

ASSESSMENT OF SEDIMENT CONTAMINANT TESTING PRIOR TO PROPOSED DREDGING OF SEARSPORT HARBOR, MAINE, AND RECOMMENDATIONS

Dr. Kevin M. Yeager
Department of Earth and Environmental Sciences
University of Kentucky
Lexington, KY 40506

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1.0 INTRODUCTION:

Searsport Harbor is located on Penobscot Bay, ME. The eastern side of the harbor, known as Mack Point, is served by a federal navigation channel and contains two piers. The federal navigation channel is less than a mile long and has an authorized depth of -35 ft. mean lower low water (MLLW) (Fig. 1). This channel has experienced minimal shoaling since its construction in 1964. Accretion has filled portions of this channel to -33 ft. MLLW. Neither the port nor the U.S. Army Corps of Engineers (USACE) has been successful in obtaining maintenance dredging funds (100% federal cost) to remove the accumulated sediment, (estimated to be ~37,100 cubic yards).

The USACE, in cooperation with the Maine Department of Transportation (MaineDOT), produced a draft Feasibility Study and Environmental Assessment (FSEA) in 2013 calling for an \$11 million USD project that would **(1)** deepen the existing channel from -35 to -40 feet MLLW, **(2)** extend the existing 3,500 foot channel by another 2,000 feet seaward to the 40 foot contour line, and **(3)** create a turning basin parallel to the eastern dock (Fig. 1). Additionally, the non-federal sponsor or its agents would dredge two berths (one at the liquid pier and one at the cargo pier) to -43 ft. MLLW. The study further indicates that all dredge spoils derived from these activities would be disposed of in Penobscot Bay as open-water disposal sites, with no capping or confining structures. The location(s) of these spoil sites is approximately six miles from the Searsport Harbor.

For nearly a decade, a federal court-appointed study panel consisting of scientists across a range of relevant disciplines have been studying the Penobscot River and Bay to quantify the degree and extent of mercury (Hg) contamination derived from the former HoltraChem facility in Orrington, ME. This investigation, the Penobscot River Hg Study (PRMS), is of unprecedented depth, diversity and scale, and is a key component of ongoing litigation (*Maine People's Alliance and the Natural Resources Defense Council, Inc. v. Mallinckrodt*). The most recent report of the study panel (Phase II) definitively documents that sediments in the lower Penobscot River and upper Bay are polluted with Hg at levels of concern in terms of impacts on biota and human health. Dredging (hydraulic or mechanical) always involves the resuspension, or remobilization of sediment, there is no way to avoid this with existing dredging technology. The remobilization of sediment known to be contaminated with considerable quantities of Hg may result in the spread of Hg contamination, increased conversion of Hg into its most toxic form, methyl-Hg, and the introduction of formally unavailable (i.e., buried) Hg to the aquatic food chain. This risk is compounded by the likelihood of other contaminants at concentrations above levels of concern in these same sediments (metals, PAHs, dioxins, etc.). Negative environmental quality impacts associated with the remobilization of contaminated sediments during dredging have been well-

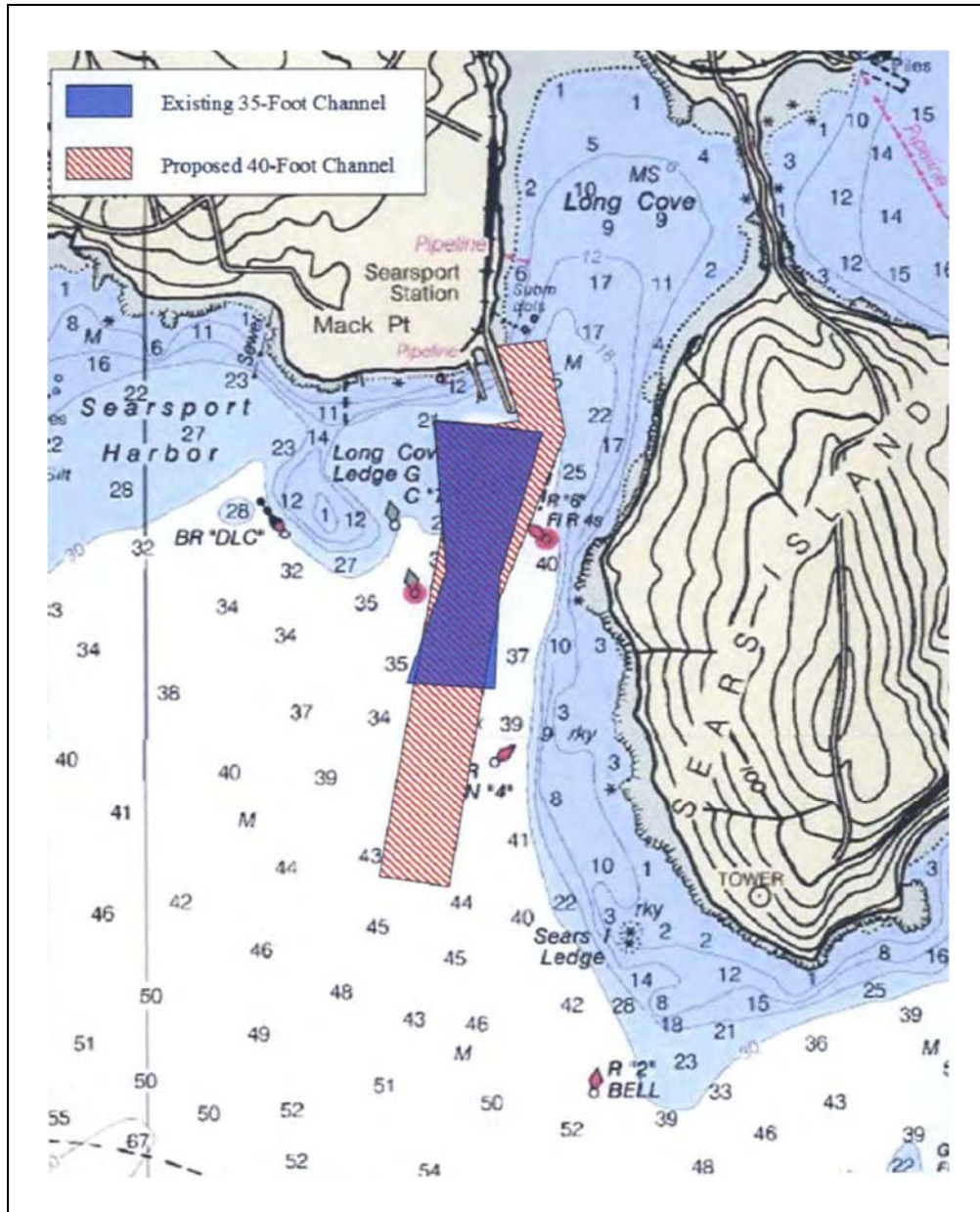


Figure 1 – Bathymetric map showing the Mack Point piers, the existing federal navigation channel, and the outline of the proposed dredging area for the expanded navigation channel.

documented (e.g., Latimer et al., 1999; Bocchetti et al., 2008; Hedge et al., 2009; Knott et al., 2009; Torres et al., 2009; Martins et al., 2012).

Two recent actions (2014), one state and one federal, further emphasize the need to exercise due diligence in terms of the execution of a thorough environmental assessment (EA) in order to properly inform any environmental impact statement (EIS) produced by the USACE and MaineDOT in terms of dredging this area at any scale. The first was the decision by the Maine Department of Marine Resources to close a seven square mile area in the lower Penobscot River to lobster and crab fishing for a period of no less than two years due to methy-Hg contamination found in the muscle meat of lobsters

and crabs during the PRMS. The second was the federal designation of the Penobscot River watershed as a Habitat Focus Area, which incorporates it into Habitat Blueprint, a national program administered by the National Oceanographic and Atmospheric Administration (NOAA) that focuses on protecting and restoring important habitat.

2.0 REVIEW OF PREVIOUS FIELD SAMPLING AND SEDIMENT TESTING:

2.1 Battelle, 2008

In 2008, Battelle produced the “Final Report: Field Sampling and Sediment Testing, Searsport Harbor Federal Navigation Project, Searsport, Maine” (hereafter referred to as Battelle, 2008), the results of a sediment sampling and analyses project sponsored by the USACE-New England District. A total of 10 sediment cores were collected, three from the existing federal navigation channel limits, and seven from the proposed project limits outside of the existing channel (Fig. 2). Additionally, reference sediment grab samples were collected from the Belfast Bay disposal site (BBDS) and Penobscot disposal site (PDS) (Fig. 2). These reference samples were collected and analyzed to “...determine suitability for disposal of dredge material.” (Battelle, 2008; attachment A, p. 1), which relates to the legal prohibition that dredge spoils cannot be disposed of at a site where the sediment is less contaminated than the dredge spoils. In this case, the field sampling program was not adequate. Four additional sediment coring stations should have been included, to represent the area between stations C, and D and E; and beyond station A, to cover the full length of the proposed dredged channel. All samples underwent physical and chemical analyses, including grain size, Atterberg limits, total organic carbon (TOC), metals, polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), and chlorinated pesticides. The report notes that all sampling and core processing methods utilized were consistent with guidance provided by *Evaluation of Dredged Material Proposed for Discharge in Waters of the U.S. – Testing Manual* (EPA/USACE, 1998), and *Final Regional Implementation Manual for the Evaluation of Dredged Material Proposed for Disposal in New England Waters* (EPA/USACE, 2004; hereafter referred to as RIM, 2004). Sediment from the 10 sediment cores was then combined, to produce a total of only four composite samples, which were then subject to geochemical analyses. The reference samples consisted of triplicate, homogenized grab samples (to 0.5 ft. depth), and were analyzed in the same fashion as the core samples. This process, as outlined in the report, calls into question the validity of the reports subsequent conclusions, in summary:

- (1)** The four composite sediment core samples were produced from contributions from different numbers of cores. Composite sample HAC-19 from three cores (stations A, B, and C), composite sample HAC-20 from two cores (stations D, and F), composite sample HAC-21 from four cores (stations E, G, H, and I), and composite sample HAC-22 from one core (station J). As a result, each composite sample is comprised of sediment from different locations on the estuary bottom, and which represent different sizes of area on the estuary bottom. There are no justifications provided to explain why all of the composite samples contain sediments from a different number of sediment cores, nor to explain the basis upon which the particular sediment cores were chosen for each composite sample.
- (2)** One of the four composite sediment core samples was produced from contributions of sediment from different depth sections of the respective core(s) that comprise each. Composite samples HAC-19, HAC-21, and HAC-22 were all comprised of homogenized sediment, in equal volumes,

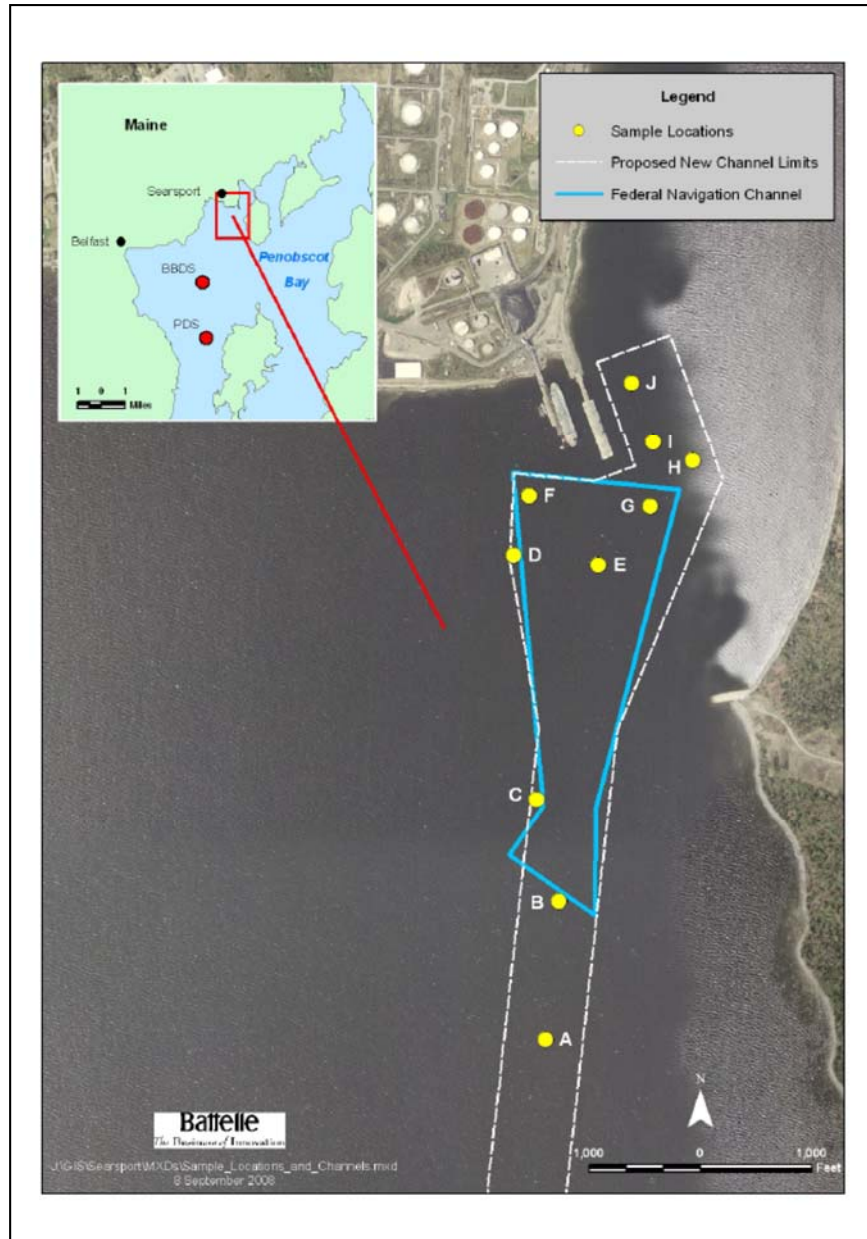


Figure 2 – Locations of sediment cores collected by Battelle relative to the existing federal navigation channel, and the proposed extended navigation channel (Battelle, 2008).

from the depth intervals of 0-1 ft., and 1-2 ft. in each of the cores or core that comprises each. However, composite sample HAC-20 was comprised of homogenized sediment, in equal volumes, from the depth intervals of 0-1 ft., and 1-2 ft. from one core (station D), and from the depth intervals of 0-1.9 ft., and 1.9-3.6 ft. from a second core (station F). The inclusion of sediment over both significantly different depth intervals, and maximum depth, for this composite sample as compared to the other composite samples introduces a significant bias. As such, the results obtained from composite sample HAC-20 should be omitted. There is no justification provided in the report to explain this sample processing anomaly.

- (3) The direct comparison of contaminant data from the four composite sediment core samples to the reference sediment grab samples in an effort to assess whether the BBDS or PDS open-water disposal sites were appropriate (i.e., equal to or more contaminated than the proposed dredged sediment) is not scientifically sound. The composite sediment core samples were produced by the inclusion of sediments over several feet of an individual or multiple individual sediment cores, whereas the reference samples were discrete, homogenized sediments collected from the surface (no greater than 0.5 ft.) of the BBDS and PDS sites. There are no justifications provided to explain why the same sampling, and sample processing protocols were not used for these two groups of samples, despite the fact that the reference samples were collected for the purpose of direct comparison to the sediment core samples of proposed sediment to be dredged. Consequently, determinations of the appropriateness of either the BBDS or PDS sites for open-water disposal of dredged sediment cannot be supported by these data.
- (4) This report lists the effect range low (ERL) for all contaminants based on Long et al. (1995) in Table 3-2 (p. 16), however most of the metal ERL values do not match those presented in Long et al. (1995), which are listed here in Table 1. These metals and their corresponding ERL levels as listed in the Battelle report include arsenic (As) (33 µg/g), cadmium (Cd) (5 µg/g), copper (Cu) (70 µg/g), nickel (Ni) (30 µg/g), lead (Pb) (35 µg/g), and zinc (Zn) (120 µg/g), all of which save Zn and Pb represent values significantly higher than those reported in Long et al. (1995). As a result, the report's conclusions that only the metals chromium (Cr), Ni and Hg were observed at concentrations above sediment quality guidelines is incorrect. Comparing the metal concentration values as determined by Battelle (2008) to the actual Long et al. (1995) ERL values for each shows that As is above the ERL in all samples; Cr is above the ERL in reference samples from the BBDS and PDS, and in composite sample HAC-19; Ni is above the ERL in reference samples from the BBDS and PDS, and in composite samples HAC-19, HAC-20, and HAC-21; and Hg is above the ERL in reference samples from the BBDS and PDS. The results show that all six of the reference samples meet or exceed the ERL (Table 1) for the metals As, Cr, Ni and Hg.
- (5) The Battelle (2008) data, regardless of their quality, are irrelevant to any planned dredging operations at Searsport, ME, at any scale, because the sampling was done six years ago. According to RIM (2004), any location for which data are available must be re-evaluated if those data are more than three years old. The Battelle (2008) data exceeded this time frame at the time that the USACE used these data in the FSEA, released on April 5, 2013.

2.3 Sprague Energy, 2013

In 2013, Sprague Energy commissioned a study, conducted by Absolute Resources Associates, to evaluate sediment quality adjacent to the Mack Point piers in preparation for a planned maintenance dredging project. Absolute Resources Associates produced the "2013 Sediment Sampling Report" (hereafter referred to as ARA, 2013). A total of six sediment cores were collected, three from each of the two berths identified for dredging (Fig. 3). In this case, the field sampling program was not adequate. All six sediment cores were collected from shallow waters immediately adjacent to either the piers serving each of the two berths, or from the landward termination of each berth. While these locations were likely selected due to ease of access during coring, they do not result in a representative spatial distribution, reflecting sampling of sediment that would be removed from each of the entire berthing areas should dredging proceed. Samples from these sediment cores underwent physical and

Table 1 - Concentrations of metals and organic contaminants in sediments at the effect range low (ERL) concentration (Long et al., 1995; U.S. EPA, 2002; U.S. EPA, 2009).

Contaminant	ERL concentration (dry weight)*
<i>Metals</i>	
Arsenic (As)	8.2 µg/g
Cadmium (Cd)	1.2 µg/g
Chromium (Cr)	81 µg/g
Copper (Cu)	34 µg/g
Lead (Pb)	47 µg/g
Mercury (Hg)	0.15 µg/g
Nickel (Ni)	21 µg/g
Silver (Ag)	1 µg/g
Zinc (Zn)	150 µg/g
<i>Polycyclic Aromatic Hydrocarbons (PAHs)</i>	
Acenaphthene	16 ng/g
Acenaphthylene	44 ng/g
Anthracene	85 ng/g
Fluorene	19 ng/g
2-Methyl Napthalene	70 ng/g
Napthalene	160 ng/g
Phenanthrene	240 ng/g
Benzo(a)anthracene	261 ng/g
Benzo(a)pyrene	430 ng/g
Chrysene	384 ng/g
Dibenzo(a,h)anthracene	63 ng/g
Fluoranthene	600 ng/g
Pyrene	665 ng/g
Low MW PAH	552 ng/g
High MW PAH	1,700 ng/g
Total PAH	4,000 ng/g
<i>Total DDT</i>	1.58 ng/g
<i>Total PCB</i>	22.7 ng/g
<i>Dioxin</i>	Toxic Equivalent (TEQ)**
State of Maine – Restricted (commercial/industrial) soil cleanup level	31 ng/kg

*Long et al., 1995; U.S. EPA, 2002

**U.S. EPA, 2009

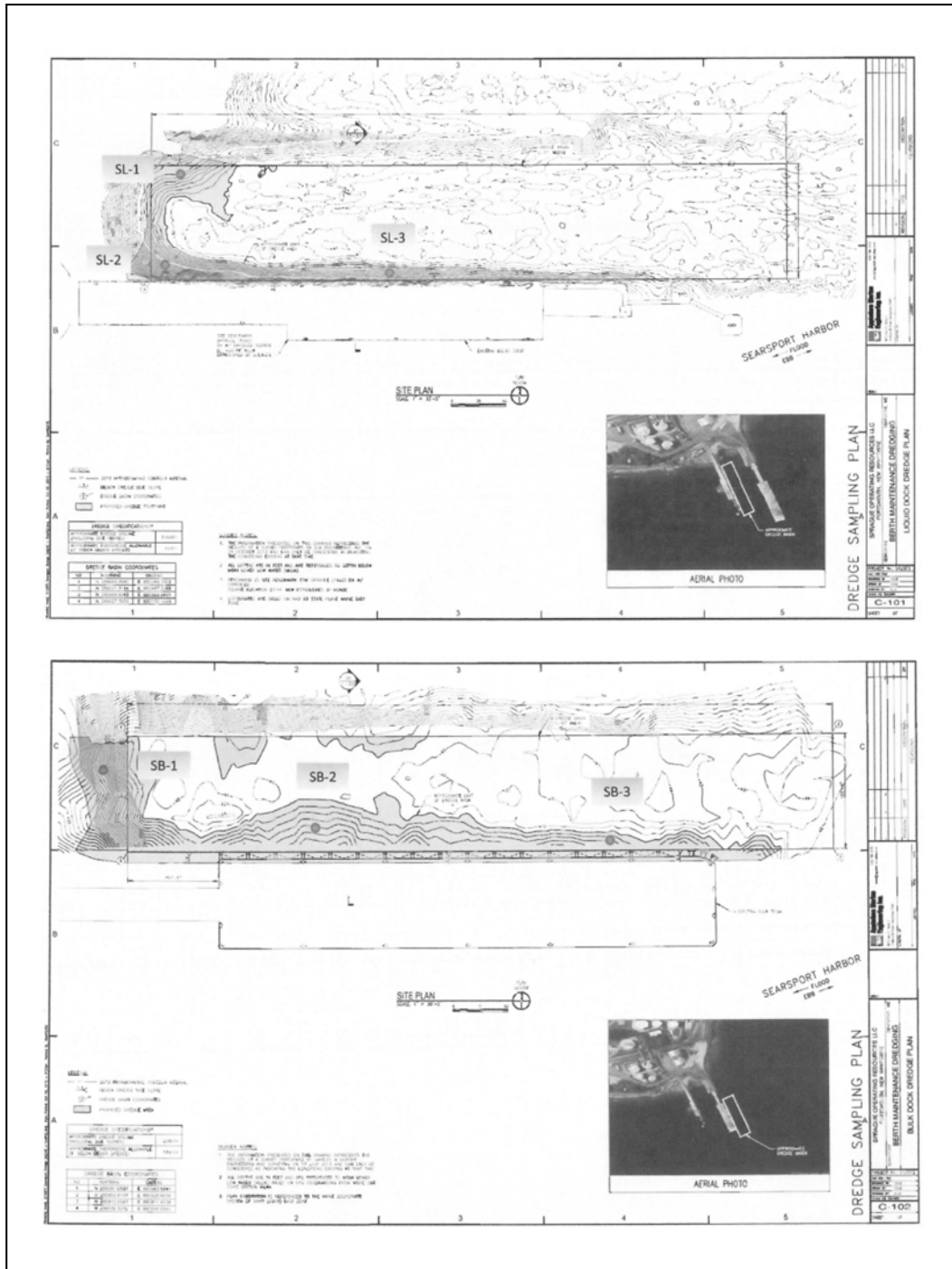


Figure 3 – Locations of sediment cores collected by Absolute Resources Associates relative to the two piers at Mack Point, Searsport, ME (ARA, 2013).

chemical analyses, including grain size, TOC, metals, PCBs, PAHs, dioxin toxic equivalence (TEQ) and chlorinated pesticides. The report notes that all sampling and core processing methods utilized were consistent with guidance provided by RIM (2004). The approaches used to process these cores, and to conduct subsequent analyses, calls into question the validity of the report’s conclusions, in summary:

- (1) Despite the proposed maintenance dredging requiring that several feet of sediment be removed from the substrate at each berth, the lengths of the six cores collected are not reported. At a minimum, every core collected should have encompassed the entire sediment depth planned for dredging (subject to refusal). If this was not the case, then it is impossible to accurately quantify the distributions, concentrations or total amounts (inventories) of any of the contaminants of interest.
- (2) Two of the six sediment cores (SB-3 and SL-1) report grain size and geochemical data. However, these data are reported for a single sample. It is not specified in the report how this single sample was produced. Was it a discrete depth interval? Was it a bulk sample constituted from a mixture of all sediment collected in those cores? Even if the answers to these questions were known, the reporting of physical and geochemical data from a single sample derived either from a discrete interval, or a mixed, bulk sample from two sediment cores is not an acceptable scientific approach to quantify either physical or geochemical data.
- (3) The remaining four sediment cores were composited (SL-2/SL-3 and SB-1/SB-2), yielding a total of just one sample per composite (per two cores). As discussed in #2 above, the report does not specify how each of these single samples were produced. The analytical results produced using this approach are even less representative of the actual physical and geochemical condition of the sediment sampled.
- (4) While a total of six sediment cores may have been adequate spatial coverage given the maintenance dredging objectives (*if they had been more evenly distributed in the two berths and recovered sediment over the full depth of intended dredging*), the processing and analysis of those cores were wholly inadequate to determine **(a)** the actual concentrations and distributions of contaminants quantified; **(b)** the total quantities (inventories) of contaminants of interest within the sediments to be dredged; and therefore **(c)** the prospective environmental impacts of either the sediment resuspended as a function of dredging, or the level of contamination of the dredged sediment to be disposed of.
- (5) Despite the facts outlined above, the results of the geochemical analyses suggest that these sediments are quite contaminated (see below). It is highly likely that a proper sampling plan, core sectioning and analyses protocol would yield data reflecting an even greater degree of contamination than those data included in this report.

Metals: All four sediment samples show metal concentrations in excess of the U.S. EPA's ERL concentrations (Table 1), including: SB-3 - As (8.6 µg/g) and Ni (47 µg/g); SL-1 – As (11 µg/g); SL-2/SL-3 (composite 1) – As (9.3 µg/g) and Cu (42 µg/g); and SB-1/SB-2 (composite 2) – As (16 µg/g), Pb (300 µg/g) and Ni (27 µg/g).

PAHs: Three of the four sediment samples show concentrations of multiple PAH compounds in excess of the U.S. EPA's ERL concentrations (Table 1), including: SB-3 – naphthalene (320 ng/g), acenaphthene (70 ng/g), fluorene (130 ng/g), phenanthrene (1,040 ng/g), anthracene (460 ng/g), fluoranthene (1,260 ng/g), pyrene (2,130 ng/g), benzo(a)anthracene (1,840 ng/g), chrysene (2,290 ng/g), and benzo(a)pyrene (1,880 ng/g); SL-2/SL-3 (composite 1) – naphthalene (170 ng/g), acenaphthene (140 ng/g), fluorene (130 ng/g), phenanthrene (620 ng/g), anthracene (160 ng/g), fluoranthene (1,040 ng/g), pyrene (970 ng/g), benzo(a)

anthracene (370 ng/g), and chrysene (410 ng/g); and SB-1/SB-2 (composite 2) – naphthalene (350 ng/g), acenaphthene (110 ng/g), fluorene (180 ng/g), phenanthrene (1,770 ng/g), anthracene (200 ng/g), fluoranthene (1,470 ng/g), pyrene (1,360 ng/g), benzo(a)anthracene (420 ng/g), and chrysene (680 ng/g).

2.4 Inadequacy of the RIM (2004) Approach for the Searsport, ME Site:

The sediment testing procedure outlined in RIM (2004) consists of a "tiered" approach, whereby sediments are analyzed only to the level of detail required to make a decision on the environmental impact of disposal. Physical, chemical and biological tests are performed on the sediments as necessary to determine the potential for environmental impact. Certain areas, such as those where the material is coarse grained and found in areas of high current or wave velocity (coastal areas with shifting bars and channels), may be exempt from chemical testing based on the results of a physical analysis and an assessment of the potential for contaminated sediments. Areas where chemical test results suggest the possibility of adverse environmental effects from dredging or disposal operations may have to undergo biological testing. Most sites in Maine undergo physical and chemical testing at a minimum. Areas where existing data are available, but are more than three years old, require re-testing.

As discussed previously, each of the sediment sampling and analyses reports (Battelle, 2008; ARA, 2013) reviewed have serious inadequacies that are both independent of the RIM (2004) guidelines, and associated with those guidelines. In terms of Hg contamination and the possibility of dredging operations at any scale spreading Hg, or resulting in the increased methylation of Hg held in sediments of Searsport Harbor, ME, the RIM (2004) guidelines are inadequate to accurately quantify the level of risk associated with the disturbance and removal of those sediments by dredging. While this is certainly also true of other contaminants of concern in these same sediments (metals, PAHs, dioxins, PCBs), we will focus here on Hg. The primary reason for the inadequacy of the RIM (2004) guidelines relates to the compositing of sediment core samples, from both different depth sections within a single core, and from different cores entirely. If one had very high levels of contamination within the upper 30 cm of two sediment cores, and the upper 60 cm of each of those cores were mixed and homogenized with sediment from the lowermost 60 cm of those same cores, to produce a single composite sample, the apparent concentrations of the contamination would be significantly reduced. The result is that decisions regarding the environmental impact of the disturbance, dredging and disposal of these sediments would be based on contaminant data which grossly under-estimate the actual level of contamination. The PRMS's Phase II report includes data from some 58 sediment cores collected throughout the lower Penobscot River system, from Veazie Dam in the north, to the southern end of Islesboro in the south. Each of these cores were treated individually, no sample compositing in any form was done. Each of these 58 cores were sectioned in the same fashion. Cores were sectioned at 1 cm intervals of the first 20 cm, at 2 cm intervals to 40 cm, and at 5 cm intervals to 90 cm, resulting in a total of 40 samples per core. Each of these samples were then analyzed for a range of variables, including grain size, porosity, bulk density, particulate organic carbon (POC), total Hg, and fallout radionuclides (^{137}Cs , ^{210}Pb and in discrete intervals, ^7Be , $^{239,240}\text{Pu}$). Of the 58 cores analyzed, 18 were sampled from stations in Penobscot Bay (designated ES-#). In these 18 cores, the peak concentrations of total Hg ranged in depth from 20 to 70 cm from the surface, with a mean depth of 36.7 cm (14.4"), and the maximum concentrations of total Hg ranged from 346 to 2,710 ng/g, with a mean of 1,055.8 ng/g. It is worthy of note that the peak total Hg concentrations in all 18 of these cores significantly exceeded the

EPA's ERL for Hg (Table 1; 0.15 µg/g or 150 ng/g). While the closest of these 18 cores to Mack Point is ~2 km to the northeast in Stockton Harbor (ES-4), given the circulation in Penobscot Bay, there is no reason to believe that sediments at Mack Point are any less polluted with Hg. Contrary to public statements made by the USACE, it is not appropriate to use data from PRMS sediment core stations ES-7 or ES-8 as proxies for sediment quality in terms of Hg at Searsport Harbor or Mack Point, given their geographic distance (5.8 and 7.4 km, respectively), or to the proposed PDS, which is approximately 5.5 km from ES-7 and 5.4 km from ES-8. If these 18 PRMS sediment cores were processed and analyzed using the RIM (2004) guidelines, the concentrations of total Hg would have been significantly under-estimated.

In summary, the primary limitations of the RIM (2004) guidelines include:

- (1) Guidelines are intended to focus on determining averaged levels of contamination in sediment to be disposed of only. The guidelines do not address in any way the prospective environmental impact of sediments which are resuspended, or remobilized during the dredging process, which is an unavoidable certainty.
- (2) Because of the compositing approach endorsed by these guidelines, it is not possible to quantify crucial contaminant variables, which are needed to adequately found interpretations regarding possible environmental impacts (of disturbance, dredging or open-water disposal). These include the maximum concentrations of contaminants of concern, the distribution of those contaminants in the sediment, and the inventories, or total quantities of those contaminants of interest in the sediment.

2.5 Dawson and Associates, 2014:

In 2014, the Islesboro Island Trust commissioned a review of the USACE's 2013 draft Feasibility Report and Environmental Assessment for enlarging the federal navigation channel serving Searsport, ME by Dawson and Associates. After review of this report, points of agreement between my review and that of Dawson and Associates include:

- (1) A principle finding was that the potential for the spread of Hg contamination exists, and that additional analyses and coordination is warranted as part of the USACE's study process to move forward.
- (2) Analysis shows that material on the bay bottom is mostly marine clay. Some glacial till is located along the eastern and northeastern edge of the project. This till is very dense with numerous cobbles and boulders. Dredging this material will be potentially difficult, and likely would impact overall project costs.
- (3) Citing the Battelle (2008) report, Dawson and Associates note that in addition to Hg, several other metals are also present at concentrations above sediment quality guidelines (EPA's ERL; Table 1). Upon review of both the reports produced by Battelle (2008) and ARA (2013), contaminants documented at levels above the EPA's ERL, in addition to Hg, include As, Cr, Ni, Pb, and Cu, as well as a large number of PAH congeners.
- (4) The USACE sampling plan included an outline of the project which did not include the surrounding, extended areas that must be dredged to provide a stable slope. The 1H:3V slope would require that the channel disturbance extend 15 feet or more to either side, areas which were not sampled.

3.0 RECOMMENDATIONS:

In order to develop an accurate EA, to properly inform any EIS, for either maintenance dredging of the existing federal navigation channel and berths at Mack Point, or to expand the federal navigation channel, the USACE and MaineDOT should commission a study similar in execution as that conducted by the PRMS, focused on the contaminants of concern (Hg and methyl-Hg, As, Ni, Cu, Pb, PAHs, and dioxins). Such an approach would provide reliable and representative quantitative information on maximum contaminant concentrations, distributions and inventories of contaminants in sediments to be disturbed or removed by dredging, and properly inform any decisions regarding the appropriate disposal (open-water, sanitary landfill) of dredge spoils. An example of these are given below for the maintenance-scale dredging operation, and for the channel-extension dredging operation.

3.1 Maintenance Dredging:

To develop an accurate EA, and properly inform any EIS, it is recommended that 14 coring stations be established in the area identified for dredging (Fig. 4). It is recommended that each core be sectioned identical to those collected and analyzed as part of the PRMS study, yielding a total of 40 samples per core. Recommended field sampling and analyses are summarized in Table 2.

3.2 Channel Extension Dredging:

To develop an accurate EA, and properly inform any EIS, it is recommended that 21 coring stations be established in the area identified for dredging (Fig. 4). It is recommended that each core be sectioned identical to those collected and analyzed as part of the PRMS study, yielding a total of 40 samples per core. Recommended field sampling and analyses are summarized in Table 2.

Table 2 – Recommended field sampling and sediment analytical elements associated with recommended sediment coring prior to dredging operations at either the maintenance or channel extension scales.

Core collection	Physical properties (grain size, porosity, bulk density, POC)
Total Hg	Methyl Hg
Metals (As, Cd, Cr, Cu, Pb, Ni, Zn)	PAHs
Dioxins	Data interpretation and preparation of final report

3.3 Dredge Spoils:

Given that the Battelle (2008) report shows that samples from both the BBDS and PDS disposal sites already have metal concentrations in surface sediment (upper 0.5 ft.) above the ERL (As, Cr, Hg, Ni), the unknown quality of dredge spoils at the Rockland disposal site (RDS), and the high likelihood of considerable quantities of contaminants associated with sediments proposed to be removed by dredging, open-water disposal of dredged sediments in state or federal waters should not be considered without a comprehensive sediment sampling of any candidate dredge spoil disposal sites first. If open-water disposal is considered, sampling and analyses as previously described (PRMS study method) is recommended to assess **(1)** whether any of the considered open-water disposal sites are appropriate for the disposal of dredged sediments (accurate comparison of contamination levels); and **(2)** the risk of resuspending Hg-laden (and other contaminants) sediments, in terms of possible environmental impact.

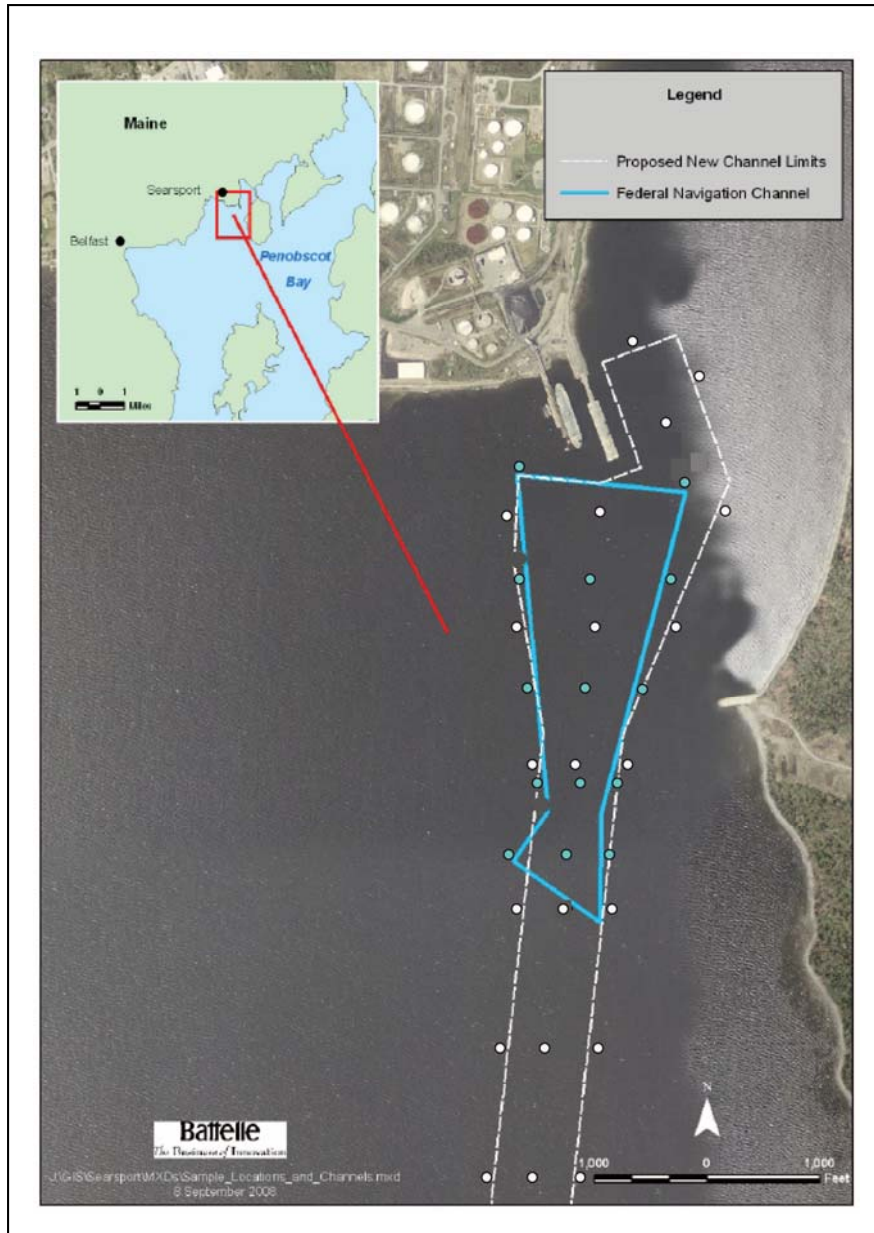


Figure 4 – Locations of recommended sediment coring stations for maintenance (blue) and channel extension (white) dredging projects. Figure modified from Battelle (2008).

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