JAMES RIVER, VIRGINIA
DREDGING DEMONSTRATION IN CONTAMINATED MATERIAL (KEPONE)
DUSTPAN VERSUS CUTTERHEAD

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ABSTRACT

The James River, Virginia, is a tributary of the Chesapeake Bay polluted with the toxic pesticide Kepone. The Norfolk District, Corps of Engineers, will conduct a dredging demonstration project as part of the maintenance of the James River Channel. The goals of the demonstration are to achieve containment of a layer of polluted sediment; to minimize resuspension of pollution at the dredge head; and to remove the sediment at in situ density. In order to achieve these goals, a dustpan suction head will be specially adapted and fitted on a typical hydraulic pipeline dredge. The dredge will be operated in the dustpan mode using a dredging method designed to obtain precise positioning of the suction head within the specified layer of polluted sediment. The dredge will also be operated as a conventional cutter suction dredge for comparison with the dustpan arrangement. Monitoring of operating parameters on board the dredge, and of water quality parameters around the perimeter of the operation, will be accomplished with appropriate instrumentation to document the effectiveness of the two dredging methods. It is anticipated that the dredging demonstration will result in a method of adapting readily available cutterhead dredge plant for the cleanup of polluted sediments.

INTRODUCTION

The waterways within the Norfolk District of the Corps of Engineers are generally free of hazardous substances. Where dredging is required to maintain navigable channels, pollution normally does not impede this activity. The James River, however, where the toxic pesticide Kepone has polluted the waterway, the dredging of the channel has became a major issue. The Kepone pollution has also directly resulted in the Norfolk District's dredging demonstration for Kepone removal.

BACKGROUND

The James River is a tributary of the Chesapeake Bay and is located in the State of Virginia about 400 miles (640 kilometers) south of New York (Figure 1). Its sources are in the Allegheny Mountains of West Virginia and Virginia. Between the City of Richmond and the mouth at Hampton Roads, a distance of 90 miles (145 kilometers), the James is tidal and navigable. In this portion of the river, a navigation channel 25 feet (7.6 meters) deep is maintained to serve the ports of Richmond, Hopewell, and the industries between these cities. These industries and port activities depend on the James River Channel for the economical transport of many commodities and raw materials. As is the case on many of the world's waterways, local industries have created pollution. In particular, the Allied

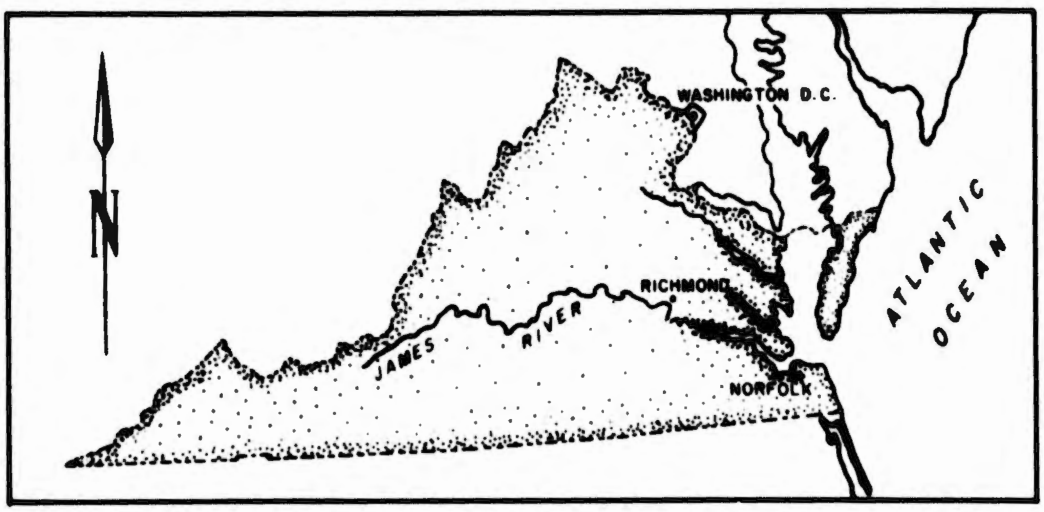

Figure 1. Location of the James River, Virginia

Chemical Corporation, at plants in the vicinity of Hopewell, Virginia, was responsible for the release of Kepone into the James River system. Between 1967 and 1975 it is estimated that as much as 65,000 pounds of the highly toxic chemical were discharged into the James River basin.

The extent of the Kepone pollution was not fully discovered until 1975, and the production and resultant discharge of the chemical was ceased that year. The closing of the James River to fishing and shellfishing was ordered by the Governor of Virginia in December 1975. Since that time the State has periodically sampled the river and its seafood in order to monitor Kepone levels, and promulgated regulations pertaining to seafood harvesting in the James River. In recent years, Kepone levels have decreased in organisms to the extent that, for most species, commercial harvesting is again permitted within certain geographic and seasonal limits. However, Kepone data obtained during the summer and fall of 1981 by the State show that this trend has reversed, perhaps only temporarily, and that Kepone levels in certain fish have risen. While the now relaxed fishing regulations have not been made more restrictive, it is apparent that the Kepone problem will persist for years. Following discovery of the extent of Kepone pollution, and formation of State and Federal task forces, the U.S. Environmental Protection Agency (EPA) conducted the Kepone Mitigation Feasibility Study. As part of this effort, the Norfolk District was requested to evaluate alternatives for the removal of Kepone-contaminated sediments, and to investigate all potential dredging technology and methods to control resuspension and secondary pollution. During this mitigation study, a delegation from EPA and the Norfolk District visited Japan to observe specialized methods of handling toxic sediments. The group was favorably impressed with the Oozer Dredge because of its alleged ability to achieve a high solids to water ratio and minimize resuspension. As a result of the Japan visit, the Norfolk District recommended that a demonstration project be conducted on the James River to evaluate the Oozer Dredge in comparison with a conventional cutter suction dredge. The basis for the recommendation was that there would be a need to know the best method of removing pollutant "hot spots", whether consisting of Kepone in the James River or toxics in other areas of the country if the Corps were assigned a cleanup mission.

The recommendation to conduct a demonstration project was made to higher authority in early 1979, and resulted in much discussion among dredging experts both within and outside the Corps. Informally, it was suggested that a dustpan dredge, appropriately modified, could perform as well as the Oozer Dredge in removing polluted sediments. The dustpan type dredge uses hydraulic transport, as do cutter suction dredges, and is extensively employed by the Corps for navigation dredging of granular materials on the Lower Mississippi River. Furthermore, it was suggested that parts from retired Corps dustpan dredges, available in the St. Louis District, could be adapted to available cutterhead dredge plant. As a result of these discussions, Amalgamated Dredge Design, Incorporated, presented a formal proposal to modify an available dustpan suction head and adapt the dustpan to a contractor's cutter suction dredge. The effectiveness of this arrangement for dredging polluted sediment would then be tested and compared to the conventional cutterhead arrangement. The dredging would be accomplished as part of the maintenance of the James River Channel. This proposal was the basis for the dredging demonstration project in the James River.

PROBLEM DESCRIPTION

The problem is not just to dredge the contaminated sediments--it is to attempt total containment at the dredge head of a specified layer of material as near in-place density as possible. This will involve minimizing resuspension of material at the head, minimizing the volume of the specified material left behind, and minimizing the amount of water added during the dredging process.

To achieve total containment, the problems discussed in the following paragraphs must be solved.

Entry Design

The entry design of the dustpan head must ensure that there is no escape of polluted material. The entry design must also be based on the characteristics of the channel sediments to be dredged, which are shown on Table 1.

TABLE 1. SEDIMENT PROPERTIES

Property	Value
Classification (USCS)*	Silty-clay (CH)
Moist Unit Weight (Avg.)	84 pounds per cubic foot (1300 grams per liter)
Moisture Content (Avg.)	144 percent
Liquid Limit	100 percent or greater
Plastic Index	60 percent or greater
Kepone Content (Avg.)	0.1 parts per million

* Unified Soil Classification System.

The material to be dredged from the James River Channel exists in a fluid state. Therefore, it is not necessary to have any means to agitate or fluidize the material; in fact, this would be undesirable since the goal is to minimize dilution and resuspension of the material.

An existing dustpan suction head from the retired Corps Dredge KENNEDY will be used for the demonstration project. Since dustpan dredges normally operate in granular materials, the head was equipped with digging teeth and water jets at the mouthpiece to enhance the flow of material. This mouthpiece section was removed from the head and will be replaced with a newly fabricated section without water jets or teeth.

The KENNEDY dustpan head is 28 feet (8.5 meters) wide and 8 inches (20 centimeters) deep. In order to overcome the entry losses of the flat, rectangular mouthpiece, and to accelerate the material through the dustpan, it will be necessary to build up a layer of material above the top edge of the entrance. A rollover plate, shaped like a bulldozer blade, will be installed on the top of the dustpan to artifically create the needed head of material (Figure 2).

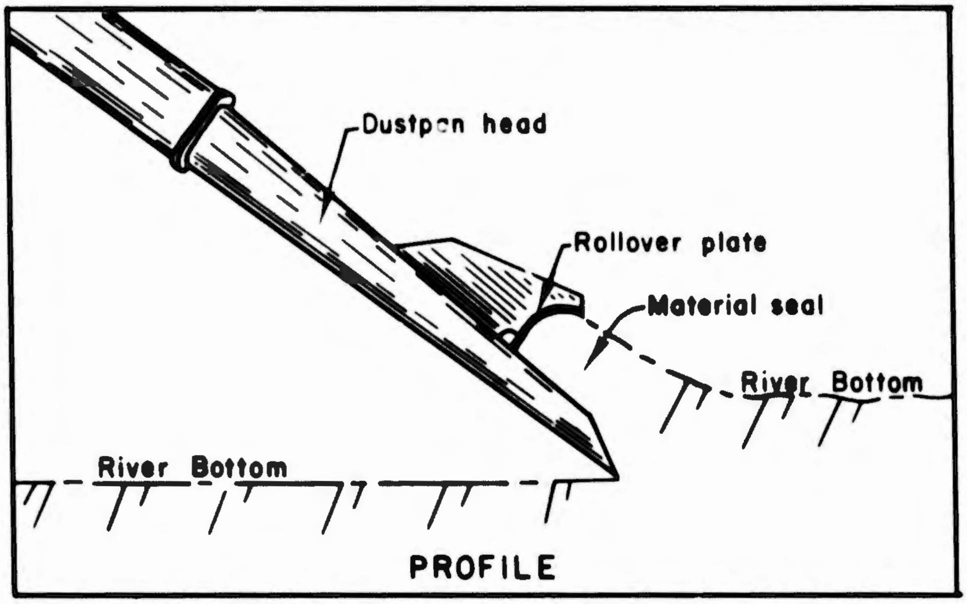

Figure 2. Dustpan head with rollover plate

The layer of material created above the entrance may have a tendency to spill over the sides, leaving some of the specified material undredged. To prevent this condition, wing plates will be attached to either side of the dustpan head and a splitter plate will be attached in the center, as shown in Figure 3.

These wing plates and splitter plate will keep the layer of material above the entrance and provide some stability for the head as it advances into the cut. The wing plates will also prevent the ingress of dilution water at the sides.

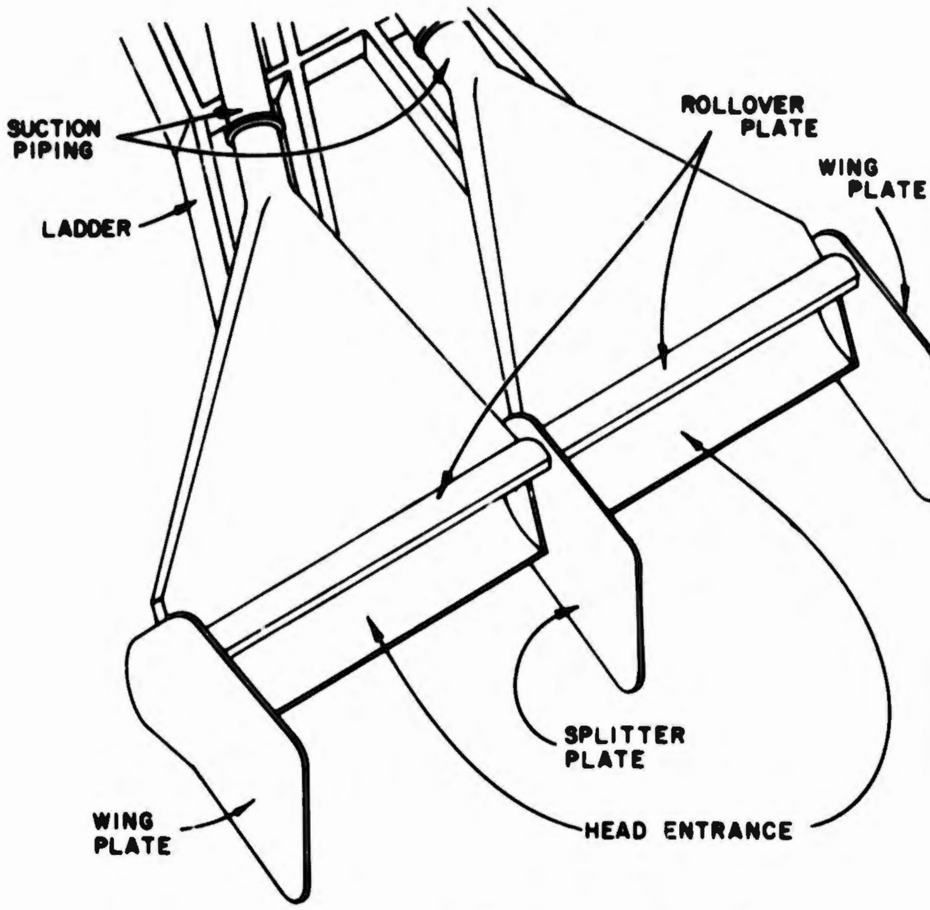

Figure 3. Modified dustpan head

Dredge Positioning

Positioning of the dredge will be another problem which must be solved in order to achieve total containment of the polluted material.

Dustpan dredges normally operate by anchoring two crossed headwires upstream of the dredge, and advancing on these wires into the cut. The strong river currents of the Mississippi or Missouri Rivers and the crossed headwires keep the dredge in position within limits acceptable for channel maintenance dredging.

On the James River, this system would not work well. The river currents vary in strength and direction with the tidal cycle as compared to the strong, steady current in one direction on the Mississippi. Greater positioning accuracy, estimated to be ± 1 foot (0.3 meter), must be achieved for the goal of total containment. The lack of a strong, steady current on the James, coupled with the need for greater accuracy, requires that other methods of dredge positioning be investigated.

Electronic positioning systems were explored as a means of positioning the dredge. It was determined that there is no commercially available system which can guarantee the desired degree of accuracy. The most accurate system available, which utilizes measurements from three separate shore stations and a computerized least squares adjustment of these measurements (Figure 4), can guarantee precision of ± 3 feet (1 meter).

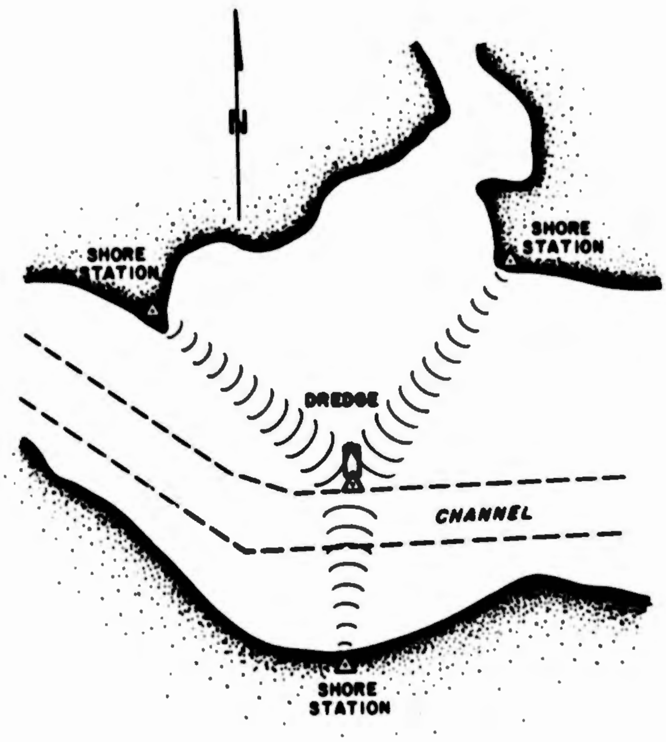

Figure 4. Electronic positioning system

This system will be used in the demonstration project to delineate the specified areas to be dredged. The problem of positioning the dredge with the required degree of accuracy, however, cannot be solved with electronic equipment, but must instead be solved by the choice of an appropriate dredging method.

DREDGING METHOD

The method of dredging by dustpan chosen for the project is unorthodox, but will enable accurate and positive positioning of the dredge. Rather than working along the length of the navigation channel, the dredge will be working across the channel and perpendicular to the tidal currents.

Five wires will be used to position and maneuver the dredge in the dustpan mode (Figure 5).

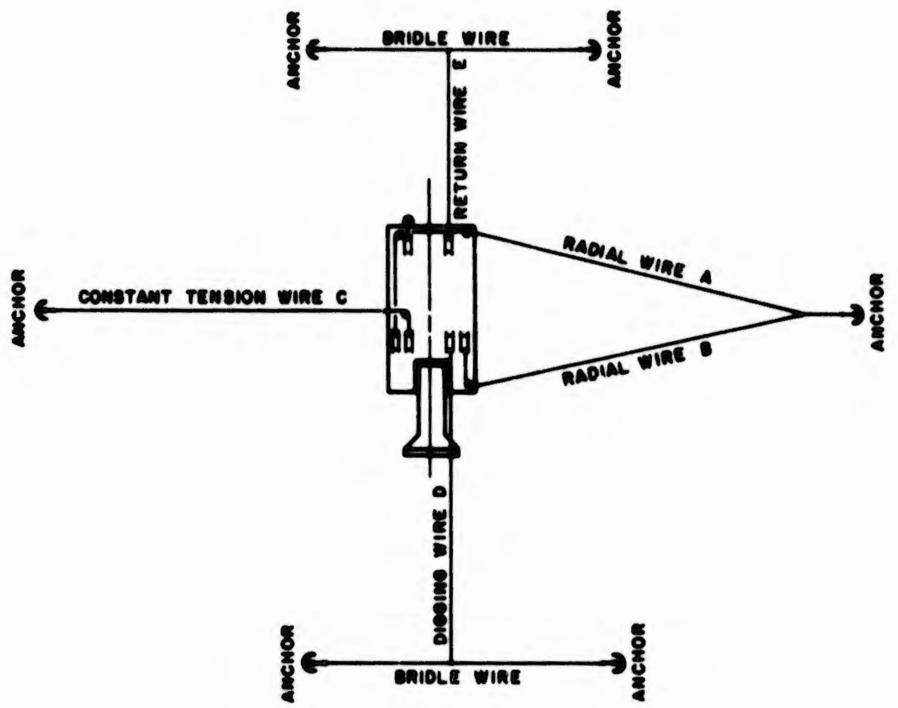

Figure 5. Dredging wire diagram

Radial wires A and B with a common anchor point will maintain the dredge on a slightly curved path across the channel. Wire C will maintain a constant tension in wires A and B with the use of an in-line tensiometer having a remote display in the dredge lever room. Digging wire D will pull the dredge into the cut, and return wire E will bring the dredge back to the beginning of the cut.

The step from one cut to the next is 28 feet, the width of the dustpan head. This step will be accomplished by paying out an equivalent amount of wire on the calibrated radial wires and adjusting the constant tension wire. The desired accuracy of ± 1 foot (0.3 meters) for dredge positioning will be obtained by accurate calibration and measurement of the amount payed out on the radial wires.

CUTTER SUCTION DREDGE

During May 1981, the Norfolk District advertised for bids for lease of a cutter suction dredge to be used in the James River demonstration project. A contract was subsequently awarded to Norfolk Dredging Company, the low bidder, for lease of the 18-inch cutter suction dredge ESSEX. It was at this time that Amalgamated Dredge Design, under a separate contract with the Norfolk District, began detailed engineering and design work for the project based on the characteristics of the ESSEX. The principal characteristics are shown in TABLE 2.

TABLE 2. CUTTER SUCTION DREDGE ESSEX
PRINCIPAL CHARACTERISTICS

Characteristics		Value
Hull -	Length	140 feet (42.7 meters)
	Breadth	36 feet (10.0 meters)
	Depth	10 feet (3.0 meters)
Cutting Power		300 horsepower (225 kw)
Dredging Depth		40 feet (12.2 meters)
Pump -	Suction	21 inches (53 cm)
	Discharge	18 inches (46 cm)
	Power	2250 horsepower (1680 kw)
Ladder and Swing		75 horsepower (56 kw)
Winch Power		≈ 400 rpm

Upon close inspection it was determined that the dredge ESSEX is well equipped to accommodate the installation of the dustpan from the dredge KENNEDY, with a minimum of modifications. The winches on board can also be easily modified to enable the dredge to operate in the dustpan mode as proposed.

MONITORING OF DREDGING OPERATIONS

In order to compare the operation of the dredge ESSEX while tests are carried out in the dustpan mode with the operation of the dredge in the conventional cutterhead mode, several parameters will be closely monitored.

On Board Instrumentation

Dredge output will be continuously monitored through the use of a package of automatic instrumentation. The package consists of vacuum indicator, pressure indicator, density meter, velocity meter, production calculator, and yield indicator. A ladder depth indicator will enable accurate control of the dredging depth. Continuous tidal information will be provided by a radio tide transmitter, in order that the dredging depth may be accurately adjusted for the height of tide.

The efficiency of removal at the dredge head will be monitored in order to determine if the goal of total containment is being achieved. This will be accomplished by taking water samples with a series of tubes mounted around the head and measuring the turbidity of the samples with a transmissometer mounted on a sampling tank.

Off-Dredge Monitoring

Around the perimeter of the dredge and disposal sites, the Norfolk District will monitor water quality. Parameters to be measured include turbidity, suspended solids, dissolved Kepone, total water column Kepone, and current speed and direction. The monitoring program is designed to detect significant changes in Kepone levels resulting from the dredge operation. The Virginia State Water Control Board will also be monitoring the bioaccumulation of Kepone in local species of marine organisms. The effectiveness of a submerged discharge diffuser developed by the Waterways Experiment Station will be tested at the disposal site as well.

POTENTIAL PROBLEM AREAS

The testing of the modified dustpan arrangement for dredging contaminated sediments may potentially present operational problems.

Crew training will be essential in overcoming these problems. The dredge crew of the cutter suction dredge ESSEX is not familiar with the dustpan method of dredging, much less the unorthodox adaptation of this method for dredging in the James River Channel. Comprehensive crew training sessions are being planned and will be conducted prior to start-up of dustpan operations in order for the crew to become familiar with the dredging method.

Prior to start-up of dredge operations, but following the successful alteration of the ESSEX and installation of the dustpan head and test equipment, a series of tests will be run. These tests will ensure that each of the systems on board the dredge is functioning properly, and that the dredge as outfitted is capable of conducting the dredging tests. An adequate supply of spare parts will be kept on hand so that downtime of the instrumentation package will be kept to a minimum.

Much time will be required during the demonstration project for moving the dredge to start each new cut since the cuts will be no more than 350 feet (107 meters) in length. There will also be considerable time spent resetting the various anchors for each new series of cuts. While production is not a primary goal of the demonstration project, excessive nonpumping time would nonetheless be undesirable. Accordingly, procedures will be developed, and the crew properly trained, so that the maneuvering and resetting time of the dredge between cuts will be minimized.

One minor problem is the possibility of the choking or blocking of the dustpan head. It is anticipated that this condition will seldom occur; however, procedures will be developed to unblock the head should it become choked or blocked with debris.

CONCLUSIONS

Design drawings and specifications for the modifications to the ESSEX are in the process of finalization, and detailed plans for crew training and accomplishment of the dredging tests are in preparation. The dustpan head and dredging ladder from the dredge KENNEDY have been removed and delivered to the contractor's yard. The demonstration project as a whole is about to make the transition from design phase to the construction and operation phases.

A great deal of effort has gone into the project up to this stage by the Norfolk District, our contractors, and the many technical advisors within the Corps. Environmental coordination of the project with the various regulatory agencies has also been a monumental task. While it is believed, at this stage, that the technical phase of design and environmental coordination is behind us, the construction and operation phases may pose additional hurdles to overcome. The Norfolk District is optimistic, however, that the successful completion of the project will result in resumption of full maintenance of the James River and a proven method of adapting readily available dredge plant for cleanup of polluted sediments.

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