DRP-5-05
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Dredging Research Technical Notes

Equipment and Placement Techniques for Capping

Purpose

This technical note describes equipment and placement techniques for capping projects. The equipment and techniques are applicable to placement of contaminated material to be capped and clean material used for capping, and include conventional discharge from barges, hopper dredges, and pipelines; diffusers and tremie approaches for submerged discharge; and spreading techniques for cap placement.

Background

Some dredged material may be unsuitable for open-water disposal because of potential contaminant effects on benthic organisms. Capping contaminated dredged material with a layer of clean material is considered an appropriate contaminant control measure for benthic effects in the Corps' dredging regulations (33 CFR 335-338) and supporting technical guidelines (Francingues and others 1985) and is recognized by the London Dumping Convention as a management technique to "rapidly render harmless" otherwise unsuitable materials.

Guidelines are available on planning and design concepts (Truitt 1987a, 1987b), design requirements (Palermo 1991a), site selection considerations (Palermo 1991b), and monitoring (Palermo in preparation) for capping projects. This technical note supplements and updates the available guidance by describing conventional and specialized dredging equipment and dredged material placement techniques for capping projects.

Additional Information

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Introduction

Capping is the controlled, accurate placement of contaminated dredged material at an open-water disposal site, followed by a covering or cap of clean isolating material. For purposes of this note, the term "contaminated" refers to material found to be unacceptable for unrestricted open-water disposal because of potential contaminant effects, while the term "clean" refers to material found to be acceptable for such disposal.

Level bottom capping (LBC) may be defined as the placement of a contaminated material on the bottom in a mounded configuration and the subsequent covering of the mound with clean sediment. Contained aquatic disposal (CAD) is similar to LBC but with the additional provision for some form of lateral confinement (for example, placement in bottom depressions or behind subaqueous berms) to minimize spread of the materials on the bottom. Conceptual illustrations of CAD and LBC are shown in Figure 1.

Design Requirements for Capping

Use of appropriate equipment and placement techniques for both the contaminated material and the capping material is a critical requirement for any capping operation. However, all components of design for a capping project are strongly interdependent. The major design requirements for a capping project and the sequence in which the design requirements should be considered are fully described in *Dredging Research Technical Notes* (TN) DRP-5-03 (Palermo 1991). Equipment and replacement techniques for a specific project

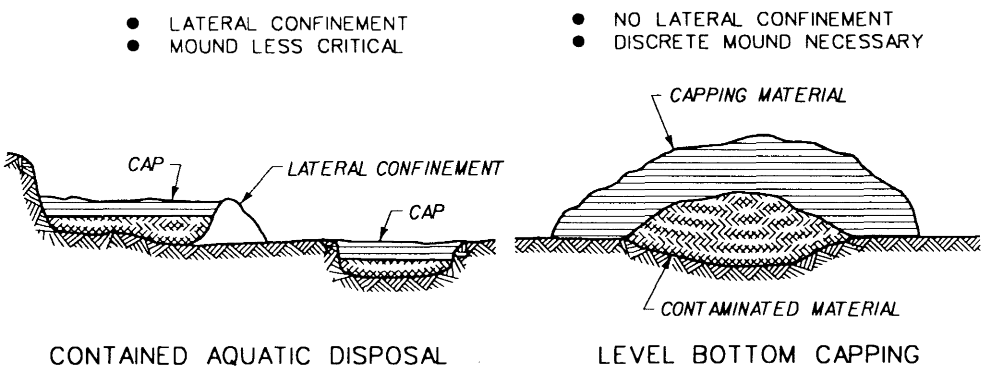

Figure 1. Schematic illustrating level bottom capping and contained aquatic disposal

should be selected within the context of the overall design requirements for the project as described in TN DRP-5-03.

Considerations for Contaminated Material Placement

Placement of contaminated material for a capping project should be accomplished so that the resulting deposit is easy to cap. Therefore, the equipment and placement technique must be compatible with that of the capping material. Since capping is a contaminant control measure for potential benthic effects, the contaminated material should be placed such that the exposure of the material prior to capping is minimized. In most cases, the water column dispersion and bottom spread occurring during placement should be reduced to the greatest possible extent. This minimizes the release of contaminants during placement and provides for easier capping. If the placement of the contaminated sediment has potentially unacceptable water column impacts, controls to specifically reduce water column dispersion (for example, submerged discharge) may be required.

For LBC, the dredging equipment and placement technique for contaminated sediment must result in a tight, compact mound which is easily capped. Tight mounds generally result when the material is dredged and placed at or near its in-situ density prior to dredging. This is most easily accomplished with mechanical dredging techniques and precision point discharges from barges.

For CAD projects, the provision of lateral containment in the form of a bottom depression or other feature defines and limits the extent of bottom spread. For this reason, either mechanical dredging and placement or hydraulic placement of the contaminated material may be acceptable for CAD. If the contaminated material is placed hydraulically, a suitable time period (usually a few weeks) must be allowed for settling and consolidation to occur prior to placement of the capping material to avoid potential mixing of the materials.

Considerations for Capping Material Placement

Placement of capping material should be accomplished so that the deposit forms a layer of required thickness over the deposit of contaminated material. The surface area of a deposit of contaminated material to be capped may be several hundred feet or more in diameter. Placement of a cap of required thickness over such an area requires spreading the material to some degree to achieve coverage.

The equipment and placement technique should be selected and rate of application of capping material should be controlled to avoid displacement or mixing with the previously placed contaminated material to the extent possible. Placement of capping material at equal or lesser density than the contaminated material would generally meet this requirement. Since water column dispersion of capping material would not usually be of concern, the use of submerged discharge for capping placement should only be considered from the standpoint of control during placement.

Navigation and Positioning Equipment and Controls

Placement of both the contaminated material and capping material must be carefully controlled, regardless of the equipment and placement technique selected. Electronic positioning systems; taut-moored buoys; mooring barges; various acoustical positioning devices; and computer-assisted, real-time helmsman's aids should be considered in selecting the equipment and placement technique (Truitt 1986b, Palermo 1991).

Compatibility of Operations

An acceptable match of equipment and placement techniques for contaminated and capping material is essential to avoid displacement of the previously placed contaminated material or excessive mixing of capping and contaminated material. The nature of the materials (cohesive versus noncohesive), the dredging method (mechanical versus hydraulic), the method of discharge (instantaneous dump from hopper dredge or barge versus continuous pipeline), the location of discharge (surface or submerged), frequency and scheduling of discharges, and other factors will influence the tendency of the material to mound or flow and to displace or mix with material already placed.

Table 1 summarizes field and laboratory observations of flow characteristics of dredged material. In general, if the contaminated material were mechanically dredged and released from barges, the capping material could be similarly placed or could be placed hydraulically. However, if the contaminated material were hydraulically placed, then only hydraulic placement of the capping material may be appropriate due to the potentially low shear strength of the contaminated material. The exposure of the contaminated material to the environment and the need to allow consolidation of the contaminated material to occur prior to cap placement must be balanced in scheduling both placement operations.

The equipment and placement techniques described in the following paragraphs may apply to the contaminated dredged material to be capped as well as to the capping material, depending on the project conditions. Regardless of the equipment and placement techniques considered, the compatibility of contaminated material placement and capping operations must be determined by considering the material characteristics and site conditions (Palermo 1991).

Table 1
Flow Characteristics of Dredged Material Placed in Aquatic Site (from Shields and Montgomery 1984)

Dredged Material Characteristics	Placement Method	
	Point Dump	Pump Down
Noncohesive Material		
Mechanically dredged	Tends to mound	Not applicable
Hydraulically dredged	Tends to flow[1,2,3]	Tends to mound[4]
Cohesive Material		
Mechanically dredged	Tends to mound[1,2]	Not applicable
Hydraulically dredged	Tends to flow[1]	Tends to flow[2]

[1]JBF Scientific Corporation 1975.
[2]Morton 1983.
[3]Sustar and Ecker 1972.
[4]Nichols, Thompson, and Faas 1978.

Surface Discharge Using Conventional Equipment

The behavior of a discharge of dredged material into open water is dependent on a number of factors, including physical characteristics of the material, site conditions, and method of dredging and placement (that is, from barges, hopper dredges, or direct pipeline) (Headquarters, US Army Corps of Engineers 1983). Dredged material released at the water surface using conventional equipment tends to descend rapidly to the bottom as a dense jet with minimal short-term losses to the overlying water column (Bokuniewicz and others 1978, Truitt 1986). Thus, the use of conventional equipment can be considered for placement of both contaminated and capping material if the bottom spread and water column dispersion resulting from such a discharge are acceptable.

The surface release of mechanically dredged material from barges results in a faster descent, tighter mound, and less water column dispersion as compared to surface discharge of hydraulically dredged material from a pipeline. Placement characteristics resulting from surface release of hydraulically dredged material from a hopper dredge fall between the characteristics resulting from surface release of mechanically dredged material from barges and from surface discharge of hydraulically dredged material from a pipeline; that is, the descent is slower than the former but faster than the latter, the mound is looser than the former but tighter than the latter, and more water column dispersion results from the former than from the latter.

Field experiences with LBC operations in Long Island Sound and the New York Bight have shown that mechanically dredged silt and clay released from barges will tend to remain in clumps during descent and form nonflowing discrete mounds on the bottom which can be effectively capped. Such mounds have been capped with both mechanically dredged material released from barges and with material released from hopper dredges (O'Conner and O'Conner 1983, Morton 1983, 1987). In fact, mechanically dredged cohesive sediments often remain in a clumped condition, reflecting the shape of the dredge bucket. Mounds of such material are very stable, resist displacement during capping operations, and present conditions ideal for subsequent LBC (Sanderson and McKnight 1986). A conceptual illustration showing the use of conventional equipment for capping is shown in Figure 2.

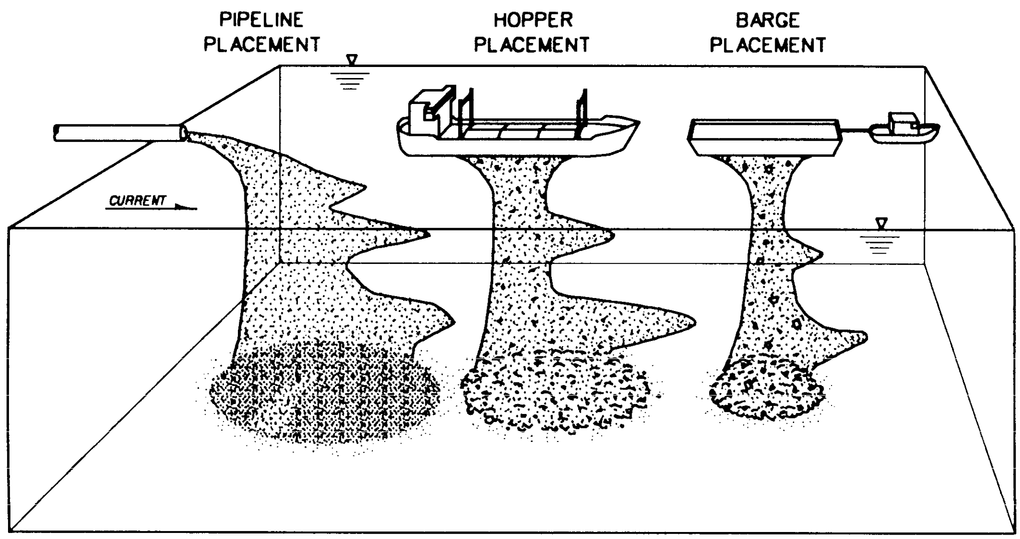

Figure 2. Conventional open-water placement for capping

Spreading by Barge Movement

A layer of capping material can be spread or gradually built up using bottom-dump barges if provisions are made for controlled opening or movement of the barges. This can be accomplished by slowly opening a conventional split-hull barge over a 30- to 60-min interval, depending on the size of the barge. Such techniques have been successfully used for controlled placement of predominantly coarse-grained, sandy capping materials (Sumeri 1989). The gradual opening of the split-hull allows the material to be released from the barge in a sprinkling manner. If tugs are used to move the barge slowly during the release, the material can be spread in a thin layer over a large area (Figure 3). Multiple bargeloads would be necessary to cap larger areas in an overlapping manner. The gradual release of mechanically dredged fine-grained silts and clays from barges may not be possible due to the potential "bridging" action; that is, the cohesion of such materials may

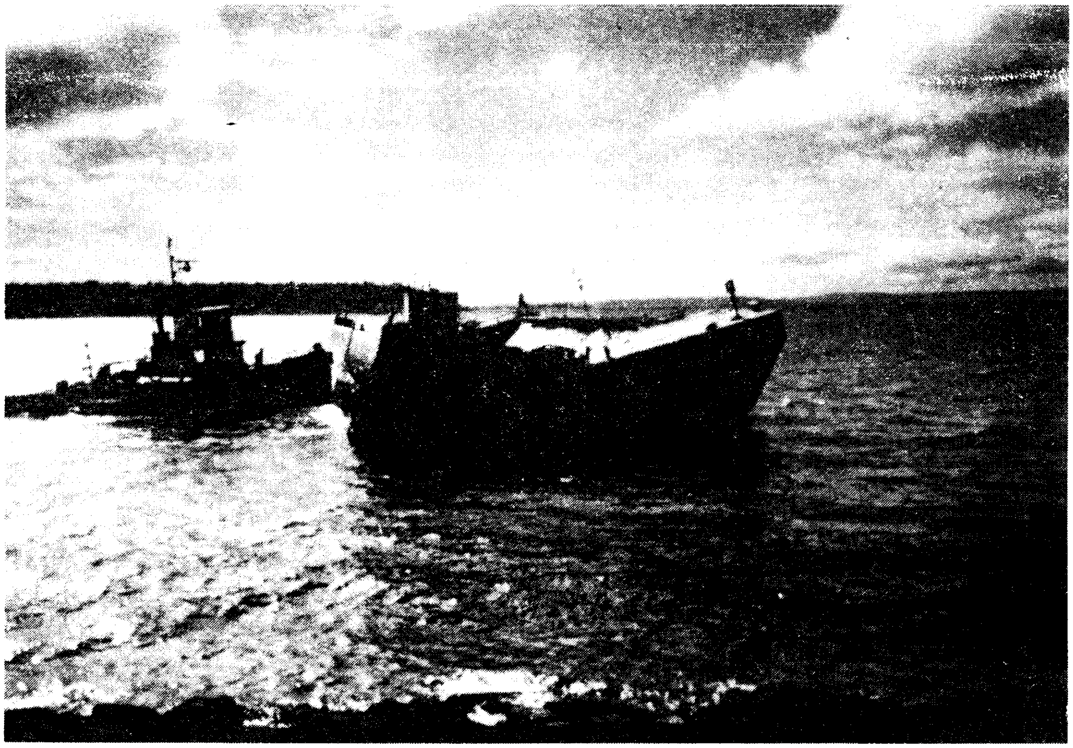

Figure 3. Spreading technique for capping by barge movement

cause the entire bargeload to "bridge" the split-hull opening until a critical point is reached at which time the entire bargeload would be released. If the water content of fine-grained material is high, the material may exit the barge in a matter of seconds as a dense slurry, even though the barge is only partially opened.

Pipeline with Baffle Plate or Sand Box

Spreading placement for capping operations can easily be accomplished with surface discharge from a pipeline aided by a device such as a baffle plate or sand box attached to the end of a pipeline. Hydraulic placement is well-suited to placement of thin layers over large surface areas.

A baffle plate, sometimes called an impingement or momentum plate, serves two functions. First, as the pipeline discharge strikes the plate, the discharge is sprayed in a radial fashion and the discharge is allowed to fall vertically into the water column. The decrease in velocity reduces the potential of the discharge to erode material already in place. Second, the angle of the plate can be adjusted so that the momentum of the discharge exerts a force which can be controlled to swing the end of the pipeline in an arc. Such plates are commonly used in river dredging operations where material is deposited in thin layers in areas adjacent to the dredged channel (Elliot 1932). Such equipment can be used in capping operations to spread very thin layers of material over a large area, thereby gradually building up the required capping thickness. Figure 4 shows an impingement plate in operation.

A device called a "sand box" (Figure 5) serves a similar function. This device acts as a diffuser box with baffles and side boards to dissipate the energy of the discharge. The bottom and sides of the box are constructed as an open grid or with a pattern of holes so that the discharge is released through the entire box. The box is mounted on the end of a spud barge so that it can be swung about the spud using anchor lines (Sumeri 1989).

Submerged Discharge

If the placement of contaminated sediment by surface discharge would result in unacceptable water column impacts, or if the anticipated degree of spreading and water column dispersion for either the contaminated or capping material would be unacceptable, submerged discharge is a potential control measure.

In the case of contaminated dredged material, submerged discharge serves to isolate the material from the water column during at least part of its descent. This isolation can minimize potential chemical releases due to water column dispersion and significantly reduce entrainment of site water, thereby reducing bottom spread and the area and volume to be capped. In the case of capping material, the use of submerged discharge provides additional control and accuracy during placement, thereby potentially reducing the volume of capping material required. Several equipment alternatives are available for submerged discharge and are described in the following paragraphs.

Submerged Diffuser

A submerged diffuser (Figure 6) can be used to provide additional control for submerged pipeline discharge (Neal, Henry, and Greene 1978; Palermo, in preparation). The diffuser consists of conical and radial sections joined to form the diffuser assembly, which is mounted to the end of the discharge pipeline. A small discharge barge is required to position the diffuser and pipeline vertically in the water column. By positioning the diffuser several feet above the bottom, the discharge is isolated from the upper water column. The diffuser design allows material to be radially discharged parallel to the bottom with a reduced velocity. Movement of the discharge barge can serve to spread the discharge to cap larger areas. The diffuser could be used with any hydraulic pipeline operation including hydraulic pipeline dredges, pumpout from hopper dredges, and reslurried pumpout from barges.

Sand Spreader Barge

Specialized equipment for hydraulic spreading of sand for capping has been used by the Japanese (Kikegawa 1981, Sanderson and McKnight 1986).

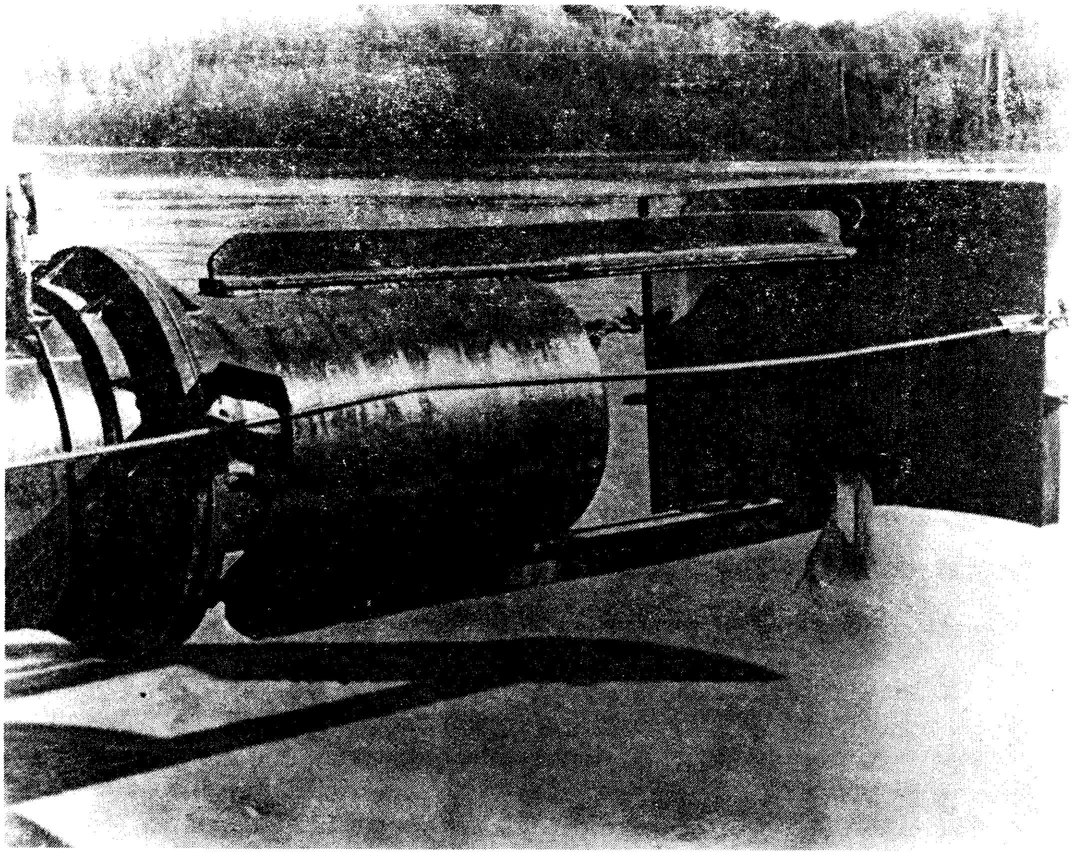

Figure 4. Spreader plate for hydraulic pipeline discharge

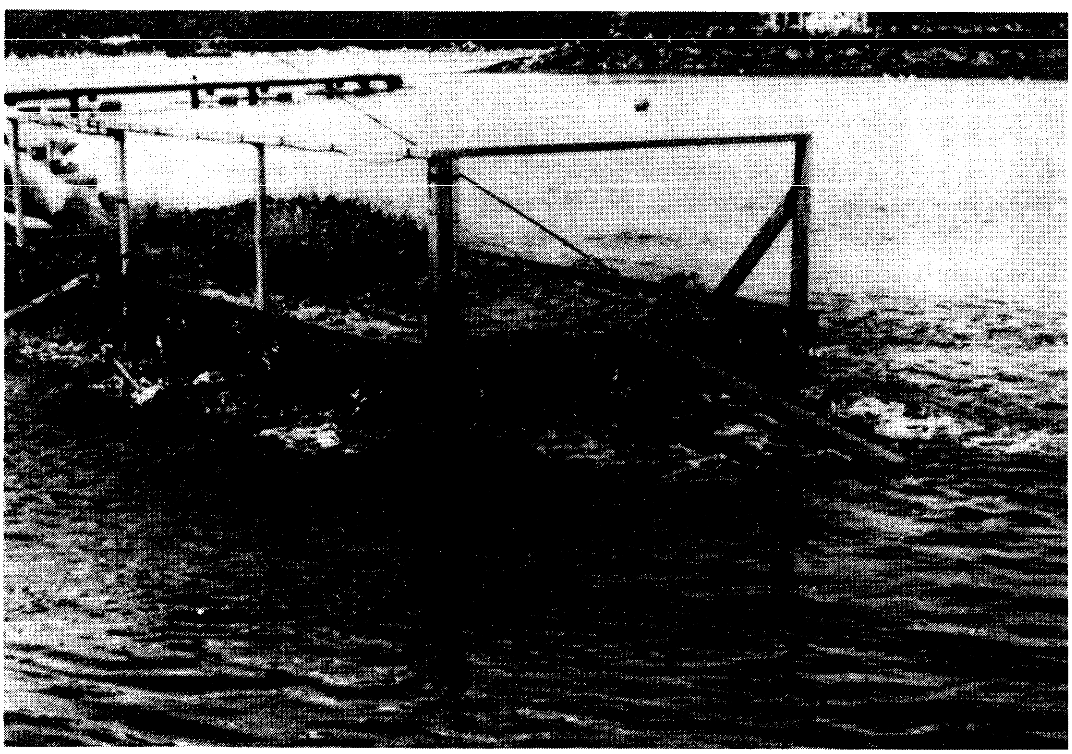

Figure 5. Spreader box or "sand box" for hydraulic pipeline discharge

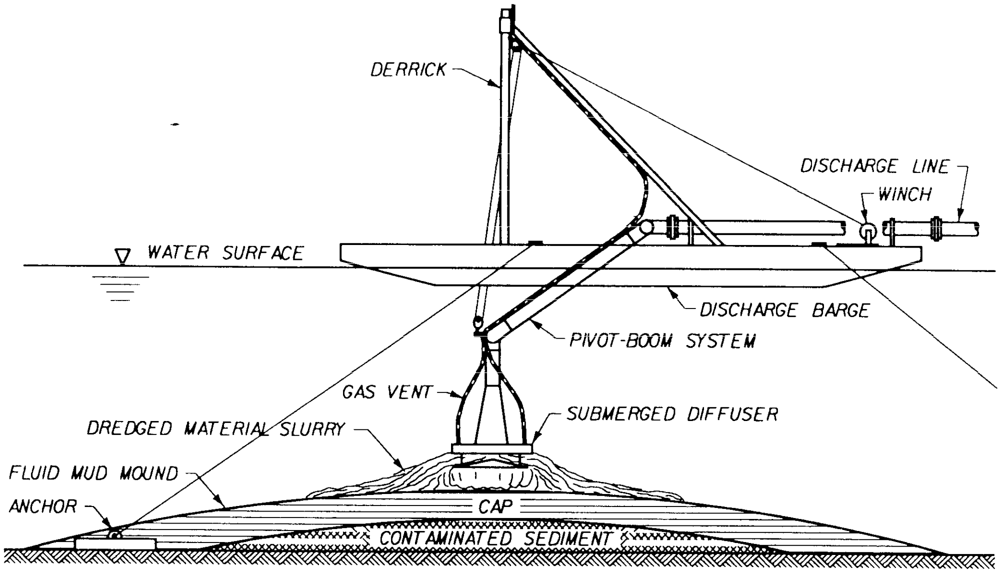

Figure 6. Submerged diffuser system, including the diffuser and discharge barge

This equipment employs the basic features of a hydraulic dredge with submerged discharge (Figure 7). Material is brought to the spreader by barge, where water is added to slurry the sand. The spreader then pumps the slurried sand through a submerged pipeline. A winch and anchoring system is used to swing the spreader from side to side and forward, thereby capping a large area.

Gravity-fed Downpipe (Tremie)

Tremie equipment can be used for submerged discharge of either mechanically or hydraulically dredged material. The equipment consists of a large-diameter conduit extending vertically from the surface through the water column to some point near or above the bottom. The conduit provides the desired isolation of the discharge from the upper water column and improved placement accuracy. However, because the conduit is a large-diameter straight vertical section, there is little reduction in momentum or impact energy over conventional surface discharge. The weight and rigid nature of the conduit would require a sound structural design, and must consider the forces due to currents and waves.

The Japanese have used tremie technology in the design of specialized conveyor barges for capping operations (Togashi 1981, Sanderson and McKnight 1986). This equipment consists of a tremie conduit attached to a barge equipped with a conveyor (Figure 8). The material is initially placed in the barge mechanically. The conveyor then mechanically feeds the material to the tremie conduit. A telescoping feature of the tremie allows placement at depths up to approximately 40 ft. Anchor and winch systems are used to

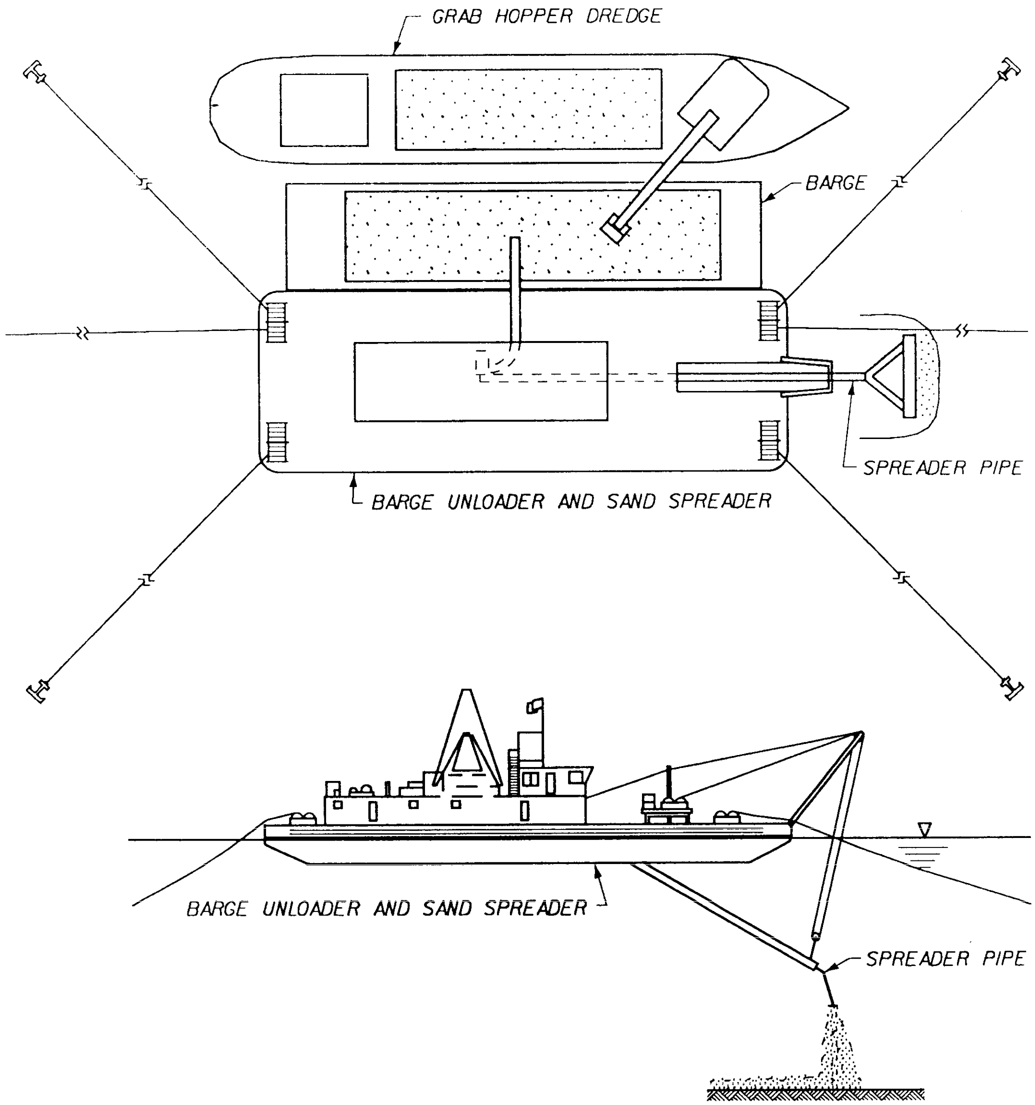

Figure 7. Hydraulic barge unloader and sand spreader barge (from Kikegawa 1981)

swing the barge from side to side and forward so that larger areas can be capped, similar to the sand spreader barge.

Hopper Dredge Pumpdown

Some hopper dredges have pump-out capability by which material from the hoppers can be discharged like a conventional hydraulic pipeline dredge. In addition, some have further modifications that allow pumps to be reversed so that material can be pumped down through the dredge's extended dragarms. Because of the expansion at the draghead, the result is similar to

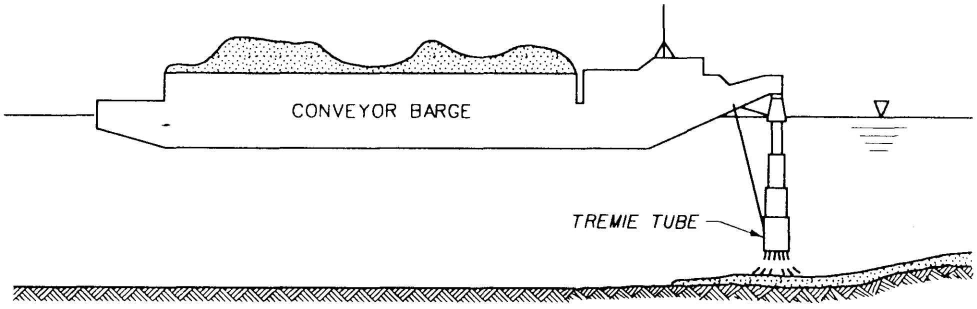

Figure 8. Conveyor unloading barge with tremie (from Togashi 1981)

use of a diffuser section. Pumpout depth is limited, however, to the maximum dredging depth, typically up to about 60-70 ft.

Summary

A number of different equipment types and placement techniques can be considered for capping operations. Conventional discharge of mechanically dredged material from barges, and hydraulically dredged material from hopper dredges or pipelines, can be considered if the anticipated bottom spread and water column dispersion are acceptable. If water column dispersion must be reduced or if additional control in placement is required, use of diffusers, tremies, or other equipment for submerged discharge can be considered. Controlled discharge and movement of barges and use of spreader plates or boxes with hydraulic pipelines can be considered for spreading a capping layer over a larger area. Compatibility between equipment and placement technique for contaminated and capping material, and accuracy and control of the equipment during placement, are essential for any capping operation.

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