Y.	1.00	4,679,840	4,679,840	4,679,840	0	0	0	0	0	0	0	4,679,840	4,679,840	4,679,840	0	0	0	0	0	0	0	4,679,840	4,679,840	4,679,840	0	0	0	0	0	0	0
Total Annual Dredging Costs		4,679,840	4,679,840	4,679,840	0	0	0	0	0	0	0	4,679,840	4,679,840	4,679,840	0	0	0	0	0	0	0	4,679,840	4,679,840	4,679,840	0	0	0	0	0	0	0
Total Annual Cost		5,259,840	5,259,840	5,259,840	0	0	0	0	0	0	0	5,259,840	5,259,840	5,259,840	0	0	0	0	0	0	0	5,259,840	5,259,840	5,259,840	0	0	0	0	0	0	0
Total Cumulative Cost (30 year)		5,259,840	10,519,680	15,779,520	15,779,520	15,779,520	15,779,520	15,779,520	15,779,520	15,779,520	15,779,520	21,039,360	26,299,200	31,559,040	31,559,040	31,559,040	31,559,040	31,559,040	31,559,040	31,559,040	31,559,040	36,818,880	42,078,720	47,338,560	47,338,560	47,338,560	47,338,560	47,338,560	47,338,560	47,338,560	47,338,560

12.0 Appendix L

FY18 SALARY SCHEDULE - DREDGE - 2% COLA

		MINIMUM	MID-POINT	MAXIMUM	
D-1	ANNUAL	40,034.59	44,021.89	52,201.55	deckhand
	80 HRS	1,539.79	1,693.15	2,007.75	
	DAILY	153.9792	169.3150	200.7752	
	HOURLY	19.2474	21.1644	25.0969	
D-2	ANNUAL	44,665.71	55,515.20	64,955.07	Leverman
	80 HRS	1,717.91	2,135.20	2,498.27	
	DAILY	171.7912	213.5200	249.8272	
	HOURLY	21.4739	26.6900	31.2284	
D-3	ANNUAL	44,665.71	55,515.20	64,955.07	Maintenance Engineer
	80 HRS	1,717.91	2,135.20	2,498.27	
	DAILY	171.7912	213.5200	249.8272	
	HOURLY	21.4739	26.6900	31.2284	
D-4	ANNUAL	48,501.44	60,499.09	71,476.08	Captain
	80 HRS	1,865.44	2,326.89	2,749.08	
	DAILY	186.5440	232.6888	274.9080	
	HOURLY	23.3180	29.0861	34.3635	
D-5	ANNUAL	79,308.18	86,662.10	97,539.10	Superintendent
	DAILY	305.0315	333.3152	375.1504	
	HOURLY	42.3131	46.2354	52.0408	