Observations Regarding Brownfields and Sediment Disposal at Indiana Harbor

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Abstract

To date, the 25-year delay in dredging the federal project at Indiana Harbor in East Chicago, IN, has emphasized the difficulties associated with implementing the current federal approach to the disposal of contaminated sediments in the Great Lakes. The current method is premised upon the availability and provision of a clean, close, cost-free upland or in-water site, which reverts back to the provider after disposal operations have ceased. An urban setting, high contaminant concentrations, and liability concerns have made application of this strategy at Indiana Harbor especially challenging. Efforts to predict the liability exposure associated with the use of a former refinery to dispose of Indiana Harbor sediments have raised issues which may possess generic utility. Concepts rooted in these issues suggest a new approach for the disposal of contaminated sediments. The new approach would preferentially select contaminated brownfield sites associated with especially challenging remedial issues for the construction of sediment disposal facilities. Properly implemented, this would enhance public acceptance, reduce expenditures, remediate unaddressed contaminated sites and allow problematic dredging projects to proceed in a more timely fashion.

The views contained in this paper represent those of the authors and not the policies or positions of the U.S. EPA or the USACE.

Introduction

Every year in the Great Lakes approximately 4 million cubic yards of sediments are dredged. Most of the dredging is performed to maintain safe depths for commercial and recreational navigation. Approximately half of these dredged materials are clean, and can be disposed in an unrestricted manner. The remaining 50% of the sediments dredged (2 million cubic yards) are sufficiently contaminated to preclude direct release to the environment. Although some contaminated dredged material may be suitable for beneficial uses such as daily landfill cover or fill, such low-cost environmentally acceptable disposal options are not always available. In the absence of such disposal options, contaminated dredged materials are generally placed in a confined disposal facility (CDF).

The United States Army Corps of Engineers (USACE) constructs CDFs for the disposal of contaminated sediments dredged from federal navigation projects. In several cases, CDFs have also been constructed for the disposal of clean material where open-water disposal was infeasible and a beneficial use was not identified. CDF designs reflect both the nature of the sediments slated for disposal and characteristics of the disposal site (1). CDFs constructed at upland sites typically resemble a simple landfill, consisting of a perimeter earthen dike with a weir for sediment dewatering. CDFs have also been constructed in open-water settings, commonly with perimeter dikes of graded stone. The graded stone dike functions as a large filter, retaining the sediment particles while allowing the free passage of water. The USACE has constructed some 44 CDFs for the disposal of contaminated dredged material from navigation projects in the Great Lakes. The size of these facilities ranges from several to hundreds of acres, with capacities of less than 100,000 to more than 15 million cubic yards.

The siting, construction, operation and closure of CDFs are handled by the USACE under its civil works project guidance. Application of this guidance is focused upon the identification of a "local sponsor" for the proposed dredging project. Referred to as "lands, easements & rights-of-way," the central responsibility of the local sponsor is to provide the USACE with a piece of property for the construction of the CDF. According to the civil works guidance (2), the site must be environmentally clean, suitably close to the water body under consideration, sufficiently sized to meet the projected disposal needs and without debilitating access problems or other restrictions. This regulation specifically mandates that the site either be uncontaminated initially or that the local sponsor render the site clean before providing it to the Corps. The purpose of this requirement is the elimination of any potential state or federal Superfund liability under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) or hazardous waste liability under the Resource Conservation and Recovery Act (RCRA-Subtitle C), due to the provision of a contaminated site by a local sponsor.

The Water Resource Development Act of 1996 contains several sections which clarify federal policy on CDFs, including the responsibilities of local sponsors. For all deep-draft navigation projects (<18 feet), the local sponsor must provide a share of the construction costs as well as the land, easements and rights-of-way for the CDF. The cash cost share for the local sponsor ranges from 25 to 50%, depending upon the depth of the harbor and the value of the property used for CDF construction. The local sponsor must be a public entity with taxing authority; typically a municipality, county, state or in several cases a port authority. Once the facility is constructed, filled with sediments and closed, the site and CDF revert back to the local sponsor for long-term care and maintenance.

As discussed below, this approach is difficult to apply and can act as a barrier to the timely implementation of navigation dredging projects. In addition to implementation problems, many of the perceived clean-site benefits as well as contaminated-site liabilities could prove illusionary.

The Two Traditional Approaches And Associated Problems

The In-Water Approach

In practice, the CDF siting strategy has been implemented in the Great Lakes in one of two ways. The more common scenario centers upon a local sponsor providing the USACE with a near-shore portion of lake or river bottom upon which a CDF can be constructed and filled. After filling and final closure, the site and the CDF reverts back to the sponsor for long-term maintenance and care. This approach is generally workable if the sediments slated for disposal are viewed as only mildly contaminated (i.e., could be essentially considered fill) and the environmental concerns associated with the project are regarded as limited. In-water sponsor identification can also be relatively straightforward, as a subaqueous site provided to the USACE at nominal cost can result in the acquisition of a valuable piece of waterfront property. In essence, the closed CDF's value as real estate compensates for the costs of maintenance and monitoring, as well as making any liability concerns more palatable. However, if the contaminant concentrations are viewed as elevated, implementation of the in-water approach tends to become problematic. In this case, environmental concerns can cause the in-lake/water CDF disposal to become highly controversial, dissipate local support and make regulatory approval questionable.

In February of 1986, the problems this scenario can entail were manifested with effect by a previous attempt to dredge Indiana Harbor. A Draft Environmental Impact Statement (DEIS) was prepared and released under the National Environmental Policy Act (NEPA) (3). The preferred alternative in the 1986 DEIS consisted of the construction of an in-lake CDF. The closed facility would have formed a small island in Lake Michigan just east of Jeorse Park in East Chicago, IN. Due to elevated contaminant concentrations (documented in the DEIS) and the associated environmental considerations, local, state and federal opposition became strident. After the inevitable delays and significant negative press, the proposal was dropped.

The Upland Approach

The second CDF siting scenario is premised upon a local sponsor providing a clean upland site at no cost to the USACE for CDF construction and sediment disposal. Like an in-water site, the CDF subsequently reverts back to the local sponsor after closure. As noted, in addition to the need for a suitably sized proximal site USACE policy has traditionally required that the site be uncontaminated. This requirement is in accordance with USACE guidance and is consistent with generally held presumptions regarding future liability and site preparation costs.

Not surprisingly, implementation of the upland disposal scenario for highly contaminated sediments (e.g., Indiana Harbor) has also proven difficult. Like Indiana Harbor, most federal dredging projects are found in highly urbanized/industrial settings, where clean, adequately sized sites are rare. Should an acceptable contaminant-free site be identified, its acquisition is almost invariably not cost free. Apparently, few entities seem willing to provide clean, multiple-acre urban sites to the federal government for the land disposal of contaminated sediments without compensation. In addition, but in contrast to the filled-inlake CDF (i.e., newly created waterfront property), reacquiring an upland site after CDF closure is generally not viewed as economically advantageous. Above and beyond maintenance responsibilities and costs, the local sponsor may also have significant concerns regarding site liability.

Lastly, as the public views an upland CDF as a landfill, the necessary public support can also be limited. Because of the urban setting, the surviving clean, adequately sized sites proximal to many federal projects exist primarily as parks or preserves. Other sites may have escaped industrialization because of the presence of wetlands and are now unavailable because of their ecological importance and state and federal protection. Invariably, local preferences for the use of these relatively rare uncontaminated properties do not include the construction of land disposal facilities, and upland CDF proposals typically find little or no support from either the local community or environmental organizations. Should the selected proposal require trucking the sediments from the federal project to the upland CDF site, the costs of transportation can be coupled with enhanced local concerns and opposition.

Application at Indiana Harbor

The difficulties outlined above tend to magnify as sediment contaminant levels increase, making efforts to implement either the in-water or the upland disposal scenarios at Indiana Harbor especially difficult. The highly industrialized urban setting in conjunction with the no-contamination stipulation in the Corps' civil works guidance, disqualified numerous sites proximal to the navigation channel from further consideration. Of the 20 clean sites identified and subjected to varying degrees of further review, all were eliminated due to excessive acquisition costs or distances to the federal project, insufficient acreage, and/or wetland or ecologic issues.

The inability of the standard federal approach to effectively identify an acceptable disposal site has precluded dredging Indiana Harbor for over 25 years. The absence of dredging has imparted a significant environmental cost on Lake Michigan in the form of the continual and unhindered migration of the grossly contaminated project sediments into the southern portion of the basin. The nature of the project sediments is discussed later in the paper. As the factors hindering disposal site selection are unlikely to abate, consideration of other disposal strategies is warranted. The purpose of this paper is to suggest and outline an alternative approach.

Navigational Projects And Brownfields

The United States Environmental Protection Agency (USEPA) has defined brownfields as abandoned, idled or under-utilized industrial or commercial sites where expansion and redevelopment is hindered by real or perceived environmental contamination (4). Ownership of brownfield sites can range from private individuals and corporations to states or municipalities which acquired the property through tax default. The current brownfield site owner may have had little or no involvement with the activities which contaminated the site and is commonly unable or unwilling to finance the site's remediation. Brownfield redevelopment can mitigate the need to develop pristine, ecologically valuable areas, while increasing the economic viability of the surrounding community through supporting the local tax base and creating jobs. Unlike the rare and costly clean properties, brownfield sites are frequently common in urban settings.

As reflected in the USACE regulation, the real or perceived presence of environmental contamination fosters reluctance on the part of owners and potential developers to invest in the site. This hesitation is a manifestation of the concern that they could become liable for site remediation even if they had no involvement with the contamination of the property. Financial institutions are also disinclined to grant loans on brownfield properties because of the same liability concerns and the fear that the remedial costs could exceed the value of the property (4).

Although reluctant to spend large sums on remediation, current brownfield owners are frequently anxious to find a productive use for their vacant or under-utilized property. Site-use proposals which would address at least a portion of the site's remedial needs would receive receptive consideration from many brownfield owners. Use scenarios coupled to entities willing to share in remedial costs and other liabilities (real or perceived), should be especially welcome. If remedial expenditures can be kept reasonable, brownfield investors would be attracted by low costs of site acquisition or access, centralized urban locations, and the likelihood of sharing the remedial costs and any liability with the current owner as well as any associated potentially responsible parties (PRPs). Site-use proposals coupled with remediation may also prove more acceptable to the local community and interested environmental groups. Given an estimated 450,000 brownfield sites in the U.S. (4) and the tendency for these sites to concentrate in the historically urbanized and industrialized areas which surround federal navigation projects, brownfield candidate sites should be readily identifiable at many locations where CDFs are needed.

The remedial needs of brownfield sites can range from the trivial to the intractable. This range is a reflection of the nature of the hydrogeologic factors at the site and the nature and extent of the contamination. Through the Technical Impracticability (TI) guidance, the USEPA has acknowledged that the presence of immiscible nonaqueous phase liquids (NAPLs) at a site can entail remedial issues which are especially challenging and which may pose technical limitations to aquifer restoration (5). Essentially this is due to the immobility of a significant portion of the NAPL contamination under most groundwater flow conditions. The immobile NAPL

fraction resides as small discontinuous accumulations in the pore space of the geologic material, and is termed, residual saturation (V_{NAPL}/V_{VOIDS}) (6, 7). The concept of residual saturation has long been recognized by the petroleum industry as a limitation to the recovery of crude oil from petroleum reservoirs (8). Residual saturation for NAPLs typically ranges from 10 to 20% in the unsaturated zone, and from 10 to 50% saturated zone (6, 7). NAPLs can be both more dense than water (DNAPLs), or less dense than water (LNAPLs). LNAPL accumulations are commonly composed of hydrocarbons and can generally be found at sites associated with the refining and storage of crude oil products.

The remedial technologies available to address NAPL contamination are not as advanced as the approaches developed for other groundwater contamination problems (6, 9, 10). NAPL accumulations at residual saturation can act as a significant and long-term source of groundwater contamination (6). Due to the practical limitations regarding NAPL recovery, containment of the NAPL may be a technically implementable and environmentally acceptable remedial option (7).

Conceptually, containment can be conducted in one of four ways. While not eliminating the source of the contamination, the purpose behind all containment approaches is to render the impact of the contamination in the area to be contained on adjacent areas environmentally negligible. With proper consideration of the site's hydrogeology, all of the containment approaches discussed below can be incorporated into the design of the CDF.

The first approach relies on the manipulation of the groundwater gradients in the vicinity of the region under consideration through the creation of areas of low hydraulic head. This can eliminate or significantly mitigate the migration of impacted water from the area to be contained. Gradient alteration is generally conducted by the placement of water removal mechanisms (commonly in the form of wells). Without the physical placement of a barrier material between the area to be segregated and the adjacent areas of the site, hydraulic isolation can effectively segregate the contaminated area from the other portions of the site. In contrast, a second approach would rely on the placement of a physical barrier between the contamination and the adjacent materials. Usually a barrier material associated with a reduced ability to transmit water (e.g., hydraulic conductivity values in the range of 10^{-6} to 10^{-7} cm/s, comparable to a compacted soil liner) would be constructed around the area to be isolated. A third approach is a composite design which couples both of the gradient control and barrier placement approaches. Specifically, this involves constructing a barrier with a reduced ability to transmit around the area to be isolated and placing a water removal mechanism within the interior side of the perimeter to control the hydraulic gradient. Most containment systems which incorporate physical barriers also include groundwater extraction (7). Currently, a fourth approach is receiving much attention and is actively being investigated by the research community (7, 11). This method consists of surrounding the area to be contained (or at least a section of the down-gradient boundary) with a barrier composed of a reactive material. As impacted groundwater migrates through the reactive barrier, the contaminant concentration(s) is sufficiently reduced through chemical, physical or biological processes to meet the remedial needs of the site.

At brownfield sites where containment is viewed as an appropriate remedial goal, the remedial containment components could be incorporated into the proposed CDF design. Such a "composite or remedial CDF," addressing at least a portion of the site's environmental needs could significantly enhance the potential for local acceptance as well as support from interested environmental organizations. After closure of the CDF, the property could be used for a variety of low-impact applications, such as parks (e.g., a golf course), or light industry.

The Indiana Harbor Experience

Indiana Harbor

The Grand Calumet River and the Indiana Harbor Canal (GCR/IHC) drain an area of approximately 174 km² (67 mi²) located on the southern shore of Lake Michigan in northwest Indiana (12) (Figure 1). The area surrounding the GCR/IHC is home to one of the most significant concentrations of heavy industry in the world. The federal navigation project extends from the harbor at Lake Michigan to approximately 4 miles upstream and covers approximately 265 acres (Figure 2). Initially a drainage ditch, the federal project at Indiana Harbor was originally authorized by the River and Harbor Act of 1910, and has been repeatedly widened, deepened and dredged since that time. Sediments which enter the GCR/IHC tend to accumulate in the artificially deepened federal navigation channel, reducing depths and ultimately restricting navigation traffic. In order to maintain adequate navigational depths, the USACE is authorized to dredge these sediments when necessary.

From 1955 to 1972, approximately 75,000 m³ of sediments were dredged annually from the federal project at Indiana Harbor (12). Until 1966, dredged materials were dumped directly into Lake Michigan at approved open-lake disposal areas. During the next several years, maintenance dredgings were placed at several lake-fill disposal sites in the vicinity of the project. However, since 1972, the inability to identify an acceptable disposal site has precluded dredging. This has resulted in the accumulation of over 760,000 m³ (one million cubic yards) of highly contaminated sediments within the limits of the federal project.

Current contaminant sources for the federal project include municipal and industrial discharges, combined sewer overflows, runoff from urban and industrial areas, contaminated sediment migration from the upstream river reaches, and potential erosion of contaminated soil

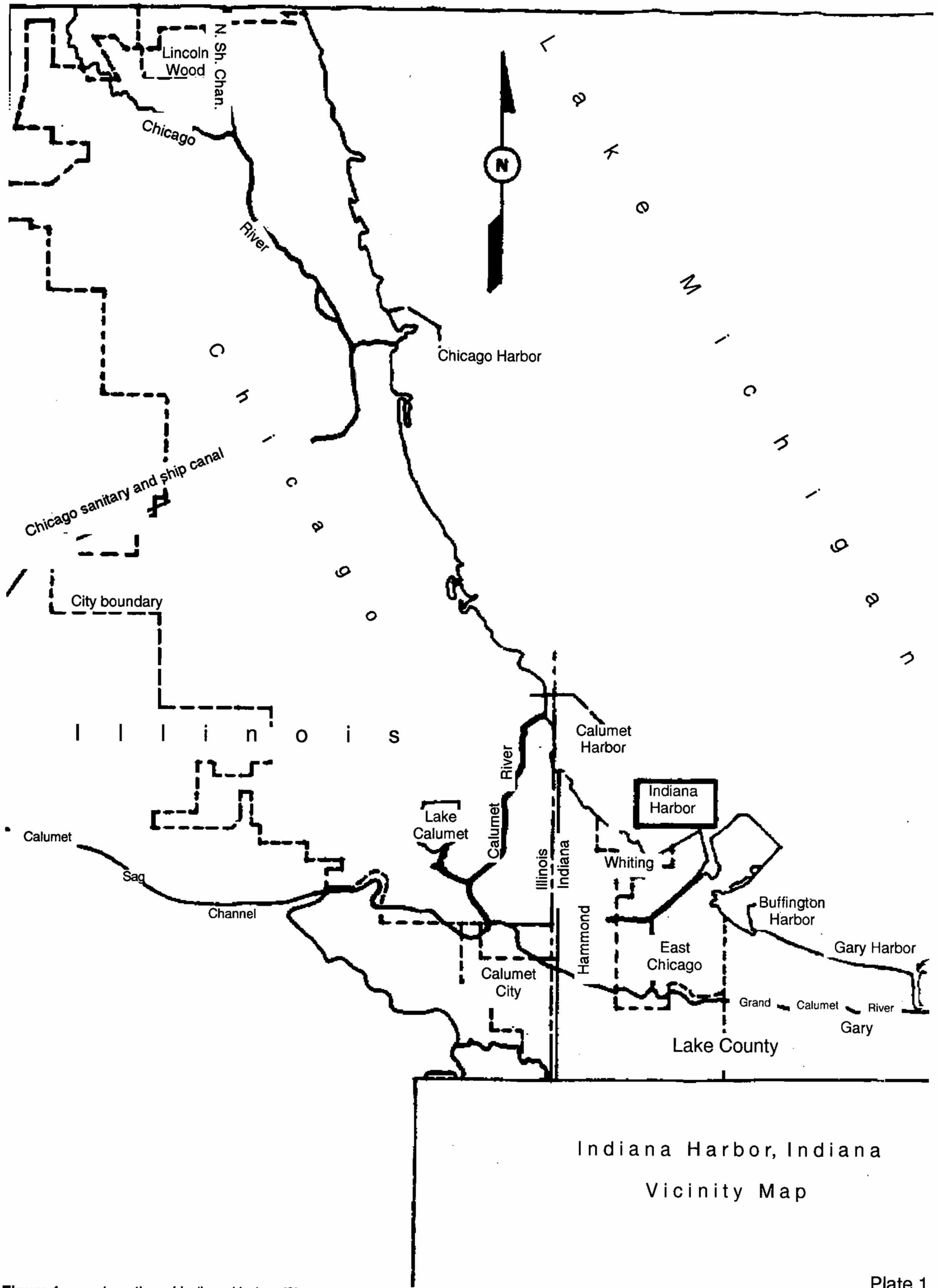

Figure 1. Location of Indiana Harbor (3).

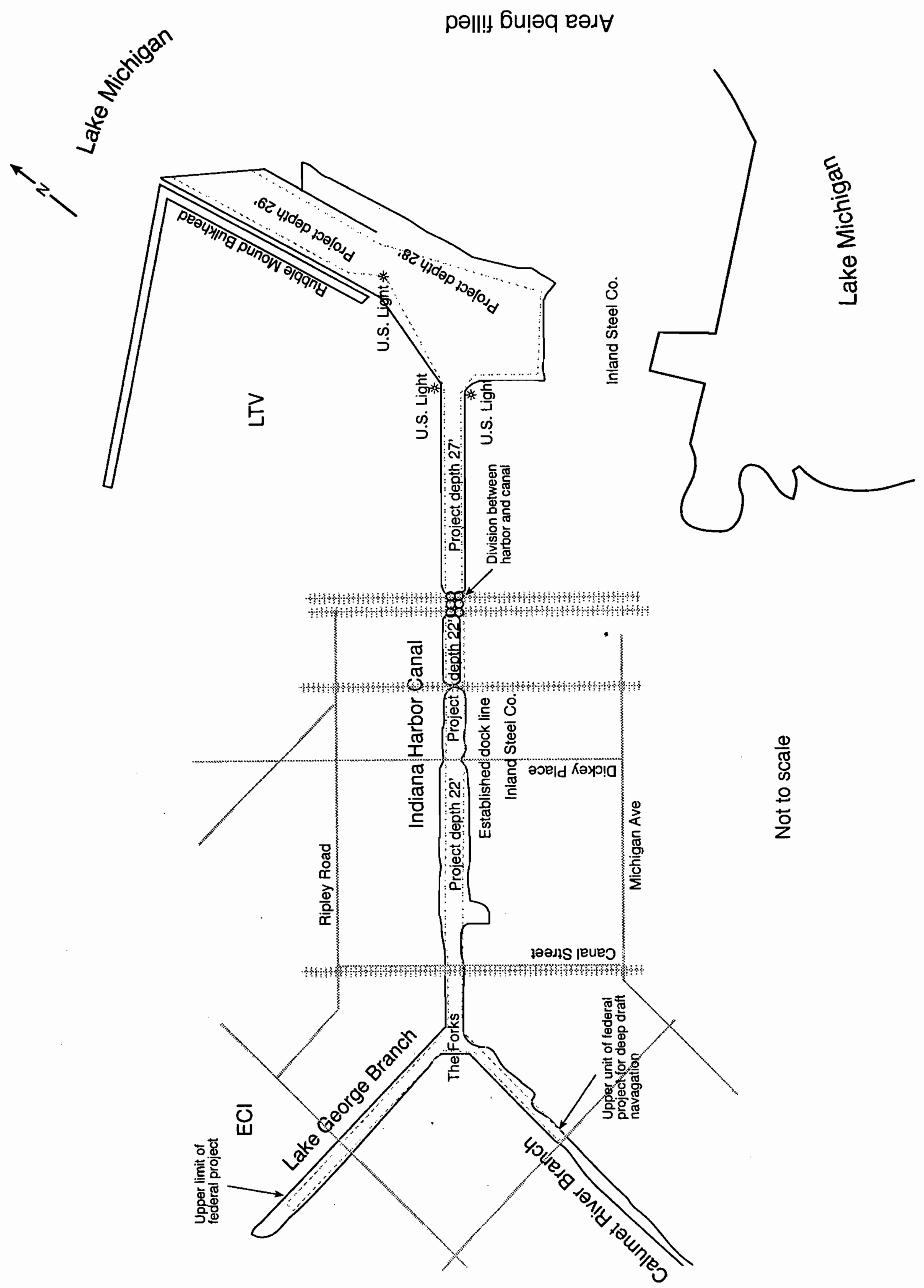

Figure 2. Federal navigation project at Indiana Harbor (12).

and fill along the unrestrained portions of the channel banks. Municipal and industrial discharges, combined sewer overflows and urban runoff have been estimated to contribute over 110,000 m^3 of sediment to the IHC/GCR annually (12). A significant portion of the existing sediment contamination is considered to be the result of spills and point-source releases which predated most of the current federal and state environmental legislation including the Clean Water Act.

Indiana Harbor contains some of the most heavily contaminated sediments in the Great Lakes. The bottom sediments in all portions of the IHC/GCR are known to be associated with a variety of contaminants, including free phase oil, polychlorinated biphenyls (PCBs), polycyclic aromatic compounds (PAHs), volatile organic compounds, and heavy metals. For example, dry weight oil and grease concentrations for 0.91 m (3 ft) core samples collected by the USACE in 1979 from 13 locations within the project, averaged 56,146 mg/kg (3). In 1973, the IHC/GCR were designated a "Problem Area" by the International Joint Commission (IJC) for the Great Lakes. In addition, the project sediments have been classified as "heavily polluted," under the USEPA 1977 Guidelines for the Pollutional Classification of Great Lakes Harbor Sediments (13), and in 1981, the IJC designated IH/GCR as one of the Areas of Concern (AOC) around the Great Lakes (12). Two reaches of the channel have been found to contain PCB concentrations exceeding 50 ppm, and would be regulated under the Toxic Substance Control Act (TSCA) if dredged. Through a sampling effort in 1992, Region 5 determined that a portion of the sediments in the outer harbor would require handling under the RCRA-Subtitle C as hazardous waste if dredged.

The federal project at Indiana Harbor has not been dredged since 1972. As a result, it is believed that the federal channel is no longer functioning as a trap for the sediments which enter the project. In essence, sediment input into the federal project equals sediment output to Lake Michigan. This conclusion is supported by 25 years of bathymetric survey data. These data reveal that the rates of sediment accumulation in the project were greatest between 1972 and 1980 and that subsequently sedimentation rates have decreased notably (12). Currently, sediments which would settle within the limits of the project if dredged to authorized depths, are discharging to the Lake. The contaminated nature of the sediments make their release to Lake Michigan highly undesirable. Contaminants which enter Lake Michigan are quickly dispersed by wave action and near-shore currents, rendering subsequent capture and remediation unlikely. The USACE has estimated that 75,000 to 150,000 m^3 of contaminated sediments are currently being discharged from the mouth of Indiana Harbor annually (12). Restoring and maintaining the navigation channel at authorized depths would create a sediment trap capable of reducing this release rate by an estimated 50 to 70% (12).

Current Indiana Harbor Proposal

A second DEIS for the dredging of Indiana Harbor was jointly issued by the USACE and USEPA Region 5 in October 1995. Despite the USACE preference for clean sites, the recommended alternative in the DEIS consisted of the construction of an upland CDF at the Energy Cooperative Incorporated (ECI) site in East Chicago, IN (Figure 3). As documented in the DEIS, the selection of the ECI property was based upon the absence of available, clean, close, cost-effective, adequately sized sites in the area surrounding the federal navigation project at Indiana Harbor (12).

From 1919 until the early 1980s, the ECI site housed a petroleum refining operation. In 1980, ECI acquired interim status under RCRA Subtitle C through the operation of several onsite hazardous waste units. Shortly thereafter, ECI declared bankruptcy under chapter 7. Subsequently, the facility structures were razed and the site was graded. Despite these activities, the RCRA hazardous waste units were never formally closed and the onsite contamination was never addressed. In compensation for taxes, the site was acquired by the City of East Chicago in 1990. As a consortium of companies, ECI left an estate of almost $33 million upon filing for chapter 11 bankruptcy in 1984. In May of 1992, the Department of Justice on behalf of USEPA and the Coast Guard, filed a claim for the costs of environmental remediation. This activity resulted in the procurement of $13.22 million for site remediation and CDF construction. As discussed in more detail below, the site remediation components and the CDF design components exhibit considerable overlap, thereby further reducing the expenditures associated with the use of the ECI site.

Covering approximately 168 acres, the ECI site-use proposal is large enough to meet the disposal needs at Indiana Harbor for approximately 30 years. The site also is located to the north of the Lake George Branch of the federal navigation project (Figure 3). This proximal location minimizes transportation difficulties, costs and any associated public concerns. In addition, because of the nature and extent of the onsite contamination, the ECI site is available for use by a local sponsor through the City of East Chicago at nominal cost.

The geology at the ECI site consists of a 30-foot layer of sand overlying a glacial till of low permeability. In addition, much of the site is covered by a thin veneer of fill (generally thought to consist primarily of iron and steel slag), ranging in thickness from several to approximately 10 feet and hydraulically behaving much like the sand (14). The water table at the site ranges from grade to several feet below grade. The 60-plus years of refinery operations severely contaminated the onsite soil materials and ground water. Over large portions of the site, the water table is covered by a layer of lighter-than-water free-phase hydrocarbons (oil) or LNAPLs, which in places

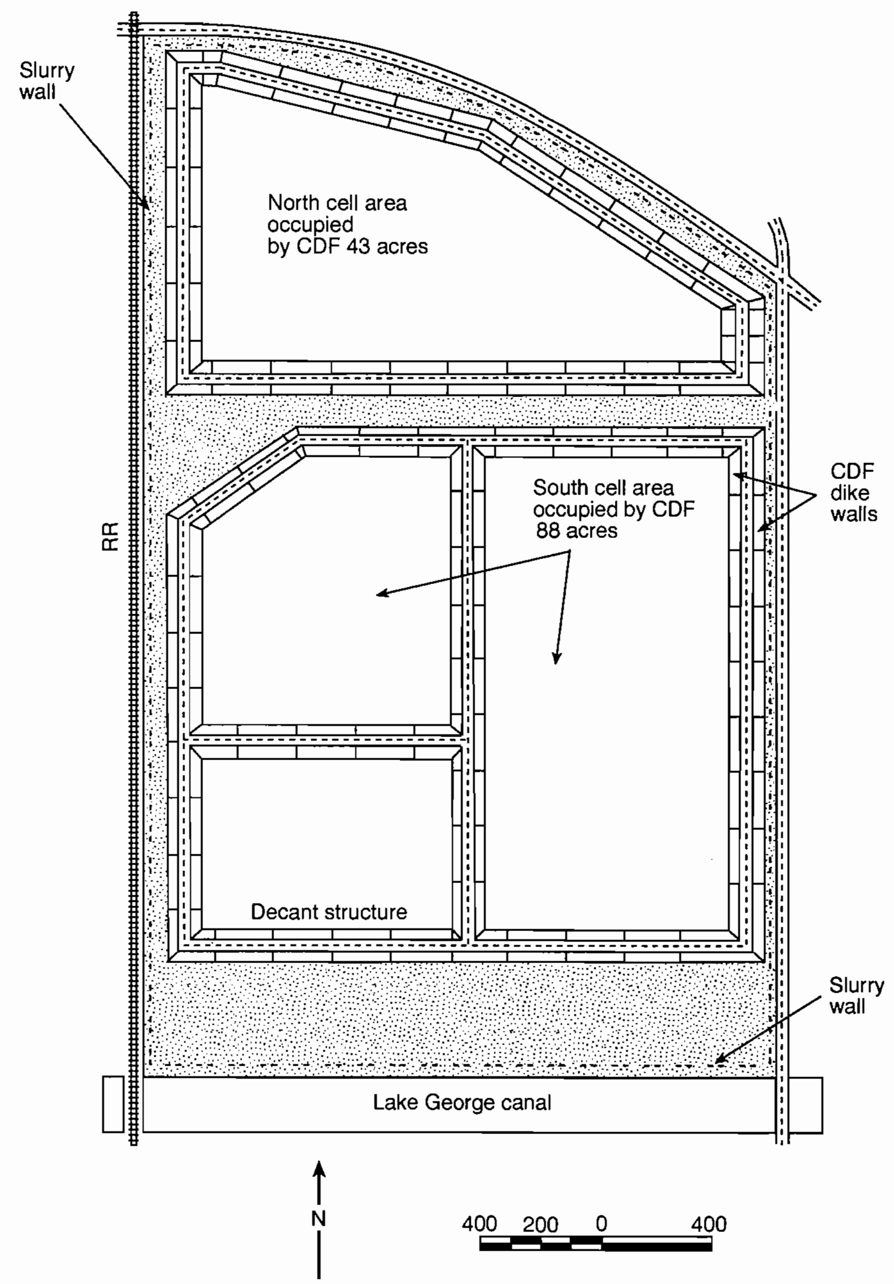

Figure 3. Plan view of the proposed ECI site CDF (12).

can exceed a thickness of 8 feet. In addition to the hydrocarbon contamination, other contaminants known to be associated with the site include PCBs and heavy metals. Many of these same contaminants are also found in the IHC sediments. The ground water at much of the site initially discharged to the Lake George Branch of the federal navigation project. This resulted in the release of free-phase oil from the site to the surface water in the IHC. This situation was corrected in the early 1990s, when under the direction of the Indiana Department of Environmental Management (IDEM), an oil removal system was installed along the edge of the canal.

Composite/remedial CDF Design

In the early 1990s, Region 5, USACE, IDEM, the City of East Chicago and other parties became actively involved in assessing the feasibility of coupling the conceptual CDF design with the outstanding RCRA closure and corrective action needs of the site. After extensive discussions, consensus was reached regarding a CDF design which would meet the engineering necessities of the USACE, and fulfill the closure and corrective action needs of RCRA. If constructed and operated properly, this CDF design would provide a comprehensive environmental solution for the underlying portions of the ECI site and a sediment disposal capacity projected to meet USACE needs for 30 years. The proposed CDF design would cover approximately 168 acres of the ECI site, and would have a containment capacity of 4.7 million cubic yards. Once the CDF is filled and closed, future site use options could include use as a park or a golf course.

The proposed CDF design (Figure 4) features a trapezoidal dike wall which would surround the perimeter of the facility. The interior face of the dike wall will be covered by a compacted layer of clay several feet thick. The compacted layer of clay will be tied into an underlying vertical slurry wall of low permeability. The slurry wall would extend down through the slag and sand layers into the underlying low permeability clay till. A series of well points located along the interior perimeter of the CDF would function as a gradient control/sediment dewatering/leachate collection system (12) (see figure 4). After the CDF is filled, the closure design would consist of a layer of compacted clay, overlain by a drainage layer and topped by a layer of seeded top soil. The proposed CDF design should ensure the containment of the underlying *in-situ* LNAPL contamination, address the RCRA corrective action requirements and comply with the closure performance specifications for RCRA hazardous waste units. In addition, the CDF will also environmentally isolate the contaminated IHC sediments, meet the TSCA requirements for PCB contaminated sediment disposal, fulfill the USACE's engineering requirements for sediment disposal and meet the long-term disposal capacity needs of the USACE at Indiana Harbor. Obviously, the same CDF design components will meet the needs of various overlapping regulatory and engineering requirements. For example, the well points placed into the underlying sand aquifer and used to extract ground water from the interior of the facility, would function as a gradient control, sediment dewatering and/or leachate collection system. As all of these terms refer to the same mechanism, language preferences would tend to be Agency and program dependent.

Liability Considerations

Successful CDF partnerships are commonly based upon the equitable partitioning of the liability which the CDF could represent. Liability for existing CDFs is shared between USACE and the local sponsor. The sponsor is required to "hold harmless" the federal government from any damages not due to the fault or negligence of the Corps or its contractors. Essentially, the USACE retains liability for the CDF design and construction in perpetuity, while the sponsor is primarily liable for maintenance of the facility after closure and any damages or impacts due to a lack of maintenance during the post-closure period. The time needed for CDF construction, project completion and CDF closure can range from several years to several decades. For example, the projected operational life of the Indiana Harbor CDF is 30 years. Should a third party wish to use the CDF for sediment disposal, an agreement for the partitioning of the associated liability would need to be established.

In the case of Indiana Harbor, a worst-case remedial scenario has been projected as a situation which would require complete replacement of the CDF's perimeter slurry wall. The cost of implementing this worst-case scenario has been estimated to be approximately $6 million (1993 dollars). During the approximately 30 years needed to construct, operate and close the CDF, the USACE will bear most of the liability associated with the site, and could be called upon should the CDF require some form of remediation. During this same period, the local sponsor would need to establish the assurances required to effectuate the worst-case remedial scenario (the $6 million at the same 1993 valuation). This would need to be completed prior to the reversion of the site back to their control. Lastly, any local entity which used the CDF for sediment disposal would also acquire a portion of the liability represented by the CDF. This could be converted into a negotiated cash sum provided to the local sponsor and/or the USACE.

At Indiana Harbor, although final agreements have not been reached, a conceptual framework for the management of the liability has been discussed. These ideas include: environmental insurance purchased as part of the local sponsor's annual operation and maintenance (O&M) responsibilities; a per-cubic yard surcharge to the local CDF users for the establishment of the $6-million fund; and local bonding that would provide the necessary funds though a number of possible surcharges.

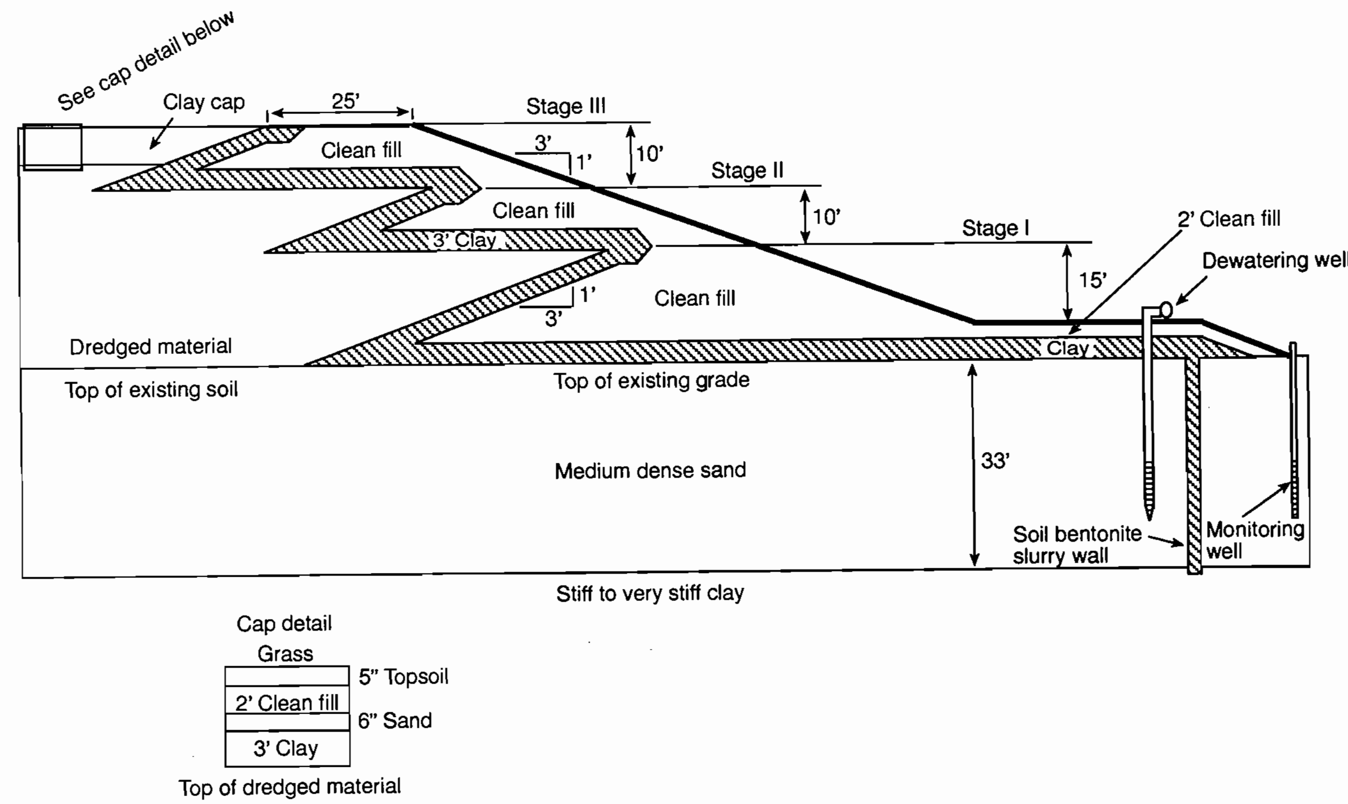

Figure 4. Section view of the proposed ECI site CDF (12).

Brownfields vs. Greenfields

At first glance, although use of a green site would appear to have fewer liability concerns than use of a brownfield site, this may not always be the case. The soils and ground water at a pristine site would need to be kept pristine. Consequently, acceptable green-site CDF designs for highly contaminated sediments tend to be more involved and costly to construct than an acceptable brownfield site design. Although site-specific, an upland clean-site CDF designed to contain highly contaminated sediments could entail several feet of compacted clay, and one or more synthetic liners and leachate collection systems. Generally, these green/clean-site CDF design components would cover the entire base of the facility. Such enhanced designs are premised upon the need to isolate the contamination associated with the sediments from the proximal environment and preclude groundwater contamination. However, should a contaminant release to ground water occur despite the more-involved design, the resulting remediation effort can entail significant and long-term expenditures. Lastly, groundwater monitoring at a pristine CDF site needs to be sufficiently sensitive to detect slight alterations in the aqueous chemistry of the underlying aquifer. Such monitoring programs can entail significant costs through both the operational and post-closure periods.

The environmental benefits associated with the construction of a more-enhanced and costly clean/green site CDF design at locations with significant LNAPL accumulation, could be limited. At such sites, the additional expenditures required by the enhanced green-site design components may only succeed in segregating the *in-situ*/onsite contamination from the contamination associated with the sediments. Specifically, the placement of such a green-site design at the ECI site would do little to remediate the underlying LNAPL contamination, and would leave the RCRA corrective action and closure needs unaddressed. Should a more-costly green-site CDF design be placed at the ECI site, a second containment unit for the underlying onsite hydrocarbon contamination could still be needed. If both the green-site CDF and an underlying containment unit were constructed, these stacked containment units would perform in a manner comparable to the current proposal. These stacked units (with their duplicative design components) would substantially increase the complexity and cost of the project, while providing little additional environmental benefit.

A review of the potential liability exposure associated with use of the ECI site versus a clean site also raises some interesting issues. Many of the liability issues encountered are rooted in the current technical limitations associated with the remediation of sites with NAPL contamination. As discussed, the soils and ground water at a pristine site used for CDF construction would need to be kept pristine. Once constructed, should the more involved green-site CDF design fail and a contaminant release to the adjacent soils and ground water occur, remediation would need to be initiated. This would include steps to correct the facility defect which caused/allowed the release, as well as the remediation of any impacted soils and ground water. Such a green-site event could represent significant liability exposure, as standard groundwater cleanup approaches tend to be long-term and costly. In contrast and as acknowledged by USEPA, the probable remediation scenarios at a NAPL site such as ECI can be much more limited (5, 7). Unfortunately, at ECI the same LNAPL contamination which the slurry wall will be placed to contain also exists in abundance on the exterior of the slurry wall. As the characteristics of the contamination outside as well as isolated by the slurry wall are similar, the same remedial limitations associated with the *in-situ* contamination underlying the CDF (once constructed) would also generally apply to the contamination beyond the CDF boundary. These remedial limitations would not be altered by a short-term release from the CDF. Consequently, in the event of a release from the proposed CDF, an argument could be made that the required remedial steps should focus upon correcting the facility defect which allowed the release to occur. In addition it should also be noted that the ECI site is located in an area where the problems associated with LNAPL contamination are well documented. Due to the widespread nature of the problem, Agency representatives and local property owners are attempting to address the issue from a regional perspective.

Traditionally, under many waste disposal programs, (e.g., TSCA, RCRA-Subtitle C, RCRA-Subtitle D), the performance of the waste disposal unit is monitored through the periodic assessment of the adjacent groundwater quality down-gradient of the unit's perimeter. The detection of or an increase in the concentration of a contaminant known to be associated with the waste in the disposal unit, is generally viewed as an indication of unit failure. This definition of failure presumes a notable difference in the chemical nature and/or concentration of contaminants associated with the material in the unit versus the material along the unit's exterior. However, these prerequisites may not exist at the ECI site. Due to the similarities between the IHC sediment and onsite contamination, and the extensive and problematic nature of the onsite contamination (LNAPLs); monitoring the performance of the proposed CDF through alterations in the quality of the groundwater adjacent to the facility may not be feasible. In essence, the nature and extent of the contamination within the unit may be little different from the contamination along the unit's exterior. Although groundwater samples could be collected and alterations in the level of chemical constituents would no doubt be measured, these alterations may involve significant interpretational challenges and have little to do with the performance of the CDF. Properly constructed and operated, measured alterations in groundwater quality are at least as likely to reflect events which occurred on the CDF's exterior than an indication of contaminant migration from the facility interior. Since it seems probable that water quality monitoring along the facility perimeter would provide little direct indication of unit performance, facility performance monitoring may need to rely primarily upon monitoring the hydraulic gradient across the slurry wall. The hydraulic gradient would be monitored by tracking the hydraulic head values on both the interior and exterior sides of the vertical slurry wall. As long as the hydraulic head value (groundwater levels) along the exterior of the facility exceeded the hydraulic head value along the adjacent facility interior, the flow of groundwater would be directed toward the interior of that portion of the CDF.

Application to Sediment Remediation Projects

Contaminated sediments have been identified as a significant non-point source of pollution in many rivers, harbors and lakes. Contaminated sediments have been positively linked to elevated levels of contaminants in fish, degraded water quality conditions, and waterway use limitations. At all of the 43 Areas of Concern (AOCs) in the Great Lakes identified under the Great Lakes Water Quality Agreement between the U.S. and Canada, contaminated sediments have been associated with a number of use impairments. The remediation of contaminated sediments is also an integral part of the Remedial Action Plans at many of these AOCs, and is the focus of numerous remedial activities under Superfund and other cleanup authorities.

There are several prerequisites which must be met to initiate the remediation of contaminated sediments. First and most critically, a source of funding must be identified. This has resulted in a number of projects where enforcement cases were brought against responsible parties with the ability to fund sediment cleanups (e.g., Waukegan Harbor-OMC; Black River-USX Kobe; Indiana Harbor-LTV Steel). Unfortunately, the sediment contamination at most sites commonly originated from a variety of point and non-point sources. This can make it difficult to assign responsibility, and require a substantial effort to build a sediment enforcement case. Although rarely seen as the sole funding source, public funding (federal or state) has also been used to augment or match funding provided by the responsible party.

In addition to funding, sediment remediation projects that involve removal (dredging) invariably entail access and use of a piece of property. Ideally, the site is adjacent to the area to be dredged, minimizing logistical costs and difficulties. Where the volume of sediments removed is small, and ultimate disposal is to an existing disposal facility (not uncommonly a commercial landfill), the property is needed to conduct sediment dewatering and rehandling (e.g., Cedar Creek-Tecumseh; Manistique River-Manistique Paper). For projects with large sediment volumes, where commercial facilities are unavailable or cost prohibitive, the property is also needed for CDF construction (e.g., Waukegan Harbor-OMC; Black River-USX Kobe; Sheboygan River-Tecumseh).

As exhibited by the discussion above, the prerequisites needed for navigation dredging and sediment remediation can exhibit considerable overlap. Both require a proponent (i.e., local sponsor or responsible party) armed with sufficient funds, and access to a suitably placed and appropriately sized piece of property. For a navigation project, the proponent must provide all the property and a portion of the funding, although the federal government provides the larger share of the construction costs. For an enforcement-based sediment remediation project, the proponent(s) may be responsible for all or part of these requirements. The primary need for brownfield restoration is an investor willing to work with the site owner and the appropriate agencies to review and approve an acceptable restoration plan for the property. In the case of a remedial CDF constructed for sediment cleanup, the required investor could consist of the PRP(s) liable for the contamination, or a partnership consisting of the PRP(s) and the brownfield site owner. The PRP(s) in turn would acquire use or access of a suitably sized and located brownfield site at minimal cost, while the site owner would have a site-use scenario identified which would address at least a portion of the site's remedial needs.

Conclusions

The considerations outlined above are not unique to the USACE project at Indiana Harbor or the ECI site. The approach outlined in this paper preferentially selects highly contaminated brownfield sites where containment is a preferred remedial option for the construction of sediment disposal facilities. Such brownfield sites adjacent or proximal to a federal navigation channel in need of dredging should prove much more common than proximal, clean, and sufficiently sized upland sites. In contrast to the owners of clean upland sites, the owners of a contaminated brownfield may welcome local sponsor status and may prove willing to not only provide the needed property, but also help finance a CDF project which would utilize their idle site as well as address at least a portion of the site's environmental/remedial needs. Should the future performance of the CDF prove inadequate, it is likely that the costs to upgrade the CDF and/or remediate any resultant environmental contamination would be shared by the local sponsor(s) and other involved parties. A brownfield CDF, coupling the overlapping remedial and engineering aspects into the design and addressing the underlying *in-situ* soil and groundwater contamination can be simpler and less costly than a green-site design. Arguments can also be made that such remedial CDFs can represent less future liability than a comparable facility constructed at an uncontaminated upland site. As discussed in this paper, the selection of a site adjacent to the federal project also minimizes logistical expenditures and eliminates any associated public relations problems. The inherent remedial aspects of the CDF design should also help to enhance overall public acceptance for the project. Should this approach prove generically feasible, long-delayed dredging projects could be initiated removing large volumes of contaminated sediments from ecologically sensitive near shore channels and harbors, and idle brownfield sites could be addressed and utilized. This same approach may also be applicable to the remediation of contaminated sediment sites.

References

1. Richardson G.N., D.M. Petrovski, R.C. Chaney, and K.R. Demars, 1995. State of the Art: CDF Containment Pathway Control, from *Dredging, Remediation and Containment of Contaminated Sediments,* ASTM, STP 1293, ASTM publication code number 04-012930-38.

2. USACE, June 1992. *Hazardous, Toxic, and Radioactive Waste (HTRW) Guidance for Civil Works,* ER 1165-2-132

3. USACE, February 1986. Draft Environmental Impact Statement, Indiana Harbor Confined Disposal Facility and Maintenance Dredging, Lake County, Indiana.

4. U.S. EPA, January 1996. *Basic Brownfields,* U.S. EPA Region 5 Fact Sheet Publication

5. U.S. EPA, September 1993. Interim Final Guidance for Evaluating the Technical Impracticability of Water Restoration, EPA/540-R-93-080

6. Mercer J.W. and R.M. Cohen, 1990. A review of Immiscible Fluids in the Subsurface: Properties, Models, Characterization and Remediation. *Journal of Contaminant Hydrology,* 6, pp. 107-163.

7. U.S. EPA, 1996b, *Pump-and-Treat Ground-Water Remediation, A Guide for Decision Makers and Practitioners,* EPA/625/R-95/005, July 1996.

8. Levorsen A.I., 1967. *Geology of Petroleum,* 2nd Edition, p 461

9. Fetter C.W., 1993. *Contaminant Hydrogeology*

10. Domenico P.A. and F.W. Schwartz, 1990. *Physical and Chemical Hydrogeology*

11. Rumer R.R. and J.K. Mitchell, editors, 1995, Chapter 11. *Assessment of Barrier Containment Technologies/A Comprehensive Treatment for Environmental Remediation Applications;* U.S. DOE/

U.S. EPA/DuPont Company, product of an International Containment Technology Workshop in Baltimore, Maryland, August 29-31, 1995.

12. USACE, 1995. Letter Report and Draft *Environmental Impact Statement, Maintenance Dredging and Disposal Activities, Indiana Harbor and Canal, Lake County, Indiana.*

13. U.S. EPA, Region 5, 1977. *Guidelines for the Pollutional Classification of Great Lakes Harbor Sediments.*

14. USGS, 1997. *Characterization of Fill Deposits in the Calumet Region of Northwestern Indiana and Northeastern Illinois, Water-Resources Investigations Report 96-4126*