PROCEEDINGS

OF THE

SIXTH DREDGING SEMINAR

Partially supported through Institutional Grant 04-3-158-18
to Texas A&M University
by the National Oceanic and Atmospheric
Administration's Office of Sea Grants,
Department of Commerce

Center for Dredging Studies
Report No. CDS-176

Sea Grant Report
TAMU-SG-74-104

March 1974

$3.00

Order from:

Department of Marine Resources Information
Center for Marine Resources
Texas A&M University
College Station, Texas 77843

SIXTH DREDGING SEMINAR
504, E. RUDDER CONFERENCE TOWER, FRIDAY, JANUARY 25, 1974

Morning Session		*Moderator: Dr. John B. Herbich*
8:00 - 8:30	*Registration*	*(at Second Floor Lobby Conference Tower, $10.00)*
	Welcoming Address	Dr. Richard Thomas, Associate Dean, College of Engineering.
8:45 am		"The 1973 Mississippi Flood and the Role of Hydraulic Dredging", C.B. Hakenjos, Vice President, Williams-McWilliams Co., Inc., New Orleans, Louisiana.
10:00 am		"Significance of Chemical Contaminants in Dredge Spoil", Dr. Fred Lee, Texas A&M University, College Station, Texas.
	(Break)	
10:45 am		"Systems Engineering and Dredging - The Feedback Problem", Dr. D.R. Basco, Coastal, Hydraulic & Ocean Group, Texas A&M University.
12:15 pm	*Luncheon*	"A Newcomer's Look at the Industry", Eric P. Tanzberger, C.F. Bean Co., New Orleans, La.
Afternoon Session		*Moderator: Dr. David R. Basco*
1:45 pm		"Estuarine Impacts Related to Dredge Spoiling", Dr. L.S. Slotta, Director Ocean Engineering Programs, Oregon State University, Oregon.
2:50 pm		"Environmental Statement on Shell Dredging, San Antonio Bay, Texas", Dr. Arnold Bouma, Gary L. Hall, Oceanography Dept. Texas A&M University and Barry W. Holliday, Waterways Experiment Station, Vicksburg, Mississippi.
	(Break)	
3:50 pm		"The Case for Dredge Specification Standards", Alf H. Sorensen, General Sales Manager, Ellicott Machine Corp., Baltimore, Maryland.
4:40 pm		"Dredge for 1984", R. Jantzen, President, Jantzen Engineering Company, Inc., Baltimore, Maryland.
5:30 pm	*Adjournment*	

LIST OF CONTENTS

LIST OF ILLUSTRATIONS

ACKNOWLEDGMENT

The Proceedings were assembled and edited by Dr. John B. Herbich. Editorial assistance of Dr. Gisela Mahoney was greatly appreciated.

The Seminar was partially supported by the Oceanic and Atmospheric Administration Sea Grant Program Institutional Grant 04-3-158-18 to Texas A&M University.

Mrs. Mattie Ford typed the manuscript for publication.

THE 1973 MISSISSIPPI RIVER FLOOD AND THE ROLE OF HYDRAULIC DREDGING

By

Carl B. Hakenjos
Vice President
Williams-McWilliams Co., Inc.

In 1973, the lower Mississippi Valley experienced the most severe flood of this century which created very unusual and large channel maintenance problems never before encountered. These problems were primarily alleviated by the dredging industry working through the Corps of Engineers, which has the responsibility of maintaining our navigable waterways.

This high water has been referred to by many as "The Great Flood of 1973". Few people realize, and perhaps I should emphasize, very few people in the United States fully realize, the magnitude of this flood. To me, because of the horror and devastation of this past spring's high water, and because these events will go down in history and be well remembered by the people directly affected by this disaster, I prefer to use the term:

"THE HISTORIC FLOOD OF 1973"

One important and unique aspect of the flood was its duration. Above normal stages on the Mississippi River began in November 1972, and did not subside until July 1973, which was a 9-month period.

Given the rainfall pattern that developed during the fall of 1972 and the spring of 1973, it can be seen why the flood developed. The Mississippi River Basin drains approximately one and one quarter million square miles, which comprise forty-one percent of the land mass of the forty-eight contiguous states. To give you an idea of this volume, one inch over this area would be a volume of approximately 21.8 trillion gallons. This basin resembles a funnel with the upper part fanned across the United States and its spout at the Gulf of Mexico. The rainfall during this period amounted to 100 percent above normal in the Arkansas River Basin, 70 percent and 50 percent in the Missouri River and Upper Mississippi River Basins respectively. Fortunately, the Ohio Basin had only 12 percent above normal.

This rainfall washed enormous quantities of topsoil from the midsection of the country into the Mississippi River. This material caused shoals as thick as 25 feet across the river, large sandbars the size of small islands were moved about, channels were lost, and coupled with the increased currents, river navigation was severely hampered and at times brought to a virtual standstill for days.

To alleviate this situation and restore conditions to as near normal as possible in a minimum of time, the Lower Mississippi Valley Division deployed a fleet of 21 dredges, mostly from contractors from the St. Louis area to the Gulf of Mexico. Dredges were also put to work in the Atchafalaya River and along the Gulf Intracoastal Waterway.

Little recognition has been given to the dredging industry and the Corps of Engineers for the mammoth job they performed during the recent flood and few people outside these areas realize the magnitude of the flood. Without going into too many figures, I think it would be very interesting to briefly touch on the four Corps districts that were primarily involved in hydraulic dredging and present some idea of the amount of work that was performed to maintain navigation during this flood.

Starting at the upper limits of the Mississippi system, the St. Louis District has 380 miles of navigable waterways, which encompass the upper Mississippi, the Missouri, and the Illinois Rivers. Normally, about 30 river crossings are maintained by hydraulic dredging; however, after the flood, the Mississippi River had 32 shoals, and the Missouri and Illinois had 19 and 9 respectively which were a total of 60. Having twice the normal trouble areas, the maintenance dredging doubled and an estimated 14,000,000 cubic yards were removed.

Below the St. Louis District, the Memphis District had a severe channel problem at the island 63 bar revetment. At this area a massive failure occurred when the flood flows topped and flanked the revetment. These flows then eroded the land behind the revetment forming a new channel 2,000 feet landward, which re-entered the main channel 6,500 feet downstream. Because of a sharp angle where the new channel returned to the main stream, a giant eddy occurred and created an extremely hazardous navigation situation. Also, the former navigation channel was blocked by encroachment of the sandbar opposite the left bank. Two government dredges and one contract dredge were used to alleviate this critical situation. At times tows were waiting in line over a distance of 20 miles to pass this area. Hydraulic dredges finally opened this area to navigation after a minimum delay period.

The Vicksburg District had several trouble spots in the Mississippi River, the primary ones being at Browns Field and Choctaw Bar. At Browns Field, deep pools filled in as much as 50 feet and required dredging to bring the channel across and down the revetment on the opposite shore. Choctaw Bar had a fill of 35 feet deposited in this crossing, compared to a normal fill of 15 feet. At one point, navigation came to a standstill and 74 tows were tied up awaiting passage. Government and contract dredges once again, working in the shallow water, swift current, and strong cross-currents, finally succeeded in opening the channel to navigation.

The New Orleans District had by far the greatest maintenance problem during the flood. In the period from February to July 1973, the Mississippi River carried some 2.2 million tons of sediment daily into the crucial head of passes area near its mouth. For comparison, this daily load of suspended solids was enough to fill the holds of the bulk carrier "Manhattan" 20 times. During a normal maintenance season in Southwest Pass, about 15 million cubic yards of material are dredged. This year an additional 22 million cubic yards have been removed from the channel as of the beginning of August. To keep the channel open and return this navigation artery to its project dimensions, 6 contractors and Corps dredges were used. Moving up to New Orleans, severe shoaling in the harbor initiated dredging in March and it continued through October. Between New Orleans and Baton Rouge, 10 crossings had to be dredged instead of the normal 6. In the Baton Rouge Harbor, which has required dredging on only 2 occasions in the past, one (1) million cubic yards had to be removed. On the Gulf Intracoastal Waterway west of Morgan City, two lease dredges removed 1.8 million cubic yards from a 27 mile section that last required maintenance dredging in 1951. On the Atchafalaya River below Morgan City, a lease dredge was used to open the channel and then 3 contract dredges restored the channel to project dimensions in 3 months. Some sections were dredged as often as 3 times. Material in excess of the normal dredging program here amounted to 3.5 million cubic yards.

In summarizing these overall areas, the following additional dredging was performed as a direct result of the flood flows:

(1) In the Mississippi River from Baton Rouge through Southwest Pass, 32.8 million cubic yards.

(2) In the Gulf Intracoastal Waterway, 1.4 million cubic yards.

(3) In the Atchafalaya River below Morgan City and the Atchafalaya Basin navigation channels, 4.8 million cubic yards.

This was a total of 39 million cubic yards of material that was hydraulically moved in approximately 5 months, which is an average of about 8 million cubic yards per month.

"The Historic Flood of 1973" called on the dredging industry to muster all of its operational forces to move from trouble area to trouble area, operate at peak capacity one hundred percent of the time, and work under adverse and, at times, dangerous conditions. Throughout the flood, navigation on the lower Gulf Coast and the Mississippi River systems was made possible at all times, even though dredging was being performed in the middle of the channel and tows with and against strong currents passed within a few feet of the dredges.

Never before has an industry been called upon to perform so much in so short a period of time, under very adverse conditions, and receive so little recognition. Dredging management and the people in the field who lived with this flood and fought it 24 hours a day should be complimented and thanked. It is however, gratifying to those of us close to dredging to see what capabilities we have and what technical progress we have made in past years. I am very proud and I know others in this room who were also very close to this flood and who are proud to have been an integral part of the one unique aspect of this "Historic Flood", which was hydraulic dredging.

LITERATURE REVIEW ON RESEARCH STUDY FOR THE DEVELOPMENT OF DREDGE MATERIAL DISPOSAL CRITERIA*

By

Dr. Fred Lee
Texas A&M University

Some of the sediments that are dredged for waterways improvement are contaminated with municipal, industrial and agricultural wastes and run-off. This contamination consists of potentially significant amounts of chemical toxicants and growth stimulants. It is conceivable that under certain conditions the contaminants present in these sediments could have an adverse effect on environmental quality at both the dredging and disposal sites. One area of concern is the release of these contaminants from the solids. Such a release could be adverse to water quality in the water columns and adjacent areas at both sites. In order to protect and where possible enhance environmental quality, a test or tests need to be developed that can be used on samples of sediments that are scheduled to be dredged in order to determine whether or not release of potentially significant amounts of the contaminants present could occur under the various methods used for dredging and dredge material.

A review of the literature on the release of chemical contaminants from dredge material and natural water sediments has shown that the bulk chemical composition is not a useful index of potential environmental quality problems for waters that come in contact with these sediments. Chemical constituents exist in sediments in a wide variety of forms, many of which are not available to aquatic organisms. In

---

*Adapted from Summary of Report to U.S. Army Engineers Waterways Experiment Station.

addition, for deposited sediments, the primary factor often controlling contaminant release is the mixing or degree of agitation of the sediments with the overlying waters.

It has been generally found that natural water sediments tend to be sinks of chemical toxicants where toxicants present in the water column become associated with particulate matter and become incorporated in the sediments. Eventually, a contaminated sediment particle will become buried in the sediments so that it becomes part of the historical sediments and thereby be removed from interaction with the overlying waters. A key part of the sediment chemical contaminant holding capacity is the hydrous metal oxides of iron, manganese and aluminum. It has been found that these species tend to prevent the release of chemical contaminants during dredging operations and disposal.

The Corps of Engineers and the U.S. Environmental Protection Agency have developed an Elutriate Test which is designed to detect any significant release of chemical contaminants in dredge material. This test involves the mixing of one volume of the sediments which are to be dredged with four volumes of the disposal site water for a 30-minute shaking period. A one-hour settling period followed by appropriate filtration or centrifugation is used to determine the release of potentially significant chemical constituents from the sediments. A review of the literature on the leaching of contaminants from dredge material and sediments shows that a wide variety of factors could affect the results of the Elutriate Test. These factors include: solid-liquid ratio, time of contact, pH, dissolved oxygen concentration, agitation, particle size, handling of solids, characteristics of water and sediments and solid-liquid separation. It is apparent that a considerable amount of research is needed on the significance of these factors in influencing the Elutriate Test results for a wide variety of sediments that are likely to be dredged. From these studies it should be possible to develop a modified Elutriate Test which would be relatively insensitive to minor modifications to test procedures, yet simulate to a reasonable degree, the release of chemical contaminants in the sediments that may take place at the dredging and disposal sites during normal dredging operations.

The standard Elutriate Test requires that if at any time the soluble chemical constituents of selected contaminants in the elutriate exceed 1.5 times the ambient concentration in the disposal site water that special conditions will govern the disposal of this dredge material. The 1.5 factor is not intended to be a critical concentration increase which would signify significant environmental damage in the disposal site water column. It should be used to indicate that release does occur and this release deserves further consideration in order to ascertain its potential significance with respect to environmental quality. The proper interpretation of the amount of release that occurs requires consideration of the contaminant assimilative capacity in the disposal site water column relative to the critical concentration for this contaminant to selected organisms in the water column. Because of the intermittent nature of normal dredge material disposal and the high dilution available in almost any open water disposal operation it is improper to apply water quality criteria based on chronic continuous exposure of the organism to the contaminant. Also, the 96-hour LC_{50} commonly used in the water pollution control field to detect acute lethal toxicity should not be used. The proper approach for bioassays is to estimate the concentration-time relationship that will exist in the water column at the disposal site for soluble contaminants released from the dredge spoil. From this relationship a bioassay should be conducted in which selected organisms would be exposed to a similar concentration-time relationship. It should be emphasized that lesser importance should be attached to toxicity to planktonic organisms because of their high reproductive capacity. Some toxicity or inhibition of phytoplankton growth at the disposal site may be of no significance in the water body as a whole due to the fact the nutrient-limited populations which did not grow at the site may compensate for this lack of growth by increased growth in nearby waters.

One of the areas of potential concern in the disposal of chemically contaminated dredge material is the possibility of toxicity of the chemical contaminants to benthic organisms at the disposal site. The Elutriate Test is not designed to detect potential problems of this type. This test is designed to detect water column problems. Since the physical and chemical environments that occur at the disposal site water column and sediments are likely to be markedly different, another type of test may be necessary in order to detect potential toxicity problems to benthic organisms. A laboratory test based on the chemical characteristics of the interstitial waters that would be formed at the disposal site is suggested.

It is important to emphasize that the conventionally developed water quality criteria such as those recently proposed by the U.S. EPA (October, 1973) are not suitable to judge the toxicity of chemical contaminants present in solid form. Further, there is little or no basis to use an application factor of 0.01 that is commonly used for soluble solutes to relate acute lethal to chronic sublethal toxicity where the acute lethal toxicity is caused by contaminants present in solid form. Further research is needed in this area in order to define the proper application factor that should be used under these conditions.

The key to the sucessful development of an Elutriate Test will be a number of intensive studies in which the results of the tests are compared to the actual environmental impact of the chemical contaminants present in the dredge material. It is recommended that as soon as some of the key factors influencing the response of the Elutriate Test are evaluated, detailed large scale field studies be initiated in order to develop an empirical correlation between the results of the Elutriate Test and actual environmental impact.

SYSTEMS ENGINEERING AND DREDGING - THE FEEDBACK PROBLEM

By

Dr. David R. Basco
Coastal, Hydraulic & Ocean Engr. Group
Texas A&M University

ABSTRACT*

A hydraulic cutterhead dredge which excavates soil at one point and disposes of it some distance away is an extremely complicated system. Much is unknown and remains to be discovered about its operation, consequently attempts to model the system are hampered by this lack of basic understanding of critical areas of the system. Soil, operation, and other considerations vary considerably, therefore actual, on-the-job, field dredging projects must be employed to gather information and overcome these gaps in dredging knowledge. Unfortunately, the feedback of information from real dredging projects is practically non-existent today.

This paper attempts to outline the important and critical links in the dredging system chain and to develop and discuss methods for overcoming those obstacles that inhibit or eliminate the feedback cycle. A computer model of a hydraulic dredging system is developed and used to examine the four major limitations on solids output, namely: horsepower, cavitation, line plugging and dislodgement limits. A full scale feedback program is also developed.

The feedback of knowledge gained on one project for use as input for future jobs and as basic knowledge is undoubtedly the industry's biggest problem today.

---

*The complete paper is not reproduced here since it is available as a technical Report, TAMU-SG-74-205, Texas A&M University, December 1973.

A NEWCOMER'S LOOK AT THE INDUSTRY

By

Eric P. Tanzberger
Marketing Manager
C.F. Bean Corporation
New Orleans, Louisiana

Ladies and gentlemen, it is my pleasure to be here this afternoon to address this seminar on the position of the U.S. dredging industry as seen by a relative newcomer. In this regard, I want to address myself to the impressions I have gained about the industry's outlook, its opportunities and its potential problem areas. It may be said that with only nine months experience in the industry I am not one to evaluate or comment on this topic. While I am certainly not an expert, it is sometimes beneficial to have a fresh viewpoint expressed on a particular subject and it is in this regard that I hope to make a contribution.

Prior to my joining C.F. Bean Corporation in April of last year, I was employed in the oil industry for six years, both domestic and international. At the beginning of my tenure there in 1967, the industry was already talking about a probable energy shortage and the problems that confronted them. Whether or not one believes the relative degree of the current energy situation, I think all will agree a problem exists. However, during six years the industry did not effectively convince the general public and others (primarily the government) about the seriousness of our impending shortage. They certainly tried, but people did not respond or did not want to listen. I want to point out that I am not suggesting that the dredging industry is heading toward a crisis of that magnitude, but I feel there are some interesting parallels and that similar comparisons exist in our industry. Wherever I have gone, i.e., to public hearings in Washington, symposiums or conferences, and talked to industry people, they recognize what problems we face; yet there does not seem to be a planned, coordinated effort to take action. We need to tell our story clearly and to the right people; in essence initiate a public relations program. Setting up such a program will not guarantee its overall success; however, without it we may be put into a defensive position and find ourselves reacting to situations, instead of creating them. Of particular concern is the effect recent government actions could have on our industry, i.e., the recent National Water Commission Report and its potentially profound effect on our waterways development and consequently on our industry. Also, the on-going National Dredging Study which I will touch on shortly.

Thus, I would like to briefly review some of the problems I have observed and relate them to the opportunities that I see ahead. First, because it has such a visible effect on our profitability, is idle plant. Depending on with whom one speaks, either government or private sources, the general range is 25-50% of U.S. private dredging equipment being idle. This may be one of the highest idle plant rates among major U.S. manufacturing industries. I think the basic reason for this is the lack of new industry work, along with the unique situation of private dredge plant having to compete with government plant. I say unique because it was quite surprising, entering a new industry in a marketing capacity, to learn that our best "customer" (the U.S. government) is also our biggest competitor. I don't need to dwell on this situation, but I feel a few statistics that quickly put this problem into perspective for me are in order: In 1963, $166 million was appropriated for federal projects with $132 million, or 80%, done by private industry. In 1970, total appropriation declined by $38 million to $128 million with $79 million, or 62%, done by private plant. In other words, while both government and private work declined in absolute dollars, the percentage of each, or the mix, shifted substantially in favor of the government. From 1970 through 1973, the same trend continued and in addition the private sector increased its capacity. Thus, the combination of a decline in funds, an increase in capacity and an increase in the government's percentage of the market was disastrous in terms of profitability.

I also found a declining trend in the growth of new work over this period. New work is the lifeblood of the private industry, particularly since it creates additional maintenance dredging. However, during periods of federal budget limitations new work is susceptible to being dropped while the necessary maintenance dredging associated with existing ports and project depths is continued. Therefore, my reaction was--what is being done and what is being planned in order to try and turn this situation around. One alternative would be to attempt to limit the government's role in dredging, or eliminate their participation altogether; however, I don't feel this is feasible or necessary. In reading over past testimony to the Public Works Committee of both the House and Senate, I get the impression that too much effort has been spent in this direction. I am not saying that keeping close tabs on your competition or attempting to limit their growth into your segment is all bad, but I feel more time and commitment should be placed towards increasing the overall or total market for dredging--particularly the new work category, since it is this area that private industry continues to dominate. This should be done by working with all parties concerned, including the Corps of Engineers, and means education, if you will, of the responsible government officials who control the federal funds. It means collectively supporting and promoting the critical needs of our nation that affect our industry, i.e., the development of our waterway systems, expanding our deep draft channels. In essence, I am getting back to the basic thrust of my message--public relations for our industry.

I have indicated so far that, in my opinion, formed through observation of our industry after nine months, our biggest hurdle is idle capacity. However, there are three related areas I would like to discuss that have affected already or potentially will affect idle plant. First is the National Dredging Study. As many of you are aware, this is a study created by an Act of Congress to analyze the dredging industry. It will effectively recommend the capability of the Corps' and contractors' dredge fleets to meet future requirements and the various alternatives of contractor award versus government award dredging plants to accomplish the future work. Its recommendations to Congress will have a wide and far-reaching impact; and while we should welcome the study since is will hopefully answer many questions that are being raised by the industry and our critics, we should also be cognizant of its potentially detrimental effect. Therefore, to be sure of a fair evaluation of the industry, every effort must be made to, first, cooperate with the independent group conducting the study to insure that it gets an accurate view of our situation and secondly, to support the Advisory Committee in its effort to gather and assimilate all the facts. This committee, acting as the interface between the Chief's office and the study groups, has the responsibility to steer and coordinate this study and the support of our industry to this group is essential, particularly regarding what is at stake, i.e., idle plant discussed above.

A second problem that has affected the industry's growth has been an unprecedented increase of environmental regulations that have drastically reduced dredging as a viable alternative to many projects, both public and private. Unfortunately, there is a great deal of emotionalism involved in this area, which usually indicates the end will justify the means, and as a result, the facts are ignored; people will not listen or they do not want to listen.

An example that left an impression on me when regarding the seriousness of this aspect was when I attended a meeting of the Florida Dredging Association and the environmental problem was discussed. There was a newspaper article about a project that would have created additional land area at or near an existing island being used as a sanctuary for birds. The project was delayed indefinitely due to environmental problems on the basis that dredging near this natural sanctuary would be disastrous. I later learned that the "natural" sanctuary referred to was actually an artificial island created by dredge spoil. This is a small example, but I am sure there are other similar cases that provide an opportunity for us to exploit what we have done to preserve the environment and what contribution we have made in creating such habitats. Most importantly, however, the industry needs to educate, inform, and where necessary, disprove false environmental charges. The

Corps of Engineers is doing a lot of work in this area, but it will take time. There is also a lot of new private research in this area and what we need to do is become up to date on these findings and be sure they are disseminated to the right groups and the public in general. Most of all, we need to do something to correct an apparent thought concept or image that surfaces whenever the word dredging is used--a concept that seems to indicate imminent disaster. To give you an idea of what I mean and to demonstrate what can be accomplished when various organizations decide that positive action is needed relates to the project that we are working on in Bayport, Texas. The E.P.A. wanted a sanctuary or area that was unpolluted in order to not harm the fish and marine biology in the area. The Corps of Engineers wanted a containment area for the spoil and the Port of Houston wanted a channel. All three parties were able to arrive at a common solution whereby we as a dredging contractor were able to satisfy all needs by providing the spoil in which unpolluted material was deposited, while at the same time providing the channel for the Port Authority.

Lastly, I feel we need to be concerned about the expanding number of inquiries from foreign companies and U.S. organizations requesting foreign type equipment to be put in service here in the United States. As an example, there was a recent call for a European type hopper dredge to alleviate the problem of the Southwest Pass located at the Louisiana Gulf, while there was no specific mention of importation, I feel the underlying point was well made. The basic question here is why--there should be no need for foreign equipment given our idle plant situation unless there is a general feeling that the capability and/or technology is not present here in the U.S. We all know this isn't true, so we need to determine the motives for wanting non-U.S. equipment and then convince the parties concerned that the job can be done without foreign equipment. Again, this means a coordinated public and government relations effort.

What are the opportunities I have been speaking of that will alleviate our fundamental problem of idle plant? We all should recognize that such opportunities are vast--superports; existing port development along with inland waterways development in order to keep our shipping industry internationally competitive; beach and shoreline restoration and protection; construction of our highway and road systems; offshore airports; ocean mining; and artificial islands for commercial and residential development. The list doesn't stop here by any means so it is quite clear, at least to this newcomer, that a large market exists for our service. My thinking is further reinforced by the so-called "European Threat". Assuming that the European businessman is astute in his finance and economic analysis and will not enter a new market unless he foresees a good chance for earning an acceptable return on his investment, there must be something tangible and worthwhile here in the U.S. Therefore, let <u>us</u>, as an industry, recognize the same opportunities and be sure the responsible people here in government and other key places are also aware of them.

And so in conclusion, I have attempted to identify what I see are the threats and problems to our industry and also the potential, with both areas tied together through more effective public relations. Essentially, I feel we need to think more in terms of marketing or selling our product and what it can do for our nation as a whole and waterways' development in particular. A vehicle that has been involved in this type of activity in the past and which I feel will be even more involved and applicable for our message is the National Association of River and Harbor Contractors. They have taken a new direction in the goals of their organizations, primarily emphasizing the need for the market development which has been the basic thrust of my talk this afternoon. It will attempt to monitor development, promote industry and, for example, try and have representatives at conferences that would pertain to potential dredging work. Here I speak, for example, about an Offshore Airport Conference held in Washington last year and where to the best of my knowledge and through discussion with the F.A.A. no one in the dredging industry attended. Once the market has been identified and some of the projects implemented and on-stream, the technology that is inherent to the American industry will come forth--but only after the economics and incentive have been created. We have to assume that the people we need to talk to are open-minded and will give fair consideration to what we have to say and understand that our ultimate objective and goals are to provide the necessary services and dredging requirements for the needs of the American consumer.

ESTUARINE IMPACTS RELATED TO DREDGE SPOILING

By

Larry S. Slotta and K.J. Williamson
Civil Engineering Department
Oregon State University

The majority of U.S. waterways depend on dredging to insure adequate water depths for shipping. Other minor, but important, functions of dredging include creation of land areas; mining of underwater mineral deposits; correction of erosion; and excavation of sand, gravel, shells and rocks.

A. Types of Dredges. Dredges can be typically categorized as either hydraulic or mechanical. Hydraulic dredges mix large volumes of water with the sediment and the fluidized slurry is pumped away as a sludge. Environmentally this type of dredge results in the discharge of large volumes of water that have come in direct contact with the dredged sediments. As a result, these waters will reflect the pollutional nature of the dredge spoil.

The dredged sediments which are termed spoils can be disposed by several different procedures. For hopper dredge operations, the spoils are collected in large sedimentation tanks (hoppers) aboard the dredge. These are then dumped within the estuary or offshore. For pipeline dredging operations, the sediment slurry usually is pumped to a nearby diked area which is subsequently filled with the spoil.

Mechanical dredges directly resemble dryland excavation machines and are usually mounted on a barge. This type of dredge is primarily used for projects with rocky deposits and for limited operations. Such dredges create fewer environmental concerns since interaction of the sediments with the water column is minimized. The spoils typically are barged to a land or water disposal site.

B. Scope of U.S. Dredging. Dredging activities remove and redeposit tremendous quantities of material. In the U.S., in 1972, maintenance dredging and new dredging projects accounted for the transfer of over 200 million cu. yds. and 80 million cu. yds. of dredge spoils, respectively. Total costs of these projects exceeded $150 million (Boyd, et al., 1972).

A soils characterization of the spoil materials of navigation channels which are maintenance dredged annually revealed that:

> "By far the largest category (approximately 153,000,000 cu. yds. per year) is that classified as mixed sand and silt. About half this value is associated with the coastal areas of the United States, and the other half the inland rivers. Approximately 30,000,000 cu. yds. per year of that category including sand, gravel, and shell is dredged from the nation's inland waterways, while the remaining 22,000,000 cu. yds. is dredged from the coastal zone. The ill-defined materials mud, clay, silt, topsoil and shale account for 80,000,000 cu. yds. per year, all but 8,400,000 cu. yds. of which are dredged from the eastern one-third of the United States. Finally, although the group including organic muck, sludge, peat and municipal-industrial wastes accounts for only 1,400,000 cu. yds. per year, some of the more pressing environmental problems are associated with this group. Generally speaking, the materials dredged and disposed of in inland waterways are sand and gravel. The moving sand bottoms of many of the nation's navigable rivers have been a supply of sand and gravel for construction purposes for years. Again, generally in lakes, harbors and many areas of the coastal zones where the carrying capacity of the water is quite low, the dredged materials often consist of small, light particles such as clays and silts". (Boyd et al., 1972).

C. Environmental Concerns. Environmental concerns in relation to dredging have risen due to the relatively fragile nature of estuarine ecosystems and the widespread use of dredging in estuaries. Particular interest has been generated around the two common practices of spoil disposal by either filling marshlands or dumping in estuarine waters. Only the latter case and other dredging activities that could directly affect water and benthic environments are examined in this paper.

Many positive environmental impacts have been documented for dredging in addition to the obvious creation and maintenance of channels. Improved circulation which results from the removal of choked inlets can increase production of shellfish and fish due to the increased availability of food. Increased circulation also can reduce the impact of man-made wastes which are frequently discharged into estuaries. In many cases, dredge spoils are economically processed to produce sand and gravel for construction.

In contrast to the several positive impacts, many potential negative environmental impacts have been cited (Table 1). These impacts result from various physical alterations such as the change in the underwater topography, the removal of benthic animals and plants and the discharge of large quantities of particulate matter into the water column. In all cases, serious degradation of water quality and destruction of ecological systems potentially can occur.

Table 1. Potentially Negative Environmental Impacts of Dredging of Sediments

Alteration of the Estuarine Environment	Environmental Impact
Changed Topography	Alteration of Currents, Tides, Salinity Regimes and Water Quality
Removal of Benthic Animals	Significant Animal Kills, Alteration of Important Habitat
Removal of Benthic Plants	Alteration of Pelagic and Benthic Habitats, Increased Instability of Benthic Deposits
Discharge of Particulate Matter	Increased Turbidities and Sedimentation Rates, Release of Soluble Pollutants.

SCOPE

During the past fifteen months, an interdisciplinary team at Oregon State University, under the sponsorship of the NSF-RANN program, has been conducting research on the environmental effects of dredging in estuarine waters. From this study, much insight has been gained into the potentially acute and chronic impacts of dredging on estuarine environments. This paper will consist of listing the potentially acute and chronic environmental impacts of dredging, the proposal of guidelines to minimize the acute impacts and the identification of research needs to effectively monitor dredging projects. A proposal by the OSU research team is presently being considered by NSF-RANN for continued studies on the potentially chronic, longterm effects (Slotta, 1973).

PRESENT EPA GUIDELINES

The disposal of dredge spoils in estuarine waters is presently controlled by the EPA guidelines termed "The Basic Seven" (Table 2). Any sediments which exceed any of the seven parameters are termed polluted and can not be disposed of in estuarine waters. These guidelines basically restrict the open disposal of spoils with high organic contents (i.e., high volatile solids, COD, or TKN) and/or high industrial wastes (I.E., high oils, greases or heavy metals).

Table 2. EPA "Basic Seven" Guidelines
(After O'Neal and Sceva, 1971)

Parameter	Allowable Percentage Concentration (dry wt. basis)
Total Volatile Solids (TVS)	6.0
Chemical Oxygen Demand (COD)	5.0
Total Kjeldahl Nitrogen (TKN)	0.10
Oil-Grease	0.15
Mercury	0.0001
Lead	0.005
Zinc	0.005

In addition to the chemical analysis of the sediments, the following guidelines are included in the EPA guidelines (O'Neal and Sceva, 1971):

> "The decision to oppose plans for disposal of dredged spoil in United States waters must be made on a case-by-case basis after considering all appropriate factors; including the following:
>
> (a) volume of dredged material;
> (b) existing and potential quality and use of the water in the disposal area;
> (c) other conditions at the disposal site such as depth and currents;
> (d) time of year of disposal (in relation to fish migration & spawning, etc.);
> (e) method of disposal and alternatives;
> (f) physical, chemical and biological characteristics of dredged materials;
> (g) likely recurrence and total number of disposal requests in the receiving water area;
> (h) predicted long and short term effects on receiving water quality".

Towards their desired dredging impacts, these guidelines have numerous advantages and disadvantages. These will be briefly described.

A. Advantages. The establishment of these guidelines for dredging operations was undoubtedly a difficult task. The EPA has made a concerted effort to establish a simple and direct measure of environmental impact. The guidelines have been uniformly applied and have, at least, established a method for controlling dredging. The result of these guidelines has been an increased interest in dredging impacts and substantial effort to obtain more information. Such concerns had been widely overlooked previously.

The guidelines have been instrumental in focusing attention on the pollutional nature of the sediments. Previous to these guidelines, enforcement was based on the degradation of existing water quality. Thus enforcement was only possible after the damage had occurred, which was an unworkable situation.

B. Disadvantages. The limitations and questionable applicability of these criteria has been acknowledged by the EPA. In the publication entitled "Proposed Guidelines for Determining the Acceptability of Dredge Spoils to Marine Waters" (Region IX, 1972), it is stated that "there is no simple method for determining whether or not a sediment is polluted." Pollution cannot be defined by a collection of unrelated parameters with arbitrary and inflexible limits. The permutations of cause and effect are enormous, and each dredging and disposal operation has a unique impact on the environment". Within the above document, additional parameters were included to encompass the many potential toxicological problems associated with polluted sediments. Due to the complexity of the proposed monitoring schemes and to the lack of concensus on acceptable levels, these additional parameters were not adopted as criteria. An alternate set of criteria are presently being reviewed (Region IX, 1973). Limitations for certain pollutants such as radioactivity and heavy metals in dredge spoils to be dumped at sea have been included into the criteria for ocean dumping (Ocean Dumping - Criteria, 1973).

The main objections to the use of the listed guidelines in Table 2 center around the methods of sampling and the unknown relations between sediments and water quality before, during and after dredging. No instructions, guidelines or standards were included pertaining to the collection, storage, analysis, or interpretation of the collected data. In addition, a general formulation does not exist to predict the resulting water quality after dredging from a known pollutant concentration in a sediment.

Even though the Environmental Protection Agency explicitly stated that the values for the "Basic Seven" represented guidelines and that other factors must be considered, those pollutant concentrations have been established as criteria in some locations. This action has resulted in considerable problems for agencies like the U.S. Army Corps of Engineers which are charged with the task of maintaining navigable waterways. Considerable increase in costs have resulted in certain cases for which little is known about the benefits accrued from such expenditures.

It can be concluded that the EPA should establish a more realistic set of criteria based on an increased knowledge of dredging impacts. The present guidelines were a definite positive step in the right direction, but further refinements are needed. In relation to future criteria, May (1973) has concluded that "the most realistic approach to the dredging problem is to understand the effects of the practice fully before trying to apply extensive restrictions on the dredging industry and those dependent on it. Placing proper emphasis on what dredging does and what it does not do is an important step in insuring that dredging is done with the least harm and that regulatory policies are realistic both from environmental and economic standpoints".

ACUTE ENVIRONMENTAL IMPACTS

The interactions within estuaries are highly complex and involve geological, hydraulic, biological, chemical, social, economic and political factors. Presently, the impacts of dredging are primarily identified as acute changes in the important system properties of one or several of these categories. However, dredging also induces many potentially long-term or chronic impacts that also must be incorporated into the decision-making process. To fulfill national goals of protecting our environments, dredging must be regulated and both acute and chronic environmental impacts must be considered. The potentially acute and chronic problems and monitoring procedures to regulate their impacts are described in the following sections.

A. Altered Circulation. Dredging can have a wide influence on estuarine environments by altering the circulation patterns. Many of the biological species are adversely affected by permanent changes in either salinity or temperature which result from the circulation changes. St. Amant (1956) and Waldo (1956) both reported long-term changes in biological production to such dredge-induced alterations. Some populations such as herbivore *Acartia tonsa* (Johnson and Miller, 1973) are extremely sensitive to specific circulation patterns which can be significantly altered by either spoil removal or disposal.

These studies suggest that dredging that could significantly alter circulation patterns needs to be regulated and at least monitored. The necessary techniques of determining circulation patterns by airphoto analysis have been developed and successfully utilized (Weise, 1973; Burgess and James, 1971).

B. Physical Removal of Organisms. The most apparent biological impact of dredging pertains to the removal of benthic organisms in the dredge spoil. Although this process probably does result in a large kill of these organisms, the impact does not appear to be significant for localized dredging operations. Harrison, Lynch and Altschaeffl (1964); Saila, Pratt and Polgar (1972); and Slotta, *et al.* (1973), all measured an immediate decrease in the infaunal populations after dredging, but a fairly rapid repopulation did occur.

C. Burial of Organisms. The ability of animals to withstand the adverse effects of burial in areas near the dredge site or in the spoil site depends primarily on their behavior and morphology. Species such as large polychaetes and bivalves which can burrow have been shown to survive burial of up to 21 cm of sediments (Saila, Pratt and Polgar, 1971). However, attached sessile species are probably killed by burial of any magnitude. Numerous authors (see Saila, Pratt and Polgar, 1971, for a review) have reported acute kills from burial of various benthic organisms including oysters. Slotta, et al. (1972) reported that readjustment of benthic infauna to former abundance levels occurred within two weeks of spoiling. Thus the impacts in the spoil areas also do not seem to be significant for small localized projects.

The rapid recovery rates at both the dredge site and the spoil disposal area have been attributed to a resistant biological population (Slotta, et al.). It has been hypothesized that activities related to dredging such as increased marine traffic also disturb the benthic deposits for frequent short time intervals. Thus, acute biological impacts due to actual dredging operations may not be significant even though large quantities of sediments are removed and deposited because the benthic organisms have adjusted to a state of continuous physical overturn.

D. Turbidity and Suspended Solids. The most commonly reported effect of dredging on water quality is an increase in turbidity and suspended solids. However, almost all investigators have concluded that such increases do not represent a significant impact (May, 1973) (Saila, Pratt and Polgar, 1972) (Mackin, 1952) (Bronin, 1970) (Sulivan, 1973). This conclusion has been reached based on two premises. First, the increases in turbidity and suspended solids occurs over localized areas which pelagic species can probably avoid. Second, periodic high turbidity levels are part of the evolutionary experience of estuaries. Sediments are resuspended by wind, waves and tidal scour and large sediment loads are carried with the winter fresh water flows.

Shubel (1968) has reported a 20-fold increase in suspended sediment concentrations in Chesapeake Bay caused by natural occurrences. With this evolutionary experience, many estuarine animals are tolerant to waters carrying suspended solids. Saila, Polgar and Rogers (1971) cited several examples of tests with fish and lobsters held in waters with several grams/liter of suspended sediments; no significant mortalities were measured. Thus, turbidity-related impacts do not seem to be significant in most cases.

E. Nutrient Release. Nutrients in the various chemical forms of nitrogen and phosphorus are commonly released from dredge spoils which results in significant increases in the ambient concentrations. Cronin, et al. (1970) reported increases near the discharge plume from 50 to 1,000 times ambient total phosphorus and total nitrogen levels. However, no increase in phytoplankton was observed. Windom (1973) also reported large releases of nutrients in his studies of five estuaries on the southeastern coast of the United States.

However, in contrast to Cronin's results, significant algal growths were reported when dredge spoils were placed with the receiving waters in closed bottle experiments. Stimulation of algal growths was also noted at the dredging sites from light-dark bottle experiments. Thus, such phytoplankton stimulation may or may not be significant. In most cases, such factors as the localized nature of most dredging projects, the large dispersion in most estuaries and the decrease in available light from increased turbidity will reduce the potentiality of serious environmental problems from nutrient stimulation.

F. Oxygen Demand. Dredging of sediments may result in the release of organic materials and inorganic materials (such as sulfides) that can create an oxygen demand in the water at the dredging and disposal sites. Under certain conditions, significant reductions of dissolved oxygen concentrations can result during dredging operations (Brown and Clark, 1968). In addition, dredging operations may expose benthic deposits of high oxygen demand that had been previously covered with relatively clean materials. Organic material resuspended by dredging operations may settle on the benthic surface and increase the benthic oxygen demand. The reverse can also be true if dredging operations lead to the removal of polluted sediments.

The exact causes of oxygen depletion resulting from dredging operations are unknown even though at least two studies have been completed on the oxygen demand of resuspended sediment (Seattle University, 1970, and Touhey, 1972). The reported insensitivity of the oxygen uptake rates to both organisms' concentrations and salinity strongly suggests that the majority of the demand is chemical in nature, not biochemical. The most probable species involved are various iron sulfides which are rapidly oxidized. Preliminary studies at OSU have shown that the oxidation of 10^{-3}M FeS to $FeOH_3$ and oxidized sulfur compounds occurs within several minutes in an aerobic environment.

The adverse impacts of low dissolved oxygen concentrations on a variety of pelagic and benthic organisms are well documented. Standardized procedures are being developed by the EPA (Region IX, 1973) to enable the estimation of whether DO depressions will be significant.

G. Free Sulfides. High concentrations of free sulfides within the deposits and the release of free sulfides to the overlying water and atmosphere as a direct or indirect result of dredging operations can be environmentally significant for a number of reasons. First, the release of free sulfides can increase the benthic oxygen demand rate and thus lead to a decline in the aerobic zone of the deposit and a rapid lowering of the DO concentrations within the overlying waters. Second, free sulfides, particularly hydrogen sulfide, are toxic at low concentrations to fish, crustaceans, polychetes, and a variety of benthic micro-vertebrates (Fenchel, 1969; Servizi, et al., 1969; and Ivanov, 1968). Actual toxic concentrations reported in the literature usually represent only initial sulfide concentrations and thus may be too low due to chemical oxidation throughout the test period. In tests which maintained nearly constant conditions, hydrogen sulfide concentrations below 0.075 mg/l (pH 7.6-8.0) were found to be significantly harmful to rainbow trout, sucker, and walleye, particularly to the eggs and fry of these fish (Colby and Smith, 1967). For these reasons, specific criteria need to be established to regulate such releases of free sulfides.

H. Heavy Metals. The release of heavy metals from polluted sediments as a result of dredging has been postulated by many authors and has resulted in specific guidelines being developed by the EPA (Table 2). However, in sediments where sulfides are being produced, the possible chemical transformations from resuspension become quite complex. Presently it is unknown whether heavy metals will be released from sulfide bearing sediments.

Ferrous sulfides are common minerals in anaerobic sediments and are probably responsible for the characteristic black color. Preliminary studies at OSU have shown that heavy metals absorb both Fe(III) oxides and Fe(II) sulfides. In addition, the heavy metals are readily co-precipitated and incorporated within the sulfide-bearing sediments; a similar hypothesis is in agreement with the data reported by Windom (1973) and May (1973) in which heavy metals present in the dredge spoils were not released to the water column.

More research is required to elucidate the important mechanism occurring in this process. Present data are not adequate to establish exact criteria.

I. Toxic Hydrocarbons. Important hydrocarbons in relation to the toxicity of dredge spoil include the organochloride insecticides, the organophosphorous insecticides and the polychlorinated biphenols. The possible adverse effects of spoils contaminated with these compounds are numerous; however, direct cause-and-effect relationships are virtually non-existent. More research is needed in this area in relation to monitoring methods and acceptable criteria.

CHRONIC ENVIRONMENTAL IMPACTS

As described in the last section, the acute impacts of dredging are highly complex and not well-defined. Even less is known about the extent of chronic or long-term environmental impacts. These chronic impacts include not only dredging but also such activities as shipping, industrialization, and urbanization which alter the environment in complex ways. The measurement of such chronic impacts requires an understanding of the important geological, hydraulic, biological and chemical factors which control the interactions in estuaries.

Presently, the impacts of dredging have been primarily identified as acute changes in important system properties. Little is known of chronic impacts for two reasons. First, chronic impacts are not so immediately apparent upon examination of a problem. An understanding of the system properties is often required to sort out the chronic problem from the multitude of other changes. In reference to dredging, the understanding of important system properties has been almost non-existent. Second, the detection of chronic impacts requires reasonable lengths of time, and few research efforts have been funded for periods over twelve months. For our proposed NSF-RANN studies we have identified several chronic impacts which we feel should be examined. These will be briefly discussed in this section.

A. Particle Size Change. A dominant feature of hopper dredging activities is the resuspension of bottom sediments. As a dredge suction head passes through a dredge site, surface sediments are drawn into the head and pass to the hopper. Some of the material around the suction head is disturbed mechanically and thrown into suspension. Heavier particles settle out after the disturbance passes, while lighter particles remain in suspension due to ambient turbulence and may be transported from the original site by local currents. The material which passes into the hopper is initially in suspension, but the heavier particles settle to the hopper bottom. The lighter particles remain in suspension and some are returned to the estuary water column via the hopper overflow.

At the spoil area, the contents of the hopper are released and settle to the bottom as a slurry. Surface shear during descent and impact-induced mixing at the bottom resuspend a portion of the material;

again, the fines may be transported from the spoil site. As a result of repeated resuspensioning and settling, and the subsequent loss of fines, it has been found that dredge spoils may contain smaller fractions of fines than occur at the dredge site.

Specifically, it was observed on the Coos Bay hopper dredge project that a five-fold increase in mean particle size occurred in the spoils immediately after spoiling and persisted for two months. The escaping fines probably contributed to long-term siltation in the adjacent shallow areas.

The dependence of animal populations on a specific particle size distribution has been clearly identified. Rhoads and Young (1970) reported that suspension feeders and benthic infauna are largely confined to sandy or firm mud bottoms. Sanders (1956) showed that suspension feeders in Long Island Sound comprised 80 percent of the organisms on coarser sediments, but only 6 percent on fine sediments. Selective and non-selective deposit feeders were the dominant forms in fine sediments. Thus it can be concluded that changes in particle size from dredging operations probably seriously affect the distribution of the benthic populations.

B. Reduced Sediment Turnover. Polluted spoils standards have promoted the practice of spoil deposition behind "water-tight berms" and/or in diked, sacrificial channels. In either case, a sediment system results in which the bottom deposits have increased stability over their previous conditions. With this increased stability the sediments are turned over less frequently and the build-up of anoxic, sulfide-bearing sediments can result. In addition, more organics are deposited in this relatively quiescent region which further encourages the growth of sulfate-reducing bacteria. The end result can be a significant reduction in the biological populations present before spoiling.

C. Increased Sediment Turnover. Dredging can increase current velocities by several methods including the removal of inlet choking, channelization or the removal of eel grass. These increased current velocities will subsequently increase the turnover of the sediments, which, as the reverse of the previous case, can also adversely affect the biological communities.

D. Resistant Biological Communities. Preliminary studies (Slotta, *et al.*,) have suggested that the benthic infaunal communities may become modified in an estuary which has repeated dredging into a relatively resistant community. This community may have become adapted to a more or less continual resuspension of the sediments and its persistence may actually depend on this turnover. The turnover may depend more upon the prop wash of large ships than on the continual maintenance dredging. Irregardless, the biological community will exhibit characteristics commonly attributed to communities in polluted environments and will not be significantly altered by dredging.

RESEARCH NEEDS

In relation to monitoring of dredging projects, we believe the following research areas should be employed:

A. Improve Monitoring Requirements. A system needs to be developed in which the required parameters to be monitored vary with the degree of pollution. Some easily measured parameters (e.g., volatile solids) which roughly correlate with pollution potential should be used to determine both the sampling methods and the required parameter to be monitored. For low volatile solids (<2% by dry wt.), little additional monitoring would be necessary; for high volatile solids (>10% by dry wt.) many tests both before and during the dredging would be necessary. Such a system would tend to optimize the funds spent for monitoring.

B. Release of Heavy Metals and Toxic Hydrocarbons. In many cases sediments exceed the present EPA criteria for heavy metal concentration. Research needs to be initiated to determine if heavy metals can be released from dredge spoils under natural environmental conditions. If such releases are minimal, as has been reported in the literature, then consideration should be given to new, more realistic criteria. Additional studies are required to elucidate the important transport mechanisms and the environmental impacts of the chlorinated hydrocarbons which are known to exist in high concentrations in certain sediments.

C. Turbidity. The exact role of turbidity as a controlling factor is relatively unknown for estuaries. Work concerning long-term increases from all man-made activities including dredging and the possible impacts of such increases should be established.

D. Turnover of Benthic Deposits. Man-made activities of estuaries will undoubtedly alter the rate at which benthic deposits are turned over. Natural causes include tides, currents, fresh water flows and benthic burrowers. Important man-related causes are dredging, ship props, anchor dragging and channelization. The interrelationship and importance of each of these activities needs to be examined further.

CONCLUSIONS

1. Present monitoring technology is available to determine all important parameters in relation to dredging projects.

2. Improved criteria are required to specify which parameters should be monitored.

3. More research is necessary to elucidate cause-and-effect relationships especially in relation to chronic impacts.

ENVIRONMENTAL STATEMENT ON SHELL DREDGING; SAN ANTONIO BAY, TEXAS

By

Arnold H. Bouma, Barry W. Holliday* and Gary L. Hall

Texas A&M University
Department of Oceanography
College Station, Texas

*Presently with: Office of Dredged Material
Waterways Experiment Station
Vicksburg, Mississippi

ABSTRACT

A study of the environmental effects of shell dredging in San Antonio Bay, Texas, on the Aransas National Wildlife Refuge and adjacent bays, was undertaken by a team of approximately fifty investigators. It included a comprehensive investigation coordinating biological, chemical, physical, sedimentological, geophysical, hydrological and meteorological information. Certain changes to the bay environment, as a direct result of dredging were studied and evaluated. These included the changes in circulation, aquatic life, population density of dredge holes, feeding habits of fishes, oyster reef distribution, dispersal of pollutants and navigation routes. Other studies dealt with the effects of spoil distribution from dredging operations on live reefs, dredging fossil reefs, and implantation of artificial reefs. In addition, the effects on economics and revenue to the State were regarded in light of the termination of shell dredging as a detrimental measure or due to depletion of resources.

A large portion of the population and industry of the Texas Gulf Coast depends heavily on shell, as it is the second largest import to

the Port of Houston in terms of bulk volume. Serious problems and astronomical costs would be involved if industries were suddenly forced to change to limestone as their source of calcium carbonate. At present, transportation problems appear to be unsolvable in bringing strip-mined limestone from the Edwards Plateau to the coastal area. Thus, it is extremely important to develop a management program that would determine the extent of both living and fossil reefs, evaluate the environmental effects of shell dredging operations, and develop techniques to insure a more constant future supply of this slowly renewable resource.

The Environmental Impact Statement study clearly indicated that no long-term detrimental effects are caused by the present shell dredging operations. The primary problem lies between the needs of the shell dredging industry and the State and Government permit issuing and management programs. It has become glaringly apparent that the study did not completely solve all problems pertaining to dredging in San Antonio Bay as too many preconceived ideas and biased opinions had to be dealt with.

INTRODUCTION

Shell dredging in Texas bays is contingent upon a State Permit issued by the Texas Parks & Wildlife Department after which a Federal Permit is considered by the U.S. Army Corps of Engineers. The Galveston District Office determined that an Environmental Impact Statement should be prepared on the effects of shell dredging in the San Antonio Bay area in response to the provisions of the National Environmental Policy Act. After meetings with interested State and Federal Agencies, the

Corps decided to contact Texas A&M University to carry out a field study and to provide a report.

The Environmental Impact Statement on the effects of shell dredging activities in San Antonio Bay, on the Aransas National Wildlife Refuge and adjacent bays developed by the Texas A&M University team includes a comprehensive investigation coordinating biological, physical, chemical, sedimentological, geological-geophysical, hydrological and meteorological information. A schematic outline is shown in Table I.

GEOGRAPHIC SETTING

The investigation was centered on the Aransas National Wildlife Refuge and surrounding water bodies including San Antonio Bay, Hynes Bay and Guadalupe Bay on the northeast, Mesquite, Ayres and Carlos Bay on the south and St. Charles Bay on the west, Figure 1. However, the overwhelming majority of the field investigations concerned with the influence of shell dredging were made in San Antonio Bay proper, Hynes and Guadalupe Bays. These three bays cover an area of approximately 132 square miles and have an average depth of 4 feet. All aforementioned water bodies are connected by the Intracoastal Waterway which has an average depth of 12 feet and an average width of 200 feet. Connected to the Waterway and located on the eastern edge of San Antonio Bay is the Channel to Victoria.

Two main rivers drain into San Antonio Bay. These are the Guadalupe and San Antonio Rivers which join a few miles before entering Guadalupe Bay on the Northeast side of San Antonio Bay. These two rivers drain a predominantly agricultural area of 9,594 square miles.

The 54,423 acre Aransas National Wildlife Refuge was established in 1937 for the protection of all forms of wildlife. It consists

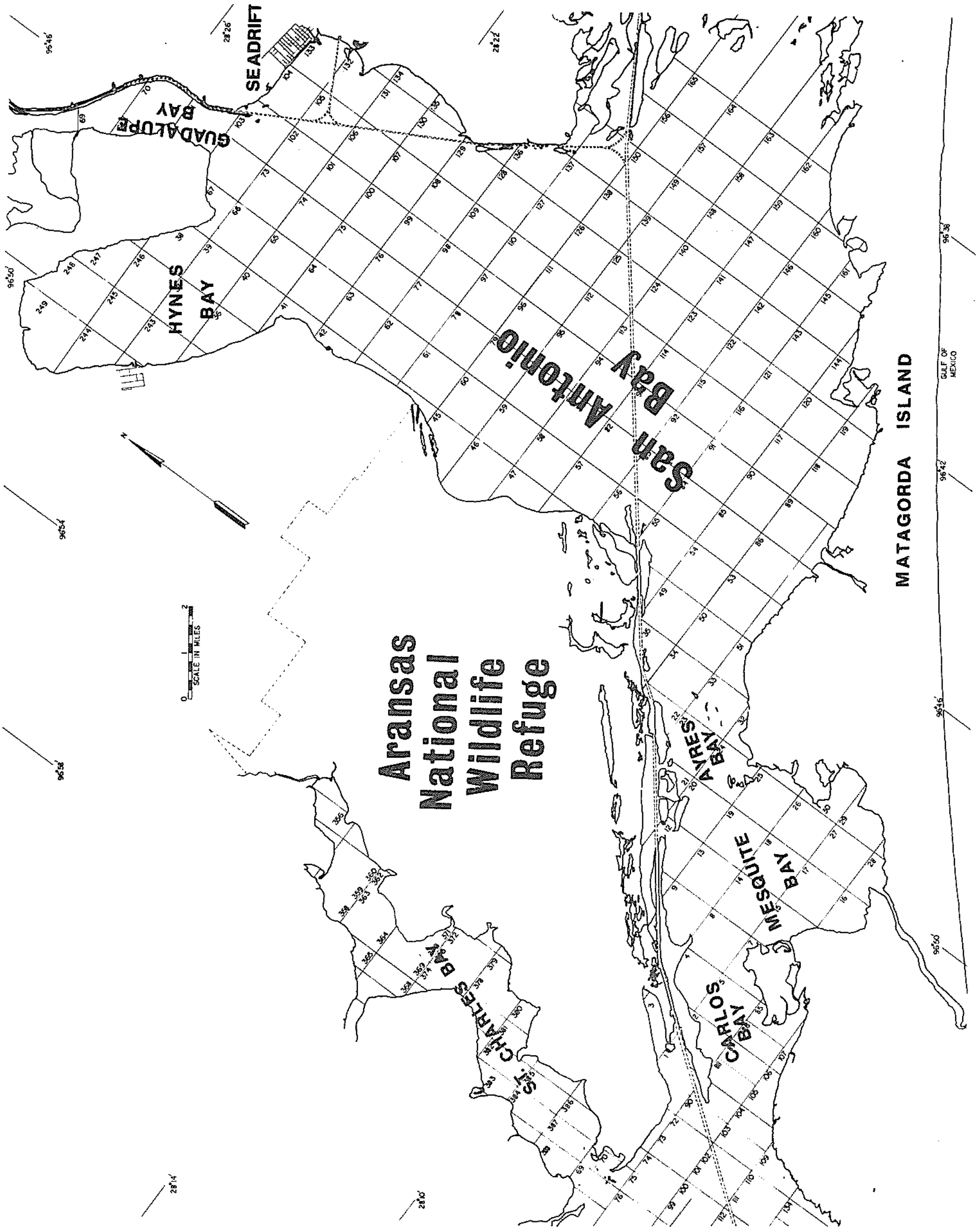


Figure 1. The area surrounding the Aransas National Wildlife Refuge in Texas. The numbered squares are State tracts.

primarily of tidal flats, marshes and sandy ridges interrupted by long narrow ponds. The ridges are mainly covered with live oak and redbay brush. The ponds vary in size from 1 to 385 acres and are fed by local runoff and water pumped from nearby wells. The Refuge is an important link in the chain of waterfowl wintering areas along the Gulf Coast, and it is the only wintering site for the almost extinct whooping crane (see also Bouma and Holliday, 1973; Bouma et al., 1973; EIS, 1973).

PHYSICAL ASPECTS

Salinity. The salinity in San Antonio Bay, as in other bays surrounding the Aransas National Wildlife Refuge, is extraordinarily variable. The bay system receives nearly all its fresh water from the Guadalupe and San Antonio Rivers. This river system has a highly variable discharge ranging from a low annual flow of 234,000 acre-feet in 1956 to a high of 3,400,000 acre-feet in 1957 (Arndt, in prep.). During years of abnormally high rainfall, San Antonio Bay contained nearly all fresh water from the Guadalupe River and local runoff. When this phenomenon occurs, as it did in May and June of 1972, most sessile organisms such as oysters and barnacles are killed. The more mobile species vacate to areas of higher salinity. Normally the fresh water of the Guadalupe River runs into Guadalupe Bay and flows southward out the mouth of this bay. Since the winds are dominantly from the southeast, the water is pushed in a southwestward direction where it begins to mix with more saline waters of upper San Antonio Bay and lower Hynes Bay. The water continues along San Antonio Bay's western shore to the Intracoastal Waterway where it veers right into Intracoastal Waterway and Ayres Bays, mixing with high salinity waters of lower San Antonio Bay (Figure 2). The usual source of high salinity

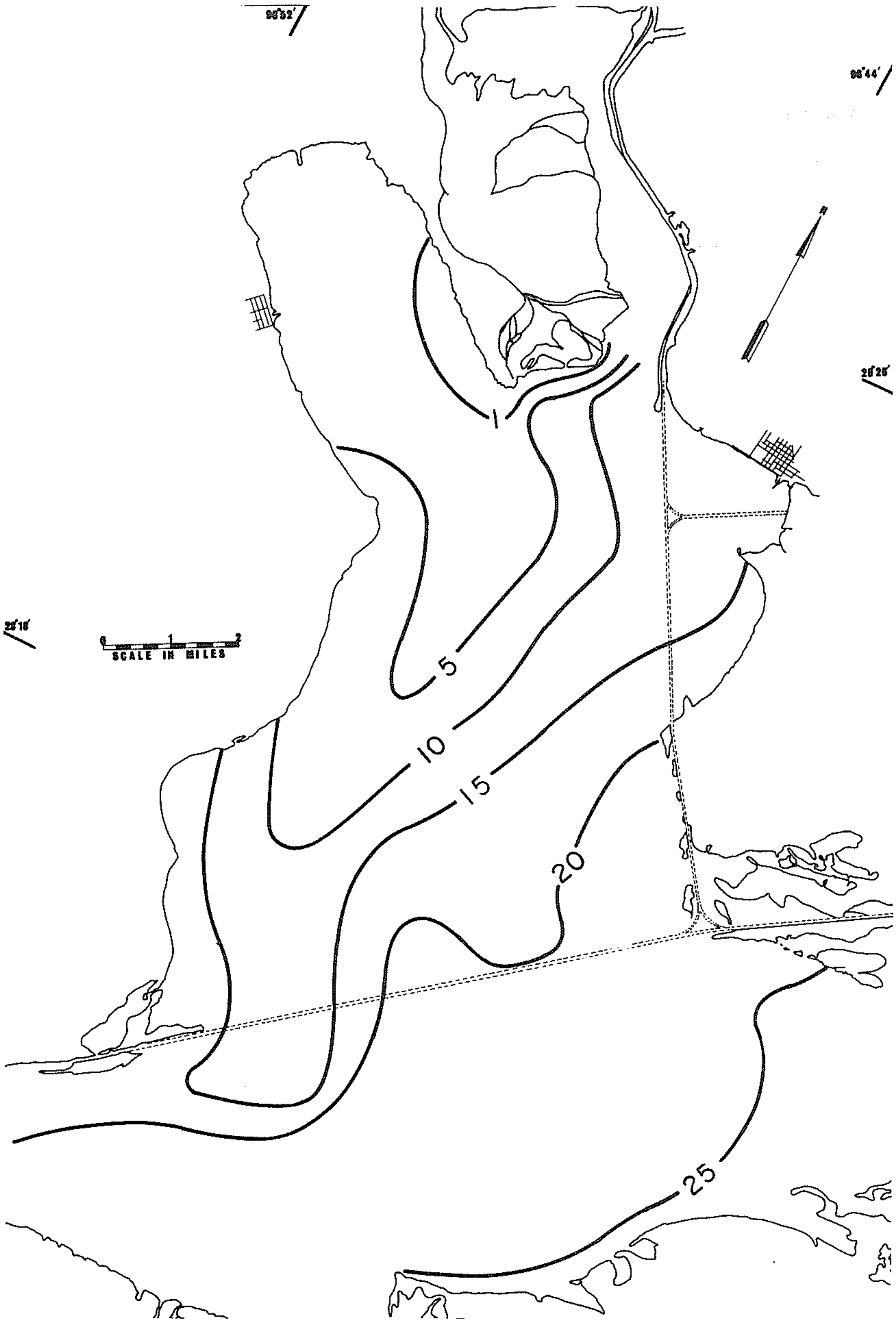


Figure 2. Surface salinity distribution in parts per thousand for October, 1972. San Antonio Bay, Texas.

water enters from the Gulf of Mexico through Pass Cavallo and mixes with Matagorda Bay waters. This water passes through Espiritu Santo Bay into San Antonio Bay where it tends to turn and move northwestward along the eastern side and through the Channel to Victoria to the upper part of the bay where it mixes with river water. Central San Antonio Bay has relatively poor circulation and consists of well-mixed water with salinities from 14 to 18 ppt.

Tides. The normal diurnal tidal fluctuation in San Antonio Bay is only 0.25 ft. In recent years major tidal fluctuations have occurred during hurricanes and times of high river runoff. In response to Hurricane Carla in 1961, the Seadrift tide gauge crested at 11.2 feet. The rains and consequent flooding of the Guadalupe River in May 1972 caused an increase in tide height of 2.7 feet at the Seadrift gauge.

During the winter, strong "northers" cause drastic tidal drops of two feet or more in less than three hours. These strong winds tend to blow the water southward causing it to pile up on the lee shore which results in inundation of the marshy areas of Matagorda Island. As the "norther" subsides, the water responds by moving back into the upper portions of the bay where it finally equilibrates.

Temperature. San Antonio Bay is a relatively shallow water body whose waters are well mixed. Consequently, warming and cooling rapidly follow changes in air temperature. The maximum and minimum temperatures recorded during the sampling period were 37.0°C on 9/28/72 and 3°C on 1/11/73. In areas such as the Intracoastal Waterway and the deeper dredge cuts, temperature differences of 2°C between the surface and bottom were occasionally measured.

Possible Effects on Circulation Caused by Shell Dredging. Shell dredging under the present State and Federal regulations does not involve removal of exposed reefs except when special permits are granted for experimental purposes. Therefore, all shell presently being dredged in San Antonio Bay is in the form of buried deposits that do not affect the circulation in the bay. But as these deposits are dredged from depths up to 40 feet, pits and gullies are made, known as dredge cuts. If the long axes of such cuts run transversely to the circulation pattern the major effect would be the retention of water of slightly higher salinity in the bottom of the cut. The temperature of this water would be cooler than the shallow water around it during the summer but warmer than the water surrounding it in winter. Most cuts are too shallow and tend to fill up too rapidly with sediment to serve as refuges for fishes during the winter "northers" that sometimes cause "cold kills". On the other hand, where the long axis of a dredge cut runs parallel to the direction of major current flow it has the effect of a channel in which water could flow faster than in the shallows. As stated earlier, these cuts are usually very shallow and since they are not kept deep by repeated dredging they tend to fill up as flow of water is not fast enough to prevent sediments from settling out. They can conceivably affect the salinity to some extent while new, but have little if any long-term effect.

GEOLOGICAL ASPECTS

The major aspects falling under this heading are bathymetry and surficial reef distribution, bottom sediments and subbottom characteristics.

Since no electronic positioning equipment is used by the Texas Parks & Wildlife Department or the dredging companies, it was financially impossible for the Texas A&M team to carry out a detailed bathymetric and reef distribution survey. The existing bathymetric maps were used and changes were made where new data warranted.

About 120 cores, four to eight feet long, were taken and studied. Several charts resulted from these studies (Hall, 1973, EIS, 1973). They represent sediment distribution, subenvironments of deposition, mineral distribution, grain size and various statistical grain size parameters. With the aid of visual descriptions, black and white photography and X-ray radiography, all cores were carefully examined and described. Lithologies and sedimentary structures were noted in order to evaluate sediment types, mechanisms of transport and deposition of the sediments. Also some detailed studies on clay mineralogy and grain surface texture were made to better understand the source of the different sediments. The northern part of the bay contains a preponderance of fine-grained sediments introduced by the Guadalupe-San Antonio River system, while the sands occurring along the southern margins are washover deposits from Matagorda Island (Figure 3).

A subbottom survey, totaling 244 miles, was designed to obtain insight into the distribution of buried non-living reefs in San Antonio Bay. The source of this project was a 12 kHz transducer and the track lines were approximately 1/2 mile apart which proved too open to allow any correlation between fossil reefs as they are for the most part smaller than 1/2 mile in any direction (Figure 4). It should be required by the State to investigate all bays in this manner and with denser coverage to provide the public with good information as to the

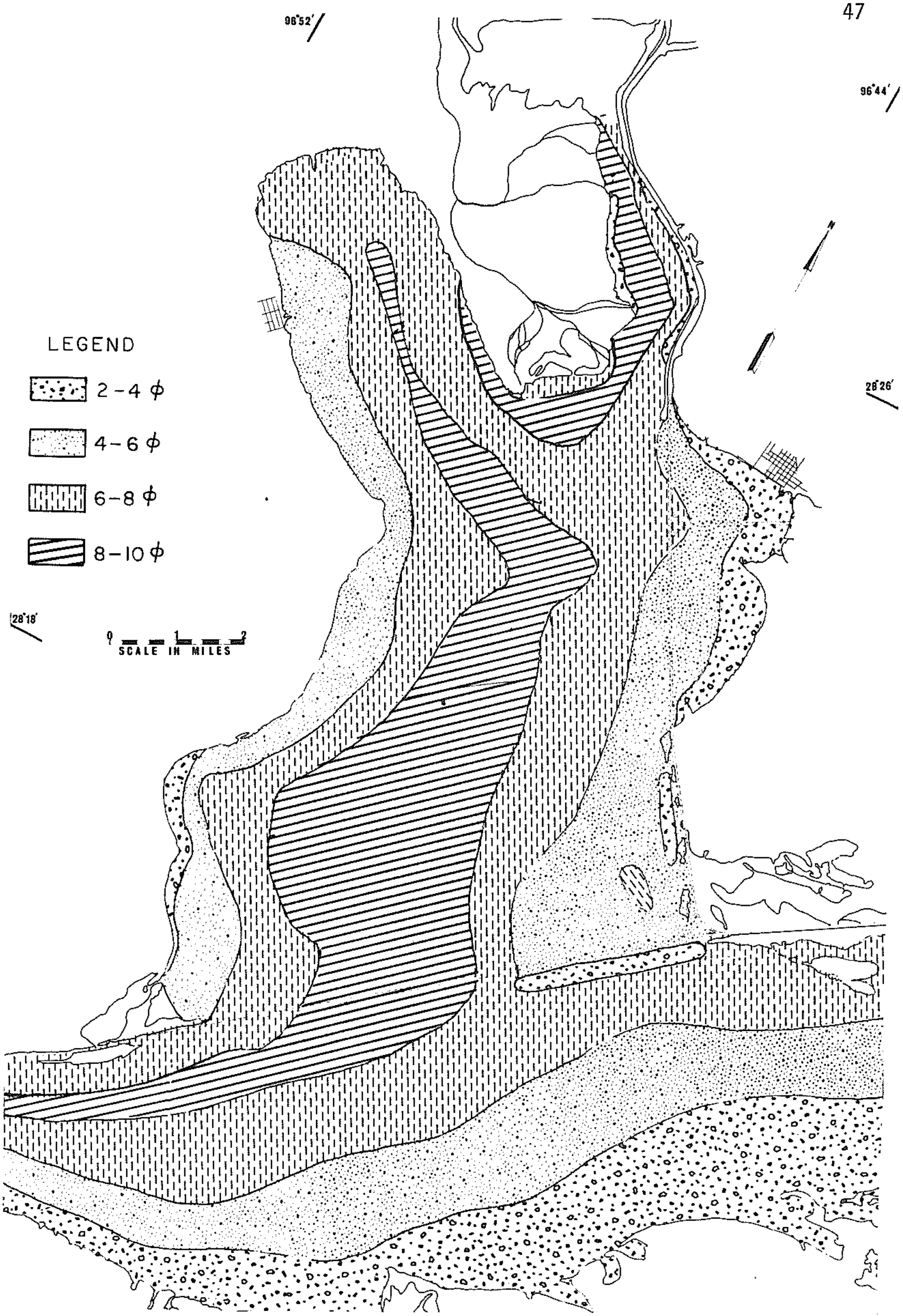


Figure 3. Mean grain size distribution map in ϕ units for San Antonio Bay, Texas.

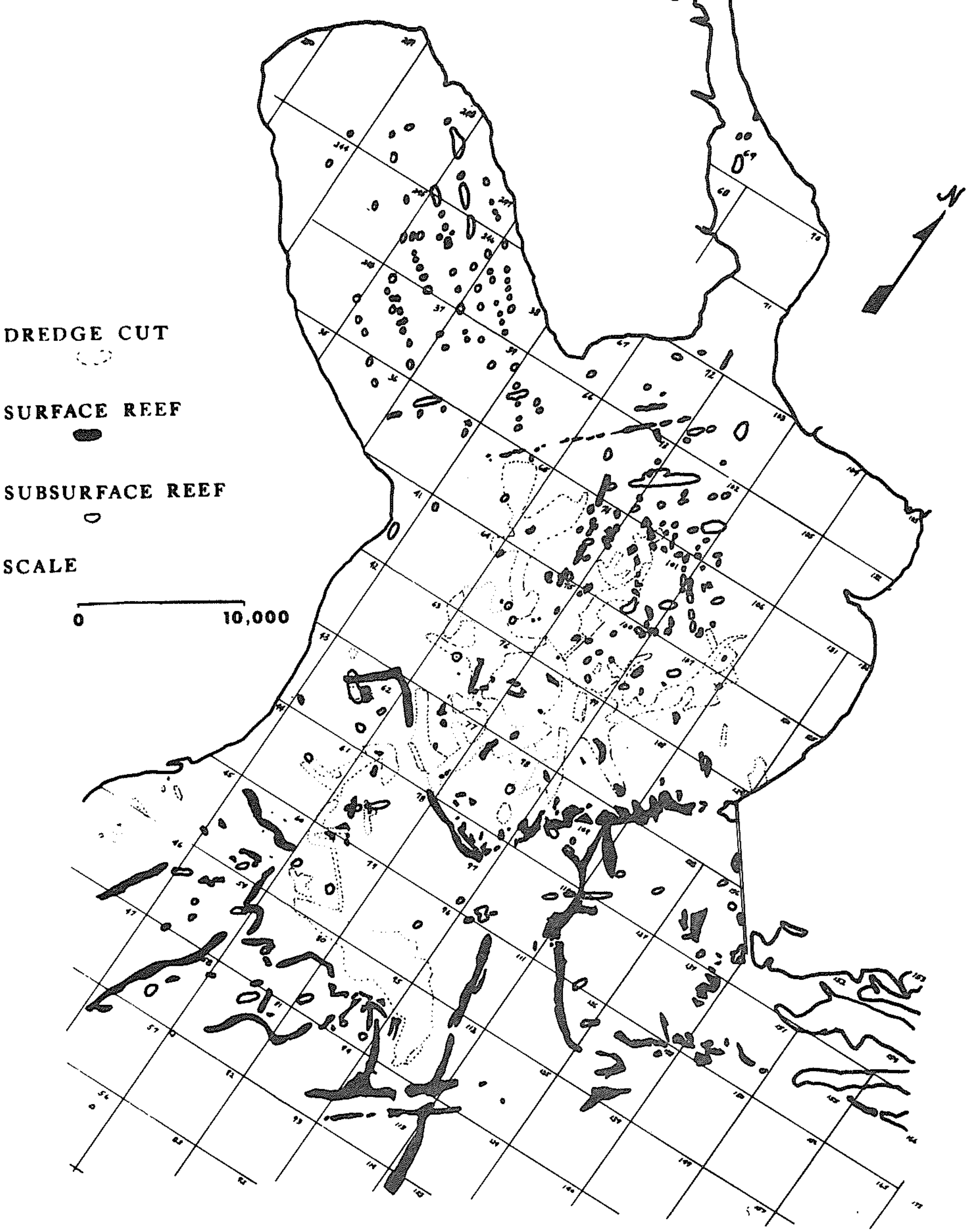


Figure 4. Map of San Antonio Bay with dredge cuts, surface reefs and subsurface reefs.

amount and distribution of these and other natural resources.

A new tool, a towed electrical logging array, was utilized to provide data on sand budgets and reefal distributions in the bay. Although this tool's capabilities have not fully been realized, it can at the present provide data that cannot be obtained by seismic studies (Figure 5).

CHEMICAL ASPECTS

Part of the chemical studies involved the uptake and release of chlorinated hydrocarbon insecticides by animals. The clam Rangia was selected for tank experiments. Several species were collected for analyses on the amount of insecticides, and measurements of pesticide levels in the water column and in the sediment were also carried out. The greatest input of these chemicals is by means of land drainage. Consequently, heavy rains and storms also produce major changes in the insecticide levels in the bay system. When sediments are contaminated, a dredging operation will resuspend sediment and thus change the insecticide level in the water column and the depth of penetration of insecticides into the bottom sediment. Resuspension of contaminated sediment allows at least some portion of these adsorbed chemicals to be returned to the water column. Due to the very low levels of contamination caused by chlorinated hydrocarbons and by trace metals, dredging does not appear to pose a great threat in regard to increasing the insecticide levels in the water column. On the contrary, resuspended uncontaminated sediments will adsorb part of the pesticides thus causing a water filtering action. Since burrowing animals do not penetrate very deeply into the bottom, dredging exposes much more "clean" sediments.

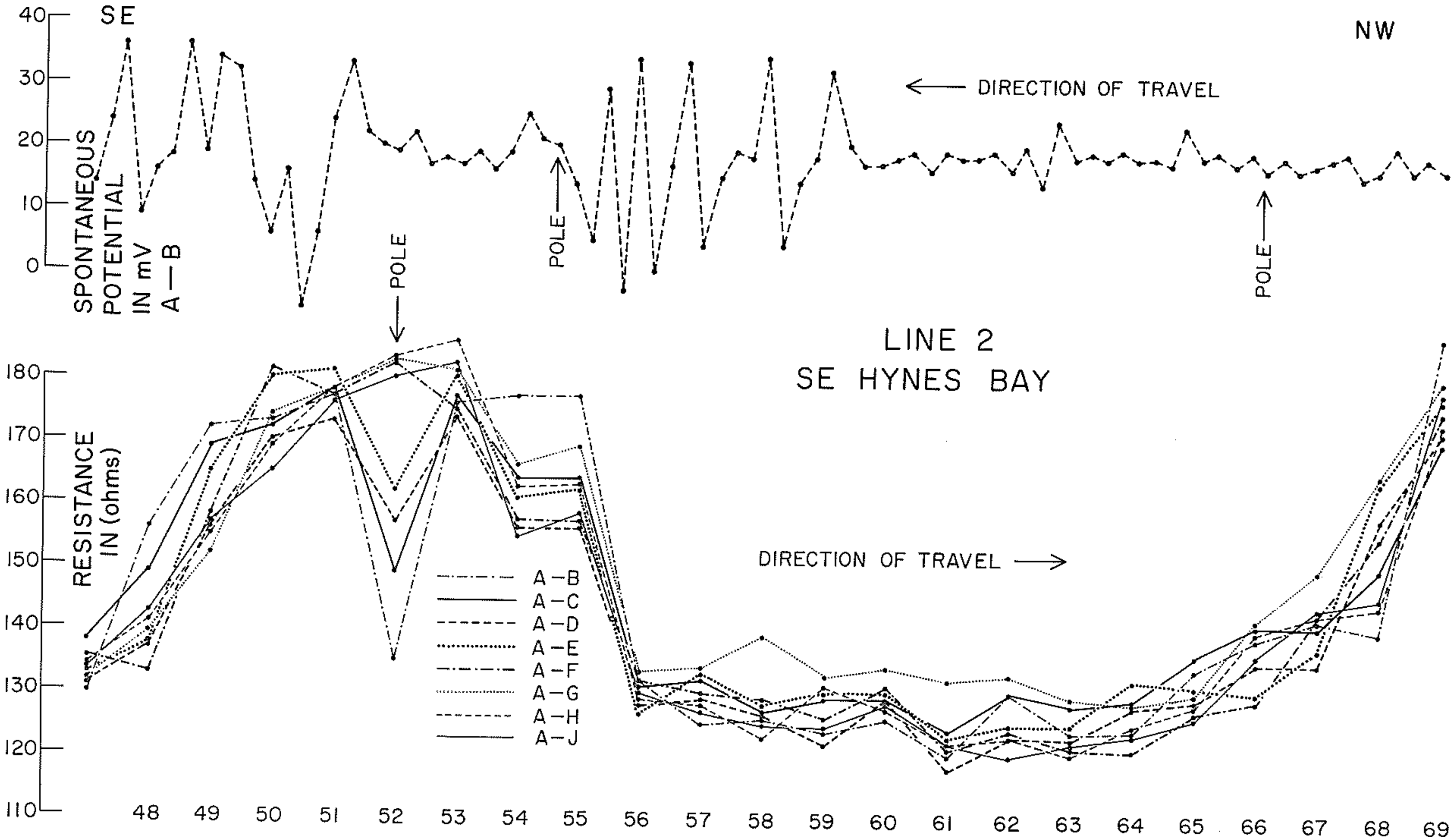


Figure 5. Portion of a towed electrical logging array record. Electrode spacing increases linearly from A-B to A-J. Note offset between resistance and spontaneous potential records due to reversal in two directions. Resistance profile indicates large reef between markers 48 and 56 which separates into two reefs near the reef top. This portion corresponds to the spontaneous potential curve between markers 55 and 60. Eastern Hynes Bay, San Antonio Bay system, Texas.

WILDLIFE ASPECTS

This phase of the program included studies of the general Wildlife Refuge vegetation and animal kingdom as well as the rooted aquatic plants along the shorelines. Marsh plants can act as natural traps for sediment, thereby contributing to any outbuilding of the coastline. Most rooted aquatic plants are rather fragile and can be killed by excessive silting or by the process of uprooting due to storms or artificial means. As algae grows on these plants direct light is necessary for photosynthesis. If these plants receive too much light the result will be an overproduction of algae which gives the rooted plants a positive buoyancy. If this does occur, the plants could conceivably be uprooted by winds of less than storm strength. Removal of these plants presents a serious problem in that currents that were once slowed down by the rooted aquatic plants, can now seriously erode the coastline.

It has been found that the present dredging activities have no noticeable effect on the coastline and on the wildlife species that live on or migrate to the Refuge. However, amateur bird watchers, campers and sport fishermen appear to create more of a disturbance to wildlife on and around the Refuge than ship traffic or the noise made by operating dredges.

BIOLOGICAL ASPECTS

The biological and the wildlife studies are considered to be the main items of any environmental investigation. The fact that the previously discussed aspects have a direct effect on the biology of a study area is often overlooked. In failing to understand this, many biological studies have not answered relevant questions.

The biologists do have a very difficult task. It is often hard to decide on whether the study should be concentrated on economically important species, on species which are important in the food chain, or on the most abundant species in the study area. It is impossible to incorporate all types of life into any study, thus the selection of the organisms to be studied can lead to objections from special interest groups. The Texas A&M team concentrated on two large groups: species that are important in the food chain of the Refuge birds and on game fish.

Due to differences in physical conditions some variations in type and density of species can be observed. Consequently field observations had to be made in different areas. The same stations were occupied at monthly intervals for seasonal effects and at other times to determine the effects of severe weather. The stations were located throughout the bay in flats, old dredge cuts and new dredge cuts.

Large metal towers were placed at several points in the bay and around a dredge. Panels made from wood, asbestos, floor tile and shell were inserted in these towers to observe the effect of turbidity on fouling. Wire-mesh cages with young oysters were also placed in the towers at different heights above the bottom.

OTHER ASPECTS

Shell dredging activities, shell management and permitting, and economics form the main items in this group.

The dredging, tate management and economics are very important aspects. Unfortunately, they are analyzed from various points of view by conservation oriented agencies and groups. Since Texas A&M

was acting consultant to the Corps of Engineers, care had to be taken not to influence political views and guidelines but to restrict our comments to suggestions.

Dredge discharge in San Antonio Bay is done via the overflow principle from settling tanks or from pipes. Since no two dredges were ever in comparable positions no attempts were made to measure the difference in influence on the bay. Turbidity measurements carried out around a dredge operating just north of the Intracoastal Waterway showed that no measurable bottom density flow could be detected over 1200 to 1500 feet away from the dredge. Similar measurements and results were made by May (1973) in Mobile Bay.

The management program as issued and enforced by the Texas Parks & Wildlife Department can be improved as our investigations pointed out (EIS, 1973). It is felt that presently one of the main deficiencies is the lack of proper positioning equipment by both the State Agency and the dredging companies. This results in frequent disagreements as to the distance the dredge operates off reefs and shorelines. The regulations also do not properly take into account the variations in climatic and circulation conditions. The State's siltation measurements, done with silt traps, do not present true values as they do not measure the removal of silt by currents and waves.

The policies and techniques used in Mobile Bay may form a good example for the Texas Parks & Wildlife Department as they will aid in preventing many of the present misunderstandings and subsequent violations. It was not the Texas A&M team's responsibility to discuss the present distribution of permit areas in the bay although suggestions have been made to open certain areas. The deepening caused by the dredging operation would increase flushing and remove small shallow highs which can be a hazard to recreational activities. It is realized that temporary damage may result. Implantation of artificial reefs was discussed but lack of data from such experiments in Texas bays prevented suggestion of proper guidelines.

The economics of shell dredging is considered to be very important to the State. Shell is number two in bulk volume in the Port of Houston and any sudden change in supply would create a serious economic impact. Most of this material is used as calcium carbonate in cement production, the chemical industry and for road construction. A complete change to limestone will be necessary in the near future as shell deposits become depleted. Presently no sufficient means of transportation exist for a complete change over. It is felt that the State should carry out a careful study on its natural resources and prepare guidelines for their exploitation. Strip mining of limestone in the Edwards Plateau has been done on a relatively small scale for a long time. A complete change over to that source should be investigated.

CONCLUSIONS

The Impact Assessment study as undertaken by the large Texas A&M University team has covered many aspects of the influence of shell dredging on the environment. It should be realized that certain phases of the study require much more time than was allowed. Nevertheless, it was concluded that the Environmental Impact Statement represents an unbiased scientific evaluation based on field work and the scientific merit of the investigations. It is realized that existing biased opinions cannot be changed and that whatever our conclusions were, objections would be raised.

The study revealed that the present shell dredging activities in San Antonio Bay, under the present managerial guidelines, do not create any long-term detrimental effect to the bay and to the Aransas National Wildlife Refuge. However, there is room for improvement in many aspects. These should be seriously considered by all agencies and industries involved. The economic impact should be considered heavily before establishing any policies. Although any artificial activity has some detrimental and some beneficial impact on its surroundings and on the people, it is unfortunate that too many people look at one side of the picture and refuse to accept some compromises or to change preconceived ideas when facts and data are produced by sound scientific practices.

Table I. Schematic presentation of the main parameters studied in the San Antonio Bay area for an Environmental Impact Statement.

Major groups	Main topics	Some specific subjects
PHYSICAL ASPECTS	Input and output	Seasonal extremes
	Flushing rates	
	Tides	Normal, storm effects, floods
	Circulation	Currents, remote sensing, bathymetry changes
	Salinity and temperature	
	Water quality	Nutrients, oxygen, sulphate, phosphate, Eh-pH, metals pollutants
	Turbidity	Natural, artificial
	Climate	Wind, temperature, humidity, precipitation, solar radiation, seasonal variations, extremes: flood, drought, freeze, storm, hurricane
	Dredge discharge	Suspension, bottom flow, density, gradients, directions
GEOLOGICAL ASPECTS	Bathymetry	
	Reefs and dredge cuts	Distribution
	Sediments	Distribution, lithology, mineralogy, textural parameters sedimentary structures
	Subbottom	Seismic profiling, electrical logging, stratigraphy
	Engineering properties	
BIOLOGICAL ASPECTS	Fisheries	Commercial, sports
	Oyster reefs	Characteristics, siltation effects
	Trawling	Bay flats, dredge cuts
	Food habits	Fish, invertebrates
	Tower experiments	Settling plates, cages
	Toxicity levels	Biochemistry
	Dredge effects	Fish, invertebrates
	Foraminifera	
	Interstitial fauna	
	Others	Primarily other bottom invertebrates

Major groups	Main topics	Some specific subjects
WILDLIFE ASPECTS	Refuge	Fauna, flora (types, distribution)
	Coastline	Aquatic plants
	Food chain	Primarily birds
CHEMICAL ASPECTS	Uptake	Tank experiments on uptake of chlorinated hydrocarbons
	Pesticides	Water, sediment, animals. Absorption
	Trace metals	
OTHER ASPECTS	Archeology	By the University of Texas
	Dredging	Dredging operations
	Management	State management
	Economics	Influence of change to limestone

REFERENCES

Arndt, R.N. "The Shell Dredging Industry of the Gulf Coast Region: Report of Investigation", U.S. Dept. of the Interior, Bureau of Mines, in preparation.

Bouma, A.H. and Holliday, B.W., 1973. "Shell Dredging and Environmental Impact Statements", Ocean Mining Symposium II, Houston, Texas, World Dredging Conf., p. 65-84.

Bouma, A.H., Holliday, B.W., Poag, C.W., Hall, G.L. and Appelbaum, B.S., 1973. "The Role of the Geologist in an Environmental Impact Study", Trans. Gulf Coast Assoc. Geol. Soc., XXIII, p. 401-412.

EIS, 1973. "Draft Environment Statement: Shell Dredging in San Antonio Bay, Texas", U.S. Army Eng. District, Galveston, Texas, 68 pp., and Environmental Impact Assessment of Shell Dredging in San Antonio Bay, Texas. Prepared by Texas A&M Res. Found. for the U.S. Army Engineer District, Galveston, Texas, 5 volumes, 741 pp.

Hall, G.L., 1973. "The Subenvironments of Deposition in San Antonio Bay, Texas", Unpubl. thesis, Texas A&M University, 153 pp.

May, Edwin B., 1973. "Environmental Effects of Hydraulic Dredging in Estuaries", Alabama Marine Resources Bull. #9, Alabama Marine Resources Lab., Dauphin Island, Alabama, 85 pp.

THE CASE FOR DREDGE SPECIFICATION STANDARDS
(Hydraulic Cutterhead Type)

By

Alf H. Sorensen
General Sales Manager
Ellicott Machine Corporation
Baltimore, Maryland

INTRODUCTION

The word "specification" is (in Webster's Dictionary) defined as the act or process of specifying; and to specify, in turn, means "to name or state explicitly." In modern times, the actual meaning of "specifications" has been dewatered to include anything...that can be stated...right or half-right, or not clear.

My research tells me that specifications are written often by one man, sometimes by two engineers, or several people, and once in a while by a whole department - and some of my findings can best be told by an illustration:

A governmental agency presented specifications for competitive public bidding describing a small dredge as follows: 200 cy/hr - 26 ft. digging depth - 2000 ft. P.L., Material: silt, clay, sand, gravel and 5 ft. waves - and some detailed mechanical specifications.

It was left up to the bidder to decide what to do with the 5 ft. wave height, and how to measure output. It was up to the bidder to define silt, clay, sand, gravel.

Bids ranged from $100,000 to $700,000 and, of course, low bid system dictated award to the $100,000 bidder. Result - the dredge never worked - a white elephant and tremendous waste of the taxpayer's money.

To go further into detail is useless. The cause, of course, poor specification writing - no standards and ambiguous dredge criteria.

Who Writes Specifications? Naval architects, civil engineers, consultants, contractors, designers, manufacturers - and if you took, let's say, 25 sets of specifications written in the last 5 years for tender, and try to correlate trends, tendencies, communality of criteria and technology, you would be most disappointed. As a matter of fact, if you did not know the specification writers, you could tell which was written by a naval architect or a civil engineer, for instance by attention to certain detail. A naval architect would know how to specify navigation instruments and galley equipment, but give little attention to dredge equipment.

If the specifications are full of detail on frame construction and soil mechanics, you can be sure that a civil engineer had his hand in it.

Further research will also bring out that there is a direct proportion (ratio) between a) nonsuccessful dredges, or degree of failure of dredge and, b) the expertise and clarity with which specifications are written.

As a matter of fact, I even found dredges in the industry that were built without writing specifications, and in very few cases specifications are written after the dredge is built.

Types of Specifications: There are basically two groups of specifications. (Figure 1) The left column shows technical criteria. Under the Performance column you will find details on operation, output, material to be dredged, etc., and on the right, under Mechanical, you will find mechanical detail such as hull size, stability, engine data,

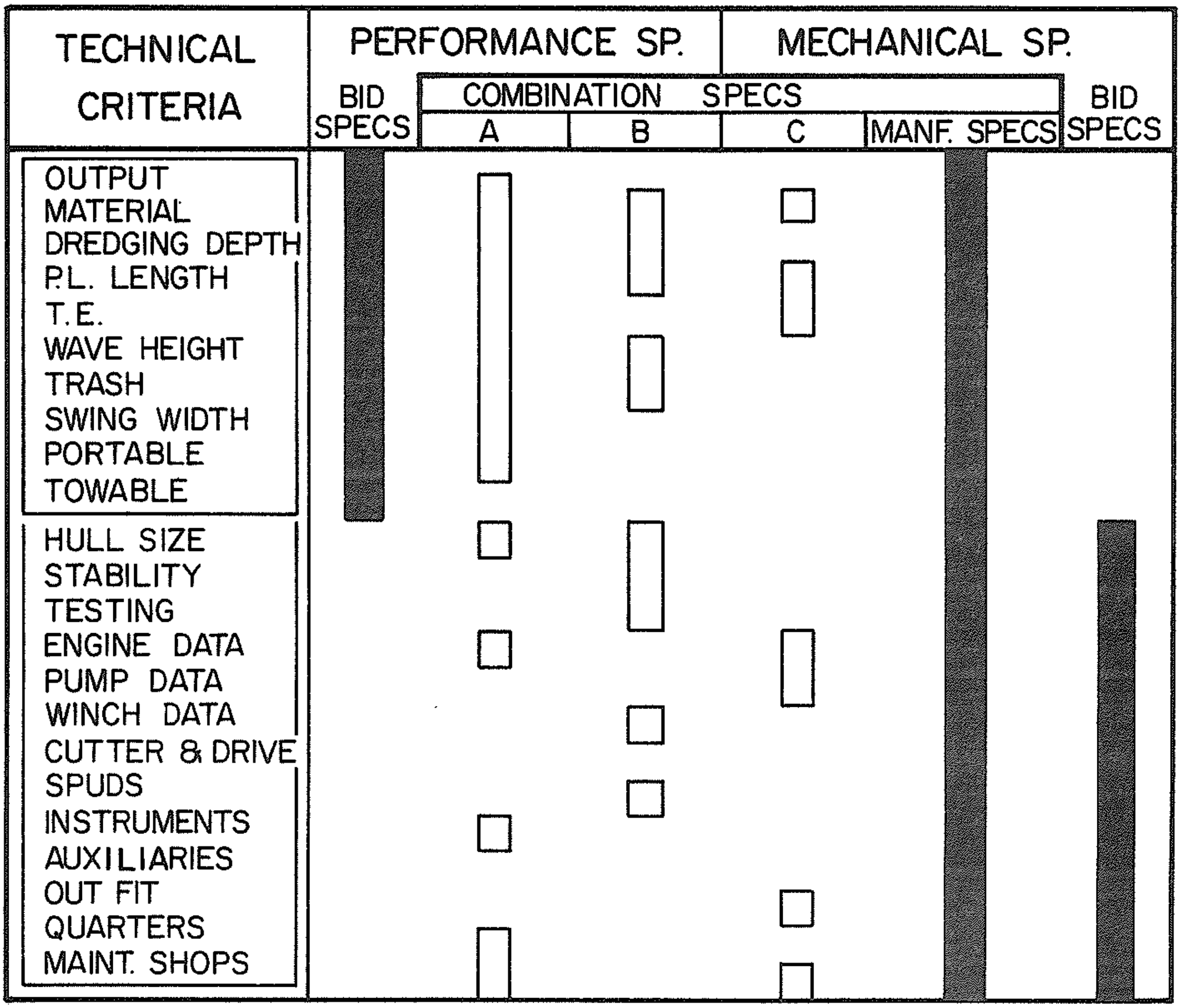


Figure 1. Types of specifications.
Cutter suction dredge
(Illustrative only)

pump data, winch data, etc. A number of specification writers who prepare bid tenders will only outline performance and leave it up to the builder to prescribe mechanical detail. This particular specification writer assumes that the bidder knows what he is doing and can build the right machine for the job. The mechanical specification writer is usually a "so-called dredge expert" and can design a machine and give the bidder all the detail he needs for his estimators to prepare a bid price. Such bid specifications are extremely dangerous - they are never complete, and force the bidder to make many guesses. Usually, this type of specification writer ends up as a customer's engineer on the job - throughout the job, designing and specifying as he goes along.

Our Dredge Industry has a very high rate of economical failures in this category. Some of you here in this audience have seen both builders and owners go bust due to poor management of risk taking offered by this system.

In the center bracket, I have shown a combination: that is, three specifications, A, B, and C, where the specification writer gives you pieces of the performance requirement and pieces of the mechanical detail, and you will never find two specifications alike in this category.

The long column I call Manufacturers or Builders Specifications - and this type of specification should normally be complete, both in performance and mechanical detail. Such specifications do exist, but there are very few companies in the dredge world that can produce specifications that will fit this column. As we build up standards, more will.

Figure 2 is a further analysis of specification writing. The grouping of components is shown in the left column, and the percentage

GROUPING OF BASIC DREDGE COMPONENTS	% OF TOTAL COST	SPECIFICATION INFORMATION RATING							
		A	%	B	%	C	%	D	%
STRUCTURAL COMPONENTS, HULL, HOUSE, FRAMES	28	10	24	14	4	3	11	35	22
DREDGING COMPONENTS, CUTTER, PUMP(S), SUCT/ DISCH PIPE, SPUDS, WINCH(S), LADDER	32	2	5	2	4	1	4	5	3
MOTIVE POWER, ENGINES	10	1	2	1	2	0	0	3	2
ELECTRIC SYSTEM HYDRAULIC SYSTEM	15	0	0	5	9	3	11	10	6
CONTROL CENTER	3	1	2	1	2	2	7	15	11
MISCELLANEOUS AND OPTIONAL EQUIPMENT	7	5	12	10	19	10	40	30	20
OUTFIT, PAINTING, TESTING	5	22	55	22	40	7	27	55	36
TOTAL	100%	41	100%	55	100%	26	100%	153	100%
COST OF DREDGE		0.6 M $		0.3 M $		1.2 M $		9 M $	

Figure 2. Analysis of four (4) dredge specifications

of total dredge cost of each group is shown in the next column. I have examined four different specifications - A, B, C, and D. In the first column under each, I rated the individual specification on the basis of completeness of detail and meaningful description, as well as my estimate of work put into each specification and the number of pages.

The four specifications were quite different, written by different people, so I did not assign the same grading system but a grand total of points of 41 for A, 55 for B, 26 for C, and 153 for D. After I had graded these, I converted the grade into a percent of total rating for each grouping (example: Grade 10 gives 24% of 41). This may appear on the surface to be a very academic exercise, but look what it illustrates.

For structural components, designers did reasonably well with 24% for A and 22% for D, compared to 28% of total cost. But, for dredging components, motive power and systems (32 + 10 + 15) totaling 57% of dredge cost, the specifications were 5 + 2 + 0 = 7% for A, and 4 + 2 + 9 = 15% for B. For A, the specification effort is 12 + 55, or 67%, for only 7 + 5, or 12% of dredge cost.

Now Gentlemen, I show this to illustrate that effort, expertise or meaningful work is lacking in important areas and we must upgrade our efforts in specification writing.

<u>Suggested Communality for Dredge Industry Specifications:</u> Several industries, such as Shipbuilding Industry, Construction Equipment

Industry, Automotive Industry, have agreed to standards to design, safety rules, ratings, performance and reliability.

Time has come for the Dredging Industry to set up a Standards Committee and begin with elementary concepts or criteria, and find out what industry leaders can agree on.

It may take several years of work before a committee will have a set of meaningful standards or format for specifications which will put our industry on par with other modern industrial associations.

Too many times I have been asked, "What is the Dredging Industry?" "Who can I contact for meaningful information about dredges, dredging and dredge engineering?" Many of us here in this audience have met people who ask such questions. Personally, I tell them that I know all the answers, and I snow them with all kinds of high pressure and low pressure sales talk - technology and expertise - by gosh, I am it - nobody else.

I mentioned the Construction Equipment Industry (Figure 3). A crane manufacturer shows the working range of one of his units and also the lifting capacity throughout this range. This is meaningful information, both to the user, designer and builder. It gives mechanical engineering facts, and all facts can be tested. All crane builders today recognize this format of specifications; all use this format so buyer can compare one crane with another. He also spells out that the capacities comply with standards of the Power Crane and Shovel Association as issued by the U.S. Department of Commerce Commercial Standards and SAE Load Test Code.

I have chosen some of the important parameters that dictate dredge design and performance, which could form the basis for future meaningful

MOTO-CRANE®
LIFTING CAPACITIES AND WORKING RANGES

1. The rated loads as determined by boom length, radius and weight of load apply to this machine as originally manufactured and equipped and as mounted on a Thew manufactured MC-330, 8 x 4 carrier. THEY ARE MAXIMUM lifting capacities and comply with standards of the Power Crane & Shovel Association as issued by the U.S. Department of Commerce Commercial Standard CS90-58 and the SAE Crane Load Stability Test Code J765.

1a. Rated loads are based on 85% of stability with the machine being on a firm, level and uniform supporting surface.

1b. Do not exceed the "over-the-rear" capacities when lifting over a corner.

1c. All lifting must be done with gantry erected.

1d. The total weight of bucket plus load must not exceed 80% of the rated "without outriggers" lifting capacities up to a maximum of 6000 lbs. for dragline service and 8000 lbs. for clamshell service.

2. Load-handling devices are part of the load. For jibs, see notes 4, 4a and 4b.

3. Maximum length of main boom .... 140 ft.

4. Jibs may be used straight or goosenecked only on 130 ft. boom or shorter. 20 ft. jib is two-piece and may be extended to 50 ft. with center sections. The following data apply:

Jib Lgth	Max. Lgth. of Boom Including Jib	Maximum Lifting Capacity (Lbs.) Offset from Extended Center Line of Boom			Weight of Jib and Backstays
		0 Ft.	6 Ft.	12 Ft.	
20 Ft.	150 Ft.	15,000	14,000	13,000	1350 lbs.
30 Ft.	150 Ft.	12,000	11,000	9,000	1675 lbs.
40 Ft.	160 Ft.	8,000	7,500	6,000	2000 lbs.
50 Ft.	160 Ft.	5,500	5,000	4,500	2325 lbs.

4a. Capacities for jibs are the same as for the boom length which is equal to the length of main boom plus jib, but in no case may they exceed the capacities shown above.

4b. With jib installed, lifting capacities over main boom head must be reduced as follows:

1550 lbs. for 20 ft. jib
1930 lbs. for 30 ft. jib
2310 lbs. for 40 ft. jib
2700 lbs. for 50 ft. jib

5. The following maximum boom lengths may be carried over the rear.

With gantry erected (15 ft. 7 in. overall height) or gantry lowered (12 ft. 0 in. overall height) (straight forward or backward movement at max. vehicle speed 5 MPH).

110 ft. boom without jib
80 ft. boom plus 30 ft. jib
70 ft. boom plus 50 ft. jib

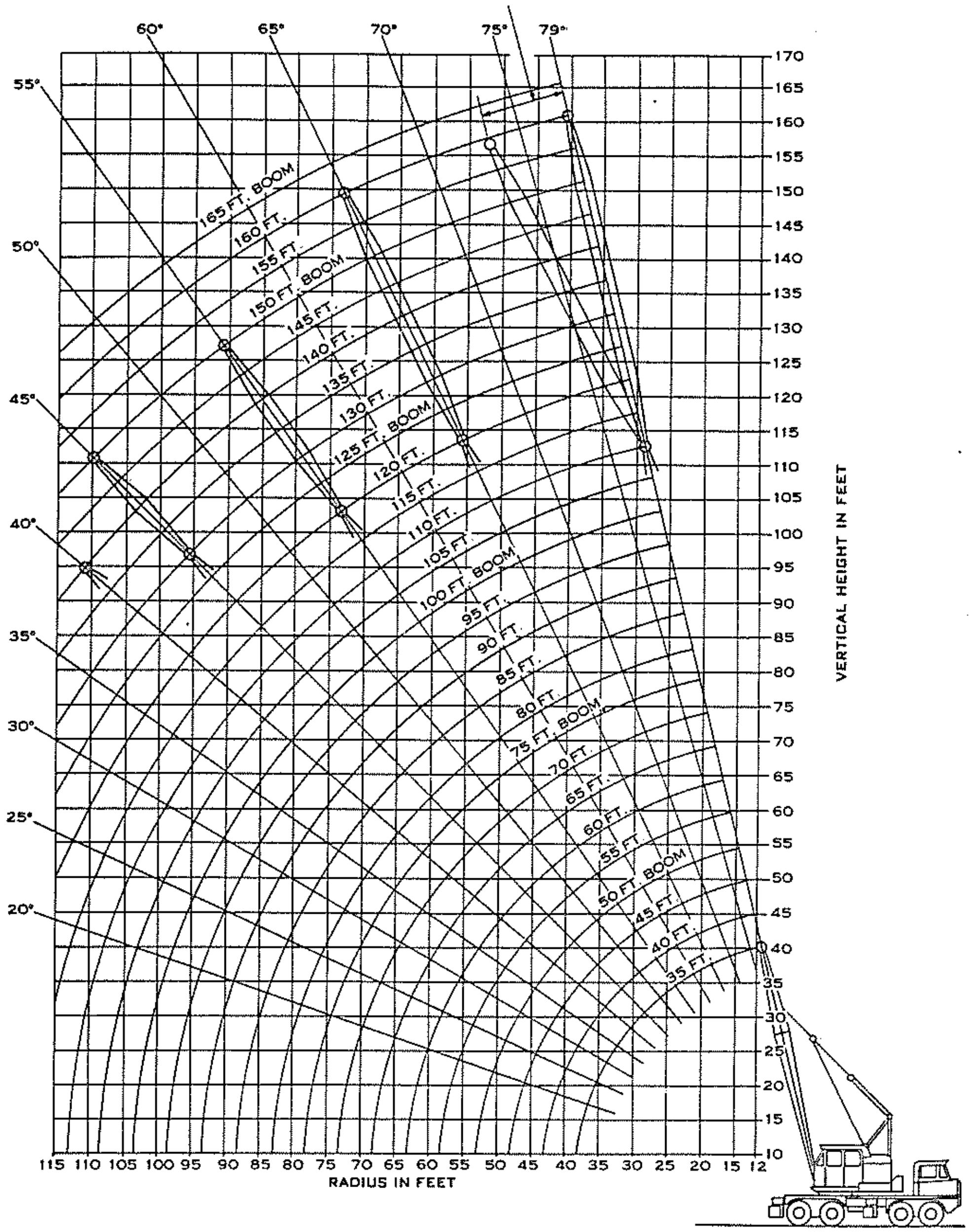
With gantry erected (15 ft. 7 in. overall height) or gantry lowered (12 ft. 0 in. overall height)

90 ft. boom without jib
70 ft. boom plus 20 ft. jib
60 ft. boom plus 40 ft. jib
50 ft. boom plus 50 ft. jib

6. With outriggers set and gantry erected, the following boom lengths may be raised, unassisted, from the horizontal over the rear.

140 ft. boom without jib
130 ft. boom plus 20 ft. jib
120 ft. boom plus 40 ft. jib
110 ft. boom plus 50 ft. jib

7. Minimum number of parts of hoist line to be determined by dividing the load by 10000 lbs. for standard ⅝ in. hoist cable.



BY COURTESY OF **Koehring** Lorain Division Lorain, Ohio 44055

Figure 3.

dredge specification standards.

Instead of submitting to you a 200-page specification (Figure 4), I am suggesting here a two-part beginning format. The left column is entitled "Suggested Standard Specification Format - Index for 7000 HP Dredge." I list Sections 1 to 11 (Read from figure).

The next two columns are named, "Suggested Principal Dimensions and Particulars for 7000 HP Dredge." This is a list of specification items only, etc. (read from figure), and I am confident that, as a starter, we could agree to use this as a basic look-sheet for future work and refinement.

To make this practical, I have extracted from this format certain sections and principal items 5 through 14 are circled, and I think it is logical to start with these.

A. Range Diagram (Figure 5): Figure 5 shows the basic geometry of the range of dredge operation, minimum swing width, minimum D.D., maximum D.D., maximum swing width at maximum D.D. and minimum D.D. This is very basic information, it can be measured and, although obvious to many here, it is meaningful information.

B. Pump (Figure 6): Let's take a look at the pump. What does it look like? After all, if you don't know all the facts about the pump you really don't know what kind of a dredge you are buying. This is the heart of your dredge. Specify it. Describe it. (See figure).

At this point, I want to refer you to Tom Turner's paper submitted to this group giving the basic slurry hydraulics criteria for a dredge system, and this paper would constitute source material for any standards consideration.

Suggested Standard Specification Format - Index for 7000 HP Dredge

SECTION

1. GENERAL DESCRIPTION
   - Performance and Arrangement
2. STRUCTURAL COMPONENTS
   - Hull, Type Construction
   - Frames and Supports
   - Deck House and Control Center
3. DREDGING COMPONENTS
   - Cutter Excavating Unit, Type Construction, Cutter-Swing Acquisition
   - Suction/Discharge Pipe
   - Ladder, Type Construction
   - Main Dredge Pump, Make Model, B.H., HQ Curves, Output Curves, Basic Drives
   - Ladder Dredge Pump, Make, Model, B.H., HQ Curves, Output Curves, Basic Drives
   - Spuds (and/or Stern Swivel) O.D., Length, Type Constr., Operation
   - Winches, Type Construction Reduction Gear Data
4. PRIME MOVERS
   - Make, Model, HP/RPM Curves, Reduction Gear Data
5. HYDRAULIC POWER SYSTEM) Schematic
6. ELECTRICAL SYSTEM)
7. CONTROL CENTER & OPERATING CONTROLS
   - Detailed List
8. MISCELLANEOUS EQUIPMENT
   - Detailed List of Items Such As Sea Chest, Pump, Flap Valves, Swivel Elbow, Gauges, Etc.
9. INSTRUCTION MANUALS
10. PAINTING
11. ASSEMBLY AND TESTING
    - Full Procedure, Nozzle Tests

SUGGESTED PRINCIPAL DIMENSIONS & PARTICULARS FOR 7000 HP DREDGE

HULL:

- Length ______
- Width ______
- Depth ______
- Weight, Approx. (inc. deckhouse) ______
- Plate Thickness ______
  - Bottom ______
  - Bilge Radius ______
  - Sides, Except Sheer Strake ______
  - Sheer Strake ______
  - Main Deck ______
  - Bulkheads ______

PRIME MOVERS:

- Main Dredge Pump Engine (Model) SHP ______
- Ladder Dredge Pump Engine (Model) SHP ______
- Auxiliary Engines (Models) SHP ______
- Main Generator (KW) - (Model) SHP ______
- Auxiliary Generator (KW) SHP ______
  - Total Connected SHP ______

CUTTER:

- Shaft Horsepower ______
- Speed Range, RPM ______
- Cutting Force ______
  - Total Pounds ______
  - Pounds Per Linear Inch ______
- Head Mean Diameter ______
- Number Of Blades ______
- Reduction Gear Ratio ______
- Shaft Diameter ______
- Number of Motors ______
- Cutterhead Weight ______

FORWARD WINCH, SWING & LADDER:

- Shaft Horsepower ______
- Line Speed) On Second Layer ______
- Line Pull) ______
- Ladder Hoisting Speed ______
- Wire Size ______
- Number of Drums ______
- Drum Capacities ______
  - Swing Wire - Two @ ______
  - Ladder Wire ______
  - Type Motors ______

STERN WINCH, SWIVEL:

- Number of Drums ______
- Shaft Horsepower ______
- Type of Motors ______
- Line Speed) On Second Layer ______
- Line Pull) ______
- Holding Capacity ______
- Wire Size ______
- Drum Capacity ______

GENERAL:

- Mean Draft, Operating Condition ______
- Mean Freeboard, Operating Cond. ______
- Digging Depth, Using Spuds ______
- Digging Depth, Using Swivel ______
- Fuel Oil Tank Capacity ______
- Suction Pipe (ID & OD) ______
- Discharge Pipe (ID & OD) ______
- Ladder Length, Overall ______
- Fresh Water Tank Capacity ______
- Lube Oil Tank Capacity ______

WEIGHTS, POUNDS - ESTIMATED:

- Total Assembled Dry Weight ______
- Ladder ______
  - Ladder-Cutter Drive Section ______
  - Ladder Extension ______
  - Ladder Pump Section ______
  - Ladder-Aft Section ______
  - TOTAL ______
- Forward Frames Incl. Fittings ______
- Stern Swivel Assembly ______
- Fairleader Assembly ______
- Control Room ______
- Dredge Pump Casing ______
- Dredge Pump Engine (Bare) ______
- Dredge Pump Reduction Gear ______

Figure 4. Suggested Standard Specification Format - Index for 7000 HP Dredge

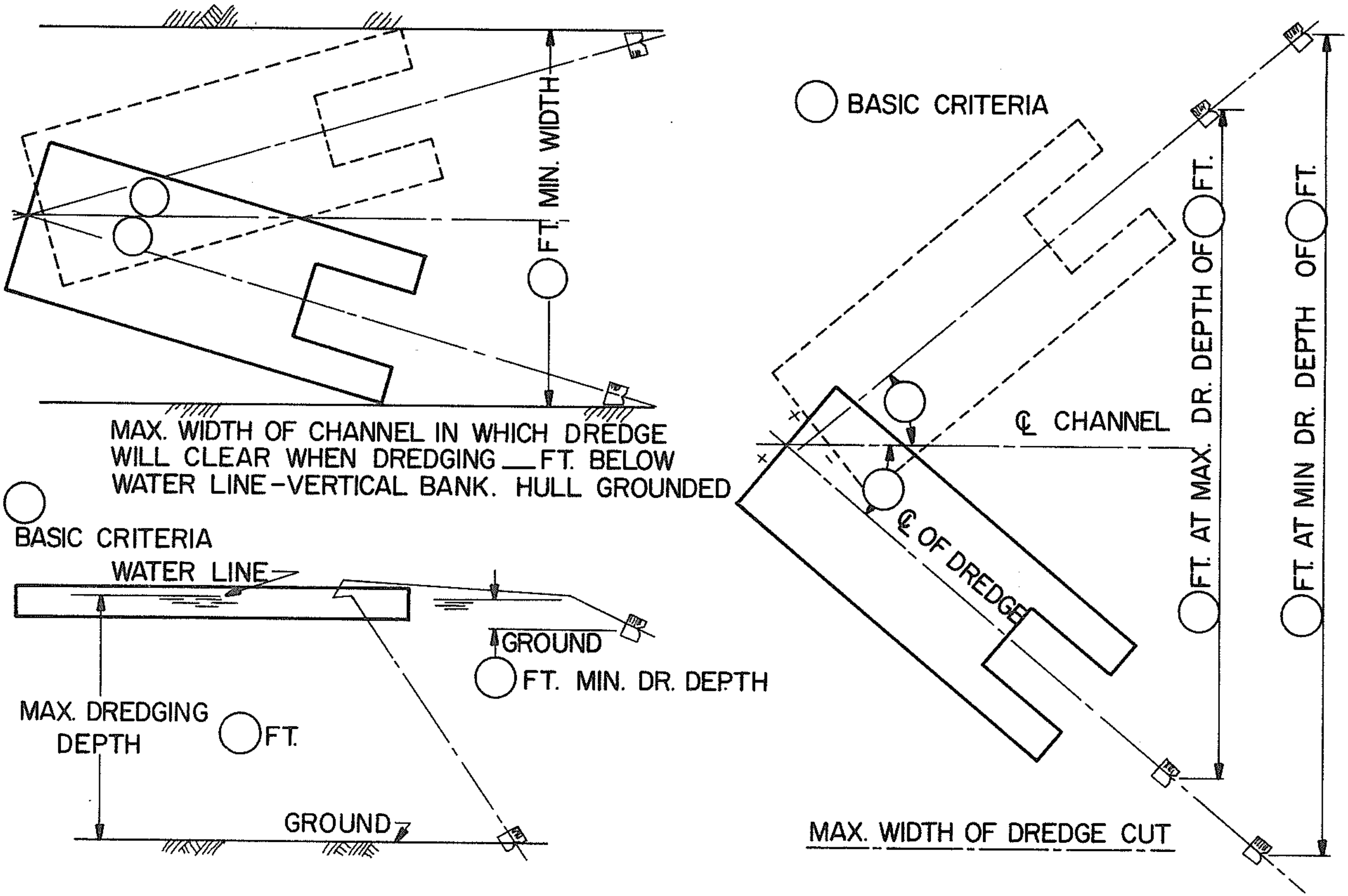
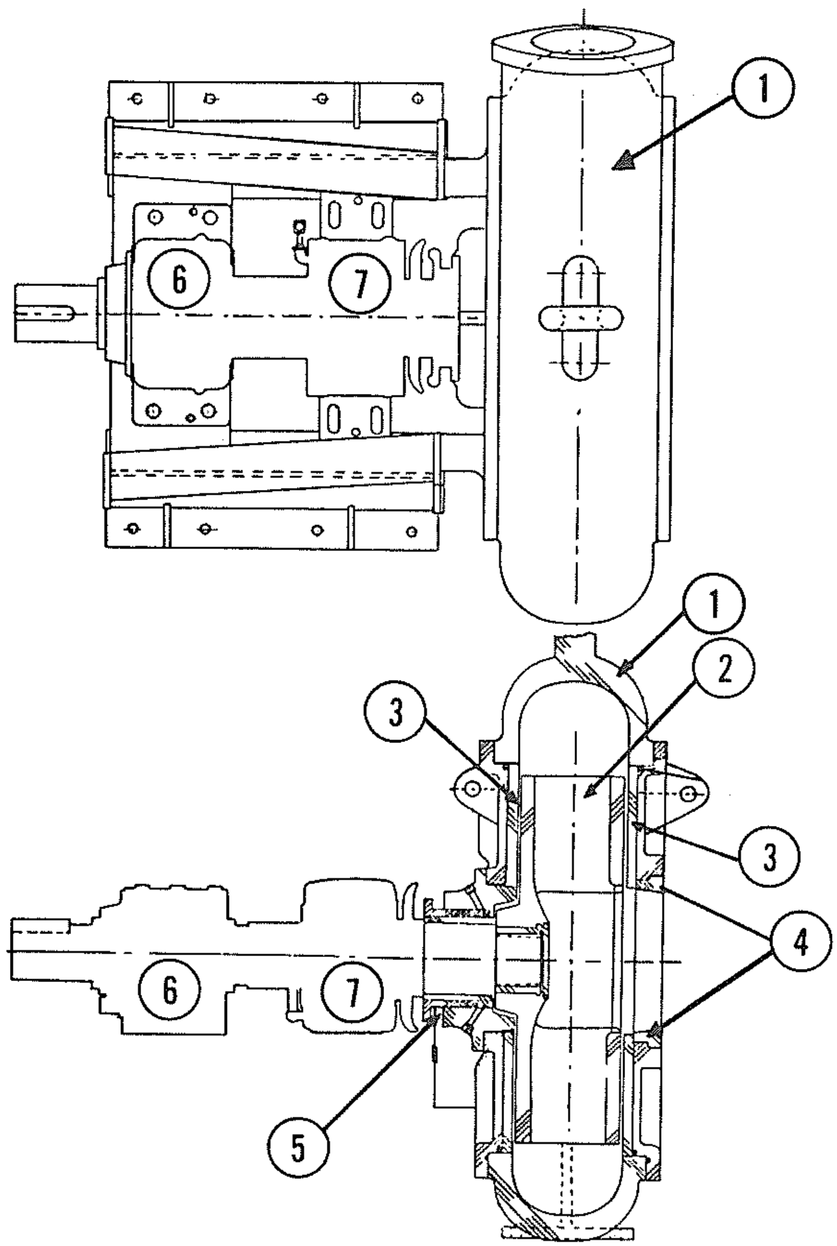

FT. MIN. WIDTH
MAX. WIDTH OF CHANNEL IN WHICH DREDGE
WILL CLEAR WHEN DREDGING __ FT. BELOW
WATER LINE-VERTICAL BANK. HULL GROUNDED
BASIC CRITERIA
WATER LINE
GROUND
FT. MIN. DR. DEPTH
MAX. DREDGING
DEPTH
FT.
GROUND
BASIC CRITERIA
℄ CHANNEL
℄ OF DREDGE
FT. AT MAX. DR. DEPTH OF FT.
FT. AT MIN DR. DEPTH OF FT.
MAX. WIDTH OF DREDGE CUT

Figure 5.

DREDGE PUMP ASSEMBLY



1.Pump Case

2.Impeller

3.Liners

4.Throat Piece

5.Stuffing Box

6.Combination Radial-Thrust Bearing

7.Radial Bearing

NOTE:All wet parts made from 600 BH Chrome Carbide.

Figure 6.

Ellicott MACHINE CORPORATION
Baltimore, Maryland 21230 U.S.A.

C. HQ Curve (Figure 7): This shows a head-quantity curve. If a HQ is to mean anything at all, it should show: Impeller diameter, blade width, number of blades, SG of liquid to pump (this should be 1 for SG of water) and should show RPM curves - SHP curves - and efficiency curves. Many dredge pump manufacturers show only some of these parameters. For example, they eliminate efficiency and we should insist that all these parameters are shown, otherwise HQ data is not meaningful.

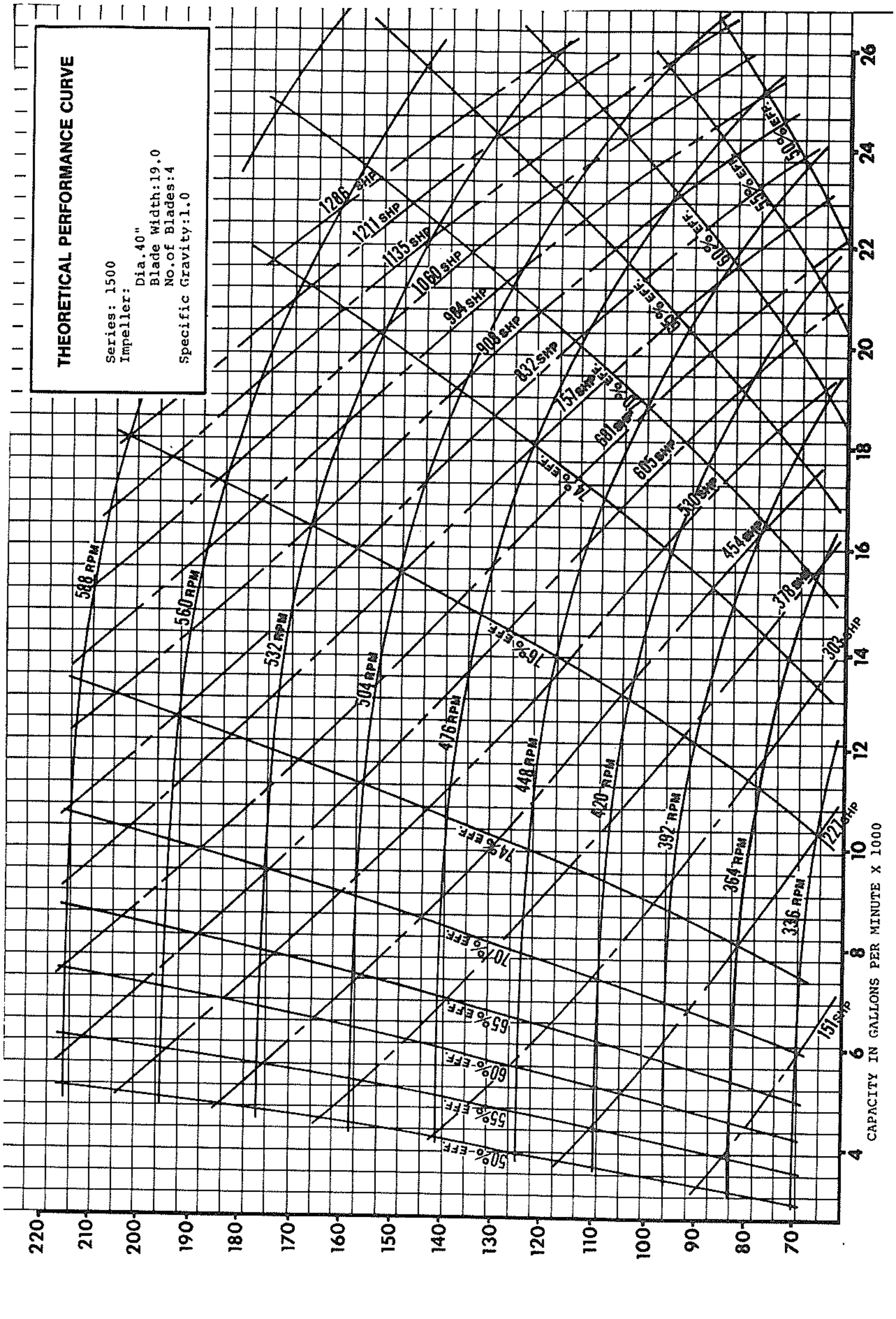
Figure 8 shows a similar curve for an underwater dredge pump, if this is to be installed. To make both of these curves meaningful, it must be tested by the well-known Nozzle or Orifice Test, the details of which are not shown.

D. Output Information: In my experience, it is difficult to get a group of dredge engineers, let alone the naval architects and civil engineers, to agree on all criteria needed to establish output information. The main reason for this is that from job to job the operating conditions and materials to be dredged vary so much that it is physically impossible to assemble enough true empirical data before each job is bid.

The compactness of soils - density, S.G., the grain size distribution, etc., all vary.

There are, however, a few parameters we can agree to - and let's start with these:

Grain Size Scale - (Figure 9): We should have a common definition of sand. You will be surprised how many different definitions there are for sand. My suggestion is that we start with agreeing on a grain size definition and specification. Only after agreeing to this can we get down to agreeing on other parameters within the field of soil mechanics (hardness, swell factor, void ratio, L.C., etc.).



THEORETICAL PERFORMANCE CURVE
Series: 1500
Impeller:
Dia.40"
Blade Width:19.0
No.of Blades:4
Specific Gravity:1.0
CAPACITY IN GALLONS PER MINUTE X 1000
588 RPM
560 RPM
532 RPM
504 RPM
476 RPM
448 RPM
420 RPM
392 RPM
364 RPM
336 RPM
1286 SHP
1211 SHP
1135 SHP
1060 SHP
984 SHP
908 SHP
832 SHP
757 SHP
681 SHP
605 SHP
530 SHP
454 SHP
378 SHP
303 SHP
227 SHP
151 SHP
50% EFF.
55% EFF.
60% EFF.
65% EFF.
70% EFF.
74% EFF.
76% EFF.
74% EFF.
70% EFF.
65% EFF.
60% EFF.
55% EFF.
50% EFF.

Figure 7

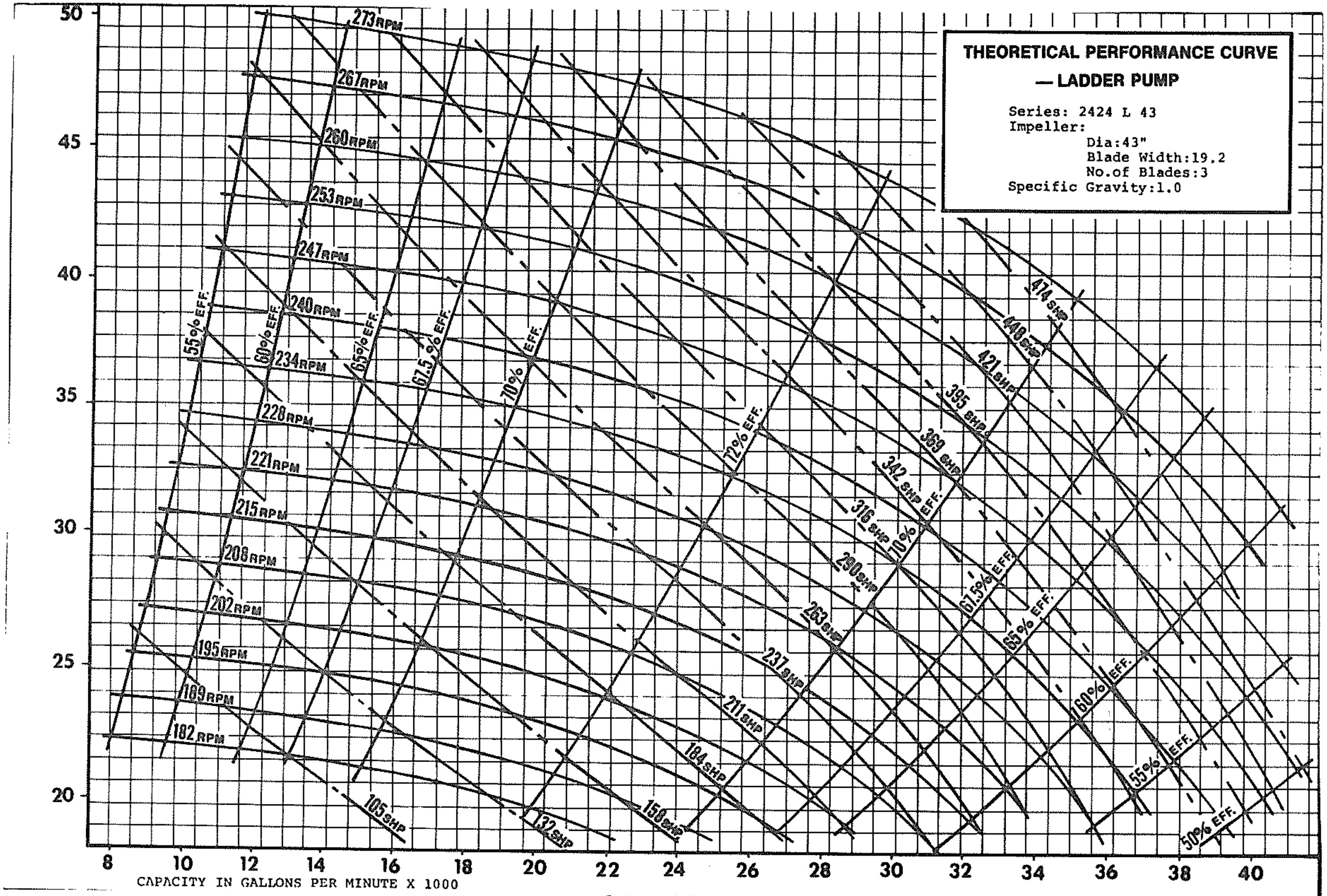

THEORETICAL PERFORMANCE CURVE
— LADDER PUMP
Series: 2424 L 43
Impeller:
Dia:43"
Blade Width:19.2
No.of Blades:3
Specific Gravity:1.0
273 RPM
267 RPM
260 RPM
253 RPM
247 RPM
240 RPM
234 RPM
228 RPM
221 RPM
215 RPM
208 RPM
202 RPM
195 RPM
189 RPM
182 RPM
55% EFF.
60% EFF.
65% EFF.
67.5% EFF.
70% EFF.
72% EFF.
50% EFF.
105 SHP
132 SHP
158 SHP
184 SHP
211 SHP
237 SHP
263 SHP
290 SHP
316 SHP
342 SHP
369 SHP
395 SHP
421 SHP
448 SHP
474 SHP
CAPACITY IN GALLONS PER MINUTE X 1000

Figure 8

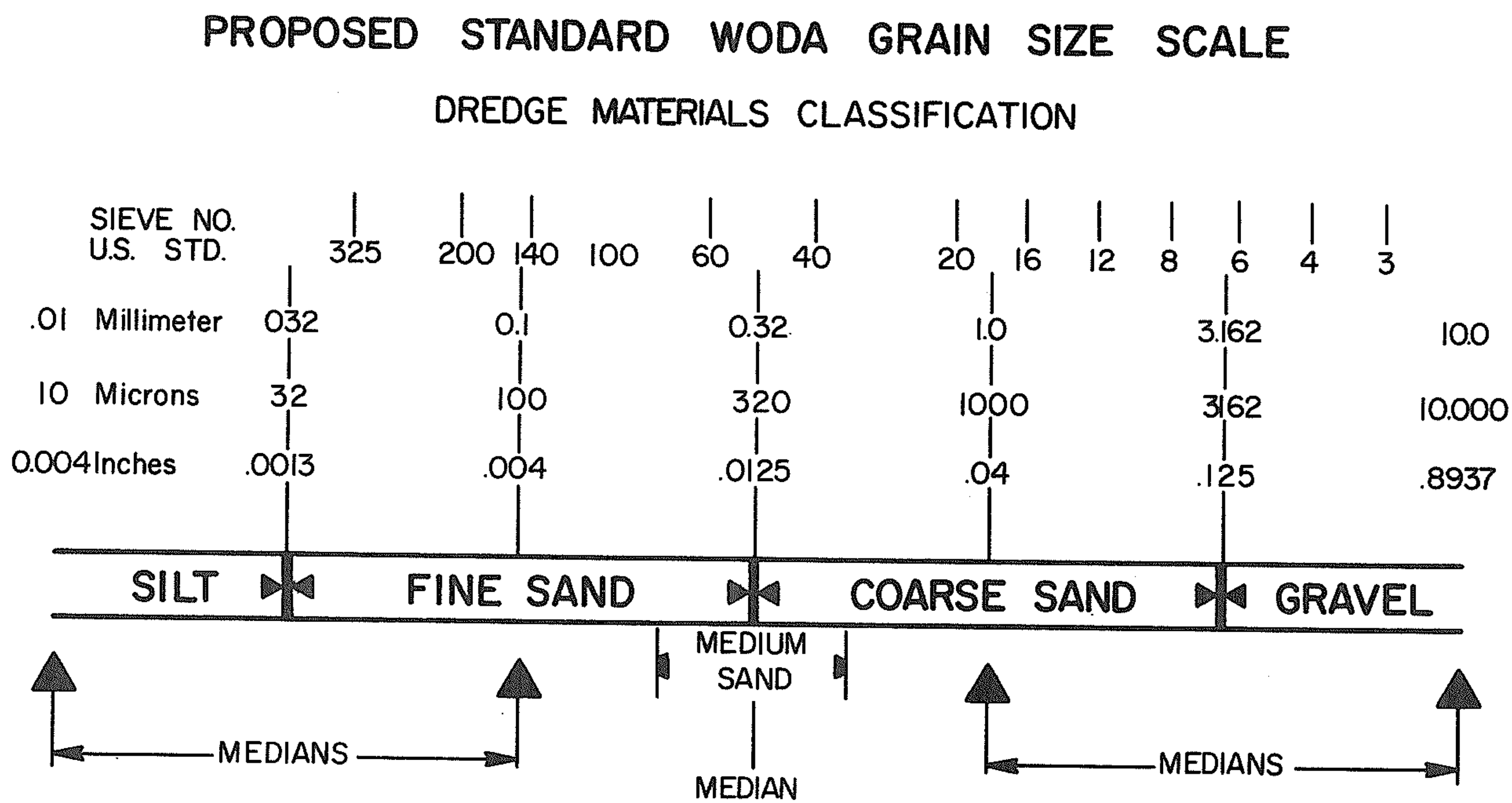

PROPOSED STANDARD WODA GRAIN SIZE SCALE
DREDGE MATERIALS CLASSIFICATION
SIEVE NO. U.S. STD.
325
200
140
100
60
40
20
16
12
8
6
4
3
.01 Millimeter
032
0.1
0.32
1.0
3.162
10.0
10 Microns
32
100
320
1000
3162
10.000
0.004 Inches
.0013
.004
.0125
.04
.125
.8937
SILT
FINE SAND
COARSE SAND
GRAVEL
MEDIUM SAND
MEDIANS
MEDIAN
MEDIANS

Figure 9.

I suggest that we define silt as anything smaller than (see Figure 9) 0.032 mm, 32 microns or 0.013". Fine sand should be materials in the range of 0.032 mm to 0.32 and the median 0.1; coarse sand is in the range of 0.32 - 3.162 mm, median is 1.0; and gravel larger than 3.162 with median at 10.0 m.

Some of you will object to this and challenge my use of the word "meaningful", since no job has material that is so easy to classify. You are right. We are familiar with grain size distribution curves and how they vary, but let us agree on something, and agree on how to specify.

E. Calculated Output Curves (Figure 10): If we use this grain size standard, we can then give Calculated Output Curves for a dredge and further develop meaningful tools for relating material, suction diameter, discharge diameter, impeller speed and diameter, terminal elevation, dredge efficiency, output, pipeline length, and digging depth. The development of these curves is given in Tom Turner's paper, to which I referred earlier.

F. Cutter-Winch Equipment: Note that I combine cutter-winch. Don't specify one without relating to the other. Most of us are used to rating a cutter by H.P. What H.P.? Where is the power? At the diesel engine? At the electric motor? At the cutter shaft? Where is it? How do you measure it? How does it relate to the winch, prime mover, cutter speed, line speed, line pull? Is it constant? Does is vary?

A 1000 H.P. cutter in Belgium means an 800 H.P. in Chicago and a 1500 H.P. cutter in Australia. I have seen specifications call for a 500 H.P. cutter and when the dredge got on the job, it only measured 250 H.P.; and the purchaser and specification writer did not even know

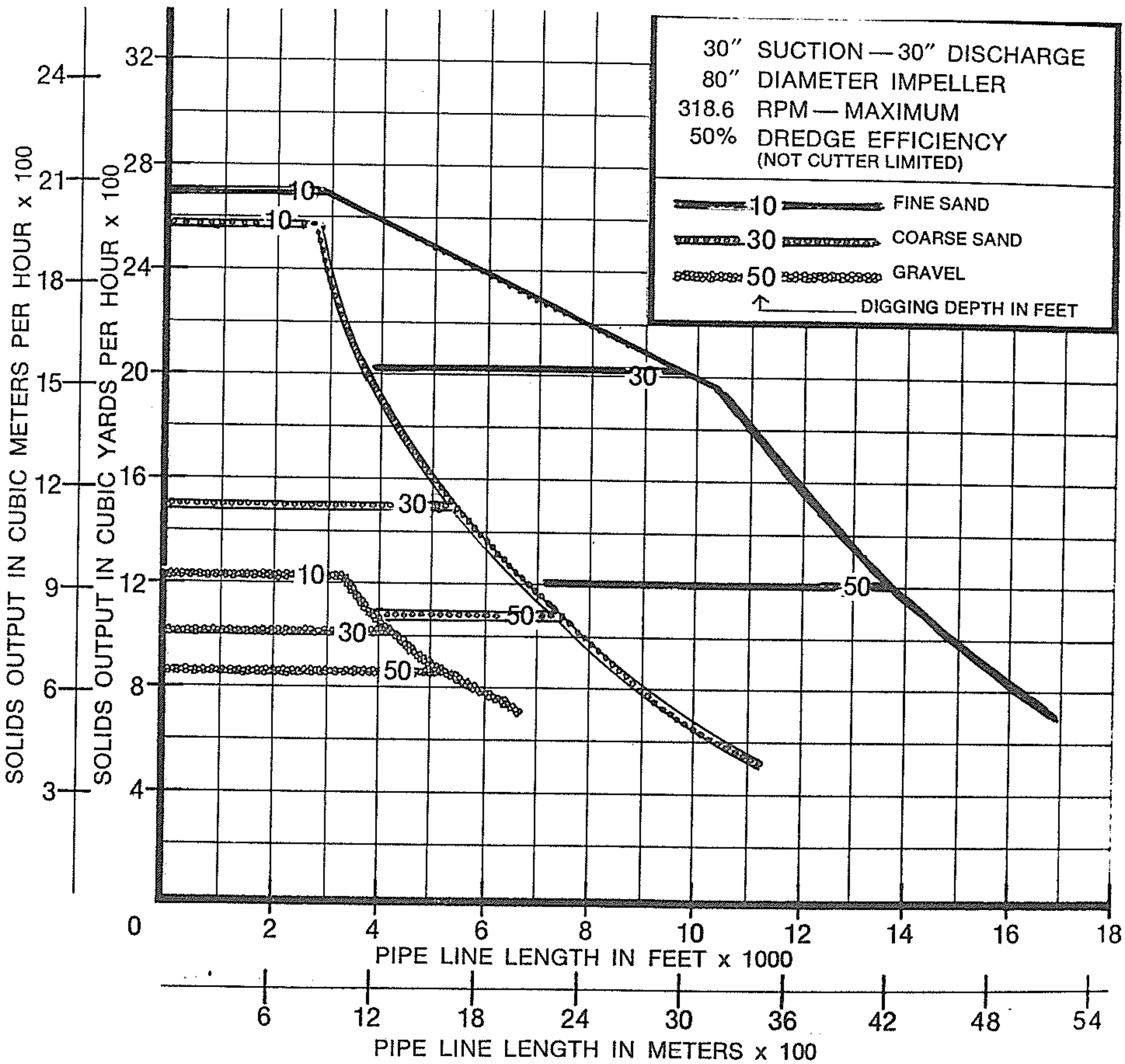


Figure 10. Typical calculated output

that they had only 250 H.P.

I am convinced that engineers in this industry today can do better than this (Figure 11).

Let us describe the cutter module, type cutter, size of cutter, shape, bearings, shaft, gear, drive motors, couplings - how does it work? (Figure 12) Instead of cutter power, specify cutter force. Let us wade through all of the double talk that has existed in specification writing at this point, and select, for instance, cutter diameter, calculate or measure power losses and manage our way from motive power drive to actual cutter force. This can be measured. Let us assume a cutter force F, of about 50,000 lbs. This figure shows suggested standard cutter-winch curves. On top, cutter force is on the Y-axis and speed is on the X-axis. It is easy to specify how the cutter force relates to speed, i.e., to show actual cutter force at all speeds. For example, if you have constant force over the 10 to 100% speed range, show it. Specify it as on this upper line.

If you want a 3-step system, constant speed, constant force at the 33% speed line, show it. If you switch in a second hydraulic motor at 66% speed to get twice the cutter force, you can show a line like this in the middle.

If you, for instance, have a cutter force from 0 to full force over the 0 to 100% speed range, this can conveniently be shown as on the angled line.

The exact same method of specifying can be done for the winch (see Figure 12).

Figure 13. The relationship between cutter and line pull can also easily be standardized. If a cutter has a cutting force (F), the line

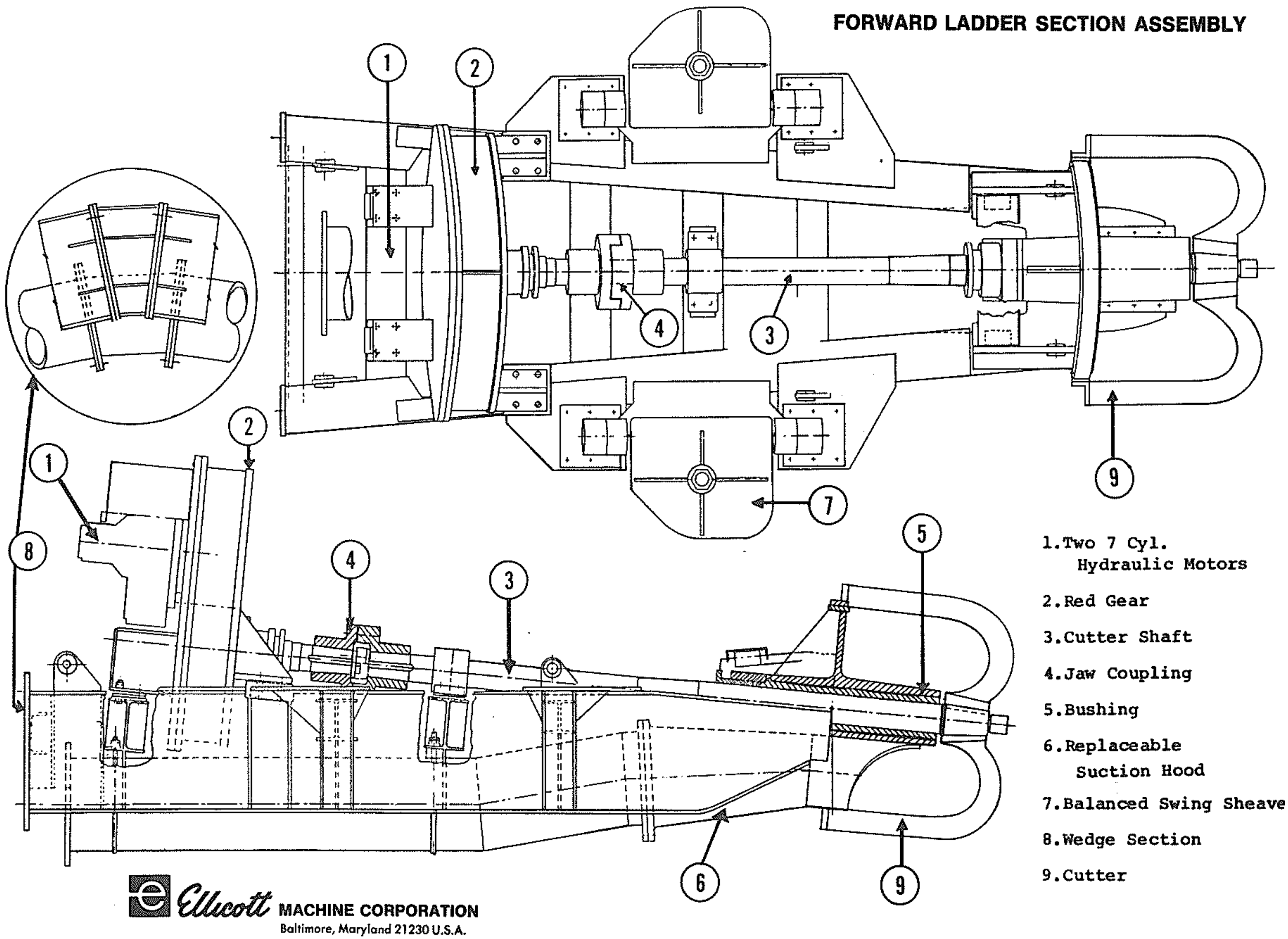

FORWARD LADDER SECTION ASSEMBLY
1
2
3
4
5
6
7
8
9
1.Two 7 Cyl. Hydraulic Motors
2.Red Gear
3.Cutter Shaft
4.Jaw Coupling
5.Bushing
6.Replaceable Suction Hood
7.Balanced Swing Sheave
8.Wedge Section
9.Cutter
Ellicott MACHINE CORPORATION
Baltimore, Maryland 21230 U.S.A.

Figure 11.

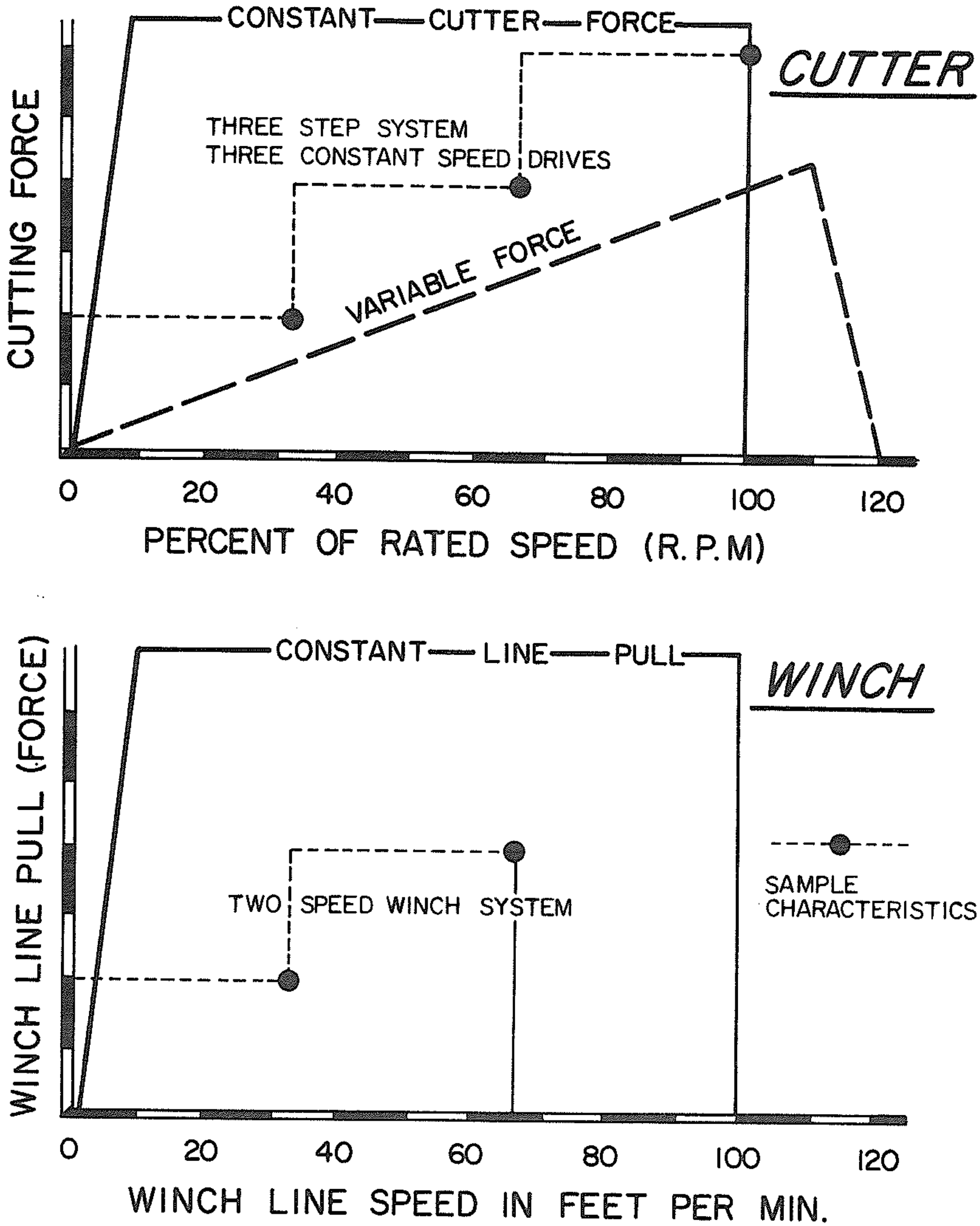


Figure 12. Suggested standard cutter & winch curves.

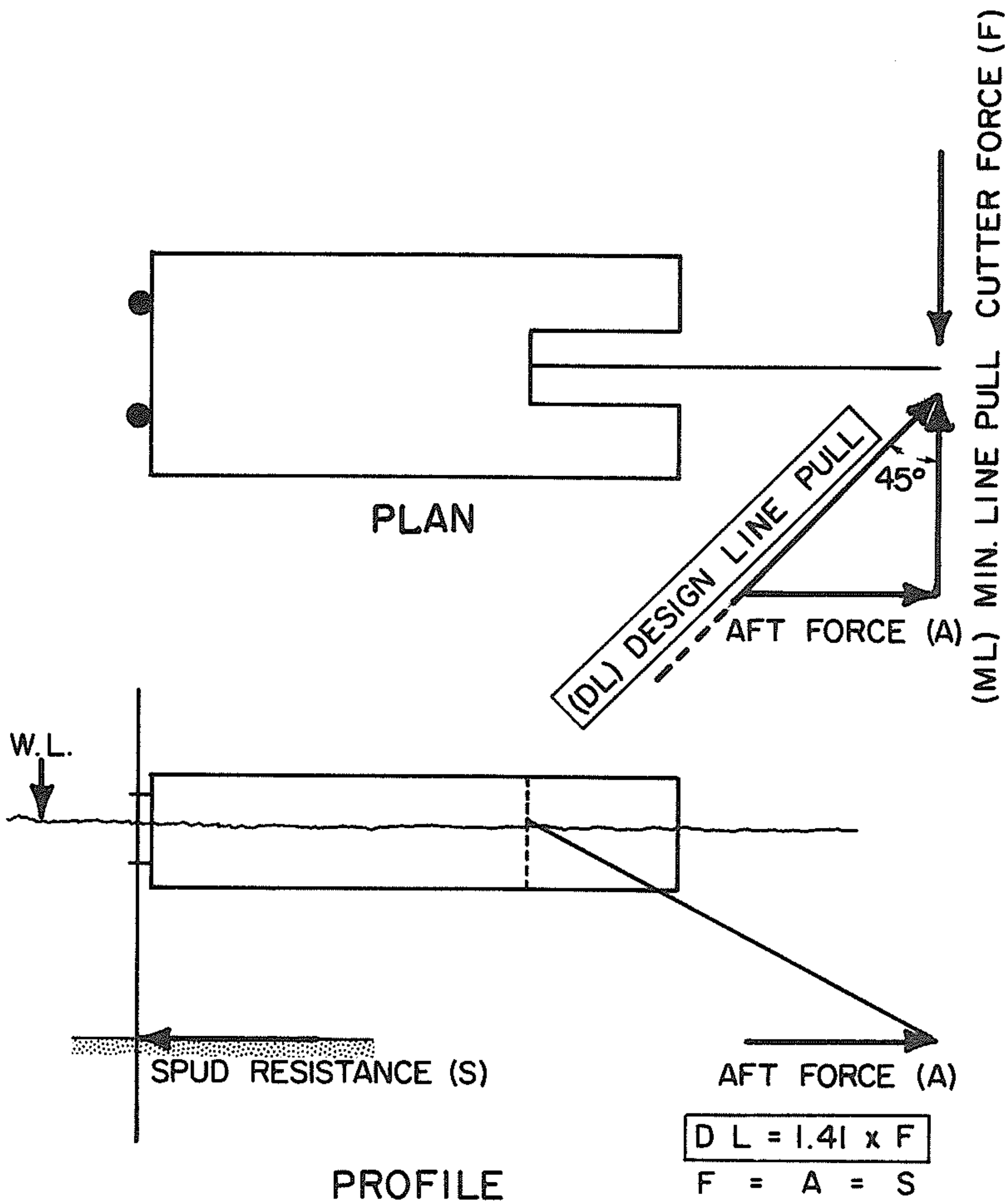

CUTTER FORCE (F)
(ML) MIN. LINE PULL
45°
(DL) DESIGN LINE PULL
AFT FORCE (A)
PLAN
W.L.
SPUD RESISTANCE (S)
AFT FORCE (A)
D L = 1.41 x F
F = A = S
PROFILE

Figure 13.

pull must be at least equivalent when the cable is at 90° to the ladder (M.L.). However, because of the spud-cable-swing system, the cable will at times pull at an angle up to 45%. Therefore, the design line pull (D.L.) must be 1.41 x F (if you have a cutter force of 50,000 lbs., the line pull must be about 70,000 lbs.)

Now, this I am convinced will be one of the first basic sketches that a Standards Committee will agree to. But, look out. What happens when the cable is pulling at 45%? It causes a vector or aft force (A) which induces a spud resistance S. This is equal to F (F=A=S).

This analysis of forces, of course, must be carried through a whole dredge design - wave, wind force, etc., enter in, but are too lengthy for this paper, and it may be more difficult to get agreement among dredge engineers at an early stage.

Let me mention, by the way, you very soon get into spud design at this point. If anyone specifies F = 50,000 and an 8" I.D. spud - watch out! I will let you guess what will happen. You are right! It will bend or break and some of you know that as a fact.

Furthermore, another basic specification item is what I call cutter-swing acquisition (Figure 13). If a cutter-swing system is to be balanced with the pumping or suction system, the cutter needs to acquire (cut and feed) the material. I suggest this basic curve. A cutter must be able to excavate a given volume -- theoretically, the same volume the pump suction can take in. We cannot, however, design for <u>one</u> single condition. We must have a design that has a wide range of cutter-swing acquisition, thus variable cutter and line speed.

This graph shows measurable and calculable parameters, volume, swing speed, percentage of cutter area. For example, - if the pump can handle 1000 cy/hr., but the cutter cannot penetrate the material more than 25% even at full 100% speed, the cutter can feed the suction only 800 cy/hr. However, if you can bury the cutter 100%, you can theoretically excavate over three times as much as the pump can handle.

G. Schematics: Last, but not least, how should we describe electric or hydraulic systems? Practically no specifications give any information on this. Today, either the specification writer underestimates the importance, the builder or designer holds this top secret, or, in case of new design, the information is only developed as the unit is being designed and built. Some day this will be an outmoded procedure, when engineers become "return on investment" minded.

The schematic and design of electric or hydraulic systems and components, such as motors, generators, etc., are a very vulnerable part of the dredge, and a very large part of the cost.

How anybody can launch into the purchase of a dredge of any size without knowing everything about this part of the dredge, is very dangerous. As a starter, I don't insist that we always draw up detailed schematics such as this and make it part of the specifications, but what I do think we can do is to describe at least the type of equipment and operation we want. For example, we can specify from the figures.

CONCLUSION

I have not included specification items such as quarters, instruments, workshop, piping systems, painting, all of which are also proportionately important. I have tailored this presentation to cover some of the most expensive parts of a cutter suction dredge, and I am fully aware that some of you in this audience take these criteria for granted. But there are those who have never known that these criteria exist. I submit that if more attention is paid to this, and further development and thought put into this subject, that both dredge building and dredge operation (ever more and more competitive), will become a more recognizable and significant industry and a more profitable one.

Thank you.

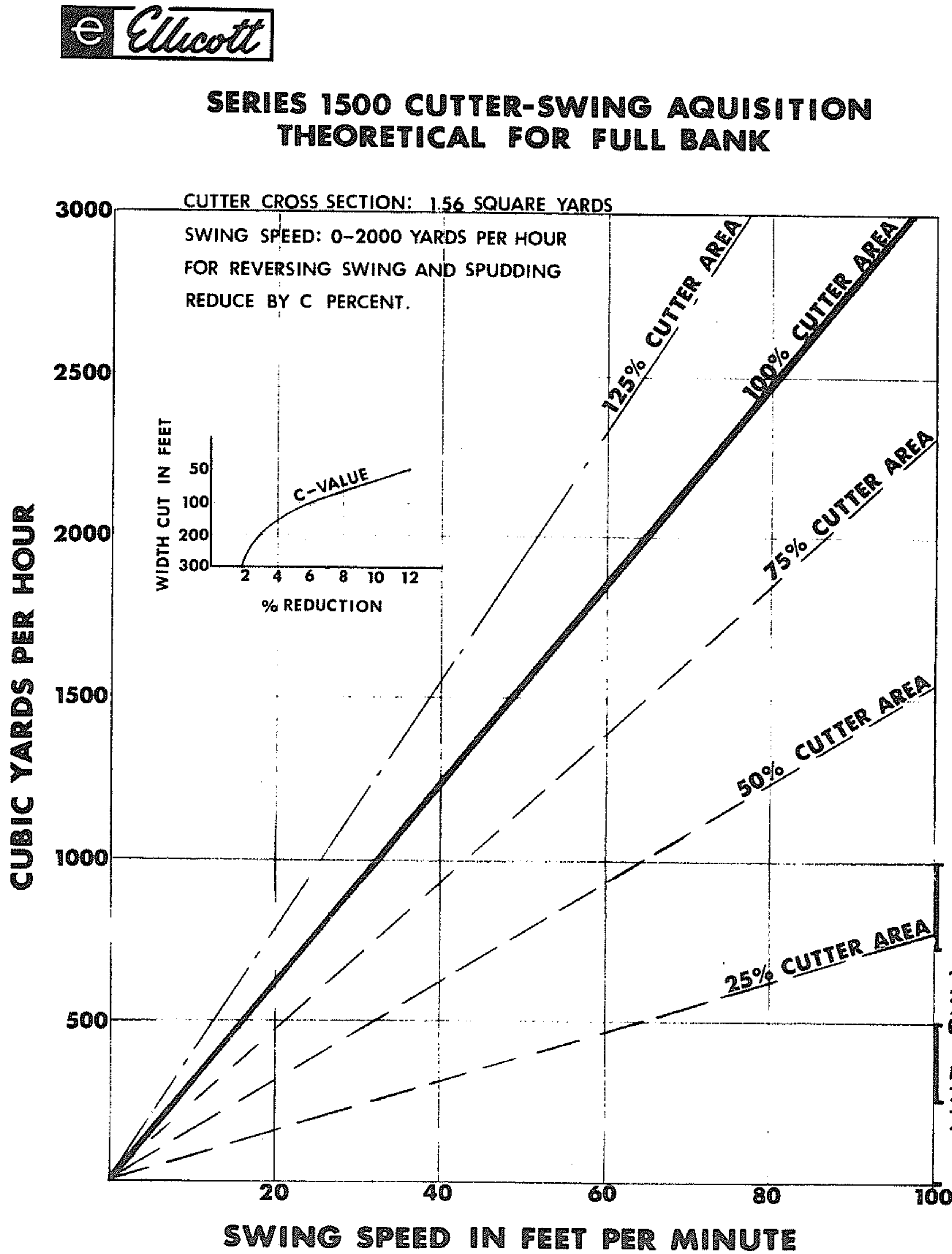

Ellicott
SERIES 1500 CUTTER-SWING AQUISITION
THEORETICAL FOR FULL BANK
CUTTER CROSS SECTION: 1.56 SQUARE YARDS
SWING SPEED: 0-2000 YARDS PER HOUR
FOR REVERSING SWING AND SPUDDING
REDUCE BY C PERCENT.
WIDTH CUT IN FEET
50
100
200
300
C-VALUE
2
4
6
8
10
12
% REDUCTION
3000
2500
2000
1500
1000
500
CUBIC YARDS PER HOUR
125% CUTTER AREA
100% CUTTER AREA
75% CUTTER AREA
50% CUTTER AREA
25% CUTTER AREA
LINE PULL
20
40
60
80
100
SWING SPEED IN FEET PER MINUTE

Figure 14.

SCHEMATIC, HYDRAULIC

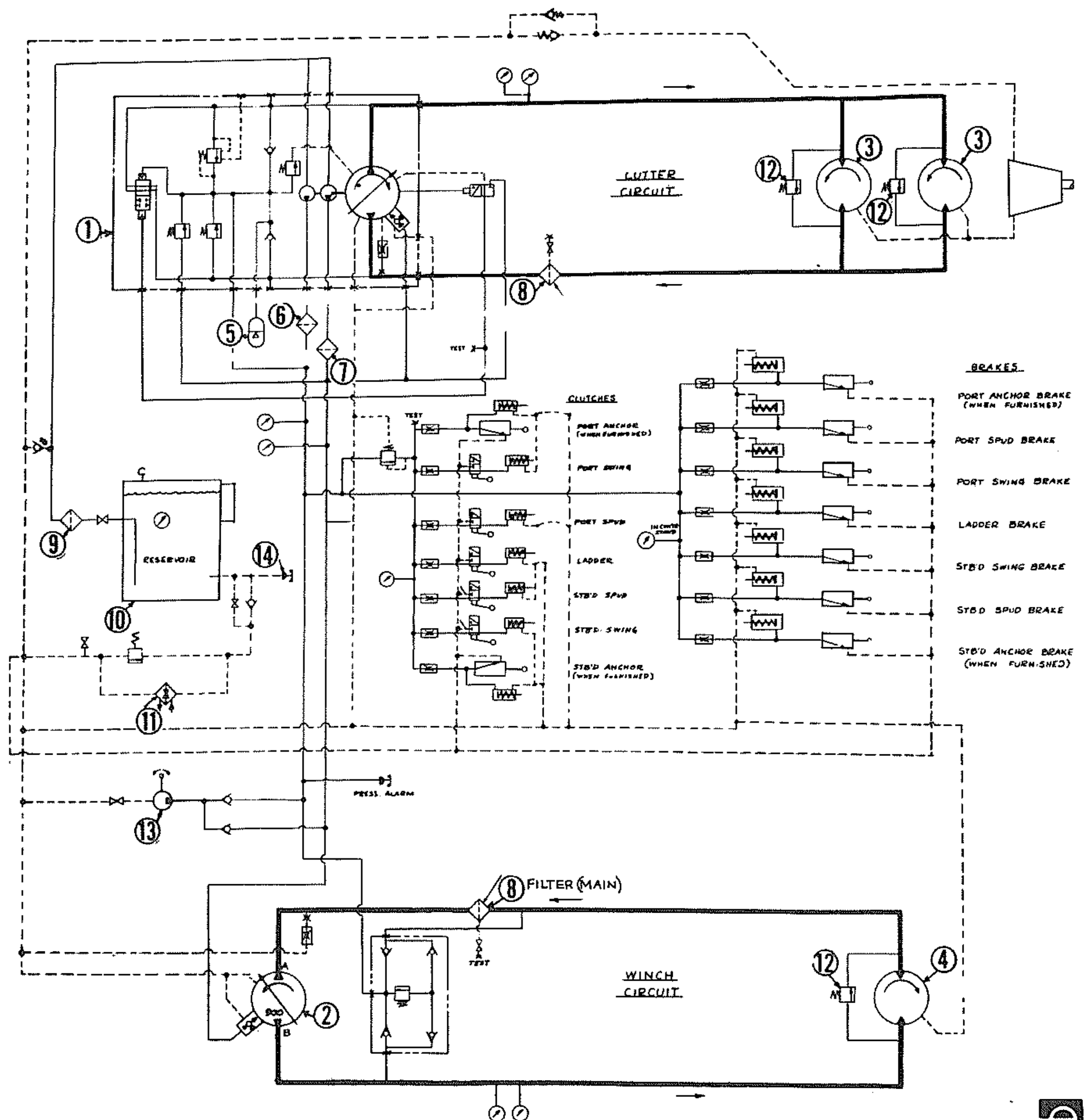


Figure 15

1. CUTTER PUMP, PACKAGE
2. WINCH PUMP
3. CUTTER MOTOR
4. WINCH MOTOR
5. ACCUMULATOR
6. FILTER (MAKE-UP)
7. FILTER (SERVO)
8. FILTER (MAIN)
9. STRAINER (SUCTION)
10. RESERVOIR
11. HEAT EXCHANGER
12. RELIEF VALVE CARTRIDGE
13. HAND PUMP
14. LOW LEVEL ALARM

Ellicott MACHINE CORPORATION
Baltimore, Maryland 21230 U.S.A.

DREDGE FOR 1984

By

Robert J. Jantzen
President
Jantzen Engineering Company
Baltimore, Maryland

As one works in the dredging industry it becomes apparent that very seldom does anyone write about ideas for the future. It is easily understood why this happens since the industry is a well-established one where it is a process of refinements rather than breakthroughs that has led to our present day designs. This, together with the competitive edge that one company tries to gain over another, leads to not only a lack of published literature but a minimum in the exchange of ideas. For this reason I felt it might be of interest to take some of the things that we know about the dredging market ten years into the future and respond with a preliminary design to suit those conditions. As has been noted by many companies in the last ten years, the dredging market has been changing and we are getting more opponents to dredging. The industry's response to these outside pressures has been minimal and most dredging people have felt that if we waited long enough their complaints would go away and the same old machinery could be resurrected and put back competitively into the dredging market. I, for one, do not think this is going to happen and that dredging in the future is going to require more innovation and research in the next ten years than we have seen in the last fifty years. If one lists the problems facing the industry it can be seen there is a lot of work to be done, and we ought to seize the opportunity to have dredging people do it rather than watch outside people take over the lead and we just follow along. So let us take a look at the problems the industry is having.

1. Environmental restrictions.
2. Energy crisis.
3. Ocean work.
4. Long distance pumping.
5. Deeper digging.

I do not feel any of these problems are going to disappear, and we should face the fact that the equipment will have to be designed to meet these influencing factors. The question then comes up of how do you design for these conditions when it is very hard to put good descriptions or numbers to go with these restraints. This has been the problem facing the dredge owner and I am aware of several instances where the dredge owner, when questioned about design considerations, replies that he does not know what his dredging market is going to be in the future.

The proposed "Dredge for 1984" takes into account these problems and attempts to give an insight into the kind of new thinking and research and development that is necessary in what is going to become the next generation of dredges. To help make the jump to this new generation more believable, we have included photographs of jobs we have designed which serve to illustrate that some of the features proposed are already in existence.

The first point we tackled was the hull. As many of you know, this is a constraining item in modifying a dredge. Accordingly, we propose to eliminate the hull as we presently know it. In its place we incorporated four longitudinal trusses above the deck line. These trusses develop tremendous strength since the moment of inertia gets large due to the separation of the steel as opposed to trying to make a shallow hull strong by putting a large amount of steel close to the centerline of the beam. This takes care of the longitudinal strength, and the transverse strength comes from tying the top of the trusses together and tying the bottom of the trusses together with the pontoons that actually provide the flotation for the vessel. To further illustrate this refer to Figure No. 1, which shows a wet mill that belongs to Titanium Enterprises in Green Cove Springs, Florida. This serves to illustrate the type of construction; the overall size of the main hull is 221 feet long by 112 feet wide by 7 feet deep. To have tried to build the longitudinal strength required in only a 6-foot-deep hull would have been almost impossible. One of the hopes of this design is that all the pontoons will be similar and no machinery will be mounted below decks. Between each of the pontoon sections is a gap which provides a place for sea water suctions, as well as cooling water discharges which would be close to the machinery utilizing the water. It has also been noted that general house cleaning is much better since it is easier to perform and there are no bilges full of mud. By referring to Figure No. 2 one will see that the Figure proposed "Dredge for 1984" incorporates this type of hull and truss design. In looking at this drawing it becomes apparent that the hull can be lengthened quite easily by adding another panel with the truss section. This section could be the addition of quarters, or other modifications, which can be done ahead of time in a shipyard and can be waiting until the dredge is available for a relatively fast installation. The utilization of the dredge is helped because the main investment in the dredge is not tied up while a relatively small investment is added to the machine.

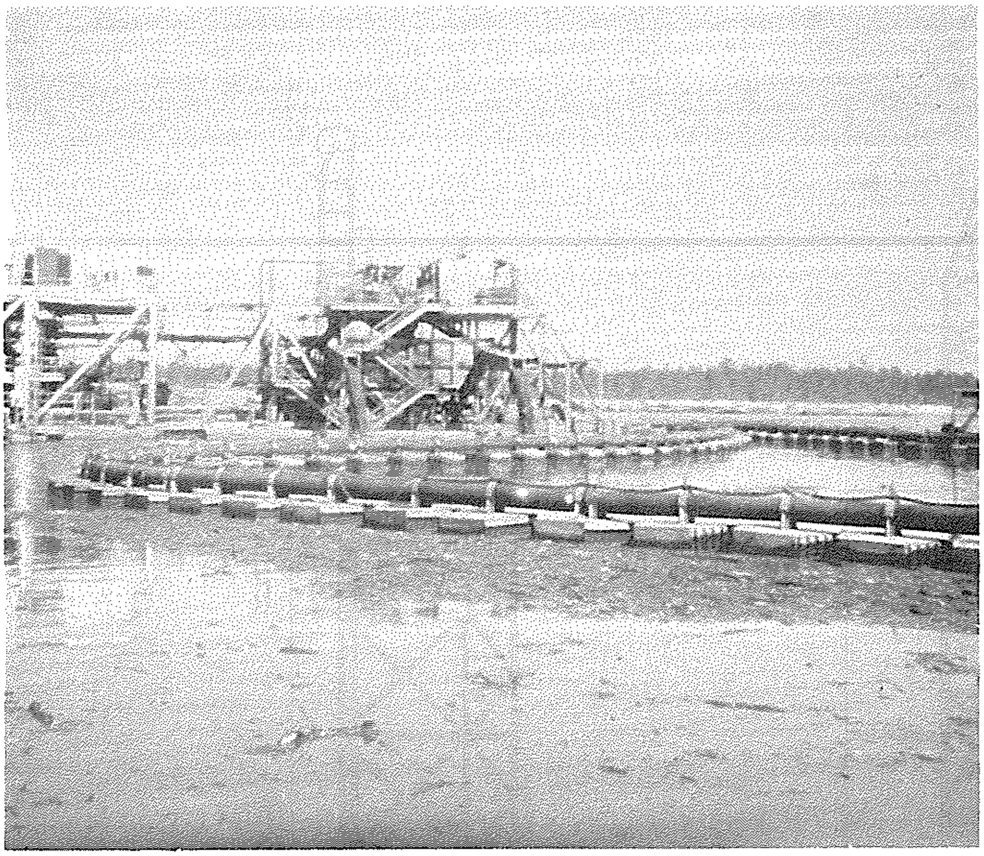
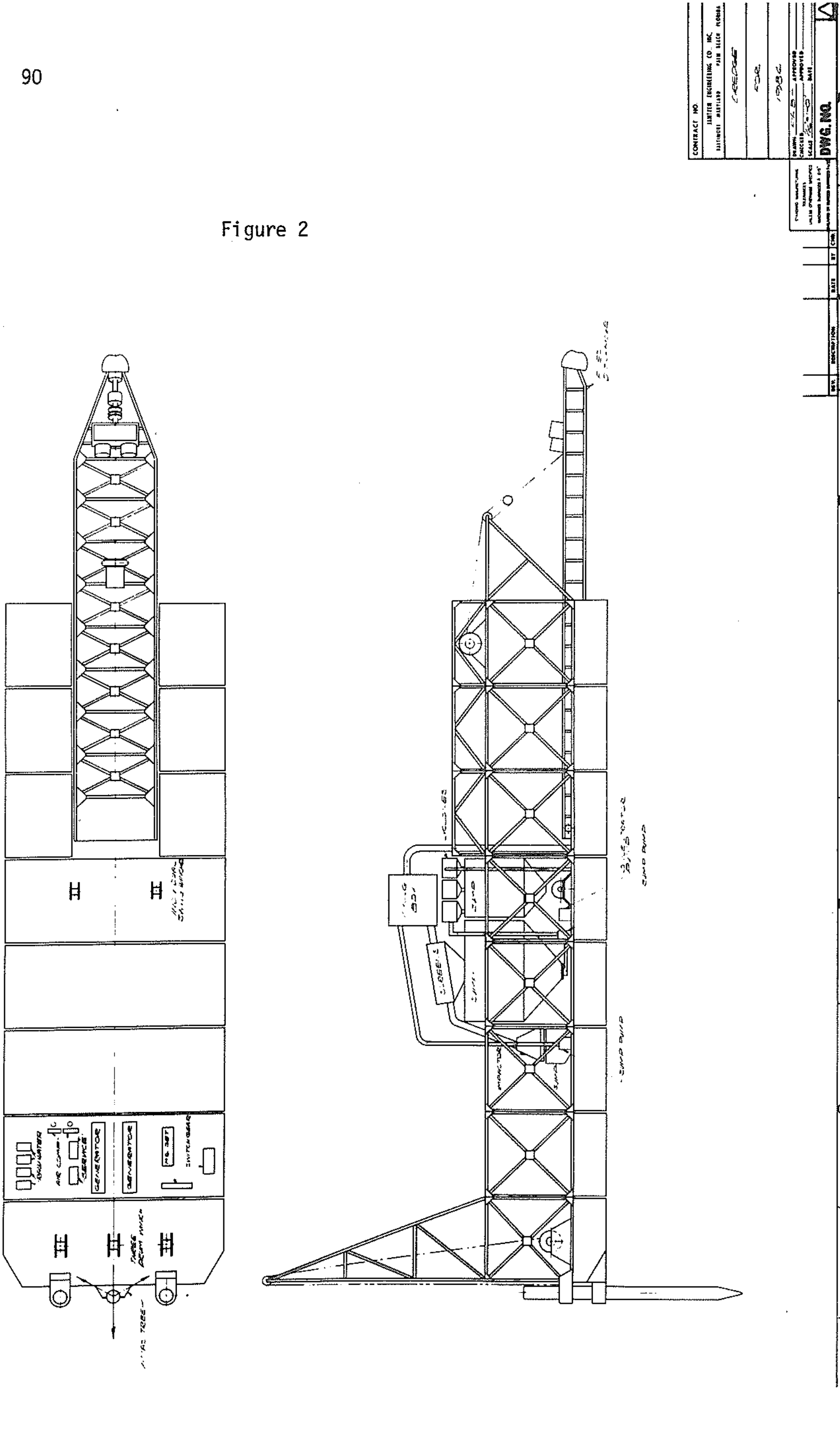


Figure 1. A wet mill belonging to Titanium Enterprises in Green Cove Springs, Florida.

Figure 2



In looking at Figure No. 2 one can see we have not only sectionalized the hull, but we have also sectionalized the ladder to give an easier addition for deeper digging depths. To alleviate some of the structural problems as the ladder gets longer, there are flotation pontoons in the sections to eliminate some of the bending in the beam as it gets longer. On the ladder are mounted both an underwater pump and an underwater cutter drive. As seen in Figure No. 3, the C.F. Bean Corporation of New Orleans, Louisiana has incorporated this on the ladder of their new dredge the "Jim Bean". On this ladder the underwater pump is driven by an electric motor mounted on the surface through a line shaft, and the cutter is an underwater hydraulic drive. Since the ladder has straight sides, the addition of longer lengths is relatively easy. On the "Dredge for 1984" I propose that both systems be powered by underwater electric. To those that have been familiar with the problems that have developed in using underwater electrics this may seem a designer's hope that is difficult to manufacture. In Figures No. 4 and 5 are pictures of the underwater dredge which is owned by Ocean Science and Engineering, Inc. of Long Beach, California. This machine is designed to operate under 100 feet of water with a two-man crew, and the dredge contains about 850 HP in electric motors which never overheated, neither the motors nor the dredge in actual operation. In fact, if our cooling had not been correct the interior temperature would have been up to 212°F in less than one minute. The main pump drive had speed controls and we do not envision any problem with putting this type of system on a deep digging ladder. It should also be noted in Figure No. 2 that the trunnions are located on the framework of the dredge, which eliminates the problem of going to drydock for trunnion repair and suction-hose replacement.

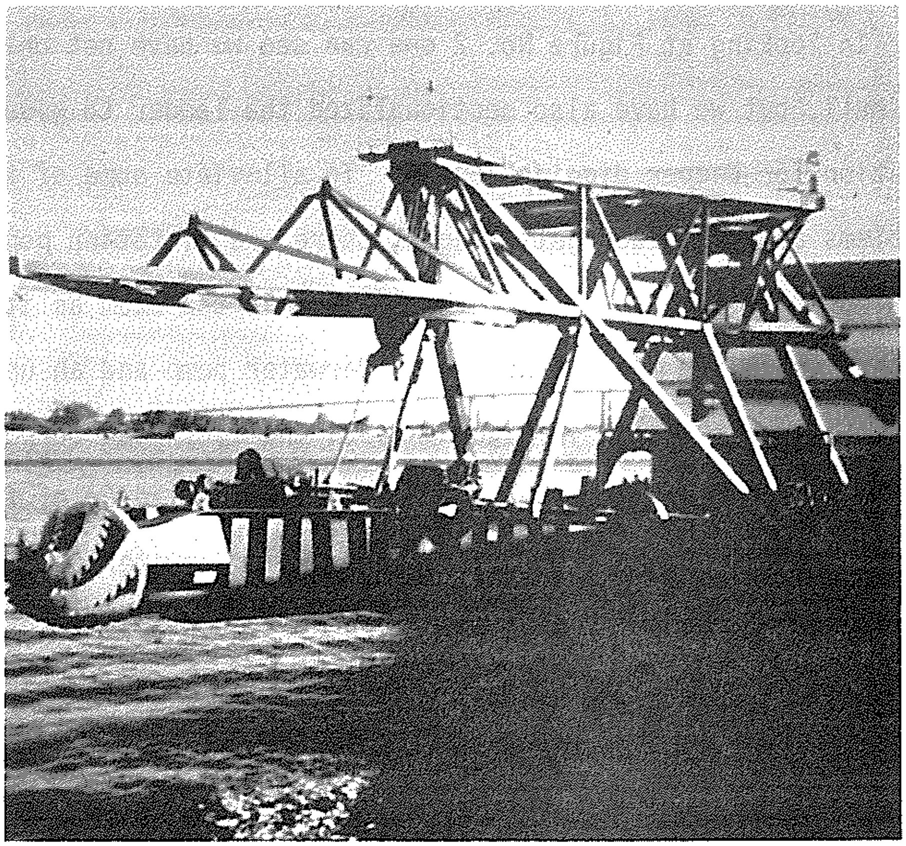


Figure 3. The dredge "Jim Bean" owned by the C.F. Bean Corporation of New Orleans, Louisiana.

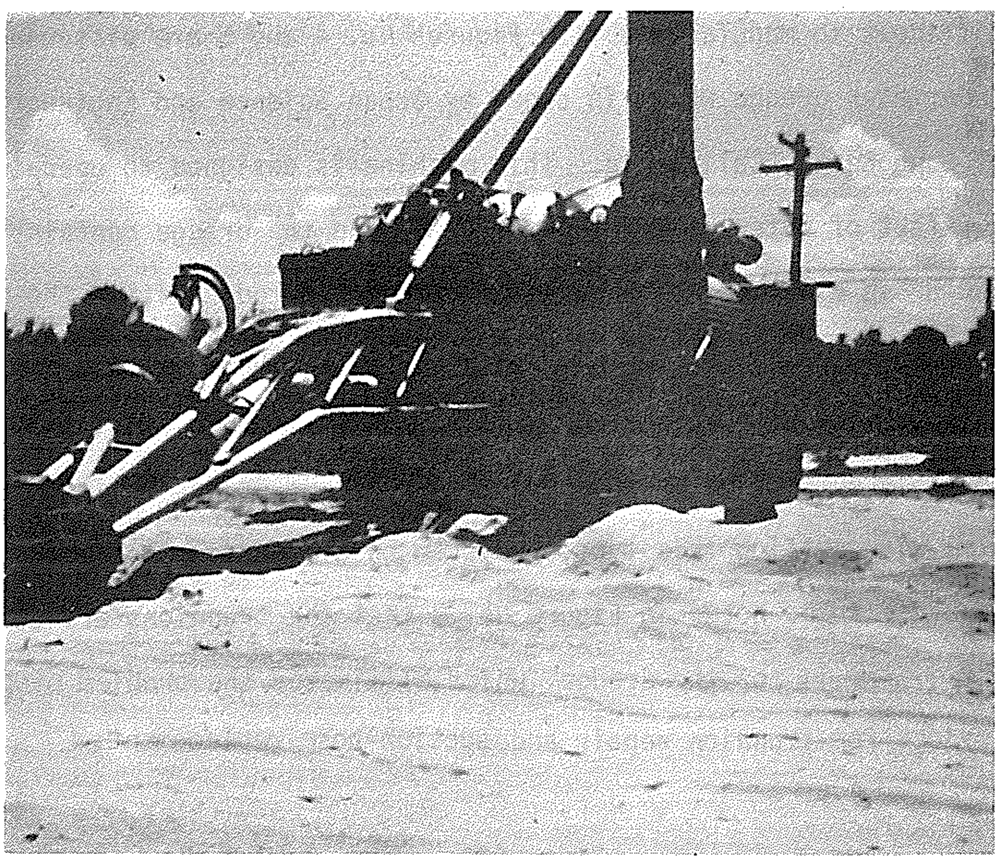


Figure 4. (See Figure 5)

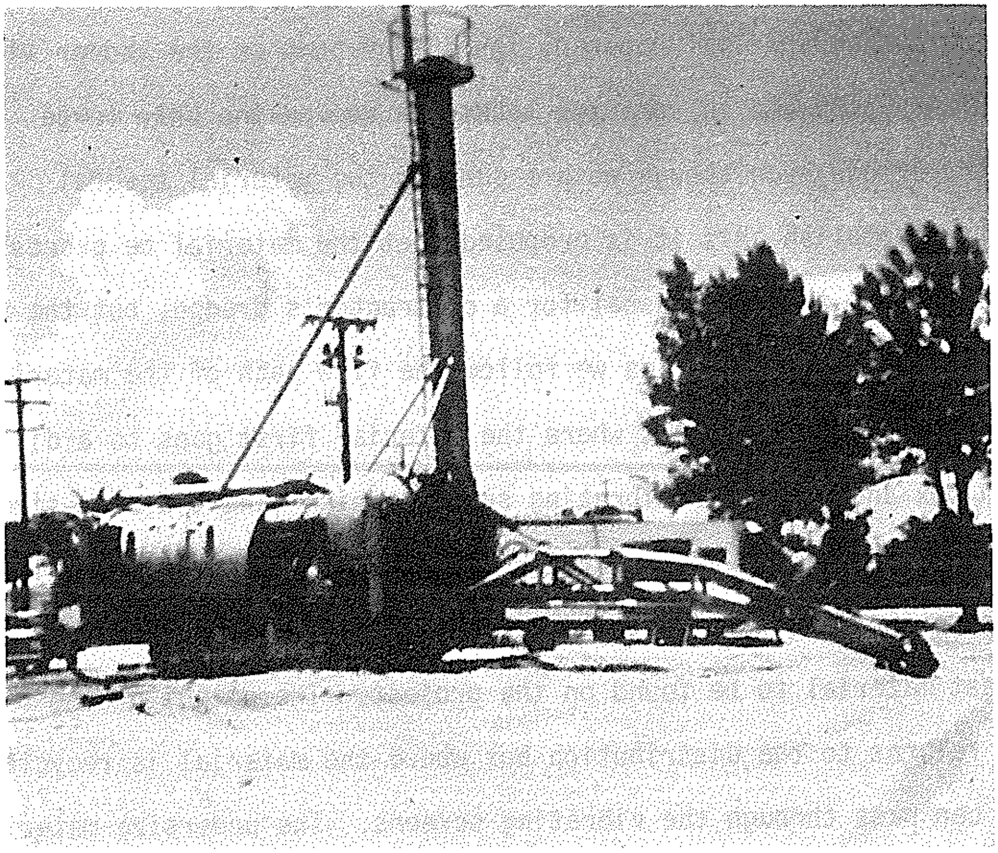


Figure 5. An underwater dredge owned by Ocean Science and Engineering Inc., of Long Beach, California.

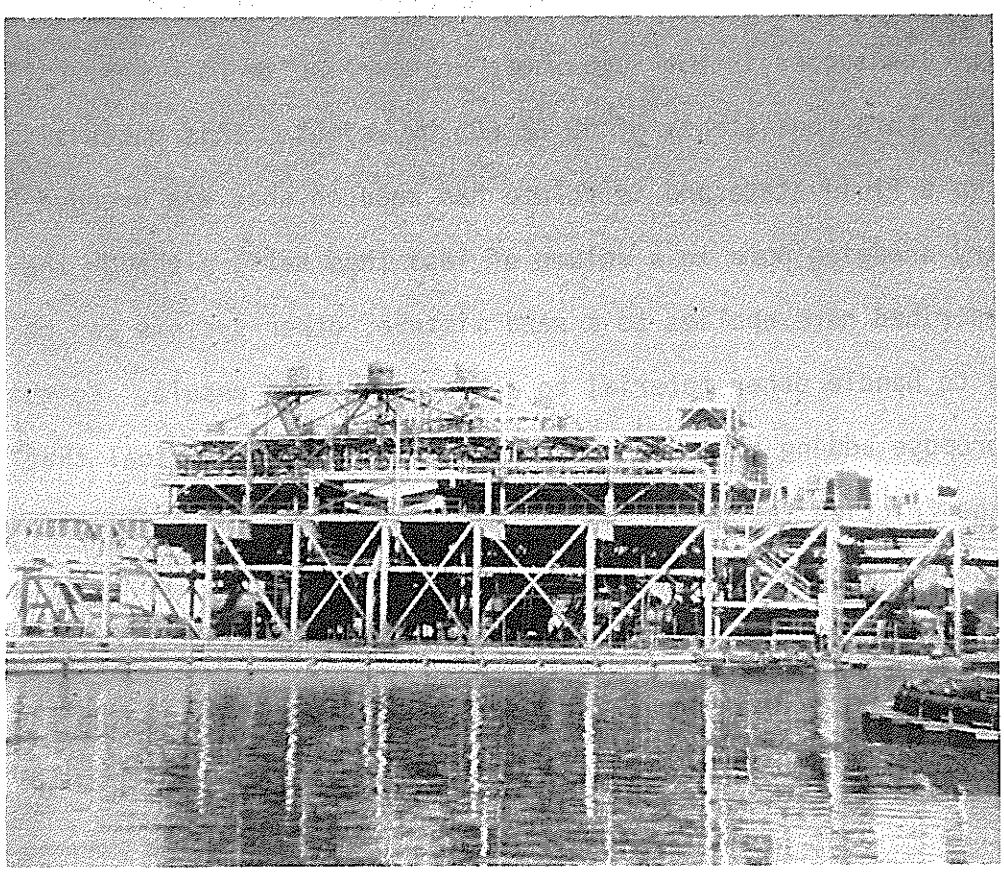


Figure 6. A dredging plant.

In the system that is proposed, the dredge pump on the ladder will be the primary pump and in some job locations may be the only large pump on the dredge even though we are pumping the material several miles. To accomplish this it is proposed that the material be processed. This is a concept that is unusual for a contractor's dredge, but the reason will become more evident as we follow the flow path of the material. In Figure No. 6 we see a plant where the material first goes to a distribution box and then over vibrating screens which take the over-size material and sends it to an impactor which reduces the size of the large particles so that the size of the discharge pipeline is not governed by the largest material to be found on the project. The output of the impactor returns to the distribution box where the material is recycled until it can pass through the vibrating screens. The undersize material from the screens goes into a sump where a variable speed pump draws from and delivers the material to a set of cyclones. The underflow from the cyclones goes into a sump where we now find we have concentrated the material to a consistency of 55 to 60% by weight. This material is still in a fluid state and in volume has reduced what was dredged by the primary dredging pump to a volume of less than half, although the system described here applies to a sand mixture, other systems can be developed to handle other material to achieve the same result. To this sump we propose adding a long chain polymer, which is a chemical that reduces the friction factor in the discharge pipeline. To those of you who are not familiar with this relatively new chemical, it sounds like magic but the product is manufactured by Union Carbide under the trade name of "Polyox". Just a small amount of this chemical can change the properties of water as we know them. At the present time the chemical can reduce the friction factor in half, which will reduce the discharge pump power requirements in half. We tested this material in 1972 on an intercoastal waterway job outside of Charleston, South Carolina, and we encountered problems with getting the material into the dredging slurry since it is hygroscopic and can get to be a sticky mess with moisture from the air. We know the problems can be licked by using a dry storage bin and adding the material directly to a sump that leads to the discharge system.

The overflow from the cyclones we propose to lead back to the suction area of the cutterhead so that the contamination from dredging can be reduced to a minimum. On the underwater dredge we became familiar with the sphere of influence of the suction and where the material that went into the suction pipe actually came from. For this reason we feel the fluid carrier can be used over and over again to eliminate a part of the pollution at the cutterhead of the dredge.

As we mentioned before, the discharge from the dredge is now in a super-concentrated form and the discharge can either be piped away conventionally, placed in hopper barges, or discharged under water to reduce pollution. In all cases we feel new methods for handling the discharge will have to be learned. On the mining dredges of Titanium Enterprises we have observed the discharge of the spoil in this concentrated form and it can almost be used to build sand castles, as shown on Figure No. 7, with little or no water running back into the mining pond.

As we mentioned in the beginning, we sought to gain flexibility in the design and we realize we have reached out for "1984", but we feel the more you look at the concept you can see where it can be changed

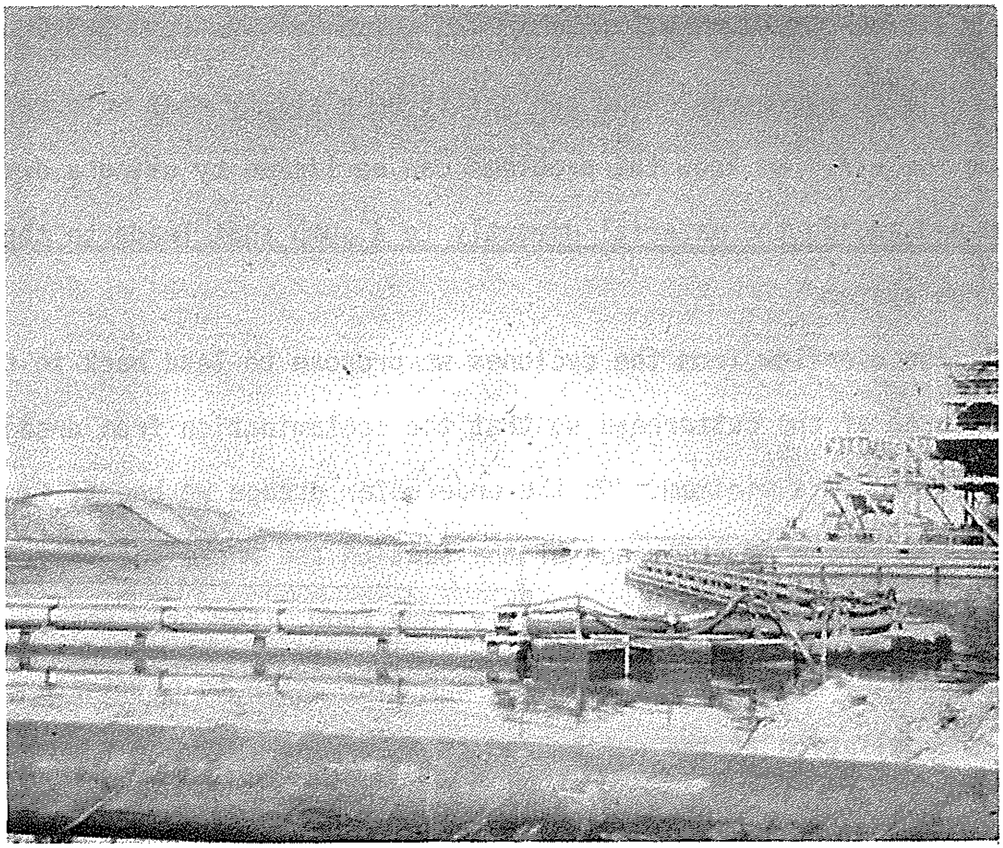


Figure 7. Sand castles formed by discharge of the spoil.

to give the following:

1. Conventional pumping system.
2. Deeper digging.
3. Rough water operation.
4. Ocean mining.
5. Travelling carriage spud.
6. Addition or removal of quarters.
7. Change of main power source.
8. Changing the length of the dredge.

In conclusion we hope we have shown a dredge concept that can be changed even after it is built to cope with the energy crises, ecology problems and a market place of which no one is certain what is needed.

LIST OF PARTICIPANTS

Mohamed Abdallah
C.F. Bean Corporation
One Shell Square, Suite 3700
New Orleans, Louisiana 70139

D.R. Basco
Coastal, Hydraulic & Ocean Engineering Group
Civil Engineering Department
Texas A&M University
College Station, Texas 77843

A.G. Davis
U.S. Army Corps of Engineers
5932 Yorktown Street
Southaven, Mississippi 38671

R.F. Dominguez
Coastal, Hydraulic & Ocean Engineering Group
Civil Engineering Department
Texas A&M University
College Station, Texas 77843

J. Donmeyer
Howard, Needles, Tammen & Bergendoff
221 North La Salle St.
Chicago, Illinois 60601

P.J. Fraering
Bd. of Commerce - Port of New Orleans
6646 Dorian St.
New Orleans, Louisiana 70126

E.R. Gonzalez
Bovay Engineers, Inc.
P.O. Box 8098
5009 Caroline St.
Houston, Texas 77004

C.B. Hakenjos
Vice President
Williams - McWilliams Co.
P.O. Box 52677
New Orleans, Louisiana 70152

G.L. Hall
Oceanography Department
Texas A&M University
College Station, Texas 77843

W.D. Helpenstell
Nueces County Navigation District No. 1 - District Engineer
222 Power Street
P.O. Box 1541
Corpus Christi, Texas 78403

J.B. Herbich
Center for Dredging Studies
Texas A&M University
College Station, Texas 77843

B.W. Holliday
Waterways Experiment Station, U.S.A.E.
Vicksburg, Mississippi 39180

D.B. Harb
C.F. Bean Corporation
One Shell Square, Suite 3700
New Orleans, Louisiana 70139

W.A. Hunt
Chief Mechanical Engineer
Merritt Dredging Company
P.O. Box 3288
Charleston, South Carolina 29464

R. Jantzen
Jantzen Engineering Co., Inc.
15 Charles Plaza
Baltimore, Maryland 21201

J.J. Kelly
Chief, Dredge Operations Sec.
USA Corps of Engineers, New Orleans
P.O. Box 60267
New Orleans, Louisiana 70160

Dr. Fred Lee
Civil Engineering Department
Texas A&M University
College Station, Texas 77843

Nick Liberto
C.F. Bean Corp.
One Shell Square
Suite 3700
New Orleans, Louisiana 70139

Robert Male
Coastal, Hydraulic & Ocean
Engineering Group
Texas A&M University
College Station, Texas 77843

R.W. McDonough
Bovay Engineers, Inc.
5009 Carolina
Houston, Texas 77004

Patrick Montag
Superintendent
Atlantic, Gulf & Pacific
400 Main Street, Suite 717
Houston, Texas 77002

Patrick Murphy
Atlantic, Gulf & Pacific
400 Main Street, Suite 717
Houston, Texas 77002

Charles Panciuk
Project Engr.
Dept. of Public Works
Sir Charles Tupper Bldg.
Riverside Drive
Ottawa, Canada

L.A. Rabalais
Navigation Branch
U.S. Army Corps of Engineers
1961 Durham Drive
Memphis, Tennessee 38127

P.A. Ramirez
Area Supervisor
Offshore Navigation Inc.
3311 W. Alabama
Houston, Texas 77006

A.B. Richardson
Navigation Branch
U.S. Army Corps of Engineers
900 Kensington Place
Memphis, Tennessee 38107

W.H. Rusk
Chief Const. Operations
Corps of Engineers
7015 Delbrose
Dallas, Texas 75202

R.E. Schiller, Jr.
Center for Dredging Studies
Civil Engineering Dept.
Texas A&M University
College Station, Texas 77843

G.W. Sheary III
Ocean Mining Division
Summa Corp.
764 National Blvd.
Houston, Texas 77024

S.L. Slotta
Ocean Engineering Program
Oregon State University
Corvallis, Oregon 97331

A.H. Sorensen
Ellicott Machine Corp.
1600 Block of Bush Street
Baltimore, Maryland 21230

G.S. Spain
Electrician
Merritt Dredging Company
P.O. Box 3288
Charleston, South Carolina 29464

H.D. Stephens
Squad Leader
Howard, Needles, Tunner & Bergendoff
6350 LBJ Freeway
Dallas, Texas 75240

E.P. Tanzberger
Mgr. Marketing
C.F. Bean Corporation
One Shell Square, Suite 3700
New Orleans, Louisiana 70139

M. Thompson
Civil Engineer
USA Engineer District, New Orleans
3810 Mansfield Avenue
Algiers, Louisiana 70114

H.R. Vick
Civil Engineer
Army Corps of Engineers, New Orleans
P.O. Box 60267
New Orleans, Louisiana 70160

R.O. Whitman
Port Captain
Lone Star Industries
Seadrift, Texas 77983