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THE CORPS OF ENGINEERS DREDGED MATERIAL RESEARCH PROGRAM.(U)

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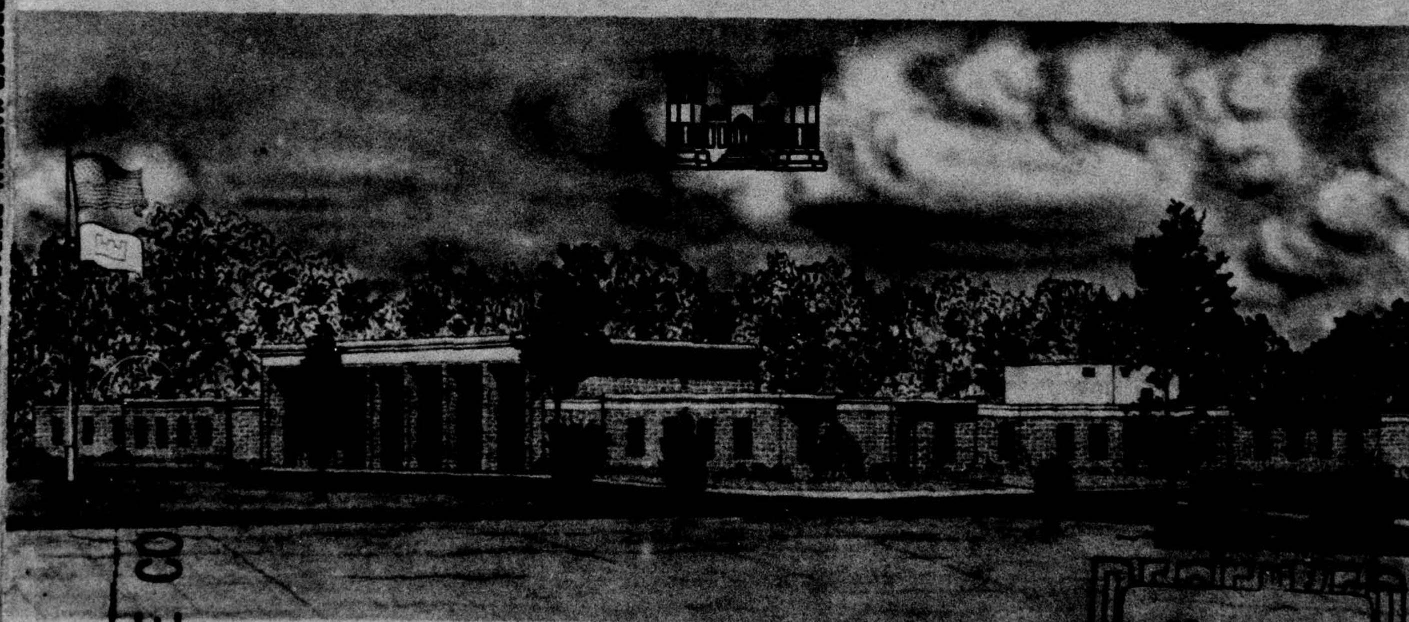
by

R. L. Montgomery, F. H. Griffis, Jr.



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## FOREWORD

This paper was presented at the Fifth Annual World Dredging Conference in Hamburg, Germany, in June 1973 by Mr. R. L. Montgomery and MAJ F. H. Griffis, Jr. This report summarizes the results of the first two phases of the Dredged Material Research Program (DMRP) and describes the technical structure, management, and implementation of the research (Phase III). A large portion of this report is a summarization of U. S. Army Engineer Waterways Experiment Station (WES) Technical Report H-72-8. The DMRP is sponsored by the Office, Chief of Engineers (DAEN-CWO-M), and was formally authorized by letter, "Study Program for Disposal of Dredge Spoil," dated 27 December 1971. The purpose of publishing this report in this format is to provide an introductory summary of the DMRP to interested parties.

Members of the Office of Dredged Material Research, WES, who made important contributions to this report were Dr. John Harrison, Chief, Dr. R. T. Saucier, Assistant Chief, Mr. M. B. Boyd, Technical Consultant, Dr. J. W. Keeley, Project Manager, and Dr. C. J. Kirby, Project Manager. This report was prepared by Mr. R. L. Montgomery, Project Manager, and MAJ F. H. Griffis, Jr., Program Manager.

Directors of WES during the preparation and publication of the report were BG E. D. Peixotto, CE, and COL G. H. Hilt, CE. Technical Director was Mr. F. R. Brown.

CONTENTS

## CONVERSION FACTORS, BRITISH TO METRIC UNITS OF MEASUREMENT

British units of measurement used in this report can be converted to metric units as follows:

| Multiply | By | To Obtain |
|---|---|---|
| cubic yards | 0.764555 | cubic meters |
| miles (U. S. statute) | 1.609344 | kilometers |
| tons (2000 pounds) | 907.1847 | kilograms |

## SUMMARY

The Corps of Engineers, in fulfilling its mission in the development and maintenance of the navigable waters of the United States, is responsible for the dredging of large volumes of sediment each year. Annual quantities approach 400,000,000 cu yd of dredged material each year for both maintenance and new work dredging, with costs exceeding $150 million. In recent years, concern has been expressed about these operations from a number of viewpoints including fish and wildlife considerations, effects on water quality, and land use impacts. Because of these concerns, the necessity to establish regulatory criteria, and the lack of definitive information on many important questions, the Corps was authorized by Congress in the 1970 River and Harbor Act to initiate a comprehensive study relating to the disposal of dredged material. The study was divided into four phases: (1) problem identification and assessment, (2) development of a research program, (3) accomplishment of the needed research, and (4) field evaluation of new or improved disposal practices.

This paper summarizes the results of Phases I and II, the problem identification and assessment, and the development of the research program. It describes specific conclusions reached in problem definition relative to open water disposal, land disposal, and marsh disposal. It alludes to possible changes in dredging equipment and techniques. In addition, this paper discusses the technical structure of the developed research program to include broad research areas and specific task objectives. The implementation of Phase III is discussed with the organization of the Office of Dredged Material Research. The technical development and its associated unique management system are presented. The basis for using a systems approach in the development of the technical and management structure and implementation of the research is discussed in detail.

# THE CORPS OF ENGINEERS DREDGED MATERIAL RESEARCH PROGRAM

## PART I: INTRODUCTION

1. The U. S. Army Corps of Engineers has been concerned with the development and maintenance of navigable waterways in the United States since Congressional authorization was received in 1824 to remove sand bars and snags from major navigable rivers.[1] Presently, the Corps maintains over 19,000 miles* of waterways and 1,000 harbor projects. The importance of these projects to economic growth of the U.S. is evidenced by record-breaking advances in waterborne commerce during the 20-year period from 1950 to 1970. An 85 percent increase resulted in a total tonnage transported in 1970 of over 1.5 billion tons.[2] Future projections indicate a continuing important role for waterborne commerce in the nation's economic development. In addition to enhancing waterborne commerce expansion, the maintenance of waterways provides extensive recreational opportunities.

2. To accomplish the maintenance and development of the nation's waterways, the Corps is responsible for dredging large volumes of materials each year. The volume of maintenance dredging on authorized projects has been a relatively stable figure of approximately 300,000,000 cu yd per year in recent years. The volume of new work dredging depends upon approval of appropriated projects and has averaged about 80,000,000 cu yd per year over the past 3 years. These volumes exclude dredging performed by other agencies or private interests under the permit program administered by the Corps. Figure 1 shows a geographical distribution of dredging equipment and average annual material quantities of dredging operations by Corps Districts.

3. In the past, the Corps' decisions concerning open water disposal of dredged materials have been based primarily on economic considerations. Disposal costs have been minimized by depositing the material

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* A table of factors for converting British units of measurement to metric units is presented on page vii.

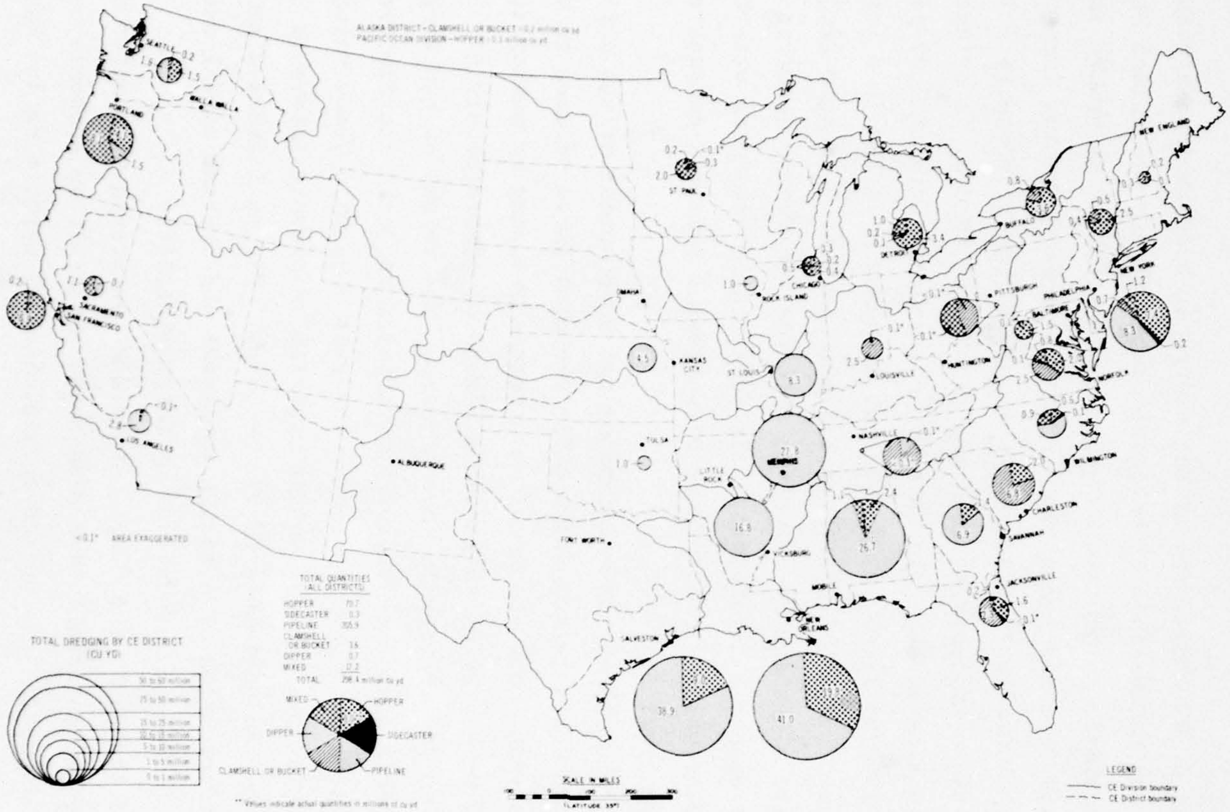


Figure 1. Types of dredges used in maintenance dredging operations and average annual quantities of dredged material moved by each by District

removed by dredging activities at selected disposal sites near the dredging sites, but in locations which would have a minimum direct effect on other important activities in the area (beach areas, water intakes, commercial fishing areas, etc.). The maintenance dredging data shown in Figure 2 provide an indication of the relative importance of the common disposal methods (open water, confined, and unconfined disposal) in the various geographical regions. The term "undifferentiated" has been used to cover projects where both confined and open water disposal are practiced and no breakdown of the total quantity was available. It can be easily seen from the data in Figure 2 that open water disposal is by far the most common disposal method, with about two-thirds of the material dredged during maintenance operations being disposed of in this manner.

4. Future trends in dredging volumes and associated cost are difficult to predict. There are several significant factors or eventualities that could cause future trends to alter dramatically from previous trends. Whereas some factors such as the need for channel enlargements for deeper draft vessels and the need for new port and harbor developments are somewhat predictable and could form the basis for trends, they could be completely negated by such factors as Congressional authorization and funding rates for new projects, national defense considerations, offshore terminal development trends, and the development of new shipping concepts. Perhaps the greatest potential for change in future cost and volume trends relates to the magnitude and patterns of environmental impact of dredging and disposal operations and developing national pollution control policy and legislation. These factors also are currently considered to be the most difficult to predict as far as consequences to future trends are concerned.

5. The dredging activities of individual districts vary from the removal of a few thousand cubic yards of sediments deposited in a critical area of a harbor to the removal of millions of cubic yards over an entire project. The cost of dredging is extremely variable from location to location. It ranges from $0.20 to several dollars per cubic yard depending upon a number of factors including type of material, type of dredge, disposal practice, and distance to disposal site. A rough

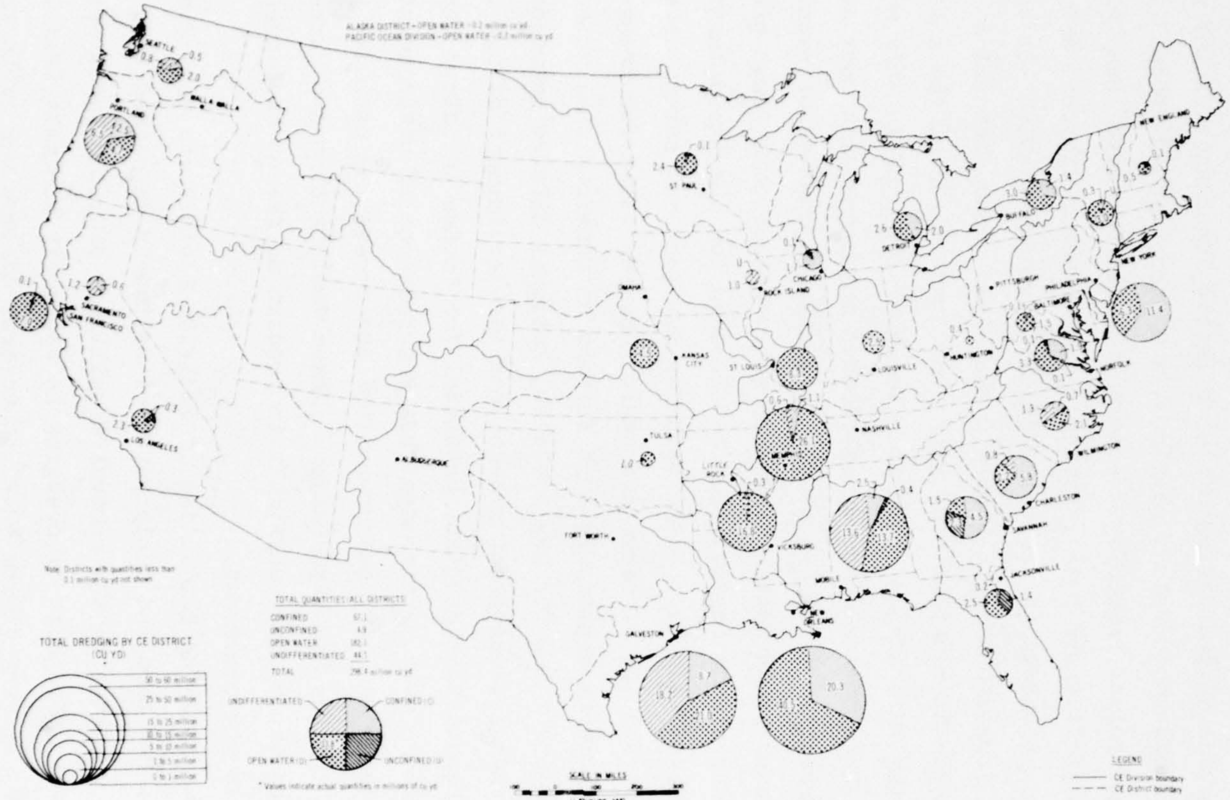


Figure 2. Disposition of dredged material generated in maintenance dredging operations and average annual quantities of material disposed by area by District

national average with an extremely high variance is $0.40 per cu yd, thus requiring an annual Corps dredging budget of approximately $150 million.

6. The materials dredged from some harbors and channels have become polluted mainly as a result of continued rapid industrialization and population growth in such areas. As early as 1966, the Corps realized that polluted dredged materials might have adverse effects on water quality and aquatic organisms and began investigating the feasibility of alternative dredged material disposal methods at selected harbors in the Great Lakes. It was obvious from earlier Corps studies assessing the environmental impact of dredged material disposal that realistic assessments were difficult and that a comprehensive program of research was necessary to provide more definitive information on the environmental impact of both open water and land disposal as well as to develop new or improved dredged material disposal methods. The Corps of Engineers Dredged Material Research Program was authorized on 31 December 1970 by Section 123(i) of the River and Harbor Act of 1970 (Public Law 91-611). Under this authorization, the Chief of Engineers initiated a comprehensive nationwide research program concerned with study and experimentation relating to dredging and dredged material disposal. The U. S. Army Engineer Waterways Experiment Station (WES) was assigned responsibility for the first two phases of the study, which included problem identification and assessment and the development of a comprehensive research program. The results of this effort are reported in WES Technical Report H-72-8, dated November 1972. The Office of Management and Budget approved the proposed research program on 9 February 1973, and the WES was assigned the responsibility for the actual research accomplishment and implementation by the Office, Chief of Engineers.

## PART II: PROBLEM DEFINITION AND ASSESSMENT

### Dredged Material Composition and Characteristics

7. Dredged material in the simplest sense is comprised of solids and liquids. The complicating factor is that the solids and liquids consist of a wide range of constituents, many of which are possibly harmful to the environment. Because of the magnitude of the Corps' dredging operations and the fact that much of the sediment throughout the U.S. reflects the cultural pollution of the nation's waters, the U. S. Environmental Protection Agency (EPA) established guidelines governing the disposal of dredged material considered polluted in the open water. Figure 3 presents a rough estimate of the pollution status of material generated in maintenance operations based on information available in 1971. The Corps fully appreciates the responsibility of the EPA and is in agreement that criteria are needed. However, the pollutional properties of dredged materials and their effects on water quality and aquatic organisms are poorly understood. In view of the high costs of alternatives to open water disposal, research is justified to provide definitive information regarding the harmful characteristics of dredged material and to establish and implement meaningful criteria for dredged material disposal.

8. Ideally, the Corps envisions criteria that serve as a vehicle to generate information for at least the following purposes:

- a. Provide a basis for quantitative evaluation of water quality, aquatic organisms, etc., in terms of various use requirements.
- b. Provide information that would aid resource managers in viewing dredged material as a resource.
- c. Provide base-line conditions of value to the scientific community, thereby hopefully reducing costs of future research investigations.
- d. Provide a basis for policy decision making.

There are insufficient data available on sampling and analysis to develop and implement criteria that provide the above information. Uniform

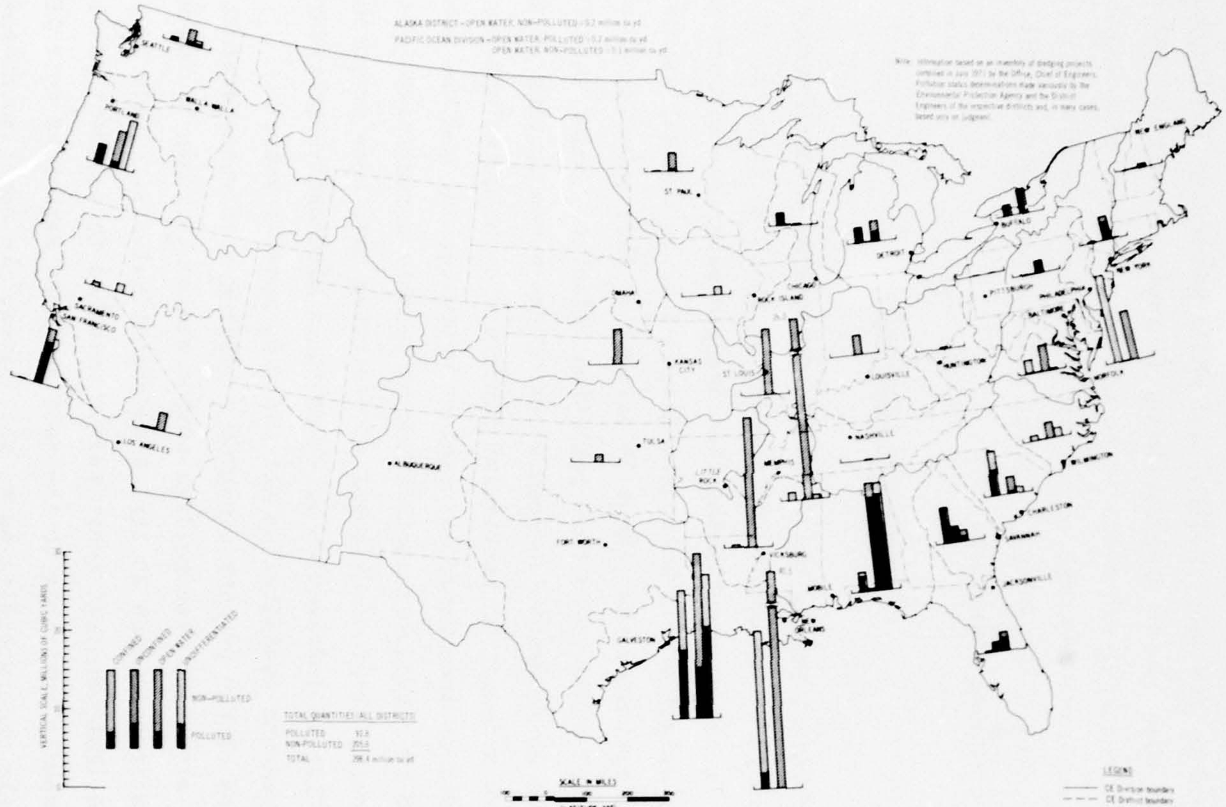


Figure 3. Pollution status of dredged material generated in maintenance dredging operations

guidelines, methods, and procedures are needed for sampling sediments, dredged materials, and biota associated with dredging operations. Similarly, no comprehensive analytical chemistry guidelines exist for detailing sample preparation techniques and for the examination of sediments. There is a need to evaluate, modify, and where necessary, develop chemical techniques that can be used routinely in standard testing laboratories. The state-of-the-art needs to be advanced to the point where the sampling and analyses required to satisfy pollution criteria will provide adequate data to identify potential cause-effect relationships prior to the dredging operations.

## Open Water Disposal

9. In recent years, the Corps has dredged an annual average of 380,000,000 cu yd of sediments, 65 percent of which is disposed of in open water. It has been estimated that dredged materials account for 80 percent by weight of all materials disposed of in coastal waters.[3] It is further estimated that about 34 percent of this material is considered polluted based on current pollution criteria. Major questions concerning the environmental consequences of the ocean dumping of dredge materials have arisen. Of particular concern are the questions regarding the effects of open water disposal on water quality and the subsequent effects of subaqueous spoil sites on benthic communities. Because of these concerns, various disposal alternatives have been proposed. There exists little information by which these alternative procedures can be compared and evaluated in all the U.S. coastal waters.

10. One of the primary concerns regarding open water disposal is the chemical effect of resuspending bottom sediments known to contain chemical constituents such as toxins and biostimulants. While it is generally agreed that chemical constituents attached to sediment particles are not as readily available to the food chain as dissolved materials, there is little understanding as to what extent the constituent-to-sediment attachment mechanisms are altered by the dredging or disposal process, thereby causing the possible release of these constituents to

the water and, subsequently, increasing their availability to the food chain.

11. Another concern over the Corps' open water disposal operations is directed toward the resulting effects on biological communities. The most common short-term effects that have been reported are turbidity, sediment buildup, and oxygen depletion. Although these effects have been detected, little is known on their magnitude, duration, and ecological significance in various environments.

## Land Disposal

12. Land disposal as discussed herein includes spoil that is placed in either a confined (naturally or artificially) or an unconfined state on both upland areas and paludal environments, i.e., marshes and other wetlands. However, in view of the rather unique problems associated with spoil disposal on marshlands, they are discussed in the following section.

13. Historically, the Corps has depended upon open water disposal as its principal mode of dredge spoil disposal. However, during the last decade or so, much open water disposal has been phased out in favor of confined land disposal because of known, suspected, or alleged adverse environmental effects.

14. Mostly because of the relative newness of land disposal and the consequent lack of experience and research, the Corps increasingly finds itself unable to answer questions regarding the potential environmental effects of this type of disposal. In fact, the state-of-the-art is such that not only can questions of the nature and extent of suspected adverse effects not be answered, but it is felt that certain types of environmental consequences have not yet even been identified.

## Marshland Disposal

15. Marshlands (wetlands) are among the most biologically productive areas on earth. Although the structure and function of marsh and

wetland systems are only partially understood, it is recognized that they serve a major role as nurseries, breeding areas, and zones of biological production for many of the U.S. coastal and inland waters. Accordingly, it has been recommended that disposal of dredge materials in these areas be discontinued in all possible cases.[4] Yet, there are wetlands where for varied reasons disposal of dredged materials appears to be the only viable alternative.

16. The Corps annually disposes of approximately 90,000,000 cu yd of maintenance dredged materials within the marine marsh environment. Most of this material is placed on marshlands within the estuarine zone. Additional volumes of dredged materials are placed within freshwater swamps and backwater areas.

17. There are major unanswered questions regarding the environmental impact on marshlands due to the disposal of dredged materials. Research is needed to provide guidance to the Corps Districts and Divisions so that dredged materials can, where necessary, be placed in marshlands with minimal adverse effects. Operational guidelines are needed that detail optimum methods of disposal for varying types of marshlands and the amount, chemical quality, and physical type of dredged material. In addition, information is needed on the rate of recovery of various types of marshlands subsequent to deposition of dredged materials.

## Dredging Equipment and Techniques

18. Since the amounts of pollutants and their potentially more toxic effects on marine and aquatic life are increasing, far more consideration will have to be given to both the direct environmental impacts of dredging and disposal operations and the long-term fate (and effects) of the dredged material. There is a need for the employment of new equipment and techniques that minimize the adverse direct and indirect effects on the environment.

19. The types of dredging equipment used, both by the Corps and private contractors, and the average annual amount of Corps maintenance dredging associated with each type are shown in Figure 1. The dredging

methods employed by the Corps vary considerably throughout the U.S. Principal types of dredges include pipeline (dustpan and cutterhead), hopper, sidecaster, dipper, clamshell, and bucket. However, there are basically only three mechanisms by which dredging is actually accomplished.

a. Suction dredging--removal of loose materials by dustpans, hoppers, and sidecasters; usually for maintenance dredging projects.

b. Mechanical dredging--removal of loose or hard compacted materials by clamshell, bucket, dipper, or ladder dredges; either maintenance or new work projects.

c. Suction/mechanical dredging--removal of loose or hard compacted materials by cutterheads; either maintenance or new work projects.

20. Of the three types of dredging mechanisms, suction dredging appears to be the least likely to cause significant direct or indirect biological effects. This is primarily because suction dredging is usually used to remove light materials from previously dredged areas.

21. Because mechanical dredging is used in both maintenance and new work construction activities, some possibility exists for both direct and indirect adverse effects on the biological communities. However, because of the manner in which these dredges operate, most of the effects would be confined to those resulting from alterations in bottom geometry.

22. Cutterhead (suction/mechanical) dredging appears to be the type of operation with the most potential for creating adverse direct and indirect effects on the biological communities. This is primarily because of the extensive use of cutterhead dredges in both new work and maintenance projects. Also, because of the manner in which these dredges operate, turbidity clouds can be generated in the vicinity of the cutterhead. There is also the greater possibility of causing the sediments to release any biostimulants or toxins contained therein. What the significance of any such release would be depends on the magnitude and duration of the dredging operation as well as the sensitivity of the local ecosystem.

23. Many concerns are now directed toward the effects of dredging

operations. Both the dredging and disposal aspects of the operations are involved in these concerns, but as might be suspected, disposal operations are responsible for the greatest amount of concern. In order to assess the effects of disposal, it is necessary to know, as a minimum, how much of what kinds of materials is being disposed of in what kind of aquatic, marine, marsh, and upland ecosystems. Yet, the types of materials, amounts, rates, and methods of disposal vary tremendously from time to time and location to location.

24. The magnitude and duration of the effects of dredged material disposal can vary significantly depending on the amounts and types of materials involved and the disposal techniques. Generally speaking, hopper dredges and barges practicing dump disposal minimize the extent of dredged material water contact. Therefore, the intensity of the short-term effects might be high, but the duration and range, relatively small. This is particularly true for stationary dumping as opposed to the slowly moving type of dumping. On the other hand, sediment buildup is usually intensified by this type of disposal.

25. The short-term effects associated with pipeline and side-caster disposal are much more difficult to assess, primarily because of the extent and diversity of these operations. In many cases, these types of disposal operations maximize the extent of the dredged material and water contact as shown in Figure 4. This is particularly true in the channel maintenance operations in inland rivers where the materials are "cast" out of the navigation channel back into the mainstream flow.

26. In other instances, where pipeline dredges discharge continuously over a period of time into the same location, as in many new work projects, any or all of the short-term effects may be detected. This is especially true where the materials are being discharged into shallow waters, causing significant dredged material and water contact as well as sediment buildup (Figure 5).

27. In other areas where pipeline dredges have been used, elbows are placed in the ends of the discharge pipes, directing the flow downward. These devices often minimize surface turbidity and oxygen

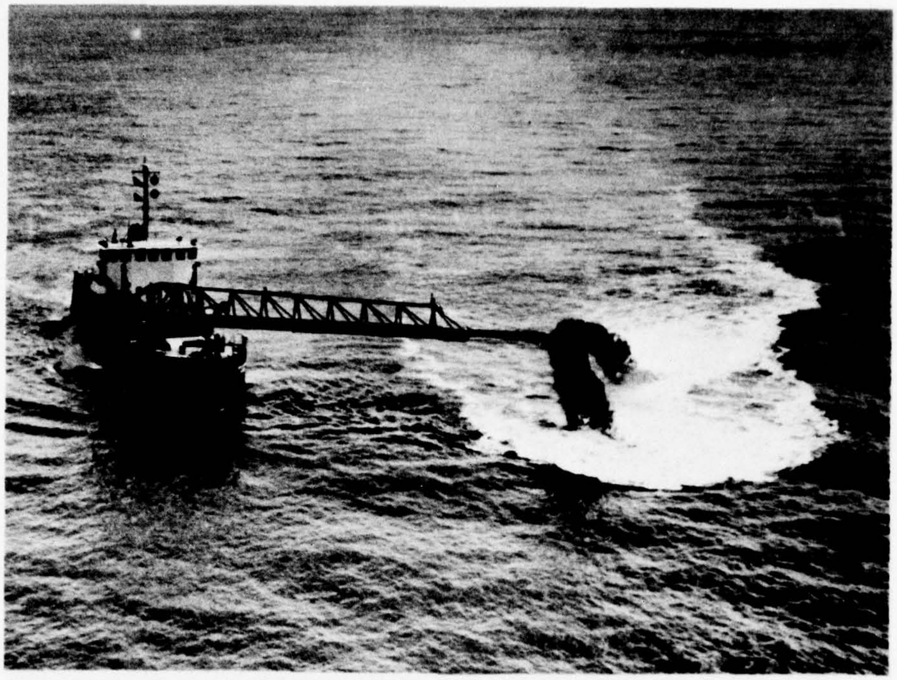

Figure 4. Sidecaster dredge

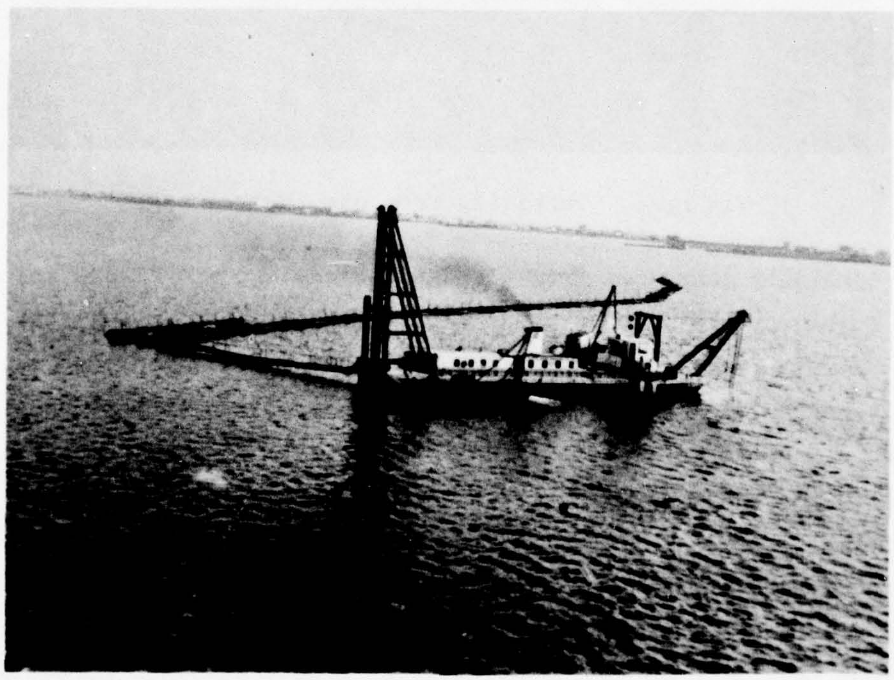

Figure 5. Pipeline dredge

depletion, but the bottom changes due to sediment buildup can still occur, depending on bottom geometry.

28. Most of the current objections to the Corps' dredging activities are related to turbidity and sediment buildup. These two objections both fall into the "direct biological effects" category. Figure 6

Figure 6. Turbidity from clamshell dredge

shows turbidity generated from clamshell dredging, and Figure 7 indicates turbidity that can be generated from pipeline disposal operations.

29. The above discussion is mainly devoted to open water disposal. This is not to say that land disposal techniques are without problems. The basic purposes of confining dredged material (preventing its direct return to the water) are to prevent the spread of pollutants into the environment, reduce the level of biologically harmful or aesthetically unpleasant constituents in the effluent, and decrease the unrestricted spread of dredge materials into the adjacent environment. It is essential that this be done as economically as practical while maintaining a satisfactory level of safety. It must be done in such a manner that the

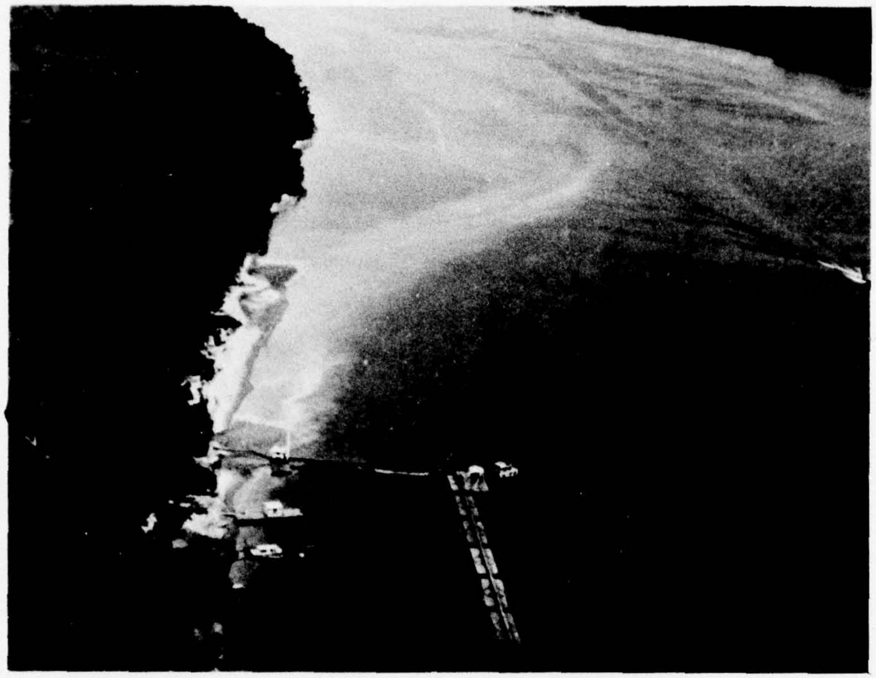

Figure 7. Turbidity from pipeline dredge disposal operations

confined facility itself does not create or aggravate local environmental problems. An examination of existing land disposal techniques and facilities has shown that the intents of confinement have not been met in all cases, as illustrated in Figure 8. In some instances, failures have occurred in the containment facilities, thereby releasing the dredged materials into the adjacent environment. The environmental and economic consequences of such failures have not been assessed.

Figure 8. Failure in containment dike

## PART III: THE DREDGED MATERIAL RESEARCH PROGRAM

### The Technical Structure

30. During the problem assessment phase of this research program, many aspects of dredging and material disposal were identified as areas where additional and more definitive information would help in properly assessing and alleviating current problems. It is obvious that many of the restrictions placed on the disposal of dredged material result from a lack of knowledge of the true consequences of the disposal practices. For instance, dredge material is termed polluted if it contains certain traces of specific chemicals. This polluted status places severe restrictions on its disposal. However, the question becomes readily apparent, from a water-quality point of view, how much of the trace chemicals are transmitted from the dredged material to the water? Many problem areas can be directly addressed by research, and most others will benefit from research directed toward other specific problems. In this regard, the problem of site acquisition for land disposal is considered a major problem by virtually every Corps District. It can be enhanced indirectly from research to find new uses for dredged material and dredged material disposal areas and development of techniques which permit reuse of sites and make disposal areas more environmentally and aesthetically acceptable.

31. It is obvious from the diversity of environmental situations encountered in the U.S. dredging program that no one dredging or disposal procedure will be satisfactory everywhere. Consequently, this research program is to be directed toward the development of the widest possible choice of technically satisfactory, environmentally compatible, and economically feasible dredging disposal procedures. These procedures will be developed to the point of working systems rather than left to the level of plausible ideas. Results of field evaluations will be made available to Corps District operating officials and other interested agencies on a worldwide basis. These are the people who make the

day-to-day decisions concerning appropriate procedures to use in accomplishing their dredging objectives.

32. The research program is developed under seven major research areas with each major area subdivided into several research tasks. An outline of the research program is shown in Table 1. The program outline includes the seven major research areas with their more specific research tasks. These specific research needs are continually being extended to cover the entire 5-year program. In order to plan and accomplish the specific research effectively, a dynamic planning effort must be superimposed on the program. Only through timely dynamic planning can the research effort accomplish a program of this magnitude and complexity. Figure 9 shows the second-order network logic for the Dredged Material Research Program.

Environmental impacts and aspects of open water disposal

33. Coastal disposal sites will be evaluated to determine the magnitude and extent of effects of disposal sites on organisms and the quality of surrounding water, and the rate, diversity, and extent of recolonization of such sites by benthic flora and fauna. Studies will be made to identify and determine the significance of those physical, chemical, and biological factors that govern the rate, extent, and diversity of colonization of subaqueous dredged material banks by benthic organisms. All currently available information pertinent to the coastal dumping of dredged materials will be consolidated, and monitoring studies will be designed and implemented.

34. Techniques will be developed for determining the spatial and temporal distribution of dredged materials discharged into various hydraulic regimes. Several dispersion equations designed to predict the physical fate of various materials disposed of in open waters are in existence. Initial efforts will be directed toward assessing presently available dispersion models. Their applicability to varying types of dredged material disposal as well as to varying types of aquatic environments will be included. In addition, long-term research efforts will be directed toward the development of techniques for predicting sediment

Table 1

Outline of Dredged Material Research Program

| Research Area | Research Task |
|---|---|
| 1. Environmental Impact and Aspects of Open Water Disposal | A. Evaluation of Disposal Sites (1)* |
| | B. Fate of Dredged Materials (1) |
| | C. Effects of Dredging and Disposal on Water Quality (1) |
| | D. Effects of Dredging and Disposal on Aquatic Organisms (1) |
| | E. Pollution Evaluation (1) |
| 2. Environmental Impacts and Aspects of Land Disposal | A. Environmental Impact Studies (1) |
| | B. Marsh Disposal Research (1) |
| | C. Containment Area Operation Research (1) |
| 3. New Disposal Concepts | A. Open Water Disposal Research (2) |
| | B. Inland Disposal Research (3) |
| | C. Coastal Erosion Control Studies (3) |
| 4. Productive Uses of Dredged Material | A. Artificial Habitat Creation Research (1) |
| | B. Habitat Enhancement Research (2) |
| | C. Land Improvement Research (3) |
| | D. Products Research (2) |
| 5. Disposal Area Reuse and Multiple Utilization | A. Dredged Material Drainage/Quality Improvement Research (2) |
| | B. Wildlife Habitat Program Studies (1) |
| | C. Disposal Area Reuse Research (1) |
| | D. Disposal Area Subsequent Use Research (2) |
| | E. Disposal Area Enhancement (2) |
| 6. Dredged Material Treatment Techniques and Equipment | A. Dredged Material Dewatering and Related Research (2) |
| | B. Pollutant Constituent Removal Research (1) |
| | C. Turbidity Control Research (1) |
| 7. Dredging/Disposal Equipment and Techniques | A. Dredge Plant Related Studies (3) |
| | B. Accessory Equipment Research (2) |
| | C. Dredged Material Transport Concept Research (4) |

* Numbers in parentheses indicate the beginning year of the research task.

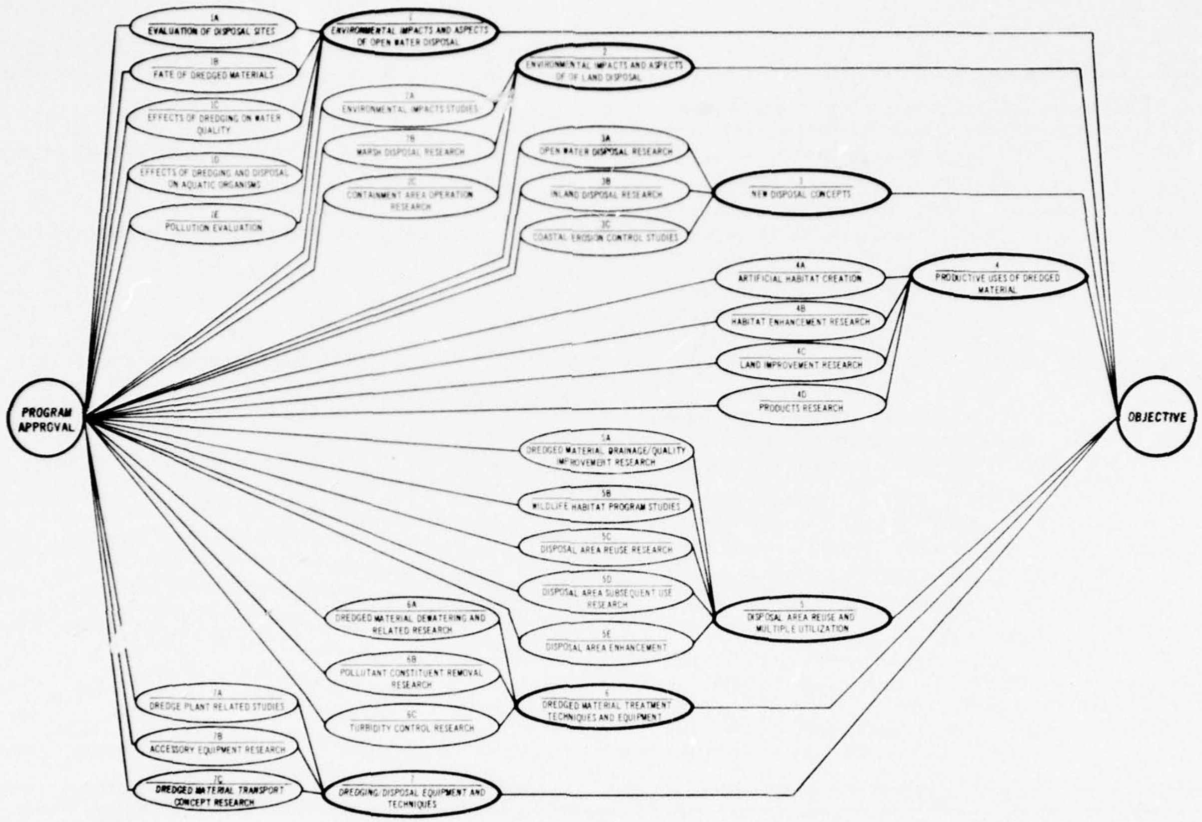


Figure 9. Second-order network logic for the Dredged Material Research Program

resuspension and transport. Emphasis will be placed on determining those factors controlling or related to resuspension, such as shear stress-initial grain motion relationships, grain-size distribution, and water and organic matter content.

35. Studies will be made to determine on a regional basis the direct and indirect effects on aquatic organisms due to dredging and disposal operations. Both field pilot studies and laboratory studies will be utilized. Particular emphasis will be placed on the spatial and temporal variations of turbidity resulting from dredging and disposal operations as they affect aquatic organisms.

36. Techniques will be developed for determining the pollution properties of various dredged material types on a regional basis. A number of manuals will be developed to provide guidelines for sampling and testing dredged material to provide meaningful information on its physical and chemical nature. Studies will determine on a regional basis the short- and long-term effects on water quality due to dredging and discharging bottom sediments containing pollutants. Field pilot studies will be used extensively to evaluate the effects on water quality due to dredged material disposal in varying aquatic environments and to identify, whenever possible, control mechanisms.

Environmental impacts
and aspects of land disposal

37. The upsurge in land disposal during the last several years is directly related to the current concern over the effects of pollutants in dredged material on water quality. Land disposal as discussed here includes all types of disposal areas and paludal environments, i.e., marshes and other wetlands. Studies addressing the environmental impact of land disposal have been subdivided into three major research tasks: (a) environmental impact studies, (b) marsh disposal research, and (c) containment area operation research. The environmental impact studies will be concerned with broad and basic relationships between the disposal site and all aspects of the adjacent environment. Marsh disposal research will be directed toward the biological, ecological, water-quality, and related problems peculiar to confined and unconfined

disposal on marsh or other wetlands. In addition to determining as completely as possible the overall environmental impact of marshland disposal, the studies will be designed to provide operational guidance to the Corps for subsequent use.

38. Containment area operation research will involve the development of new or improved methods for the operation and management of confined disposal areas and associated facilities. Results from this research should provide a containment facility that is efficient and environmentally acceptable. These efforts should promote greater public acceptance of land disposal; planned efforts in furthering public acceptance through landscaping and related efforts will be addressed under other research tasks.

New dredged material disposal concepts

39. Research is aimed at developing completely new disposal concepts or improving and expanding existing disposal practices to reduce the adverse ecological consequences of dredged material. Research task objectives include: (a) investigation of environmental and economic factors involved in deepwater (oceanic) disposal, disposal in subaqueous borrow pits, and related possibilities; (b) evaluation of new disposal possibilities such as utilizing abandoned pits and mines and investigation of systems involving long-distance transport of dredged material to large inland disposal facilities; and (c) investigation of methods of expanding dredged material use in direct and indirect beach nourishment and development of marsh erosion and subsidence control concepts. The apparent attractiveness of the deep ocean basins for solid waste disposal, including dredged material, has drawn much attention and comment in the U.S., but very little definitive research or investigation. Differences in opinion as to the environmental impact of deepwater disposal are widespread and reach the proportions of major controversy when polluted and/or toxic substances are involved.

Productive uses of dredged material

40. Research is directed at productive uses for dredged material

such as creation of artificial wildlife habitat, habitat enhancement, land improvement, and useful products. It should be pointed out that using dredged material for productive uses, developed for environmentally compatible disposal, will in most cases result in increased initial cost, and the benefits will not always be tangible. Thus, this research is aimed at providing the most economical construction methods possible without sacrificing environmental compatibility. It is a dream of most engineers responsible for dredging and disposal operations that someone someday will find a need which can be fulfilled using dredged material.

Disposal area reuse
and multiple utilization

41. The potential for reuse and multiple utilization of confined disposal areas is widely recognized but unfortunately still largely untested and unapplied. Reasons for this are sometimes technical, sometimes political, and, more often than not, economic. Multiple utilization of disposal sites will be investigated in light of improving the dredged material quality by drainage and subsequently developing the disposal site for recreation-oriented and other public or private land use concepts. Research is aimed at improving the traditional bad image of dredged material disposal sites to encourage public and private interests to use more dredged material in their community development projects. Considerable research will be devoted to develop new and adapt existing methods for the effective improvement of dredged material. Studies will be undertaken for development and testing of wildlife- and fisheries-oriented multiple-utilization concepts for confined disposal areas.

42. Disposal area reuse research will investigate dredged material improvement and rehandling procedures aimed at permitting the removal of materials from containment areas for landfill or other uses elsewhere. This appears to be an attractive concept for increasing the life expectancy of disposal areas in the estuarine zone. This research task will concern itself with (a) dredged material separation, improvement, and rehandling facilities and procedures, particularly

large-capacity systems; (b) attainment of materials of certain specification through mixing or blending; and (c) investigations of factors influencing the potential implementation of dredged material concepts.

Dredged material treatment techniques and equipment

43. Dredged material treatment and equipment research is subdivided into (a) dredged material dewatering and related research, (b) pollutant constituent removal research, and (c) turbidity control research. This research is aimed at developing equipment and treatment procedures which would permit more environmentally compatible dredging and disposal operations. This may be accomplished through physical, chemical, and/or biological treatment of dredged material. The nature of the problem of turbidity associated with both dredging and disposal operations will be investigated and physical or chemical control methods will be developed. Research will be aimed at developing techniques for densifying the dredged slurries in hopper dredge bins and pipelines prior to discharge into land disposal areas. Research will be devoted to concept development of appurtenant equipment for densifying and dewatering dredged materials at the dredge plant and at the land disposal site. Evaluations will be made of concepts developed through first-year research to determine their feasibility prior to their further development and field implementation.

Dredging/disposal equipment and techniques

44. Research is aimed at developing specialized accessory equipment designed to deal with the special engineering, economic, and environmental problems of a given area. This approach is taken rather than the development of radically new dredges. However, the established importance of dredging plus the need for new and sophisticated environmentally compatible dredging techniques requires that dredging be established as a scientific and engineering discipline within the U.S., with new emphasis placed on the formal training of dredging engineers and technicians.

45. Research is subdivided as follows: (a) dredge plant related

studies, (b) accessory equipment research, and (c) dredged material transport concept research. Specific research will be concerned with the development and application of dredging and disposal operations-related equipment for the control of turbidity and related problems. Investigations will be made of the dredged material transport equipment and dumping practices with the objective of identifying causes of turbidity which can be effectively reduced or eliminated through the use of new or accessory equipment. Investigations will be made of dredging equipment modifications and improvements and operational improvements applicable to environmental impact reduction and dredged material volume control. Also, the technical and economic applicability of pipeline and vehicle transport concepts will be assessed, particularly in regard to new disposal concepts.

46. It is felt that numerous engineering-related steps can be taken, often at nominal cost, to improve (in an environmental sense) dredging operations. As stated previously, radically new dredges appear to be of doubtful immediate value, but specialized equipment looks promising. Nontechnical measures are more difficult to deal with since they touch upon social, economic, and even national policy aspects. Even so, some steps will lead to more environmentally compatible dredging activities. A change in the method of payment based on care and accuracy rather than primarily quantity criteria, coupled with closer inspection, will help. Such a step (coupled with inspection and enforcement) can be expected to greatly modify present practice on many projects. Also, a closer look at contracting procedures is desirable and the use of improved techniques and modern equipment should be encouraged.

## The Management Structure

47. A sound management structure to conduct a program of such technical complexity and magnitude as this research program is crucial. To manage the Dredged Material Research Program, WES has organized the Office of Dredged Material Research (ODMR) as shown in Figure 10. A management structure was designed using every element of systems theory.

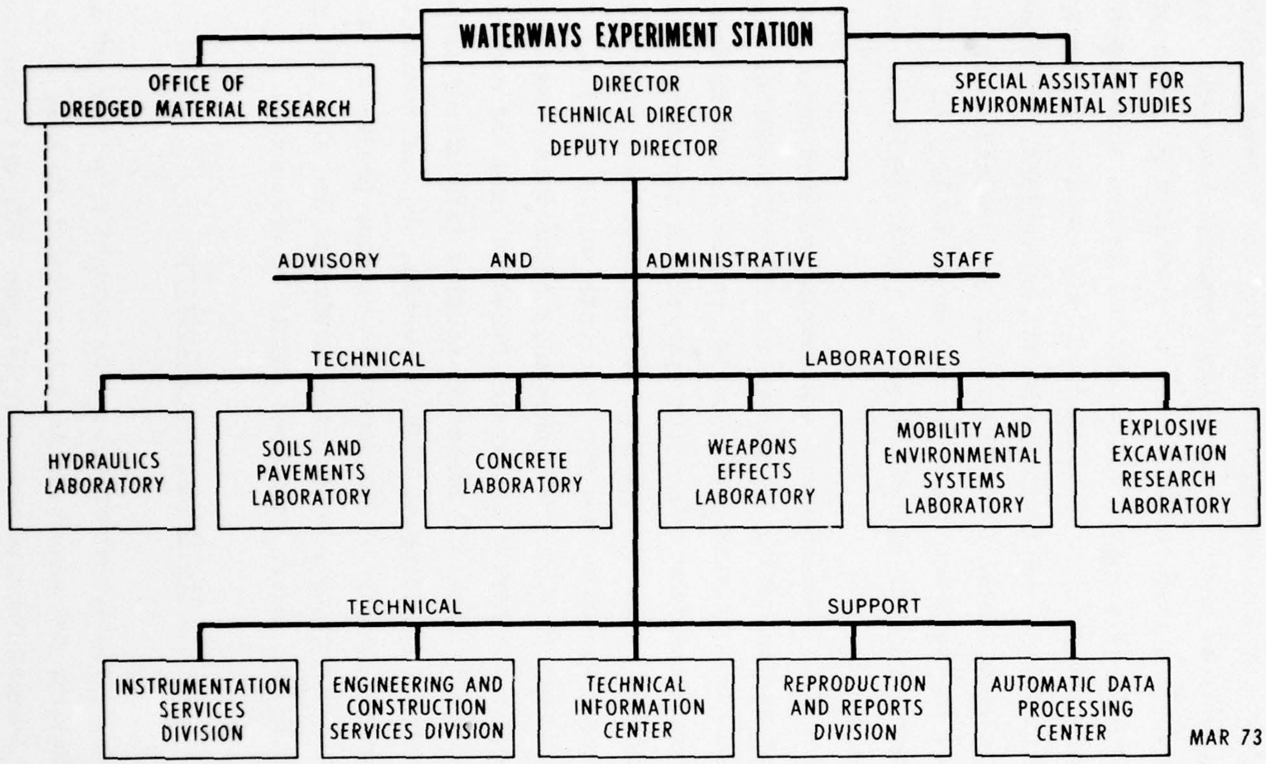


Figure 10. *Organizational relationship between the ODMR and other WES agencies*

Inherent in the requirements of this system is the necessity for dynamic planning and absolute control. Dynamic planning is essential because of the interdependencies of the individual packages of work. Since an abundance of the work is to be accomplished by contract, absolute control is necessary to prevent agencies from pursuing a side issue and losing primary direction to the objective of the program. The system provides ease of all management functions and establishes a framework within which optimum and effective decisions can be made.

48. The organizational structure uses the project manager concept. This type of organization is used for many major Governmental programs such as hardware procurement, the Safeguard System, and the research for the Polaris submarine development. In addition, many U.S. industries use this concept, especially the aircraft industry. This type of organization provides for central direction of projects within the program and efficient utilization of resources. Each project manager can draw upon the resources in the various functional elements, and their assignment is based upon the priorities of the work packages established by the program manager. The schematic of the ODMR is shown in Figure 11.

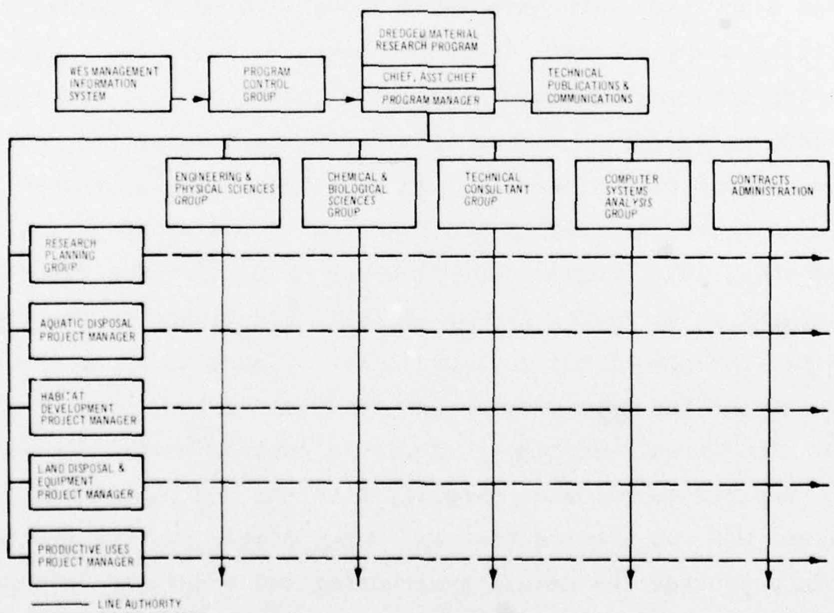


Figure 11. ODMR organization

49. The basis for the dynamic planning and technical guidance of the program is the Research Planning Group (RPG). The RPG is the technical thermostat of the closed system. It is composed of the Chief, Assistant Chief, a technical consultant, the project managers, and the program manager and is chaired by the program manager. The basis for the planning is a PERT-decision network, an example of which is shown in Figure 12. The smallest division of research is the work unit. The network logic of the PERT-decision network consists of the work units. Whereas the project is an artificial division of the technical plan for control purposes, the work units with their technical interdependencies are grouped within their technical research areas for planning purposes. An attempt is made to continually extend this network. A network path ends in this network with two types of nodes. A sink node implies that the research path is completed and ready for implementation. The decision node is a stochastic nodal point implying that the RPG must make a decision concerning the direction to be taken along the path. In the advance planning, subjective probabilities using the Delphi technique can be attached to the various alternatives emanating from the decision nodes, and a new path with associated probabilities of success can be calculated by means of newly developed computer software. Technical guidance operates on a feedback system of control to the RPG. Since each project manager is a member of the RPG, he informs the RPG of the activities in his project weekly. In addition, interim reports, final reports, and field information are reported to the group during the weekly meeting. The Program Control Group (PCG) provides reports and updated charts to allow the RPG to maintain cognizance of the fiscal and time performance of the work packages. Figure 13 shows the information flow of the input-process-output-feedback system.

50. The fiscal and time performance control unit of the system is the PCG. The PCG coordinates directly with the WES Management Information System (MIS) to provide time and money status for the project managers. They provide the detail programming and budgeting in the system and advise the program manager of necessary actions in the areas of resources allocation and emphasis necessary to maintain projected

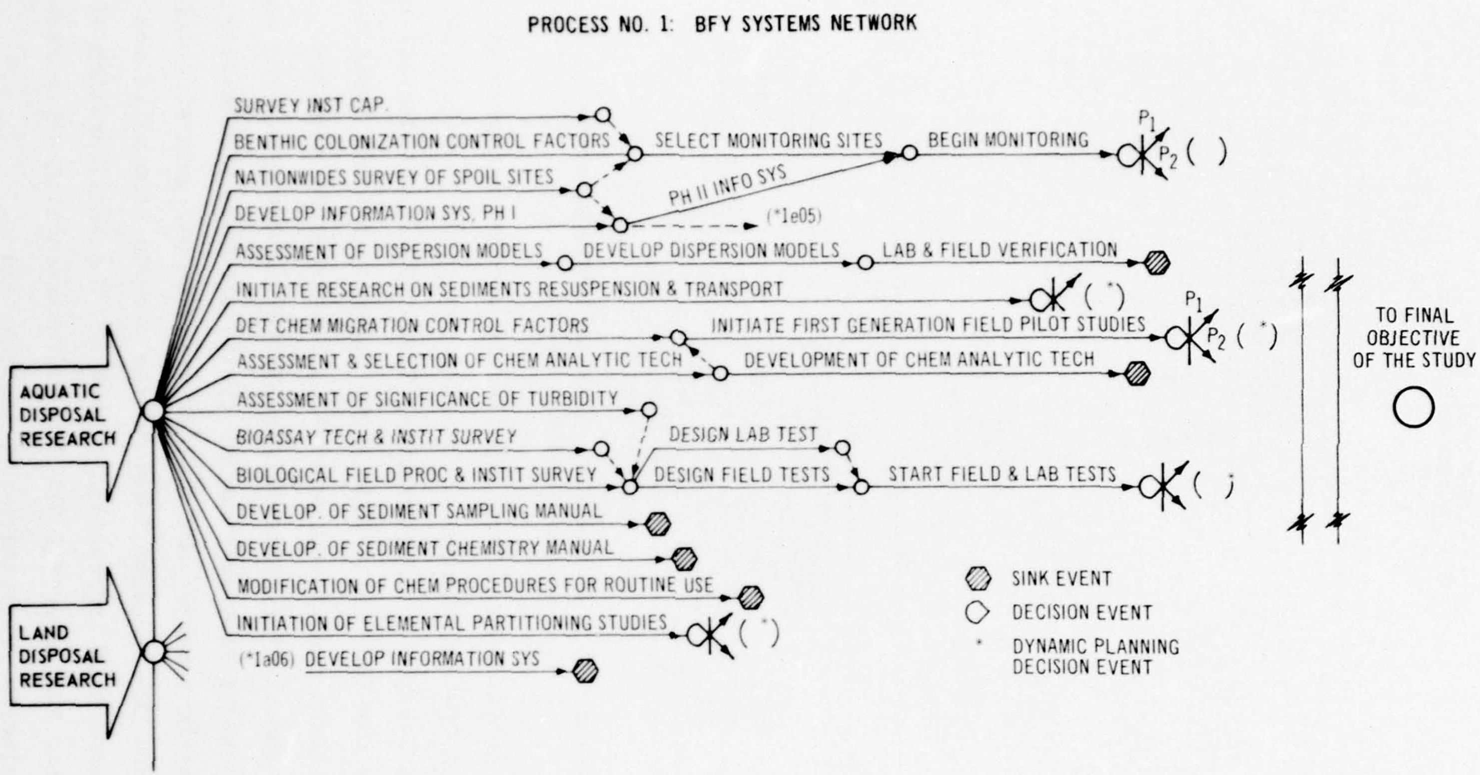


Figure 12. Example of PERT-decision network for Dredged Material Research Program

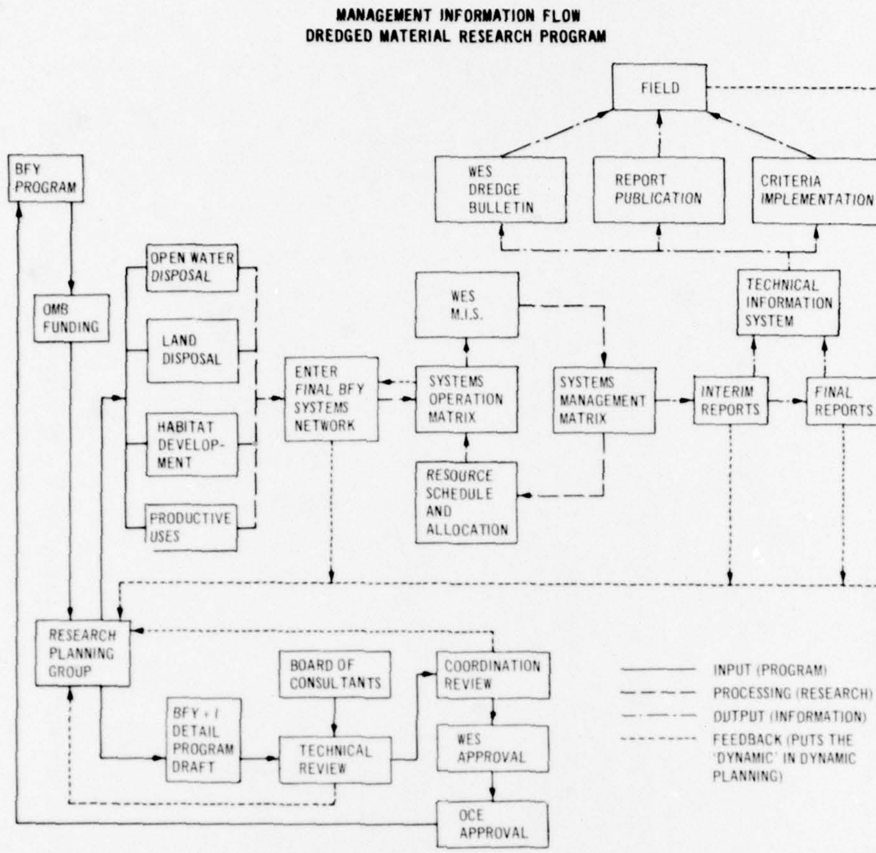


Figure 13. Information flow of input-process-output-feedback system

schedule completion dates. They provide the project managers with monthly updated Systems Management Matrices as shown in Figure 14.

51. The Technical Communications Group (TCG) provides all external communications for the ODMR. This group ensures that all technical reports are published and disseminated to all interested agencies. It publishes an approximately bimonthly news-type letter providing Corps personnel and others with information of the program, preliminary results from interim reports, and news of criteria and general interest. In addition, the TCG requests input to the program from all field agencies and presents this information to the RPG for consideration of incorporation into the program. The TCG coordinates with other Federal agencies on criteria preparation and implementation.

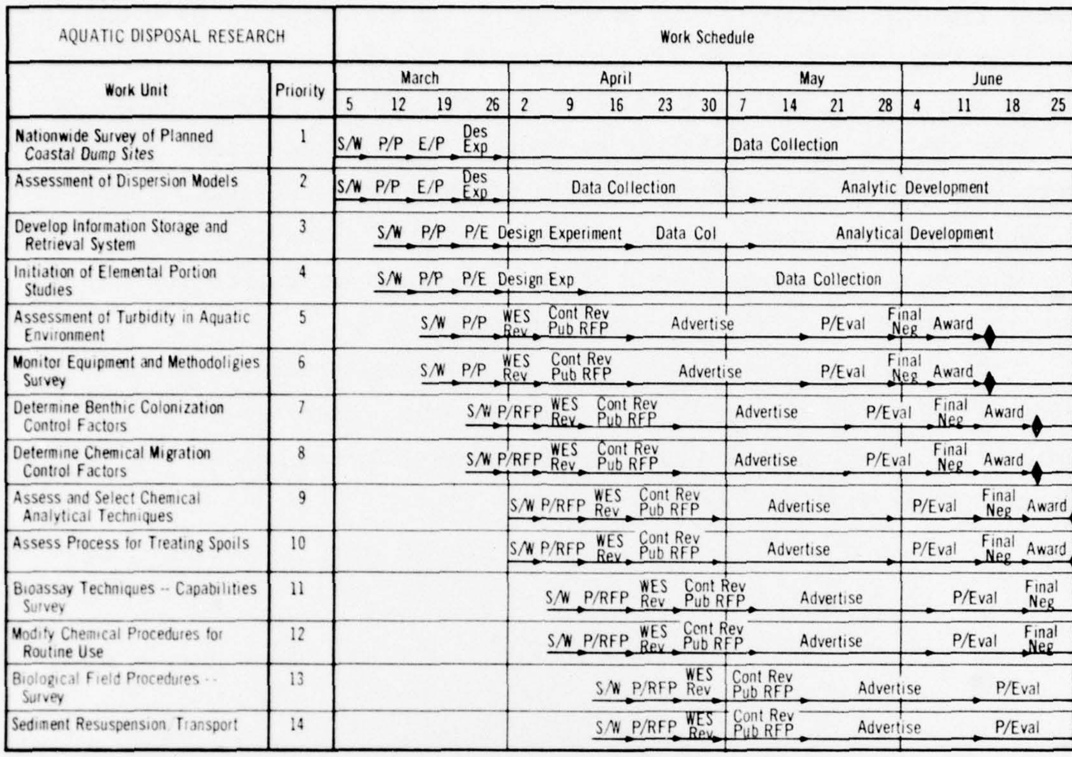


Figure 14. Example of Systems Management Matrix

## Implementation of the Research

52. The actual implementation of the research program is accomplished in-house by WES laboratories, contract sources, and interagency agreements. WES has considerable expertise in most engineering and scientific fields. It conducts some $30 million of research yearly in the areas of soils and pavements, hydraulics, weapons effects, mobility and environmental aspects of engineering, and concrete technology. It has to a lesser degree capabilities in the chemical and biological fields. Because of the large volume of commitments in these areas, WES will probably accomplish only 20 to 35 percent of the research in-house.

53. There is considerable contractural expertise in the areas of environmental engineering available in the U.S. These firms may be categorized as consulting firms, not-for-profit research firms, and universities. The majority of research is expected to be accomplished by

these types of agencies. The procedure for contracting in general is to outline the specific objective and broadly the method of accomplishment as agreed upon by the RPG in a published request for proposal. The contractor with the most satisfactory proposal, evaluated according to concept and methodology, expertise, form for portrayal of results, and, to a lesser extent, price, is awarded the contract. Each contract is supervised closely by a team made up of the necessary scientific disciplines representing the respective project managers.

54. Numerous Government agencies have considerable expertise associated with the disposal of dredged material. Such agencies will be involved with the planning and accomplishment of research to take advantage of their specific capabilities.

## PART IV: SUMMARY AND CONCLUSIONS

55. The preceding material has summarized the results of the phases of the Dredged Material Research Program which consist of identifying and assessing problems associated with the Corps dredging and disposal operations, and the development of a broad-based research program with seven major research areas. Within these research areas, research tasks were defined as far as possible to answer specific problems identified.

56. The following conclusions are warranted based on the work accomplished in the early phases of the Dredged Material Research Program:

- a. The importance of our navigable waterways and harbors to the nation's economic growth dictates that large volumes of material will continue to be dredged each year.
- b. The nation's increasing concern over the environmental impact of man's activities will result in significant controls over methods used to dredge and dispose of this dredged material.
- c. The research program must be a broad-based program which will develop the widest possible choice of technically satisfactory, environmentally compatible, and economically feasible dredging and disposal practices.
- d. Because of the highly variable environmental situations in which dredging and dredged material must be accomplished, there is no universally acceptable method for doing these tasks.
- e. Alternative methods designed to make the dredging and disposal operations more environmentally compatible will in most cases result in increased direct initial costs.
- f. There will be constraints on the type of material which can be disposed of in open water. For the foreseeable future, the constraints will probably refer to the pollution status of the dredged material.
- g. There are strong reservations within the scientific community over the current guidelines which rely upon the chemical composition of dredged material as the sole indicator of pollution status, and thus as the basis for deciding the acceptability of the dredged material for disposal in open water.
- h. There will be more land disposal of dredged material in future years. In the past, decisions concerning land

disposal or open water disposal have been based primarily on economic considerations. More recently, land disposal has been recommended by many as the preferred disposal method for polluted dredged material. Until more definitive answers can be provided for questions concerning the environmental impact of open water and land disposal, it is virtually certain that the percentage of land disposal will increase.

_i_. At least four basic problem areas associated with land disposal can be identified. These are: the environmental impact of land disposal, problems related to obligations of local sponsors of a project, problems related to site availability, and technical problems related to design, construction, operation, and utilization of land disposal sites.

_j_. Substantial improvements are necessary in containment area dike design and construction to prevent expensive and environmentally damaging failures. This is particularly true where they are the responsibility of the local sponsors. Contract specifications regarding dikes are frequently inadequate and could benefit from major revision. Subsurface investigations are essential to adequate dike design as is the application of existing soil mechanics principles.

_k_. Land disposal sites should in every possible case be selected and developed so that the area can be used for some beneficial purpose (commercial development, recreation area, wildlife habitat) after it has been filled. It is recognized that accomplishment of this objective will require additional regional planning and coordination with State and local groups.

_l_. The established importance of dredging plus the need for new and sophisticated environmentally compatible dredging techniques requires that dredging be established as a scientific and engineering discipline, with new emphasis placed on the formal training of dredging engineers and technicians.

_m_. A significant reduction of adverse environmental effects appears feasible by the careful and controlled operation of existing equipment and associated facilities. Improvements can be expected from the employment, by trained operators under the supervision of qualified personnel, of the latest equipment, instrumentation, and chemicals now available or within the state-of-the-art.

_n_. Radically new dredging concepts do not appear to provide significant potential for immediate relief from current problems, but specialized auxiliary equipment designed to deal with specific engineering or environmental problems does look promising. Incremental improvements from both production and environmental viewpoints also appear possible through various proposed cutterhead modifications.

57. To adhere to the guidelines set forth early in the program, a management system has been devised to provide the best possible means by which to continue the dynamic planning necessary while maintaining the strictest control over the direction of the program. The organization of the program utilizes the project manager concept, and every element of the systems theory has been addressed to provide a simple framework within which optimal decisions can be made. This effort places the initiation of actual research on a solid foundation, and consequently the solution of serious dredging problems will be imminent in the not too distant future.

## LITERATURE CITED


1. U. S. Army, Office, Chief of Engineers, "1968 Annual Report of the Chief of Engineers on Civil Works Activities," Washington, D. C.
2. Department of the Army, Corps of Engineers, "Waterborne Commerce of the United States, Calendar Year 1970; Part 5, National Summaries," Washington, D. C.
3. "Ocean Dumping, A National Policy," report to the President by the Council on Environmental Quality, Oct 1970, Washington, D. C.
4. Boyd, M. B. et al., "Disposal of Dredge Spoil, Problem Identification and Assessment and Research Program Development," Technical Report H-72-8, Nov 1972, U. S. Army Engineer Waterways Experiment Station, CE, Vicksburg, Miss.

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13. ABSTRACT

The Corps of Engineers, in fulfilling its mission in the development and maintenance of the navigable waters of the United States, is responsible for the dredging of large volumes of sediment each year. Annual quantities approach 400,000,000 cu yd of dredged material each year for both maintenance and new work dredging, with costs exceeding $150 million. In recent years, concern has been expressed about these operations from a number of viewpoints including fish and wildlife considerations, effects on water quality, and land use impacts. Because of these concerns, the necessity to establish regulatory criteria, and the lack of definitive information on many important questions, the Corps was authorized by Congress in the 1970 River and Harbor Act to initiate a comprehensive study relating to the disposal of dredged material. The study was divided into four phases: (1) problem identification and assessment, (2) development of a research program, (3) accomplishment of the needed research, and (4) field evaluation of new or improved disposal practices. This paper summarizes the results of Phases I and II, the problem identification and assessment, and the development of the research program. It describes specific conclusions reached in problem definition relative to open water disposal, land disposal, and marsh disposal. It alludes to possible changes in dredging equipment and techniques. In addition, this paper discusses the technical structure of the developed research program to include broad research areas and specific task objectives. The implementation of Phase III is discussed with the organization of the Office of Dredged Material Research. The technical development and its associated unique management system are presented. The basis for using a systems approach in the development of the technical and management structure and implementation of the research is discussed in detail.

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