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Indiana Harbor and Canal (IHC) Dredging and Disposal Alternatives Analysis

Mechanical Dredging Comparative Analysis

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WES

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Acronyms

AACEI - Association for the Advancement of Cost Engineering International
BTEX - Benzene, Toluene, Ethylbenzene, Xylene
CDF - Confined Disposal Facility
DDAA - Dredging and Disposal Alternatives Analysis
DDR - Design Documentation Report
FTTER - Final Treatment Technology Evaluation Report
HELP - Hydrologic Evaluation of Landfill Performance
IHC - Indiana Harbor and Canal
MWH - Montgomery Watson Harza
O&M - Operation & Maintenance
OM&M - Operation, Monitoring & Maintenance
TOC - Total Organic Carbon
TSCA - Toxic Substances Control Act
TSS - Total Suspended Solids
WES - Waterways Experiment Station
WWTP - Wastewater Treatment Plant

Preface

This report describes a follow on study to the alternatives analysis completed previously (Estes et al. 2003), in which three mechanical and hydraulic dredging alternatives for the operation of the Indiana Harbor and Canal Confined Disposal Facility (CDF) were evaluated. The purpose of this study is to further evaluate mechanical dredging offloading alternatives, including: mechanical dredging with mechanical offloading, mechanical dredging with hydraulic offloading, and mechanical dredging with recycle of effluent for hydraulic offloading operations. Issues to be addressed include: 1) contaminant concentrations in effluent and relative volatilization and particulate emission rates between the alternatives, 2) required CDF design and operation modifications for hydraulic offloading, 3) re-evaluation of area climatological data, and 4) relative life cycle cost of the three offloading alternatives for mechanical dredging. The Environmental Laboratory (EL) of the U.S. Army Engineer Research and Development Center (ERDC) at the Waterways Experiment Station (WES) conducted this work. The U.S. Army Corps of Engineers (USACE) Chicago District funded ERDC under Project Order W81G6623056283. The project manager was Ms. Shannon R. Rose of USACE Chicago District.

This report was written by Ms. Trudy J. Estes and Dr. Paul R. Schroeder, Environmental Engineering Branch (EEB), Environmental Processes and Engineering Division (EPED), EL, and Mr. Dave Druzbicki, Cost Engineering and Specifications Section, Technical Services Division, Chicago District. The WWTP cost estimates were prepared by Mr. David C. Scharre and Mr. Rich Gallas of Montgomery Watson Harza. Technical reviewers were Dr. Tommy E. Myers, EEB, and Ms. Cynthia L. Price, Environmental Processes Branch, EPED. Technical editing was performed by Ms. Cheryl M. Lloyd, EEB. Internal reviewers for USACE, Chicago District were Mr. John Breslin, Mr. Jay Semmler, Ms. Le Thai, Mr. Jay Tanaka, and Ms. Brigid Briskin. Independent Technical Review (ITR) members were Mr. Thomas Kenna, Mr. Paul Polanski, and Mr. Kevin McAuley, USACE, Buffalo District and Mr. S. Edward Mead, USACE, Omaha District.

This study was conducted under the direct supervision of Dr. Richard E. Price, Chief, EPED, and under the general supervision of Dr. Edwin A. Theriot, Director, EL. Dr. James R. Houston was Director, ERDC, and Col. James R. Rowan, EN, was Commander.

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1 - Project Background

Indiana Harbor and Canal (IHC) is an authorized Federal navigation project located in East Chicago, Indiana (Figure 1). Project features include breakwaters at the harbor entrance and a deep-draft navigation channel (USACE, Chicago 1999). Channel depth ranges from 22 to 29 feet. Sediments in the IHC are contaminated and have been determined to be unsuitable for open water disposal, unconfined upland disposal or beneficial use. Dredging of the IHC has been deferred since 1972 while a technically and economically feasible and environmentally acceptable management plan was developed. As a result of studies undertaken by the US Army Corps of Engineers Chicago District to address disposal issues, dredging is to be undertaken throughout the IHC Federal navigation project to authorized project depths and widths. Dredging will also be completed in the appropriate berthing areas outside of the authorized channel limits at non-Federal expense to provide depths commensurate with those in the Federal channel.

The results of environmental studies and technical evaluations conducted in the course of developing a management plan for Indiana Harbor sediments are summarized in the Comprehensive Management Plan (CMP) (USACE, Chicago 1999), the Design Documentation Report (DDR) (USACE, Chicago 2000), the Disposal Alternatives for PCB-Contaminated Sediments from Indiana Harbor, Indiana (Environmental Laboratory 1987a and 1987b), and the Indiana Harbor and Canal (IHC) Dredging and Disposal Alternatives Analysis (DDAA) (Estes et al 2003). Design parameters and assumptions used in the present study were largely obtained from these documents, with modifications to reflect current study objectives.

The CMP is a two-volume report: Volume 1 – Final Feasibility Report and Environmental Impact Statement and Volume 2 – Technical Appendices. The CMP provides general project background, a description of plan formulation over several phases, the selected plan, and aspects of plan implementation, including discussion of disposal sites that were considered for the project. Three dredging plans were evaluated in the CMP (USACE, Chicago 1999). The first plan consisted of dredging the harbor and canal to authorized depths from the entrance in Lake Michigan to the E.J.E. Railroad Bridge (Reaches 1 through 5), plus the PCB hotspot along the north bank of Reach 6. This plan was identified as Alternative 1 - Partial Federal Channel Dredging. The second plan consisted of dredging the entire Federal navigation project to authorized depths from the entrance to the upstream project limits on the Lake George and Calumet River Branches (Reaches 1 through 13). This plan was identified as Alternative 2 - Complete Federal Channel Dredging. The third plan included the complete Federal channel dredging of Alternative 2, plus additional dredging provided for in a 1993 Consent Decree between the U.S. EPA and the Inland Steel Company. This plan was identified as

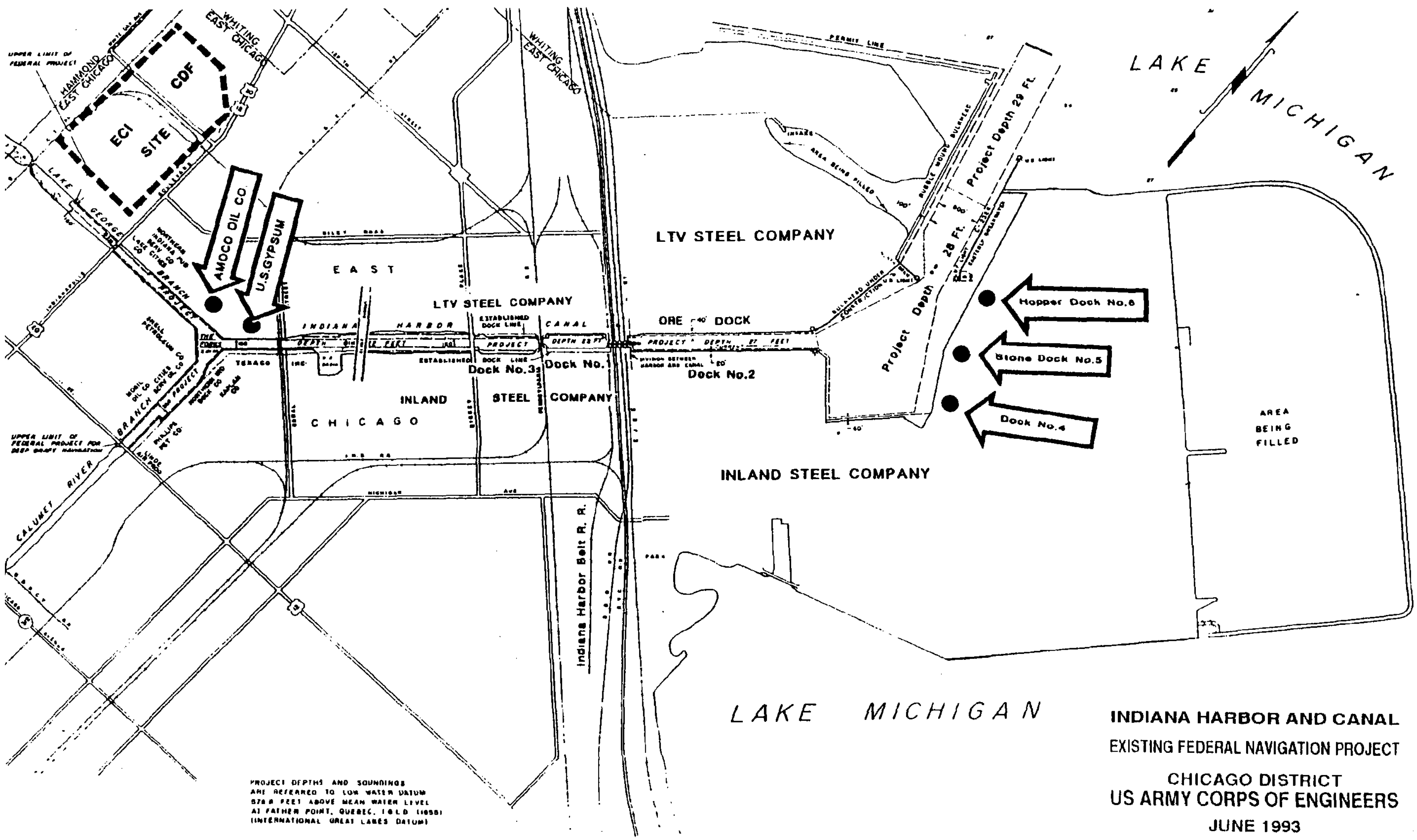

Figure 1. Indiana Harbor and Canal

Alternative 3 - Cooperative Dredging Program. All three plans include dredging in appropriate non-Federal dock/berthing areas to provide depths commensurate with the adjacent Federal channel depths. The selected plan in the CMP is the Cooperative Dredging Plan.

The DDR documents a design prepared for the selected plan from the CMP. The supporting technical analysis for hydrology and hydraulics, environmental engineering, geotechnical, structural, mechanical, and civil design along with a detailed cost estimate are presented in the ten appendices to the DDR. Based on previous examination of dredging technologies conducted during formulation of the CMP, it was determined that dredging would be conducted using a mechanical dredge, specifically a closed-bucket clamshell dredge. In the DDR, a projected dredging rate was established based on documented sediment depths and projected accumulation over a period of 30 years, and a design was developed for the selected disposal site.

The DDAA summarizes subsequent efforts undertaken to re-evaluate the use of hydraulic dredging and disposal for this project, in order to expedite backlog dredging and minimize contaminant releases to the environment. The primary objective of the study was to perform a comparative, planning-level evaluation of a limited number of dredging and placement alternatives for the operation of the Indiana Harbor and Canal Confined Disposal Facility (CDF). Specific objectives of the study included evaluation of the compatibility of hydraulic dredging and placement with the CDF design developed for mechanical dredging and documented in the Design Documentation Report (DDR) (USACE, Chicago 2000), feasibility of expediting backlog dredging using hydraulic dredging rather than mechanical dredging, relative air emissions (volatile and particulate) from the CDF and overall life cycle cost of hydraulic dredging versus mechanical dredging. The overall design process encompassed in previous and present efforts is reproduced in Figure 2.

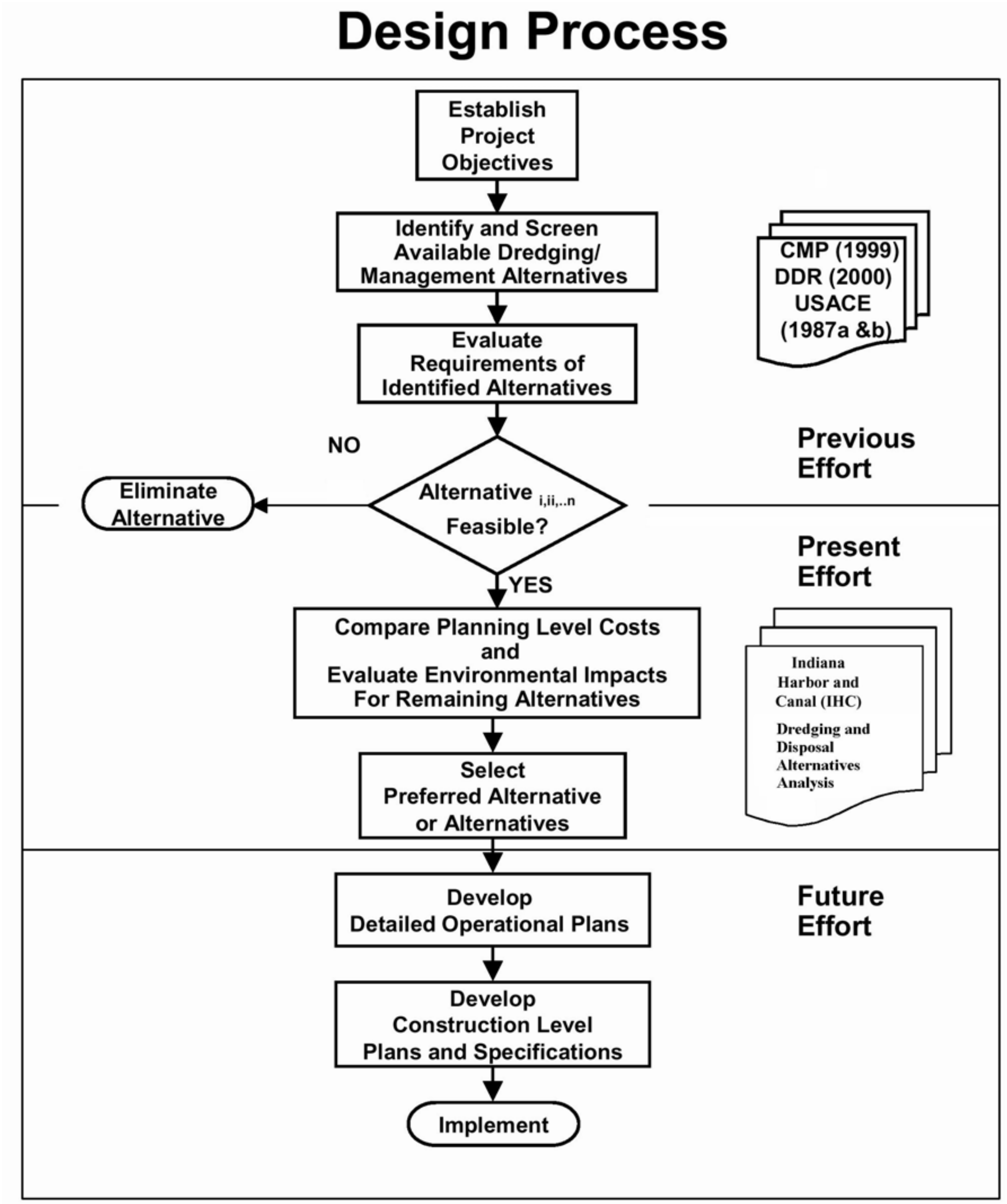

Figure 2. Overall design process

2 - Introduction

Based on the evaluations presented in the DDAA (Estes et al. 2003) and previous studies, mechanical dredging has been identified as the preferred dredging method for Indiana Harbor. In the alternatives analysis (Estes et al. 2003), mechanical dredging and disposal was found to be the least costly alternative. Wastewater volumes and dike height requirements were less than for the hydraulic dredging alternatives considered. However, hydraulic offloading of mechanically dredged sediments is still being considered because of operational concerns regarding barge access, trafficability of the previously placed dredged material, spreading of dredged material in the confined disposal facility (CDF), truck access, potential for increased loss of fugitive dust and worker safety. In order to minimize wastewater volume, recirculation of effluent and runoff for offloading of sediments may be desirable. Contaminant concentrations in the recirculated effluent and runoff would be expected to be elevated over those resulting from conventional mechanical or hydraulic dredging and disposal, potentially impacting wastewater treatment costs and volatilization rates. A planning level comparative analysis was therefore conducted for three placement options:

- Mechanical dredging with mechanical offloading (Alternative 1, Option 1)
- Mechanical dredging with hydraulic offloading (Alternative 1, Option 2)
- Mechanical dredging with hydraulic offloading and recirculation (Alternative 1, Option 3)

A conceptual schematic of hydraulic offloading including recirculation of ponded water is shown in Figure 3.

Elements of the comparative analysis included:

- Effluent volumes and contaminant concentrations
- Storage and dike height requirements
- Volatilization and particulate emission rates
- Cost

The sediment data used for the analysis reported in the DDAA was obtained from a sediment sampling effort conducted in 1986. Pore water and groundwater concentrations used in that analysis were taken from data reported in several independent studies conducted over a period of years. Effluent concentrations predicted from the 1986 sediment data and selected pore water values were also normalized using the results of historical elutriate data. The 1986 sediment data does not contain information regarding BTEX compounds and a number of other organics, which are of particular concern with respect to volatilization. Additionally, groundwater concentrations used in the DDAA

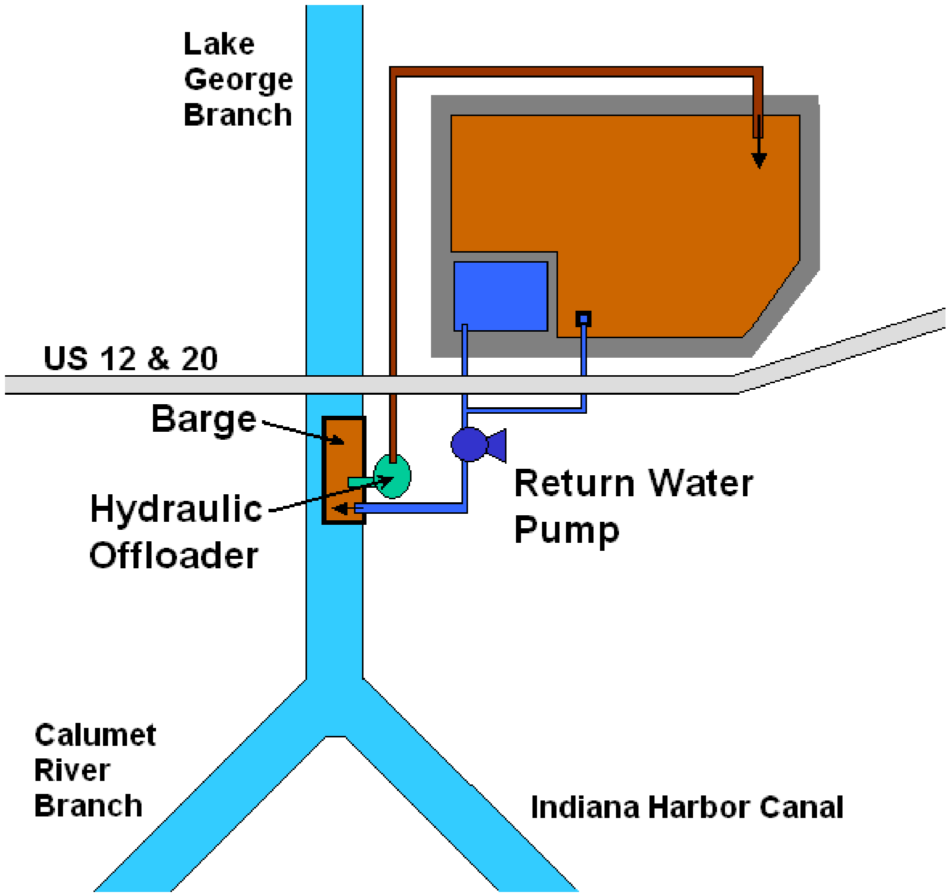

Figure 3. Conceptual schematic of hydraulic offloading and recirculation

appear to be higher than would be realistically anticipated over the long term, assuming free product under the disposal site is removed during initial drawdown of the groundwater prior to any dredging taking place. Therefore, for the analyses reported in this study, the sediment data was modified to incorporate compounds not included in the 1986 sediment data but for which data is available in EPA records. Additionally, groundwater concentrations from relatively recent Corps sampling efforts were used in these analyses to be more representative of expected conditions. The new groundwater data set is a consolidation of data obtained from sampling efforts conducted in 1990, 1991, 1992, 1995, 1998 and 2003. The data was collected by the Corps or A/E consultants working for the Corps, including ERM, E&E, and MWH. Effluent, runoff, and expelled pore water concentrations (ponded water in the disposal cells and equalization basin) were calculated for all three placement options from the revised data sets, in order to provide an equivalent basis for comparison. Therefore, the reported values for the various discharge streams are somewhat different from values given in the DDAA.

Additionally, differences in climatic data from O'Hare airport, used to generate the synthetic data used in the alternatives analysis (Estes et al. 2003), and the proposed disposal site in East Chicago, Indiana, could be important to the design of the pumps, equalization basin and wastewater treatment plant. More recent climate data from O'Hare airport and weather stations closer to the disposal site were compared with the data used in the DDAA, and possible impacts on storm water volumes were assessed.

3 - Screening Analysis for Ponded Water

Option 1 - Mechanical Offloading of Mechanically Dredged Sediments

This option considers the relative flows and contaminant concentrations for mechanical offloading of mechanically dredged sediments and was designated as Alternative 1 in the alternatives analysis (Estes et al. 2003). Based on the cost analysis for this alternative reported in the alternatives analysis, wastewater treatment costs were governed primarily by design flow rate, annual wastewater volume, and effluent TOC and ammonia concentrations. Annualized treatment volumes, flow rates and TOC and ammonia concentrations, which were the basis of the WWTP cost estimate, were given in Table D5 of the alternatives analysis. In order to minimize operating costs, flow rates, TOC and ammonia concentrations have been modified to reflect seasonal operation of the WWTP, with runoff and consolidation flows collected during non-dredging periods to be treated in the four-month period during and/or following dredging each year. Treatment volumes, flow rates and TOC and ammonia concentrations reflecting the seasonal operating assumption are summarized for Option 1 in Table 20 in the costing section of this report.

Option 2 - Hydraulic Offloading of Mechanically Dredged Sediments without Recycle

This option considers the relative flows and effluent contaminant concentrations for hydraulic offloading of mechanically dredged sediments to an upland confined disposal facility. Water used to offload sediments would be pumped from the water body (Indiana Harbor canal) adjacent to the offloading barge. Effluent from the CDF would be pumped directly to the wastewater treatment plant without recycle. Total effluent and runoff volumes for these waste streams would be the same as those given for Alternative 2 hydraulic dredging and disposal in the alternatives analysis (Estes et al. 2003). However, the duration of dredging, and the flow rates, would be different from Alternative 2, being constrained to correspond to the daily mechanical dredging rate. (In the DDAA, the annual dredging volume for Alternatives 1 and 2 was the same, but the rate of dredging was greater for hydraulic dredging than for mechanical dredging, resulting in a shorter dredging duration each year. Because material cannot be offloaded faster than it is dredged, the rate of hydraulic offloading of mechanically dredged sediments will be controlled by the rate of dredging.) As for Option 1, modifications were made to reflect seasonal WWTP operation. The average flow rate for wastewater treatment was estimated based on the treatment flow rate during the dredging season for Alternative 2 in the DDAA, but adjusted by the ratio of dredge production rates for mechanical dredging and hydraulic dredging. Runoff occurring in the summer non-dredging and winter non-dredging seasons would be stored in the equalization basin and treated each year in the month before dredging is initiated. Treatment volumes, flow rates and TOC and ammonia concentrations reflecting the seasonal operating assumption are summarized for Option 2 in Table 20 in the costing section of this report.

Option 3 - Hydraulic Offloading of Mechanically Dredged Sediments with Recycle

This option considers the relative flows and effluent contaminant concentrations for hydraulic offloading of mechanically dredged sediments to an upland confined disposal facility, with runoff stored in the CDF throughout the non-dredging seasons used for offloading in place of canal water. Once a pond of a specified depth has been formed in the disposal cell, ponded water will be recycled for offloading in order to minimize wastewater volumes. Some canal water could be used as make-up water if necessary to compensate for losses due to bulking of the material during placement. For purposes of this analysis, it was assumed that sufficient runoff water would be available. This should be a worst-case assumption for water quality and volatile losses, as the runoff will have contacted the sediments once and would be expected to have higher contaminant concentrations than the canal water. The recycled water and any remaining stored runoff would be treated over a four-month interval at the end of the dredging period. The WWTP would then be shut down for the remainder of the year. In order to estimate the volume of water required for resuspending sediment and the number of times it would be recycled, assumptions regarding production rate and CDF configuration are required.

Production Rate

The analysis is based on a mechanical dredging production rate of 250 in situ cy/hr operating 16 hours/day for 6 days/week, as specified in the alternatives analysis (Estes et al. 2003) for Alternative 1 Mechanical Dredging. Annual dredging volumes for this alternative are reproduced here in Table 1.

CDF Configuration

The CDF configuration specified for Alternative 1 Mechanical Dredging in the DDAA was utilized for this option (Figure 4) instead of the configuration for Alternative 2 Hydraulic Dredging because Alternative 1 provided a larger equalization basin. The larger equalization basin was required in order to manage storm flows, given that the WWTP capacity required for the mechanical dredging alternative was much smaller than for the hydraulic dredging alternatives. A large equalization basin will also be necessary for this alternative (hydraulic offloading of mechanically dredged sediments), in order to provide storage capacity for annual runoff flows.

Table 1. Material Placement Schedule			
Year	Alternative 1 Mechanical		
	Volume (cy)	Lift Thickness (ft)	Cell No.
1	85333 42667	3.5 2.4	1 TSCA
2	132017 162983	3.1 3.1	2 3
3	89333 44667	3.6 2.5	1 TSCA
4	136939 169061	3.2 3.2	2 3
5	140000	5.7	1
6	142309 175691	3.4 3.4	2 3
7	146000 *	8.3	TSCA
8	147680 182320	3.5 3.5	2 3
9	102000 51000	4.2 2.9	1 TSCA
10	153050 188950	3.6 3.6	2 3
11	0	Dikes Raised	
12	106000 53000	4.3 3.0	1 TSCA
13	159000	3.8	2
14	196000	3.8	3
15	0	Dewatering	
16	106667 53333	4.4 3.0	1 TSCA
17	160000	3.8	2
18	194000	3.7	3
19	0	Dewatering	
20	76000 76000	3.1 4.3	1 TSCA
21	152000	3.6	2
22	193000	3.7	3
23	0	Dewatering	
24	77000 77000	3.1 4.4	1 TSCA
25	154000	3.7	2
26	195000	3.8	3
27	0	Dewatering	
28	78000 78000	3.2 4.4	1 TSCA
29	156000	3.7	2
30	198000	3.8	3

* TSCA Material. Other placements in TSCA cell are non-TSCA material.

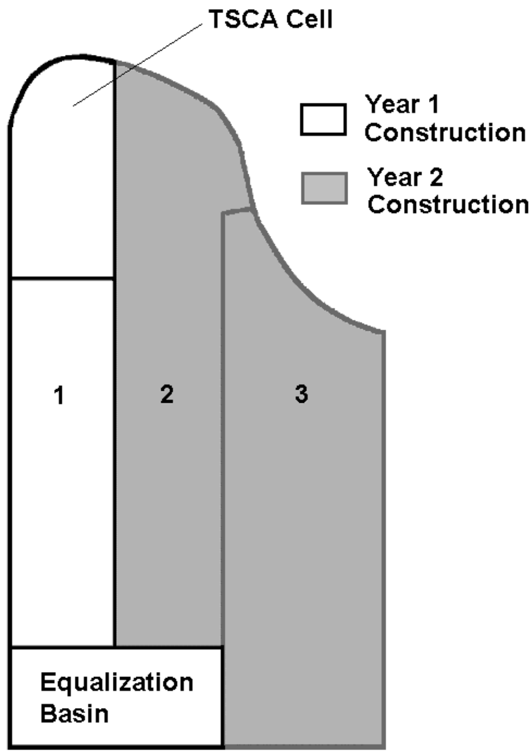

Figure 4. CDF configuration for Alternative 1 Mechanical Dredging (from DDAA)

The mechanical dredging alternative specified a CDF with 3 primary storage cells, a fourth cell for placement of TSCA material, and an equalization basin with relative areas as summarized in Table 2. Dike heights as specified for Alternative 2 (32.5 ft) were assumed for estimating pond volumes (this was later revised to 34 ft based upon the outcome of the consolidation analysis). A ponding depth of 4 ft was initially assumed, as previously specified in the alternatives analysis, to achieve adequate suspended solids removal prior to treatment of the wastewater. Alternative ponding depths were also evaluated, and a 2.8 ft ponding depth was found to be feasible for the average annual runoff volumes available for offloading. Additional suspended solids removal can be achieved with this ponding depth by allowing a quiescent period in the disposal cell(s) following completion of dredging, prior to pumping the wastewater to the WWTP.

Water Balance for Hydraulic Offloading

There are several terms used in describing the operation of the system that are frequently a source of confusion. They are defined here to facilitate understanding of the water balance and subsequent discussions. For the purposes of the water balance, make-up water is water introduced to the system (defined here as the disposal cell, the

Table 2. Cell Areas for 32.5 ft Dike Height (from DDAA)	
Cell	**Area (acres)**
1	16.1
2	28.6
3	35.1
TSCA	12
Equalization	10

offloading barge and all interconnecting piping between the two) to satisfy volume demand. Make-up water is used to provide the adequate carrier water to slurry the sediment for offloading, providing the water to generate the needed ponded water in the disposal cell and supplementing the recycled water to compensate for storage losses after the pond is established. Depending upon the need, make-up water flows may be large (as at dredging startup, when the make-up water is the principal source being used to slurry the material), or relatively small (as when recycle water is available to slurry the material and make-up water is only required to offset system losses). Make-up water may be obtained from any available sources external to the system, such as the equalization basin or the canal. Recycled water is water obtained from the disposal cell (internal to the system) after a pond has formed. In this case, its sole use would be to slurry the material for offloading. Carrier water is another term used to describe water used to slurry the sediment, without specifying anything about the source of the carrier water (internal or external to the system). Both make-up water and recycled water would be considered carrier water if used for this purpose. The quality of carrier water is important in the evaluation of expected contaminant concentrations in the ponded water because it contributes to the total concentration of contaminants in the slurry. This is discussed further under the section on partitioning analysis.

The hydraulic offloading rate was estimated using the ADDAMS SETTLE program (Hayes and Schroeder 1992) for the same input parameters as the hydraulic dredging alternatives from the alternatives analysis (based on the in situ sediment properties from the 1986 analysis), at a production rate equivalent to the mechanical dredging rate (250 cy in situ/hr). This corresponds to an influent discharge flow rate of 8.85 cfs including solids, at 170 g/L suspended solids concentration. During the initial stages of offloading while a pond is forming over the surface of the disposal cell in the CDF (before recycle begins), the influent water is composed of 1.32 cfs pore water and 6.97 cfs make-up water from the equalization basin (Figure 5). A portion of the influent water is lost to storage due to material bulking during processing. A median bulking factor of 1.50 was estimated using the SETTLE program, giving a water loss rate to storage of approximately 2.23 cfs and an accumulation (pond formation) rate of 6.06 cfs. (Water balance figures reflect only flows produced by the active dredging operation. Flows resulting from precipitation are not reflected, but are considered in the volume of water assumed to be stored in the equalization basin and available for offloading. Annual dredging and water production volumes given in Table 3 reflect long-term operating conditions of the CDF, after initial drawdown of groundwater and placement of the first layers of material in all cells, when infiltration of rainwater or carrier water to the groundwater would be minimal.)

After a pond of the desired depth is formed ($t = t_p$), recycle can begin. From this point forward ($t > t_p$), a combination of 0.91 cfs make-up water (stored water or canal water) and 6.06 cfs recycle water are required to slurry the material and to maintain the pond at the specified depth. The combined water flow (inflow to the CDF) is fixed by the assumed operating parameters for the dredge (8.29 cfs water discharge rate). The amount of that water contributed from the pore water of the sediment is assumed to be constant (1.32 cfs), as are the losses to bulking (2.23 cfs). (Bulking of newly placed material varies from year to year as a function of the duration of dredging. The mean bulking factor was used to obtain the bulking losses for the conceptual water balance figures. Actual bulking factors were used for the annualized flow calculations given in Table 3.) The combined water flow minus bulking losses gives the available recycle flow rate (6.06 cfs, the same as the pond accumulation rate during pond formation). The make-up water requirement is then determined by difference: 8.29 cfs – 6.06 cfs – 1.32 cfs = 0.91 cfs (Figure 6).

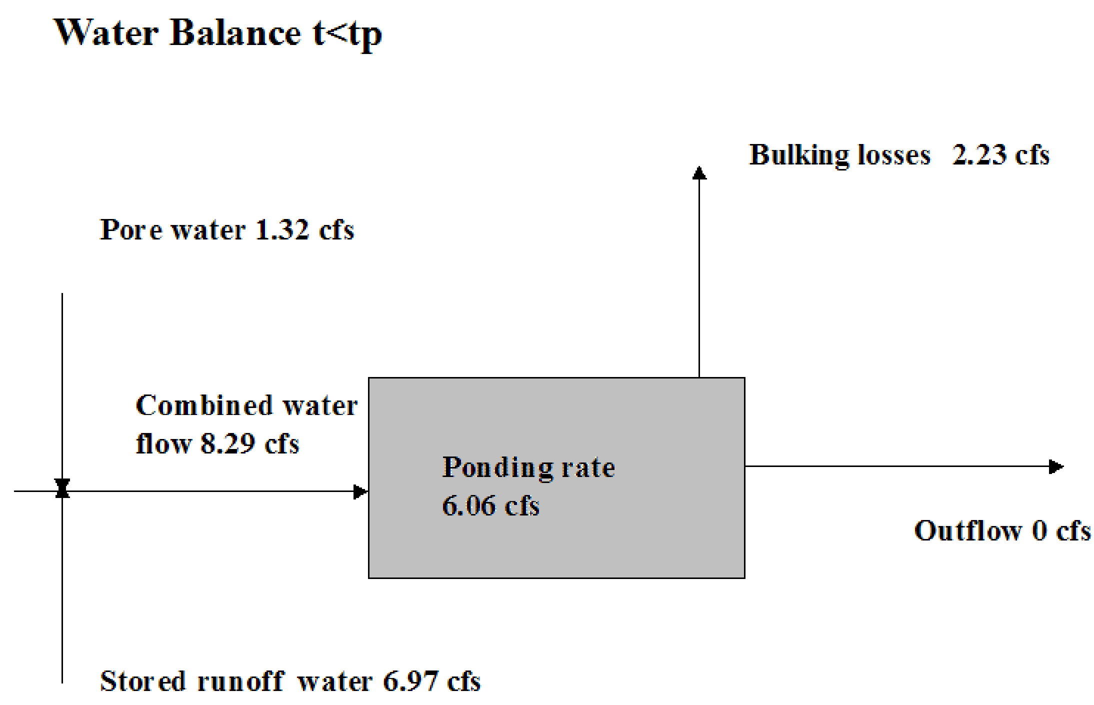

Figure 5. Water balance during pond formation

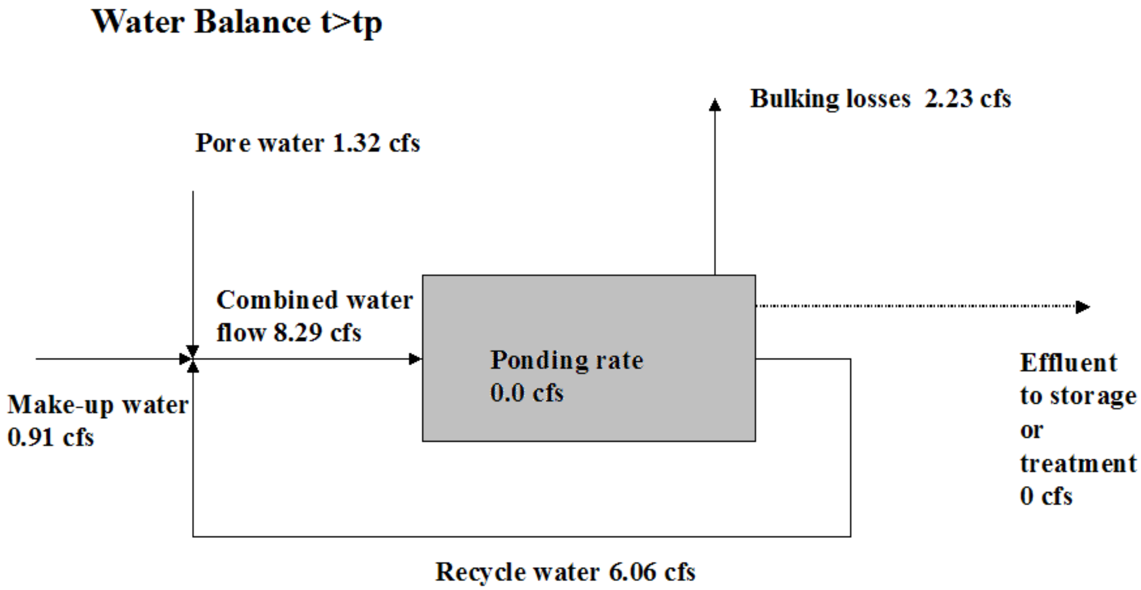

Figure 6. Water balance after pond formation

The analysis was also based on the following assumptions:

1) Runoff would be collected from inactive cells throughout the year and held in the equalization basin for use as make-up water for offloading operations. In the event of runoff flows exceeding the capacity of the equalization basin, excess runoff would be held in the cell next scheduled to receive material.
2) Canal water would be used for make-up water only in the event that an insufficient volume of stored runoff water was available.
3) In years where multiple cells were used, make-up water for disposal in the first cell would be taken from the equalization basin (runoff), and make-up water for disposal in the second cell would be taken from the pond created in the first cell. This increases the number of times the water is recycled (and is a function of the size of the cells and the order in which they are filled) but potentially minimizes the volume that must be treated at the end of disposal annually.
4) After disposal is completed, water ponded in the disposal cells would be transferred to the equalization basin in order to facilitate dewatering and then treated as a batch over a period of approximately 4 months.
5) Due to the much higher concentration of BTEX in the groundwater, a separate equalization tank and treatment system is being considered for the groundwater. Therefore, due to the low impact of groundwater on cost, groundwater was excluded from the cost estimates but was considered in the volatilization analysis.

Based on the water volume reported in Table D5 of the Alternatives Analysis (winter non-dredging period for Alternative 2) and the median projected bulking of the material (to account for losses of water to bulking), the maximum average pond depth that could be formed in a 30-acre cell using stored runoff water is approximately 2.8 feet. This is the depth of ponding that was assumed for this analysis. The annual dredging, pond and make-up water volumes (for $t>t_p$) are summarized in Table 3. Derivation of these volumes is explained below. The number of times the water would be recycled for these relative volumes is summarized by year in Table 4.

Volume pond (Vp) = Average area at ½ ponding depth * ponding depth (acre*ft)

Dredging duration (D) = $V_{in\ situ}$ / "active" dredging rate (days)

Total volume recycle (Vr) = $Q_r (D - t_p)$ x (gal)

Volume make-up water (V_{mu}) = $Q_b (D - t_p)$ x (gal)

Where:

	Q_r	=	recycle flow rate, cfs
	Q_b	=	storage loss rate, cfs
	t_p	=	ponding time, as previously defined, days
	x	=	units conversion factor

From these quantities can also be determined:

Total annual system water input requirements ($V_T = V_p + V_{mu}$)

Number of times water is recycled ($N = V_r/V_p$)

Table 3. Annual Dredging and Water Production Volumes

Year	Volume (cy)	Cell No.	Area @ 1/2 Storage Depth (acres)	Ponding Depth (ft)	Pond Volume (acre*ft)	Time of ponding (t_p) (days)	Total (Active) Dredging Duration (D) (days)	Volume Pond (V_p) (gal)	Total Recycle Volume (V_r) (gal)	Total Volume Makeup Water (V_{mu}) (gal)	Total Annual System Water Input Requirements (V_T) (gal)
1	85333	1	16.1	2.76	48.9	6.3	21.3	15,917,888	38,146,694	6,911,076	22,828,964
	42667	TSCA	12	2.76	36.4	4.7	10.6	11,864,264	15,168,343	2,748,065	14,612,329
2	162983	3	34.1	2.76	103.5	13.3	40.6	33,714,285	69,547,147	12,599,929	46,314,214
	132017	2	27.6	2.76	83.8	10.7	32.9	27,287,808	56,354,439	10,209,792	37,497,601
3	89333	1	16.1	2.76	48.9	6.3	22.3	15,917,888	40,680,981	7,370,216	23,288,104
	44667	TSCA	12	2.76	36.4	4.7	11.1	11,864,264	16,435,487	2,977,634	14,841,899
4	169061	3	34.1	2.76	103.5	13.3	42.2	33,714,285	73,397,996	13,297,591	47,011,876
	136939	2	27.6	2.76	83.8	10.7	34.1	27,287,808	59,472,880	10,774,764	38,062,571
5	140000	1	16.1	2.76	48.9	6.3	34.9	15,917,888	72,782,163	13,186,020	29,103,908
6	175691	3	34.1	2.76	103.5	13.3	43.8	33,714,285	77,598,577	14,058,615	47,772,900
	142309	2	27.6	2.76	83.8	10.7	35.5	27,287,808	62,875,160	11,391,158	38,678,966
7	146000	TSCA	12	2.76	36.4	4.7	36.4	11,864,264	80,637,218	14,609,129	26,473,393
8	182320	3	34.1	2.76	103.5	13.3	45.5	33,714,285	81,798,525	14,819,524	48,533,809
	147680	2	27.6	2.76	83.8	10.7	36.8	27,287,808	66,278,074	12,007,668	39,295,476
9	102000	1	16.1	2.76	48.9	6.3	25.4	15,917,888	48,706,435	8,824,195	24,742,083
	51000	TSCA	12	2.76	36.4	4.7	12.7	11,864,264	20,447,897	3,704,567	15,568,831
10	188950	3	34.1	2.76	103.5	13.3	47.1	33,714,285	85,999,106	15,580,547	49,294,832
	153050	2	27.6	2.76	83.8	10.7	38.2	27,287,808	69,680,355	12,624,062	39,911,871
11	0										
12	106000	1	16.1	2.76	48.9	6.3	26.4	15,917,888	51,240,722	9,283,335	25,201,223
	53000	TSCA	12	2.76	36.4	4.7	13.2	11,864,264	21,715,041	3,934,136	15,798,401

(continued)

Table 3. (Concluded)

Year	Volume (cy)	Cell No.	Area @ 1/2 Storage Depth (acres)	Ponding Depth (ft)	Pond Volume (acre*ft)	Time of ponding (t_p) (days)	Total (Active) Dredging Duration (D) (days)	Volume Pond (V_p) (gal)	Total Recycle Volume (V_r) (gal)	Total Volume Makeup Water (V_{mu}) (gal)	Annual System Water Input Requirements (V_T) (gal)
13	159000	2	27.6	2.76	83.8	10.7	39.6	27,287,808	73,450,107	13,307,032	40,594,840
14	196000	3	34.1	2.76	103.5	13.3	48.9	33,714,285	90,465,787	16,389,781	50,104,065
15	0										
16	106667	1	16.1	2.76	48.9	6.3	26.6	15,917,888	51,663,315	9,359,896	25,277,785
	53333	TSCA	12	2.76	36.4	4.7	13.3	11,864,264	21,926,020	3,972,360	15,836,624
17	160000	2	27.6	2.76	83.8	10.7	39.9	27,287,808	74,083,679	13,421,817	40,709,625
18	194000	3	34.1	2.76	103.5	13.3	48.4	33,714,285	89,198,643	16,160,211	49,874,496
19	0										
20	76000	1	16.1	2.76	48.9	6.3	18.9	15,917,888	32,233,568	5,839,789	21,757,677
	76000	TSCA	12	2.76	36.4	4.7	18.9	11,864,264	36,287,192	6,574,188	18,438,453
21	152000	2	27.6	2.76	83.8	10.7	37.9	27,287,808	69,015,105	12,503,538	39,791,346
22	193000	3	34.1	2.76	103.5	13.3	48.1	33,714,285	88,565,072	16,045,426	49,759,711
23	0										
24	77000	1	16.1	2.76	48.9	6.3	19.2	15,917,888	32,867,140	5,954,574	21,872,462
	77000	TSCA	12	2.76	36.4	4.7	19.2	11,864,264	36,920,764	6,688,973	18,553,238
25	154000	2	27.6	2.76	83.8	10.7	38.4	27,287,808	70,282,248	12,733,108	40,020,916
26	195000	3	34.1	2.76	103.5	13.3	48.6	33,714,285	89,832,215	16,274,996	49,989,281
27											
28	78000	1	16.1	2.76	48.9	6.3	19.4	15,917,888	33,500,712	6,069,359	21,987,247
	78000	TSCA	12	2.76	36.4	4.7	19.4	11,864,264	37,554,336	6,803,758	18,668,022
29	156000	2	27.6	2.76	83.8	10.7	38.9	27,287,808	71,549,392	12,962,678	40,250,486
30	198000	3	34.1	2.76	103.5	13.3	49.4	33,714,285	91,732,931	16,619,351	50,333,635

Table 4. Number of Exchanges of Pond Volume During Recycle, 2.8 ft Ponding Depth

Year	Volume (cy)	Cell No.	Number of Days to Exchange Pond Volume Once (days)	Number of Full Exchanges of Pond Volume
1	85333	1	6.3	2.4
	42667	TSCA	4.7	1.3
2	162983	3	13.3	2.1
	132017	2	10.7	2.1
3	89333	1	6.3	2.6
	44667	TSCA	4.7	1.4
4	169061	3	13.3	2.2
	136939	2	10.7	2.2
5	140000	1	6.3	4.6
6	175691	3	13.3	2.3
	142309	2	10.7	2.3
7	146000	TSCA	4.7	6.8
8	182320	3	13.3	2.4
	147680	2	10.7	2.4
9	102000	1	6.3	3.1
	51000	TSCA	4.7	1.7
10	188950	3	13.3	2.6
	153050	2	10.7	2.6
11	0			
12	106000	1	6.3	3.2
	53000	TSCA	4.7	1.8
13	159000	2	10.7	2.7
14	196000	3	13.3	2.7
15	0			
16	106667	1	6.3	3.2
	53333	TSCA	4.7	1.8
17	160000	2	10.7	2.7
18	194000	3	13.3	2.6
19	0			
20	76000	1	6.3	2.0
	76000	TSCA	4.7	3.1
21	152000	2	10.7	2.5
22	193000	3	13.3	2.6
23	0			
24	77000	1	6.3	2.1
	77000	TSCA	4.7	3.1
25	154000	2	10.7	2.6
26	195000	3	13.3	2.7
27				
28	78000	1	6.3	2.1
	78000	TSCA	4.7	3.2
29	156000	2	10.7	2.6
30	198000	3	13.3	2.7

For the purposes of this analysis, for single cell disposal it was assumed all make up water would be taken from the equalization basin (stored runoff). For two cell disposal, it was assumed that the first cell would be filled from the equalization basin. Then, all water used for slurrying the material for disposal in the 2nd cell would be drawn from the pond in the 1st cell. (Alternatively, the 2nd cell could be filled using ponded water from the first cell until the pond was depleted, and then additional water drawn from the equalization basin. Canal water would be employed only if stored water volumes were depleted. Given the relative cell areas assumed in Table 1, in all cases sufficient volume should be available in the 1st cell to provide necessary make-up water for the 2nd cell, if the larger cell is filled first. For the purposes of calculating final contaminant concentrations in the ponds, it was assumed that sufficient water was available in the first cell for filling of the 2nd cell.) Conceptually, single cell and two-cell disposal and recycle are illustrated in Figures 7 - 12.

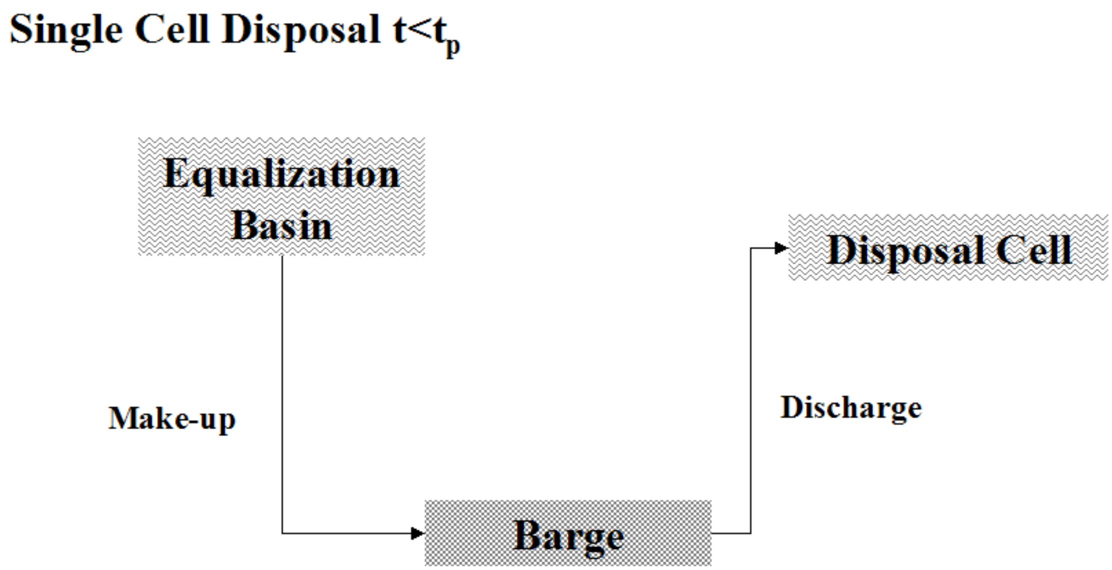

Figure 7. Single cell disposal during ponding

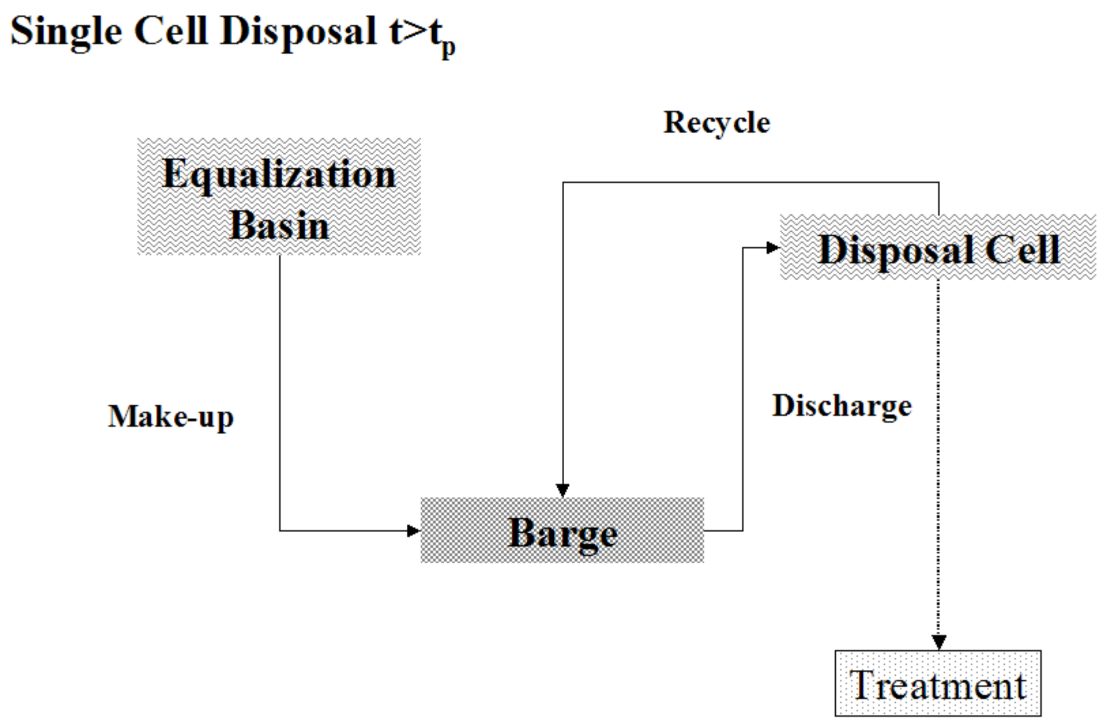

Figure 8. Single cell disposal after ponding

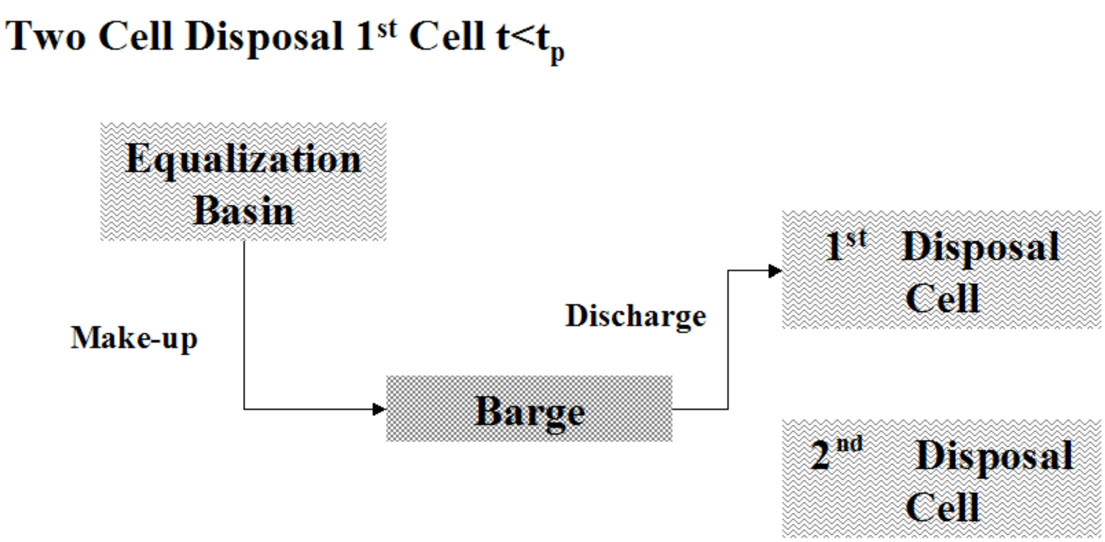

Figure 9. Multiple cell disposal, ponding of first cell

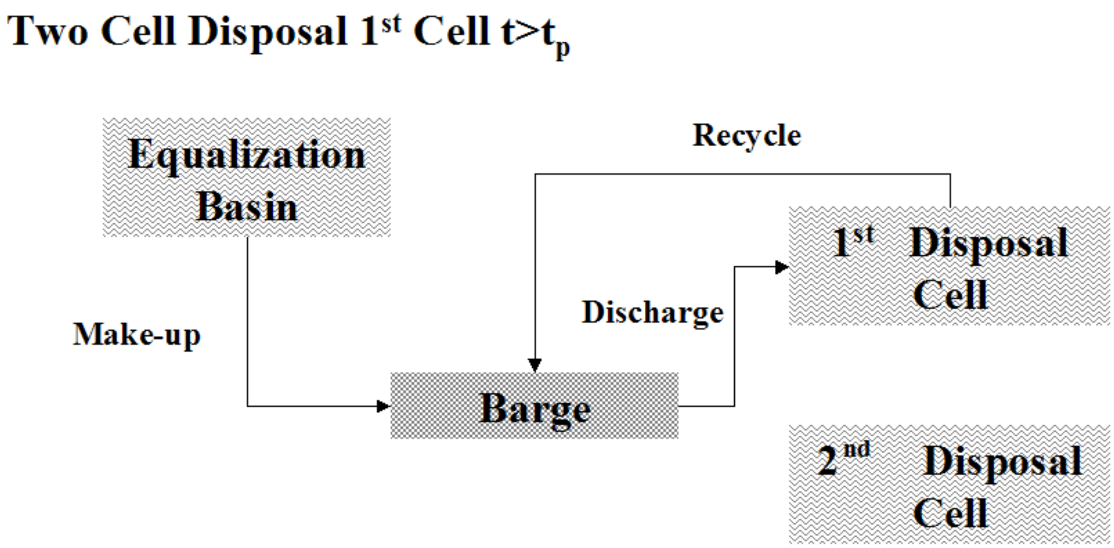

Figure 10. Multiple cell disposal, after ponding in first cell

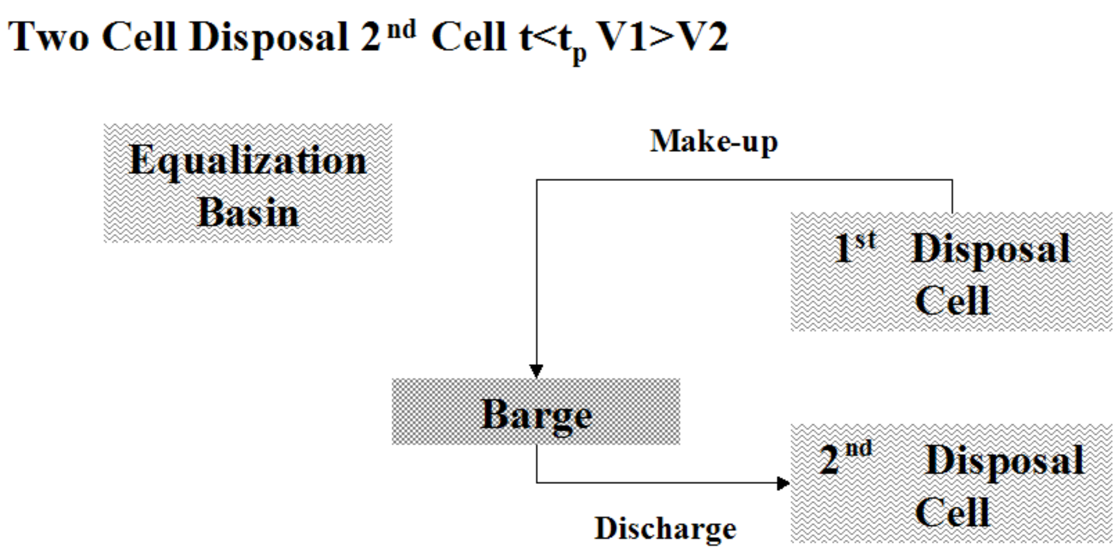

Figure 11. Multiple cell disposal, ponding of second cell

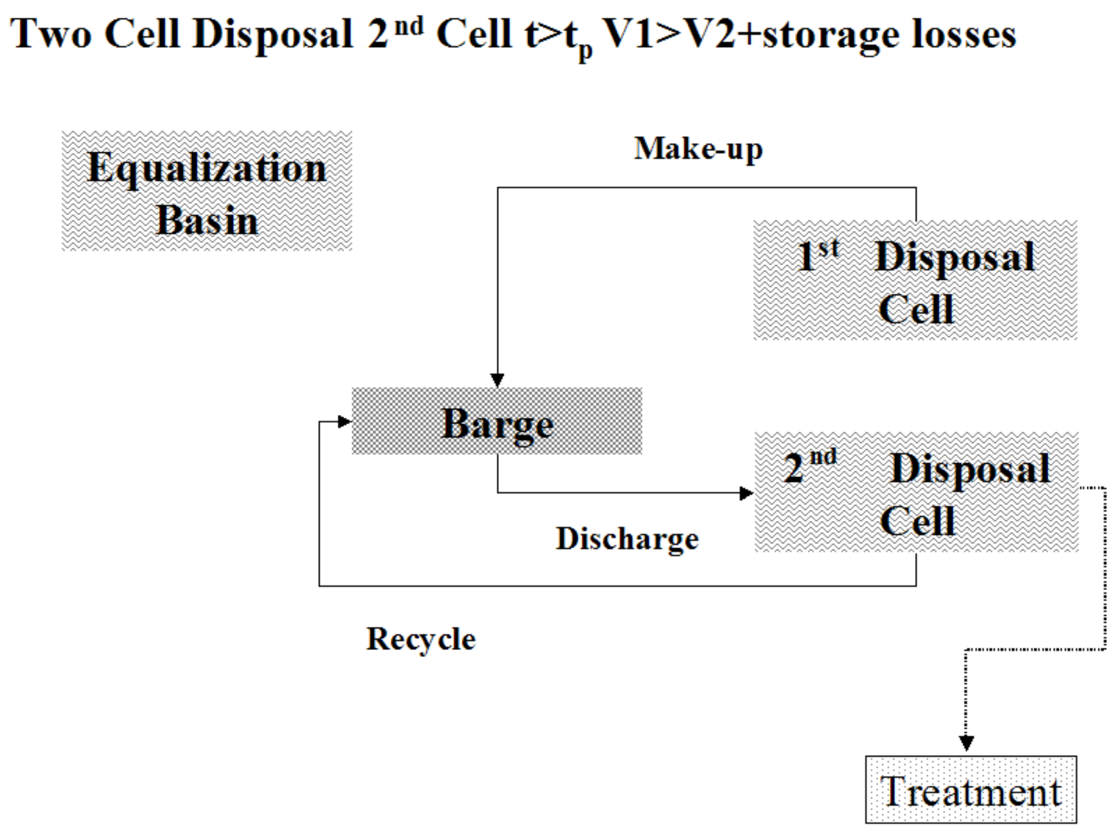

Figure 12. Multiple cell disposal, after ponding of second cell

Partitioning Analysis

When contaminants exist in a sediment-water "system," they distribute between the solid and aqueous phases proportionally. This distribution occurs as a function of the solubility and hydrophobicity of the contaminant, the characteristics and content of carbon-bearing phases within the sediment, length of time the phases have been in contact with each other, and other characteristics of the system. Partitioning analysis uses the known properties of the contaminants of concern to predict this distribution, and arrive at estimated dissolved concentrations of contaminants in the aqueous phase. Two boundary conditions are assumed: mixing and equilibrium. In this case, the mixing assumption reflects the concentrations obtained by simply diluting the pore water with the carrier water (water used for slurrying), taking into account the respective volumes of each. After a period of time, however, the solids in contact with the combined pore water and carrier water will establish a new equilibrium, partitioning according to the properties of the combined system, as previously explained. The equilibrium assumption usually results in the highest estimates of dissolved contaminant concentrations. Pond concentrations reported in this document reflect the equilibrium assumption. Sediment data used in the partitioning analysis is summarized in Table 5.

Table 5. Bulk Sediment and Water Concentrations			
Analyte	**Bulk Sediment Concentration (mg/kg)**	**Canal Water Conc. (ug/L)**	**Selected Groundwater Conc. (ug/L)**
Metals			
Arsenic	36.8	2.5	4.6
Cadmium	22.2	0.7	10
Chromium (hex)	514	4	52.7
Copper	266	5	53.2
Lead	933	0.5	332
Mercury	0.262	0.0008	0.37
Nickel	120	8	123
Zinc	3780	15	213
Organic Tins			
Dibutylin	0.115	0	0
Monobutyltin	0.017	0	0
Tributyltin	0.438	0	0
Inorganic/General Chemistry			
Carbon, Total Organic	48300	4600	53800
Ammonia-N	1100	607	3300
Phosphorus, Total	2760	100	100
PAHs			
Acenaphthene	110	0	199
Acenaphthylene	22	0	154
Anthracene	64	0	121
Benzo(a)anthracene	110	0	0
Benzo(a)pyrene	165	0	0
Benzo(b)fluoranthene	165	0	0
Benzo(g,h,i)perylene	42	0	0
Benzo(k)fluoranthene	115	0	0
Biphenyl	2.04	0	0
Chrysene	98	0	0
Dibenzo(a,h)anthracene	4.67	0	0
Fluoranthene	175	0	0
Fluorene	83	0	203
Indeno(1,2,3-c,d)pyrene	60	0	0
2-Methylnaphthalene	9.59	0	39500
Naphthalene	2050	0	255
Phenanthrene	210	0	403
Pyrene	145	0	62.9
Semi-Volatile Organic Compounds			
Benzyl butyl phthalate	16	0	0
Bis(2-ethylhexyl)phthalate	21.9	0	0
2-Chlorophenol	0.570	0	0
Di-N-Octyl Phthalate	7.70	0	0
			(continued)

Table 5. (Continued)			
Analyte	**Bulk Sediment Concentration (mg/kg)**	**Canal Water Conc. (ug/L)**	**Selected Groundwater Conc. (ug/L)**
Semi-Volatile Organic Compounds (continued)			
Dibenzofuran	10.2	0	1600
1,2-Dichlorobenzene	2.99	0	0
1,3-Dichlorobenzene	1.28	0	0
1,4-Dichlorobenzene	0.364	0	0
2,4-Dichlorophenol	2.81	0	0
2,4-Dimethylphenol	0	0	102
2,4-Dinitrophenol	1.54	0	0
2,4-Dinitrotoluene	0.01	0	0
Hexachlorobenzene	0.495	0	0
Hexachlorobutadiene	0.33	0	0
Isophorone	0	0	223
4-Methylphenol	1.61	0	0
2-Nitrophenol	4.3	0	0
Pentachlorophenol	2.69	0	0
Phenol	4.02	0	94.8
1,2,4-Trichlorobenzene	0.36	0	0
Volatile Organic Compounds			
Acetone	4.5		146
Benzene	1.26	0	3060
Chlorobenzene	3.56	0	29.4
Chloroform	0.73	0	0.4
Ethylbenzene	0.986	0	20060
Isopropylbenzene	0	0	42.9
4-Methyl-2-pentanone	0	0	31100
Methylene chloride	3.59	0	50.3
1,1,2,2-Tetrachloroethane	0	0	36.4
Tetrachloroethylene	0.02	0	0
Toluene	0.476	0	8800
1,1,2-Trichloroethane	0	0	32.5
Xylenes, Total	1.41	0	39700
Chlorinated Pesticides			
Aldrin	2.41	0	0.323
alpha-BHC	0.043	0	0.162
beta-BHC	0.18	0	0.183
delta-BHC	0.017	0	0.246
gamma-BHC (Lindane)	0.011	0	0.253
Chlordane, Techincal	1.89	0	0.7
4,4'-DDD	0.096	0	0.202
o,p'-DDE (2,4)	0.19	0	0
p,p'-DDE (4,4)	0.164	0	0.205
p,p'-DDT (4,4)	0.198	0	0.2
			(continued)

Table 5. (Continued)			
Analyte	**Bulk Sediment Concentration (mg/kg)**	**Canal Water Conc. (ug/L)**	**Selected Groundwater Conc. (ug/L)**
Chlorinated Pesticides (continued)			
Dieldrin	0.091	0	0.202
Endosulfan I	0.026	0	0.165
Endosulfan II	0.06	0	0
Endosulfan sulfate	0	0	0.209
Endrin	0.029	0	0.235
Endrin aldehyde	0.052	0	0.181
Endrin ketone	0.325	0	0.364
Heptachlor	0.26	0	0.167
Heptachlor epoxide	0.146	0	0.27
Methoxychlor	0.5	0	0.334
Toxaphene	3.670	0	0
Dioxins and Furans			
1,2,3,4,6,7,8-HPCDD	0	0	0
1,2,3,4,6,7,8-HPCDF	0	0	0
1,2,3,4,7,8,9-HPCDF	0	0	0
1,2,3,4,7,8-HXCDD	0	0	0
1,2,3,4,7,8-HXCDF	0.1	0	0
1,2,3,6,7,8-HXCDD	0	0	0
1,2,3,6,7,8-HXCDF	0	0	0
1,2,3,7,8,9-HXCDD	0	0	0
1,2,3,7,8,9-HXCDF	0	0	0
1,2,3,7,8-PECDD	0	0	0
1,2,3,7,8-PECDF	0	0	0
2,3,4,6,7,8-HXCDF	0	0	0
2,3,4,7,8-PECDF	0	0	0
2,3,7,8-TCDD	0	0	0
2,3,7,8-TCDF	0	0	0
OCDD	2.240E-05	0	0
OCDF	7.250E-06	0	0
Total HPCDDS	8.640E-06	0	0
Total HPCDFS	3.860E-06	0	0
Total HXCDDS	2.770E-06	0	0
Total HXCDFS	1.710E-06	0	0
Total PECDDS	4.430E-07	0	0
Total PECDFS	7.500E-07	0	0
Total TCDDS	1.840E-07	0	0
Total TCDFS	0	0	0

(continued)

Table 5. (Concluded)			
Analyte	**Bulk Sediment Concentration (mg/kg)**	**Canal Water Conc. (ug/L)**	**Selected Groundwater Conc. (ug/L)**
PCB Aroclors			
PCB(Aroclor-1016)	9.27	0	0
PCB(Aroclor-1221)	1.11	0	0
PCB(Aroclor-1232)	1.11	0	0
PCB(Aroclor-1242)	10.4	0	0
PCB(Aroclor-1248)	29.4	0	0
PCB(Aroclor-1254)	1.68	0	0.941
PCB(Aroclor-1260)	1.11	0	0
PCB Total*	43	0	3.7

*PCB Total is the sum of 19 PCB Congeners.

Water in the equalization basin is assumed to have the character of runoff. Dissolved contaminant concentrations for runoff were estimated by partitioning, taking predicted effluent concentrations, which are typically conservative, to be representative. Where recycle is employed, final pond concentrations in the disposal cells will be higher than the predicted effluent concentrations. Because the recycle water will be exposed to the sediment multiple times, a new equilibrium will be established each time the water is recycled. Final contaminant concentrations in the ponds will be dependent upon the number of times the water is recycled, or the number of times the total pond volume is "exchanged." The effective number of pond exchanges during recycle differs based on the respective pond volumes, annual dredging duration, and order of filling, for years in which multiple cells are utilized. Based on a preliminary evaluation of the pond concentrations obtained for various recycle assumptions, it appears that the highest pond concentrations are obtained for the following scenario:

- Disposal occurs in two cells.
- The largest cell is filled first, using water from the equalization basin to slurry the material.
- Material for the second cell is slurried using only water from the pond formed in the first cell.
- Equilibrium concentrations are assumed.

The order of filling resulting in the maximum effective number of recycles was calculated for each year of dredging, and the mean of these values was used to estimate worst-case contaminant concentrations in the disposal cell pond. A full listing of dissolved contaminant concentrations for the recycle option is summarized in Table 6 (for years with disposal in multiple cells) and in Table 7 (for years with disposal in a single cell). Predicted concentrations for benzo(k)fluoranthene and chrysene exceed the solubility for these compounds as shown in Table 6 but their concentrations were limited

Table 6. Predicted Final Pond Concentrations (Disposal in Multiple Cells)

Make-up Water from Equalization Basin under Equilibrium Conditions

Analyte	**Solubility (ug/L)**	**Concentration (ug/L)**	
		First Cell (2.4 exchanges)	**Second Cell (1.3 exchanges)**
Metals			
Arsenic	1.82E+07	104	104
Cadmium	5.70E+08	27.1	27.2
Chromium (hex)	1.00E+09	102	102
Copper	2.60E+03	22.0	22.0
Lead	6.25E+08	155	155
Mercury	7.00E+05	0.052	0.0519
Nickel	6.42E+08	33.8	33.9
Zinc	1.00E+09	578	578
Organic Tins			
Dibutylin	NA	46.9	57.0
Monobutyltin	NA	7.03	8.54
Tributyltin	NA	3.74	3.74
Inorganic/General Chemistry			
Carbon, Total Organic	1.00E+09	266000	351000
Ammonia-N	5.31E+08	420650	503000
Phosphorus, Total	1.25E+08	30400	40200
PAHs			
Acenaphthene	4.24E+03	148	148
Acenaphthylene	1.61E+04	24.6	24.6
Anthracene	4.50E+01	22.6	22.6
Benzo(a)anthracene	1.10E+01	2.45	2.45
Benzo(a)pyrene	3.80E+00	1.17	1.17
Benzo(b)fluoranthene	1.50E+00	1.16	1.16
Benzo(g,h,i)perylene	2.60E-01	0.0937	0.0937
Benzo(k)fluoranthene	8.00E-01	.8*	.8*
Biphenyl	7.00E+03	12.3	12.3
Chrysene	1.80E+00	1.8*	1.8*
Dibenzo(a,h)anthracene	6.00E-01	0.0104	0.0104
Fluoranthene	2.60E+02	11.8	11.8
Fluorene	1.90E+03	58.5	58.5
Indeno(1,2,3-c,d)pyrene	6.20E+01	0.150	0.150
2-Methylnaphthalene	2.50E+04	14.8	14.8
Naphthalene	3.10E+04	10400	10400
Phenanthrene	1.15E+03	81.4	81.4
Pyrene	1.35E+02	12.9	12.9
Semi-Volatile Organic Compounds			
Benzyl butyl phthalate	2.69E+03	2.59	2.59
Bis(2-ethylhexyl)phthalate	4.00E+02	0.0123	0.0123
2-Chlorophenol	2.85E+07	40.8	41.3

*Value was greater than solubility value; therefore solubility value was substituted. **(continued)**

Table 6. (Continued)			
Make-up Water from Equalization Basin under Equilibrium Conditions			
Analyte	**Solubility (ug/L)**	**Concentration (ug/L)**	
		First Cell (2.4 exchanges)	**First Cell (2.4 exchanges)**
Semi-Volatile Organic Compounds (continued)			
Di-N-Octyl Phthalate	3.00E+03	0.000684	0.000684
Dibenzofuran	4.75E+03	7.19	7.19
1,2-Dichlorobenzene	1.45E+05	13.3	13.3
1,3-Dichlorobenzene	1.33E+05	5.68	5.68
1,4-Dichlorobenzene	8.30E+04	1.54	1.54
2,4-Dichlorophenol	4.50E+06	25.9	25.9
2,4-Dinitrophenol	6.00E+06	340	368
2,4-Dinitrotoluene	2.70E+05	0.975	0.995
Hexachlorobenzene	6.00E+00	0.00713	0.00713
Hexachlorobutadiene	3.23E+03	0.0572	0.0572
4-Methylphenol	2.20E+07	170	174
2-Nitrophenol	2.19E+06	627	654
Pentachlorophenol	1.40E+04	0.256	0.256
Phenol	8.84E+07	1010	1110
1,2,4-Trichlorobenzene	4.00E+04	0.393	0.393
Volatile Organic Compounds			
Acetone	1.00E+09	2420	3180
Benzene	1.78E+06	96.0	97.3
Chlorobenzene	4.88E+05	56.7	56.7
Chloroform	8.20E+06	85.0	87.4
Ethylbenzene	1.52E+05	7.75	7.75
Methylene chloride	2.00E+07	1150	1330
Tetrachloroethylene	2.00E+05	0.468	0.468
Toluene	5.35E+05	8.49	8.50
Xylenes, Total	1.75E+05	11.9	11.9
Chlorinated Pesticides			
Aldrin	1.80E+01	0.135	0.135
alpha-BHC	2.00E+03	0.0758	0.0758
beta-BHC	7.00E+02	0.318	0.318
delta-BHC	3.14E+04	0.0134	0.0134
gamma-BHC (Lindane)	7.80E+03	0.0252	0.0252
Chlordane, Technical	5.60E+01	0.351	0.351
4,4'-DDD	1.60E+02	0.00108	0.00108
o,p'-DDE (2,4)	4.00E+01	0.000212	0.000212
p,p'-DDE (4,4)	4.00E+01	0.00665	0.00665
p,p'-DDT (4,4)	2.50E+01	0.00143	0.00143
Dieldrin	1.95E+02	0.00434	0.00434
Endosulfan I	5.30E+02	0.0697	0.0697
			(continued)

Table 6. (Continued)			
Make-up Water from Equalization Basin under Equilibrium Conditions			
Analyte	**Solubility (ug/L)**	**Concentration (ug/L)**	
		First Cell (2.4 exchanges)	**Second Cell (1.3 exchanges)**
Chlorinated Pesticides (continued)			
Endosulfan II	4.50E+02	0.0991	0.0991
Endrin	2.50E+02	0.00205	0.00205
Endrin Aldehyde	5.00E+04	0.0583	0.0583
Endrin ketone	8.60E+02	0.0372	0.0372
Heptachlor	1.80E+02	0.0156	0.0156
Heptachlor Epoxide	3.50E+02	0.0163	0.0163
Methoxychlor	4.50E+01	0.0465	0.0465
Toxaphene	7.40E+02	0.130	0.130
Dioxins and Furans			
1,2,3,4,6,7,8-HPCDD	4.20E-01	4.9E-10	4.9E-10
1,2,3,4,6,7,8-HPCDF	7.62E-01	1.8E-10	1.8E-10
1,2,3,4,7,8,9-HPCDF	NA	3.2E-11	3.2E-11
1,2,3,4,7,8-HXCDD	1.00E+00	2.6E-11	2.6E-11
1,2,3,4,7,8-HXCDF	2.50E-02	3.3E-07	3.3E-07
1,2,3,6,7,8-HXCDD	NA	3.3E-11	3.3E-11
1,2,3,6,7,8-HXCDF	1.77E-02	7.1E-12	7.1E-12
1,2,3,7,8,9-HXCDD	NA	1.3E-10	1.3E-10
1,2,3,7,8,9-HXCDF	NA	8.6E-12	8.6E-12
1,2,3,7,8-PECDD	1.15E+01	1.0E-10	1.0E-10
1,2,3,7,8-PECDF	9.13E+00	4.4E-11	4.4E-11
2,3,4,6,7,8-HXCDF	NA	1.3E-12	1.3E-12
2,3,4,7,8-PECDF	6.36E+00	8.7E-11	8.7E-11
2,3,7,8-TCDD	2.00E-01	2.3E-10	2.3E-10
2,3,7,8-TCDF	4.19E-01	1.1E-09	1.1E-09
OCDD	7.40E-05	1.6E-09	1.6E-09
OCDF	NA	1.0E-09	1.0E-09
Total HPCDDS	1.90E+00	1.6E-09	1.6E-09
Total HPCDFS	NA	2.5E-10	2.5E-10
Total HXCDDS	4.00E-03	1.9E-10	1.9E-10
Total HXCDFS	NA	5.0E-10	5.0E-10
Total PECDDS	1.20E-01	1.6E-09	1.6E-09
Total PECDFS	NA	9.6E-10	9.6E-10
Total TCDDS	3.50E-01	8.2E-10	8.2E-10
Total TCDFS	NA	1.1E-08	1.1E-08
			(continued)

Table 6. (Concluded)

Make-up Water from Equalization Basin under Equilibrium Conditions			
Analyte	**Solubility (ug/L)**	**Concentration (ug/L)**	
		First Cell (2.4 exchanges)	**Second Cell (1.3 exchanges)**
PCB Aroclors			
PCB(Aroclor-1016)	4.20E+02	0.273	0.273
PCB(Aroclor-1221)	4.00E+04	1.03	1.03
PCB(Aroclor-1232)	4.07E+05	7.77	7.77
PCB(Aroclor-1242)	2.30E+02	9.04	9.04
PCB(Aroclor-1248)	5.40E+01	0.571	0.571
PCB(Aroclor-1254)	3.10E+01	0.0172	0.0172
PCB(Aroclor-1260)	2.70E+00	0.000984	0.000984
PCB Total*	7.00E+01	0.439	0.439

*PCB Total is the sum of 19 PCB Congeners.

Table 7. Predicted Final Pond Concentrations (Disposal in Single Cell)

Make-up Water from Equalization Basin under Equilibrium Conditions

Analyte	Solubility (ug/L)	Concentration (ug/L) First Cell (2.8 exchanges)
Metals		
Arsenic	1.82E+07	104
Cadmium	5.70E+08	27.1
Chromium (hex)	1.00E+09	102
Copper	2.60E+03	22.0
Lead	6.25E+08	155
Mercury	7.00E+05	0.052
Nickel	6.42E+08	33.8
Zinc	1.00E+09	578
Organic Tins		
Dibutylin	NA	48.3
Monobutyltin	NA	7.24
Tributyltin	NA	3.74
Inorganic/General Chemistry		
Carbon, Total Organic	1.00E+09	277000
Ammonia-N	5.31E+08	432000
Phosphorus, Total	1.25E+08	31700
PAHs		
Acenaphthene	4.24E+03	148
Acenaphthylene	1.61E+04	24.6
Anthracene	4.50E+01	22.6
Benzo(a)anthracene	1.10E+01	2.45
Benzo(a)pyrene	3.80E+00	1.17
Benzo(b)fluoranthene	1.50E+00	1.16
Benzo(g,h,i)perylene	2.60E-01	0.094
Benzo(k)fluoranthene	8.00E-01	.8*
Biphenyl	7.00E+03	12.3
Chrysene	1.80E+00	1.8*
Dibenzo(a,h)anthracene	6.00E-01	0.0104
Fluoranthene	2.60E+02	11.8
Fluorene	1.90E+03	58.5
Indeno(1,2,3-c,d)pyrene	6.20E+01	0.150
2-Methylnaphthalene	2.50E+04	14.8
Naphthalene	3.10E+04	10400
Phenanthrene	1.15E+03	81.4
Pyrene	1.35E+02	12.9

*Value was greater than solubility value; therefore solubility value was substituted.

(continued)

Table 7. (Continued)

Make-up Water from Equalization Basin under Equilibrium Conditions		
Analyte	**Solubility (ug/l)**	**Concentration (ug/L) First Cell (2.8 exchanges)**
Semi-Volatile Organic Compounds		
Benzyl butyl phthalate	2.69E+03	2.59
Bis(2-ethylhexyl)phthalate	4.00E+02	0.0123
2-Chlorophenol	2.85E+07	40.8
Di-N-Octyl Phthalate	3.00E+03	0.000684
Dibenzofuran	4.75E+03	7.19
1,2-Dichlorobenzene	1.45E+05	13.3
1,3-Dichlorobenzene	1.33E+05	5.68
1,4-Dichlorobenzene	8.30E+04	1.54
2,4-Dichlorophenol	4.50E+06	25.9
2,4-Dinitrophenol	6.00E+06	344
2,4-Dinitrotoluene	2.70E+05	0.977
Hexachlorobenzene	6.00E+00	0.00713
Hexachlorobutadiene	3.23E+03	0.0572
4-methylphenol	2.20E+07	170
2-Nitrophenol	2.19E+06	630
Pentachlorophenol	1.40E+04	0.256
Phenol	8.84E+07	1020
1,2,4-Trichlorobenzene	4.00E+04	0.393
Volatile Organic Compounds		
Acetone	1.00E+09	2530
Benzene	1.78E+06	96.1
Chlorobenzene	4.88E+05	56.7
Chloroform	8.20E+06	85.3
Ethylbenzene	1.52E+05	7.75
Methylene chloride	2.00E+07	1180
Tetrachloroethylene	2.00E+05	0.468
Toluene	5.35E+05	8.49
Xylenes, Total	1.75E+05	11.9
Chlorinated Pesticides		
Aldrin	1.80E+01	0.135
alpha-BHC	2.00E+03	0.0758
beta-BHC	7.00E+02	0.318
delta-BHC	3.14E+04	0.0134
gamma-BHC (Lindane)	7.80E+03	0.0252
Chlordane, Technical	5.60E+01	0.351
4,4'-DDD	1.60E+02	0.00108
o,p'-DDE (2,4)	4.00E+01	0.000212
p,p'-DDE (4,4)	4.00E+01	0.00665
p,p'-DDT (4,4)	2.50E+01	0.00143

(continued)

Table 7. (Continued)		
Make-up Water from Equalization Basin under Equilibrium Conditions		
Analyte	**Solubility (ug/l)**	**Concentration (ug/L) First Cell (2.8 exchanges)**
Chlorinated Pesticides (continued)		
Dieldrin	1.95E+02	0.00434
Endosulfan I	5.30E+02	0.0697
Endosulfan II	4.50E+02	0.0991
Endrin	2.50E+02	0.00205
Endrin Aldehyde	5.00E+04	0.0583
Endrin ketone	8.60E+02	0.0372
Heptachlor	1.80E+02	0.0156
Heptachlor Epoxide	3.50E+02	0.0163
Methoxychlor	4.50E+01	0.0465
Toxaphene	7.40E+02	0.130
Dioxins and Furans		
1,2,3,4,6,7,8-HPCDD	4.20E-01	4.9E-10
1,2,3,4,6,7,8-HPCDF	7.62E-01	1.8E-10
1,2,3,4,7,8,9-HPCDF	NA	3.2E-11
1,2,3,4,7,8-HXCDD	1.00E+00	2.6E-11
1,2,3,4,7,8-HXCDF	2.50E-02	3.3E-07
1,2,3,6,7,8-HXCDD	NA	3.3E-11
1,2,3,6,7,8-HXCDF	1.77E-02	7.1E-12
1,2,3,7,8,9-HXCDD	NA	1.3E-10
1,2,3,7,8,9-HXCDF	NA	8.6E-12
1,2,3,7,8-PECDD	1.15E+01	1.0E-10
1,2,3,7,8-PECDF	9.13E+00	4.4E-11
2,3,4,6,7,8-HXCDF	NA	1.3E-12
2,3,4,7,8-PECDF	6.36E+00	8.7E-11
2,3,7,8-TCDD	2.00E-01	2.3E-10
2,3,7,8-TCDF	4.19E-01	1.1E-09
OCDD	7.40E-05	1.6E-09
OCDF	NA	1.0E-09
Total HPCDDS	1.90E+00	1.6E-09
Total HPCDFS	NA	2.5E-10
Total HXCDDS	4.00E-03	1.9E-10
Total HXCDFS	NA	5.0E-10
Total PECDDS	1.20E-01	1.6E-09
Total PECDFS	NA	9.6E-10
Total TCDDS	3.50E-01	8.2E-10
Total TCDFS	NA	1.1E-08
		(continued)

Table 7. (Concluded)		
Make-up Water from Equalization Basin under Equilibrium Conditions		
Analyte	**Solubility (ug/l)**	**Concentration (ug/L) First Cell (2.8 exchanges)**
PCB Aroclors		
PCB(Aroclor-1016)	4.20E+02	0.273
PCB(Aroclor-1221)	4.00E+04	1.03
PCB(Aroclor-1232)	4.07E+05	7.76
PCB(Aroclor-1242)	2.30E+02	9.04
PCB(Aroclor-1248)	5.40E+01	0.571
PCB(Aroclor-1254)	3.10E+01	0.0171
PCB(Aroclor-1260)	2.70E+00	0.000984
PCB Total*	7.00E+01	0.439
*PCB Total is the sum of 19 PCB Congeners.		

to their solubility values in the analyses. Comparative pond concentrations for Options 1, 2 and 3 (mechanical offloading, hydraulic offloading, and hydraulic offloading with recycle) are given in Table 8. Assuming the wastewater treatment will be deferred until dredging is completed annually, contaminant concentrations in the (disposal cell) pond at the completion of dredging are assumed to represent the concentrations of the influent to the WWTP. Equalization basin concentrations represent the runoff, consolidation, and groundwater (when assumed to be stored untreated in the equalization basin) flows that are collected in the equalization basin during the post-treatment period. These concentrations were used for calculating volatile losses from the equalization basin. The effects of groundwater storage in the equalization basin were not considered for calculating the disposal cell concentrations with recycling because the groundwater will probably be handled separately or pre-treated before storage in the equalization basin. Groundwater flows are based on expected long-term pumping rates (after initial drawdown and the first layers of dredged material are placed in all disposal cells), rather than initial drawdown rates.

Ponded Water Predictions Summary

Final pond concentrations were calculated for Options 1, 2 and 3 from a revised data set that included data for BTEX and other organic compounds obtained from an EPA data set. Concentrations were estimated based on partitioning analysis for all three options, in order to establish a consistent basis of comparison. Pond concentrations for Option 3 assumed all make-up water would be obtained from runoff stored in the equalization basin, and mean recycle requirements for a 2.8 ft ponding depth. Flow volumes and concentrations obtained should be conservative estimates for established operating conditions, when infiltration would be expected to be minimal. Groundwater was not included in pond concentration estimates since separate treatment of the groundwater is being considered.

Table 8. Ponded Water Concentrations							
Analyte	Disposal Pond Concentration (ug/L)			Equalization Basin Concentration (ug/L)			
	Option 1	Option 2	Option 3	Option 1 w/o GW	Option 1 w/GW	Options 2 & 3 w/o GW	Options 2 & 3 w/GW
Metals							
Arsenic	93.6	97.5	104	26.4	26.2	62.1	61.7
Cadmium	24.2	24.4	27.2	6.6	6.66	14.9	14.8
Chromium(hex)	95.4	100	102	30.6	30.8	74.6	74.4
Copper	20.5	21.2	22.0	5.99	6.52	14.5	14.8
Lead	146	153	155	51.0	54.2	121	123
Mercury	0.237	0.0497	0.0519	0.0138	0.0178	0.0331	0.036
Nickel	31.3	31.8	33.9	8.62	9.91	20.2	21.1
Zinc	531	559	578	160	160	388	387
Organic Tins							
Dibutylin	59.4	18.2	57.0	15.67	15.49	31.4	31.2
Monobutyltin	8.90	2.73	8.54	2.35	2.32	4.71	4.67
Tributyltin	3.42	3.60	3.74	1.01	1.00	2.46	2.44
Inorganic/General Chemistry							
Carbon, Total Organic	358000	346000	351000	99100	98600	241000	240000
Ammonia-N	508000	169000	503000	134000	133000	269000	264000
Phosphorus, Total	54500	10030	40200	14400	14200	28700	28300
PAHs							
Acenaphthene	143	147	148	64.7	66.2	131	131
Acenaphthylene	23.9	24.5	24.6	11.5	13.1	22.2	23.2
Anthracene	22.4	22.6	22.6	15.4	16.6	21.8	22.6
Benzo(a)anthracene	2.45	2.45	2.45	2.37	2.35	2.45	2.43
Benzo(b)fluoranthene	1.16	1.16	1.16	1.15	1.14	1.16	1.15
Benzo(k)fluoranthene	1.16	1.16	1.16	1.15	1.14	1.16	0.800
Benzo(g,h,i)perylene	0.0937	0.0937	0.0937	0.0934	0.0924	0.0937	0.0930
Benzo(a)pyrene	1.17	1.17	1.17	1.16	1.14	1.17	1.16
Biphenyl	11.3	12.0	12.3	3.53	3.49	8.64	8.57
Chrysene	2.19	2.19	2.19	2.12	2.09	2.18	2.16
Dibenzo(a,h)anthracene	0.0104	0.0104	0.0104	0.0104	0.0103	0.0104	0.0103
Fluoranthene	11.8	11.8	11.8	10.7	10.6	11.7	11.6
Fluorene	57. 5	58.5	58.5	32.1	34.0	54.6	55.8
Indeno(1,2,3-c,d)pyrene	0.150	0.150	0.150	0.150	0.148	0.150	0.149
2-Methylnaphthalene	14.3	14.7	14.8	6.17	450	12.9	328
Naphthalene	9690	10200	10400	3100	3070	7570	7510
Phenanthrene	80.5	81.3	81.4	54.0	57.9	78.2	80.8
Pyrene	12.8	12.9	12.9	11.4	12.0	12.8	13.2
							(continued)

Table 8. (Continued)							
Analyte	Disposal Pond Concentration (ug/L)			Equalization Basin Concentration (ug/L)			
	Option 1	Option 2	Option 3	Option 1	Option 1	Options 2 & 3	Options 2 & 3
				w/o GW	w/GW	w/o GW	w/GW
Semi-Volatile Organic Compounds							
Benzyl butyl phthalate	2.57	2.58	2.59	2.10	2.08	2.54	2.52
Bis(2-ethylhexyl) phthalate	0.0123	0.0123	0.0123	0.0122	0.0121	0.0123	0.0122
2-Chlorophenol	36.1	30.9	41.3	9.64	9.54	20.2	20.1
Di-n-octyl phthalate	0.000683	0.000683	0.000684	0.000684	0.000676	0.000684	0.000678
Dibenzofuran	7.06	7.17	7.19	3.94	21.9	6.71	19.4
1,2-Dichlorobenzene	12.4	13.0	13.3	4.065	4.019	9.87	9.79
1,3-Dichlorobenzene	5.30	5.56	5.68	1.74	1.72	4.23	4.19
1,4-Dichlorobenzene	1.44	1.51	1.54	0.478	0.472	1.16	1.15
2,4-Dichlorophenol	23.6	24.9	25.9	6.95	6.87	16.8	16.6
2,4-Dimethylphenol	0.0	0.0	0.0	0.0	1.14	0.0	0.812
2,4-Dinitrophenol	330	177	368	87.3	86.4	177	175
2,4-Dinitrotoluene	0.870	0.682	0.995	0.231	0.229	0.479	0.475
Hexachlorobenzene	0.00712	0.00713	0.00713	0.00697	0.00689	0.00711	0.00706
Hexachlorobutadiene	0.0569	0.0571	0.0572	0.0458	0.0453	0.0561	0.0557
Isophorone	0.0	0.0	0.0	0.0	2.504	0.0	1.78
4-Methylphenol	152	116	174	40.5	40.0	83.6	82.9
2-Nitrophenol	574	386	654	152	150	311	308
Pentachlorophenol	0.255	0.256	0.256	0.224	0.222	0.254	0.252
Phenol	1010	497	1110	267	265	539	536
1,2,4-Trichlorobenzene	0.383	0.391	0.393	0.185	0.183	0.355	0.352
Volatile Organic Compounds							
Acetone	4190	809	3180	1100	1090	2210	2190
Benzene	85.1	71.7	97.3	22.7	56.9	47.5	71.6
Chlorobenzene	50.8	52.8	56.8	14.3	14.5	33.2	33.2
Chloroform	76.5	56.4	87.4	20.3	20.1	41.8	41.5
Ethylbenzene	7.09	7.48	7.75	2.13	228	5.17	165
Isopropylbenzene	0.0	0.0	0.0	0.0	0.482	0.0	0.342
4-Methyl-2-pentanone	0.0	0.0	0.0	0.0	350	0.0	248
Methylene chloride	1260	505	1330	333	330	670	665
1,1,2,2-Tetrachloroethane	0.0	0.0	0.0	0.0	0.409	0.0	0.290
Tetrachloroethylene	0.416	0.422	0.468	0.114	0.113	0.258	0.256
Toluene	7.59	7.85	8.50	2.12	101	4.88	75.0
1,1,2-Trichloroethane	0.0	0.0	0.0	0.0	0.366	0.0	0.259
Xylenes, Total	10.8	11.4	11.9	3.22	450	7.82	324
Chlorinated Pesticides							
Aldrin	0.135	0.135	0.135	0.125	0.127	0.134	0.136
alpha-BHC	0.0729	0.0752	0.0758	0.0302	0.0317	0.0650	0.0658
beta-BHC	0.306	0.316	0.318	0.127	0.127	0.273	0.272
delta-BHC	0.0132	0.0134	0.0134	0.00703	0.00972	0.0124	0.0143
gamma-BHC (Lindane)	0.0241	0.0249	0.0252	0.00932	0.0121	0.0210	0.0228

(continued)

Table 8. (Continued)

Analyte	Disposal Pond Concentration (ug/L)			Equalization Basin Concentration (ug/L)			
	Option 1	Option 2	Option 3	Option 1 w/o GW	Option 1 w/GW	Options 2 & 3 w/o GW	Options 2 & 3 w/GW
Chlorinated Pesticides (continued)							
Chlordane, Techincal	0.349	0.350	0.350	0.277	0.282	0.344	0.347
4,4'-DDD	0.00108	0.00108	0.00108	0.00106	0.00332	0.00108	0.002687
o,p'-DDE (2,4)	0.000212	0.000212	0.000212	0.000212	0.000209	0.000212	0.000210
p,p'-DDE (4,4)	0.00664	0.00664	0.00665	0.00626	0.00850	0.00662	0.008207
p,p'-DDT (4,4)	0.00143	0.00143	0.00143	0.00141	0.00365	0.00143	0.00301
Dieldrin	0.00434	0.00434	0.00434	0.00405	0.00628	0.00432	0.00590
Endosulfan I	0.0662	0.0689	0.0697	0.0244	0.0260	0.0565	0.0574
Endosulfan II	0.0955	0.0984	0.0991	0.0404	0.0400	0.0857	0.0851
Endosulfan sulfate	0.0	0.0	0.0	0.0	0.00235	0.00000	0.00167
Endrin	0.00205	0.00205	0.00205	0.00185	0.00448	0.00203	0.00389
Endrin aldehyde	0.0568	0.0580	0.0583	0.0272	0.0290	0.0526	0.0536
Endrin ketone	0.0371	0.0372	0.0372	0.0319	0.0356	0.0368	0.0394
Heptachlor	0.0156	0.0156	0.0156	0.0143	0.0161	0.0155	0.0167
Heptachlor epoxide	0.0162	0.0163	0.0163	0.0140	0.0169	0.0161	0.0181
Methoxychlor	0.0464	0.0465	0.0465	0.0409	0.0442	0.0461	0.0484
Toxaphene	0.130	0.130	0.130	0.123	0.122	0.129	0.128
Dioxins and Furans							
1,2,3,4,6,7,8-HPCDD	4.93E-10	4.93E-10	4.93E-10	4.93E-10	4.88E-10	4.93E-10	4.89E-10
1,2,3,4,6,7,8-HPCDF	1.82E-10	1.82E-10	1.82E-10	1.82E-10	1.79E-10	1.82E-10	1.80E-10
1,2,3,4,7,8,9-HPCDF	3.20E-11	3.20E-11	3.20E-11	3.20E-11	3.16E-11	3.20E-11	3.17E-11
1,2,3,4,7,8-HXCDD	2.55E-11	2.55E-11	2.55E-11	2.55E-11	2.52E-11	2.55E-11	2.53E-11
1,2,3,4,7,8-HXCDF	3.32E-07	3.32E-07	3.32E-07	3.32E-07	3.28E-07	3.32E-07	3.29E-07
1,2,3,6,7,8-HXCDD	3.30E-11	3.30E-11	3.30E-11	3.30E-11	3.26E-11	3.30E-11	3.27E-11
1,2,3,6,7,8-HXCDF	7.10E-12	7.10E-12	7.10E-12	7.10E-12	7.02E-12	7.10E-12	7.04E-12
1,2,3,7,8,9-HXCDD	1.31E-10	1.31E-10	1.31E-10	1.31E-10	1.30E-10	1.31E-10	1.30E-10
1,2,3,7,8,9-HXCDF	8.62E-12	8.62E-12	8.62E-12	8.62E-12	8.52E-12	8.62E-12	8.55E-12
1,2,3,7,8-PECDD	1.02E-10	1.02E-10	1.02E-10	1.02E-10	1.01E-10	1.02E-10	1.02E-10
1,2,3,7,8-PECDF	4.38E-11	4.38E-11	4.38E-11	4.36E-11	4.31E-11	4.37E-11	4.34E-11
2,3,4,6,7,8-HXCDF	1.34E-12	1.34E-12	1.34E-12	1.34E-12	1.33E-12	1.34E-12	1.33E-12
2,3,4,7,8-PECDF	8.71E-11	8.71E-11	8.71E-11	8.70E-11	8.60E-11	8.71E-11	8.64E-11
2,3,7,8-TCDD	2.30E-10	2.30E-10	2.30E-10	2.30E-10	2.27E-10	2.30E-10	2.29E-10
2,3,7,8-TCDF	1.14E-09	1.14E-09	1.14E-09	1.14E-09	1.12E-09	1.14E-09	1.13E-09
OCDD	1.58E-09	1.58E-09	1.58E-09	1.58E-09	1.56E-09	1.58E-09	1.57E-09
OCDF	1.02E-09	1.02E-09	1.02E-09	1.02E-09	1.01E-09	1.02E-09	1.02E-09
Total HPCDDS	1.60E-09	1.60E-09	1.60E-09	1.60E-09	1.59E-09	1.60E-09	1.59E-09
Total HPCDFS	2.54E-10	2.54E-10	2.54E-10	2.54E-10	2.51E-10	2.54E-10	2.52E-10
Total HXCDDS	1.91E-10	1.91E-10	1.91E-10	1.91E-10	1.89E-10	1.91E-10	1.90E-10
Total HXCDFS	5.03E-10	5.03E-10	5.03E-10	5.03E-10	4.97E-10	5.03E-10	4.99E-10
Total PECDDS	1.57E-09	1.57E-09	1.57E-09	1.56E-09	1.54E-09	1.57E-09	1.55E-09

(continued)

Table 8. (Concluded)

Analyte	Disposal Pond Concentration (ug/L)			Equalization Basin Concentration (ug/L)			
	Option 1	Option 2	Option 3	Option 1	Option 1	Options 2 & 3	Options 2 & 3
				w/o GW	w/GW	w/o GW	w/GW
Dioxins and Furans (continued)							
Total PECDFS	9.63E-10	9.63E-10	9.63E-10	9.61E-10	9.50E-10	9.63E-10	9.55E-10
Total TCDDS	8.19E-10	8.19E-10	8.19E-10	8.14E-10	8.05E-10	8.19E-10	8.12E-10
Total TCDFS	1.14E-08	1.14E-08	1.14E-08	1.13E-08	1.12E-08	1.14E-08	1.13E-08
PCB Aroclors							
PCB(Aroclor-1016)	0.273	0.273	0.273	0.261	0.258	0.272	0.270
PCB(Aroclor-1221)	1.005	1.025	1.029	0.513	0.507	0.942	0.934
PCB(Aroclor-1232)	7.13	7.52	7.77	2.17	2.15	5.30	5.26
PCB(Aroclor-1242)	8.84	9.00	9.041	4.62	4.56	8.32	8.25
PCB(Aroclor-1248)	0.571	0.571	0.571	0.555	0.549	0.570	0.566
PCB(Aroclor-1254)	0.0171	0.0172	0.0172	0.0169	0.0273	0.0171	0.02450
PCB(Aroclor-1260)	0.000983	0.000983	0.00098	0.00098	0.00097	0.00098	0.00098
PCB Total*	0.439	0.439	0.439	0.432	0.469	0.438	0.464

*PCB Total is the sum of 19 PCB Congeners.

4 - CDF Designs and Operation and Management Plans for Three Placement Options

Storage area requirements for mechanical dredging with hydraulic offloading were evaluated using the CDF configuration assumed in the DDAA for Alternative 1 mechanical dredging (Figure 13). Approximate cell areas were given in Table 2. Initial lift depths (calculated using the USACE SETTLE model of ADDAMS) and predicted shrinkage from desiccation and consolidation (calculated using USACE PSDDF model of ADDAMS) for hydraulic offloading are illustrated in Figures 14 to 17. Mean maximum surface elevation of dredged material is approximately 29.3 ft. Allowing for 2.8 ft ponding and 2 ft freeboard, a maximum dike height of 34 ft would be required. Cell areas may need to be adjusted slightly from those given in Table 2 to equalize the lift depths. Mean maximum surface elevation at the end of backlog dredging is approximately 16.7 ft; a 21.5 ft dike height will be required for the first stage of construction. Material depths will be the same for hydraulic offloading with or without recirculation. Comparative average material depths for mechanical dredging for mechanical and hydraulic offloading options are summarized in Table 9. Additional data relevant to design and operation of the CDF are given in Tables 10 and 11. Table 10 provides the pumping rates and durations for three placement options, and Table 11 provides the dike lengths for phased construction.

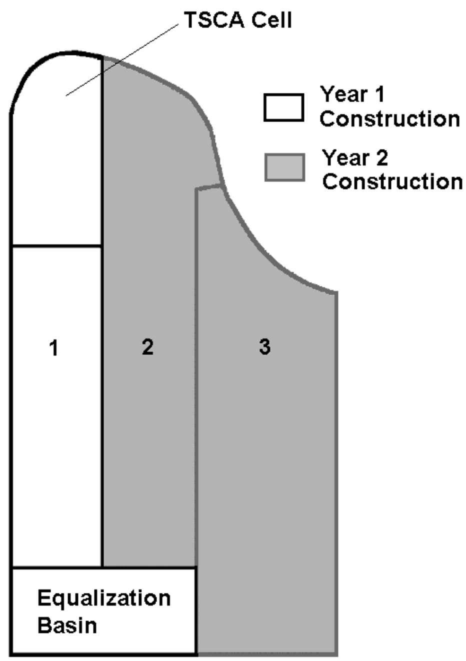

Figure 13. Approximate CDF configuration for all placement options

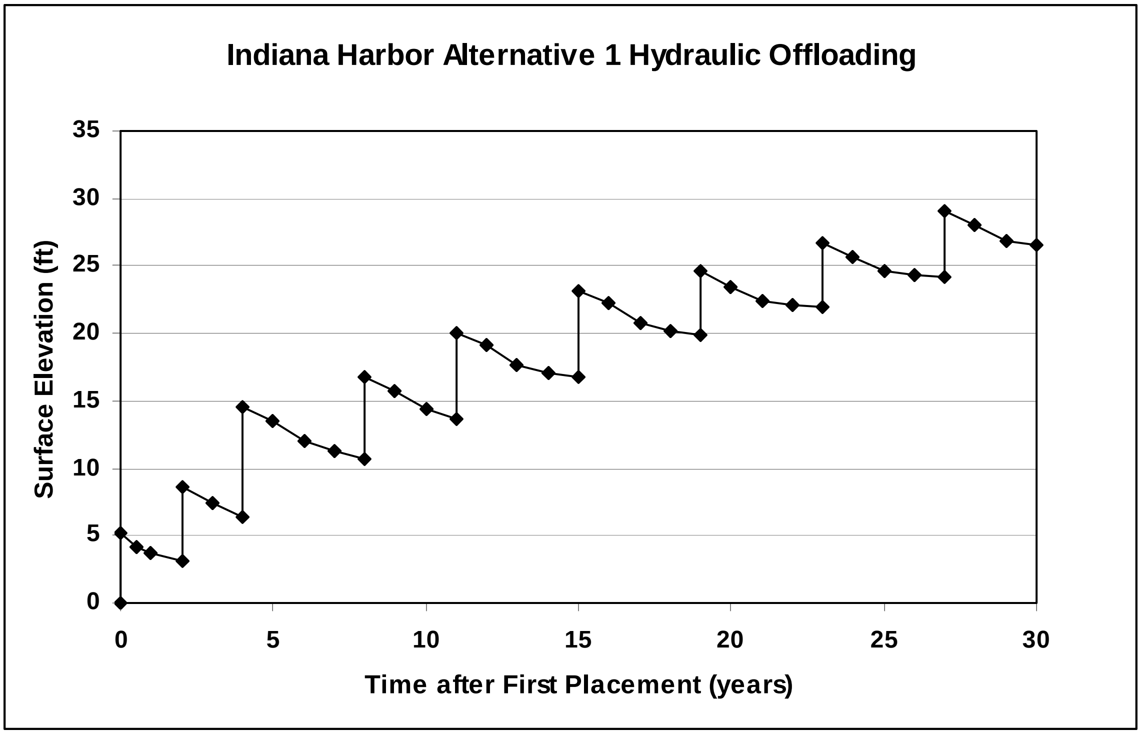

Figure 14. Cell 1 surface elevations from consolidation analysis

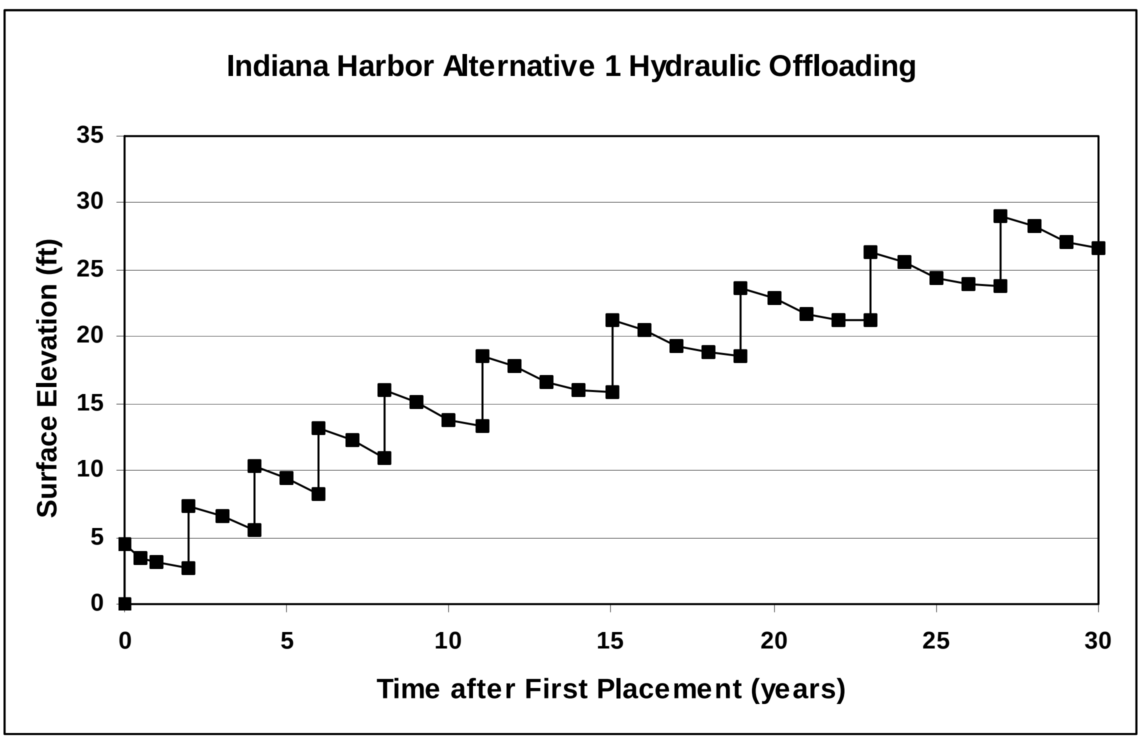

Figure 15. Cell 2 surface elevations from consolidation analysis

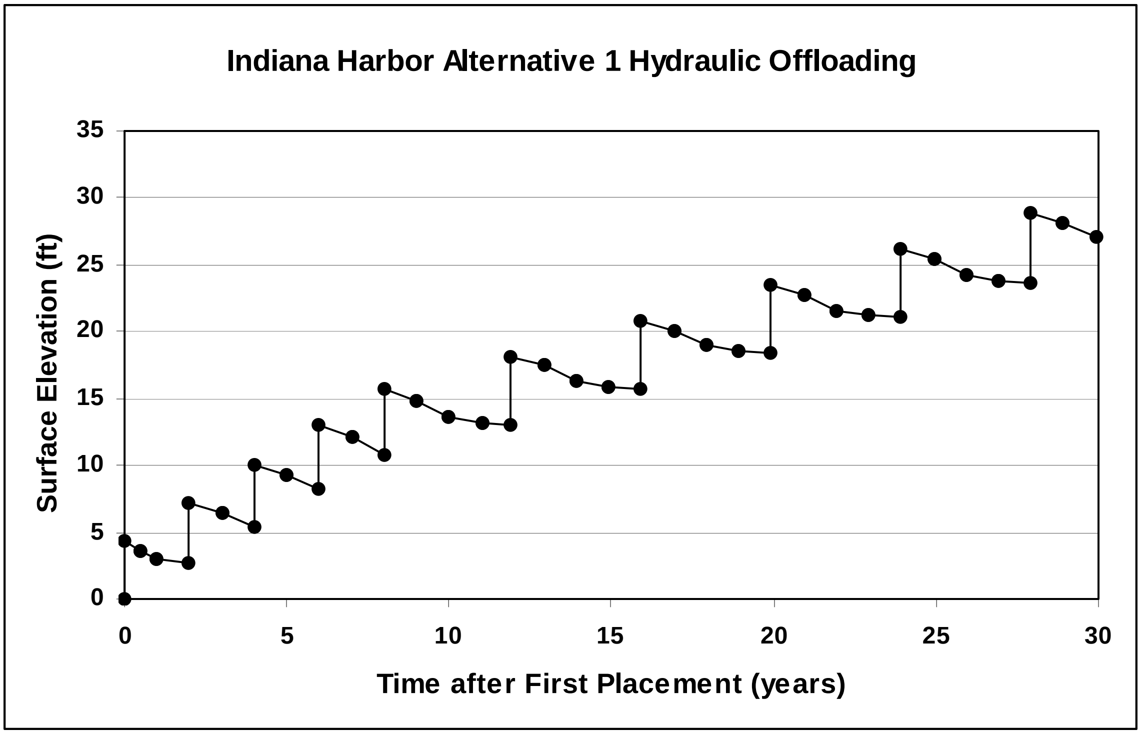

Figure 16. Cell 3 surface elevations from consolidation analysis

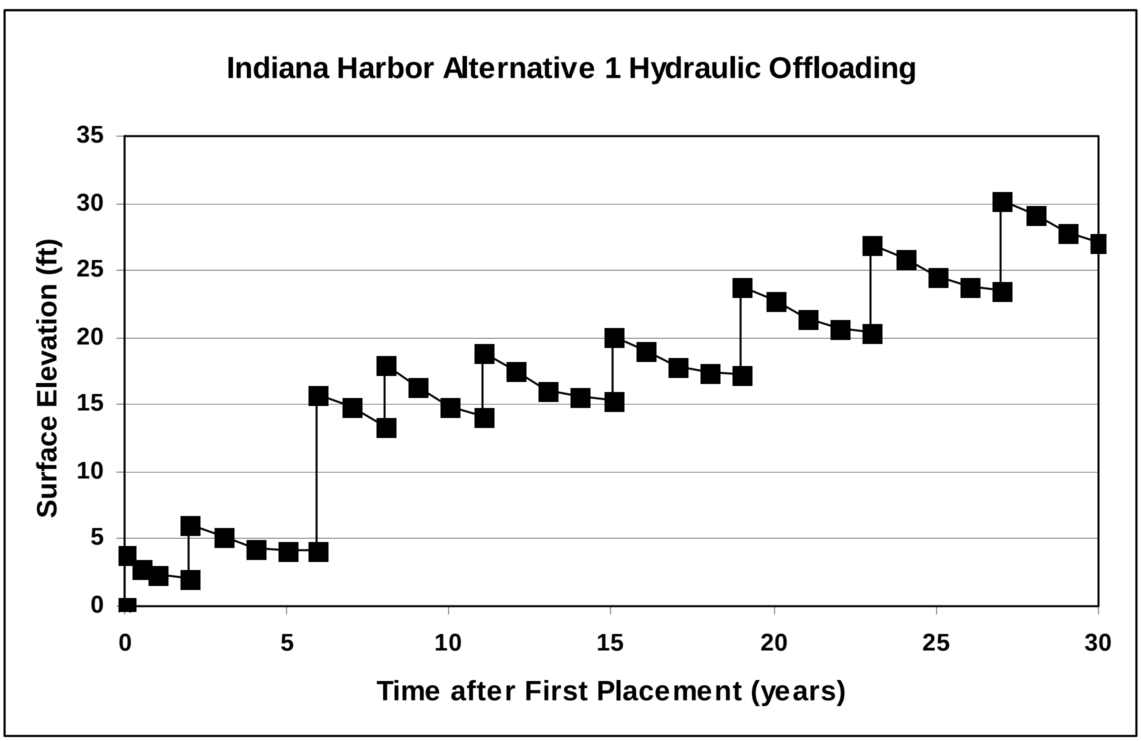

Figure 17. TSCA cell surface elevations from consolidation analysis

Table 9. Average Dredged Material Storage Requirements			
Option	**Maximum Backlog Elevation (ft)**	**Maximum Elevation (ft)**	**30-yr Surface Elevation (ft)**
Option 1 Mechanical Offloading	13.3	26.5	25.4
Options 2 and 3 Hydraulic Offloading	16.7	29.3	26.8

Table 10. Pump Flow Rates and Pumping Duration				
Option	**Avg. Duration**	**Transfer Pumps for Cells**	**Equalization Basin Pump**	**Offloading Pump**
Fixed Standpipe/Weirs & Pumps (Non-Dredging)				
Alternative 1 Option 1 (Mechanical)	32 years	2 @ 300 gpm (Cells 2 & 3); 1 @ 200 gpm (Cells 1); 1 @ 100 gpm (TSCA Cell) Operating 33 days for all pumps Standby 332 days/yr	1 @ 300 gpm Operating 97 days/yr Standby 268 days/yr	N/A
Alternative 1 Option 2 (Mechanical w/Hydraulic Offloading)	32 years	2 @ 300 gpm (Cells 2 & 3); 1 @ 200 gpm (Cells 1); 1 @ 100 gpm (TSCA Cell) Operating 33 days for all pumps Standby 332 days/yr	N/A	N/A
Alternative 1 Option 3 (Mechanical w/Hydraulic Offloading and Recirculation)	32 years	2 @ 300 gpm (Cells 2 & 3); 1 @ 200 gpm (Cells 1); 1 @ 100 gpm (TSCA Cell) Operating 33 days for all pumps Standby 332 days/yr	1 @ 300 gpm Operating 97 days/yr Standby 268 days/yr	N/A
				(continued)

Table 10. (concluded)				
Alternative	**Avg. Duration**	**Transfer Pumps for Cells**	**Equalization Basin Pump**	**Offloading Pump**
Floating Weirs & Transfer Pumps (During Dredging)				
Alternative 1 Option 1 (Mechanical)	N/A	N/A	N/A	N/A
Alternative 1 Option 2 (Mechanical w/Hydraulic Offloading)	25 years @ 56 days/yr	1 @ 2500 gpm Operating 35 days/yr Standby 21 days/yr	1 @ 2000 gpm Operating 64 days/yr Standby 37 days/yr	1@ 6000 gpm Operating 32 days/yr Standby 24 days/hr
Alternative 1 Option 3 (Mechanical w/Hydraulic Offloading and Recirculation)	25 years @ 56 days/yr	1 @ 5000 gpm Operating 25 days/yr Standby 15 days/yr	1 @ 5000 gpm Operating 10 days/yr Standby 6 days/yr	1@ 6000 gpm Operating 32 days/yr Standby 24 days/hr

Table 11. Estimated Dike Lengths for All Placement Options		
Year	**Cell**	**LF**
Year 1:	Cell 1, TSCA subcell & Equalization Basin	
	Interior walls	3790
	Perimeter walls	4930
Year 2:	Cells 2 & 3	
	Interior walls	2470
	Perimeter walls	3760
Total interior walls		6260
Total perimeter walls		8690

Interior dikes divide the CDF into the respective cells. The dikes are assumed to have a 1 on 1 slope on both sides of the dike. The perimeter walls form the exterior of the CDF and are assumed to have a 3 on 1 slope on the outside face and a 1 on 1 slope on the inside face of the dike. Dikes are inset from the property perimeter for the first stage of construction. When dikes are raised, construction will be outward, with the foot of the perimeter dikes extended toward the property line rather than toward the interior of the CDF. Dike height for Stage 1 construction for Option 1, allowing for two feet of freeboard, is 15.5 ft, as specified in the alternatives analysis. Stage 1 dike height for Options 2 and 3, allowing for two feet of freeboard and a minimum of 2.8 feet of ponding, is 21.5 ft. Final required dike height for Option 1 is 28.5 ft, but dikes will be constructed to a final height of 30 ft in keeping with the DDR (USACE, Chicago 2000). Final required dike height for Options 2 and 3 is 34 ft. Further refinement of cell areas and dike height may be made in the optimization analysis. The required cell areas based on present assumptions for Options 1, 2 and 3 are given in Table 12. Areas are slightly different from those given in Table 2, reflecting efforts to equalize the total lift depths between the cells.

Table 12. CDF Configuration Design Assumptions for Options 1, 2 and 3

Cell	**Areas for Option 1 (acres)**	**Areas for Options 2 and 3 (acres)**
1	16.7	15.9
2	28.7	27.7
3	35.4	34.4
TSCA	12.0	11.5
Equalization	10.0	10.0

Design and Operation Summary

For the same CDF configuration and dike slopes assumed in the DDAA, a Stage 1 dike height of 15.5 ft is required for Option 1 and 21.5 ft for Options 2 and 3. Final dike heights are 30 ft and 34 ft, respectively, with the final height of the dike for Option 1 being determined by the DDR, rather than maximum lift depth. This configuration will allow for 2 ft of freeboard for all three options, and 2.8 ft of ponding for Options 2 and 3. Cell areas adjusted to equalize the lift depths are: Cell 1--15.9 acres, Cell 2--27.7 acres, Cell 3--34.4 acres, TSCA cell--11.5 acres, and equalization basin--10 acres.

5 - Volatilization and Particulate Emission Rates

Volatilization was evaluated on a unit concentration basis in the alternatives analysis (Estes et al. 2003). Benzene, toluene, ethylbenzene, xylene (BTEX compounds) and a number of other compounds of lesser importance to the volatilization analysis were not analyzed for the sediments used as the basis for the DDAA (Estes et al. 2003). However, BTEX compounds and other compounds have been found in other IHC sediment samples cataloged by the EPA. EPA reported sediment concentrations for these additional compounds as given in Table 5 were used in this analysis to provide a more complete comparison of the placement options. Since the average contaminant concentrations of the bulk sediment and the partitioning coefficients have not been established specifically for the current Indiana Harbor sediments, comparisons of the volatilization for the three placement options are performed on a relative basis using bulk sediment chemistry data given in Table 5.

Volatile Emissions

The relative flux rates for constituents of concern were calculated for representative conditions at the CDF for three placement options for mechanically dredged material, assuming representative concentrations of the organic constituents of concern in the sediments and corresponding predicted concentrations in effluent, runoff and consolidation flows based on equilibrium partitioning. These ponded water concentrations for the various options are given in Table 8. Published, conservative values of partitioning coefficients and mass transfer coefficients commonly used for risk assessment and dredged material contaminant pathway screening analysis were used for the predictions. Actual conditions may differ from those assumed for the purposes of the comparative analysis; therefore, the predictions are not intended to represent the actual magnitude of emissions expected.

Mass transfer rates differ between dry, wet and ponded surfaces. To estimate flux rates, assumptions must be made regarding surface conditions and areas. Equalization basins were assumed to be ponded at all times. The chemistry of the water in the equalization basin would be expected to be dominated by effluent of disposal during the 4-month wastewater treatment season and by runoff and consolidation flows in the off-season. In addition, runoff from recently placed, unoxidized material would be different in character to runoff from dried, oxidized material. Concentrations in ponded areas and emissions from ponded areas and exposed dredged material surfaces were estimated based on representative steady-state conditions for hydraulic and mechanical placement without initial consideration of depletion of the volatiles in the source. As such, the estimates of emissions are somewhat high, perhaps 30 to 40% higher than would be computed using unsteady, depleting concentrations of volatiles. However, the estimates are suitable for comparisons between placement options because the estimates are consistent between placement options. Corrections were made to insure that emissions in excess of the source availability by locale were restricted to the availability. The totals of the emission estimates for the various placement options ranged from 30 to 35 percent of the total quantity of volatile organics added to the CDF annually.

Table 13 summarizes the relative flux rates of each placement option for all constituents of concern with and without groundwater being stored in the equalization basin between seasonal treatment periods. The flux rates are compared with the flux rates of mechanical placement without storage of groundwater to compute the ratios. The relative flux rates in volatilization among contaminants are shown in Table 14 as percentages of the total flux of the organic contaminants of concern for the placement option. Hydraulic placement increases total volatiles losses by about 11% without recirculation and about 12% with recirculation. The principal constituents (listed in order of decreasing magnitude) contributing to volatilization are naphthalene, methylene chloride, and acenaphthene. Those constituents contributing at least 0.1% of the total organic volatile emissions are listed in order of importance in Table 15.

The relative flux rates from the various sources in the disposal facility are given in Table 16. The exposed dredged material conditions are the main contributors to volatilization, comprising 84 to 95% of the emissions. The disposal pond contributes 2% to 9% of the emissions and the equalization basin produces 3% to 7%. Table 17 lists additional comparisons of the placement options. Storing groundwater in the equalization basin during the off-season adds 0.44% to the volatile emissions. Hydraulic placement increases the emissions from the disposal pond by 410%, from the equalization basin by 204%, and by about 11% overall, actually decreasing the losses from the exposed sediment by 0.3%.

If volatilization controls are needed as determined by an air risk analysis or a predicted exceedance of an emission criterion, controls must be placed on the exposed sediment due to its large contribution to the overall emissions because of its large area and exposure time. Control of the emissions from ponded water without also reducing the losses from exposed sediment would not provide significant reductions in emissions. Some volatilization control measures could provide controls for all emission locales.

Table 13. Ratios of Total Volatile Losses (Sum of All Locales) as Compared to Placement Option 1 w/o Groundwater Storage

Volatile Analyte	Placement Option 1		Placement Option 2		Placement Option 3	
	w/o GW	with GW	w/o GW	with GW	w/o GW	with GW
Metals						
Mercury	1.00	1.00	1.00	1.00	1.00	1.00
Inorganic/General Chemistry						
Ammonia-N	1.00	1.00	1.00	1.00	1.00	1.00
PAHs						
Acenaphthene	1.00	1.00	1.10	1.10	1.10	1.10
Acenaphthylene	1.00	1.01	1.12	1.13	1.12	1.13
Anthracene	1.00	1.00	1.10	1.10	1.10	1.10
Benzo(a)anthracene	1.00	1.00	1.04	1.04	1.04	1.04
Benzo(b)fluoranthene	1.00	1.00	1.02	1.02	1.02	1.02
Benzo(k)fluoranthene	1.00	1.00	1.02	1.02	1.02	1.02
Benzo(g,h,i)perylene	1.00	1.00	1.00	1.00	1.00	1.00
Benzo(a)pyrene	1.00	1.00	1.00	1.00	1.00	1.00
Biphenyl	1.00	1.00	1.17	1.17	1.18	1.18
Chrysene	1.00	1.00	1.02	1.02	1.02	1.02
Dibenzo(a,h)anthracene	1.00	1.00	1.00	1.00	1.00	1.00
Fluoranthene	1.00	1.00	1.11	1.11	1.11	1.11
Fluorene	1.00	1.00	1.13	1.13	1.13	1.13
Indeno(1,2,3-c,d)pyrene	1.00	1.00	1.00	1.00	1.00	1.00
2-Methylnaphthalene	1.00	2.98	1.09	2.49	1.09	2.49
Naphthalene	1.00	1.00	1.11	1.11	1.11	1.11
Phenanthrene	1.00	1.01	1.17	1.17	1.17	1.17
Pyrene	1.00	1.00	1.10	1.10	1.10	1.10
Semi-Volatile Organics						
Benzyl butyl phthalate	1.00	1.00	1.01	1.01	1.01	1.01
Bis(2-ethylhexyl) phthalate	1.00	1.00	1.00	1.00	1.00	1.00
2-Chlorophenol	1.00	1.00	2.13	2.12	2.45	2.45
Di-n-octyl phthalate	1.00	1.00	1.03	1.03	1.03	1.03
Dibenzofuran	1.00	1.16	1.08	1.19	1.08	1.19
1,2-Dichlorobenzene	1.00	1.00	1.05	1.05	1.05	1.05
1,3-Dichlorobenzene	1.00	1.00	1.04	1.04	1.04	1.04
1,4-Dichlorobenzene	1.00	1.00	1.04	1.04	1.04	1.04
2,4-Dichlorophenol	1.00	1.00	1.40	1.41	1.40	1.42
2,4-Dimethylphenol	Only in GW	Only in GW	Only in GW	Only in GW	Only in GW	Only in GW
2,4-Dinitrophenol	1.00	1.00	0.14	0.13	0.07	0.07
2,4-Dinitrotoluene	1.00	1.00	1.71	1.65	1.71	1.73
Hexachlorobenzene	1.00	1.00	1.00	1.00	1.00	1.00
Hexachlorobutadiene	1.00	1.00	1.00	1.00	1.00	1.00
Isophorone	Only in GW	Only in GW	Only in GW	Only in GW	Only in GW	Only in GW

(continued)

Table 13. (Continued)

Volatile Analyte	Placement Option 1		Placement Option 2		Placement Option 3	
	w/o GW	with GW	w/o GW	with GW	w/o GW	with GW
4-Methylphenol	1.00	1.00	1.10	1.05	0.74	0.76
2-Nitrophenol	1.00	1.00	1.70	1.70	1.54	1.54
Pentachlorophenol	1.00	1.00	1.05	1.05	1.05	1.05
Phenol	1.00	1.00	1.34	1.21	1.34	1.36
1,2,4-Trichlorobenzene	1.00	1.00	1.03	1.03	1.03	1.03
Volatile Organic Compounds						
Acetone	1.00	1.00	1.00	1.00	1.00	1.00
Benzene	1.00	1.04	1.00	1.04	1.00	1.04
Chlorobenzene	1.00	1.00	1.00	1.00	1.00	1.00
Chloroform	1.00	1.00	1.00	1.00	1.00	1.00
Ethylbenzene	1.00	1.31	1.00	1.31	1.00	1.31
Isopropylbenzene	Only in GW	Only in GW	Only in GW	Only in GW	Only in GW	Only in GW
4-Methyl-2-pentanone	Only in GW	Only in GW	Only in GW	Only in GW	Only in GW	Only in GW
Methylene chloride	1.00	1.00	1.09	1.09	1.21	1.21
1,1,2,2-Tetrachloroethane	Only in GW	Only in GW	Only in GW	Only in GW	Only in GW	Only in GW
Tetrachloroethylene	1.00	1.00	1.03	1.03	1.03	1.03
Toluene	1.00	1.42	1.04	1.34	1.04	1.34
1,1,2-Trichloroethane	Only in GW	Only in GW	Only in GW	Only in GW	Only in GW	Only in GW
Xylenes, Total	1.00	1.43	1.00	1.43	1.00	1.43
Chlorinated Pesticides						
Aldrin	1.00	1.00	1.02	1.02	1.02	1.02
alpha-BHC	1.00	1.01	1.63	1.63	1.63	1.63
beta-BHC	1.00	1.00	1.07	1.07	1.07	1.08
delta-BHC	1.00	1.03	1.07	1.09	1.07	1.10
gamma-BHC (Lindane)	1.00	1.07	1.67	1.72	1.67	1.72
Chlordane, Techincal	1.00	1.00	1.29	1.29	1.29	1.29
4,4'-DDD	1.00	1.08	1.03	1.09	1.03	1.09
o,p'-DDE (2,4)	1.00	1.00	1.03	1.03	1.03	1.03
p,p'-DDE (4,4)	1.00	1.01	1.03	1.04	1.03	1.04
p,p'-DDT (4,4)	1.00	1.04	1.02	1.04	1.02	1.04
Dieldrin	1.00	1.06	1.11	1.15	1.11	1.15
Endosulfan I	1.00	1.03	2.29	2.30	2.29	2.30
Endosulfan II	1.00	1.00	2.18	2.17	2.18	2.18
Endosulfan sulfate	Only in GW	Only in GW	Only in GW	Only in GW	Only in GW	Only in GW
Endrin	1.00	1.07	1.00	1.06	1.00	1.06
Endrin aldehyde	1.00	1.00	1.02	1.03	1.02	1.03
Endrin ketone	1.00	1.01	1.07	1.08	1.07	1.08
Heptachlor	1.00	1.00	1.00	1.00	1.00	1.00
Heptachlor epoxide	1.00	1.02	1.11	1.12	1.11	1.12
Methoxychlor	1.00	1.01	1.13	1.14	1.13	1.14
Toxaphene	1.00	1.00	1.00	1.00	1.00	1.00

(continued)

Table 13. (Concluded)						
Volatile Analyte	**Placement Option 1**		**Placement Option 2**		**Placement Option 3**	
	w/o GW	**with GW**	**w/o GW**	**with GW**	**w/o GW**	**with GW**
Dioxins						
1,2,3,4,6,7,8-HPCDD	1.00	1.00	1.00	1.00	1.00	1.00
1,2,3,4,6,7,8-HPCDF	1.00	1.00	1.04	1.04	1.04	1.04
1,2,3,4,7,8,9-HPCDF	1.00	1.00	1.04	1.04	1.04	1.04
1,2,3,4,7,8-HXCDD	1.00	1.00	1.04	1.04	1.04	1.04
1,2,3,4,7,8-HXCDF	1.00	1.00	1.03	1.03	1.03	1.03
1,2,3,6,7,8-HXCDD	1.00	1.00	1.03	1.03	1.03	1.03
1,2,3,6,7,8-HXCDF	1.00	1.00	1.04	1.04	1.04	1.04
1,2,3,7,8,9-HXCDD	1.00	1.00	1.09	1.09	1.09	1.09
1,2,3,7,8,9-HXCDF	1.00	1.00	1.04	1.04	1.04	1.04
1,2,3,7,8-PECDD	1.00	1.00	1.03	1.03	1.03	1.03
1,2,3,7,8-PECDF	1.00	1.00	1.06	1.06	1.06	1.06
2,3,4,6,7,8-HXCDF	1.00	1.00	1.04	1.04	1.04	1.04
2,3,4,7,8-PECDF	1.00	1.00	1.06	1.06	1.06	1.06
2,3,7,8-TCDD	1.00	1.00	1.07	1.07	1.07	1.07
2,3,7,8-TCDF	1.00	1.00	1.03	1.03	1.03	1.03
OCDD	1.00	1.00	1.03	1.03	1.03	1.03
OCDF	1.00	1.00	1.01	1.01	1.01	1.01
Total HPCDDS	1.00	1.00	1.03	1.03	1.03	1.03
Total HPCDFS	1.00	1.00	1.04	1.04	1.04	1.04
Total HXCDDS	1.00	1.00	1.03	1.03	1.03	1.03
Total HXCDFS	1.00	1.00	1.04	1.04	1.04	1.04
Total PECDDS	1.00	1.00	1.02	1.02	1.02	1.02
Total PECDFS	1.00	1.00	1.07	1.07	1.07	1.07
Total TCDDS	1.00	1.00	1.00	1.00	1.00	1.00
Total TCDFS	1.00	1.00	1.00	1.00	1.00	1.00
PCB Aroclors						
PCB(Aroclor-1016)	1.00	1.00	1.01	1.01	1.01	1.01
PCB(Aroclor-1221)	1.00	1.00	1.43	1.43	1.44	1.43
PCB(Aroclor-1232)	1.00	1.00	2.96	2.95	3.01	3.00
PCB(Aroclor-1242)	1.00	1.00	1.04	1.04	1.04	1.04
PCB(Aroclor-1248)	1.00	1.00	1.00	1.00	1.00	1.00
PCB(Aroclor-1254)	1.00	1.00	1.00	1.00	1.00	1.00
PCB(Aroclor-1260)	1.00	1.00	1.00	1.00	1.00	1.00
PCB Total*	1.00	1.00	1.00	1.00	1.00	1.00
Overall (all volatiles)	**1.00**	**1.01**	**1.11**	**1.11**	**1.12**	**1.12**

*PCB Total is the sum of 19 PCB Congeners.

Table 14. Volatilization of Individual Compounds as a Percent of Total Volatile Organic Losses for the Placement Option

Volatile Analyte	Placement Option 1		Placement Option 2		Placement Option 3	
	w/o GW	with GW	w/o GW	with GW	w/o GW	with GW
PAHs						
Acenaphthene	1.47	1.45	1.44	1.46	1.44	1.43
Acenaphthylene	0.19	0.19	0.19	0.19	0.19	0.19
Anthracene	0.19	0.19	0.19	0.19	0.19	0.19
Benzo(a)anthracene	0.01	0.01	0.01	0.01	0.01	0.01
Benzo(b)fluoranthene	0.03	0.03	0.03	0.03	0.03	0.03
Benzo(k)fluoranthene	0.03	0.03	0.03	0.03	0.03	0.03
Benzo(g,h,i)perylene	0.00	0.00	0.00	0.00	0.00	0.00
Benzo(a)pyrene	0.00	0.00	0.00	0.00	0.00	0.00
Biphenyl	0.07	0.07	0.07	0.07	0.07	0.07
Chrysene	0.07	0.06	0.06	0.07	0.06	0.06
Dibenzo(a,h)anthracene	0.00	0.00	0.00	0.00	0.00	0.00
Fluoranthene	0.08	0.08	0.07	0.07	0.07	0.07
Fluorene	0.43	0.43	0.43	0.43	0.43	0.43
Indeno(1,2,3-c,d)pyrene	0.00	0.00	0.00	0.00	0.00	0.00
2-Methylnaphthalene	0.17	0.16	0.16	0.49	0.37	0.37
Naphthalene	88.41	88.44	88.02	87.88	88.10	87.64
Phenanthrene	0.42	0.44	0.44	0.42	0.44	0.44
Pyrene	0.05	0.05	0.05	0.05	0.05	0.05
Semi-Volatile Organic Compounds						
Benzyl butyl phthalate	0.00	0.00	0.00	0.00	0.00	0.00
Bis(2-ethylhexyl) phthalate	0.00	0.00	0.00	0.00	0.00	0.00
2-Chlorophenol	0.02	0.05	0.05	0.02	0.05	0.05
Di-n-octyl phthalate	0.00	0.00	0.00	0.00	0.00	0.00
Dibenzofuran	0.08	0.08	0.08	0.10	0.09	0.09
1,2-Dichlorobenzene	0.26	0.25	0.25	0.26	0.25	0.24
1,3-Dichlorobenzene	0.13	0.12	0.12	0.13	0.12	0.12
1,4-Dichlorobenzene	0.03	0.03	0.03	0.03	0.03	0.03
2,4-Dichlorophenol	0.02	0.02	0.02	0.02	0.02	0.02
2,4-Dimethylphenol	0.00	0.00	0.00	0.00	0.00	0.00
2,4-Dinitrophenol	0.00	0.00	0.00	0.00	0.00	0.00
2,4-Dinitrotoluene	0.00	0.00	0.00	0.00	0.00	0.00
Hexachlorobenzene	0.00	0.00	0.00	0.00	0.00	0.00
Hexachlorobutadiene	0.00	0.00	0.00	0.00	0.00	0.00
Isophorone	0.00	0.00	0.00	0.00	0.00	0.00
4-Methylphenol	0.04	0.04	0.03	0.04	0.04	0.03
2-Nitrophenol	0.30	0.46	0.41	0.29	0.45	0.41
Pentachlorophenol	0.00	0.00	0.00	0.00	0.00	0.00
Phenol	0.32	0.39	0.39	0.32	0.35	0.39
1,2,4-Trichlorobenzene	0.01	0.01	0.01	0.01	0.01	0.01

(continued)

Table 14. (Continued)

Volatile Analyte	Placement Option 1		Placement Option 2		Placement Option 3	
	w/o GW	with GW	w/o GW	with GW	w/o GW	with GW
Volatile Organic Compounds						
Acetone	0.53	0.48	0.47	0.53	0.48	0.47
Benzene	0.15	0.13	0.13	0.15	0.14	0.14
Chlorobenzene	0.42	0.38	0.37	0.42	0.38	0.37
Chloroform	0.09	0.08	0.08	0.09	0.08	0.08
Ethylbenzene	0.12	0.10	0.10	0.15	0.14	0.14
Isopropylbenzene	0.00	0.00	0.00	0.00	0.00	0.00
4-Methyl-2-pentanone	0.00	0.00	0.00	0.05	0.05	0.05
Methylene chloride	5.17	5.09	5.60	5.13	5.07	5.58
1,1,2,2-Tetrachloroethane	0.00	0.00	0.00	0.00	0.00	0.00
Tetrachloroethylene	0.01	0.01	0.01	0.01	0.01	0.01
Toluene	0.18	0.16	0.16	0.25	0.21	0.21
1,1,2-Trichloroethane	0.00	0.00	0.00	0.00	0.00	0.00
Xylenes, Total	0.17	0.15	0.15	0.24	0.21	0.21
Chlorinated Pesticides						
Aldrin	0.01	0.00	0.00	0.01	0.00	0.00
alpha-BHC	0.00	0.00	0.00	0.00	0.00	0.00
beta-BHC	0.00	0.00	0.00	0.00	0.00	0.00
delta-BHC	0.00	0.00	0.00	0.00	0.00	0.00
gamma-BHC (Lindane)	0.00	0.00	0.00	0.00	0.00	0.00
Chlordane, Techincal	0.00	0.00	0.00	0.00	0.00	0.00
4,4'-DDD	0.00	0.00	0.00	0.00	0.00	0.00
o,p'-DDE (2,4)	0.00	0.00	0.00	0.00	0.00	0.00
p,p'-DDE (4,4)	0.00	0.00	0.00	0.00	0.00	0.00
p,p'-DDT (4,4)	0.00	0.00	0.00	0.00	0.00	0.00
Dieldrin	0.00	0.00	0.00	0.00	0.00	0.00
Endosulfan I	0.00	0.00	0.00	0.00	0.00	0.00
Endosulfan II	0.00	0.00	0.00	0.00	0.00	0.00
Endosulfan sulfate	0.00	0.00	0.00	0.00	0.00	0.00
Endrin	0.00	0.00	0.00	0.00	0.00	0.00
Endrin aldehyde	0.00	0.00	0.00	0.00	0.00	0.00
Endrin ketone	0.00	0.00	0.00	0.00	0.00	0.00
Heptachlor	0.00	0.00	0.00	0.00	0.00	0.00
Heptachlor epoxide	0.00	0.00	0.00	0.00	0.00	0.00
Methoxychlor	0.00	0.00	0.00	0.00	0.00	0.00
Toxaphene	0.02	0.02	0.02	0.02	0.02	0.02

(continued)

Table 14. (Concluded)

Volatile Analyte	Placement Option 1		Placement Option 2		Placement Option 3	
	w/o GW	with GW	w/o GW	with GW	w/o GW	with GW
Dioxins						
1,2,3,4,6,7,8-HPCDD	0.00	0.00	0.00	0.00	0.00	0.00
1,2,3,4,6,7,8-HPCDF	0.00	0.00	0.00	0.00	0.00	0.00
1,2,3,4,7,8,9-HPCDF	0.00	0.00	0.00	0.00	0.00	0.00
1,2,3,4,7,8-HXCDD	0.00	0.00	0.00	0.00	0.00	0.00
1,2,3,4,7,8-HXCDF	0.00	0.00	0.00	0.00	0.00	0.00
1,2,3,6,7,8-HXCDD	0.00	0.00	0.00	0.00	0.00	0.00
1,2,3,6,7,8-HXCDF	0.00	0.00	0.00	0.00	0.00	0.00
1,2,3,7,8,9-HXCDD	0.00	0.00	0.00	0.00	0.00	0.00
1,2,3,7,8,9-HXCDF	0.00	0.00	0.00	0.00	0.00	0.00
1,2,3,7,8-PECDD	0.00	0.00	0.00	0.00	0.00	0.00
1,2,3,7,8-PECDF	0.00	0.00	0.00	0.00	0.00	0.00
2,3,4,6,7,8-HXCDF	0.00	0.00	0.00	0.00	0.00	0.00
2,3,4,7,8-PECDF	0.00	0.00	0.00	0.00	0.00	0.00
2,3,7,8-TCDD	0.00	0.00	0.00	0.00	0.00	0.00
2,3,7,8-TCDF	0.00	0.00	0.00	0.00	0.00	0.00
OCDD	0.00	0.00	0.00	0.00	0.00	0.00
OCDF	0.00	0.00	0.00	0.00	0.00	0.00
Total HPCDDS	0.00	0.00	0.00	0.00	0.00	0.00
Total HPCDFS	0.00	0.00	0.00	0.00	0.00	0.00
Total HXCDDS	0.00	0.00	0.00	0.00	0.00	0.00
Total HXCDFS	0.00	0.00	0.00	0.00	0.00	0.00
Total PECDDS	0.00	0.00	0.00	0.00	0.00	0.00
Total PECDFS	0.00	0.00	0.00	0.00	0.00	0.00
Total TCDDS	0.00	0.00	0.00	0.00	0.00	0.00
Total TCDFS	0.00	0.00	0.00	0.00	0.00	0.00
PCB Aroclors						
PCB(Aroclor-1016)	0.01	0.01	0.01	0.01	0.01	0.01
PCB(Aroclor-1221)	0.00	0.00	0.00	0.00	0.00	0.00
PCB(Aroclor-1232)	0.00	0.01	0.01	0.00	0.01	0.01
PCB(Aroclor-1242)	0.23	0.21	0.21	0.23	0.21	0.21
PCB(Aroclor-1248)	0.03	0.03	0.03	0.03	0.03	0.03
PCB(Aroclor-1254)	0.00	0.00	0.00	0.00	0.00	0.00
PCB(Aroclor-1260)	0.00	0.00	0.00	0.00	0.00	0.00
PCB Total*	0.02	0.02	0.02	0.02	0.02	0.02
Overall (all volatiles)	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**

*PCB Total is the sum of 19 PCB Congeners.

Table 15. Relative Magnitude of Volatile Emissions by Major Contributors (All Placement Options)

Contaminant	Without GW, percent	With GW, percent
Naphthalene	88.3	87.9
Methylene chloride	5.29	5.26
Acenaphthene	1.45	1.44
Acetone	0.49	0.49
2-Methylnaphthalene	0.16	0.41
Fluorene	0.43	0.43
Phenanthrene	0.43	0.43
Chlorobenzene	0.39	0.39
Phenol	0.37	0.36
2-Nitrophenol	0.39	0.38
1,2-Dichlorobenzene	0.25	0.25
Toluene	0.17	0.22
Xylenes, Total	0.15	0.22
PCB(Aroclor-1242)	0.22	0.22
Acenaphthylene	0.19	0.19
Anthracene	0.19	0.19
Benzene	0.14	0.14
Ethylbenzene	0.11	0.14
1,3-Dichlorobenzene	0.12	0.12

Table 16. Relative Volatile Losses by Source Component

Component	Percent of Volatile Losses					
	Placement Option 1		Placement Option 2		Placement Option 3	
	w/o GW	with GW	w/o GW	with GW	w/o GW	with GW
Disposal Pond	2.0	1.9	8.5	8.5	9.4	9.3
Equalization Basin	3.1	4.0	6.3	6.8	6.0	6.6
Exposed Sediment	94.9	94.1	85.2	84.7	84.6	84.0

Table 17. Additional Comparisons of Emissions

Condition	Mechanical Emissions	Hydraulic Emissions	Percent Change by Hydraulic Off-loading
Disposal Pond	1970	10000	410
Equalization Basin	3560	7210	203
Exposed Sediment	95200	94900	-0.3
Overall	101000	121000	11

Particulate Emissions

Particulate emissions (losses of fugitive dust) for the various alternatives will be a function of the quantity of area and period of time that the area is present in an exposed, unvegetated, dried condition. The areas in ponded, wet drained, and dry drained conditions for the three placement alternatives are virtually identical. For the hydraulic placement options, one 30-acre cell will be in a wet drained condition (instead of a dry drained condition conducive to dust formation) about two extra months per year as compared to the mechanical placement option. These two months will reduce conditions conducive to fugitive dust creation by about 6%, 960 acre-months for mechanical placement versus 900 acre-months for hydraulic placement. (An acre-month is a unit of measure reflecting the period of time that a specific number of acres will have a surface moisture content or condition facilitating particulate transport. It is merely the product of the number of acres and the average time in months that the acreages will be in a dry drained condition.)

In addition to losses from the exposed surfaces, losses can also occur from the dredged material transfer operations. Mechanical transfer operations and trucking are subject to much greater losses than hydraulic pipeline operations. The losses are specific to the design of the transfer systems. With good management, such as truck washing and appropriate loss controls, particulate emissions from the transfer operations can be minimized, and should be much less than losses from the CDF, where the area is much larger and controls more difficult to implement.

Volatilization Summary

Estimates of volatilization were predicted for all three placement options with and without storage of groundwater in the equalization basin between wastewater treatment seasons. The principal constituents (listed in order of decreasing magnitude) contributing to volatilization are naphthalene, methylene chloride, and acenaphthene. The exposed dredged material conditions are the main contributors to volatilization, comprising 84 to 95% of the emissions. The disposal pond contributes 2% to 9% of the emissions and the equalization basin produces 3% to 7%. Table 17 lists additional comparisons of the placement options. Storing groundwater in the equalization basin during the off-season adds 0.44% to the volatile emissions. Hydraulic placement increases volatile losses by about 11 to 12% overall due to increased emissions from the disposal pond and the equalization basin. Losses from the disposal pond increased by 410% and from the equalization basin by 204%. Losses from the exposed sediment decreased by 0.3% with hydraulic placement. If emission controls are needed, control measures that control the losses from the exposed sediment should be selected. Certain control measures could reduce losses from all emission locales.

6 - Comparison of Chicago and East Chicago Climate Data

Estimated stormflows for the East Chicago disposal site reported in the Indiana Harbor and Canal (IHC) Dredging and Disposal Alternatives Analysis (Estes et al. 2003) were based on synthetically generated precipitation values obtained using the HELP model (Schroeder at al. 1994) with O'Hare climatic properties and normal mean monthly precipitation values stored in the HELP model for 1951-1980. A comparison of the normal mean monthly precipitation values obtained using this method and more recent (1971-2000) normal mean monthly precipitation values for areas closer to the disposal site are summarized in Table 18. Locations and corresponding average normal precipitation values are also given in Figure 18.

Table 18. Normal Precipitation Values (Inches)

Month	Location				
	HELP Model O'Hare 1951-1980	**O'Hare 1971-2000**	**Midway 1971-2000**	**Park Forrest 1971-2000**	**Valporaiso 1971-2000**
Jan	1.60	1.53	1.70	1.5	1.08
Feb	1.31	1.36	1.52	1.39	1.66
Mar	2.59	2.69	2.86	2.71	2.84
Apr	3.66	3.64	3.93	4.03	3.96
May	3.15	3.32	3.55	3.83	3.86
Jun	4.08	3.78	3.89	4.17	4.22
Jul	3.63	3.66	4.18	4.00	4.00
Aug	3.53	4.22	3.74	3.60	3.81
Sep	3.35	3.82	3.68	3.64	4.20
Oct	2.28	2.41	2.51	2.64	2.77
Nov	2.06	2.92	2.99	3.11	3.41
Dec	2.10	2.47	2.83	2.50	1.06
Annual	33.34	35.82	37.38	37.12	36.87

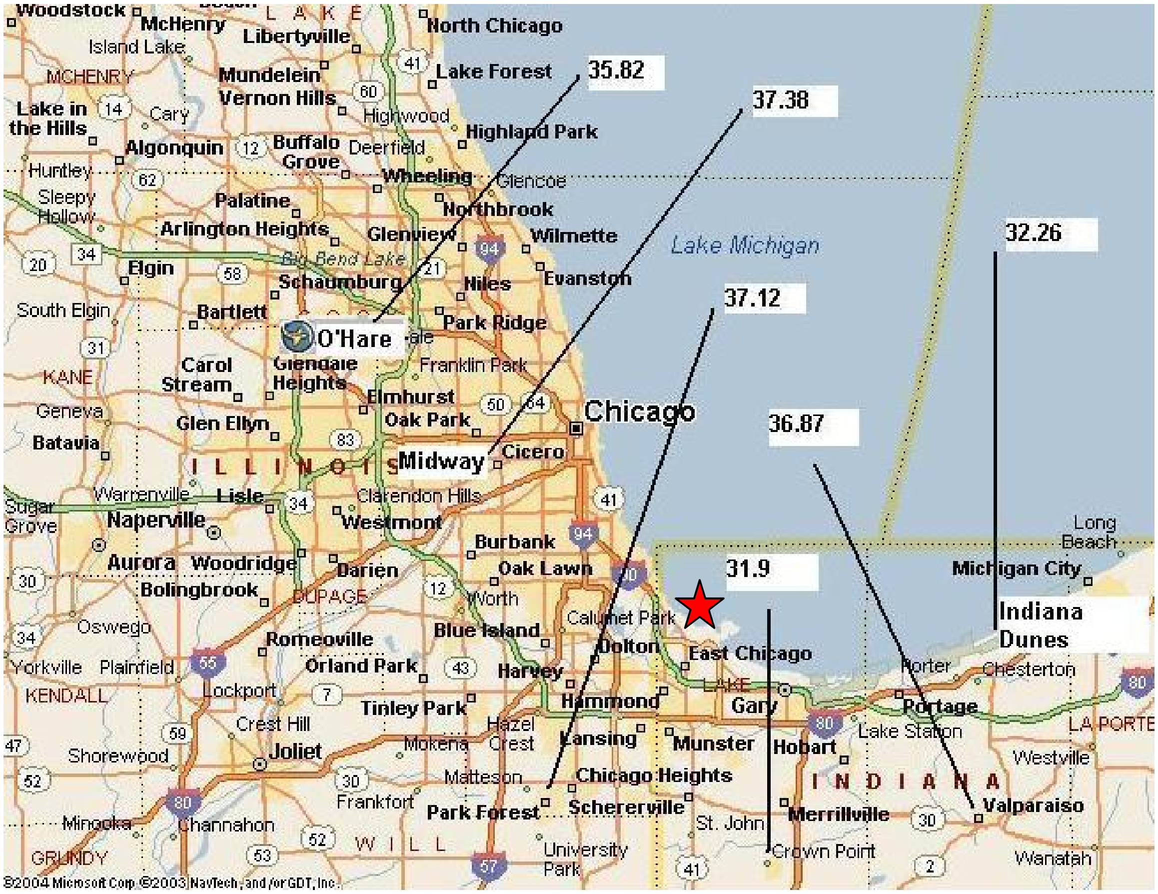

Figure 18. Average normal precipitation (inches) reported for regional weather stations

Of the sites with the highest annual precipitation values (Park Forrest and Midway), Park Forrest is closest to the proposed disposal site. For the same period of record, the difference in normal annual precipitation between O'Hare and Park Forrest is 1.30 inches. The difference between normal annual precipitation between the period of 1951-1980 and the period of 1971-2000 is 2.48 inches. The climate in the Northeast Illinois and Northwest Indiana has been getting wetter over the last 50 years (about 1.9 inches). Considering the difference in location and the period of record, the precipitation at the CDF site is expected to be about 3.5 inches greater annually than predicted using the original HELP model runs. In spring and early summer (April through June) Park Forrest receives about 1.5 inches more precipitation than O'Hare, and in July through August, about 0.5 inches less. In June, evaporation is roughly 1 inch greater at Park Forrest than at O'Hare. Evaporation values for the remainder of the year at the two locations are similar to each other. Evaporation roughly offsets the differences in precipitation for these two locations through the spring and summer months. Mean temperature differences between the HELP model (O'Hare during 1951-1980) and average normal values for O'Hare during 1971-2000, as compared to Park Forrest values during 1971-2000, were +0.125 and –0.05 degrees Fahrenheit, respectively.

Using the normal mean monthly precipitation values for Park Forrest (1971-2000), the HELP model was used to synthetically generate 100 years of daily precipitation values. The HELP model was then run to predict the average annual runoff and compared with the previous runoff predictions. The difference in the predicted average annual runoff was 4.075 inches, approximately equal to the 3.78 inches difference in normal annual precipitation between two HELP model runs. The 4.075 inches of runoff from the interior of the diked CDF area are equivalent to an increase of 12.1-12.5M gallons of wastewater to be treated annually over those reported based in the Indiana Harbor and Canal (IHC) Dredging and Disposal Alternatives Analysis report (Estes et al. 2003).

Climate Summary

Previous estimates of precipitation appear to underestimate precipitation that would be expected for the disposal site, based a re-evaluation of precipitation from several nearby weather stations. Actual runoff may be 12.1-12.5M gallons greater than initially estimated. Because flow-dependent predictions and cost estimates for Alternatives 1 and 2 from the DDAA were used for predictions and cost estimates for Options 1 and 2 in this study, the original precipitation estimates and flow rates from the DDAA were used in this study for Option 3 to maintain consistency in the predictions. Adjustments to flows reflecting the increased precipitation should be made in the design phase.

7 - Cost Estimates

Planning level cost estimates were prepared to provide an economic basis for comparison of the dredging and disposal alternatives. These cost estimates do not represent complete project construction cost estimates; rather, they are a comparison of major cost elements that reflect differences between the alternatives. The cost estimate for Option 1 was based on the cost estimate for Alternative 1 of the DDAA (Estes et al. 2003) and the cost estimate for the 300-gpm wastewater treatment plant of Option 3. The cost estimate for Option 2 was based on a modified wastewater treatment and pumping cost estimate for Alternative 2 of the DDAA and the cost estimate of Option 3 for construction and dredging. The cost estimate for Option 3 was newly developed to account for the differences in the wastewater treatment schedule and the use of a hydraulic offloader with recirculation. As in the DDAA, costs common to all alternatives/options, such as groundwater containment measures, railroad relocation, air, groundwater and surface water sampling and testing, and dike maintenance, among others, were not included. Capital and/or operating costs were estimated for the following items for which significant differences were anticipated between the options under consideration:

- Dike, liner and cap construction
- Dredging and placement
- Surface water pumping
- Wastewater treatment

As in the DDAA (Estes et al. 2003), cost estimates for some items were developed from lump sum and unit prices published in Appendix H of the DDR (USACE, Chicago 2000), which included indirect costs. All DDR cost estimates were adjusted to a March 2004 basis. For the cost estimates developed in 2003, indirect costs have been added to direct costs: 12% for overhead, 10% for profit, and 1% for bond. Next, contingency was applied to every item, ranging from 15 to 50%, with the majority falling within 15 to 25%. The level of design, cost of the individual component, and level of inherent risk associated with each item determine the contingency applied. This is more fully discussed in Appendix D of the DDAA. Costs were then converted to present value, taking into account the year in which expenditures will occur and the federal discount rate of 5.875%. Additional information regarding cost estimating for federal projects can be obtained from the Office of Management and Budget (OMB 2003).

Major Cost Items

Dike Construction

Dike construction is common to all three options, but differences in storage requirements dictate different dike heights for the three options, resulting in cost differentials between mechanical and hydraulic placement alternatives for a number of cost components. In the detailed cost breakdown, dike construction was separated into initial dike construction, dike raising, clay liner construction, and cap construction. Initial dike construction is phased over 2 years, during which time all dikes will be constructed to a specified initial height. Dikes will be raised to their final height after backlog dredging is completed, before maintenance dredging begins. Although a clay liner is required on the interior face of the exterior dikes for all alternatives, the clay liner construction included in the cost estimate reflects only the additional cost associated with the construction of the liner for the equalization basin. Differences in the liner cost for the dikes are included in the dike construction cost. (The DDR (USACE, Chicago 2000) specifies dike construction using a combination of off-site materials and materials stripped from the site.) As a simplifying assumption for the cost estimate, all clay dike construction was assumed. The validity of this assumption will be verified during the detailed design. Capping of all cells was assumed to occur approximately 2 years after the final year of dredging.

Dredging

Costs to dredge the total project volume, including the cost to mobilize/demobilize each year of dredging, were based on the production rate for a commonly available mechanical dredge. The cost of dredging included the cost of unloading the barges and placement of the dredged material in the CDF.

Surface Water Pumping

Pumping will be required to maintain the groundwater gradient, transfer effluent and precipitation from primary disposal cells to the equalization basin, and transfer water from the equalization basin to the WWTP and to the barge when recirculation is being employed. Groundwater pumping requirements are assumed to be the same for all options and are not included in this comparative analysis. Surface water pumping rates from the disposal cells will occur at different rates, depending upon the time of year and dredging activity. Pumping requirements will be highest during hydraulic placement and lowest during non-dredging periods. Table D2 in Appendix D summarizes the estimated pump capacity required to handle peak flows, average annual operating periods for these pumps, and capacity and operating periods for pumps required to handle average flows for non-dredging periods. Annual pumping rates and durations are the same as previously given in Table 10 to provide a uniform basis for cost estimating.

Separate sets of pumps were assumed to handle effluent produced during dredging and storm flows during non-dredging periods. During hydraulic offloading with recirculation, temporary transfer pumps will be utilized to transfer water from the equalization basin or the disposal cell to the barge. These pumps will be part of the contract of the dredging company and will be removed after dredging is completed each year. No effluent transfer pumps are required for the mechanical placement option. Standpipe/weir pumps will be permanently installed; they will operate during lower flow conditions of the non-dredging season, transferring storm and consolidation flows from the disposal cells to the equalization basin and from the equalization basin to the WWTP. All options will require standpipe/weir pumps; pump capacities will vary for the options due to differences in consolidation flows and WWTP capacity.

Wastewater Treatment

The cost estimate for the wastewater treatment plant was developed utilizing the design flows and contaminant concentrations presented in this report. Plant capacity was based on peak flows: 300 gpm for Options 1 and 3, and 2000 gpm for Option 2. Unlike Alternative 2 in the DDAA, Option 2 would employ a plant for 2000 gpm instead of 2700 gpm because the production rate of the mechanical dredge for Option 2 is lower than that the production of the hydraulic dredge of Alternative 2 of the DDAA. O&M costs were based on average seasonal flows. The treatment plant is assumed to be operated seasonally: 23 weeks in the summer and fall for Options 1 and 3, and 16 weeks in the summer and fall for Option 2. Capital costs included pumps, accessory tanks, and chemical feed systems for a complete system. Additional details on the costing are provided in a later section of this report.

Operation and Maintenance Costs

The operation and maintenance activities associated with pre-closure (through capping of the CDF) were presented in Appendix H of the DDR (USACE, Chicago 2000). As for the capital costs, O&M costs were only developed for activities considered to vary significantly between alternatives. O&M costs were developed for water treatment and standpipe/weir pumps, which replace the CDF surface water collection pumping presented in the DDR.

WWTP

Annual O&M costs for the wastewater treatment plant include:

- Labor
- Process chemicals
- Energy
- Building and equipment maintenance

Chemical costs were developed assuming typical dosages to estimate necessary quantities. Labor costs were assumed to vary seasonally, with less labor required during non-dredging periods in most cases. Additional discussion pertaining to the O&M cost basis for the WWTP is contained in Appendix D of the DDAA (Estes et al. 2003).

Pumping

The annual cost of operating, inspecting, maintaining and replacing the standpipe/weir pumps was included as an O&M cost. No O&M costs will be incurred for the transfer pumps, which will be part of the dredging contract and removed annually after dredging is completed each year.

Option 3 Wastewater Treatment Cost Estimate

This Capital and OM&M Cost Estimate presents the estimated capital costs and annual operations, process monitoring, and maintenance (OM&M) costs associated with implementation and operations of the hydraulic placement option with recirculation (Option 3) for the Indiana Harbor and Canal (IHC) Confined Disposal Facility (CDF) Wastewater Treatment Plant (WWTP).

Cost estimates presented herein are only intended for comparison with the cost estimates presented in the Final Treatment Technology Evaluation Report (FTTER)[1] for mechanical dredging and for hydraulic dredging to assist in alternative selection. These cost estimates are not intended for use in future program planning and budgeting, because USACE's Waterways Experiment Station (WES) have revised estimates of annual water volumes requiring treatment. Specifically, WES has revised its estimated annual average volume upward from 42 million gallons (used herein and in the FTTER) to 54 million gallons. Furthermore, none of these cost estimates include consideration of initial groundwater drawdown treatment requirements. Therefore, to provide estimates suitable for program planning and budgeting, new cost estimates will be needed for the larger facility that would be required to handle the increased volumes.

WWTP Conceptual Design

The conceptual design of any treatment system must be developed to a degree that allows for estimation of the quantities on which a cost estimate must be based. The mechanical dredging method using hydraulic placement with recirculation option is considered for the IHC CDF WWTP. Under this option, precipitation water held in an equalization basin would provide the make-up water for the hydraulic placement slurry operation. At the end of each dredge season the precipitation/recycle water, along with the dredge water, would be treated as the influent of the WWTP. The cost estimates were prepared for an annual average volume of 42 million gallons of dredge and precipitation

[1] Indiana Harbor and Canal CDF Waste Water Treatment, Final Treatment Technology Evaluation Report, May 2003. MWH, Warrenville, IL.

water, with treatment over a four-month period at the end of each dredge season, resulting in a peak flow of 300 gallons per minute (gpm).

The influent TOC and NH_3 concentrations were based on WES estimated concentrations in the equalization basin make-up water under equilibrium conditions[2]. The wastewater treatment plant consists of the following unit processes: inlet surge tank, chemical coagulation and precipitation, clarification, biological aeration, upflow biofilter, zeolite filter, granulated activated carbon filter, and effluent holding tank for recycle. The process flow diagram is presented in "IHC CDF Wastewater Treatment Hydraulic Placement Cost Estimate, Process Flow Diagram," dated April 26, 2004.

Process design criteria were selected for the major process units and preliminary sizing calculations were performed using the selected design flow and influent concentrations, as listed in Table 19. The values of the process design criteria were chosen as representative of standard industry practice based on published references and experience with other similar projects. The process option was developed to include necessary pumps, accessory tanks, and chemical feed systems for a complete system. Area requirements for each unit were estimated, and a tentative plant layout was prepared ("IHC CDF Wastewater Treatment, Hydraulic Placement Cost Estimate, General Arrangement Sketch," dated April 26, 2004).

Table 19. General Design Criteria for Flow from CDF to WWTP

BOD_5 /TOC Ratio	**BOD_5 /NH_3 Ratio**	**Nitrification F/M**	**CDF Discharge TSS (mg/L)**
1.8	2.7	0.2	80

Capital Costs

Capital cost estimates were prepared using the same approach, assumptions, and factors as were used for the mechanical dredging and hydraulic dredging alternatives in the FTTER.

Cost Estimate Basis. In order to develop the IHC CDF WWTP estimate, MWH drew from the most recent archives (within last 2 years) of previous estimates that shared common parameters. (Conceptual cost estimates have been developed by MWH for similar projects. A typical conceptual estimate ranges in accuracy basis, scope, and cost. At the conclusion of each conceptual estimate, the costs are evaluated and archived for use as a basis for future estimates that have like parameters.)

[2] Effluent Predictions and Flow for Treatment Design and Costing, Draft for Review, March 2, 2004. WES. The estimated concentrations were based on the assumption that the water would be recycled for two cells disposal. These results were confirmed in an attached document (Average number recycles single cell disposal years.doc) through email communication of MWH and USACE on March 17, 2004.

In addition to previous estimating data, MWH maintains a pricing database that is closely aligned with RS Means, Richardson's, and other industry pricing sources. MWH drew upon these resources to further develop the IHC CDF WWTP estimate.

Accuracy Basis. MWH has adopted the AACEI's accuracy classification system. The AACEI defines the IHC CDF WWTP estimate as a class 4 estimate (defined below).

> "Traditionally, Engineering is from 1 to 5% complete, and would comprise at a minimum the following: plant capacity, block schematics, indicated layout, process flow diagrams for main process systems, etc. Typical accuracy ranges for Class 4 estimates are from +/- 15 to 50% (sometimes higher), depending on the technological complexity of the project, appropriate reference information, and the inclusion of an appropriate contingency determination. Class 4 estimates virtually always use stochastic estimating methods such as equipment factors, Lang factors, Hand factors, Chilton factors, Peters-Timmerhaus factors, Guthrie factors, the Miller method, gross unit costs/ratios, and other parametric and modeling techniques. (Source: Cost Engineering Vol. 39/No. 4, April 1997)"

Subcontractors. For this estimate, MWH combined subcontractor's labor and material into a cohesive estimate. In other words, the subcontractor's resources to perform the job have been blended into the General Contractors resources and the costs have been presented in that fashion. Most General Contractors will not have the resources to self-perform this work and seek the following subcontractors:

- Electrical & Instrumentation Subcontractor
- Mechanical Piping Subcontractor
- Building Erector Subcontractor
- Asphalt Subcontractor

Depending on market conditions, some General Contractors may seek out other subcontractors such as earthwork and concrete subcontractors to name two. The subcontractor plan would depend on the staffing load, local labor market, and capabilities of the General Contractor.

Trade Labor Rates. MWH has prepared this estimate using Lake County, Indiana, prevailing wage rates for the trade labor associated with the project. The rates include the appropriate fringe benefits, taxes, and other applicable burdens for that labor.

Overall Pricing Sheet. All costs presented in the detailed portion of the estimate are "raw" costs. Those raw costs are then inserted into a pricing sheet that applies the necessary mark-ups. A further description of each of the mark-ups is included in the Pricing Summary Sheet included with the estimate. The Pricing Summary Sheet is included in a pdf file titled "IHC CDF WWTP Facility Estimates Submittal 42004.pdf."

Operation and Maintenance Costs

OM&M cost estimates also were prepared using the same approach, assumptions, and factors as were used for the mechanical dredging and hydraulic dredging alternatives in the FTTER. Average annual treatment volumes, operating duration, flow rate and TOC and ammonia concentrations, which were the basis for the O&M costs for Options 1, 2 and 3, are given in Table 20.

Table 20. Cost Estimating Criteria for O&M Costs for the WWTP

Option/ Period	Average In Situ Sediment Volume (cy)	Flow Volume (gallons)	Duration (days)	Flow Rate (gpm)	TOC (mg/L)	Ammonia (mg/L)
Option 1 (Mechanical Offloading) – 25 years plus 5 off-years; design flow of 300 gpm						
Summer Dredging Period	190,000	41,949,326	120	243	186	275
Option 2 (Mechanical/Hydraulic Offloading no Recycle)[a] - 25 years plus 5 off-years; design flow of 2000 gpm						
Summer Dredging Period	190,000	183,564,873	70	1814	104	172
Option 3 (Mechanical/Hydraulic Offloading with Recycle) - 25 years plus 5 off-years; design flow of 300 gpm						
Summer Dredging Period	190,000	41,949,326	120	243	184	503

[a] Design and operation is comparable to Alternative 2 (Hydraulic Dredging) which provides the basis for analysis of this option (Estes et al. 2003)

MWH developed the OM&M costs based on the conceptual treatment plant design discussed above. The estimate was summarized in a table titled "Evaluation of Treatment Alternatives, Operations and Maintenance Estimate with Parametric Capital Cost Estimate, Mechanical Dredging with Hydraulic Placement," dated April 26, 2004. The detailed calculations of the estimates were contained in an excel file titled "WWTP Operating Cost 42mgd.xls." The annual OM&M activities for the wastewater treatment plant include:

- Operating the plant
- Maintaining the plant
- Monitoring the unit processes

Annual OM&M costs were developed by first assuming typical dosages and calculating the projected chemical quantities and costs for process chemicals. The electrical costs for the major pumps and process equipment items were added. The third major cost element, operating labor, was estimated both on a process-by-process basis and by assuming a shift-based staffing program for the entire WWTP as a whole. Costs were added for maintenance parts and labor based on a parametric factoring of the equipment costs for each process. Monitoring costs were added by estimating the frequency and cost of sampling and analytical work for both process control and permit compliance verification. Finally, costs were added for equipment rental, process unit cleaning, and sludge disposal.

The annual OM&M costs were developed based on a total period of twenty-three weeks of operation per year, including four weeks of startup, seventeen weeks of treatment and discharge, and two weeks of shutdown. Costs associated with the remainder of the year, while the WWTP is idle, will consist primarily of brief periodic operator visits to check on facility status and heating for freeze protection; these costs are considered negligible.

Present Worth Analysis

Estimated costs for individual project components were converted to present value for comparison of the alternatives. The discount rate is established by the Office of Management and Budget for federal projects and is presently at 5 7/8%. The present value formula is:

$$PV = \frac{V_1}{(1+i)^1} + \frac{V_2}{(1+i)^2} + \frac{V_3}{(1+i)^3} + \ldots.. + \frac{V_n}{(1+i)^n}$$

where

i = federal discount rate, %
n = the period of consideration, years
V_i = costs incurred in year i, constant 2004 $

Table 21 summarizes the results of the present worth analysis. Option 3, Mechanical Dredging with Hydraulic Offloading and Recirculation, is the least cost option with a present value of $75,741,000 with contingency. Option 1 is the next least cost option with a present value of $77,451,000, and Option 2 is the highest cost option with a present value of $88,230,000.

Table 21. Present Value Comparison with Contingency [1]			
Parameter	**Option 1: Mechanical with Mechanical Offloading (000s of dollars)**	**Option 2: Mechanical with Hydraulic Offloading (000s of dollars)**	**Option 3: Mechanical with Hydraulic Offloading and Recirculation (000s of dollars)**
Construction and Dredging Activities			
Year 1, cell construction	$6,011	$9,103	$9,103
Year 2, cell construction [2]	$4,094	$6,215	$6,215
Clay liner for equalization basin	$904	$904	$904
Standpipes/weirs	$220	$220	$220
Pumps in standpipes	$56	$89	$89
Raise dike heights	$6,760	$5,717	$5,717
Wastewater treatment plant (WWTP)	$4,283	$11,392	$4,283
Dredging (including placement in CDF)	$41,890	$29,923	$29,923
Pumps during dredging		$5,371	$5,371
Cap	$2,642	$2,642	$2,642
Total Construction and Dredging Activities	$**66,860**	$**71,576**	$**64,466**
Operations and Maintenance Activities			
O&M of WWTP	$10,458	$16,380	$10,946
O&M for pumps in standpipes	$132	$274	$329
Total Operations and Maintenance Activities	**$10,591**	$**16,654**	$**11,274**
Comparison Total (000s)	**$77,451**	$**88,230**	$**75,741**

[1] A contingency, ranging from 15 to 50% with the majority within the 15 to 25% range, was applied at each item level. The contingency assignment was based on the level of design detail, inherent risk associated with each item and the anticipated cost growth due to factors not yet identified at this time.
[2] Final dike crest width is assumed to be 20 ft for hydraulic offloading options.

Costs Summary

The least costly placement option is hydraulic offloading with recirculation of CDF water from runoff, consolidation and dewatering. This option is about 2% less costly than mechanical dredging and placement and about 15% less costly than hydraulic placement without recirculation.

8 – Summary

This report provides a comparison of three placement options for mechanically dredged material based on cost and contaminant losses by volatilization and fugitive dust emissions. An option of storing contaminated groundwater in the equalization basin for treatment was also examined for impacts on volatile losses. Additionally, a review of the climatic data used in the DDAA was conducted to verify its appropriateness for the Indiana Harbor CDF.

The cost estimates from the DDAA were updated in time and operating assumptions for the cost comparisons presented in this report. Unlike the operating conditions used in the DDAA, treatment is assumed to operate seasonally during and/or immediately following the disposal project for all three placement options, saving about 6% of the cost. The least costly placement option is hydraulic offloading with recirculation of CDF water from runoff, consolidation and dewatering. This option is about 2% less costly than mechanical dredging and placement and about 15% less costly than hydraulic placement without recirculation.

The volatile losses are lowest for the mechanical placement option and greatest for the hydraulic placement option with recirculation. Hydraulic placement increases total volatiles losses by about 11% without recirculation and about 12% with recirculation. The losses are primarily from losses of naphthalene, methylene chloride, and acenaphthene, which account for about 95% of the volatile emissions. Storing contaminated groundwater in the equalization basin between treatment seasons would increase the volatile losses from the CDF by about 0.44%. If emission controls are needed as determined from an air risk analysis or a predicted exceedance of an emission criterion, control measures that control the losses from the exposed sediment should be selected because emissions from exposed dredged material comprise 84 to 95% of the emissions. Certain control measures could reduce losses from all emission locales.

Particulate emissions (losses of fugitive dust) for the various alternatives will be a function of the area present in an exposed, unvegetated, dried condition. The areas in ponded, wet drained, and dry drained conditions for the three placement alternatives are virtually identical. For the hydraulic placement options, one 30-acre cell will be in a wet drained condition about two extra months per year as compared to the mechanical placement option. These two months will reduce conditions conducive to fugitive dust creation by about 6%, 960 acre-months for mechanical placement versus 900 acre-months for hydraulic placement.

Estimated runoff for the East Chicago disposal site reported in the Indiana Harbor and Canal (IHC) Dredging and Disposal Alternatives Analysis (Estes et al. 2003) were based on synthetically generated precipitation values obtained using the HELP model (Schroeder at al. 1994) with O'Hare climatic properties and normal mean monthly precipitation values stored in the HELP model for 1951-1980. These data were compared with more recent (1971-2000) normal mean monthly precipitation values for areas closer to the disposal site. For the same period of record, the difference in normal annual precipitation between O'Hare and Park Forrest is 1.30 inches. The difference between normal annual precipitation between the period of 1951-1980 and the period of 1971-2000 is 2.48 inches. The climate in the Northeast Illinois and Northwest Indiana has been getting wetter over the last 50 years (about 1.9 inches in annual precipitation). Considering the difference in location and the period of record, the precipitation at the CDF site is expected to be about 3.5 inches greater annually than predicted using the original HELP model runs.

The HELP model was run to predict the new average annual runoff for comparison with the previous runoff predictions. The new predicted average annual runoff was 4.075 inches greater. This increase in runoff from the interior of the diked CDF area is equivalent to an increase of 12.1-12.5M gallons of wastewater to be treated annually over those reported based in the Indiana Harbor and Canal (IHC) Dredging and Disposal Alternatives Analysis report (Estes et al. 2003). This corresponds to a 30% increase in average annual runoff, from 42 million gallons to 54 million gallons.

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