BENEFICIAL USES OF DREDGED MATERIAL FROM NARRAGANSETT BAY

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There are currently several coastal projects where dredging is planned within Narragansett Bay, Rhode Island. These projects, which include dredging of the Providence River channel, development of a port facility at Quonset Point/Davisville (QPD), and maintenance dredging of several marinas, would generate over 10 million cubic yards (7.6 million m3) of dredged material. The issues surrounding the disposal of this very large quantity of material will have a significant impact on both economic development in the region and the environment. Current plans are to dispose of the uncontaminated sediments from the Providence River Channel either in Narragansett Bay or in Rhode Island Sound, both of which face opposition from environmental groups and local fishermen. Contaminated materials would be disposed of in a CAD cell within the Providence River. With the large amount of dredged sediments being generated from the Bay, there is a clear need to consider reuse alternatives to disposal. Development of economically viable beneficial use alternatives have several attractions including reducing the need for aquatic disposal with attendant environmental advantages. Upland uses could include fill for highway construction and capping material for brownfields remediation projects. Other uses being considered are restoration of aquatic habitats and dewatering the sediments with subsequent use for beach replenishment.

This paper presents the results of a current laboratory testing program to evaluate beneficial use alternatives for uncontaminated materials from the channel and turning basins at the Quonset Point/Davisville facility. Results of a site investigation indicate that significant amounts of sand/gravel will be encountered within the planned dredged depths (approximately -42ft MLW). The testing program includes blending sandy sediments with building debris for construction fill and compaction and hydraulic conductivity tests of organic silts for use as capping material. The effectiveness of admixture stabilization with Portland cement, lime, and flyash is also investigated. The cost of these reuse options are compared to existing aquatic disposal options in the Bay.

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GRAVITATIONAL FLOWS AND THE DISPERSION OF DREDGED RESUSPENDED SEDIMENTS: THE FORGOTTEN FACTOR ?

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Key words: sediment resuspension, sediment plumes, gravitational flow, dispersion

Dredging in and adjacent to sensitive marine habitats often requires implementation of protocols intended to minimize the far-field dispersion of sediments resuspended by the operating dredge or discharged from the transport barge and/or the repository basin. The majority of these protocols seek to minimize resuspension through the selection of specialized equipment and the control of production rates. While significantly reducing source concentrations of suspended materials none of these methods eliminates resuspension. The resultant plume spreads under the combined effects of gravitational settling and horizontal advection. The relative importance of these two factors ultimately governs spatial settlement patterns and depositional characteristics including thickness, grain size distributions, and material composition. Horizontal advection varies as a function of local flow characteristics and is site specific. With some few exceptions, this velocity field shows minimal dependence on dredging protocols and is difficult or impossible to control. In contrast, gravitational settling rates, dependent on both the concentration and composition of the materials in suspension, display particular sensitivity to dredging protocols. Analyses of data obtained in the wake of a variety of estuarine dredging operations indicate that as source concentrations decrease settlement rates progressively decrease and in the limit approach values governed simply by particle grain size. For fine-grained silts and clays limiting values of individual particle settling velocities can range below mm/sec resulting in long term retention of these particles in the water column and potentially significant far-field transport prior to deposition. Increasing source concentrations favors the onset of mass settling in which depositional velocities are governed by the density contrast between the plume of suspended materials and the surrounding waters. The resulting gravitational flows proceed over the vertical at rates far in excess of those characteristic of individual particle settlement. Analysis of conditions in a number of typical estuarine projects yields settling rates ranging from cm/sec to m/sec. Such rates favor minimization of far-field dispersion with settlement in large part confined to the immediate dredge site. These results suggest that efforts to minimize dredge associated resuspension may be counterproductive if the goal is to control far-field dispersion. The implications of gravitational flow analysis are discussed with the results used to develop guidelines for the specification of dredging protocols for application in both navigational and environmental dredging projects.

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BOTTOM IMAGING FOR PRE-DREDGE HAZARD IDENTIFICATION ON CONTAMINATED SEDIMENT REMOVAL PROJECTS

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Key words: imaging, subbottom profiling, side scan sonar, magnetics, dredging, contaminated sediments, hazards identification

Historically, dredging projects have focused on the removal of sediment from channel areas of navigable waterways, where anecdotal information and simple sensing instrumentation can be relied upon in the assessment of the amount and type of hazards to dredging that will be encountered. Recently, the scale of contaminated sediment cleanup projects has elevated the issue of identifying dredging hazards to a higher level. Cleanup projects such as the New Bedford Harbor Superfund Site Cleanup involve shore-to-shore dredging of large portions of entire harbors. For such projects, costly delays can occur when a complete picture of the harbor bottom is not obtained prior to the planning of the dredging.

At the New Bedford Harbor Site, Foster Wheeler Environmental Corporation scientists worked with the U.S Army Corps of Engineers to design a multi-phase imaging program focussed on providing critical information in advance of the design of the dredging program. High quality images of the bottom and subbottom of the harbor were collected using Side Scan Sonar, Subbottom Profiler, and Magnetometer equipment in order to identify potential hazards to the future dredging program, and to obtain information on the character of the sediments to be dredged. In addition to locating objects of concern such as modern debris, abandoned moorings, former pilings, sunken vessels, pipelines and cables, the data revealed information concerning the relative bottom hardness. Both the hazards identification and bottom hardness information is being used in the design of the dredging program at the Harbor. The information gathered is highly useful in the determination of dredging rates and in the identification of areas of particular concern (which will require pre-dredge clearance prior to sediment removal), and has decreased the liability normally associated with such large dredge design projects.

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"SHOOTING THROUGH THE GAS" - INNOVATIVE GEOPHYSICAL IMAGING OF THE DEEP SUBSURFACE FOR SHORELINE DISPOSAL CELL GEOTECHNICAL DESIGN IN A SHALLOW MARINE ENVIRONMENT

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Key words: geophysics, seismic refraction, shoreline disposal facilities, geotechnical design

A significant technical problem, which has previously hindered the collection of foundation information in marine environments, has been solved through the modification of a land-based geophysical technique for use in the marine environment. Traditional marine design involves the evaluation of geotechnical design options based upon a limited set of data collected from widely spaced borings and test probes. On land seismic refraction can be used along with a few drilled borings to generate a relatively clear picture of the bedrock surface. In the marine environment, seismic refraction has not traditionally worked well because of a troublesome characteristic of marine sediments in shallow (harbor and bay) areas. This has forced engineers in the past to drill a significant amount of expensive borings in the water in order to gain the information they need.

The Seismic refraction technique does not work well in the marine environment because shallow marine sediments contain a significant amount of organic material that degrades, producing biogenic gas. This "gas" becomes trapped within the sediment. Traditional seismic methods in ocean areas have relied on acoustic signals generated in the water column (air guns, pingers and "sparkers"), however these techniques only work in areas gas is absent in the sediment. An approach was developed for a marine Superfund site cleanup, which mimics the procedure used on land, to collect the necessary information in the shallow marine environment. By laying out sensors (hydrophones) on the harbor bottom, and burying seismic sources in the harbor bottom (below the gas pockets), the bedrock surface can be imaged, producing results that are comparable with land-based methods.

Information previously considered unattainable is now available, providing engineers seeking details on the subsurface bedrock configuration in marine environments a new method of data collection. The benefits include a significant increase in the volume of information available to engineers concerning bedrock character (thus improving interpretations and reducing risk), and a reduction in the cost of obtaining the information that engineers consider necessary to make conclusions concerning foundations in the marine environment.

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BIOLOGICAL AND CHEMICAL ANALYSES OF BOSTON HARBOR CONFINED AQUATIC DISPOSAL CELLS

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Key words: confined aquatic disposal, dredging, disposal, contaminated sediments, benthic, colonization

This study investigated biological and chemical characteristics related to benthic recolonization of confined aquatic disposal (CAD) cells constructed during the Boston Harbor Navigation Improvement Project (BHNIP). Through the Environmental Impact Review/Statement (EIR/S) process, confined aquatic disposal (CAD) was chosen as the method for dredged material disposal. CAD was intended to minimize environmental impacts and to maximize cost-efficiency and environmental benefits. One proposed benefit is the improvement of existing low-grade benthic habitat in the Inner Harbor and Mystic River. A clean sand cap over the CAD cell may provide a more favorable substrate for benthic recolonization and result in changes to ambient benthic conditions and communities.

In April, 1999, a random stratified sampling plan was used to sample bottom sediments from the Phase I pilot cell (July 1997 construction), a Phase II cell (February 1999 construction), and from undisturbed sediments. Sediment profile images, water quality data, grain size distribution, invertebrate species composition and abundance, trace metals concentrations, and organic carbon concentrations were analyzed for ten stations in the Inner Harbor.

Preliminary results indicate that sediments sampled from the cells are qualitatively similar to sediments adjacent to the cells or in an undisturbed area. Fine sediment fractions (72% to 98%) were consistently larger than sand fractions (2% to 32%). Sediment profile images revealed shallow (<3cm) redox potential depths (RPDs). Concentrations of trace metals appear to be similar among the ten stations. Invertebrate abundance was low at all locations, and only seven polychaete genera were found in total. While further data analysis is required, these preliminary results indicate that no major changes to the benthic habitat and community have resulted thus far from the construction of CAD cells in the Inner Harbor and tributaries.

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TREATMENT OF PCB CONTAMINATED DREDGE WATER FROM THE NEW BEDFORD HARBOR SUPERFUND SITE

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Key words: dredging, contaminated sediments, PCBs, water treatment

Operable Unit No. 2 of the New Bedford Harbor Superfund Site will involve the dredging of approximately 750,000 yd3 of PCB contaminated sediments and disposal of the sediments in near shore confined disposal facilities. Wastewaters generated as part of this remedial action will require treatment prior to discharge back into the harbor.

In September 2000, a 165-gpm pilot study was conducted to evaluate the effectiveness of proposed water treatment system to meet the discharge requirements of 0.065 ppb for PCBs. The pilot system consisted of: an inclined plate clarifier, chemical addition, sub-micron sand filtration and carbon adsorption. The existing UV/Oxidation system utilized during the Hot Spot sediment removal (Operable Unit No. 1, 1994-95) was also evaluated.

The results and conclusions of the pilot study will be presented.

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ASSESSMENT AND CONTROL OF SEDIMENT CONTAMINANT EXPOSURES: CONSIDERATIONS AND RECOMMENDATIONS

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Sediment chemistry is an important component of any assessment of toxicological risk associated with bedded sediment. Both mechanistically- and correlation-based approaches have been developed to provide useful tools for assessing potential sediment toxicity based on the concentrations of chemicals or chemical classes in bulk sediment. However, in the preponderance of cases it is not possible to account for, let alone distinguish the causes of, observed toxicity to test species based upon sediment chemistry data. We argue in this paper that our ability to make further progress in the assessment of causes of sediment toxicity will depend upon better understanding of sediment chemistry and development of methods that allow for better control of contaminant exposure in laboratory toxicity and bioaccumulation tests. Our understanding of field exposures is affected by the choice of chemical species to analyze and the experimental design used in field sampling. Laboratory toxicity and bioaccumulation experiments may not approximate in-situ exposure for a variety of reasons including: removal of contaminant and organic matter sources; high infaunal densities that act to deplete contaminant exposure reservoirs and oxygenate sediments; and various manipulations (including storage) of sediments or porewaters that can alter contaminant bioavailability or change the buffering capacity of contaminant in the sediments. In this paper we will provide an overview of important sediment chemistry issues that should be considered in future studies designed to assess the toxicological risks associated with in-place or dredged sediments. Questions that will be addressed include: (1) what contaminants, in addition to those conventionally measured, are most likely to be contributing to observed toxicity? (2) what are the pitfalls of field-based determinations of bioaccumulation of contaminants and what new approaches might be useful?; (3) why are pore water toxicity tests, as presently employed, inherently flawed?; (4) what are the ways in which contaminant exposures are modified in laboratory exposures with benthic invertebrates?; and (5) what general approaches might be used to best control, characterize, and mimic in-situ sediment exposures in the laboratory?

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