CONSOLIDATION SETTLEMENT OF DREDGED SEDIMENT IN A CONFINED DISPOSAL FACILITY E. Marciano1*, P. Dunlop2, and G. Matthews1

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Key words: consolidation, confined aquatic disposal facility, New York/New Jersey ports

As part of a study of the Newark Bay Confined (aquatic) Disposal Facility (NBCDF), numerical analyses of the consolidation settlement of the deposited sediment were performed and the results compared to actual settlement data. The consolidation parameters for the sediments were estimated using existing data for sediments from dredged sites within the New York and New Jersey port area and by inference from measurements of the in situ void ratios of the placed sediment in the NBCDF. In addition, approximate analyses were performed using Terzaghi's Fourier series solution for one-dimensional rate of consolidation of a single, homogeneous soil layer.

In the approximate analyses, the effect of large strain on the rate of consolidation of the layer of placed sediments was accounted for using the suggestion by Olson (1998), for which he obtained close agreement between Terzaghi's Fourier series solution and a numerical solution. Nonlinear compression was taken into account by using the void ratio versus effective stress relationship, taken for the sediment, directly and thus introducing no additional error into the analysis. The coefficient of consolidation (cv) versus effective stress was calculated from the permeability versus effective stress and the void ratio versus effective stress relationships taken for the sediments, and a suitable "average" value of CV was used for the approximate analysis.

The settlement data and both the numerical analysis results and the approximate analysis results are similar in magnitude. Comparison of the data and the results is used to discuss the degree of accuracy obtainable in prediction of settlements of sediments deposited below water.

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DESIGN AND PERMITTING OF A NEARSHORE CONFINED DISPOSAL FACILITY IN PORTLAND, OREGON

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Key words: contaminated sediments, site selection, confined disposal facility, clay liner, capping

The Columbia and Willamette River Systems of Oregon and Washington support a variety of commercial and recreational navigational interests including deep-draft access to the ports of Portland, Oregon and Vancouver, Washington. In this metropolitan area of approximately 1.5 million people, there are more than fifty marinas with moorage for thousands of vessels and numerous point and non-point source discharges of waste water and storm water run-off that impact sediment and water quality. Over the 100 years of river usage, pollutants from these sources such as heavy metals, petroleum hydrocarbons, pesticides, herbicides, organo-tins, polychlorinated biphenyls (PCBs), volatile- and semi-volatile organic compounds have rendered certain sections of this watershed potentially harmful to human health and the environment. This has led to the proposed listing of a 6.5 mile section of the Willamette River known as the Portland Harbor under the U.S. Environmental Protection Agency's (US EPA) Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA a.k.a. Superfund program.) In addition, the National Marine Fisheries Service (NMFS) has recently listed as threatened under the Endangered Species Act (ESA), several species of salmonids that utilize this vital watershed. These events, along with ever increasing public awareness have set forth a genuine need for viable solutions to maintain the navigational and ecological integrity of the region.

This paper addresses the history of events in Oregon and what has lead to the planning of a nearshore confined disposal facility (CDF) and the process (legal, technical, political) that is currently being undertaken. The site is a 22-acre island parcel originally excavated for the construction of a marina. The proposed CDF design will provide a disposal capacity of approximately 1.2 million cubic yards of non-hazardous contaminated sediments dredged from the Columbia and Willamette Rivers. The challenges of locating and permitting a CDF in a state that has never had one and in a freshwater environment where effects based sediment quality criteria have not been established are formidable. Design efforts have included containment berm seismic stability improvements, and the use of a geosynthetic clay liner (GCL) installed in 20 to 25 feet of water as additional security to prevent contaminant migration off-site. The completed CDF will be capped, contoured, and revegetated as open space and riparian habitat.

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The remediation of contaminated sediments is often accomplished by dredging the contaminated material and transporting it to a confined disposal facility. While these actions lead to a long term improvement in the quality of the local sediment and surface water, a short term increase in ambient air PCB concentrations may result during the implementation of the remedial construction activities. Volatile PCB compounds and congeners may be released during dredging, materials handling and transport, dewatering and water treatment, and disposal facility filling operations. These releases contribute to increased ambient air concentrations above background levels at downwind locations where residents or commercial workers in the public may be exposed. The airborne concentrations at the points of public exposure are influenced by: the type, magnitude, timing and spatial distribution of the emission sources (e.g., dredges and disposal facilities); the level of sediment contamination present; and the local meteorology and air dispersion patterns between the sources and the public receptors. Maximum ambient concentrations of airborne PCBs may be calculated to meet target risk goals given prescribed exposure and remediation production scenarios. Taken together, calculated risk-based exposure point concentrations may be combined with local dispersion behavior to develop a cumulative exposure budget relationship that can be compared to actual monitoring data to ensure that air concentrations at public exposure points would not exceed risk-based target values over the course of the project. This relationship can be identified for different points in time as the location of dredging operations and the quality of the contaminated sediments change. A program of air action levels, monitoring objectives, and management triggers and required responses that is built around such a chronic exposure budget can be demonstrated to be protective of all members of the potentially affected public. An approach for establishing a program for risk-based management of PCB emissions from contaminated sediment remedial construction activities is presented and discussed.

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Operating the Newark Bay Confined Disposal Facility

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Key words: Sediment, New York/New Jersey Harbor, bathymetric, subaqueous disposal, confined disposal facility

The Port Authority of New York and New Jersey has constructed and is operating a subaqueous confined disposal facility at Port Newark, New Jersey since November of 1997. The Newark Bay Confined Disposal Facility (NBCDF) is a 1.5 million cubic yard subaqueous "pit" excavated from the bottom of Newark Bay. Malcolm Pirnie, Inc. was retained by the Port Authority to develop an Operations and Management Plan and manage the facility.

The NBCDF is a much-needed disposal site for dredged materials that are deemed unsuitable for ocean disposal at the federally designated Historic Area Remediation Site (HARS) off of Sandy Hook, New Jersey.

Over the past three years, nine disposal projects have been successfully completed. Operation of the facility includes visual observation during every disposal event, water quality monitoring, and periodic bathymetric surveying. Operations and monitoring has shown that no release of sediments from the facility has occurred. In addition, a sediment sampling program was implemented to help better understand how material behaves once it is deposited in the facility.

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GULF OF MEXICO CASE STUDY

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Abstract not submitted.
ALTERNATIVE APPROACHES TO SEDIMENT TOXICITY TESTING: REVERSE-TIE AND CRITICAL BODY RESIDUES

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The presence of contaminated sediments in urban harbors raises management concerns with regards to dredging and dredge disposal, seafood safety, and the health of aquatic organisms. Elevated levels of a wide range of persistent organic contaminants and a handful of metals have been documented nationwide, yet many of these compounds have limited bioavailability. Determining which chemicals in urban sediments are contributing most to toxic effects will help focus enforcement and source reduction activities. There are a number of approaches for evaluating sediment toxicity. Methods that involve selective removal of contaminants (i.e., ammonia, selected metals, relatively hydrophobic organic contaminants) are typically referred to as toxicity identification evaluation (TIE), and have been most frequently employed in effluent testing. More recently the TIE approach has been extended to evaluate sediment pore water or whole sediments (e.g., mixing of sediment with selective sorbent materials). Pore water TIE tests have fundamental limitations for highly bioaccumulative chemicals such as hydrophobic organic chemicals (HOCs) and mercury. The small solution volumes typically used in static pore water assays severely limit the exposure concentrations of contaminants with bioconcentration factors (BCFs) of >103 - 104. Under these conditions, most of the contaminant in solution is quickly accumulated by the test organisms. Exposure levels may be lowered further by contaminant loss to volatilization or sorption to container surfaces. Whole sediment TIE methods have only recently begun to be developed. In this paper we discuss recent work taking two alternative approaches to sediment toxicity assessment. In the first we used Amberlite resins to isolate easily desorbable HOCs from highly contaminated urban sediment. This material was then amended onto reference sediment to assess toxicity using tests with the amphipod Ampelisca abdita. We term this approach "reverse-TIE" as instead of inferring toxicity by selective removal of contaminants as in done in conventional TIE, the actual toxicity of specific fractions can be tested directly. Another advantage of this approach is that material isolated can be chromatographically separated into compound or compound-class specific fractions, and these testing independently. A second approach employing a micro-extraction techniques measuring critical body residues (the body burden of contaminant at 50% mortality, LD50) was also used to assess sediment toxicity. In these experiments, LD50s for Ampelisca exposed to a suite of standard organic toxicants were compared with contaminant body burdens in animals exposed to sediments from US Environmental Protection Agency's (US EPA) Regional Environmental Monitoring and Assessment Program (REMAP) study of the New York/New Jersey Harbor Complex in 1998. The results of this work provide insight on which chemical classes may or may not be causing toxicity observed in standard tests with New York/New Jersey Harbor sediments, and provide promising approaches that compliment more traditional approaches to sediment toxicity evaluation.

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Sediment trend analysis (STA) is a technique that enables patterns of net sediment transport to be determined by relative changes in grain-size distributions of all naturally occurring sediments. In addition, STA can determine the dynamic behavior of bottom sediments with respect to erosion, accretion or dynamic equilibrium. Invented by GeoSea Consulting, STA has been used in dredging and harbor management concerns in over 70 projects worldwide. The data requirements are sediment grab samples collected at a regular spacing that is determined by the area under consideration. The samples are analyzed for their complete grain-size distribution using a laser technique. Transport pathways are then determined by searching for sample sequences whose distributions change according to the "rules of transport."

STA has been particularly useful in many dredged material management issues including (i) locating disposal sites to minimize environmental impact, (ii) predicting the fate of dredged material, (iii) locating CAD sites to ensure minimum disturbance, (iv) providing alternative routes for navigation channels to minimize dredging, (v) directing numerical models, (vi) planning habitat restoration projects, (vii) assessing remediation options for contaminated sites, and (viii) providing a fundamental data base for all environmental concerns. This talk will describe briefly the theory of STA, which will then be followed by a presentation of a number of specific studies undertaken in Europe, Canada and the United States demonstrating its use in all the above described dredged material management issues.

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USE OF DYNAMIC PENETROMETERS TO DETERMINE FLUID MUD PROPERTIES


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Key words: CPT, cone penetrometer, sediment, capping

During early capping operations at the Boston Harbor Confined Aquatic Disposal Project, layers of fluidized mud and suspended sediments were found on the cap sand at some locations. At issue are the physical and mechanical properties of these sediments as well as the thickness of the individual mud layers. These data are needed to assist in determining how much, if any, disposal material is transported into the water column due to the passage of ships.

A technology that shows potential for addressing these problems is the Free Fall Cone Penetrometer (FFCPT) concept. A cone penetrometer (CPT) trailing a data/recovery wire falls through the water column, impacts the bottom and penetrates a meter or more into the sediment. Variations in sediment grain size, shear strength, dynamic stiffness and stress state are reflected in the deceleration history recorded by the sensor package in the FFCPT. The sediment pore pressure response during the penetration of the probe into the bottom provides an independent measure of shear strength and permits sediment classification in a quantitative manner. An Optical Backscatter Sensor (OBS) provides data about the amount of sediment suspended in the water column and is useful for determining the boundaries of fluff or mud layers. Bulk sediment properties such as the void ratio, porosity, water content and density can be inferred from the results when the sediment composition is known. After the CPT has stopped it is retrieved and deployed again.

A FFCPT is being beta tested at the Engineer Research and Development Center (ERDC) in Vicksburg, MS. The experiments will examine the response of the FFCPT when dropped into sand and sediment with known physical properties. The data obtained with the FFCPT will be presented with the results from other traditional sediment characterization techniques.

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DETRIPTMENTAL EFFECTS OF SEDIMENTATION ON MARINE BENTHOS: WHAT CAN BE LEARNED FROM NATURAL PROCESSES AND RATES?

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Key words: sedimentation, erosion, sand storage, site selection, benthic communities

Sediment movement, erosion, and deposition are natural processes to which benthic organisms are adapted. Benthic infauna burrow upwards and downwards with these events to maintain an ideal position in the sediment. Laboratory studies have cataloged the range of responses to flow and sediment movement that allow benthos to survive under intense storm-generated conditions including resilience to sandblasting by bedload transport.

Sedimentation patterns are often altered significantly with commercial and recreational modifications of the marine environment. While the scales of these alterations greatly exceed that of natural occurrences, there is little quantitative information vital for predicting how materials placement will affect the ecology of these environments. If biological effects are appropriately parameterized, is it possible to predict disturbances and to design management projects that will minimize these disturbances while still maximizing the benefits?

In Delaware Bay, we are using several approaches to determine what rates and frequencies of sediment movement are natural events, and further, what rates and frequencies are detrimental to representative benthic species, developmental stages and functional groups. Transects for determining erosion and deposition rates were established at four beach sites along lower Delaware Bay. Concurrently, we are using a lab approach to establish what sedimentation rates and frequencies are detrimental to infauna, epifauna, and functional groups. Laboratory burial experiments include measurements of limiting depth and frequency of sedimentation. We are also investigating the susceptibility of the Bay's hard-bottom epifauna to natural disturbances using side scan sonar and a laboratory water tunnel.

These results are intended to address the ecological aspects of dredge materials placement and site selection. Quantifying natural sedimentation rates and the susceptibility of macrofaunal functional groups is one approach towards predicting environmental impacts. If materials placement can be planned to be analogous to natural events, then community responses will follow natural seasonal and successional trends. When sedimentation exceeds natural thresholds, ensuing impacts will likely involve total loss of the community and subsequent colonization by pioneer species. Thus an entirely different suite of ecological processes will drive impacts and recovery, potentially leading to dramatically altered benthic communities.

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