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# **Long-Term Management Strategy for Dredged Material Disposal for Naval Facilities at Pearl Harbor, Hawaii**

**Phase III – Analysis of Alternatives and Development of an LTMS**

Michael R. Palermo and Paul R. Schroeder

March 2000

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# **Long-Term Management Strategy for Dredged Material Disposal for Naval Facilities at Pearl Harbor, Hawaii**

## **Phase III - Analysis of Alternatives and Development of an LTMS**

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## Preface

This report describes Phase III of a Long-Term Management Strategy for disposal of dredged material from the Pearl Harbor Naval Complex (PHNC). This work was conducted by the Environmental Laboratory (EL) of the U.S. Army Engineer Research and Development Center (ERDC). Funding was provided by the U.S. Navy, Naval Station, Pearl Harbor, under Project Order N6281398MP25001. The project manager is Ms. Suzanne Baba of Pacific Division, Naval Facilities Engineering Command.

This report was written by Dr. Michael R. Palermo and Dr. Paul R. Schroeder, both of the Special Projects Group, Environmental Engineering Division (EED), EL. Technical editing was performed by Ms. Cheryl M. Lloyd of the Environmental Resources Engineering Branch (EREB), EED, EL. Technical review of this report was provided by Mr. Daniel E. Averett of the Environmental Restoration Branch, EED, EL, and Mr. Thomas R. Patin, EREB, EED, EL.

This study was conducted under the direct supervision of Mr. Norman R. Francingues, Chief, EED, and under the general supervision of Dr. John Keeley, Acting Director, EL.

Dr. Lewis E. Link, Jr., was Acting Director, ERDC, and COL Robin R. Cababa, EN, was Commander.

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## Conversion Factors, Non-SI to SI Units of Measurement

Non-SI units of measurement used in this report can be converted to SI units as follows:

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Multiply	By	To Obtain
acres	4046.873	square meters
cubic feet per second	0.02831685	cubic meters per second
cubic yards	0.7645549	cubic meters
feet	0.3048	meters
inches	2.540	centimeters

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# **Long-Term Management Strategy for Dredged Material Disposal for Naval Facilities at Pearl Harbor, Hawaii**

## **Phase III - Analysis of Alternatives and Development of an LTMS**

### **1 - Executive Summary**

The purpose of this report is to describe a Long-Term Management Strategy (LTMS) for disposal of dredged material unsuitable for ocean disposal from the Pearl Harbor Naval Complex for the next 30 years. This report documents Phase III of the overall LTMS study, focusing on considerations for LTMS implementation. Phase I of the study included a review of dredging volumes and frequencies, dredging and disposal equipment and techniques, environmental resources, and disposal alternatives/management options presently available. The results of the Phase I study indicated that upland disposal in a confined disposal facility (CDF) on Waipio Peninsula would be the least costly and most technically feasible and implementable alternative that can accommodate the disposal requirements for the next 30 years or longer. Therefore, the selected LTMS consists of use of ocean disposal for all material found to be acceptable for such disposal and use of the CDF as a long-term option for all material found to be unsuitable for ocean disposal. Phase II of the study consisted of environmental and engineering studies including laboratory testing and modeling to determine design parameters and operating conditions for a CDF option. Phase III of the LTMS study includes preliminary CDF design, placement operations and handling requirements, need for contaminant pathway restrictions and controls, operational guidelines, dewatering procedures, and regulatory and testing considerations.

The CDF was designed to accommodate a maximum placed volume of up to 300,000 cubic yards\* in a single year and a total placed volume over the life of the LTMS of 1,600,000 cubic yards. The CDF was designed to retain both coarse and fine particles during filling operations. Sediment from upper areas

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\* A table of factors for converting non-SI units to SI units is presented on page v.

of Pearl Harbor is primarily fine-grained silt with some clay and fine sand. The CDF would be constructed within a 124-acre footprint on the southern tip of Waipio Peninsula between the 60% and 100% ESQD (Explosive Safety Quantity Distance) arcs; locating the CDF in this area requires approval of the Department of Defense Explosive Safety Board (DDESB). The CDF would be subdivided into two cells to facilitate dewatering and desiccation and to increase management options. Material can be pumped into one cell while operations for dewatering or material removal for beneficial use would continue in the other cell until it is needed for a subsequent disposal operation.

The CDF could be filled by direct hydraulic placement from pipeline dredges (although this method is unlikely to be utilized because of mobilization constraints), hydraulic offloading from hopper dredges, or mechanical or hydraulic offloading from barges filled by clamshell dredges. The Whiskey 22 Wharf located at the south end of Waipio Peninsula is a suitable facility for offloading.

CDF retaining dikes with an average height of 10 feet would be constructed of 6- to 12-inch lifts of onsite materials using conventional earthmoving equipment. A detailed engineering design is not warranted for the site conditions at Waipio considering the shallow height of the proposed dikes, but the foundation conditions for the dike alignment should be confirmed by field survey and borings or sample trenches as appropriate. A smaller area (30 acres) within the proposed southern cell could be diked as an initial cell for the dredging at Sierra 10-12, Bravo 22-26, and Mike 1-4 piers; the remainder of the southern cell as well as the entire northern cell could be diked in stages for subsequent maintenance projects or in one larger construction effort. However, it would be preferable to build the entire southern cell (60 acres) with a shallower dike height (7 feet) as an initial cell and to raise the dike height to 10 feet in two stages as required. Similarly, construction of the northern cell (60 acres) could be delayed until needed and built initially with shallow dikes (7 feet) that could be raised in two stages to 10 feet. Staging could be continued throughout the life of the site, minimizing the area in use by CDF cells, if restrictions were imposed on the frequency and volume of placement projects.

An evaluation of the CDF contaminant pathways indicated the need for a mixing zone to meet water quality standards for effluent discharge during filling operations and discharge of surface water runoff following precipitation. Contaminant controls for effluent discharge will be limited to management of the ponded surface area and depth to optimize suspended solids retention in the CDF. Surface runoff will be managed by ponding the runoff near the weirs and gradually releasing the ponded water after the suspended solids have settled. No other contaminant control measures for dissolved contaminants in the effluent or runoff discharge such as treatment are warranted. No controls or management activities are needed to restrict contaminants losses via the leachate and volatilization pathways. Plant uptake testing indicated a potential

need to restrict or control future use of the site, to amend the material with soil additives, to phytoremediate, or to provide a final surface cover of clean material for CDF closure. Availability of certain metals in the dredged material was more than 10 times higher than in the native soils from the proposed CDF site. Additional testing of the materials in the CDF at the time when closure is planned should be performed to determine the best course of action for closure. Prior to closure no plant control activities are likely to be needed due to the salinity of the dredged material which will limit plant growth for years following each disposal event. If the site is left idle for several years and vegetation becomes abundant, vegetation control such as annual mowing or burning may be necessary to reduce the attractiveness of the site for habitat or feeding.

After each filling operation, site management efforts should be concentrated on maximizing the containment storage capacity gained from continued drying and consolidation of dredged material and foundation soils. Once dredged material is placed in the site, a passive dewatering program should be implemented. Passive dewatering would consist of draining ponded water following dredged material placement and building trenches in the site when borrowing material for initial construction of the dikes and for raising the dikes later in service life to restore the storage capacity. The minimal periphery and interior trenching performed for acquiring dike construction materials should be sufficient to insure efficient drainage of precipitation and expelled water from consolidation and to pond runoff near the weir for sedimentation.

A monitoring program must be developed to comply with regulatory requirements and to operate the CDF effectively. The implementation of this LTMS involving use of a CDF will require appropriate National Environmental Policy Act (NEPA) documentation. Regulatory evaluations, including testing for bulk sediment chemistry, effluent elutriate testing, and/or water column bioassay testing as appropriate, will also be required for each specific project or group of projects.

## **2 - Introduction**

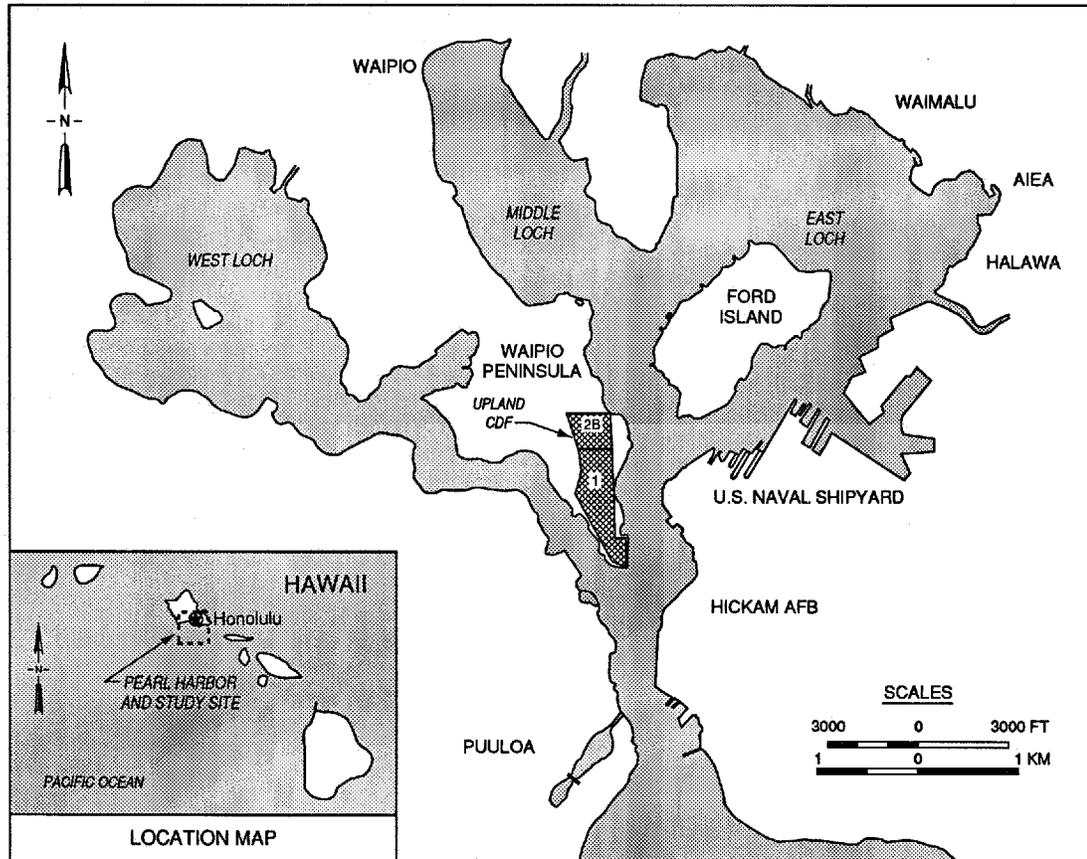
### **Background**

The Naval Station (NAVSTA), Pearl Harbor, dredges a number of locations throughout the Pearl Harbor Naval Complex (PHNC) intermittently to maintain harbor operations. A general layout of the Pearl Harbor channels and facilities is shown in Figure 1. The quantity of sediments dredged totals as much as a million cubic yards every five to seven years. Up to the present time all of the dredged material has been disposed in the ocean. Recent testing of some sediments has indicated that some of the material is unsuitable for ocean disposal because of potential impacts from contaminants present in the sediments. Presently, more than 100,000 cubic yards of sediment at NAVSTA Pearl Harbor docks and piers have been identified as unsuitable for ocean disposal. Additional sediments in other areas of operations are also expected to be unsuitable for ocean disposal.

Practicable, economical, and environmentally sound alternatives are needed for materials unsuitable for ocean disposal. These alternatives should provide disposal solutions for the next 30 years and maintain the future viability of naval operations at Pearl Harbor. Investigations of alternatives require development of a long-term management strategy (LTMS) and evaluation of the environmental effects of various disposal alternatives. The Pacific Division, Naval Facilities Engineering Command (PACNAVFACENGCOM) has tasked the U.S. Army Corps of Engineers (USACE) Engineer Research and Development Center (ERDC) to develop the LTMS for PHNC.

### **Objective and Scope**

The overall objective of this study is the development of an LTMS for disposal of Pearl Harbor dredged material unsuitable for ocean disposal. The LTMS identifies needs for additional disposal alternatives including quantities and frequencies of use, provides alternatives to accommodate the needs, and applies the findings of detailed screening procedures. An integral part of this development is the environmental evaluation of dredged material disposal alternatives and the determination of the need for imposing restrictions (operational controls, treatment, or structures) on the disposal alternatives. Evaluation of environmental effects is performed by executing detailed screening procedures using Tier 1, Tier 2, or Tier 3 approaches as outlined in



**Figure 1.** General layout of the Pearl Harbor channels and facilities showing the location of the Waipio Peninsula site

"Estimating Contaminant Losses from Components of Remediation Alternatives for Contaminated Sediments," Assessment and Remediation of Contaminated Sediments (ARCS) Program EPA 905-R96-001 (Myers et al. 1996). The approaches employ screening tools, laboratory testing, and modeling.

Tier 1 procedures apply sediment physical and chemical characteristics, management and operations data, and conservative literature contaminant release parameters to predict contaminant releases from the suite of contaminant pathways. Tier 2 employs sediment physical and chemical characteristics, management and operations data, and chemically based laboratory testing emulating the exposure mechanism. Tier 3 employs sediment physical and chemical characteristics, management and operations data, and biologically based laboratory testing emulating the exposure mechanism. Separate procedures are applied to each contaminant pathway, including water column impacts from initial release including toxicity and bioaccumulation, effluent, runoff, leachate, plant uptake, upland and aquatic animal uptake, and volatilization.

The scope of the study consists of three phases:

- 1) development of viable alternatives taking into consideration cost, existing technology, logistics, environmental concerns, and regulations;
- 2) evaluation of viable alternatives from Phase I by applying screening tools, performing laboratory tests, and numerically modeling the alternatives; and
- 3) analysis and report of evaluation findings as an LTMS report that includes preliminary design, need for restrictions and controls, and operations/handling requirements of the recommended and viable alternatives identified by Phase II evaluations.

The purpose of this report (the Phase III report) is to describe an LTMS for implementation to include preliminary design, size, need for contaminant pathway restrictions and controls, and operations/handling requirements. Collectively, the LTMS reports will support an appropriate environmental documentation by describing the direct environmental impacts of the selected disposal alternatives. A more detailed discussion of the overall LTMS process as applied to this project is found in the Phase I report.

## **Summary of Phase I and Phase II Findings**

Results of Phase I and Phase II as applied in this study are summarized below. Detailed findings of Phase I and Phase II efforts are documented in two earlier reports:

Schroeder, P.R., and Palermo, M.R. (2000). "Long-term management strategy for dredged material disposal for naval facilities at Pearl Harbor, Hawaii: Phase I - Formulation of preferred disposal and management alternatives," ERDC/EL SR-00-3, U.S. Army Engineer Research and Development Center, Vicksburg, MS.

Schroeder, P.R., Price, R.A., Averett, D.E., Wade, R., Pranger, S.A., Neumann, D.C., and Figueroa-Gonzalez, J. (2000). "Long-term management strategy for dredged material disposal for naval facilities at Pearl Harbor, Hawaii: Phase II - Evaluation of alternatives," ERDC/EL SR-00-4, U.S. Army Engineer Research and Development Center, Vicksburg, MS.

## **Geographic Limits and Time Frame for LTMS**

NAVSTA is responsible for dredging activities to maintain navigation at the PHNC. Most of the dredged material from these projects has been historically

placed at a designated ocean disposal site, but more recent testing indicates a percentage of the total material to be dredged is unsuitable for ocean disposal. Sites for this material must be identified and developed for use. Therefore, an LTMS for dredged material disposal is required for these projects. Considering the locations of the dredging areas and potential disposal areas, the geographic limits for the LTMS encompassed the entire island of Oahu. A 30-year disposal capacity was assumed as the time frame for the LTMS.

## **Dredging Requirements**

The estimated total volume for the 30-year LTMS time frame and the average and maximum annual volumes were estimated under the Phase I effort. The volume of unsuitable material is projected to be 40,000 to 80,000 cubic yards in a typical year when dredging of operational areas is performed. A total required disposal volume of 1,600,000 cubic yards was set for the LTMS capacity requirement. In addition, the disposal alternative should be able to handle up to 300,000 cubic yards in a single year to support periodic dredging of the main channels and other large areas.

## **Material Characteristics**

Previous physical testing showed that sediment from upper areas of Pearl Harbor was primarily fine-grained lagoonal silt with clay and fine sand, while sediment from lower channels was primarily sand. Previous chemical analyses performed on the sediments indicated that metals and some organic contaminants were present, but concentrations were low. Most areas exhibit insignificant toxicity and bioaccumulation, but some areas exhibit both statistically significant toxicity and bioaccumulation. Phase II testing confirmed that the dredged material poses short-term adverse environmental impacts on a small volume of the water column of Pearl Harbor from discharges of effluent and runoff. Similarly, testing of the unsuitable sediment indicates that elevated uptake and accumulation of metals will occur in plant and animal tissue in the CDF at Waipio Peninsula without the use of controls.

## **Environmental Resources**

The waters of Pearl Harbor are a significant habitat for numerous organisms; therefore, disposal of dredged materials and upland disposal discharges of effluents into Pearl Harbor will require careful evaluation of their environmental impacts. In almost its entirety, the land in the Pearl Harbor Naval Complex is developed or ecologically disturbed. As such, outside of national wildlife refuge areas and wetlands, there are not many upland environmental resources.

## Disposal Alternatives

The Phase I study results indicated that a number of disposal alternatives are available for dredged material that is unsuitable for ocean disposal. Disposal alternatives identified as available options during Phase I included contained aquatic disposal, confined disposal, and beneficial uses. Several of the alternatives by themselves can provide adequate capacity for the next 30 years. The costs of the alternatives are a function of the alternative; some are slightly higher than open water disposal, while others are much higher. Most of the alternatives would have high public acceptance and low environmental impacts.

## Selected LTMS

The Phase I study found that upland disposal in a CDF on Waipio Peninsula would be the least costly and most technically feasible and implementable alternative. Figure 2 shows a typical upland CDF similar to that needed at Waipio Peninsula. Other alternatives which provide for beneficial use of the dredged material would typically require an upland disposal site as a storage and preparation area prior to implementation of the beneficial use. The State of Hawaii's Reef Runway CDF could supplement the Waipio CDF to meet short-term disposal requirements.



**Figure 2.** Typical upland CDF constructed with earthen dikes

Based on the Phase I effort, more detailed engineering and environmental evaluations for confined disposal alternatives were conducted in Phase II, focusing on the Waipio Peninsula and the State of Hawaii's Reef Runway sites. Later discussions with the State of Hawaii's airport authority indicated that any large volume of fill material placed in the State of Hawaii's Reef Runway site must be classified as select fill with good engineering properties. This excluded the State of Hawaii's Reef Runway site from consideration as an interim or a long-term site under the LTMS.

Consequently, the selected LTMS for dredged material from Pearl Harbor consists of the use of the South Oahu Ocean Disposal site for all dredged material suitable for ocean disposal and the use of a CDF at the Waipio Peninsula for all dredged material unsuitable for ocean disposal. This Phase III report focuses on the CDF at Waipio Peninsula.

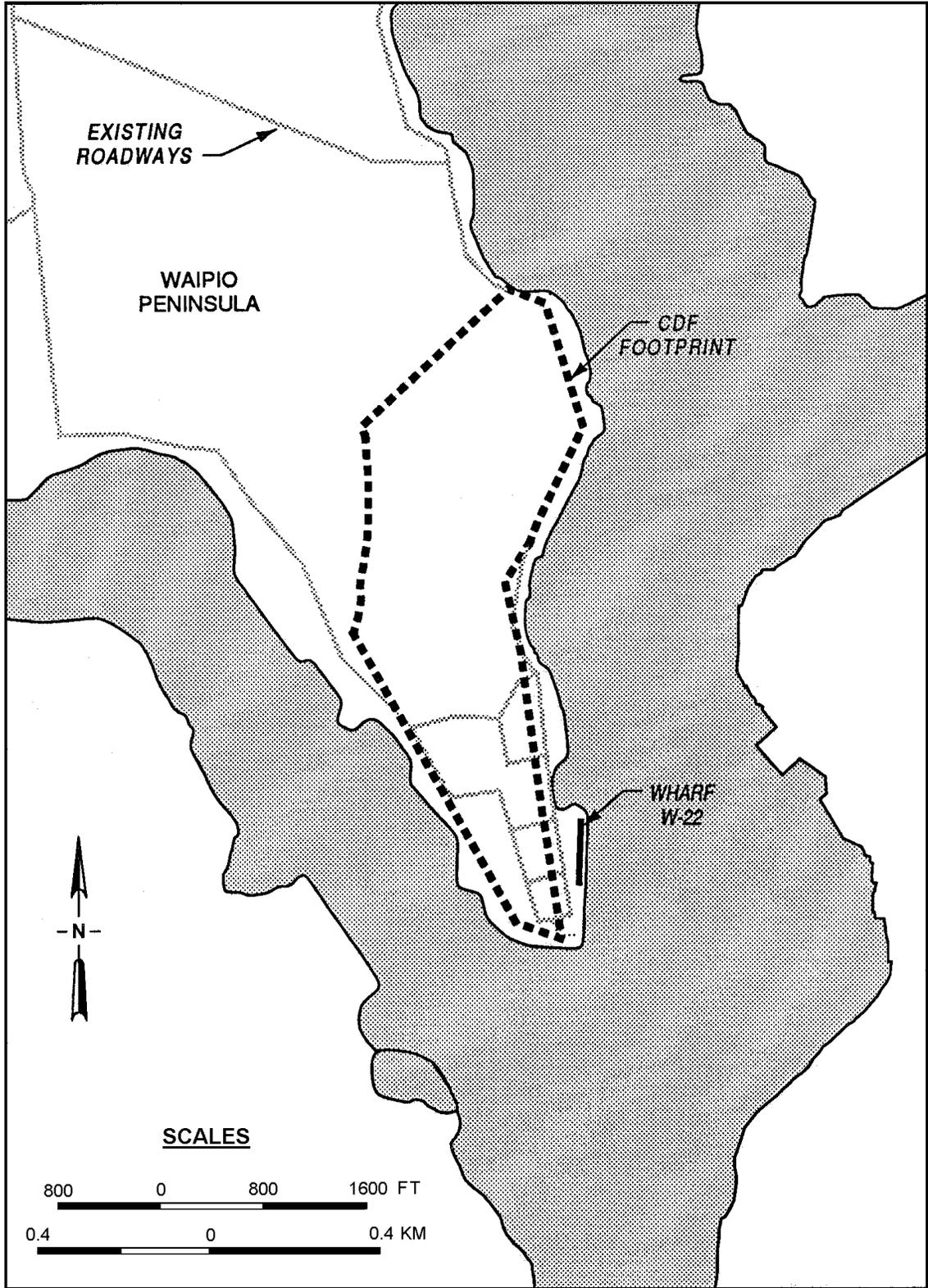
### **3 - Implementation of a Long-Term CDF Alternative at Waipio Peninsula**

The selected LTMS for Pearl Harbor involves an upland confined disposal facility (CDF). The CDF would be sited on the southern end of Waipio Peninsula and would be used for placement of dredged materials found unsuitable for ocean disposal. The location of the Waipio site is shown in Figure 1, and the overall footprint of the site is shown in Figure 3. The available area for the site was defined in the Phase I effort, but Figure 3 shows slight modifications to take advantage of the existing road network around the exterior of the site. This chapter describes the technical considerations for implementing a CDF alternative on Waipio Peninsula to include design, operation, management, and monitoring.

#### **General Considerations**

CDFs are engineered structures designed to retain dredged material solids and, in the case of hydraulic dredging, to reduce suspended solids and/or contaminant concentrations to acceptable levels for discharges to receiving waters. A true upland CDF would allow for all dredged material fill to be placed above the water table. CDFs constructed in water may become upland sites once the fill reaches elevations above the mean high water elevation. Upland CDFs are not solid waste landfills. They are designed and constructed specifically for disposal of dredged material and would normally have a return flow as effluent to waters of the United States. With such return flow, they would be regulated under Section 404 of the Clean Water Act (CWA). The issue of return waters and regulation under Section 404 is a major consideration.

Upland CDFs are one of the most common disposal alternatives, and such sites exist in most regions of the U.S. The use of upland CDFs in coastal areas is extensive in the Atlantic and Gulf Coast regions. Many of these sites were constructed in areas adjacent to estuaries or tributary rivers near the navigation channels they were intended to serve. Some of these sites were constructed in wetland areas (prior to wetlands protection regulations) and have been filled to become upland areas. Large upland sites, some larger than 1000 acres, are now in active use in Wilmington, Charleston, Savannah, Jacksonville, Mobile, New Orleans, and Galveston Districts. CDFs initially constructed in water and which are now upland sites are located in the Great Lakes,



**Figure 3.** Footprint of the Waipio Peninsula site

California, and Puget Sound. There has been very limited use of confined (diked) disposal of dredged material in Hawaii. Small CDFs have been constructed and used for placement of dredged material at Kaunakakai, Molokai; Kawaihae Harbor, Hawaii; and Manele Bay, Lanai. These sites were used once, and no long-term CDF is designated at any of these locations (Personal communication with Mr. Mike Lee, Pacific Ocean Division, USACE, 17 Nov 1998).

The three objectives inherent in design and operation of CDFs are to provide for adequate storage capacity for meeting dredging requirements, to maximize efficiency in retaining the solids, and to control contaminant releases to within acceptable limits. Basic guidance for design, operation, and management of CDFs is found in Engineer Manual 1110-2-5027 (USACE 1987).

Guidance on contaminant pathway evaluations is found in the USACE/EPA Technical Framework for evaluation of the environmental aspects of dredged material management alternatives (USACE/EPA 1992). The testing conducted under the Phase II effort and the evaluations of implementation requirements under this Phase III effort were conducted using the procedures in these guidance documents.

A principal design criterion of CDFs is to retain as high a percentage of the fine-grained dredged material particles as practicable because most contaminants in dredged material remain attached to solid particles during dredging and placement in the CDF. Therefore, sedimentation and retention of solids are reasonably efficient for containment of contaminants.

A CDF is neither a conventional wastewater treatment facility nor a conventional solid waste disposal facility. What makes it different are the physical and chemical properties of the dredged materials placed in the CDFs. Wastewater treatment facilities are designed to receive water with low levels of solids. Solid waste facilities are designed to receive solids with very little water. Dredged sediments typically contain 10 to 50 percent solids (dry weight basis), depending on the physical characteristics of the sediment and the dredging and handling techniques used. An effective CDF must borrow features from both the wastewater treatment facility and the solid waste disposal facility in a combination that is unlike either.

The hydraulic dredging (or hydraulic reslurry) alternative generally adds several volumes of water for each volume of sediment removed. This excess water is normally discharged as effluent from the CDF during the filling operation. The amount of water added depends on the design of the dredge, physical characteristics of the sediment, and operational factors such as pumping distance. When the dredged material is initially deposited in the CDF,

it may occupy several times its original volume. After disposal dredged material will undergo settling and consolidation. The degree of settling/consolidation is a function of time, but dredged material will eventually consolidate to in situ volume or less, about 25% less if desiccation occurs. Adequate volume must be provided during the dredging operation to contain the total volume of sediment to be dredged, accounting for any volume changes during placement.

In this case, the CDF at Waipio would be used over a period of many years, storing material dredged periodically over the design life. Long-term storage capacity of the CDFs is therefore a major factor in design and management. Once water is drained from the CDF following active disposal operations, natural drying forces begin to dewater the dredged material which provide additional storage capacity. The gains in storage capacity are therefore influenced by consolidation and drying processes and by the techniques used to manage the site both during and following active disposal operations.

## **Processes and Design Considerations**

There are several major considerations for design, operation, and management of an upland CDF at Waipio Peninsula:

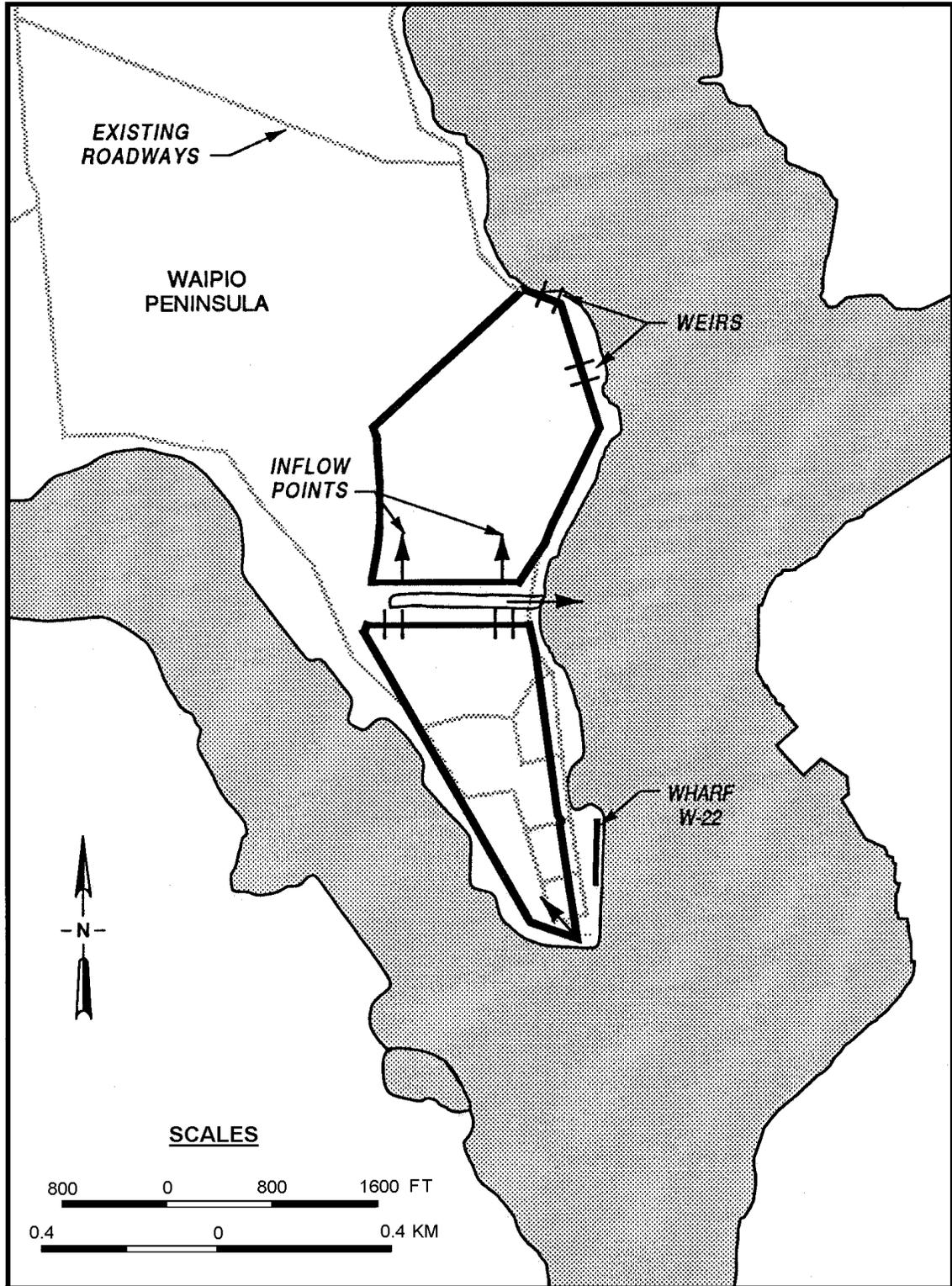
- a. Retaining dikes. The site conditions must allow for construction of structurally and geotechnically sound retaining dikes for effective containment of dredged material and excess water.
- b. Transport and placement of material. Upland sites require an acceptable method of transportation of material from the dredging site to the placement area and rehandling as necessary.
- c. Site geometry and sizing. The site must be volumetrically large enough to meet both short-term storage capacity requirements during filling operations and long-term requirements for the anticipated life of the site. Sufficient surface area and dike height with freeboard must be available for retention of fine-grained material to maintain effluent water quality.
- d. Contaminant pathway controls. Provisions for control of contaminant release through any of several pathways and protection of the environment must be considered in the site design. These may include treatment of runoff or excess water prior to discharge, liners, covers, site management, or other control measures.

- e. Dewatering and long-term management. Upland sites should be managed to allow for passive or active dewatering of fine-grained material. Passive dewatering involves the management and drainage of ponded surface water to promote drying by designing the CDF to drain quickly the ponded water and excess precipitation naturally by sloping and trenching the site during construction and ensuring that the outlet works are lower than any other point in the CDF. Active dewatering normally involves creating drainage trenches for removal of surface precipitation water to allow for efficient drying and additional drainage of excess pore water released during consolidation. Removal of dewatered material to another site for beneficial use may also be possible.
- f. Preventing releases that exceed Federal or State standards. Management activities, operational controls, and design features can limit contaminants releases by all pathways.
- g. Determination of factors required to seek site approval related to location within the Explosive Safety Quantity Distance (ESQD) arc. Operation and design of the dredged material disposal alternative can be performed in a manner to limit requirements for manpower and exposed structures at the site.

## **Description and Layout**

The proposed configuration of the CDF constructed on the southern tip of Waipio Peninsula is shown in Figure 4. The total area available for the CDF is 124 acres, and use of the entire area for the long-term storage requirement is desirable. However, the total area is not required immediately, and staged construction and use of the site are anticipated. Staged construction could be used throughout the life of the site if restrictions may be placed on the scheduling of dredging projects, allowing placement of dredged material no more frequently than every second year. Similarly, staged construction may require that restrictions be placed on the maximum size of the annual placement of dredged material to reduce the area of CDF required in the first 10 to 15 years of the CDF.

The CDF is designed for final disposal and storage of only dredged material unsuitable for ocean disposal. As such, it would be designed to require minimal management (e.g. drainage and dike raising) and minimal maintenance (e.g. vegetation control and dike erosion repair). Under typical operation the dredged material would be hydraulically placed (pumped) into the facility, and the excess water would be discharged through a weir structure back to the waterway. At the end of the disposal site life when the site has been filled to its design elevation or the need for the site has been exhausted, a 12-inch layer of



**Figure 4.** Configuration of Waipio CDF showing dike alignment, two cells, and locations of weirs and inflow points

cleaner dredged material or a surface cover of 6 to 12 inches of topsoil may be placed on the site if necessary to control runoff water quality and plant or animal contaminant uptake. However, other options exist to control or manage the runoff water quality and the plant and animal uptake, including phytoremediation, vegetation selection, soil amendments, and use restrictions. Additionally, closure may be performed to prepare the site for post-closure use; this would typically involve leveling of the dikes, filling of drainage trenches, and perhaps removing inlet and outlet structures. The disposal does not fall under the regulatory purview of Resource Conservation and Recovery Act (RCRA) and its closure requirements.

Subdivision of the site into cells would facilitate dewatering and desiccation and increase management options. Configuring the site with two containment cells provides for flexibility in operation of the site. Material can be pumped into one cell while operations for dewatering or material removal for beneficial use would continue in the other cell until it is needed for a subsequent disposal operation. Alternatively, restrictions may be placed on the scheduling of dredging projects, allowing placement of dredged material no more frequently than every second or third year and eliminating the need for multiple cells. A photo of a multicell CDF, similar to the configuration proposed for Waipio, showing dewatering trenches in two cells is shown in Figure 5.



**Figure 5.** Multicell CDF with dewatering trenches in two cells

The use of multiple cells or subcontainments allow a longer period of drying as placement operations are alternated between cells. Another consideration for effective drying is to limit the lift thickness of newly placed material so that drying can extend throughout the lift prior to placement of the next lift. Experience has shown that limiting the lift thickness to 1.5 to 2 feet meets this need. Even though the total surface area available at the site is 124 acres, the effective diked area for storage would be less due to the space needed for the dikes, access roads, and a drainage trench between the two subcontainments. The area occupied by the dike footprint would be offset by the added capacity created within the footprint by excavation of the dike construction material. Considering the fact that the LTMS must allow for a single placement as large as 80,000 cubic yards in a single cell, only two cells at the site are feasible if the lift thickness is limited to 1.5 feet. Figure 4 shows the proposed configuration of the two cells. The precise area in each cell cannot be determined at this stage, but an effective diked surface area of about 50 acres for each cell is used for purposes of the design evaluations.

## **Dredging and Placement Methods**

### **Dredging Equipment**

The availability of dredging equipment and logistics involved in mobilization of equipment to Hawaii were discussed in the Phase I report. Although hopper dredges will continue to be used for the main channels when removing materials suitable for ocean disposal, the project areas where unsuitable materials are encountered are too constricted for use of a hopper dredge. These project areas have been historically dredged by clamshell, with material transported by barge to the ocean disposal site.

The use of specific dredging equipment and methods for transport and placement to the CDF would normally be left to the dredging contractor, and there is no need to place restrictions on the type of dredging equipment used or on the dredging operation itself. However, the design of the site must consider viable means for placement. The Waipio site is located near the project areas to be dredged, and the material could be placed directly into the CDF by hydraulic pipeline dredges. There are no known pipeline dredges in Hawaii at present, but pipeline dredges could be mobilized to Hawaii for larger dredging contracts. Because of the long distances to the islands from mainland areas, the mobilization and demobilization of a pipeline dredge to Hawaii would be very expensive. Purchase of a small pipeline dredge is an option which could be considered, but dredge ownership would present maintenance problems as well as institutional problems regarding the perception of competition with private industry. For these reasons, use of a pipeline dredge with direct pumping to a CDF will be unlikely.

The Waipio site is located adjacent to or near channels. Transport to the sites by barge or hopper dredge is therefore possible. Pumpout from hopper dredges to the CDF is a viable option for placement, when a hopper dredge can be used. For cases where a hopper dredge is not feasible, the use of clamshell for mechanical dredging is a viable option, with hydraulic reslurry from the barges. This rehandling operation would require use of a portable pump or “mud pump” with water injection to reslurry the material. Another option is mechanical rehandling directly from the barges to trucks for transport to the CDF.

The presence of debris in the sediment is an issue which may influence the ability to manage the CDF for dewatering and the ability to manage and remove dewatered material for beneficial use. The dredging method would directly determine the best options for separation of debris from the sediment, if separation is deemed necessary. Only small pieces of debris will be moved through the hydraulic pumps of pipeline or hopper dredges, and no separation of these small pieces of debris will be needed at the CDF. However, mechanical clamshell dredges will directly remove larger pieces of debris such as pilings, cable, etc. from the harbor bottom along with the sediment. Separation of debris removed by clamshell dredging can be accomplished either at the dredging site or at the offloading facility. Separation at the dredging site would be preferable if the barge offloading at the CDF is to be accomplished by hydraulic means. An appropriately sized angled bar screen can be arranged over the barge intended for sediment transport. A second barge intended for debris transport would be moored alongside. As material is dredged, the clamshell would drop each bucket load over the bar screen. The bar screen would retain the larger pieces of debris and they would slide down the angled screen into the debris barge. Sediment would fall through the screen into the sediment barge. This method has been used successfully at Pearl Harbor for recent dredging operations.

### **Offloading Facilities and Methods**

The Phase I effort indicated that materials could be placed in the CDF by hydraulic pipeline, either directly from the dredging areas or from hydraulic offloading facilities located adjacent to or near the site. Mechanical methods are also feasible for barge offloading. The details of the offloading procedure would be normally left to the dredging contractor responsible for a specific project, but the suitability of facilities and a workable method for offloading must be developed for the LTMS.

Offloading from barges will require an appropriate mooring dock for barges with sufficient shoreside access and surface area for operation of the equipment needed for material rehandling. The Whiskey 22 Wharf located at the south end of Waipio Peninsula, adjacent to the east face of the CDF

alignment as shown in Figure 4, is a suitable facility for offloading. Hydraulic offloading equipment would likely be deployed on a mooring barge located at the wharf. Dredged material barges would be moored to this barge for offloading. Mechanical offloading could be accomplished either from a mooring barge or from the wharf, depending on the method used.

**Mechanical Offloading.** For projects dredged by clamshell, mechanical rehandling and offloading methods would be feasible and economical for small volume projects. Since relatively small barges would be used for transport, a backhoe with long reach would be an efficient means for rehandling and offloading for small volumes. If dikes are constructed sufficiently near the offloading facility, mechanical rehandling directly from barges to the CDF may be possible. Figure 6 shows a chute constructed for this type of operation. A backhoe could also mechanically rehandle material directly from the barge to trucks. A clamshell operated from a land-based crane could also be used for the rehandling operation.

Debris separation for mechanical offloading could be accomplished either at the dredging site, as described above, or could be accomplished at the



**Figure 6.** Chute constructed for direct mechanical rehandling to a CDF

offloading site. An appropriately sized angled bar screen can be erected at the offloading facility at a height allowing trucks to pull underneath. As material is removed from the barge, the backhoe or clamshell would drop each bucket load over the bar screen. The bar screen would retain the larger pieces of debris, and they would slide down the angled screen into the debris truck. Sediment would fall through the screen into the sediment truck.

The sediment-filled trucks would drive into the diked area and dump the material so that it is spread as uniformly as possible to drain and dry. The drained material could be later removed for dike upgrading. Several methods for truck placement are possible. The placement of material in the CDF by truck could employ use of a ramp so that the trucks could back to the end of the ramp and end-dump. If the material has a sufficiently high water content, it will flow and spread. Another possible method for truck placement would involve use of lanes in which the truck loads would be placed in sequence forming windrows, with space left between the windrows to allow for drainage and drying. Front end loaders could also be used in the CDF to spread the material end-dumped from the trucks. The best method for placement and spreading will depend on the physical characteristics of the dredged materials from any given project, especially the water content. Hydraulic placement could later be used for larger projects within the same cell following mechanical placement if sufficient depth and area for ponding is provided.

**Hydraulic Filling or Offloading.** Several methods for hydraulic offloading are possible, depending on the dredging method. For direct placement by a pipeline dredge, the dredge size will determine the rate of filling. Figure 7 shows a typical hydraulic inflow from a pipeline dredge. For the maximum anticipated seasonal placement volume of 300,000 cubic yards, a 12-inch pump with 19.6 hr/day effective operating time would require approximately 90 days for placement with a production rate of 170 in situ cubic yards/hour. This rate was used in evaluation of the efficiency of the CDF in retaining and storing the fine-grained material (see discussion in section to follow).

Pumpout directly from hopper dredges is possible using the on-board pumping capabilities. However, some shoreside equipment such as a crane and shoreside pipeline for attachment to the dredge will be required. Figure 8 shows a typical hydraulic pumpout operation from a hopper dredge.

Size and design of the offloading system would dictate the required time to accomplish placement for a given volume in a given placement season. For small volumes (say less than 100,000 cubic yards) to be placed in a given season, a portable pump system or mechanical rehandling would likely be workable. These approaches would have a relatively low production rate for removal of the material from the barges. For larger projects (say greater than 100,000 cubic yards), mobilization of a specialized hydraulic offloader would likely be practical and economical.



**Figure 7.** Hydraulic inflow from a pipeline dredge



**Figure 8.** Hydraulic pumpout operation from a hopper dredge

A backhoe could be used to maneuver a portable pump suction head for hydraulic offloading, but field experience with hydraulic reslurry from barges using portable mud pumps is limited. A practical arrangement for offloading would involve a pump with suction head attached to a backhoe for movement within the barge; a jet would normally be attached to the pump to provide sufficient water to fluidize the dredged material for pumping directly to the CDF by pipeline. Eductor pumps are available with 10-inch discharges; comparable submersible pumps (also with 10-inch discharges) are also available. Both can be obtained from U.S. and foreign manufacturers. A 10-inch submersible pump assisted by a water cannon has been used to fill geotextile tubes, with average transfer rates for clayey silt with some sand of 130 in-barge cubic yards/hour (personal communication with Mr. Jim Clausner, ERDC). Based on the available information, a production rate of 100 in-barge cubic yards/hour is considered a conservative estimate for barge offloading with a portable pump, but this production must be verified by experience. With a production rate of 100 cubic yards per hour, a single pump would have a capability to offload only 1800 cubic yards per day, assuming 18 effective hours of operation per day. A single clamshell dredge of average size would have a production rate greater than the offloading rate for a single pump. Multiple portable pumps (with multiple backhoes for moving the pumps in the barge) could also be used to increase the offloading rate.

Specialized offloading equipment would be appropriate for hydraulic offloading for projects involving large volumes. Such equipment has been used very successfully at the Hart-Miller Island CDF in Baltimore and a CDF for Oakland Harbor where high production rates for the offloader were required. The preliminary cost estimate for the Waipio site, prepared in the Phase I effort by the USACE Portland District and based on discussions with dredging contractors, assumed use of a hydraulic offloader. The specific equipment assumptions of offloading included a discharge pipeline landing with splitter valve and 500 feet of shore pipe (12-inch diam plastic). The pipeline is assembled and deployed by the shore crew to initiate placement of material with subsequent deployment of an additional 2,500 feet of shore pipe along the south, east, and west perimeter dikes of the two cells in order to promote even dispersal of the material during the progress of work. The unloader consists of a platform mounted DSC BARRACUDA 12-inch diam pumping system, a 14500-GPM Griffin upwater pump, and a 4100 class Manitowoc crawler crane; all of which is staged on a 750-ton spud barge. The unloader barge is tended by a 25-foot tender/crew boat. The spud barge is positioned in useable water immediately adjacent to the shore pipe landing and connected to the floating pipe deployed by the unloader crew. The pumping platform is placed athwart the material barge by the attending crane. Transit of material barges between the dredging site and the offloading station will be accomplished by subcontracted tug services (800 to 1200 hp).

Spillage and leakage are concerns for hydraulic offloading facilities involving pipelines or hydraulic offloading. Special controls such as hydraulic checks should be considered to prevent significant spills in the event of a pipeline break. Offloading facilities should have appropriate provisions to minimize spillage and leakage.

## **Volumes and Frequencies**

The estimated total volume for the 30-year LTMS time frame and the range in annual volumes were estimated under the Phase I effort. The volume of unsuitable material is projected to be 40,000 to 80,000 cubic yards in a typical year when dredging of operational areas is performed. A total required disposal volume of 1,600,000 cubic yards was set for the LTMS capacity requirement. In addition, the disposal alternative should be able to handle up to 300,000 cubic yards in a single year to accommodate periodic main channel dredging or other large volumes in anchorage areas.

Scheduling of dredging projects will have an influence on the lift thicknesses placed in the CDF in any given season and will therefore have an effect on the efficiency of dewatering and the long-term capacity. The projects should be scheduled to produce a disposal sequence that is more uniform and compatible with the disposal alternatives. For example, dredging of operational areas containing unsuitable dredged material should not be scheduled for the same time when maintenance dredging of unsuitable material from the main channels is scheduled. For purposes of design, an annual placement volume was assumed, but placement would be alternated between the two cells or performed no more frequently than once every two years, allowing for at least a full one-year drying period. If the site is kept well-drained, significant desiccation typically occurs in the top 1.5 feet of the lift thickness which will be completely dry in about 9 months following disposal. Placement volumes should be restricted to lifts of 1.5 feet to minimize storage requirements and to maximize consolidation.

## **Containment Dike Design and Construction**

Containment dikes are retaining structures used to form confined disposal facilities. Earth-fill embankments are the most common type of retaining dike for upland CDFs. The principal objective of a dike is to retain solid particles by ponding supernatant water in the CDF while at the same time allowing the release of clarified effluent or runoff to natural waters.

For the Waipio site, the preferred location and available footprint for the CDF were established by the Navy in the Phase I effort, considering proximity to the dredging areas and the total capacity required for the LTMS. The

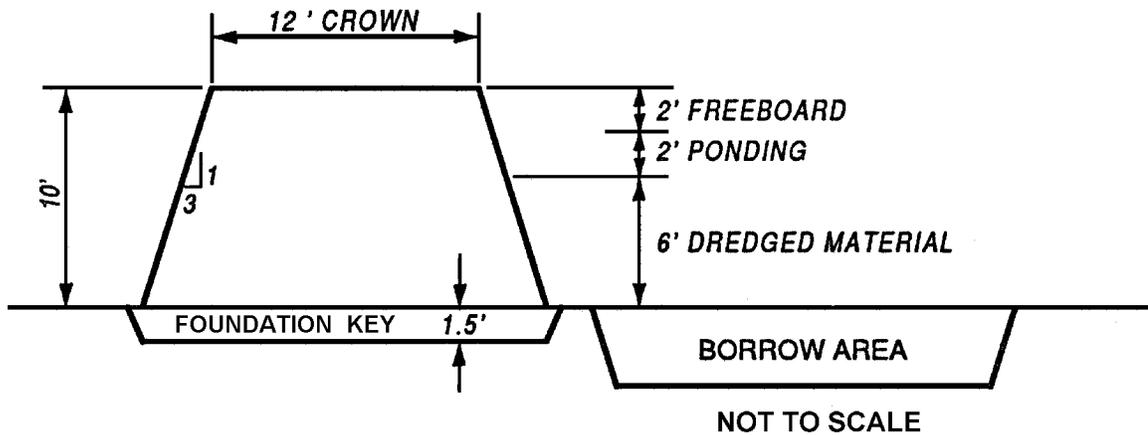
heights and geometric configurations of containment dikes are generally dictated by containment capacity requirements, availability of construction materials, site restrictions, and prevailing foundation conditions.

Figure 4 shows the preliminary alignment of the main retaining dikes. The total area enclosed by this alignment is somewhat less than the total 124-acre footprint due to the division of the site into two cells. A detailed survey of the site will be necessary to finalize the dike alignment and avoid any localized areas of concern such as old foundations, roadways, or conditions which may increase the cost of construction or weaken the integrity of the dike. The survey should also define the topography within the site interior. The area enclosed by the dikes and intended for hydraulic filling should be essentially flat or sloping slightly from inflow points to the weirs. Depending on the site topography, grading may be required. Only minimal grading for areas intended for mechanical placement would be required to ensure flow of drainage water to the weirs. For purposes of this conceptual design, the area enclosed by both the north and south cells is assumed to be approximately 50 acres.

## **Dike Design**

The engineering design of a dike includes selection of location, height, cross section, material, and construction method. The selection of a design is dependent on project constraints, foundation conditions, material availability, and availability of construction equipment. The existing ground within the boundaries of the Waipio site is relatively flat and is suitable to be used as dike construction material. Construction could be accomplished with conventional earthmoving equipment. Dikes for this site could be initially constructed using onsite soils removed from the site interior, resulting in increased capacity.

A dike cross section employing side slopes of 1 foot vertical on 2 feet horizontal (1V:2H) was assumed in the Phase I. The proposed dike design called for a dike height of 10 feet above original ground with a minimum top width of twelve feet. Side slopes of 1V:2H are suitable for dike stability (This must be confirmed by an appropriate engineering evaluation using site-specific soils data.), but side slopes of 1 foot vertical on 3 feet horizontal (1V:3H) may require less maintenance and would be easier to maintain. Therefore, despite the larger initial cost of construction and the smaller resulting CDF interior area available for sedimentation and storage, the flatter side slope of 1V:3H is recommended. The cross section is shown in Figure 9. The ultimate dredged material fill height would be 6 feet. This allows for 2 feet of freeboard and 2 feet of ponding during dredged material placement. A foundation “key” of 1.5 feet is recommended to ensure removal of existing vegetation and to provide good bonding of the dike material with the foundation soils.



**Figure 9.** Dike cross section

For a dike with a limited height, a detailed engineering design is not warranted, but the foundation conditions for the dike alignment should be confirmed by field survey and borings or sample trenches as appropriate. The development of an investigation for the dike foundation and for proposed borrow areas, the selection of a foundation preparation method, and the design of the embankment cross section require specialized knowledge in soil mechanics. Therefore, all designs and specifications should be prepared under the direct supervision and guidance of a geotechnical engineer. Proposed cross-section designs should be analyzed for stability as it is affected by foundation and/or embankment shear strength, settlement caused by compression of the foundation and/or the embankment, seismic conditions, and external erosion. Seismic conditions should be considered as an integral part of dike design. The extent to which the site investigation(s) and design studies are carried out is dependent, in part, on the desired margin of safety against failure.

For the Waipio Peninsula site, the geotechnical design for the dikes should be simple and straightforward. Guidance in USACE EM 1110-2-5027 (1987) indicates that the level of effort required for design is dependent on several factors, including the proposed final height of the dikes, the consequence of a dike failure, and the known foundation conditions. At Waipio, the dike height is limited to 10 feet, and the dredged material fill is limited to 6 feet. Further, if possible, the maximum initial lift thickness should be limited to no more than 1.5 to 2.5 feet (accounting for some bulking during filling operations). The dikes will be constructed using onsite soils which are believed to be a mixture of sand and fines. Dewatering will occur for the lifts of material as they are placed in the facility. Therefore, the potential for failure and the potential consequences of failure are limited. Seismic activity or storm events are not considered important design factors for retaining dikes at Waipio Peninsula. The recommended dike cross section is conservative with a 12-foot crown width and

1 vertical on 3 horizontal side slopes. Based on these considerations, there is little potential for dike failure to occur with the proposed cross section or for adverse consequences if a slump in the dike were to occur. These considerations should be confirmed by a geotechnical engineer prior to preparation of plans and specifications.

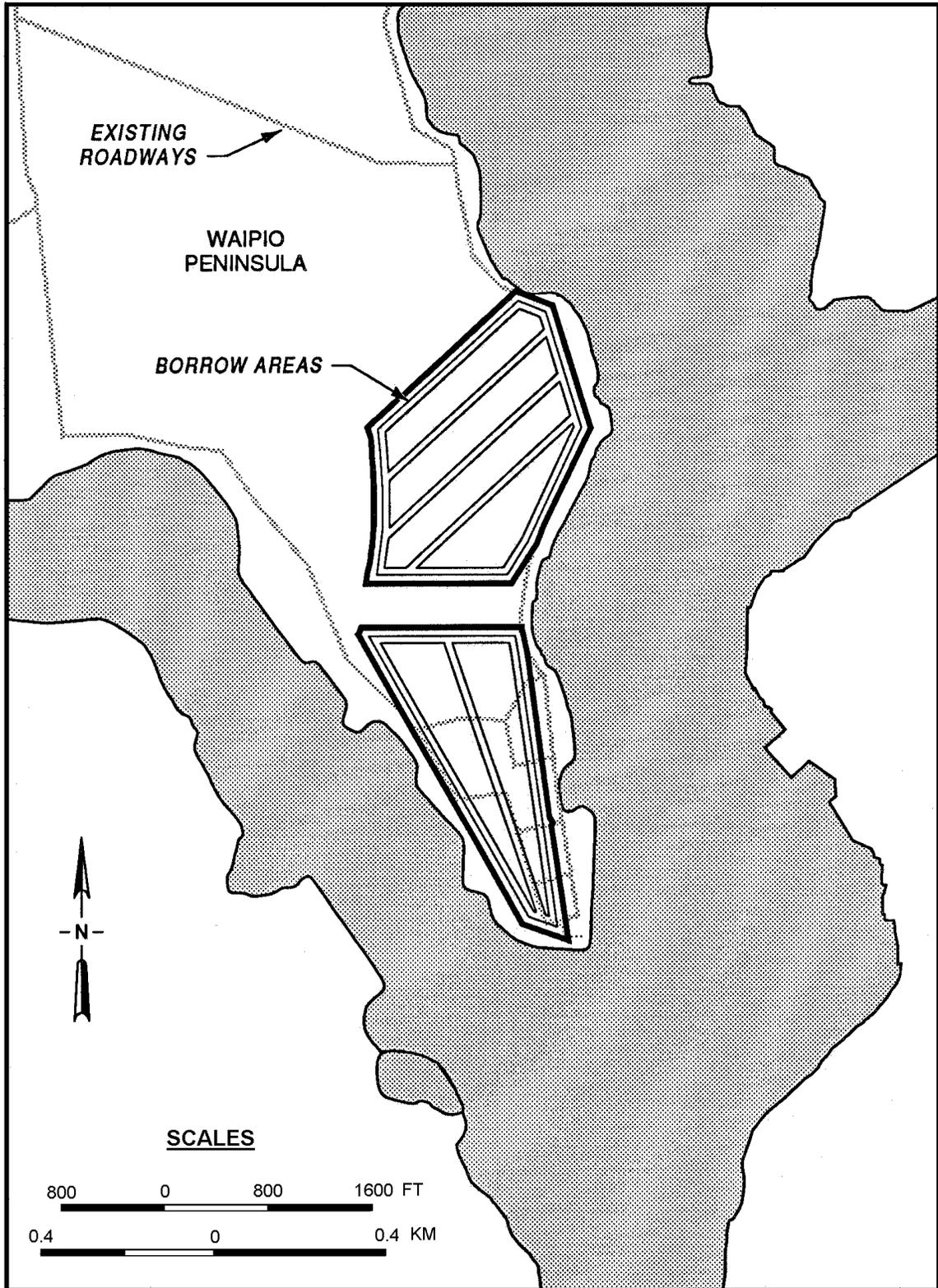
## **Site Preparation**

Site preparation requirements were defined for purposes of the cost estimate in Phase I. Preparation of the site consists of clearing and grubbing the site and constructing a perimeter dike around the entire outer boundary of the area. A typical dike cross section consists of a 72-foot-wide base with foundation key, one foot vertical on three feet horizontal side slopes, capped with a compacted 12-foot-wide top that will provide vehicle access for maintenance and management operations. The site preparation cost estimate is based on employing three D8 class Caterpillar tractors to:

1. Clear and grub the foundation area and establish a dike foundation “key” approximately 72 feet wide by 1.5 feet deep. Note that the key should be included in the dike cross section, regardless of the results of the soil survey, since its purpose is to ensure complete clearing and grubbing and to provide good contact between dike materials and foundation soils.
2. Construct 13,600 linear feet of perimeter dike, 10 feet high, by excavating (“pushing up”) material from within the existing site boundaries in 6-inch lifts. Each lift would be dry compacted by the tractors.

## **Borrow Plan**

The borrow material for dike construction would be taken from inside the dike alignment. A plan of the borrow locations is shown in Figure 10. The borrow would essentially be taken adjacent and parallel to the dike alignment. This would form a continuous trench inside the CDF parallel to the dike. Such a trench produces benefits for site management and dredged material dewatering. As a dredged material layer is placed in the site, the thickness of material over the trench is greater than the site interior. Once the material settles and consolidates, the magnitude of consolidation over the trench will be greater, and a lateral depression parallel to the dikes will be formed on the dredged material surface. This lateral depression forms a flowpath trench for more efficient removal of rainwater, speeds up the drying process, minimizes the need for trenching, and supports the passive dewatering process. The borrow plan in Figure 10 also shows parallel interior borrow areas which could



**Figure 10.** Plan of the borrow locations for dike construction

be used if the full dike cross section is constructed prior to initial dredged material placement. Removal of material from the site interior borrow areas would produce similar benefits for site drainage. The precise width and depth of the borrow trenches would be determined based on the construction requirements, but a depth of only 4 to 5 feet would be required. Excavation to this depth would not be expected to interact with the water table.

### **Staged Construction**

The total surface area available at the Waipio site does not require diking to the ultimate 10-foot height in the initial phases of construction. Additionally, the dike does not need to be constructed initially to its ultimate 10-foot height. A small dredging project is planned in the near future for Sierra 10-12. Upcoming maintenance dredging projects at Sierra 10-12, Bravo 22-26, and Mike 1-4 piers planned for FY 2000 will require removal of approximately 62,000 cubic yards (approximately 58 acre-feet considering bulking during filling as described below). These projects would comprise the initial stages of construction if a staged approach is implemented.

Several options are possible for staged construction. First, an area could be constructed for direct mechanical placement as an initial cell. This cell would require only minimal diking to control the drainage water from the mechanical placement by trucks. Such a cell is recommended to accommodate the small volume from the Sierra 10-12 project.

The next stage could be constructed to accommodate the larger 62,000-cubic-yard volume and could be designed for either mechanical or hydraulic placement. For hydraulic placement, a 25- to 30-acre parcel of the southern subcontainment could be constructed with 6- to 7-foot dikes as an initial cell. The southern cell shown in Figure 4 would be subdivided by a cross dike running north-south to create a long, narrow cell which would have a higher hydraulic efficiency, yielding a cleaner effluent for a given set of operating conditions.

Alternatively, the total area of southern subcontainment could be initially constructed with a shallow dike, built to a height (5 to 5.5 feet) needed to satisfy the storage requirements for the initial stage. Shallower dikes can be used due to the greater area for ponding and storage, reducing the depth of storage and ponding required.

The Navy could fund construction of an initial cell as a part of a specific maintenance project. The remaining portion of the subcontainment could be diked later for subsequent maintenance projects using funding for those subsequent projects. Similarly, the dikes could be raised in 1.5- to 2-foot increments in stages as required for subsequent maintenance projects using

funding for those subsequent projects. The dikes would be raised to the full design height of 10 feet for later projects using desiccated dredged material from the earlier projects. The full dike height for one or both of the cells could also be funded at a later stage in one larger construction effort using a separate construction contract under the MILCON authority.

Use of desiccated dredged material would not present adverse environmental impacts because the dikes would not be used for production of food or animal feed, the primary concern for plant and animal uptake from the dredged material. In addition, the vegetation will be stunted until the salt leaches from the dredged material, and vegetation on the dikes will be managed until final closure. Runoff from the outside face of dikes constructed with dredged material has never been raised as an issue and should not be an issue for this site. The area of the dike face is small compared to the drainage area outside the CDF; as such, the runoff from the dike will be well diluted with the other runoff prior to reaching the receiving water. A drainage ditch could be constructed around the site perimeter to direct all runoff from the outside face to the drainage ditch used for weir discharge and thus to the mixing zone, but this should not be necessary. Additionally, the crown of dikes could also be cupped or sloped to prevent runoff from the dike crown, reducing area of runoff from the dikes raised with dredged material. Once the dike is vegetated, runoff quality should not be of concern.

The minimum surface area of ponding which can be effective for settling the fine material during hydraulic placement by a 12-inch dredge or pump having a flow rate of 12 cfs is approximately 9.3 acres (see discussion below) or a CDF interior area of about 10 acres. However, diking and filling such a small area would result in an uneven surface area in the larger cell for later disposal. Also, the initial dikes forming the smaller area would need to be later removed to allow for settling within the total area of the larger cell, and this would incur an additional cost. Diking the total area of one cell with a low elevation dike holds two advantages. First, all dike construction would occur along the final alignment, eliminating the need for removal of temporary diking at a later stage. Second, the outlets would be located in their final positions, eliminating the need to move or reconstruct them.

Based on these considerations, diking the total area of the south cell (less that area used for Sierra 10-12) with a low elevation dike is recommended for the second stage. The initial occupied volume of 58 acre-feet for the FY 2000 projects would result in an initial lift thickness of approximately 1.2 feet over a 50-acre diked area in the south cell. The FY 2000 projects could therefore be accommodated with construction of dikes with a height of approximately 5.2 feet above the level of the surrounding ground. This provides for the storage volume plus 2 feet of ponding and 2 feet of freeboard during filling. The full crown width of 12 feet would not be necessary for the low elevation dike, and this would further reduce the cost for the initial stage of construction.

However, the full crown width may be desirable if the crown is to be used as an access road for inspection, maintenance, and general site access.

Although mechanical rehandling to the CDF from the wharf would be efficient for the 62,000-cubic-yard volume, hydraulic rehandling is recommended for this stage so that the larger scale design and operational considerations can be field verified and some field experience with hydraulic offloading can be gained.

## **Storage Capacity and Solids Retention**

Even though direct mechanical rehandling into the CDF is possible at Waipio, hydraulic filling by a pipeline dredge or a reslurrying operation is assumed for purposes of design and matching the site size (surface area and potential ponding depth) with the dredge production rate. A hydraulically filled site must be designed and operated to retain suspended solids such that clarified water is discharged. The required initial storage capacity, ponded water depth, and surface area are governed by settling processes which occur in a CDF during placement of fine-grained dredged material.

Settling tests of the sediments to be dredged were performed in Phase II. The tests provided numerical values for design criteria that can be projected to the size and design of the containment area. The results of the tests were analyzed, and the CDF design for sizing and suspended solids retention was developed using design procedures in Engineer Manual EM 1110-2-5027 (USACE 1987). The computer model called SETTLE (Hayes and Schroeder 1992), which is based on the design procedures in EM 1110-2-5027, was used for the calculations. The SETTLE program also contains procedures for computer-assisted plotting and reduction of settling column data. The model is used to evaluate the required surface area and storage volume during active filling operations, to estimate effluent suspended solids concentrations, and to design other features for CDFs.

The settling analysis involves evaluation of zone, flocculent, and compression settling processes. Any of these processes could control the required size of the CDF (area or volume). Zone settling refers to the process in which the fine dredged materials settle as a mass and produce clarified water as a supernatant in the CDF pond. Zone settling requires a minimum surface area for effective settling as a function of the inflow rate to the CDF. Flocculent settling refers to the process in which fine particles in the pond form flocs which settle and clarify the ponded water. Flocculent settling controls the solids concentration of the effluent discharge as a function of the retention time of the pond. Compression settling refers to the process in which the accumulating dredged material layer in the CDF is compressed during filling. Compression

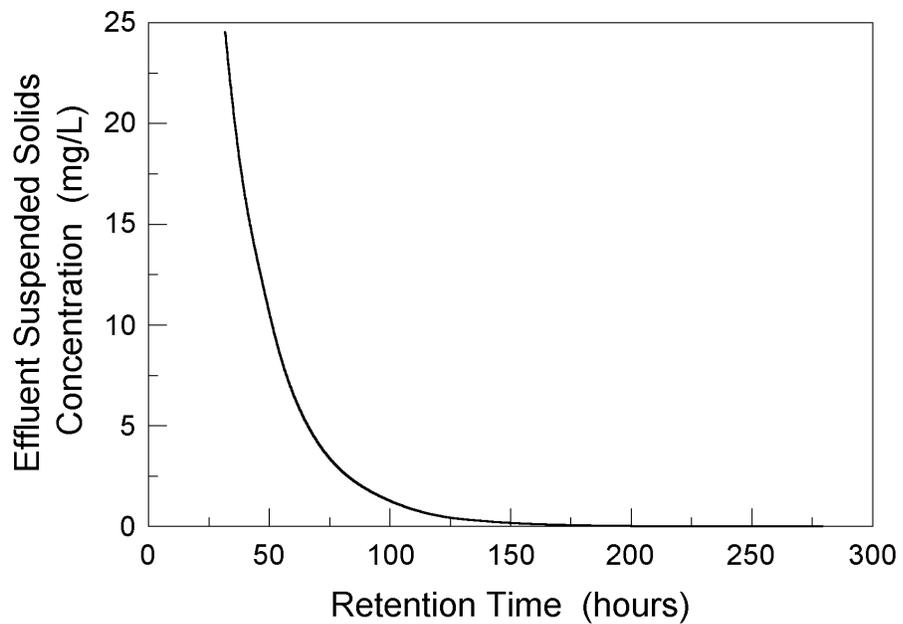
settling controls the required storage volume which must be provided to include the increase in volume due to the hydraulic filling process.

The minimum required diked surface area for zone settling is a linear function of the flow rate for the hydraulic filling operations. This surface area must be ponded during placement operations so that dredged material slurry can be clarified by zone settling processes prior to discharge. The higher the hydraulic filling rate is, the larger the required minimum surface area is. A minimum area of 9.3 acres was calculated for a 12-inch dredge or pump having a inflow rate of 12 cfs. This is the minimum surface area which could be considered for diking if hydraulic filling is used. The analysis also indicates that the surface area of 50 acres recommended for both the north and south cells at Waipio Peninsula would be sufficiently large to accommodate the flow rate for two 12-inch dredges, equivalent to the largest flow rate that might be anticipated. The optimum surface area is generally much greater than the minimum required area for clarification. The optimum design area is a function of storage requirements and suspended solids removal.

The effluent suspended solids concentration is a function of retention time of ponded water in the CDF. The larger retention time is, the better effluent quality is. However, the relationship between retention time and effluent suspended solids is nonlinear. The increase in suspended solids removal decreases with increases in retention time; that is, there are diminishing returns for retention times greater than a day or two. The relationship between effluent total suspended solids concentration and retention time was determined in Phase II. The retention time is dependent on the dredge size (or offloader pump size) and the ponded area and depth in the CDF. Calculated effluent suspended solids concentrations are given in Table 1 for a range of operating conditions using one 50-acre cell and in Figure 11 for a range of retention times (resulting from any combination of dredge sizes, operating hours, ponded areas, and ponded depths). The maximum calculated TSS concentration was only 24 mg/L for the severest operating condition (two 12-inch dredges operating simultaneously with a minimum ponding depth of 2 feet). This analysis indicated that the Pearl Harbor dredged material can be retained with a high degree of efficiency in the CDF under the range of operating conditions. The water quality standard for suspended solids is expressed as turbidity. The standard allows the long-term average turbidity to be no greater than 4 NTU; this corresponds to a suspended solids concentration of about 4 mg/L based on the results of settling tests from Phase II of this LTMS study. The relationship is presented in Figure 25 in the section on monitoring. Table 2 presents the calculated effluent suspended solids concentrations for a range of operating conditions using one 25-acre cell, typical of a cell for staged construction.

**TABLE 1. EFFLUENT SOLIDS CONCENTRATIONS FOR 50-ACRE CELL**

Ponded Depth in 50-acre Cell	Pump or Dredge Size	Effluent Suspended Solids Concentration, mg/L		
		Daily Production Time		
		8.0 hours	12.8 hours	19.6 hours
2 feet	10-inch	0.01	0.26	1.80
	12-inch	0.15	1.45	5.65
	14-inch	0.71	2.99	12.44
	16-inch	2.08	8.51	20.13
	2 x 12-inch	3.05	11.46	24.54
3 feet	10-inch	0.00	0.02	0.29
	12-inch	0.01	0.21	1.56
	14-inch	0.08	0.95	4.24
	16-inch	0.36	2.57	8.98
	2 x 12-inch	0.64	3.74	11.97
4 feet	10-inch	0.00	0.00	0.05
	12-inch	0.00	0.03	0.43
	14-inch	0.01	0.23	1.68
	16-inch	0.07	0.86	3.98
	2 x 12-inch	0.15	1.45	5.65

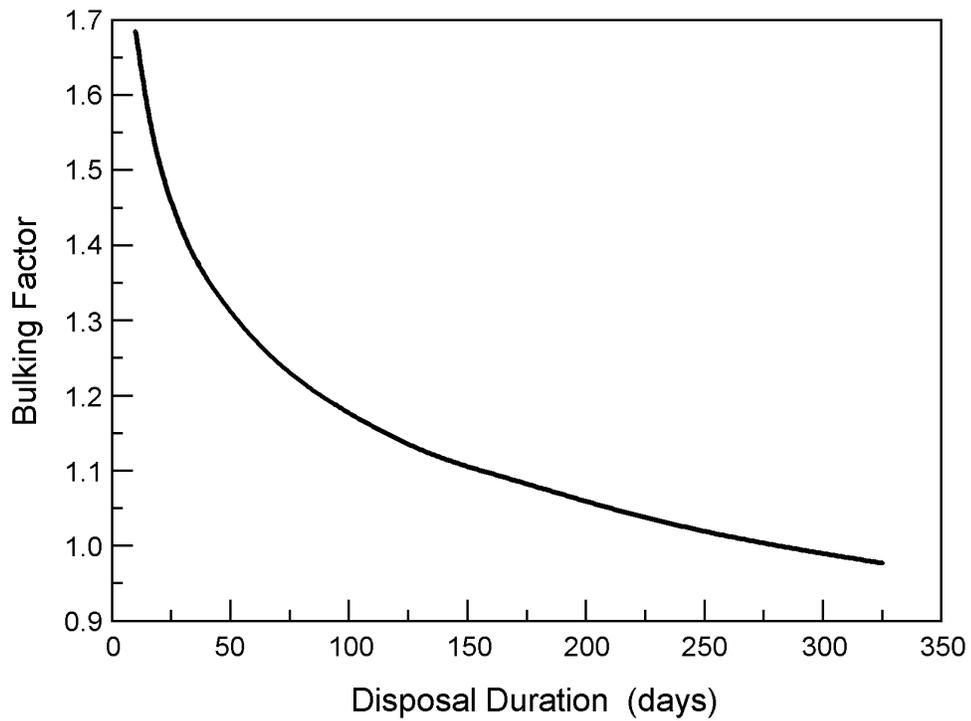


**Figure 11.** Effluent TSS concentration versus retention time

**TABLE 2. EFFLUENT SOLIDS CONCENTRATIONS FOR 25-ACRE CELL**

Ponded Depth in 25-acre Cell	Pump or Dredge Size	Effluent Suspended Solids Concentration, mg/L		
		Daily Production Time		
		8.0 hours	12.8 hours	19.6 hours
2 feet	10-inch	0.34	2.45	8.66
	12-inch	1.73	7.35	18.29
	14-inch	4.64	14.81	30.37
	16-inch	9.69	23.60	50.74
	2 x 12-inch	12.65	28.49	56.54
3 feet	10-inch	0.03	0.46	2.63
	12-inch	0.27	2.15	7.77
	14-inch	1.19	5.61	15.38
	16-inch	3.02	11.37	24.42
	2 x 12-inch	4.36	14.25	29.41
4 feet	10-inch	0.00	0.10	0.89
	12-inch	0.05	0.67	3.36
	14-inch	0.30	2.30	8.21
	16-inch	1.08	5.27	14.80
	2 x 12-inch	1.73	7.35	18.29

The volume occupied by the dredged material in the CDF at the end of a given filling operation was computed based on the volume dredged and the duration of disposal project. The ratio of the volume occupied by the dredged material stored in the CDF to the in situ volume of the material prior to dredging is termed the bulking factor. The bulking factor of the newly placed material immediately at the end of a disposal project is a function of the duration of the disposal project; the greater the duration is, the greater the time that material has to consolidate, yielding a smaller bulking factor. The SETTLE model was used to compute the bulking factor for a broad range of disposal durations. The resulting relationship between bulking factor and disposal duration is presented in Figure 12. Table 3 summarizes calculated bulking factors for a range of pump sizes and fill rates for the largest annual fill volume of 300,000 cubic yards. For a filling time of 90 days (based on an 19.6-hour daily production time with a 12-inch pump), a bulking factor of 1.20 was calculated. The 300,000 cubic yards dredged from the channels would occupy approximately 360,000 cubic yards, equivalent to 223 acre-feet of material as initially placed in the CDF.



**Figure 12.** Bulking factor versus dredging duration

**TABLE 3. BULKING FACTORS**

Pump or Dredge Size	Bulking Factor for 300,000 cubic yards		
	Daily Production Time		
	8.0 hours	12.8 hours	19.6 hours
10-inch	0.98	1.06	1.13
12-inch	1.04	1.12	1.20
14-inch	1.09	1.17	1.25
16-inch	1.14	1.22	1.30
2 x 12-inch	1.15	1.24	1.33

Preferably, projects greater than 100,000 to 125,000 cubic yards would use both cells to minimize the lift thickness and to increase the effectiveness of the passive dewatering system. The higher end of the range of project sizes which can use a single 50-acre cell is for sediments with low in situ solids concentration (below 500 g/L) while the lower end is for sediments with high solids concentration (above 700 g/L). With an effective storage area of approximately 100 acres when using both the north and south cells, the lift thickness resulting from the largest anticipated placement would be about 2.2 feet. Dewatering efficiency would be less for this lift thickness than for smaller lifts, but the material could still be effectively dewatered over most of the lift thickness if the site was allowed to dewater a year following drawdown of the ponded water.

The relationship in Figure 12 can be used to determine the bulking factor for any duration time of filling, regardless of the volume disposed. The volume required for storage would be equal to volume of in situ sediment dredged times the bulking factor. The depth of storage for the lift of dredged material at the end of the disposal project would be equal to volume required for storage divided by the storage area of the CDF cell. The long-term storage needs are a function of consolidation and desiccation and are addressed below.

Mechanically filled CDFs are designed to retain dredged material at approximately the in situ density of the sediment in the waterway. A small amount of additional water may be added by bucket dredges, but drainage and evaporative drying will reduce the free water in a matter of a few weeks. A CDF must be designed and operated to provide adequate initial storage volume and surface area to hold the dredged material solids during an active filling operation. For mechanically filled sites the design can assume no bulking for short-term storage requirements. As for hydraulically filled sites, the long-term storage requirements are a function of consolidation and desiccation as addressed in the next section. The long-term storage requirements for mechanically filled sites are identical to those for hydraulically filled sites if both are well-managed to promote dewatering and desiccation.

## **Long-Term Capacity**

The area available at the Waipio CDF must be sized to ensure that the total LTMS requirement of 1,600,000 cubic yards can be placed at the site within reasonable dike heights. It is assumed that a relatively low dike profile would be preferable from both the cost and aesthetic viewpoints.

The Primary Consolidation, Secondary Compression, and Desiccation of Dredged Fill model (PSDDF) was used to predict the long-term capacity gains possible through consolidation and desiccation at the Waipio site. The data required to estimate long-term storage capacity using the PSDDF model include

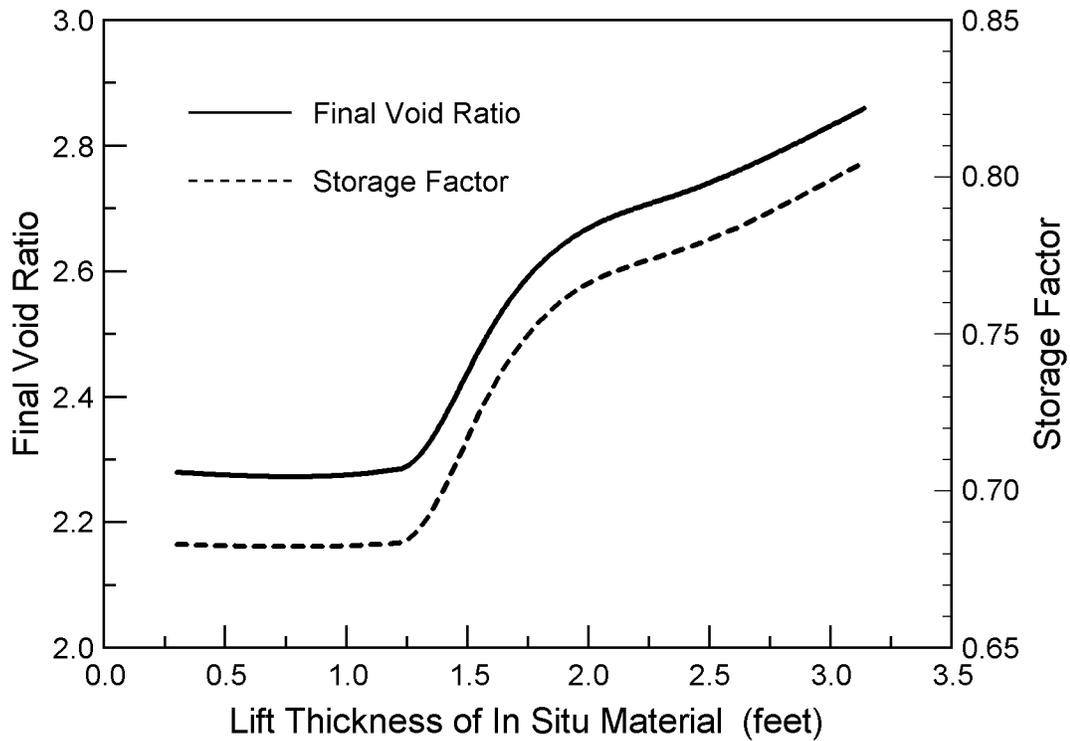
physical properties of the sediments and foundation soils such as specific gravity, grain-size distributions, Atterberg liquid and plastic limits, and water contents; the consolidation properties of the fine-grained dredged material and foundation soils (relationships of effective stress and permeability versus void ratio); CDF site characteristics such as surface area, ultimate dike height, groundwater table elevations, average pan evaporation rates, average rainfall; and dredging data such as volumes to be dredged, rate of filling, and frequency of dredging (USACE 1987 and Stark 1996).

Consolidation tests performed in Phase II on the sediment samples provided the needed data on consolidation behavior and dewatering behavior of the Pearl Harbor sediments. The model was used to predict the degree of consolidation for individual lift thicknesses of 1.5 feet, 2 feet, 3 feet, and 4 feet placed at intervals of each 2 and 3 years. Lift thicknesses of 1.5 to 4 feet correspond to an in situ volume of 95,000 to 254,000 cubic yards placed over one of the two cells with surface area of approximately 50 acres with an approximate bulking factor of 1.27. The frequency of each 2 to 3 years reflects alternating placement between the two cells, with an occasional year in which no material is placed at the site. The results for this range of lift thicknesses are given in Table 4 and are plotted in Figure 13. The storage factor and final average void ratio are plotted as a function of the lift thickness expressed in terms of the in situ volume without bulking (in situ sediment volume divided by the storage area). The results for the two frequencies were identical to each other, indicating that desiccation and consolidation were complete for these lift thicknesses within a year following the end of disposal. The storage factor, defined as the ratio of long-term storage volume to in situ sediment volume, ranges from about 0.68 to 0.80. The storage factor for small projects is likely to be 0.68, typical of uncompacted, fully desiccated dredged material, while the storage factor for the large projects is likely to be about 0.75. The overall long-term storage factor should be about 0.70.

To size the CDF, the 1,600,000 cubic yards of in situ sediment for the LTMS design life was multiplied by the long-term volume ratio of 0.70 which computes the effect of desiccation and consolidation of the dredged

**TABLE 4. LONG-TERM STORAGE FACTORS**

<b>Lift Thickness of In Situ Material</b>	<b>Long-Term Storage Factor</b>	<b>Final Void Ratio</b>
1.18 feet	0.683	2.28
1.57 feet	0.728	2.49
2.35 feet	0.776	2.72
3.14 feet	0.805	2.86



**Figure 13.** Long-term storage properties

material. This ratio is considered conservative in that ratios of 0.5 have been achieved in sites along the Atlantic seaboard and Gulf Coast. The higher storage ratio is probably due to higher organic content and lower clay content for the silty Pearl Harbor sediment than found for the clayey sediments of the Atlantic seaboard and Gulf Coast. The total volume occupied by fill in the long term is approximately 1,120,000 cubic yards, equivalent to approximately 694 acre-feet. With a total effective storage area of about 100 acres, the average depth of the dredged material fill would be about 7 feet or 6 feet above existing ground surface considering the volume of borrow for dike construction. This confirms the required 10-foot dike heights, allowing for ponding and freeboard.

## Contaminant Pathway Evaluation

### Analysis of Pathways for CDFs

Potential contaminant pathways for CDFs include effluent, surface runoff, leachate, plant and animal uptake, and volatilization. The effluent pathway is of concern for hydraulic filling, while all other pathways are of potential concern for both hydraulic and mechanical filling. Evaluation of environmental effects was

performed under the Phase II effort by executing detailed screening procedures using Tier 1 or Tier 2 approaches as outlined in "Estimating Contaminant Losses from Components of Remediation Alternatives for Contaminated Sediments," Assessment and Remediation of Contaminated Sediments (ARCS) Program EPA 905-R96-001 (Myers et al. 1996). A screening (Tier 1) analysis of most of the CDF pathways of concern was conducted. A Tier 2 analysis was conducted for the effluent pathway since this pathway will potentially involve movement of large masses of water for hydraulically filled sites and has the greatest potential for moving significant quantities of contaminants out of CDFs. The results of the Phase II evaluations and the needs for contaminant controls are summarized for each pathway in the following paragraphs.

### **Effluent Discharge**

There will only be minimal effluent discharge from a mechanically filled CDF. In the event of hydraulic filling, effluent will be discharged from the CDF due to the settling and consolidation of the dredged material. The effluent from a hydraulically filled CDF may contain both dissolved and particulate-associated contaminants.

A Tier 2 (chemical) evaluation of the effluent pathway was conducted for the Phase II study. Predictions of dissolved concentrations of contaminants in effluent were made using the effluent elutriate test (Palermo 1985; Palermo and Thackston 1988; and EPA/USACE 1998). Results for all contaminants of concern were analyzed using the Effluent Quality Evaluation Program (EFQUAL) model (Palermo and Schroeder 1991) and are presented in the Phase II report and compared to Federal marine water quality criteria for chronic toxicity, Hawaii marine water quality standards for chronic toxicity, and Pearl Harbor Estuary water quality standards for eutrophication. Only copper (17 ug/L) exceeded the acute marine toxicity standard, while arsenic (45 ug/L), selenium (151 ug/L) and ammonia (1,830 ug/L or 1510 ug/L as NH<sub>3</sub>-N) exceeded just the chronic marine toxicity standard as summarized in Table 5. The background site water concentration for the three metals also exceeded the chronic toxicity standard. The background site water sample was collected at the same location as the sediment sample. The water quality at the proposed dredged material offloading facility and at the CDF discharge points would be expected to be similar but somewhat better. The concentrations of copper, arsenic, and selenium in the elutriate were similar to their concentrations in the site water (12 ug/L, 38 ug/L, and 141 ug/L, respectively). Since the background concentrations of copper, arsenic, and selenium in the site water exceed the water quality standards, the effluent concentrations of copper, arsenic, and selenium cannot decrease to or below their water quality standards within a mixing zone; the effluent concentrations can only become similar to the background concentrations. The predicted concentrations of all other parameters were below the Federal marine water quality criteria for chronic

**TABLE 5. EFFLUENT QUALITY AND MIXING ZONE REQUIREMENTS**

Parameter	Predicted Dissolved Concentration ug/L	Marine Water Quality Std. for Toxicity ug/L	Dilution Ratio	Mixing Zone Length* feet
Ammonia	1830 as NH <sub>3</sub> 1510 as NH <sub>3</sub> -N	Pearl Harbor: 10.** as NH <sub>3</sub> -N (Eutrophication)  Federal for NH <sub>3</sub> : 5000. (Acute) 500. (Chronic)	Pearl Harbor: 150  Federal: 0.0 (Acute) 2.0 (Chronic)	Pearl Harbor: 1230. (Eutrophication)  Federal: 0. (Acute) 135. (Chronic)
Copper	17	Hawaii: 2.9 (Acute) 2.9 (Chronic)	3.2*** (Acute) 3.2*** (Chronic)	140. (Acute) 140. (Chronic)
Arsenic	45	Hawaii for As(III): 69. (Acute) 36. (Chronic)	0 (Acute) 0.8*** (Chronic)	0. (Acute) 130. (Chronic)
Selenium	151	Hawaii: 300. (Acute) 71. (Chronic)	0 (Acute) 0*** (Chronic)	0. (Acute) 0. (Chronic)

\* Based on a discharge rate of 11.8 cfs (a 12-inch dredge).

\*\* Pearl Harbor Estuary water quality standard for eutrophication.

\*\*\* Dilution to 10% above background because background exceeds standard.

toxicity and Hawaii marine water quality standards for chronic toxicity at the point of effluent discharge (at the weir) and would not require consideration of a mixing zone.

The Clean Water Act regulations (40 CFR 230.11(f)(2) and 40 CFR 230.61(b)(2)(ii)) provide for a mixing zone for effluent discharge from CDFs. A mixing zone analysis was conducted for the Waipio site using the CDFATE (Continuous Discharge Fate) model (Chase 1994 and Havis Environmental 1994), an adaptation of the USEPA CORMIX (Cornell Mixing System) model (Doneker and Jirka 1990). The mixing zone calculations were confirmed by comparison with the MacIntyre procedure (EPA/USACE 1998 and MacIntyre 1987). Since the background concentrations of copper, arsenic, and selenium in the site water exceed the water quality standards, the mixing requirements to lower the effluent concentrations of copper, arsenic, and selenium to a concentration 10 percent greater than the background concentrations instead of the water quality standards are given in Table 5. In addition to mixing zone requirements for the various marine water quality standards for acute or chronic toxicity, Table 5 provides the mixing zone requirement to satisfy the Pearl

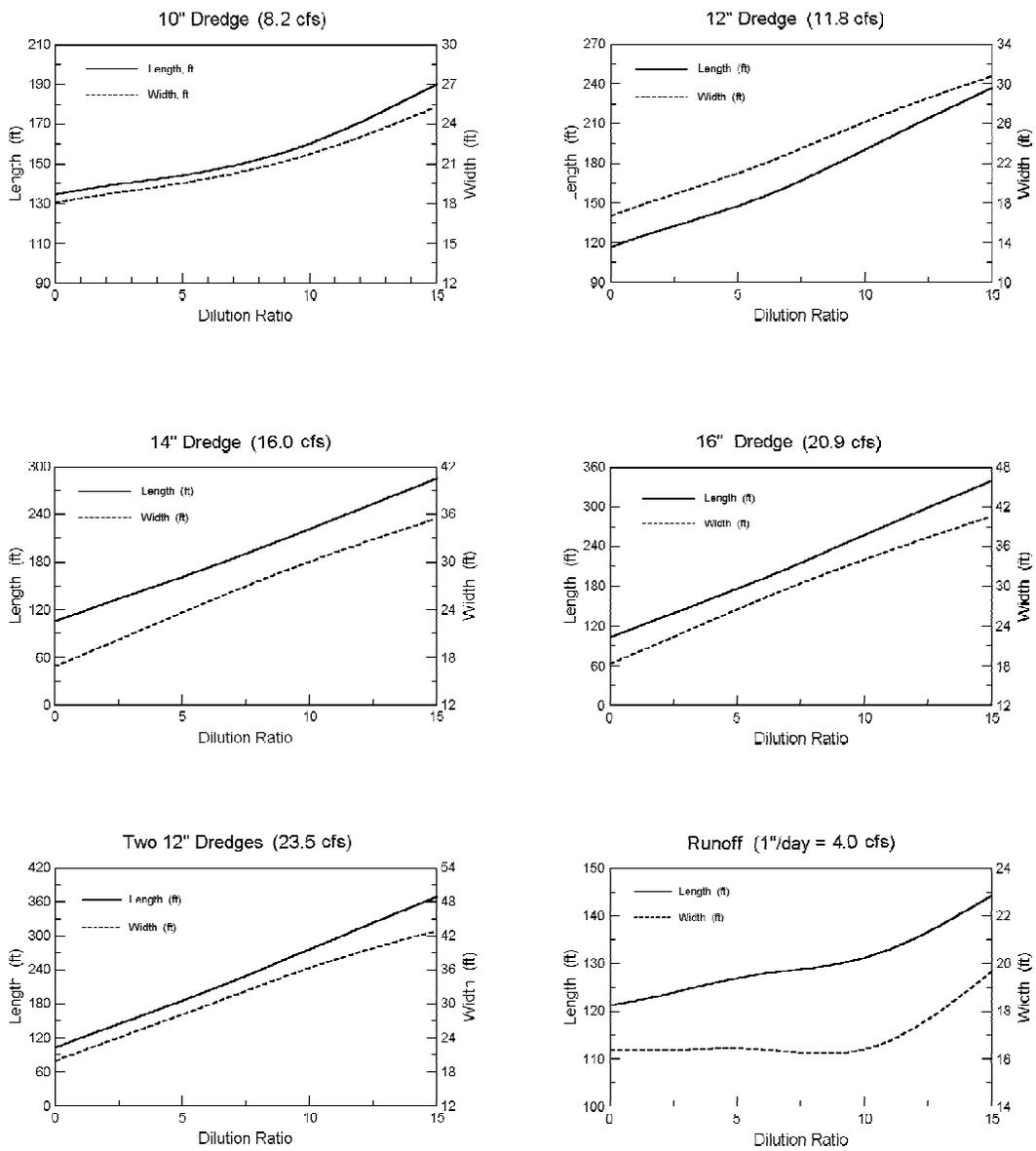
Harbor Estuary water quality standards for eutrophication. The size of the mixing zone required to meet the standards was also evaluated in the Phase II report and is also presented in Table 5 for an effluent discharge rate equivalent to the pumping rate of a 12-inch dredge. The mixing zone requirements for other flow conditions can be determined using Figures 14 and 15 with the required dilution ratios given in Table 5. The distance that is needed to achieve vertically well-mixed conditions is 1420 feet. The distance to achieve vertically well-mixed conditions is much longer than the required mixing zone indicating that the entire water column depth will not be impacted by the discharge.

The dilution and mixing zone required to meet the Pearl Harbor Estuary water quality standard for eutrophication by ammonia nitrogen was much greater than that required for any of the marine water quality standards for acute or chronic toxicity. Dr. Hans Krock of the University of Hawaii served as a member of the Technical Advisory Board responsible for developing this standard for the State. Dr. Krock was contacted regarding the applicability of the standard to dredged material effluent discharges. He indicated that he would be in support of a less stringent standard for dredged material effluent discharges since they result from removal of potentially eutrophic sediments from the water body and are of a sporadic nature (Personal communication with Dr. Hans Krock, 25 November 1998). A request for a variance from the ammonia standard is therefore recommended, and the resulting mixing zone for this parameter would be less than indicated in Table 5. The maximum dilution ratio required for all of the other parameters is 3.2 which would require a mixing zone length of 160 feet for highest flow rate that might be anticipated (23.5 cfs, the discharge rate of two 12-inch dredges).

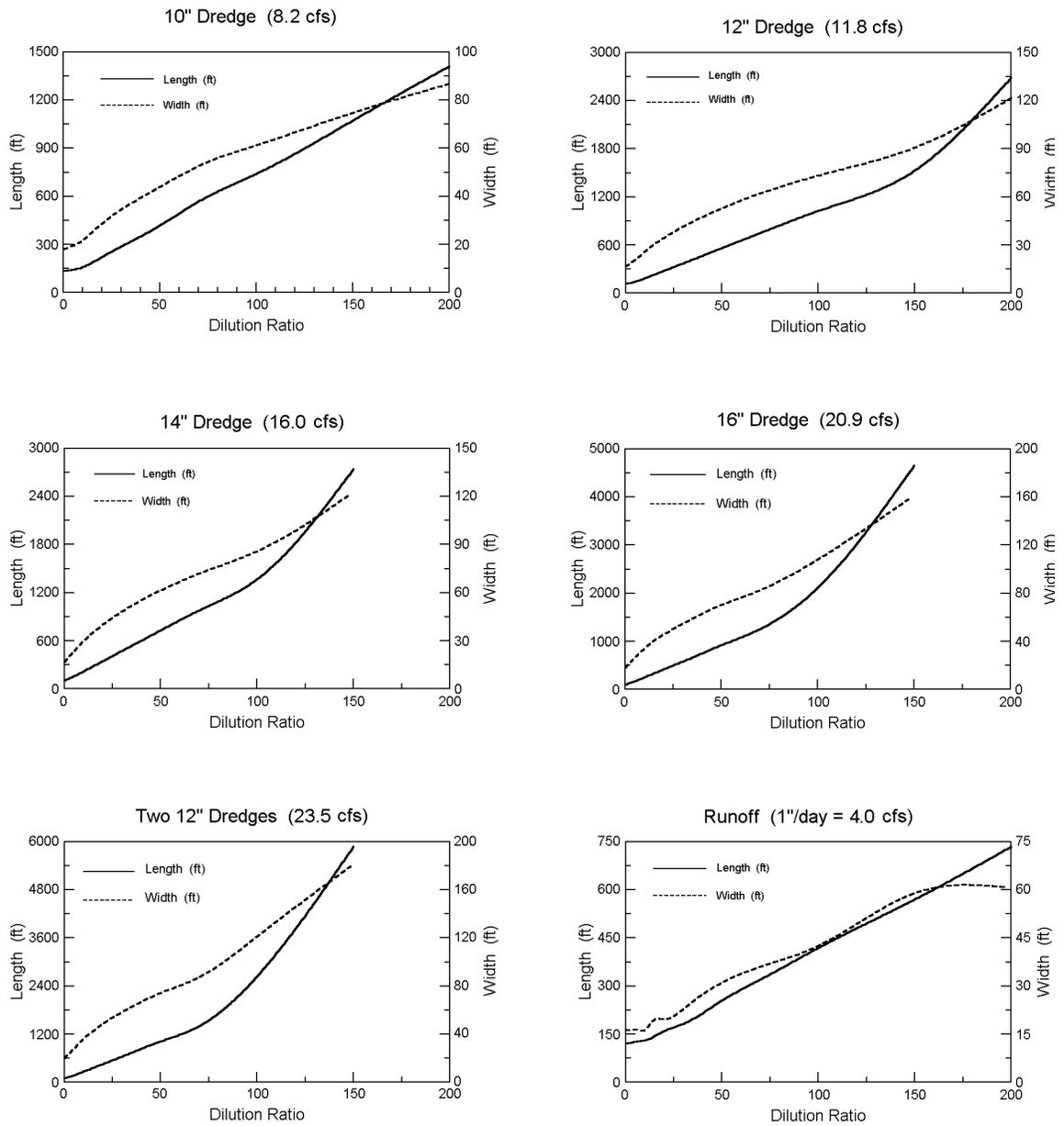
Based on these results no contaminant control (treatment) measures for dissolved contaminants in the effluent discharge are warranted if a mixing zone is allowed. Management of the ponded surface area and depth will optimize suspended solids retention and retention of contaminants associated with the suspended solids in the CDF.

## **Surface Runoff**

Immediately after material placement in a CDF and after ponded water is decanted, the settled material may experience surface runoff. A Tier 1 evaluation of the surface runoff quality using the simplified laboratory runoff procedure (SLRP) for predicting the long-term effects of drying and oxidation on surface runoff water quality was conducted (Price et al. 1998). The predicted dissolved concentrations of all parameters in the runoff from a wet, reduced surface of Pearl Harbor dredged material were below all Federal and Hawaii water quality standards for acute or chronic toxicity. These concentrations are much lower than the effluent concentrations because the runoff is generated with clean precipitation instead of site water of poor quality. The predicted



**Figure 14.** Mixing zone dimensions for dilution ratios from 0 - 15 for a variety of flow conditions



**Figure 15.** Mixing zone dimensions for dilution ratios from 0 - 200 for a variety of flow conditions

concentration of ammonia exceeds the Pearl Harbor Estuary water quality standard for eutrophication. The results of the SLRP test for runoff from a dried, oxidized dredged material surface were similar to those for effluent discharge in that the dissolved concentrations of several parameters exceeded the Federal marine water quality criteria for chronic toxicity, Hawaii marine water quality standards for chronic toxicity, and Pearl Harbor Estuary water quality standards for eutrophication at the point of discharge. The critical condition for runoff water quality is during discharge from a dried, oxidized surface. The runoff quality in the dried oxidized state exceeds the marine toxicity standards for only copper (23.3 ug/L) and ammonia (892 ug/L as NH<sub>3</sub>). The runoff water quality exceedances, dilution requirements, and mixing lengths are given in Table 6.

**TABLE 6. RUNOFF QUALITY AND MIXING ZONE REQUIREMENTS**

Parameter	Predicted Dissolved Concentration ug/L	Marine Water Quality Std. for Toxicity ug/L	Dilution Ratio	Mixing Zone Length* feet
Ammonia	Oxidized surface:  892 as NH <sub>3</sub>  735 as NH <sub>3</sub> -N  Reduced surface:  257 as NH <sub>3</sub>  212 as NH <sub>3</sub> -N	Pearl Harbor: 10.** as NH <sub>3</sub> -N (Eutrophication)  Federal for NH <sub>3</sub> : 5000. (Acute) 500. (Chronic)	Oxidized surface: Pearl Harbor: 73 (Eutrophication)  Federal: 0.0 (Acute) 0.8 (Chronic)  Reduced surface: Pearl Harbor: 20 (Eutrophication)  Federal: 0.0 (Acute) 0.0 (Chronic)	Oxidized surface: Pearl Harbor: 240. (Eutrophication)  Federal: 0. (Acute) 125. (Chronic)  Reduced surface: Pearl Harbor: 180. (Eutrophication)  Federal: 0. (Acute) 0. (Chronic)
Copper	Oxidized surface:  23.3  Reduced surface:  1.1	Hawaii: 2.9 (Acute) 2.9 (Chronic)	Oxidized surface: 8.4*** (Acute) 8.4*** (Chronic)  Reduced surface: 0.0*** (Acute) 0.0*** (Chronic)	Oxidized Surface: 135. (Acute) 135. (Chronic)  Reduced Surface: 0. (Acute) 0. (Chronic)

\* Based on a discharge rate of 4 cfs (1"/day from 100 acres).

\*\* Pearl Harbor Estuary water quality standard for eutrophication.

\*\*\* Dilution to 10% above background because background exceeds standard.

Based on these results, the runoff pathway will be controlled by maintaining the weir board elevations such that surface runoff water will be ponded in the portion of the CDF near the weirs where it can gradually be released following a rainfall event. The maximum rate of discharge would be about 4 cfs, corresponding to 1 inch of discharge from 100 acres per day. This flow rate is equal to the minimum flow rate that might be generated by a hydraulic filling operation (a 10-inch dredge operating 8 hours/day). Higher flow rates could be used as long as the required mixing zone length does not exceed the mixing zone required for effluent discharge. The 4-cfs discharge rate can be accomplished by lowering the weir boards 1 to 4 inches each day until the area is drained; the boards are lowered more than 1 inch if the CDF is only partially ponded. Alternatively, notched weir boards that limit the area of flow over the weir and therefore limit the flow rate could be used to manage the ponded water level at the site.

## **Leachate**

Subsurface drainage from upland CDFs may reach adjacent aquifers or may enter surface waters. There are no drinking water aquifers at Waipio Peninsula, and the groundwater at the site is saltwater. The only potential groundwater impact relates to the discharge of leachate to receiving waters.

A Tier 1 screening evaluation of the leachate quality and quantity was conducted in Phase II of this LTMS study. The bulk sediment chemical concentrations and site conditions at Waipio (Honolulu airport climatic data and Waipio Peninsula hydrogeologic data) were used to estimate the leachate quality and quantity using the Hydrologic Evaluation of Leachate Production and Quality model (HELPQ) (Aziz and Schroeder 1999). This model is based on equilibrium partitioning principles and considers site-specific characteristics and groundwater hydrology and the estimated water balance (budget) for dredged material CDFs. The predicted leachate parameters were then used as input to the USEPA Multimedia Environmental Pollutant Assessment System (MEPAS) multimedia model to evaluate the attenuation (adsorption and dispersion) of leachate in site foundation soils prior to discharge to receiving waters (Streile et al. 1996). The model results were compared to the Federal and Hawaii marine water quality standards for chronic toxicity and Pearl Harbor Estuary water quality standards for eutrophication, and all parameters were below the standards. Based on these results, no liner or other contaminant controls for leachate to groundwater are warranted.

## **Plant and Animal Uptake**

A di-ethylene tri-amine penta-acetic acid (DTPA) extraction procedure was used for a simplified screening prediction of plant uptake of metals (Folsom and

Houck 1990) in Phase II of this LTMS study. The screening evaluation presented in the Phase II report indicated that Pearl Harbor sediment may contribute to elevated levels of cadmium and copper in leafy freshwater plants that may colonize the CDF, and elevated levels of lead may be of concern under limited situations. The predicted uptake of these heavy metals was compared with the predicted uptake from two reference soils taken from the proposed CDF site on Waipio Peninsula. The comparisons showed that the uptake from the dredged material would be about ten times higher than the reference samples. Animal uptake would also be similarly elevated because animal uptake is strongly correlated with DTPA extraction (Folsom et al. 1981). These elevated levels of uptake pose some concern for using the material for food production or animal feed and merit a marginal level of environmental concern, indicating a need for further testing. Therefore, at the end of the service life of the CDF the surficial materials should be tested using plant bioassay tests using a variety of plants selected to represent anticipated use of the site. After the results of the plant bioassay tests are analyzed, appropriate control measures or restrictions will be implemented. These measures could include plant control, use restrictions, capping, phytoremediation, or soil amendments. The levels of uptake pose insignificant environmental concern during the service life of the facility because plant growth and animal inundation are unlikely until the salt has leached from the dredged material. In addition, using the dredged material to raise the dikes poses insignificant environmental concern, especially considering that vegetation on the dikes will be controlled.

Water birds may be attracted to the site to feed on aquatic organisms in the dredged material following disposal during dewatering. The site will resemble a large mud flat during the initial period of dewatering until a crust is formed. At the Waipio site which has a high evaporation demand and low precipitation, it is estimated that it will take about six to eight weeks to form a crust following drawdown of the ponded water. If this condition poses an environmental concern, measures could be taken to discourage feeding at the site such as setting out noise makers, netting, and decoys.

### **Volatilization and Odor**

In Phase II of this LTMS study a Tier 1 evaluation of potential volatilization of contaminants to air was made using the method proposed by Thibadeaux in "Estimating Contaminant Losses from Components of Remediation Alternatives for Contaminated Sediments," Assessment and Remediation of Contaminated Sediments (ARCS) Program EPA 905-R96-001 (Myers et al. 1996). Ponded, wetted, dry, and re-wetted conditions were evaluated. The results of this evaluation were compared with Occupational Safety and Health Administration (OSHA) human health effects levels for workers at the site. The predicted contaminant levels in the air were well below OSHA health effects levels.

The potential for odor problems was also evaluated in Phase II of this LTMS study using testing procedures corresponding to American Society for Testing and Materials (ASTM 1967). A panel was used to sample the odors, and the response indicated that there was no strong odor or no objectionable odor for ponded, wet, dry, and re-wetted conditions. The odor was qualitatively described as earthy or musty, essentially the odor of a coastal soil. In addition, air dispersion modeling using a Gaussian dispersion model for a surface source was conducted to estimate dilution and dissipation of volatiles and odors from the site. Predictions were made at intervals of 820 feet (250 m) up to a distance of 4900 feet (1.5 km), equal to the distance from the CDF to most points of the Naval Station. Odors at the site would be decreased 40-fold at 1600 feet (0.5 km) and more than a hundredfold at distances greater than 3300 feet (1 km) from the CDF and should not be noticeable. No controls for odors are needed at the Waipio Peninsula CDF.

## **CDF Operation and Management**

### **Placement of Weirs and Inflow Points**

Outflow weirs are usually placed on the site perimeter at the point of lowest elevation. The material offloading area or the dredge pipe inlet for hydraulic filling is usually located as far away as practicable from these outflow weirs. However, these objectives may sometimes be conflicting, depending on the geometry of the site. During hydraulic filling, the dredged material surface will develop a very slight slope or downward elevation gradient from the inflow point to the weirs. Effective operation may require that the inflow location for the pipeline for hydraulic filling be moved periodically from one part of the site to another to ensure a proper filling sequence and obtain proper surface elevation gradients from inflow points to the weirs. Also, shifting inflow from one point of the site to another and changing outflow weir locations may facilitate obtaining a proper suspended solids concentration in disposal site effluent or rainfall runoff.

The proposed locations of inflow points and multiple outlet weirs for the Waipio CDF are shown in Figure 4. This arrangement allows for multiple inflow points and multiple outlet weirs at the north cell to alternate the inflow and better distribute the material within the site, avoiding excessive mounding of coarse sand at any one point. The triangular geometry of the south cell precludes effective location of multiple inflow points, but does allow for multiple outlet weirs with a single inflow point at the south corner.

Weir structures will be required to allow discharge of the excess carrier water as effluent during active filling. The flow rate of effluent discharge will be determined by the rate of filling. The weir length required to pass a design discharge consisting of rainfall runoff for a 25-year rainfall event plus flow rate

for the largest offloading pump was calculated using a module of the SETTLE program. This module calculates the required weir length using procedures in EM 1110-2-5027. Although multiple weir locations were defined for purposes of site management, each of the structures should be sized to pass the design effluent discharge flow rate. The weir outlet pipe should also be designed to accommodate an emergency drawdown of ponded water if required.

For a ponded depth of 2 feet the length of the weir should be sufficiently long to maintain a weir loading rate that is no greater than 0.88 cfs/foot. The discharge rate from a 50-acre cell for a 6-inch storm is about 13 cfs, and the maximum inflow rate is about 24 cfs, equivalent to two 12-inch dredges. Therefore, the weir design flow rate is 37 cfs. The calculated effective weir length for that flow rate for a material exhibiting zone settling behavior is approximately 42 feet. This effective weir length should be distributed between the two weir locations in each cell because both weirs would be employed under this flow condition. Each weir would have a length of 21 feet.

Weirs can be constructed of sheet steel as shown in Figure 16 or of corrugated metal as shown in Figure 17. Corrugated metal drop inlets, commonly available, are recommended for the weirs. These can be obtained in a range of sizes, and multiple inlets can be ganged together to provide the needed weir crest length (e.g., four 6-foot drop inlets could meet the 14-foot total length requirement). A photo of the interior of a newly constructed CDF showing a corrugated metal weir structure in place is shown in Figure 17.



**Figure 16.** Rectangular weir constructed from sheet steel



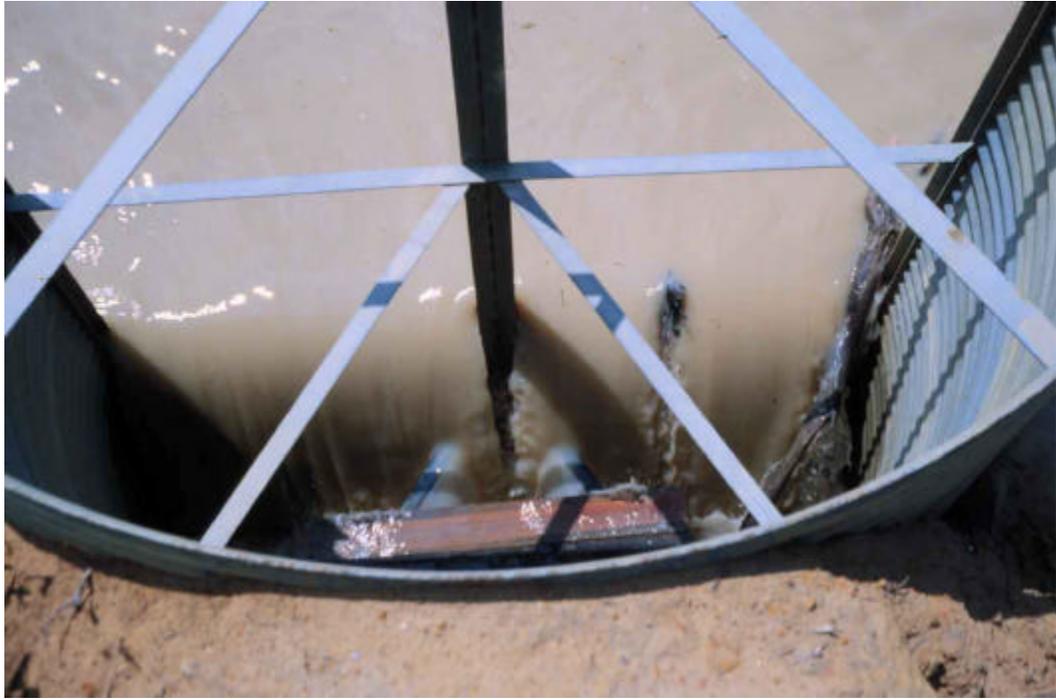
**Figure 17.** Newly placed corrugated metal weir structure

An operating corrugated metal weir is shown in Figure 18. (Note: The effluent suspended solids concentration shown in the photo is much greater than would be achieved at typical saltwater sites such as in Pearl Harbor.) Alternatively, an 8-foot-square weir box with drainage on three sides could be constructed. A square weir box during operation is shown in Figure 19.

### **Surface Water Management**

The management of surface water during the disposal operation can be accomplished by controlling the elevation of the outlet weir(s) throughout the disposal operation. A mechanically filled CDF will generate a minimum volume of excess water compared to a hydraulically filled site. This water can normally be contained within the site during filling. After active filling is completed, free water, not already removed by evaporation, may be drained from the site through the adjustable weirs.

At the beginning of a hydraulic disposal operation, the outlet weir is set at a predetermined elevation (3 feet above the existing fill elevation is recommended to obtain an average ponded depth of 2 feet.) to ensure that the ponded water will be deep enough for settling as the containment area is being filled. As the disposal operation begins, slurry is pumped into the area; no effluent is



**Figure 18.** Operating corrugated metal weir structure



**Figure 19.** Operating sheet steel box weir structure

released until the water level reaches the weir crest elevation. Effluent is then released from the area at about the same rate as slurry is pumped into the area. Monitoring (see section below) is conducted to ensure effluent quality is within Hawaii water quality standards. The ponding depth decreases as the thickness of the dredged material deposit increases. As the dredged material fill increases, the weir crest elevation is raised by adding stoplogs to maintain the desired ponding depth and effluent quality. A ponding depth of 2 feet over the level of the dredged material is recommended. Figure 20 shows a CDF with water ponded in this manner during filling operations. After completion of the disposal operation and the activities requiring ponded water, the water is removed as quickly as effluent water quality standards will allow. Typically, the weirs can be lowered about 3 inches per day during drawdown without resuspending settled solids. Figure 21 shows a CDF and weir structure during drawdown and dewatering.

### **Post Dredging Management Activities**

Periodic site inspections and site management following the dredging operation are desirable. Once the dredging operation has been completed and the ponded water has been decanted, site management efforts should be concentrated on maximizing the containment storage capacity gained from continued drying and consolidation of dredged material and foundation soils.



**Figure 20.** CDF with ponded water during filling operations



**Figure 21.** CDF and weir structure during drawdown and dewatering

Management at this stage consists of keeping the weir boarded to an elevation just above the level of the dredged material fill. Removal of ponded water will expose the dredged material surface to evaporation and promote the formation of a dried surface crust. Some erosion of the newly exposed dredged material may be inevitable during storm events; therefore, weirs should be boarded at a level above the dredged material surface to pond the rainwater within a small area at the weir to avoid excessive erosion of material. The potential for erosion will be minimized once the dried crust begins to form within the containment area. As the fill consolidates, the weir boards should be periodically lowered to maintain the small ponded area. The formation of a dried surface crust does not significantly contribute to fugitive dust. Initially, the crust forms large cohesive blocks that will crumble only after a long period of time. At the point when crumbling occurs, vegetation would typically develop, eliminating dust problems. Rehandling of the dried material for removal or dike raising may require watering for dust control.

## **Dewatering Operations**

### **Factors Affecting Long-Term Storage Capacity**

Long-term storage capacity should be considered for an upland CDF intended for long-term use (Palermo 1992). Consolidation and desiccation

(evaporative drying) are long-term processes which will affect the long-term storage capacity. The coarse-grained fraction of dredged material (sands and coarser material) undergoes sedimentation quickly and will occupy essentially the same volume as occupied prior to dredging. However, the fine-grained fractions of the material (silts and clays) require longer settling times, initially occupy considerably more volume than prior to dredging, and will undergo a considerable degree of long-term volume change due to consolidation if hydraulically placed. Such materials are essentially under-consolidated soils, and the consolidation takes place due to self-weight loading.

Dredged material placement also imposes a loading on the containment area foundation, and additional settlement may result from consolidation of compressible foundation soils. Settlement due to consolidation is therefore a major factor in the estimation of long-term storage capacity. Since the consolidation process for fine-grained materials is slow, total settlement may not have taken place before the containment area is required for additional placement of dredged material. Settlement of the containing dikes may also significantly affect the available storage capacity and should be considered.

Once a given active filling operation ends, any ponded surface water required for settling should be decanted to expose the dredged material surface for desiccation (evaporative drying). This process can further add to long-term storage capacity and is a time-dependent and climate-dependent process. However, active dewatering operations such as surface trenching enhance the natural dewatering process. Since the dredged material is of low permeability, the placement of successive thin lifts will allow better drying.

Desiccation of dredged material is basically removal of water by evaporation and transpiration. Plant transpiration can also enhance dewatering, but is not considered in this report because limited plant growth is expected if the site is used regularly. Evaporation potential is controlled by such variables as radiation heating from the sun, convective heating from the earth, air temperature, ground temperature, relative humidity, and wind speed. However, other factors affect actual evaporative drying rates. For instance, the evaporation efficiency is normally not a constant but some function of depth to which the layer has been desiccated and also is dependent on the amount of water available for evaporation.

### **Dredged Material Dewatering Operations**

If the CDF is well-managed following active filling, the excess water will be drained from the surface and natural evaporation will act to dewater the material. However, dewatering operations should be evaluated to speed up the dewatering process and achieve the maximum possible volume reduction, considering the site-specific conditions and operational constraints.

Once dredged material is placed in the site, a management program for dewatering should be implemented as needed. This would consist of draining the ponded water following disposal, peripherally trenching for minimal dewatering enhancement, and removing the dewatered material from the area adjacent to the dikes for use in upgrading the dikes.

Dewatering results in several benefits. Shrinkage and additional consolidation of the material resulting from dewatering operations leads to creation of more volume in the CDF for additional dredged material. The drying process changes the dredged material into a more stable soil form amenable to removal. Dewatered material remaining in the CDF forms a more stable fast land with predictable geotechnical properties. Also, the drainage associated with dewatering helps control mosquito breeding. Figure 22 shows the typical appearance of material in a CDF after dewatering, with surface crust blocks formed by desiccation.

A number of dewatering techniques for fine-grained dredged material have been studied (Haliburton 1978 and Haliburton et al. 1978). However, only surface trenching and use of underdrains were found to be technically feasible and economically justifiable (Haliburton 1978). Techniques such as vacuum filtration or belt filter presses can be technically effective, but are not economical for dewatering large volumes of fine-grained material.



**Figure 22.** Surface crust blocks formed by desiccation

The concept of surface trenching to dewater fine-grained dredged material was first applied by the Dutch (d'Angremond et al. 1978) and was field-verified under conditions typical of CDFs in the U.S. (Palermo 1977). Surface trenching has become a commonly used management approach for dewatering in CDFs (Poindexter 1988, Poindexter-Rollings 1989).

Construction of trenches around the inside perimeter of confined disposal sites using draglines is a procedure that has been used for many years to dewater and/or reclaim fine-grained dredged material. Figure 23 shows a trench excavation using a dragline operating on mats. In many instances, the purpose of dewatering has been to obtain convenient borrow material to raise perimeter dikes. Draglines and backhoes are adaptable to certain perimeter trenching activities because of their relatively long boom length and/or method of operation and control. The perimeter trenching scheme should be planned carefully so as not to interfere with operations necessary for dewatering or other management activities. Figure 24 shows a typical dragline excavation of dewatered material for dike raising operations.

Dewatering will be limited to management of surface water following each filling operation and to measures to promote drainage of precipitation water in the intervals between filling. Periodic inspection and adjustment of the weir height will be necessary to drain surface water and ensure that effective drainage continues as the newly placed material consolidates. Inspections



**Figure 23.** Trench excavation using a dragline operating on mats



**Figure 24.** Dragline excavation of dewatered material for dike raising

should be planned on a quarterly basis during site maintenance. Trenches will be constructed around the inside perimeter of confined disposal sites, especially near the weirs to promote increased drainage efficiency for rainwater. The material removed from the trenches will be placed against the inside face of the dike.

Since two full years is anticipated between dredged material placements, sufficient time should be available for dewatering. Placement operations should be accomplished within a time period of a few months. If needed, trenching operations should begin a few months following completion of filling, and it should be accomplished within a time period of a few months. The completed trenching should be in place within the first year. This would allow another year for additional dewatering prior to placement of a new lift of material in the cell. Interior trenches can be used to further increase drying; however, the small size of the Waipio cells does not justify the construction of interior trenches. This management approach is needed throughout the life of the project.

## **Removal of Material for Beneficial Use**

Removal of coarse-grained material for productive offsite beneficial uses will further add to capacity. Dewatered fine-grained material may also be used for dike maintenance or raising. This concept has been successfully used by CE Districts and demonstrated in field studies. One beneficial use option under

consideration is manufacturing a soil product by mixing dewatered dredged material with other materials and applying the product as a topsoil, landscape soil, or other similar application. Studies are planned for this option with the University of Hawaii. USACE guidance on these and other beneficial uses of dredged material will be considered in developing beneficial use options for the CDF (USACE 1986).

## **Monitoring**

A monitoring program must be developed to comply with regulatory requirements and to operate the CDF effectively. Monitoring could include evaluation of all of the environmental pathways (surface water, groundwater, plant and animal uptake, and air) identified as being important for a given placement operation; however, the testing conducted during Phase II indicated that only effluent and runoff would be of concern. The CDF monitoring program should therefore be limited to sampling for effluent quality and maintaining good records for the volumes and types of materials placed in the facility. Effluent monitoring will be required during filling and may be required for rainfall runoff while material with elevated contaminant levels is exposed, i.e., prior to final closure or revegetation since capping with clean material following each disposal project is not recommended. Chemical analysis of effluent quality in addition to turbidity may be necessary for contaminated sediment with concentrations equivalent to or exceeding those in the composite sample tested for the LTMS. The parameters analyzed should target contaminants of concern that are present in the sediment. A proposed monitoring plan is provided in Chapter 4 of this report.

## **Site Closure**

The Waipio CDF is located on lands which have a potential beneficial use following completion of dredged material disposal operations at the site. Agricultural leases are active on the peninsula, and agricultural use is considered the most likely ultimate use of the CDF site. No formal closure plan is required for a CDF, but minimal site closure operations would be appropriate with an objective of preparing the surface of fine-grained material in a manner suitable for agriculture. The closure operations would be conducted after placement of the last layer of dredged material and completion of dewatering of the layer. At the end of the service life of the CDF the surficial materials should be tested using plant bioassay tests on a variety of plants selected to represent anticipated use of the site. After the results of the plant bioassay tests are analyzed, appropriate control measures or restrictions will be implemented. These measures could include plant control, use restrictions, capping, phytoremediation, or soil amendments. Other closure activities would include grading any mounds near inflow points or removing any significant sand mound

for beneficial use, grading and filling any dewatering trenches to the level of the surrounding surface, grading any remaining excess dike heights protruding above the site surface, and removing inlet pipes and weir structures.

An important consideration in future use of the site for agriculture is the suitability of the material for agricultural use. Suitability is comprised of many components including physical structure of the soil matrix, drainage characteristics of the soil and overall land mass, chemical composition of the soil, contaminant mobility and effects, soil salinity, organic content, fertility, plant species, and type of agricultural use. Dewatering and desiccation will provide the physical structure of the soil required for agriculture. Grading and blending with the coarse-grained material will improve the drainage characteristics. Adding soil amendments such as lime, nutrients, and organic material will decrease the mobility and uptake of heavy metals and increase soil fertility. Maximizing infiltration of rainwater or irrigation can increase elution of salts from the dredged material, accelerating recovery of soil fertility and improving the range of plant species that could be readily supported. In addition, the water used for slurring the dredged material could be freshwater which would reduce the salinity of the dredged material during the disposal operation to a level that would support most plants. This option could be employed for all disposal projects or just the last project of each cell. Finally, careful selection of agricultural use would minimize many concerns regarding contaminant mobility, plant uptake, and soil infertility.

### **Considerations Related to ESQD**

Since a portion of the site is located within the ESQD arc, the types and amounts of equipment and personnel operating at the site at various times and the requirements for permanent facilities must be considered in requesting site approval. Precise numbers of personnel and equipment types would be determined by the contractors responsible for construction or management at any given time. However, realistic estimates are possible based on past experience.

During the construction phase, approximately 10 individuals would be required on site during dike construction. Equipment required during construction phases would consist of dozers, graders, and ancillary trucks, etc. The personnel would be operating this equipment during shifts, and the presence of 10 individuals on site 24 hours a day during the construction period could be assumed. If the site is constructed in a staged fashion, the construction period would extend over 1 to 2 months and would be repeated for each construction stage. If the entire site is built under one large contract, a construction period of 3 to 4 months could be assumed.

During active site operations (time periods during which the site is being actively filled), approximately 6 individuals would be required on site, both at the offloading facility dockside and at the CDF inflow point and outflow weirs. These individuals could be assumed to also work in shifts, and the presence of 6 individuals on site 24 hours a day during the filling period could be assumed. Equipment required during active filling periods would include the barges and tugs, a dozer or front-end loader, and ancillary trucks, etc. The personnel would be working mainly dockside, mooring the barges and operating the pumps at the offloading facility. The activities at the inflow points and outflow weirs would be conducted every few hours, with personnel checking and adjusting the location of the end of the inflow pipe with a dozer or checking and adjusting the outflow weir by removing or adding boards. These same personnel may be tasked with reading turbidity instruments or collecting samples for monitoring purposes. The time period required for filling operations would vary with the volume placed, but would be a maximum of approximately 90 days in any given year.

During site management periods (between active filling operations), approximately 6 individuals would be required on site to perform trenching and dike upgrading activities. Equipment required during these periods would include a dragline or long-reach backhoe and ancillary trucks, etc. These personnel would be operating the equipment to construct trenches along the inside of the dikes and placing the excavated material on the dike sections to raise the elevation. These individuals could be assumed to also work in shifts, and the presence of 6 individuals on site 24 hours a day during the management period could be assumed. Site management activities could be conducted over a period of 2 to 3 months and scheduled between active filling operations.

Periodic ordnance handling operations at W-22 may occur. Such an operation would create an ESQD which would prohibit any other work in the area during the operation. Scheduling of site operations and maintenance activities and dredging contracts must be coordinated with any anticipated ordnance handling operations. It may be necessary to include appropriate clauses in site maintenance and dredging contracts for cessation of work to accommodate emergency ordnance handling operations.

ESQD considerations would prohibit construction of any type of structure which could be considered permanently inhabited. This would not present any technical constraints on the construction, operation, management, and eventual beneficial use of the CDF.

## **4 - Testing and Regulatory Considerations**

This chapter focuses on the specific testing and regulatory considerations for implementing the LTMS as described in this report. As part of the regulatory considerations, a general monitoring plan for CDF effluents is presented.

### **Testing Considerations**

Sediment samples from representative project areas were collected and tested under Phase II of the LTMS. However, the purpose of this testing was to obtain representative data for Pearl Harbor sediments and use those data for design of the CDF. The results of the testing conducted for the LTMS may reduce the need for future testing of specific projects, but will not meet all future needs because project dredging for Pearl Harbor is in scattered locations and the sediment properties will vary. Additional testing for future projects will therefore be needed to determine if the site operation and management procedures are adequate for a given future project. Future testing would include physical and chemical characterization and environmental pathway testing as appropriate. In general, the testing should be conducted using guidance in the EPA/USACE ocean testing manual and inland testing manual (EPA/USACE 1991 and EPA/USACE 1998).

### **Characterization and Compositing Plan**

As plans are developed to dredge either the main channel or project areas, the materials should be appropriately characterized. Engineering and environmental tests may also be required, and the specific tests to be conducted will depend on the disposal options proposed (ocean disposal or CDF disposal). Since there is the potential for considerable variability within specific channel or project areas, a compositing plan prior to pathway testing is advisable. The variability of the physical and chemical properties of the sediments in the areas to be dredged, as well as the potential disposal options, should be considered in developing the compositing plan. This plan should be agreed to by the regulatory agencies for each project or group of projects prior to testing.

## **Ocean Suitability Testing**

If ocean placement is proposed for sediments from specific project areas, these sediments can be evaluated and tested to determine acceptability using guidance in the Ocean Testing Manual (EPA/USACE 1991). Testing for suitability for ocean placement is not a requirement. If there is reason to believe that materials to be dredged from specific channel or project areas will not be suitable for ocean placement, the cost of testing for ocean suitability could be bypassed if the decision is made up front to place those materials in the CDF. Testing resources would then be focused only on those considerations pertinent to placement in a CDF.

## **CDF Testing**

The initial characterization of sediment proposed for placement in the CDF would consist of both physical characterization and a sediment chemical inventory. Characterization data can be used to screen the pathways of concern for CDF placement and determine the need for additional pathway testing for the specific project. The testing and screening conducted for the LTMS indicated that the effluent pathway was the pathway of most concern when the dredged material is disposed hydraulically. Additionally, this pathway must be evaluated for purposes of the state water quality certification. It is anticipated that an evaluation of the effluent pathway will be required for projects proposed for CDF placement; this evaluation would include conducting the effluent elutriate test and water column elutriate bioassay test when representative data are unavailable. The test and evaluation procedures should be conducted using procedures in Appendix B of the inland testing manual (EPA/USACE 1998). The effluent evaluation in the inland testing manual can be conducted as a screening evaluation or can be conducted using effluent elutriate test data and effluent water column bioassay test data. If a sufficient database for Pearl Harbor sediments is developed over time, evaluations of sediments which do not pass the screening procedures could be made based on the testing database (an alternate approach for screening evaluation).

The testing and screening conducted for the LTMS indicated that the runoff pathway was the pathway of most concern when the dredged material is disposed mechanically. Additionally, this pathway must be evaluated for purposes of the state water quality certification. It is anticipated that an evaluation of the runoff pathway will be required for projects proposed for CDF placement; this evaluation would include conducting the SLRP test and water column elutriate bioassay test when representative data are unavailable. The test and evaluation procedures should be conducted using procedures in Environmental Effects of Dredging Technical Notes EEDP-02-25 (Price et al. 1998). A screening protocol based on the findings of this LTMS study could be used to determine when testing should be performed.

Other pathway tests may also be required, depending on the levels of contaminants present and the pathways of concern. The sediment characterization tests will be sufficient in most cases and likely required unless the sediment contaminant levels are significantly elevated above those previously tested. The pathway evaluations and screening procedures are found in the USACE/EPA Technical Framework (USACE/EPA 1992) and the ARCS Remediation Guidance Document (USEPA 1994).

## **Regulatory Overview**

A general overview of the regulatory considerations for dredged material disposal was included in the Phase I report. The selection of the LTMS involving use of a CDF will require appropriate NEPA documentation. Considering the facts that the proposed disposal site is located on Navy property and that there are no likely significant environmental impacts, an Environmental Assessment would likely be sufficient.

Since the construction of the CDF will disturb a surface area greater than 5 acres, a National Pollutant Discharge Elimination System (NPDES) permit will be required for the construction activity. Regulatory actions will also be required for each specific dredging project or group of projects. Dredging operations will require a Section 10 permit from the USACE regardless of the disposal option. A Section 103 permit from the USACE will be required for transport of dredged material to the Oahu ocean placement site. Effluent from a CDF is defined as a dredged material discharge under Section 404 of the CWA. All planned options for placement of dredged material at the Waipio CDF involve discharge of excess water back to Pearl Harbor. Therefore the projects placed at the CDF at the Waipio Peninsula will involve an effluent discharge to waters of the U.S. and would require a Section 404 permit from the USACE and a Section 401 water quality certification and coastal zone consistency from the State of Hawaii. It is USACE policy that, once a CDF is regulated under Section 404 for purposes of effluent discharge, the management activities at the site during inactive periods (such as dewatering or surface runoff) would also be regulated under Section 404.

## **Monitoring Plan for Effluent Quality**

### **General Considerations**

The Section 401 water quality certification for placement of dredged material in a confined disposal facility (CDF) at Waipio Peninsula will require that Hawaii water quality standards are met after consideration of initial mixing. This section describes a recommended monitoring plan for effluent quality. The

monitoring plan is focused on effluent quality during filling operations, but a similar effort could be conducted for surface runoff as needed (e.g. for drainage of water from the CDF following a major storm event).

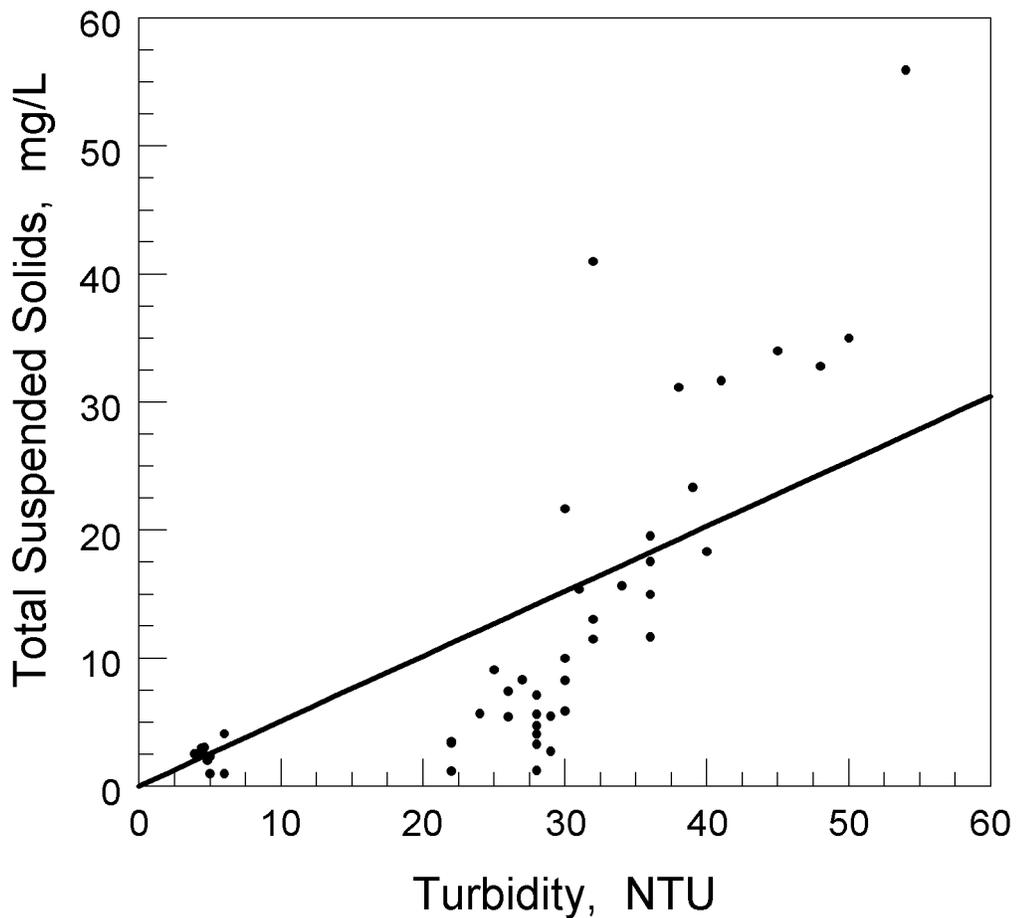
The data gathered by this monitoring can be used to (1) demonstrate 401 water quality certification compliance, (2) aid inspection of the dredging contractor to ensure compliance, (3) aid in demonstrating the adequacy of the disposal area design, and (4) document the water quality impact (or lack thereof) if there are public concerns. The following considerations are addressed:

1. Parameters to be monitored.
2. Sampling and analysis techniques.
3. Sampling locations.
4. Monitoring frequency.

### **Parameters To Be Monitored**

Parameters to be monitored for a specific project involving placement of dredged material into the CDF should be chosen only after an analysis of all conditions relating to the project, including the bulk sediment analysis, the results of effluent quality testing, and the requirements set forth by the state in the water quality certification. Contaminants should only be monitored if they are expected to be present at levels of concern. All parameters of concern need not be monitored at all locations at all times.

Effluent suspended solids is the only parameter which should be monitored for projects involving placement of materials with contaminant concentrations below those in the composite sample tested for the LTMS. Suspended solids (SS) or turbidity should always be monitored because it helps in management of the facility and evaluation of the design. SS is the best indicator of overall performance of the disposal area, both for solids retention and for most other contaminants which are strongly associated with SS by adsorption or ion exchange. Turbidity is a much more easily measured parameter than SS (it can usually be measured by the inspector in the field) and can often be used instead of SS for routine monitoring after a correlation between the two has been established for the particular sediment and site. Methods are available (Thackston and Palermo 1998) for correlating these parameters. A correlation between suspended solids concentration and turbidity was established for Pearl Harbor CDF effluents in Phase II of the LTMS study using the data from the flocculent settling test. The relationship is shown in Figure 25. Often, water quality standards are expressed in terms of turbidity, and thus, it becomes the basic controlling parameter itself. Other parameters such as temperature, Ph, and dissolved oxygen (DO) are easy to measure with a probe, but these parameters are rarely of concern because dredging has little impact on them.



**Figure 25.** Turbidity versus effluent suspended solids concentration

Specific chemicals are not normally required to be monitored, unless there is evidence of their presence in the sediments in concentrations high enough to be of concern. Effluent elutriate testing, recommended for those projects in which the sediment contaminant concentrations exceed those in the composite sample tested for this LTMS, would provide the contaminants of concern. Chemical parameters to be monitored should be limited to those exceeding the Hawaii water quality standards in the elutriate: ammonia, copper, arsenic, and selenium based on the sediment tested in Phase II of this study.

### **Sampling and Analysis Technique**

Standard procedures for sampling, preserving, and analyzing water samples should be followed for effluent quality monitoring programs (EPA/USACE 1995).

## **Sampling Locations**

Under Section 404, the effluent should meet applicable water quality standards within an acceptable mixing zone. Therefore, sampling should always be conducted at the edge of the mixing zone to determine permit compliance. Upstream or background receiving water should always be sampled to determine ambient conditions. Sampling at the overflow weir will provide data on the adequacy of the site design and the accuracy of laboratory tests used for effluent quality prediction.

## **Monitoring Frequency**

Three samples should be the minimum number taken at any location during a single monitoring event because three samples are required to determine a variance. One sample per average hydraulic retention time is the maximum frequency that can be practically justified. The average retention time varies during the project, so the sampling frequency should vary also. Because most sites have an average retention time on the order of 24 hours, daily sampling for SS or turbidity is convenient and is recommended.

Sampling for nutrients, toxic metals, or organics, if required, can be less frequent, approximately once every two weeks. If frequent samples are analyzed for SS, which is easy and inexpensive to determine, less frequent samples for chemical contaminants are necessary because variations in chemical concentrations are usually proportional to SS concentrations. Also, more frequent sampling does not necessarily provide more usable information because analytical results for nutrients, metals, and organics frequently are not available for several weeks.

Although water quality at the overflow weir is normally relatively stable, it can change very rapidly with changes in the weather. Therefore, samples should not be taken when the effluent from the disposal area is especially high in SS for short periods because of high winds, hydraulic surges from the dredge, weir problems, or other brief upsets unless it is desired to document worst-case conditions. Such samples should not be taken from the first overflow following an extended period of zero outflow because these samples will be uncharacteristically low in SS and other contaminants.

Composite samples may be more accurate indicators of the true average conditions at a point than grab samples, especially for situations in which conditions fluctuate greatly. This is the case for many confined disposal areas. Therefore, if conditions and resources allow, composites should be used. Composite samples may be taken in many ways. If sampling personnel will be on site for several hours, several grab samples may be taken during this time and composited. Automatic samplers may also be used to obtain periodic grab

samples which can then be composited. It may be especially desirable to use composites for samples taken only infrequently, such as the ones for nutrients, heavy metals, total organic carbon (TOC), and organics.

### **Typical Monitoring Program**

As an illustration, a sampling schedule is presented below for a typical project for the Waipio CDF.

1. At the point of permit compliance (downstream end of mixing zone).
  - a. SS -- daily.
  - b. Nutrients, metals, and organics (if needed) -- once every two weeks.
2. Background in receiving water.
  - a. SS -- once per week.
  - b. Nutrients, metals, and organics (if needed) -- three samples.
3. At the weir(s).
  - a. Turbidity -- daily.
  - b. SS -- twice per week.
  - c. Nutrients, metals, and organics (if needed) -- once every two weeks.

### **Other Monitoring Requirements**

In addition to taking water samples for analysis to determine concentrations of contaminants, other monitoring should be done to provide control over the quality of water discharged or to furnish background information to aid in the interpretation of the analytical results. This monitoring should be done by the project inspector for the Navy.

On at least a daily basis, the inspector should observe and record the physical condition of the levees and discharge structure. The inspector should note the condition of the weir boards, whether the weir is leaking, whether floating solids are caught on the weir, whether the weir is unlevel, and whether there are other unusual circumstances. Any change in weir elevation should be recorded.

The inspector should also note and record the visual quality of the effluent (whether clear, slightly turbid, or very turbid); any obvious flow patterns or changes, such as formation of deltas or obvious short-circuiting; and wind and weather conditions, especially the direction of the wind and relative wind velocity.

## 5 - Conclusions

The findings of this Phase III evaluation and their basis can be summarized as follows:

- a. The estimated time frame is 30 years for the LTMS. The volume of unsuitable material is projected to be 40,000 to 80,000 cubic yards in a typical year when dredging of operational areas is performed. A total required disposal volume of 1,600,000 cubic yards was set for the LTMS capacity requirement. In addition, the disposal alternative should be able to handle up to 300,000 cubic yards in a single year to support periodic dredging to the main channels and other large areas.
- b. Sediment from upper areas of Pearl Harbor is primarily fine-grained lagoonal silt with some clay and fine sand, while sediment from lower channels is primarily sand. Metals and some organic contaminants are present in the sediments, but concentrations are low.
- c. The selected LTMS consists of use of ocean disposal for all material found to be suitable for such disposal and use of a CDF constructed on the southern end of Waipio Peninsula as a long-term option for all material found to be unsuitable for ocean disposal.
- d. The CDF will be constructed within a 124-acre footprint on the southern tip of the peninsula and should be subdivided primarily into two cells to facilitate dewatering and desiccation and to increase management options. For purposes of design, volumes in most years would be placed in one of the cells, with placement alternated between the two cells, allowing for at least a full one-year drying period. Operations for dewatering or material removal for beneficial use may continue while the alternate cell is used for a subsequent disposal operation. Material would be placed in both cells for years with large volume requirements (greater than 100,000 cubic yards). A detailed survey of the Waipio Peninsula site will be necessary to finalize the dike alignment.
- e. The CDF could be filled by direct hydraulic placement from pipeline dredges (unlikely to be utilized because of mobilization constraints), hydraulic offloading from hopper dredges, or mechanical or hydraulic offloading from barges filled by clamshell dredges. The Whiskey 22 Wharf located at the south end of Waipio Peninsula is a suitable facility for offloading.

f. For small volumes (less than 100,000 cubic yards) to be placed in a given season, a portable pump system or mechanical rehandling would be workable. These approaches would have a relatively low production rate for removal of the material from the barges. For larger projects, mobilization of a specialized hydraulic offloader would be practical and economical.

g. Construction of retaining dikes could be accomplished with conventional upland earthmoving equipment using onsite soils selectively removed from the site interior, resulting in increased capacity.

h. A dike cross section is assumed for the design with a height of 10 feet above original ground level with a minimum top width of 12 feet and side slopes of 1 foot vertical on 3 feet horizontal. The ultimate dredged material fill height would be 6 feet, allowing for 2 feet of freeboard and 2 feet of ponding during dredged material placement. A detailed engineering design is not warranted for the site conditions at Waipio Peninsula, but the foundation conditions for the dike alignment should be confirmed by field survey and borings or sample trenches as appropriate. All designs and specifications should be prepared under the direct supervision and guidance of a geotechnical engineer.

i. The borrow for dike construction would essentially be taken adjacent and parallel to the dike alignment. This would form a continuous trench inside the CDF parallel to the dike. Such a trench produces benefits for site management and passive dewatering of the dredged material. Additional interior borrow areas could be used if the full dike cross section is constructed prior to initial dredged material placement.

j. The total surface area available at the Waipio site does not require diking to the ultimate 10-foot height in the initial phases of construction. Upcoming maintenance dredging projects at Sierra 10-12, Bravo 22-26, and Mike 1-4 piers planned for FY 2000 will require removal of approximately 62,000 cubic yards (approximately 58 acre-feet considering bulking during filling as described below). These projects would comprise the initial stage of construction if a staged approach is implemented. The initial stage would be constructed by dividing the southern cell in half to create a long, narrow cell or by constructing a dike over the entire southern cell with sufficient height to satisfy the storage requirements for the initial stage. The remainder of the area could be diked in stages using later maintenance projects or in one larger construction effort using a separate construction contract under the MILCON authority.

k. The required initial storage capacity, ponded water depth, and surface area in the CDF during placement of fine-grained dredged material were evaluated using the SETTLE model. Results indicated that for the largest anticipated annual placement of 300,000 cubic yards the required storage should account for a bulking factor of 1.20. Therefore, the largest volume occupied by any

annual placement would be approximately 360,000 cubic yards which would occupy an initial lift thickness over both cells of approximately 2.2 feet.

l. The requirement for long-term storage of the total 1,600,000 cubic yards was evaluated with the PSDDF model, considering consolidation and drying. The results for the range of lift thicknesses and placement frequencies indicated that the long-term volume was approximately 0.70 times the accumulated applied volume. The total volume of fill occupied in the long term is therefore approximately 1,120,000 cubic yards which would require a depth of the dredged material of approximately 7 feet over the available surface area, or about 6 feet above existing ground surface considering volume borrowed for dike construction. This confirms the required 10-foot dike heights, allowing for ponding and freeboard.

m. An evaluation of the CDF contaminant pathways indicated the need for a mixing zone to meet water quality standards for effluent during filling operations and surface water runoff following precipitation. No contaminant control measures for dissolved contaminants in the effluent or runoff discharge are warranted. Contaminant controls for effluent discharge will be limited to management of the ponded surface area and depth to optimize suspended solids retention in the CDF. Surface runoff will be collected by ponding near the weirs and gradually released. No liner or other controls for leachate or volatilization are needed. Plant uptake testing indicated elevated uptake as compared to reference materials, indicating a need for further evaluation of the surficial materials at the end of the service life of the CDF.

n. The CDF should provide for multiple inflow points and two outlet weirs in each of the two cells to better distribute the material within the site, avoiding excessive mounding of coarse sand at any one point. A weir crest length of 21 feet is needed for each weir. Corrugated metal drop inlets are recommended for the weirs. Water should be ponded during active filling operations to provide a minimum of 2 feet of ponded depth. After active filling is completed, free water, not already removed by evaporation, may be drained from the site through the adjustable weirs.

o. After each filling operation, site management efforts should be concentrated on maximizing the containment storage capacity gained from continued drying and consolidation of dredged material and foundation soils. Once dredged material is placed in the site, a passive management program for dewatering should be implemented. This would consist of drainage following disposal, periphery trenching for minimal dewatering enhancement, and removing the dewatered material from the area adjacent to the dikes for use in upgrading the dikes.

p. A monitoring program must be developed to comply with regulatory requirements and to operate the CDF effectively. The CDF monitoring program

should be limited to sampling for effluent quality and maintaining good records for the volumes and types of materials placed in the facility.

q. The sediments to be dredged from project areas should be appropriately characterized and tested to determine acceptability for ocean disposal if ocean disposal is a preferred option. Testing for ocean suitability could be bypassed if the decision is made up front to place those materials in the CDF. An evaluation of the effluent pathway will be required for projects proposed for CDF placement; the evaluation would include conducting the effluent elutriate test as needed. If a sufficient database for Pearl Harbor sediments is developed over time, evaluations of sediments which do not pass the Tier 1 screening procedures could be made based on the elutriate testing database (an alternate approach for a Tier 1 evaluation). Other pathway tests may also be required, depending on the levels of contaminants present and the pathways of concern. The sediment characterization tests will be sufficient in most cases for purposes of screening evaluations for the other CDF pathways, and testing will not likely be required unless the sediment contaminant levels are significantly elevated above those previously tested. The pathway evaluations and screening procedures are found in the USACE/EPA Technical Framework (USACE/EPA 1992) and the ARCS Remediation Guidance Document (USEPA 1994).

r. The implementation of this LTMS involving use of a CDF will require appropriate NEPA documentation. Considering the facts that the proposed disposal site is located on Navy property and that there are no likely significant environmental impacts, an Environmental Assessment would likely be sufficient.

s. Regulatory actions will also be required for each specific project or group of projects. Dredging operations will require a Section 10 permit from the USACE regardless of the disposal option. A Section 103 permit from the USACE will be required for transport of dredged material to the Oahu ocean placement site. Use of a CDF at the Waipio Peninsula would require a Section 404 permit from the USACE and a Section 401 water quality certification and coastal zone consistency from the State of Hawaii.

## References

American Society for Testing and Materials (ASTM), Committee D-22 on Sampling and Analysis of Atmosphere. (1967). *Standard method for measurement of odor in atmospheres*. Philadelphia, PA.

Aziz, N.M., and Schroeder, P.R. (1999). "Documentation of the HELPQ module for ADDAMS: hydrologic evaluation of leachate production and quality for confined disposal facilities," *Environmental Effects of Dredging Technical Notes EEDP-06-20*, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Chase, D. (1994). "DROPMIX user's manual," Draft Report, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

d'Angremond, K., Brakel, J., Hoekstra, A.J., Kleinbloesem, W.C.H., Nederlof, L., and Nekker, J. de. (1978). "Assessment of certain European dredging practices and dredged material containment and reclamation methods," Technical Report D-78-58, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Doneker, R.L., and Jirka, G.H. (1990). "Expert system for the hydrodynamic mixing zone analysis of conventional and toxic submerged single port discharges (CORMIX1)," EPA/600/3-90/012, USEPA Environmental Research Laboratory, Athens, GA.

Environmental Protection Agency (EPA)/U.S. Army Corps of Engineers (USACE). (1991). "Evaluation of dredged material proposed for ocean disposal (testing manual)," EPA-503/8-91/001, Office of Water, U.S. Environmental Protection Agency, Washington, DC.

EPA/USACE. (1995). "QA/QC guidance for sampling and analysis of sediments, water, and tissues for dredged material evaluations - chemical evaluations," EPA-823-B-95-001, U.S. Environmental Protection Agency, Washington, DC.

EPA/USACE. (1998). "Evaluation of dredged material proposed for discharge in waters of the U.S. testing manual," EPA-823-B-98-004, U.S. Environmental Protection Agency, Washington, DC.

Folsom, B.L., Jr., and Houck, M.H. (1990). "A computerized procedure for predicting plant uptake of heavy metals from contaminated freshwater dredged material," *Environmental Effects of Dredging Technical Notes* EEDP-04-12, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Folsom, B.L., Jr., Lee, C.R., and Bates, D.J. (1981). "Influence of disposal environment on availability and plant uptake of heavy metals in dredged material," Technical Report EL-81-12, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Haliburton, T.A. (1978). "Guidelines for dewatering/densifying confined dredged material," Technical Report DS-78-11, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Haliburton, T.A., Fowler, J., and Langan, J.P. (1978). "Perimeter dike raising with dewatered fine-grained dredged material at Upper Polecat Bay disposal area, Mobile, Alabama," Miscellaneous Paper D-78-3, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Havis Environmental. (1994). "Mixing zone simulation model for dredge overflow and discharge into inland and coastal waters," Contract Report, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Hayes, D.F., and Schroeder, P.R. (1992). "Documentation of the SETTLE module for ADDAMS: design of confined disposal facilities for solids retention and initial storage," *Environmental Effects of Dredging Technical Notes* EEDP-06-18, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

MacIntyre, D.F. (1987). "Interim procedures for estimating mixing zones for effluent from dredged material disposal sites (single-point discharge)," *Environmental Effects of Dredging Technical Notes* EEDP-04-5, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Myers, T.E., Averett, D.E., Olin, T.J., Palermo, M.R., Reible, D.D., Martin, J.L., and McCutcheon, S.C. (1996). "Estimating contaminant losses from components of remediation alternatives for contaminated sediments," EPA 905-R96-001, March 1996, Assessment and Remediation of Contaminated Sediments (ARCS) Program, U.S. Environmental Protection Agency, Great Lakes National Program Office, Chicago, IL.

Palermo, M. R. (1977). "An evaluation of progressive trenching as a technique for dewatering fine-grained dredged material," Miscellaneous Paper D-77-4, U. S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Palermo, M. R. (1985). "Interim guidance for predicting the quality of effluent discharged from confined dredged material disposal areas," *Environmental*

*Effects of Dredging Technical Notes EEDP-04-4*, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Palermo, M.R. (1992). "Long term storage capacity of confined disposal facilities." Chapter 8, *Handbook of Dredging Engineering*. McGraw Hill, New York, NY.

Palermo, M.R., and Schroeder, P.R. (1991). "Documentation of the EFQUAL module for ADDAMS: comparison of predicted effluent water quality with standards," *Environmental Effects of Dredging Technical Notes EEDP-06-13*, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Palermo, M. R., and Thackston, E. L. (1988 (Dec)). "Test for dredged material effluent quality," *Journal of Environmental Engineering*, American Society of Civil Engineers, 114(6).

Poindexter, M.E. (1988). "Current District dredged material dewatering practices," *Environmental Effects of Dredging Technical Notes EEDP-06-4*, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Poindexter-Rollings, M.E. (1989). "Dredged material containment area management practices for increasing storage capacity," *Environmental Effects of Dredging Technical Notes EEDP-06-6*, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Price, R.A., Skogerboe, J.G., and Lee, C.R. (1998). "Predicting surface runoff water quality from upland disposal of contaminated dredged material," *Environmental Effects of Dredging Technical Notes EEDP-02-25*, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Schroeder, P.R., and Palermo, M.R. (2000). "Long-term management strategy for dredged material disposal for naval facilities at Pearl Harbor, Hawaii: Phase I - Formulation of preferred disposal and management alternatives," ERDC/EL SR-00-3, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Schroeder, P.R., Price, R.A., Averett, D.E., Wade, R., Pranger, S.A., Neumann, D.C., and Figueroa-Gonzalez, J. (2000). "Long-term management strategy for dredged material disposal for naval facilities at Pearl Harbor, Hawaii: Phase II - Evaluation of alternatives," ERDC/EL SR-00-4, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Stark, T.D. (1996). "Program documentation and user's guide: PSDDF primary consolidation, secondary compression, and desiccation of dredged fill," Draft Instruction Report EL-96-XX, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Streile, G.P., Shields, K.D., Stroh, J.L., Bagaasen, L.M., Whelan, G., McDonald, J.P., Droppo, J.G., and Buck, J.W. (1996). "Multimedia environmental pollutant assessment system (MEPAS): Source term formulations," PNL-11248, Pacific Northwest National Laboratory, Richland, WA.

Thackston, E.L., and Palermo, M.R. (1998). "Improved methods for correlating turbidity and suspended solids for dredging and disposal monitoring." *Proceedings, Fifteenth World Dredging Congress, Las Vegas, NV, June 28-July 2, 1998.*

USACE. (1986). "Dredged material beneficial uses," Engineer Manual 1110-2-5026, Office, Chief of Engineers, Washington, DC.

USACE. (1987). "Confined disposal of dredged material," Engineer Manual 1110-2-5027, Office, Chief of Engineers, Washington, DC.

USACE/EPA. (1992). "Evaluating environmental effects of dredged material management alternatives - A technical framework," EPA-842-B-92-008, U.S. Environmental Protection Agency and U.S. Army Corps of Engineers, Washington, DC.

USEPA. (1994). "ARCS remediation guidance document," EPA 905-B94-003, Assessment and Remediation of Contaminated Sediments (ARCS) Program, U.S. Environmental Protection Agency, Great Lakes National Program Office, Chicago, IL.

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