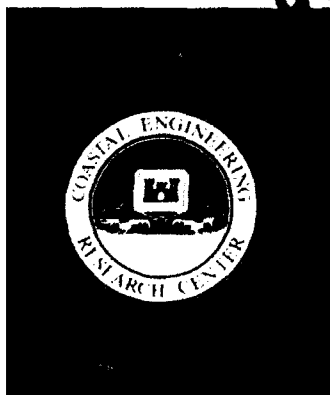
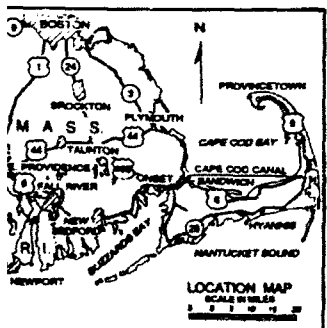


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US Army Corps
of Engineers



PROCEEDINGS
OF THE 55TH MEETING OF THE
COASTAL ENGINEERING RESEARCH BOARD

2

30 October - 1 November 1991

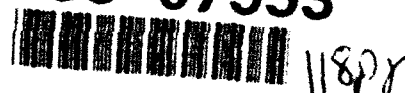
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Hosted by

US Army Engineer Division, New England

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December 1992

Final Report

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Washington, DC 20314-1000

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PREFACE

The Proceedings of the 55th Meeting of the Coastal Engineering Research Board (CERB) were prepared for the Office, Chief of Engineers, by the Coastal Engineering Research Center (CERC), of the US Army Engineer Waterways Experiment Station (WES). These proceedings provide a record of the papers presented, the questions and comments in response to them, and the interaction among program participants and the CERB.

The meeting was hosted by the US Army Engineer Division, New England (NED), under the direction of COL Philip R. Harris, Commander.

Acknowledgements are extended to the following from NED: Mr. Carl G. Boutilier, who assisted with the coordination of the meeting and field trip; Ms. Sharon M. Vienneau, who assisted with the coordination of the meeting; Mr. Francis N. Ciccone and his staff at the Cape Cod Canal, who assisted with the coordination of the field trip; Ms. Ethel Goyette, who assisted with various administrative details; and Mr. Ivan Massar, photographer. Thanks are extended to Messrs. Bill Monroe, Tracy DeGrace, and Doug Candella for their audio/visual support. Special thanks are extended to guest participants Dr. David G. Aubrey, Woods Hole Oceanographic Institute, Woods Hole, MA, and Dr. Robert G. Dean, University of Florida, Gainesville, FL. Thanks are extended to Mrs. Sharon L. Hanks for coordinating and assisting in setting up the meeting and assembling information for this publication; Dr. Fred E. Camfield for preparing the draft proceedings from the transcript; and Ms. Janean Shirley of the Information Technology Laboratory for editing these proceedings, all of whom are at WES. Thanks are extended also to Ms. Dale N. Milford, Certi-Comp Court Reporters, Inc., for taking verbatim dictation of the meeting.

The proceedings were reviewed and edited for technical accuracy by Dr. James R. Houston, Director, CERC, and Mr. Charles C. Calhoun, Jr., Assistant Director, CERC. COL Leonard G. Hassell, Executive Secretary of the Board and Commander and Deputy Director, WES, provided additional review.

Approved for publication in accordance with Public Law 166, 79th Congress, approved 31 July 1945, as supplemented by Public Law 172, 88th Congress, approved 7 November 1963.

Arthur E. Williams

ARTHUR E. WILLIAMS
Major General, US Army
President, Coastal Engineering Research Board

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31 October

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INTRODUCTION

The 55th Meeting of the Coastal Engineering Research Board (CERB) was held at the Christ the King Roman Catholic Parish Center in Mashpee, MA, on 29 October - 1 November 1991. It was hosted by the US Army Engineer Division, New England (NED), under the direction of COL Philip R. Harris, Commander.

The Beach Erosion Board (BEB), forerunner of the CERB, was formed by the Corps in 1930 to study beach erosion problems. In 1963, Public Law 88-172 dissolved the BEB by establishing the CERB as an advisory board to the Corps and designating a new organization, the Coastal Engineering Research Center (CERC), as the research arm of the Corps. The CERB functions to review programs relating to coastal engineering research and development and to recommend areas for particular emphasis or suggest new topics for study. The Board's four military and three civilian members officially meet twice a year at a particular coastal Corps District or Division to do the following:

- a. Disseminate information of general interest to Corps coastal Districts or Divisions.
- b. Obtain reports on coastal engineering projects in the host (local) District or Division; receive requests for research needs.
- c. Provide an opportunity for state and private institutions and organizations to report on local coastal research needs, coastal studies, and new coastal engineering techniques.
- d. Provide a general forum for public inquiry.
- e. Provide recommendations for coastal engineering research and development.

Presentations during the 55th CERB meeting dealt with dredging. Documented in these proceedings are summaries of presentations made at the meeting, discussions which followed these presentations, and recommendations by the Board. A verbatim transcript is on file at CERC, US Army Engineer Waterways Experiment Station.

THE COASTAL ENGINEERING RESEARCH BOARD

October-November 1991



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55TH COASTAL ENGINEERING RESEARCH BOARD MEETING

Mashpee, MA

30 October - 1 November 1991

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MG John F. Sobke
BG Roger F. Yankoupe
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Professor Fredric Raichlen
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Mr. Arthur T. Shak, CESPL-ED-DC
Mr. William J. Brick, CESP-PE-W

55TH COASTAL ENGINEERING RESEARCH BOARD MEETING

ATTENDEES (CONTINUED)

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Mr. Jeffrey C. Cole, CESPN-PE-W
Mr. Kerry P. Guy, CESPN-PE-R

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Mr. J. Michael Kieslich, CESWG-PM-J
Mr. Herbie A. Maurer, CESWG-CO-M

WATERWAYS EXPERIMENT STATION

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Mr. Robert F. Athow, CEWES-HE
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Mr. D. Donald Davidson, CEWES-CW-R
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Mr. Thomas W. Richardson, CEWES-CD
Ms. Jane M. Smith, CEWES-CR-P
Dr. Donald K. Stauble, CEWES-CD-SG
Dr. C. Linwood Vincent, CEWES-CV-Z

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Dr. Robert G. Dean, University
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Mr. Vyto L. Andreliunas,
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MA
Mr. Aram V. Terchunian, First Coastal
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55TH COASTAL ENGINEERING RESEARCH BOARD MEETING

ATTENDEES (CONTINUED)

COURT REPORTER

Ms. Dale N. Milford, Certi-Comp Court
Reporters, Inc., Jackson, MS

55TH COASTAL ENGINEERING RESEARCH BOARD MEETING
30 October - 1 November 1991
Mashpee, MA

AGENDA

THEME: Dredging

TUESDAY, 29 OCTOBER

1830 - 2030 Registration and Cash Bar Icebreaker
(New Seabury Country Club)

WEDNESDAY, 30 OCTOBER

0700 - 0800 Registration (Church Parish Center)

0800 - 0805 Opening Remarks MG Arthur E. Williams

0805 - 0820 Welcome to New England Division COL Philip R. Harris

0820 - 0850 Review of CERB Business and Coastal Engineering Research Program COL Larry B. Fulton, WES
Dr. James R. Houston, CERC

0850 - 0910 An Overview of the SUPERTANK Laboratory Data Collection Project Dr. Nicholas C. Kraus, CERC

0910 - 0930 A First Look at the SUPERTANK Hydrodynamic Data Ms. Jane M. Smith, CERC

0930 - 0945 Break

0945 - 1045 Hurricane Bob Report Mr. Andrew W. Garcia,
Ms. Monica A. Chasten, CERC
Mr. John Kennelly, NED

1045 - 1105 Capping Experiences Under the Disposal Area Monitoring System (DAMOS) Program: Success Breeds Skepticism? Dr. Thomas J. Fredette, NED

1105 - 1130 New Bedford Harbor, Massachusetts Mr. Mark J. Otis, NED

1130 - 1200	Field Trip Overview (New Inlet Formation and Resulting Evolution of the Multiple Inlet System - Chatham, Massachusetts)	Dr. Donald K. Stauble, CERC Mr. Carl G. Boutilier, NED
1200 - 1700	Lunch and Field Trip (Field trip will include Cape Cod Canal and The Breach at Nauset Beach)	
1830 -	Dinner	

THURSDAY, 31 OCTOBER

0800 - 0810	Opening Remarks and Chief's Charge to the Board	MG Arthur E. Williams
0810 - 0940	Review of Corps of Engineers Dredging Program, Policy and Practices	Mr. Barry W. Holliday, Mr. Robert H. Campbell, Mr. David B. Mathis, HQUSACE
0940 - 1000	Break	
1000 - 1200	Fate of Dredged Material Placed Offshore (Panel)	
1000-1010	Introduction	Mr. E. Clark McNair, Jr., CERC
1010-1045	DRP Research into Dredged Material Placed in Subaqueous Locations	Dr. Nicholas C. Kraus, CERC
1045-1115	The Mobile Berms Project	Mr. J. Patrick Langan, SAM
1115-1145	Management of Dredged Material Placed in Subaqueous Environments	Mr. James E. Clausner, CERC
1145-1200	Discussion	
1200 - 1300	Lunch	
1300 - 1500	Effects of Inlet Dredging Projects on Adjacent Shorelines (Panel)	
1300-1310	Introduction	Dr. C. Linwood Vincent, CERC

1310-1330	Sediment Transport in the Vicinity of Inlets	Dr. David G. Aubrey, Woods Hole Oceano- graphic Institute
1330-1345	Section 933 and 111 Programs	Mr. John G. Housley, HQUSACE
1345-1410	Impact of Inlet Dredging on Shoreline Erosion in Florida with Recommendations	Dr. Robert G. Dean, University of Florida
1410-1430	Application of Material from Inlet Dredging	Mr. Barry W. Holliday, HQUSACE
1430-1450	Proposed Coastal Inlet Research Program	Dr. C. Linwood Vincent, CERC
1450-1500	Discussion	
1500 - 1530	Review of Questions	MG Arthur E. Williams
1530 -	Recess for Day (Board in Executive Session)	

FRIDAY, 1 NOVEMBER

0900 - 0915	Opening Remarks	MG Arthur E. Williams
0915 - 0945	Public Comment	
0945 - 1100	Board Response to Charge	CERB
1100	Adjourn	

OPENING REMARKS
AND
WELCOME TO NEW ENGLAND DIVISION

MG Arthur E. Williams opened the 55th Meeting of the Coastal Engineering Research Board, and introduced the members of the Board. He noted that it was a public meeting, and that time was provided on the meeting agenda for public comments. He then turned the floor over to COL Philip R. Harris, Commander, New England Division.

COL Harris welcomed the meeting participants to Cape Cod. He noted that people on the tour that afternoon would be able to directly observe the effects of Hurricane Grace. COL Harris said that the tour would deal with some of the coastal erosion problems in the immediate area, and would also go by the Cape Cod Canal. He indicated that a number of interested personnel from local and state agencies were attending the meeting.

REVIEW OF COASTAL ENGINEERING RESEARCH BOARD BUSINESS

COL Larry B. Fulton, Executive Secretary
Coastal Engineering Research Board
Commander and Director
US Army Engineer Waterways Experiment Station
Vicksburg, MS

There were several action items resulting from the last Coastal Engineering Research Board (CERB) meeting in New Orleans, LA. The list in Appendix B covers the status of action items from the New Orleans meeting and continuing action items from previous Board meetings. All other action items have been completed. We will continue to update the status of action items prior to each meeting, and provide a list to the Board as read-ahead material. At the 47th CERB meeting in Corpus Christi, TX, we were asked to formalize the action item list. A master list showing actions taken since the 47th meeting is maintained at the Coastal Engineering Research Center (CERC), US Army Engineer Waterways Experiment Station (WES).

Item 54-1 recommended the establishment of a technical advisory committee for the proposed Coastal Inlets Research Program (CIRP). Membership on a technical advisory committee will have to be limited to members of the CERB. Researchers most qualified for an advisory committee are the same people we would most likely want to contract with for implementing the work in the program. According to Counsel, this would create a conflict of interest, i.e., people on the advisory committee would be disqualified from doing any work on the program. Of course, in addition to the technical advisory committee, the Program will be monitored by Headquarters Technical Monitors and a Field Review Group.

Item 54-2 directed CERC to establish a formal seminar series for CERC Principal Investigators. That has been done, and seminars are now being conducted bi-weekly.

Item 54-3 requested a report at this meeting on the SUPERTANK Experiment. An overview will be given by Dr. Nick Kraus this morning, immediately following my report to the Board. There also will be a report by Ms. Jane Smith on SUPERTANK hydrodynamic data.

Item 54-4 directed us to assess tidal inlets maintained by the Corps of Engineers to determine the need for sand bypassing. The assessment was performed by the Engineering Division, Directorate of Civil Works, Headquarters, and is in Appendix C.

The Corps of Engineers maintains channels, with associated navigation and shore protection structures, at more than 110 coastal inlets. Nineteen of the inlet projects presently, or at one time, included sand bypassing. Over 30 of the inlets have shore protection and beach erosion control projects in their proximity.

The assessment by Headquarters (HQ), US Army Corps of Engineers (USACE), is that it is good practice to aid movement of sand around inlets. This can be done through use of fixed sand-bypass plant or by dredging channels and placing beach quality sand in the active downdrift littoral zone. Bypassing helps preserve the finite quantity of sand in the littoral zone and to some degree mitigates erosion of downdrift shores. The assessment concludes that "... sand bypassing is needed and should be implemented as an integral feature of the inlet project where practicable."

Present Corps policy is to consider mitigation of shore erosion caused by Federal navigation projects when requested by a non-Federal public body. The mitigation measures must be economically justified and the non-Federal public body must agree to operate and maintain the mitigation measures in accordance with regulations prescribed by the Corps. Included in tomorrow's discussions will be a presentation on mitigation of project impacts through Section 111 authorities.

Item 54-5 was to determine methods to provide more of the sand dredged from Corps of Engineers projects for beach nourishment. The Corps considers the beach placement alternative whenever a new dredged material placement option is being evaluated for a project. A Dredging Guidance Document is being developed by HQUSACE, that will emphasize placement of suitable dredged material on beaches or in the nearshore zone as berms. With upland placement sites becoming more difficult to locate, the option of pumping to a beach is becoming more viable. An integral part of all long-term management strategies for dredged material placement includes consideration of beach nourishment/placement as an alternative. Increased environmental pressure to

minimize the time when hopper dredges can operate in some ocean inlets because of potential harm to endangered sea turtle species may require consideration of large pipeline dredges and subsequent beach or nearshore placement as an alternative to ocean placement. Recycling upland placement areas with suitable beach quality material is being considered for several portions of the Atlantic Intracoastal Waterway. This methodology has been incorporated in the Morehead City Harbor, NC, Project. Sand dredged from the interior harbor project is being pumped into an upland site and will continue for approximately 8 to 10 years. When the placement area reaches capacity, a separate contract will be let to dredge out the placement area and pump approximately 3 million cu yd of sand to the beach.

Item 54-6 was to establish a CERC rapid response team to coastal flooding events. CERC has deployed rapid response teams following two recent hurricanes, Hugo, reported on at the Board's meeting in Redondo Beach, and Bob, which will be reported on following this morning's break. CERC has developed some experience concerning the makeup, mission, and operation of such a team or teams. Under the Episodic Events work unit of the Coastal Field Data Collection Program, we will be convening a Corps-wide workshop to discuss field needs, coordination, field office participation, and the mechanisms that need to be in place prior to a flooding event for such a team to function effectively. The workshop will be prior to next spring's CERB meeting, and results and recommendations will be available then for presentation. The goal is to have the first version of this "team" concept in place for the 1992 storm season.

There were five action items resulting from the Chief's charge to the Board to determine if technology is adequate for calculating inundation, waves, coastal erosion, and storm surge due to hurricanes. The first of these, Item 54-7, was to conduct an interagency collaborative study to upgrade the wind model. A realization of the need for accurate wind-field modeling prompted funding of a new work unit a year ago in the Coastal Engineering Research and Development (R&D) Program.

CERC has made initial contacts with the National Weather Service (NWS) of the National Oceanic and Atmospheric Administration (NOAA). A CERC representative visited two NWS offices: the Marine Predictions Branch of the

National Meteorological Center in Camp Springs, MD, and the Techniques Development Laboratory (TDL) in Silver Spring, MD. The visits included presentation of CERC's plans and progress in modeling hurricane wind fields as well as discussions about NWS wind-field modeling.

The TDL presently uses a hurricane wind-field model developed by Jelesnianski and Taylor (1973) to predict surge levels. As part of the Coastal Hazards component of NOAA's new Coastal Ocean Program planned for FY 92, TDL is proposing a joint effort with the National Hurricane Center (NHC) to improve the wind-field model. The objective is to more accurately estimate surface stress by representing observed wind-field asymmetries associated with translation speed, land-sea frictional differences, environmental flow interactions, and rainband convection. Boundary layer development, where overwater flow changes to overland, and vice versa, at the coastline, is of particular interest.

The TDL/NHC tentative plan for FY 92 includes collection of hurricane wind-field measurements in at least one landfalling hurricane and initiating the effort to upgrade the existing wind-field model. CERC will work with TDL/NHC in early FY 92 to develop a collaborative wind modeling investigation to achieve the goals of both agencies.

Item 54-8 was to increase the priority for upgrading CERC's hurricane surge numerical model to include calculation of the wave setup contribution to nearshore surge, land inundation, and the increase in bottom stress caused by wave-current interaction. Work planned in the proposed CIRP that I will discuss in a few minutes will result in most of these upgrades and model testing. Model validation will be made using data collected by the Corps' Coastal Field Data Collection Program or a joint NOAA/CERC measurement program.

Item 54-9 was to increase priority of development of a three-dimensional (3-D) beach profile change model. Discussion of this model was a byproduct of the Board's analysis of hurricane surge modeling. CERC's schedule for development of a 3-D beach profile model was not discussed at the last Board meeting. There is a currently funded work unit in the Coastal Engineering R&D Program for development of a 3-D beach profile change model. The work unit already has an ambitious schedule for development of a preliminary model by

June 1993. A fully tested and validated engineering model that can be used routinely by Corps District personnel will be available by FY 95. Field data sets collected by coastal research programs, including the proposed CIRP, will be used for model validation. We believe that the current development and validation schedule for the 3-D beach profile change model is appropriate. The schedule is consistent with data collection efforts that will be made in programs including the CIRP (that does not start until FY 93).

Item 54-10 directs us to determine what additional laboratory and field data are required to implement items 54-8 and 54-9. Improved calculation of hurricane inundation, including canopy effects, will require simultaneous measurement of wind, water levels, and water flows over land during a hurricane. We will investigate whether additional synoptic measurements can be added to the new NOAA wind-modeling program to provide necessary data for model verification. Highly accurate synoptic measurements of waves, currents, and water levels will be required to assess the effect of wave-current interactions on enhanced bottom stresses. The proposed CIRP will provide necessary data. A 3-D beach profile change model will require data of geomorphic change following major engineering projects such as placement of beach fill or construction of coastal structures. Data required include synoptic measurements of beach and nearshore bottom topography; forcing functions such as waves, water levels, and currents; and sediment and structure characteristics. We believe the measurements CERC has been making at the beach fill at Ocean City, MD, over the past few years will provide an excellent data set to test a 3-D model. CERC also is currently making measurements of coastal evolution produced by the recently built terminal groin at Oregon Inlet, NC. A future major series of beach fills in New Jersey will be in an area with extensive structures. The New York District will be making a variety of measurements, and we will supplement them to provide data that will be used to test a 3-D model.

Item 54-11 asked us to estimate what degree of improvement in modeling capability will accrue from upgrades recommended in items 54-8, 54-9, and 54-10. Significant improvement to hurricane surge modeling will come from improvements to hurricane wind-field modeling, especially at landfall. It is not possible, a priori, to determine how much the other upgrades will improve

surge calculations. Therefore, we will concentrate initially on improvements to hurricane wind modeling. A 3-D beach change model will integrate cross-shore and longshore processes that are presently treated separately. We expect that this model upgrade will significantly enhance the Corps' ability to predict shoreline evolution for beaches that exhibit significant alongshore variability, particularly those characterized by coastal structures.

There were also four action items from the Chief's second charge to the Board, to determine what research and development is needed to improve emergency operations during coastal flooding emergencies. Item 54-12 directed us to conduct workshops to determine interest in CERC tools that could be used to improve planning for flooding emergencies. CERC personnel met in July with staff of the Readiness Branch, HQUSACE, to discuss this item.

The Readiness Branch would like to broaden the scope of this effort beyond the bounds of the CERB initiative to include other than coastal flooding emergencies, e.g., earthquakes, volcanic eruptions, chemical spills, navigation blockages, structure failures, droughts, tornadoes, dam breaching, shipwrecks, etc. --oil spills would be covered under another initiative. The Readiness Branch requested that WES review recent Hazard Mitigation Team (HMT) reports to summarize findings so that this information can assist in guiding development of the R&D Program. HMT reports are prepared to assess the effectiveness of responses to declared disasters.

WES has formed an HMT team, composed of one representative of each WES lab, to conduct this review. The Readiness Branch has sent a letter to Corps' field offices requesting that they forward selected HMT reports and other applicable "lessons-learned" reports directly to WES for review. CERC has the lead in coordinating this effort.

The Readiness Branch also has initiated formation of a field review group, possibly including representatives from agencies outside the Corps, to provide guidance on developing and implementing the R&D previously discussed. The field review group will address timing, location, and agenda for the workshops recommended by the CERB.

Item 54-13 was to increase coordination of technical aspects (including data collection) of coastal flooding with other Federal agencies. The next step in the ongoing coordination process discussed at the Board's last meeting

in New Orleans was for the four Federal agencies involved (Corps, NOAA, US Geological Survey, and Federal Emergency Management Agency) to appoint representatives to a coordination group. All the agencies have now appointed representatives, and the group will meet in the near future to initiate the formal coordination process. Also, the Office of the Federal Coordinator for Meteorology (OFCM) has agreed in principle for one of its existing working groups to act as the "umbrella" under which this coordination will take place. The topic will be proposed at the next meeting of the OFCM Hurricane and Winter Storms Operations Working Group, and their concurrence should finalize this part of the action. The meeting is scheduled for 9 December 1991.

Item 54-14 directed us to investigate performing interagency R&D to improve emergency operations. The Readiness Branch and the Directorate of Research and Development will pursue this after formation of the Corps' field review group and HMT report review by the WES team.

Item 54-15 is to conduct research on dynamic loading of expedient flood control structures. CERC has provided a proposal to the Readiness Branch for preparation of WES' field test site to conduct static (hydrostatic head) and dynamic (waves) load testing of expedient levee-raising structures. Test facilities and equipment are being prepared for initiation of tests at the end of flood season (late March or early April 1992). The Corps' Lower Mississippi Valley Division is assisting with this item since they are a primary advocate of this type structure.

Older items on which action is continuing include ...

I am pleased to announce the success of another initiative of the Board. Item 50-4 was developed at the 50th meeting of the Board in November 1988, and had the goal to obtain funding from the Army Research Office (ARO) for universities to conduct basic research in coastal engineering to advance the state of the art. CERC and the Research and Development Directorate, HQUSACE, worked extensively with ARO to develop a program. ARO recently announced that through a highly competitive process, the University of Delaware is the recipient of a grant worth up to \$2 million over the next 5 years. The program is another concrete example of the impact the Board has had in advancing coastal engineering in the Corps and nation.

Item 52-1 concerned restrictions on foreign travel by CERC staff members and on foreign visitors to WES. Although these restrictions have not eased, CERC has worked within the restrictions and is happy to announce that Professor Eivind Bratteland of Trondheim University in Norway will be spending the next year on sabbatical at CERC. Dr. Bratteland has considerable experience in port engineering and coastal structures design and will be working on a variety of harbor research at CERC. The Norwegian Government is paying Dr. Bratteland's salary.

Item 53-1 from the Board's meeting in Fort Lauderdale directed us to take necessary action to have "Coastal Engineer" added to the Federal personnel classification system. The proposal to do this has been forwarded by the Department of the Army to the Office of Personnel Management (OPM). OPM is scheduled to complete a study of the 0810 Civil Engineer job series in FY 93. They may review this on an interim basis before then, but it is more probable that they will include it in the study of the entire series.

Item 53-7 was to determine the feasibility of conducting a major Operations and Maintenance funded research program on inlets. The CIRP was developed by a field review group and CERC and discussed with civilian CERB members. The Program was reviewed and approved by the Construction, Operations and Readiness Division of Headquarters. The Assistant Secretary of the Army, Civil Works, reviewed and approved the Program, but at a funding level less than half required by the Program recommended by the Corps, and discussed previously with the civilian CERB members. The proposed program still must be accepted by the Office of Management and Budget and by Congress. A workshop of CERC researchers, field and Headquarters personnel, and the civilian members of the Board will be held in November to flesh out technical details of the Program. The Program is scheduled for initiation in FY 93. Dr. Linwood Vincent will discuss this Program in more detail tomorrow.

Item 50-15 from the Board's meeting in Virginia Beach was related to convening an American Society of Civil Engineers (ASCE) Specialty Conference on Coastal Engineering Practice. A technical committee chaired by Dr. Steven Hughes of CERC organized this conference, which will be held in Long Beach, CA, on 8-12 March 1992. Dr. Hughes also has been recently appointed to the

Executive Committee of the Waterway, Port, Coastal, and Ocean Division of ASCE.

Also of interest to this group is that another Specialty Conference, Dredging '94, has been approved by ASCE. Many of you will remember the highly successful Dredging '84 Conference. As the title implies, Dredging '94 will be held in 1994, which coincides with the completion of the Dredging Research Program (DRP). This will provide an excellent tech transfer mechanism for the DRP. The chairman of the technical committee organizing the conference is Charles Calhoun of CERC.

On other items of interest ...

I reported at the last Board meeting on the Coastal Engineering Education Program which was in progress at that time. The six Corps coastal specialists who were in that program successfully completed the program in August. MG Sobke and Prof. Reid represented the Board at the graduation ceremony held at CERC. The graduates were Matthew Walsh from Buffalo District, Heidi Pfeiffer from Chicago District, James Aidala from Rock Island District, Ken Eisses from Alaska District, Jane Grandon from Los Angeles District, and Ferris Chamberlain from New Orleans District.

Finally, I will yield the floor for a few minutes to Dr. Houston, Chief of CERC, who will bring you up to date on FY 92 funding in the General Investigations funded Coastal Engineering R&D Program. I will return to answer any questions you may have on my report on the action items.

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COASTAL ENGINEERING RESEARCH PROGRAM

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Funding for the General Investigations-(GI-) funded Coastal Engineering Research Program was reduced 13.5 percent in FY 92 as a result of a 2-percent cut by the Civil Works Research and Development (R&D) Review Committee to increase funding for other programs and an 11.5 percent savings and slippage cut. The Directorate of Research and Development (DRD), Headquarters, has argued in the past that savings and slippage should not apply to R&D because R&D has consistently spent 100 percent of its year's funding. DRD believes that the 11.5 percent or some portion may be restored at mid-year, if GI-funded R&D Programs can spend at a rate that demonstrates there is not slippage in the R&D Program.

The Coastal Engineering Research Program has had almost uninterrupted declines in funding since FY 81. Funding in FY 81 was \$6.8 million, whereas funding in FY 92 will be only \$4.9 million (or about \$3.2 million in FY 81 dollars). The GI-funded Coastal Engineering Research Program is the Program traditionally reviewed by the Board and the Program used by the Corps to address systemic problems the Corps faces in the coastal zone. Since FY 92 funding in constant dollars is less than half FY 81 funding, the Corps' ability to address many coastal problems has dwindled significantly. Should the trend continue, it will become increasingly difficult for the Corps to address the complex problems of the coastal zone.

The Coastal Engineering Research Center (CERC) has weathered the continual decline in the GI-funded Coastal Engineering Program through increasing reimbursable support of Corps Districts and applying expertise to particular problem areas of the coastal zone (e.g. the Dredging Research Program). About 90 percent of CERC's work in the early 1970's was in the Coastal Engineering Research Program. Today only about 20 percent of CERC's work is in this Program and the percentage continues to decline. The decline in the Corps' GI-funded R&D Program needs to be stemmed and reversed for the

Corps to be able to address the problems that it faces today and in the Year 2000.

DISCUSSION

Prof. Robert O. Reid expressed concern that there has been a steady decline of R&D funds over many years, and that the decline was continuing. He said that the Coastal Engineering Research Board (CERB) can try to bolster those funds by making recommendations for research with the hope that they may serve as a catalyst to bring in more funds. MG Arthur E. Williams said they needed to continue watching the funding situation very closely, and he wished to echo what Prof. Reid had said with reference to the Board making recommendations in regard to the type of research that should be pursued.

AN OVERVIEW OF THE SUPERTANK LABORATORY DATA COLLECTION PROJECT

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During the 8-week period from 29 July to 20 September 1991, the Coastal Engineering Research Center (CERC), US Army Engineer Waterways Experiment Station (WES), conducted an intensive laboratory data collection project called SUPERTANK to investigate, at large scale, cross-shore hydrodynamics, sediment transport, and beach change. This cooperative, multi-institutional project centered around the large wave tank (LWT) located at the O. H. Hinsdale Wave Research Laboratory, Oregon State University (OSU), Corvallis, OR, and drew participation of investigators and students from 17 Federal agencies, universities, and private companies in the United States, Denmark, Japan, Sweden, and The Netherlands.

The LWT at OSU is 104 m long, 3.7 m wide, and 4.6 m deep, into which a 76-m-long beach was emplaced for the project. The beach was composed of approximately 600 cu m of uniform-size glacially deposited quartz sand of 0.26-mm median diameter. At the peak of SUPERTANK, data were collected simultaneously from 16 resistance wave gages, 10 capacitance wave gages, 18 two-component electromagnetic current meters, 10 pore-pressure wave gages, 34 optical backscatterance meters (that measure sediment concentration), four acoustic devices to measure sediment concentration (and 3-dimensional (3-D) current field for one instrument), one laser-Doppler velocimeter, one acoustic sensor to measure acoustically the 3-D current field, and five video cameras focussed on various locations across the wave channel. SUPERTANK was the most densely and comprehensively instrumented coastal processes data collection project ever performed.

SUPERTANK was proposed by the author in May 1987 to address severe needs identified in development of the Storm-induced BEACH CHange (SBEACH) model (Larson and Kraus 1989), for which it was found that no data sets existed to relate sediment transport and beach change to the waves and currents that produced that change. Model development had to rely on CERC LWT tests

performed by Saville (1957), supplemented by other laboratory tests and indirect field data. Clearly, movable-bed beach profile change tests were warranted that could (a) take advantage of modern instrumentation and (b) address specific needs of beach profile change modeling. In the course of planning SUPERTANK, the project evolved to include equal emphasis on beach change, on surf zone waves and currents (in particular, on the vertical structure of the current), and on bottom boundary layer and sediment transport processes of concern in the Dredging Research Program (DRP). The direct cost of SUPERTANK was approximately \$400,000, funded nearly equally by two research work units each in the Coastal Program and DRP. Numerous non-CERC participating researchers provided instrumentation, data loggers and computers, and labor more than equaling the direct costs.

SUPERTANK data collection was designed to verify and refine existing predictive technology and provide data and insights on detailed physical processes for development of the next generation of predictive coastal processes numerical models. Thus, SUPERTANK was anchored in the present but aimed toward the future. The objectives of SUPERTANK were to:

- a. Collect data to verify and improve existing *macro-scale* beach profile change numerical simulation models.
- b. Collect data to develop advanced hydrodynamic, cross-shore sand transport, and *meso-scale* beach profile change numerical simulation models.
- c. Collect data to quantify performance of sand bars (nearshore "berms") constructed offshore as a beneficial use of dredged material.
- d. Test and compare sediment-sensing acoustic instruments in a controlled, field-scale environment.
- e. Collect data to improve understanding of *micro-scale* fluid and sand motion.

The strength of the SUPERTANK project was integration of a wide range of instrumentation and expertise to achieve these objectives, resulting in extraordinarily comprehensive and dense coverage of fluid and sediment motion. Project design and coordination were the responsibility of a seven-person steering committee composed of the author (as chairman), Dr. William Dally (Florida Institute of Technology), Dr. Lanny Glover (CERC), Dr. David Kriebel (US Naval Academy), Dr. William McDougal (OSU), Ms. Jane McKee Smith (CERC), and Dr. Charles Sollitt (OSU). Other principal investigators were:

Dr. Yogesh Agrawal (Quest Integrated, Inc.); Dr. Reginald Beach (OSU); Dr. Keith Bedford (Ohio State University); Ms. Cheryl Burke (CERC); Drs. John Fisher and Margery Overton (North Carolina State University); Dr. Daniel Hanes (University of Florida); Dr. Robert Holman (OSU); Dr. Paul Komar (OSU); Dr. Susumu Kubota (Nihon University, Japan); Mr. Atle Lohrmann (RD Flow, Inc.); and Dr. Edward Thornton (Naval Postgraduate School). Visitors included Dr. Julio Zisserman (Danish Hydraulic Institute) and Dr. Marcel Stive (Delft Hydraulics Laboratory), who assisted in data collection to become familiar with the database and to study project administration for organizing similar cooperative projects in Europe, possibly with participation by CERC.

The first and last weeks of SUPERTANK were devoted to mobilization and demobilization. Mobilization involved placement of sand in the LWT by caterpillar and clamshell excavator, forming of the beach by caterpillar and by hand, and placement of instruments, with demobilization the reverse. The standard operating water depth of the tank was 10 ft, and it took approximately 1-1/2 hours to raise the water level 1 ft and 1 hour to lower the water level 1 ft. Most of the extensive sand moving, beach remolding, and structure building (such as seawalls and dunes), and instrument relocation took place on weekends and in the evening, after regular operating hours. Regular hours were from 7:00 AM to 7:00 PM on Monday through Thursday, and from 7:00 AM to 5:00 PM on Friday. Smith (1991; present volume) describes the cross-shore array of wave gages and current meters. The acoustic instrumentation was deployed offshore, seaward of the wave breaking line. An important feature of the project was extensive tests conducted with random waves (random in height and period), in addition to monochromatic wave tests. The wave generator was equipped to absorb waves at the peak spectral frequency, greatly reducing reflected wave persistence in the tank. Accurate beach profile surveys were made with a rod mounted on wheels that supported a prism targeted by a robot infrared geodimeter tracking system outputting 3-D coordinates of the prism. Data were checked and selected analyses performed in real time and nearly real time to verify instrument operation, examine water level time series and spectra, and observe beach profile change. This feedback increased data quality and capture, and promoted optimization of test design.

The following summarizes the major test series in order of performance:

EROSION TESTS, RANDOM WAVES
ACOUSTIC CONCENTRATION PROFILER TESTS (random and monochromatic waves)
ACCRETION TESTS, RANDOM WAVES
DEDICATED HYDRODYNAMICS TESTS (bimodal spectra, time-varying waves, etc.)
DUNE EROSION TESTS
SEAWALL TEST 1
BERM FLOODING TEST 1
FOREDUNE BLOWOUT TEST
DEDICATED SUSPENDED SEDIMENT TESTS
SEAWALL TEST 2
BERM FLOODING TEST 2
EROSION TESTS, MONOCHROMATIC WAVES
STORM TRANSITION TESTS, MONOCHROMATIC WAVES
ACCRETION TESTS, MONOCHROMATIC WAVES
NEARSHORE BERM TESTS (random and monochromatic waves)

The instruments performed very well, and data were collected with but a few hours of gaps on individual instruments for approximately 139 hours of wave action. The data set contains a wealth of information ranging from foreshore beach processes to inception of sediment motion in the offshore, and will be a valuable resource for coastal engineering research for many years. The presentation will give an overview of the SUPERTANK test series objectives and design, focussing on the observed beach profile change. A companion paper following the presentation (Smith, 1991; present volume) will focus on the associated hydrodynamics.

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A FIRST LOOK AT THE SUPERTANK HYDRODYNAMIC DATA

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The SUPERTANK hydrodynamic measurements were made not only to support the study of beach profile change, but also to conduct a series of tests on wave transformation, vertical structure of undertow, and sediment suspension. These topics are interrelated and address basic questions about sand transport; the wave conditions that suspend the sand and drive mean currents, the vertical distribution of sediment concentration, and the vertical structure of the mean current that moves the sand. The SUPERTANK hydrodynamic data will be used to improve treatment of breaking waves in wave transformation models (Davis, Smith, and Vincent 1991; Kraus and Larson 1991), develop nonlinear wave transformation models, improve guidance on modeling multiple wave trains (Smith and Vincent 1991), develop a hydrodynamic model of the three-dimensional nearshore current, understand the role of bottom friction in a combined wave and undertow regime, improve modeling of setup, and support beach profile change and sediment transport modeling efforts. An overview of the SUPERTANK project and the large wave tank facility is given by Kraus (1991; present volume).

Wave transformation was measured with 16 resistance wave gages mounted on the west tank wall, spaced 12 ft apart. The array of resistance gages extended from near the wave generator to a water depth of approximately 2 ft. An array of 10 capacitance wave gages extended from the most shoreward resistance gage to the maximum runup limit. These gages were also mounted from the tank wall, but they were mobile with spacing that varied from 2 to 6 ft. In addition to measuring wave transformation, the capacitance gages also measured runup and the elevation of the sand surface. Fourteen Marsh-McBirney electromagnetic current meters were mounted on the east tank wall. The meters were deployed in vertical arrays of 1-4 meters with vertical spacing of approximately 1 ft. The arrays were designed to quantify the undertow profile. Each array was configured to share a timing pulse (slave

option) to reduce meter interference. The meters were deployed in depths of 1 to 6 ft, with the selection of meter position based on the wave conditions, water level, and bottom profile. An additional four electromagnetic current meters and one capacitance wave gage were deployed on a moveable carriage. The current meters were deployed in a vertical array (1-ft spacing) off an adjustable wing extending beneath the carriage. The carriage was positioned prior to each test to locate the wave gage and current meters in the incipient breaking zone, adjacent to a wall-mounted current meter array (for finer vertical resolution), or some other point of interest. Three video cameras, mounted on a scaffold overlooking the surf zone, recorded a continuous image of the surf zone wave transformation, swash, and runup. Ten pressure gages were deployed within the sand beach to measure pore pressure.

Portions of the hydrodynamic data were analyzed (spectra and time series) during or immediately after the tests for quality control and planning of subsequent tests. The instrumentation performed extremely well during the project. Instrument noise and cross-talk problems were identified and eliminated prior to the experiment in "dry-run" tests in March and June. The wave gages were calibrated once a week during the project by raising and lowering the water level. Wave gage offsets were recorded once a day by collecting water level data with no waves. The current meters were calibrated prior to the project and presently are being recalibrated at the same facility.

The SUPERTANK wave conditions were designed to balance the need for repetition of wave conditions to push the beach profile to equilibrium and the desire for a variety of conditions for hydrodynamic considerations. A total of 21 monochromatic and 47 random wave conditions were generated in over 200 tests. Wave heights typically ranged from 0.2 to 1.0 m, and peak periods ranged from 3 to 10 sec. The TMA spectral shape (Bouws et al. 1985) was used for all random wave tests with a spectral width parameter γ between 1 (broad-banded) and 100 (narrow-banded). Other parameters that affected the hydrodynamics, such as water level, bottom profile, and seaward boundary conditions (seawall, dune, and terrace) also varied between tests, changing the nearshore hydrodynamics for the same imposed offshore wave conditions. The digitally controlled wave paddle was equipped to absorb waves (at the peak

frequency) reflected from the beach. Spectral analysis of 20-, 40-, and 70-minute wave records showed minimal differences in low frequency energy.

A three-day series of tests conducted the third week were dedicated to hydrodynamics. These tests included time-varying wave conditions, varying spectral width, and bimodal spectra (two wave trains). The time-varying tests were designed to investigate the response of the current to varying wave conditions. During a test, the wave amplitude was increased and decreased in 10-to 20-min steps. These data will be used to verify modeling efforts involving time-varying processes such as surf beat. Varying the spectral width gave wave trains with very different characteristics. The narrow spectral peak produced very regular wave trains with obvious wave groups, and the broad peak produced less regular wave trains typical of active wind seas. These data will be used to supplement previous laboratory tests (with constant spectral width) used in the development of a spectral wave-breaking model. The effect of spectral width on statistical breaking models will also be assessed. The test series on bimodal spectra is unique. The velocity measurements will provide improved understanding of the nonlinear interactions between the wave trains. During the final week of tests, an offshore mound was constructed in approximately 6 ft of water to study beneficial use of dredged material for storm wave attenuation and beach profile nourishment. Surf zone wave conditions with and without the mound will be compared to estimate the benefit of the mound for wave attenuation.

The hydrodynamic data collected at SUPERTANK provide critical information needed in present and future hydrodynamic modeling efforts. The tests include much needed data on random wave breaking, vertical current structure, spectral parameters, irregular wave runup, wave attenuation by offshore mounds, and multiple wave trains. The hydrodynamic data, together with the sediment transport and beach profile change measurements, will support future work on advanced sediment transport modeling. The presentation will include some examples of SUPERTANK wave and current measurements.

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DISCUSSION

Prof. Robert A. Dalrymple extended his congratulations for an outstanding laboratory experiment series. He noted the value of CERC's cooperative efforts with universities and international researchers over the last several years, and said that it provides a magnifier effect for science that is obtained from experiments. He said he was impressed by the comprehensive work over a short time period.

MG John F. Sobke asked if any experiments used two offshore mounds, and what effect that might have on harmonics and wave attenuation. He also asked how close the top of the mound was to the water surface. Dr. Kraus said that there was insufficient time to do that. It is possible that energy would be entrapped between bars, which would greatly increase the effect of two bars. Ms. Smith said that the ideal depth of the top of the mound would vary based on wave height and wave period. There is not a simple answer for that. Dr. Kraus said the DRP is addressing that. MG Sobke said he is very interested in results from this work.

BG Roger F. Yankoupe asked about future plans for analyzing the data. Dr. Kraus said that researchers should have their preliminary analysis completed a year after the experiment, and will interchange data at that point. The data will start to become public the second year, and will be completely public the third year. The teams that were formed will be cooperating in analyzing data, and there will be researchers and graduate students around the country working on that.

BG Yankoupe said the challenge is getting the information translated into the essences with which the political problems can be addressed, and translating theory into practice. Anything that would appear to be producible in the short range would be of great value. There is a tremendous amount of value that takes some time to get into the public perception process, and the tools of that are what come out of the research. Mr. Jesse A. Pfeiffer, Jr., said the DRP is a 7-year program, and they do not wait until the end to publish findings. They routinely reduce findings to practice, as a method of operation, by working very closely with field people and Headquarters people. When there is confidence in the findings that have been produced, they are moved out to the field in Engineer Technical Letters, bulletins, etc., even though final data reports may take a good while longer.

Prof. Fredric Raichlen said that he found the whole concept of the experiment very exciting, and he was quite impressed. He asked about the placement of the current meters and wave gages, and whether the current and wave data were affected by the walls of the tank. Ms. Smith said they had not looked at that in detail yet, but they had data from the centerline of the tank as well as the quarter points. For the most part, everything looked very two-dimensional.

MG Sobke asked, if funding was available, what type of experiment could be conducted to test additional parameters and get away from boundary effects. Dr. Kraus said it would be desirable to instrument a real engineering project to make the field our laboratory. He feels that this is possible with the present state of experience and instrumentation, and that it would be successful.

MG Sobke also asked about communication between this program and other programs at WES, for example, the California Coastal Storm and Tidal Waves Effect study, and the Coast of Florida study. Can some of this information be used in those studies? Dr. Kraus said that the offshore berm used was qualitatively designed after the Silver Strand berm emplacement off San Diego, California. That was scaled to the tank. Mr. Jaime R. Merino said it looked like there was an opportunity to already use the results, even though they are preliminary, in some areas like the Silver Strand. Mr. Merino suggested the west coast as a possibility for a prototype measurement.

BG Yankoupe said a lot of data had been gathered along the California coast. He said that Mr. Merino was suggesting some sites that would be particularly relevant for detailed experimentation or instrumentation. Mr. Merino said they had already started the Silver Strand project, and there were other projects where dredged material was being placed in the near surf zone. It may be a synergistic effect to use a prototype, and some of the information we have, with what came out of SUPERTANK.

MG Williams said he would encourage those who have an opportunity to do those types of things to get together with Dr. Kraus and the rest of his team, to utilize that information and perhaps expand it from there.

Dr. Albert G. Holler, Jr., asked about the sand that was used in the experiment. Dr. Kraus said the sand had a median grain size of 0.26 millimeters, so it's right in the range of most American recreational beach sand. It was obtained from a glacial dune on the Oregon coast. It was a very uniform grain size, but did contain some of the Oregon metallic placers. SUPERTANK also replicated the onshore movement of those placers.

Mr. Robert E. Sattin asked about the method for redistributing sand in the tank between tests, and whether consideration was given to doing that

hydraulically rather than draining the tank to redistribute sand mechanically. Dr. Kraus said they had considered that, but could not acquire and test equipment in the time frame of the experiments.

HURRICANE BOB REPORT

Dr. Andrew W. Garcia
Prototype Measurement and Analysis Branch
and
Monica A. Chasten
Engineering Applications Unit
Coastal Structures and Evaluation Branch
Engineering Development Division
Coastal Engineering Research Center
US Army Engineer Waterways Experiment Station
Vicksburg, MS

and

John R. Kennelly III
Planning Directorate
US Army Engineer Division, New England
Waltham, MA

Hurricane Bob is the first hurricane to affect the New England area since Hurricane Gloria of 1985. Bob attained Category 3 status on the Saffir-Simpson Hurricane Scale on 19 August while located about 100 miles southeast of Norfolk, VA. At this time the maximum sustained surface wind speed and minimum central pressure were approximately 115 miles per hour (mph) and 950 mb, respectively. During the next 12 hours, Bob accelerated from a forward speed of approximately 23 mph to 33 mph in a north-northeasterly direction, which took it over the cooler waters off the mid-Atlantic Coast. As Bob passed off the eastern tip of Long Island and approached landfall near Newport, RI, it had weakened to a Category 2 status with maximum sustained surface wind speed of approximately 98 mph and a minimum central pressure of 964 mb. Reconnaissance aircraft personnel were unable to definitively fix the eye position just prior to landfall because of lack of an eyewall in two quadrants of the storm. Bob continued to weaken as it crossed Massachusetts Bay and made a final landfall as a tropical storm near Rockland, ME.

More detailed meteorologic and hydrographic data acquired during Hurricane Bob are presently being assembled. A brief summary and overview of these data will be presented.

Following Hurricane Bob's landfall, an area reconnaissance was carried out to determine, qualitatively, the storm's impact to Federally authorized navigation projects and to conduct a general survey of the region's shore and upland property damage. Two reconnaissance teams from the Coastal Engineering Research Center covered the impacted area west from Point Judith, RI, east to Chatham, MA, on Cape Cod. Table 1 presents the Federal navigation projects that were inspected to ascertain damage caused by Bob.

Table 1

Federal Project	Structure
Point Judith, RI	Jetty
New Bedford	Hurricane Barrier
Falmouth Harbor	Jetty
Hyannis Harbor	Jetty/Breakwater
Andrews River	Jetty
Chatham	Jetty
Vineyard Haven Harbor, Martha's Vineyard	Breakwater
Menemsha Creek	Jetty
Harbor of Refuge, Nantucket	Jetty

The southern shore along Rhode Island and Massachusetts is rocky with elevations ranging from near sea level to cliffs over 100 ft high. Structures at the Federal navigation projects were primarily jetties or breakwaters. Each navigation project experienced some degree of structural damage, ranging from minimal to moderate, as a result of Bob. Minimal damage included movement or displacement of a few stones along the jetty or breakwater, where moderate damage included displacement of large sections of stone along a structure. The most severe structural damage was observed at the jetty at Point Judith and the breakwater at Hyannis.

Beach erosion along sandy sections of coastline occurred from storm waves and surge, and overwash. Upland property damage ranged from minimal to moderate, and in a few cases, catastrophic. The most significant property damage occurred along low-lying sections of coast such as Horseneck Beach where several houses were completely destroyed by direct wave attack. However, structures at moderately higher elevations received much less damage due to Bob's landfall occurring near low tide. In many cases, the only damage

these properties incurred was caused by sailboats breaking their moorings and being driven by wind into the dwellings.

A summary of the Federal projects will be presented to characterize Bob's effect on these navigation structures and an overview will be given of damage to area property and shoreline.

DISCUSSION

Prof. Raichlen asked about the accuracy of the SLOSH model. Dr. Garcia said the SLOSH model had been likened to a 10-dollar hydrodynamic model being run with a 10-cent wind field. The SLOSH model, by its very nature, is intended to serve as a guide for preparation of evacuation maps, and also is primarily intended to be used in an almost real-time application. There is a presumption that the meteorological data that would be available to drive the SLOSH model would be very limited. Consequently, the model uses a parametric wind-field model that contains only two or three variables, and that does cause the SLOSH model not to perform as well as it might otherwise if more detailed wind-field data were available. The model is tuned to capture the elevation and time of the surge peak.

Prof. Raichlen asked what the maximum SLOSH model referred to. Mr. Kennelly said the model was run with different intensities, forward speeds, and directions at 15-mile intervals. In most cases, the maximum values are the worst track, on a north to northeast direction, at 60 mph for a Category 4 storm event. That is a category greater than the 1938 storm.

Prof. Reid noted that Hurricane Bob appeared to be a rather unusual storm in terms of pressure field. There was a very significant secondary dip in the pressure. Dr. Garcia said the secondary pressure dip occurred when Bob was classified as extratropical, and was somewhere over the mid-Atlantic Ocean after it had exited the continental United States. He had not looked into the cause of the dip.

Mr. Barry W. Holliday asked if there was any analysis of the condition of structures before the storm. Ms. Chasten said they had not looked into that with too much detail as yet, but were anticipating looking further into it.

Mr. John H. Lockhart, Jr., asked how much damage was prevented by closing the hurricane barriers. COL Harris said the estimate from closing the New Bedford barrier was prevention of \$9 million in damages. Other barriers, not operated by the Corps, were also closed, and it is estimated that a total of \$11 million in damages was prevented.

Dr. Fred Camfield noted that a Category 4 storm was being used in the SLOSH model, and noted those were rather rare at that latitude. He asked about the possible recurrence interval for such storms. Mr. Kennelly said the 1938 storm was close to a Category 4, based on information from the National Hurricane Center, so a Category 4 storm can occur. They are using this for evacuation planning purposes, so they looked at extreme worst-case situations.

MG Sobke asked if there were predictions of maximum surge for all areas where hurricanes might occur. Mr. Kennelly said he believed the National Hurricane Center was working towards that goal, and that most of the South

Atlantic and Gulf coasts had been covered, but some refinement was under way on parts of the coastline. MG Sobke asked if the US Army Engineer Waterways Experiment Station could provide to Divisions concerned the status of development of the SLOSH model so that they would know where they stand in terms of the predictive capability of the National Weather Service. Mr. Kennelly said that the National Hurricane Center has an up-to-date listing of where all those models stand.

BG Yankoupe asked how much variability would be expected between one storm and another following a similar track, with generally the same conditions. Dr. Garcia said that although certain characteristics about them may be common, the details of the structures of the storms can be very different in terms of, for example, the time histories of the radius of maximum winds, which affect the calculations that would result from a storm surge model. One would have to run a great number of storms, using a great number of varying values for the parameters, in order to get some idea of what the possible storm surge effects would be due to different hurricanes.

MG Sobke asked about the amount of warning time provided. Mr. Kennelly said the hurricane model does not provide that. They do a transportation analysis to determine how long it would take to evacuate an area. That gives local officials the amount of lead time they need to make a decision. When they are tracking a storm progressing towards them, they determine when the storm is a certain number of hours away, and use that as a means of gaging when they should make a decision on evacuation. Mr. Holler commented that in the case of Hurricane Hugo, they were predicting 12 hr before landfall that it would hit Savannah, so there is a large uncertainty in the predictions.

Prof. Keid commented that SLOSH predicts overland flow, and that it is not intended for design. Dr. Kraus added that, from the perspective of beach erosion, it is necessary to know both peak surge and duration. Just knowing the peak surge is not adequate.

**CAPPING EXPERIENCES UNDER THE DISPOSAL AREA MONITORING SYSTEM (DAMOS) PROGRAM:
SUCCESS BREEDS SKEPTICISM?**

Dr. Thomas J. Fredette
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Monitoring of open-water dredged material disposal sites in New England in the past few years has, in part, focused on (a) evaluating long-term effectiveness of capped disposal mounds, and (b) assessing the feasibility of capping at sites four to five times deeper (80-90 m) than we have in Long Island Sound.

Long-term effectiveness in isolating contaminants from the environment involves maintaining both physical and chemical integrity of caps. Physical cap integrity has been documented through successive bathymetric surveying of capped disposal mounds. Severe storms during the last 10 years, such as Hurricane Gloria, have had limited effects once the caps have consolidated and stabilized.

Chemical stability of caps has been assessed by physically and chemically analyzing sectioned cores taken through capped mounds. These data, taken from mounds more than 10 years old, have shown very sharp physical and chemical transitions, which suggest there has been limited mixing and transport between layers. Biological sampling on capped disposal mounds has provided further evidence of cap effectiveness, as recolonization and contaminant levels within organisms have been found to be similar to reference conditions.

The feasibility of capping at New England's deepest open-water dredged material disposal site, in approximately 90 m of water in Massachusetts Bay, has received increasing attention because of the growing number of projects in the Boston region for which few other practical options exist. Ongoing monitoring efforts have documented the development of a well-defined disposal mound centered around the disposal point in use since 1985. This, along with similar observations at two Puget Sound sites, has lent empirical support to the theoretical hypothesis that capping could be successfully applied at such water depths.

Although the weight of evidence supporting the success and effectiveness of capping is increasing rapidly, resource agencies and public interest groups remain skeptical, especially about proposals to apply capping in the deeper water sites. Of particular concern are questions about the loss and fate of sediments and their associated contaminants. Concerns include the percentage of contaminants lost during disposal relative to the percentage of sediments lost and the further losses of sediments and contaminants during the placement of sequential loads of both contaminated and cap materials. Much of this concern arises due to the relatively small number of studies that have focused on mass and contaminant balance, particularly studies that have followed up on projects with multiple disposal events.

Capping is increasingly being considered as a management practice for both navigation dredging projects and for sediment remediation. However, the degree of skepticism that exists among concerned agencies and groups suggests that there is a need to either more effectively synthesize the existing information or conduct a multidisciplinary study to more closely couple considerations of sediment transport with contaminant concerns.

DISCUSSION

Prof. Raichlen noted that when contaminated material is placed, some water is entrained and there is an opportunity for contaminants to be released. He asked if, after the cap is placed over the material, contaminants could leach through the cap. Dr. Fredette said that samples taken from the cap should show a gradation of material up through the cap if leaching is taking place. The analysis that they have done so far does not seem to suggest that type of process is occurring.

BG Yankoupe said this technology is going to be very useful for both maintenance dredging and new-work projects in estuaries. We should not raise issues of skepticism, but should move the technology forward as rapidly as possible. The technology needs to be packaged and disseminated. There are people opposed to placement of the material. As with many of the environmental problems that the country will be facing in the future, there are going to be trade-offs. We will have to decide how much risk we are willing to accept to get a permanent solution. We also need to be cognizant of the fact that long-term monitoring is expensive. It usually ends up in a surcharge on dredge quantities. Dr. Fredette said we know a lot about how this material behaves, and a lot about our ability to conduct these types of projects, but we need to do a better job of getting the information that we do know out to where it can be used by people who are concerned about these types of issues.

Mr. Pfeiffer asked if other agencies were involved in taking data in the DAMOS Program, and also if there was any water column data above the sites or any biological sampling. Dr. Fredette said they do a lot of interacting with the Environmental Protection Agency (EPA) but that the EPA and the states were not directly involved in the DAMOS Program. It would be desirable in the future to get them more involved. Periodic symposia on the program are held now. He said that they had not been doing a great deal of water column sampling. Most of the sites have very well-mixed water columns, so it is very difficult to discern any effects. They do look at biological conditions, such as recolonization of the sites and whether contaminants are showing up in tissue samples.

Mr. Pfeiffer noted that the Corps had a Field Verification Program a few years back, sponsored by Operations and Readiness Division, Directorate of Civil Works, addressing the problem of putting a very contaminated soil on the bottom and capping it. It looked at placement in three areas: deep water, intertidal, and upland, and the object was to establish a multiagency baseline of what really happens out there so that we don't have to continually monitor the sites. He suggested that a future Board meeting could consider an update from that program on where we are. MG Williams and BG Yankoupe agreed with that suggestion. BG Yankoupe added that the focus of these kinds of programs is also important. These kinds of efforts should be focused under some kind of umbrella.

Mr. Eugene F. Cavanaugh said that Massachusetts had started working with the New England Division to come up with some sort of monitoring program for other sites in Massachusetts. They were a little out of step because of the state's financial problems, but Massachusetts has made a commitment, and they hope to be able to move forward with that.

NEW BEDFORD HARBOR, MASSACHUSETTS

Mark J. Otis
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New Bedford, MA, is a port city located on the southeastern Massachusetts coast where harbor sediments contain elevated levels of polychlorinated biphenyl (PCB) and heavy metals including copper, chromium, zinc, and lead. PCB concentrations in the sediment range from a few parts per million (ppm) to over 100,000 ppm. The harbor is listed on the National Priorities List as one of the nation's worst hazardous waste sites and has been the subject of numerous studies carried out under the Superfund program. The initial remedial action at the site is scheduled to begin this fall.

The New England Division and the US Army Engineer Waterways Experiment Station have performed several studies at this site to evaluate dredging as a means of removing the contaminated sediments from the harbor. The studies focused on determining the effectiveness of the dredging operation and the contaminant release associated with it. The studies included both an engineering feasibility study and a pilot study. The information obtained from the studies was critical to the Environmental Protection Agency in its decisions as to how to clean up the site.

This presentation will review the problem at New Bedford and the work done by the Corps of Engineers. The focus will be on our attempts to estimate the contaminant release associated with the dredging operations.

DISCUSSION

MG Williams asked what the cleanup costs would be. Mr. Otis said the first phase, or "hot spot" cleanup, of 10,000 cu yd would cost \$20 million. Subsequent cleanup of the entire harbor would involve more material, up to 1/2 million cu yd, but would require less treatment. The cost of that could range from \$50 million to \$200 million, depending on the extent of the cleanup and the level of the treatment.

**NEW INLET FORMATION
AND RESULTING EVOLUTION OF
THE MULTIPLE INLET SYSTEM, CHATHAM, MASSACHUSETTS**

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Morphodynamic processes of inlet formation and interaction of multiple inlets within a tidal estuarine system have been investigated with the breach of Nauset Spit, a narrow barrier spit which separates the Chatham Harbor from the mainland town of Chatham, MA. Nauset Spit, also referred to locally as North Beach, is located at the southeastern end of Cape Cod, approximately 64 km east of mainland Massachusetts. The barrier spit originally sheltered the Chatham mainland from direct wave attack, creating a relatively stable inner shoreline and navigable harbor. On 2 January 1987, during a severe northeast storm occurring concurrently with a perigean spring tide, the spit was breached at a point almost directly east of Chatham Lighthouse. The southern portion of the spit has become a barrier island known as South Beach. Chatham Harbor Estuary is now composed of four tidal inlets linked together into a complex system (Figure 1).

New Inlet originally formed by overwash of a narrow barrier spit due to storm conditions. Tidal and wave forces interacted to establish this breach as a permanent inlet feature by capturing most of the tidal flow in the system. The tidal flow between the estuary and the ocean is now mainly exchanged through the new inlet, which has continued to widen and migrate to the south within the first 31 months (Liu et al., in preparation). The inlet-adjacent shorelines of both North and South beaches have evolved into spit-like features extending into the estuary. They have fluctuated in length and orientation as the inlet throat has progressively increased in width since its formation.

As New Inlet developed, ebb- and flood-tidal shoal complexes have formed. The ebb shoal contains the main ebb delta and a large swash platform, which is mainly located on the updrift northern ocean side of the newly formed inlet. With the migration of the main ebb channel to the south, the ebb shoal

has grown seaward and downdrift. The swash platform has grown as swash bars evolve and are modified by waves and currents. The flood-tidal shoal complex contains four major shoal features. Due to the narrow width of the estuary at the breach, the flood shoal features are divided into northern and southern components. A linear shoal and northern portion of the flood-tidal delta located on the northern side of the new inlet are modified by coastal processes from remnant shoal features of the old enclosed estuary. These features have frequently changed shape and presented challenges to navigation as adjacent channels have shoaled and reoriented. The southern portion of the flood-tidal delta and a south sand flat area also developed from a remnant estuarine shoal. These shoal features have grown in size and area, and have merged with the South Beach inlet-adjacent spit to effectively close off the southern portion of the estuary to tidal flow at all but high water stages. This shoaling of the southern flood delta and landward growth of the inlet-adjacent spit have created a shorter exchange route with the northern two-thirds of the estuary. The main ebb channel has reoriented itself to form the bend through the throat of New Inlet. Within the first 31 months of formation, the tidal flow through New Inlet has not reached a state of equilibrium with inlet bed form features or littoral drift, and it continues to evolve.

Morphologic trends suggest that the estuary has developed into two separate segments since the formation of New Inlet. The northern portion of the estuary is actively interacting with the dynamic coastal processes through New Inlet. The southern portion of the estuary is becoming a remnant feature. The three inlets in the southern portion of the system have also evolved since the opening of the new breach. The South Beach barrier island has grown to the south with a series of spits and shoals moving the original Chatham Bars inlet to the south. The South Channel, as it is now called, is within the estuary and has elongated. The former main channel has been convoluted by a series of shoals deposited within this portion of the estuary. The West Channel Inlet, the flood channel of the original inlet into Nantucket Sound at the southern end of Morris Island, is now experiencing rapid shoaling. An unnamed inlet that formed when Monomoy Island was breached in 1978 is now opposite the South Channel entrance. Both West Channel Inlet and the unnamed

inlet bisecting Monomoy Inlet have extensive flood-tidal shoals. Tidal differences between the Atlantic Ocean and Nantucket Sound produce flood-dominated flow into Nantucket Sound with return ebb flow deflected to the southern end of Monomoy Island (Hine 1975).

With the capture of the main tidal circulation of Chatham Harbor Estuary at New Inlet and the southern growth of South Beach, the estuary is gradually evolving into two parts. The northern part, including the southward-migrating New Inlet throat and ebb delta, has become the main inlet of the system. The southern part of the system will gradually become remnant and disappear. Historically, this temporal process of growth of Nauset Spit, breaching of the spit during a storm event, and disintegration or landward migration of the southern barrier island has occurred in the past, with the last breach forming in 1871 at almost the same point on the spit (Giese 1988). As the barrier island/estuary complex breaks up, the mainland is exposed to open ocean wave action and mainland shoreline erosion. Nauset Spit will eventually grow to the south again and the cycle will be repeated.

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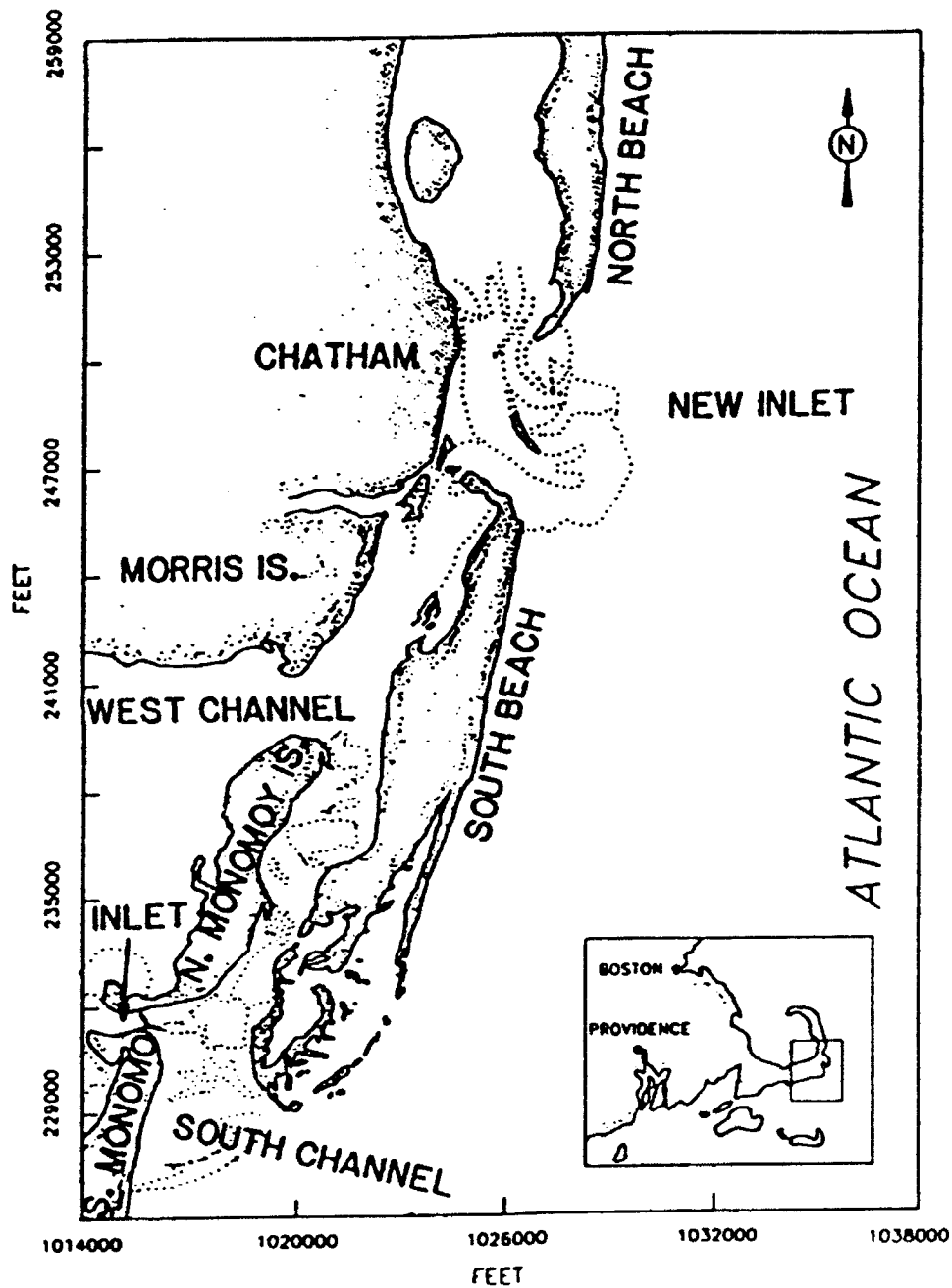


Figure 1. Location and morphology of Chatham multiple inlet system

(There was no discussion following this presentation.)

FIELD TRIP

The field trip took place during the early stages of the storm since referred to as the 1991 Halloween Northeaster. The first stop was at Chatham Harbor, which was experiencing heavy wave action due to waves penetrating through the breach in the barrier spit. Wave action through the breach had previously eroded the shoreline at Chatham. Severe erosion and substantial property damage occurred along this section of shoreline during the storm because of the loss of protection previously provided by the spit.

The next stop was at Sandwich Town Beach, where sand from a private dredging project was used for dune reconstruction, followed by a stop at the East Boat Basin on the Cape Cod Canal, where a storm-driven tide was causing flooding. A stop was made at the historic Aptucxet Trading Post on the way to the Hog Island Dike at the west end of the canal. From there, the field trip proceeded to its last stop at the canal's Marine Traffic Control Center, where rangers made presentations on the history of the project as well as current operations.

CHIEF'S CHARGE TO THE BOARD

MG Arthur E. Williams
Director of Civil Works
US Army Corps of Engineers
President, Coastal Engineering Research Board
Washington, DC

At this Board meeting, I charge you to consider the following two issues:

First, a significant area of the Dredging Research Program deals with developing procedures for predicting the behavior of dredged material placed in the subaqueous environment. These procedures will be used to attain the following goals:

- a. Predict the fate of dredged material placed offshore.
- b. Design berms or mounds to be either stable or feed the beach.
- c. Design caps for contaminated dredged material.
- d. In general, better manage placement operations.

The question posed to the Board is: What modifications, if any, to the current program or additional work is needed to meet these goals?

Second, the Corps of Engineers has received criticism for allegedly causing adverse impacts on shorelines adjacent to some inlet navigation projects. The State of Florida maintains that such projects account for 85 percent of the sand lost from their beaches. The question for the Board is: What research is required to adequately define and prescribe the effects of projects on adjacent shorelines?

Professor Raichlen, Professor Reid, and BG Genega are asked to address Issue No. 1. Professor Dalrymple, MG Sobke, and BG Yankoupe are asked to address Issue No. 2. In order for the Board to address the assigned issues, a Headquarters Management Panel has been assembled to provide an overview and respond to questions. This briefing will provide an appreciation of the magnitude of the Program, the Corps practices, and the policies by which the Corps is governed.

PANEL
CORPS OF ENGINEERS DREDGING
PROGRAM, POLICY, AND PRACTICES

Robert H. Campbell, Moderator
Chief, Dredging/Navigation Branch
Operations, Construction and Readiness Division
US Army Corps of Engineers
Washington, DC

Barry W. Holliday
Dredging/Navigation Branch
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US Army Corps of Engineers
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David B. Mathis
Office of Environmental Policy
US Army Corps of Engineers
Washington, DC

REVIEW OF CORPS OF ENGINEERS DREDGING PROGRAM

Barry W. Holliday

The purpose of the Corps of Engineers dredging program is to improve and maintain the Nation's waterways to make them suitable for navigation and other purposes consistent with Federal laws and regulations. As a result, the Corps of Engineers is responsible for the dredging and subsequent disposal of approximately 300 million cu yd of sediments annually. Of this quantity, about 20 million cu yd are placed on beaches or used for other nourishment purposes including nearshore berms.

Dredging Regulations

The regulations for dredging are prescribed in ER 1130-2-307, "Dredging Policies and Practices." This regulation authorizes all District Commanders to develop methods of securing the maximum practicable benefits from material dredged from authorized Federal navigation projects, after taking into consideration economics, engineering, and environmental requirements in accordance with applicable Federal laws and regulations. In addition, the regulation states that dredging of any and all navigation projects shall be justified to reflect the current level of navigation activity at the project, to provide rationale for the channel dimensions to be dredged, and the frequency of dredging. When specifying a disposal method, all disposal alternatives including beneficial uses should be investigated in accordance with applicable laws and regulations.

Dredge Plant

The four types of dredges that operate in the coastal and Great Lakes projects are: (a) hopper dredges, (b) hydraulic cutter-suction pipeline dredges, (c) sidecast dredges, and (d) mechanical grab or bucket dredges. The mode of disposal of each dredge type will dictate where and how dredged material is placed for nourishment purposes. The sidecast dredge is a special dredge that removes shallow inlet sediments via a trailing suction pipe and

draghead assembly and discharges the dredged material adjacent to the channel through a pipe while dredging. This particular dredging operation returns the material back to the littoral zone within the inlet system. However, sidecast dredges cannot be considered for specific placement like other dredge plants and will not be addressed further.

The cutter-suction pipeline dredge is the most widely used dredge plant for maintenance dredging operations. It is generally limited to areas with low energy environments with minimal wave heights. A few (10-12) are designed to withstand more substantial energy levels and have the capability to operate in open ocean inlet channels and offshore borrow sites. Because of their size and large horsepower ratings, these dredges are expensive to mobilize and operate. The pipeline dredge produces a continuous slurry of dredged material and water that is transported from the dredge to the disposal area by a discharge pipeline. This mode of disposal is particularly suitable for beach nourishment operations. Normal operation is continuous, 24-hour pumping directly on the beach. Vulnerability factors for this dredge plant include high energy environments (waves and currents), narrow and high-traffic channels (lack of maneuverability, not self-propelled), distance from the disposal site to the dredging site (booster requirements, reduced production), and plant availability (only a few ocean certified).

The hopper dredge is a sea-going self-propelled vessel that is designed to perform dredging operations in open water and ocean inlet environments. Dredged material is removed from the channel while the vessel is under way and the sediments are collected in the vessel's hoppers. When the hopper is full, the vessel stops dredging and transports the dredged material to a disposal site. The dredged material is generally deposited in open water by a rapid release of the sediment through bottom doors in the mono-hull vessels or through the bottom of the split-hull vessels. This mode can be used for constructing nearshore berms. Many of the current fleet of hopper dredges have the capability to pump out their loads through a pipeline and mooring barge configuration or a special pump-out buoy/pipeline system directly on the beach. This operation adds substantial time to the dredging cycle and additional mobilization/production costs. Vulnerability factors for this dredge plant include minimum operating draft restrictions for berm

construction, site restrictions for pump-out operations (protected mooring), distance from the disposal site to the mooring/pump-out site (booster requirements, reduced production), and inability to control sediment type in hoppers.

The mechanical grab or bucket dredge is a floating derrick with a large, 14- to 50-cu-yd bucket that removes material from the bottom and places it in a barge or scow moored alongside. The scow is transported to a disposal site with a tug, usually in open water, and the disposal operation is similar to the hopper dredge. This mode can be used for constructing nearshore berms. Production is best in softer, finer-grained sediments that allow effective penetration of the bucket. Vulnerability factors for this dredge plant include distance from the dredging site to the disposal site (round trip time for the scow impacts production), high energy environments (mooring difficulties for scows), and minimum operating draft of barges for berm construction.

All of the above dredge plants are vulnerable to environmental constraints. Specifically, endangered species of turtles have caused restrictive dredging windows for operation of hopper dredges in ocean inlets in the Southeast and Gulf. Turtle nesting and endangered shore bird species have caused restrictive disposal windows for beach disposal. Open-water disposal and berm construction activities have been impacted by state water quality criteria for turbidity. Other biological species impacts issues, such as anadromous fish migration periods and shrimp nursery designations, have impacted when and where dredging and disposal operations can occur. As these dredging windows are closed tighter and tighter, the dredge plant availability issue and the cost become even more critical.

An important concern for future planning and an environmental concern is the fact that a substantial quantity of the dredged material removed annually from ocean inlet projects is not suitable for beaches. The distribution of the suitable sand deposits in these inlet channels is often such that only about 25 to 30 percent of the quantities dredged could be placed on a beach. When an evaluation of what is actually removed is used to equate beach losses of sand-sized material, caution should be exercised in fully understanding the sediment distribution within the dredged channel. Conversely, when designing

a beach project or evaluating the potential beneficial use of dredged material from an inlet channel, the operational constraints and actual distribution of the sand deposits should be carefully considered.

Long-Term Management Strategies

The Corps is developing the concept of Long-Term Management Strategies (LTMS) for navigation projects for the purpose of establishing dredging and dredged material management practices for long periods of time (>10 years). The LTMS procedure involves consideration and evaluation of all feasible disposal options, including the use of beach disposal and near-shore berm disposal. It is expected that the beach disposal option will be incorporated in more projects as the availability of viable upland sites is diminished. New management strategies may evolve from the changing endangered species restrictions concerning hopper dredging operations. As these strategies are developed, industry may identify the need to invest in more cost-effective dredge plants that can produce more over longer distances.

(Discussion was deferred until after Mr. James E. Clausner's presentation.)

PANEL
FATE OF DREDGED MATERIAL PLACED OFFSHORE

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OVERVIEW OF THE DREDGING RESEARCH PROGRAM

E. Clark McNair, Jr.

The Dredging Research Program (DRP) is now in the fourth year of its 7-year life. The funding level for the DRP is \$35 million. The overall objective of the DRP is to provide technical and managerial tools for the Corps so that Federal funding can be saved in carrying out the navigation mission where dredging must be performed. The program is divided into five major technical areas as follows:

- a. Analysis of Dredged Material Disposed in Open Water.
- b. Material Properties Related to Navigation and Dredging.
- c. Dredge Plant Equipment and Systems Processes.
- d. Vessel Positioning, Survey Controls, and Systems Processes.
- e. Management of Dredging Projects.

Each of the technical areas develops technical products for our Tech Transfer area to disseminate to Corps users and to the public.

The status of the DRP is that much of the fundamental research and development has now been completed and the demonstration and fine-tuning of technical products is under way. There is much interaction of field personnel with DRP personnel in the demonstration phase of DRP in order to assure that the technical tools are functioning properly and correctly address field needs.

Management of the dredging process requires a variety of technical tools in order to assure that the benefits that come from dredging are assessable, identifiable, and quantifiable. Technical Area 5, "Management of Dredging Projects," draws heavily upon other areas of the DRP for technical tools. It is, in fact, much like a matrix into which the products of the other four technical areas will be woven.

The others on this panel will expand upon the need for and the benefits of research into dredging management.

DRP RESEARCH INTO DREDGED MATERIAL PLACED IN SUBAQUEOUS LOCATIONS

Dr. Nicholas C. Kraus

Of the five technical areas comprising the Dredging Research Program (DRP), Technical Area 1 (TA1), entitled "Analysis of Dredged Material Placed in Open Water," has the responsibility for developing techniques to measure, monitor, and numerically model the movement of dredged material placed or located in open water. This work is being performed under the direction of five principal investigators from the Coastal Engineering Research Center (CERC) and the Hydraulics Laboratory at the US Army Engineer Waterways Experiment Station, for which the author serves as TA1 Technical Manager.

Research and development in the subject area may be classified into three categories: (1) movement of sediments through the water column in the course of placement operations, (2) movement of sediments that already reside on the bottom in relatively deep water seaward of the surf zone, and (3) movement of sediment, principally sand, that may sometimes be located in the surf zone or otherwise be influenced by depth-limited breaking waves. In DRP terminology, Category 1 is referred to as the "short-term fate of dredged material," Category 2 as the "long-term fate," and Category 3 as "berm processes," where the word "berm" refers to a physically definable, sub-aqueous feature such a linear bar that is constructed in the nearshore of dredged material. Presently, efforts are under way to link Categories 1 and 2. The subject matter of Category 1 has been presented to the Coastal Engineering Research Board at the 52nd and 54th Meetings, and will not be further discussed here except to note that recent work includes model refinement and testing in cooperation with staff of the US Environmental Protection Agency's Narragansett Laboratory, and initiation of an intensive calibration program of acoustic field instrumentation for measuring suspended sediment concentrations in FY 92 as a cooperative project between the DRP and staff of the Atlantic Oceanographic and Meteorological Laboratory of the National Oceanic and Atmospheric Administration. The coming year will see considerable advances in both field data collection, instrumentation development, and modeling of the short-term fate of dredged material.

Concerning the movement of dredged material that has reached the sea bottom (or evaluation of sites where material might be placed), perspective is gained by noting that the Shore Protection Manual (1984) contains only about 18 pages that may be considered as dealing quantitatively or semi-quantitatively with cross-shore and deepwater movement of sediment. Thus, at the inception of the DRP there was great need to advance this area, and much time was spent in planning by DRP investigators to make optimal use of limited and finite-lived resources. The presentation will focus on selected major DRP thrusts in the areas of long-term fate and berm processes, describing progress and areas identified as needing further investigation.

The basic structure of the DRP long-term fate model has been developed by Dr. Norman Scheffner of CERC. Long-term predictions of dredged material fate are made through the use of a coupled hydrodynamic, sediment transport, and bathymetry change model that was developed for desk-top computer application (Scheffner and Tallent, in preparation). The model utilizes driving force database input to predict dredged material fate, and is valid for deeper water and non-breaking waves. The driving force is a calculated or externally input current field. The empirically based Ackers and White non-cohesive sediment transport formulas are used, modified to include increased shear due to the presence of waves. Although the transport rate formulation is considered an interim measure until improved predictive formulas are available, as under development by Dr. O. S. Madsen (Massachusetts Institute of Technology) under contract with the DRP, the model has produced reasonable results in a number of applications and comparisons (Scheffner 1990, 1991; Scheffner and Swain, in preparation). This coming year will see an effort to compare more theoretically based transport rate formulas and empirical formulas against available data and for hypothetical extreme flow conditions. Additionally, we are in the process of including cohesive material transport relations. An identified need is for high-quality field and laboratory data on sediment transport, both cohesive and non-cohesive, under waves and currents. The SUPERTANK project will provide data on sand transport in the offshore to help address these questions.

Predictive simulations of the fate of dredged material must be based on localized driving forces such as waves, tidal currents, and storm surge

hydrographs, which erode and transport sediment from the ocean floor. As part of TAL activities, Borgman and Scheffner (1991) developed a procedure for simulating time sequences of waves that contain the statistical properties of the Wave Information Study 20-year hindcast database, including seasonality and wave sequencing. A TAL-developed finite-element hydrodynamic model (Westerink and Gray 1991, Luettich and Westerink 1991) is currently providing tidal elevation and velocity predictions along the east and gulf coasts of the United States and will soon be used to generate frequency-indexed storm surge hydrographs. Efforts within the present year include development of a database of tidal information for the west coast. Future efforts beyond the current DRP will concentrate on a storm surge hydrograph database for the west coast and the Great Lakes, as well as improved methodologies for making the system readily available to District personnel.

Numerical modeling of shallow-water berms is being undertaken in TAL, and initial work was reported by Larson, Kraus, and Hanson (1990). The concept is development of a *decoupled* model of bottom bathymetry change, in which basic elements are cross-shore lines rather than grid cells as in conventional box models. The idea is to calculate cross-shore and longshore transport independently on the lines, then couple the rates through the mass conservation equation. This procedure has the advantages of great efficiency, direct use of previous surf zone formulations, and robustness of computations. A major need is improved transport rate formulas, in particular, formulas that are valid in transition from the surf zone to the offshore. Recent work on the longshore current and longshore sediment transport over barred profiles (Kraus and Larson 1991, Larson and Kraus 1991) performed in the DRP as part of the coupled model development is being revisited to examine newly acquired field data taken on bar and trough beach profiles.

Empirical predictive approaches developed based on DRP monitoring of shallow-water berms are also proceeding and have provided useful guidance for the siting of such features. At present, the DRP database contains information on 11 berms on three coasts of the United States. On the basis of this information, Hands and Allison (1991) developed a procedure for predicting whether a berm in a certain depth will be stable or move under wave conditions of certain frequency of occurrence of wave action. Similarly, McLellan,

Kraus, and Burke (1990) developed a rational predictive procedure for estimating whether a berm of given grain size will move onshore or offshore under waves of certain characteristics, based on empirical results developed for beach change (Kraus, Larson, and Kriebel 1991). This interim guidance is now being modified through analysis of natural bar movement contained in the 8-year profile survey data set from CERC's Field Research Facility in Duck, NC. Rigorous monitoring of dredged material placement sites is essential if advances are to be made in the area of berm processes.

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DISCUSSION

MG Sobke and BG Yankoupe asked about the source of the data shown in the presentation. Dr. Kraus indicated that some of the results shown were from an intensive analysis of data taken at CERC's Field Research Facility at Duck, NC. Other results were from data taken at a number of field projects on the Atlantic, Gulf, and Pacific coasts. BG Yankoupe asked if the results could be used as a predictive tool, and Dr. Kraus said they could be used right now for that purpose. These results are expected to be out quickly in the form of technical notes.

Prof. Reid asked about the correlation between parameters. Dr. Kraus said that h_o/L_o represents the wave symmetry, while h_o/w_t is a sediment transport-related parameter that is different. Intensive work done for SBEACH showed that both parameters were needed to describe the processes. He could provide other parameters. Prof. Dalrymple noted that the plot as shown could be misleading.

Prof. Dalrymple said he was concerned that there was some degree of error in the wave height and dissipation across the surf zone, the driving mechanism, but the result exactly predicts the current. Dr. Kraus said that the advection of the turbulence needs to be considered, and that has now been modeled and added to this model.

THE MOBILE BERMS PROJECT

J. Patrick Langan

The US Army Corps of Engineers is responsible for dredging and disposal of many millions of cubic yards of material each year. Alternatives are needed in many cases to conventional open-water disposal for the large volumes of clean sand dredged annually. The concept of using suitable dredged material to construct submerged features parallel to the shore in order to derive physical and substantive environmental benefits is gaining acceptance. The Corps has been involved in building underwater berms since the mid-1930's. In the early 1980's, a test berm was constructed off Norfolk, VA, to determine if a designed feature could be created on the ocean bottom with relatively poor quality construction material by conventional dredging and positioning equipment. A mound 11 ft high, 1,600 ft wide, and 2,800 ft long was successfully created in 40 ft of water with 850,000 cu yd of dredged material.

Based in part on the positive results for the Norfolk pilot study, the berm concept was endorsed in principle by the Corp's Environmental Advisory Board and the Coastal Engineering Research Board. In 1986 the Director of Civil Works approved a National Demonstration Project to assess and document potential physical and fishery benefits associated with underwater berms as a beneficial uses application of dredged material. The demonstration was the first ever extensively documented large-scale implementation of the concept. Mobile Harbor was chosen as the National Demonstration Site and the Mobile District proposed to demonstrate both berm types - feeder and stable. Prior to starting the project, coordination with the local Congressional offices, the non-Federal sponsor, and navigation and environmental interests was conducted to gain broad support.

Relatively little design guidance for berms was available at the start of the project. The majority of the design factors were based on equipment limitations. For example, draft limitations on the hopper dredges that constructed the feeder berm dictated the minimum water depth in which the berm could be placed and its maximum elevation.

Both berms are located west of the Mobile Ship channel and south of Dauphin Island. The feeder berm was placed less than 1.5 miles from the channel and the stable berm is about 2.5 miles from the channel. The feeder berm was located with the expectation that the sand would gradually move toward the north and west contributing to the sand system off Dauphin Island. It was built in February 1987 by two shallow draft, split-hull hopper dredges owned by Gulf Coast Trailing Company. About 450,000 cu yd of sand from the entrance channel bar was placed in 18 to 19 ft of water. Considerable time was spent by the contractor in following a precise alignment to build the 6,500-ft-long bar a maximum height above the bottom, in some positions as great as 8 ft, with an average elevation of 6 to 7 ft.

Monitoring on the feeder berm began in 1987 with surveys to characterize pre-berm bathymetry and native bottom sediment. Monitored items include bathymetry, sediments, bottom currents, and wave climate. The first post-construction survey was conducted in March 1987. By the January 1988 survey, the berm had begun to move to the west and minimum depths increased to approximately 12 ft. By August 1989, some sections of the monitored berm had moved 280 ft to the northwest. Recent surveys show the berm is still a definable feature, and is now merging with the ebb-tidal delta.

Construction of the stable berm began in February 1988 and was completed in May 1990 placing about 16.6 million cu yd of widely varying new work material from the Mobile Ship Channel deepening project in 34 to 45 ft of water. The berm was constructed to 20 ft in height with design crest dimensions of 1,000 ft by 9,000 ft. The exterior slopes resulted in a berm about 1 mile by 2.5 miles at its base, making it the largest underwater feature ever constructed in the United States. The berm was constructed with Great Lakes Dredge and Dock Company's clamshell dredge Chicago, and with 6,000-cu-yd dump scows, which transported the material to the berm construction site from the bay channel. Medium class hopper dredges were used on the bar channel.

For the stable berm demonstration, the entire berm is not being monitored, but only a test section that was the first part of the berm constructed. Monitoring elements included bathymetry, cores, wave data, side-scan sonar, subbottom profiles, benthic and fisheries surveys. After an

initial period of adjustment, the test area has been relatively stable since January 1989. There is no doubt that the material that was new work, clamshell dredged, and placed in such large volumes helped increase berm stability.

One of the main goals of the stable berm was to reduce wave energy in its lee. Directional wave data were collected offshore and inshore of the stable berm to measure changes in energy across the berm. Analysis of data to date has shown the stable berm's ability to reduce wave energy allowing low energy waves to pass while reducing storm wave energy up to 70 percent.

Monitoring of the berms primarily has been a joint effort between the Mobile District and the Coastal Engineering Research Center (CERC). However, the US Army Engineer Waterways Experiment Station's Environmental Laboratory (EL) and the National Marine Fisheries Service have contributed significantly to this effort. Considerable support for the monitoring effort has also come from the Dredging Research Program.

The demonstration project has been enormously successful and it owes its success to the team members from various offices in the Mobile District, CERC, EL, and to the support of the South Atlantic Division (SAD) and the Office, Chief of Engineers. The demonstration project was the recipient of the 1990 SAD Planning Team of the Year Award.

While the berms at Mobile have been very successful, and have provided general berm design guidance, additional design guidance is needed to increase the use of the concept. The primary need for Corps Districts is the ability to select the least costly placement location that results in an environmentally sustainable project. Therefore, additional information and predictive techniques are needed to convince the Resource Agencies that lower cost options, properly planned, may produce better solutions. This will require more study of placement techniques and assessment of environmental and economic benefits associated with both berm concepts. Present equipment limits certain berm locations and configurations, and shallower water placement techniques should be investigated. For berms intended to directly nourish the beach, we need to know when, where, and in what quantities it will occur. For both berm concepts, there needs to be more definitive information on reduction of wave energy and a possible corresponding decrease in beach erosion and flooding.

MANAGEMENT OF DREDGED MATERIAL PLACED IN SUBAQUEOUS ENVIRONMENTS

James E. Clausner

The Corps of Engineers (CE) Districts oversee the dredging and disposal of about 300 million cu yd of sediment each year to maintain the country's waterways and harbors. In addition, the CE is responsible for permitting another 100 million cu yd of material to be dredged for other organizations (e.g. the US Navy). Basic policy covering the dredging and disposal process is the Federal standard (33 CFR Parts 209, 335, 336, 337, and 338) which can be summarized as "selecting the dredged material disposal alternative(s) which is the least costly and consistent with sound engineering practices and appropriate environmental standards." Management of this dredged material is controlled by over 30 laws and executive orders, the most important being the National Environmental Policy Act of 1969, the Marine Protection, Research, and Sanctuaries Act of 1972 (commonly referred to as the Ocean Dumping Act), the Clean Water Act of 1977, the Coastal Zone Management Act of 1972, and the Endangered Species Act of 1973. Legislation encouraging beach nourishment with dredged material by allowing the Federal government to cost share any increased costs with local sponsors was part of the Water Resources Development Act (WRDA) of 1976 and modified in WRDA 1986 and 1990.

Management of dredged material can be defined as controlling the dredging and subsequent placement of the dredged material to meet navigation requirements while complying with applicable laws, policies, and attempting to meet the desires of local and state agencies and cost-sharing partners. To accomplish this complex mission in a timely, low cost manner, CE planning, operations, and regulatory personnel need the most up-to-date tools. These tools include a variety of dredges to accomplish cost-effective removal and subsequent disposal of differing materials under a range of environmental conditions. Numerical models and empirical relations for predicting the fate of dredged material in the water column and the long-term fate of material deposited on the bottom are also needed. The ability to effectively store,

find, display, and manipulate the vast amount of data associated with the dredging and disposal process is also urgently needed.

Despite advances made under the Dredging Research Program (DRP), continuing improvements in the dredging fleet are needed. For example, the present hopper dredge fleet is limited in its ability to dredge shallow channels (15 ft and less) and place the material in shallow water (less than 18 ft). There is strong interest in placing dredged sand in nearshore berms to keep this material in the littoral system at low cost. This enables the Districts to comply with state coastal zone management plans and meet the requirement of the Federal standard. Additional work to develop shallow draft hopper dredges to accomplish shallow water dredging and placement is needed.

Concern over turtles has restricted hopper dredging along the east coast. Research into innovative dredging techniques, such as water injection dredging (WID), is needed to allow continued use of these east coast facilities with turtle populations. The DRP will be demonstrating WID on the upper Mississippi in the summer of 1992.

Prior to and along with improved equipment for nearshore berm construction is the requirement for predicting berm performance. Significant advances in nearshore berm predictive models have been made under the DRP to date (e.g. the On-Off program, long-term fate program, empirical guidance on whether a berm is active or stable). These advances are being transformed into design guidance (DRP Dredging Research Tech Notes 5-01, 02, and 03). However, several other areas relating to nearshore berm use must be researched before they gain wider acceptance. First, the number of berms actually constructed is low (approximately 10 in the United States), and the number of berms receiving intensive monitoring is even lower (two). To effectively update existing predictive models, monitoring of existing and future berms to include both the driving hydrodynamic forces and berm reactions is needed. Additional monitoring will also increase public and resource agency acceptance of the berm concept.

Equally important is the ability to take the predictive tools and use them to calculate cost/benefit ratios. To expand nearshore berm use beyond the limited demonstration projects and least cost disposal operations will require the ability to calculate the value of a cubic yard of sand placed

anywhere along the active profile for reducing beach erosion and the corresponding reduction in overtopping and flooding. Since the CE is not allowed to consider recreation as a benefit of a coastal project, beach fills and nearshore berms have to be justified for their ability to reduce coastal flooding (and corresponding reduced damages to property). The DRP Open Water Disposal Site Management Work Unit is addressing this problem by working with District planners to determine how nearshore berm wave attenuation can be factored into flooding reduction values.

The amount of data generated by a dredging project is immense. Dredging volumes are needed requiring bathymetric surveys, and the degree of sediment contamination has to be checked using cores and subsequent sediment chemistry and bioassay testing. During the dredging operation the actual placement volumes and locations must be confirmed by post-placement bathymetric surveys and cataloging of placement coordinates. A single dredging project often involves the following types and amounts of data: multiple bathymetric surveys (thousands of survey points); sediment sampling data (sediment type and vertical extent, grain size data from several to more than 10 cores), sediment chemistry data (testing of a number of single and composite samples for up to 100 chemicals, metals, pesticides, and organic compounds of concern); bioassay data (up to several species of concern tested in up to several different sediment units and reference sediments with replication); the location and amount of material placed (tens to more than 100 individual placements). The ability to effectively manage this amount of information during increased scrutiny from resource agencies and with ever-decreasing manpower is crucial. Initial efforts under the DRP Open Water Site Management work unit to investigate Geographic Information System-based software to accomplish this are under way. Additional work will be needed beyond the DRP.

The short- and long-term fate models are important to be able to simulate initial site geometry and its evolution over time to maximize the limited number of existing Environmental Protection Agency (EPA)-approved open-water disposal sites. These models can help the disposal site manager confirm that material is staying on site (or leaving for dispersive sites), and increase the site capacity by selective placement location and controlling the rate of material entering the site. The short- and long-term fate models

have been combined into an effective site simulation model. However, field verification of model predictions is very limited. Additional development of the models, especially for fine-grained material, and additional field verification are needed.

DISCUSSION

Prof. Raichlen asked about environmental input into the DRP. Mr. McNair said that the driving force for the DRP was cost saving, managerial, and operational considerations. Environmental aspects of dredging are covered under other, existing Research and Development programs. The DRP was formulated as a program that would take environmental information from the existing programs, but would not in itself look into environmental aspects of dredging. The environmental programs run in parallel, and interact with the DRP. Prof. Raichlen asked for a presentation at the next CERB meeting on how that had been integrated. MG Williams said they would make that an action item.

MG Sobke stated that, in relation to dredging, nearly all the challenges he sees are in the environmental area. He feels that environmental considerations and research should be incorporated as a major objective of the DRP. He thinks the present focus of the program is constrained and limited.

MG Williams asked the Board to develop well-thought-out recommendations from the Board to the Chief of Engineers in regard to how to address the environmental issues that were brought up.

Mr. Pfeiffer said, as background information, that during the mid 1970's there was a 7-year, \$35-million research program where the entire focus was on the environmental aspects of dredging. That was followed in the 1980's by a \$7-million field verification program where the entire purpose was dredging and the environment. When the DRP was started, all of the problems had not been solved, but there had been no research focused on the other part of the mission, the very important management, machinery, and so on, and the dredging industry was not producing any new techniques. The DRP was sold to Congress as a "save Federal dollars" program.

Prof. Raichlen said that after hearing the discussions of the capping problem, he thinks there should be some continuing work in that area.

Mr. Pfeiffer said that, although intensive monitoring ceased at the end of the field verification program, the Environmental Laboratory at the US Army Engineer Waterways Experiment Station has continued monitoring the sites that were established. He feels the Board needs to be given a briefing on that program and some other monitoring efforts so that they would have a basis to recommend what to do next.

Mr. Calhoun said he had previously headed up those programs in the EL, and that capping was considered under both the field verification program and the Long-Term Effects of Dredging Operations Program. Work has been conducted in both the field and the laboratory, and they have an excellent handle on how thick the cap has to be from an environmental standpoint. MG Sobke indicated that the issues were more than just capping and, notwithstanding the original intent of the DRP, since then the WRDA of 1990 gave the environment

as a primary mission of the Corps of Engineers. Within that context, he suggests that the Board take a look at the mission of the DRP, and bring the two separate efforts together.

BG Yankoupe asked what were seen as the major shortcomings of the program. Where can directive guidance be focused to assist in moving the program forward? Mr. Campbell said he has found that operating procedures at the field level lag far behind the vision of how we are going to do some of the environmentally good things. The challenge is to close the gap and get the environmental vision translated into a standard operating procedure that the Corps field elements can use on a day-to-day basis without the uncertainty of how to treat some of this dredged material. Mr. Campbell added that environmental standards seem to be a moving target. He thinks they need to identify what some of the big problems are, and get agreement between state and Federal agencies on a prescription for fixing them; and then it will be much easier to implement new standard operating procedures for how to treat dredged material at the field level.

Mr. Pfeiffer said that conversations had been initiated with the Corps Operations and Readiness Division about a DRP II. The present program is in its fifth year, and is at the stage where products are being moved out to the field. They are presently taking a long-term, 10-year downstream look to see where they should be going with new program initiatives.

BG Yankoupe asked if they could see where the long-term management strategy (LTMS) fit into things. Standards have been translated forward at a much more rapid rate than our abilities to deal with them. He thinks we are looking at the emergence of a concept for dealing with them. The LTMS is an intellectual concept that begins to help us look into the future.

Mr. Campbell said he thinks it is better to come up with a plan, and have it in place, rather than always being in a crisis mode, but he thinks we need to face some of the realities of what drives the LTMS. In getting a consensus, some agendas may be satisfied by some of the agencies involved doing nothing. That is a negative from reaching an end goal with LTMS. Some agendas may be satisfied with an extended study because it's a means of funding programs.

Mr. Campbell added that an LTMS is difficult because of changing environmental standards. We are doing something different than we did five years ago, and we may be doing something different in the future. LTMS is a good vision and good concept, but we need to recognize some of the things that are keeping us from achieving a plan that is on the shelf.

Mr. Mathis said LTMS denotes a national strategy, and it is kind of a misnomer. What we are really talking about is developing long-term dredged material management plans. They are trying to move quickly forward with EPA to determine how to evaluate dredged materials. If they cannot come to some better agreement on how to define dredged materials, environmental aspects and so on, they will never effectively manage dredged material.

Prof. Dalrymple asked about the mixing of materials and the determination of whether it was quality material to be placed on the beach. Mr. Holliday said there are problems in both dredge productivity and in defining in advance where the good quality material is located. The highest productivity comes from dredging the entire width of channel, mixing the material in the process. It is possible to selectively dredge parts of the channel determined to contain good quality sand, but that has been found to substantially decrease productivity, i.e., the cubic yards per day that can be dredged, and material from the undredged portion can be carried into the

dredged portion, requiring redredging. It is difficult to write contracts in advance for dredging good quality material because material moves around. You might identify good quality material, get water quality certification, and then a storm may rework a lot of the material in the channel. The contractor then goes in to dredge the channel, and the material may no longer meet the water quality standards. As a contractual management concern, the process is not as easy as it sounds.

Mr. Holliday said they do not have a really good idea on time-varying distributions of sediments within our channels. They are hopeful that some of the monitoring and modeling efforts will help address that issue in the future. One of the things that needs to be added to the DRP is some kind of model for the channel itself. He is not convinced that the Corps can specify where a dredge must put its draghead, but he knows the Corps will have a difficult time specifying to a contractor exactly what he puts in his hopper because Mother Nature always gives a surprise. The environmental regulatory agencies need to be educated in the variability that might be expected in some of these channels and how the resource can best be used. What is the acceptable level of percentage of fines? They have obtained one-time agreements in the past, on a case-by-case basis, so it is not impossible.

Prof. Dalrymple asked what factors are considered in determining the least-cost placement alternative for the dredged material. Mr. Holliday said that on continuing Operations and Maintenance Projects, that have no adjacent beach nourishment project, there is no authority or regulation that allows beach nourishment to be considered as a benefit.

Prof. Reid asked how and when the results of contract studies would be factored into the modeling efforts of the DRP. Dr. Kraus said the first sets of transport relationships were being delivered to him for evaluation. This is the year that the separate work begins converging to the model. That was planned at the start of the DRP. They have another year to implement everything, and a final year in the program to clean things up.

Prof. Raichlen asked about a model for the initial stage of the plume. Dr. Kraus said that at the start of the DRP, three-dimensional modeling technology was not adequate to start a research program to build a three-dimensional first principles of plume dynamics. After four years, they have concluded that such a model could be built with an effort, and they are recommending that as something they should do in a follow-on project. An older model is presently being updated with the data obtained from the DRP. The model they deliver at this time has to be something the field can use. It is not helpful to the field to have a model housed on a supercomputer.

Mr. Cavanaugh said that, as his agency is a local sponsor for many Corps projects, he would like the Board to review the policy on benefits analysis. On many of the projects, the direct benefits seem to be the main control. On small projects, they are limited to direct benefits. Many indirect benefits, such as tourism and recreation for small harbors, are not considered. His agency has produced reports showing that they are worthwhile.

Dr. Drew A. Carey said Science Applications, Inc., was working very closely with the Disposal Area Monitoring System Program. He said the primary concern of public interest groups and resource agencies focuses on the loss of contaminants during the disposal activities. He suggested linking the physical measurements to give better field verification of movement and material loss during disposal. Tie that in with some cooperation from EPA to look at how that balances with the actual contaminants. He commented on their

review of capping projects, and said there is no evidence for active migration of materials through the cap. He feels the open-water disposal question is more important. MG Williams said the Board would consider those comments. Dr. Fredette indicated that there are a lot of data available, and it is necessary to look at all the data. A wrong conclusion could be drawn just looking at one piece of data. As Dr. Carey mentioned, the entire body of data shows that the caps are working well.

Dr. Holler asked about the placement of material in 400 ft of water, and asked about the need for going that deep. Dr. Kraus pointed out that the material in question was mud and silts. It was moved far offshore to avoid any problems with deposition on reefs. The PLUMES model was used to validate Jacksonville District's initial placement plan based on oceanographic data that they had collected.

PANEL
EFFECTS OF INLET DREDGING PROJECTS
ON ADJACENT SHORELINES

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INTRODUCTION

Dr. C. Linwood Vincent

Inlets are characterized by strong cross-shore ebb and flood flows that interrupt the alongshore movement of sand resulting in often large deltaic deposits and unstable channel configurations. Many were originally used for navigation without modification, but as ships became larger, the Corps of Engineers instituted dredging and other stabilization projects to facilitate safe navigation. The Corps now maintains over 100 inlet projects nationwide.

Coastal engineers have long recognized the possible impact of channels and structures on the shores immediately adjacent to the inlet. Most such projects developed today are designed to minimize any effect. However, recent studies in Florida indicate that the dredging and disposal of sand offshore may be responsible for much of the long-term beach loss on the Florida Atlantic coast.

This session of the meeting will explore the effects of dredging projects on adjacent shorelines. The first paper will explore the sediment transport in inlets; the second paper will discuss the regulations under which the Corps of Engineers must perform its dredging projects; the third paper will discuss the evidence in Florida for long-term beach impact; the fourth paper will review Corps dredging activities where efforts have been made to recycle material to the beach; and the final paper will discuss efforts proposed to study these problems in the Coastal Inlet Research Program.

SEDIMENT TRANSPORT IN THE VICINITY OF INLETS

Dr. David G. Aubrey

Inlets are common features amongst the coastlines of the entire United States. Many of these inlets are tidal inlets, and many are influenced by riverine flow. The inlets have tremendous importance for many reasons, and we are starting to understand some of that importance in more detail.

The inlets are extremely important for interdisciplinary and interagency interests. The academic community is starting to focus on the role of inlets in moderating the freshwater flow from the land to the coastal sea by affecting the buoyancy flux, therefore affecting large-scale circulation patterns. From a biological standpoint, inlets are important for various recruitment processes, for exchange of both living and non-living organic matter, and as filters for land-based and ocean-based processes.

There are navigation interests in inlets, but there are also other interests involved that have to do with natural resources within the estuaries and lagoons. Managing these inlets is not a simple process partly because the inlets are so complex hydrodynamically that it is very difficult to predict with any certainty the effects of modifications to inlets or of natural processes on inlets. This complexity is made worse because inlets are very commonly associated with unconsolidated sediment. Once water interacts with the sediment, prediction of the status of the inlet becomes extremely complex.

Conflicting uses within inlets and the growing awareness of inlets are going to change the framework of how we manage inlets in the future. From an engineering standpoint, we no longer have to just understand long straight beaches. We have to understand the first order effect of inlets on flow processes, on sediment exchange, and on sediment budgets along the coast. The inlet at Chatham is one example to illustrate this philosophy. Immediately after the inlet opened in 1987, there were large changes to the form of the barrier beach and large changes to the inside and outside morphology of the sand bodies along the beach. The transfer of sand from north to south was altered dramatically. The flow of water, the type of water, the magnitude of the flow, and the storm levels within the bay system were changed dramatically due to this natural inlet breaching process.

The important thing to note is that when you modify an inlet system, you modify many aspects of the coastal processes both seaward and landward of that inlet. We are just now beginning to understand in a quantitative fashion what some of those modifications are, and we need a greater focus in the future in order to be able to predict what the effects of some of those modifications might be.

Part of the sand that is transported alongshore into an inlet goes around the inlet in complex fashion to nourish downdrift beaches. When nature or man impedes this process, severe and rapid shoreline changes occur updrift and downdrift of the inlet.

Natural processes control the evolution of an inlet. Many inlets are unstable in position, some are more stable, some are not unstable, and by affecting the natural processes either by human influence or other influence, we can affect the stability of the inlets and, hence, the exchange processes within the interior bay and the exchange between the bay waters and the ocean itself. At present, we do not understand these processes well enough to predict what the effects of various modifications will be, and we need to have an improved understanding.

On a project about 10 years ago, the formation of a flood-tide delta on the inside of a tidal inlet caused a redirection of the flow. The redirection of the flow interacted with the jetty and caused about \$12 million in damage to the jettied inlet system. We need to be able to predict these kinds of effects so that we can avoid them in the future. To do that, we need to understand the complex hydrodynamics as well as the sediment transport within the inlet systems.

We now have an opportunity to understand some of these interactions. The Corps has a number of projects where inlets have been modified one way or another, and some of these inlets have been monitored so we can understand the pre-jetty condition, and post-jetty condition, and it is only through a study of large-scale systems like these that we will be able to improve our understanding of inlet modifications on the exchange of fresh water, salt water, and other materials through an inlet. Murrells Inlet, South Carolina, is one such system that has been monitored fairly well in the past.

The movement of sediment across tidal deltas occurs in very complex fashions. There are various large-scale bed forms in the inlet channel. The size of a bed form varies, and is dependent on tidal prism, flow velocity, and where in the inlet the bed form occurs. Trying to predict the movement of sediment through these various bed forms is beyond our present capability. If we want to predict the effects of dredging activities or other activities on an inlet environment, we need to understand the sediment transport processes much better.

These are very complex bed forms. Most of the sediment transport arises due to complex hydrodynamics. Not only do you have extremely large tidal flow, there also is significant wave action, at least on the ocean end of the channel, and these two interact in a very complex fashion with very complex bathymetry. Also, there is freshwater flow from a river system to the coastal waters, and you have a strongly stratified flow interacting nonlinearly with tides and surface waves.

Examples of complex morphology and sediment transport patterns can be seen around St. Mary's Inlet on the Florida-Georgia border. There are extremely large bed forms adjacent to the channel, which cause severe shoaling of the channel, as well as the bed forms along the margin of the channel. The bed forms along the margin of the channel are the primary conduit for sediment to bypass tidal inlets. The bed forms are extremely complex.

It should be reemphasized that tidal inlets are an important national resource. They are a problem in that they have to be maintained for navigation, but interrupting the sediment transport or modifying the flow to these inlets causes complex alterations to the entire coastal zone, and we need an improved understanding of how that ripple effect proceeds down the coast if we are to monitor and manage these inlet systems any better.

SECTIONS 933 AND 111 PROGRAMS

John G. Housley

ABSTRACT

Section 933. Section 933 authorizes the Corps of Engineers to place beach-quality sand, which has been dredged in constructing and maintaining navigation inlets and channels, onto adjacent beaches. There are a number of qualifying conditions, including (a) a request from the state, (b) whether placement of sand is deemed in the public interest, and (c) a requirement that non-Federal interests pay one half of the additional costs.

Section 111. Section 111 authorizes investigation and construction of projects to prevent or mitigate shore damages resulting from Federal navigation works. This is subject to the requirement that a non-Federal public body maintain and operate the measures, and cost share the implementation in the same proportion as the costs for the works causing the shore damage.

SECTION 933 PROGRAM **DISPOSAL OF DREDGED MATERIALS ON BEACHES**

Legislation

Section 145 of PL 94-587 (Water Resources Development Act (WRDA) '76) authorized the Secretary of the Army, acting through the Chief of Engineers, to place beach-quality sand, which has been dredged in constructing and maintaining navigation inlets and channels, onto adjacent beaches if: (a) such action is requested by the state; (b) the Secretary deems such action to be in the public interest; and (c) upon payment of the cost above the cost required for alternative methods of disposing of such sand.

Section 933 of PL 99-662 (WRDA'86) amends Section 145 of PL 94-587 to increase to 50 percent the proportion that may be borne by the Federal government of the additional costs, above that required for alternative least-

cost method for disposal for placement of material dredged during the construction and maintenance of navigation inlets onto adjacent beaches. In other words, it provides for 50-50 cost sharing, Federal and non-Federal.

Policy

It is Corps policy to accomplish construction and maintenance dredging in the least costly and most environmentally sound manner possible. If placement of dredged material on a beach or beaches is determined by the Corps to be the least costly acceptable means for disposal of the material, then such placement should be considered integral to accomplishment of the project work and not subject to any special non-Federal cost-sharing requirements (unless benefits from the on-beach placement are required for project justification and those benefits are of a kind with which special cost sharing is associated).

Existing shore erosion control authority provides for "restoration" and "protection." It does not provide for Federal cost sharing in extending a beach beyond its historic shoreline unless the extension is needed for engineering reasons to provide protection from erosion or as otherwise specifically authorized under public law.

It is Corps policy to participate in the additional costs for placing clean sand or other suitable material dredged by the Corps during construction or maintenance of Federal navigation projects onto adjacent beaches or nearshore waters subject to the following:

- (a) Placement of the material on a beach or beaches and Federal participation in the costs must be requested by the state in which the beach or beaches are located.
- (b) The added cost of such disposal must be justified by the benefits associated with protection of such beach or beaches.
- (c) The storm damage reduction benefits resulting from the beach protection must exceed 50 percent of the total benefits, unless the placing of the dredged material is economically justified based on storm damage reduction benefits alone.
- (d) The beaches involved must be open to the public.
- (e) Local interests must pay 50 percent of the added cost of disposal above the alternative least costly and environmentally sound method of disposal.

- (f) Local interests must provide (without cost sharing) any necessary additional lands, easements, rights-of-way, and relocations.

Should all of the foregoing conditions not pertain, it is Corps policy to place beach-quality sand or other suitable material, dredged by the Corps during construction and maintenance of Federal navigation projects, onto beaches or nearshore waters, even though more costly than alternative means of disposal, subject to the following:

- (a) Placement on a beach or beaches must be requested by the state in which the beach (or beaches) is located.
- (b) A finding can be made that, regardless of evaluated benefits, protection of the beaches involved is in the public interest.
- (c) The placement must be environmentally acceptable, pursuant to all applicable statutes and regulations.
- (d) Local interests must pay 100 percent of the added cost of disposal above the alternative least costly method of disposal.
- (e) Local interests must provide any necessary additional lands, easements, rights-of-way, and relocations.

Procedure

When a state request for placement of dredged materials on a beach or beaches is received by the District Engineer, a formal evaluation and report are prepared. This report, with the Division Engineer's recommendation, is forwarded to Headquarters, US Army Corps of Engineers, for review and preparation of a recommendation to the Assistant Secretary of the Army for Civil Works (ASA(CW)) for a decision. If the Division Engineer recommends that dredged material should be placed on beaches and ASA(CW) approves the evaluation report, a draft local cooperation agreement (LCA) is then developed with the state. All draft LCAs are written for signature and execution by the ASA(CW).

The District may proceed with the necessary studies using available funds for the project improvements involved, but with the condition that the actual costs be separately accounted for. The cost of preparing the evaluation report will be added to the separable construction costs for placement of dredged material on the beaches, and cost shared accordingly. In the event that the Corps-financed studies do not result in placement of

material on beaches as requested by the state, costs will be absorbed by the Federal government. In FY 92, the Corps has \$600K for Section 933 studies.

Only one project has been completed under Section 933 authority: Virginia Beach, VA. Two others are authorized, Bald Head Island, NC, and Brunswick Harbor, GA. Thirteen other studies are under way.

An Army legislative initiative being prepared for forwarding to Congress would amend Section 933 to allow sponsors other than the state (e.g., town, counties, etc.) to request that sand be placed on a beach and to be the sponsoring party.

SECTION 111 PROGRAM MITIGATION OF SHORE DAMAGES

Legislation

Section 111 of PL 90-481 (R&H&FCA'68) authorized the Secretary of the Army, acting through the Chief of Engineers, to study, plan, and implement structural and nonstructural measures for the prevention or mitigation of shore damages attributable to Federal navigation works at full Federal expense, limited to \$1M per project unless specifically authorized by Congress. This authority applies to both public and privately owned shores along the coastal and Great Lakes shorelines.

Section 111 was amended by Sections 915(f) and 940 of PL 99-992 (WRDA'86) which increased the limit of Federal funding to \$2M per project, required a non-Federal public body to operate and maintain the project, and implemented cost sharing for the project in the same proportion as the cost-sharing provisions applicable to the original project, including projects constructed at full Federal expense.

Policy

In the case of a navigation project comprised of a number of authorized modifications, costs for Section 111 measures will be cost shared in accordance with the cost sharing for the specific modification or modifications to which the cause of shore damage can be traced. When adopted,

the plan for Section 111 measures is considered to constitute a modification to the related navigation project. When the Federal share of the construction costs on this basis for suitable mitigation measures would exceed \$2 million (based on bids, or Corps estimates prior to obtaining bids) the measures may not be undertaken pursuant to the Section 111 authority; specific congressional authorization is required in such circumstances. The Section 111 authority applies to both public and privately owned shores located along the coastal and Great Lakes shorelines damaged by Federal navigation projects. Exercise of the Section 111 authority to provide mitigation measures with the authorized Federal cost sharing is not mandatory. Normally, the degree of the mitigation is the reduction of erosion or accretion to the level that would result without the influence of navigation works at the time navigation works were accepted as a Federal responsibility. It is not intended that shorelines be restored to historic dimensions, but only that existing shore damage be lessened or that subsequent damages be prevented by action based on sound engineering and economic principles when equitable and in the public interest. This authority is not utilized to construct, maintain, modify, or change an authorized shore protection project or an authorized shore damage mitigation element of a navigation project, or for river bank erosion or vessel-generated wave wash damage.

SHORE PROTECTION POLICIES

It is Corps policy to provide Federal assistance in reducing damages to shorefront development and coastal resources from shore erosion, hurricane, and abnormal tidal and lake flooding by undertaking shore protection projects where such projects best serve the public interest. Plans will be developed, evaluated, and selected in accordance with the Water Resources Council's (WRC) Economic and Environmental Principles and Guidelines (P&G) for Water and Related Land Resources Implementation Studies (dated 10 March 1983). WRC P&G directs water and related land resources planning toward the Federal objective of contributing to national economic development consistent with protecting the Nation's environment, pursuant to national environmental statutes, applicable Executive Orders, and other Federal planning requirements. In

connection with existing shore protection, hurricane protection, and/or beach erosion control projects, it is Corps policy to consider extension of Federal participation in any periodic nourishment for the project as a new investment decision subject to current evaluation criteria, and cost apportionment and cost sharing will be in accordance with PL 99-662. In any case in which the use of fill material for beach erosion control or beach nourishment is authorized as a purpose of an authorized water resources project, it is Corps policy to consider acquiring such material by purchase, exchange, or otherwise from nondomestic sources and use such materials for such purposes only if such materials are not available from domestic sources for environmental or economic reasons. Section 934 of PL 99-662 will not be used to extend the period of authorized periodic nourishment of projects that use sand-bypassing/back-passing plants.

IMPACT OF INLET DREDGING
ON SHORELINE EROSION IN FLORIDA
WITH RECOMMENDATIONS

Dr. Robert G. Dean

Introduction

Inlets in their natural condition can play a significant role in local sediment transport processes, causing instability to the adjacent shorelines and inducing cycles of accretion and erosion as well as trends. Many inlets in the United States have been modified for navigational purposes through the construction of jetties and the maintenance of a channel that is deeper than natural. The potential of these modified channels to cause adverse impacts on the adjacent shorelines is increased greatly over natural inlets, especially if the inlet is constructed in an area of substantial net longshore sediment transport.

The Problem

The problem can best be considered by recognizing that most navigational projects were constructed prior to the recognition of the potential impacts of such projects or the present development and high values of the adjacent shorelines. Thus, there was little concern if the projects caused severe erosion and, indeed, a number of these projects have rendered portions of the adjacent shorelines uninhabitable or in other cases, the downdrift property owners are required to provide expensive shore protection measures to protect their property from loss by erosion.

The interaction of modified inlets with the adjacent shorelines is at least threefold: (1) For many years, prevailing practice was to place maintenance dredging material in water too deep to be returned by natural processes to the nearshore system. Along the east coast of Florida, approximately 55 million cu yd of sand has been disposed of in this manner. This sand has a current replacement value of between \$400 million to \$600 million and the volume loss is equivalent to a uniform shoreline recession of approximately 24 ft over the entire 400 miles of Florida's east coast. This

practice is still in effect at too many locations and loss of this precious natural resource must be stopped; (2) in areas of high net longshore sediment transport, the updrift jetties block the sediment transport and create a downdrift deficit, which is made up by erosion of the shoreline; and (3) at some constructed or modified inlets, sand is shunted by tidal currents to ebb-(offshore) or flood-(bay) tidal shoals where it is lost to the nearshore natural system.

In those cases where maintenance dredging material is disposed offshore, there is an associated severe downdrift beach erosion. In many of these cases, the erosion has been addressed later by a relatively expensive beach nourishment project using sand dredged offshore, which is poorer in quality than that spoiled offshore. The net cost to the US public of dredging with offshore placement and replacement of sand by nourishment is greater than effective sand transfer to the downdrift shoreline.

As a summary statement on the impacts of inlets on the adjacent Florida shorelines, I have estimated that 80 to 85 percent of the erosion on Florida's east coast is due to poor management of the sand resources at inlets. The actual amount may be higher.

The Need

In formulating a plan for inlet study, there are certainly scientific and engineering needs to understand at a much higher predictive level, the hydraulic and sedimentary mechanics at inlets. There is also a very compelling need to develop reliable and cost-effective methods and equipment for transferring sand at modified inlets to reinstate the flows that were present in the natural system. Finally, ebb-tidal shoals can contain massive volumes of sand which is of high quality and, therefore, very suitable for beach nourishment. A study program should include a focus on ebb-tidal shoals with emphasis on sand quality, effect of partial removal, and rates of volumetric regeneration.

Summary Comments and Recommendations

The impacts of navigational entrances on adjacent shorelines are of first order in coping with the problem of stabilizing our sandy coastal resources and in costs of maintaining these resources. In my view, this problem is of such high priority that it warrants central concern by the next generation of coastal engineers.

The Corps of Engineers (CE) has the responsibility for Federal stewardship of the Nation's rivers, harbors, and shorelines, including effective management of the beach resources. Legislation (Sections 111 and 933) exists to assist in the mitigation and repair of shoreline damage due to the impacts of navigational projects; however, the implementation of this capability has not been uniform, may take decades, and is perceived by some as "drawing out the process." It is recommended that the CE adopt and take the lead as a high priority mission the research and implementation (with emphasis on implementation) of methodologies to: (a) stop the practice of wasting valuable natural sand resources as now occurs by offshore dumping, and (b) reinstate, to the degree possible, the natural flows of sand around Federal navigational projects.

APPLICATION OF MATERIAL FROM INLET DREDGING

Barry W. Holliday

The Corps of Engineers dredging program has contributed substantial amounts of dredged material to adjacent beaches and shores as an integral part of the project operations. The growth of projects that contribute their dredged material has been substantial. During the period 1978-1980, Vallianos (1990) reported that there were 52 projects out of a total of 211 where dredged material was used for nourishment purposes, while during the period 1986-1988, 152 projects out of 348 navigation projects involved placement of dredged material on beaches or for other nourishment purposes. This figure is growing.

Dredged material is being placed on beaches from various navigation projects for various reasons. Even the classic beach nourishment projects have additional dredged material included as part of the maintenance dredging of the navigation channel. Other examples include the following:

Morehead City Harbor, North Carolina - approximately 4,000 ft of beach received 3.6 million cu yd of sand recycled from an interior upland disposal area. This operation is designed to occur every 8-10 years. There is no cost to the local sponsor.

Mobile Harbor, Alabama - Dredged material from the deepening project has been used to build two berms off Mobile Bay. One of these is designed as a feeder berm.

Atlantic Intracoastal Waterway - Dredged material from inlet crossings and other navigation channels with suitable dredged material has been going to the beaches in ever-increasing quantities. In almost all cases, this is the least costly alternative disposal method. Several small disposal islands are being considered for recycling of the sand and placement on the beach.

Oregon Inlet, North Carolina - The inlet is being dredged with a pipeline dredge with the dredged material placed on the beach on Pea Island. This inlet has historically been dredged by hopper and sidecast dredge. The unit cost of the pipeline dredge was substantially more than previous unit costs for hopper dredging (\$8.96 per cubic yard for pipeline versus \$1.86 per cubic yard for hopper).

These are just a few examples of positive efforts of placing sand back on the beaches. There are many more projects on all the coasts and the Great Lakes. There are sand bypassing operations in place that appear to be working quite well, such as the Indian River Inlet, Delaware, system. There are numerous beach nourishment projects with local sponsor cost-sharing with the Corps that have and continue to provide storm protection and recreational beaches at reasonable costs. There are Section 933 projects that have resulted in very encouraging unit prices for pipeline dredging in environments that have normally been dredged by hopper dredge, such as Baldhead Island, North Carolina.

But there are still many questions and probably many potential new options for using suitable dredged material from our coastal projects for beneficial uses. Some of the questions that need to be answered are:

- a. How close should dredged material be placed on beaches adjacent to inlet channels?
- b. Should dredging an ocean inlet channel be accomplished in the same way that an interior channel is dredged? Specifically, are advanced maintenance techniques and overdepth values being properly considered?
- c. Are nearshore berms placed in the proper configurations and distances from the channels?
- d. How can we segregate more effectively the suitable dredged material from the channels for future beneficial uses?
- e. Is it more cost-effective to pump wide beaches on short pipeline lengths close to the inlet channel, or will the long-term impacts be less costly to pump a narrow beach for longer distances?

There are more questions and the need is clear for a better understanding of what is happening in the inlet systems of our navigation projects, especially with the increasing demand for beach quality dredged material.

PROPOSED COASTAL INLET RESEARCH PROGRAM

Dr. C. Linwood Vincent

The proposed Coastal Inlet Research Program (CIRP) was developed as a result of initiatives arising from the 48th Coastal Engineering Research Board (CERB) meeting in Savannah, GA, and the 53rd CERB meeting in Fort Lauderdale, FL, in which the impact of Corps of Engineers (CE) activities in inlets on adjacent beaches and the problems of maintaining inlets were highlighted. In February of 1991, the Coastal Engineering Research Center (CERC) held an inlet problems workshop at which CE field representatives provided a lengthy list of CE problems at inlets. CERC proposed a \$43-million program over 7 years to address these problems. The program had a three-prong approach: (a) improving operational procedures to reduce the cost of dredging, (b) reducing impacts on adjacent beaches, and (c) improving the fundamental understanding of inlet systems to aid in more cost-effective engineering. Subsequent budgetary constraints had led to a \$20-million, 6-year program directed at improving the fundamental understanding. The rationale for this emphasis was a general consensus that until this was achieved more practical results could not be readily achieved.

The current structure of the program consists of: (a) assembly and analysis of existing inlet data; (b) field measurement of hydrodynamic and sediment transport information at selected inlets; (c) theoretical, laboratory and numerical studies of inlet hydrodynamics and sediment transport; (d) analysis of scour; and (e) collection of field data on the impact of inlet projects on adjacent shorelines. In addition to improved understanding, the primary goal is a series of prediction and analysis tools that can be immediately used by the field in practical engineering studies.

With regard to the shoreline impact problem, one primary goal of the program is an improved model for inlet hydrodynamic predictions. With such a model, the CE field engineer should be able to decide where in the inlet sand can be disposed from dredging so that it has a high chance of going on down the beach rather than back into the channel. Coupling the sediment transport and hydrodynamic efforts should produce better estimates of inlet shoaling rates and better methods for bypassing sand. Improved technology should allow

better decisions on the optimal times to dredge and dispose of sand as well. The field study on shoreline impact will allow documentation of how CE projects may impact the shoreline and separation of natural variability from man-induced change.

DISCUSSION

MG Sobke asked about the specific set of problems that would be addressed by the CIRP. He asked what the most important problem would be, and what the priorities were for the program. Dr. Vincent said the data would give an understanding about what the processes are in the inlet system, their relative importance, and which theories apply the best. This database is needed for a series of numerical and physical modeling techniques which would allow prediction of inlet flow fields, including the complexities of structures, irregular channels, and irregular shoals. It would allow us to include not only the tidal flows, but the tide and wind-generated currents, which would allow inclusion of the simultaneous effect of breaking on an ebb current. These data are absolutely essential for describing how water is moving in the inlet system.

Dr. Vincent said these models are not very adequate at this moment and would be vastly improved with this program. That would allow us to provide simulation techniques to determine where the sand is going. For example, if you place material in a feeder berm, you need to determine that it will move onshore and not back into the channel.

MG Sobke asked why these models were needed to solve simple problems, to get sand moving along the beach the way it would naturally. Dr. Vincent said you could do that by simply dredging sand and placing it some distance down the beach, but that is not necessarily the most cost-effective solution. It would be desirable to design projects so that nature does most of the work, and the nation expends the least amount of money, i.e., to get the sand to move where you want it at least cost. He noted that there are other things in the program like answering questions about why scour occurs against jetties in a particular fashion, how long jetties should be, and what size channels should be. Ability to predict flow and channel bed response are also critical to those issues.

MG Sobke said that there are current projects that need to be addressed now and practitioners get frustrated by having questions raised without answers. Dr. Vincent said there is a lack of fundamental information about the inlet systems, and at the moment we just cannot provide information that will convince people that our answers are right.

Dr. Dean said to answer the question of what he considers to be the highest priority, he would recommend development of economical and effective techniques or equipment to reinstate the natural longshore transport. He thinks we need to fix the problem at inlets.

Some of the problems at inlets are complicated, and some are simple. If longshore transport of sand is being blocked, there is a one-for-one deposition on one side and loss on the other. Dr. Dean said he would put that

as a top priority. It will take a long time to develop all of the techniques needed for inlets.

Dr. Aubrey said, to put things in a different perspective, the problems are not simply problems of sand. They are problems of managing entire coastal systems, lagoons and estuaries. When you alter an inlet, it will make changes to the waters both inside and outside the inlet. We do not know at this time whether or not those changes are significant, but those questions are being asked more and more when a new project comes along. What are the effects of this particular structure or this particular activity on all of the other environmental resources that may be affected by this project?

Dr. Aubrey said part of his interest in seeing this Coastal Inlets Research Program develop is to be able to answer those questions. If the activities of the Corps are damaging, perhaps they can be mitigated or redesigned. If they are not damaging, then let the project go forward. Right now we do not have the capability to determine that.

Mr. Pfeiffer said to put a national perspective on things, it was necessary to consider the problems of all the Corps Divisions in developing the R&D program. The problems are different in different parts of the country. The decision was to look at all of the problems, rather than just problems in a specific region or of a specific type, so the proposed program was quite large. As things worked out, only half the request was approved by the ASA(CW). It was necessary to reduce the original proposal, and the decision was to go for the fundamental information.

BG Yankoupe quoted from two of Dr. Dean's papers, and noted that Dr. Dean had indicated we will have very few new inlets and should concentrate efforts on fixing problems at existing inlets. But Dr. Dean had also indicated that, "Based on working examples, the present technical capability to accomplish this must be considered as poor." Dr. Dean indicated that he was trying to say that our track record has not been good, so our demonstrated capability is not there in general. He does not think that means we should wait. We should start trying to fix the system rather than waiting until we completely understand it. He thinks we should move ahead. There may be some mistakes along the way, but we can learn from those mistakes and make the next design better.

Dr. Dean said we do have a lot of problems at inlets. We have got to start fixing them because every year they cause a little more grief, a little more erosion, and that can no longer be tolerated. He thinks if we put our best minds together, using what we have now, we have two parallel tracks to follow. One is implementation, and one is gaining new knowledge. The state of Florida has contracts underway or completed for inlet management plans for at least 30 of the 56 inlets in the state. These are just engineering studies to identify what needs to be done.

Dr. Dean said he is afraid we are going to get far down the study process, and find we have not fixed one inlet. He has proposed to the state of Florida that they set a goal of fixing one inlet per year, starting with St. Lucie Inlet. He thinks we can proceed along both pathways simultaneously, implementation and gaining new knowledge.

BG Yankoupe said he agreed with that. He does not think we want to spend \$20 million on basic research without fixing one inlet. He suggested Dr. Dean and MG Sobke get together on this. He thinks we should try to do both. We need to demonstrate progress at practical solutions.

Mr. Pfeiffer said he would like to address the topic of structures,

particularly the armor units that have been failing, where there was an analogous R&D development. He said after years of problems, they finally went back to basics and looked at why they were failing. They now have some answers that surprised everyone, and they think they will work and they can now design armor units like engineers.

Dr. Vincent said the emphasis he wanted to make is that the tools in the numerical models and physical models will be directly usable for analysis of problems such as St. Lucie Inlet. In fact, one of the things one would want to do in such a study is select one or two inlets that you would study in great detail. He noted that the tools would be available for use in studying individual problems as soon as the tools are produced, and he thinks they will be very useful for analysis. We would not be able to do that on a generic, nationwide basis immediately.

MG Williams referred to Dr. Dean's comment concerning the sampling of dredged material during dredging in the hopes of finding material suitable for sand placement. Dr. Dean said he thought the material being dredged should be sampled, and the data stored. There is often a question about whether the material dredged would have been suitable for beach placement, and no records to document how good or bad it was. There is a gradation from coarse to fine sand as you move offshore, and material in the channel may be a mix of what you find on a wide cross-section of the beach.

Mr. Holliday said there is a paucity of information. The question of suitability becomes a question of water quality. Different states have different criteria. In some cases criteria are strict, and in some cases lenient. Generally, when you get 20 percent fines, you have a muddy mixture that is deemed unacceptable based on water quality standards, but that is very generalized.

MG Williams asked if samples are taken of the undisturbed material before dredging. Mr. Holliday said no, because many projects are dredged repeatedly, and you see the same type of material repeatedly. That does not warrant collecting information. If you have done it once, you basically declare that the material is the same. There is certainly a need to have a better grasp of what is being dredged each time. MG Williams said that is the subject of an action that he needs to discuss internally with his staff.

DISCUSSION OF CHARGE TO THE BOARD

BG Yankoupe asked about the feasibility of a program that would look at sand bypassing systems on a national basis. Do we have information nationwide to look at a pilot study that would prioritize those projects from levels of success on down to failure? There are a number of systems operating.

Mr. Lockhart said there are a number of bypassing systems in operation that he considers successful, but success depends on your point of view. He noted that no two inlets are alike, and he would be hesitant to try to come up with some generic type approach to the bypassing problem for all of the inlets. Experience has shown that they have to be studied carefully. One of the biggest problems is determining the quantity of material you need to bypass. The data for that are not precise, the confidence limits are very wide, but it is improving.

There are structural sand bypassing systems, like Channel Islands Harbor, CA, where material is trapped behind detached breakwaters. They seem to work very well. There is a similar system at Santa Barbara, CA, where the shoal accumulates behind an attached breakwater, and is then bypassed with a pipeline dredge, and that works very well.

There is an eductor system in operation at Indian River Inlet, Delaware. It has been very successful.

There is an experimental sand bypassing plant at Oceanside, CA, that is being evaluated.

BG Genega noted that we may be looking for the perfect solution when we should accept something less than what we had originally. Some bypass may be better than none.

PUBLIC COMMENT

(There was no public comment at this meeting.)

BOARD RESPONSE TO CHARGE
55TH MEETING OF THE COASTAL ENGINEERING RESEARCH BOARD

The following is the response of the Coastal Engineering Research Board (CERB) to the two issues (underlined) addressed at the 55th meeting in Mashpee, MA.

A significant area of the Dredging Research Program (DRP) deals with developing procedures for predicting the behavior of dredged material placed in the subaqueous environment. These procedures will be used to attain the following goals: a) predict the fate of dredged material placed offshore; b) design berms or mounds to be either "stable" or "feeder"; c) design caps for contaminated dredged material; and d) in general, better manage placement operations. What modifications, if any, to the current program or additional work is needed to meet these goals?

The members of the CERB feel the technical program presently contains the essential elements to address those goals of the DRP stated in the Charge. However, the Board feels that there are many elements of the present Program that should be studied further. The Board supports an extension to the DRP to bring to a satisfactory completion the original goals of a cost-effective, environmentally acceptable dredging operation. The Board has chosen the following four research topics for a high priority in an extended DRP.

The first topic is the development of a three-dimensional, fundamental hydrodynamic model of the developing plume that addresses the method of dredged material release; the entrainment of sea water with the sediment dropping as a plume; the stripping of sediment within the plume; and resuspension. The model should incorporate capabilities to consider water quality issues.

The second topic is a high quality field data collection program related to the short- and long-term fate of the dredged material. These data would support the results of numerical models used to look at the fate of the material.

The third topic is an adequate verification of the transport relations used in both short- and long-term models. This embodies the development of up-to-date transport relations, and their verification in the broadest sense.

This could mean both field and, if reasonable and feasible, laboratory type confirmations.

The fourth research topic is the development of an operational model for dealing with nearshore and offshore berm processes that include both the sediment transport aspects, the stability and/or movement cross-shore, and berm-wave interaction, i.e., the wave mechanics associated with the berm placement and the resultant effects on the waves.

What research is required to adequately define and describe the effects of inlets and inlet dredging projects on adjacent shorelines?

It is not likely that the Corps of Engineers will construct many new inlets in the future. There needs to be a change of focus towards remediation of downdrift erosion at existing inlets. The Board concurs with the proposed Coastal Inlets Research Program (CIRP), with the emphasis on fundamental research on coastal hydrodynamics and sediment processes. Considerable work is needed to understand the hydrodynamics of inlets. The present models are crude in terms of the complicated flow processes that exist in inlets. Our present understanding of the various mechanisms for bypassing sand at inlets, e.g., bar bypassing and tidal bypassing, are also fairly crude, and there is a considerable amount of work needed on sedimentation as well. Sediment pathways that are analyzed also should include the pathway of sand going over and through structures, as that pathway tends to be neglected and it is a major pathway for sand to get into inlets.

The CIRP should fully integrate environmental considerations. Inlets need to be maintained or rebuilt to remediate downdrift erosion. This involves interacting with the environment.

Furthermore, when field studies are selected, where the CIRP will make measurements of waves and currents in inlets, we should try to solve the problems of these inlets. That should be done in conjunction with the fundamental research program.

Finally, addressing the problem of assessing the downdrift damage associated with some tidal inlets, the CIRP should provide a manual of procedures to assist the District offices in determining the adverse impacts of inlets. For example, we have seen the techniques of Professor Robert Dean, where you simply look at the historical erosion rates as a function of

distance away from the inlet to determine downdrift areas that have been adversely impacted. Professor Dean has developed even-and-odd analyses as a way to determine how much shoreline recession near an inlet is caused by the inlet and how much is uniform shoreline recession. Sediment budget analyses have long been used by the Corps. How do we specifically apply them to inlets, and what new tools do we need to improve the existing sediment budget analyses?

DISCUSSION

Dr. Kraus asked if consideration had been given to where the 3-D fundamental process model would reside or run, e.g., should it be on the US Army Engineer Waterways Experiment Station (WES) supercomputer or should it be brought out to the field. Prof. Raichlen said that, ultimately, one wants to have a usable procedure. He thinks WES has the best people to determine whether that should be on a PC or an interactive mode over a network. Prof. Reid said they had not gone into details of implementation, but Item 1 is perhaps a research mode model that would reside within CERC, while Item 4 would be something implemented on PC's available for field operation.

Mr. Lockhart asked for clarification on high quality field data collection on the fate of dredged material, and whether that would include material placed in beach-fill projects. He noted that a number of beach-fill projects had been in the initial Monitoring Completed Coastal Projects Program. This program is funded under the Operations and Maintenance Program, and beach fills were dropped out. Different means were tried for funding the monitoring of beach-fill projects, but he fully supports the need for monitoring the fate of beach fills. He feels we need data on why and how projects failed, where the material went, and so forth. BG Yankoupe said that was a good point.

Mr. David G. Roellig said the Chief's Charge indicated inlet dredging projects. He thought we should also look at possible structural modifications for some projects. Some of the problems are caused strictly by the structures rather than dredging practices. Prof. Dalrymple said he meant to imply addressing the entire problem. MG Sobke said that was also his understanding, that we should look at structures. BG Yankoupe said the problem is determining which projects have the highest priority to be addressed.

MG Sobke said it was the sense of the Board that products need to be put out that show some sort of movement early on, and that is why there was a recommendation to select at least two inlets where some of the research can be applied to make corrections. Dr. Kraus said he thought this would have a profound influence in focusing the research on getting out information, and promoting the work of groups of researchers to focus together. He thinks working at two inlets (one might be structured and one unstructured) is doable and a way of getting out products which are in a fundamental research program. This would provide concrete products early on for the field, and continue to do so for the life of the program.

MG Sobke said that, with BG Yankoupe's concurrence, he would volunteer SAD and SPD to come up with an example from each Division to participate in the program. BG Yankoupe concurred. Mr. Pfeiffer said Headquarters Research and Development fully agrees with using that method whenever possible. It is being used with good effect in the Wetlands Research Program.

CLOSING REMARKS

MG Sobke expressed his appreciation to the Board, particularly the members from academia who gave of their time to participate in the meeting, and without whose participation the meetings would be less than a fruitful process. He noted the Board's appreciation for all of the things done at all of the US Army Engineer Waterways Experiment Station (WES) laboratories. He said that, in his view, they are a national treasure with a set of truly talented and dedicated people who are contributing greatly to the needs of the nation in many areas. Ultimately, all of these products result in something for the Corps Divisions and Districts. He expressed appreciation to key field representatives who come to the meetings, and asked that they share what they learn at the meetings with other members of their teams who were not able to attend.

MG Sobke noted that attendees should be mindful of the storm which occurred during the meeting, and which gave a vivid demonstration for all of the people involved of what Mother Nature can do and why this work is a critical effort. The morning news had reported that 15,000 people were forced out of their homes by the storm. This is the kind of thing which we must think about as we contemplate research in this field and try to protect the lives and property which can be affected.

MG Sobke expressed thanks to Ms. Sharon Hanks for the work done over the months leading up to the meeting. He thanked the New England Division for the support services they provided for the meeting, particularly Wally St. John, Bill Cavanaugh, Ethyl Goyette, Carl Boutilier, Sharon Vienneau, and Ed O'Donnell. He thanked the staff of Christ the King Church Parish including George Kress and George Clish, Tracy DeGrace and Bill Monroe, who provided audiovisual support, and Ivan Masser, the photographer.

MG Sobke extended his appreciation to Frank Ciccone, the engineer in charge at the Cape Cod Canal, Frank Morris, the assistant engineer, Phil Norman, and the marine traffic controllers at the canal for their briefings during the field trip. He also thanked Susan Ernst of the New Seabury Resort, and the members of the Bourne Historical Society.

MG Sobke noted that the next meeting would be on 9-11 June 1992 in Newport, OR.

The 55th meeting of the Coastal Engineering Research Board was declared adjourned.

APPENDIX A
BIOGRAPHIES OF SPEAKERS/AUTHORS

ROBERT H. CAMPBELL

Mr. Campbell received a B.S. degree in engineering from Mississippi State University in 1963. After graduation, he joined the US Forest Service designing and constructing roads for that agency. In 1965, Mr. Campbell transferred to the US Army Engineer District, Vicksburg, working in both Operations and Construction Divisions on navigation, dredging, and river stabilization projects. He served as Chief, Mat Sinking Unit, from 1971 to 1979; Chief, Revetment Branch from 1970 to 1985, and Assistant Chief, Operations Division, from 1985 to 1990. In 1991, Mr. Campbell was selected as Chief, Dredging and Navigation Branch, Operations, Construction and Readiness Division, Civil Works Directorate, Washington, DC. Mr. Campbell is a registered professional engineer in the state of Mississippi.

MONICA A. CHASTEN

Ms. Chasten is a hydraulic engineer in the Coastal Structures and Evaluation Branch, Engineering Development Division, Coastal Engineering Research Center (CERC), US Army Engineer Waterways Experiment Station (WES). She has a B.S. degree in civil engineering from Drexel University and an M.S. degree in hydraulic and coastal engineering from Lehigh University. Since joining CERC in 1989, Ms. Chasten has worked on a wide range of coastal projects and research areas including tidal inlets, shallow draft ports, and detached breakwaters.

JAMES E. CLAUSNER

Mr. Clausner is a hydraulic engineer with the Coastal Structures and Evaluation Branch, Coastal Engineering Research Center (CERC), US Army Engineer Waterways Experiment Station (WES). He joined CERC in 1981 after several years at the Naval Civil Engineering Laboratory where he was involved in design and testing of propellant embedment anchors and measuring submerged sediment properties. In his present position at WES, Mr. Clausner is responsible for research on sand bypassing and open-water disposal site management and monitoring. Mr. Clausner received his B.S. (1974) and M.S. (1982) degrees in ocean engineering from Florida Institute of Technology.

Mr. Clausner is a registered professional engineer in the state of Mississippi.

DR. ROBERT G. DEAN

Dr. Dean is presently a Graduate Research Professor in the Coastal and Oceanographic Engineering Department at the University of Florida. He obtained a B.S. degree in civil engineering from the University of California, Berkeley; an M.S. degree in civil engineering from Texas A&M University; and a Ph.D. degree in civil engineering from the Massachusetts Institute of Technology. Dr. Dean is a registered professional engineer in the state of Florida, a member of the National Academy of Engineering, and a member of the American Society of Civil Engineers (ASCE). He is a past member of the Coastal Engineering Research Board, serving from June 1969 to June 1981. His past experience is in consulting as well as research and development, primarily in the fields of coastal and ocean engineering. Dr. Dean has written over 80 publications in the areas of coastal erosion, wave force analysis, wave theories, and coastal structure design.

DR. THOMAS J. FREDETTE

Dr. Fredette is the program manager for the Disposal Area Monitoring System (DAMOS) at the US Army Engineer Division, New England (NED), Waltham, MA. DAMOS is a multidisciplinary environmental monitoring program that investigates impacts of sediments disposed at more than nine sites in the offshore waters of New England. Prior to arriving in New England, he worked for the Coastal Ecology Group, Environmental Laboratory, US Army Engineer Waterways Experiment Station, in Vicksburg, MS, on environmental impact studies of coastal engineering activities. Dr. Fredette earned his B.S. degree in 1977 from Southeastern Massachusetts University, his M.S. degree in 1980 and Ph.D. degree in 1983 from the Virginia Institute of Marine Science at The College of William and Mary.

COL LARRY B. FULTON

COL Fulton became the 25th Commander and Director of the US Army Engineer Waterways Experiment Station (WES) in August 1989. Prior to his assignment at WES, he served as the Assistant Chief of Staff Engineer for the Southern European Task Force in Vicenza, Italy. COL Fulton has a B.S. degree in civil engineering from the University of Colorado and an M.S. degree in civil engineering from Oklahoma State University. He is also a graduate of the Industrial College of the Army Forces. Other command assignments include Company Commander, 70th and 84th Engineer Battalions, Vietnam; Commander, 4th Engineer Battalion, 4th Infantry Division (Mechanized), Fort Carson, Colorado; and Commander and District Engineer of the Far East District, Korea. His major staff assignments include Egypt Area Engineer, Middle East Division; Assistant Director of the Directorate of Engineering and Construction, Headquarters, Washington, DC; Deputy District Engineer, Omaha District; Instructor, Department of Tactics, Fort Leavenworth, Kansas; Resident Engineer, US Army Engineer Command, Europe; Augsburg, Germany; Executive Officer, 20th Engineer Battalion, Vietnam; and Platoon Leader and Operations Officer, 23rd Engineer Battalion, Germany.

DR. ANDREW W. GARCIA

Dr. Garcia is a research oceanographer at the Coastal Engineering Research Center, US Army Engineer Waterways Experiment Station. He has been involved in the development of numerical long wave and wind wave models, and automated tide and wind wave analysis procedures. His present research interests include the coastal hydrodynamic effects and air-sea interaction processes of tropical and extratropical storms. He received his B.S. degree in physics from the University of South Florida, his M.S. degree in physical oceanography from Texas A&M University, and his Ph.D. degree in atmospheric science from Purdue University.

BARRY W. HOLLIDAY

Mr. Holliday is Chief of the Dredging Section in the Dredging and Navigation Branch, Operations, Construction and Readiness Division,

Headquarters, US Army Corps of Engineers (HQUSACE), Washington, DC. He has recently come to Washington from Wilmington, NC, where he served as Navigation Branch Chief, in the Construction-Operations Division, Wilmington District, from 1977 to March of 1991. From 1973 to 1977, he was an oceanographer in the Dredged Material Research Program at the US Army Engineer Waterways Experiment Station. Mr. Holliday received his B.S. degree in geology from the College of William and Mary in 1969, and obtained his M.S. degree in oceanography from Old Dominion University in 1971. He attended Texas A&M University from 1971-1973 in graduate studies in geological oceanography. Mr. Holliday has served as a subcommittee member of the Automated Coastal Engineering System, and as a field review member of the Coastal Research Program and the Dredging Research Program.

JOHN G. HOUSLEY

Mr. Housley is the senior coastal engineer in the Planning Division, Directorate of Civil Works, Headquarters, US Army Corps of Engineers (HQUSACE). He received a B.S. degree in civil engineering from Lehigh University and an S.M. degree in civil engineering from Massachusetts Institute of Technology. His entire professional career has been with the Corps of Engineers, first with the US Army Engineer Waterways Experiment Station, then the US Lake Survey, where he conducted hydraulic and coastal research. His present assignment is in the Flood Plain Management Services and Coastal Resources Branch, HQUSACE. Mr. Housley was the Program Manager for the Shoreline Erosion Control Demonstration Program.

DR. JAMES R. HOUSTON

Dr. Houston is Director of the Coastal Engineering Research Center, US Army Engineer Waterways Experiment Station (WES). He has worked at WES since 1970 on numerous coastal engineering studies dealing with explosive waves, harbor resonance, tsunamis, sediment transport, wave propagation, and numerical hydrodynamics. He is a recipient of the Department of the Army Research and Development Achievement Award. Dr. Houston received a B.S. degree in physics from the University of California at Berkeley, an M.S. degree in physics from the University of Chicago, an M.S. degree in coastal

and oceanographic engineering, and a Ph.D. degree in engineering mechanics from the University of Florida.

JOHN R. KENNELLY III

Mr. Kennelly is a 1980 graduate of the University of Lowell, MA, with a B.S. degree in civil engineering. He has been working with the Corps of Engineers, New England Division, since 1980, and has completed numerous water resources investigations in the fields of flooding, flood damage reduction, hydropower, and water supply. Since 1990, Mr. Kennelly has been the chief of the Long-Range Planning Branch of the New England Division's Planning Directorate. He supervises the conduct of diverse water resources and environmental restoration projects for the states and communities of New England under several Corps of Engineers planning assistance programs.

DR. NICHOLAS C. KRAUS

Dr. Kraus is a senior scientist at the Coastal Engineering Research Center (CERC), US Army Engineer Waterways Experiment Station (WES), and works in the area of coastal sediment transport processes. Prior to joining CERC in 1984, Dr. Kraus was a senior engineer at the Nearshore Environment Research Center, Tokyo, Japan. Dr. Kraus is the Technical Manager of Dredging Research Program area "Analysis of Dredged Materials Disposed in Open Waters," where he heads a group of five principal investigators involved with the mathematical prediction and field measurement of the movement of dredged material. In the Coastal Research Program, Dr. Kraus was codeveloper of the shoreline change numerical simulation GENESIS and the storm-induced beach erosion model SBEACH. He is a member of the American Society of Civil Engineers (ASCE), currently serving as Chairman of the ASCE specialty technical conference Coastal Sediments '91, American Geophysical Union, and Society of Economic Paleontologists and Mineralogists.

J. PATRICK LANGAN

Mr. Langan has worked for the US Army Engineer District, Mobile, for the past 15 years. He is presently responsible for the Disposal Area Management

practices for the navigation program. Mr. Langan served in Executive Development Assignment from July through December 1987 at the Dredging Division in Fort Belvoir, VA, and the Coastal Engineering Research Center, US Army Engineer Waterways Experiment Station, Vicksburg, MS. He received his B.S. degree in civil engineering from Auburn University in 1963 and his M.S. degree in civil engineering from Purdue University in 1968.

DAVID B. MATHIS

Mr. Mathis received his B.S. degree in fisheries biology from Auburn University in 1969 and his M.S. degree in environmental engineering from Virginia Tech in 1979. He presently works in the Directorate of Civil Works Office of Environmental Policy. Prior to this, he served for eight years as Chief of the Disposal Management Branch in the Corps' Dredging Division and was a research biologist for 11 years at the US Army Engineer Waterways Experiment Station. Mr. Mathis' major responsibilities involve oversight for ocean dredged material disposal activities regulated by the Corps, issues relating to management of highly contaminated bottom sediments, and policy/procedural development relating to the concept of Long-Term Disposal Management Strategies for dredged sediments.

E. CLARK McNAIR, JR.

Mr. McNair is Program Manager of the Dredging Research Program (DRP), at the Coastal Engineering Research Center, US Army Engineer Waterways Experiment Station (WES). The DRP is an integrated, multi-disciplinary research program that addresses the operational and managerial aspects of dredging. Several WES laboratories, as well as other Corps laboratories and Field Operating Activities, are actively involved in the DRP. New equipment and techniques will be identified, developed, or adapted for use by the Corps of Engineers for performing dredging operations more efficiently and economically. Mr. McNair earned a Bachelor's degree in civil engineering from Mississippi State University and a Master's degree in civil engineering from Texas A&M University. He is a member of the American Society of Civil Engineers, the Permanent International Association of Navigation Congresses, and the Western

Dredging Association. He is a registered professional engineer in the state of Mississippi.

MARK J. OTIS

Mr. Otis graduated from the University of New Hampshire in 1977 with a degree in civil engineering and has been with the US Army Corps of Engineers, New England Division (NED) since November 1977. His professional experience has focused on dredging projects and their related issues. From 1977 to 1987, Mr. Otis was a project manager on numerous projects involving maintenance dredging within Federal navigation projects. Mr. Otis has managed the NED's efforts at the New Bedford Harbor Superfund site. These efforts have included an Engineering Feasibility Study and a Pilot Study carried out to evaluate this site. Mr. Otis is a registered professional engineer in the state of New Hampshire.

JANE M. SMITH

Ms. Smith is a research hydraulic engineer at the Coastal Engineering Research Center, US Army Engineer Waterways Experiment Station, and she works in the area of coastal hydrodynamics. Her research interests include spectral wave transformation, wave breaking, and nearshore currents. Ms. Smith has been involved in hydrodynamic data collection at the DUCK85, SUPERDUCK, Great Lakes '88, and DELILAH field experiments as well as the SUPERTANK laboratory project. Ms. Smith earned a B.S. degree from South Dakota State University and an M.S. degree from Mississippi State University. She is a member of the ASCE and the American Geophysical Union.

DR. DONALD K. STAUBLE

Dr. Stauble is a team leader of the Coastal Geology Unit, Coastal Structures and Evaluation Branch, Engineering Development Division, at the Coastal Engineering Research Center (CERC), US Army Engineer Waterways Experiment Station. The Coastal Geology Unit investigates geologic process and response changes to the coastlines of the United States. These studies encompass a broad range of research topics, including historic shoreline

trends, beach nourishment technology, barrier island and other coastal sedimentation processes, coastal engineering geographic information systems, and remote sensing image analysis, the effect of sea level rise, and general research into coastal geomorphic and geologic problems pertinent to the Corps of Engineers. Dr. Stauble earned his B.S. degree in geology from Temple University in 1969, his M.S. degree in oceanography from Florida State University in 1971, and his Ph.D. degree in marine/environmental science from the University of Virginia in 1979. Prior to working at CERC, he taught and conducted research for 9 years in the Department of Oceanography and Ocean Engineering at the Florida Institute of Technology. His research has been in the fields of beach nourishment technology; coastal processes; storm-induced beach changes; inlet, beach, shoal, and estuarine sediment transport and morphology; and coastal remote sensing. Dr. Stauble is a member of the Society of Economic Paleontologists and Mineralogists, American Shore and Beach Preservation, Florida Shore and Beach Preservation Association, American Society of Photogrammetry and Remote Sensing, American Geophysical Union, and the Marine Resources Council of East Central Florida. Dr. Stauble is a registered professional geologist in the state of Florida.

DR. C. LINWOOD VINCENT

Dr. Vincent is currently Senior Research Scientist (Coastal Hydrodynamics) for the Coastal Engineering Research Center (CERC), US Army Engineer Waterways Experiment Station (WES). His positions in the past include Chief, Coastal Branch, Wave Dynamics Division, Hydraulics Laboratory, WES; Chief, Coastal Oceanography Branch, Research Division, CERC, Fort Belvoir, VA; Senior Scientist, Research Division; and Program Manager, CERC, WES. Dr. Vincent's research interests include ocean wave mechanics, air-sea interaction, spectral wave modeling, wave climatology, and tidal inlet processes. Dr. Vincent has received an Army Research and Development Achievement Award, the American Society of Civil Engineers Walter L. Huber Prize for his wave research, and the Meritorious Civilian Service Award. He has written over 80 reports and papers. Dr. Vincent has a B.A. degree in mathematics and M.S. and Ph.D. degrees in environmental sciences (earth sciences) from the University of Virginia.

APPENDIX B
STATUS OF ACTION ITEMS

CERB ACTION ITEMS AND STATUS

ACTION ITEM	PLACE AND DATE OF ACTION	RESPONSIBLE AGENT	ACTION AND STATUS
54-1. Establish a technical advisory committee for the proposed Coastal Inlets Research Program.	New Orleans, LA 4-6 Jun 91	CERC CERD CECW-O CECW-E CECW-P	Membership would have to be limited to CERB members. This will be monitored by Headquarters Technical Monitors and a Field Review Group.
54-2. Establish formal seminar series for CERC PI's.	New Orleans, LA 4-6 Jun 91	CERC	Seminars are being conducted bi-weekly.
54-3. Report on SUPERTANK at next meeting.	New Orleans, LA 4-6 Jun 91	CERC	Reported at this CERB meeting.
54-4. Assess tidal inlets maintained by CE to determine need for sand bypassing.	New Orleans, LA 4-6 Jun 91	CECW-E	Assessment performed CECW-EH-D (see Appendix C of this Proceedings).
54-5. Determine methods to provide more sand dredged from CE projects for beach nourishment.	New Orleans, LA 4-6 Jun 91	CECW-O	A guidance document is being developed by HQ USACE.
54-6. Establish a CERC rapid response team to coastal flooding events.	New Orleans, LA 4-6 Jun 91	CECW-O CERD CERC	Rapid response to two recent hurricanes reported at this CERB meeting. Workshop scheduled to discuss needs and participation. A report will be presented at the 56th CERB meeting in Newport, OR.
54-7. Conduct interagency collaborative study to upgrade wind model.	New Orleans, LA 4-6 Jun 91	CECW-E CERD CERC	Proposed joint effort with National Hurricane Center.
54-8. Increase priority for upgrading the WIFM Model to include direct calculation of wave set-up and wave-current interaction related to bottom stress.	New Orleans, LA 4-6 Jun 91	CECW-E CERD CERC	Work will be accomplished in the proposed Coastal Inlets Research Program.

CERB ACTION ITEMS AND STATUS

ACTION ITEM	PLACE AND DATE OF ACTION	RESPONSIBLE AGENT	ACTION AND STATUS
54-9. Increase priority of development of three-dimensional beach profile change model.	New Orleans, LA 4-6 Jun 91	CECW-E CERD CERC	Work funded in Coastal R&D Program.
54-10. Determine what additional laboratory and field data are required to implement Items 54-8 and -9.	New Orleans, LA 4-6 Jun 91	CECW-E CERD CERC	Planned data collection efforts will meet needs.
54-11. Estimate what degree of improvement in modeling capability will accrue from upgrades recommended in Items 54-8, -9, and -10.	New Orleans, LA 4-6 Jun 91	CECW-E CERD CERC	Initial concentration will be on improving hurricane wind modeling. Three-dimensional beach change model will enhance ability to predict shoreline evolution.
54-12. Conduct workshops to determine interest in CERC tools to improve planning for flooding emergencies.	New Orleans, LA 4-6 Jun 91	CECW-O	Readiness Branch, HQ USACE, requested expanding the scope of the effort beyond coastal. WES to review Hazard Mitigation Team Reports. Readiness Branch to form Field Review Group to assist in developing R&D Programs.
54-13. Increase coordination of technical aspects (including data collection) of coastal flooding with other Federal agencies.	New Orleans, LA 4-6 Jun 91	CECW-O	Agencies have appointed representatives to a coordination group. A related meeting is scheduled for 9 Dec 92.
54-14. Investigate performing interagency R&D.	New Orleans, LA 4-6 Jun 91	CECW-O CERD	Will be pursued after formation of Field Review Group.
54-15. Conduct research on dynamic loading of expedient flood control structures.	New Orleans, LA 4-6 Jun 91	CECW-O CERD	Proposal provided by CERC. Tests scheduled for early 1992. LMVD assisting.

CERB ACTION ITEMS AND STATUS

ACTION ITEM	PLACE AND DATE OF ACTION	RESPONSIBLE AGENT	ACTION AND STATUS
50-4. Discuss with Army Research Office (ARO) and Office of Naval Research (ONR) the potential for basic research support for coastal engineering.	Virginia Beach, VA Nov 88	CERD	ARO announced that the University of Delaware is the recipient of a grant worth up to \$2 million over the next 5 years.
52-1. Report on restrictions on foreign travel by CERC staff members and on foreign visitors to CERC, and effects on tech transfer into the US.	Redondo Beach, CA Oct 89	CERC CERD	Restrictions have not eased, but CERC worked within the restrictions, and Professor Elvind Bratteland of Trondheim University in Norway is spending a year on sabbatical at CERC. The Norwegian Government is paying Dr. Bratteland's salary.
53-1. Take necessary action to have "Coastal Engineer" added to Federal personnel Classification System.	Fort Lauderdale, FL June 90	CEHR	Proposal has been forwarded by the Department of the Army to the Office of Personnel Management (OPM). OPM is scheduled to complete a study on this.
53-7. Determine feasibility of conducting a major O&M-funded research program on inlets.	Fort Lauderdale, FL June 90	CERD-C	The Coastal Inlets Research Program was developed, reviewed, and approved by HQ and ASA/CW, but has not been approved by Congress.
50-15. Propose ASCE hold a conference for practicing coastal engineers and combine with a CERB meeting and appropriate theme.	Virginia Beach, VA Nov 88	CERC	Dr. Steve Hughes organized ASCE Specialty Conference and Coastal Engineering Practice to be held 8-12 Mar 92.
49-1. Formalize the education proposal for USACE coastal engineers and submit to CECW for HQ staffing.	Oconomowoc, WI, May 88	CERC	The Coastal Engineering Education Program is in progress. Six Corps coastal specialists completed the program.

APPENDIX C

**ASSESSMENT OF TIDAL INLETS MAINTAINED BY THE
CORPS OF ENGINEERS TO DETERMINE NEED FOR SAND BYPASSING**

54TH COASTAL ENGINEERING RESEARCH BOARD MEETING
ACTION ITEM 54.4

Assess tidal inlets maintained by the Corps of Engineers (CE) to determine need for sand bypassing.

References:

EP 1165-2-1, Engineer Pamphlet - Digest of Water Resources Policies and Authorities, US Army Corps of Engineers, 15 February 1989.

EM 1110-2-1616, Engineer Manual - Sand Bypassing System Selection, US Army Corps of Engineers, 31 January 1991.

IWR-Policy Study-90-ps-1, Beach and Nearshore Placement of Material Dredged from Federally Authorized Navigation Projects, US Army Corps of Engineers, April 1990.

CEWES-CV-CH (70) Memorandum, Subject: Proposed Coastal Inlet Research Program, dated 21 June 1991.

Present CE policy is to consider mitigation of Federal navigation project caused shore erosion when requested by a non-Federal public body. The mitigation measures must be economically justified and the non-Federal public body must agree to operate and maintain the mitigation measures in accordance with regulations prescribed by the CE.

The CE maintains marked or dredged channels, with associated navigation and shore protection structures, at more than 110 coastal inlets. Nineteen of the inlet projects presently, or at one time, included sand bypassing. Over 30 of the inlets have shore protection and beach erosion control projects in their proximity.

It is commonly agreed that when an inlet is stabilized by structures or improved by dredging a channel the littoral regime is perturbed. The extent and consequences of such action depend on the specific circumstances and environment existing at the site. In a few rare cases the consequences are minimal, in most cases the consequences are a significant loss of the sand moving in the littoral zone. Along adjacent undeveloped shorelines the loss may not be economically significant enough to warrant mitigation. In such cases, distant developed shorelines may not be affected. Erosion of the economically insignificant shore will make up the deficit in the littoral regime generated by the navigation improvements at the inlet. However, when the affected adjacent shore is economically significant, requests are made and mitigation is considered and may be economically justified.

Structures generally divert sand to areas in the vicinity of the littoral environment where motive forces are inadequate for further transport. Such circumstances readily accommodate sand bypassing schemes. Dredging, on the other hand, frequently results in the physical removal of the sand from the vicinity of the littoral environment to inland or deep ocean disposal areas. Such cases are often a permanent loss of the material from the shore zone and over an extended period may adversely impact the regional sediment budget. The cumulative effect of sand removal at a number of inlets could represent a significant regional sediment budget deficit.

Public recognition of the need to conserve littoral sand resources is reflected in an April 1990 Institute for Water Resources Report titled "Beach and Nearshore Placement of Material Dredged from Federal Authorized Navigation Projects." In comparing the 1990 study to a similar 1981 study, the author makes the following comparisons:

<u>ITEM</u>	<u>1981 STUDY</u>	<u>1990 STUDY</u>
Study period	1978 - 80	1986 - 88
Number of navigation projects examined	211	348
Projects which utilized material for beach nourishment or nearshore placement		
Number	52	152
Percent of total	25%	44%
Total average annual maintenance dredging quantities (million cu yd)	291	317
Average annual quantity of material placed on the beach or nearshore (million cu yd)	12.5	15.6
Percent of total	4.3%	4.9%
Activities reporting beach or nearshore placement	13 of 21	19 of 21
Projects requiring non-Federal cost sharing	9	67

Of note are the increase in the number of projects placing material on or near the beach, the number of activities participating, and the number of projects cost shared. At the same time the average quantity per placement has decreased from about 300,000 cu yd to about 100,000 cu yd reflecting only about a 0.7 percent increase in the percentage of total average annual quantity of material placed on or near the beach. This is attributed to the large areal extent of the projects where only a small fraction of the total quantity of dredged material is used for nourishment purposes because the various dredging zones are far removed from beaches and/or much of the material is not suitable for nourishment purposes.

As indicated, there are a relatively small number of active sand bypass projects at inlets (19 of 110+). Increased public awareness of the need to bypass sand at improved inlets has resulted in increased activity to conserve beach quality maintenance material. The increased activity has not, however, produced a proportional increase in the material conserved.

Catching the sand before it enters the navigation channel and bypassing it to the downdrift shore, conceptually provides three advantages over catching the material in the channel. First, it would result in shorter, more direct material transportation distances. Second, it avoids the likely degradation of the quality of the material by fine silts and clays. And third, it may reduce the amount of material entering the channel, thereby increasing the period between maintenance dredging operations.

Taking the material from dredging the channel or bypassing the material around the inlet and placing it in the downdrift littoral or beach zones both helps to preserve the finite amount of sand available in these zones and, to some degree, mitigates the erosion of downdrift shores, which often accompanies improvement work at inlets. To that end, this assessment determines that such sand bypassing is needed and should be implemented as an integral feature of the inlet project where practicable.

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