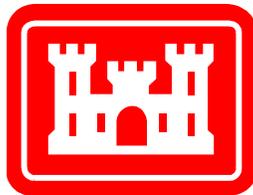


APPENDIX 2

**EVALUATION of the POTENTIAL EFFECTS of the
NEWARK BAY HARBOR DEEPENING PROJECT
on CHEMICAL CONTAMINATION IN NEWARK BAY
SEDIMENTS**



**U.S. ARMY CORPS OF ENGINEERS
NEW YORK DISTRICT**

TABLE OF CONTENTS

ACRONYMS.....	ix
1 INTRODUCTION.....	1
1.1 OBJECTIVES	1
1.2 CONCEPTUAL MODEL OF IMPACTS OF DREDGING ON RI/FS SAMPLES.....	1
2 APPROACH.....	4
2.1 GENERAL APPROACH.....	4
2.2 ESTIMATION OF THE CHANGE IN CONCENTRATION IN SURFACE SEDIMENTS RESULTING FROM DREDGING RESUSPENSION	5
2.3 EFFECTS OF UNCOVERING AREAS OF ELEVATED CONCENTRATIONS	7
3 CHEMICAL DATA.....	9
3.1 DATA SOURCES.....	9
3.2 NBSA RI/FS PHASE I DATA.....	10
3.3 HISTORICAL DATA.....	10
3.4 DATA USAGE AND COMPATIBILITY.....	11
4 APPLICATION TO NEWARK BAY.....	12
4.1 ESTIMATION OF CHEMICAL CONCENTRATIONS.....	12
4.1.1 <i>Chemical Concentrations in Dredged Material</i>	12
4.1.2 <i>Chemical Concentrations in Surface Sediments</i>	12
4.2 MODEL PARAMETERS	13
5 RESULTS	14
5.1 PRESENTATION AND ANALYSIS.....	14
5.2 EFFECTS OF THE HDP	17
5.3 EFFECTS OF UNCOVERING AREAS OF ELEVATED CONCENTRATION	21
5.4 EFFECTS AT PROPOSED NBSA PHASE II LOCATIONS	23
6 CUMULATIVE ASSESSMENT	25

7	SUMMARY	29
8	REFERENCES.....	31

List of Tables

Table 1.	Comparison of Depth Integrated Estimate Concentrations in the Channels and Slopes of Southern Newark Bay, 2005 NBSA RI/FS Phase I Data only
Table 2.	Calculated dredged material concentrations
Table 3.	Comparison of Active Historic Data with 2005 NBSA RI/FS Phase I Data.
Table 4.	Gross Dredging Volumes for the HDP
Table 5.	Duplicates in the NBSA RI/FS Phase I Data
Table 6.	Calculation of the Uncertainty Threshold Based Upon the NBSA RI/FS Phase I Duplicates
Table 7.	Comparison of concentration changes computed by the model with data precision as measured using the NBSA RI/FS Phase I field duplicates
Table 8.	Estimated changes to contaminant concentrations at NBSA RI/FS Phase II sampling locations
Table 9.	Estimated changes to contaminant concentrations at NBSA RI/FS Phase II sampling locations , AEC analysis
Table 10.	Dredge volumes used in the calculation of cumulative effects
Table 11.	Estimated changes to contaminant concentrations at NBSA RI/FS Phase II sampling locations, cumulative assessment

List of Figures

Figure 1a.	Conceptual model of potential effects of dredging on the RIFS
Figure 1b.	Schematic of the analysis of effects
Figure 2.	Dredge areas used in the model
Figure 3a.	2,3,7,8-TCDD in the sediments of Newark Bay under current conditions: Thiessen polygons

Figure 3b. Total PCBs in the sediments of Newark Bay under current conditions: Thiessen polygons

Figure 3c. DDT in the sediments of Newark Bay under current conditions: Thiessen polygons

Figure 3d. Benzo(a)pyrene in the sediments of Newark Bay under current conditions: Thiessen polygons

Figure 3e. Mercury in the sediments of Newark Bay under current conditions: Thiessen polygons

Figure 3f. Chromium in the sediments of Newark Bay under current conditions: Thiessen polygons

Figure 4. 5-year sedimentation due to resuspension caused by the HDP

Figure 5. Field duplicates in the NBSA Phase I Data set: Relative percent differences

Figure 6a. 2,3,7,8-TCDD: Comparison of current surface sediment concentrations with post-dredging concentrations predicted by the model

Figure 6b. 2,3,7,8-TCDD: Change in surface sediment concentrations due to dredging as predicted by the model

Figure 6c. 2,3,7,8-TCDD: Predicted changes in surface sediment concentration greater than the uncertainty threshold

Figure 7a. Total PCBs: Comparison of current surface sediment concentrations with post-dredging concentrations predicted by the model

Figure 7b. Total PCBs: Change in surface sediment concentrations due to dredging as predicted by the model

Figure 7c. Total PCBs: Predicted changes in surface sediment concentration greater than the uncertainty threshold

Figure 8a. DDT: Comparison of current surface sediment concentrations with post-dredging concentrations predicted by the model

Figure 8b. DDT: Change in surface sediment concentrations due to dredging as predicted by the model

Figure 8c. DDT: Predicted changes in surface sediment concentration greater than the uncertainty threshold

Figure 9a. Benzo(a)pyrene : Comparison of current surface sediment concentrations with post-dredging concentrations predicted by the model

Figure 9b. Benzo(a)pyrene : Change in surface sediment concentrations due to dredging as predicted by the model

Figure 9c. Benzo(a)pyrene: Predicted changes in surface sediment concentration greater than the uncertainty threshold

Figure 10a. Mercury: Comparison of current surface sediment concentrations with post-dredging concentrations predicted by the model

Figure 10b. Mercury: Change in surface sediment concentrations due to dredging as predicted by the model

Figure 10c. Mercury: Predicted changes in surface sediment concentration greater than the uncertainty threshold

Figure 11a. Chromium: Comparison of current surface sediment concentrations with post-dredging concentrations predicted by the model

Figure 11b. Chromium: Change in surface sediment concentrations due to dredging as predicted by the model

Figure 11c. Chromium: Predicted changes in surface sediment concentration greater than the uncertainty threshold

Figure 12a. 2,3,7,8-TCDD: Comparison of current surface sediment concentrations with post-dredging concentrations predicted by the model, AEC analysis

Figure 12b. 2,3,7,8-TCDD: Change in surface sediment concentrations due to dredging as predicted by the model, AEC analysis

Figure 12c. 2,3,7,8-TCDD: Predicted changes in surface sediment concentration greater than the uncertainty threshold, AEC analysis

Figure 13a. Total PCBs: Comparison of current surface sediment concentrations with post-dredging concentrations predicted by the model, AEC analysis

Figure 13b. Total PCBs: Change in surface sediment concentrations due to dredging as predicted by the model, AEC analysis

Figure 13c. Total PCBs: Predicted changes in surface sediment concentration greater than the uncertainty threshold, AEC analysis

Figure 14a. DDT: Comparison of current surface sediment concentrations with post-dredging concentrations predicted by the model, AEC analysis

Figure 14b. DDT: Change in surface sediment concentrations due to dredging as predicted by the model, AEC analysis

Figure 14c. DDT: Predicted changes in surface sediment concentration greater than the uncertainty threshold, AEC analysis

Figure 15a. Benzo(a)pyrene : Comparison of current surface sediment concentrations with post-dredging concentrations predicted by the model, AEC analysis

Figure 15b. Benzo(a)pyrene : Change in surface sediment concentrations due to dredging as predicted by the model, AEC analysis

Figure 15c. Benzo(a)pyrene: Predicted changes in surface sediment concentration greater than the uncertainty threshold, AEC analysis

Figure 16a. Mercury: Comparison of current surface sediment concentrations with post-dredging concentrations predicted by the model, AEC analysis

Figure 16b. Mercury: Change in surface sediment concentrations due to dredging as predicted by the model, AEC analysis

Figure 16c. Mercury: Predicted changes in surface sediment concentration greater than the uncertainty threshold, AEC analysis

Figure 17a. Chromium: Comparison of current surface sediment concentrations with post-dredging concentrations predicted by the model, AEC analysis

Figure 17b. Chromium: Change in surface sediment concentrations due to dredging as predicted by the model, AEC analysis

Figure 17c. Chromium: Predicted changes in surface sediment concentration greater than the uncertainty threshold, AEC analysis

Figure 18. Cumulative 5-year sedimentation due to resuspension caused by the HDP and other dredging

Figure 18a. 2,3,7,8-TCDD in the sediments of Newark Bay under current conditions: Thiessen polygons, cumulative assessment

Figure 18b. Total PCBs in the sediments of Newark Bay under current conditions: Thiessen polygons, cumulative assessment

Figure 18c. DDT in the sediments of Newark Bay under current conditions: Thiessen polygons, cumulative assessment

Figure 18d. Benzo(a)pyrene in the sediments of Newark Bay under current conditions: Thiessen polygons, cumulative assessment

Figure 18e. Mercury in the sediments of Newark Bay under current conditions: Thiessen polygons, cumulative assessment

Figure 18f. Chromium in the sediments of Newark Bay under current conditions: Thiessen polygons, cumulative assessment

Figure 19a. 2,3,7,8-TCDD: Comparison of current surface sediment concentrations with post-dredging concentrations predicted by the model, cumulative assessment

Figure 19b. 2,3,7,8-TCDD: Change in surface sediment concentrations due to dredging as predicted by the model, cumulative assessment

Figure 19c. 2,3,7,8-TCDD: Predicted changes in surface sediment concentration greater than the uncertainty threshold, cumulative assessment

Figure 20a. Total PCBs: Comparison of current surface sediment concentrations with post-dredging concentrations predicted by the model, cumulative assessment

Figure 20b. Total PCBs: Change in surface sediment concentrations due to dredging as predicted by the model, cumulative assessment

Figure 20c. Total PCBs: Predicted changes in surface sediment concentration greater than the uncertainty threshold, cumulative assessment

Figure 21a. DDT: Comparison of current surface sediment concentrations with post-dredging concentrations predicted by the model, cumulative assessment

Figure 21b. DDT: Change in surface sediment concentrations due to dredging as predicted by the model, cumulative assessment

Figure 21c. DDT: Predicted changes in surface sediment concentration greater than the uncertainty threshold, cumulative assessment

Figure 22a. Benzo(a)pyrene : Comparison of current surface sediment concentrations with post-dredging concentrations predicted by the model, cumulative assessment

Figure 22b. Benzo(a)pyrene : Change in surface sediment concentrations due to dredging as predicted by the model, cumulative assessment

Figure 22c. Benzo(a)pyrene: Predicted changes in surface sediment concentration greater than the uncertainty threshold, cumulative assessment

Figure 23a. Mercury: Comparison of current surface sediment concentrations with post-dredging concentrations predicted by the model, cumulative assessment

Figure 23b. Mercury: Change in surface sediment concentrations due to dredging as predicted by the model, cumulative assessment

Figure 23c. Mercury: Predicted changes in surface sediment concentration greater than the uncertainty threshold, cumulative assessment

Figure 24a. Chromium: Comparison of current surface sediment concentrations with post-dredging concentrations predicted by the model, cumulative assessment

Figure 24b. Chromium: Change in surface sediment concentrations as predicted by the model, cumulative assessment

Figure 24c. Chromium: Predicted changes in surface sediment concentration greater than the uncertainty threshold, cumulative assessment

List of Attachments

Attachment 1. NBSA RI/FS Phase I data.

Attachment 2. Historical data.

Attachment 3. Map showing data locations.

Attachment 4. Bulk density data and calculations.

Attachment 5. NBSA RI/FS Phase II sampling locations.

ACRONYMS

2,3,7,8-TCDD - 2,3,7,8-tetrachlorodibenzo-p-dioxin
AK-41/40 - Arthur Kill Channel 41/ 40 foot Federal Navigation Project
AOC - Administrative Order on Consent
BMP - Best Management Practice
CARP - Contaminant Assessment and Reduction Program
CERCLA - Comprehensive Environmental Response, Compensation and Liability Act
CFR – Code of Federal Regulations
CWA - Clean Water Act
EA - Environmental Assessment
EIS - Environmental Impact Statement
EPA – U.S. Environmental Protection Agency
HARS - Historic Area Remediation Site
HDP - NY and NJ Harbor Deepening Project 50’ and the Arthur Kill 41/40’ Project combined
HTRW - Hazardous, Toxic, and Radioactive Waste
KVK/NB-45 - Kill Van Kull and Newark Bay Channels 45 foot Federal Navigation Project
NEPA - National Environmental Policy Act
NBSA - Newark Bay Study Area
N.J.A.C. – New Jersey Administrative Code
NJDEP - New Jersey Department of Environmental Protection
NOAA - National Oceanic and Atmospheric Administration
NYD – New York District
NYSDEC - New York State Department of Environmental Conservation
PAH - polycyclic aromatic hydrocarbon
PCB - polychlorinated biphenyl
PCDD - polychlorinated dibenzo-p-dioxin
PCDF - polychlorinated dibenzofuran
PJ-41 - Port Jersey Channel 41 foot Federal Navigation Project
REMAP - Regional Environmental Monitoring and Assessment Program
RI/FS - Remedial Investigation and Feasibility Study
TEQ - Toxicity Equivalency Quotient
TSS - Total Suspended Solid
USACE - United States Army Corps of Engineers
USEPA – United States Environmental Protection Agency
U.S.C. – United States Code
WQC - Water Quality Certification

1 INTRODUCTION

1.1 Objectives

This appendix evaluates the effects of the Harbor Deepening Project (HDP) on measurements of sediment contamination to be performed as part of the Remedial Investigation and Feasibility Study for the Newark Bay Study Area (NBSA RI/FS). The results of the MIKE 3 PA model, described in Appendix 1, were used to estimate the resuspension, transport and deposition of dredged material. The analyses described in this Appendix estimate the effects of contaminants in this redeposited dredged material on contaminant concentrations in surface sediments in the NBSA. Predicted post-dredging concentrations in surface sediments are compared with current estimates of surface sediment contaminant concentrations.

1.2 Conceptual Model of Impacts of Dredging on RI/FS Samples

The Dredging Process

Dredging releases suspended sediments to the water. Much of this material will redeposit within the channel adjacent to the dredging operation, because deposition tends to be greater closer to a source, and because the channels are depositional environments (Suszkowski 1978; USACE 1999).

The channel bed is an environment that is disturbed on an ongoing basis, containing sediments that are physically mixed due to tides, storms, periodic dredging and ship traffic. The channels planned for deepening have been dredged previously to depths below the layer deposited during the industrial period. Thus, much of the silt in the channel has been deposited since the last dredging event; the HDP will remove these silts as well as underlying pre-industrial sediments. Following the HDP, the residual sediments in the channel will be a mixture of these materials as well as newly deposited silt that will quickly cover the bottom. These processes will lead to post-HDP contaminant levels that are similar to current conditions.

The term transitional zone is applied to the area that extends from the bottom of the channel to the shallow water flats (Tierra Solutions 2004). This includes the side slopes of the channel, which differ from both the adjacent channels and the shallow flats in their characteristics. The side slopes

include newly deposited material, sediments from the slumping of the adjacent flats, and historical sediments uncovered during previous dredging. They are disturbed on an ongoing basis by tides, wind waves and ship traffic.

Material from the transitional zone will be dredged during channel deepening because of the need to widen the channel prism, and because the HDP calls for widening navigational channels in some areas. Thus, the transitional slopes are a source of material that is resuspended, transported and redeposited may be the flats. Planned channel widening may also result in the exposure of material from the adjacent flats that has not been exposed in a long time. The effects of this resuspended material on surface sediment contaminant concentrations throughout the bay are evaluated in this appendix.

Some of the resuspended dredged material (DM) will disperse outside of the channels and redeposit on the surface of the sediment bed in the shallower flats and transitional zones. This DM is mixed into the top few inches of the sediment bed along with other newly deposited sediments that originate in the watershed, within the bay and within other parts of the harbor complex. The depth of this mixing (the “Biologically Active Zone” or BAZ) was estimated to be approximately six inches, based on work performed on behalf of USEPA as part of the NBSA RI/FS Phase I activities in Newark Bay (BBL 2006). This is consistent with the NBSA Phase I sampling, for which six-inch layers of surface sediments were collected and analyzed for contaminants.

The NBSA Remedial Investigation

The NBSA RI/FS includes sediment sampling to determine the distribution of chemical contamination in the bay, to support risk assessment, and to identify chemical sources (Tierra Solutions 2004). Phase I of this program has been completed. Sediment samples were collected in Fall, 2005 from 69 locations. The data were analyzed for geotechnical properties, radiochemistry activity, and contaminant levels. Additional sediment collections are anticipated; the next phase of sample collection is in the planning stage (Tierra Solutions 2006).

NBSA RI/FS Phase I sediment cores collected for chemical analysis included a surface layer six inches in depth, followed in general by one-foot-thick layers. The draft NBSA RI/FS Phase II plan

calls for a similar collection procedure (Tierra Solutions 2006). The conceptual model of the potential effects of navigational dredging on RI/FS sediment samples is illustrated in Figure 1.

Transported and redeposited DM may affect the RI/FS by changing the concentrations of contaminants within the surface layer of sediments. This appendix provides estimates of potential changes in surface sediment contaminant concentrations outside of the channel and slopes that will result from the redeposition of material resuspended during dredging. In some cases, contaminant concentrations may be higher in DM than in the existing surface sediments, and in some cases, lower. Both of these situations are addressed here, since in both cases, future contaminant concentrations may differ from those that would be observed without the HDP. In either case, future NBSA RI/FS sampling may be affected by the HDP.

The portions of the flats that lie adjacent to the slopes are a focus of this investigation. First, the dredging of sediments that have not been previously dredged or have not been dredged in some time may expose Areas with Elevated Concentrations of chemical contaminants (AECs) adjacent to the channel that have not been previously discovered and might be resuspended during dredging. The EA includes an explicit evaluation of this possibility (Figure 1).¹

In addition, the areas of the flats that lie adjacent to the channel and that are not disturbed by the dredging are likely to experience more redeposition of DM than other areas of the flats, due to their proximity to the source of the material. The evaluation presented in this appendix includes estimates of redeposition and the consequent changes in chemical concentrations in these areas.

¹ There is no chemical level that defines an AEC; the importance of such an area depends on its location, its size, the extent of dispersal within the bay due to local hydrodynamic conditions, as well as nearby surface sediment concentrations. All of these factors are incorporated into the analysis of the effects of AECs.

2 APPROACH

2.1 General Approach

To evaluate the potential effect of the HDP on RI/FS sampling, we computed the expected contaminant concentrations in a six inch surface layer that might be measured following the HDP, and compared these with existing conditions in the top six inches of the sediment bed. Results were computed assuming the entire HDP was completed. This is conservative, since much of the RI/FS sampling may be performed prior to completion of the HDP. A cumulative analysis was performed in the same manner, incorporating O&M and other dredging anticipated in Newark Bay.

The approach relied on integrating the hydrodynamic and sediment transport model results (Appendix 1) with chemical data collected by USEPA, USACE, and others. Based on the conceptual model presented above, the evaluation quantified each step of the process by which the dredged material (DM) and its associated contaminants may be transported from the dredging site and redeposited. The first step used the results of the MIKE3 hydrodynamic/particle tracking model that predicted the mass of DM deposited per unit area (kg/m²) in each cell of a 75 m grid in Newark Bay. This involved the following components (the numbers below refer to Figure 1b):

- (1) the mass of dredged material (kg) to be resuspended during dredging. The amount of DM was estimated based upon the contract data provided by USACE.
- (2) the transport of dredged material throughout the bay. Transport was computed using a state-of-the-art hydrodynamic model (NY/NJ Harbor Partnership 1999).
- (3) the subsequent deposition of the dredged material. This was computed by the particle tracking component of the hydrodynamic model (Appendix 1).

Next, levels of chemical contaminants in the redeposited material were used to characterize effects on the RI/FS sediment samples. The post-dredging concentrations of contaminants in the top six inches, resulting from mixing the original sample and the newly deposited material, were calculated. These values were compared with the existing concentrations in the top six inches. Differences

between the new and the existing concentrations represent the effects of the HDP. The analysis required estimates of the following:

- (4) concentrations of contaminants in the dredged material. This was based upon the latest NBSA RI/FS Phase I data (Tierra Solutions 2006), the USACE data collected as part of the dredging project, as well as historical data collected throughout Newark Bay.
- (5) concentrations of contaminants on surface sediments under current conditions. This was based upon the NBSA RI/FS Phase I data as well as historical data.

2.2 Estimation of the Change in Concentration in Surface Sediments Resulting from Dredging Resuspension

The concentration of each contaminant anticipated in a post-dredging core (C_{post}) was calculated using the following formula:

$$C_{post} = \frac{1}{D_{core}} [D_{DM} C_{DM} + (D_{core} - D_{DM}) C_{SS}] \quad (1)$$

where:

- C_{SS} = the contaminant concentration in the surface sediments prior to deposition of the dredged material (mg/kg)
- C_{DM} = the concentration of contaminant in the dredged material (mg/kg)
- D_{core} = depth of the core (mm)
- D_{DM} = depth of dredged material deposited on the sediment surface (mm)

The depth of deposition (D_{DM}) was calculated using the mass of sediment deposited on the sediment bed at each location within the bay (M_{DM} , in units of kg/m², computed by the model) along with the dry bulk density value (BD, kg/m³) estimated from the NBSA RI/FS Phase I surface sediment data (Tierra Solutions 2006):

$$D_{DM} = \frac{M_{DM}}{BD}$$

D_{core} , the depth of the simulated core, was six inches (150 mm). This is the depth of the biologically active zone identified in Phase I data (BBL 2006) and the depth of the surface layer collected during the NBSA RI/FS Phase I sampling program (Tierra Solutions 2006).

Chemical data collected in Newark Bay were used to estimate concentrations in DM (C_{DM}) and in surface sediments (C_{SS}). The chemical data included historical measurements performed by a variety of agencies (most of which was reported in the USEPA Remedial Investigation Work Plan for the Newark Bay Study Area); sediment cores collected by USACE to evaluate disposal options for the DM; and cores collected in October-December, 2005 by Tierra Solutions as part of the Phase I sampling in the Newark Bay Study Area.

In each core lying with the region to be dredged, C_{DM} was estimated by computing the depth-integrated concentration of each contaminant:

$$C_{depth-weighted} = \sum_{i=1}^n L_i C_i$$

where:

$C_{depth-integrated}$ = depth-integrated concentration in the core

L_i = length of core layer i

C_i = contaminant concentration in core layer i

Cores collected by the USACE were not segmented and were thus included directly in the estimation of C_{DM} .

All calculations were performed based upon the 75m X 75m model grid. Depth-integrated chemical concentrations in each sediment grid cell were calculated by interpolating between the cores using Thiessen polygons drawn around each sample location². Chemical concentrations in each model cell within each polygon were set equal to the concentration measured at the polygon's data point.

² Thiessen polygons are a set of adjacent polygons that cover the entire area, one polygon for each data point. All locations within a given polygon are closer to the data point within the polygon than to any other data point.

The particle tracking model simulated resuspension from 11 HDP “dredge areas” (Figure 2; and Appendix 1). For each dredge area, the contaminant concentrations on the resuspended material were set equal to the average of the interpolated concentrations in all model cells lying within it.

Surface sediment contaminant concentrations (C_{SS}) were estimated for each model sediment grid cell lying outside of the 11 dredge areas were estimated in a similar fashion, using Thiessen polygons created around the surface sediment sampling locations.

The analysis was performed for 2,3,7,8-TCDD, total PCBs, total DDT (pp-DDT, pp-DDE, and pp-DDD), benzo(a)pyrene, mercury, and chromium. To represent dioxins and furans, the analyses presented here focused on the concentration of 2,3,7,8-TCDD. One congener was chosen, because not all databases include multiple congeners. Benzo(a)pyrene (BAP) was used to represent polynuclear aromatic hydrocarbons (PAHs), because the list of PAH compounds is not consistent across databases.

2.3 Effects of Uncovering Areas of Elevated Concentrations

An analysis was performed to evaluate the effect of dredging potential but presently unidentified AECs in the side slopes and adjacent areas. The analysis estimated changes in the surface sediment concentrations throughout the bay that might be attributable to resuspension from such areas.

The first step in this analysis involved determining whether there is evidence of higher contaminant concentrations on side slopes compared with the channel. Based upon the NBSA Phase I data, overall, there were no significant differences in depth-integrated concentrations (Table 1). Thus, contaminant concentrations are not in general elevated on the slopes, indicating that AECs, if they exist, are local. Furthermore, the available slope data cannot be used to represent AECs.

In the absence of data adjacent to the channels that could be used to represent AECs, and acknowledging the limitations of the available data, the “elevated concentration” was set equal to the 90th percentile of all data collected south of the northern tip of the HDP³ (Table 2). This analysis is

³ The 90th percentile is the concentration value that is greater than 90% of the data.

designed to be conservative, as the data used to compute the 90th percentile included all NBSA Phase I data as well as all historical data collected within approximately half of Newark Bay and at any depth, including previously dredged core locations.

The transitional zones comprise approximately 15% of the volume of dredged material, based upon estimates available for dredge contract area S-NB-1 (total sediment volume = 580,000 cy; slopes = 90,000 cy). To estimate the effect on the overall concentration of contaminant in the dredged material, it was assumed that one entire edge of the dredge area (approximately equal to ½ of the total slope volume, or 7.5% of the DM) was contaminated at the elevated concentration.

The contaminant concentration used for the AEC analysis was thus set equal to:

$$C'_{DM} = SC_{90} + (1 - S)C_{DM}$$

where:

C'_{DM} = contaminant concentration in the dredged material used for the AEC analysis

S = proportion of sediment volume that consists of slopes along one side of the dredge area = 0.075

C_{90} = 90th percentile concentration of data collected within the vicinity of the dredge area

Values used in the calculation for each dredge area are presented in Table 2. For example, for dredge area S-AK-1, the concentration of TCDD in DM is estimated to be 6.8 ng/kg, based on the Thiessen polygon analysis. The 90th percentile was 340 ng/kg. $S = 0.075$, $1 - S = 0.925$, $C_{DM} = 6.8$, $C_{90} = 340$. The calculated concentration (C'_{DM}) = 32 ng/kg = $0.075(340.) + 0.925(6.8)$.

3 CHEMICAL DATA

3.1 Data Sources

The analyses rely in part on the data collected in October- December 2005 as part of Phase I of the Newark Bay RI/FS (Tierra Solutions 2006). In addition, all relevant sediment studies described in Volume 1 of the Newark Bay Study Area Remedial Investigation Work Plan (Tierra Solutions 2005) were incorporated. These studies include those provided in the NOAA Query Manager database put together for Newark Bay by NOAA's Office of Response and Restoration/Coastal Protection and Restoration Division (NOAA 2005), as well as USEPA's Regional Environmental Monitoring and Assessment Program (REMAP; USEPA 2005) and the Contaminant Assessment and Reduction Program datasets (CARP 2004). The studies included were conducted from 1991 to 2001, and the data have been used in numerous other environmental assessments and studies. These data were used, in addition to the NBSA Phase I data, to define contaminant concentrations in surface sediments and dredged material.

Table 3-49 of the RIWP Volume 1 indicates that 7 of the 11 studies included in the analyses presented here were subjected to quantitative QA/QC procedures or USEPA Region 2 data validation. Moreover, the individual studies for which quantitative QA/QC is indicated as being "not specified" do include standard measures of quality assurance and quality control, such as duplicates, spike recoveries, and method blanks. These include the NOAA NS&T Hudson-Raritan Study, the REMAP studies, and the Newark Bay Reach B,C,D data collection conducted by the USACE for the Confined Disposal Facility FEIS. It is reasonable to combine these data for the purposes of this study because QA/QC information was incorporated in all of the studies.

In addition, USACE has collected cores from Newark Bay, Arthur Kill and Kill van Kull contract areas, as well as Port Elizabeth, for the purpose of evaluating the dredged material for placement options. For the surficial silty sediment strata targeted for upland beneficial use, core depths ranged from 2 feet to 25 feet and were chosen to characterize the material down to where it meets underlying consolidated Pleistocene, HARS suitable till and clay materials, or to the project depth of the HDP. The bulk sediment chemistry test results of the composites made from these cores were incorporated into the estimate of the concentrations of contaminants in the DM.

Together, these data include all relevant sediment data for Newark Bay and adjacent tidal straights, and thus are considered sufficient for the purposes of assessing the potential impacts on the NBSA RI/FS by the HDP. These data include multiple sampling locations within each geomorphic area and geographical region within the Bay (Tierra Solutions 2004 and 2006). Further, data are available from the sediment surface and at depth, in each of these areas. Thus, concentrations of chemicals within each dredge area and potential impact area are characterized by representative distributions. To the extent that there are areas with concentrations of chemicals in sediments that fall outside of the distributions characterized by the existing data, these areas would be limited in spatial extent (between existing data points).

3.2 NBSA RI/FS Phase I Data

Tierra Solutions, Inc collected 69 cores in Newark Bay for contaminant analysis as part of Phase I of the NBSA RI/FS (Tierra Solutions 2006). Details regarding the sampling are available in the NBSA RI/FS Work Plan (Tierra Solutions, 2004). The data are available at www.ourpassaic.org. Duplicate results were averaged and samples that were below detection were included as one-half the detection limit. Cores were sectioned from 0 – 0.5 ft and then generally at 1 ft intervals down to 5 to 6.5 ft, with two samples going down to 8 ft. The top 0.5 ft are included in surface analyses presented below. In the channels, the result for each core is presented as a depth-integrated concentration. The contaminant data used here are provided in Attachment 1. A map showing sample locations is provided in Attachment 3.

3.3 Historical Data

The data collected prior to the Phase I sampling are referred to as “historical”. These data were collected from 1991 to 2001 and included surface and core samples collected during various monitoring and permit compliance programs. Many of these cores included a surface layer of up to six inches in thickness, which was used here to represent surface contamination. These cores also included a series of subsurface layers that were used to characterize the dredged material.

In the channels, contaminant concentrations either represent whole core composites (USACE cores collected for the purpose of characterizing dredged material) or depth-integrated concentrations.

Data from a total of 125 core and grab samples were included. (207 samples were collected in total, although chemical concentrations were not available for all samples.) Concentrations of the contaminants evaluated in this study are provided in Attachment 2, in which duplicates have been averaged and non-detects set at one-half the detection limit. Also provided in Attachment 2 is the geomorphic area determined for each sample location.

Some of these areas have been dredged since sample collection; the dredging status was determined by comparing the sampling location with available information concerning past dredge locations and contract dates and is indicated on the data table. Samples collected after the last dredging event are termed “active”. Only active historical data were included in the analysis.

3.4 Data Usage and Compatibility

The type of analysis for which each sample was used is indicated by a “use” designation. These are provided for the NBSA RI/FS and Historical data in Attachments 1 and 2, respectively. A use designation of “S” indicates the sample was used to estimate surface sediment concentrations in the impact areas. A use of “DW” indicates the sample was used to estimate the depth-integrated concentrations of dredged material. Samples designated “DW&S” were located within the navigational channel but will not be dredged as part of the HDP, so they were used in estimating dredged material concentrations for other non-HDP dredging, including maintenance, as well as surface sediment concentrations for assessing the effects of the HDP. A designation of “NA” indicates the sample was not analyzed for this contaminant. A designation of “S, NA” indicates the sample was not used in the analyses presented here because it was collected at depth in an impact area, where only surface sediments impacts are evaluated. A designation of “EXCL” means the sample was excluded due to its location being outside the NBSA.

Contaminant concentrations measured in the NBSA RI/FS Phase I data and in the “active” historical data were found to be generally similar. Concentrations measured in the channels and out of the channels were compared for all six chemicals using a Student’s t-test. Only one of the twelve statistical comparisons resulted in a P-value less than 0.05 (Table 3).

4 APPLICATION TO NEWARK BAY

4.1 Estimation of Chemical Concentrations

4.1.1 Chemical Concentrations in Dredged Material

The depth-integrated concentrations are presented in the left-hand panels of Figures 3a through 3f. In these figures, the concentration data are presented in five groups, differentiated by color intensity. Cutoffs were set so as to provide a reasonable number of values in each color group, using round values approximately equal to the 25th, 50th, 75th and 90th percentiles of the entire data set. (For each chemical, the same cutoff concentrations were used in all figures.) The groupings are for presentation purposes only; they do not represent statistical significance.

The estimated contaminant concentrations in DM for each dredge area (Table 2) was applied to the volume of silt to be dredged as part of the HDP. The total volume of all materials (silt, sand and gravel, rock) are listed in Table 4.

The analysis presented here is conservative, insofar as the contaminant data were collected almost exclusively in black silt, but were used to represent a mixture of black and red-brown silt. Black silt is relatively recently deposited material and has contaminant levels that are relatively high, generally sufficient to require upland disposal. The dredge volumes used here include black silt as well as red-brown silt. Red-brown silt, also termed Pleistocene silt and clay, was deposited long before the industrial period; this material has been tested and shown to have relatively low contaminant levels, suitable for placement at the Historic Area Remediation Site (HARS).

4.1.2 Chemical Concentrations in Surface Sediments

Surface sediments include all core layers lying completely within the top six inches of the sediment bed. This includes all surface layers of the NBSA RI/FS Phase I data, as well as historical data. Thiessen polygons of the surface sediment concentrations in all areas not to be dredged are presented in the right-hand panels of Figures 3a through 3f. Color coding is the same as for the dredge areas.

4.2 Model Parameters

As discussed in Appendix 1, 3% of the dredged material was assumed to resuspend into the water column.

The analysis was based upon a surface layer thickness of six inches. It is possible that future sediment sampling may include high-resolution cores with more than one layer within the top six inches. This EA provides an indication of what areas are expected to experience relatively elevated deposition due to the HDP; this information will be useful to USEPA in choosing locations for the collection of any such cores.

A dry bulk density of 1,500 kg/m³ was used to calculate the mass of sediments resuspended during the HDP. This value was calculated based upon sediment cores collected by USACE throughout Newark Bay for the purpose of geotechnical characterization. A value of 800 kg/m³ was used for other dredging, including maintenance, based upon NBSA Phase I data collected in the channels and on the side slopes. The dry bulk density of the material redeposited on the impact areas was set equal to 750 kg/m³, calculated based upon surface sediment percent moisture data reported in the NBSA Phase I database. The field data and bulk density calculations are presented in Attachment 4 to this appendix.

5 RESULTS

5.1 Presentation and Analysis

The estimated total deposition due to the entire HDP (all dredge areas, for the entire duration of the project) is presented in Figure 4. Each circle represents the results for a model sediment grid cell. These results represent the direct output from the MIKE 3 model (Appendix 1). The left-hand panel is a copy of Figure 35 from Appendix 1, showing interpolated model results. The right-hand panel presents the same results individually for each model sediment grid cell. This panel presents the information used in all subsequent calculations in this Appendix, which are performed individually for each model grid cell. Results are not presented for the channel, because contaminant concentrations in the residual material are expected in general to be similar to pre-dredging concentrations.

Predicted post-HDP contaminant concentrations in the surface sediments of the NBSA are summarized in Figures 6 through 11. Results are presented in two ways.

Semi-Quantitative Comparisons

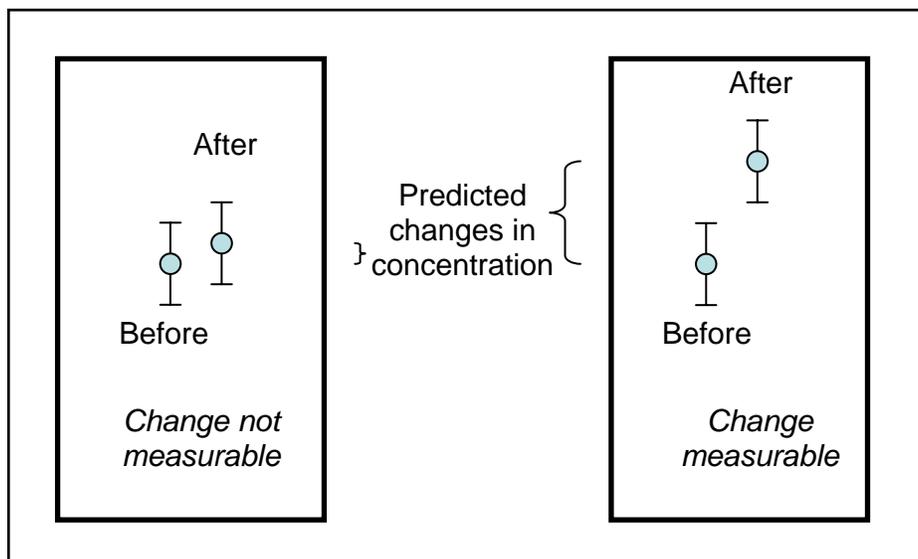
First, predicted changes in concentration are presented semi-quantitatively on maps, with the goal of showing where within the bay increases and decreases in concentration are expected, and roughly how much they are expected to change. Figures 6a, 7a, 8a, 9a, 10a, 11a present current concentrations in surface sediments (left-hand panel) and predicted post-dredging concentrations (right-hand panel) for each model sediment grid cell. The pre-dredging values in the left-hand panels are the same as those in Figure 3, except that in Figures 6 through 11, values are presented on the model grid. Values are grouped together in the same color coded groups used in Figures 3a through 3f.

In Figures 6b, 7b, 8b, 9b, 10b, and 11b, the difference between post- and pre-dredging concentration is presented for each model grid cell (pre-dredging minus post-dredging; thus, a positive value indicates a higher post-dredging concentration). Values are grouped, and groups are indicated by color: purple represents an increase in concentration, and brown represents a decrease. Differences in color intensity indicate the extent of change expected; for each chemical, the groups are

approximately equal to one-half and one-tenth of the 25th percentile of the entire data set. The same concentration ranges were used in all figures for each chemical. Note that the groups were selected for presentation only; they are not based upon risk and are not intended to imply significance.

Quantitative Comparisons

The second presentation of the results is quantitative and is based upon a comparison of predicted change with data uncertainty. Because changes that cannot be measured cannot affect the RI/FS, comparison of predicted changes with data uncertainty puts the predicted changes in context. For example, in the diagram below, pairs of points representing average concentrations measured before and after dredging are presented, along with error bars representing data uncertainty. In the panel on the left, the predicted change in concentration is less than the precision of the data; a comparison of pre- and post-dredging data would not be different. In the figure on the right, the difference would be noticeable.



The NBSA RI/FS Phase I dataset included the results of a number of field duplicates. These were used to estimate the uncertainty associated with the measurements. Tierra Solutions prepared field duplicates of selected sediment samples by mixing a double portion and placing equal aliquots of the homogenate in two sets of glassware (Tierra Solutions 2004). To compare the precision of the measurements in the Phase I data with the computed changes in concentration, the relative percent

difference (RPD) was calculated for both⁴. For the field duplicates collected during the NBSA RI/FS Phase I program, the percent difference between the duplicates was calculated as follows:

$$RPD_{dups} = \frac{dup1 - dup2}{average(dup1, dup2)} \times 100$$

where:

dup1 = chemical concentration in one of the duplicate samples

dup2 = chemical concentration in the other of the duplicate sample

The RPD_{dup} was calculated for each pair of duplicates for each chemical.

These values were then compared with a relative percent difference calculated from the pre- and post-HDP model results for each model grid cell:

$$RPD_{model} = \frac{post - pre}{pre} \times 100$$

where:

pre = chemical concentration prior to dredging (i.e., current conditions)

post = chemical concentration after the HDP is complete

These RPD values were used to evaluate which predicted HDP-induced changes in concentration were greater than the precision of the Phase I data, that is, lay outside the range of data uncertainty. Uncertainty was quantified using the upper 95th percentile of the mean of the RPD_{dup} values: changes smaller than this are expected to be indistinguishable from data uncertainty⁵. This value is termed here the “uncertainty threshold” (UT) and was calculated using Land’s method for lognormal populations (Gilbert 1987, Land 1975). Each model grid cell with an RPD_{model} value greater than

⁴ The RPD is a common measure of precision, discussed, for example, in the NBSA Phase I data program (Tierra Solutions 2004, Section 5.2.2.1).

⁵ Most of the time, on average, sets of paired measurements are expected to differ less than this value. This means that a predicted change less than this amount would most likely not be noticeable.

the UT was identified and mapped; these cells were characterized in the discussion presented below as having potentially noticeable predicted changes, that is, changes greater than the uncertainty in the data.

Twenty pairs of duplicate samples were collected by Tierra Solutions. Duplicate pairs in which both samples were non-detect were not included in the analysis. Duplicate pairs in which one sample was below the limit of detection were included, and the non-detect value was set equal to one-half the detection limit. After eliminating pairs of non-detects, between 13 and 20 pairs of duplicates remained in the analysis for the six chemicals, depending upon the chemical species. The data for the duplicates are presented in Table 5. The distributions of the RPD values are presented graphically in Figure 5. The RPD statistics and resulting UT values are presented in Table 6.

In Figures 6c, 7c, 8c, 9c, 10c, 11c, the left-hand panel presents the quantitative relationship between pre- and post-dredging concentrations on a grid cell-by-grid cell basis in the form of a crossplot. The pre-dredging (current) concentration of each contaminant for each model sediment grid cell is plotted on the horizontal axis and the predicted post-HDP concentration for the same grid cell is plotted on the vertical axis. The 1:1 line is presented; symbols below this line represent a decrease in concentration following the HDP, and symbols above this line represent an increase. The dashed lines represent the UT. Symbols that lie outside of the bounds of the dashed lines represent model grid cells which are predicted to change in concentration more than the UT; these are indicated with a different color. The middle panel presents the same information with a magnified scale to aid in comparing the lower values. The right-hand panel provides a map of Newark Bay in which the model grid cells exhibiting changes greater than the UT are indicated with a different color.

5.2 Effects of the HDP

Figures 6a and 6b provide both an indication of where changes are expected to occur, and roughly how strong those changes are expected to be. It should be noted that this presentation is qualitative⁶.

⁶ For example, a small predicted change in concentration may move a cell from roughly the 49th percentile to the 51st percentile, resulting in a color change. A larger change, from say the 30th percentile to the 49th would not be visible on these figures. Thus, a change in color group does not imply significance; it is simply a qualitative means of describing relative changes in concentration following the HDP.

Concentrations of TCDD showed relatively little change throughout the bay (Figures 6a and 6b). Only two cells out of a total of 2380 model cells⁷ changed color groups (Figure 6a). Most of the changes in concentration are visible in the northern portion of the navigational channel, and in southern Newark Bay alongside the channel, areas where the greatest deposition occurred (Figure 6b). All visible changes in concentration in Figure 6b were decreases, because in these locations, the channels showed somewhat lower TCDD concentrations than nearby surface sediments.

In the quantitative evaluation, only 10 cells out of 2380 (0.4%) had predicted changes that were greater than the uncertainty in the data (Figure 6c and Table 7). All but one of these cells were located at the northern end of the HDP; these were in one polygon which contained a sample with a very low TCDD concentration. All of the predicted changes that were greater than the uncertainty in the data were increases in concentration (Figure 6c, left and middle panels). Even after the HDP, these concentrations were predicted to remain below 5 ng/kg after the HDP is complete, considerably less than the overall median TCDD concentration in the bay, which was approximately 50 ng/kg. Thus, nearly all of the predicted differences throughout Newark Bay were within the precision of the data, and changes greater than the precision of the data were small absolute changes at low concentrations.

Concentrations of total PCBs throughout the bay showed relatively little change, similar to TCDD (Figures 7a and 7b). Only 42 cells changed color groups (Figure 7a). Most of the visible changes occurred in the navigational channel, both towards the north and in the KVK, as well as alongside the channel; these were areas where the greatest deposition occurred. Twelve cells had predicted changes that were greater than the uncertainty in the data (0.5%; Figure 7c, Table 7). Similar to TCDD, these were all located at the northern tip of the HDP in an area with very low current PCB concentrations (Figure 7c, left and middle panels). Also similar to TCDD, all of these potentially noticeable changes were increases in concentration. None were predicted to exceed approximately 0.011 mg/kg after the HDP is complete. This is much less than the overall median PCB concentration in the bay, approximately 0.5 mg/kg.

⁷ 2,380 model sediment cells lie within the surface sediment polygons presented in Figure 3, right hand panels.

Concentrations of DDT throughout the bay showed more changes than TCDD and PCBs (Figures 8a and 8b). Eight cells changed color groups (Figure 8a). The spatial pattern differed from TCDD and PCBs. Most of the visible changes occurred along the northern edge of the HDP, along the south Elizabeth Channel, and along the Arthur Kill channel. Along the Arthur Kill, concentrations were predicted to increase following the HDP, while in the other areas, concentrations decreased. Twenty-five model grid cells had predicted changes that were greater than the uncertainty in the data (1.1%; Figure 8c and Table 7); all of these cells were located along the Arthur Kill. All of these potentially noticeable changes were increases in concentration, occurring in areas with relatively low current DDT concentrations (Figure 8c, left and middle panels). None of these concentrations were predicted to exceed 0.08 mg/kg after the HDP is complete. For comparison, the overall median DDT concentration in the bay was approximately 0.05 mg/kg and the 75th percentile was about 0.10 mg/kg.

Concentrations of BAP throughout the bay showed less change than TCDD, PCBs and DDT (Figures 9a and 9b). Four cells changed color groups (Figure 9a). All of the visible changes that appear on Figure 9b were decreases, and most of these were located at the northern edge of the HDP. Thirty-six model grid cells had predicted changes that were greater than the uncertainty in the data (1.5%; Figure 9c and Table 7). All of these cells were located in the Kill van Kull, lay within one Thiessen polygon with a very low current BAP concentration (Figure 9c, left and middle panels), and showed increases in concentration. Post-HDP concentrations in this area were not predicted to exceed 0.007 mg/kg after the HDP is complete, considerably less than the overall median BAP concentration in the bay, approximately 0.7 mg/kg. Thus, the predicted differences throughout Newark Bay were nearly all within the precision of the data, and changes greater than the precision of the data were small absolute changes at low concentrations.

Concentrations of mercury throughout the bay showed relatively little change (Figures 10a and 10b). Two model grid cells changed color groups (Figure 10a). Visible changes in Figure 10b were scattered along the edges of the dredge channels; all changes visible in Figure 10b were decreases. Ten model grid cells had predicted changes that were greater than the uncertainty in the data (0.4%; Figure 10c and Table 7). All of these cells were located at the southern edge of the NBSA within the Arthur Kill. All of the potentially noticeable changes were increases in concentration, and all occur

in areas with very low current mercury concentrations (Figure 10c, left and middle panels): concentrations in this area were not predicted to exceed 0.04 mg/kg after the HDP is complete, considerably less than the overall median mercury concentration in the bay, approximately 2 mg/kg. (Note that the cells that showed decreases in Figure 10b were not the same cells that showed changes greater than the precision of the data in Figure 10c; the latter figure provides a more quantitative assessment than the former).

Concentrations of chromium throughout the bay showed relatively little change, similar to BAP and mercury (Figures 11a and 11b). Seventeen cells changed color groups (Figure 10a). All changes that were great enough to appear in Figure 11b were decreases, and most were located at the northern tip of the HDP and by the south Elizabeth Channel. Three model grid cells had predicted changes that were greater than the uncertainty in the data (0.1%; Figure 11c and Table 7). These were decreases in concentration of at most approximately 20% (Figure 11c).

In summary, few predicted changes in concentration were greater than the uncertainty threshold. These tended to be found within or adjacent to the navigational channel at the northern tip of the HDP (TCDD and PCBs) and along the Arthur Kill (DDT, Hg). For BAP, the changes that were greater than the precision of the data were all associated with one data value in the Kill van Kull. For TCDD, PCBs, BAP and mercury, changes greater than the precision of the data occurred only in locations where the data indicated very low surface sediment concentrations, and the predicted changes in concentration were relatively small. A few model cells with intermediate DDT and chromium concentrations changed to an extent greater than the precision of the data. Thus, for nearly all of Newark Bay, predicted changes in concentration lay within the precision of the data. This lack of dramatic, widespread effects was due to the fact that contaminant levels in the channels were generally similar to levels in the surface sediments. This similarity also explains the observation that changes greater than the precision of the data were generally increases and generally occurred in areas with relatively low surface sediment concentrations. Consequently, chemical concentrations in samples collected after the HDP are, with a few exceptions, likely to be indistinguishable from concentrations in samples collected prior. It is improbable that deposition due to the HDP will affect USEPA's ability to interpret sediment samples in Newark Bay

5.3 Effects of Uncovering Areas of Elevated Concentration

This analysis was designed to evaluate the effects of encountering previously unknown AECs in the transitional zone as the channel is widened (Figure 1a). Results are presented in Figures 12 through 17, which are structured the same as Figures 6 through 11.

For TCDD, effects on surface concentrations were similar to the HDP evaluation discussed above. Twenty-six model grid cells had predicted changes that were greater than the uncertainty in the data, compared with 10 cells in the HDP evaluation (Figure 12c, Table 7). As in the HDP evaluation, most of these were located at the northern tip of the HDP. Changes were observed in a small number of model grid cells in the Kill van Kull. As in the HDP-only case, all of the changes that were greater than the uncertainty in the data were increases in concentration, and occurred in areas with low current TCDD concentrations (Figure 12c, left and middle panels). Furthermore, in all areas showing potentially noticeable increases in concentration, concentrations were predicted to remain below 10 ng/kg after the HDP is complete.

For PCBs, some cells showed increases in concentration (Figure 13b), in contrast to the HDP evaluation (Figure 7b). Twenty-seven model grid cells had predicted changes that were greater than the uncertainty in the data, compared with 12 cells in the HDP evaluation (Figure 13c, Table 7). All but one of these model grid cells were located at the northern tip of the HDP. One cell was located in northern Newark Bay. Similar to HDP evaluation, all of these potentially noticeable changes were increases in concentration, and occurred in an area with low current PCB concentrations (Figure 13c, left and middle panels). Concentrations in this area were not predicted to exceed 0.07 mg/kg after the HDP is complete.

For DDT, more increases were observed in the AEC analysis (Figure 14b) than in the HDP evaluation (Figure 8b). Thirty-three model grid cells had predicted changes greater than the uncertainty in the data, compared with twenty-five cells in the HDP evaluation. These were largely located along the Arthur Kill (Figure 15c), similar to the HDP evaluation. A few cells were located north of the HDP. As in the HDP evaluation, all of the potentially noticeable changes were increases in concentration. They occurred in areas with relatively low current DDT concentrations (Figure

14c, left and middle panels). As in the HDP evaluation, concentrations were not predicted to exceed 0.08 mg/kg after the HDP is complete.

For BAP, results for the AEC analysis (Figure 15b) and the HDP evaluation were similar (Figure 9b). Thirty-eight model grid cells had predicted changes that were greater than the uncertainty in the data, compared with 36 cells in the HDP evaluation. These were largely located in Kill van Kull (Figure 15c), similar to the HDP evaluation (Figure 9c). Two cells were located in Newark Bay (Figure 15c). All of the potentially noticeable changes in Kill van Kull were increases in concentration. Post-HDP concentrations in this area were not predicted to exceed 0.007 mg/kg after the HDP is complete. Two locations in Newark Bay showed increased in concentration slightly more than the uncertainty in the data (Figure 15c), although they remained around the median (0.7 mg/kg).

For mercury, the AEC analysis (Figure 16b) produced fewer visible changes than the HDP evaluation results, based upon the color scheme used in Figure 10b. The number of model grid cells that changed more than the precision of the data were similar: 12 in the AEC analysis, compared with ten in the HDP evaluation. All but two of these were located along the Arthur in Kill (Figure 16c). Two model cells in northern Newark Bay also had predicted changes that were greater than the uncertainty in the data (Figure 16c). All of these potentially noticeable changes were increases in concentration. All of the changes in the Arthur Kill occurred in areas with very low current mercury concentrations (Figure 16c, left and middle panels): concentrations in this area were not predicted to exceed 0.05 mg/kg after the HDP is complete. In northern Newark Bay, a change from approximately 0.3 mg/kg to approximately 0.4 mg/kg was predicted in one model grid cell; these values are small relative to the bulk of the concentrations observed in the surface sediments of Newark Bay (median about 2 mg/kg; Figure 16c, Figure 3e).

For chromium, both the AEC analysis (Figure 17b) and the HDP evaluation produced very few changes (Figure 11b). Two model grid cells had predicted changes greater than the uncertainty in the data (Figure 17c), compared with 3 cells in the HDP evaluation (Figure 11c). Both increases were only slightly greater than the uncertainty in the data.

Results are summarized in Table 7. Few predicted changes in concentration were greater than the uncertainty threshold, similar to the HDP evaluation. The spatial distribution was generally similar to the HDP evaluation, although more increases in concentration were observed than in the HDP evaluation, as was expected. Thus, chemical concentrations in samples collected after the HDP are likely to be indistinguishable from concentrations in samples collected prior. It is improbable that deposition due to the HDP will affect USEPA's ability interpret sediment samples in Newark Bay.

5.4 Effects At Proposed NBSA Phase II Locations

Tierra Solutions has developed a draft Phase II sampling program that is currently under review by USEPA (Tierra Solutions 2006). A total of 18 coring locations were proposed for Phase II sampling by Tierra Solutions. Eleven of these were previously sampled during Phase I activities; the Phase II cores will be collected within 50 feet of their associated Phase I locations (Table 6-1 from Tierra Solutions 2006). Two additional cores represent new sampling locations within select Industrial Waterfront Areas; one within the NBSA (082) and one in the adjacent tidal straight, the Kill Van Kull (081). The proposed location 081 was included in the analysis, despite its location outside of the NBSA, because it was within the study area (the model domain). Five Phase II cores are proposed to be collected from outside the NBSA and the study area (one in Arthur Kill and four from tributaries to the Arthur Kill) were not considered in the analysis. Additionally, USACE proposed the collection of samples from 15 other locations within the NBSA. Using the results of the analysis discussed above, current and model-predicted post-HDP chemical concentrations at these 28 proposed Phase II sampling locations were compared.

For the HDP evaluation, the changes computed to occur within each of the model grid cells representing the Phase II sampling locations are listed in Table 8. Out of 168 comparisons (6 chemicals X 28 sites), two values were computed to change from existing concentrations by more than the precision of the Phase II data; one value for mercury and one for DDT. The changes for both chemicals were predicted to occur at USACEP2-14. These were the result of low existing concentrations, as measured in closest core, 39_PRP-99-01. The mercury concentration changed from 0.016 to 0.026 mg/kg; both of these values are considerably lower than the median concentration in surface sediments (approximately 2.0 mg/kg). The DDT concentration changed

from 0.001 to 0.003 mg/kg; both of these values are considerably lower than the median concentration in surface sediments (0.05 mg/kg). Thus, the concentrations change by a relatively small amount in absolute terms, but because the estimated existing concentrations are low, the change exceeds the precision of the data. Thus, overall, predicted changes in surface sediment chemical concentrations are anticipated to be minimal. This analysis can be repeated for future revised sampling plans for the NBSA to help USEPA locate sampling sites.

Results for the AEC analysis are provided in Table 9. As for the HDP evaluation, out of 168 comparisons (6 chemicals at 28 sites), two values were computed to change from existing concentrations by more than the precision of the data. These were the same chemicals and the same location as or the HDP evaluation and thus, the significant changes were also the result of low existing chemical concentrations, relative to the overall distribution. Thus, overall, predicted changes in surface sediment chemical concentrations are anticipated to be minimal.

6 CUMULATIVE ASSESSMENT

While the HDP is underway, additional dredging is expected to occur in Newark Bay for other projects including channel and berth operations and maintenance (O&M). Anticipated volumes of dredged material are discussed in the EA and are summarized in Table 10. To simulate the impact of this additional dredging, the total volumes likely to be dredged while the HDP is under construction were distributed among the HDP dredge areas as well as additional areas in Port Newark Channel. The MIKE3 model was used to estimate the deposition due to the combination of the HDP and other dredging anticipated in Newark Bay during construction of the HDP.

Predicted deposition is more widespread in the cumulative assessment than in the HDP-only case, as expected (Figure 18)⁸. This is especially evident in the Port Newark Channel, where no HDP dredging is to take place, but where additional dredging is planned.

Thiessen polygons representing dredged material concentrations including the Port Newark O&M areas are presented in Figures 18a through 18f. Contaminant results are presented in Figures 19 through 24, which are structured the same as Figures 6 through 11. The predicted changes in surface sediment chemical concentrations are compared with the precision of the NBSA RI/FS Phase I data in Table 7.

Qualitative results for TCDD are shown in Figure 19b. Thirteen model grid cells had predicted changes that were greater than the uncertainty in the data, compared with 10 cells in the HDP evaluation. As in the HDP evaluation, most of these were located at the northern tip of the HDP (Figure 19c). Three cells were located in southern Newark Bay and in Kill van Kull. All but one of these potentially noticeable changes were increases in concentration, and all of the increases occurred in areas with very low current TCDD concentrations (Figure 19c, left and middle panels). The concentrations that increased were predicted to remain below 10 ng/kg after the HDP is complete. One cell was predicted to decrease slightly more than the precision of the data (Figure 19c).

Qualitative results for PCBs are shown in Figure 20b. Seventeen model grid cells had predicted changes that were greater than the uncertainty in the data, compared with 12 cells in the HDP evaluation (Figure 20c). Similar to the HDP evaluation, these were located at the northern tip of the HDP. Also similar to HDP evaluation, all of these potentially noticeable changes were increases in concentration, and all occurred in areas with low current PCB concentrations (Figure 20c, left and middle panels). These concentrations were not predicted to exceed 0.012 mg/kg after the HDP is complete.

Qualitative results for DDT are shown in Figure 21b. Twenty nine model grid cells had predicted changes that were greater than the uncertainty in the data, compared with 25 cells in the HDP evaluation. Concentrations increased along the Arthur Kill (Figure 21b), similar to the HDP evaluation (Figure 8b). Similar to the HDP evaluation, these potentially noticeable changes were increases in concentration, and none of these concentrations were predicted to exceed 0.10 mg/kg after the HDP is complete.

Qualitatively, results for BAP produced some visible changes in the Port Newark Channel (Figure 22b), in contrast to the HDP evaluation results (Figure 9b). However, only 37 model grid cells had predicted changes that were greater than the uncertainty in the data, compared with 36 cells in the HDP evaluation (Figure 22c). All but one of these cells were located in the Kill van Kull, the same location is in the HDP evaluation (Figure 22c, right panel). These changes were due to one data value, as in the HDP evaluation (Figure 9c). One grid cell in South Elizabeth Channel showed a change slightly greater than the precision of the data (Figure 22c).

Qualitatively, cumulative assessment results for mercury (Figure 23b) produced more visible changes than the HDP evaluation (Figure 10b). Nonetheless, the number of changes that exceeded the uncertainty in the data was similar: 11 model grid cells, compared with ten cells in the HDP evaluation. These were located in the Arthur in Kill (Figure 23c), as in the HDP evaluation (Figure 10c). All of these potentially noticeable changes were increases in concentration. All of the changes

⁸ The left-hand panel of Figure 18 is a copy of Figure 38 from Appendix 1, showing interpolated model results. The right-hand panel presents the same results individually for each model sediment grid cell.

in the Arthur Kill occurred in areas with relatively low current mercury concentrations (Figure 23c, left and middle panels): concentrations in this area were not predicted to exceed 0.16 mg/kg after the HDP is complete. This value is relatively small compared with the overall level of contamination within the bay, for which the median is approximately 2 mg/kg.

For chromium, the cumulative assessment (Figure 24b) showed slightly more visible changes than the HDP evaluation (Figure 11b). These occurred along Port Elizabeth and south Elizabeth Channels (Figure 24c) and were due to decreases in concentrations. Six model grid cells had predicted changes that were greater than the uncertainty in the data (Figure 24.1), compared with three cells in the HDP evaluation (Figure 24c). Four were located along the south Elizabeth channel and two along the Port Elizabeth channel.

Results are summarized in Table 7. While more changes were predicted in the cumulative assessment than in the HDP evaluation, the proportion of Newark Bay that showed changes greater than the precision of the data was low. As in the HDP evaluation, changes greater than the precision of the data occurred at the northern tip of the HDP, in the Arthur Kill, and, for BAP, in Kill van Kull. In the cumulative assessment, changes were also observed in or adjacent to the port channels, in or adjacent to the transitional zones. Also, more decreases in concentration were predicted than in the HDP evaluation. Overall, though, throughout the bay, those few changes that were greater than the uncertainty in the data were often only slightly greater. Furthermore, it should be noted that the analysis is conservative, insofar as a portion of the additional dredging is to be performed irrespective of the HDP, and thus predicted changes in contaminant levels in surface sediments represent, in part, the continuation of an ongoing process. In conclusion, for nearly all of Newark Bay, predicted changes in concentration were generally less than or similar to the precision of the data. Consequently, chemical concentrations in samples collected after the HDP are likely to be indistinguishable, in general, from chemical concentrations in samples collected prior. Deposition due to the HDP and other dredging is unlikely to affect USEPA's ability to interpret chemical concentrations in sediment samples from the flats.

The results of the analysis presented here for proposed Phase II sediment sampling locations are provided in Table 11. As for the HDP and AEC analyses, out of 168 comparisons (6 chemicals X 28

sites), two values were computed to change from existing concentrations by more than the precision of the data. These were the same chemicals and the same location as for the HDP and AEC evaluation. Concentrations changed to a greater degree than in the HDP-only and AEC evaluations (for mercury from 0.016 to 0.058 mg/kg, and for DDT from 0.001 to 0.01 mg/kg. For comparison, all values remained considerably less than the overall medians of the data (approximately 2.0 mg/kg Hg and 0.05 mg/kg DDT). Thus, the predicted concentration increases are still relatively minor. Overall, predicted changes in surface sediment chemical concentrations are anticipated to be minimal.

7 SUMMARY

Overall, few predicted changes in concentration were greater than the uncertainty threshold. This was true of the HDP evaluation, the AEC evaluation, and the cumulative analysis.

Flats. In the HDP evaluation and in the AEC analysis, very few cells lying in the flats exhibited changes greater than the precision of the data, for all chemicals. This is due to limited deposition and to the general similarity between contaminant concentrations in dredged material and in surface sediments on the flats.

Channels. Changes in contaminant concentrations in surface sediments were assessed in the channels that lie outside of the HDP; these extend from the Bergen Point area into Kill Van Kull and in the channels in northern Newark Bay, including Port Newark Channel. Predicted changes in concentration that were greater than the precision of the data were found within the navigational channel at the northern tip of the HDP (TCDD and PCBs). For BAP, the changes that were greater than the precision of the data were all associated with one data value in the Kill Van Kull.

Results were generally similar for the AEC analysis, with the following exceptions. For TCDD, changes that were greater than the precision of the data were also found in the Kill van Kull. For DDT, a few cells in the channel in northern Newark Bay exceeded the precision of the data.

Transitional zones. The transitional zones were represented by the model cells lying adjacent to the channel. Predicted changes in concentration due to the HDP that were greater than the precision of the data tended to be found adjacent to the navigational channel at the northern tip of the HDP (TCDD and PCBs) and along the Arthur Kill (DDT, Hg). The few cells that showed changes in chromium levels greater than the precision of the data were located along the Port Elizabeth Channel.

Results were generally similar in the AEC analysis.

In the cumulative assessment, the locations of cells showing changes greater than the precision of the data were generally similar to the HDP and AEC evaluations.

In conclusion, the analysis presented here shows that chemical concentrations projected to be present after the HDP is completed are, with a few exceptions, indistinguishable from current sediment concentrations. Furthermore, in general, those few changes that were greater than the uncertainty in the data were often only slightly greater. Therefore, it is improbable that deposition due to the HDP will affect USEPA's ability to interpret sediment samples in Newark Bay.

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