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TECHNICAL REPORT H-78-5

EFFECTS OF DEPTH ON DREDGING FREQUENCY

Report 1

SURVEY OF DISTRICT OFFICES

by

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The overall objective of this investigation was to evaluate the effectiveness of advance maintenance dredging (overdepth dredging) in reducing dredging frequency and/or costs in the maintenance of coastal and inland channels and harbors and to establish necessary guidelines for governing the practice. This report, the first of a series, defines the state of the art and presents the results of a survey of U. S. Army Engineer Corps — cont'd

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20. ABSTRACT (Continued).

district offices to determine the extent of the usage of advance maintenance dredging. Thirty-five Corps district offices and two division offices (no districts within the division) participated in the survey. The districts are classified as either coastal or inland. Coastal districts are those which include a part of the coastline of the Atlantic or Pacific Ocean or the Gulf of Mexico. Inland districts are those which do not include any of these coastlines within their boundaries. The results of the survey indicate that advance maintenance dredging is practiced on many projects in the coastal districts, particularly those along the southeast Atlantic and Gulf coasts, while it is sparingly practiced (beyond the current dredging season) in the inland districts. The survey results indicate that advance maintenance dredging applicability is determined in most cases by previous experience with the practice and, to a lesser degree, by historical shoaling rates. The survey also indicates significant interest by the district offices in participating in further studies of the effectiveness of advance maintenance dredging.

PREFACE

The study reported herein was conducted by personnel of the Hydraulics Laboratory, U. S. Army Engineer Waterways Experiment Station (WES), Vicksburg, Mississippi, under the Civil Works Research and Development program, Office, Chief of Engineers, U. S. Army.

The study was conducted during the period 1 July 1975 to 30 September 1977 under the direction of Messrs. H. B. Simmons, Chief of the Hydraulics Laboratory; F. A. Herrmann, Jr., Assistant Chief of the Hydraulics Laboratory; R. A. Sager, Chief of the Estuaries Division; W. H. Bobb, former Chief of the Interior Channel Branch; R. A. Boland, present Chief of the Interior Channel Branch; and W. H. McAnally, Technical Manager for Estuarine Research Projects, Estuaries Division. This report was prepared by Messrs. M. J. Trawle, Project Engineer, and J. A. Boyd, Jr., Senior Technician, with the assistance of Messrs. Boland and McAnally.

Directors of WES during this investigation and the preparation and publication of this report were COL G. H. Hilt, CE, and COL John L. Cannon, CE. Technical Director was Mr. F. R. Brown.

CONTENTS

CONVERSION FACTORS, U. S. CUSTOMARY TO METRIC (SI) UNITS OF MEASUREMENT

U. S. customary units of measurement used in this report can be converted to metric (SI) units as follows:

Multiply	By	To Obtain
feet	0.3048	metres
cubic yards	0.7645549	cubic metres
miles (U. S. statute)	1.609344	kilometres

EFFECT OF DEPTH ON DREDGING FREQUENCY

SURVEY OF DISTRICT OFFICES

PART I: INTRODUCTION

Background

1. Among the Corps of Engineers responsibilities is that of improving and maintaining navigation channels and harbors in the United States. During the 10-year period from 1964-1973, the Corps dredged or contracted for dredging approximately 1.4 billion cu yd* in maintenance and new work for navigation purposes at a cost of about $500,000,000.** As a result of the environmental regulations created within the last several years, dredging has become a much more expensive operation in many parts of the country. The effects of environmental regulations on dredging costs will be felt even more heavily in the future.

2. In view of these substantial, rapidly rising dredging costs, any equipment, operation procedures, or methodology that enhances the cost-effectiveness of dredging should be utilized to full advantage. This report addresses an aspect of dredging methodology known as "advance maintenance" or "purposive overdepth" dredging.

3. Engineering Regulation 1130-2-307, paragraphs 9a, b, c, and d, of the Department of the Army, Office of the Chief of Engineers, states:

> "a. It is the policy with respect to authorized navigation projects to have full project dimensions maintained where feasible and justified. To avoid frequent redredging in order to maintain full project depths overdepth dredging should be performed in critical, fast shoaling areas to the extent that it results in the least overall cost. Such additional dredging is exclusive of and beyond the allowable overdepth to compensate for dredging inaccuracies.

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* A table of factors for converting U. S. customary units of measurement to metric (SI) units is presented on page 3.

** A. D. Little, Inc., "The National Dredging Study; Summary, Part 1: Past Performance," page 24.

b. The foregoing pertains not only to projects on which dredging operations are relatively continuous throughout the year, but also to those projects on which dredging is performed periodically and by application of this additional dredging principle dredging intervals could be extended with attendant savings or justified needs of commerce can be satisfied.

c. In the accomplishment of new work dredging, additional overdepth should be performed in those areas in which it is planned to provide additional maintenance dredging depth in accordance with a and b above.

d. Division Engineers are hereby authorized to approve additional overdepth for new work and subsequent maintenance in conformance with the above stated policy."

4. The above regulation says that in high shoal areas where almost continuous dredging is required, overdepth dredging may be necessary to maintain authorized or required project depths and that in areas where periodic dredging is required, advance maintenance may be advantageous since the frequency of dredging required will be decreased with a resulting decrease in mobilization costs. A third factor not directly addressed in the above regulation concerns dredging equipment efficiency. For example, a dredge may be capable of a 3-, 4-, or even 5-ft-deep cut in soft material, even though only a 1- or 2-ft cut is required for project depth. In this type of situation, it may be cost-effective to include several feet of advance maintenance to allow the dredge to operate with greater efficiency.

5. A typical dredged channel with no provision for advance maintenance dredging is illustrated in Figure 1. The basic specifications for the dredged dimensions are the authorized or required depth, the authorized or required bottom width, the side slopes, and the allowable pay overdepth for dredging inaccuracies. The authorized depths and widths are those channel dimensions authorized by the Congress of the United States. If, for some reason, it becomes unnecessary to maintain a channel at authorized dimensions, the channel is then maintained only at the required dimensions, which are less than authorized.

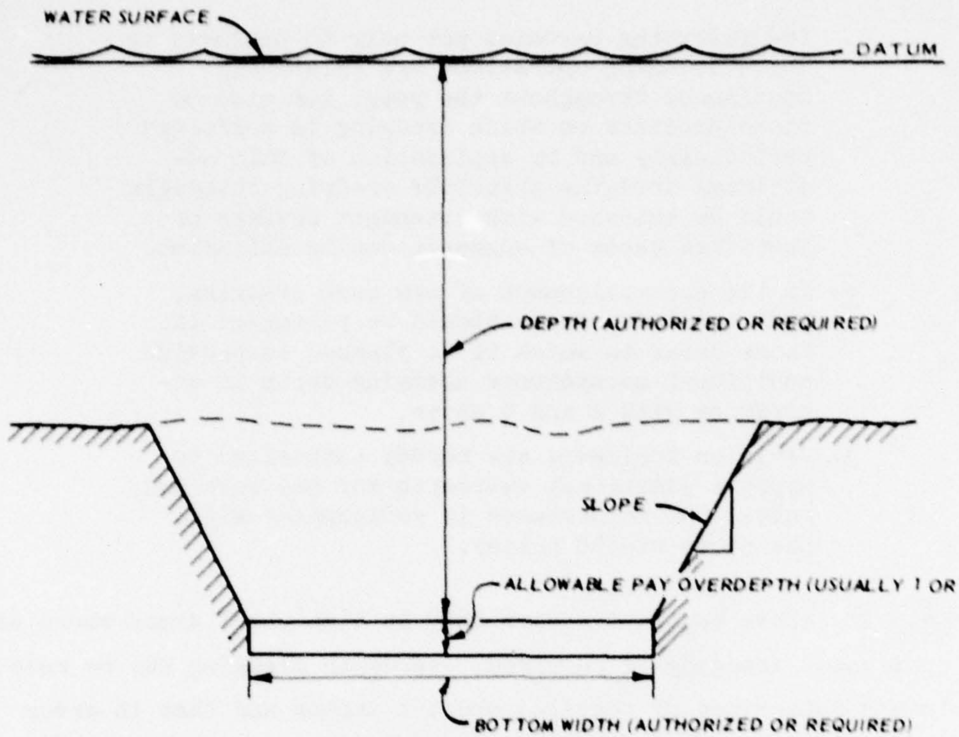

Figure 1. Typical dredged channel cross section

6. Allowable pay overdepth, also termed allowable overdepth, should not be confused with advance maintenance dredging (Figure 2).

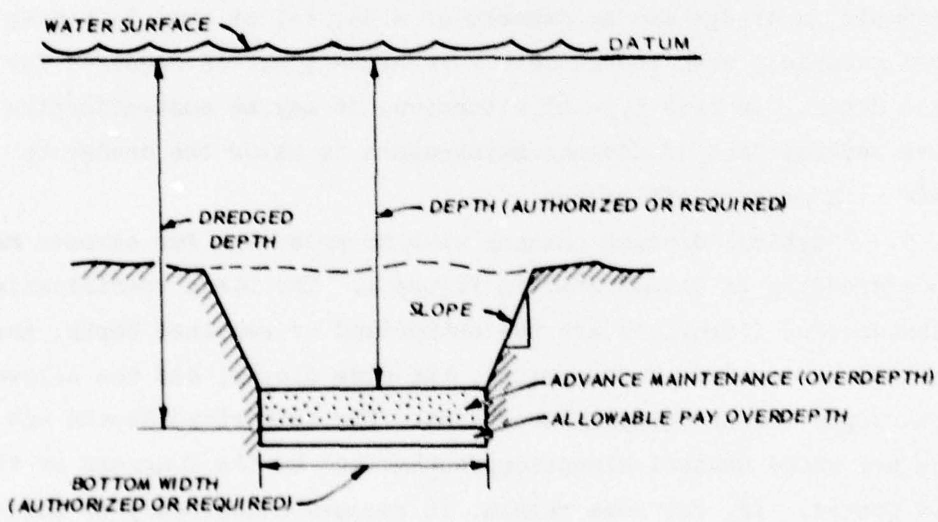

Figure 2. Dredged channel cross section with advance maintenance included

Allowable overdepth, usually 1 or 2 ft, is simply a margin of error that allows the contractor to be paid for material dredged within a specified depth (usually 1 or 2 ft) below the authorized depth. Allowable overdepth is necessary to allow for dredging inaccuracies.

Objective

7. The overall objective of this investigation is to evaluate the effectiveness of advance maintenance dredging in reducing dredging frequency and costs in coastal and inland channel and harbor maintenance and to establish guidelines necessary for governing this practice.

8. The objective of this report is to define the state of the art regarding the practice of advance maintenance dredging and to present the results of a survey of Corps district offices to determine the extent of usage of advance maintenance dredging.

Approach

9. The overall investigation is being approached as follows:

a. A literature survey has been completed to establish the state of the art and an annotated bibliography has been compiled.

b. Corps of Engineer district offices have been surveyed to (1) obtain information not documented in the literature, (2) define current criteria used to decide when advance maintenance dredging is to be performed, (3) identify potential sites for passive field studies, and (4) identify previous efforts by district offices to perform advance maintenance.

c. Results of the literature and Corps of Engineer offices surveys have been analyzed to identify those aspects of the technique requiring additional study.

d. Field and laboratory studies of those items found to require additional study will be undertaken.

Literature Survey

10. During the summer of 1975, an advance maintenance dredging

literature review was initiated to determine the state of the art. An in-house search of documents at the U. S. Army Engineer Waterways Experiment Station (WES) Library was conducted. These documents included books, technical reports, conference proceedings, and technical journals such as ASCE journals, Center for Dredging Studies News Letter (Texas A&M University), Ports and Dredging, Shore and Beach, Terra Et Aqua (International Journal on Public Works, Ports, and Waterway Development), and World Dredging and Marine Construction. Other possible sources of information concerning advance maintenance dredging explored at the WES Library included Engineering Index, Applied Science and Technology Index, and the Delft Hydraulic Laboratory Index. Also searched were the computer files of the Defense Documentation Center and the National Technical Information Service. By utilizing all of these sources, over 600 articles were selected from the library card files under the general topics of channels, dredging, estuaries, and waterways. Approximately 150 to 200 of these articles were examined closely for any statements regarding advance maintenance dredging. Other than a few references which acknowledged that advance maintenance dredging exists, there was practically no mention of the subject. The more pertinent items are listed in the Annotated Bibliography.

11. The only sources that contained comments on the merits of advance maintenance dredging were the general design memorandums published by the Corps district offices for various projects authorized in their districts. For example, the Design Memorandum for the Corpus Christi Ship Channel, Texas, 45-Foot Project, Article VI - Project Plan, published in February 1971 by the Galveston District states:

> 6.1 Plan of improvement. - The proposed plan of improvement consists of modifying the Corpus Christi Ship Channel project to provide the authorized channel depths and widths, and mooring facilities listed in paragraphs 2.1.1 through 2.1.10, and as shown on plates 2 through 5. The required dredging of the channels and basins will be to depths greater than the authorized depth depending on the amount of advance maintenance proposed in various reaches as discussed in paragraph 6.2. The allowable overdepths for dredging inaccuracies and proposed channel

side slopes are discussed in paragraphs 6.3 and 6.4, respectively. Spoil disposal plans and methods are discussed in paragraph 6.5.

6.2 Advance maintenance. - All channels and basins to be improved will be dredged to the authorized project depth plus an additional depth for advance maintenance. Experience has shown that a minimum of 2 feet of advance maintenance is justified and should be provided in dredging of all channels and basins to be improved. However, in this project, there are three reaches where extremely high shoaling rates prevail and a larger amount of advance maintenance is proposed as follows:

6.2.1 Six feet in the main channel from Mile 20.6 in the Corpus Christi Bay to Mile 23.3 in the Corpus Christi turning basin and in the LaQuinta Channel between Mile 0 and 0.6.

6.2.2 Four feet in the LaQuinta Channel from Mile 3.4 to the upper end of the LaQuinta turning basin.

6.3 Allowable overdepth. - To compensate for possible dredging inaccuracies, 2 feet of allowable overdepth is proposed in all reaches of the channel to be improved except the landlocked reach of the waterway from the western end of the Corpus Christi turning basin through the Viola turning basin, where only 1 foot of allowable overdepth is proposed. Two feet of allowable overdepth in the Corpus Christi turning basin is considered necessary because of the high wave conditions.

6.4 Proposed side slopes. - The proposed channel side slopes are 1 on 3 for the main channel from the Gulf of Mexico to Corpus Christi turning basin entrance, 1 on 2 from Corpus Christi turning basin to Viola turning basin, and 1 on 2 in LaQuinta Channel and turning basin. The toe of slope of required dredging will be set at a depth equal to the authorized depth plus the additional advance maintenance proposed.

This example is typical of the advance maintenance dredging provisions found in Corps design memorandums. A partial annotated listing of design memorandums containing advance maintenance dredging provisions is presented in Table 1.

PART II: SURVEY OF DISTRICT OFFICES

Description

12. Thirty-five Corps district offices and two division offices (no districts within the division) were asked the following questions:

  a. Which of the maintenance dredging projects in your district have in the past used or presently use advance maintenance dredging?

  b. What criteria, if any, are used in your district to determine if advance maintenance dredging would be advantageous to a project?

  c. Are there any projects, not necessarily advance maintenance, in your district that are surveyed frequently (weekly, monthly, semiannually) for depths in which shoaling quantities versus depth relations can be developed from available survey data?

13. The districts have been classified either as coastal districts or inland districts. Coastal districts are those whose boundaries include the coastline of the Atlantic Ocean, Pacific Ocean, or Gulf of Mexico. The inland districts are those districts whose boundaries do not include any of the above coastlines. The survey results presented below are grouped into coastal district results and inland district results.

Coastal Districts

Advance maintenance projects

14. The advance maintenance projects and their dimensions for each of the coastal districts are listed in Table 2. A summary of the number of advance maintenance projects and the depths involved for each coastal district is presented in Table 3. The number of projects in each district varies from 88 in the Galveston District to none in the San Francisco and Wilmington Districts and the Pacific Ocean Division for a total of 303 advance maintenance projects. Of these 303 projects, 106 are considered deep draft (depth of 30 ft or greater) and

197 shallow draft. The depth of advance maintenance ranges from 1 to 8 ft, with about 69 percent of the projects 2 ft or less advance maintenance and 84 percent 3 ft or less advance maintenance. The districts with the largest volumes of advance maintenance dredging were the New Orleans and Galveston Districts.

Advance maintenance criteria

15. The criteria used for determining the applicability of advance maintenance dredging by the coastal districts are summarized by district office response as follows:

a. Alaska District. No specific criteria are used to determine where advance maintenance dredging would be advantageous.

b. Baltimore District. Advance maintenance is predicted on high shoaling rates experienced so that dredging will not be required more frequently than annually.

c. Charleston District. Historical shoaling records and past localized experience are used to determine the need for and extent of advance maintenance dredging.

d. Galveston District. The criteria utilized for the current maintenance standards were based on varying shoaling rates and experiences in dredging frequencies for selected channel reaches. In an attempt to maintain full project dimensions through a project channel and decrease dredging frequencies, varying advance maintenance depths were utilized along selected reaches of the project channels to allow the various shoaling rates to occur and eventually shoal the channel to a point where the same controlling dimensions would occur throughout the channel length. Initially, the intent was to redredge when the controlling dimensions were even and the same as the authorized dimensions for the channel. This was considered the ideal situation and a possible goal for the "improved maintenance standard." Funding restraints, however, restricted the implementation of this plan. The current maintenance standard evolved through experience and decisions to add extra maintenance to change the dredging frequencies from annual to periodic.

e. Jacksonville District. No empirical methods (equations or formulas) are used to predict maintenance dredging. All maintenance dredging is programmed, based on analyzing project maintenance history including surveys to determine areas with high shoaling rates. Overdepth dredging is performed in high shoaling areas to reduce the maintenance frequency.

f. Los Angeles District. Past dredging experience is the criterion used to determine if advance maintenance dredging would be useful in reducing the mobilization cost by extending the time period between maintenance dredging operations.

g. Mobile District. It is the policy, if sufficient funds are available, to provide 2 ft of advance maintenance dredging on all maintenance dredging projects.

h. New Orleans District. Experience gained from previous dredging projects is needed to determine whether advance maintenance would be advantageous. Reconnaissance surveys are also used to provide information on the shoaling rates of various waterways. Before-dredging and after-dredging surveys are made for purposes of payment but are not used to determine shoaling rates.

i. New York District. Accelerated shoaling rates are used as the criteria for determining which projects require advance maintenance.

j. Norfolk District. The criteria used to determine when advance maintenance will be performed and the amount to be dredged involve shoaling rates, dredging frequencies, economics, disposal area capacities, and logistics. As a matter of routine, 1 ft of advance maintenance dredging is generally applied to all jobs, unless the above parameters dictate otherwise. Shoaling rates are determined by averaging channel depths over specified channel areas. The specified areas are generally locations of known or suspected rapid shoaling. The average depths are then plotted against time. The connected plotted points yield a rate-of-fill curve which is used to determine how effectively overdredging will prolong the dredging frequency and which areas should be overdredged to assure a uniform frequency over several shoals. This, in turn, provides economical dredging quantities since the cost per cubic yard is generally less for greater quantities of material. Disposal area capacities generally restrict overdredging to the most critical channel sections and must be considered. Regarding logistics, often remote dredging sites are exposed and, consequently, are hazardous to pipeline dredges. This is particularly critical during the winter. In such cases, advance maintenance is considered to reduce mobilization costs by extending the dredging frequency at these sites. This benefit is in addition to reducing exposure of the dredge plant. The point to recognize is that advance maintenance must be evaluated on its merits for each specific job.

k. Philadelphia District. Advance maintenance is generally performed on projects where it is anticipated that shoaling may occur between dredging jobs to such an extent that the channel will be of insufficient depth for normal usage.

l. Portland District. Criteria used to determine advance maintenance dredging depths are based on hydrographic surveys. Quantities derived from hydrographic surveys recorded at various times of the year are used to establish least-squares-fit curves for in-fill and shoal values. These curves are then utilized to establish beneficial advance maintenance depths. Quantities versus controlling depths are also applied to establish an advance maintenance depth. Studies have been accomplished at specific locations, particularly on the Columbia and Lower Willamette River Project, to evaluate additional advance maintenance dredging benefits.

m. San Francisco District. Criteria or equations relating to advance maintenance have not been developed.

n. Savannah District. Historically, advance maintenance dredging has been performed in portions of dredging projects subject to rapid shoaling.

o. Seattle District. Current criterion is to use advance maintenance dredging in locations where rapid shoaling would reduce depths available to navigation in a very short time. This concept is utilized on the Swinomish Channel, in which sand wave peaks would project into the project depth shortly after dredging if advance maintenance were not utilized. On the other projects in the district, the criterion used is that advance dredging reduces the frequency of required dredging and, therefore, mobilization costs. Basically, the district evaluates the cost of the increased advance quantity dredged (corrected to annual cost) versus reduced mobilization costs realized by less frequent dredging.

p. Wilmington District. Other than rapid shoaling, there are no criteria such as equations or formulas that are used for the purpose of determining if advance maintenance is advantageous.

q. New England Division. The criterion for determining if advance maintenance dredging would be advantageous to a project is based on the history, past dredging experience, and periodic surveys of the project. Those projects that are characteristically fast shoaling are the ones that advance maintenance dredging would benefit. The division does not use any equations or formulas for predicting shoaling rates as a function of depth.

r. Pacific Ocean Division. This division has no criteria for advance maintenance.

16. As can be seen from the above results, the main criterion used for advance maintenance is past shoaling history. There are no general relations, empirical or otherwise, for use in predicting the effectiveness of advance maintenance for a particular project. However, the degree of sophistication in analyzing past shoaling data for application in predicting advance maintenance shoaling appears to vary widely among districts. Two districts, Norfolk and Mobile, have a policy of including advance maintenance of 1 and 2 ft, respectively, on all maintenance dredging projects, unless additional parameters dictate otherwise. The Alaska District, San Francisco District, and Pacific Ocean Division have no established criteria for advance maintenance dredging.

Frequently surveyed projects

17. Frequently surveyed projects (weekly to semiannually) in the coastal districts are summarized by district office response as follows:

a. Alaska District. Anchorage Harbor, Dillingham Harbor, Homer Harbor, Ninilchik Harbor, and Nome Harbor are thoroughly surveyed a minimum of twice each ice-free season. Complete soundings have been taken monthly at Dillingham during the 1976 season.

b. Baltimore District. Due to the backlog of required surveys, no projects are surveyed as frequently as semiannually.

c. Charleston District. Several heavy shoaling areas in Charleston Harbor are surveyed semiannually. All other areas are surveyed annually or less frequently.

d. Galveston District. No projects are surveyed more frequently than annually.

e. Jacksonville District. Twelve projects are designed to be surveyed twice yearly: Fernandina Harbor, Jacksonville Harbor, St. Augustine Harbor, Ponce De Leon Inlet, Canaveral Harbor, Ft. Pierce Harbor, Palm Beach Harbor, Port Everglades Harbor, Miami Harbor, Charlotte Harbor, Tampa Harbor, and St. Lucie Inlet.

f. Los Angeles District. No projects are surveyed more frequently than annually.

g. Mobile District. No projects are surveyed more frequently than annually.

h. New Orleans District. Twenty-four maintenance dredging projects are surveyed semiannually: Bayou Lacombe; Bayou Bonfouca; Chefuncte River and Bogue Falia; Tangipahoa River; Barataria Bay Waterway (Bar Channel and Inside Channel); Bayou Dupre; Bayou Lafourche and Lafourche Jump Waterway; Bayou La Loutre; Waterway from Gulf Intracoastal Waterway (GIWW) to Bayou Dulac; Mermentau River; Bayou Segnette; Bayou Teche; Vermilion River; Calcasieu River and Pass Bar Channel, Pass, and Pass Channel to Cameron; Freshwater Bayou Bar Channel; GIWW (Main Stem); GIWW, Morgan City-Port Allen, Alternate Route; GIWW (Franklin Canal); Houma Navigation Canal; Little Caillou Bayou; Mississippi River-Baton Rouge to Gulf of Mexico (South Pass); Petit Anse, Tigre, and Carlin Bayous; Atchafalaya Basin (Six Mile Lake); and Atchafalaya Basin (Berwick Harbor). One project, the Mississippi River-Gulf Outlet (Breton Sound, Bar Channel, and Land Cut), is surveyed monthly. Eight projects are surveyed weekly: GIWW (Lock Forebays in vicinity of New Orleans Harbor), Mississippi River-Baton Rouge to Gulf of Mexico (Deep Water Channel), Mississippi River-Baton Rouge to Gulf of Mexico (New Orleans Harbor), Mississippi River-Baton Rouge to Gulf of Mexico (Southwest Pass and Southwest Pass Bar and Jetty Channel), Atchafalaya Basin (Three Rivers), Baton Rouge Harbor (Devil's Swamp), Mississippi River Channel (Rivers Crossing), and Old River (Old River Lock Forebay and Tailbay).

i. New York District. Four projects are surveyed semiannually: East Rockaway Inlet, Fire Island Inlet, Jones Inlet, and Hudson River Channel (Weehawken-Edgewater).

j. Norfolk District. No projects are surveyed more frequently than annually.

k. Philadelphia District. Various ranges of the Delaware River, Philadelphia to the sea, navigation project are surveyed on a frequent (at least semiannually) basis. These ranges include Marcus Hook, Deepwater, and New Castle Ranges, each of which is dredged approximately three times annually. Other projects surveyed at least semiannually are Wilmington Harbor and Schuylkill River.

l. Portland District. Ten projects are surveyed on an approximate 3- to 6-week basis, except during inclement weather periods at the coastal entrance: Chetco River, Oregon; Columbia and Lower Willamette Rivers, Oregon; Columbia River, Vancouver, Washington-The Dalles, Oregon; Coos Bay, Oregon, entrance and inner channel; Coquille River, Oregon; Rogue River, Oregon; Siuslaw River, Oregon; Tillamook Bay, Oregon; Umpqua River, Oregon; and Yaquina Bay and Harbor, Oregon.

m. San Francisco District. The entrance channel to Santa Cruz Harbor is presently being surveyed monthly in conjunction with WES testing of sand bypassing equipment at this location. Mare Island Strait is surveyed at least semiannually in conjunction with semiannual dredging of this waterway.

n. Savannah District. Savannah Harbor and East River in Brunswick Harbor are surveyed frequently, and probably sufficient data are on record that could be used to establish shoaling rates.

o. Seattle District. No projects are surveyed more frequently than annually.

p. Wilmington District. Records are available on Wilmington Harbor at about 6-month intervals.

q. New England Division. No projects are surveyed frequently.

r. Pacific Ocean Division. No projects are surveyed more frequently than on an annual basis.

Inland Districts

Advance maintenance projects

18. The advance maintenance projects and their dimensions for each of the inland districts are presented in Table 4. The total number of advance maintenance projects within the inland districts is 24. The depths of advance maintenance involved are 1, 2, and 3 ft.

Advance maintenance criteria

19. The criteria used for determining the applicability of advance maintenance dredging by the inland districts are presented by district office response as follows:

a. Buffalo District. The advance maintenance dredging procedure is based on long-term experience and represents a balance of that experience, available funds, available dredge capacity, river traffic capacity, confined disposal site capacity, barge unloading capacity, seasonal river stages, and navigational needs. The majority of shoaling is a function of frequency, duration, and stage reached of riverflows. There is no known predictive mechanism that can cope with these conditions other than relying on experience and real-time management to meet immediate needs.

b. Chicago District. Historically severe shoaling rates causing more-frequent-than-annual dredging is the criterion for advance maintenance dredging.

c. Detroit District. Under normal water level circumstances on the Great Lakes, the 2-ft allowable overdepth (for dredging inaccuracies) is dredged and is needed, especially at the inlets to projects where the adjoining lake bottom is primarily sand. When the lake stage is high, not all (and in some cases none) of the allowable overdepth is dredged. Annual shoaling rates are determined from soundings and material removed. No attempt has been made to relate shoaling to time of year, with the exception of Pentwater Harbor where the U. S. Army Coastal Engineering Research Center has studied shoaling extensively. Certain storm conditions on Lake Michigan and Lake Superior can cause considerable shoaling in one fall or spring storm, especially in low-water periods. One of these storms spoils all averages and predictions.

d. Fort Worth District. The district has no criteria for advance maintenance dredging.

e. Huntington District. The district has no criteria for advance maintenance dredging.

f. Kansas City District. The district has no criteria for advance maintenance dredging.

g. Little Rock District. It has been determined that advance maintenance of 3 ft or less is advantageous because it eliminates redredging of shoals that are caused by minor rises and shifting currents. It is not practicable to perform deeper advance maintenance dredging because the waterway carries a heavy sand sediment load during high river stages. Where there is a shoaling tendency, this sediment load is more than enough to fill any reasonable channel depth that may be dredged for advance maintenance and to re-form the shoal during the course of a routine river rise.

h. Louisville District. Because of the annual cycle of high-water stages during the winter/spring and low-water stages in summer/fall, and the unpredictability of high-water stages/duration and shoaling conditions/duration, the district feels that advance dredging beyond the needs of the current season would be of doubtful value. All dredging projects in the district involve only overdepth dredging as necessary to avoid repeat dredging later in the same season.

i. Memphis District. The district has no criteria for advance maintenance dredging.

j. Nashville District. The district has no criteria for advance maintenance dredging.

k. Omaha District. The district has no criteria for advance maintenance dredging.

l. Pittsburgh District. The district has no established criteria for advance maintenance dredging.

m. Rock Island District. The district has no criteria for advance maintenance dredging.

n. Sacramento District. When a persistent shoaling pattern develops that may cause vessel groundings and may require more-than-annual dredging, advance maintenance depths of from 2 ft to 4 ft would be included to solve the problem. No special equations or formulas have been developed for predicting shoaling rates.

o. St. Louis District. No empirical methods are used for predicting shoaling areas or rates. Historical records or shoaling areas are evaluated for determining the applicability of advance maintenance dredging.

p. St. Paul District. The district is currently conducting research of incremental overdepth dredging on the Mississippi River 9-Foot Channel Project through the application of field pilot studies, physical modeling, and theoretical evaluation utilizing one- and two-dimensional mathematical modeling. This research effort is being accomplished in conjunction with the Great River Environmental Action Team (GREAT) which is a joint Federal-State cooperative effort under the Upper Mississippi River Basin Commission, funded by the Corps of Engineers. This research is being conducted to determine correlations between dredging depth, dredging width, channel longevity, dredging quantities, channel alignment, and main stem and tributary discharge. The purpose of this effort is to minimize the average annual dredging requirement volume to reduce the environmental impact of material placement.

Historically, the Upper Mississippi River 9-Foot Channel Project has been dredged to a standard total depth, including overdepth, of 13 ft. Experience has proven a channel with a minimum depth of 10 ft has closed within days during stable flow conditions when utilized by motor vessels and tows drawing 9 ft or less. Therefore, an 11-ft channel is considered essential to retain a stable condition and the additional 2 ft of depth was considered as advance maintenance dredging and tolerance for dredging equipment. The St. Croix River has been maintained with the same standards as the Mississippi. The Minnesota River 9-Foot Channel Project is dredged to a total depth of 11 ft. This depth is limited by the 100-ft channel width and adjacent bank stability.

The incremental overdepth pilot program has been field-tested during 1975-1977 and will be continued in 1978. The distribution of dredging depths on the Mississippi River was as follows:

Date	Number of Projects at Depths of 13 ft	12 ft	11 ft
1975	7	10	6
1976	7	7	7
1977	3	6	5

The site selection criteria include location of the site, type of reach, location of the cut (with respect to the thalweg), stability of previous dredged cuts during low flow, and dredging frequency at the site. These criteria are summarized as follows:

(1) Location of site just above a lock and dam or other hydraulic structures (such as bridges), or in the vicinity of a heavy sediment-carrying tributary such as the Chippewa River, is considered a negative factor in the analysis.

(2) The straight, divided reach is considered the least desirable location for a reduced-depth (less than 13 ft) dredged cut and an undivided bend the most desirable.

(3) Location of the dredged cut in alignment with and on the thalweg is considered a positive factor, while location on or near a point bar where there is a readily available source of sediments to refill the cut was considered a negative factor.

(4) Dredged cuts may be eroded or may be filled at low flow. A filling of the dredged cut at low flow is considered the most undesirable factor. Overdepth dredging is generally required at this site.

(5) A large dredging frequency at a site indicated that the dredged cut made at this site is filled up easily at medium and high flows. Since there is a possibility of late floods occurring in the fall or early winter, the filling of the dredged cut could create navigation problems for the rest of the period of the low-flow season. This risk is higher at sites having larger dredging frequencies.

During the 1975, 1976, and 1977 test periods, the St. Paul District dredged 706,207 cu yd, 645,544 cu yd, and 182,303 cu yd, respectively, for the Mississippi River 9-Foot Channel Project. These years represent extremely low dredging requirements primarily due to low-flow conditions. The average annual dredging during the 1968-1977 period was 1.4 million cu yd. The reduced depth resulted in a 28.2, 27.9, and 35.0 percent dredging quantity reduction, in 1975, 1976, and 1977, respectively, for the sites dredged. As normal spring runoff has not been encountered during the last two years, the program conclusions have not been finalized. With a couple of exceptions where the initial trend indicates an increase in frequency of dredging, the program has proven successful under low-flow conditions. All sites are being monitored.

The field results have been documented several times a year in lower pool #4, Cairo mile 753-764. Other sites are documented two to three times a year if the channel condition is marginal. Colorado State University has run a one-dimensional model study of this reach. They also have been contracted to develop a two-dimensional model and apply it to this reach. The field documentation has been and is being utilized to calibrate the mathematical models. A physical model is being constructed for testing at the University of Minnesota to study the Mississippi-Chippewa Rivers confluence, sediment transport characteristics, existing wing dam system, and varying parameters of channel maintenance. This research is also evaluating the benefits of a tributary sediment supply reduction and effect of dredged material placement on flood stages. These contract efforts are scheduled for completion, with final reports, by 1 July 1979.

Normal practice for harbors located on Lake Superior is to dredge 2 ft of overdepth beyond project depth. During extremely high dredging requirements, the overdepth is reduced to assure navigation at all harbors.

q. Tulsa District. When shoaling occurs to such an extent that the authorized section is no longer available, the channel (Table 4) is dredged to include 3 ft advance maintenance with an additional foot possible for allowable overdepth. No equations or formulas are in use to predict shoaling as a function of depth changes.

r. Vicksburg District. The district has no established criteria for determining the applicability of advance maintenance dredging.

s. Walla Walla District. The district has no criteria for advance maintenance dredging.

20. As shown in all the above responses, except that of the St. Paul District, advance maintenance beyond the needs of the current season

is apparently not considered effective in most riverine or inland projects. In most cases, the shoal material available during the high-water season far exceeds that which could be stored effectively by advance maintenance dredging. However, advance maintenance may be effective in eliminating the necessity of redredging within the same season, as indicated by the Buffalo, Chicago, Detroit, Little Rock, Louisville, and Sacramento Districts. The ongoing research effort described in the St. Paul District response may provide definitive results concerning the effectiveness of advance maintenance beyond the needs of the current season.

Frequently surveyed projects

21. Frequently surveyed projects within the inland districts are summarized by district response as follows:

a. Buffalo District. The Cuyahoga River Channel is usually sounded four times per year. No other projects are surveyed more frequently than annually.

b. Chicago District. No projects are surveyed more frequently than annually.

c. Detroit District. Usually, no projects are surveyed more frequently than annually.

d. Fort Worth District. No projects are surveyed frequently.

e. Huntington District. No projects are surveyed more frequently than annually.

f. Kansas City District. No appropriate survey data are available.

g. Little Rock District. No appropriate survey data are available.

h. Louisville District. Three line soundings of critical bars and lock approaches in the Ohio River have been made from three to five times each low-water season. Other projects in this district are normally sounded only once per year. Although a complete record of the bar sheets (numerical depths at pool stage) is available for many years past, the sounding tapes have not been maintained. However, their usefulness for comparison is questionable as the soundings were made largely on the basis of buoy positions or visual estimates, lacking the precision of hydrographic surveying procedures.

i. Memphis District. No projects are surveyed frequently.

j. Nashville District. No projects are surveyed frequently.

k. Omaha District. No projects are surveyed frequently.

l. Pittsburgh District. No projects are surveyed frequently.

m. Rock Island District. The 9-ft Mississippi River navigation project is patrolled by a channel reconnaissance team biweekly throughout most of the navigation season. Although these are not detailed hydrographic surveys, they could provide some indications of depths, shoaling, and subsequent scour or increased shoaling during differing discharge conditions.

n. Sacramento District. No projects are surveyed frequently.

o. St. Louis District. The Upper Harbor Survey, mile 181.5 to mile 184.1, Upper Mississippi River is conducted monthly. There are no other projects surveyed frequently.

p. St. Paul District. Some sections of the Mississippi River 9-Foot Channel Project are surveyed several times a year.

q. Tulsa District. No projects are surveyed frequently.

r. Vicksburg District. Hydrographic surveys are made frequently on the Mississippi River and associated harbors.

s. Walla Walla District. Two projects, Ice Harbor Dam downstream lock approach channel and downstream navigation channel are sounded frequently.

22. As indicated above, there are only several frequently surveyed projects within the inland districts.

PART III: SUMMARY

23. The literature review of advance maintenance dredging offered no documentation of the effectiveness of this practice in reducing dredging costs. The only published comments on this subject were those contained in the general design memorandums for projects in various Corps districts.

24. The survey of Corps district offices indicated that advance maintenance dredging was being done on many projects in the coastal districts, particularly those districts along the southeast Atlantic and Gulf coasts. The eight districts from Norfolk, Virginia, to and including Galveston, Texas, contained 89 percent of the advance maintenance projects listed in Table 3.

25. One factor brought out by the survey is that even though advance maintenance dredging is used extensively by the districts, the use of advance maintenance is generally not well documented in an easily accessible format. To determine the advance maintenance dredging history of a project (overdepth dredging) requires researching the dredging contract specifications, the before- and after-dredging cross-section drawings, or similar records.

26. The survey also indicated that advance maintenance dredging beyond the current dredging season was sparingly practiced in the inland districts. Only eight inland districts (Buffalo, Chicago, Detroit, Little Rock, Louisville, Sacramento, St. Paul, and Tulsa) cited experiences with advance maintenance dredging. It should also be noted that four coastal districts (Mobile, New Orleans, Norfolk, and Portland) included riverine projects as advance maintenance. The Mobile District listed the Black Warrior and Tombigbee Rivers, Alabama; the Pearl River, Mississippi-Louisiana; and the waterway connecting the Tennessee and Tombigbee Rivers as advance maintenance projects. The New Orleans District listed the Red River below Fulton, Arkansas; the Red River from the Mississippi River to Shreveport, Louisiana; and the Mississippi River shallow-draft crossings above Baton Rouge as advance maintenance projects. The Norfolk District listed the Appomattox River and Hoskins

Creek as advance maintenance projects. The Portland District listed the Columbia River from Vancouver, Washington, to The Dalles, Oregon, as advance maintenance. Additionally, these and other coastal districts include other projects which although classified as estuarine projects, are actually within the transition zone between estuarine and riverine environments.

27. The use of advance maintenance dredging was in most cases determined by previous experience and past shoaling rates. Another important criterion was economics, mainly based on two factors--the availability of funds to perform advance maintenance dredging and the estimated cost-benefit ratio of advance maintenance dredging.

28. Responses to the survey questionnaire showed significant interest by the district offices in participating in further studies of advance maintenance effectiveness. Fifteen coastal and six inland districts expressed such interest.

29. Based on the results of the survey of the district offices, the first aspect of advance maintenance dredging which requires additional investigation is that advance maintenance is used widely, although not uniformly, within the Corps but is mostly limited to 2 ft or less in depth. The possibility of using increased depths of advance maintenance to enhance maintenance dredging effectiveness should be explored. A second aspect requiring additional study is that the criteria for advance maintenance dredging use are vague and vary from district to district. The need exists to standardize advance maintenance criteria and to develop a procedure for their use.

30. Subsequent reports in this series will address the abovementioned aspects of advance maintenance through the analyses of historical dredging, shoaling, and other data for existing advance maintenance projects. Both physical and mathematical models will be evaluated for predictive capability with regard to advance maintenance by comparison with prototype shoaling data. A procedure will be developed that will allow the engineer to determine rationally the effectiveness of proposed or past advance maintenance dredging on any maintenance dredging project.

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Maintenance dredging of the proposed extension is discussed including a reference to the "wetted surface" method for computation of siltation.

Table 1

Partial Listing of U. S. Army Corps of Engineers Design Memorandums with Advance Maintenance Dredging Provisions

Alaska District Office

1962, Juneau Small Boat Basin #2

Proposed authorized depths are 12 and 14 ft plus 2 ft allowable overdepth for dredging inaccuracies. An additional 2 ft is recommended for advance maintenance.

1964, Sitka Harbor

Proposed authorized depth is 10 ft plus 2 ft allowable overdepth for dredging inaccuracies. An additional 2 ft for advance maintenance is recommended.

1962, Wrangell Narrows Anchorage Basin

Proposed authorized depth is 26 ft plus 2 ft allowable overdepth for dredging inaccuracies. An additional 2 ft for advance maintenance is recommended.

Baltimore District Office

1961, Baltimore Harbor and Channels, Maryland

Proposed authorized depth is 42 ft plus 1 ft allowable overdepth for dredging inaccuracies. An additional 2 to 3 ft for advance maintenance is recommended.

Charleston District Office

1962, Charleston Harbor, South Carolina, Anchorage Area 30 ft Deep in the Water Area Between Castle Pinckney and Fort Moultrie

Proposed authorized depth is 30 ft plus 2 ft allowable overdepth for dredging inaccuracies. An additional 5 ft for advance maintenance is recommended.

Galveston District Office

1971, Cedar Bayou, Texas, mile -0.1 to mile 3.0

Proposed authorized depth is 12 ft plus 1 and 2 ft allowable overdepth for dredging inaccuracies. An additional 2 ft for advance maintenance is recommended.

1970, Corpus Christi Ship Channel, Texas

Proposed authorized depth is 45 ft plus 1 and 2 ft allowable overdepth for dredging inaccuracies. Additional 2, 4, and 6 ft are recommended for advance maintenance.

(Continued)

Table 1 (Continued)

1965, Galveston Harbor and Channel, Texas

Proposed authorized depth is 36 ft plus 2 ft allowable overdepth for dredging inaccuracies. An additional 3 ft for advance maintenance is recommended.

1960, Gulf Intracoastal Waterway, Channel to Port Mansfield, Texas

Proposed authorized depths are 12 ft to 16 ft plus 2 ft allowable overdepth for dredging inaccuracies. An additional 2 ft for advance maintenance is recommended.

1964, Gulf Intracoastal Waterway-Channel to Palacios, Texas

Proposed authorized depth is 12 ft plus 1 and 2 ft allowable overdepth for dredging inaccuracies. An additional 2 ft for advance maintenance is recommended.

1968, Gulf Intracoastal Waterway, Texas--Chocolate Bayou

Proposed authorized depths are 9 and 12 ft plus 1 and 2 ft allowable overdepth for dredging inaccuracies. An additional 2 ft for advance maintenance is recommended.

1962, Matagorda Ship Channel, Texas

Proposed authorized depth is 38 ft plus 2 ft allowable overdepth for dredging inaccuracies. An additional 2 ft for advance maintenance is recommended.

1963, Port Aransas-Corpus Christi Waterway, Texas

Proposed authorized depths are 40 and 42 ft plus 1 and 2 ft allowable overdepth for dredging inaccuracies. An additional 2 ft is recommended for advance maintenance.

1963, Sabine-Neches Waterway, Texas (40-ft Project and Channel to Echo)

Proposed authorized depths are 42, 40, and 12 ft plus 1 and 2 ft allowable overdepth for dredging inaccuracies. An additional 2 ft is recommended for advance maintenance dredging.

Jacksonville District Office

1961, Gulf Coast Shrimp Boat Harbors, Naples, Florida

Proposed authorized depths are 10 and 12 ft plus 1 ft allowable overdepth for dredging inaccuracies. An additional 1 ft for advance maintenance is proposed for initial dredging.

1967, Jacksonville Harbor, Florida

Proposed authorized depth is 38 ft plus 2 ft allowable overdepth for dredging inaccuracies. An additional 2 ft for advance maintenance is recommended for the initial dredging only.

(Continued)

Table 1 (Continued)

1971, Miami Harbor, Florida

Proposed authorized depths are 36 and 38 ft plus 1 ft allowable overdepth for dredging inaccuracies. An additional 1 ft of advance maintenance is recommended.

1968, Pithlachascotte River, Florida

Proposed authorized depth is 6 ft plus 1 ft allowable overdepth for dredging inaccuracies. An additional 1 ft for advance maintenance is recommended for the initial dredging only.

1959, Port Everglades Harbor, Florida

Proposed authorized depths are 37 and 40 ft plus 2 ft allowable overdepths for dredging inaccuracies. An additional 2 ft for advance maintenance is recommended.

1961, San Juan Harbor, Puerto Rico

Proposed authorized depth in the Entrance Channel (bar) is 45 ft plus 2 ft allowable overdepth for dredging inaccuracies. An additional 1 ft for advance maintenance is recommended.

1965, Ybor Channel, Tampa Harbor, Florida

Proposed authorized depth is 38 ft plus 2 ft for allowable overdepth for dredging inaccuracies. An additional 2 ft for advance maintenance is recommended for the initial dredging only.

Mobile District Office

1968, Biloxi Harbor, Mississippi

Proposed authorized depth is 12 ft plus 2 ft allowable overdepth for dredging inaccuracies. An additional 2 ft for advance maintenance is recommended.

1956, Mobile Harbor, Alabama

Proposed authorized depths are 46 and 38 ft plus 1 ft allowable overdepth for dredging inaccuracies. An additional 2 ft for advance maintenance is recommended.

1963, Pascagoula Harbor, Mississippi

Proposed authorized depths are 38 and 40 ft plus 2 ft allowable overdepth for dredging inaccuracies. An additional 2 ft for advance maintenance is recommended.

1967, Perdido Pass Channel, Alabama

Proposed authorized depth is 12 ft plus 2 ft allowable overdepth for dredging inaccuracies. An additional 2 ft is proposed for advance maintenance.

(Continued)

Table 1 (Concluded)

New Orleans District Office

1961, Freshwater Bayou, Louisiana

Proposed authorized depth is 12 ft. An additional 2 ft for advance maintenance is recommended during the initial dredging.

1968, Mermentau River, Louisiana

Proposed authorized depth is 12 ft plus 2 ft allowable overdepth for dredging inaccuracies. An additional 2 ft for advance maintenance is recommended.

1957, Mississippi River-Gulf Outlet, Louisiana, Channels, mile 63.77 to mile 68.85

Proposed authorized depth is 36 ft plus 2 ft allowable overdepth for dredging inaccuracies. An additional 2 ft for advance maintenance is recommended.

1958, Mississippi River-Gulf Outlet, Louisiana, Channels, mile 39.01 to mile 63.77

Proposed authorized depth is 36 ft plus 2 ft allowable overdepth for dredging inaccuracies. An additional 2 ft for advance maintenance is recommended.

1959, Mississippi River-Gulf Outlet, Louisiana (Bayou La Loutre), mile 0 to mile -9.75 (38-ft contour), Channels, mile 0 to mile 36.43

Proposed authorized depth is 38 ft plus 2 ft allowable overdepth for dredging inaccuracies. An additional 2 ft for advance maintenance is recommended.

1959, Mississippi River-Gulf Outlet, Louisiana

Authorized depth is 36 ft plus 2 ft allowable overdepth for dredging inaccuracies. An additional 2 ft for advance maintenance is recommended.

1973, Mississippi River-Gulf Outlet, Michoud Canal, Louisiana

Proposed authorized depth is 36 ft plus 2 ft allowable overdepth for dredging inaccuracies. An additional 2 ft for advance maintenance is recommended.

Table 2

Coastal District Advance Maintenance Dredging Projects

District	Project	Authorized (Maintained)* Depth, ft	Authorized (Maintained)* Width, ft	Advance Maintenance Depth, ft	Allowable Overdepth, ft
Alaska	Anchorage Harbor	35		1	2
	Dillingham Harbor	+2		1	2
	Homer Harbor	12		1	2
	Ninilchik Harbor	+2		1	2
	Nome Harbor	8		1	2
Baltimore	Ocean City Harbor and Inlet of Sinepuxent Bay, Md	10	150	2	2
Charleston	Charleston Harbor				
	Horse Reach	35	800	4	2
	Hog Island Reach	35	600	4	2
	Drum Island Reach	35	600	2	2
	Myers Bend	35	600-900	4	2
	Daniel Island Reach	35	600-800	4	2
	Daniel Island Bend	35	600-800	4	2
	Clouter Creek Reach	35	600	2	2
	Navy Yard Reach	35	400-800	3	2
	North Charleston Reach	35	400-600	3	2
	Filbin Creek Reach	35	400	2	2
	Port Terminal Reach	35	400-700	2	2
	Ordnance Reach	35	400	2	2
	Anchorage Basin	30	2200	5	2
	Custom House Reach	35	1385	3	2
	Shipyard River				
	Main Channel	30	200-900	6	2
	Lower Turning Basin	30	700	6	2
	Upper Turning Basin	30	500	6	2
	South Channel				
	Town Creek Upper Reach	35	500-600	4	2
	Myers Bend	35	600	4	2
	Navy Channel				
	Range A	35	400-1350	2	2
	Range B	35		2	2
	Range C	35		2	2
	Range D	35		2	2
Galveston	Brazos Island Harbor, Texas				
	Sea Bar and Jetty Channel	36-38	300	2 and 4	2
	Brownsville Channel				
	Channel across Laguna Madre	36	200	4	2
	Laguna Madre to Goose Island	36	200	2	1
	Goose Island to Turning Basin Extension	36	300(200)	2	1
	Turning Basin Extension	36	500	2	1
	Brownsville Turning Basin	36	1000(955)	2	1
	Channel to Port Isabel	36	200	2	1
	Turning Basin	36	1000	2	1
	Cedar Bayou, Texas	10	100	1 and 2	1 and 2
	Channel to Port Bolivar, Texas				
	Channel	30(14)	200	8	2
	Turning Basin	30(14)		8	2
	Corpus Christi Ship Channel				
	Outer Bar Channel	47	700	2	2
	Jetty Channel	45	600	2	2
	Inner Basin	45	730-1720	2	2
	Inner Basin to Bn 19	45	500-600	2	2
	Bn 19 to La Quinta Junction	45	500	2	2
	La Quinta Junction to Corpus Christi Turning Basin	45(40)	400	2 and 6	2
	Corpus Christi Turning Basin	45(40)	800	2 and 6	1 and 2
	Industrial Canal	45(40)	400	2	1
	Avery Point Turning Basin	45(40)	1000(950)	2	1
	Channel to Chemical Turning Basin	45(40)	400(350)	2	1
	Tule Lake Channel	45(40)	300(200)	2	1
	Channel to Viola	45(40)	300(200)	2	1
	Channel to La Quinta	45	300-400	2 and 6	2
	Jewel Fulton Canal	12	100	2	1
	Channel to Port Aransas	12	100	2	1
	Double Bayou, Texas				
	Entrance Channel	7	125	2	2
	Bayou Channel	7	100	2	1
	Freeport Harbor, Texas				
	Outer Bar and Jetty Channel	47-45(38-36)	400(300-200)	2	2
	Channel to Brazosport Turning Basin	45(36)	400(200)	4	1

(Continued)

* Numbers in parentheses indicate that project is maintained at depth or width less than authorized.

Table 2 (Continued)

District	Project	Authorized (Maintained) Depth, ft	Width, ft	Advance Maintenance Depth, ft	Allowable Overdepth, ft
Galveston (Continued)	Brazosport Turning Basin to Upper Turning Basin	45(36)	375	4	1
	Brazos Harbor Channel	36(30)	200	2	1
	Brazos Harbor Channel Turning Basin	36(30)	750(525-675)	2	1
	Galveston Harbor and Channel				
	Entrance Channel	42	800	2	2
	Outer Bar Channel	42	800	2	2
	Inner Bar Channel	40	800	2	2
	Bolivar Roads Channel	40	800	2	2
	Galveston Channel	40	1125	3	2
	GIWW - Main Channel				
	Port Arthur Canal to High Island	16(12)	150(125)	2	1
	High Island to HSC	16(12)	150(125)	4	1 and 2
	Alternnate Route Galveston Channel to Main Channel in West Bay	12	125	2	2
	HSC to Matagorda Bay	12	125	2 and 4	1 and 2
	Matagorda Bay to Corpus Christi Bay	12	125	2 and 4	1 and 2
	Corpus Christi Bay to Mud Flats	12	125	2 and 4	1
	Mud Flats to Port Isabel	12	125	2 and 4	1
	GIWW - Tributary Channels				
	Offatts Bayou Channel	12	125	2	2
	San Bernard River Channel	9	100	2	1
	Colorado River Channel	9	100	2	1
	Channel to Palacios	12	125	2	2
	Channel to Victoria	9	100	2	1 and 2
	Channel to Aransas Pass	14(12)	125	2	1
	Channel to Port Mansfield				
	Entrance Channel (to and including H. D. Turning Basin)	16(26)	250	2	2
	H. D. Turning Basin to Main Channel, GIWW	14	100	2	2
	From Main Channel, GIWW, to Port Mansfield	14	125	2	1 and 2
	Channel to Harlingen via Arroyo Colorado	12	125	2	1 and 2
	Port Isabel Side Channels	12	60	1	1
	Port Isabel Small Boat Harbor	6 and 7	50 and 75	2	1
	Houston Ship Channel				
	Bolivar Roads to Morgan Point	40	400	2	2
	Morgan Point to Boggy Bayou	40	400	2	1
	Boggy Bayou to S.P. Slip	40	300	2	1
	S.P. Slip to Brady Island	40(36)	300	2	1
	Brady Island to Houston Turning Basin	36	300	2	1
	Houston Turning Basin	36	400-1000 (250-900)	2	1
	Five-Mile Cut Channel	8	125	2	2
	Barbour Terminal Channel	16	100	2	1
	Brady Island Channel	10	60(50)	2	1
	Light Draft Channel Houston Turning Basin to Jenson Drive	10	60	2	1
	Greens Bayou Channel				
	Mile 0 to Mile 0.34	36	175	2	1
	Mile 0.34 to Mile 1.55	15	100	2	1
	Matagorda Ship Channel				
	Outer Bar and Jetty Channels	38	300	4 and 2	2
	Channel to Point Comfort	36	200	2	2
	Channel to Port Lavaca	12	125	2	2
	Channel to Harbor of Refuge	12	125	2	2
	Harbor of Refuge	12	250-300	2	1
	Sabine-Neches Waterway				
	Sabine Bank Channel	42	800	2	2
	Sabine Pass Outer Bar Channel	42	800	2	2
	Sabine Pass Jetty Channel	40	800-500	2	2
	Sabine Pass Channel	40	500	2	2
	Port Arthur Canal	40	500	2	1
	Port Arthur Turning Basin	40	Irregular	2	1
	Sabine-Neches Canal				
	Section A (land locked)	40	400	2	1
	Section B	30	200	2	2
	Neches River Channel	40	400	2	1
	Sabine River Channel	30	200	2	1
	Texas City Channel				
	Channel	40	400	3	2

(Continued)

Table 2 (Continued)

District	Project	Authorized Depth, ft	(Maintained) Width, ft	Advance Maintenance Depth, ft	Allowable Overdepth, ft
Galveston (Continued)	Turning Basin	40	1200(1000)	3	1
	Trinity River and Tributaries				
	Channel to Liberty	6	100	2	1
	Anahuac Channel	6	100	2	2
Jacksonville	IWW (J to M)				
	Cut SJ-60	12	125	2	2
	Cut V 24	12	125	2	2
	Cut V 26	12	125	2	2
	Cut P 4	10	125	2	2
	Cut DA-10	10	125	1	2
	Clearwater Pass	10	150	2	2
	Naples to Gordon Pass				
	Cut 1	10	100	4	2
Los Angeles	Oceanside Harbor	20		5	2
Mobile	Apalachicola Bay, Florida	10	100-200	2	2
	Bayou Coden, Alabama	8	60-100	2	2
	Bayou LaBatre, Alabama	12	100-75	2	2
	Biloxi Harbor, Mississippi				
	E. Access	12	150	2	2
	Lateral	12	150	2	2
	W. Approach	10	100	2	2
	Black Warrior and Tombigbee Rivers, Alabama	9	200	2	2
	Blackwater River, Florida	9	100	2	2
	Bon Secour River, Alabama	10-6	80	2	2
	Cadet Bayou, Mississippi	8	100-80	2	2
	Carrabelle Harbor, Florida				
	Entrance Channel	27	200	2	2
	Harbor Channel	25	150	2	2
	Dauphin Island Bay, Alabama	7	150	2	2
	Dog and Fowl Rivers, Alabama	8-6	150-100	2	2
	East Pass Channel, Florida	12-6	180-100	2	2
	East Pearl River, Mississippi	9	200	2	2
	Escombia and Conecuh Rivers, Florida-Alabama	10-5	100	2	2
	Fly Creek, Alabama	6	80	2	2
	Gulf Intracoastal (GIWW)	12	125-150	2	2
	Grand Lagoon, Panama City, Florida	8	100	2	2
	Gulfport Harbor, Mississippi	32-30	300-220	2	2
	LaGrange Bayou, Florida	12	100	2	2
	Mobile Harbor, Alabama				
	Entrance Channel	42	600	2	2
	Bay Channel	40	400	2	2
	River Channel	40	500-775	2	2
	Panacea Harbor, Mississippi	8	100	2	2
	Panama City Harbor, Florida	42-40	450-300	2	2
	Pascagoula Harbor, Mississippi				
	Entrance Channel	40	350	2	2
	Ship Channel	38	350	2	2
	Bayou Casotte	38	225-300	2	2
	Pass Christian Harbor, Mississippi	7	100	2	2
	Pearl River, Mississippi-Louisiana	7	100-80	2	2
	Pensacola Harbor, Florida				
	Entrance Channel	35	500	2	2
	Bay Channel	33	300	2	2
	Approach (2)	33	300	2	2
	Inner Harbor	33	500	2	2
	Perdido Pass Channel, Alabama	12-9	150-100	2	2

(Continued)

Table 2 (Continued)

District	Project	Authorized Depth, ft	(Maintained) Width, ft	Advance Maintenance Depth, ft	Allowable Overdepth, ft
Mobile (Continued)	Port St. Joe Harbor, Florida				
	Entrance Channel	37	500	2	2
	North Channel	37-35	400-300	2	2
	South Channel	27	200	2	2
	St. Marks River, Florida	12	125	2	2
	Waterway Connecting Tennessee-Tombigbee, Alabama-Mississippi				
	River Section	9	300	2	2
	Canal Section	12	300	2	2
	Divide Section	12	300	2	2
	Wolf and Jordan Rivers, Mississippi	7	100	2	2
New Orleans	Bayou Lacombe, Louisiana	8	60	4	2
	Bayou Bonfouca, Louisiana	10	60	2	1
	Chefuncte River and Bogue Falia, Louisiana	8-10	125	2	1
	Tangipahoa River, Louisiana	8	100	2	2
	Atch. River, Morgan City to the Gulf of Mexico				
	Bay	20	400	2	2
	Bar Channel	20	400	2	2
	Barataria Bay Waterway, Louisiana				
	Bar Channel	12	150	6	2
	Land Cut	12	125	3	2
	Bayous Laloutre, St. Malo, and and Ycloskey, Louisiana	5	30	2	0
	WW from GIWW to Bayou Dulac (Lecarpe)	5 and 10	40 and 45	2	1
	Mermentau River (Nav. and Flood Control)	6 and 12	60 and 125	2 and 3	0
	Bayou Segnette	6 and 9	80 and 60	2	0
	Calcasieu River and Pass				
	Bar Channel	42	800	2	2
	Mile 1-34	40	400	1	1
	Mile 34-36	35	250	5	2
	Channel to Cameron	12	300	2	2
	Freshwater Bayou (Bar Channel)	12	250	2	2
	GIWW (Main Stem)				
	New Orleans-Rigolets Section				
	Harvey Lock forebay	12	150	3	1
	MRGO to Lake Borgne	12	150	3	0
	Lake Borgne	12	150	4	0
	Miss. River to Atch. R. Section				
	Harvey Lock tailbay	12	125	3	1
	Harvey Lock to Barataria Bay WW	12	125	3	1
	Barataria to Bayou Lafourche	12	125	3	1
	Bayou Lafourche to Houma Navigation Canal	12	125	3	1
	Houma to Bayou Boeuf Lock	12	125	3	1
	Bayou Boeuf to Atch. River	12	125	3	1
	Atch. River to Vermilion River Section				
	Intersection of Atch. River	12	125	4	0
	Atch. River to Wax-Lake Crossover	12	125	4	0
	Wax-Lake Crossover	12	125	4	0
	Wax-Lake to Charenton Naval and Drainage Canal	12	125	3	1
	Charenton to Vermilion Lock	12	125	3	1
	Vermilion River-Mermentau River Section				
	Vermilion Lock to Isle Marone	12	125	3	1
	Isle Marone to Mermentau River	12	125	3	1
	Mermentau River-Calcasieu River Section				
	Mermentau River to Calcasieu Lock	12	125	3	1
	Calcasieu Lock to Calcasieu River	12	125	3	1
	Algiers Alternate Route				
	Algiers Lock forebay	12	125	3	3
	Algiers to Harvey	12	125	3	1
	GIWW, Morgan City-Port Allen, Alternate Route				
	Port Allen Lock forebay	12	125-200	2	2
	Sorrell Lock	12	125	3	1
	GIWW - Franklin Canal				
	Intersection at GIWW - Mile 120.6 WHL	8	60	2	1
	GIWW to Franklin, Louisiana	8	60	2	1
	Houma Navigation Canal				
	Bay Welsh	15	150	3	2
	Land Cut	15	150	2	1

(Continued)

Table 2 (Continued)

District	Project	Authorized Depth, ft	(Maintained) Width, ft	Advance Maintenance Depth, ft	Allowable Overdepth, ft
New Orleans (Continued)	Little Caillou Bayou	5	40	3	1
	Miss. River - Baton Rouge to Gulf of Mexico				
	10 Deepwater Crossings	40	500-1000	3	0
	Southwest Pass	40	800	2	1
	Bar and Jetty Channel, SWP	40	600	5	1
	Miss. River - Gulf Outlet				
	Land Cut	36	500	4	1
	Breton Sound	36	500	6	2
	Bar Channel	38	600	5	2
	Red River below Fulton, Arkansas	9	100	3	0
	Red River - Miss. River to Shreveport, Louisiana	9	200	3	2
	Atchafalaya Basin				
	East and West Access Channels	8	80	1	1
	Six-Mile Lake	12	125	3	0
	Three Rivers	12	125	3	2
	Berwick Harbor	12		2	0
	Miss. River - Shallow Draft Crossings above Baton Rouge	12(9)	300	3	3
	Old River - Lock forebay and tailbay	12	125	0-2	2
	Miss. River Outlets, Venice, Louisiana				
	Land Cut	14	150	2	2
	Bar Channel	16	250	2	2
	Atchafalaya River				
	Bayou Boeuf	20	300	2	2
	Bayou Chene	20	400	2	2
	Bayou Black	20	400	2	2
New York	East Rockaway Inlet	12	250	2	2
	Fire Island Inlet	10	250	4	2
	Jones Inlet	12	250	2	2
	L. I. Intracoastal	6	100	4	2
Norfolk	Appomattox River	12(6)	80(60)	1	1
	AIWW				
	A and C Canal	12	90-250	1	1
	Dismal Swamp Canal Route				
	Dismal Swamp Canal	9(6)	50	4	1
	Turners Cut	10	80	1	1
	Pasquotank River	10	100	1	1
	Baltimore Harbor and Channels				
	Cape Henry Channel	50(42)	1000	3	2
	York Spit Channel	50(42)	1000	2	2
	Cape Charles City Harbor				
	Mud Creek Basin	10	180	1	1
	Channel to Newport News	45	800	2	2
	Chincoteague Bay	5	60	1	1
	Davis Creek	10	80	3	1
	Delmarva Waterway	6	60	1	1
	Greenvale Creek	6	50-60	1	1
	Hampton Creek	12	80-200	1	2
	Horn Harbor	7	100	1	1
	Hoskins Creek	10	80-100	1	1
	Jackson Creek	8	60-80	1	1
	James River				
	Mouth to Hopewell	35(25)	300	2	1
	Hopewell to Richmond DWT	35(25)	300(200)	1	1
	Richmond DWT	35(25)	825	1	1
	RDWT to Richmond Harbor	18	200	1 and 2	1
	Little Creek	20	400	1	1
	Little Machipongo River	8	80	1	1
	Lynnhaven Inlet				
	Entrance Channel	10	150	2	1
	Mooring and Turning Basin	10	700	2	1
	Channel to Broad Bay	9	90	1	1
	Narrows Channel	6	90	1	1
	Nansemond River, West Branch	10(6)	80	1	1

(Continued)

Table 2 (Concluded)

District	Project	Authorized (Maintained) Depth, ft	Authorized (Maintained) Width, ft	Advance Maintenance Depth, ft	Allowable Overdepth, ft
Norfolk (Continued)	Norfolk Harbor				
	Hampton Roads Channel	45	800-1500	2	2
	Elizabeth River Channel	40	375-750	2	2
	Oyster Channel	6	80	2	1
	Quinby Creek				
	Outer Channel	8	80	2	1
	Inner Channel	8	60	1	1
	Basin	8	200	1	1
	Rappahannock River	12	100-200	1	1
	Starlings Creek				
	Channel	7	60-100	1	1
	Basin	7	200	1	1
	Tangier Channel				
	Channel to Tangier Sound	8	60-100	1	1
	Channel to Chesapeake Bay	7	60	1	1
	Turning Basin	7	400	1	1
	Thimble Shoal Channel	45	1000	2	2
	Totuskey Creek				
	Bars	10	100-150	1	1
	Basin	10	275	1	1
	Tylers Beach				
	Channel	6	50	1	1
	Basin	6	150	1	1
	Whitings Creek	4	70	1	1
	Winter Harbor				
	Channel	12	100	1	1
	Basin	12(8)	400	1	1
Philadelphia	Absecon Inlet	20	400	2	2
	Delaware River (Philadelphia to the Sea)	40	800	2	2
	Wilmington Harbor	35	400	2	2
Portland	Chetco River, Oregon	14	120	3	2
	Columbia and Lower Willamette Rivers, Oregon	40	600	3	2
	Columbia River, Vancouver Washington - The Dalles, Oregon	27	300	1	2
	Coos Bay, Oregon				
	Entrance	40	300	5	2
	Inner Channel	30	300	3 and 5	2
	Coquille River, Oregon	13		3	2
	Rogue River, Oregon	13	300	3	2
	Siuslaw River, Oregon	18	300	3	2
	Tillamook Bay, Oregon	18	Varied	3	2
	Umpqua River, Oregon	26	Varied	3	2
	Yaquina Bay and Harbor	40	400	5	2
San Francisco	None				
Savannah	Savannah Harbor	38	500	4	2
	Brunswick (East River)	30	400	1	2
	AIWW (3 areas)	12	150	3	2
	SRBA	9	90	1	2
Seattle	Swinomish Channel			4 and 8	
	Grays Harbor			5	
	Lake Crockett			2	
	Blair Waterway (Tacoma Bay)			3	
Wilmington	None				
New England	Block Island, Rhode Island Harbor of Refuge	15	100	1	1
	Green Harbor, Massachusetts	8 and 6	100	1	1
	Newburyport Harbor				
	Entrance Channel	12	400	2	1
	Hampton Harbor, New Hampshire	8	150	1	1
	Scarboro River, Maine	8	200	1	1
Pacific Ocean	None				

Table 3

Summary of Advance Maintenance Dredging Projects in Coastal Districts

District	Projects	Advance Maintenance Depth, ft							
		1	2	3	4	5	6	7	8
Alaska	5	5	--	--	--	--	--	--	--
Baltimore	1	--	1	--	--	--	--	--	--
Charleston	23	--	9	3	7	1	3	--	--
Galveston	88	1	69	3	10	--	3	--	2
Jacksonville	7	1	5	--	1	--	--	--	--
Los Angeles	1	--	--	--	--	1	--	--	--
Mobile	34	--	33	--	--	1	--	--	--
New Orleans	63	2	23	27	6	3	2	--	--
New York	4	--	2	--	2	--	--	--	--
Norfolk	48	34	11	2	1	--	--	--	--
Philadelphia	3	--	3	--	--	--	--	--	--
Portland	11	1	--	7	--	3	--	--	--
San Francisco	0	--	--	--	--	--	--	--	--
Savannah	6	2	--	3	1	--	--	--	--
Seattle	4	--	1	1	--	1	--	--	1
Wilmington	0	--	--	--	--	--	--	--	--
New England Division	5*	4	1	--	--	--	--	--	--
Pacific Ocean Division	0*	--	--	--	--	--	--	--	--
Total	303	50	158	46	28	10	8	0	3

* No districts in division.

Table 4

Inland District Advance Maintenance Dredging Projects

District	Project(s)	Authorized (Maintained) Depth, ft	Authorized (Maintained) Width, ft	Advance Maintenance Depth, ft	Allowable Overdepth, ft
Buffalo	Cuyahoga River Channel and Harbor				
	Upstream 7200 ft	23-26	125-250	2 and 3	
	Remainder	23	125-250	2	
Chicago	None				
Detroit	Ludington, Michigan	27-29 (18-21)	230-600	2 and 3	2
Fort Worth	None				
Huntington	None				
Kansas City	None				
Little Rock	McClellan-Kerr Arkansas River Navigation System	9	250-300	3	0
Louisville	None				
Memphis	None				
Nashville	None				
Omaha	None				
Pittsburgh	None				
Rock Island	None				
Sacramento	Stockton Deepwater Ship Channel	30	225	3	2
St. Louis	None				
St. Paul	Upper Mississippi River Channel	9	--	3	1
	Minnesota River Channel	9	--	3	1
	St. Croix River Channel	9	--	3	1
	Ashland Harbor, Wis.	20-27	--	1	1
	Bayfield Harbor, Wis.	10	--	1	1
	Big Bay Harbor, Wis.	10-12	--	1	1
	Black River Harbor, Mich.	8-12	--	1	1
	Cornucopia Harbor, Wis.	8-10	--	1	1
	Duluth-Superior Harbor	20-32	--	1	1
	Grand Marais Harbor, Minn.	8-20	--	1	1
	Grand Traverse Bay Harbor, Mich.	10-12	--	1	1
	Keweenan Waterway, Mich.	25	300	1	1
	Knife River Harbor, Minn.	8-10	--	1	1
	Lac La Belle Harbor, Mich.	10-12	--	1	1
	Marquette Harbor, Mich.	27	--	1	1
	Ontonagon Harbor, Mich.	12-17	--	1	1
	Presque Isle Harbor, Mich.	28-30	--	1	1
	Saxon Harbor, Wis.	8-10	--	1	1
	Warroad Harbor and River, Minn.	8	200-300	1	1
Tulsa	McClellan-Kerr Arkansas River Navigation System (Fort Smith, Ark., to head of navigation near Catoosa, Okla.)	9	150-250	3	1
Vicksburg	None				
Walla Walla	None				

In accordance with letter from DAEN-RDC, DAEN-ASI dated 22 July 1977, Subject: Facsimile Catalog Cards for Laboratory Technical Publications, a facsimile catalog card in Library of Congress MARC format is reproduced below.

Trawle, Michael J

Effect of depth on dredging frequency; Report 1: Survey of District offices / by Michael J. Trawle, Jesse A. Boyd, Jr. Vicksburg, Miss. : U. S. Waterways Experiment Station ; *Springfield, Va. : available from National Technical* Information Service, 1978.

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