DEPARTMENT OF THE ARMY
CHICAGO DISTRICT, U.S. ARMY CORPS OF ENGINEERS
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CHICAGO IL 60606-7206

REPLY TO
ATTENTION OF

JAN 0 9 2009

CELRC-DE

MEMORANDUM FOR RECORD

SUBJECT: NEPA Coordination for the Indiana Harbor and Canal Confined Disposal Facility

1. INTRODUCTION

This MFR documents the rationale and decision not to supplement the January 1999 Environmental Impact Statement (EIS) on the Indiana Harbor and Canal Confined Disposal Facility.

2. BACKGROUND

An EIS entitled *The Indiana Harbor and Canal maintenance Dredging and Disposal Activities, Comprehensive Management Plan, January 1999* was prepared and distributed to Federal and State agencies and the public for comment. After careful consideration of the review comments the Director of Civil Works signed a record of decision (ROD) on February 2, 1999, with the statement that the proposed Confined Disposal Facility (CDF) would not have significant, long-term, or cumulative adverse environmental impacts. The ROD summarized the dredging and disposal plan as well as the basic CDF layout and construction.

3. IMPACTS

a. At the time of the EIS, the general CDF operation plan included dewatering the dredged sediment as quickly as possible to ensure maximum storage capacity within the CDF. To facilitate dewatering, decant structures and an equalization basin for holding water temporarily prior to treatment would be needed. The emissions from the dredged material were estimated based on initial laboratory flux studies conducted by the USACE Waterways Experiment Station. The CDF was subsequently given a "registered" status by the Indiana Department of Environmental Management, which limits the facility emissions to 25 tons per year particulates and 25 tons per year volatile compounds.

b. Subsequent research on volatile and particulate emissions from dredged sediment has greatly increased the understanding of the dynamics of volatile compound mass transfer, as well as the physics of particulate movement. This research is documented in the following reports:

   i. Hagen, L.J. 2005. Estimates of Particulate Emissions by Wind Erosion from the Indiana Harbor CDF. Wind Erosion Research Unit, U.S. Department of Agriculture, Agricultural Research Service (ARS), Grain Marketing and Production Research Center (GMPRC), Manhattan, KS.

ii. Thibodeaux, L.J., K.T. Valsaraj, R. Ravikrishna, K. Fountain, C. Price, "Investigations on the Controlling Factors for Air Emissions Associated with Dredging of the Indiana Harbor Canal and CDF Operations" Report (ERDC/EL TR-08-17), U.S. Army Engineer Research and Development Center, Vicksburg, MS, 2008.

iii. Schroeder, Paul R., 2007, Memorandum for Ms. Le Thai, CELRC-TS-DH, Subject: Prediction of Volatile Losses from Ponded Indiana Harbor CDF, prepared under DOTS request, December 5, 2007.

c. Based on the updated emissions estimates provided by the above research and modeling, it is apparent that without particulate controls at the dewatered CDF, particulate emissions will likely exceed the 25 ton per year limit. One possible control method is to maintain a ponded CDF, so that the sediment surface does not dry out, and particulate emissions are essentially zero. Modeling indicates that keeping a ponded facility also decreases the volatile emissions from the CDF, which is beneficial to the environment in this Clean Air Act non-attainment area.

d. Because of the lowered emissions, it has been determined that the IHC CDF would be best operated as a ponded facility. The attached memorandum documents the design and operation changes, as well as the impacts of these changes. Multiple beneficial impacts, in addition to lowered emission rates, will be realized.

4. PERTINENT GUIDANCE

The regulations for implementing the procedural provisions of NEPA (40 CFR Parts 1500-1508) provide guidance for supplementing environmental impact statements (EIS). Pertinent language from 40 CFR § 1502.9(c) follows.

"... Agencies:
(1) Shall prepare supplements to either draft or final environmental impact statements if:
- *(i) The agency makes substantial changes in the proposed action that are relevant to environmental concerns; or*
- *(ii) There are significant new circumstances or information relevant to environmental concerns and bearing on the proposed action or its impacts..."*

Because the ponded CDF operation will not result in any additional significant adverse impacts to the environment, it is not a substantial change relevant to environmental concerns nor are there significant new circumstances or information relevant to environmental concerns that bear on the proposed action or its impacts. See Marsh v. Oregon Natural Resources Council, 490 U.S. 360, 374 (1989) (the new information must "'affect the quality of the human environment' in a significant manner or to a significant extent not already considered" before a supplemental EIS must be prepared).

DECISION

I have determined that the impacts of the ponded operation of the IHC CDF as described in the attached memorandum do not constitute significant changes in the type or magnitude of the impacts from the original proposed operation of the CDF. The proposed ponded operation of the CDF, as documented in the attached memorandum, is a sufficient description of the rationale and implications of the change in design and operation of the facility. A supplement to the 1999 EIS is not necessary and will not be prepared.

Vincent V. Quarles
Colonel, U.S. Army
District Engineer

CELRC-TS-DH 13 November 2008

MEMORANDUM FOR RECORD, THRU

TS-DC
TS-DG
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SUBJECT: Decision Document on Operating the IHC CDF as a Ponded Facility

SUMMARY OF DECISION

The Indiana Harbor and Canal Confined Disposal Facility should operate as a two cell ponded facility, without complete dewatering of the dredged material between dredging seasons. The facility will have two cells separated by a center dike. This change will result in construction and operating cost savings, will simplify the CDF operation, and will greatly reduce particulate and volatile emissions. The proposed handling of the TSCA regulated sediment will not be affected by this change.

DISCUSSION

1. The Indiana Harbor and Canal Confined Disposal Facility (IHC CDF) currently operates under an air registration status issued by the Indiana Department of Environmental Management (IDEM). The air registration limits the volatile emissions from the CDF to a total of 25 tons per year, with a limit of 10 tons per year for any individual hazardous air pollutant. Particulate emissions are also limited to a total of 25 tons per year.

2. Over the last several years, various research and modeling projects have been conducted by researches at several agencies to address the question of what would be emitted from the CDF, and under what conditions. Research results are included in the following reports:

   a. Hagen, L.J. 2005. Estimates of Particulate Emissions by Wind Erosion from the Indiana Harbor CDF. Wind Erosion Research Unit, U.S. Department of Agriculture, Agricultural Research Service (ARS), Grain Marketing and Production Research Center (GMPRC), Manhattan, KS.

   b. Thibodeaux, L.J., K.T. Valsaraj, R. Ravikrishna, K. Fountain, C. Price, "Investigations on the Controlling Factors for Air Emissions Associated with Dredging of the Indiana Harbor Canal and CDF Operations" Report (ERDC/EL TR-08-17), U.S. Army Engineer Research and Development Center, Vicksburg, MS, 2008.

   c. Schroeder, Paul R., 2007, Memorandum for Ms. Le Thai, CELRC-TS-DH, Subject: Prediction of Volatile Losses from Ponded Indiana Harbor CDF, prepared under DOTS request, December 5, 2007.

d. United Stated Environmental Protection Agency (USEPA), 2006, "Supplemental Risk Assessment of Potential Air Emissions from the Confined Disposal Facility for the Indiana Harbor and Shipping Canal Sediment Dredging and Disposal Project," Prepared by Region V, December 2006.

3. Based on the information provided by research and modeling, it appears that the CDF will exceed the 25 tons per year limit for particulate emissions unless controls are used. Although a number of controls of various types are options, only one control method addresses both volatile and particulate emissions: keeping the CDF entirely ponded. The purpose of this memorandum is to document the decision to operate the CDF as a two cell ponded facility, to minimize both particulate and volatile emissions.

4. The decision to operate the CDF as a ponded facility raised a number of other design and operational questions. These questions include:

   Would we need an equalization basin?
   Would we need two storage cells?
   What impacts would it have on operations?
   Water availability?
   Volume of sediment that could be slurried with recirculated water?
   Treatment volume?
   Water quality for treatment?
   Dredged material distribution?
      Sand recovery for raising interior dike?
      Effects on decant structures?
      Need for wildlife control?
      Need for mosquito control?
   What are the impacts on storage needs?
   What are the impacts on dike height requirements?

These questions are addressed individually, below.

5. Need for an Equalization Basin: No need for an equalization basin in a ponded CDF operation could be envisioned. The only potential impact was on the synchronization of the initial groundwater drawdown and groundwater treatment, which can be addressed in other manners and will be documented elsewhere. The potential benefits of eliminating the equalization basin is the increased area and volume for storage (which would be needed due to greater storage needs if the dredged material remains ponded), reduced costs for dike construction, elimination of the costs for an additional decant structure and associated pumps and operations, elimination of the costs to line the equalization basin, reduced pumping and operational costs for runoff pumping, reduced operational costs for trenching (dewatering), and reduced volatile losses from open groundwater storage during initial drawdown.

6. The reduction in volatile losses will depend on how the drawdown is accomplished. If the groundwater is stored in an enclosed container or if groundwater is pumped directly to a treatment facility with no storage in open tanks or ponds, then the reduction in volatile losses

from open groundwater storage would be realized. If an open tank of some type is still used to hold the water temporarily, then volatile losses from open groundwater storage will remain the same.

7. Need for Two Storage Cells: Two storage cells are still needed for efficient CDF operation under the ponded scenario. Having two separate cells allows flexibility to deal with future dredging scenarios, including the potential to dry out the material in future years. A strong potential exists that future dredge materials (15-20+ years out) from the IHC will be significantly less contaminated than those that will be dredged during the backlog and early maintenance periods. Analysis of the ponded scenario indicates that future desiccation of a cell will "buy back" a significant amount of the potentially lost storage volume. Hence, when the material is cleaner, one cell can be dried out to increase consolidation, while also planning for particulate management. In order to dry out one cell, a second cell in which to place the dredge water and precipitation would be needed, since there would no longer be an equalization basin.

8. Additionally, the flexibility of having two cells is an advantage for potential maintenance issues. Although failures are not considered likely, it is prudent to be prepared for contingencies. If, for example, there are future dike erosion problems, dike seepage, etc, the availability of a second cell in which to place the majority (or all) of the pond will help enhance the safety of the design, and ease of perimeter dike maintenance.

9. Splitting the CDF into two cells also increases the ease of managing the sediments within the facility. In the ponded scenario, one alternative is that the dredge pipe outlet would originate from the center dike, directed either east or west, allowing for an initial flow of material perpendicular to the grade of the site. Periodically moving the dredge pipe outlet south along the center dike will ease the management of the larger-sized sediments (i.e. sands) because the sediment mound found at the outlet of the pipe would be kept closer to the center dike. Subsequent use of a long-arm excavator to reach out and pile up the sediments onto the center dike will enhance operations because it will 1) reduce the amount of mounding, 2) reduce the amount of water necessary to keep a pond, 3) and provide beneficial use of the sediments to continually raise the center dike. Additionally, the maximum difference in height of equipment used to manage the sediments from the surface of the sediment will be about 10 feet (for the first lift) from the center dike, as opposed to a reach of 18 ft from the top of the existing perimeter dike. This will allow a longer reach into the CDF, without actually having to traverse the dredged materials. In order to construct the center dike in this manner, it is proposed to have the center dike initially wider at the base, as shown in Attachment 4.

10. Finally, the ability to segregate materials placed into the CDF may provide regulatory benefits. Designating one cell as a "TSCA" cell is a similar tactic to what US Steel used for the construction of their CAMU, and could help gain regulatory acceptance of the TSCA material management. The management of TSCA regulated sediment will be discussed in a separate decision memo, and will be consistent with the summary presented in Attachment 5.

11. In summary, two cells provide flexibility, permit future drying operations to increase storage capacity or material recovery for raising the interior dikes, provide a backup decant and pumping structure, and allow for drawdown of ponded water (transfer to the other cell) in the event of a structural or seepage problem. The use of an interior dike also will allow one or both cells to be dewatered at some time in the future, if sediment quality improves and air emissions are low or can be controlled. Dewatering the CDF completely in the future would be beneficial since the sediment would consolidate and additional capacity would be regained (see storage calculations in Attachment 2).

12. Impacts on Operations and Design, Water Availability: Due to the elimination of the equalization basin and depending on how drawdown is accomplished, limited water may be available from the groundwater drawdown for slurrying the first lift of dredged material for each cell. If needed, water would be drawn from the canal for slurrying, which would increase the overall volume of water that would require treatment. Ponded conditions will also affect the total evaporation from the CDF. Based on historical measurements of pan evaporation (provided in the EM on Confined Disposal of Dredged Material), increased evaporation is expected to reduce the normal net accumulation of precipitation (less evaporation and seepage) onto the dredged material and inner face of the dikes from the previous prediction of 55 million gallons per year to about 28 million gallons per year without an equalization basin.

13. Sediment Volume Dredged with Recirculated Water: 28 million gallons per year is sufficient to slurry 130,000 cy of sediment with recirculation. In addition to precipitation, 25 million gallons of water will be available from the expulsion of pore water from the previously placed dredged material, sufficient for an additional 170,000 cy of sediment with recirculation (more than proportional additional sediment volume can be slurried for an additional volume of water because the dredged material settles more during larger disposal projects, releasing additional water to be used from the dredged material being placed). Additional water will be available from the groundwater pumping; its volume will be a function of the seepage through the slurry wall. Therefore, sufficient water should be available most years without drawing additional water from the canal after the initial two lifts are placed in the CDF. Disposal of more than 300,000 cy of sediment per year in the short term could require supplemental water from the canal and increase the total volume of water to be treated.

14. Water Treatment Volume: In the short term under normal conditions for 200,000 cy lifts, the volume of water to be treated is about 13 million gallons per year. Likewise, in the short term under normal conditions for 230,000 cy lifts, the volume of water to be treated is about 12 million gallons per year. In the short term, water will be going into storage or bulking within the sediment, so that the larger dredge volume results in larger bulking losses and thus less volume to be treated. Over the long term, additional consolidation of earlier lifts will occur, yielding on average an additional 17 million gallons per year of water to be treated. As such, the treatment volume is expected to be about 30 million gallons per year plus the volume of seepage through the slurry wall, representing a decrease of about 25 million gallons per year due to the increased evaporation from maintaining a permanent pond.

15. Water Quality: The water quality for treatment is expected to change due to the holding time in the CDF before treatment is conducted. It is anticipated that the holding will cause differences in the concentrations of volatile constituents, ammonia, and BOD/TOC; little to no change is expected in the dissolved concentrations of metals. These changes can be estimated from the volatilization predictions and previous treatability testing results. The concentration of the dominant volatile components would be very near zero, the concentration of ammonia would be reduced by more than 90% and would be expected to be less than 10 mg/L, and the BOD/TOC would be reduced by more than 80% and would be expected to be less than 15 mg/L, providing that oil is skimmed/absorbed in the CDF. The impact of the change in water quality on wastewater treatment will be the subject of a separate decision memo.

16. Dredged Material Distribution: To facilitate ponding with a practical minimal ponded depth of 2 ft, attention must be provided to the uniform distribution of fine-grained dredged material in the CDF cells. The dredged material should be pumped into the CDF at multiple points throughout the length of the CDF at a spacing of about 600 ft to limit differences in the dredged material height to about 1 ft along the length of the cells.

17. Sand Recovery for Raising Interior Dike: To facilitate sand recovery, the dredged material discharge into the CDF should be along the interior dike. Discharging at the water surface, as opposed to using a submerged discharge, would facilitate sand mounding and recovery. Surface discharge would increase the local release of volatiles at the point of discharge, but would not measurably increase the volatile losses from the facility.

18. Decant Structures: The design of the decant structures would be unchanged by the maintenance of a ponded CDF or the elimination of the equalization basin. One less decant structure would be needed if the equalization basin is eliminated from the design. The decant structures should be located in the corners closest to the canal and treatment facility.

19. Wildlife Control: Wildlife control will change somewhat if the CDF is kept ponded; wildlife will be restricted primarily to waterfowl, including migratory species. The need for control should be limited if the pond is maintained and the formation of exposed mud flats are avoided. The wildlife exclusion plan for the project will need to take the ponded operation into account; the wildlife exclusion plan is under development by US Fish and Wildlife.

20. Mosquito Control: Mosquito control should be investigated since the facility will remain ponded year round. The need for mosquito control is mitigated by the size and openness of the CDF that will limit stagnation.

21. Impacts on Storage Needs and Dike Height: Dr. Paul Schroeder, ERDC, calculated the storage needs and dike heights for various scenarios. The complete calculations are given in Attachment 2. Operating the CDF under a ponded scenario, the final height of the dredged material would be approximately 20.2', verses a height of 20.5' for a more conventional dewatered operation. This reduction in dredged material height is mainly due to the elimination of the equalization basin in the ponded scenario. With a dewatered operation, the equalization basin is still needed, and storage space is lost. However, a ponded operation

does require a greater dike height, to allow for freeboard and precipitation storage. The dike height difference is 26.7' for ponded operation verses 24.5' for the dewatered scenario. The interior dikes would need to be raised sooner for ponded operation than for dewatered operation.

22. Considering all the impacts, including changes to the design and operation of the CDF, a number of conclusions can be drawn regarding the ponded operation. The pros and cons of switching to a ponded operation are given below.

Pros	**Cons**
Allow elimination of the equalization basin which will maximize the available sediment storage area.	Need to redesign "Dikes III" plans and specifications.
Cost less to construct the remaining dike facilities, due to a simpler layout, one less decant structure, and one less pump. A separate dike and liner construction will not be needed for the equalization basin since there will not be an equalization basin.	Regulatory acceptance of the ponded CDF idea is unknown, particularly with respect to the handling of the TSCA regulated sediment. This is more of an unknown issue than a negative, since other aspects of the TSCA sediment handling are also undetermined at this time. Regulatory coordination is needed regardless of whether the CDF is operated ponded or drained. A separate decision document addressing the TSCA regulated sediment handling will be prepared.
Improve the water quality going to the treatment plant, notably by reducing the ammonia and degradable organic matter. Better water quality has impacts on the water treatment plant design and operation, with possible savings (this topic requires more in depth investigation.)	Wastewater Treatment Plant design needs to be re-evaluated and possibly redone. This will be a separate decision memo.
Reduce volatile emissions by about 50%	Interior dikes will need to be raised sooner, and possibly also the exterior dikes.
Eliminate particulate emissions completely except for potential sand mounds around discharge points, and thus reduce operation/maintenance costs because no particulate controls will be needed.	
Reduce volume of water to treat by about 40% because additional evaporation will occur (the ponded water will be held in a shallow, comparatively large surface area basin and more evaporation will occur). The reduction in water volume translates to a reduction in treatment costs.	

Pros	Cons
Reduce pumping and water management for the CDF, since stormwater will simply remain in the cell. No dewatering will be needed. No trenching will be needed to encourage water run-off. No run-off transfer will be needed. This translates to fewer operations activities, and a simpler CDF operation.	

23. Operating the CDF as a ponded facility will change in storage and dike height requirements. About 2 ft increase in dike height is required to accommodate the depth of ponding between disposal and storage of excess precipitation water. This will require the interior dikes to be raised sooner. However, operating the CDF in a ponded manner may facilitate the dike construction. The discharge piping for the sediment can be laid along the interior dike, with multiple discharge points to distribute the sediment in a fairly even layer. Sand will tend to settle out first, and will tend to be piled along the interior dike. This makes sand retrieval for dike construction easier. The placement of slurried sediment into the CDF will be a separate decision memo topic.

24. The cost savings were estimated for the ponded CDF operation. Cost savings are assumed to come from two basic changes: the dikes and equalization basin layout will be changed (the equalization basin will be eliminated), and the amount of water to be treated will be less. Cost impacts on operation and maintenance of the CDF (for example, for dewatering sediment and for particulate control) were not estimated. Only the two main costs described above were estimated.

25. Attachment 3 contains the estimated cost savings for the wastewater treatment plan. The costs were estimated based on the Indiana Harbor and Canal Wastewater Treatment Plant Final Design. The operating costs were prorated based on a treatment volume of 30 Mgal instead of 55 Mgal. The treatment season (4 months) and unit processes were assumed to be the same. Labor was assumed to be a fixed cost since a minimum level of staff would be on-site regardless of the treatment volume. The prorating was mainly on materials, supplies, and utilities. Based on this estimate, changing from a dewatered to a ponded CDF operation will result in an estimate annual wastewater treatment plant operating cost savings of $142,894. This represents approximately 17% reduction in treatment costs. Additional savings may also be realized, because the ponded CDF will have somewhat improved water quality as well as less water. The impact of the ponded CDF operation on the wastewater treatment needs is being addressed in a separate decision memo.

26. Operating the CDF as a ponded facility would allow the equalization basin and one decant structure to be eliminated from the design. In addition, the clay dikes, including the center dike, would be realigned somewhat. Attachment 4 contains the calculations for the construction cost savings for the equalization basin elimination and the dike realignment. The costs were estimated based on the government estimate for the 100% "Dikes III" design, completed in November 2007. Costs were not adjusted for inflation for this calculation.

Based on the November 2007 design and costs, the proposed changes in dikes and the elimination of the equalization basin would result in a construction cost savings of approximately $4.15 M.

27. In summary, the conservatively estimated cost savings for operating the CDF as a ponded facility would be over $4 M in construction costs, with an annual operating cost savings of approximately $140,000. It is likely that other cost savings would also be realized, due to lower operating and maintenance costs of the facility (no particulate control, for example). A separate decision document will investigate whether additional wastewater treatment plant savings could be realized also, since the quality of the water to be treated in a ponded scenario will also be better.

28. Considering all issues, it is our decision that the Indiana Harbor and Canal Confined Disposal Facility should be operated in a two cell, ponded manner. The benefits of this change will be positive for the adjacent community (lower emissions of all types), for the government (lower capital and operating costs), and for the CDF operator (less dewatering, no material trenching, simplified CDF operation).

Recommended by:

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Attachment 1

IHC CDF VOLATILE EMISSION MODELING (November 21, 2008)

Selection of Chemicals of Concern for Volatile Emissions Modeling

The first step in the volatile emissions modeling was to identify the chemicals of concern. The chemicals of concern were selected based on potential for volatilization and relative toxicity. Chemical concentration in IHC sediment was also taken into consideration in the selection of COCs. The potential for volatilization was determined by low octanol-water coefficients (Kow) and high Henry's law constants (H) relative to other chemicals in IHC sediment. Relative toxicity was determined by multiplying the chemical concentration in sediment with the cancer slope factor (normalized to Benzo(a)pyrene).

The list of COCs is presented on Table 1. The basis for COC selection is presented next to each COC.

Attachment 1

Table 1. Chemicals of Concern

Chemical	Criteria for selection (see Notes)	Sediment Conc., waD (mg/kg)	Henry's Const., H dimensionless	Kow (mg/kg)	Slope Factor (mg/kg-day)$^{-1}$	Slope Factor Normalized to BaP dimensionless	Normalized Slope Factor * Sediment Conc. (mg/kg)
PAHs							
Acenaphthene	Low Kow	21.7	0.0066	8318	NA	NA	NA
Acenaphthylene	Low Kow	27	0.0049	10000	NA	NA	NA
Anthracene	Low Kow	26	0.0018	31623	NA	NA	NA
Benzo(a)anthracene	Relative Toxicity	39.6	0.0002	501187	3.9E-01	0.1	4.0
Benzo(b)fluoranthene	Relative Toxicity	39.6	0.0000822	1584893	3.9E-01	0.1	4.0
Benzo(k)fluoranthene	Relative Toxicity	12.8	0.0000822	1584893	3.9E-01	0.1	1.3
Benzo(a)pyrene	Relative Toxicity	26.6	0.000085	1096478	3.9E+00	1	26.6
Benzo(ghi)perylene		11.2	0.0000582	3162278	NA	NA	NA
Chrysene	Relative Toxicity, High Sediment Conc.	62.1	0.0003	501187	3.9E-02	0.01	0.62
Dibenzo(a,h)anthracene	Relative Toxicity	11.8	0.0000219	5011872	4.1E+00	1.05	12.4
Fluoranthene	High Sediment Concentration	69.8	0.00075	165959	NA	NA	NA
Fluorene	Low Kow	36.9	0.0026	15849	NA	NA	NA
Indeno(1,2,3-c,d)pyrene	Relative Toxicity, High Sediment Conc.	53.9	0.0000654	4466836	3.9E-01	0.1	5.4
Naphthalene	Low Kow, Relative Toxicity, High Sediment Conc.	478.4	0.011	2188	1.2E-01	0.031	14.7
Phenanthrene	Low Kow, High Sediment Conc.	192.4	0.0029	28840	NA	NA	NA
Pyrene	High Sediment Concentration	91	0.00092	125893	NA	NA	NA
BTEX							
Benzene	Low Kow, High H	3.09	0.224	135	1.0E-01	0.026	0.079
Ethylbenzene	Low Kow, High H	0.739	0.316	1413	NA	NA	NA
Toluene	Low Kow, High H	4.94	0.251	537	NA	NA	NA
Xylenes, Total	Low Kow, High H	0.782	0.275	1318	NA	NA	NA
PCBs							
PCB(Aroclor-1248)	Relative Toxicity	10.98	0.009	575440	2.0E+00	0.51	5.6
PCB Total	Relative Toxicity	35.6	0.0090	1096478	2.0E+00	0.51	18.3
Other Organic Compounds							
Dibenzofuran	Low Kow	8.7	0.0043	20417	NA	NA	NA
Vinyl Chloride	Low Kow, High H, High Relative Toxicity	2.9	1.1	24	2.7E-01	0.07	0.2

NOTES

Low Kow <50,000 mg/kg
High H >0.1
High Bulk Sediment Concentration >50 mg/kg
High Relative Toxicity, Slope Factor Normalized to BaP x Sed Conc > 0.1
Unit Risks and Slope Factors from "Air Toxics Hot Spots Program Risk Assessment Guidelines - Part II, Technical Support Document for Describing Available Cancer Potency Factors", California Environmental Protection Agency, Office of Environmental Health Hazard Assessment, Air Toxicology and Epidemiology Section, May 2005.

Attachment 1

Volatile Emissions Modeling

The chemical emissions from dredging operations at IHC are comprised of the following primary source "locales": the dredging operable unit (DOU), the barges transporting the dredged material from the dredging area to the CDF, the disposal point, and the final disposal CDF site. Volatile emissions modeling to estimate emissions from these source "locales" are discussed below.

Dredge Operations Emission Modeling

The Dredging Operable Unit Emission model developed by LSU was used to estimate volatile emissions flux rates during dredging. A discussion of the model development as well as a detailed description of the model can be found in the "Investigations on the Controlling Factors for Air Emissions Associated with Dredging of the Indiana Harbor Canal and CDF Operations" report (ERDC/EL TR-08-17), L.J. Thibodeaux, K.T. Valsaraj, R. Ravikrishna, K. Fountain, C. Price, U.S. Army Engineer Research and Development Center, Vicksburg, MS, 2008.

The DOU Emission model calculates emissions from three types of dredging areas: two with flowing rivers or streams and one in non-flowing waters such as an embayment, lake or harbor. The two types of dredging areas in flowing rivers/streams are: a dredging area enclosed within a silt curtain or other semi-permeable membrane device, and dredging area without enclosure.

Input to the DOU Emission model can be grouped into five main categories: 1) sediment properties such as sediment chemical concentration, 2) dredging operational parameters such as dredging rate and resuspension factor, 3) dredging area characteristics such as flow rate through the DOU, 4) external characteristics such as wind speed and chemical concentration in air above the CDF, and 5) chemical parameters such as Henry's Law Constant, sediment to water partitioning coefficient, and solubility of the chemical in water.

Sediment concentration and chemical parameters such as Henry's Law Constant, sediment to water partitioning coefficient, and other characteristics used in all emission modeling for the COCs are presented in Table 2. Chemical concentrations in the sediment used in the modeling were averages from the USEPA sediment sampling conducted at IHC in 1992-1993. For chemicals that were not analyzed in the 1992-1993 USEPA sediment sampling, average concentrations from the entire USEPA database (which includes data from sediment sampling conducted from 1977 to 1996) were used.

Henry's law constants and sediment to water partitioning coefficients were measured for some PAHs and PCBs in experiments using IHC sediments (Chapter 1 of ERDC/EL TR-08-17). The report also presented Henry's constants (H) and partitioning coefficients for other PAHs and PCBs which were not directly measured but were estimated using correlations based on experimental data. Aroclor 1248 chemical characteristics were used to represent Total PCBs as Aroclor 1248 concentration was highest of all Aroclors. Henry's constants and partitioning coefficients for BTEX, which are VOCs, are well established and the values reported in literature are used in the modeling. H and partitioning coefficients values for other organic compounds used in the model are also from literature because concentrations of these compounds in the IHC sediments used in the experiments were very low or non-detect, making site-specific H and partitioning coefficient measurements unreliable. Solubility values, diffusivity in air, and diffusivity in water were obtained from literature for all chemicals.

Table 2. Sediment Concentration and Chemical Characteristics Used in Emission Modeling.

Chemical	Sediment Conc., waD (mg/kg)	Sand Mound Conc. (mg/kg)	Henry's Const., H dimensionless	Solubility, ρ'al (mg/L)	Diffusivity in Air, DA_1 (cm^2/s)	Diffusivity in Water, DA_2 (cm^2/s)	Partitioning Coefficient, K_{a32} (L/kg)
PAHs							
Acenaphthene	21.7	1.1	0.0066	3.8	0.0421	7.70E-06	1030
Acenaphthylene	27	1.4	0.0049	3.93	0.0440	7.50E-06	1826
Anthracene	26	1.3	0.0018	0.075	0.0324	7.74E-06	29691
Benzo(a)anthracene	39.6	2.0	0.0002	0.0128	0.0510	9.00E-06	17226
Benzo(b)fluoranthene	39.6	2.0	0.0000822	0.0015	0.0226	5.60E-06	560982
Benzo(k)fluoranthene	12.8	0.6	0.0000822	0.0008	0.0226	5.60E-06	2011866
Benzo(a)pyrene	26.6	1.3	0.000085	0.0038	0.0430	9.00E-06	600776
Benzo(ghi)perylene	11.2	0.6	0.0000582	0.0026	0.049	4.90E-06	3189180
Chrysene	62.1	3.1	0.0003	0.0019	0.0248	6.21E-06	235953
Dibenzo(a,h)anthracene	11.8	0.6	0.0000219	0.00067	0.0202	5.20E-06	1009413
Fluoranthene	69.8	3.5	0.00075	0.26	0.0302	6.40E-06	33612
Fluorene	36.9	1.8	0.0026	1.9	0.0360	7.88E-06	3367
Indeno(1,2,3-c,d)pyrene	53.9	2.7	0.0000654	0.00053	0.0190	5.60E-06	1140825
Naphthalene	478.4	23.9	0.011	31.0	0.0590	5.13E-06	298
Phenanthrene	192.4	9.6	0.0029	1.10	0.0330	7.47E-06	13344
Pyrene	91	4.6	0.00092	0.132	0.0272	7.24E-06	77706
BTEX							
Benzene	3.09	0.2	0.224	1780	0.088	1.02E-05	9.8
Ethylbenzene	0.739	0.04	0.316	152	0.075	7.80E-06	88.2
Toluene	4.94	0.2	0.251	515	0.087	8.60E-06	35.6
Xylenes, Total	0.782	0.04	0.275	200	0.071	9.30E-06	82.7
PCBs							
PCB Total (Aroclor 1248)	35.6	1.8	0.0090	0.041	0.018	8.00E-06	8700
Other Organic Compounds							
Dibenzofuran	8.7	0.4	0.00436	4.75	0.0267	6.00E-06	1078
Vinyl Chloride	2.9	0.15	1.1	2763	0.106	1.23E-06	1.9

Sediment physical characteristics such as total organic carbon content and sediment bulk density used in all emission modeling are presented in Table 3. Values used are typical for IHC sediments.

Table 3. Sediment Physical Characteristics Used in Emission Modeling.

Sediment Properties	Symbol	Units	Value Used in Model
Bulk Sediment Total Organic Carbon Content	TOC_{Bulk}	%	10
Sand Mound Total Organic Carbon Content	TOC_{Sand}	%	0.5
Bulk Sediment Silt & Clay Fraction	SCF_{Bulk}	%	67
Sand Mound Silt & Clay Fraction	SCF_{Sand}	%	3.35
Bulk Sediment Clay Fraction	CF_{Bulk}	%	5
Sand Mound Clay Fraction	CF_{Sand}	%	0.2
Specific Gravity of Sediment	SG		2.71
In situ Sediment Water Content	w	%	88
Particle bulk density	ρ3	gm/ml	2.71
In situ Sediment Porosity	e2	unitless	0.70

The inputs to the DOU model are presented on Table 4 below. Notes on how the DOU model input values were selected are presented in the last column on the table.

Table 4. Inputs to Dredging Operable Unit Emission Model

Parameters	Symbol	Units	Value Used in Model	Notes on Value Used
Dredging Operational Parameters				
Dredging rate	Qds	cy/hr	125	Anticipated dredging rate
Resuspension factor	R	dimensionless	0.01	Mass of solids suspended in water by the dredge per unit of solids extracted
Chemical loading ratio	f	dimensionless	0.5	Surficial bed sediment-to-DM average, downstream of the dredge site. Typically this factor is less than unity and is quantified using bed sediment concentration profile data. A value of 0.5 is used.
Dredging Area Characteristics				
Flow rate through DOU	QDOU	m3/sec	0.5	Water volumetric rate moving through the DOU
Water depth in DOU	h	m	6	Assumed average water depth in canal and harbor
External Parameters				
Wind speed	Vw	mi/hr	10	Average wind speed
Chemical concentration in air above DOU	ρa1	kg/l	0	Conservative assumption for highest emissions
Chemical conc. in water approaching DOU	ρAS	ng/cm3	0	Conservative assumption for highest emissions

Emissions of COCs from three types of dredging areas (confined DOU, unconfined DOU, and embayment DOU) were estimated using the DOU emission model and are presented on Table 5. Dredging seasons of 75 days were assumed to estimate emissions from dredging areas in a typical year. (The 75-day dredging season was obtained using an average production rate of approximately 3000 cubic yards of sediment per day and a total dredging volume of 230,000 cubic yards per dredging season. This assumption is discussed in further details below.) Estimated emissions associated with dredging and dredged material transport and placement operations are shown in Figure 1.

Table 5. Results of the Dredging Operable Unit Model

	Confined DOU Emissions		*Unconfined DOU Emissions*		*Embayment DOU Emissions*	
Chemical	**kg/day**	**tons/yr (75 day dredging season)**	**kg/day**	**tons/yr (75 day dredging season)**	**kg/day**	**tons/yr (75 day dredging season)**
PAHs						
Acenaphthene	0.04	0.0033	0.024	0.0020	0.022	0.0018
Acenaphthylene	0.042	0.003	0.022	0.0018	0.015	0.0012
Anthracene	0.028	0.0023	0.002	0.0002	0.0013	0.0001
Benzo(a)anthracene	0.0107	0.00088	0.0015	0.00012	0.00075	0.00006
Benzo(b)fluoranthene	6.50E-04	0.000054	2.60E-05	0.000002	8.90E-05	0.000007
Benzo(k)fluoranthene	3.54E-04	0.000029	2.37E-06	0.000000	2.90E-05	0.000002
Benzo(a)pyrene	1.70E-02	0.00140	1.70E-05	0.00000	6.60E-05	0.00001
Benzo(ghi)perylene	8.46E-04	0.0000698	9.63E-07	0.0000001	1.80E-05	0.0000015
Chrysene	2.20E-03	0.00018	2.60E-04	0.00002	3.90E-04	0.00003
Dibenzo(a,h)anthracene	8.60E-05	0.0000071	1.26E-06	0.0000001	7.73E-06	0.0000006
Fluoranthene	0.0537	0.004	0.0033	0.000	0.0021	0.00017
Fluorene	0.047	0.004	0.018	0.001	0.01	0.0008
Indeno(1,2,3-c,d)pyrene	1.90E-04	0.000016	1.40E-05	0.000001	2.70E-05	0.0000022
Naphthalene	1.369	0.11	0.977	0.08	1.761	0.15
Phenanthrene	0.24	0.020	0.034	0.003	0.018	0.001
Pyrene	0.078	0.006	0.0021	0.0002	0.0022	0.0002
BTEX						
Benzene	0.152	0.013	0.094	0.008	0.4	0.033
Ethylbenzene	0.0051	0.00042	0.0034	0.00028	0.0107	0.00088
Toluene	0.072	0.0059	0.046	0.0038	0.176	0.0145
Xylenes, Total	0.0057	0.00047	0.0038	0.00031	0.0121	0.00100
PCBs						
PCBs	0.055	0.005	0.011	0.0009	0.006	0.0005
Other Organic Compounds						
Dibenzofuran	0.014	0.0012	0.009	0.0007	0.0077	0.0006
Vinyl Chloride	0.64	0.053	0.39	0.032	1.9	0.16
Total	**2.9**	**0.24**	**1.6**	**0.14**	**4.4**	**0.36**

Attachment 1

Barge Transfer Volatile Emission Modeling

To estimate the volatile emissions from the barges transporting dredged material from the dredge site to the CDF, it is assumed that there are two barges present at IHC at any time during the dredging season. One of the barges will be loading dredged material at the dredge site, and the second barge will be unloading in the vicinity of the CDF. The barges are assumed to be 30 feet wide by 150 feet long by 10 feet deep. The barges are assumed to be full of dredged material and also to be uncovered during the loading and transport. The dredged material is assumed to be covered by a layer of water in the barge, similar to the ponded conditions in the CDF as described below. Therefore, volatile emissions from the barges are estimated using the ponded CDF emissions equations discussed below. In addition, because the time period when the barges are present at IHC is approximately the same time period when the dredged material is discharged into the CDF, the calculation of volatile emissions from the CDF pond can incorporate volatile emissions from the barges by simply increasing the ponded area of the CDF by an area equivalent to two barges. It should be noted, however, that if volatile emissions from the barges are estimated together with emissions from the CDF pond by summing the areas, there may be some overestimation of emissions, as chemical loss from the dredged material in the barges is not taken into account as chemicals that would be unavailable to be emitted in the CDF. Alternately, the sediment chemical concentrations can be recalculated due to emissions in the barges, and the new sediment concentrations can be entered as the starting sediment concentration in the CDF. Because the chemical loss from the barges is estimated to be relatively small, in this initial estimate of emissions, sediment concentrations will not be recalculated due to loss from the barges. Volatile emissions from the barges are presented in Table 6. (All inputs to the barge volatile emission estimates are the same as for the CDF pond and are discussed below.) Dredging seasons of 75 days were assumed to estimate emissions from dredging barges in a typical year. Estimated emissions associated with dredging and dredged material transport and placement operations are shown in Figure 1.

Attachment 1

Table 6. Volatile Emissions during Barge Transfer

	kg/day	tons/yr (75 day dredging season)
PAHs		
Acenaphthene	6.2E-03	5.2E-04
Acenaphthylene	4.1E-03	3.5E-04
Anthracene	1.8E-04	1.5E-05
Benzo(a)anthracene	1.4E-04	1.2E-05
Benzo(b)fluoranthene	1.3E-06	1.1E-07
Benzo(k)fluoranthene	1.2E-07	9.9E-09
Benzo(a)pyrene	1.2E-06	9.7E-08
Benzo(ghi)perylene	6.7E-08	5.6E-09
Chrysene	1.6E-05	1.3E-06
Dibenzo(a,h)anthracene	5.7E-08	4.8E-09
Fluoranthene	2.6E-04	2.2E-05
Fluorene	2.6E-03	2.2E-04
Indeno(1,2,3-c,d)pyrene	6.5E-07	5.4E-08
Naphthalene	4.2E-01	3.5E-02
Phenanthrene	3.4E-03	2.9E-04
Pyrene	1.6E-04	1.4E-05
BTEX		
Benzene	1.1E-01	9.2E-03
Ethylbenzene	2.8E-03	2.4E-04
Toluene	4.8E-02	4.0E-03
Xylenes, Total	3.5E-03	2.9E-04
PCBs		
PCB Total	1.2E-03	1.0E-04
Other Organic Compounds		
Dibenzofuran	1.9E-03	1.6E-04
Vinyl Chloride	1.4E-01	1.2E-02
Total	**0.74**	**0.06**

Emissions from Disposal Pipe

The dredged material will be pumped from the transfer barge into the CDF using either water stored in the CDF cells or water from the canal. It is assumed that the slurry of dredged material and carrier water is discharged into the sediment cells above the sediment surface in the receiving cells. The discharge of slurry from the pipe will result in emissions of volatiles into the air. The discharge point can be submerged, and this would reduce emissions, but for this emission calculation, it is assumed conservatively that the discharge is above the sediment surface.

Attachment 1

The equations for estimating volatile losses during disposal into the CDF were developed by Dr. L.J. Thibodeaux and are presented in "Theoretical Models for Evaluation of Volatile Emissions to Air during Dredged Material Disposal with Applications to New Bedford Harbor, Massachusetts" (Misc. Paper EL-89-3, USACE, May 1989).

The inputs to the dredge disposal pipe emission calculations are presented on Table 7 below. Notes on how the input values were selected are presented in the last column on the table. Estimated emissions associated with dredging and dredged material transport and placement operations are shown in Figure 1

Table 7. Inputs to Dredge Disposal Pipe Model.

Parameters	Symbol	Units	Value Used in Model	Notes on Value Used
Dredging Operational Parameters				
Volumetric rate of water (solids-free) flow in pipeline	Q	m^3/hr	625	Average flow in 8-inch pipe
Sediment Slurry Concentration	Cps	Kg/L	0.170	170 g/L: typical pumpable slurry concentration
Water Temperature	Tw	Degree Celsius	20	
Height through which water falls	Hd	feet	5	Assumed ¼ distance of dike height

For the emission analysis, it is assumed that disposal into the CDF will occur 24 hours a day during the dredging season. Dredging seasons of 75 days were assumed to estimate emissions from the disposal pipe in a typical year. Volatile emissions from the discharge pipe are presented in Table 8.

Attachment 1

Table 8. Volatile Emissions from Discharge Pipe

	kg/day	tons/yr (75 day dredging season)
PAHs		
Acenaphthene	0.092	0.008
Acenapthylene	0.064	0.0053
Anthracene	0.0039	0.00032
Benzo(a)anthracene	0.0107	0.0009
Benzo(b)fluoranthene	0.00028	2.28E-05
Benzo(k)fluoranthene	0.000025	2.06E-06
Benzo(a)pyrene	0.00021	1.70E-05
Benzo(ghi)perylene	0.000013	1.08E-06
Chrysene	0.00107	0.00009
Dibenzo(a,h)anthracene	0.00004	3.67E-06
Fluoranthene	0.009	0.0007
Fluorene	0.048	0.0040
Indeno(1,2,3-c,d)pyrene	0.00019	1.53E-05
Naphthalene	6.0	0.49
Phenanthrene	0.063	0.0052
Pyrene	0.0050	0.00042
BTEX		
Benzene	0.94	0.08
Ethylbenzene	0.038	0.0031
Toluene	0.54	0.044
Xylene	0.041	0.0034
PCBs		
Total PCBs (Aroclor 1254)	0.018	0.0015
Other Organic Compounds		
Dibenzofurans	0.032	0.0027
Vinyl Chloride	0.23	0.019
Total	**8.1**	**0.67**

IHC CDF Volatile Emission Modeling

Volatile emissions from two operational scenarios were estimated for the CDF: a ponded CDF and a drained CDF. Both operation scenarios assumed that approximately 230,000 cubic yards of sediment would be dredged every year and hydraulically placed in the CDF. The placement of the dredged material would alternate between two 45-acre storage cells every other year. It was assumed that the dredging and placement would take about 75 days (2.5 months) using an average production rate of approximately 3000 cubic yards of sediment per day.

Attachment 1

To estimate the volatile emissions from both the ponded CDF and the drained CDF, a two-year dredging cycle was assumed, with dredging and disposing into alternating CDF sediment cells in alternating years. This two-year dredging cycle resulted in CDF conditions that were approximately presented in Figure 2 for a ponded CDF and Figure 3 for a drained CDF. Two calendar years are presented in the figures with May being the first month, with the assumption that dredging would start in May in a typical year. The dredging, disposal, decant, and dewatering time periods presented in the CDF condition figures assume an average dredging volume per year of approximately 230,000 cubic yards. Actual dredging volumes may vary from year to year, but the two-year cycle presented in Figures 2 and 3 is expected to represent most dredging scenarios at IHC.

The difference between the two operational scenarios will be the management of water in the sediment cell after each sediment placement/disposal. In Scenario 1 (Ponded CDF Scenario), the water released from the sediment after disposal is not removed from the CDF cell. The dredged material is allowed to consolidate for the next 21.5 months with an overlying pond of water until the next disposal operation occurs in the cell. In Scenario 2 (Drained CDF Scenario), free water is drained off the dredged material after disposal is completed and the sediment is allowed to consolidate and desiccate for the next 21.5 months until the next disposal operation into the same cell.

Emissions from Ponded CDF

A CDF that is kept ponded between dredging operations can be represented by two conditions that have quantifiable volatile emissions: the ponded portions and the drained portions. Emissions from the ponded CDF can be further characterized by two regimes: emission during disposal into the CDF and emission from the pond after the disposal period. Volatile emissions from these sources are discussed below.

Ponded Portions of CDF – Emissions during Disposal

Volatile emissions from a ponded CDF are composed of emissions during disposal and emissions from the pond after the disposal period. Volatile emissions from the CDF cell during disposal were predicted using Dr. Thibodeaux's formulation for a ponded CDF cell. A discussion of the model development as well as a detailed description of the model can be found in ERDC/EL TR-08-17.

Input to the Ponded CDF Emission model can be grouped into five main categories: 1) sediment properties such as sediment chemical concentration, 2) dredging operational parameters such as influent slurry solids concentration and dredging rate, 3) CDF characteristics such as water depth and CDF cell dimensions, 4) external characteristics such as wind speed and chemical concentration in air above the CDF, and 5) chemical parameters such as Henry's Law Constant, sediment to water partitioning coefficient (Kd), and solubility of the chemical in water.

The volatile emission losses for the 75 days of disposal were computed using the PCDF Excel spreadsheet. Sediment chemical concentrations and sediment physical characteristics used in the

PCDF spreadsheet were presented previously on Tables 2 and 3, respectively. Other inputs specific to the PCDF model are presented on Table 9. Notes on how the PCDF model input values were selected are presented in the last column on the table. Volatile emission losses during disposal are presented on Table 11.

Table 9. Inputs to Ponded CDF Emission Model.

Parameters	Symbol	Units	Value Used in Model	Notes on Value Used
Dredging Operational Parameters				
Influent Slurry Solids Concentration	TSS_{sl}	gm/L	170	170 g/L: typical pumpable slurry concentration
Dredging rate	Q_{ds}	yd^3/hr	125	Anticipated dredging rate
CDF Parameters				
Water Depth	Z	m	1	Typical CDF ponding condition
Length of CDF Cell	L	m	622	CDF design dimensions
Width of CDF Cell	W	m	293	CDF design dimensions
CDF Total surface area	$A_{,stot}$	acre	45.0	CDF design dimensions
External Parameters				
Wind Speed	v'_1	mph	10	Average wind speed
Chemical Concentration in air above CDF	ρ_{a1}	mg/l	0	Conservative assumption for highest emissions

Ponded Portions of CDF – Emissions after Disposal

Volatile emissions from a ponded CDF after sediment disposal arise from four principal sources. The first source is the organic constituents remaining in the ponded water from the disposal operation. The second source is the dredged material pore water expelled by consolidation of the dredged material. The third source is diffusion from the settled dredged material, and the fourth source is the suspended solids that are in equilibrium with the mixed layer of the settled dredged material that undergo resuspension and settling continuously under the influence of erosion forces.

Estimates of the volatile emissions for the 9.5 month (1 year) and 21.5 month (2 years) post-disposal periods were predicted using the PSDDF and RECOVERY models. PSDDF was used to estimate the rates of consolidation (sediment lift settlement rate and water discharge rate) which were then used to calculate the contaminant mass loadings to the ponded water along with pore water concentrations using partitioning coefficients. RECOVERY models diffusion from the dredged material layer, mixing in a 2-cm surficial material layer, settling of solids from the ponded water, and resuspension of solids from the mixed layer to maintain a TSS concentration of 10 mg/L, equilibrium partitioning of contaminants between the solid and liquid phases as a function of organic carbon concentration in the phases, and volatilization from the ponded water.

Volatile emissions during disposal and during the post-disposal period from the ponded CDF were estimated by Dr. Paul Schroeder and presented in a memo from 5 December 2007. The emission estimates are presented in Table 11 for Cell 1 and Cell 2. For a bi-annual disposal schedule, it is assumed that dredged material is placed into Cell 1 in Year 1, into Cell 2 in Year 2, into Cell 1 again in Year 3, and so forth. Therefore, it is estimated that loss in Year 1 for Cell 2 is equivalent to loss in Year 2 for Cell 1 (see Figure 2 for clarification) or the losses from one cell over the two-year cycle is equal to the losses from both cells in a one-year period.

Exposed Portions of CDF

Even if the CDF sediment cells are kept ponded between dredging and disposal operations, it is likely that a portion of the cells will be exposed (not ponded) during a significant portion of the time due to natural sloping of the dredged material surface created during sediment disposal. The planned hydraulic placement method into the CDF is expected to create a mound composed primarily of sand size particles in the vicinity of the discharge points (expected to be on the north side of the CDF). The sand mounds, which are estimated to be approximately 10 to 15% of the entire cell area, will be higher in elevation than the rest of the sediment cells as well as be composed of material that is more easily drained than the rest of the cells. For purpose of the emission prediction, it is assumed that the sand mound areas will be 15% of the sediment cell area and that this area will be exposed during the entire post-disposal period. (The ponded portions were modeled assuming that the area undergoing consolidation with contaminant mass loading due to release of pore water was 85% of the CDF area.) Emissions from the sand mound will likely be lower than from the rest of the CDF, primarily due to two reasons: 1) the chemical concentrations of the sand mound should be significantly lower than in the bulk sediment, and 2) surface enrichment which results in a thin soil layer containing elevated chemical concentrations (i.e., higher than the bulk sediment concentrations) being deposited on the dredged material surface in the rest of the CDF would not occur in the sand mound. For purpose of the emission prediction, it is assumed that the chemical concentrations in sand mound areas are approximately 5% of the bulk sediment. The surface enrichment, which is discussed in further detail below, is represented by a flux calibration factor (C_f), which is greater than 1 when surface enrichment is present. In addition, the sediment properties (such as porosity and moisture fractions) of the material in the sand mounds would likely be different from the sediment properties of the bulk material. For this emission calculation, it is assumed that the flux calibration factor (C_f) for the sand mound is 1, i.e., which is equivalent to no surface enrichment for the sand mound.

Volatile emissions during the post-disposal period from the sand mound areas were estimated using the Exposed Sediment Emissions spreadsheet based on Dr. Thibodeaux's formulation. The exposed sediment model was developed and calibrated to fit measured fluxes obtained from a series of wind tunnel experiments conducted by ERDC-WES on IHC sediments. Details of the experiments, a discussion of the model development as well as a detailed description of the model can be found in ERDC/EL TR-08-17.

Attachment 1

The exposed sediment condition covers the time periods: 1) when the dry areas start to appear until the surface is completely dry, then 2) the air-filled pore spaces are created at depth, surface cracks form and widen, chemicals at the surface are depleted, chemicals at depth move to the surface, until finally a crust forms and emissions are significantly lower than the initial drying period. These two time periods are represented in the model as Regime I and Regime II.

Input to the Exposed Sediment Emission model can be grouped into four main categories: 1) sediment properties such as sediment solid particle density sediment and chemical concentration, 2) CDF characteristics such as fetch of emission area and CDF cell dimensions, 3) external characteristics such as wind speed and chemical concentration in air above the CDF, and 4) chemical parameters such as Henry's Law Constant, sediment to water partitioning coefficient (K_d), and molecular diffusivity in air.

Sediment chemical concentrations and parameters were presented previously on Table 2. Sediment physical characteristics were presented on Table 3. The inputs specific to the Exposed Sediment Emission model are presented on Table 10. Notes on how the Exposed Sediment Emission model input values were selected are presented in the last column on the table.

Table 10. Inputs to Exposed Sediment Emission Model.

Parameters	Symbol	Units	Value Used in Model for Bulk Sediment	Value Used in Model for Sand Mound	Notes on Value Used
Sediment Properties					
Moisture fraction at start of Regime I	$moisture_1$		1.08	0.37	Initially saturated and equals 1.8 times Liquid Limit = 60%
Moisture fraction at end of Regime I	$moisture_2$		0.887	0.091	Based on 1.9 inches of crust at desiccation limits
Moisture fraction at start of Regime II	$moisture_3$		0.81	0.075	Based on 2.8 inches of crust at desiccation limits
Water porosity at start of Regime I	e_1		0.745	0.5	Initially saturated and equal to porosity computed from moisture fraction
Water porosity at end of Regime I	e_2		0.658	0.13	Based on 1.9 inches of crust at desiccation limits
Water porosity at start of Regime II	e_3		0.619	0.11	Based on 2.8 inches of crust at desiccation limits
CDF Parameters					
Length of CDF Cell (fetch)	L	m	varies	varies	
Width of CDF Cell	W	m	varies	varies	
CDF Total surface area	A_{stot}	acre	varies	varies	
External Parameters					
Wind Speed	v'_1	mph	10	10	Average wind speed
Chemical Concentration in air above CDF	ρ_{a1}	mg/l	0	0	Conservative assumption for highest emissions

A few of the model inputs require some discussion and are included in the following paragraphs. The surface water evaporation time (t_d) is defined as the time when the entire sediment surface layer is dry (i.e., covered with dry soil patches.) The t_d value is an empirical parameter controlled by the combined consolidation and evaporation processes that drive liquid from the surface layer, and is one of the parameters obtained from the wind tunnel experimental observations. The t_d value is significant as it indicates when maximum fluxes are observed from the drying sediment surface. Based on the wind tunnel experiments observations, the t_d value used in the model was 425 hours.

The exposed sediment emissions period (t_{tol}) is defined as the total time when chemical fluxes from a drying sediment surface are quantified. As such, the t_{tol} value is the total time the exposed sediment emissions model is run. To estimate emissions after one year, the t_{tol} value used in the model was 290 days (365 days minus 75 days) or 6960 hours. To estimate emissions after two years, the t_{tol} value used in the model was 655 days (365 days * 2 years minus 75 days) or 15,720 hrs. This is based on the assumption that the sand mound areas are exposed immediately after the dredged material is disposed into the CDF.

Attachment 1

A flux calibration factor (C_f) was used in the exposed sediment model to enhance model and experimental data congruence, as the model was consistently underestimating the measured fluxes. This fitting coefficient is based on the premise that during sediment pumping and placement, a thin soil layer containing elevated chemical concentrations (i.e., higher than the bulk sediment concentrations) is likely deposited on the dredged material surface. This is due to the solids-water mixing process that produces a supernatant rich in fine particles in suspension since the sand and silt fractions of the sediment will settle relatively quickly. The fine particles, which include clays and organic colloids and typically contain higher chemical concentrations, are deposited on the surface on top of the coarser fraction during evaporation creating a thin layer that is "enriched" with elevated chemical concentrations. The enrichment factors observed in the wind tunnel experiments generally ranged from 3 to 20. The C_f value is presented in the model as the inverse of the fines fraction (defined as the clay fraction and 10% of the silt fraction) in the sediment. The C_f value used in the model was 9 for all chemicals. As discussed previously, the sand mound likely has a value of C_f less than 17, as enrichment should be minimal. A C_f value of 1 was used for the sand mound.

It should be noted that the sediment chemical concentrations were calculated and reset in the model for the exposed sediment post-disposal estimates as there was significant loss of some chemicals during disposal. For vinyl chloride, the entire mass (i.e., entire mass of the chemicals in 230,000 cubic yards assumed to be dredged each year), was calculated to be emitted after disposal into the CDF. Therefore, all post-disposal emission estimates assumed that the sediment concentration of vinyl chloride is zero.

The emission estimates from the sand mound areas of a ponded CDF are presented in Table 11 for Cell 1 and Cell 2. Also presented on Table 11 are the sums of the emissions from the disposal period and the post-disposal periods or the total annual losses from the two ponded 45-acre CDF sediment storage cells.

Attachment 1

Table 11. Annual Emissions from Ponded Sediment Cells, Bi-Annual Disposal – in Tons.

	Cell 1				Cell 2			Cells 1 and 2
	During Disposal	**Post-Disposal - Ponded Portions of Cell**	**Post-Disposal - Exposed Portion of Cell (Sand Mound)**	**Total Emission - Cell 1**	**Yr 2 Post-Disposal - Ponded Portions of Cell**	**Yr 2 Post-Disposal - Exposed Portion of Cell (Sand Mound)**	**Total Emission - Cell 2**	**Total Annual Loss from Both Cells**
PAHs								
Acenaphthene	0.020	0.0050	0.00044	0.026	0.0050	0.00027	0.0053	0.031
Acenaphthylene	0.014	0.0028	0.00034	0.017	0.0028	0.00021	0.0030	0.020
Anthracene	0.0008	0.00026	0.000035	0.0011	0.00027	0.000022	0.00029	0.0014
Benzo(a)anthracene	0.0012	0.00058	0.000017	0.0018	0.00060	0.000010	0.00061	0.0025
Benzo(b)fluoranthene	0.000015	0.00014	0.00000037	0.000158	0.00017	0.00000023	0.00017	0.00033
Benzo(k)fluoranthene	0.000001	0.0000033	0.000000035	0.000005	0.0000066	0.000000022	0.0000066	0.0000113
Benzo(a)pyrene	0.000013	0.0000011	0.00000024	0.000014	0.000023	0.00000015	0.000023	0.000038
Benzo(ghi)perylene	0.000001	NA	0.000000014	0.0000008	NA	0.0000000087	0.0000000087	0.00000082
Chrysene	0.0001	0.00026	0.0000042	0.0004	0.00031	0.0000026	0.00032	0.00073
Dibenzo(a,h)anthracene	0.000001	0.00000011	0.000000018	0.0000009	0.0000021	0.000000011	0.0000021	0.00000297
Fluoranthene	0.0016	0.00066	0.000047	0.0023	0.00069	0.000030	0.00072	0.0030
Fluorene	0.0102	0.0022	0.00024	0.0126	0.0022	0.00015	0.0024	0.015
Indeno(1,2,3-c,d)pyrene	0.000008	0.000041	0.00000021	0.000049	0.000059	0.00000013	0.000060	0.000108
Naphthalene	1.52	0.27	0.02	1.82	0.24	0.015	0.25	2.07
Phenanthrene	0.013	0.0034	0.00059	0.017	0.0035	0.00037	0.0039	0.021
Pyrene	0.0009	0.00053	0.000039	0.0015	0.00058	0.000024	0.00060	0.0021
BTEX								
Benzene	0.2429	0.00	0.014	0.261	0.00	0.00087	0.0023	0.26
Ethylbenzene	0.0080	0.0011	0.002	0.011	0.00085	0.0010	0.0018	0.013
Toluene	0.1268	0.012	0.016	0.156	0.0082	0.0077	0.016	0.17
Xylenes, Total	0.0091	0.0012	0.002	0.012	0.00092	0.0010	0.0019	0.014
PCBs								
PCB Total	0.0038	0.00087	0.00027	0.0050	0.00093	0.00017	0.0011	0.0061
Other Organic Compounds								
Dibenzofuran	0.0075	NA	0.00064	0.0081	NA	0.00040	0.00040	0.0085
Vinyl Chloride	0.4490	0.00	0.00	0.4490	0.00	0.00	0.00	0.45
Total	**2.43**	**0.30**	**0.06**	**2.80**	**0.27**	**0.03**	**0.29**	**3.09**

Notes:

Emissions during Disposal and Post-Disposal (ponded) from Paul Schroeder's Analysis 5 Dec 2007

Emissions during Post-Disposal (exposed) estimated using "exposed_ponded12_425new_sqrt_td.xls" at 6960 hours (=365-75*24) for year 1 and at 15,720 hrs (=2*365-75*24) for year 2

Each cell is approximately 45 acres; assume area that is exposed (not ponded) in each cell is approx. 15% of total area or 6.7 acres

Dredging and disposing of 230,000 cy sediments in each cell every other year

Dredging and placement would take about 75 days or 2.5 months

Cell 1 = Disposal Cell in Year 1; Cell 2 = Non-Disposal Cell in Year 1

Ponded Scenario: The dredged material allowed to consolidate under ponded water for the next 21.5 months until the next disposal operation in the cell

Emissions from Drained CDF

Volatile emissions from a drained CDF are composed of emissions during disposal and emissions after water is drained from the sediment during the drying period and afterwards from the exposed sediment. The estimate of volatile emissions from the CDF cell during disposal was discussed previously in the Ponded CDF section.

Losses from the CDF cells after water is drained from the sediment were estimated using the Exposed Sediment Emissions spreadsheet based on Dr. Thibodeaux's formulation discussed in the Exposed Portions of CDF section above. Separate emissions were calculated for the sand mound and the rest of the exposed areas of the CDF, as the sand mounds are assumed to have significantly lower chemical concentrations and no surface enrichment. Inputs were discussed previously in the exposed sediment section.

As discussed previously, the sediment chemical concentrations were calculated and reset in the model for the exposed sediment post-disposal estimates as there was significant loss of some chemicals during disposal. For vinyl chloride, the entire mass (i.e., entire mass of the chemicals in 230,000 cubic yards assumed to be dredged each year), was calculated to be emitted after disposal into the CDF. Therefore, all post-disposal emission estimates assumed that the sediment concentration of vinyl chloride is zero. In addition, benzene was all lost after the first year in the CDF cell, therefore, Year 2 post-disposal emission estimates assumed that sediment concentrations of benzene is zero.

Emissions from a drained CDF are presented in Table 12. The emissions from the disposal period and the post-disposal periods are summed to obtain the total annual losses from the two drained 45-acre CDF sediment storage cells.

Attachment 1

Table 12. Annual Emissions from Drained Sediment Cells, Bi-Annual Disposal.

	Cell 1				Cell 2			Cells 1 and 2
	During Disposal	Post-Disposal - Exposed Portion of Cell	Post-Disposal - Exposed Portion of Cell (Sand Mound)	Total Emission - Cell 1	Yr 2 Post-Disposal - Exposed Portions of Cell	Yr 2 Post-Disposal - Exposed Portion of Cell (Sand Mound)	Total Emission - Cell 2	Total Annual Loss from Both Cells
PAHs								
Acenaphthene	0.020	0.026	0.00044	0.046	0.016	0.00027	0.017	0.063
Acenaphthylene	0.014	0.021	0.00034	0.035	0.013	0.00021	0.013	0.048
Anthracene	0.0008	0.0029	0.000035	0.0037	0.0018	0.000022	0.0019	0.0055
Benzo(a)anthracene	0.0012	0.0018	0.000017	0.0031	0.0012	0.000010	0.0012	0.0042
Benzo(b)fluoranthene	0.000015	0.00012	0.00000037	0.00014	0.000079	0.00000023	0.000079	0.00022
Benzo(k)fluoranthene	0.000001	0.000015	0.000000035	0.000016	0.000010	0.000000022	0.000010	0.000026
Benzo(a)pyrene	0.000013	0.000080	0.00000024	0.000093	0.000051	0.00000015	0.000052	0.00014
Benzo(ghi)perylene	0.000001	0.0000069	0.000000014	0.0000076	0.0000044	0.0000000087	0.0000044	0.000012
Chrysene	0.0001	0.00080	0.0000042	0.00095	0.00051	0.0000026	0.00052	0.0015
Dibenzo(a,h)anthracene	0.000001	0.0000083	0.000000018	0.0000091	0.0000053	0.000000011	0.0000053	0.000014
Fluoranthene	0.0016	0.0045	0.000047	0.0062	0.0029	0.000030	0.0029	0.0091
Fluorene	0.0102	0.015	0.00024	0.025	0.010	0.00015	0.0097	0.035
Indeno(1,2,3-c,d)pyrene	0.000008	0.000083	0.00000021	0.000091	0.000053	0.00000013	0.000053	0.00014
Naphthalene	1.52	1.43	0.02	2.95	0.85	0.015	0.87	3.82
Phenanthrene	0.013	0.041	0.00059	0.054	0.026	0.00037	0.027	0.081
Pyrene	0.0009	0.0042	0.000039	0.0052	0.0027	0.000024	0.0027	0.0079
BTEX								
Benzene	0.2429	0.30	0.014	0.55	0.0023	0.00087	0.0031	0.55
Ethylbenzene	0.0080	0.034	0.002	0.042	0.012	0.0010	0.013	0.055
Toluene	0.1268	0.30	0.016	0.43	0.10	0.0077	0.10	0.53
Xylenes, Total	0.0091	0.033	0.002	0.043	0.012	0.0010	0.013	0.056
PCBs								
PCB Total	0.0038	0.017	0.00027	0.021	0.011	0.00017	0.011	0.032
Other Organic Compounds								
Dibenzofuran	0.0075	0.0082	0.00064	0.016	0.0051	0.00040	0.0055	0.021
Vinyl Chloride	0.4490	0.00	0.00	0.45	0.00	0.00	0.00	0.45
Total	**2.43**	**2.24**	**0.06**	**4.67**	**1.07**	**0.03**	**1.09**	**5.77**

Notes:

Emissions during Disposal from Paul Schroeder's Analysis 5 Dec 2007

Emissions during Post-Disposal (exposed) estimated using "exposed_ponded12_425new_sqrt_td.xls" at 6960 hours (=365-75*24) for year 1 and at 15,720 hrs (=2*365-75*24) for year 2

Each cell is approximately 45 acres

Dredging and disposing of 230,000 cy sediments in each cell every other year

Dredging and placement would take about 75 days or 2.5 months

Drained Scenario: Free water is drained off the dredged material after disposal is completed and the sediment is allowed to consolidate for the next 21.5 months until the next disposal operation in the cell

SUMMARY

Volatile emission losses during dredging and CDF operation activities are summarized for the two dredged material storage scenarios in Tables 13 and 14. For losses around the dredge, it is assumed that the dredge site will be unconfined and only emissions from this case are presented.

Table 13. Annual Emissions during Dredging and CDF Operation – Ponded Sediment Cells, Annual Dredging, Bi-Annual Disposal into Individual CDF Sediment Cells (Emissions in Tons)

	Unconfined DOU	Barge Transfer	Discharge Pipe	Ponded CDF During Disposal into CDF	Post-Disposal - Ponded Portions of Cell 1 (Sand Mound)	Post-Disposal - Exposed Portion of Cell 1	Post-Disposal - Ponded Portions of Cell 2	Post-Disposal - Exposed Portion of Cell 2 (Sand Mound)	Total Annual Emissions
Acenaphthene	0.0020	0.00052	0.0076	0.020	0.0050	0.00044	0.0050	0.00027	0.041
Acenaphthylene	0.0018	0.00035	0.0053	0.014	0.0028	0.00034	0.0028	0.00021	0.028
Anthracene	0.00017	0.000015	0.00032	0.0008	0.00026	0.000035	0.00027	0.000022	0.0019
Benzo(a)anthracene	0.00012	0.000012	0.00088	0.0012	0.00058	0.000017	0.00060	0.000010	0.0035
Benzo(b)fluoranthene	0.000002	0.00000011	0.000023	0.000015	0.00014	0.00000037	0.00017	0.00000023	0.00036
Benzo(k)fluoranthene	0.0000002	0.000000010	0.0000021	0.0000014	0.0000033	0.000000035	0.0000066	0.000000022	0.000014
Benzo(a)pyrene	0.000001	0.000000097	0.000017	0.000013	0.0000011	0.00000024	0.000023	0.00000015	0.00006
Benzo(ghi)perylene	0.00000008	0.0000000056	0.0000011	0.0000008	NA	0.000000014	NA	0.000000008	0.0000020
Chrysene	0.000021	0.0000013	0.000088	0.00014	0.00026	0.0000042	0.00031	0.0000026	0.0008
Dibenzo(a,h)anthracene	0.00000010	0.0000000048	0.0000037	0.0000007	0.00000011	0.000000018	0.0000021	0.000000011	0.000007
Fluoranthene	0.00027	0.000022	0.00070	0.0016	0.00066	0.000047	0.00069	0.000030	0.0040
Fluorene	0.0015	0.00022	0.0040	0.010	0.0022	0.00024	0.0022	0.00015	0.021
Indeno(1,2,3-c,d)pyrene	0.0000012	0.000000054	0.000015	0.000008	0.000041	0.00000021	0.000059	0.00000013	0.00012
Naphthalene	0.08	0.035	0.49	1.52	0.27	0.024	0.24	0.015	2.7
Phenanthrene	0.0028	0.00029	0.0052	0.013	0.0034	0.00059	0.0035	0.00037	0.029
Pyrene	0.00017	0.000014	0.00042	0.0009	0.00053	0.000039	0.00058	0.000024	0.0027
Benzene	0.008	0.0092	0.078	0.24	0.0034	0.014	0.0014	0.00087	0.36
Ethylbenzene	0.00028	0.00024	0.0031	0.008	0.0011	0.0020	0.00085	0.0010	0.017
Toluene	0.0038	0.0040	0.044	0.13	0.012	0.016	0.0082	0.0077	0.22
Xylenes, Total	0.00031	0.00029	0.0034	0.009	0.0012	0.0020	0.00092	0.0010	0.018
PCB Total	0.0009	0.00010	0.0015	0.0038	0.00087	0.00027	0.00093	0.00017	0.009
Dibenzofuran	0.0007	0.00016	0.0027	0.007	NA	0.00064	NA	0.00040	0.012
Vinyl Chloride	0.032	0.012	0.019	0.45	0.00	0.00	0.00	0.00	0.51
TOTAL	**0.14**	**0.06**	**0.67**	**2.43**	**0.31**	**0.06**	**0.27**	**0.03**	**4.0**

Attachment 1

Table 14. Annual Emissions during Dredging and CDF Operation – Drained Sediment Cells, Annual Dredging, Bi-Annual Disposal into Individual CDF Sediment Cells (Emissions in Tons)

	Unconfined DOU	Barge Transfer	Discharge Pipe	Ponded CDF During Disposal into CDF	Post-Disposal - Exposed Portions of Cell 1	Post-Disposal - Exposed Portion of Cell 1 (Sand Mound)	Post-Disposal - Exposed Portions of Cell 2	Post-Disposal - Exposed Portion of Cell 2 (Sand Mound)	Total Annual Emissions
Acenaphthene	0.0020	0.00052	0.0076	0.020	0.026	0.00044	0.016	0.00027	0.073
Acenaphthylene	0.0018	0.00035	0.0053	0.014	0.021	0.00034	0.013	0.00021	0.056
Anthracene	0.00017	0.000015	0.00032	0.0008	0.0029	0.000035	0.0018	0.000022	0.0060
Benzo(a)anthracene	0.00012	0.000012	0.00088	0.0012	0.0018	0.000017	0.0012	0.000010	0.0053
Benzo(b)fluoranthene	0.000002	0.00000011	0.000023	0.000015	0.00012	0.00000037	0.000079	0.00000023	0.00024
Benzo(k)fluoranthene	0.0000002	0.000000010	0.0000021	0.0000014	0.000015	0.000000035	0.000010	0.000000022	0.000028
Benzo(a)pyrene	0.000001	0.000000097	0.000017	0.000013	0.000080	0.00000024	0.000051	0.00000015	0.00016
Benzo(ghi)perylene	0.00000008	0.0000000056	0.0000011	0.0000008	0.0000069	0.000000014	0.0000044	0.000000008	0.000013
Chrysene	0.000021	0.0000013	0.000088	0.00014	0.00080	0.0000042	0.00051	0.0000026	0.0016
Dibenzo(a,h)anthracene	0.00000010	0.0000000048	0.0000037	0.0000007	0.0000083	0.000000018	0.0000053	0.000000011	0.000018
Fluoranthene	0.00027	0.000022	0.00070	0.0016	0.0045	0.000047	0.0029	0.000030	0.010
Fluorene	0.0015	0.00022	0.0040	0.010	0.015	0.00024	0.010	0.00015	0.041
Indeno(1,2,3-c,d)pyrene	0.0000012	0.000000054	0.000015	0.000008	0.000083	0.00000021	0.000053	0.00000013	0.00016
Naphthalene	0.08	0.035	0.49	1.52	1.43	0.024	0.85	0.015	4.5
Phenanthrene	0.0028	0.00029	0.0052	0.013	0.041	0.00059	0.026	0.00037	0.090
Pyrene	0.00017	0.000014	0.00042	0.0009	0.0042	0.000039	0.0027	0.000024	0.0085
Benzene	0.008	0.0092	0.078	0.24	0.30	0.014	0.0023	0.00087	0.66
Ethylbenzene	0.00028	0.00024	0.0031	0.008	0.034	0.0020	0.012	0.0010	0.060
Toluene	0.0038	0.0040	0.044	0.13	0.30	0.016	0.10	0.0077	0.60
Xylenes, Total	0.00031	0.00029	0.0034	0.009	0.033	0.0020	0.012	0.0010	0.062
PCB Total	0.0009	0.00010	0.0015	0.0038	0.017	0.00027	0.011	0.00017	0.034
Dibenzofuran	0.0007	0.00016	0.0027	0.007	0.0082	0.00064	0.0051	0.00040	0.025
Vinyl Chloride	0.032	0.012	0.019	0.45	0.00	0.00	0.00	0.00	0.51
TOTAL	**0.14**	**0.06**	**0.67**	**2.43**	**2.24**	**0.06**	**1.07**	**0.03**	**6.7**

Figure 1. Estimated Emissions Associated with Dredging Operation during Annual Dredging and Sediment Placement in CDF

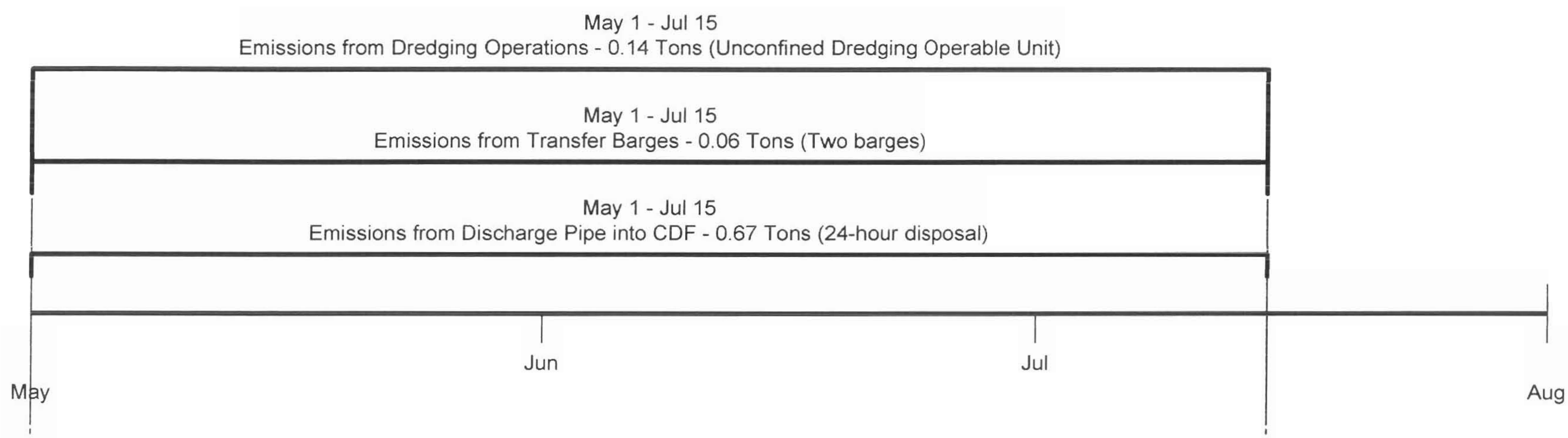


Figure 2. Estimated Emissions from Ponded Sediment Cells, Annual Dredging, Bi-Annual Disposal into Individual CDF Sediment Cells

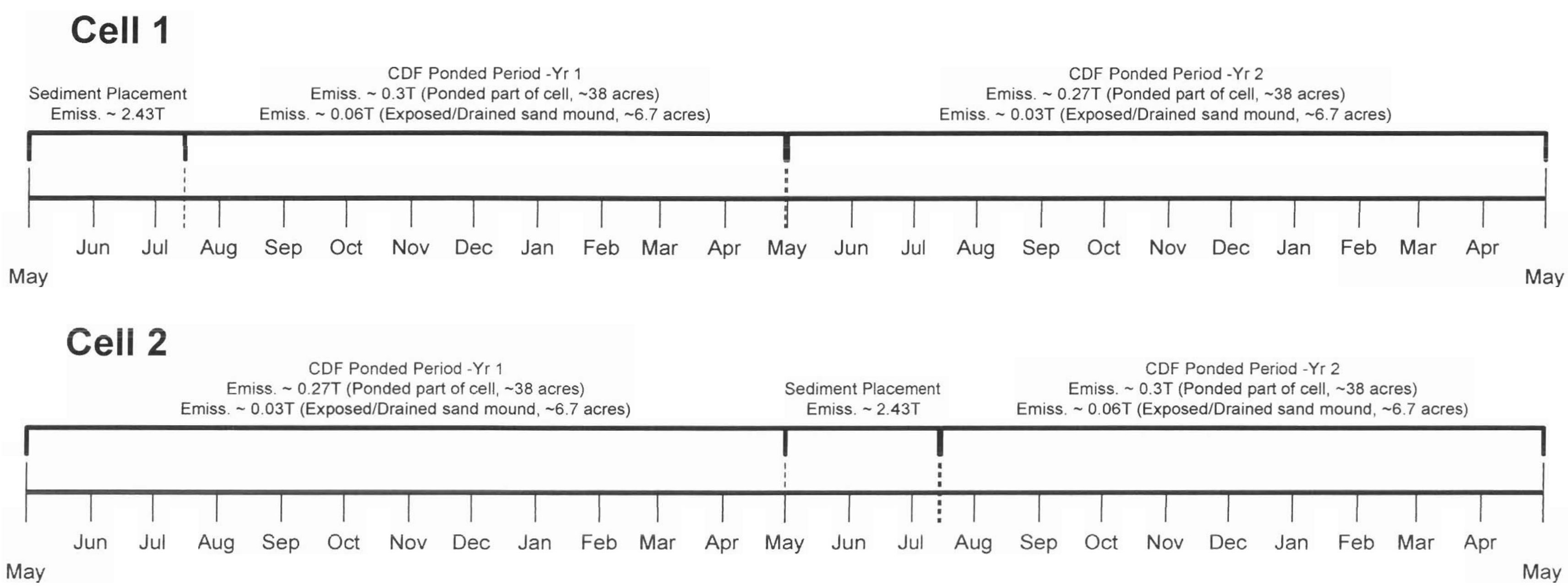
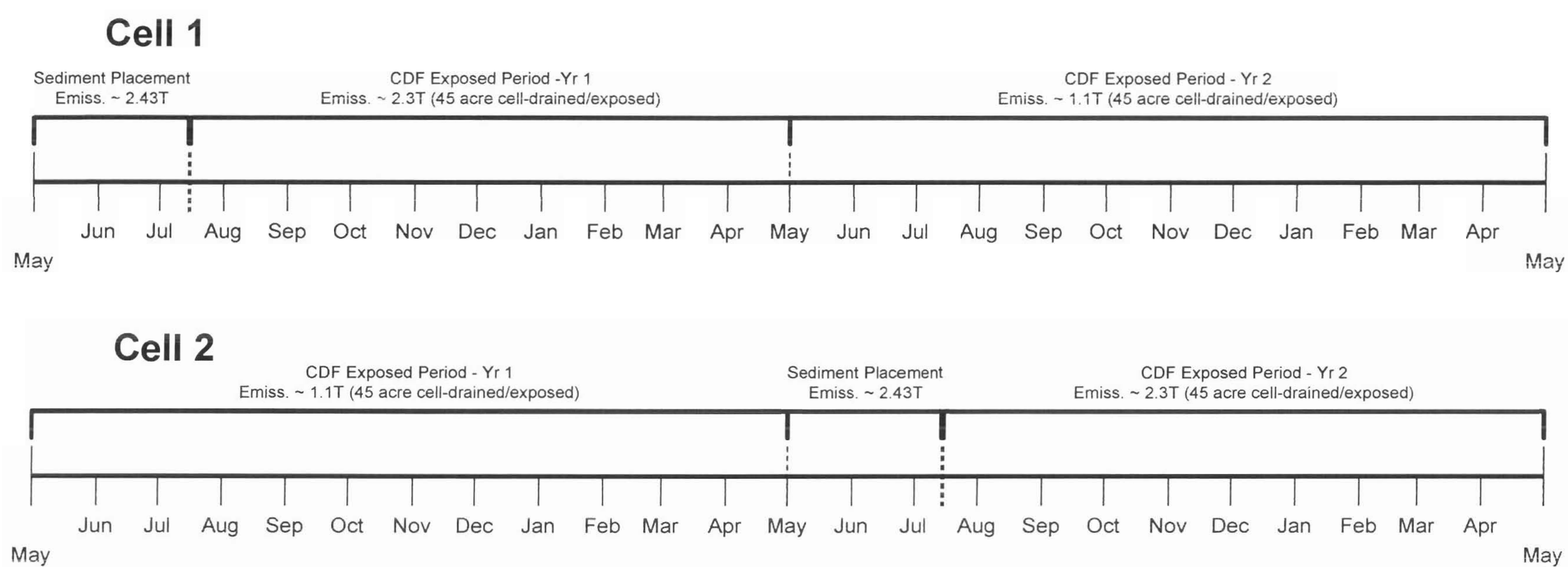


Figure 3. Estimated Emissions from Drained Sediment Cells, Annua Dredging, Bi-Annual Disposal into Individual CDF Sediment Cells



Attachment 2

15 September 2008

Storage and Dike Height Calculations for Indiana Harbor CDF

Consolidation Analysis for 200-KCY Lifts

Full Project: For 2 MCY in the first 10 years (200 KCY placed during year 0, 2, 4, 6 and 8 in Cell 1 and 200 KCY placed during year 1, 3, 5, 7 and 9 in Cell 2) and another 2 MCY in the following 20 years (200 KCY placed during year 11, 15, 19, 23 and 27 in Cell 1 and 200 KCY placed during year 12, 16, 20, 24 and 28 in Cell 2), the predicted stored dredged material heights are:

Permanently Ponded for 30 years without an equalization basin (two 51-acre storage cells)

Maximum Dredged Material Height (following last disposal in Year 27): **20.2 ft**

Dredged Material Height after 30 years (3 years after last lift): **18.2 ft** for 4 MCY

Dike Height Needed for 4.5 MCY: 22.5 ft Storage* + 2.0 ft Ponding** + 1.5 ft Precipitation + 3 ft Freeboard = **29.0 ft**

Ponded for only first 11 years (backlog) without an equalization basin (two 51-acre storage cells)

Maximum Dredged Material Height: Height (following last disposal): **18.4 ft**

Dredged Material Height after 30 years (3 years after last lift): **16.1 ft** for 4 MCY

Dike Height Needed for 4.5 MCY: 20.5 ft Storage* + 1.0 ft Ponding + 1.5 ft Precipitation + 3 ft Freeboard = **26.0 ft**

Moderately dewatered (perimeter trenching along all dikes as needed and runoff regularly transferred to equalization basin) with an equalization basin (two 45-acre storage cells)

Maximum Dredged Material Height: Height (following last disposal): **20.5 ft**

Dredged Material Height after 30 years (3 years after last lift): **18.0 ft** for 4 MCY

Dike Height Needed for 4.5 MCY: 23 ft Storage* + 1.0 ft Ponding + 0 ft Precipitation + 3 ft Freeboard = **27.0 ft**

* Storage for 4.5 MCY estimated from the storage for 4 MCY.

** Minimum of 2 ft of ponding assumed to maintain ponding across the entire area considering variable bottom height due to non-uniform spreading and wind impacts; only 1 ft of ponding assumed for final pond depth if it will be dewatered. 1 ft of ponding is assumed to be needed to facilitate recirculation (provide settling and free water for decanting).

Attachment 2

Stage 1 of Project (Backlog): For 2 MCY in the first 10 years (200 KCY placed during year 0, 2, 4, 6 and 8 in Cell 1 and 200 KCY placed during year 1, 3, 5, 7 and 9 in Cell 2), the predicted stored dredged material heights are:

Permanently Ponded for 10 years without an equalization basin (two 51-acre storage cells)

Maximum Dredged Material Height: Height (following last disposal): **12.2 ft**

Dredged Material Height after 10 years (2 years after last lift): **10.3 ft**

Dike Height Needed for 2 MCY: 12.2 ft Storage + 2.0 ft Ponding + 1.5 ft Precipitation + 3 ft Freeboard = **18.7 ft**

Moderately Dewatered (perimeter trenching along all dikes as needed and runoff regularly transferred to equalization basin) for 10 years with an equalization basin (two 45-acre storage cells)

Maximum Dredged Material Height: Height (following last disposal): **12.3 ft**

After 10 years (2 years of consolidation after last lift): **9.8 ft**

Dike Height Needed for 2 MCY: 12.3 ft Storage + 1.0 ft Ponding + 0 ft Precipitation + 3 ft Freeboard = **16.3 ft**

Rapid Removal of Backlog Sediments on Full Project Storage: For 2 MCY in the first 5 years (400 KCY placed in Cell 1during year 0 and 2 and 200 KCY placed during year 4, and 400 KCY placed in Cell 2 during year 1 and 3 and 200 KCY placed during year 4) and another 2.0 MCY in the following 22 years (200 KCY placed during year 6, 10, 14, 18, and 22 in Cell 1 and 200 KCY placed during year 8, 12, 16, 20, 24 and 28 in Cell 2), the predicted stored dredged material heights are:

Permanently Ponded for 30 years without an equalization basin (two 51-acre storage cells)

Maximum Height: 20.3 ft following last disposal in Year 22

After 25 years (3 years of consolidation after last lift): **18.1 ft**

Dike height needed for 4.5 MCY: 22.8 ft Storage* + 2.0 ft Ponding** + 1.5 ft Precipitation + 3 ft Freeboard = **29.3 ft**

Ponded for only first 6 years without an equalization basin (two 51-acre storage cells)

Maximum Height: 18.4 ft following last disposal

After 25 years (3 years of consolidation after last lift): **16.1 ft**

Dike height needed for 4.5 MCY: 20.7 ft Storage* + 1.0 ft Ponding + 1.5 ft Precipitation + 3 ft Freeboard = **26.2 ft**

Attachment 2

Moderately dewatered (perimeter trenching along all dikes as needed and runoff regularly transferred to equalization basin) with an equalization basin (two 45-acre storage cells)

Maximum Height: **20.7 ft** following last disposal

After 25 years (3 years of consolidation after last lift): **18.2 ft**

Dike height needed for 4.5 MCY: 23.3 ft Storage* + 1.0 ft Ponding + 0 ft Precipitation + 3 ft Freeboard = **27.3 ft**

* Storage for 4.5 MCY estimated from the storage for 4 MCY.

** Minimum of 2 ft of ponding assumed to maintain ponding across the entire area considering variable bottom height due to non-uniform spreading and wind impacts; only 1 ft of ponding assumed for final pond depth if it will be dewatered. 1 ft of ponding is assumed to be needed to facilitate recirculation (provide settling and free water for decanting).

Required Interior Dike Heights

The required interior dike heights as a function of the number of 200-KCY lifts placed in a cell are shown in the tables below. If a 400-KCY lift were placed in a cell, it is shown as two lifts in the same row of the table. The results are shown for the anticipated dredging schedule and an accelerated dredging schedule for the backlog dredging. The results also provide an indication of the effects of disposal of additional projects such as the Grand Calumet dredging in the same facility while disposing Indiana Harbor sediments.

Attachment 2

For 200-KCY Lifts:

Lift	Scenarios					
	Permanently Ponded		Ponded for Backlog		Dewatered	
	Maximum Dredged Material Height, ft	Interior Dike Height Needed[1], ft	Maximum Dredged Material Height, ft	Interior Dike Height Needed[2], ft	Maximum Dredged Material Height, ft	Interior Dike Height Needed[3], ft
1	3.8	10.3	3.8	10.3	4.3	8.3
2	6.2	12.7	6.2	12.7	6.5	10.5
3	8.2	14.7	8.2	14.7	8.6	12.6
4	10.2	16.7	10.2	16.7	10.5	14.5
5	12.1	18.6	12.1	18.6	12.3	16.3
6	13.8	20.3	13.7	17.7	13.8	17.8
7	15.3	21.8	14.7	18.7	15.4	19.4
8	16.9	23.4	15.7	19.7	17.1	21.1
9	18.5	25.0	17.0	21.0	18.8	22.8
10	20.2	26.7	18.4	22.4	20.5	24.5

[1] Storage + 2.0 ft Ponding + 1.5 ft Precipitation + 3 ft Freeboard
[2] Storage + 2.0 ft Ponding + 1.5 ft Precipitation + 3 ft Freeboard during backlog;
Storage + 1.0 ft Ponding + 0 ft Precipitation + 3 ft Freeboard during maintenance
[3] Storage + 1.0 ft Ponding + 0 ft Precipitation + 3 ft Freeboard

For Rapid Removal of Backlog (400-KCY Lifts in Years 0 to 4):

Lift	Scenarios					
	Permanently Ponded		Ponded for Backlog		Dewatered	
	Maximum Dredged Material Height, ft	Interior Dike Height Needed[1], ft	Maximum Dredged Material Height, ft	Interior Dike Height Needed[2], ft	Maximum Dredged Material Height, ft	Interior Dike Height Needed[3], ft
1-2	7.6	14.1	7.6	14.1	8.6	12.6
3-4	12.3	18.8	12.3	18.8	13.6	17.6
5	14.1	20.6	14.1	20.6	15.8	19.8
6	14.6	21.1	14.3	18.3	16.1	20.1
7	15.7	22.2	15.1	19.1	16.6	20.6
8	17.2	23.7	15.9	19.9	17.6	21.6
9	18.7	25.2	17.0	21.0	19.1	23.1
10	20.3	26.8	18.4	22.4	20.7	24.7

Storage + 2.0 ft Ponding + 1.5 ft Precipitation + 3 ft Freeboard
Storage + 2.0 ft Ponding + 1.5 ft Precipitation + 3 ft Freeboard during backlog;
Storage + 1.0 ft Ponding + 0 ft Precipitation + 3 ft Freeboard during maintenance
[3] Storage + 1.0 ft Ponding + 0 ft Precipitation + 3 ft Freeboard

Attachment 2

Rapid backlog removal increases storage needs by 0 to 0.2 ft over the life of the project (4.5 MCY) and 2.0 to 3.5 ft over the backlog period (2.0 MCY).

Prepared for Indiana Harbor CDF PDT by:

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Attachment 3

Estimated Savings in Wastewater Treatment Costs for Ponded CDF Operation

Estimated based on costs provided in the IHC Wastewater Treatment Plan Final Design

	Volume treated in Mgal	Volume treated in Mgal	
O&M Cost for Season:	**54**	30	**NOTE: IF CDF IS OPERATED PONDED, THE VOLUME OF WATER TO BE TREATED DECREASES FROM 55 Mgal to Mgal**
		44%	Reduction in treatment volume
Season Duration (wk):	23.0	23.0	Cost estimate for 30 Mgal assumes same treatment season as 55 Mgal (4 months)

Weekly O&M Per Process:

SiteWork	$1,688	$1,688	Fixed cost
Inlet Surge Tank	$2,118	$1,763	Prorated by materials, supplies, & power but NOT labor
Flash Mix & Clarification	$6,589	$5,576	Prorated by materials, supplies, & power but NOT labor
SBR	$7,953	$7,143	Prorated by materials, supplies, & power but NOT labor
Sand Filtration	$2,347	$2,226	Prorated by materials, supplies, & power but NOT labor
Backwash Holding Tank	$1,109	$1,058	Prorated by materials, supplies, & power but NOT labor
GAC Filtration	$10,222	$6,735	Prorated by materials, supplies, & power but NOT labor
Effluent Holding Tank	$2,369	$2,009	Prorated by materials, supplies, & power but NOT labor
Emergency Overflow Sump	$838	$823	Prorated by materials, supplies, & power but NOT labor
General WWTP Operation	$953	$953	Fixed cost
Non-Operating Labor	$279	$279	Fixed cost
Subtotal Weekly O&M:	$36,466	$30,253	Total Weekly Operating Cost for 30 Mgal
	$838,713	**$695,819**	**Annual Operating Cost**
		17%	Reduction in treatment cost

Assumptions:

1. Volume of water is reduced from 55 Mgal to 30 Mgal.
2. Duration of treatment season is the same (4 months)
3. Unit processes are the same.
4. Labor is fixed since the same personnel will be on site.

Attachment 4

Estimated Cost Reduction for Elimination of Equalization Basin, Realignment of Dikes

As of the 100% design milestone (November 2007), the cost estimate for Dikes III was $12.7 M. A specific line item for the EQ basin was called out in the estimate (including the liner, etc) at a cost of $3.5 M. The entire cost of the equalization basin would be eliminated because the entire equalization basin would be eliminated under a ponded CDF operation scenario.

The 100% Dikes III design also included decant structure costs. Individual decant structures (3 of them) were called out in the estimate, a single one was approximated at $650K. With a ponded CDF, one decant structure would be eliminated.

Finally, a total of 199,000 cy of clay dike material was called out in the Dikes III estimate, for a total cost of approximately $4.3 M. The volume of clay material that could be removed by eliminating the northern/western "elbow" formed by the EQ basin was estimated to be approximately 98,600 cyd. However, additional material would be needed for the realigned center dike and the wider width based, as shown in the figure below. Conservatively then, it was assumed that there would be no cost savings in clay dike material. Some cost savings may be realized if the center dike is constructed with steeper slopes or from material collected from on-site; this decision is independent of the decision to operate the CDF as a ponded facility and will be made and documented separately.

The summary cost savings for eliminating the equalization basin and decant structure would be:

$ 3.5 M - EQ Basin Line Item
$ 0.65 M - Decant Structure

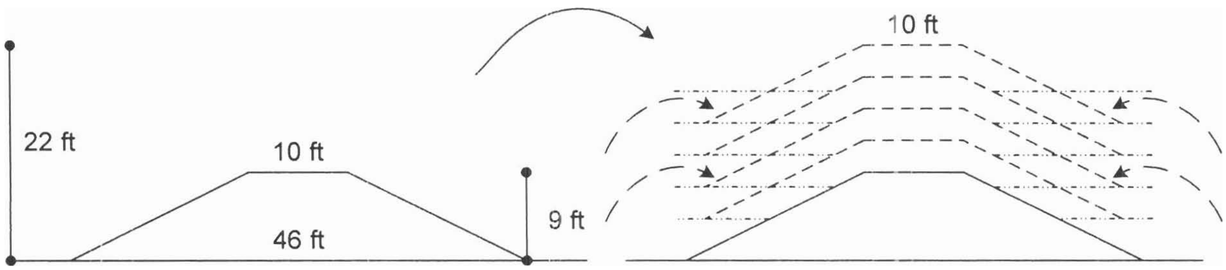
$ 4.15 M Cost Reduction

This would be a one time capital cost savings for the CDF construction.

Attachment 4

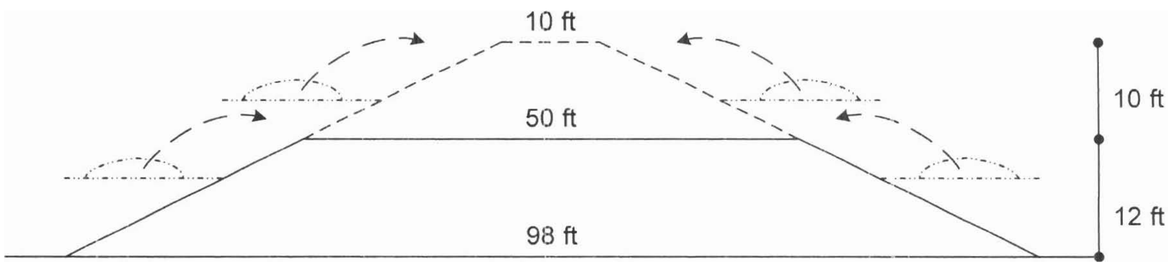
A) Existing Design - Desiccated Scenario

Volume of Material to Construct Base of Center Dike: **27,100 yd³**



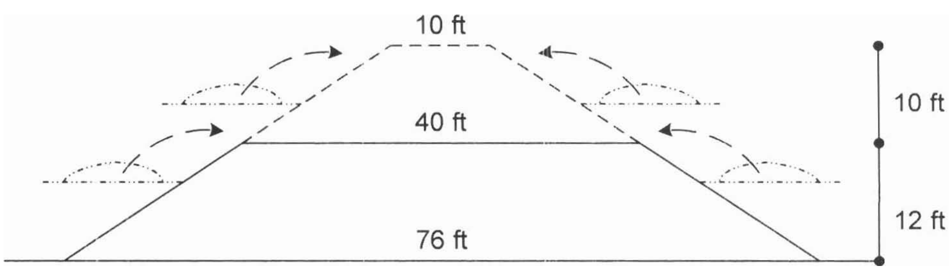
B) Proposed Design - Ponded Scenario (2:1)

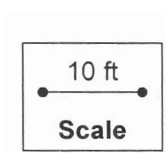
Volume of Material to Construct Base of Center Dike: **95,400 yd³**



C) Proposed Design - Ponded Scenario (1.5:1)

Volume of Material to Construct Base of Center Dike: **74,800 yd³**





Attachment 5

Miller, Jennifer LRC

From: Wethington, David M LRC
Sent: Friday, February 01, 2008 9:02 AM
To: Deda, Roy J LRC; Sorn, Linda M LRC; Abou-El-Seoud, Shamel LRC; Schmidt, Joseph J LRC; Wethington, David M LRC
Subject: IHC CDF Path Forward, 31-Jan-2008 (UNCLASSIFIED)

Classification: UNCLASSIFIED
Caveats: NONE

All,

In the interest of capturing a conversation which was held on January 31, 2008, this E-mail documents several key operational points, establishing a "path forward" for the Indiana Harbor and Canal Federal Navigation Project.

1) The CDF is being designed to contain approximately 4.6 million cubic yards of sediment, dredged from the Federal and non-Federal portions of the Indiana Harbor Ship Canal.

2) In order to achieve this capacity, it is anticipated that the CDF will be constructed in two lifts.

2) The operational life of the CDF is designed to be 30 years.

3) It is the Chicago District's intent to permit the CDF as a TSCA facility. Further investigation as to the benefits/disadvantages to limiting disposal of TSCA materials to a single cell (as opposed to utilizing both cells) is being conducted by the Hydraulics and Environmental Engineering Section (TS-DH). Results of that investigation will be documented by TS-DH, and an operational decision will be made in consultation with the Construction-Operations Branch, as well as the Indiana Harbor PDT.

Parties present to this conversation are copied on the distribution list of this E-mail, as well as listed below:

Roy Deda, Deputy for Project Management
Linda Sorn, Chief Technical Services Division Shamel Abou-el-Seoud, Chief Construction-Operations Branch Joseph Schmidt, Chief Design Branch Dave Wethington, Project Manager

In addition, the IHC PDT has been briefed (during a team meeting of the same date) on this path forward.

If anyone has any questions, concerns, or modifications, please contact me by noon, 04-Feb-2008, otherwise I will pass this along to the IHC Team as an FYI.

Regards,
Dave

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Classification: UNCLASSIFIED
Caveats: NONE