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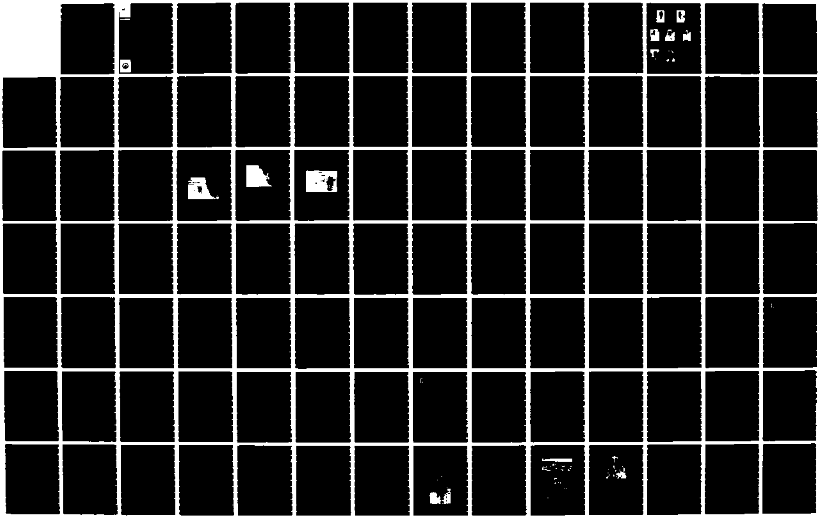

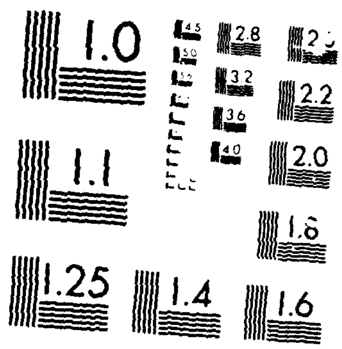
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US Army Corps of Engineers

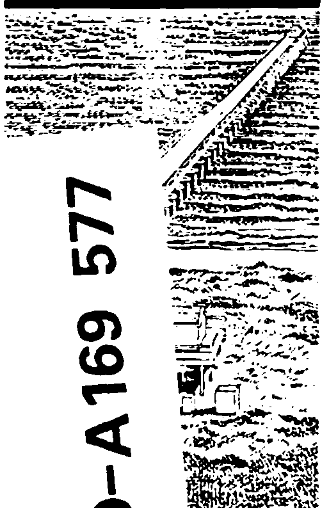
AD-A169 577

PROCEEDINGS OF THE 44TH MEETING OF THE COASTAL ENGINEERING RESEARCH BOARD

4-6 November 1985

SAUSALITO, CALIFORNIA

Hosted by
US Army Engineer Division
South Pacific



April 1986

Final Report

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These proceedings provide a record of the papers presented at the 3-day semiannual meeting of the Coastal Engineering Research Board (CERB). Also included are the following: (1) discussions of CERB business, the paper presentations, and the tour of US Army Engineer Division, South Pacific, Corps of Engineers projects; (2) challenges by LTG E. R. Heiberg and CERB's response to them; (3) recommendations for research and development by CERB members; and (4) responses to the research needs of US Army Engineer Division, New England, and US Army Engineer Division, South Pacific.

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PREFACE

The Proceedings of the 44th Meeting of the Coastal Engineering Research Board (CERB) were prepared for the Office, Chief of Engineers (OCE) by the Coastal Engineering Research Center (CERC), of the US Army Engineer Waterways Experiment Station (WES). They provide a record of the papers presented, the questions and comments in response to them, the interaction among program participants and the CERB, and the tour.

The meeting was hosted by the US Army Engineer Division, South Pacific (SPD), under the direction of BG Donald J. Palladino, Commander. Acknowledgements are extended to the following: Mr. Hugh Converse who coordinated the meeting; Ms. Daphne Dervin and her staff whose assistance in setting up the meeting location proved invaluable; Mr. Mark R. Dettle for his preparation of materials prior to the meeting and for having executed many of the planning details; Ms. Elizabeth J. Brady, Court Reporter, for taking verbatim dictation of the meeting; MAJ Stephen Thomas for coordinating the transportation for the field trips; and Mr. Frank Rezac for his photography and videotaping assistance. Worthy of commendation also are Mrs. Harriet L. Hendrix and Mrs. Sharon L. Hanks (CERC/WES) whose assistance in setting up the meeting and assembling information for this publication proved invaluable, and Mrs. Shirley A. J. Hanshaw (Publications and Graphic Arts Division/WES) who designed the format, edited, and compiled these proceedings.

Acknowledgements are also extended to the following for providing summaries of discussions following the papers: Mr. Charles C. Calhoun, Jr., Mr. Andre Z. Szuwalski, Dr. C. Linwood Vincent, Dr. Nicholas C. Kraus, Mr Thomas W. Richardson, Mr. C. E. Chatham, Jr., and Mr. Douglas Outlaw.

The proceedings were reviewed and edited for technical accuracy by Dr. James R. Houston, Chief, CERC, and Dr. Robert W. Whalin, Technical Director, WES. COL Allen F. Grum, USA, Executive Secretary of the Board and 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.

A-1

Patrick J. Kelly
Brigadier General, Corps of Engineers
President, Coastal Engineering Research Board

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CONTENTS (CONTINUED)

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INTRODUCTION

The 44th Meeting of the Coastal Engineering Research Board (CERB) was held at the San Francisco Bay-Delta Tidal Hydraulic Model, Sausalito, California, on 4-6 November 1985. It was hosted by the US Army Engineer Division, South Pacific (SPD), under the direction of BG Donald J. Palladino, Commander. The program format was designed to promote information exchange among members of the Board and attendees from various US Army Corps of Engineers (Corps) Districts and Divisions and the Office of the Chief of Engineers.

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 advisory board to the Corps and designating a new organization, the Coastal Engineering Research Center (CERC), as the research arm of the CERB. 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 meet twice a year at a particular coastal Corps District or Division to do the following:

(1) Disseminate information of general interest to Corps coastal Districts and Divisions.

(2) Obtain reports on coastal engineering projects in the host (local) District or Division; receive requests for research needs.

(3) Provide an opportunity for State and private institutions and organizations to report on local coastal research needs, coastal studies, and new coastal engineering techniques.

(4) Provide a general forum for public inquiry.

(5) Provide recommendations for coastal engineering research and development.

Paper presentations during the 44th CERB meeting dealt with local, national, and international concerns ranging from the evolution of the San Francisco Bay-Delta Tidal Hydraulic Model to sea level monitoring at the National Oceanic and Atmospheric Administration to a muddy coast study in the Peoples Republic of China. The major presentation at this meeting, however, was the issuance of various challenges to the Board by LTG E. R. Heiberg. The discussions which followed these presentations as well as recommendations by the Board for coastal engineering research and development are documented in these proceedings.

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NOVEMBER 1985

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44TH COASTAL ENGINEERING RESEARCH BOARD MEETING
San Francisco Bay-Delta Tidal Hydraulic Model
Sausalito, California
4-6 November 1985

ATTENDEES

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BG Donald J. Palladino
BG Paul F. Kavanaugh
Dr. Bernard J. Le Mehaute
Dr. Chiang Chung Mei
Dr. Dag Nummedal

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Mr. Carl Enson, SPL
Mr. Daniel Muslin, SPL
LTC Andrew M. Perkins, SPN
Mr. William J. Brick, SPN
MAJ Kenneth H. Clow, SPN
Ms. Daphne Dervin, SPN
Mr. Mark R. Dettle, SPN
Mr. Jack E. Farless, SPN
Mr. Thomas Kendall, SPN
Mr. Robert R. Mooney, SPN
Mr. William T. Prout, SPN
Mr. Sal Polito
Mr. Frank J. Rezac, SPN
Mr. Jay K. Soper, SPN
MAJ Stephen Thomas, SPN
Mr. Dennis W. Thuet, SPN
Mr. Lester Tong, SPN
Mr. Thomas H. Wakeman, SPN
Ms. Jody A. Zaitlin, SPN
Mr. Thomas A. Denes, SPN

SOUTHWESTERN DIVISION (SWD)

Mr. Ronald R. DeBruin

WATERWAYS EXPERIMENT STATION (WES)

COL Allen F. Grum, Director Executive Secretary, CERB
Dr. Robert W. Whalin, Technical Director

WATERWAYS EXPERIMENT STATION (WES) (Continued)

Mr. Charles C. Calhoun, Jr., CERC
Mr. C. E. Chatham, Jr., CERC
Mrs. Sharon L. Hanks, CERC
Mrs. Shirley A. J. Hanshaw, P&GAD
Mrs. Harriet L. Hendrix, CERC
Dr. James R. Houston, CERC
Dr. Nicholas C. Kraus, CERC
Mr. Curtis Mason, CERC
Mr. Douglas G. Outlaw, CERC
Mr. Thomas W. Richardson, CERC
Mr. Richard A. Sager, HL
Mr. Andre Z. Szuwalski, CERC
Mr. Michael J. Trawle, HL
Dr. C. Linwood Vincent, CERC

NATIONAL OCEAN SERVICE (NOS)

Mr. Paul M. Wolff

INVITED GUESTS

Dr. Robert A. Holman, Oregon State University
Mr. Edward Flavell, Commissioner, Santa Cruz Harbor District
Dr. Volker W. Harms, University of California, Berkeley
COL Ralph L. Hodge, Office of Air Force Regional Civil Engineer, Western Region

COURT REPORTER

Ms. Elizabeth J. Brady

44th MEETING OF THE COASTAL ENGINEERING RESEARCH BOARD

4-6 November 1985
San Francisco Bay-Delta Tidal Hydraulic Model
Sausalito, California

AGENDA

4 November

7:15	Leave Hyatt Regency Oakland	
8:00 - 8:30	Registration at Bay Model	
8:30 - 8:45	Opening Remarks	LTG E. R. Heiberg III, OCE
8:45 - 8:55	Handing Over Gavel	BG C. E. Edgar III, SAD
8:55 - 9:05	Acceptance of Chairmanship	BG Patrick J. Kelly, OCE
9:05 - 9:10	Welcome to San Francisco District	LTC Andrew M. Perkins, Jr, SPN
9:10 - 9:35	Welcome to South Pacific Division and SPD Coastal Overview	BG Donald J. Palladino, SPD
9:35 - 9:40	Announcements	Mr. Hugh D. Converse, SPD
9:40 - 9:55	Review of CERB Business	COL Allen F. Grum, WES
9:55 - 10:10	Coffee Break	
10:10 - 10:30	Overview of FY 86 Coastal Engineering Research and Development Program	Mr. Charles C. Calhoun, Jr., CERC
10:30 - 10:45	Joint CERC/People's Republic of China Muddy Coast Study	Dr. James R. Houston, CERC
10:45 - 11:30	The Fall 1985 Nearshore Processes Experiment, DUCK-85	Mr. Curtis Mason, CERC Dr. Nicholas C. Kraus, CERC Dr. Robert A. Holman, Oregon State University
11:30 - 12:00	Fisherman's Wharf Harbor	Mr. Dennis W. Thuet, SPN Mr. Douglas G. Outlaw, CERC
12:00	Lunch	
1:15	Bus pickup to return to Bay Model	
1:30 - 2:00	Dredged Material Disposal Management Program for the San Francisco Bay Area	Mr. Lester Tong, SPN Ms. Jody A. [illegible], SPN Mr. Thomas A. [illegible], [illegible]
2:00 - 2:20	Noyo River and Harbor, California Design for Wave Protection	Mr. Douglas G. Outlaw, [illegible]
2:20 - 2:35	Coastal Storm Observer Program	Mr. George W. [illegible], [illegible]
2:35 - 2:55	Imperial Beach Breakwater Project	Mr. Douglas [illegible], [illegible]
2:55 - 3:10	Coffee Break	
3:10 - 3:30	Framework Geomorphology Reports	Mr. [illegible], [illegible]
3:30 - 3:45	Oceanside Experimental Sand Bypass System	Mr. [illegible], [illegible]
3:45 - 4:15	Research and Development Needs for [illegible]	Mr. [illegible], [illegible]
4:15 - 4:45	NED's Coastal Research Needs	Mr. [illegible], [illegible]
4:45 - 5:00	Tour Briefing	Mr. Hugh [illegible] Converse, [illegible]
5:00	Adjourn/Return to Hyatt Regency Oakland	

AGENDA (Concluded)

<u>November 5</u>

8:00 - 5:00	Field Trip	
	(1) Helicopter flight for Board members and VIP's (A bus tour will serve as foul weather backup plan)	
7:45	(2) Bus tour for attendees	
7:00	Leave Hyatt regency Oakland for cocktails and dinner at Fort Mason Officers' Club	

<u>November 6</u>

7:15	Leave Hyatt Regency Oakland	
8:00 - 8:05	Open Meeting	BG Patrick J. Kelly, OCE
8:05 - 8:10	Announcements	Mr. Hugh D. Converse, SPD
8:10 - 8:35	Evolution of the San Francisco Bay-Delta Tidal Hydraulic Model	Mr. Thomas Wakeman, SPN
8:35 - 9:35	Model Inspection	SPN
9:35 - 9:50	Coffee Break	
9:50 - 10:30	Discussion of Field Trip and Bay Model	CERB
10:30 - 11:00	PUBLIC COMMENT	
11:00 - 11:30	NOAA Sea Level Monitoring	Mr. Paul M. Wolff, NOS)
11:30 - 12:05	*Recommendations by Members of the Board*	CERB
12:05 - 12:15	Selection of Date and Place for Next CERB Meeting	
12:15 - 12:30	Closing Remarks	BG Patrick J. Kelly, OCE
12:30	Adjourn/Return to Hyatt Regency Oakland for those attendees not participating in boat tour	
12:30 - 2:00	Lunch	
2:00 - 5:00	Boat Tour in conjunction with the West Coast Regional Design Conference	
5:00	Return to Hyatt Regency Oakland	

OPENING REMARKS

LTG E. R. HEIBERG III, Commander
Chief of Engineers
Washington, DC

I didn't know much about what a Coastal Engineering Research Board (CERB) was when I was a district engineer. It was my loss. As time went on, I got to know something about the CERB, and when I became CERB president in 1979, I started a relationship with this coastal engineering business that I intend to stay with. That is one of the reasons I wanted to be here today.

I want to thank this group of people for being here. There is a lot of voluntarism on the part of many who are present here, and I particularly want to note the expertise in a couple of the areas represented by the Board. We have not only four uniformed leaders from the US Army Corps of Engineers (Corps) who represent some of the most important regional leadership in the Corps at the Division levels but also three civilian members who are a very strong technical addition to the things that we need to do and think about.

I got a lot of help in preparing my presentation, but I am not going to follow anyone's advice, exactly. So I have changed my remarks here several times in the last 48 hr. But I do want to start off by expressing my appreciation to the Army for the kind of expertise we have focused here for this CERB meeting and for the days and years ahead.

This is a time for passing the gavel. At the end of my remarks, which will be relatively brief, I will formally relieve GEN Edgar of his duties; however, Pat Kelly has been wielding the gavel since he came to the job of deputy director of Civil Works.

Many of you who have worked closely with me know the reasoning and a little bit of the agony that I went through when we decided what we were going to do about the CERB presidency. I maintained the presidency after I moved from the position of director of Civil Works to that of deputy simply because I wasn't sure what the right thing was to do before I advised Joe Bratton how to move out. Then suddenly we were blessed with two general officers coming into the Civil Works Directorate to run that part of the Chief of Engineer's empire that is known as Civil Works. Both John Wall and Ernie Edgar essentially came in at about the same time. And my reasoning at that time was that if I gave John Wall the presidency of the CERB at the same time that he was taking on a huge responsibility in Civil Works during a time of great turmoil (that time is not behind us, but it was even more tumultuous then), there was less of a prospect of smooth sailing than we have today. I am not saying we have smooth sailing today, but at least it looks like we might have a bill in the Civil Works arena pretty soon. It was a tumultuous time for the new Administration. I had been working with them for about a year and half. But John Wall had to focus on that and, besides, he had other responsibilities. For example, he was the US Section head of the Permanent International Association of Navigation Congresses (PIANC), and he had never even heard of a PIANC before. I wanted him to grab hold of that international responsibility that the director of Civil Works had, and I gave GEN Bratton my advice to pass the gavel from me to Ernie Edgar.

I deliberately chose the deputy director rather than the director because I felt he could focus on it. Another reason I chose to recommend the deputy director is that, the way things work, the deputy director probably will be around the Corps longer; and this is a valuable resource we have with the four general officers who are on the Board. Hopefully they will graduate into continuing senior positions and responsibility and take what they have learned as members of the Board into the Corps for their future leadership responsibilities. Indeed, Ernie now has the US Army Engineer Division, South Atlantic (SAD), and he now has the many things that he learned in this arcane world of coastal engineering that he carries with him to his responsibilities in Atlanta. Those were the two reasons I gave to GEN Bratton, and he accepted them. So Ernie became the president for almost 3 years.

I went through the same process when I decided--with the help of the Chief of Staff of the Army--to move Ernie to Atlanta. Elizabeth helped in that process, too. When Ernie went to Atlanta, we again had a new director of Civil Works, Hank Hatch, coming onboard along with Pat Kelly as the deputy director. Of the two people coming on, Hatch had to look at other responsibilities. It is still a pretty intense time in Civil Works, and I felt that Pat would be able to devote more attention than Hank. So, again, I decided to make the deputy director of Civil Works the CERB president. The only difference was that this time I did not have to check with the Chief of Engineers.

But I thought I ought to explain that to this group because most of you do not know how we go through our decision process, and I thought I would tell you the reasons that we have the deputy director rather than the director of Civil Works. There was another reason in the back of my mind, too. The last two presidents we had at the CERB, before I took over, left the Corps immediately upon leaving the presidency of the CERB. Chuck McGinnis left for retirement a little bit earlier than I think he should have. And before that Ernie Graves left for other responsibilities in the Defense Department. So, again, I don't expect Pat to leave us quite that quickly. If he does, he will be back. I will make that promise, if I have anything to do with it.

Again, we have a brigadier rather than a major general as president of the CERB. We do have a promotable brigadier general on the Board, though. So, George, if you want to check the dates of rank, then you can do that; but he still has the gavel. I want everyone to understand that.

Another thing I will say about Pat is that he came to his responsibilities out of US Army Engineer District, Mobile (SAM). Since the only coastal training I have had in the operational side was in US Army Engineer District, New Orleans, (LMN)--and as most everyone in this room knows the only beach New Orleans has is Grand Isle, and every hurricane wipes out Grand Isle--my practice was sort of limited. That situation continues for the LMN district engineer. However, SAM has a much better view of the world of beaches, and Pat is much better prepared, with his knowledge of Mobile's history, to take on these coastal engineering responsibilities.

Then we have the other part of the new leadership. For a year, we borrowed COL Grum, from West Point, and he will take my hot seat when I leave in an hour to go on to the Pacific. Al Grum is the permanent head of the Department of Engineering at West Point, and he has extremely good credentials. Not only that, he knows how to talk California. So, it is very appropriate to have him back here. Even though we have him for only a year, I am making sure that the Corps makes maximum use of his talents. And though you will see Al's "fried egg" on his lapel rather than the castles we are used to seeing, I assure everyone here he is an engineer of the highest credentials.

We also lost recently the Chief of the Coastal Engineering Research Center (CERC); but the loss was, I think, coastal engineering's gain, in a sense. Bob Whalin, who had been running CERC since Thorndike Saville retired some time ago, came up to Fort Belvoir for a year to preside over that very difficult and traumatic move of CERC down to Vicksburg, Mississippi. Bob was kicked upstairs; but as such, he is still in the chain of command as Technical

Director of the US Army Engineer Waterways Station (WES) and is in a unique position to continue to influence coastal engineering. So I don't see Bob's departure from CERC as a minus; in fact, I see it as a plus for coastal engineering.

Now, that leaves me with the embarrassment of having to report to this group something I didn't want to. I was hoping that by today I would be able to announce the new Chief of CERC, but I am not quite in a position to do that. I wanted to explain to this very knowledgeable group that I am reasonably close to that decision. I have named a panel of three very knowledgeable Corps people to give me advice concerning those people who are candidates for the Chief of CERC position, and I expect that effort to be finished pretty soon. I made the chairman of that panel Cecil Goad, John Mikel's boss. He isn't here today; but he, as most of you are aware, knows the Corps. He also knows a lot of the business of the CERB and CERC and is very well acquainted with the way we do our business. So Mr. Goad will chair that panel, and I hope he will have a recommendation, or prerecommendations, to me very soon.

Another reason I wanted to be here is that this is a very appropriate time to contemplate the future of our coast and the future of the CERB and CERC. I am very heartened by the continuing mix of excellence that we have here that I referred to earlier. We have a combination of outside as well as inside expertise that is without parallel. There are four general officers here on the Board, backed up by the superb talents of not only CERC and WES but also the other parts of the Corps that assist the Board and CERC in the coastal engineering world.

The things that I would like the CERB to focus on include a pretty general charge; I guess it is sort of asking you to do your mission, Board. I want to get from you recommendations of specific approaches to solve coastal engineering challenges. And I don't mean necessarily today or in the next 3 days, but I mean during these months as we look for a bill and as we wait to see which way the budget is going to influence the way the United States goes. This is an extremely good time for the CERB to talk about specific approaches to help us in the Corps to solve the problems of coastal engineering and the various problems that coastal engineering focuses on across this great country.

At the last meeting, the Corps presented major policy and technical issues to the Board. I note here we have several changes to the Board;

therefore, you probably want to review what you have done before. GEN Edgar outlined to me some of his views from the last Board meeting about some possible approaches to use. I recommend that the Board take a look at GEN Edgar's comments (Appendix D) in that regard based on his 3 years with the CERB responsibilities and his continuing responsibility as the head of SAD which shares many of these challenges.

The Corps has a unique historical role in coastal engineering. We are, at the same time as we have that role, looking at an opportunity--in fact, a challenge, if not even indeed a requirement--to find some significant funding sources, or help, for that role of coastal research and development from sources outside the Corps. I do not know what is really there, but I think we need to explore what might be there. As we just found out with the action by the Senate a few days ago, there is not a great deal of support for Federal research and development in the world today. And I don't think that is going to change. I don't want to stand up here and promise you that either I or the people in this room will be able to influence that rate of change. In fact, I am not sure that any one person, no matter who he or she is in the United States, can influence that. I just think that is the way of the Federal world. Federal research and development are going to be in a troubled fiscal arena for the foreseeable future.

I realize, in fact I reaffirm, that we in the Corps realize that we have a premiere responsibility for advancing coastal engineering technology not only in the US but also across the world. The coastal engineering side is one where we cannot depend on outside sources for funding. There just isn't much of that there today. I do not know if that can be worked on, but I would like the Board to consider that issue. Therefore, I am charging you, Mr. Chairman and members, to do your best to provide specific fiscal and technical recommendations about long-term directions of coastal engineering.

In short, realizing that the engine of what we do is money, people, and expertise, money is an important part of that; and I am asking you for both fiscal as well as technical recommendations about where we should go. My problem in the past has been when I asked the Board--when I was on the Board--to try to find directions in which to go. The easy, comfortable way is just to come back out and beat our fiscal folks on the head and say, "Hey, we have got to get more money." It is not that easy. So I am asking you to chart the future for the Corps and coastal engineering and to try to find some specific ways, both technically and fiscally, in which we can go forward.

What I would like to find is a way for the Corps to make a strong and dramatic commitment to solving those coastal engineering problems that we have into the future instead of continuing to nibble around the corners as we have been doing.

Now, I very deliberately have not used the term "basic research and development" in anything I have said over the last 15 minutes. That goes back to my comments about the support of both the Administration and the Congress for Federal research and development. We need a dose of realism here, and I need to have it from the Board. Federal basic research and development is simply not a winner. That doesn't mean we cannot find ways to do what we must do for coastal engineering, and we have got to get away from the thought that is has to be a slice of the budget. You do not want to wave red flags at those who would like to help us do what we do, but part of that also is finding imaginative ways to find the fiscal wherewithal to do what we need to do without direct attack on the Federal Treasury. So I would like for you to see if you can find some way to make that commitment to the future with imaginative ways to get it done.

Now, there are some things I know we need to do, and this is not the first time the Board has looked at these. It is time--and we have been talking about it at least since 1979 when I first came on the Board--to try to revolutionize and settle down the accuracy and reliability of the coastal engineering practice. Mike O'Brien and I have had many soliloquies on getting from the art to the science; but before we do that, we need to have that long-term plan. That is what I am asking from the Board during this and future meetings. We need to find ways to influence budgets. My comment about mobilizing agencies and organizations--some of them outside the Federal government --to get them interested in coastal problems is crucial. Where that interest is latent, we have to bring that interest up. In that way, perhaps, if we are imaginative and bright enough to figure out ways to do that, we can find ways to get significant, sustained, and cooperative advances.

Now, I have a continuing disappointment in not being able to shout about "support basic research," and we have talked about this a good deal before. But I must have a package that sells--one I can point to and say, "innovation." I must have a package that I can point to that shows how we are reducing Federal shares, not necessarily the dollars but the Federal share of the cost of doing business. I must find ways--and I hope you can help me--to bring in others who have that latent interest such as universities, other countries, some parts of the private sector, and maybe elements of the chain of government other than the Federal government. I know it takes imagination. There are no easy solutions there, but we do need some imagination. So I am asking you specifically in this charge to investigate a way to increase the traditional General Investigations (GI) funding and find funding from other areas. It doesn't go into the rubric of basic research and development, operations and maintenance, or construction general money, as I mentioned. Maybe there are some ways we can cost share with the states or universities and others. I do not want to preside over something or be presented something that is not feasible, but I just do not think we have turned over all the opportunities and looked at them closely.

One other continuing charge--it comes from conversations that I have had before and I know you have had more recently since I left the Board--is the responsibility that the Board has for addressing coastal engineering education. It is just a plain recognition of the fact that to a certain extent we have to grow our own professionals. We do not have enough in the Corps; and if we do not grow them--if we do not provide the right kind of soil there to grow them--they are probably not going to get grown. Perhaps also in that area we can find some innovative solutions whereby, through cooperative programs, CERC and the universities, as an example, can get together and find ways to help with this challenge of educating professionals for the future as coastal engineers.

Another charge that GEN Edgar has discussed with the Board before and that he feels still needs to be addressed--and I agree with him--is looking at the lack of sufficient highly advanced and large-scale lab facilities. Perhaps we can find ways to start conversations or seek understandings with the Marine Board, the National Research Council, or the National Science Foundation (NSF) to find national laboratory facilities that honor the constraints I mentioned before. Things that the Corps and the NSF could support could be at CERC, but not necessarily. If we find a way to do that, perhaps we can find a way to provide what we would all like--a quantum leap in the science and practice of coastal engineering. Then we could move from the art to the science. But again, it is extremely important as you do this that we maximize the impact of every Federal dollar that we can get so that we can give a good story to our congressional and administrative masters.

Sources of funding across the Federal government for operational priorities have been changing. Operations and maintenance (O&M) today constitutes over 50 percent of our budget, which it has done for the last 2 or 3 years; and that is going to continue for the near term. Maybe in the long term we will "get back to work" as the moves on the bills go forward. Therefore, we have to look at ways to get appropriate O&M funding for new things that are in the research and development arena, such as the Repair, Evaluation, Maintenance, and Rehabilitation (REMR) program that has been discussed by the Board.

The CERB has to look beyond the additional GI funding for areas of payoff. Maybe it is in dredging. We are going to continue to dredge. This country still has a great hunger for deeper harbors and deeper channels and for maintaining those harbors and channels that we have. So dredging is here to stay. Maybe there is a payoff there.

Maybe we can find ways to do the research that we want and to tie it into specific projects, for example, the dolos prototype project at Crescent City and the regional coastal studies that we now have under way in a couple of our districts (Los Angeles and Jacksonville). I am asking you as another of my charges to provide advice on these and to recommend ways for expanding that kind of approach. Again though, as I ask you to do that, be mindful of my cautions on the use of Federal dollars.

The charges that I have given you are difficult and complex. I do not think my predecessor or I made any promises to any of you when you came on the Board that your charges were going to be easy. Maybe you cannot do it all at once; I can appreciate that. Maybe we have to nibble at it for a while, but I think the directions I have given you are the only ones that I am going to have to sell to the Administration and to the Congress.

Through the guidance over the years that the CERB has given to CERC, the coastal center has become synonymous around the world with excellence in coastal engineering. I think everyone here knows that the Shore Protection Manual (SPM) is a "bible" throughout the world. You can find the SPM wherever you go. I am confident with that kind of background and the kind of expertise we have--and much of it is right here in the room--that the Board and CERC can meet these challenges. So, I'm looking for imaginative and innovative--and perhaps some controversial--recommendations. I can handle that as long as you recognize the constraints of the real world.

To help you with your tasks, there are some pluses and some minuses; and I thought I ought to divulge those to you. I have mentioned several of them, but I would like to give you my tally sheet of how you are starting. You are starting with an immensely talented Board. This is a very talented group of Corps officers with the maximum capability to manage the Corps challenges in a number of arenas. That is an extremely strong plus. Furthermore, a good slice of the future leadership of the Corps is right here before us on the Board in uniform. I think you have a plus today in the fact that I was privileged to serve on the Board myself for 3 years. I note that of my four predecessors only one had done that. Neither GEN Bratton, GEN Gribble, nor GEN Park, as I recall, had served on the Board, although GEN Morris had.

I have already mentioned Pat Kelly and the advantages he brings, with some practical knowledge down at the District level where the "rubber meets the road." He will be around awhile; and his credentials are better than mine were. We also have some other leadership here. We have Don Cluff who has just joined us. Many of you know Don from working with him when he was in his prior assignment with the Office of Management and Budget. Bory Steinberg, who isn't here--he's minding our store, I believe, in Washington--and Lew Blakey, who is here, together with Cecil Goad, are in the hierarchy of our Civil Works arena. They provide us with very strong leadership, and I have a good deal of personal confidence in them. Those four senior civilians of the Corps provide us a promise of leadership in the Pulaski Building at Fort Belvoir. I feel very good about that, and I think that is positive for the Board. So those four people are in a position to help.

I have already talked about Bob Whalin and the move from his good stewardship at CERC up to the position of technical director which is a plus for coastal engineering and for the work that the Board is going to do. This is a plus that might be controversial, and I know some people--maybe some in this room--who would argue that this is a minus, as they did 5 years ago. But that very painful move that Jim Choromokos and I had an opportunity to try to protect and nurture in the Washington, D.C., arena--that is, moving CERC to WES after it had already made one move within the decade prior--was absolutely needed at that point in time. It is now accomplished; it is set. We now have CERC at the right place, and we will continue to give the best leadership that we can provide in the Corps at WES. We have it today, but we will also have it tomorrow. Having CERC down there working with the rest of WES is an absolutely important plus for us. I think many here know that both Jim and I discussed that with former civilian CERB members before we made that painful decision. It is always difficult to move a Federal outfit from place A to place B, and there are lots of minuses. But it is done; it is behind us; it is a success.

I mentioned earlier that we will have a new director of CERC soon, but I am sorry I can't say this early day in November that I have already approved him. It is even more important for me to be able to say I have done it right. And I believe this special panel that I have asked to give me advice in this area will be able to get the best people who are knowledgeable not only of the coastal engineering technical requirements but also of the requirements for good management of CERC for the future. They will be able to decide who the right man or woman is to be the next head of CERC. I do have to quickly say "or woman," although right now the competitors do not include any women. Maybe sometime in the future we can handle that.

I have already mentioned that I have a great deal of confidence in the experience, background, and wisdom of our three civilian members here. This front row up here at this meeting is a super one.

I admit we have some minuses, and I have addressed some of them. We have tough dollar challenges that are not going to be overcome by any rhetoric we give each other here. We have to get beyond our traditional approach on dollars to bring to bear ways to get coastal engineering going forward. And, as I promised you, it is a minus today that we don't have a new Director of CERC, but it is not going to be a minus much longer.

It is our job to advance the state of the art, and it is our job to try to get that state of the art more into the engineering practice world. Therefore, I need your commitment, and I am not talking just to the CERB; but I need the commitment of other Corps folks and those who help us do our business.

Implementing the recommendations that you come up with is going to impact the entire coastal engineering community. If we do it right, it will be an impact for the good. I intend to make sure we all do it right. It is the only major mission that the Corps has where we really stand virtually alone in the Corps. I would like to change that a little bit. It is a little bit too lonely for the Corps out there. We are a little bit too much the victims of budgets, Federal budgets. I have a commitment that I wanted to report to you. It is a charge to myself, and I wanted to make sure you understood that I have made that commitment. I commit myself to this Board that I will seriously consider and take appropriate action, and I will provide feedback on all the recommendations that you bring to me through the chairman.

I am sorry I cannot stay here for the meeting. I have enjoyed many CERB meetings before, and I would love to join this one. You have a rich mix of things to do, including the field trips you are going to make.

What I am going to do now is to ask the past president--and I guess we can call you a member emeritus, more or less, Ernie,--to come forward. As I told Ernie earlier this morning, as a division engineer, as long as his travel funds are straight, he can continue to come to these meetings; he just can't sit in the front row any longer. But this time I think the incoming chairman allowed him to sit in the front so he doesn't have to go very far when I make a couple of presentations to him.

I think I will let Ernie pass the gavel as the last act because I want to sit down when he does that. This is given to Ernie in appreciation from those in the coastal engineering arena for the stewardship that he has provided us for the last 3 years as the president of the Board. Ernie, it goes along with my warm congratulations. I have been watching you do your work on your last three jobs, and you have been doing a super job. Along with that, we hope you do not put them in your footlocker. You are allowed to find some place in your palatial mansion there in Atlanta to put a couple of things that the coastal engineering folks here would like you to have. One is a picture of CERC. I am delighted to report to this group that CERC, indeed, did not wash out to sea a couple of weeks ago with that hurricane. It is still there. It is doing its job. In fact, I think we are all looking forward to seeing what comes out of the data we got during the passage of the hurricane. This is another piece of paper that shows our formal thanks to you for your stewardship.

HANDING OVER GAVEL

BG C. E. Edgar III, President (Outgoing)
Coastal Engineering Research Board
Commander
US Army Engineer Division, South Atlantic
Atlanta, Georgia

Before I perform this symbolic act, I rule the podium at least for a few short moments. I would like to share some thoughts with you. I think in the four plus years I have been a member of the Coastal Engineering Research Board (CERB)--a year or so as division engineer, and then again the last 3 years as president--have been very much a time of change. In fact, Robert reminded me last night that I am the oldest of the members of the CERB. We have seen the move of the Coastal Engineering Research Center (CERC) to the US Army Engineer Waterways Experiment Station (WES) as the Chief pointed out, and I happen to be enrolled in that group of folks who thinks that was a great decision. It was great in many respects, but most especially it now allows CERC to participate fully in both military and civil activities involved on the coast. I think the future is bright for CERC and for the coastal engineering community because of that move.

Our last meeting at Vicksburg, I think, was a milestone. I came away from that meeting very excited because I think it brought to the table some of the things that we had been talking about privately among ourselves and on occasion in the forum of the CERB, but it laid out where we thought as a group we wished to take coastal engineering and the Corps of Engineers (Corps). I did write the Chief a memorandum which summarized that, and Pat Kelly has a copy of it which I am sure that he will share in the deliberations of the board meeting. I think the Board is on the verge of some very new initiatives. The Chief's charge to the Board today, I think, sets in motion some great opportunities. We have talked in the past about voices not being heard--voices crying in the wilderness. I don't think that is true anymore. I think the Board is going to have to come up with whatever it is that it is going to come up with in a realistic fashion and present that to the Chief in order to allow coastal engineering to move on.

The Chief's vision for the Corps of leaders in customer care is one that all the division engineers have committed themselves to. It is a vision that all senior leaders, both military and civilian, have committed themselves to. The Corps by its very mission in coastal engineering is a leader. Our customers have been battered and buffeted by various storms for many many years, and this Board has an opportunity to make a difference which I am sure that it most certainly will.

In Pat Kelly you have someone who can help show you that way. Pat and I go back a long way, both professionally and personally; and as the Chief pointed out, he comes with credentials as a district engineer from a coastal district, one which during his tenure saw a number of heavy storms, hurricanes, and what not. Though I have been in the South Atlantic Division a little over 6 weeks, we have had four of those hitting our coastline.

Besides having been a district engineer, Pat also has a background in research and development. And with the exception of, perhaps, Ernie Graves, in recent times, I am not sure that we have had someone with expertise in research and development in recent years who has been president of the CERB.

Chief, I thank you for the opportunity of being the president of this organization and for your kind words a few moments ago. I also want to thank my colleagues on the Board--those who are left--who have served with me and, in absentia, those who have gone off. I also wish to thank the folks at CERC and WES for all their help and support. In good times and in bad, it has been a great opportunity as well as an education and a pleasure for me to know you and serve with you. Certainly as I go on to my duties in the US Army Engineer Division, South Atlantic (SAD), I certainly will continue my interest in what this Board does. And yes, Chief, I will come back and put in my two cents on occasion.

I regret that I am not going to be able to be with you the entire time. I must go back and mind the store. I must find out what is going on in SAD because I seem to spend more of my time away than I spend in Atlanta these days.

So, Pat, without further ado, it is my pleasure to pass to you the gavel of leadership, together with a well-worn block. There are some imprints here which perhaps indicate the frustration of the chairman on occasion, but I know that you will wield the gavel well; and I wish you all the best and pledge you the support of SAD in your new endeavors.

ACCEPTING GAVEL AND CONVENING 44TH CERB

BG Patrick J. Kelly, President (Incoming)
Coastal Engineering Research Board
Deputy Director of Civil Works
Washington, D.C.

I, too, would like to express my appreciation to Ernie for the fine work that he has done as president of the Coastal Engineering Research Board (CERB). I will get a copy out to everyone here today of Ernie's remarks and recommendations as to how he personally felt the direction of this Board should go. A lot of the thoughts that were expressed by the Chief are expressed also in that particular document, and it gives us a good vision for the future.

There is also one appreciation I would like to give, and that is to Bob Whalin who is now the new technical director of the US Army Engineer Waterways Experiment Station (WES). In just the short 3 months that I have been in as the deputy director of Civil Works, Bob has given me little tutorials here and there about getting ready for this meeting concerning where we should go and how we should organize things. I began to realize the tremendous work that he has put in all of these years not only as the past director of the Coastal Engineering Research Center (CERC) but also as the real mover and shaker of the CERB. So, Bob, I think you deserve a round of applause.

I am really looking forward to being the president of the CERB. As the Chief and Ernie mentioned, I recently came from a coastal district with a lot of interesting projects and with a certain amount of sensitivity toward our coastal projects, particularly, coastal engineering. But I guess my interest and experience go back even farther than that. I grew up in Connecticut in New Canaan, just about 5 miles away from Long Island Sound. We spent half our lives as kids down at Norwalk and Stamford, and we literally lived on the beach. Over the years I have developed a hobby which I have pursued, and that is sailing. I have always been extremely interested in coastal engineering.

Now, there are some very interesting challenges that the Chief has given us, the new Board, to look into. Every time I thought I had one of your challenges, Chief, you popped another one. And if we review those, we have a fantastic opportunity to literally make something happen, during, hopefully, the next year that the Board is going to convene. There are some very interesting challenges, and there's going to be a lot of innovation, not only in the fiscal area but also in the technical area.

So, I ask for your help, not only the members of the Board but also those of you who are appearing here today and who will also participate in today's events. Give us whatever ideas, innovation, and talents that you have to lend us.

Now, I would like at this time to introduce our new members of the Board. First we have BG Paul Kavanaugh who is commander of US Army Engineer Division, North Atlantic, from New York City. We also have Dr. C. C. Mei, Professor of Civil Engineering at the Massachusetts Institute of Technology up in Cambridge. C. C., it is good having you here. We also have another civilian member of the Board, Dr. Dag Nummedal. Dag is from Louisiana State University where he is a professor of geology. So, Dag, we would like to welcome you as well.

Now, Al Grum has already been introduced, but I will formally introduce him as our new executive secretary. And, as the Chief stated earlier, he is the acting director right now for WES where he is on sabbatical, I guess, for one year, as professor and head of the Engineering Department at the US Military Academy at West Point.

So, with no further ado, the 44th meeting of the Coastal Engineering Research Board is hereby convened. I will now turn it over to LTC Perkins who will greet us formally.

WELCOME TO SAN FRANCISCO DISTRICT

LTC Andrew M. Perkins, Jr.
Commander
US Army Engineer District, San Francisco
San Francisco, California

General Heiberg, members of the Coastal Engineering Research Board, and distinguished guests, it is a distinct pleasure to welcome you to the US Army Engineer District, San Francisco, and the San Francisco Bay-Delta Tidal Hydraulic Model. We are honored that you chose San Francisco for your meeting and happy to have the opportunity to provide you with your conference facilities. Figure 1 provides a geographic overview of the San Francisco District and northern California.

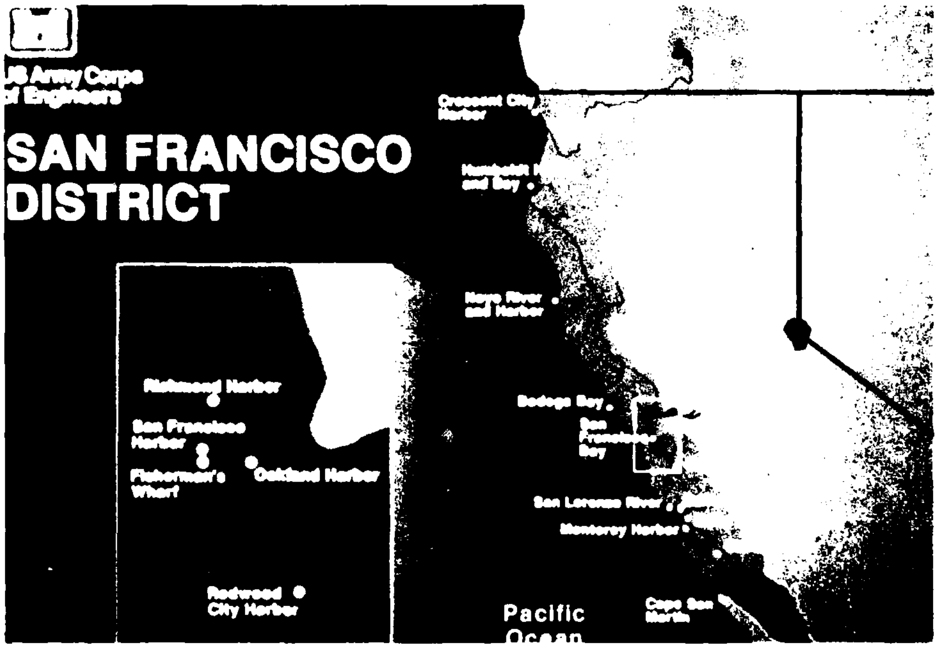

FIGURE 1. OVERVIEW OF SAN FRANCISCO DISTRICT

We are responsible for over 600 miles of the California coast, ranging roughly from Monterey Bay to the Klamath River basin in southern Oregon. San Francisco is one of the Corps' tailored civil works districts. Most of our resources are dedicated to navigation and coastal projects. We have full responsibility for planning, design, construction, and maintenance of our navigation program.

Figure 2 shows the nine-county bay area which is dynamic for many reasons. It is a major tourist center--a center of environmental awareness with both the Sierra Club and the Audubon Society having national headquarters here. Silicon Valley is located south of the city on the peninsula, and our latest bay area attraction is Humphrey "The Whale" who has taken residence in the brackish waters of the delta.

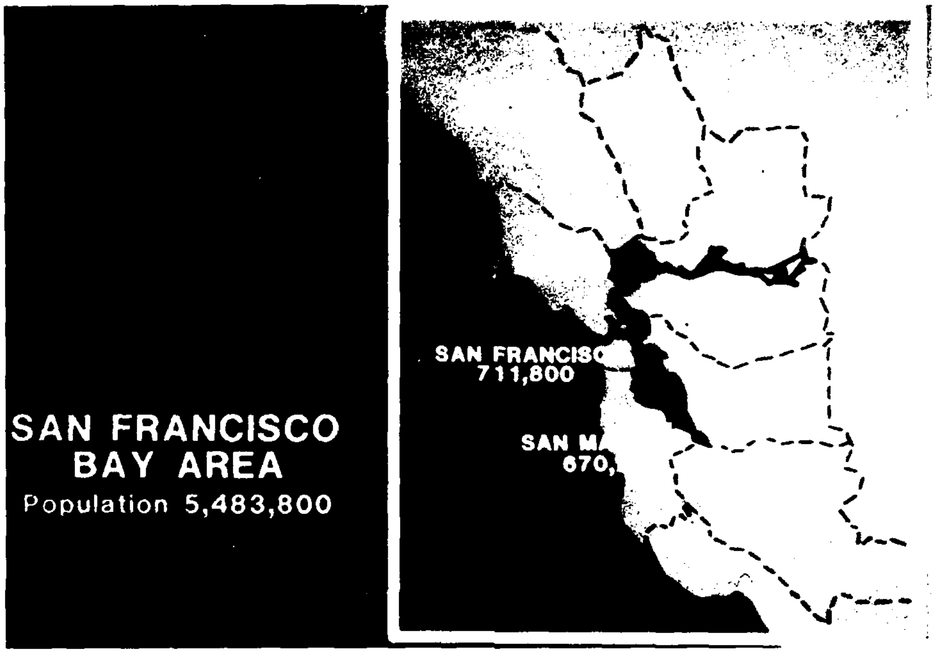

FIGURE 2. OVERVIEW OF SAN FRANCISCO BAY AREA

A closer look at the area reveals Sausalito where the San Francisco Bay-Delta Tidal Hydraulic Model is located (Figure 3). Later this week many of you will take the boat inspection tour which will take you from here past the Golden Gate Bridge and along San Francisco's waterfront. We will then cross the bay to Oakland and proceed up the east side of the bay past the port of Richmond and then return to the model. We hope you will take advantage of this opportunity to see firsthand our beautiful bay and the cities which call it home.

Again, thank you for being here. My staff and I are dedicated to making your stay fruitful and enjoyable.

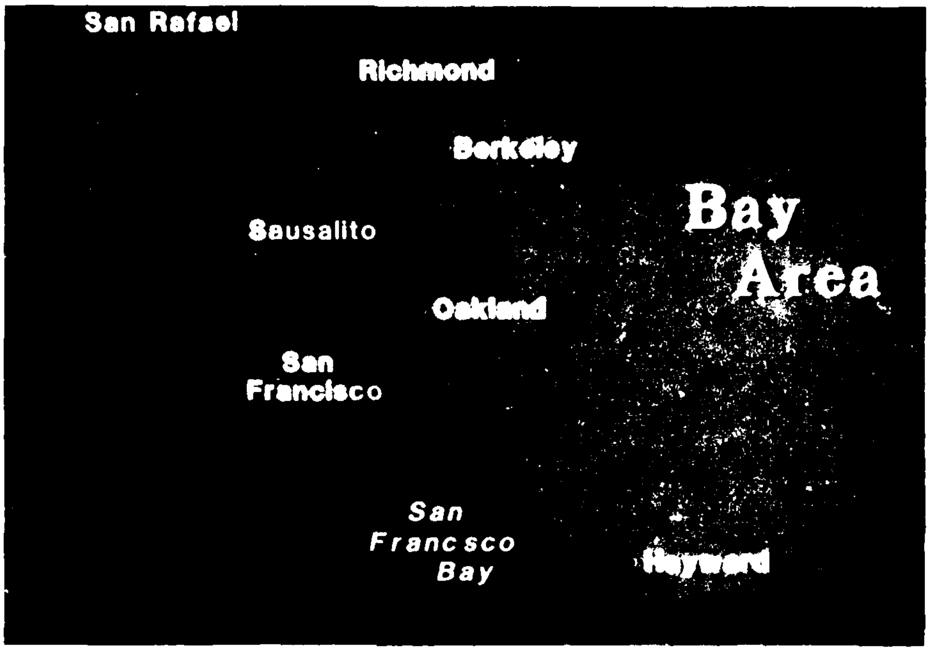

FIGURE 3. SAUSALITO, CALIFORNIA AND ENVIRONS

WELCOME TO THE SOUTH PACIFIC DIVISION

BG Donald J. Palladino
Coastal Engineering Research Board
Commander, US Army Engineer Division, South Pacific
San Francisco, California

INTRODUCTION

I want to take this opportunity to welcome the Coastal Engineering Research Board (CERB) members, the Coastal Engineering Research Center (CERC), the Office of the Chief of Engineers' staff, and other US Army Corps of Engineers (Corps) attendees and visitors to the South Pacific Division (SPD)--a Division which not only neatly encompasses the coast of California within its boundaries but also extends well inland.

The SPD area is in the midst of a sustained population explosion that will continue to have profound regional and national significance. Between 1940 and 1980, our region's population more than tripled, and this trend is continuing. Recent estimates indicate that the population has already increased nearly 10 percent since the 1980 census. There are an estimated 32 million people who depend on us to fulfill our mission of support to the Nation.

As administrator of this area's diverse and unique coastline, ports, and harbors and as protector of its wetlands, SPD and its three districts--located in San Francisco, Los Angeles, and Sacramento--are busy maintaining the navigation channels, developing much needed water and energy resources, improving floodplain water management, preserving natural and cultural heritages, and increasing recreational opportunities for the public.

The civil works territory we manage includes nearly one-fifth the land mass of the contiguous 48 states. It includes parts, or all, of nine of the Nation's largest states--virtually all of California, Nevada, Utah, and Arizona--and parts of Oregon, Idaho, Wyoming, Colorado, and New Mexico. Our coastal jurisdiction coincides with the ocean and bay shoreline of California.

Naturally, we believe that the location of our Division office, here in San Francisco, California, is a favored one. I believe that the sights you see this week will strengthen the national and international vision of

California as a storied, fabled place--beginning right here at our Bay-Delta Model in the picturesque town of Sausalito; continuing with your drives across the Bay; extending to your stay in the San Francisco area (with its views, its night life, its wonderful food); and ending with the coastal field trips which we have prepared for you tomorrow.

And if you can stay after adjournment on the day after tomorrow, we are also offering you a 3-hr tour by boat of San Francisco Bay coastal structures leaving from the dock outside. This will be a large tour vessel, and we will be accompanied by a number of non-Corps engineers and professionals who will also be convening on Thursday and Friday at the Hyatt Regency, Oakland, for the West Coast Regional Coastal Design Conference. We are jointly sponsoring the conference with the North Pacific Division, the American Society of Civil Engineers, and the American Shore and Beach Preservation Association.

California, from its beginning, has always looked outward from its coastline--a province linked quite literally with the rest of the world by its seaborne commerce. This has held true from its days as a remote Spanish and Mexican province--through the goldrush period, with vessels coming round the Horn while overland travel was still hindered by deserts, distance, and hostile tribes--then, through the golden years of agricultural and industrial development when other transport links were forged. And now, much later, as a mature state--an economic giant--California has ports and sea lanes that carry an enormous volume of trade and traffic, including over 110 million tons of foreign and coastal trade at our major San Francisco and Los Angeles area ports; capital ships of the Navy here, at Long Beach, and in the San Diego area; offshore oil vessels; and the fishing fleet. In these days of swift travel by individuals, sea commerce does not of itself loom large in the public mind; however, its importance is undiminished. The Nation expects still greater things of California. And from the Nation's Pacific trade, as large as it is, the only partly realized dreams of the first decades of this century loom before us. The metaphorical "Open Door to China" and the full promise of the Panama Canal--so jubilantly celebrated here 70 years past at the famous Panama-Pacific Exposition--were foreclosed by war and political events. Changes now afoot--spectacular economic growth in the Orient, changes in China, renewed interest in a sea-level canal, and higher world interest in trade generally--offer this hope.

The California Coast, then, is sea trade and commercial navigation; and

I wish to emphasize the point that the Corps has a vital role in this large mission through our deep-draft harbor and channel activities. But the California Coast is also much more. California remains the Nation's most populous state, 26,000,000 people, the overwhelming majority of whom live within 60 miles of the Coast; and California's growth is continuing both by natural increase and migration. For them, as for us, the coastline also means pleasure boating, fishing, clamming, hiking, and just plain viewing and cooling breezes. It also means desirable housing for recreation or retirement for a fortunate few and--almost a symbol of California--broad, sandy beaches, with swimming, sunbathing, and surfing.

If these largely recreational needs are put together with those of the ports, of oil and other industry, and of the military, there is a scramble for access and a real public awareness of the value of the Coast. These values are manifested by some of the most expensive real estate in California, one of the most comprehensive and strict state coastal management laws in the country, and some very, very sticky controversies. Here again the Corps has a vital role.

In California we have built and currently maintain 17 deep-draft harbor and channel projects and 25 small-craft harbor projects both on the open ocean coast and in protected waters. We also have constructed 12 beach erosion control projects primarily in Southern California where the need is greatest and circumstances are more favorable for year-round beach recreation. We currently spend about $20 million a year for harbor dredging with structural repairs, as needed, on top of that figure.

Of course, we also have the San Francisco Bay-Delta Tidal Hydraulic Model, a number of active coastal engineering studies, and ongoing new coastal construction and CERC-directed research studies--some of which will be touched on during the meeting. There is also an important coastal function less related to the functions of this Board but which is especially important here in the San Francisco Bay Area. This is our permit function which we exercise under the 1899 Rivers and Harbors Act and the Section 404 Clean Water Act authorities. Preservation of the remaining environmentally significant wetlands and diked areas of the Bay area is an item of major concern here, and our District Engineer quite frequently finds himself called upon to make difficult permit decisions regarding preservation and development.

We also certainly welcome you to San Francisco. Our Division family, especially of the San Francisco District, has wqorked diligently on the arrangements. If there is anything you need, please let us know.

I am now going to continue with an overview of SPD coastal projects, beginning with a brief discussion of California's coastal environment. Later today there will be presentations by our District and Division staff during the course of the meeting to allow some flavor of California to be included in your consideration of the national needs of coastal engineering and planning for the Corps.

SPD COASTAL OVERVIEW

The open ocean coastline of California is about 1,100 miles in length. It is 1,350 miles if we include the coastline of the Channel Islands of southern California. Of the over 300 miles of estuarine coastline, 90 percent is within San Francisco Bay. In all, there are about 1,700 miles of saltwater coastline in the state.

Seventy percent of the 1,100-mile open-ocean coastline is bordered by cliffs characterized by either steep faces of elevated marine terraces or slopes of coastal hills and mountains. About half the coast is fronted by sand beaches--fringing and pocket beaches below some of the cliffs and wide extensive beaches where sizable streams or valleys come to the Coast. There are some notable dune areas around parts of Monterey Bay and near Santa Maria and San Luis Obispo. There are also barrier beach features commonly protecting adjacent tidal lagoons and wetlands as at Eureka in northern California, Morro Bay in central California, and the Silver Strand near San Diego.

Overall, about 85 percent, over 900 miles, of the outer coastline is being eroded. And perhaps 100 miles of this is erosion that threatens, or could eventually threaten, roads and structures mostly in developed areas around Los Angeles, San Diego, and San Francisco. This erosion is less than it could be since an additional 65 miles of the open coast is protected or partially protected by seawalls, groins, or beach fill.

In the face of this general erosive tendency, sand and sediment outflows from coastal streams are important for natural beach maintenance. Our north coast streams with high seasonal flows acting on steep slopes and erodible rocks are prodigious sediment producers. These are rivers like the Klamath, the Mad, the Eel, and the Russian.

The San Joaquin-Sacramento River system, which drains the Sierras and the Great Central Valley, is still a great producer of sediment. Much of this sediment, however, remains within the Bay system to bedevil our long-standing dredging maintenance program of Bay channels and harbors.

To the south, large sediment inflows occur, but these are quite episodic due to large fluctuations in precipitation and runoff; and there is concern about the choking-off effects of drainage-area controls like dams and debris basins which are prevalent.

Large areas of coastal wetlands have been obliterated by dredging and filling. Half of those originally associated with the open ocean coast have disappeared, and most of the rest have been damaged. The tidal marshes of San Francisco Bay and the Sacramento-San Joaquin Delta have shrunk from an original 850 square miles to about 60 square miles through dredging, diking, and filling, while the open waters of the Bay have shrunk from about 700 square miles to about 450 square miles. This loss, however, has stabilized in recent years through regulatory efforts. We will be hearing more about the Bay and the Bay-Delta Model from the District staff.

Now, San Francisco Bay is relatively well sheltered. It is true that tidal currents are significant, as are riverflows, but wave energy is low. A 5-ft wave, such as that used in our recent Fisherman's Wharf design, is an extreme condition. In contrast, the open ocean wave climate of California ranges from the moderate to the severe--fairly mild in southern California, south of Point Conception, to quite severe on the north coast. A typical southern California design wave for a structure might be on the order of 15-17 ft; whereas, at Crescent City, the waves are at least 40 ft. Generally, winds and waves from the northwesterly quadrant predominate throughout the year due to the effects of the offcoast Pacific high-pressure system or from storms in the North Pacific-Aleutians area. South of Point Conception most swells approach from the west or southwest because of the change of the trend of coast and the filtering effects of the offshore islands. Summer waves generally are long and low and tend to build beaches; but in all areas, when the winter seasons bring the close approach of storms to the coast, the winds and waves from the southwest quadrant can become very punishing, damaging structures and eroding beaches. This simplified picture is complicated in southern California by southerly swells from late summer hurricanes off western Mexico and the arrival of long-period Southern Hemisphere swell, also during the summer.

The net effect of wave conditions is to produce general north to south littoral movement of materials but with seasonal reversals and anomalous effects due to the local hydrography and orientation of the coast. Parenthetically, I want to acknowledge again--as we have at past CERB meetings--the ongoing cooperative efforts among CERC, SPD, and our Districts in learning more about the California wave climate and littoral regime through the Wave Information Study, the Coastal Field Data Collection Program, and the Coast of California Storm and Tidal Waves Study, among others. These efforts together include historical wave hindcasting, wave gaging and beach surveys, and littoral transport modeling.

The damaging effects of winter storm damage have recently become more publicly recognized. Storm damages in the severe 1977-1978 season and during the even greater storms of the 1982-1983 season were especially high. The latter series resulted from a combination of record-breaking storm waves and high astronomical tides compounded by a general rise of sea level on the West Coast due to the effects of El Nino.

Public and private damages for the 1983 storms approached $120 million, and some estimates place this as high as $200 million. Almost every coastal county was seriously affected. In general, all beaches in California south of the Bay area were completely denuded of sand by the end of the winter; fortunately, a goodly portion of this has returned, albeit slowly. A local example is here in San Francisco at Ocean Beach--a site on tomorrow's bus trip--where the beach retreated up to 185 ft, and the Great Highway was threatened.

Damage from the 1983 storm was sustained by private residences, commercial structures, coastal piers and seawalls, and numerous Corps harbors which had major damage, mostly to breakwaters. Fortunately, Jobs Bill money became available, and we were able to make repairs on all structures at a cost of $35.3 million for 28 contracts.

The 1983 storm also deposited excessive quantities of sand in some of the small-craft harbor entrances that we maintain--including those at Santa Cruz, Santa Barbara, Ventura, and Oceanside--imposing extra costs to the Corps that didn't show up in conventional damage inventories but were nonetheless real.

With this background, I would like to mention some of our coastal and coastal related projects going from north to south. This is only a selection. Overall, as I indicated, we have constructed 54 coastal and navigation-related projects.

Crescent City Harbor

On the far North Coast, in the giant redwood country, is Crescent City Harbor, a shallow-draft commercial fishing port. This has been a Corps project since 1918 and is now protected by extensive and heavily armored structures. Both the inner and outer breakwaters were damaged in the 1982-1983 storm season. Major maintenance work on the outer breakwater in 1974 used 42-ton dolosse which have had excessive breakage, and we will be placing additional dolosse this spring. As you recall, in August 1984, the civilian CERB members visited the site to review our joint research project with CERC to instrument 20 of the new dolosse to determine actual internal stresses resulting from wave action; this effort--which will continue for 3 years--has also been discussed at length in past CERB meetings.

Humboldt Harbor and Bay

Humboldt Bay is a large estuary 200 miles north of San Francisco which borders Eureka, a lumber and fishing center. There is a 40-ft bar channel through the sandspit. We maintain the entrance and interior channels and have constructed long entrance jetties on which we began work in 1881. We have just finished a major rehabilitation by placing added dolosse on the jetty heads. The CERB civilians also visited this locale in conjunction with Crescent City.

Noyo Harbor at Fort Bragg

Noyo is a commercial fishing harbor with two Corps jetties and a 10-ft dredged channel accessing public and private berths. There is a continual river-mouth shoaling problem and difficult entering conditions for boats during high wave action. We have a model study going at CERC of improvements to help this, and we will hear from CERC staff later today about the model.

Bodega Bay Harbor

Bodega Bay is a primary destination of our planned helicopter visit tomorrow. It is a small estuary about 60 miles northwest of San Francisco. Here the Corps has constructed a jettied entrance, turning basins and 12-ft-deep interior channels to serve the fishing fleet. This project is one of our most successful. The entrance is fairly well protected, and maintenance is moderate.

We did develop a project for an interior breakwater marina inside the estuary using a unique concrete sheet-pile baffle design to reduce costs and maintain tidal flushing. Because of a disagreement over cost sharing, the county has now completed the project on its own; but the construction is essentially faithful to our design.

San Francisco Bay

About 3 miles seaward from the Golden Gate Bridge begins a large arc-shaped bar--the San Francisco Bar--which must be dredged annually to allow deep-draft access. The channel is presently 55 ft deep, 2,000 ft wide, and 4 miles long; we have been dredging it since 1922.

Today this channel and an extensive net of channel and harbor facilities that we maintain inside the Bay and 100 miles inland to Sacramento and Stockton allow world sea trade to reach those two ports as well as the ports of San Francisco, Oakland, Redwood City, Richmond, and Benicia. Also we have constructed several small-craft harbor projects within the Bay which are used by thousands of small craft.

Our dredging program is a major effort, and this afternoon you will be hearing about some of the problems and solutions that we are looking at as relative to dredging.

One marina project which we are now constructing is Fisherman's Wharf right on the San Francisco Bay waterfront which is the subject of a presentation today and is on tomorrow's bus tour itinerary. Naturally, also, the Bay-Delta Model is used extensively in most of our San Francisco Bay and Delta-related studies.

Half Moon Bay

Half Moon Bay is on tomorrow's itinerary. This project is enclosed by over 1-1/2 miles of Corps breakwater. Local interests have subsequently constructed protective inner works and a marina.

Santa Cruz Harbor

Santa Cruz Harbor is a Corps project on northerly Monterey Bay and the bus tour's primary lunch destination. It has continuing maintenance problems due to harbor shoaling; and we are now in the process of turning maintenance over to the harbor district which will be doing its own dredging.

In a southerly direction, other small-craft harbor projects include Monterey, Morro Bay, Santa Barbara, Channel Islands, Redondo Beach, Dana Point, and Oceanside (site of an ongoing sand bypassing experiment which will be discussed today). As I indicated, many of these harbors were damaged during the 1983 storms.

Los Angeles-Long Beach Harbor

The combined Los Angeles-Long Beach Harbor complex is one of the world's largest artificial harbors and one of the Nation's greatest ports with a combined tonnage of about 75,000,000 tons. Our work here began in 1871 with the building of a jetty between Rattlesnake Island and Deadman's Island. We have been involved ever since constructing the majority of the main navigation channels and over 8 miles of Federal breakwater between 1899 and 1949.

The oldest breakwater structure--the venerable shore-connected San Pedro Breakwater composed of granite blocks on a rubble mound--incurred a 400-ft-wide breach during the 1982-1983 storms. It was subsequently repaired temporarily with Jobs Bill funds. You will recall at the last CERB meeting we viewed model testing at CERC to develop suitable cross-section changes to make the repair permanent. We also looked at the large model of the entire port complex which has been in generally continuous operation at WES since 1973.

San Diego Bay

San Diego Bay is one of the finest natural harbors of the world. The tidal entrance is self-scouring to a depth of 25 ft. We maintain the entrance to a depth of 42 ft to allow access by deep-draft merchant and Navy vessels. The Zuniga training jetty, which assists tidal scour, was completed by the Corps in 1904; it too was damaged by the 1982-1983 storms.

The harbor itself is separated from the ocean by a 12-mile-long sand barrier. This barrier has been considerably enlarged over the past 70 years both by filling in the Bay and placement of over 35 million cubic yards of sand on the seaward sides, mostly during the 1940's. However, the net drift is to the north, and the primary source of sand, which is the Tijuana River basin in Mexico, has been controlled by dams. Seventy-two percent of the drainage area is so controlled, cutting off an estimated 700,000 cu yd per year which could otherwise move north to nourish the barrier.

The Los Angeles District, working with the State and CERC, has developed a plan to counter resulting erosion problems at Imperial Beach at the southern end of the barrier. This project consists of a submerged breakwater with shore connecting groins--essentially a protective box--to stabilize the beach. Construction will get under way shortly. One of this afternoon's presentations will discuss the project.

CONCLUSION

This concludes my overview of SPD's coastal regime and projects. I have capsulized some of our most interesting projects, indicated that we do have significant erosion, shoaling, and coastal structure problems and concerns, and mentioned some of the ongoing collaboration that we have with CERC in these technical areas. I believe our District and Division presentations on individual projects and programs and Mr. Wanket's presentation on our Research and Development needs will further expand and clarify our interests for you.

REVIEW OF COASTAL ENGINEERING RESEARCH BOARD BUSINESS

COL Allen F. Grum, Executive Secretary
Coastal Engineering Research Board
Director
US Army Engineer Waterways Experiment Station
Vicksburg, Mississippi

GEN Heiberg asked my predecessor, Bob Lee, to move on fairly short order from the US Army Engineer Waterways Experiment Station (WES) up to Ft. Leonard Wood to be the Chief of Staff. He was having some difficulty finding a replacement for Bob Lee. Probably by a misguided burst of youthful enthusiasm, I decided that I would go down and be the Director for 1 year. Most of you know that the place is a very large and diverse research establishment. I have not been there very long, so I do not want to pretend to have some expertise and knowledge today that I simply do not have. As a result, a lot of what I am going to say will be read from some fairly prepared remarks. The only part of my presentation I was very comfortable with today was to introduce myself, and this has been sort of stolen by GEN Heiberg and GEN Kelly; consequently, I am sort of left up in the air without any firm ground underneath me, which may be appropriate in coastal engineering.

My job now, as I understand it, is to go back and basically review the unfinished actions from the last Coastal Engineering Research Board (CERB) meeting and tell you where we are in the process.

GEN Robertson asked last time that the Coastal Engineering Research Center (CERC) do a better job of marketing, that is, going out and actually soliciting work from others (even outside of the Federal government). While that was appropriate 6 months ago, we have had a very substantial manpower reduction in the interim, and we simply cannot go out and market right now. We are going to have to retract, and it is going to be unusual for us to do work for anyone outside the Federal government. This is unfortunate because CERC has a unique capability to do things. CERC has a great history of doing very good work for others, but it is just simply not in the cards right now, in the face of our manpower reduction, to be actively seeking outside work.

This manpower reduction is going to change the way we do work. It is also coupled--as GEN Heiberg has already discussed--with the Congressionally mandated 12 percent reduction in funds. So we are looking at both a reduction in people and a reduction in funds. Because of that, we probably will not be able to slant a lot of money toward universities and academic institutions for basic research. Again, this is simply an echo of what GEN Heiberg said.

That is probably the bad news. The good news is that we are looking at a couple of contracting instruments, or contracting approaches, that we hope will make us a lot smarter in the way that we do business with outsiders. The first one is called a Broad Agency Announcement, and the second is called a Task Order Contract. Let me just talk a second about each of them.

We would hope probably this month, or next month, to go into the Commerce Business Daily and be able to give a very extensive menu of all the kinds of research that WES is interested in. This says, in effect, if you people want to contract for the government in any of these areas, we are interested in hearing from you. Now, the process is for a contractor to give us a fairly short proposal that says, "Hey, I read your announcement, and these are the kinds of things I would like to do for you." If that hits a resonant chord with us, then we can go back and say, "That's fine. Would you give us a proposal?"

What it does on the contractor side is keep him from spending lots of money for a proposal that we would say we are not interested in. The Task Order Contract is somewhat similar, but there are some nuances that are different in that we would go to someone and say, for instance, "Are you interested in doing work in numerical modeling?" And if we were to get proposals back that say "yes," we would pick a contractor; and then during the year we would say, "Okay. Here is the first task we would like you to do on numerical models." We would negotiate a cost for that. Then when that is finished, we would give a second and a third. So we are looking at both of these to try to be able to acquire outside research and development better than we are presently doing.

Professor Wiegel asked at the last meeting about our use of a private consultant in Southern California to do some wave climate hindcasting. He felt there was some disparity between our hindcasts and the consultant's hindcasts. We have investigated the results of the consultant's work and compared them with ours. Without going into great detail, what we have found out is that the agreement is really better than perhaps we had realized. The private consultant represented a small subset of storms and geographical area, while ours is a much larger set of conditions. We do feel that the consultant may be useful for confirmation of our studies in the southern California area.

Let me be a little bit more careful in reading about dredging because this is an important topic that GEN Heiberg has already addressed. John Oliver asked about coastal processes, parallel dredged material disposal studies, and cooperation and coordination of such studies. Bill Murden, who most of you know is chief of the Dredging Division, agreed and said the Division would try to accomplish this. Dredging and coastal engineering have many striking similarities, and the two are inextricably tied together. You can tell this is prepared. I do not use inextricably a whole lot. I am not sure I can even pronounce the word.

Since that meeting we have worked closely with Mr. Murden and various Districts to establish closer working relationships in the areas of mutual and complementary interest. We talked to Norfolk, Charleston, Jacksonville, and Mobile districts and with Mr. Murden's people. We identified several promising sites on the East and Gulf coasts for demonstrating an underwater berm, or the "Murden's Mound" concept. You have really reached a high point in life when you get a mound named after you.

With the cooperation of Braxton Kyzer of the US Army Engineer District, Charleston, we have done some initial data collection at one site. Bill Murden described the berm concept at a previous meeting. There has been a meeting between the Marine Fisheries and Mr. Murden, and they are going to investigate several methods for creating artificial reefs with dredged material. This has potential to be a habitat for shellfish and other biological resources. We intend to keep working with the dredging people and are looking at a means of career development for our civilians, including some interchange on personnel assignments for periods of 60 to 90 days.

Another topic at the last meeting was the Coastal Field Data Collection Program. I guess GEN Edgar at that time said the current rate of funding was insufficient for development of the program and recommended we investigate some cost sharing agreements with state agencies. We currently attempt to make maximum use of wave gages supported by others, such as the Navy and the State of Florida. Let me talk about a few of the developments there. We had a 2-day workshop in August at Fort Belvoir. We had 33 Corps representatives there from 23 Districts and Divisions, a little briefing on the program status from four regional groups, and some recommendations on which way we ought to go. I am not going to talk in detail, but we can certainly provide that information to the CERB members.

The prominent recommendations were to redirect or expand the Field Wave Gaging Program to other US coasts, to add hindcasting to the Wave Information Study for 1975 through 1985, and to get a collection of long-term deepwater directional wave data as soon as reliable, affordable technology is available.

There is a follow-up to the Ft. Belvoir meeting here in San Francisco Bay, and the purpose is to provide users an overview of the national program, review data utilization by the coastal engineering community, and discuss data needs for the Pacific region. The meeting is open to both government and non-government users of the data, and there will be 30 attendees at that meeting.

The Board has asked to be kept informed of our CERC master plan down at WES. The expansion of our present CERC headquarters is coming along quite well. We have had about 2 weeks of rain. It may have set us back a little bit, but we are expecting to have our office building next month sometime. We are just about to start on a sort of utility building which we are going to use for prototype measurements, a calibration lab, an environmental staging area, equipment maintenance and repair, and a computer room. It also has a little bit of office space. We hope to get started on that in April of next year. Then the construction of another building, which will give us even more office space, will start in fiscal year 1987 (FY 87).

Also of interest, I think, to the Board is that we are converting three of our three-dimensional physical model wave generators to unidirectional spectral wave generators. This will occur in FY 86, and we have three more coming online in FY 87. At that time we will have seven unidirectional spectral wave generators and one directional spectral wave generator.

The Board members were asked to review a task force on shoreline erosion that GEN Delbridge asked us to take a look at, and I am going to ask Lew Blakey to get up to talk about that in some detail since he was the task force chairman. The Board was unanimous in commending the task force for producing such a comprehensive and factual document. Lew may have written that; I am not sure. One member suggested that the reports should be used as input to a review of the overall problem of shoreline erosion by a panel of eminent experts. The Board was unanimous in affirming the Corps of Engineers' (Corps') unique and almost total responsibility within the United States in the practice and study of coastal engineering. The Board strongly supports the Corps' research and development (R&D) program and the expanding need for Coastal R&D basic research.

People have pointed out, to our discredit perhaps, that other countries just simply have a greater national commitment to coastal engineering research than the United States does and that we are falling somewhat behind because of that. The Board has expressed an opinion that the Coastal Field Data Collection and Monitoring Completed Coastal Projects programs should be supported. The unique benefits from both of these programs stress the need for accelerating and expanding our use of numerical models for planning and designing coastal structures and shore protection. One member strongly disagreed with the report when it stated that Corps shoreline erosion projects have not in themselves encouraged further development of the shoreline. So I suppose what we are really saying is that there was somewhat a mixed bag on some of the reactions to the report.

Let me close on something of a very very personal note. I am delighted to be part of this process. I certainly was not aware of it at all, and from both an engineering perspective and an engineering academia perspective, it is just a great delight for me to be able to participate in this meeting and in your upcoming spring meeting. I thank you, GEN Kelly, that I have this opportunity. We will certainly do our part in cranking out the voluminous pieces of paper that are needed to follow up on this and pledge you our support and cooperation. Thank you.

DISCUSSION

BG KAVANAUGH: *I have a question. You changed your wave generator. What was the term you used? Spectrum?*

COL GRUM: Spectral wave generator.

BG KAVANAUGH: *What is the difference between that one and the one you had at Belvoir?*

COL GRUM: You are trying to make me look bad in front of all these people.

BG KAVANAUGH: *I didn't mean to trap you. I just didn't know the difference.*

COL GRUM: I am going to amaze you, Paul. Many of them that we have now are monochromatic in that you get--I am going to amaze Dr. Whalin, too--waves that are simply the same height and the same frequency coming down the tank. The spectral generator actually has a couple of spectra, but in the one we are discussing you can change the frequency and the height of the waves that are generated. Now, we have another wave generator that gives you control over not only the height and frequency of the waves but also the direction. And this is a piece of laboratory equipment that is unique to WES and this country.

BG KAVANAUGH: *Doesn't the David Taylor Model Basin have something like that?*

COL GRUM: Now you have gone beyond me.

DR. WHALIN: No, sir.

BG KAVANAUGH: *It doesn't do the same thing?*

DR. WHALIN: No, sir, not at all. At David Taylor they have towing tanks mostly, but some of the towing tanks do have a wave generation capability. They do more work on ship resistant studies. Studies like that are typically done.

BG KAVANAUGH: We were talking about cost. I know they do--I have been in programs where they have done a lot of wave action. I didn't know the difference between what we did and what they did; but as long as we are doing something that is unique, funding should be easier.

COL GRUM: *The spectral wave generator, in the sense of a wave coming down, is not unique to us; but the directional and spectral wave generator is the only one in the country. Is that right?*

DR WHALIN: That's right.

COL GRUM: *And does Delft have one?*

DR. WHALIN: In Norway, at Trondheim. I guess they changed the name of that.

DR. NUMMEDAL: Marine Technology Center.

DR. WHALIN: Marine Technology Center.

COL GRUM: You really need to come down and visit us someday, so that you can see the directional multispectral generator which is a mesmerizing kind of thing. You can just sit there and watch wave generation by the hour. All kinds of patterns of waves have come up. It's a very exciting process.

BG ROBERTSON: *I will get you off the hook, Al. First is a question on marketing and the resource problems we have. Is it a problem of our inability to get additional work because we don't have the people to carry out the work? Or is it a problem of not having the people to do the marketing? I think it's the former.*

COL GRUM: It's really the first part. We will be down from our peak summer employment which peaks because of bringing in college professors and college students and a lot of temporary hiring. We will be down on the order of about 500 people within the next month or two. We have had a sizable diminishment of the work force at WES, and we are not going back up. We got very hard hit on both sides of the house on the full-time equivalent employees that we will be able to use this year, and we have been hit on the military side on our annual funding authority although we had some restoration of that within the last week. What we are going to have to do is simply turn to some contracting and try to make up for this lack of people. The program dollars are not as hard hit as the people spaces are. We just cannot go out and make a pitch and say, "We would like to do work for you, City of San Diego" and then come back and say, "Hey, look, we need more full-time equivalent people because San Diego wants us to do this wonderful project." We've just been told, "Tough."

As we get into the contracting business--but I think you realize much more strongly than I do that there's not that much expertise in coastal engineering that we can turn to--we're going to try to basically supplement our loss of people by acquiring people from outside.

BG ROBERTSON: Well, I am concerned we're getting into a "Catch 22" situation where we know we have the mission as the premiere coastal engineering organization in the country, and we need to get more people interested in it. We need to do more work to solve the many problems. If we did develop a strategy and come up with some recommendations to the Chief of ways we can get additional funding, then we could turn around and say, "Well, we got the additional funding; but we can't do the work because we don't have the people."

So, I think our first task is to figure out how we can do it if we do get more funding. Contracting is one way, but I would also propose that there are other ways, such as passing the money through universities. If we let them use our facilities and our expertise maybe we can have a first step before we get to the second step. The first step is to figure out how we'll do it in the event the second step comes through and we get more money.

COL GRUM: You've talked on the plus side, and there's the same discouraging "Catch 22" on the minus side when we start to contract and people begin to say, "Well, you need even fewer and fewer people because you're not doing a lot of work." We're really caught in a very difficult management problem right now, as is everybody else in the Corps.

BG ROBERTSON: That adds another challenge to the one given to us by the Chief this morning.

COL GRUM: Yes, sir, it certainly does.

DR. MEI: *Given that CERC has probably the best equipment for coastal engineering research in the country, I wonder whether your in-house research is sufficient to make maximum use of equipment in your laboratory. And if you are already making full use of that equipment now, what is the chance for further expansion into the university and CERC collaboration?*

COL GRUM: Let me talk on that subject just briefly and then let Dr. Whalin talk about it in more detail. My impression is that certainly as far as some of the laboratory equipment is concerned we could bring in outsiders and make that available. Maybe the future of a lab like WES is to have unique kinds of laboratory equipment--the spectral wave generator is a good example--that could be available for both in-house and outside use. Perhaps we're not making enough of an effort to identify to people what our unique capabilities are. I think even at this point right now there are certainly some parts of our laboratory that could be available for outside use. I'll give a little example. It doesn't have to do with coastal engineering, but the City of Vidalia, which is a little town in Louisiana, is actually going to come in and run a model study with their people on one of our models because we told the City of Vidalia that we could not support them.

Bob, why don't you pick up and talk a little more on this.

DR. WHALIN: I think you have a very good point, Professor Mei. One of the ideas and challenges I think that we need to look at is to determine what types of additional facilities we might want--we meaning collectively the Corps, the coastal engineering profession--and explore perhaps some innovative mechanisms for obtaining those facilities. One of our problems is an in-house problem, that is, the way we fund things. If we build something and fund it differently, perhaps we can work out a mechanism for joint use. Our facilities are pretty busy now, that is, our ordinary facilities, including our model studies facility and normal wave tanks. Of course, our directional spectral wave generator is pretty busy also since it's new and we're still learning how to use it. But there's absolutely nothing wrong with doing joint studies with the academic community.

Right now one of our people is working on his dissertation at the University of Florida, with Professor Hammond, doing some work on nonlinear interaction of waves with our directional spectral generators. So, that's just one isolated case, but we don't do that very often; and we don't usually tell people "no" if we can work it out. But obviously the gentleman doing his dissertation has a very personal interest in doing that study. So, I think there is room to really expand in this area. Professor Le Méhauté has had some thoughts and ideas about facilities, and I think that ought to be one of our tasks to really explore for the future. I think we can do something innovative that would be good for all of us, that is, for the academic interest, for the coastal engineering profession, and for CERC and the Corps.

OVERVIEW OF THE FISCAL YEAR 1985 COASTAL ENGINEERING RESEARCH AND DEVELOPMENT PROGRAM

Mr. Charles C. Calhoun, Jr., Assistant Chief
Coastal Engineering Research Center
US Army Engineer Waterways Experiment Station
Vicksburg, Mississippi

Six months ago in Vicksburg I stood before this august group as a fairly new assistant laboratory chief addressing problems such as when we were going to get into buildings. Right after the meeting, Robert was selected technical director, and I became acting chief. I said "Hey, this is my chance. I will get an assistant chief, and he will get to do a lot of this." Also, about this time we got hit by the manpower problems to which COL Grum has alluded. You cannot believe the amount of experience you get in a hurry under those types of situations. The good news was, though, that the budget looked sound. I was preparing my presentation here to discuss our strong budget when Jay Lockhart called me about 2 weeks ago and told me he had just gotten word that we had a 12 percent cut in the General Investigations (GI) research and development (R&D) budget. That immediately changed the presentation.

Today, rather than go into great detail as to exactly what will be done in each of the work units that we have, I will briefly try to show you some of the impacts of this cut and look at some information that we have developed over the past few years. I have provided members of the Board a handout which lists the proposed budgets versus the actual money that we received. In Table 1 you will note that we do not go below the program level for actual funds because right now we just simply have not had time to assess what the situation is and how we will take these cuts. We are in the process of doing that and will make recommendations shortly to our tech monitors. For those of you who are not familiar with the system, we will look at the overall situation with the tech monitors, Jay Lockhart and John Housley, and decide how to take the cuts. What I want to do is show you the situation we have right now.

Table 1 indicates that we expected to have $5,750,000 in the four coastal programs of the Coastal Engineering Research Area. These are really the core programs under which we operate. The Congressional reduction was approximately 12 percent. This is significant in that we had already taken one other cut from what we had expected to get. It is extremely difficult to

TABLE 1

PROPOSED VERSUS ACTUAL BUDGETS*
FOR THE
COASTAL ENGINEERING RESEARCH CENTER

Direct Alotted Programs

Program		Planned FY 86 Funding ($K)
Coastal Flooding and Storm Protection		
Wave Estimation for Design		280
Laboratory Simulation of Spectral and Directional Spectral Waves		250
Field Research Facility		925
Developing, Updating, and Maintaining Coastal Numerical Models for Field Use		100
Hurricane Surge Prototype Data Collection		290
Nearshore Directional Wave Gage Technology		75
	Subtotal	1,920
		(1,700)
Harbor Entrances and Coastal Channels		
Inlet Bar Channel Shoaling		245
Sand Bypassing System Selection		75
Waves at Entrances		240
Nearshore Waves and Currents		235
	Subtotal	795
		(700)
Shore Protection and Restoration		
Barrier Island Sedimentation		385
Lab and Scale Effects in Movable Beds		170
Numerical Modeling of Shoreline Response		285
Regional Coastal Processes Model System		250
Littoral Data Collection Methods		140
Storm Erosion Studies		90
Beach Fill Sediment Criteria		145
	Subtotal	1,465
		(1,290)
Coastal Structure Evaluation and Design		
Developing Functional and Structural Design Criteria		530

(Continued)

* Actual budgeted amounts are in parentheses.

TABLE 1 (Continued)

Direct Alotted Programs		
Program		Planned FY 86 Funding ($K)
Coastal Structure Evaluation and Design (Continued)		
Wave Runup and Overtopping		110
Evaluation of Navigation and Shore Protection Structures		350
Design of Floating Breakwaters		150
Stability of Breakwaters		250
Riprap Stability to Irregular Wave Attack		50
Stability of Overtopped Rubble-Mound Structures		130
	Subtotal	1,570
		(1,390)
Coastal Engineering Research Area	Total	5,750
		(5,080)
Other Direct Allotted Programs		
Monitoring Completed Coastal Projects (MCCP)		1,200
Repair, Evaluation, Maintenance, and Rehabilitation (REMR) - Coastal		1,000
Coastal Field Data Collection		1,800
Remote Sensing		310 (?)
Improvement of Operations and Maintenance Techniques (IOMT)		145 (?)
Surveying and Mapping		25 (?)
	Total	4,480
CERC DIRECT ALLOTTED GRAND TOTAL		10,230
		(9,080 - ?)

plan under these conditions; but we are in the process of doing that, and we are committed to make the best we can out of the situation. Table 2 shows where we were in 1985 versus where we are now. These are actual funded dollars--5.55 million down to 5.08 million dollars--again, in the four coastal

TABLE 2

COASTAL ENGINEERING RESEARCH AREA
FUNDING FOR FY 85 AND FY 86

Program		Funding ($K) FY 85	FY 86
Coastal Flooding and Storm Protection		1,830	1,700
Harbor Entrances and Coastal Channels		795	700
Shoreline Protection and Restoration		1,465	1,290
Coastal Structure Evaluation and Design		1,460	1,390
	Subtotal	5,550	5,080

programs. Since we have prioritized work units, one way, of course, of taking a cut is to say, "Okay. We'll just wipe off the last work unit." The problem with that is there are milestones within each work unit. There are significant products going on in each of these work units. So, it is difficult to say that the last milestone of the first priority work unit is much more valuable than the first milestone priority in the last work unit. It is quite difficult to make the decisions on how to accomplish these cuts.

Later you will hear about DUCK-85, which was a field experiment that was discussed at the last Coastal Engineering Research Board (CERB) meeting. It was extremely successful. There is enthusiasm like you cannot believe from the results of this study. DUCK-85 is intended to set the stage for DUCK-86 which would be even a broader study. The DUCK-85 study was so successful we had changed the name of DUCK-86 to SUPER DUCK. DUCK refers to the location of the Field Research Facility (FRF) at Duck, North Carolina. Curt Mason came in last week to discuss his presentation and to decide whether we should continue with SUPER DUCK, DUCK-86, or LAME DUCK. We at the Coastal Engineering Research Center (CERC) are committed to conducting SUPER DUCK. Now, that is going to involve, as GEN Heiberg said, innovative financing. We will be asking people in this room for help. We are committed to doing SUPER DUCK, but we are going to need a lot of help. SUPER DUCK cannot be done within the confines of the GI/R&D budget as it stands now. However, by going outside of the GI/R&D budget we hope to be able to bring ourselves back up to, if not past, the point where we were in the planning stages of SUPER DUCK. So, many of you will be seeing our faces in the near future to talk about this really exciting experiment. At the afternoon coffee break we will have a tape of some of the activities.

Figure 1 shows funding in the Coastal Engineering Research Area, again, for the four coastal programs. For comparison, I used 1981 because the documentation from the Office of the Chief of Engineers (OCE) goes back to that particular year. In actual dollars, we are down 26 percent from where we were in 1981. And if you take 1981 dollars, we are down 53 percent from where we were. Now, it doesn't take many courses in economics to discern a trend of some sort here. GEN Heiberg, GEN Edgar, and others have touched on this. This is a fact of life right now. I can't see, and I don't think anybody else right now can see, as the Chief said, that there is going to be a significant change.

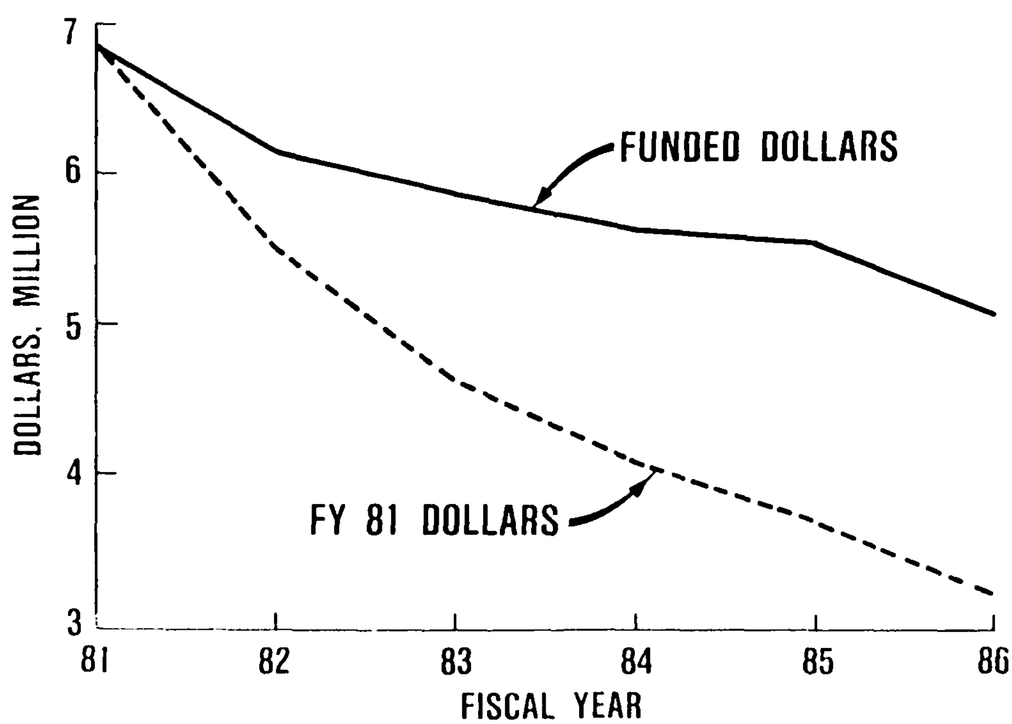

Figure 1. FUNDING IN THE COASTAL ENGINEERING RESEARCH AREA

Now the GI/R&D budget, of course, is going down, also. But you will notice in Figure 2 that the Coastal Engineering Research Area is going down considerably more. This year there is about an 8 percent reduction for the GI/R&D budget and 26 percent for us. Now, I don't mean to say that the coastal programs are being hit unfairly in relation to all of the other programs. I think you could take any other R&D area in the Corps that was in existence in 1981 and show this same trend. So, the problem really is not somebody in Washington saying, "We don't like coastal R&D." The problem is the lack of funds in the GI/R&D budget. What happens is there are other priorities in the Corps. When other high priority R&D is required, normally the GI budget is the source we have to fund it. So, until we can get the GI/R&D budget up, I can't see any hope of increasing funds in the coastal area. Dr. Choromokos or Jesse might be able to give you more details. I see definitely our having to get out, as the Chief said, into other funding sources,

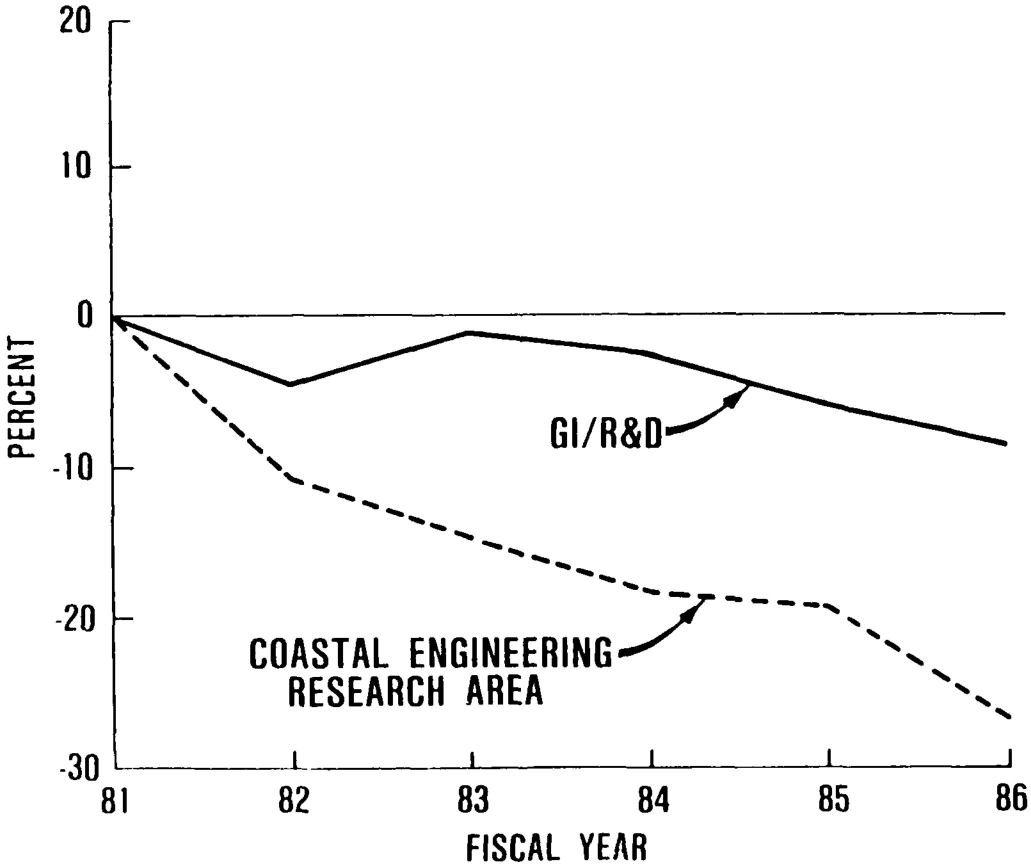

Figure 2. COMPARISON OF FUNDING FOR THE GI/R&D AND COASTAL ENGINEERING RESEARCH AREA BUDGETS

wh·ther inside or outside the Corps of Engineers (Corps).

Now, I will discuss the other direct allotted programs (Table 3) that we have in CERC starting with the Coastal Field Data Collection Program that COL Grum mentioned briefly. This year the program is funded at $1.8 million. I believe the recommendation from GEN Edgar is that it should be

TABLE 3

OTHER DIRECT ALLOTTED FUNDING

Program		FY 86 Funding ($K)
Coastal Field Data Collection		1,800
Monitoring Completed Coastal Projects		1,200
REMR--Coastal		1,000
Remote Sensing		310(?)
IOMT		145(?)
Surveying and Mapping		25(?)
	Subtotal	4,480(?)

funded somewhere in the range of $2.6 million. However, it is at $1.8 million for this year, and the guidance we have for next year is $1.8 million. So that program is staying where it is, but at least it has not been cut this year. Monitoring Completed Coastal Projects is funded at $1.2 million. The coastal portions of the Repair, Evaluation, Maintenance, and Rehabilitation (REMR) program are funded at a million dollars, and that is where we were last year. So, there's no significant change there. Now there are some problems in the last three programs shown in Table 3. We do not manage the Remote Sensing Program, so we are waiting to see what the program manager has to say about what will result from that funding cut. I found out this morning that the Improvement of Operations and Maintenance Techniques (IOMT) Program will probably be reduced to $45,000, a $100,000 cut.

In the surveying and mapping program, we had a new start to look at methods of determining beach profiles. It was funded at $25,000. It is in jeopardy also.

We will be getting information to the Board on our recommendations and what the impacts we have here will be. Again, we do look forward to a SUPER DUCK. Maybe he's not flying quite as high right now as we had anticipated, but I can say that CERC is committed to having a field experiment. I think the enthusiasm will be there in all of you after you hear the presentations later on today and see the tape.

DISCUSSION

Following is a summary of the discussion following Mr. Calhoun's presentation:

MR. PFEIFFER

Mr. Pfeiffer said Mr. Calhoun "painted an accurate and fair picture of the whole GI problem." He noted that the Civil Works R&D Committee had added new programs, while the R&D funds remained about constant or declined. Therefore, all programs suffered. Mr. Pfeiffer said the Directorate of Research and Development is proposing to take a new approach with Congress and OMB. He said he would be presenting the proposals to BG Kelly shortly when they were farther along. Mr. Pfeiffer said one of the proposals would be to paint a picture such as Mr. Calhoun presented to stress the problems. We would also show the tremendous return on the investment obtained from R&D. He said it was particularly important that the Senate be made aware of the benefits since this year's cuts came from the senate.

BG ROBERTSON

BG Robertson said we must look at more industrial, private, state, and port types of funding. He doubted if the Corps R&D budget would be increased, as it is absolutely necessary to look for the above-mentioned funding sources.

DR. MEI

Dr. Mei said that, considering the shrinking Corps R&D dollar, he thought it should be a high priority of CERC to seek outside work. He noted this approach would make a direct impact on coastal engineering projects as well as provide a source of funds for basic and applied research.

BG KELLY AND DR. CHOROMOKOS

BG Kelly asked Dr. Choromokos to review the manpower situation that presently precludes CERC from seeking outside work. Dr. Choromokos explained that manpower to conduct civil and military work was separate. In the past, military manpower subsidized civil manpower. This practice is no longer allowed and has resulted in approximately a 200 man-year shortage at WES to conduct civil (including outside) work. The problem is compounded by a shortage of military manpower.

BG KELLY

BG Kelly reminded the Board that LTG Heiberg tasked the Board to be innovative. He outlined two areas he thought DRD should work on. The first dealt with Dr. Mei's question concerning outside work. He said a "whole new scenario" should be worked out on how they handle work for others. The second should be handled by the Board and DRD. The coastal engineering community must better articulate R&D needs.

DR. MEI

Dr. Mei said he had heard the Corps was getting out of the ports business and that state and local port authorities would take a larger role.

BG KELLY

BG Kelly addressed the question as follows:

"That's an excellent question, which is something we are addressing right now in Civil Works at the Office of the Chief of Engineers. We are in a brand new era of how we handle our Federal projects and our Federal involvement. Heretofore, we have normally handled most of our deepwater ports at basically 100 percent, not all, but basically a very high percent of Federal cost sharing. We handle almost all the operations and maintenance with what we're seeing on the horizon, and it is certainly true in the Water Resources bill that is now being debated on the Senate floor and the House floor and will be coming to the committee, hopefully this year. We see a trend, in fact, toward more and more cost sharing with the non-Federal sector. Now, that brings along a whole series of questions.

As they participate in the cost sharing, clearly they are going to have a bigger and bigger viewpoint as to how that project should proceed. That includes things like scope of the project, phasing of the project, and affordability. We may have some projects in effect that were ideal. But ideal may be to the local sponsor who provides a lot of cost sharing something he just cannot afford. So, it is very interesting, and we are trying to address a lot of those. The answer is "yes," the non-Federal voice will have a louder voice, so to speak, in the future. But I might also point out that that does not mean our interest in navigation and harbor related projects is diminishing; in fact, they're quite the opposite really. Of the 41 new projects that are addressed now in the 1985 supplemental, something like 60 percent of those projects--I think that is right--are basically either navigation or harbor related projects, which is a very large percentage. So, the answer is that the interest is there; it is increasing. But the role of the non-Federal sponsor is also increasing, and he will have a much louder voice in the future."

SUMMARY OF SHORELINE EROSION REPORT

Dr. Lewis H. Blakey, Chief
Planning Division
Directorate of Civil Works
Office, Chief of Engineers

In the interest of keeping on schedule, I will not give you the 30-minute briefing that I have back here, and I will just summarize a couple of things. On behalf of the task force, we certainly appreciate the help that we got from the people I see in the room here from the Coastal Engineering Research Center (CERC), the US Army Engineer Waterways Experiment Station (WES), and others. It was a pretty short, intense effort of only about 3 weeks. We could not have produced something quite this large without a lot of people working hard under a unified kind of thought. Also, we do appreciate the comments we have gotten from the Coastal Engineering Research Board (CERB) members, which is kind of like the capstone of the effort.

Since you are familiar with the reports, I will only mention to you where we are now. The report was sent to the chairman of the Board of Engineers of Rivers and Harbors (BERH), and it was because of his initiation that we began this effort in the first place. The director of Civil Works added to this report a number of things. First, he had looked at it based on the CERB member comments and essentially endorsed what you see there. I have to be careful how I say this because apparently COL Grum thinks I have already written one set of comments that praises the work of this report, and I don't want to be in a position of doing this again. But the director of Civil Works did make the point that research and development (R&D), he felt, was in good shape in the Corps of Engineers (Corps). It needed additional funding and all the things that you could normally say about R&D, but there were no negative criticisms, either in the task force report or in what the director of Civil Works had to say in sending this on to the Board chairman.

Also, with respect to the beach restoration and nourishment alternative, which was one of the subjects of this report receiving some criticism, the director of Civil Works pointed out that this was a viable alternative and in many cases was a measure of choice. Consequently, he saw no fault either from a technical or from a plan formulation standpoint why this alternative should not continue to be pursued. You realize that is in opposition to quite a considerable body of thoughts that exist not only within but also outside the Corps.

The third point was regulatory. And I think our task group and the director say it best when they mention that here is an opportunity to address the issue of whether or not structures should be placed on the shoreline not only to protect the structures but also to be structures in themselves. But there are current laws in existence, such as the Coastal Zone Management Act, the Coastal Resources Barrier Act, and the Section 10 permitting activities that all address peripheral issues relative to this. These seem to be the statement of the country, in terms of the Administration and the Congress. The Section 10 authority deals with structures which are placed up to the high tide mark and the mean high water mark. The structures that are in question here are those which are placed beyond the dune line. However, our permanent authority really doesn't address that. Also the Administration is moving in the other direction with respect to regulatory reform in trying to allow more state interest and more local interest in these things rather than more Federal interest. So, the point of land use regulation was really non-Federal responsibility. Now, that doesn't necessarily satisfy some people, but that is what the director of Civil Works had to say.

The director did point out a couple of other things, and these are simply factual matters. The first is that recreational beaches and the general category of recreation do not have a high priority within this Administration with respect to the budget. Now, appropriation acts are another matter. Once an appropriation act is passed, funds are furnished by Congress; and the law is signed by the President. These funds are going to be expended. But as far as the budget goes, recreation, recreational opportunities, and beach nourishment that complements recreation are never going to receive a high priority in the budget. That is a euphemism for saying there will be zero dollars in the budget. So, from that standpoint, projects of a recreational and beach restoration nature are never going to be funded in a budgetary sense as either studies or projects themselves.

The second thing which the director mentioned is that there is proposed legislation, unclear as it may be, that seems to say there is no Federal interest in protecting private property on the coastline. This is just an observation that is a curious proposal since all civil works projects, whether they be flood control, hydropower, or what have you, provide benefits to private property. They provide almost no benefits to public property. So it has not been adequately explained to me why the beach issue should be singled out as having no Federal interest. But I wish to point out that proposed legislation from the Administration would provide that all costs for protecting private property would be assigned to the non-Federal interests. Now, that legislation is not passed, but it has been proposed. Also, existing studies of the shoreline under current Administration proposals, if enacted into law, would be cost shared with the locals 50/50.

The final point that the chairman received from the director of Civil Works was that Section 2 of the 1920 Act gives the Corps authority to request special cost sharing from the locals when they--the Corps--feel that there is a special benefit being provided by this project of a windfall nature. Now, it is within the purview of the BERH, when it meets, to decide if certain projects should receive certain cost sharing other than that which has normally been provided. This section, then, would permit the Board to recommend special cost sharing; and, of course, that is within the prerogative of the Board. They are an independent body, and they meet and make their own decisions. However, I must point out that the director of Civil Works has a voice in this after the Board meets, as does the Chief of Engineers. So for certain projects which are currently being considered, we do not yet have an opinion from the Chief of Engineers as to which way he wants to go in proceeding with these kinds of projects.

In summary, then, with respect to the task force report, recreational opportunities which include beach restoration, beach nourishment, and prevention of erosion are not going to receive high budgetary ranking, either for studies or for projects themselves. And that is simply a fact as far as this Administration is concerned.

Second, there are proposals to change the law with respect to what the Federal interest is in beach nourishment and beach erosion prevention projects. Those laws are obviously yet to be passed. They are only proposals. The BERH has yet to make a definitive statement on some of these issues. But they are an independent Board and rightfully so will make their independent judgment. I think that will be of note to the CERB and the rest of the Corps when they do.

Finally, just as an observation on this whole business, the Chief's division engineers met last month in Savannah, and the subject of beach erosion did not come up. But while waiting for an airplane on the last night, I turned to the back pages of the Savannah Evening Press. And buried in the back page was the following article over which the headline read: "Beach Erosion Pondered." And without reading the whole article I will quote a part of it which says "seawalls are the number one killer of recreational beaches." Think about that. Seawalls are the number one killer of recreational beaches. Now, right away you can begin to see the problem that those of us in the technical community have when we see something like this printed, reproduced, and read by a lot of people who go away convinced. If we did not build any more seawalls, we would, therefore, not have any erosion on beaches. If they are the number one killers and we do not build anymore structures on the beaches, then there is no more beach erosion. That is what it says. And then it goes on to say the developers are to blame for the continuing loss of recreational beaches, and their unwitting accomplice is the Corps which often bends the political pressures to save these structures.

Well, it seems to me the challenge to those of us in the technical community is to make sure the policy makers get the right technical kinds of information and to be able to substantiate what we say so that we do not get a mixture of policy and technical matters together. Determining policy is within the purview of a lot of us, but the technical aspects are being espoused by people who really do not know what they are talking about.

DISCUSSION

DR. LE MÉHAUTÉ: I think the latest issue of Shore and Beach by the Shore and Beach Preservation Association has five or six pages of comments. They are not signed, but I am guessing that they are from Dean O'Brien. They rebuff quite well the technical aspects of this article. A lot can be learned from these five pages. He ends up by saying that nobody is more blind than people who do not want to see. I think we are facing a problem here which requires an activist view to counterbalance the activism of the people who generate this kind of article.

DR. BLAKEY: It is interesting to note that those articles--which I guess are by Dean O'Brien--are written in a publication that does not receive too wide a distribution. When it does, it is to a community of scholars which generally have already some understanding of these forces which are at work. It is too bad that that kind of article does not appear on the back page of the Savannah Evening Press and perhaps some other publications like that because that is where the need is. It is not so much to educate the community within which we are now talking, but rather the external community of the decision makers, the policy makers, and all the rest of the people. That's really the sad thing.

Those articles are good, and it's too bad they don't receive more widespread circulation.

DR. NUMMEDAL: *Let me make a comment about the beach nourishment. If the Corps is assigning very low priority to beach nourishment, aren't we possibly on a collision course with many states like North Carolina that has just passed a regulation that there will be no other kinds of beach protection besides nourishment? And other states are making similar noises. We could essentially end up in a situation where we are running ourselves out of work.*

DR. BLAKEY: You pose a very interesting question. Once again, you see, it's not addressing the right issue. There are economic issues; there are plan formulation issues; there are Federal interest issues; and there are technical issues. They all get wrapped into one. And you're exactly right. The State of North Carolina would probably never permit any kind of solution other than beach nourishment, as well as perhaps the State of Florida and the State of Louisiana. Why do we say beach nourishment makes no sense? Our children and our grandchildren are going to pay for these. There are answers to those if you compare structures versus beach nourishment--even without the environmental issue and the state preference issue. The beach nourishment alternative may rise up just because of the economics involved. So, I don't know what the answer is.

GEN Heiberg mentioned Grand Isle. A couple of days ago the director of Civil Works asked me when we were ever going to finish Grand Isle because somebody had just told him that we needed additional construction funds on this project which started many years ago. I pointed out to him that this project is functioning exactly as intended. It is serving a useful purpose because the sand was eroding, but the structures behind the shoreline and the shoreline were still there. Everything is functioning just perfectly because the sand is being lost and not human lives. So Grand Isle, in a sense, will never be finished, as is the case with all beach restoration projects. But that's the kind of message that doesn't get across to some groups of people.

DR. NUMMEDAL: Well, I think it's very important that when the local population hears about beach nourishment they understand that you are dealing with a kind of continuous repair. It's a long-term thing.

DR. BLAKEY: That's right. You don't build it, then walk away from it, and it's done.

DR. NUMMEDAL: I was just at a meeting with Bob Dean last week, as a matter fact. He had calculated the cost of the beach nourishment project in Dade County which is probably the most successful one. And even if you were to continue that into perpetuity, the cost per year is something like a fractional percent of the tax revenue to the City of Miami Beach every year.

DR. BLAKEY: Absolutely. The Miami Beach people understand what it means in the billions of dollars of tourist revenue, as opposed to the small cost of $60 million in terms of beach nourishment and whatever the future nourishment replenishment might be.

Well, anyway, our study is complete. Once again, on behalf of all the people, you can't produce a study like this without the help of a lot of people in 3 weeks. And I guess it proves that planners can produce, on time, a quality document, given the resources.

BG KAVANAUGH: *Lew, when are you going to get that report out to the field?*

DR. BLAKEY: That's another point. I have not cleared this with GEN Kelly, but I assume now that this report has been sent to the deputy chief, or the chairman of the Board, and that it will now be available for distribution. I've had a lot of phone calls about it. We'll be discussing that. And I see no reason why I wouldn't recommend to him that we mail this out just as a matter of information.

BG KELLY: We'll sort that out here shortly and make that decision.

BG KAVANAUGH: *Can you just send us out the executive summary—the marked up draft or something—because I would be interested in getting a couple of things you brought up. It kind of fits into a couple of problems that I have.*

DR. BLAKEY: Well I see no reason why we couldn't just distribute these.

BG KELLY: What we need to do, if the decision is made to distribute it right now, is to include the executive summary because that is the director of Civil Works' analysis of the report and his recommendation to the chairman of the Board.

BG KAVANAUGH: Your timing is good.

DR. BLAKEY: Well, it's interesting that one of the new starts we got this year is down in Florida, and there are others waiting. Just one further word. Someone said that this is a big dollar problem, but it really isn't. If you read this report, it turns out that out of the over 200 reports that are currently being considered for authorization, you have these 200 and some that represent some 12 to 13 billion dollars worth of construction. If you divide that out, the average project is $60 million. That's the broad spectrum of civil works projects. Of this total, only about 20 represent beach nourishment and beach restoration problems, and the average dollar value is somewhere around $10 million. So, the beach restoration issue, in terms of a Civil Works project, is much smaller than the average Civil Works project and of the larger spectrum of 200 and some. Less than 10 percent are beach erosion projects. So, in terms of its impact on the budget, it's really very small.

DR. LE MÉHAUTÉ: I don't know how these papers will be distributed, but what we are facing here is a big public relations problem. Some parts I felt were so well written that I felt after extracting them from the report, eventually adding some photography, and maybe polishing them from a literary point of view, they could be compiled into a really good document for public education. I am afraid that the report is so thick that its distribution may be necessarily limited. I feel that part of it should have a much wider distribution.

BG KELLY: Okay.

DR. LE MÉHAUTÉ: It will be good for public education, and it will just do what we are trying to achieve.

DR. BLAKEY: As GEN Kavanaugh said, the report can be of value to, perhaps, the District people and so forth, but maybe there should be a little wider distribution for an executive summary addressing the same types of issues, such as an information pamphlet.

COL DEVINS: Lew, you mentioned in your remarks that it's one of the prerogatives of the Board of Engineers for Rivers and Harbors to implement the 1920's Act which will involve some increased cost sharing where there's a windfall benefit. It's not just a prerogative of the Board. In the plan formulation at the District level that act could be implemented. I think that's information that needs to go beyond the Board and down to the Districts. They should take that into account.

JOINT COASTAL ENGINEERING RESEARCH CENTER/ PEOPLES REPUBLIC OF CHINA MUDDY COAST STUDY

CERB Proceedings

Dr. James R. Houston, Chief
Research Division
Coastal Engineering Research Center
US Army Engineer Waterways Experiment Station

ABSTRACT

The Coastal Engineering Research Center (CERC), the Peoples Republic of China (PRC), and the University of Florida (UF) have initiated a joint study of coastal processes on muddy coastlines. The Lower Mississippi Valley Division described the sedimentation and erosion problems of the muddy Gulf Coast area during the 43rd Coastal Engineering Research Board meeting. The PRC has similar problems occurring at an accelerated rate. The joint study will be conducted in Hangzhou Bay near Shanghai; consequently, the PRC is investigating moving part of the operations of the port of Shanghai to Hangzhou Bay. The PRC is providing all in-country support, including boats, manpower, equipment, transportation, food, and lodging. CERC and UF are providing technical expertise on field studies and instrumentation. CERC personnel spent 3 weeks in the PRC in September and October 1985 planning the field tests, establishing a field measurement station, and discussing port development with PRC port officials. The Assistant Secretary of the Army will sign a protocol between the US Army Corps of Engineers and the PRC early in 1986 that will formalize the joint study, and information obtained (primarily funded by the PRC) will aid in understanding the dynamics and evolution of muddy coasts.

INTRODUCTION

Hangzhou Bay in the Peoples Republic of China (PRC) is a major bay to the south of the city of Shanghai (Figure 1). The shoreline of Hangzhou Bay has experienced dramatic changes in historical times (Figure 2). Tremendous accretion of sediment has occurred along the southern coast and large erosion along the northern coast. Shore protection works and rocky coastlines have stabilized the north shore of the bay, but accretion along the southern shore continues. The sediment depositions are largely cohesive muds. The source of the sediments is believed to be the Yangtze River which lies to the north of Shanghai. If this is the case, it is not clear why sediment accretes on the south rather than the north shore of Hangzhou Bay.

The Port of Shanghai is the largest port in the PRC. Tonnage handled by the port has increased dramatically in recent years, making it one of the most

FIGURE 1. LOCATION OF HANGZHOU BAY

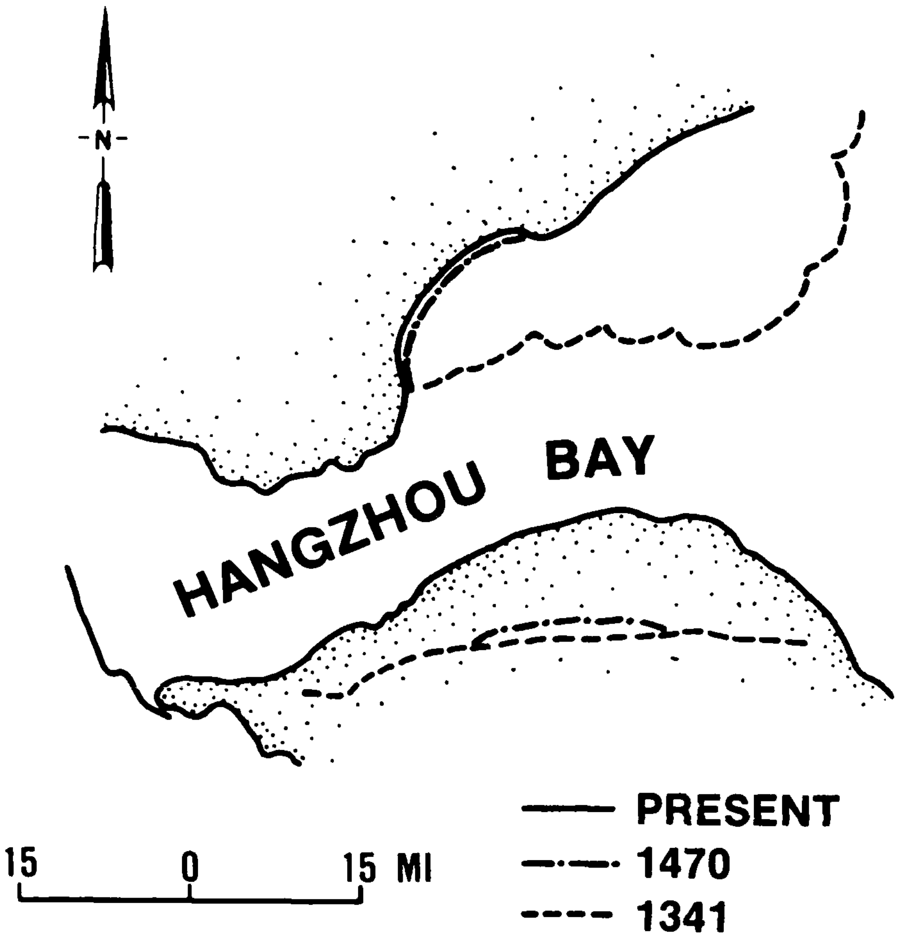

FIGURE 2. HISTORICAL SHORELINE CHANGES AT HANGZHOU BAY

congested ports in the world. Port facilities are located on the Huangpu River which bisects the city of Shanghai. Depths restrict vessel drafts to about 7 m or a tonnage of about 10,000 tons. Therefore, most ships must lighten their loads at great cost at other ports or offshore before entering the Port of Shanghai. In addition, dredging requirements of the port are very substantial. Therefore, cost of maintaining the port and severe congestion problems have led to considerations of establishing port facilities at locations other than the Huangpu River. Small port facilities have been established on the Yangtze River on the north side of Shanghai. However, heavy shoaling has restricted ship tonnage from a planned 100,000 tons to 30,000 tons, and dredging costs are substantial. A crude oil wharf has been established on Hangzhou Bay on the south side of Shanghai where shoaling has not been a problem and dredging has not been required. The Port of Shanghai is interested in studying the establishment of additional berths on Hangzhou Bay to relieve congestion on the Huangpu River and reduce long-term dredging costs. Costs to establish extensive port facilities on Hangzhou Bay will be high, since currently there is not a good transportation infrastructure from Hangzhou Bay to Shanghai.

JOINT STUDY

The University of Florida (UF) has been discussing a possible joint study with the PRC of coastal processes within Hangzhou Bay for the past few years. In September 1984 UF and the Coastal Engineering Research Center (CERC) discussed inclusion of CERC in the joint study. A draft protocol for a joint study was developed between the Corps of Engineers (Corps) and the PRC, and a formal signing of the agreement is expected in early 1986. The primary study participant for the PRC is the East China Technical University (ECTU) of Water Resources, and secondary participants are the Zhejiang Provincial Institute of Estuarine and Coastal Engineering Research (ZECER) and the Bureau of Hydraulics in Cixi Prefecture.

Hangzhou Bay provides an ideal environment as a model case study for investigating muddy coast sediment dynamics. There are both extreme erosion and deposition occurring within the bay. The joint study will focus on enhancing our basic understanding of the physical processes characterizing the flow and sedimentary dynamics of muddy coasts. The first phase of the research will emphasize the collection of prototype data and the compilation of macroscale historical information and previously collected field data. A possible later phase would involve prediction of future bay morphologic changes.

The primary benefit of this joint study to the Corps would be an increased understanding of hydrodynamics, sediment transport, and wave transformations associated with muddy coasts. A substantial portion of the coastlines of the United States consists of muddy coastlines similar to those of Hangzhou Bay. The Lower Mississippi River Division described the sedimentation and erosion problems of the muddy coast along part of the Gulf of Mexico during the 43rd Coastal Engineering Research Board meeting.

The primary role of CERC/UF in the study will be to (1) provide technical expertise in prototype measurements and analysis, (2) design field experiments that provide data that can be used later to run predictive laboratory or numerical models, and (3) establish two long-term wave and current measurement stations (using CERC and UF equipment) in Hangzhou Bay. The PRC will establish an extensive short-term field measurement program (Figure 3) which was formulated by CERC, UF, and the PRC. The PRC will provide all in-country costs of CERC/UF personnel (lodging, meals, transportation), all short-term measurement equipment, all logistic support (boats, tools, equipment), all labor support, costs for extensive collection of historical data and past prototype measurements, and costs to maintain and safeguard CERC/UF equipment. CERC costs will be a very small percentage of the study costs, but all data and study results will be shared equally.

The first phase of the study will last for approximately 2 years. At the end of this phase, a joint report will be prepared and a workshop held. Later phases of the study will be pursued only if all parties agree to a continuation. Later phases could involve more extensive data collection and the development of predictive models (physical or numerical). Continuation of studies beyond the first phase is strictly optional for all parties and will be a function of experience gained in the first phase and each participant's opinion of the usefulness of future studies to their respective organizations.

TRIP TO PRC

Mr. Andrew W. Garcia and Dr. James R. Houston of CERC traveled to the PRC at the end of September to meet with PRC study members to plan the joint study, establish a field measurement station for waves in Hangzhou Bay, and meet with officials of the Port of Shanghai concerning port development. Dr. Hsiang Wang, Chairman of the Coastal and Oceanographic Engineering Department, UF, led a three-man UF team to participate.

The trip started in Shanghai, PRC. Discussions were held with Port of Shanghai officials. In addition, an inspection was made of the current Port of Shanghai on the Huangpu River, port facilities on the north side of Shanghai on the Yangtze River, and the Chenshan crude oil wharf on Hangzhou Bay. Related tours were made of the new $4 billion Baoshan Steel Corporation served by the Yangtze River port facilities and the China Petro-Chemical Corporation served by the Chenshan crude oil wharf.

The Chenshan crude oil wharf was the first port facility totally

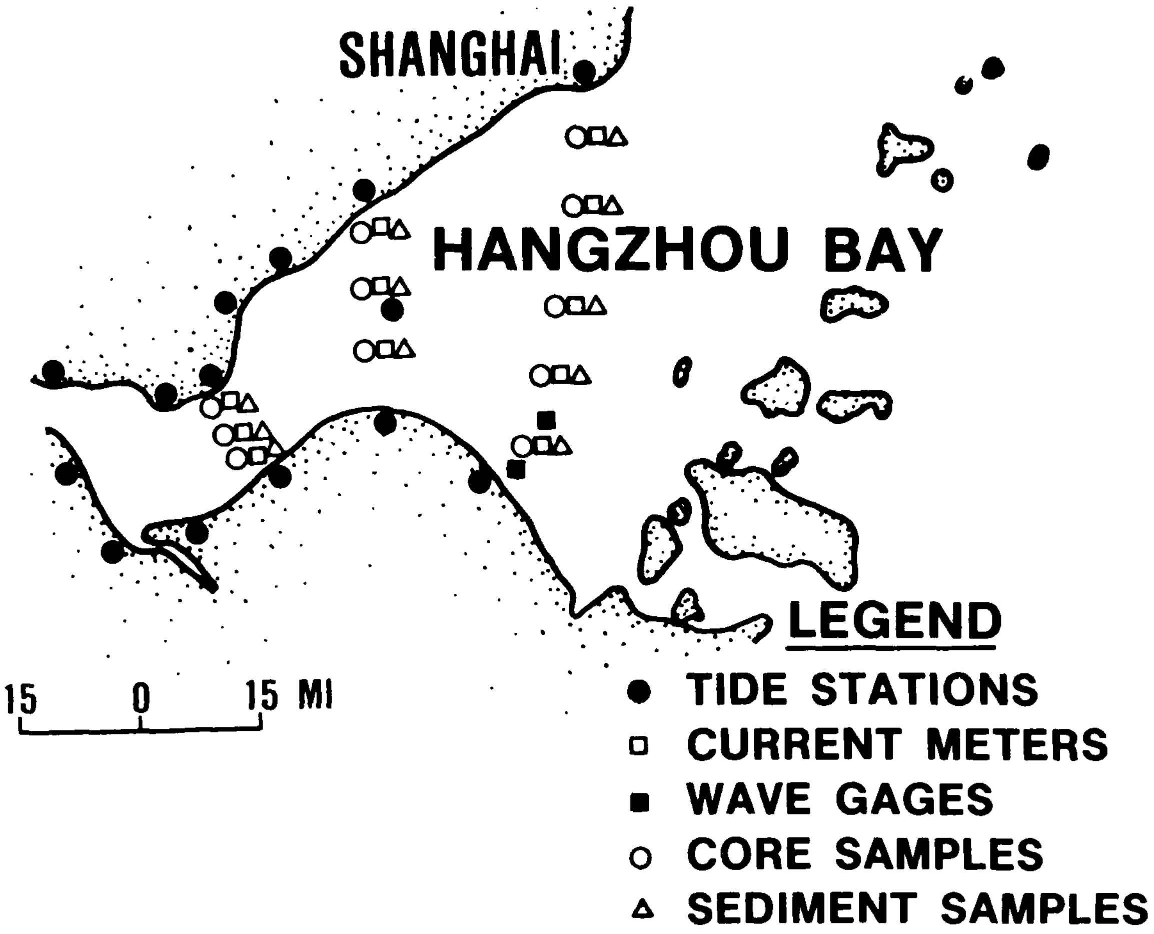

FIGURE 3. SHORT-TERM FIELD MEASUREMENT PROGRAM

designed and constructed by the PRC. Professor Guo from ECTU designed the facility. Professor Guo, who spent 2 years at UF a few years ago, is leading the technical efforts of ECTU in the joint muddy coast study. The Chenshan facility has worked quite well with dredging not having been required yet.

CERC personnel met with officials of the Port of Shanghai, including Mr. Ding Cheng Hian, Chief Engineer, Port of Shanghai. Mr. Ding expressed great interest in the joint study since the Port of Shanghai is seriously considering developing port facilities on Hangzhou Bay. Data collected by the joint study could well be the key for future port siting studies.

Following the Shanghai visit, CERC personnel traveled to ECTU in Nanjing and presented three 1.5-hr seminars on research activities, numerical modeling, and field studies at CERC. In addition, study participants had technical discussions on the muddy coast study and a major policy meeting with Mr. Zuo Dong-Qi, Professor and President of ECTU, and his staff. Responsibilities of the study participants were established as presented in the previous section.

CERC personnel toured the coastal engineering facilities at ECTU and the neighboring Nanjing Hydraulic Research Institute (NHRI). The facilities were rather impressive. They included a new $500,000 MTS wave generator for a facility similar to (but somewhat smaller than) CERC's L-shaped flume and an impressive wind/wave flume capable of 18 m/sec winds. Much of the research seemed of great practical interest to CERC. Joint laboratory studies with ECTU or NHRI appeared to be worth pursuing.

Next, CERC personnel traveled to Wuxi and visited the China Ship Scientific Research Center (CSSRC). The CSSRC is China's David Taylor Naval Ship Research and Development Center (DTNSRDC). Because of military work, the CSSRC was opened to visits only very recently. In fact, most personnel from ECTU had not visited CSSRC. The indoor facilities at CSSRC were the only facilities in China where photographs were restricted. Facilities were very similar to those at DTNSRDC and relatively advanced but at a reduced scale.

Then CERC personnel traveled to Hangzhou and presented a numerical modeling seminar to both the Second Institute of Oceanography and the ZECER. Technical discussions were held with ZECER on the joint study. A trip was made to the Qiantang Estuary of Hangzhou Bay to witness the famous Qiantang bore which has not been large this year because shoaling has reduced the Bay's depth. The bore was about 1 m high nearshore and 2 m high away from shore out of the dissipation regime caused by spur dykes. Even so, it was an impressive phenomenon.

The final week of the trip was spent at the field site location of Tzuchi on Hangzhou Bay where two wave gages were successfully installed. CERC has plans for a single electronics technician from UF to return to the PRC in early spring, replace tapes and service the meters, and establish a second measurement station. CERC and UF trained PRC personnel to perform simple maintenance, and the PRC has personnel who will guard the instruments (primarily from boat damage).

CONCLUSIONS

The joint muddy coast study being conducted by CERC, UF, and the PRC should yield valuable information on coastal processes occurring on muddy coastlines. The Corps will benefit by obtaining valuable information on muddy coast dynamics at a very low cost. The PRC is paying most of the costs of the study and obtaining a data set that would be extremely expensive (beyond CERC's financial resources) to obtain in the United States as a result of relatively high labor costs (a professor in China earns the equivalent of $40/month).

DISCUSSION

DR. MEI: *I understand the Netherlands are also very active in muddy coast studies. In particular, they have just constructed a flume specifically for investigating wave-induced motions in muddy waters. Does CERC have such facilities and research programs in the laboratory to study muddy water transport under controlled conditions?*

DR. HOUSTON: These types of facilities would be in the Hydraulics Laboratory, and perhaps Mr. Dick Sager can discuss the facilities WES has. I doubt our facilities in this area are as extensive as Delft's. It is interesting to note that Dr. Prins from Delft was at WES a few months ago and mentioned he has traveled to China a couple of times, specifically on the Port of Shanghai problem. Apparently, Delft has not been successful in obtaining a study, and the People's Republic of China has opted to join CERC and the University of Florida in a joint study.

MR. SAGER: The Hydraulics Laboratory has a small effort under way involving use of an existing flume to study transport of fine-grained sediments in a variable salinity regime. We have contracted with the University of Florida to consider the effect of waves on fine-grained sediments.

DR. WHALIN: I was at Delft recently, and the flume mentioned by Dr. Mei was under construction. It is a very nice salinity flume, and we discussed the possibility of joint WES/Delft studies using the flume. We have not discussed cooperative efforts on the joint China study.

DR. MEI: Laboratory work would be an excellent area for CERC to contribute to the muddy coast problem since CERC has expertise in top-quality laboratory work, and it is an area where little is known. I was very pleased to learn about this joint study. Perhaps it is a new direction in coastal engineering research.

MR. PFEIFFER: I have a brief comment on the discussion of Dutch work for the People's Republic of China. The Chinese have informally mentioned that the Dutch, Japanese, Australians, and Germans have all been interested in participating with the Chinese in the joint muddy coast study, but the Chinese wanted to work with the United States. I am very pleased the Chief of Engineers gave CERC the go ahead on this study. I think it is a great opportunity for the United States.

DR. KRAUS: I noticed the Japanese domestic conference this year had a remarkable number of papers devoted to cohesive sediments. Of course, the Japanese are heavily involved with the Chinese. The muddy coast subject is one with which I felt we at CERC should become involved.

THE FALL 1985 NEARSHORE PROCESSES EXPERIMENT, DUCK-85

CERB Proceedings

ABSTRACT

Between 24 August and 25 October 1985, a major nearshore processes experiment was conducted at the Coastal Engineering Research Center's (CERC's) Field Research Facility in Duck, North Carolina. Scientists from the University of Washington, Oregon State University (OSU), and the Virginia Institute of Marine Science joined the Corps' investigators from Duck and Vicksburg, Mississippi, in the collection, analysis, and interpretation of data on waves, currents, winds, and sediment movement. Wave gages, current meters, and suspended measuring systems were deployed on pipes near the beach and on bottom-mounted tripods in deeper water. Sediment traps and a photographic remote sensing technique were used to measure sediment movement and waves in the surf zone. The data sets will be used to develop a better understanding of processes in the coastal zone as well as to improve predictive capabilities for these processes. The paper is subdivided into three parts: Part I is an overview of the entire experiment; Part II is a detailed description of two CERC studies; and Part III is a discussion of OSU's participation in the experiment.

PART I. AN OVERVIEW OF THE EXPERIMENT

Mr. Curtis Mason, Chief
Field Research Facility
Coastal Engineering Research Center
US Army Engineer Waterways Experiment Station

INTRODUCTION

Description

During September and October 1985, a major nearshore processes experiment, DUCK-85, was conducted at the Coastal Engineering Research Center's (CERC's) Field Research Facility (FRF) in Duck, North Carolina. Investigators from CERC joined with several others from universities and government agencies to collect, analyze, and interpret data on waves, currents, winds, and sediment movement. This part of the paper provides an overview of the experimental objectives, describes the types of measurements and collections made, summarizes the results achieved, and outlines future plans.

Background

Previous experiments and long-term data collection efforts conducted at the FRF indicate that large morphological changes to nearshore bar systems may occur rapidly but that the processes controlling such changes require further definition (Mason, Sallenger, Holman, and Birkemeier, 1984; Holman and Sallenger, 1984; Howd and Holman, 1984; Jaffee, Sternberg, and Sallenger, 1984; and Sallenger and Holman, 1984). In addition, the US Army Corps of Engineers (Corps) coastal research program has requirements for comprehensive field data sets and techniques that can best be addressed through a comprehensive field experiment. DUCK-85 was planned with these considerations in mind.

The experiment was conducted in two parts to take advantage of seasonal variations in wave heights. Experiments requiring low wave conditions were conducted between 3 and 21 September, while those focusing on storm processes took place between 15 and 25 October. However, nearshore morphology was closely monitored throughout both phases.

Objectives

The major experimental objectives were to: (1) develop fundamental knowledge related to nearshore processes (wave transformation, coastal wind patterns, nearshore current generation, sediment transport, and nearshore morphological development; (2) collect a data set for improving numerical models of nearshore processes; and (3) test equipment and procedures applicable to Corps projects as well as those useful in planning a second, larger, experiment during the fall of 1986--"SUPERDUCK."

CERC EXPERIMENTS

In this section, the objectives, plans, and accomplishments of most CERC experiments are discussed. Details of two other CERC experiments concerning wave and sediment transport measurements are presented in Part II.

Nearshore Currents

Principal Investigator of the nearshore currents experiment was Dr. Jon Hubertz, Coastal Oceanography Branch, CERC.

Objectives

The objectives of this experiment were to (1) measure mean currents in the nearshore zone and relate them to local wind and wave conditions (as well as to larger scale circulation patterns), and (2) collect a comprehensive data set on nearshore conditions to use as input for improved numerical models of coastal processes.

Experimental Plan

Five current meters and wave gages were installed at about middepth along a cross-shore profile to determine cross-shore velocity gradients (Figure 1). Four additional sites provided data on longshore variations in the offshore velocity field. A sled containing a vertical array of current meters was placed at the seaward end of the profile to define vertical gradients in the offshore flow. Large-scale current pattern information was obtained using

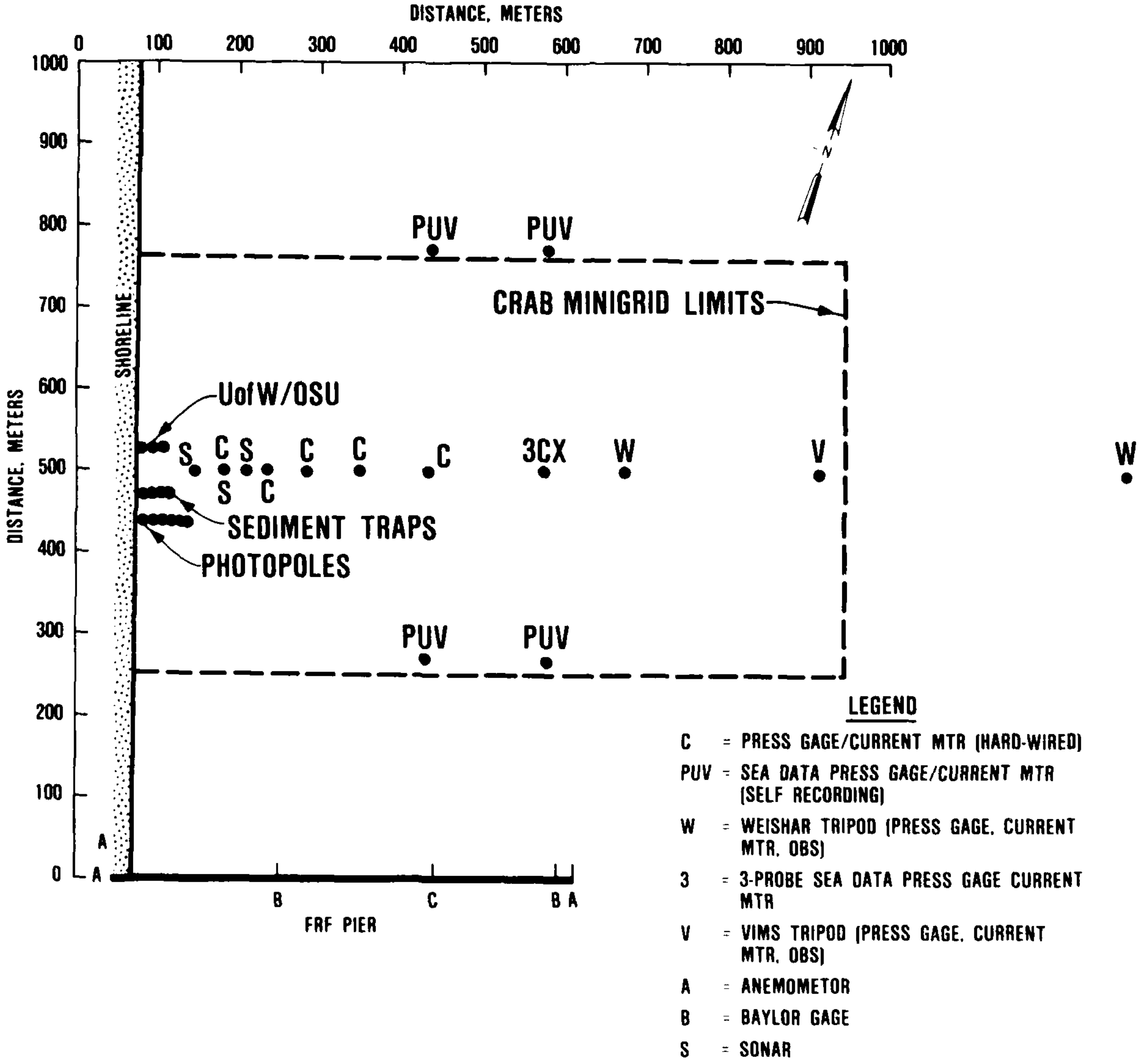

FIGURE 1. CURRENT METER AND WAVE GAGE LOCATIONS

the Coastal Ocean Dynamics Applications Radar (CODAR) system described in the next section.

Accomplishments

Forty-minute samples from the in situ instruments were collected hourly during the first phase of the experiment (i.e. between 3 and 20 September). Wave heights between the 4th and the 10th averaged less than 1 m and remained relatively constant. However, a mild northeast storm began at about noon on the 11th, and wave heights increased to as much as 2 m during the next week, remaining above 1 m until the 20th. The following representative conditions for input to the numerical models were thus obtained: steady state low waves and currents; storm onset, with rapid changes in wind, waves, and currents; steady state storm conditions; and gradually dissipating wind and wave conditions. An unexpected benefit occurred on 27 September when Hurricane Gloria passed over the site. Data collected from many of the DUCK-85 instruments during the hurricane are summarized in a preliminary data report (US Army Engineer Waterways Experiment Station (WES), 1985).

Wind Instrumentation and Measurement at the Pier

Principal Investigator of the wind instrumentation and measurement experiment was Dr. Charles E. Long, Coastal Oceanography Branch, CERC.

Objectives

The objectives of this experiment were to (1) determine the uniformity of the wind field at the FRF, and (2) investigate the suitability of the FRF building anemometer to accurately represent the wind field forcing local wave and current generation.

Experimental Plan

The long-range plan calls for a vertical array of instruments to be mounted at the seaward end of the pier to obtain profiles of wind speed, direction, air temperature, and humidity from which wind stress and heat and vapor fluxes can be determined. However, the DUCK-85 effort was limited to determining the mean wind field at three locations. Anemometers positioned 19 m above mean sea level (MSL) were mounted on the FRF building on a land-based tower just north of the building and on a tower at the seaward end of the pier. The towers also supported anemometers at the 14-m level.

Accomplishments

Data were collected simultaneously with wave and current measurements which will allow calculations of wind stress using existing drag coefficient formulae. In addition, the effects of structures, dunes, and other factors on the nearshore wind field will be investigated by comparing anemometer outputs.

CODAR System

Principal Investigator of the CODAR experiment was Mr. David Driver, Coastal Oceanography Branch, CERC.

Objective

The objective was to measure far field surface currents (i.e. to 40 km) and wave height directional spectra in the range of 5 to 15 km.

Experimental Plan

CERC's CODAR was installed on the dune in the study area and operated routinely throughout the first phase of DUCK-85.

Accomplishments

Data collection equipment and procedures provided sufficient data over the range of experimental conditions during September to assist in interpreting the impact of offshore waves and currents on nearshore processes as well as meeting numerical model input data requirements.

Cross-Shore Sediment Transport

Principal Investigators of the cross-shore sediment transport experiment were Dr. Lee Weishar and Ms. Leslie Fields, Coastal Processes Branch, CERC, and Dr. Guy Meadows, University of Michigan.

Objectives

The objectives of this experiment were to (1) measure the cross-shore movement of suspended sediment and bed load at selected depths along a profile, and (2) relate this movement to waves and currents forcing the transport.

Experimental Plan

Two tripods, each supporting a current meter, pressure wave gage, and optical backscattering suspended sediment (OBSS) measuring device, were placed on the bottom along the cross-shore profile (Figure 1). The instruments were hard-wired to shore, and data were collected on the FRF's NOVA-4 computer. To determine bed-load movement near the tripods, near-bottom grids were sampled by divers. Following placement of dyed native sand in the center of the grid, samples were taken periodically at selected grid points to determine the rate and direction of bed-load movement.

Accomplishments

Data from the offshore tripod were recorded hourly throughout the experiment. The nearshore tripod malfunctioned during the first week. Although repairs were made quickly, severe weather conditions precluded the diver-assisted reinstallation. Bed-load transport measurements were made twice during the experiment at the offshore site.

Nearshore Morphology

Principal Investigators of the nearshore morphology experiment were Mr. William Birkemeier and Mr. Peter Howd, FRF.

Objective

The objective was to determine temporal and spatial variability in nearshore morphology, including the beach, foreshore, and bar systems.

Experimental Plan

An area extending about 200 m north and south of the current meter profile line and seaward about 1 km (shown as the minigrid in Figure 1) was scheduled to be surveyed frequently using the FRF's Coastal Research Amphibious Buggy (CRAB) and a Zeiss Elta-2 total station survey instrument. Cross-shore profiles were spaced 25 m apart not only to define changes to the nearshore morphology but also to provide information to investigators requiring data on changes near the instruments. Another survey area was established that included 25 cross-shore profiles from the toe of the dune to the 9-m water depth and covered a longshore distance of 580 m both north and south of the pier. Observed changes will be correlated with wave and current data to determine the forces controlling nearshore morphological development.

Accomplishments

The minigrid was surveyed 10 times between 3 and 20 September (daily between the 15th and 20th) and extensively during the second phase of the experiment.

An unplanned addition to the morphology experiment was provided when Hurricane Gloria passed over the FRF on 27 September. A prestorm minigrid survey was obtained on 25 September with poststorm profiles obtained on 27 and 28 September. Extensive movement of the nearshore bar was observed in most areas, with eradication of several small-scale rip channels within the study area.

Storm Sedimentation Processes

Principal Investigator of the storm sedimentation processes experiment was Dr. Suzette Kimball, Coastal Processes Branch, CERC.

Objectives

The objectives were to (1) develop and test a remote sediment coring device, and (2) measure temporal and spatial variability in nearshore sediment texture, mineralogy, and structure, particularly under the influence of storms.

Experimental Plan

A remote sediment sampler was designed and constructed to obtain short (0.5-m) cores of the bottom along profiles extending from the dune line to about the 10-m water depth. If successful, the device will be used to collect a series of cores throughout a storm to define changes to the bottom material. These variations in bottom sediment will be correlated with both profile change data and forces (waves, currents, and water levels) to develop a better understanding of sediment transport processes.

Accomplishments

The sampler was constructed during September, and several trial runs were made in October. Originally attached to the CRAB, it was subsequently mounted on a sea sled to enhance its effectiveness and utility. By the last week of the experiment, the sled-mounted sampler was being towed behind the CRAB to collect cores under a wide variety of wave and current conditions.

Seabed Drifters

Principal Investigator of the seabed drifter experiment was Mr. Edward Hands, Coastal Structures and Evaluation Branch, CERC.

Objectives

The objectives were to (1) investigate the usefulness of seabed drifters (bottom following plastic drogues) for nearshore coastal engineering studies, and (2) test several methods for deploying them on the bottom.

Experimental Plan

Since CERC has had little experience with the use of drifters along an open coast, this experiment was designed to determine if it is possible to release them on the bottom without divers and to develop guidelines as to the appropriate number and frequency of releases required for this area of application. During the first 10 days of DUCK-85, packets of drifters were released simultaneously at two sites on four different occasions. The first site was at the seaward end of the FRF pier, at the 9-m water depth, where the drifters were lowered on a rope with a weight and a soluble link. The second site was at the Virginia Institute of Marine Science tripod in 8 m of water, where divers placed them on the bottom. On a fifth occasion, drifters were released simultaneously at these two sites and at Weishar's offshore tripod (Figure 1). Following deployment, landward transport of the drifters was monitored by determining the time and location of each drifter's arrival at the beach.

Accomplishments

The soluble link worked better than expected and provided a simple, reliable method for deployment of the drifters on the bottom. In addition, due to a fortuitous set of current conditions, drifter recovery was very high (90 percent). This provided evidence of strong onshore near-bottom transport from well beyond the surf zone and underscored the importance of local winds on nearshore currents. Results indicate seabed drifters have potential for development as a quick, inexpensive field method to apply to various coastal engineering R&D projects.

NON-CERC EXPERIMENTS

Wave Runup and Nearshore Morphology

Principal Investigator of the wave runup and nearshore morphology experiments was Dr. Robert Holman, Oregon State University (OSU).

Objectives

The objectives were to (1) measure wave runup characteristics during storms, and (2) determine the capability of time exposure photography to qualitatively define nearshore morphology.

Experimental Plan

A temporary scaffolding was built on the dune 100 m south of the main experiment transect to provide a camera vantage point 15 m above MSL. Survey day-marks were emplaced and surveyed at five locations on the beach to provide calibration of the photographic images. Ten-minute time exposures were shot looking in both directions from the scaffolding and the top of the pier building to yield four views of nearshore morphology. Both Polachrome and Ektachrome films were used; the Polachrome was developed daily to give a visual assessment of bar morphology changes. Runup data were collected from the scaffolding using both Super-8 time-lapse movies and videotapes (for intercalibration tests with the Super-8).

Accomplishments

Runup data were collected under a variety of incident wave conditions through both phases of the experiment. Several intercalibration runs were taken with synchronous Super-8 and video filming. One run was timed to correspond with a CERC photo-pole run, which is described in Part II of this paper.

Time exposures from the four sites were taken at least daily, and more often when the bar morphology was rapidly evolving during the mid-September storm. The Polaroid versions of the slides provided a valuable asset in real-time monitoring of the bar system.

OSU's participation in DUCK-85 is discussed in more detail in Part III of this paper.

Surf Zone Sediment Transport

Principal Investigators of the surf zone sediment transport experiment were Dr. Richard Sternberg, University of Washington, and Dr. Robert Holman, OSU.

Objectives

The objectives were to (1) examine threshold criteria for suspension events, (2) intercalibrate the OBSS sensors with CERC's sediment traps (Part II of this paper), (3) determine the spatial extent (length scales) of suspended load events using an in situ array and television cameras, and (4) to continue attempts to use electromagnetic current meters to look at vertical turbulent stresses.

Experimental Plan

DUCK-85 served as an incident-baud (i.e. wave periods <20 sec) dominated companion experiment to previous experiments conducted on the west coast over the last two years in which the infragravity band (i.e. wave periods >20 sec) controlled most suspension events. A cross-shore array of five sets of electromagnetic current meters, pressure sensors, and optical backscatter suspended-load sensors was deployed across the surf zone 25 m to the north of the main instrument profile line. Instruments were carefully leveled each day to provide the vertical control necessary to measure suspended concentration gradients.

Accomplishments

Ten 45-min data runs were collected under low wave conditions, mostly between 8 and 10 September, after a rip channel had migrated out of the area leaving fairly simple bottom morphology. In addition, several long data runs (8- and 12-hr duration) of currents and pressure were collected through the nights.

Nearshore Sedimentation

Principal Investigators of the nearshore sedimentation experiment were Drs. Don Wright and John Boone, Virginia Institute of Marine Science.

Objective

The objective was to determine the effect of wave groupiness on sediment transport processes outside the surf zone.

Experimental Plan

A tripod instrumented with self-recording current meters, a pressure wave gage, and an OBSS meter was placed on the bottom in a water depth of about 8 m.

Accomplishments

Data were collected at 2-hr intervals between 1 and 19 September, with a brief hiatus during tape changing midway through the experiment.

Profile Response Measurement System

Principal Investigators of the profile response measurement system experiment were Dr. Asbury Sallenger and Mr. Bruce Jaffee, US Geological Survey.

Objectives

The objectives were to (1) test and evaluate a system for obtaining real-time bottom elevation data at fixed points along a cross-shore profile under storm conditions, and (2) determine how rapidly the nearshore profile responded to changing wave conditions.

Experimental Plan

Three 500-kHz sonars were mounted on pipes jetted into the bottom at the locations along the main study profile shown in Figure 1. Six pressure gages positioned along the same profile provided data for determining wave spectral characteristics. The instruments were to be subjected to a wide range of conditions to evaluate their response to entrained air, suspended sediment, suspended organic material, and other influences. Therefore, this experiment was conducted during the latter phase of DUCK-85. The long-term plan is to deploy a large array of sonars to determine how three-dimensional nearshore morphology changes during storms when other means of measuring morphology are ineffective.

Accomplishments

The three sonars operated under a variety of conditions ranging from incident wave heights of 0.5 m to greater than 3 m. Initial results suggest that the sonars can operate satisfactorily even in the presence of large quantities of suspended sediment.

SUMMARY

DUCK-85 provided a comprehensive set of wave, current, and wind data which can be used for many numerical modeling applications. The success of the data collection system, combined with several different combinations of wave and current conditions, will allow realistic input conditions for model verification. In addition, daily measurements of nearshore morphology during rapidly changing conditions provided unique documentation of the temporal and spatial response of bar systems to coastal storms. Finally, testing of several original-design data collection systems resulted in improvements that will not only benefit the planning and implementation of the SUPERDUCK experiment in 1986 but also prove of both immediate and long-term value to Corps field offices involved in coastal engineering data collection and analysis.

PART II. SURF ZONE SEDIMENT TRANSPORT AND WAVE TRANSFORMATION EXPERIMENTS

Dr. Nicholas C. Kraus
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US Army Engineer Waterways Experiment Station

INTRODUCTION

Synoptic measurements of the longshore sand transport rate, waves, and longshore current in the surf zone were made by investigators from CERC during the DUCK-85 field experiment held at CERC's FRF in Duck, North Carolina. The sand transport rate was measured by employing a new type of trap (Kraus and Katori, submitted) and field experiment methodology (Kraus and Nakashima submitted) developed at CERC. The wave height across the surf zone was measured by a cinematic remote sensing technique developed in Japan (Hotta and

Mizuguchi, 1980). The cinematic wave measurement method is under study for adaptation at CERC where it is called the "photo-pole" method. Hughes (1985) has described an automated film analysis technique to digitize the resultant 16mm film images.

The sand trap and photo-pole surf zone experiments were performed as joint efforts of personnel of several work units and from different branches and divisions at CERC. The experiments were favored with excellent weather and sea conditions. High-quality data sets on the longshore sand transport rate and wave transformation in the surf zone are emerging from this effort. Considerable progress was made in testing equipment procedures for field work in support of Corps District and Division products and for larger scale deployment in SUPERDUCK.

BACKGROUND AND MOTIVATION

Accurate prediction of the longshore sand transport rate is required in projects involving shore protection, beach nourishment, harbor maintenance, inlet maintenance, coastal budgets, etc. Although considerable field, analytic, and laboratory efforts have been directed toward obtaining transport rate data and improving predictive capability, only very limited progress has been made. The Shore Protection Manual (SPM) (1984) states that the accuracy of the presently used energy flux prediction method can be estimated as ±50 percent.

In the past decade, considerable progress has been made in numerical modeling of nearshore waves and water circulation. Schematic numerical models are also available for predicting shoreline and nearshore change. These nearshore bathymetric change models, combined with advanced wave and circulation models, are moving from the research level to the practical level as engineering design tools. A crucial requirement in making the transition is improved methods for predicting the sand transport rate. This, in turn, presupposes accurate knowledge of the wave height and current across the surf zone. Similarly, the technique of physical modeling would greatly benefit from accurate field data sets on sediment transport and the waves and currents responsible for the transport. The availability of accurate data sets would contribute toward the determination of scaling laws in physical models.

Thus, accurate synoptic measurements of longshore sand transport, waves, currents, and beach morphology are required to (1) improve standard coastal engineering approaches involving sand transport and beach change; (2) advance numerical modeling capabilities for predicting nearshore waves, currents, and topography change; and (3) extend the capabilities of physical models.

SURF ZONE EXPERIMENT OPERATIONS

The labor-intensive, longshore sand transport experiment involved a large number of workers and tight scheduling. Most photo-pole experiment runs were carried out in support of the sand transport experiment to provide the wave height across the surf zone. Also, basic parameters in the photo-pole technique, such as camera settings, types of lenses, filters, etc., were investigated.

Principal investigators (PI's) from a number of work units and branches joined to carry out the experiments. A listing of the personnel, work units, and branches is given in Table 1. Through interbranch and interdivision cooperation, the varied expertise of many specialists was assembled with which to execute these complex experiments and analyze the resultant data.

In addition to CERC staff, a number of individuals from other organizations assisted in the surf zone experiments. These persons were Dr. Shintaro Hotta (Department of Civil Engineering, Tokyo Metropolitan University, Japan), Dr. Lindsay Nakashima (Coastal Studies Unit, Louisiana Geological Survey), Messrs. Hans Hanson and Magnus Larson (Department of Water Resources Engineering, University of Lund, Sweden), and three graduate students from marine science departments of universities near the FRF. Dr. Hotta, the pioneer of the photo-pole technique, supplied his camera system for use in the experiments and provided much valuable instruction on the photo-pole method.

EQUIPMENT AND PROCEDURE

Sediment Transport

The longshore sand transport rate has traditionally been measured by two methods: (1) impoundment at structures or inlets, and (2) sand tracers. These methods are mainly useful for estimating the total transport rate. Because of various limitations in these two methods, however, it is extremely difficult to relate the resultant local sand transport to the waves and

TABLE 1

CERC STAFF PARTICIPATING IN THE SURF ZONE EXPERIMENTS

Work Unit	Branch	Personnel
	Sand Trap Experiment	
Numerical Modeling of Shoreline Response to Coastal Structures	Coastal Processes	Kraus,[a] Vemulakonda[b]
Regional Coastal Processes Numerical Modeling System	Coastal Processes	Ebersole,[b] Cialone
Wave Estimation for Design	Oceanography	Hughes,[b] Smith
Beach-fill Design Criteria	Engineering Structures and Design	Hands,[a,b] Bishop
Littoral Data Collection Methods and Their Engineering Significance	Engineering Structures and Design	Dean
--	Prototype Measurement and Analysis	Howell, Townsend
	Photo-Pole Experiment	
Wave Estimation for Design Regional Coastal Processes	Oceanography Coastal Processes	Hughes,[a,b] Smith Ebersole,[b] Cialone
Numerical Modeling of Shoreline Response to Coastal Structures	Coastal Processes	Kraus

[a]Experiment PI.
[b]Work unit PI.

currents that move the sand. In order to relate sand transport to the local forcing functions and bathymetry, simultaneous point measurements of these quantities are required.

A new type of trap was used at DUCK-85 to obtain point measurements of the sand transport rate. Shown in Photo 1, this "streamer trap" (Kraus and Katori, submitted) consists of three heights: 180 cm, 130 cm, and 60 cm. The streamers, made of polyester sieve cloth, trap sediment carried by the longshore current while allowing water to pass through. The trapped sediment, consisting mostly of sand, is removed from the streamers and weighed in a natural wet condition by using portable electronic balances. The dry weight of the sediment can be obtained from its wet weight through a method specifically developed for use with the traps (Kraus and Nakashima, submitted). This method considerably reduces the cost of analyzing sediment samples.

Waves, Currents, and Bottom Bathymetry

In almost all reported longshore sand transport experiments, the wave

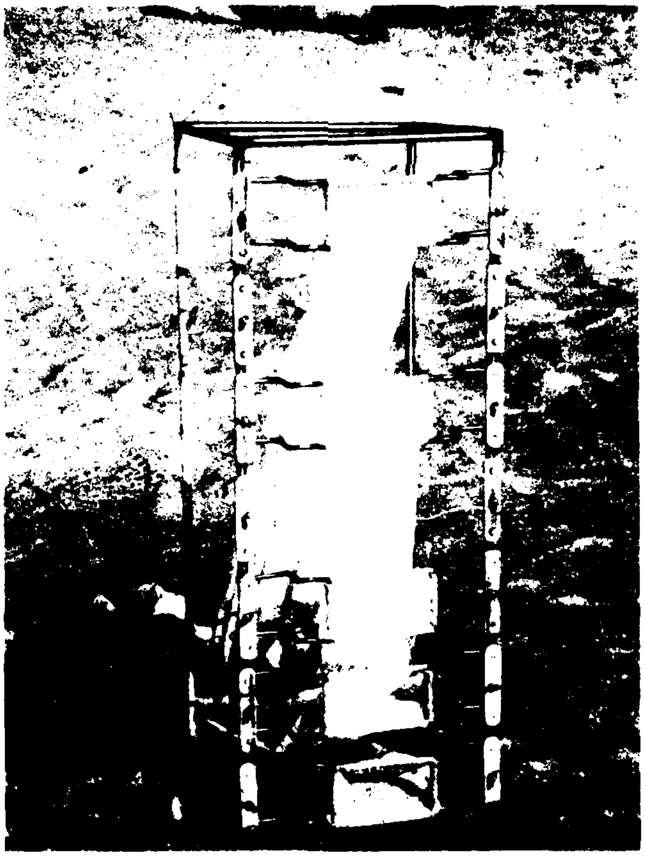


PHOTO 1. STREAMER TRAP

height was measured in relatively deep water and brought to the breaker line by a refraction calculation, assuming plane and parallel bottom contours and a wave breaker condition. The accuracy of this method was never verified in those experiments. Estimates of the breaking and surf zone wave heights obtained from deepwater wave conditions were not considered to be sufficiently accurate for the present experiments, particularly for the case of depth-limited wind seas (Hughes, 1985).

In our experiment, waves in the surf zone were measured by filming the water surface elevation at 14 steel pipes (Photo 2). The pipes were painted with yellow-green fluorescent paint to obtain maximum possible contrast with the water surface for facilitating digitization. The six synchronized 16mm memo-motion (pulsed mode) cine cameras used for filming were mounted on an industrial aluminum scaffold erected on the beach, as shown in Photo 3. The photo-pole technique provided an absolute measurement of wave height as well as a visual record of the wave conditions for possible later reference.

The longshore and cross-shore currents in the surf zone were measured by using two 2-component electromagnetic current meters. Stainless steel mounts of original design were constructed to hold the current meters. A mount and a current meter are shown in Photo 4. The mount is light, permitting easy relocation of the current meters to adjust for varying tide level, wave conditions, and current characteristics.

The surf zone bottom profile and photo-pole elevations were measured each day by using the Zeiss survey system available at the FRF. The Zeiss system permits rapid and highly accurate measurements. Standard rod and transit measurements were made as a supplement to the Zeiss measurements.

Procedure

The equipment was brought to the beach and a base camp established about 100 m south of the north property line of the FRF. Two canopies and a tent were set up to protect the electronic balances and to provide shelter from the sun. The recorders for the current meters were located in an air-conditioned trailer located about 100 m behind the dune line.

The photo poles were jetted into the bottom on a line crossing the surf zone, extending from the subaerial beach to past the breaker line for breakers up to about 1.5 m. Spacing between the photo poles was a nominal 6.5 m. The two current meters were set 5 m north of the photo-pole line, with the seaward current meter just shoreward of the breaker line and the other meter in the

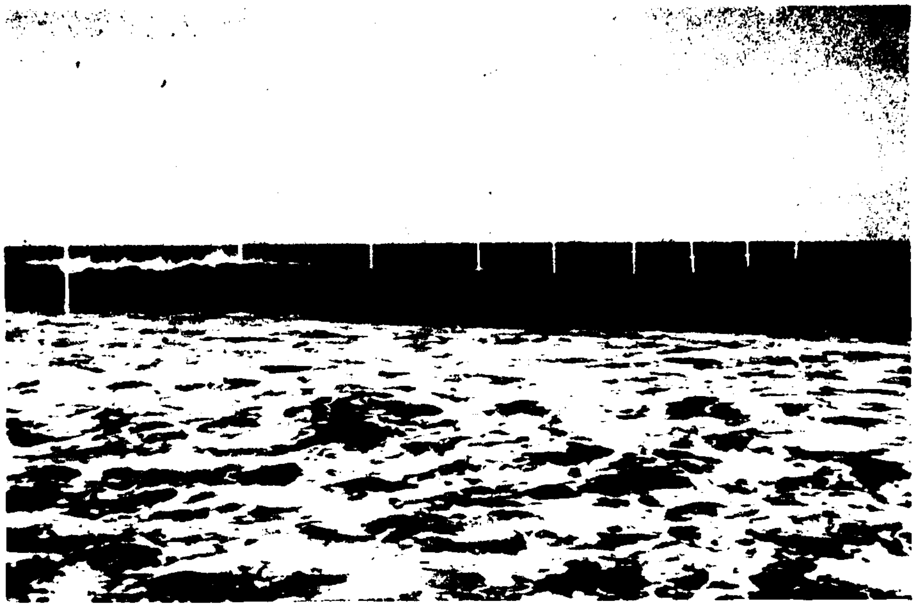


PHOTO 2. PHOTO-POLE LINE SPANNING THE SURF ZONE

PHOTO 3. SCAFFOLDING AND 16MM CINE CAMERAS MOUNTED ON TRIPODS

PHOTO 4. ELECTROMAGNETIC CURRENT METER
MOUNTED IN A TRIPOD

inner one third of the surf zone. In experiments to measure the longshore sand transport rate, six or seven streamer traps, attended by operators, were deployed on a line crossing the surf zone and about 10 m north of the photo-pole line (5 m north of the current meters).

Ten runs with the traps were made under exceptionally steady wave and longshore current conditions, as judged from visual observation. Sampling intervals with the traps were either 5 or 10 min. Photo poles were filmed simultaneously during the trapping period. The six cameras ran for approximately 13 min at a filming rate of 5 frames per second. One hundred eight rolls of film were exposed (approximately 420,000 frames) in 24 photo-pole experiment runs. The current meters recorded for 30-min intervals that included the times of trap runs.

Other experiments and tests were performed with the traps, including intercomparison of transport rates obtained with traps nearby and a measurement of the sand transport and current in a rip current. After the trap experiments were completed, the photo poles were moved to a location 75 m north of the FRF research pier, and the pier was used as a platform for the cameras to make test runs for filming breaking wave heights and wave runup.

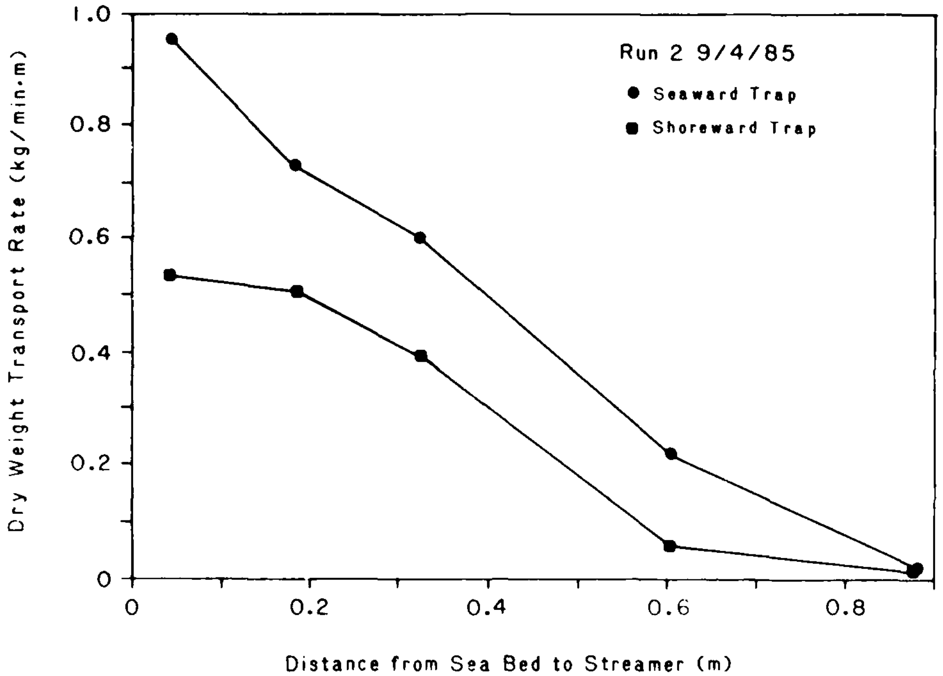
PRELIMINARY RESULTS OF TRAP EXPERIMENTS

DUCK-85 ended only one month prior to the November 1985 Coastal Engineering Research Board meeting; therefore, analysis of the obtained data has just begun. In this section, sample results of sand transport rates measured with the traps are presented. It is cautioned that these results are preliminary and may be subject to slight modification.

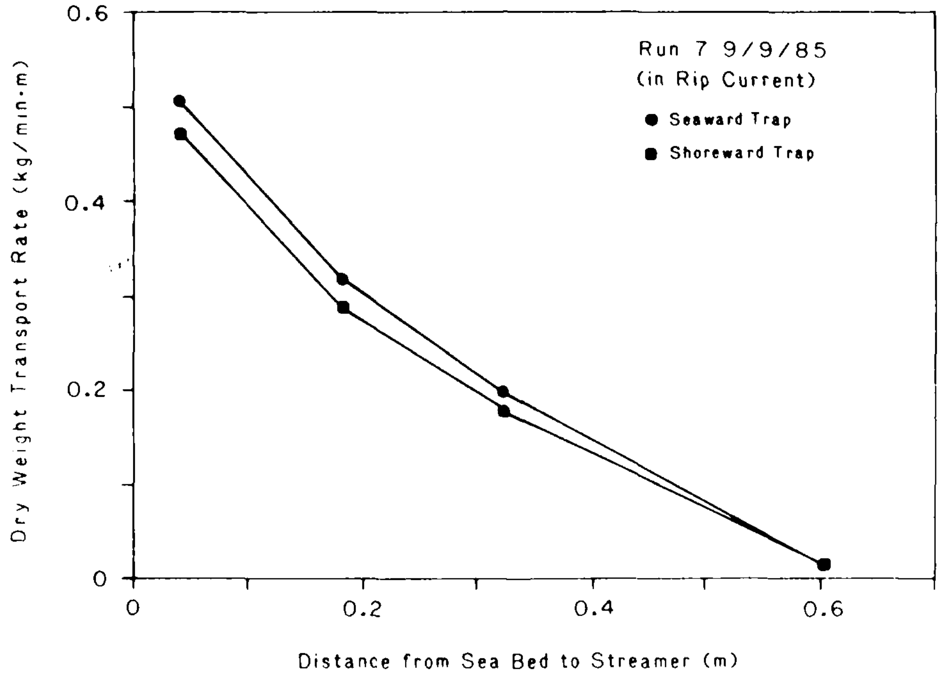
Consistency Checks

A number of runs were made with two traps placed approximately 1 m apart, and normal to the direction of the current, in order to examine the consistency of measured transport rates. Figures 2a and 2b show examples of results of these tests. In these figures, the transport rate as dry weight of sand in kilograms per minute crossing 1 m normal to the transport direction is plotted as a function of elevation from the bed. The value at the lowest elevation contains the bed-load component and some suspended load component of the transport.

Figure 2a is representative of the maximum difference in results between a pair of traps. The greatest difference, about 83 percent, occurs at the bed. The differences decrease slightly with increase in elevation from the bed and become essentially equal at the top streamer. The seaward trap collects the most sediment. Figure 2b is representative of a trap pair giving nearly equal transport rates. The drawn lines are almost parallel. The difference between rates at the bed is about 6 percent. The traps associated with Figure 2a were located in the midsurf zone in a moderate longshore current; the traps for Figure 2b were located in the neck of a rip current and aligned at a small angle (almost normal) to the shoreline. Most of the consistency tests gave results similar to those in Figure 2b. Assuming that the traps give very similar transport rates for similar transport conditions, results such as those shown in Figure 2a indicate that the transport rate can vary greatly over shore-normal distances on the order of 1 m.



a. Showing Large Difference



b. Showing Small Difference

FIGURE 2. TYPICAL TRANSPORT RATE RESULTS OBTAINED WITH CLOSE PAIRS OF STREAMER TRAPS

Distribution of the Longshore Sand Transport Rate

Figure 3 shows the locations of streamer traps, current meters, and photo poles during Run No. 1 on 6 September 1985. The elevations of the traps, current meters, and photo poles are drawn to scale. The drawn wave is located at the visually observed mean breaker line. Results to be obtained from the photo-pole experiment will precisely give the mean water level and wave height through the surf zone. It can be seen that a ridge and a runnel were located in the inner surf zone. Also note that one of the traps was located well seaward of the mean breaker line.

The transport rate results corresponding to the arrangement shown in Figure 3 are shown as histograms in Figure 4. The greatest transport rate occurs near the bed at all locations. However, it is clear that the total suspended load transport through the water column is greater than the transport at the bed. The transport rate at the trap located outside the breaker line is small compared to the rates inside the surf zone. There is considerable transport above the mean water level. Sediment above mean water was transported alongshore during the time of passage of wave crests and temporary rise in the local water level.

The cross-shore distribution of the longshore transport rate is plotted at the bottom of Figure 4. Total transport rates at each trap were obtained by interpolating rates through the water column between streamers. The total transport rate has a maximum just inside the breaker line and decreases almost linearly with approach to the shoreline. This result is somewhat surprising because the nearshore bar might be expected to significantly alter the transport rate.

SUMMARY

It is fortunate that the surf zone experiments performed at DUCK-85 took place during ideal weather and sea conditions. Relatively few problems were encountered with the equipment, despite the fact that much of the apparatus and procedures were used for the first time. These new techniques and equipment will be of direct benefit to Corps missions in the field. It is believed that a limited amount of high-quality data on the longshore sediment transport rates and wave transformation in the surf zone were obtained in this trial

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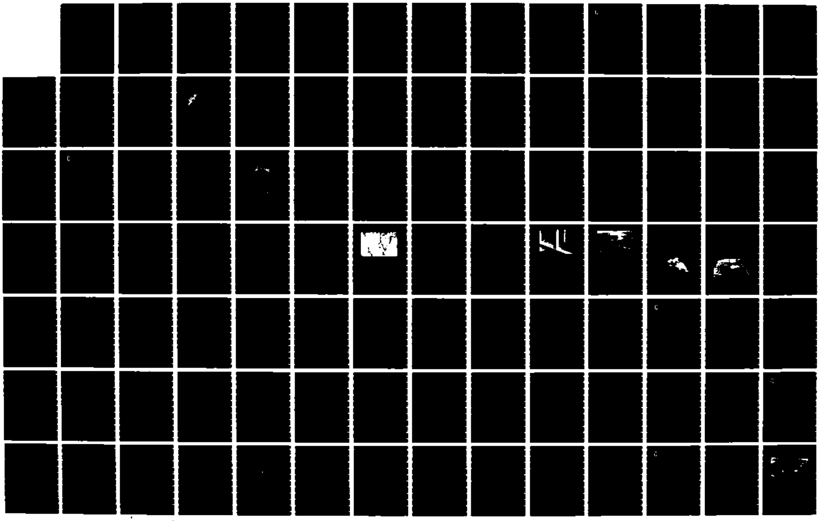

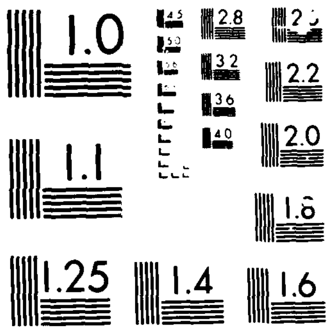
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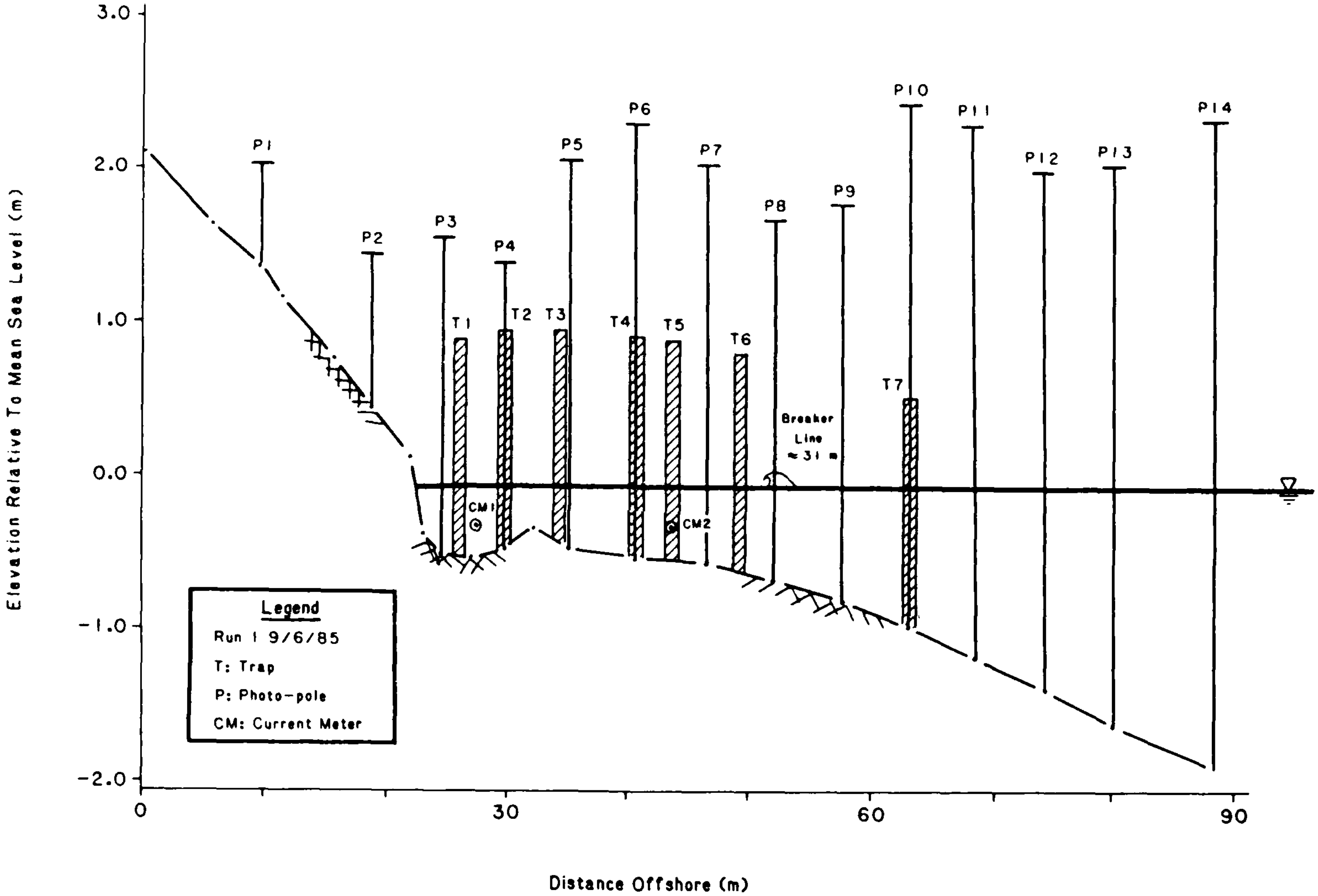

FIGURE 3. POSITIONS OF TRAPS, CURRENT METERS, AND PHOTO POLES IN A TYPICAL RUN

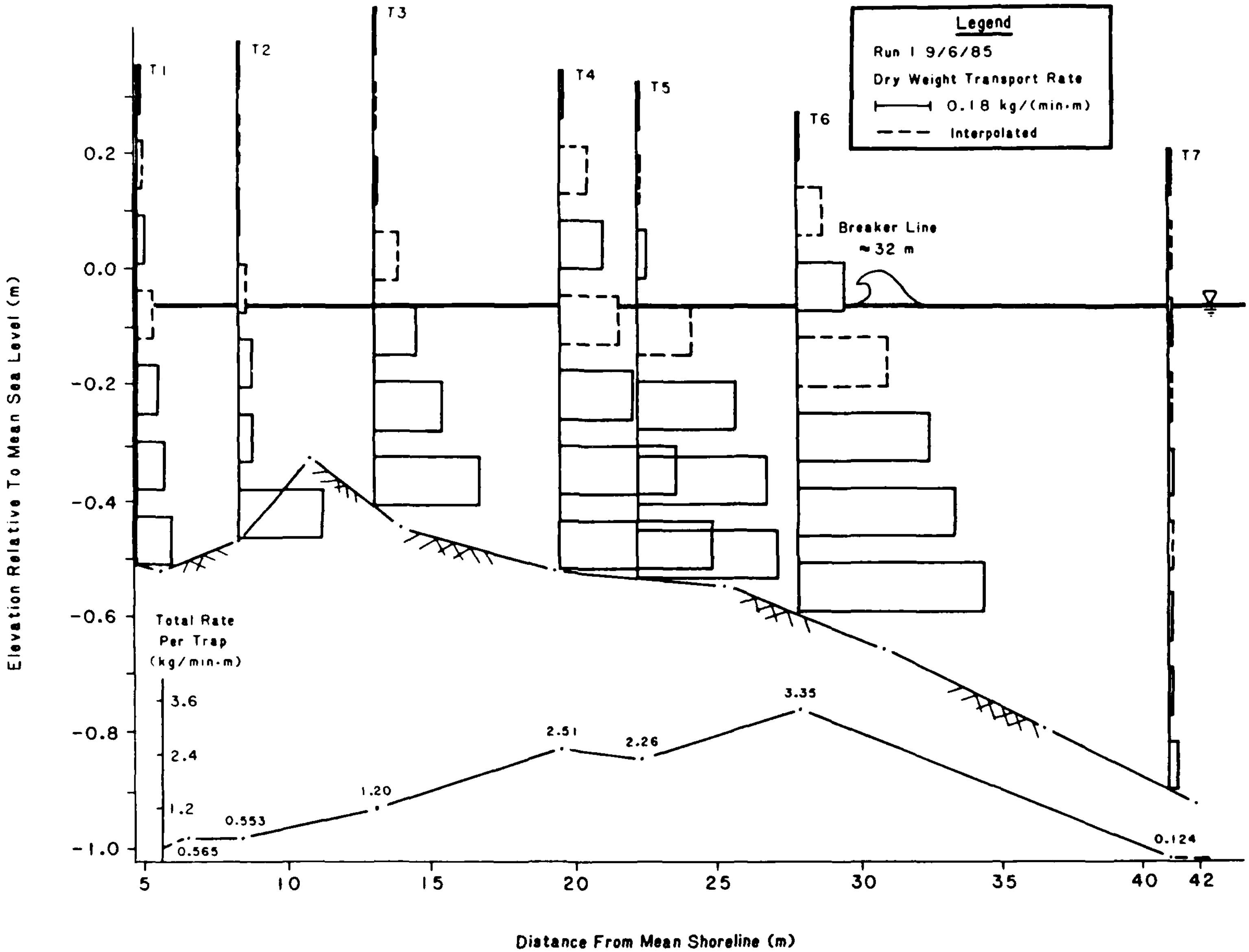

FIGURE 4. MEASURED VERTICAL AND CROSS-SHORE DISTRIBUTIONS OF THE LONGSHORE SAND TRANSPORT RATE (ABOVE) AND CROSS-SHORE DISTRIBUTION OF THE TOTAL TRANSPORT RATE (BELOW)

experiment. The data are now being analyzed. A number of new analysis techniques will be developed to examine the rich and unique data. Refinements of both the streamer trap and photo-pole equipment and methodology will also be made in preparation for the SUPERDUCK field data collection project scheduled for autumn 1986.

ACKNOWLEDGEMENTS

The research studies conducted by CERC during DUCK-85 were funded by the following US Army Corps of Engineers, Civil Works Research and Development programs in the Coastal Engineering Functional Area: Coastal Flooding and Storm Protection, Harbor Entrances and Coastal Channels, and Shore Protection and Restoration. The extensive efforts by the small but dedicated Field Research Facility staff is also acknowledged. Their tireless support, through many 12+ hour days, to arrange the many logistical details and deploy numerous oceanographic instruments, often under adverse weather conditions, contributed greatly to the overall success of the experiment.

PART III. WAVE RUNUP AND NEARSHORE MORPHOLOGY

Dr. Robert A. Holman
College of Oceanography
Oregon State University

INTRODUCTION

Oregon State University (OSU) was a participant in both the DUCK-85 experiment in September 1985 and the subsequent DUCKLING experiment in mid- to late October. Our participation focused on three main areas of research: (1) sediment transport in the surf zone, (2) the study of wave runup, and (3) the development and evolution of natural sandbar systems. Each area had its own motivation, methodology, and expected product.

SURF ZONE SEDIMENT TRANSPORT

The dynamics of sediment transport in the surf zone are of direct fundamental interest to the coastal engineering community if we are ever to understand cross-shore or longshore transport. It is also a necessary element in the successful modeling of the interaction of low-frequency wave motions (called infragravity waves) and a deformable bottom. Together with the University of Washington, OSU has run a set of experiments on suspended load transport in the surf zone, with funding by the Office of Naval Research (ONR). The DUCK-85 work was thus a companion to high energy experiments run previously on the Oregon coast. We were particularly interested in lower energies and conditions of incident band dominance. The additional logistic and data support available from integrating with a large experiment at the FRF was also extremely beneficial.

Data collection took place during the first 10 days of September 1985. The instrumentation consisted of a cross-shore array of five elements, each element containing at least one electromagnetic current meter, a pressure sensor, and a five-element optical backscatter sensor for measuring suspended load concentration. Ten data runs were collected, including one intercalibration run with the sediment traps used by Dr. Nicholas Kraus.

WAVE RUNUP

Wave runup has been the primary type of data collected by the OSU group for the last 5 years. This is largely because runup, particularly the longshore variability of runup, is an excellent diagnostic tool for the study of infragravity waves. However, the same data have been of great interest to CERC and coastal engineers. The statistics of setup and swash provide design criteria for artificial structures, beach nourishments, and the establishment of setback lines.

We have traditionally collected runup data through remote sensing techniques. A time series of images (either time-lapse photographs, or, more recently, video tapes) is collected, and the runup level in each image (at a particular longshore location) is digitized by a semiautomated system developed at OSU. For the fall experiments, a high vantage point was provided by a temporary scaffolding erected on the dune line.

This technique has proved to be very productive. From the DUCK-82 experiment runup data were collected during incident wave conditions of up to 4-m incident wave height, well beyond the operating limits of other runup sensors. More than 150 data runs have been analyzed and the results published in a paper describing the typical runup statistics (Holman and Sallenger, 1985) and a second paper specifically dedicated to the extreme value statistics

(Holman, in press). The latter work was funded directly by CERC through the Wave Runup and Overtopping Work Unit, of which Mr. John Ahrens is the Principal Investigator.

SANDBAR MORPHOLOGY

Natural sandbars involve large volumes of sand and are very important to cross-shore sediment transport budgets. They also provide a natural defense against beach erosion since they move wave dissipation away from the beach face. Thus the mechanisms whereby sandbars are generated and the way in which they evolve are of considerable interest.

Monitoring the morphology of a natural bar system is a notoriously difficult task, especially during storms when evolution is most rapid. While the pattern of wave breaking makes it obvious that a bar system might be present, the quantitative mapping of the morphology poses major problems. The FRF CRAB, located at Duck, is unique in the world in its ability to accurately measure bathymetry in up to 2-m wave heights. However, a technique was needed for larger wave heights and for other field sites that do not have the benefit of the CRAB.

Our third area of interest in the DUCK-85 experiment was the testing and calibration of a new technique to image sandbar morphology. The technique was originally conceived with funding by ONR, while the extensive testing during the fall experiment was sponsored by CERC under the Barrier Island Storm Sedimentation Work Unit of Dr. Suzette Kimball. The technique relies on the concentration of wave breaking over bars to provide the imaging signal. However, to remove the ambiguity of natural wave height modulations and to improve the statistics of a single snapshot of wave breaking, photographic images are taken using 10-min time exposures. Because of the time averaging, individual waves are not visible and are replaced by broad concentrations of white where breaking is most frequent. These concentrations of incident wave dissipation clearly outline the underlying morphology. The technique was very useful in the fall experiments in rapidly delineating the evolution of the bar system and showing the spatial relationship between in situ instrumentation and surrounding morphology. The technique was also surprisingly sensitive, detecting a series of transverse bed forms in the bar trough during the October DUCKLING experiment.

The images collected during the fall experiment are presently being quantified using photogrammetric techniques to allow a rigorous comparison between the morphology as detected by the time exposures and that measured by the CRAB.

SUMMARY

The DUCK-85 and DUCKLING experiments run at the FRF in the fall of 1985 have provided an excellent research opportunity for OSU. Some aspects of our participation were funded by ONR and had peripheral interest to CERC. However, CERC has directly sponsored two aspects of the research to the benefit of all involved. The results of these field experiments will provide much needed data for addressing coastal engineering problems.

ACKNOWLEDGEMENTS

I would like to take this opportunity to thank Mr. Curtis Mason and the entire staff of the FRF for the excellent logistic and moral support that they have always provided. The facilities at the FRF are unparalleled in the world. Thanks to Dr. Suzette Kimball for funding the time exposure work under the Barrier Island Storm Sedimentation Work Unit and to Mr. John Ahrens for support under the Wave Runup and Overtopping Work Unit. Mr. Dennis Conlon and ONR have provided generous support for the sediment transport research. Finally, I would like to thank Mr. Mike Dominguez for getting the keys out of my locked car.

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DISCUSSION

DR. NUMMEDAL: The techniques developed for time exposures of nearshore morphology and for suspended sediment sampling are really quantum leaps and progress in surf zone studies. The data shown here are tremendous; they have not been previously collected.

There are a couple of other clients out there whom I think would be extremely interested in what you're able to do. One is the dredging industry with Murden's Mound. It's quite clear that if we're going to start a large-scale program to construct linear sandy submerged reefs, then the kind of data you are collecting on sediment transport in deeper water would be a key to predicting the properties of those kinds of mounds. It seems like a natural way of involving the dredge material and disposal people and to get them to support part of the 1986 experiment, SUPER DUCK. Another potential client would be the petroleum industry, which is very interested in trying to understand how sand moves along the continental shelf. If you could add instrumentation slightly deeper on the shore face and document how sand moves from the surf zone onto the continental shelf, there is a tremendous need for exactly that kind of information in the petroleum industry.

DR. MEI: This experiment was really a first class study, and the kind of information that you have obtained is not only of basic value but also of applied value. This is a situation where both basic and applied research accomplishments are being made.

In regard to the effects of wind on the longshore currents, I believe this may be the first serious study of this kind, and that really is a tremendous effort and accomplishment.

MR. OLIVER (NPD): With SUPER DUCK, we have a tremendous opportunity for training people in coastal engineering during a very intense period of data collection. And we do have a training program in the Corps which could provide District participation during the experiment. Combined with a detailed seminar on the experimental results later in the year, District personnel could get a total picture of what's going on in the nearshore zone, almost like taking a 2-week course in coastal engineering.

FISHERMAN'S WHARF HARBOR

Proceedings

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Hydraulic Engineer
Coastal Engineering Research Center
US Army Engineer Waterways Experiment Station

Mr. Dennis W. Thuet
Civil Engineer
San Francisco District

ABSTRACT

The Fisherman's Wharf area breakwater is under construction. The harbor improvements include a detached breakwater and two segmented breakwaters installed along an existing pier. The harbor was poorly protected from incident wave attack with recurring fishing boat damage. During the study prototype wave, circulation and water quality data were acquired for the Fisherman's Wharf area. Numerical circulation and water quality studies were conducted during project design. Also storm wave protection was investigated in a physical model study. The influence of the optimum plan developed for storm wave conditions was investigated numerically for long-period harbor resonance. Improved mooring conditions will be provided for the historical ship fleet moored in the area, and the completed project will provide for the return of fishing boats from safer, although more distant, moorage.

INTRODUCTION

The first thing that comes to mind when thinking of San Francisco is either the Golden Gate Bridge or Fisherman's Wharf. Since the mid-1850's, industrial, recreational, and commercial fishing activities have been present in the Fisherman's Wharf area. Subsequently, it has also become one of the premier tourist attractions in the United States, second only to Disneyland on the west coast.

HISTORY

Around 1850, the Selby Lead and Smelting Company dominated the area with its large brick building and chimney. The area was then open land and easily accessible from town via the pass between Russian and Telegraph Hills. The proximity to the waterfront provided endless supplies of cooling water.

Shortly thereafter, the Pioneer Woolen Mills opened a very successful operation using Chinese labor who had settled in the area, followed by the Ghirardelli Chocolate Factory and the California Fruit Cannery Company.

Black Point Cove and North Beach were sheltered coves which provided a natural area for water-oriented recreation. Many bathhouses, aquatic clubs, and resort-oriented activities sprang up in the area. The recreation went hand-in-hand with industry at the time. The factories using water for cooling would, in turn, discharge heated water which added to the attraction of the cove. The Neptune Baths and Dolphin Swimming and Rowing Clubs were the first to locate in the area. The Dolphin Club has, over the years, followed the filled shoreline and is one of two clubs now located on the present shoreline. The area became even more accessible to the public in 1891 when Andrew Hallidie established cable car lines down Hyde Street.

As industry and recreation in the area grew, the need for more land became apparent. The water in the area was shallow, and developers began to fill and expand the land area. Soon Italian and Dalmatian fisherman began mooring in the area known as "Fisherman's Cove" because of its proximity to the fishing waters. By 1881, there were nearly 100 home-based fishing boats in the area. Two seawalls were constructed to protect the fishing boats, one adjacent to what is now Pier 45 (constructed in 1930) extending westward and another built out from the foot of Jones Street. In 1914, a bulkhead was constructed along Jefferson Street to stabilize the shore and to provide the fishermen with a place to mend nets and repair their boats. In 1917 the Hyde Street Breakwater and Pier was constructed to handle lumber. The Hyde Street Pier was changed into an auto ferry terminal in 1926 and served as such until the completion of the Golden Gate Bridge in 1936.

In the 1930's, restaurants began developing in old sheds and buildings in the area to serve fresh fish caught daily. Since then, the area has continued to support fishing, recreation, and, to a certain degree, tourism.

Congress authorized the US Army Corps of Engineers (Corps) to study the feasibility of providing protection to the area in 1966 but did not grant funding until the mid-1970's. The Corps submitted a favorable feasibility report to Congress in 1978 (US Army Engineer District, San Francisco (SPN), 1976) and filed the final Environmental Impact Study (EIS) (SPN, 1981) in 1981. In 1982 the Port of San Francisco (the local sponsors are the City and County of San Francisco acting through the Port of San Francisco) expressed its support of the Corps breakwater project. The Port wrote that if assurances cannot be given that adequate protective structures will be developed by Federal or local government, then the commercial fishing industry will not remain an active part of the Port of San Francisco. Congress authorized the project for construction in 1983. At that time the Mayor of San Francisco secured a commitment from the Corps to advertise construction of the project in November 1984. An extensive effort on the part of the Corps was required to complete the necessary studies prior to preparing plans and specifications for construction.

LOCATION

Located on California's San Francisco Bay on the West Coast, the Fisherman's Wharf area is situated on the northern waterfront of the San Francisco Peninsula bounded on the west by Hyde Street Pier and on the east by Pier 45. For many years Fisherman's Wharf has been one of the centers of Northern California's commercial fishing industry as well as a famous tourist attraction and local recreation area. Located on Hyde Street Pier, the Maritime Historical Park has five vessels open to the public for visitation or viewing: the "Wapama" (schooner), "Alma" (scow), "Hercules" (tugboat), "C. A. Thayer" (lumber schooner), and "Eureka" (ferryboat). Excursion vessels offering the public a waterfront tour also tie up at the foot of Mason Street, at Pier 43-1/2, east of Pier 45. Two existing mooring areas provide 165 berthing spaces for fishing boats in the harbor.

Sidewalk cafes offer seafood from fresh catches made by commercial fishermen docking at the Wharf, and popular restaurants cater to the tourist trade. Opportunities for observation of net mending and hook baiting are not as great as in the past; however, these crafts still provide a minor local attraction for tourists.

Until the beginning of World War II, the San Francisco area was a leading supplier for many species, particularly sole and other flat fish, salmon and rockfish, sablefish, crab, shrimp, and oysters. While the area is still a supplier of small quantities of a wide variety of species, its statewide importance has declined. However, Fisherman's Wharf does remain a center for commercial fishing and fish processing for the San Francisco Bay area, even though the once extensive fishing fleet has now diminished in number.

NEED FOR PROJECT

The existing fishing boat harbor is essentially unprotected, and waves damage vessels and mooring facilities. Harbor facilities for the commercial fishing fleet are limited and in a deteriorated condition. Local interests are concerned that a continued decline in the maritime character of the area may ultimately reduce its attraction to tourist, recreational, and commercial activities.

During winter storms, short-period waves generated by the north and northeast winds batter the area and cause severe damage to the fishing vessels and wharfing facilities. In addition to direct damage to vessels, these storms deter off-loading of the perishable fish cargo. The National Park Service (NPS) has experienced extensive recurring monetary losses due to wave induced damages to the historic vessels moored along Hyde Street Pier. The longer period swells approaching from the Pacific Ocean through the Golden Gate could cause considerable damage to both the Historic and the fishing fleets.

BENEFICIARIES

Commercial fisherman use these facilities as well as the NPS who are the custodians of the Historic Vessels at the Hyde Street Pier. Benefits to be derived from the plan of improvement consist of general navigation benefits, including fishing boat damage prevention, transportation cost savings, increased fish catch, and fuel savings; recreational use benefits consisting of pier fishing and sightseeing; and historic ship protection benefits. Project benefits were originally determined in 1976 and subsequently updated to 1984 conditions using indices considered to be appropriate for the benefit category. A summary of benefits, both original and updated, is given in Table 1.

ADVANCE DESIGN STUDIES

Extensive coordination was required in order to proceed without objection of local interests. A civic advisory committee was organized consisting of members of the Port of San Francisco (local sponsor), Fisherman's Wharf Association, Fisherman's Wharf Merchants Association, Golden Gate National

TABLE 1

SUMMARY OF PROJECT BENEFITS

Category	Feasibility Report 1976 ($)	General Design Memorandum 1984 ($)	Indices 1976	Indices 1984	Indices Change	Index Title[a]
Boat Damage Prevention	86,000	150,000	150	263	1.75	Consumer Durables
Transportation Cost Savings	120,000	226,800	161	305	1.89	Transportation
Increased Fish Catch	160,000	336,000	0.19/lb	0.40/lb	2.10	Landed Price of Bottom-fish Fuel Oil
Fuel Savings	69,000	175,950	243	620	2.55	Fuel Oil
Pier Fishing[c]	106,000	226,000	0.75	1.60	2.13[b]	
Sight-seeing	320,000	681,600	0.75	1.60	2.13[b]	
Historic Ship Protection	160,000	289,600	213	385	1.81	Engineering News Record Construction Cost Index
TOTAL	1,021,000	2,086,450				

[a] Indices for categories 1, 2, and 4 are from Department of Commerce, Survey of Current Business.

[b] The 1976 Feasibility Report Values are from "Methodology for Determining General Recreational Values Under Senate Document 97," Pacific Southwest Inter-Agency Committee, Report of Recreation Technical Subcommittee, July 1969, as adjusted in 1976 by 50 percent to the Water Resources Center Principles and Standards. The 1984 General Design Memorandum values are based on EC 1105-2-128, 29 February 1984, Fiscal Year 1984 Reference Handbook.

[c] This category of benefits accrues in two phases; Phase I benefits amount to $23,000; Phase II benefits, $203,000, begin 2 years after and on a present worth basis amount to $174,000.

Recreation Area (GGNRA - Department of the Interior), Association to Save Aquatic Park (representing the South End and Dolphin Rowing/Swimming Clubs), and SPN (1985). The swimming clubs provided the only opposition. As a result of their constructive criticism, additional studies were conducted. An analysis of the pre- and postconstruction sand transport on the beach at Aquatic Park was made. The results of this investigation indicate no appreciable change in beach movement will be realized. Also, the breakwater was simulated in the San Francisco Bay-Delta Tidal Hydraulic Model in Sausalito. Dye tracers were used to follow the currents with and without the breakwater in place. The tests indicate that the breakwater will cause bifurcation of the currents increasing the flushing action in the outer harbor and Aquatic Park areas. Three public workshops were held as well as one public meeting.

Due to the complexity of the structure requiring the planning and design talents of not only the Corps but also many other agencies, a technical advisory committee was needed. Prior to the beginning of actual design work, several research centers collected and analyzed data to determine the baseline conditions.

In addition to the civic interests, technical issues such as geotechnical, structural, environmental, and constructibility were investigated by the following technical advisors:

I. Port of San Francisco

II. Ben Gerwick, Inc.

III. Harvey Haynes & Associates

IV. Allstate Geotechnical Services

V. Geotechnical Consultants, Inc.

VI. Woodward-Clyde Consultants

VII. Scripps Institute of Oceanography

VIII. Norgaard Consultants

IX. Hydrologic Engineering Center

X. US Army Engineer Waterways Experiment Station

XI. US Army Engineer Division, South Pacific

XII. US Army Engineer District, Los Angeles

XIII. US Army Engineer District, San Francisco

PROTOTYPE DATA ACQUISITION AND ANALYSIS

Five pressure recording gages (Hydrologic Engineering Center (HEC), 1983) were installed in the Fisherman's Wharf area, as shown in Figure 1, by the Scripps Institute of Oceanography (SIO). Two of the gages were used to measure short-period waves, and three were used for analysis of surge waves in the long-period range above 22 sec. The data were analyzed and presented in monthly data summaries for the period from December 1982 to June 1984. Maximum monthly significant wave heights for the station at the tip of the Municipal Pier during the first winter period from 16 December 1982 through May 1983 ranged from 1.1 to 1.8 ft. Peak periods were in the 4- to 8-sec range except for April 1983, during which the maximum monthly significant wave height of 1.1 ft occurred with a peak period in the 8- to 10-sec range. Maximum long-period monthly significant wave heights were in the 0.3- to 2.1-ft range during the same data acquisition interval with peak periods in the 256- to 512-sec period range except for May 1983 (0.3-ft significant wave height in the 171- to 256-sec period range). Little long-period wave energy was observed below 128 sec. The trend of these results was similar at the other two surge gages.

Two directional gages (pressure and horizontal velocity components) also were installed for approximately 4 to 5 months. Data from these two gages were used for analysis of tidal currents. Four seasonal water quality surveys were conducted as a part of the water quality analysis conducted by the HEC. Hydrodynamic current surveys were conducted by HEC at 25 stations in the Fisherman's Wharf area for spring, mean, and neap tidal conditions. Influence of piers on circulation was observed using current meters installed on either side of the piers for a 24-hr tidal cycle.

Meteorological data were observed by SIO during the data acquisition period for a station on the Hyde Street Pier.

CIRCULATION AND WATER QUALITY MODELING

A numerical finite-element and water quality model was used (HEC, 1984b) to quantify the differences between proposed alternatives in breakwater design, with special emphasis on circulation patterns. After calculating the existing water circulation patterns and water quality in the harbor area,

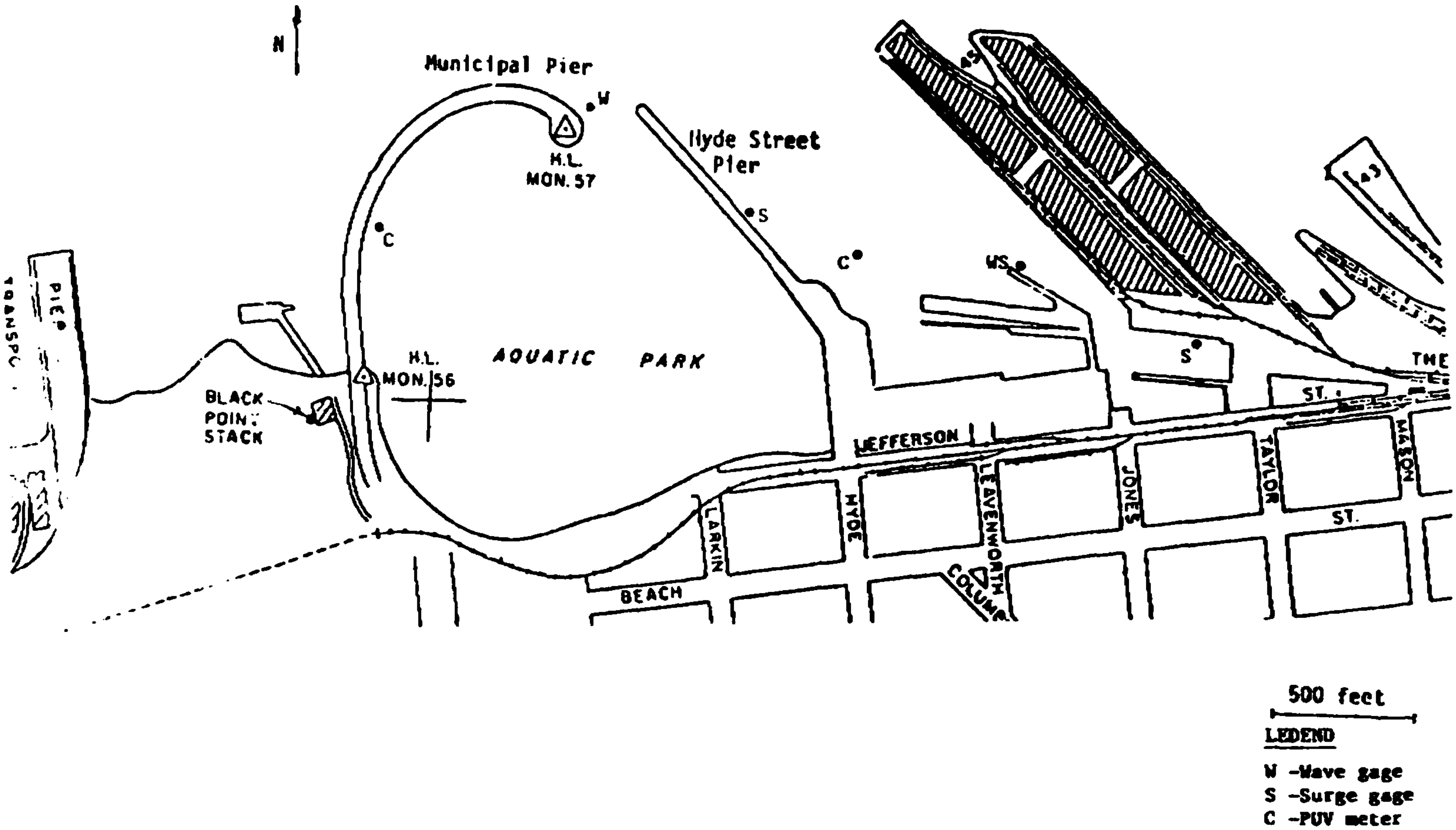

FIGURE 1. INSTRUMENT LOCATIONS FOR WAVE STUDY AT FISHERMAN'S WHARF HARBOR

predicted changes in circulation and water quality as a result of the breakwater structures were calculated. The models were initially developed using prototype data and then verified by further field data. The breakwater configuration then was added to investigate its impact on circulation and flushing as well as predicted effects on dissolved oxygen, biological oxygen demand, and suspended solids concentrations. The segmented sections are designed to allow water circulation within the harbor and still reduce the incoming wave energy.

Conclusions of the water quality study conducted by HEC were that the final proposed breakwater configuration performs well within the required range of circulation and flushing actions needed to maintain the existing level of water quality conditions in the area. The model study showed enhanced circulation in the outer harbor and Aquatic Park areas. Dissolved oxygen, biological oxygen demand, and suspended solids concentrations should not change significantly from existing harbor conditions.

SCOUR

Scour and deposition near the detached breakwater due to combined tidal and wave-induced currents were estimated (HEC, 1984a) based on the results of the circulation study and hindcast wave data. Maximum sedimented scour depths ranged from 4 to 6 ft along the bayward side of the detached breakwater and were limited to 2 ft on the lee side of the breakwater, except near the east entrance. The leeward region of the breakwater from the vicinity of the Hyde Street Pier to the west side of Pier 45 is a potential deposition zone.

WAVE PROTECTION MODELING

A 1:75 scale model (Bottin, Sargent, and Mize, 1985), was used to optimize proposed improvements for protection against incident wave attack in the Fisherman's Wharf area. The existing area consists of a complex system of piers, wharves, and pilings reproduced in the model. The decking of the piers and wharves was constructed with plexiglass, and the massive piling systems were constructed with metal and/or plastic rods. Firewalls, wave baffles, and solid landfills also were constructed beneath the piers and wharves with metal, concrete, and/or plexiglass to represent prototype features.

The model reproduced the entire Fisherman's Wharf area, which included approximately 6,400 ft of the San Francisco Bay shoreline that extended from a point east of Pier 45 to a point west of the Municipal Pier and underwater contours in the Bay to an offshore depth of -60 ft. The total area reproduced in the model was approximately 6,000 sq ft, which represents about 1.1 square miles in the prototype. Model limits are shown in Figure 2.

Test wave conditions for the model study were hindcast for local generation in the Bay using winds recorded at the Alameda Naval Air Station. Model wave test conditions used during plan optimization were as follows:

Direction	Wave Period (sec)	Wave Height (ft)
Northeast	3.6	3.3
North-northeast	4.2	4.8
North	3.6	3.1
North-northwest	3.6	3.8
Northwest	3.8	4.1
West-northwest	3.6	3.4
	10.0	2.0
	10.0	2.5
	10.0	3.0

The plans, evaluated at still-water levels of 0.0 and 5.7 ft, represent mean lower low water and mean higher high water, respectively. Wave height criteria for the harbor improvements were 1.0 ft in small-craft areas and 1.5 ft in the vicinity of the historical ship fleet.

For the 0.0-ft water level, maximum test wave heights for existing conditions were 4.8 ft in the outer harbor between the Hyde Street Pier and Pier 45, 4.8 ft along the Hyde Street Pier, and 3.5 ft in the existing fishing vessel mooring area. At the +5.7-ft water level, maximum test wave heights were 4.4 ft, 5.7 ft, and 2.7 ft for the same respective areas. Initially, a plan was optimized which included a curved solid outer breakwater and baffled walls along Pier 45. The baffle wall section was then modified to a segmented breakwater design with similar wave transmission characteristics. The recommended plan developed during the model tests is shown in Figure 3. Test wave heights for the recommended plan met the wave height criteria. Tracer tests using crushed coal indicated that sediment transport along the Aquatic Park beach would be predominantly easterly with the recommended plan and that

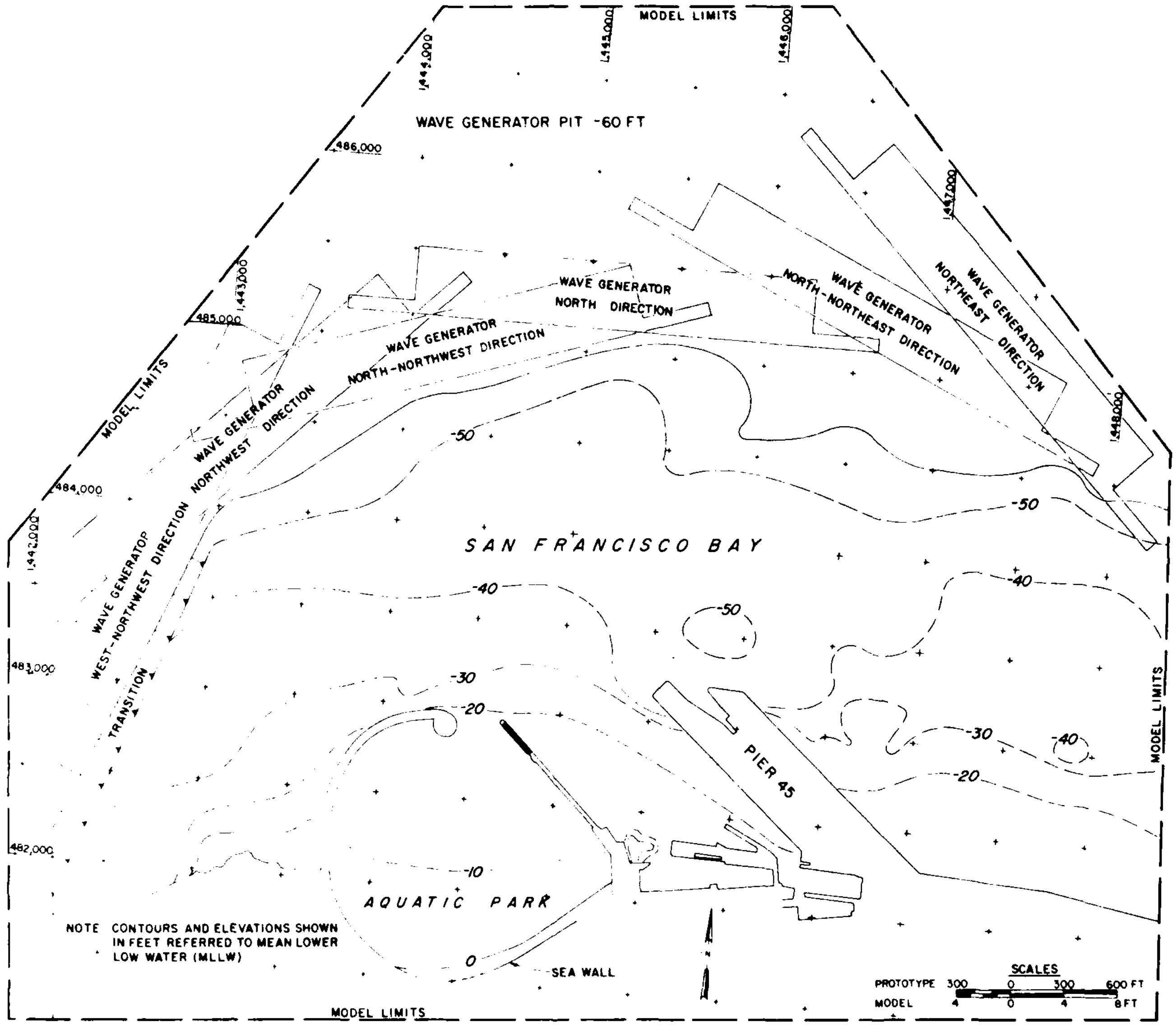

FIGURE 2. MODEL LAYOUT

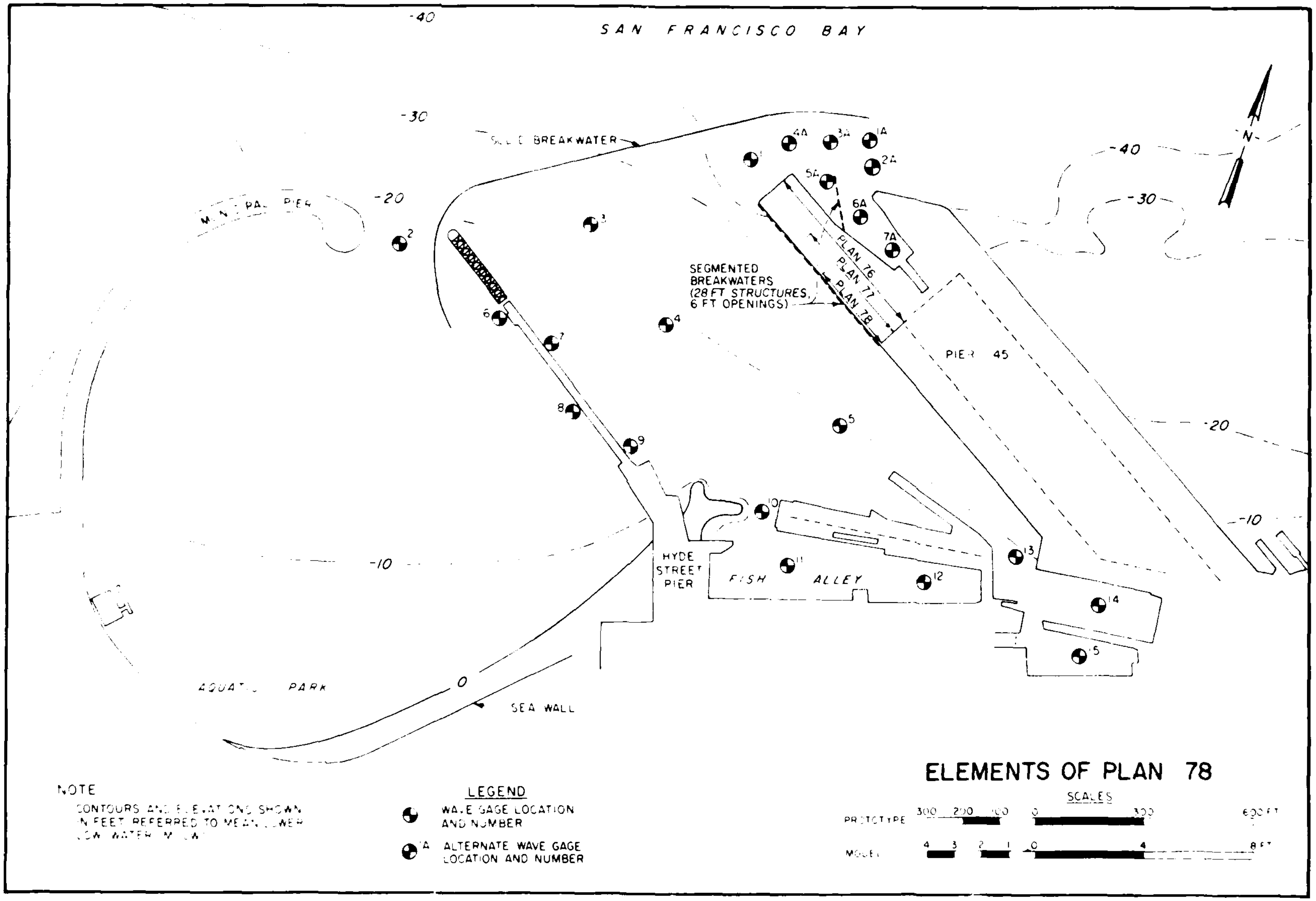

FIGURE 3. RECOMMENDED PLAN DEVELOPED DURING MODEL TESTS

reflected wave energy from the breakwater structure was not significant in the vicinity of the beach. The final alignment of the recommended plan was modified slightly to reduce the total outer breakwater length by decreasing the length of curvature around the Hyde Street Pier.

The effect of the recommended plan on long-period harbor resonance was evaluated using a hybrid numerical finite element model developed by Chen and Mei (1974) and recently improved to incorporate bottom friction and boundary absorption by Chen (1984). The finite element grid for the recommended plan is shown in Figure 4. During the harbor resonance evaluation, wavelength amplification at selected stations, contours of wave height amplification, and current velocity plots were calculated. When correlated with observed long-period wave data, harbor resonance results for existing conditions and the recommended plan indicated that a fundamental mode of oscillation with a resonant peak near 228 sec would develop for each of the two configurations. The peak amplification for the selected plan decreased approximately 15 to 20 percent in the inner harbor area. Other resonant periods of oscillation at periods less than the 228-sec mode were predicted, but the prototype data indicated that little long-period energy was available to excite the shorter period modes.

With the detached breakwater, long-period wave induced currents near the Hyde Street Pier were not changed significantly. Consequently, ship motion due to long-period waves should not change appreciably for ships moored along the pier. Two ships, the Alma and the Eppleton Hall, moored southward of the pier, will be subjected to long-period currents increased in magnitude by 14 to 18 percent. The Alma and Eppleton Hall can be moored either along the pier or northward of the pier to reduce both the long-period current magnitude and to provide additional incident wave protection in the lee of the detached breakwater. Short-period wave heights were reduced to the 1.5-ft storm wave height criteria and will decrease ship motion due to incident short-period waves. Ship mooring locations are shown in Figure 5.

CONSTRUCTION

Breakwater Structure

The pile design is unique in that the piles will be constructed of precast, prestressed reinforced concrete (Thuet, Fulton, Nizinski, and MacArthur,

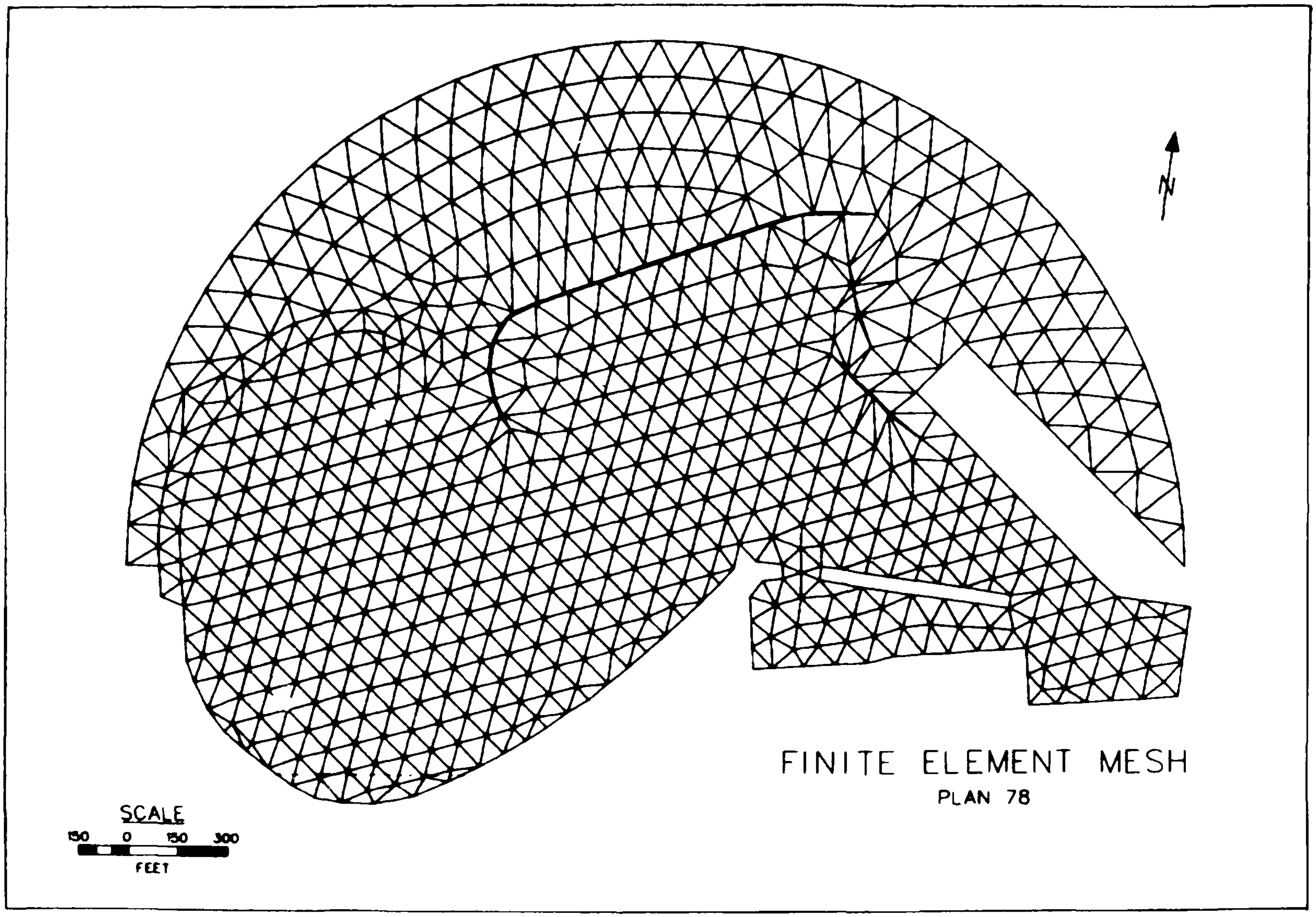

FIGURE 4. FINITE ELEMENT GRID FOR THE RECOMMENDED PLAN

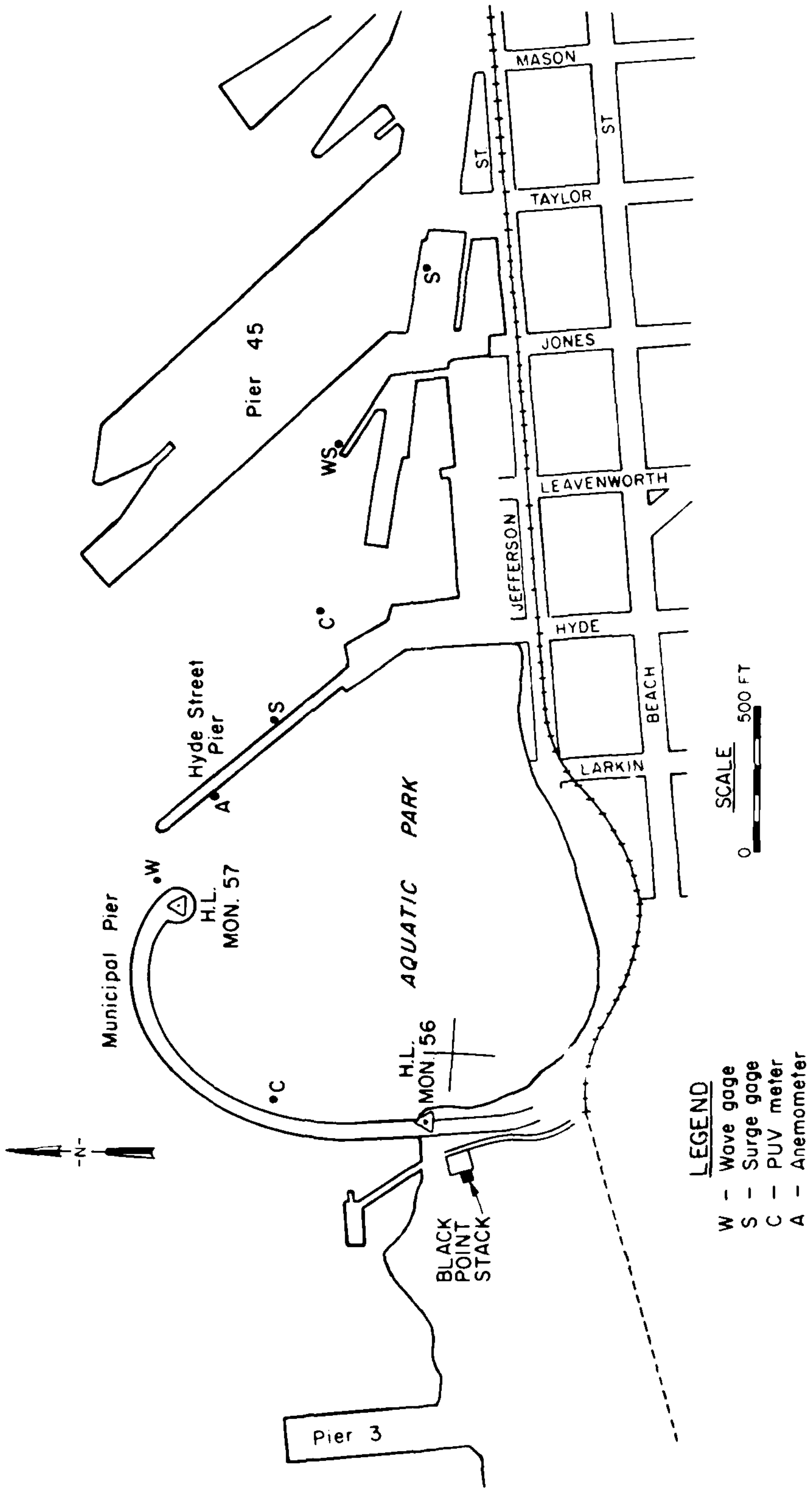

FIGURE 5. SHIP MOORING LOCATIONS

1985). The interlocking sheet piles are either 2.5 ft square or 3.33 ft by 2.0 ft, and they average 100 ft long, depending on the location. The sheet piles will be supported by batter piles spaced approximately 10 ft apart and on both sides of the sheet piles in most areas. The batter piles are tied to the sheet piles by a cast-in-place concrete cap. The cap is 10 ft wide, 4 ft deep, and beveled on the undersides. The detached breakwater is 1,509 ft long and in depths of water ranging from 20 to 55 ft. It will form a protective wall approximately 56,600 sq ft in area.

Contract Statistics

The construction contract was advertised on 26 November 1984, and the Notice to Proceed was issued to Riedel International of Portland, Oregon, on 22 March 1985. The original contract cost was $7,889,700. The total cost of the project, including service and administration, engineering and design, and contingencies is expected to be $9,600,000. To date, six modifications have been issued, increasing the contract time by 7 days (from 11 December 1986 to 18 December 1986) and decreasing the contract cost by $35,000.

Construction Activities to Date

Activities performed to date include removal of obstacles on the site, including derelict piles located at the end of Hyde Street Pier (20-31 May 1985); removal of a barge sunk in the Pier 45 ferry slip (3-17 June 1985); fabrication (21-28 July 1985); delivery (19 August 1985); driving (20-30 August 1985) and removal (23-28 September 1985) of test piles; and ordering, fabrication, and delivery (28 October 1985) of the actual piles. The construction of the actual breakwater began on 30 October 1985.

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DISCUSSION

DR. LE MÉHAUTÉ: *What was the design wave height?*

MR. OUTLAW: The design wave height for the structural design was 8 ft. The significant wave height for testing was a maximum of 5 ft.

DR. LE MÉHAUTÉ: *What was the depth?*

MR. OUTLAW: Up to 60 ft.

DR. LE MÉHAUTÉ: *The cost of the project was \$7 million. What was the cost per linear foot?*

MR. THUET: The contract is almost \$8 million, and we're talking about 1,900 linear feet.

DR. LE MÉHAUTÉ: *How does the cost compare to that for the riprap breakwater?*

MR. THUET: I really don't know. Unfortunately with riprap we have such a larger bottom area to cover we don't have the area to construct a riprap breakwater.

MR. OUTLAW: I think we were able to use the pile wall design because the wave heights were not very large. I think the riprap design would be considerably more.

MR. THUET: The original feasibility study did look into riprap; and as I recall, it was more expensive.

DR. LE MÉHAUTÉ: We see more and more of this kind of construction for two reasons. One is that it environmentally creates less detriment to the benthic biotype. And the other reason is cost. It seems as if construction with sheet pile appears to be less expensive than riprap from my experience, and you wonder why more of this was not done on past ongoing wave projects. Of course, in an exposed site, this kind of construction will fail. In a relatively sheltered site, then, this seems to be the best solution.

BG KAVANAUGH: One of the reasons is that the vertical walls allow you to have the water to go through to take care of that surge problem and that it doesn't decrease the channel in the area where you can't give up more. The other thing is that the maintenance over the life of the project is higher on this kind of structure than on the straight riprap, but it's a balancing of a number of things. I don't remember all the mathematics involved, but it has to be included. So, that's why you find that under most conditions riprap is usually cheaper because maintenance is so much lower. You've got to weigh it out in each of the cases.

DR. MEI: I've noticed from Mr. Outlaw's presentation that you have considered both experimentally and theoretically the super harmonic waves in the short wave range and in the long wave range. And it seems that you must have used the so-called linearized theory where the finite amplitude effect has not been accounted for. But we know that the incoming sea has some sort of band with it, of course. We know also that in narrow banded incoming sea, because of the nonlinearity, the difference frequency can induce long wave setdown and setup. The long wave setdowns and setups may be second order outside the harbor, but once they enter the harbor the resonant mechanism can occur such that these small, long waves from the outside can be much amplified.

In fact, there is a similar kind of phenomenon existing in offshore structures where the moored ships can be excited to large amplitudes but with long period because of this sort of difference frequency through narrow banded seas. These are the slow drift oscillations which are of a great deal of importance to dynamic positioning of submersibles and so forth. I mention this because this kind of nonlinear mechanism of harbor resonance is being studied at the Massachusetts Institute of Technology (MIT) by my group. I would think that with your experimental setup it would be interesting and useful research to propagate, with your present harbor geometry, waves with two frequencies and see whether you can excite large amplitude long waves inside with practically no long waves outside. You mentioned in particular that for this kind of long wave you don't generally get very much energy from an incident wave spectra. But through these nonlinear mechanisms there's a distinct possibility that you can get long waves. Given that the whole project costs $9 million dollars, perhaps a few weeks of extra effort at CERC might be pretty worthwhile. I think it would be very interesting.

MR. OUTLAW: We looked at the prototype data and compared periods of increased long period surge waves. We compared the surge waves with the storm wave conditions that were recorded at Farallon Island. They correlate fairly well, in that periods of higher surge waves are occurring during the same time as increased storm wave energy, and we feel that the surge energy that we are observing really is coming out of the breakup of the wave spectrum as it comes through the Golden Gate. What we're really seeing is the long period portion of the wave spectra propagating into Fisherman's Wharf. We are modifying wave generators now so that we can generate a wave spectrum where we can test the wave spectrum itself and expect to see the long waves generated in the spectra from that.

DR. MEI: *Through this nonlinear mechanism, is it not possible to have a big storm in order to have long waves inside?*

MR. OUTLAW: Yes. Also the graphs that I showed were from a fairly shallow area, around 15 ft, which does cause the wave amplitude to build up in comparison to even the 60-ft water depth near the municipal pier. They show up better in the 15-ft depth.

DR. LE MÉHAUTÉ: The long wave is not the problem unless it is a very small boat.

MR. OUTLAW: It's somewhat a problem because of the way the fishing boats are moored and a number of boats are rafting off each other. Normally you think of long waves as being a problem for floating docks in marinas. In this case there is a long wave problem from the way the boats are moored. Normally you wouldn't really expect fishing boats to be susceptible to resonant oscillation.

DR. MEI: This is precisely the reason why the slow drift oscillation is of interest to the Naval architect in that the mooring lines of a moored boat usually have very long natural frequencies. Even though you have little long wave energy in the harbor, it can put extra strain in the mooring line. So, from what you say, it is really of interest to look at long waves on small fishing boats as well.

MR. OUTLAW: In this particular case it is of interest. Let me say that in the Los Angeles and Long Beach Harbors were we do have large commercial ships, and they certainly do seem to be affected by the phenomenon you've just described. We have a study for the Harbor, and that will be part of what we look at.

DREDGED MATERIAL DISPOSAL MANAGEMENT PROGRAM FOR THE SAN FRANCISCO BAY AREA

CERB Proceedings

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ABSTRACT

This document describes the scope and conduct of the Dredged Material Disposal Management Program (DMP) for the San Francisco Bay area. The program will result in (1) identification or confirmation of suitable disposal site(s) for aquatic disposal of sediments dredged from San Francisco Bay, (2) a review and modification of regional disposal evaluation procedures, and (3) specification of management measures to enhance dispersion of discharged material.

BACKGROUND

Prior to 1972, material dredged from San Francisco Bay was disposed of at 11 known aquatic disposal sites within the Bay, and probably several undocumented sites as well. In 1972, the US Army Corps of Engineers (Corps) decided to limit dredge disposal activities to five sites within the Bay to provide for better regulatory control and decrease the dispersion of dredged material throughout the Bay. In 1978 the Corps further limited disposal to three sites in the Bay (Figure 1). The change was initiated to (1) locate all disposal in areas of high current energy to enhance dispersion of the material, (2) locate the sites as close to the ocean as possible to enhance transport to the ocean, and (3) localize potential disposal impacts.

Monitoring of disposal operations conducted as part of the San Francisco Bay Dredge Disposal Study (US Army Engineer District, San Francisco (SPN), 1977) indicated that maintenance dredged material discharged at these three

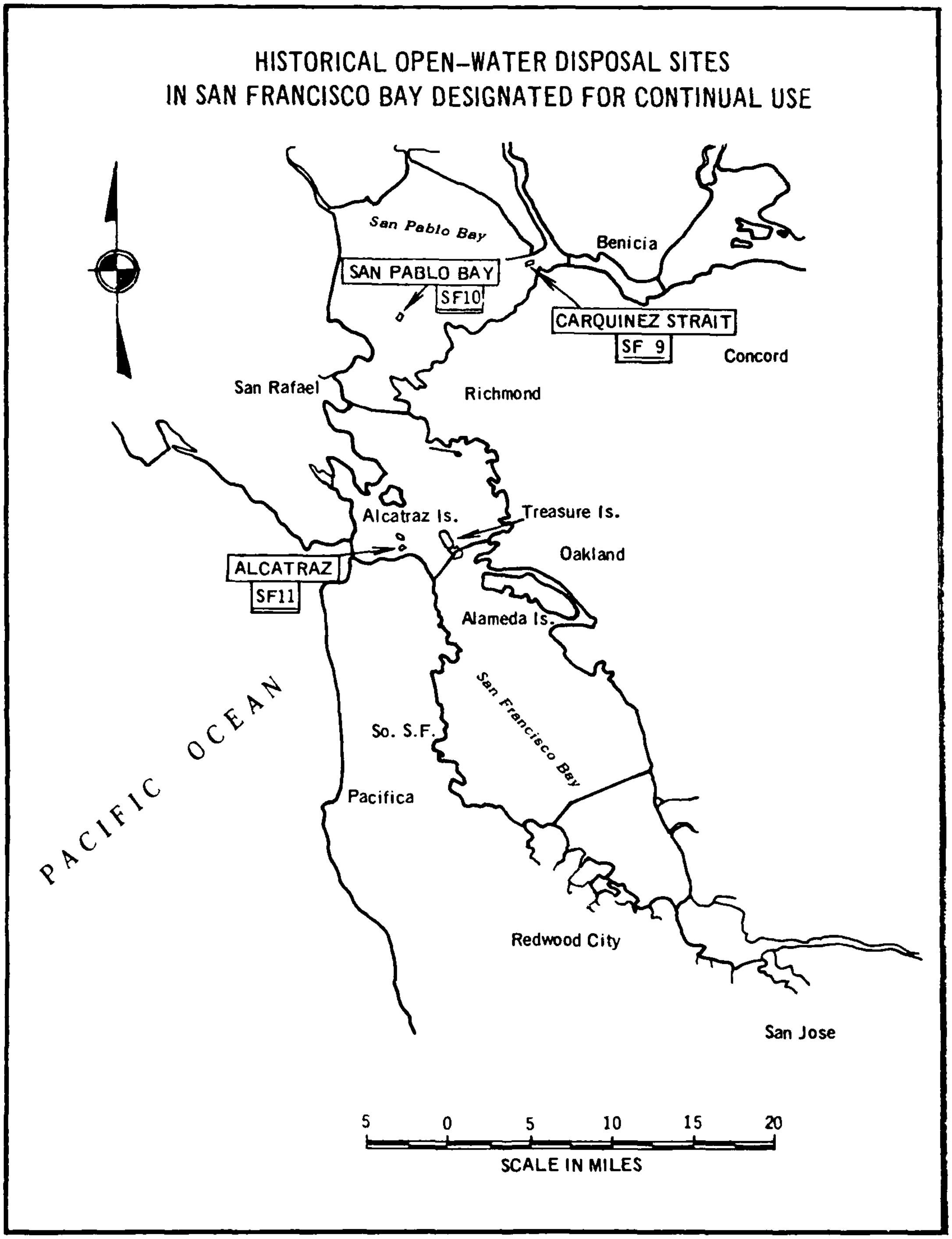


FIGURE 1. DESIGNATED DISPOSAL SITES

sites would be quickly dispersed by tidal currents. The three disposal sites and the approximate ongoing annual discharge quantities for each site are listed in Table 1.

TABLE 1
ANNUAL DISCHARGE QUANTITIES AT THREE
DESIGNATED DISPOSAL SITES
(in million cubic meters)

Disposal Site		Corps Maintenance	Private Sector
SF-9	Carquinez Straits	1.5	0.4
SF-10	San Pablo Bay	0.2	None
SF-11	Alcatraz	1.0	1.5
		TOTAL ANNUAL DISCHARGE = 4.6 M m^3/yr	

In November 1982, a subsurface mound was detected in the eastern portion of the Alcatraz disposal site (Figure 2). The top of the mound was approximately 8 m below mean lower low water (MLLW). Initial investigation by SCUBA divers indicated the presence of consolidated sediments, concrete, and debris on the surface of the mound. The findings suggested that unauthorized disposal of concrete and debris had armored sediments disposed of at the site and was preventing their dispersal. The presence of the mound conflicted with the Corps' previous assumptions of the dispersive capacity of the site. The mound posed an immediate potential hazard to deep-draft vessel navigation, and a long-range problem of diminished site capacity.

Subsequent to the discovery of the mound, bathymetric surveys were performed periodically of the entire site to determine if the mound would persist or be eroded by the swift tidal currents of up to 142 cm/sec (Winzler and Kelley, 1985). By May 1984, limited erosion had reduced the top of the mound to 9 m below MLLW where it still posed a potential threat to navigation. The mound was dredged to -12 m (MLLW) in July 1984 to remove the navigation hazard.

Twenty-seven metric tons of debris on the mound was removed to an upland location. Thirty-four thousand cubic meters of predominantly fine sediments was also dredged and redischarged in the western half of the site. It

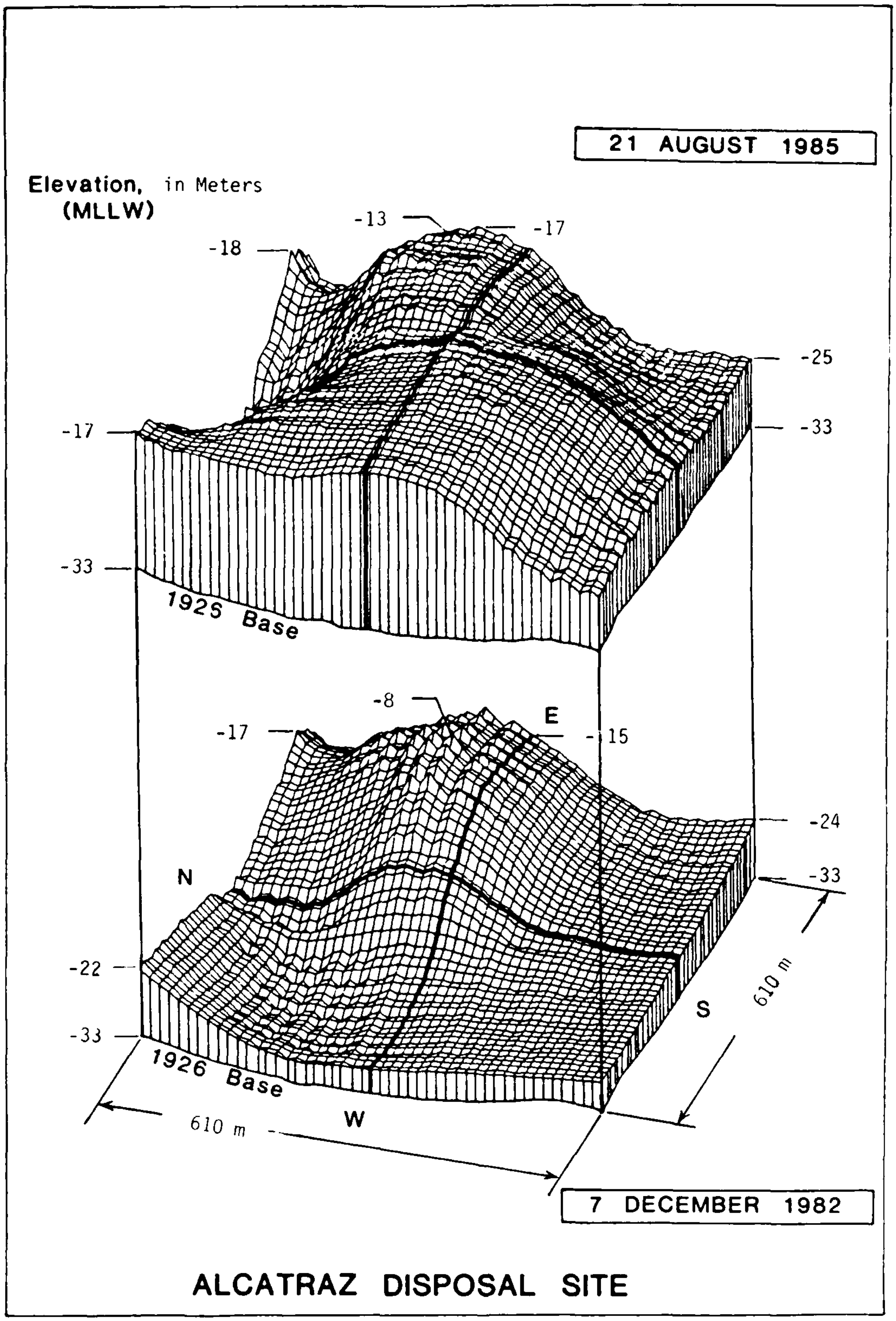


FIGURE 2. THREE-DIMENSIONAL GRAPHIC ILLUSTRATION OF THE ALCATRAZ MOUND

appeared from visual observations that the majority of the dredged sediments consisted of highly plastic clay. The mounding of discharged sediments, if allowed to continue, could critically limit disposal options within San Francisco Bay for new and existing dredging projects of the private sector, the US Navy, and the Civil Works program of the Corps. In recognition of the potential severity of the shoaling problem, SPN initiated the Dredged Material Disposal Management Program (DMP).

INTERIM POLICY

An interim disposal management policy was implemented in November 1984 (and revised in February 1985) to regulate disposal activities until the DMP is finalized. The revised interim policy is included as Appendix A. The policy, which applies to both the Corps and private dredging, requires that all new work dredged material be discharged as a homogeneous slurry to enhance dispersion. Periodic bathymetric surveys of the three San Francisco Bay disposal sites will be performed also.

The composition of an acceptable slurry is to be based on a project specific basis determined by the geotechnical index properties of the sediments. Static tank tests of dredged sediments conducted as part of previous work (SPN, 1979a) suggested that the liquidity index might be a suitable indication of the mounding potential of disposed sediments. The liquidity index is defined by the following equation:

$$L.I. = \frac{W - P.L.}{L.L. - P.L.}$$

where

L.I. = liquidity index

W = percent moisture content

P.L. = plastic limit

L.L. = liquid limit

Figure 3 presents a graph of the height of mounded material as a function of the liquidity index. Based on the limited data available, it appears that mounding is reduced at a liquidity index of 4.5 or greater. To reduce the mounding potential, the interim policy requires that the water content of the slurry for all new work dredging projects must be adjusted to achieve a liquidity index of 4.5 or greater.

MAXIMUM MOUND HEIGHT VS LIQUIDITY INDEX

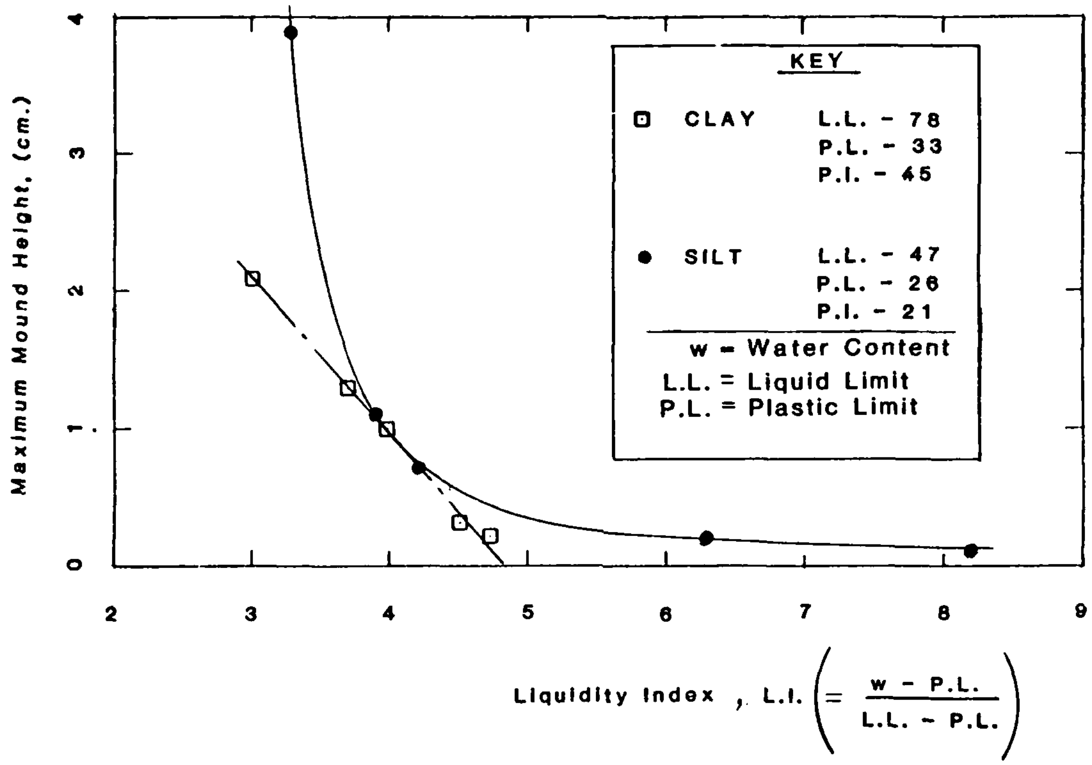


FIGURE 3. LIQUIDITY INDEX

However, the data to support the mounding/liquidity index relationship is limited. Further data will be collected and the apparent relationship refined as part of the DMP.

The interim policy also provides for periodic bathymetric monitoring of each of the three existing disposal sites, monthly at the Alcatraz site and in conjunction with disposal activities at the remaining two sites in the Bay. The interim policy will be in effect and revised as needed until the ongoing site studies are completed, the results evaluated, and a comprehensive management strategy for aquatic disposal in San Francisco Bay can be developed and implemented. The DMP has been initiated to develop that management strategy.

SCOPE AND OBJECTIVES OF THE DMP

The scope of the DMP encompasses the activities related to disposal of dredged material in the San Francisco Bay region, including Carquinez Straits, San Pablo Bay, Central San Francisco Bay, South San Francisco Bay, and ocean waters offshore of San Francisco to the 185-m contour. Construction material waste, debris, fill material, and effluent discharges are not considered within the scope of this investigation.

The purpose of the DMP is to establish an effective management program for disposal of sediments dredged from San Francisco Bay. The following section describes the three major components of this long-term dredged material disposal management program.

Suitable Bay and Ocean Disposal Sites

An effort has been initiated to locate other potential disposal sites that could receive some of the sediments now disposed at the Alcatraz site. Field surveys are in progress to document bathymetry, currents, water and sediment quality, and fauna of several ocean and bay sites. When the data collection effort is completed, formal site designation under the Ocean Dumping Act or identification of one or more sites in accordance with the Clean Water Act will be accomplished.

Disposal Evaluation Procedures

Currently the evaluation of chemical and biological impacts of disposed material in San Francisco Bay is specified by the "Supplemental Regional Procedures for Evaluating Discharges of Dredged or Fill Material into Waters of the United States" (SPN, 1979b) (Appendix B), as required by implementation of Section 404 of the Clean Water Act. The procedural evaluation for chemical and biological evaluation for dredged material disposal will be modified to incorporate the results of the present investigation as appropriate. These guidelines apply to waters landward of the boundary of territorial sea. Ocean dumping guidelines for those waters seaward of the boundary are presented in 40 CFR 225 and 227. Any modifications that may be made to the ocean dumping regulations during the course of this investigation will be incorporated into the management policies as appropriate.

Site Management Policies

Formulation of management policies will address (but will not be limited to) the following factors:

(1) Specific physical characteristics of the disposal site

(2) Source, type, and volume of dredged material

(3) Rate of dredged material disposal

(4) Type of dredging equipment

(5) Form of dredged material during disposal

(6) Conformance with chemical and biological criteria

(7) Location of disposal within the specified disposal site

(8) Bathymetric monitoring responsibilities

(9) Reporting responsibilities

(10) Purpose of dredging activity (i.e., new work, maintenance, emergency)

(11) Timing of disposal activity

SYNOPSIS OF COMPONENT ACTIVITIES

The development of the overall DMP consists of the component activities described below.

Project Management

This activity consists of the ongoing management, coordination, and administration of the activities contributing to the DMP.

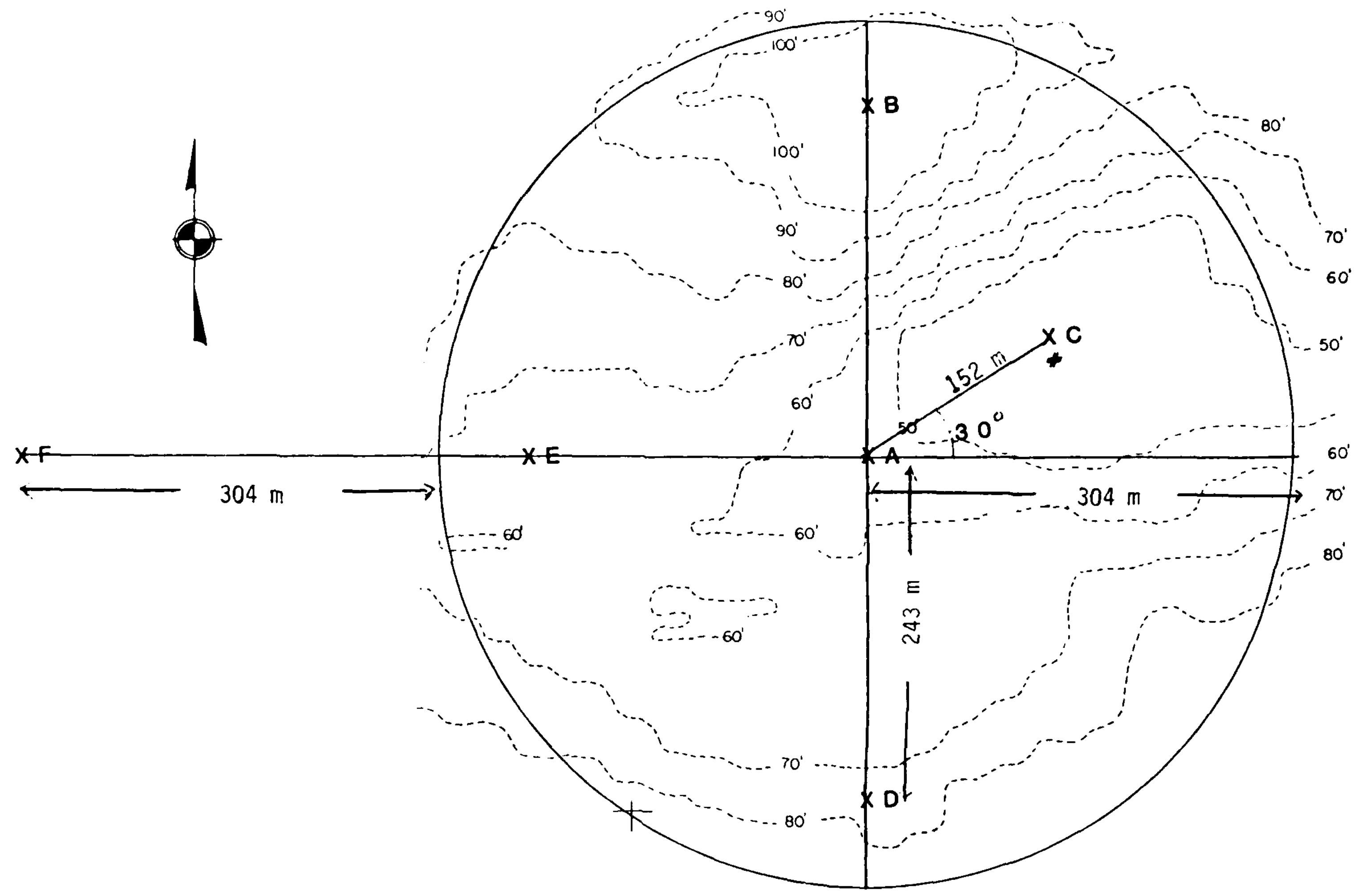
Alcatraz Current Study

For five days in July 1985, Winzler and Kelley, under contract to the Corps, placed current meters at seven locations (Figure 4) at the disposal site at three depths (near surface, midwater column, and near bottom). Readings were taken every 15 min for the entire five days which included a spring tide. The measurements indicated that current speed is strongly correlated with tidal range; the greater the range, the higher the maximum speed. Flow direction at all stations is generally east-west. The highest near surface speed encountered was 142 cm/sec at Station C, the shallowest station, and the highest near-bottom speed was 109 cm/sec, also at Station C. The data from this effort will be used in the development of a sediment transport model for the site and will be useful in developing a specific site management plan.

Bathymetric Monitoring at Existing Bay Disposal Sites

Periodic hydrosurveys have been performed at the Alcatraz site and will continue throughout the DMP. Volume estimates computed from the surveys between January and August 1985 indicate that the volume of material within the present site boundaries has increased on the average of 38,000 cu m per month. The total increase in volume from the time the accumulation was discovered and August 1985 is just under 1.5 million cubic meters.

Volume calculations are now being made for the area within a 610-m



X = current meter

✚ = wave gauge

FIGURE 4. LOCATION OF CURRENT METERS AT ALCATRAZ MOUND

radius of the site center to monitor sediment accumulation in the vicinity as well. The volume of material within the circle increased by 22,000 cu m between July and August 1985.

Hydrographic surveys for the other two disposal sites in the North Bay were completed in July 1985. Data were compared with previous hydrosurveys performed in conjunction with maintenance dredging activities at the two north bay sites, March 1984 at SF-9 and May 1983 at SF-10. The data indicated that approximately 116,000 cu m of material accumulated at SF-9, and approximately 6,400 cu m accumulated at SF-10. Additional data collection is necessary to determine whether or not the accumulations are significant or represent a normal variation of sediment transport for the sites. Bathymetric surveys will be performed prior to and upon the completion of all discharge activities at the sites to ensure early mound detection.

Composition of the Alcatraz Mound

A drilling effort was undertaken during July 1985 to determine the composition of the mounded material at the Alcatraz site. Analysis of the boring logs indicates that disposed material is mounded up to 37 m over the original Bay bottom. The most recently deposited material is an intermixed and interlayered sand and highly plastic clay and forms a layer up to 10 m thick. This material overlies a more consolidated layer of older dredged material composed primarily of clays. Beneath the older dredged material, natural dense sands and stiff clays were encountered.

Flume Test

A physical test has been designed by the US Army Engineer Waterways Experiment Station (WES) to determine the critical sheer stress for erosion and the erosion rates for the material mounded at the Alcatraz disposal site as well as from different project locations in San Francisco Bay (Trawle, in preparation). These sediments will be tested in annular, straight, and rocking flumes in the in situ condition. The samples will then be reworked to different water contents to assess the erosion rates of various slurry mixtures. Results from the test should help define an acceptable slurry for material disposed at the Alcatraz disposal site.

Studies at Alternate
Candidate Bay Disposal Sites

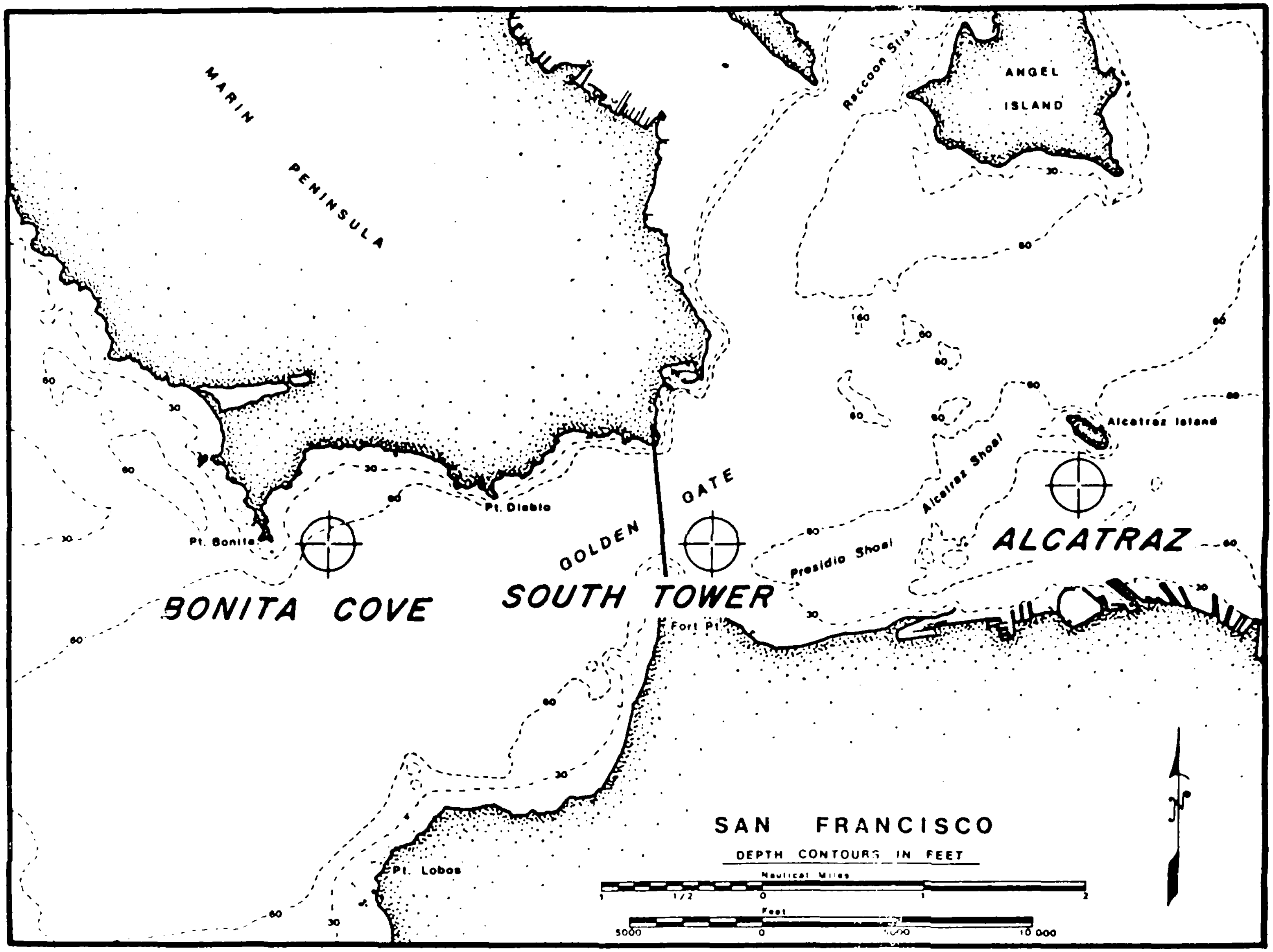
A preliminary model study using the San Francisco Bay Tidal Hydraulic Model examined areas near the Golden Gate to find potential new locations for dredged material disposal (SPN, 1984). The results indicated that two sites might be appropriate for this use: Bonita Cove and South Tower. The two sites were selected because they appeared to have net ebb flow which would carry most of the material out to the ocean (Figure 5). Field studies were undertaken in October 1984 to investigate the two sites. Current measurements were taken, and biological sampling was performed during two seasons to establish baseline data on the two sites and the existing site at Alcatraz for comparison (Goddard, et al., 1984). Initial current monitoring indicated that favorable currents of up to 86 cm/sec exist at the South Tower site. Currents at the Bonita Cove site are slower (maximum currents equal 44 cm/sec) than at the other two sites. Currents at the Bonita Cove site move in the ebb direction 68 percent of the time compared to 54 percent at South Tower and 41 percent at Alcatraz. Currents at the Alcatraz site are the fastest of the three, but they appear equally distributed between ebb and flood directions. Both the Bonita Cove and South Tower sites appear valuable as fish habitat. Because of the high fish use of these two specific sites, supplemental field current sampling is required to identify maximum current conditions at other locations. Other sampling tasks include bathymetry, sediment particle size, sediment and water chemistry, bottom grabs, and midwater and bottom trawls to establish baseline conditions at alternate sites.

Sediment Transport

This study comprises a major activity of the overall DMP. The sediment transport study will initially investigate the movement of sediments discharged at the Alcatraz disposal site. It will involve a mathematical sediment transport model to address immediate concerns of mounding at the Alcatraz disposal site. Also envisioned is the expansion of the model to include North and South Bays. The model to be used is the WES TABS-2, a two-dimensional model. Current data obtained in the field will be used in the development of the sediment transport model.

Site Designation Report

Depending upon the results of the related studies listed above, new disposal site(s) may be designated, or a set of conditions for disposal will be specified. If this occurs, appropriate actions will be taken to ensure compliance with applicable laws and regulations (National Environmental Policy Act; Advanced Identification of Suitable Disposal Sites, 40 CFR 230.80, consistency determination with the applicable state coastal plan, etc.) and to



Source: Goddard, Stevenson, and Dillingham, Kennetics Laboratories, Inc., Moss Landing, Calif., 1984

FIGURE 5. ALTERNATE CANDIDATE BAY DISPOSAL SITES

coordinate with the interested public and responsible agencies. Environmental documentation will be prepared for any site designation(s) or disposal activity as required.

Determination of Consistency for Maintenance Dredging in San Francisco Bay with the Coastal Zone Management Act

A determination on consistency with the San Francisco Bay Plan will be prepared for Federal maintenance dredging projects for the period of 1986 to 1990. No changes to the maintenance dredging practices are advisable at this time. Disposal may be directed to the western half of the Alcatraz site.

RELATED STUDIES

Mathematical Model

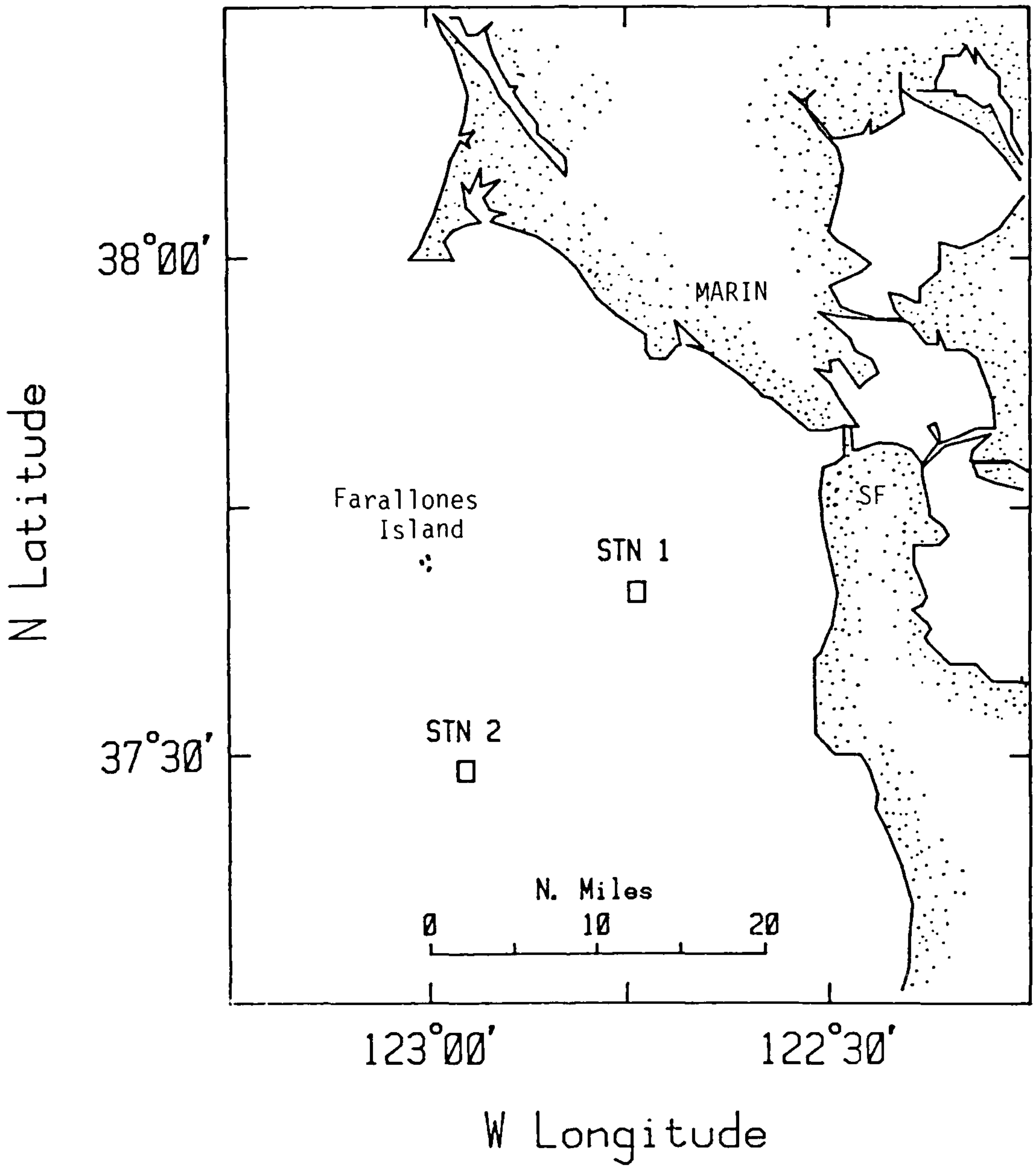
WES is using the mathematical dump model, Disposal from Instantaneous Dump (DIFID) (Johnson, in preparation), to simulate the convective descent, dynamic collapse, and initial deposition phases of hopper dredge dumped material. Boundary conditions will be provided by current studies at the Alcatraz disposal site as well as from physical analysis of potential dredged sediments. Results of these studies will be used in development of the sediment transport model for the site.

Ocean Disposal Site Designation

In 1982, baseline field studies of two potential disposal sites located southwest of the Golden Gate Bridge were completed (Nybakken et al., 1982). The first proposed site (Station 1) is located in 46 m of water, and the second site (Station 2) is in 182 m of water (Figure 6). Both sites have environmental limitations. Site 1 is heavily populated by flatfish and is an important area for the dungeness crab fishery. Site 2 supports an active rockfish fishery. Further assessment of additional alternate sites will continue during 1986 followed by the preparation of an Environmental Impact Statement (EIS) for site designation.

Review of Disposal Alternatives to Unconfined, Open-Water Disposal

Existing available information related to land disposal opportunities will be reviewed. In addition, the logistics of sand reuse opportunities will be considered.



Source: Baseline Survey and Site Selection for Ocean Disposal, Gulf of the Farallones Nybakken, et. al., Moss Landing Marine Laboratories, 1982, for USACE

FIGURE 6. OCEAN DISPOSAL SITES UNDER STUDY

South Bay Unconfined, Open-Water Sites(s)

A review of existing literature, cost evaluations, and survey data will be undertaken in 1987 to determine the feasibility of using an additional site in South San Francisco Bay for dredged material disposal. If the review indicates such an action is feasible, a baseline field study will be proposed.

STUDY OUTPUTS

A technical report will be issued upon the completion of each major study component. Ongoing monitoring activities will be logged, recorded, and summarized over the 1985 to 1988 period of data collection.

A policy formulation document will be prepared during late 1988. All information collected in the technical reports and annual monitoring data will be summarized and appropriate management policies established. The technical reports will be referenced as appendices to the policy formulation document.

Individual EIS's for new disposal site identification and designation will be prepared as appropriate. Presently, two EIS's are scheduled. The scheduled EIS's are associated with the potential designation of a suitable ocean disposal site and/or potential alternative site(s) in San Francisco Bay. Determination of need for EIS's for other site identification and designation may be made during the course of the component studies.

SUMMARY

Policy Formulation

The interim management policies for dredged material disposal will be revised to reflect input from the various overall study components as they are completed and evaluated. It is expected that after the individual component studies are completed and base data from the bathymetric monitoring is evaluated, the finalization of a set of management policies for disposal of dredged material in San Francisco Bay can be accomplished. Because of the dynamic formulation process, a final document summarizing all component studies and monitoring data and formalizing the revised interim management policies that may be in effect at the end of the period of this investigation will be prepared (Figure 7).

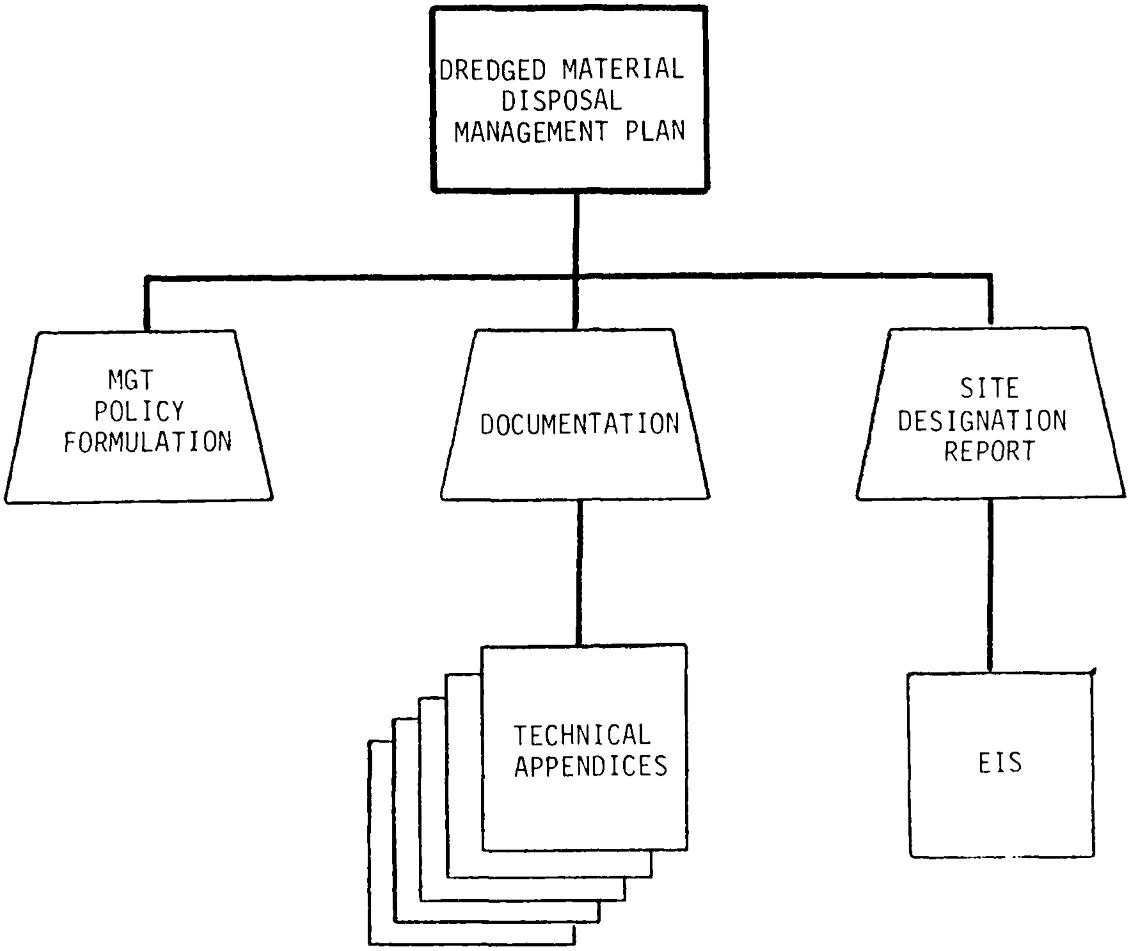


FIGURE 7. OUTPUTS

ACKNOWLEDGEMENTS

Due to the broad range of subjects being investigated by the overall program, the following SPN staff members have contributed to specific study tasks: Mr. Ron Farmer, Civil Engineer, developed the liquidity index relationship from existing data obtained during the 1973 Dredged Disposal Study testing, and Mr. Gary Rodgers, Civil Engineer, developed the three-dimensional illustration of the Alcatraz mound. Mr. Roger Golden, Environmental Resource Planner, the principal manager for the North Bay work unit, is developing the data base of material accumulation at the two North Bay disposal sites. Ms. Margaret C. Hooper, Civil Engineer, is the principal manager for the ocean disposal site designation work unit.

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DISCUSSION

BG ROBERTSON: *I recently attended a wetlands conference in Seattle and heard about a test in San Francisco to create saltwater marshes with dredged material. Is saltwater marsh creation using dredged material still of interest in the San Francisco Bay area?*

MR. TONG: Currently there is an institutional constraint on filling any part of the Bay. The Bay Conservation Development Commission governs fill operations in the San Francisco Bay. The only candidate areas for wetland restoration that would not diminish the water surface area of the Bay are areas behind dikes, and these areas are sensitive.

MR. MASON: Acoustic devices such as high-frequency sonar could be used to record the path of the dredged material cloud after the material is released in water. The same type of instrument could be used to monitor the bottom bathymetry.

DR. KRAUS: CERC is putting four sediment traps much like those described during the DUCK-85 presentation in the La Jolla Submarine Canyon to monitor sediment transport. Similar traps might be of use to your project.

MR. LOCKHART: *Have you talked with CERC or the Hydraulics Laboratory about their hydrodynamic models? Are these existing models at CERC or the Hydraulics Laboratory for the application you require?*

MR. TONG: We have talked with Mr. Mike Trawle of the Hydraulics Laboratory about using a model developed by RMA Corporation. We are considering use of this two-dimensional model.

MR. OLIVER: We are considering using one of CERC's numerical models in the Cook Inlet area to look at sediment transport. Your problem appears similar to ours in Cook Inlet. We also have used Dr. Ray Krone, University of California, several times as a consultant on models to use for this type of sedimentation problem.

MR. TONG: Yes, he is definitely a person we would like to consult.

NOYO RIVER AND HARBOR, CALIFORNIA
DESIGN FOR WAVE PROTECTION

Mr. Robert R. Bottin, Jr.
Civil Engineering Technician
Coastal Engineering Research Center

Mr. Douglas G. Outlaw
Research Hydraulic Engineer
Chief, Wave Processes Branch
Coastal Engineering Research Center

ABSTRACT

Noyo River and Harbor, located approximately 135 miles north of San Francisco, California, shelter a small-craft fishing fleet. Access is through the shallow, dredged river entrance which is protected by jetties. Additional breakwater protection is needed, and studies currently are in progress at the US Army Engineer Waterways Experiment Station's Coastal Engineering Research Center. A 1:75-scale hydraulic model is being used to reconcile adequate wave reduction in the entrance while preventing conflict of the new structures with operations of Coast Guard rescue vessels stationed there. This presentation describes various project proposals and test results to date.

INTRODUCTION

The Prototype

Noyo River and Harbor are located on the California Coast in Mendocino County, approximately 135 miles north of San Francisco and 87 miles south of Eureka. The shoreline in the locality consists of broken, irregular cliffs about 40 to 80 ft high with numerous rocks extending several hundred yards offshore. Small pocket beaches are found at the heads of coves in the immediate vicinity. The Noyo River empties into Noyo Cove which is approximately 1,800 ft wide, north to south, and 2,000 ft long, east to west.

The existing Noyo River and Harbor project was authorized by the River and Harbor Act of 1930 (US Army Engineer District, San Francisco (SPN), 1979), and construction was completed in 1961. It consists of a jettied entrance at the river mouth; a 10-ft-deep, 100-ft-wide entrance channel; and a 10-ft-deep, 150-ft-wide river channel extending upstream about 0.6 mile. Noyo Harbor is located on the south bank of the river at the upstream limit of the dredged river channel. Also further upstream, approximately 1.1 miles from the river mouth, a privately owned harbor, Dolphin Cove Marina, is located on the south bank. An aerial photograph of the area is shown in Figure 1.

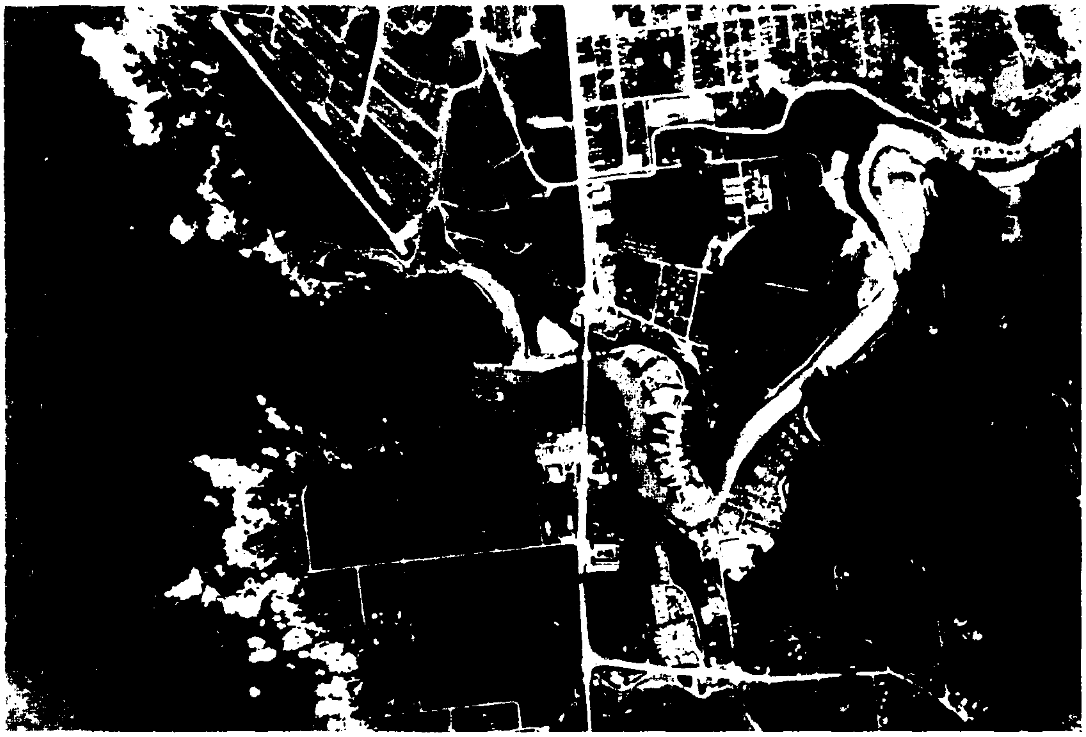

FIGURE 1. AERIAL VIEW OF PROTOTYPE SITE

The Problem

Noyo Cove is open to the Pacific Ocean and exposed to large waves generated by local coastal storms accompanied by strong winds (sea) and distant ocean storms without local winds (swell). Waves in excess of 20 ft in height approach the cove from the southwest clockwise through northwest directions. Heavy seas sweep across the cove and through the jettied river entrance, making it impassable for entry or departure during these periods. In addition to these adverse wave conditions, the harbor has experienced strong surging problems due to long-period wave energy resulting in damages to small craft moored there. Shoaling in the river channel is experienced also due to the deposition of material brought down the river during the winter rainy season. This shallow river channel results in navigational difficulties, particularly upstream of Noyo Harbor. Vessels are subject to damage by grounding and are forced to wait for favorable tide conditions to provide adequate depths.

Improvements at Noyo River and Harbor would result in prevention of boat damage, a harbor of refuge for vessels during storm activity, increased recreational boating, and area redevelopment. Potential commercial benefits would include increased lumber processing (barging of wood chips to Eureka and barging of finished lumber to Los Angeles) and commercial fishing (increased fish catch).

Proposed Improvements

Authorization of improvements at Noyo River and Harbor was granted by the River and Harbor Act of 1962. Under this authorization, however, breakwaters were proposed to protect the outer cove for development. The breakwaters required were not economically feasible due to the high cost of construction and maintenance, resulting in the project's being transferred to an inactive category. The Water Resources Development Act of 1976 modified the 1962 project to provide for construction of up to two breakwaters without a specific location to protect the harbor entrance (SPN, 1979). The location of breakwaters in more shallow water would reduce construction costs significantly. The 1976 Act also included additional channel improvements (deepening, widening, and extending) as deemed necessary to meet applicable economic and environmental criteria.

Purpose of the Model Study

At the request of SPN and the US Army Engineer District, Los Angeles (SPL), a hydraulic model investigation was initiated by the US Army Engineer Waterways Experiment Station's (WES's) Coastal Engineering Research Center (CERC) to:

(1) Study short-period and long-period wave conditions and river flow conditions in Noyo River and Harbor.

(2) Determine the most economical breakwater configuration that would provide adequate wave protection to the entrance.

(3) Provide qualitative information on the effects of the breakwaters on sediment moving down the river.

(4) Develop remedial plans for the alleviation of undesirable conditions as found necessary.

THE HYDRAULIC MODEL

Design of Model

After consideration of the factors on which scale selection is based, the Noyo River and Harbor model was constructed to a scale of 1:75, model to prototype. The model then was designed and operated in accordance with

Froude's model law (Stevens, et al., 1942). The scale relations used were as follows:

Characteristic		Model:Prototype Dimension*	Scale Relations
Length	L		$L_r = 1:75$
Area	L^2		$A_r = L_r^2 = 1:5,625$
Volume	L^3		$V_r = L_r^3 = 1:421,875$
Time	T		$T = L_r^{1/2} = 1:8.66$
Velocity	L/T		$V_r = L_r^{1/2} = 1:8.66$
Roughness (Manning's Coefficient, n)		$L^{1/6}$	$n^r = L_r^{1/6} = 1:2.054$
Discharge	L^3/T		$Q_r = L_r^{5/2} = 1:48,714$

* Dimensions are in terms of length and time.

The proposed breakwaters at Noyo included the use of concrete armor units (dolosse). Since the porosity of these units differs from that of rock and since the units could not be reproduced to scale easily (due to time and cost requirements), two-dimensional wave transmission tests were conducted at a scale large enough to have negligible scale effects (i.e., 1:31) to determine the correct transmission through the proposed structures. This transmission then was duplicated at a scale of 1:75 using smaller dolosse and rock cross sections, and the three-dimensional model structures were built accordingly. A view of the 1:31-scale breakwater cross section is shown in Figure 2.

As done in previous investigations at WES (Bottin and Chatham, 1975 and Bottin, 1982), a coal tracer material was selected to qualitatively determine the deposition of riverine sediment (degree of accretion, etc.) at the river mouth. The tracer was chosen in accordance with the scaling relations of Noda (1972), which indicate a relation or model law among the four basic scale ratios (i.e., the horizontal scale, the vertical scale, the sediment size ratio, and the relative specific weight ratio).

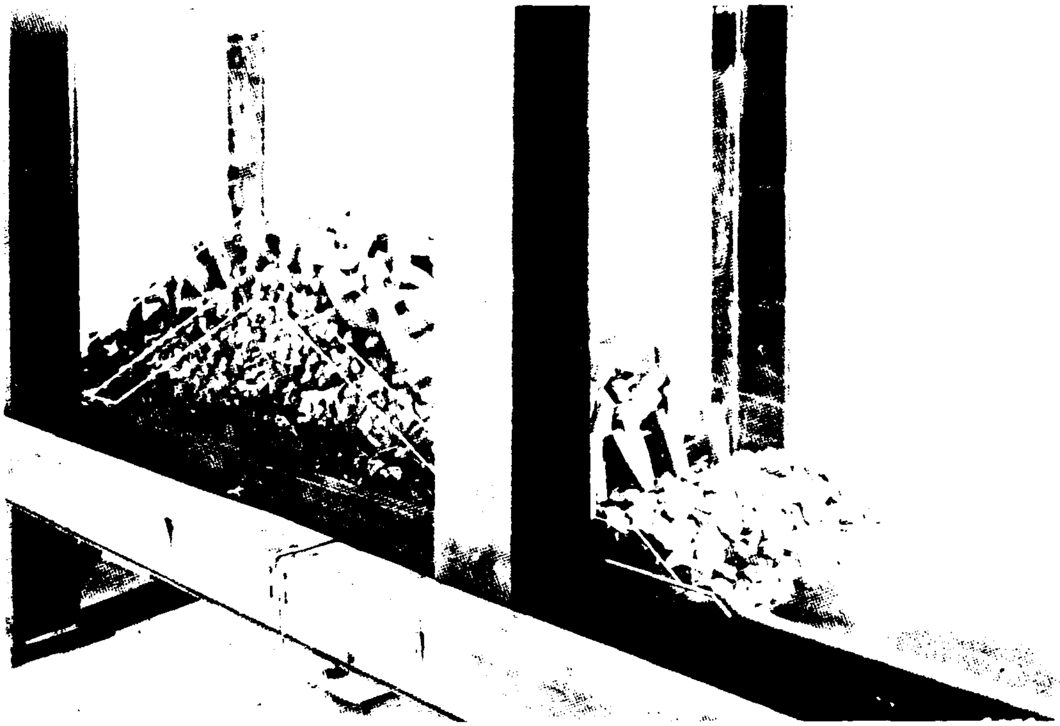

FIGURE 2. 1:31-SCALE TWO-DIMENSIONAL BREAKWATER

The Model and Appurtenances

The model reproduced the lower 15,000 ft of Noyo River, both Noyo Harbor and Dolphin Cove Marina (located on the south bank), Noyo Cove, approximately 5,500 ft of the California shoreline on each side of the river mouth, and underwater topography in the Pacific Ocean to an offshore depth of 60 ft. The total area reproduced in the model was approximately 12,000 sq ft, representing about 2.4 square miles in the prototype. A general view of the model is shown in Figure 3.

The model also utilized a water circulation system to reproduce steady-state riverflows, a 45-ft-long wave machine to generate the required test waves, and an automated data acquisition and control system to secure wave height data at selected locations.

TEST CONDITIONS

A still-water level (swl) of +6.2 ft, representing mean higher high water, initially was selected for use during model testing. During the

FIGURE 3. GENERAL VIEW OF MODEL

conduct of model testing, however, the swl was revised to +7.0 ft, representing a monthly occurrence at the site.

A wave refraction analysis was conducted for the Noyo site to determine changes in wave height and direction as a result of waves moving into water of gradually decreasing depth. The analysis was conducted using the numerical Regional Coastal Processes Wave Transformation Model (RCPWAVE) developed by Ebersole (in press). The shoaling coefficient, a function of wave length and water depth, was calculated using procedures in the Shore Protection Manual (SPM) (1984). These data provided the change in wave height and direction from deep water into shallow water (location of wave generator in model).

Representative deepwater wave hindcast data for Noyo were obtained from the Sea-State Engineering Analysis System (SEAS) by Corson (in press). These data were converted to shallow water values by application of the refraction/shoaling analysis. Waves with periods ranging from 7 to 19 sec and heights ranging from 6 to 32 ft were selected for use in the model for the northwest, west-northwest, west, west-southwest, and southwest directions.

The Noyo River drains an area of approximately 106 square miles. Based on river discharge records during the period 1952-1981, discharges of 7,000 to 41,000 cfs were selected for use in the model. These values corresponded to recurrence intervals ranging from 2 to 100 years.

TEST RESULTS TO DATE

Existing Conditions

Comprehensive wave height tests were conducted for existing conditions for test waves from the five directions. Wave heights ranged up to 15 ft in the entrance channel, and visual observations revealed breaking waves in the entrance for numerous incident wave conditions. Typical wave patterns for existing conditions are shown in Figure 4. Design wave information also was obtained at the proposed structure location to aid in breakwater design. Wave heights in excess of 20 ft were recorded at these locations. Riverine sediment patterns obtained for existing conditions indicated no accretion in the entrance channel due to the existing structures. Each successively larger flow resulted in sediment tracer deposits further seaward in Noyo Cove.

FIGURE 4. 19-SEC, 22-FT TEST WAVES APPROACHING FROM WEST-NORTHWEST FOR EXISTING CONDITIONS

Improvement Plans

Initial improvement plans involved deepening of the entrance channel to -20 and -15 ft depths from the highway bridge seaward to the -20 and -15 ft contours in Noyo Cove. No breakwaters were installed for these plans. Maximum wave heights recorded were 14.8 and 14.5 ft, respectively, in the entrances of the -20 and -15 ft channel depths. Breaking waves also were observed in the entrance for many incident wave conditions.

The original breakwater plan (Figure 5) then was installed in the model and subjected to test waves from all directions. This breakwater represented a 20.2-ft-high, 370-ft-long structure in the prototype. Maximum wave heights of 8.8 ft were obtained in the existing entrance, which substantially exceeded the 4.0-ft criterion established by SPL. The structure length was extended seaward by 75 ft; however, wave heights in the entrance were reduced by only 0.8 ft to 8.0 ft. An additional 300-ft-long breakwater was installed to the northeast in conjunction with the original 370-ft-long structure, but for this plan wave heights in the entrance increased to 9.6 ft.

As an expedient at this point in the investigation, breakwaters in the model were constructed with stone that had transmission coefficients similar

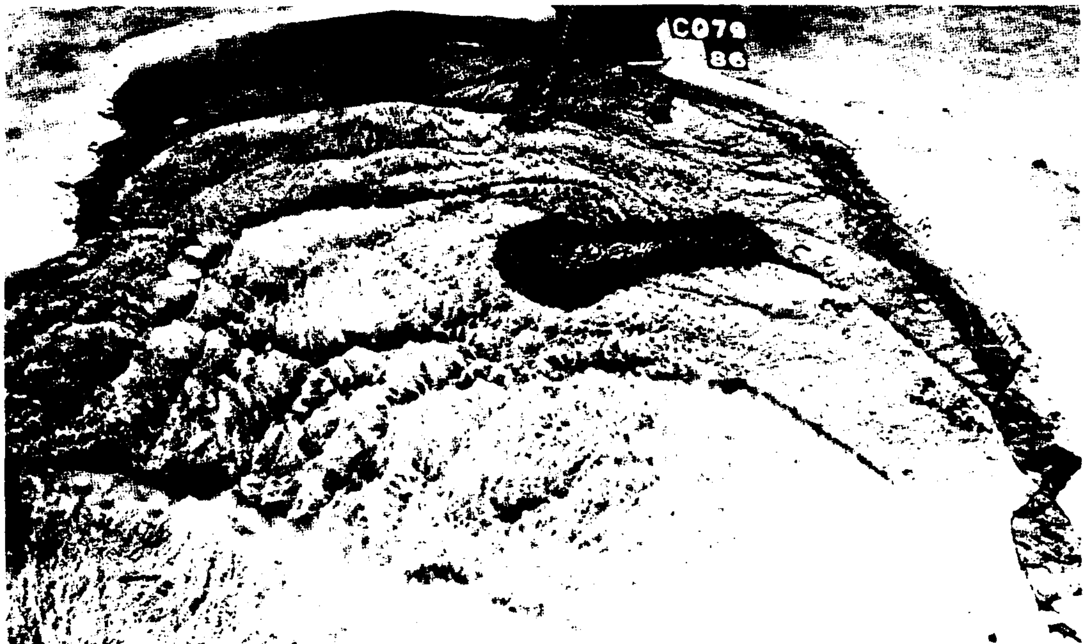

FIGURE 5. 15-SEC, 30-FT WAVES APPROACHING FROM WEST-NORTHWEST FOR THE ORIGINAL BREAKWATER PLAN

to those in the dolos structure. Tests were conducted for 21 rubble-mound breakwater plans with wave heights in the entrance ranging from 3.6 to 8.7 ft. The longest breakwater tested was 1,125 ft. Although some of these plans were promising relative to wave protection, it appeared that navigational difficulties may be experienced.

It was deemed necessary to convene a meeting with US Army Corps of Engineers personnel, representatives of the Coast Guard, and Noyo Harbor users to determine potentially new breakwater configurations. In the interim, CERC personnel removed the proposed structures in the model and initiated long-period wave testing for existing conditions.

FUTURE TESTING PROGRAM

A meeting was held at Ft. Bragg, California, among representatives of SPL. SPN, CERC, the US Coast Guard, and Noyo Harbor users on 10 October 1985. At this meeting, Noyo Harbor users and Coast Guard representatives indicated that they preferred an entrance to the north of the proposed offshore breakwater as opposed to an entrance south of the structure. They also indicated that during extreme wave conditions they could tolerate a 6-ft wave between the existing jetties, provided it was nonbreaking.

After completion of long-period wave tests for existing conditions, an offshore breakwater will be installed in the model which will provide an entrance to the north of the structure. Various lengths and alignments will be tested until an optimum plan is selected considering a 6-ft nonbreaking wave height as the criterion between the existing jetties, for extreme wave conditions. When an optimum plan is selected, sediment tracer tests and long-period wave tests will be conducted to determine if the new structure will have any negative impacts on the movement of riverine sediment in the entrance and the response of the river and harbor to long-period wave conditions.

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DISCUSSION

DR. MEI: *Is there any economic justification to build a long breakwater outside the cove such that the cove area could be used as a harbor?*

MR. OUTLAW: Noyo Cove is a fairly small harbor, and there's sufficient economic justification for the detached breakwater configurations we have looked at, perhaps even the 1,125-ft length.

If the District were to be able to justify a breakwater in the outer region, perhaps a low crested structure would be as a harbor of refuge to provide protection against summer storms and not winter storms. Probably the economic justification just isn't there for a more extensive project.

BG KELLY: *How long does it take to set one of these detached breakwater configurations up and actually go through each one of these experiments?*

MR. OUTLAW: About two a day under the hasty plan. Building the design breakwater structure takes about a day. But the test then takes about a half day.

BG KELLY: *Can you numerically model this?*

MR. OUTLAW: No. Numerical tidal circulation modeling is advanced quite well. There are numerical models of short period waves for harbors of this type; but we really still have a problem with transmission, with reflection off boundaries, and with representation of the actual topography in the models. It requires very small grids, and the results are questionable. The linear models really can't handle wave breaking in the entrance, and they're just not advanced to the point where they can be used in this application.

COASTAL STORM OBSERVER PROGRAM

Mr. George W. Domurat
Oceanographer
Navigation and Coastal Planning Branch
South Pacific Division

ABSTRACT

In September 1985 the US Army Engineer Division, South Pacific, in cooperation with the State of California Department of Boating and Waterways, initiated a prototype test program to observe and document coastal erosion events during intense winter storm activity. This experimental program intends to rapidly mobilize observer teams to five primary sites along the California coast when storm activity exceeds established criteria maximizing the probability for coastal erosion and shoreline damages. Various observations will be recorded, such as wave and wind climate, beach width measurements, nearshore bathymetric surveys using coastal piers as observation platforms, water level changes, and ground photography. Information derived from these observations will be used to supplement other coastal monitoring programs in enhancing our knowledge of shoreline changes associated with intense winter storms.

INTRODUCTION

The protection of California's sensitive coastal resources is of primary importance to both the US Army Corps of Engineers (Corps) and the State of California. As such, the task of proper management and preservation of this unique resource can be accomplished only through full and effective planning, engineering, monitoring, and regulation of all coastal zone activities. Data collection efforts in the coastal zone are critical to increasing our coastal awareness necessary for effective planning and design. The Corps' and the states' coastal staffs rely heavily on existing data collection programs to accomplish these goals.

However, present data collection efforts fail to provide information on extreme coastal erosion events. Significant shoreline modifications are often masked by periods of poststorm beach rebuilding after storm passage. Documentation of these changes can significantly enhance our knowledge of coastal processes during intense winter storm activity.

The purpose of this paper is to present a cooperative statewide program mobilizing beach erosion observer teams to document short-term coastal storm events. A prototype test program has been established for the winter of

1985-1986; observations will occur at locations in both northern and southern California.

CRITERIA FOR MOBILIZATION

In order to mobilize and deploy observer teams into the field only during extreme events, a trigger mechanism alerting the Corps to potential storm damage had to be developed.

Flick and Cayan (1984) have shown coastal damages (in excess of $100,000,000) and shoreline erosion such as that experienced along the California coast during the winter of 1982-1983 to be coincident with extreme water levels made up of high astronomical tides, higher than normal sea levels, and storm-induced wave energy. The exceedance criteria for the "mobilization trigger" parameters are described below.

For the Coastal Storm Observer Program (CSOP), predicted astronomical tides in excess of +6.5 ft mean lower low water (MLLW) during the winter months were determined to yield the highest probability of producing extreme erosional episodes if intense storm-induced wave energy is coincident. Table 1 summarizes these potential "beach erosion windows" for 1985-1986. These data were obtained from the 1985-1986 high and low water predictions published by the US Department of Commerce, National Oceanic and Atmospheric Administration.

Along with the extreme water level criteria, wind direction and magnitude, barometric pressure, and storm track information will be obtained from the National Weather Service and provided to the staff meteorologist at US Army Engineer District, Los Angeles (SPL). He will attempt to forecast potential significant storm events based on all available observations and alert SPL's CSOP representatives.

However, the most critical component affecting local beach erosion is the storm-induced wave energy. Extreme wave event summaries for the winters of 1977-1978 (Domurat, 1978) and 1980-1983 (SPL and State of California, 1984), as presented in Table 2 and Figure 1, show that the major storms during these periods causing beach loss and structural damage had significant wave heights greater than 10 ft with wave periods greater than 10 sec. Evaluation of these data led to the wave climate exceedance criteria at wave heights greater than 10 ft.

TABLE 1
DATES OF TIDE LEVELS EXCEEDING 6.5 FT FOR 1985-1986 WINTER SEASON*

Date	Tidal Range (ft)	Date	Tidal Range (ft)
11-10-85	6.6 TO -0.5	01-09-86	7.5 TO -2.0
11-11-85	7.2 TO -1.2	01-10-86	7.5 TO -2.0
11-12-85	7.5 TO -1.6	01-11-86	7.3 TO -1.8
11-13-85	7.6 TO -1.7	01-12-86	6.9 TO -1.3
11-14-85	7.4 TO -1.5	01-24-86	6.5 TO -1.0
11-15-85	7.0 TO -1.1	01-25-86	6.6 TO -1.1
12-09-85	7.0 TO -1.0	01-26-86	6.7 TO -1.1
12-10-85	7.4 TO -1.6	01-27-86	6.5 TO -1.0
12-11-85	7.7 TO -2.0	02-05-86	6.5 TO -1.3
12-12-85	7.7 TO -2.0	02-06-86	6.9 TO -1.7
12-13-85	7.5 TO -1.8	02-07-86	7.1 TO -1.8
12-14-85	7.1 TO -1.4	02-08-86	7.1 TO -1.7
12-26-85	6.5 TO -0.8	02-09-86	6.9 TO -1.4
12-27-85	6.5 TO -0.8	02-23-86	6.5 TO -1.1
12-28-85	6.5 TO -0.8	02-24-86	6.5 TO -1.0
01-07-86	6.9 TO -1.3	03-08-86	6.5 TO -1.3
01-08-86	7.3 TO -1.8		

* Tidal heights presented here are for the coastal area near San Diego. Time of arrival and tidal heights for Los Angeles and San Francisco may vary slightly. Consult the tide tables for each specific area.

TABLE 2
SIGNIFICANT WAVE HEIGHTS AND PERIODS FOR MAJOR STORMS FROM 1978 TO 1983*

Date	Significant Height (ft)	Peak Period (sec)	Date	Significant Height (ft)	Peak Period (sec)
1-09-78	14	18	1-19-82	13	15
1-13-78	21	14	1-29-82	14	16
1-16-78	18	16	2-23-82	13	12
2-09-78	20	16	3-02-82	15	14
2-10-78	16	12	3-15-82	13	15
2-13-78	17	16	3-30-82	15	15
1-13-80	11	12	1-19-83	16	17
2-19-80	18	15	1-24-83	18	20
2-28-80	12	13	1-28-83	24	20
3-18-80	11	10	2-13-83	18	22
1-22-81	16	20	2-20-83	15	18
1-28-81	18	14	3-01-83	23	21
2-24-81	11	14	3-08-83	16	18
3-05-81	12	13	3-18-83	14	20
1-03-82	17	14			

* Data not reduced for 1979. Preliminary analysis showed that maximum significant wave heights for 1979 did not exceed 12 ft.

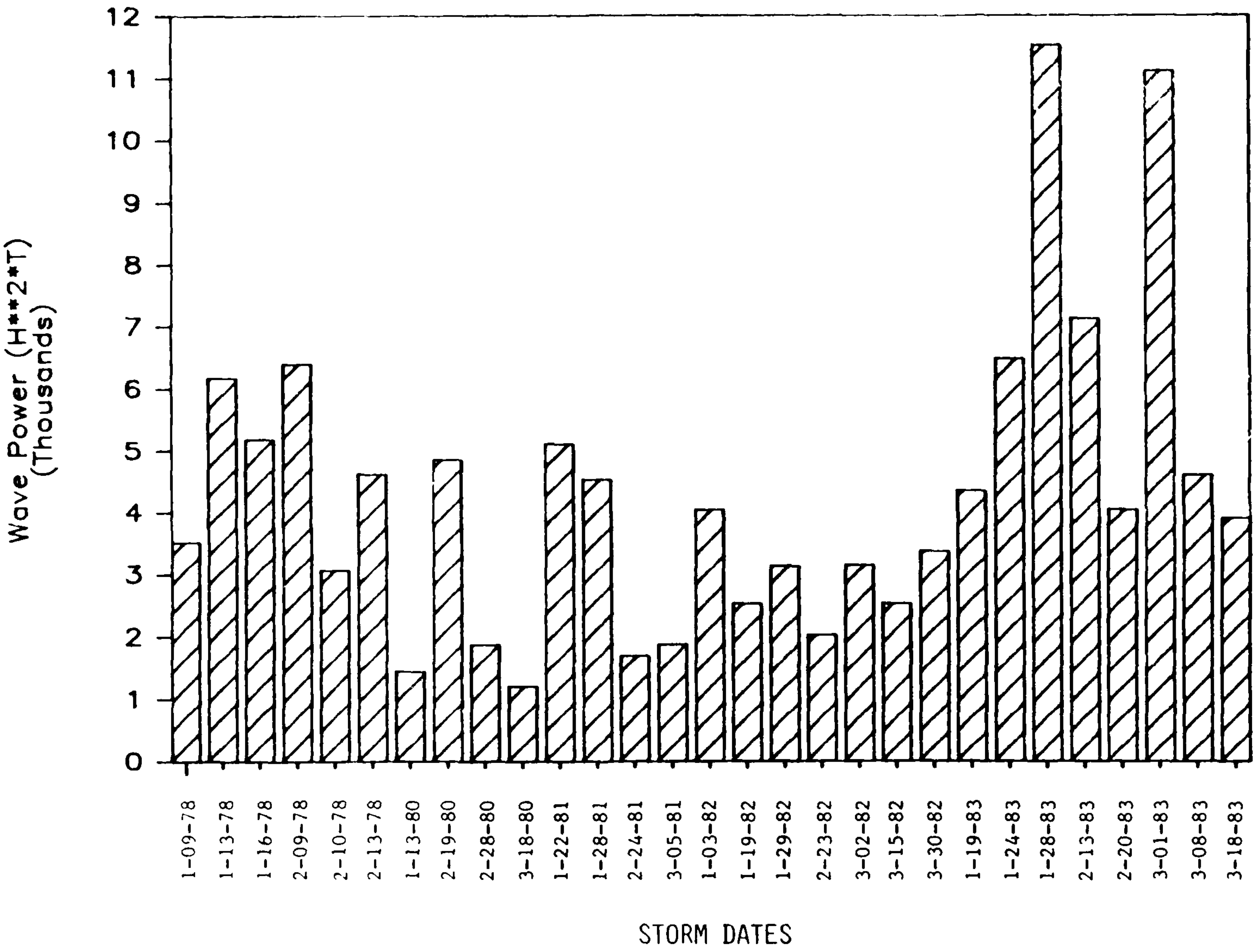

FIGURE 1. WAVE POWER FROM MAJOR STORM EVENTS, 1978-1983

A secondary component to the "mobilization trigger" is the use of local observers such as residents and county or state staffs at the prototype test sites who will notify the Corps of severe erosion events during the winter storm season.

FIELD OBSERVATIONS

The ability to acquire coastal processes information quickly, reliably, and in a cost-effective manner during winter storms is paramount to the success of this prototype test program. Typical data acquisition techniques can be very expensive, of questionable reliability during storms, or may not at all be possible to obtain because of local environmental conditions. Szuwalski (1970) described a program to monitor various natural phenomena along the California shoreline and, through the Coastal Engineering Research Center, established the Littoral Environment Observer (LEO) Program. The primary objective of the LEO program is to acquire an organized database of littoral parameters obtained by trained observers in the field not limited by the need for sophisticated and expensive instrumentation. Coastal processes observations made as part of the CSOP will include the LEO parameters with modifications and additions. The following shoreline processes will be observed and recorded twice each storm day at times of high and low water levels:

(1) Wave parameters--Visual observations of wave height, wave period, angle of breaking, wave type, highest wave runup, and an estimate of surf zone width. This wave information will be supplemental to wave data from the Coastal Data Information Program.

(2) Wind parameters--Wind magnitude and direction using handheld instrumentation.

(3) Beach parameters--Coastal piers will be used as observation platforms to monitor beach profile changes from the back shore, across the beach face, and into the nearshore zone using lead-line techniques. Beach profiles to wading depth will be taken at sites without piers using rod and level techniques. Two survey lines per site will be taken with sample points at 50-ft increments. However, in the vicinity of storm-induced beach scarps, the sampling density will be increased. The presence of beach cusps and their spacing will also be documented.

(4) Photography--35mm ground photographs and videotape will be used to document ongoing storm processes, including beach response and storm-induced structural damages.

OBSERVATION SITES

The primary monitoring sites for the Coastal Storm Observer Prototype Test Program were chosen based on historical damages to beaches and local structures (see Figure 2 for locations). All sites except Stinson Beach have coastal piers. The information observed and recorded for each site will be published in a postwinter report. Monitoring at these primary sites will not preclude documentation at other coastal locations experiencing excessive beach erosion and structural damage.

OBSERVER TEAMS

Observer teams will be made up of 2-3 personnel trained to accomplish the various monitoring tasks described above and could include individuals from the Corps, State, or local municipalities. The US Army Engineer District, San Francisco, the US Army Engineer District, Los Angeles, and the State of California Department of Boating and Waterways will each have a CSOP representative who will be responsible for monitoring coastal storms and alerting the team members when the mobilization criteria have been reached. The representatives will also be responsible for retrieving the information after each event and compiling the data for a postwinter report.

SUMMARY

The Corps and the State of California have cooperatively developed a program to observe and document the short-term extreme beach changes associated with intense winter storms. The CSOP will rapidly mobilize trained personnel to five primary sites in northern and southern California during the 1985-1986 storm season and record visual observations of wave climate, wind climate, beach changes, and associated damages to structures. This information, supplemental to other ongoing State and Federal coastal studies, should greatly enhance our understanding of coastal erosion and allow more effective management of California's coastal resources.

FIGURE 2. DATA MONITORING SITES FOR THE 1985-1986 WINTER SEASON

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DISCUSSION

DR. NUMMEDAL: *To what extent is the bathymetry right underneath the pier really representative of what is happening elsewhere up and down the beach and where we're seeing all the giant scouring beneath the Duck pier? Similar smaller scours probably exist underneath the California piers as well.*

MR. DOMURAT: We don't doubt that. In fact, Doug Inman and I have had a lot of discussion about that. Doug is interested in setting up some kind of boom to get beyond maybe two to three piling lengths away. However, we feel if you could look at some of our coastal piers during the time that these big wave events are occurring, then you're getting 20- to 30-ft seas. I'm not sure what is the greatest event that occurs. What we're looking for is that maximum extent of the erosion close to the beach to help our planners and designers to determine how to better plan for those kinds of conditions. We'll be able to see that, and, hopefully with Doug developing some type of boom system, we'll be able to address that a little more fully.

DR. KRAUS: I didn't notice if you had currents as one of the parameters and measures. It would seem that if you used the pier you could get a rather good measurement of the currents using floats or dyed rocks.

MR. DOMURAT: We considered that. What happens is that typically during these storm events you have very high wind events, and a lot of people don't like using that dye during wind events. That is something that we may consider putting back in the program.

BG KELLY: *Are we doing this anywhere else? Are we doing this on the Gulf Coast, for instance?*

DR. WHALIN: I don't think so.

MR. DOMURAT: The program is very low cost. Hopefully in future years if we can show with this experiment that the data are viable and important for people to have, we may consider trying to expand the program with more sites or better technology.

DR. WHALIN: I think the implication to your question is, perhaps, should we be thinking about doing this elsewhere. And General Kelly, I think the answer is probably, "yes," they will.

BG KELLY: I think this has applications throughout the coast everywhere.

MR. DOMURAT: It essentially is modeled after the Littoral Environment Observation (LEO) program with maybe a little bit of a different slant having people a little better trained, rather than just local residents, doing it.

MR. LOCKHART: *Have you considered trying some scour gages like we do in some of our erodible streambeds and putting those on the beach so you can relocate them and see how much scour took place during the retreat of the beach?*

MR. DOMURAT: We're trying to go low cost, quick mobilization. There are many other things we can try in the future. We'll prove out the program first for these types of data, and then many other techniques can be added.

DR. KRAUS: We'd be very much interested in the erosion that has been caused in front of seawalls and other structures in addition to the erosion on natural beaches. There are no such data. Usually by the time the survey teams come around to the seawall it has been months, and the beach has recovered. So, I'd like you to consider giving emphasis to the erosion for the structure.

MR. DOMURAT: All of the sites we've chosen do have--may have--some type of protection, but they do have buildings and structures in front of them. It was specifically picked that way to possibly entice the Federal Emergency Management Agency to work with us on this program. And they are looking at a proposal at this time.

If you notice, two of the sites in the San Francisco District face the south. We get a lot of intense wave energy from the west-northwest; however, that's where we have the structures, on the south facing beaches. Especially in the Sea Cliff areas there are some seawalls, and we can have them do their survey lines in that area.

DR. MEI: *You obviously accumulated a lot of data from this continuous observation program. Do you analyze these data?*

MR. DOMURAT: At this point the data analysis will be more of a data presentation of what the results were. It will be available to anyone to analyze in more detail. We will have the Scripps Institute of Oceanography people looking at it. If they would like to contribute more in terms of analysis, that's fine; but in terms of the beach profiles, it will just be a time-history of what occurred during those storm events.

DR. MEI: *Do you have a standard way of making known to other people the availability of these data?*

MR. DOMURAT: We are working directly with the State of California Department of Boating and Waterways. The Coast of California Storm and Tidal Wave Study puts out a newsletter. There are many ways we can alert people about the existence of this information.

BG KELLY: Okay. Thank you very much.

IMPERIAL BEACH SUBMERGED OFFSHORE BREAKWATER

CERB
Proceedings

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ABSTRACT

The Tijuana River has probably been the main source of sediment for Imperial Beach; however, damming of the drainage basin and a lack of significant flood flows since 1944 have caused a shortage of sediment at the river mouth, resulting in a decreased quantity of sand available for longshore transport to Imperial Beach. Critical erosion problems necessitated the construction of stone revetments by local interests. The Corps of Engineers was authorized to construct five groins in the area, and between 1959 and 1963 two of the five groins were constructed. The compartment between these two groins did not fill, and construction of the remaining groins was deferred while new alternatives to accomplish the project's purpose were investigated. Of the various alternatives investigated, an offshore submerged breakwater was found to have the greatest overall feasibility.

PROJECT SETTING

Imperial Beach is located on the Pacific Ocean about 3-1/2 miles north of the Mexican Border and 11 miles south of San Diego, California (Figure 1). It is primarily a recreational beach, with a 1,200-ft-long pier situated in the approximate center of the study area. Two groins are located 2,950 ft and 1,625 ft north of the pier, respectively. The sea floor is characterized by gently sloping contours with the Tijuana Shoal located south of the pier at the mouth of the Tijuana River.

PROJECT HISTORY

Historically, the Tijuana River has been the main source of sediment for Imperial Beach (Markle, 1977). However, since construction of several dams in the drainage basin, some sediment has become entrapped inland and never reaches the coast to replenish the supply of sand to the beaches. The lack of

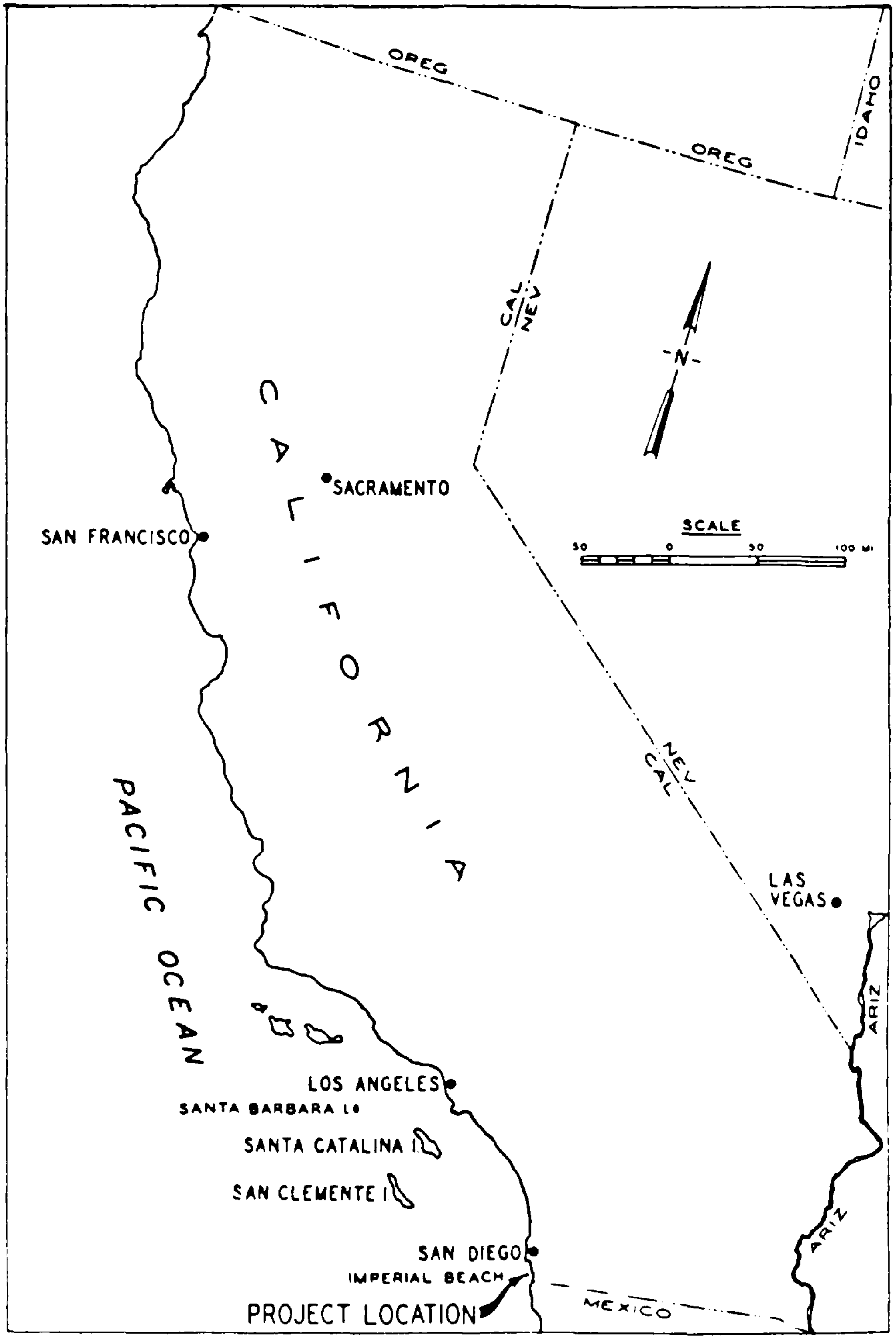

FIGURE 1. VICINITY MAP

significant flood flows on the Tijuana River since 1944 has caused a severe shortage of sediment at the river mouth, resulting in a decreased quantity available for longshore transport to Imperial Beach; consequently, increased beach erosion has occurred.

The problem became acute during the winter of 1952-1953 when wave erosion caused rapid shoreline recession and property damage. Winter storms during the next several years forced local and private interests to install a stone revetment along the shoreline.

Between 1959 and 1963, the Corps of Engineers (Corps) constructed two groins in the area in an effort to restore the beach. The project plan, as described in House Document 399 of the 84th Congress and authorized by Public Law 85-500, called for the construction of five stone groins (Figure 2). Construction was to start with the northernmost groin and proceed southward as each groin-created compartment was filled by natural littoral transport. Groin No. 1, the northernmost groin, was completed to a length of 600 ft in September 1959. Groin No. 2, 400 ft long and located about 1,000 ft south of groin No. 1, was completed in January 1961. In July 1963, groin No. 1 was extended 140 ft. The compartment between these first two groins did not fill. Construction of the remaining groins was therefore deferred while new alternatives to accomplish the project purpose were investigated.

It became apparent during model tests that onshore-offshore, rather than longshore, transport played a major role in determining loss of material at Imperial Beach (Curren, 1977), and an offshore breakwater was proposed as an alternative plan. A three-dimensional model study was authorized in 1974 to study several alternative plans for erosion control. Additionally, a two-dimensional stability study, a wave study, and a littoral processes study were undertaken.

In 1977, approximately 1.1 million cubic yards of sand dredged from San Diego Harbor was placed along the Imperial Beach project area, resulting in a 150-ft-wide, 5,000-ft-long beach. Littoral processes have eroded the beach, leaving a present width which varies from about 10 to 50 ft.

LITTORAL PROCESSES

The width of the beach and the composition of beach materials at Imperial Beach vary. Extreme high tides, storm waves, and littoral currents,

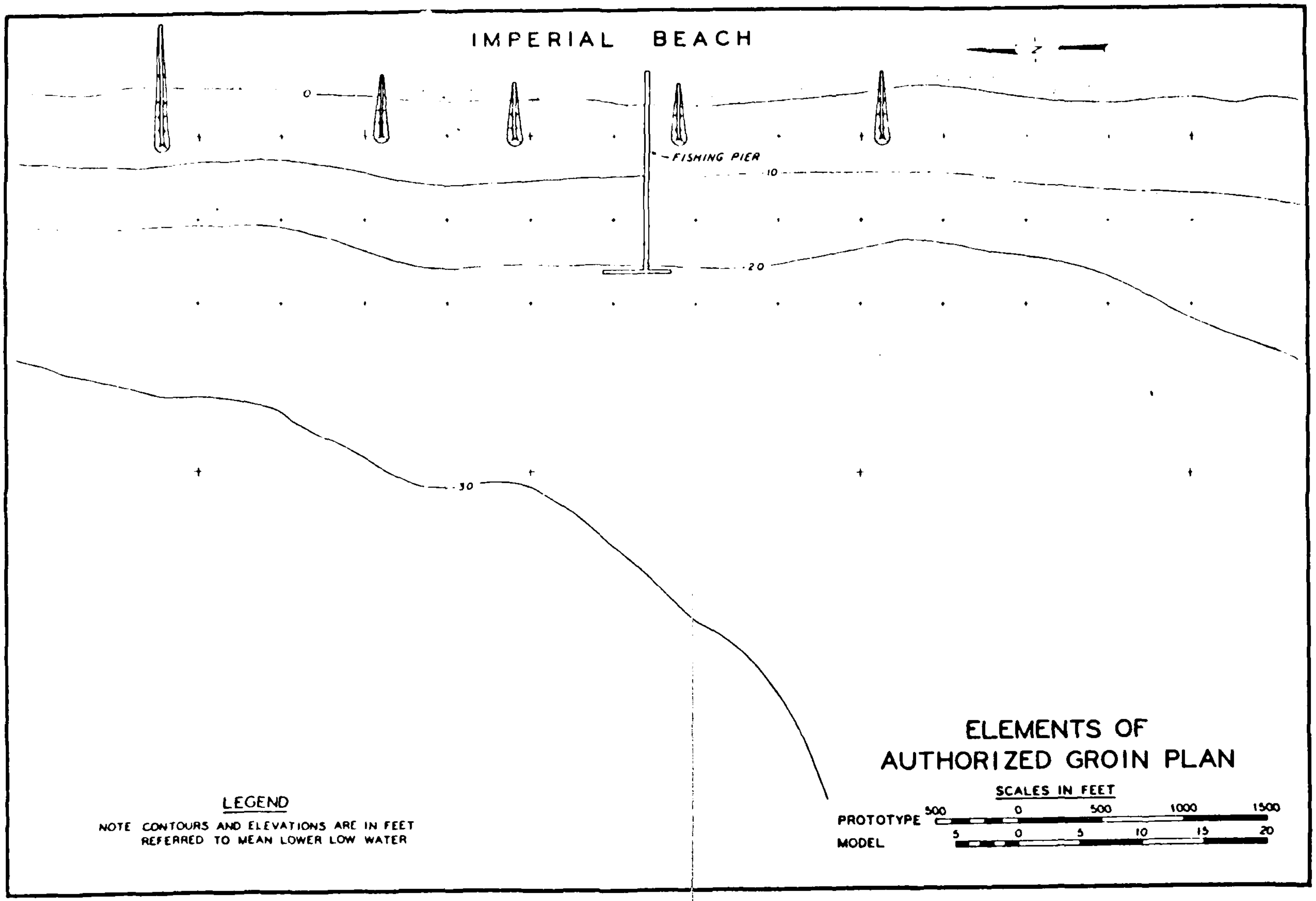

FIGURE 2. GROIN PLAN AUTHORIZATION FOR IMPERIAL BEACH

conditions typical along the California shoreline during the winter months, remove most of the sand from the beach, leaving behind a cobble-based shoreline. Wave action is less severe during the summer months, and sand is usually redeposited along the shoreline. Along the southern portion of the project area, however, cobbles are exposed almost year-round. This cobble bed, which extends several miles seaward (covered by sand), was apparently the old bed of the Tijuana River when the shore was much farther seaward (US Army Engineer District, Los Angeles, 1978).

The tides along the Pacific Coast have a diurnal inequality (i.e., there are two high waters and two low waters, usually occurring each tidal day, with a large inequality in either the high or low water heights). For San Diego County, the mean tide range is 3.7 ft, and the diurnal range is 5.3 ft. The lowest tide each year is about -2 ft mean lower low water (MLLW), and the highest tide is about +7 ft MLLW. Mean sea level is +2.9 ft MLLW.

Waves breaking along the south coast of San Diego County normally range in height from 2 to 4 ft, although large waves that range in height from 6 to 10 ft are not uncommon. Large waves may arrive at almost any season, may continue for 3 to 4 days at a time, and are frequently accompanied by strong winds. Waves exceeding 15 ft in height have been observed south of Imperial Beach. Winter waves usually have shorter periods, greater heights, and approach from the northern hemisphere. Summer waves usually have longer periods, smaller heights, and approach from the southern hemisphere. Waves greater than 5 ft that are caused by winter storms occur an average 180 hr a year.

Imperial Beach is located within the silver strand littoral cell (Figure 3). Studies indicate a net northward littoral transport (especially during winter months) at Imperial Beach (Figure 3) and some downcoast transport during the summer months (Intersea Research Corporation, 1974). However, model tests have shown that onshore-offshore, rather than longshore, transport plays a major role in determining loss of material at Imperial Beach (Curren, 1977).

THE RECOMMENDED PLAN

Of the various alternatives investigated (summarized in the next section), an offshore submerged breakwater was found to have the greatest overall

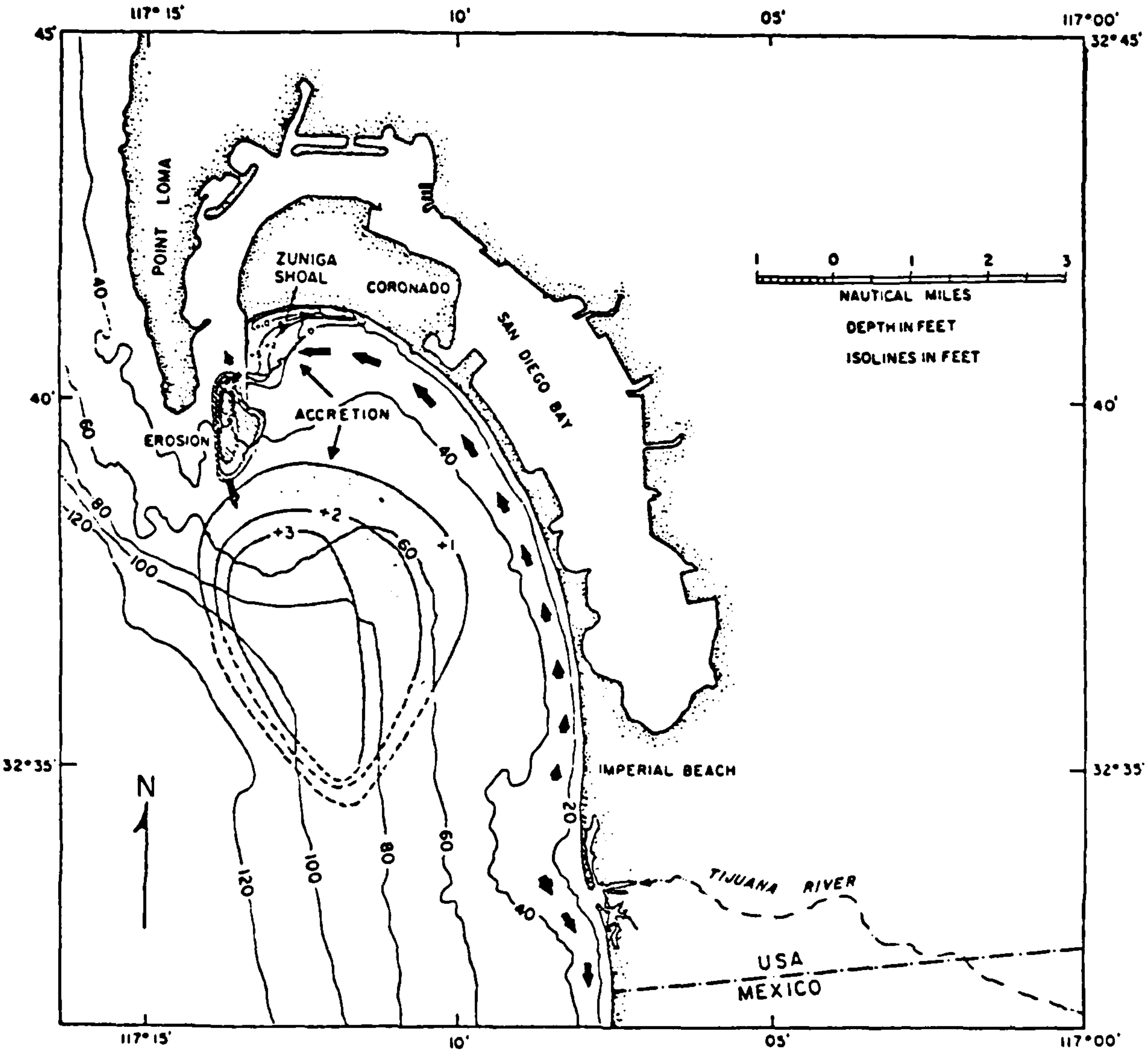

FIGURE 3. SILVER STRAND LITTORAL CELL

feasibility. Hydraulic models were constructed and tested at the US Army Engineer Waterways Experiment Station to determine the effectiveness and precise design of the breakwater.

The recommended plan of improvement for the Imperial Beach shoreline consists of a 5,000-ft-long continuous breakwater composed of alternating 10- and 7-ft-high segments (Figure 4). The breakwater will be constructed along the -10 ft contour (MLLW) and will be parallel to and approximately 600 ft from the beach berm. There will be four high and three low breakwater segments; each segment will be about 715 ft long. The northernmost existing groin will be extended approximately 100 ft to connect with the breakwater,

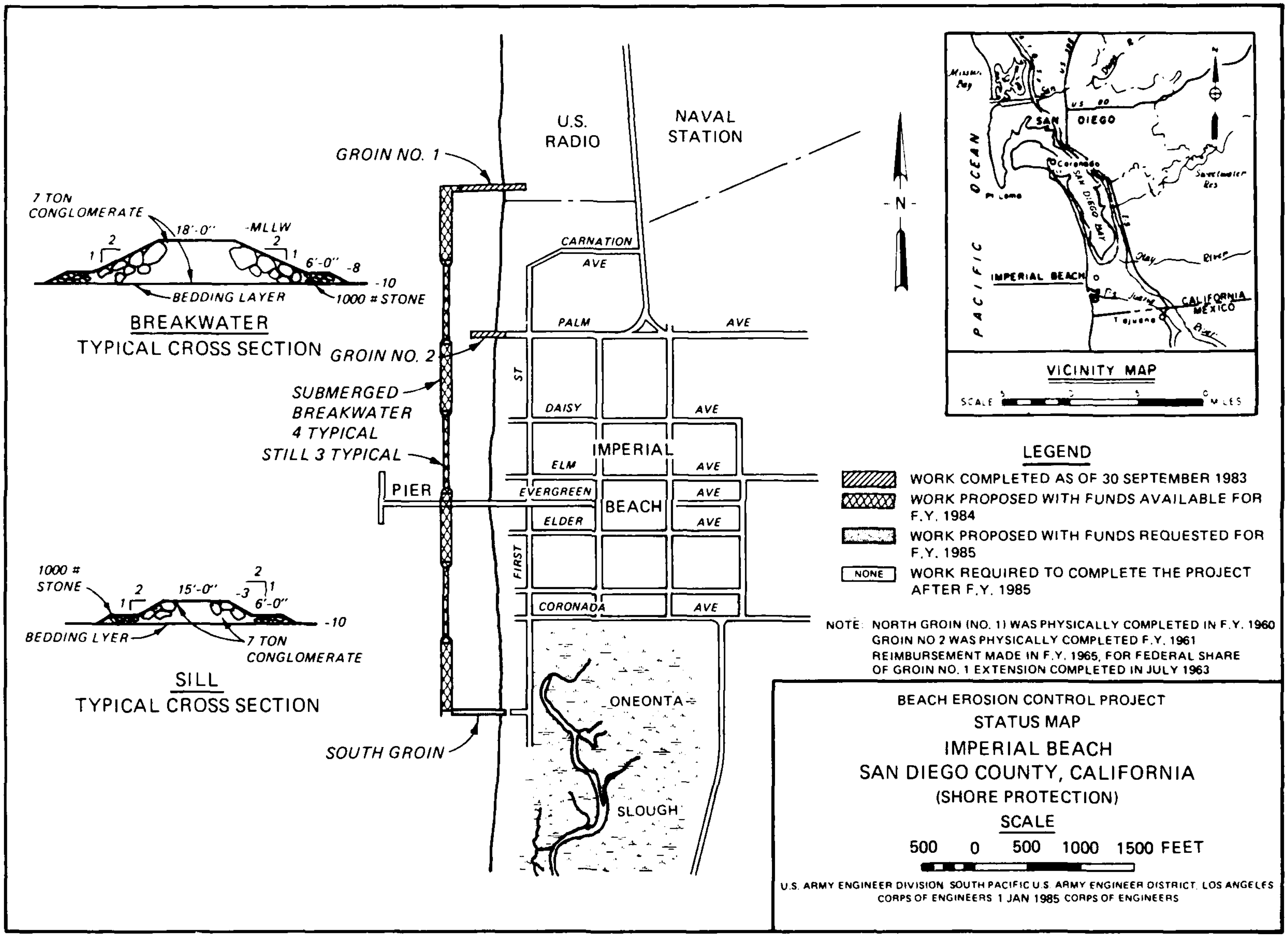

FIGURE 4. RECOMMENDED IMPROVEMENT PLAN FOR IMPERIAL BEACH

and a 5-ft-high, 600-ft-long new groin will be constructed from the shoreline to connect with the south end of the breakwater.

The breakwater will be built of 7-ton stone with 0.5-ton stone for toe protection, and it will be placed on a graded bedding layer to prevent sand from percolating into the structure. The groins will be built of 5-ton stone, having 0.5-ton stone for toe protection and a graded bedding layer. The high segments will allow the beach to build up, and the low segments will allow the beach to erode, causing the shoreline to assume a cuspate configuration. The amount of buildup or erosion will not be large enough to endanger any structure, nor will the total area of the beach change. Navigation lights will be placed on both ends of the breakwater and on the end of the fishing pier.

ALTERNATIVES TO THE PROPOSED ACTION

Several alternatives for beach erosion control were analyzed during formulation of the recommended plan. The following paragraphs provide a brief description, the environmental effects, and the reason for rejection of each alternative.

(1) Nonviable alternatives. Sand-fencing, initially considered as a possible alternative, involves the building of onshore fences to trap windblown sand. This alternative was eliminated because of insufficient sand supply and wind velocity in the Imperial Beach area. Offshore vegetation was also initially investigated, the basic idea being to plant natural kelp or fasten artificial kelp to the bottom in order to dissipate wave energy. These methods have been tried elsewhere with little success and were therefore rejected.

(2) Five groins. The authorized plan for the project consisted of the construction of five groins, and the compartments between groins were to be filled by natural accretion. After the first two groins were constructed, their compartments did not fill. Subsequent model studies indicated that this plan would be ineffective in building or maintaining a recreational beach.

(3) No action. The no action alternative would allow the beach to progressively erode away. Properties and improvements along the shoreline would again be vulnerable to storm wave damages. Further, this alternative would not accomplish the project's purpose.

(4) Condemnation and relocation. The intent of the condemnation and relocation alternative would be to condemn threatened properties for public use and to relocate residents and improvements. This alternative would have serious social and economic repercussions locally and would not accomplish the purposes of the project.

(5) Revetment. The revetment alternative involves the construction of rubble-mound revetment along the shoreline to protect properties and improvements. However, this alternative would not accomplish the project's purpose of maintaining the recreational beach.

(6) Periodic beach nourishment. The beach nourishment alternative entails depositing beach sand at intervals adequate to protect shoreline structures and to maintain a recreational beach. A viable source was identified at Zuniga Shoal. The cost of this alternative is high, and it does not stabilize the recreational beach.

(7) Seven-groin plan. The seven-groin alternative would involve construction of five additional groins spaced at closer intervals than those in the five-groin plan. The alternative was rejected because, although it would accomplish the project's purposes and is economically feasible, it would be unpleasant esthetically and would severely compartmentalize the beach. Local support for the alternative was minimal.

(8) Nine-groin plan. Seven additional groins, spaced at closer intervals than those in the five- or seven-groin plans, would be constructed along the beach. This nine-groin alternative would accomplish the project's purpose and be economically feasible. However, it was rejected because it would also be unpleasant esthetically and would compartmentalize the beach to an even greater degree than the seven-groin plan. Local support was minimal.

(9) Offshore surface-piercing breakwater plan. The offshore surface-piercing breakwater alternative would involve constructing a continuous, segmented breakwater at the -5-ft contour (MLLW). Local interests were generally favorable toward this alternative. However, the breakwater would have a significant visual impact, being visible at all times and lying close to shore. Also, because it would most likely be constructed from the shore, the breakwater would have a considerable impact on water and air quality, noise, and traffic.

(10) Submerged offshore breakwater plan. The submerged offshore breakwater alternative differs from the recommended plan only in that the breakwater would be 7,000 ft long. The alternative was rejected because it did not provide maximum net benefits.

CURRENT PROJECT STATUS

The recommended breakwater plan was authorized by the River and Harbor Act of 1958, Post Authorization Change (PAC), approved by the Office of the Chief of Engineers (OCE) in October 1979. Following the PAC and completion of the General Design Memorandum and Environmental Impact Statements in 1978, funding was made available for construction in fiscal year 1981 (FY 81). Lawsuits against the City of Imperial Beach, filed by local surfers and William

Kellogg, caused the Corps to withdraw funds until that litigation was resolved.

Funding was approved to begin construction in FY 84 under the assumption that litigation would be resolved by that time. Plans and specifications were prepared in early 1984, and the project was advertised in April 1984. Litigation dragged on due to the court's requests for more detailed information on the relevant issues. Bid opening was postponed indefinitely.

In early 1985 the San Diego Superior Court remanded the case back to the California Coastal Commission for review and a decision. On 9 July 1985 the Coastal Commission voted 7 to 4 in favor of permit issuance.

Bid opening which had been scheduled for 23 July 1985 had to be postponed when the government estimate for construction cost was prepared and found to exceed the funds available. The current estimated cost of construction is \$6.95 million. Funds presently available total \$5.11 million (\$2.74 Federal and \$2.37 local).

Additional Federal funds for completion of the breakwater can be obtained through the existing project transfer authority if the sum is less than \$364,000. If more Federal funds are required, they must be obtained through a request to the Congressional Appropriations Subcommittee. In order to obtain additional funds in this way a request is initiated at the District level, passed on to US Army Engineer Division, South Pacific (SPD), and then to OCE. OCE submits the formal request to the Committee and identifies an available source of funds. Two to three months are required to complete the request process.

Required additional local funds for completion of the project are insured by the Local Cooperation Agreement between the City of Imperial Beach and the US Government. The agreement states that once construction is started, Imperial Beach is obligated to provide the entire local share (43 percent) of the total project cost. The agreement also states that the final local share shall be determined after completion of the project.

The State is presently preparing its budget for the next fiscal year (1 July). Funds totalling \$500,000 have been programmed for additional construction at Imperial Beach, and they will be available 1 July 1986.

Value engineering meetings were held to explore options which would reduce the cost of construction. No significant changes to the design or construction procedure were implemented as a result of these meetings. However, changes were made to Supervision and Administration (S&A), Engineering and Design (E&D), and contingency apportionments in order to reduce total project costs.

As a result of discussions with the State and Imperial Beach concerning the shortage of construction funds, project phasing was recommended and supported by the State. The US Army Engineer District, Los Angeles (SPL), developed phasing alternatives for proceeding toward a contract award with the funds available. The recommended course of action was to issue an amendment to the existing advertised project to solicit new bids on the construction of 3,575 ft of breakwater and structure heads (caps) and to include as additive items the remaining 1,430 ft of breakwater (Additive 1), the northern groin extension (Additive 2), and the southern groin (Additive 3). Figure 5 shows the recommended base plan and the additive elements.

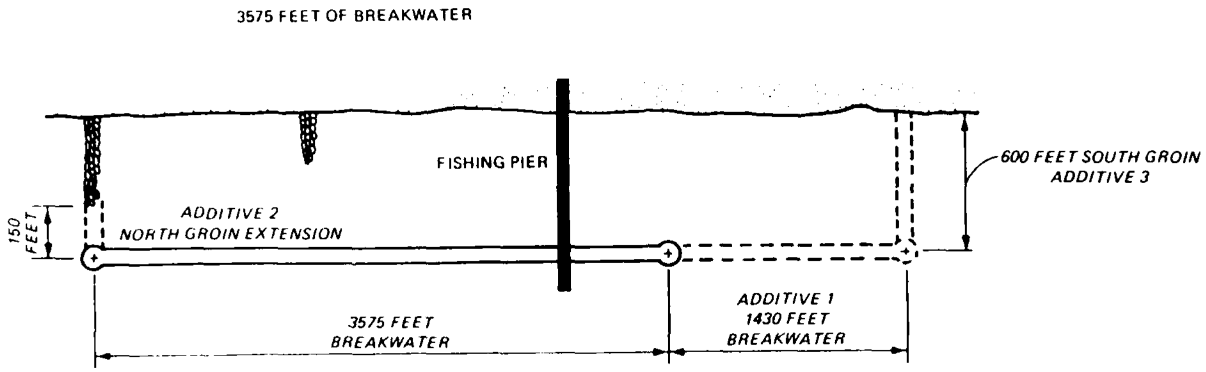

FIGURE 5. RECOMMENDED BASE PLAN AND ADDITIVE ELEMENTS FOR IMPERIAL BEACH BREAKWATER

ELEMENTS OF THE MONITORING PROGRAM AND METHODS OF MEASUREMENT

Wave, Tide, and Wind Conditions

Directional wave spectra approaching the site will be obtained with the use of an S_{xy} directional wave gauge composed of four pressure transducers. The gauge will be positioned midway between the two groins, in approximately 30 ft of water, in order to avoid reflected energy from the breakwater and to satisfy the conditions for smooth, straight contours assumed for S_{xy} data use. These data will allow us to correlate the model study waves to the prototype for height, period, and frequency of occurrence.

Wave heights on the shoreward side of the breakwater will be measured by a network of four directional pressure wave (PUV) gages. Two of these will be positioned toward the north end and two toward the south end of the box. Of these, one will be initially positioned off a high section, one off a low section, and the remaining two initially adjacent to the two end groins. The gauges may be repositioned during the study if wave and current information is desired for other locations within the box. These measurements will provide information on wave dissipation and reformation in the lee of the structure.

Tidal stage and variability will be acquired for the survey periods.

Wind speed and direction will be measured by an anemometer located at Ream Field.

We plan to establish a littoral environment observation (LEO) site at Imperial Beach which will provide backup information on waves, winds, currents, and other data.

Currents

The four directional pressure gages described above will provide information on the rates and directions of water movement within the box. These data will be supplemented with fluorescein dye tracer observations to provide a more complete indication of circulation patterns within the box.

Analysis of low altitude panchromatic photography will provide documentation of synoptic current and sediment circulation patterns.

Breakwater Stability and Scour

Underwater surveying (probably by dive team) will accomplish the following: documentation of displacement of stone and/or subsidence, if any, accomplished by regular surveys; quantitative measurement of scour and fill at regular intervals along the length of the breakwater; and inspection of the toe protection stone for failure or displacement and the bedding layer for displacement and scour effects.

Marked rods will be emplaced along the breakwater during or immediately after construction, at established survey line locations, to provide locational and elevational references for measurements of scour and fill. Selected rocks will be painted or marked before placement, and the locations and orientations of these will be noted on successive surveys.

The breakwater will be photographed immediately after construction and rod emplacement to document initial conditions. Diver surveys will be scheduled quarterly for the first 2 years after construction and seasonally (summer and winter) for the remaining 2 years. Surveys will include photography at regular intervals along the length of the structure as well as written notes on approximate scour and fill dimensions and breakwater condition (i.e., evidence of stone displacement, structure subsidence, and condition of toe protection and bedding layer).

Beach and Nearshore Response

Survey teams will perform quarterly topographic surveys of the exposed beach along 17 preestablished profile lines. Six grab samples will be obtained along each profile line (MLLW depths of -6, -12, -18, -24, -30 ft). The samples taken within the structure will be used to determine the textural changes caused by the structure. Analysis of aerial photographs will also provide information on beach geometry and configuration.

Hydrographic/topographic surveys of the nearshore zone seaward of the breakwater will be performed using a survey boat (Lark or Boston Whaler) along the 5,000-ft length of the project area at 500-ft intervals. These surveys will follow the standard profile lines established by past survey teams and will extend seaward to the -30-ft contour location. This information will be compatible with and tied into the surveys of the exposed beach and breakwater areas.

Hydrographic surveys within and adjacent to the breakwater/groin box will be performed using the profiler developed by Dr. Richard Seymour at Scripps Institute of Oceanography.

Profiling will occur quarterly for the first 2 years and semiannually thereafter.

Beach Use

Information will be acquired through the City of Imperial Beach on the number of beach users, activities, satisfaction with the project, and improvement of recreational use. An effort will be made also to acquire information from the City on the impacts of the structure on residential and economic trends.

Analysis of Data

Data collection efforts will emphasize the retrieval of quantitative information. Analysis of data will be directed toward the integration of the various pieces of information to achieve a greater understanding of performance of structures and of processes and responses associated with the emplacement of engineering structures in the nearshore zone. Data analysis will be directed also toward verification of engineering design assumptions. To this end, efforts will be made to ensure compatibility of data. Figure 6 shows the locations of the S_{xy} gage, PUV gages, and the marked rods within the project area.

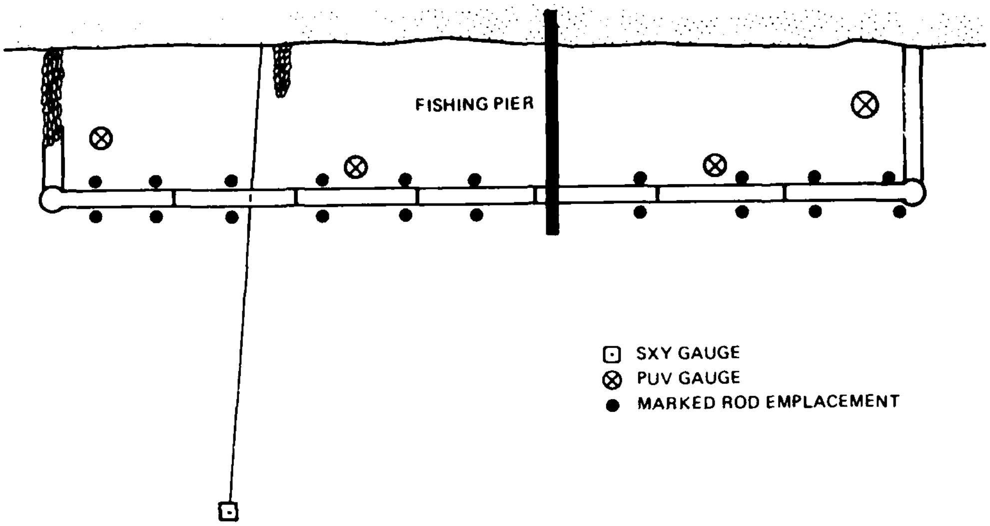

FIGURE 6. LOCATIONS OF GAGES AND RODS ON IMPERIAL BEACH BREAKWATER

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DISCUSSION

DR. NUMMEDAL: If this structure is not successful, then we are going to have to do something else. If it is successful, then all you will do is transfer the problem somewhere else, presumably the beach or the naval station to the north.

MR. DIEMER: During the process of getting permits for this project from the California Coastal Commission, one of the stipulations was that whatever sand is trapped within the breakwater and whatever effects are felt on the neighboring beaches, the City of Imperial Beach must compensate for the effects. Any effects felt on the adjacent shoreline will have to be mitigated for, and they will be mitigated for by Imperial Beach, either through beach renourishment or by other means.

DR. NUMMEDAL: *Why not consider beach nourishment right now?*

MR. DIEMER: That was considered; but from an economic analysis, it is apparent that the breakwater over a 50-year life is about half as expensive as beach nourishment.

DR. WHALIN: This is a quite complex project. The majority of transport is onshore and offshore since the waves approach almost normal to shore. Longshore transport was estimated to be approximately 200,000 cu yd. This is a submerged structure, and some energy gets over the structure. I am not sure whether we are going to fill this structure, but I know that it was recommended that it be filled. There is almost no source of sand to the south because the sand is eroded from the Tijuana shoal. So, if there was nothing done at the project, the erosion would gradually progress farther northward along the Silver strand. We are providing a recreational area for this long stretch of Imperial Beach by filling the groin. Since we are minimizing the erosion in that area by minimizing wave energy, we should provide a stable recreational beach. The idea is that we won't interfere too much with what transport there is alongshore to the north and the south. This is really an interesting project due to the direction of approach of wave energy and the fact that there is not a real source of sand to the south from the Tijuana shoal. The shoal is composed of cobbles. The project could conceivably propagate the problem farther to the north. But I do not think that it will contribute to the problem any more than the natural conditions will contribute, assuming we do go ahead and fill the beach section because storm waves will transport sediment around the structure on the seaward side. The breakwater is not a total barrier, and the groins are submerged on either end of the project.

DR. NUMMEDAL: *So sand fill is part of the plan as it now stands?*

MR. DIEMER: When the project was originally scheduled for construction, there was a beach fill that had taken place. That was in 1979. Construction of the breakwater was originally scheduled for 1980 to hold that sand which was placed in 1979. That sand has since eroded, and so we are faced with an eroding condition for construction.

DR. NUMMEDAL: *So why not go ahead and fill again?*

MR. DIEMER: It is not part of the authorized project at this point.

DR. KRAUS: In Japan, detached breakwaters are very commonly used. They are either submerged or they are subaerial, but they are porous. So, they are functioning somewhat like a submerged breakwater and allowing energy to go through. With these segmented detached breakwaters, the sand transported onshore is trapped behind the breakwater and cannot escape during storms because it is in a sheltered region. Using the onshore current to bring sand in, the longshore current puts it behind the breakwater where it is trapped. But with your perched beach you're precluding that possibility because the sand, I don't think, is going to jump over the breakwater.

CERB Proceedings

FRAMEWORK GEOMORPHOLOGY REPORTS

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ABSTRACT

Framework Geomorphology Reports are now being prepared for each segment of the Coast of California Comprehensive Study as one of the first tasks in the program. These reports serve as guidance, summarizing and evaluating available baseline information. Discrepancies in published reports and deficiencies are highlighted, and specific study needs are indicated. The objectives are twofold: (1) to develop a preliminary working hypothesis that will present an interpretation of the formation of the existing coastline to include the source of materials and their movement to and within the beaches and the marine environment and (2) to recommend sampling programs and further studies required to confirm or modify the geomorphic model. Examples of information from completed reports on Dana Point to the Mexican Border and Monterey Bay, which should be useful to planners and designers, are discussed.

INTRODUCTION

Beach erosion control and shoreline protection projects deal with a highly dynamic environment. Only by understanding the episodic nature of coastline change can we intelligently plan, design, construct, and maintain useful and cost-effective projects. We must also be able to predict the consequences of our construction on the natural or preexisting conditions. Studies of shoreline processes involve a large number of variables, many of which are not subject to direct field measurement. Therefore, it is necessary to investigate as many of these features as lend themselves to observation. Direct measurement, when possible, provides information at a specific time and place. From such data a predictive model can be constructed. Especially in the coastal environment, the limited scope and time frame upon which this predictive model is based may not afford the model a true predictive capability. Furthermore, many of these variables can be overlooked in a purely mathematical short-term or areally restricted study.

Since an existing coastline and its environment are reflections of its geologic and meteorologic history, an alternative to direct measurement is the geomorphic approach which intrinsically incorporates all variables and complexities of the processes acting on the coast. This approach yields a realistic picture of long-term trends and thus should be more useful in any predictive model. Coastal planners must be concerned with longer term patterns of weather, erosion, transport, and deposition rather than short-term models.

The value of a geomorphic study to establish baseline data on coastal evolution has long been recognized by coastal engineers. Examining an entire region and recognizing when observations reinforce or fit together is one of the main purposes of such a study. It serves as a framework in which to deal with coastal problems. Through interpretation of topographic forms, we develop an understanding of the general character of the coast, the long-term changes which have occurred in the past, and those which are still continuing. This creates the background for the other studies. Its value depends on the information it affords relative to the causes of the existing conditions and the probable future trends.

Any coastal studies we perform should make a contribution to coastal planning, management, design, construction, or maintenance of our structures. To demonstrate how Framework Geomorphology studies accomplish this, several types of examples of general applicability from the recently completed Monterey Bay report (United States Geological Survey (USGS), 1985) and the Dana Point to Mexican Border report (US Army Engineer District, Los Angeles (SPL), 1984) will be cited. Specifics for each example can be found in the individual reports.

MONTEREY BAY FRAMEWORK GEOMORPHOLOGY REPORT

Monterey Bay is located along the central coast of California about 100 km south of San Francisco. Though the coastline appears to have an equilibrium shape, much of the bay's coastline is actively eroding. In the northern part of the bay, erosion is presently threatening many coastal homes and local homeowners, and governments have had to emplace protective structures (Figure 1). In the south central part of the bay, erosion rates are even greater but have been given less attention until recently because of the lack of construction in the area.

The north shore of Monterey Bay contains several small beaches that often disappear during winter storms. The beaches are usually backed by

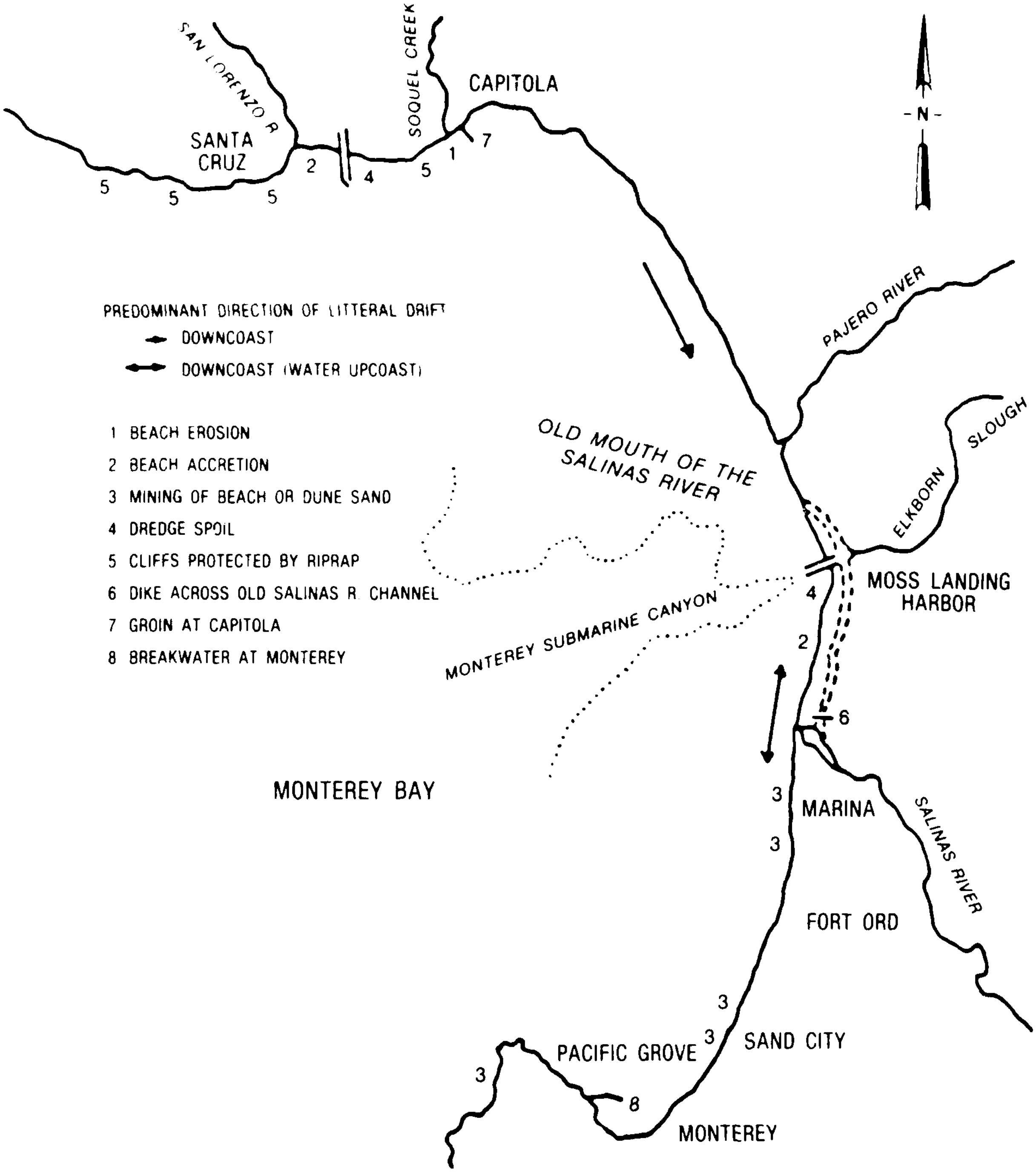

FIGURE 1. SKETCH MAP OF MONTEREY BAY SHOWING ARTIFICIAL CHANGES IN SAND SUPPLY AND DEPOSITION

cliffs that can easily erode under wave attack. Contribution of sand from cliff erosion, however, is small. Southward littoral drift from north of Point Santa Cruz supplies most of the beach sand to this area, but the San Lorenzo River episodically supplies significant amounts of sand. There are no major sediment sinks in this area.

Sand transport is very episodic--almost half moves during 10 percent of the winter months. During historic times (the last 200 years) the coastline has been stable. In fact, indications are that the sand supply was in excess of what was needed for equilibrium. It was concluded in a US Army Corps of Engineers (Corps) study (1958) that littoral drift was sufficient to maintain these northern beaches, but the sand moved downdrift so quickly that beaches could not form, especially in winter. Actually the amount of sand delivered by littoral transport may be decreasing. About 5,000 years ago, when sea level became relatively stable, we had an eroding coastline. This continued until about 200 years ago when an extensive dune field at Ano Nuevo started to erode, injecting sand into the littoral zone each year. Now, the dune field has essentially disappeared, and littoral drift is returning to that of prehistoric time. The retreat of northern beaches and direct wave attack on the cliffs during storms, coupled with high spring tides, has begun during the last few years. The possibility that this will be a continuing condition must be addressed in our planning. Any activity in this area must consider the upcoast sources beyond Point Santa Cruz, their future contribution to the north shore beaches, and the possibility of accelerated cliff erosion along the north shore.

Even though the northeast corner of the bay has generally prograded in historical time, there are seasonal beach erosion problems. Santa Cruz Harbor was constructed in the early 1960's. It consists of two rubble-mound jetties. After construction, Sea Bright Beach (which abuts the west jetty) widened by more than 12 times, and Capitola Beach (about 5 km east of the harbor) soon lost 90 percent of its sand. Though the west jetty initially impeded longshore sand transport, most of the sand currently bypasses the harbor, either naturally or through our dredging. Griggs and Johnson (1979) pointed out that erosion occurs east of the harbor because of <u>when</u> the littoral drift occurs. In winter, Santa Cruz Harbor fills in, trapping 30 percent of the annual littoral drift. In the past, sand was not reintroduced to the downdrift beaches until spring when the harbor was dredged. Therefore, in the last winter and early spring there was a net deficit of sand east of the harbor. Since this is the time of major storms, there was more erosion than before the harbor was built, even though the average annual drift rate is the same. Our dredging schedule should, and now does, mitigate the effects of harbor construction by placing sand on the downdrift beaches several times from late fall to early spring.

The eastern shore of Monterey Bay can be divided into two long beaches that are separated by the head of Monterey Submarine Canyon at Moss Landing (Figure 2). Sand is supplied to the northern area by southward littoral transport and from the Pajaro River. The amount of sand supplied by erosion of the coastal cliffs, although slightly higher than along the north shore beaches, is relatively low. Apparently, all southward moving littoral sand enters Monterey Canyon where it is permanently lost from the littoral zone.

South of Moss Landing the eastern shore consists of sand delivered to the coast by the Salinas River and sand eroded from the unconsolidated and semiconsolidated dunes on the landward edge of the beach. Median grain size increases to the south from Moss Landing, reaching a maximum at Ft. Ord, then decreases rapidly to the south. This has been attributed to removal of the coarse fraction by sand mining in the area. In addition to sand mining, sinks include Monterey Canyon, the Salinas River Delta, and, perhaps, offshore transport.

Erosion of the southern Monterey coastline is a major concern to the local sand industry as well as to environmental and regulatory agencies. Sand for commercial use has been dredged for the last 75 years. During this time, erosion rates have more than tripled. Mining and weak longshore transport of new sand are the principal causes of erosion. From analysis of sands in the various environments, it can be concluded that there is no contribution to southern beaches from north of Monterey Canyon. The Salinas River contribution, even during high discharge conditions, is minimal except for the beaches within 2.5 km south of the river mouth. These and other factors lead to the conclusion that sand dunes immediately behind the beaches are the major source of material for the southern beaches. Since the amount of sand mined is about equal to the estimated amount supplied by the bluff erosion and the Salinas River is not a significant contributor, this sand must be considered a non-renewable source for the beaches downdrift (Porter, et al. 1979).

Ft. Ord's Stillwell Hall was constructed in 1941 at Indian Head Beach

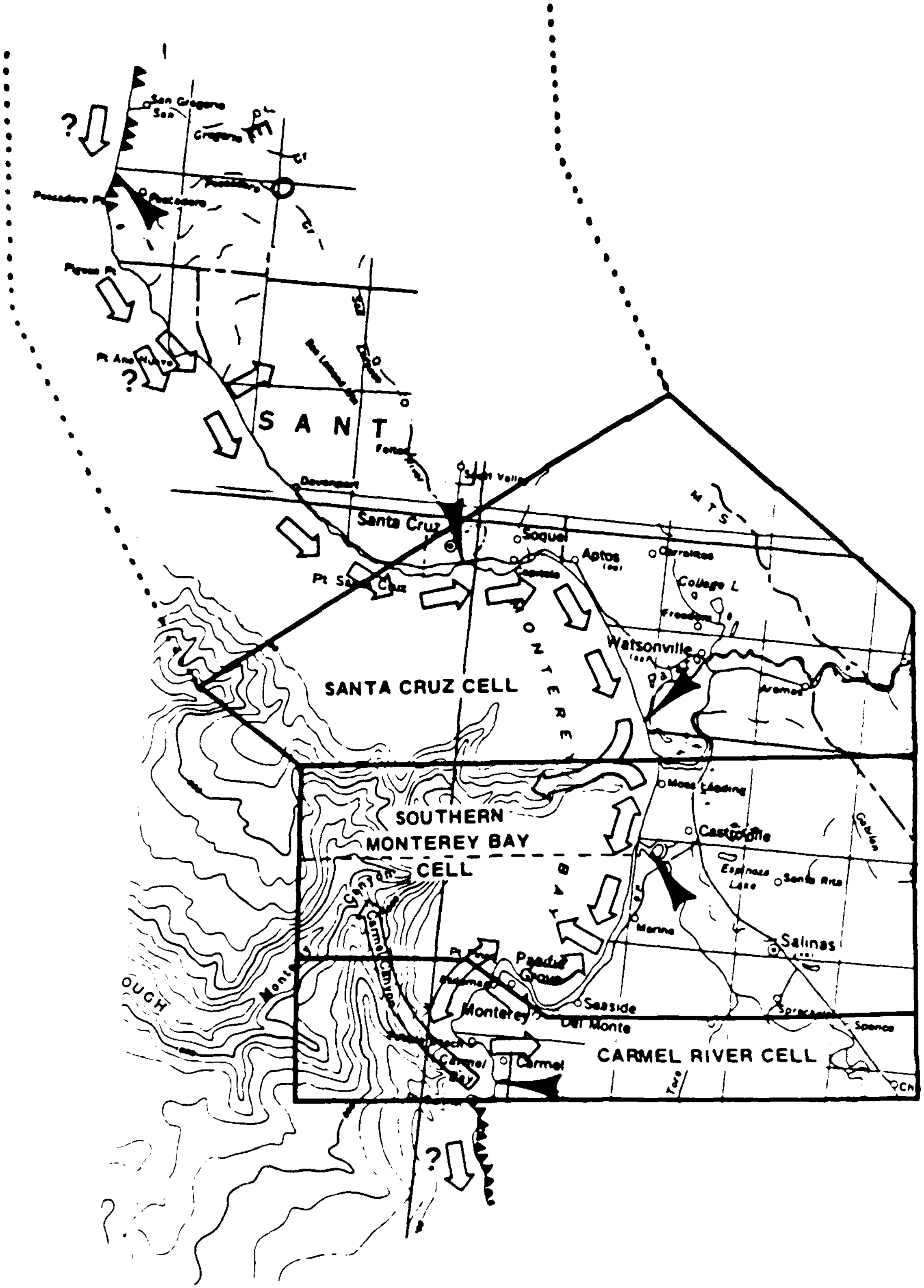

FIGURE 2. MONTEREY BAY LITTORAL CELLS

with a spectacular view of Monterey Bay. Several pipeline outfalls were also constructed subsequently in the immediate area. When it became evident in the 1970's that there was a general shoreline recession in the area, a rock revetment was constructed in front of Stillwell Hall. Riprap has also been placed around the most seaward foundations for the outfalls. Natural erosion of the cliffs has continued adjacent to each of the protected areas, making them isolated extensions into the surf zone. The average cliff retreat has been estimated at 7 ft per year. Actually, over 30 ft was eroded in a 20-day period in 1983. The runup associated with this storm was well above the toe of the dunes and probably above the top of the riprapped slope. The protected slope failed, leaving the dune subject to direct attack by subsequent storms. Part of the rear parking lot collapsed, and the foundation of the structure was endangered. Although an emergency fix (reestablishment of a protected slope) was constructed, the environment in which Stillwell Hall is located makes the entire area highly susceptible to continued erosion. A "permanent" protection solution will have to be implemented soon, or the building will be uninhabitable. All schemes for protection will be expensive and will require future extensions as erosion progresses at the flanks of any structure in this environment. The most pertinent recommendation we can make to the owner is to carefully consider the extent of his commitment to preserving Stillwell Hall, in light of the continued retreat of the bluffs, episodic nature of the erosion, high initial cost of protection, and necessity for continual extension of the protective works.

DANA POINT TO THE MEXICAN BORDER

Oceanside

In the 1880's, beaches in the Oceanside-Carlsbad area were 300 ft wide. Cliffs which backed up the beaches were retreating due to subaerial erosion during wet years. In 1922 the construction of Lake Henshaw reduced the sediment-carrying capacity of the San Luis Rey River, thereby reducing the sand supply to the beach. The last storm to contribute appreciable amounts of fluvial sediments to the beaches was in 1938. In 1940-1941 there was severe erosion of the cliffs. Camp Pendleton harbor was constructed in 1942 with additional severe erosion downcoast and silting of the harbor. In 1963 the present small-craft harbor was constructed, and 1965 saw erosion of the beaches to the south. Until 1978, beach sand levels dropped during winter and returned in the summer. In 1980, the sand did not return. Two reasons suggested by different investigators are that longshore currents apparently changed after 1980 and that Carlsbad Canyon became an active sink, intercepting sand offshore.

As part of the preliminary studies for the Oceanside Harbor Experimental Sand Bypass project, SPL completed a geomorphic and sediment study of part of the Oceanside cell. The purpose of the study was to:

(1) Use available mineralogic data to document the existence of the littoral segments proposed by Osborne and others.

(2) Examine grain size fining trends to define most likely transport directions within each segment and document the complexity of littoral transport paths as a function of bathymetry.

The preliminary sediment studies of this area by the US Army Engineer Division, South Pacific (SPD), laboratory show marked changes in both grain size and heavy mineral content downdrift of Carlsbad Canyon, strongly indicating that Carlsbad Canyon was at least an intermittent sink. Follow-on work has not confirmed this hypothesis.

We have finished the broad spectrum sampling program in this area. Still to be accomplished is after-storm sampling adjacent to what we have identified as point sources. Study of cliffs is one of the most important tasks. Four distinct littoral assemblages have been identified within the cell. The complexity of fining trends in a shore normal direction has been documented. The proposed program to use Fourier grain shape analysis will permit us to separate our total sand sources into component parts, each of which reflects the volumetric contribution of local sources.

Encenitas Area

Our shoreline change maps indicate a net accretion in the general area about 10 miles long from 1887-1982. However, the detailed studies show a very complicated picture. From 1883-1891 there was over 600 ft of erosion, mostly in 1884. Between 1891 and 1980 there was very little retreat. Beginning in 1973 condos were constructed along the bluffs, some within 10 ft of the edge. Many studies by consultants for individual projects cited negligible erosion from 1925-1973 as a basis for approving construction. In addition to the long-term potential for cliff erosion and its episodic nature, the impact of urbanization of the cliffs was not taken into account. Even during the drought period it is evident that cliff collapse was caused at least as much by groundwater changes and the effect of man as it was by wave erosion. Since 1978, expensive and elaborate remedial work has been required because of extensive landslides. Since 1980, we have had no beaches in the area, not even in the summer. Now the cliffs are subject to constant wave attack. Any private or publicly financed protection project in the area has many factors to consider for a long-term solution.

San Onofre-Camp Pendleton Area

In the 1880's reports indicated that the bluffs in this area eroded during storms, but the beaches from Los Angeles to San Diego were sufficiently wide and continuous to be a major route of travel between these two cities. In 1958 the Corps showed that all monuments placed in 1934 were recoverable. This would suggest that cliff erosion was very slight during this period. However, 80 percent of the cliffs between San Onofre Power Plant and Camp Pendleton are landslides, and the survey points were all outside the landslide areas. Actually there have been considerable canyon cutting and bluff face sloughing in the area mostly confined to only two wet periods--one in 1941 in which one landslide 1,700 by 351 ft occurred and another in 1978 when a 700- by 32-ft block began to feed the beach.

In the same area, erosion has also been caused by man. Gully erosion has been accelerated by installation of culverts during highway construction. During the 1978 storm, the southbound lanes of US 101 collapsed, leaving a 75-ft-deep canyon. There was no canyon in 1969. In 1976 there was a 60-ft cut. Between January and February 1978, 160 ft of headward erosion occurred. On 20 February alone, 235 ft of erosion resulted in a 50- to 100-ft-deep, 60- to 90-ft-wide canyon.

All of these historical data confirm the episodic nature of important parameters for any model of coastal processes and the significant deficiencies of using average annual data to depict or predict actual conditions.

Silver Strand

Erosion at Imperial Beach has been an increasing problem since 1953, even during drought periods preceding the floods of 1978 and 1980. It was during this dry period that sand became unavailable from the Tijuana River because of dam construction, and the beaches had to be nourished by dredging. Between 1945 and 1967, sand moved from Imperial Beach to Zuniga jetty (south to north) (Inman, 1976). In the early 1940's however, weekly observations showed more variable directions (Shepard, 1950). At the south end of Imperial

Beach currents were predominantly south to north, but at the northern end there was north to south movement, with the exception of an intermediate point just north of Imperial Beach. The study also showed that currents near Zuniga jetty were south to north in summer and north to south in winter.

Here we have almost diametrically opposite valid observations of recognized experts but for different time frames. It suggests longshore transport is variable both in time and location within the cell and that any short-term model would be misleading. We may be in for another change in the area. During early 1983, beaches south of the border severely eroded, and sediment moved north, accreting at Imperial Beach. However the source of the material has changed from that in the past (Tijuana River). The beach cliffs in Mexico are now eroding and may be the primary source of Imperial Beach sand (Kuhn and Shepard, 1984).

CONCLUSIONS

The episodic nature of most of the variables that must be considered in understanding the coastal environment underscores the importance of examining entire regions and for more than historical time. We must recognize when independent observations reinforce or fit together and then construct a working hypothesis or geomorphic model for conditions we have today. These studies many times raise more questions than they answer. But that is one of their purposes. As a result of our experience in the last few years with these studies, I make the following recommendations:

(1) Framework studies should be done well in advance of other tasks to be of greatest value.

(2) There must be time allotted to digest, evaluate, and disseminate these studies.

(3) There must be dialogue between the geotechnical community and the coastal designers/planners to take advantage of the synergistic value in understanding the coastal environment and planning future studies.

In a report on California's coastal storms, Brown (1983) states that the past 30 years have been a period of relatively calm weather. But experts believe we are returning to an extended period of unpredictability and extreme variability. Sea cliff erosion is the dominant feature of 86 percent of the California Coastline. Sea cliffs are inherently unstable, and the ocean is unceasingly attempting to erode them. Eventually, notwithstanding man's attempts, it will reclaim them. Brown (1983) concludes that "coastal land use controls should be based on a realistic assessment of geologic processes and economic factors, not simply continuation of past practices and sympathetic emergency disaster relief."

As the leading coastal designer in the nation, the Corps must avail itself of all the disciplines and state-of-the-art tools available to define coastal conditions before designing and constructing appropriate and realistically cost-effective coastal structures. This perspective should be a part of every coastal study. In addition to being good planning and engineering, it is common sense.

ACKNOWLEDGEMENTS

The data and evaluations presented herein are almost exclusively presented in the Framework Geomorphology Reports for Dana Point to the Mexican Border (prepared by the Los Angeles District's Mr. Anthony Price); Monterey Bay (prepared by Dr. John R. Dingler, Ms. Beth L. Leland, and Mr. Roberto J. Anima, USGS, Menlo Park); and "Sea Cliffs, Beaches and Coastal Valleys of San Diego County (Dr. G. Kuhn and Mr. F. Shepard)." Much of the coastal sedimentation data were developed by Professor Robert H. Osborne of the University of Southern California. Discussions were held with Professor Osborne, Dr. Dingler and Dr. Kuhn, University of California, San Diego, who supplied slides for the presentation. The author acknowledges also the contribution of Dr. Gerry Weber, University of California, Santa Cruz.

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OCEANSIDE EXPERIMENTAL SAND BYPASS

CERB Proceedings

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ABSTRACT

Oceanside Harbor and the neighboring downcoast beaches have been the focus of controversy and scientific study since the construction of the original harbor jetties in 1942. Shoaling of the harbor entrance channel and erosion of Oceanside city beaches have been continuous problems. The Federal government has assumed full responsibility for restoration of Oceanside beach and maintenance of the harbor. The US Army Corps of Engineers (Corps) has conducted several studies of the harbor and beach and has tried periodic renourishment of Oceanside's beaches in an attempt to slow the effects of erosion. As a result of survey studies conducted by the Corps in 1980 and the construction of an experimental sand bypass system for Oceanside Harbor, it has become clear that periodic nourishment is not effective and that alternative structural solutions do not have local support. The Oceanside Experimental Sand Bypass System is designed to reduce maintenance dredging costs in Oceanside Harbor and to provide the downcoast beaches with a continuous source of beach sand.

INTRODUCTION

Oceanside is located on the southern California coast about 30 miles north of San Diego (Figure 1). The city was founded in the late nineteenth century as a coastal resort. During the early years of the city's development, its beaches were typically wide and capable of providing recreation for the many tourists who flocked there during the summer months (Figure 2).

Since its early years the Oceanside beachfront has changed dramatically as a result of the many man-induced changes which have altered the natural physical processes shaping the coastline. The effect of these changes is beach erosion. The first evidence of development which ultimately had an impact on the beaches of Oceanside occurred in 1922 with the construction of Henshaw Reservoir on the San Luis Rey River. This structure reduced the sediment-carrying capacity of the river, thereby diminishing the natural supply of beach material for the Oceanside area. Construction of Vail Dam on the headwaters of the Santa Margarita River was completed in 1949. This construction undoubtedly had an effect on the supply of sand to the local beaches (Hales, 1978). Damming of the Santa Margarita and San Luis Rey rivers

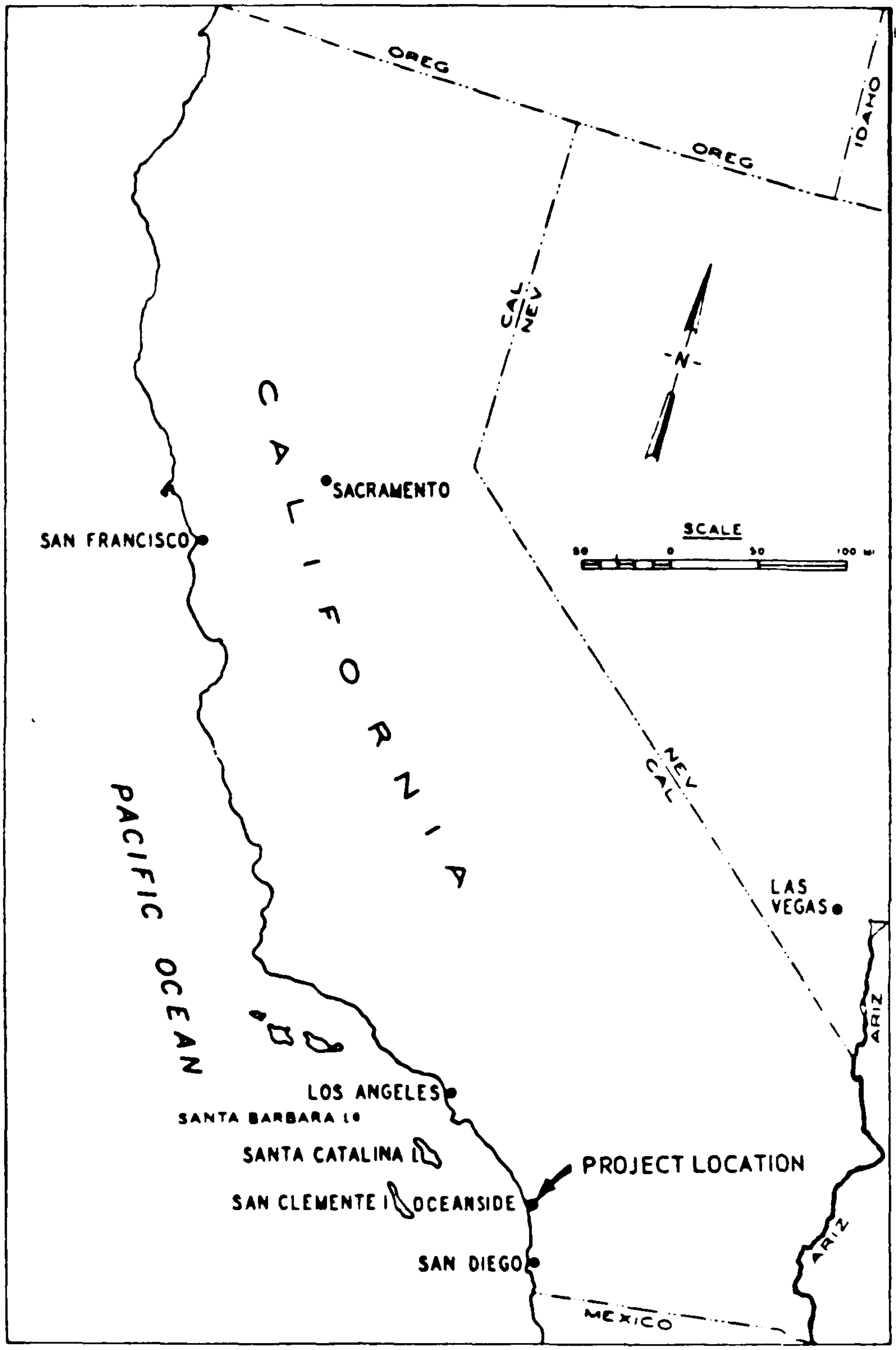

FIGURE 1. PROJECT LOCATION

FIGURE 2. TOURISTS AT OCEANSIDE BEACH

resulted in significant reductions of natural beach replenishment material for the Oceanside area.

In 1942 the United States Marine Corps constructed the Del Mar Boat Basin just north of Oceanside at the southern limit of Camp Pendleton (Figure 3). At the time of its construction, little was known about its eventual impact on local littoral processes. The original harbor construction consisted of two converging jetties extending seaward to about the -20-ft depth. The upcoast, or northern, jetty was about 2,100 ft long; and the southern jetty was 1,300 ft long.

During and immediately following construction of the harbor, effects in the area of the harbor entrance and on the local shoreline were recognized. By 1945 the entrance channel had shoaled from a constructed depth of 20 ft to only 14 ft and had decreased in width from 190 to 50 ft. The entrance channel was dredged that year with approximately 220,000 cu yd of material being removed. Within 8 months of the dredging, the harbor entrance was plugged again.

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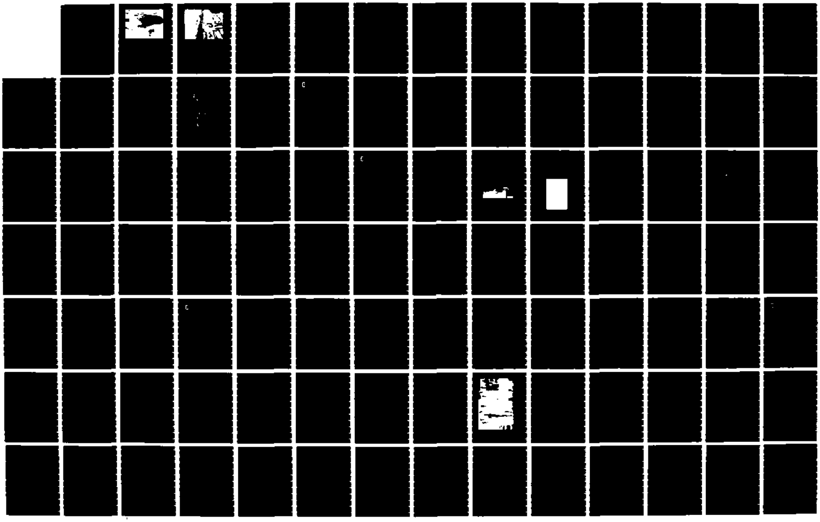

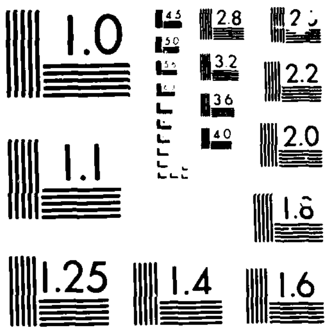
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FIGURE 3. DEL MAR BOAT BASIN

The downcoast shoreline was also immediately affected by the harbor construction. Erosion was evident during and after completion of the harbor (Figure 4). It was clear that the construction of the harbor jetties had caused the downcoast erosion of Oceanside's sandy beaches; consequently, several studies on the harbor and local littoral processes, and a search for a solution to the problem, began.

LOCAL PHYSICAL PROCESSES

The Oceanside littoral cell, extending from Dana Point on the north to Point La Jolla on the south, contains about 50 miles of mostly sandy beach predominantly facing southwest (Figure 5). Along most of the Oceanside littoral cell from Del Mar to San Onofre, the sea cliffs range in height from about 30 to 120 ft. The sandy beaches are relatively wide during the summer, but they retreat during storms when waves break directly against the cliffs.

FIGURE 4. BEACH AT OCEANSIDE, CALIFORNIA, 7 AUGUST 1949

The cliffs along this region of coastline are interrupted by eight partly filled estuaries at the mouths of mostly seasonal, winter streams. Usually these estuaries are separated from the ocean by barrier sand spits formed by a predominant southern littoral drift.

Most of the movable sediment within the cell comes from the streams and, to a lesser extent, from erosion of the sea cliffs. The beach sand moves up- and downcoast during periods of heavy wave action, depending on the angle of wave approach. A dynamic equilibrium exists along much of the cell, with a surface layer of beach sand constantly moving either up- or downcoast.

At the southern end of the cell there is strong evidence of large sand losses to the La Jolla submarine canyon. Also, there is little evidence that sand migrates around the northern boundary of the cell at Dana Point (Hales, 1978). These observations, together with considerable data gathered in the past, support the observation that net drift within the Oceanside littoral cell is to the south (Figure 6).

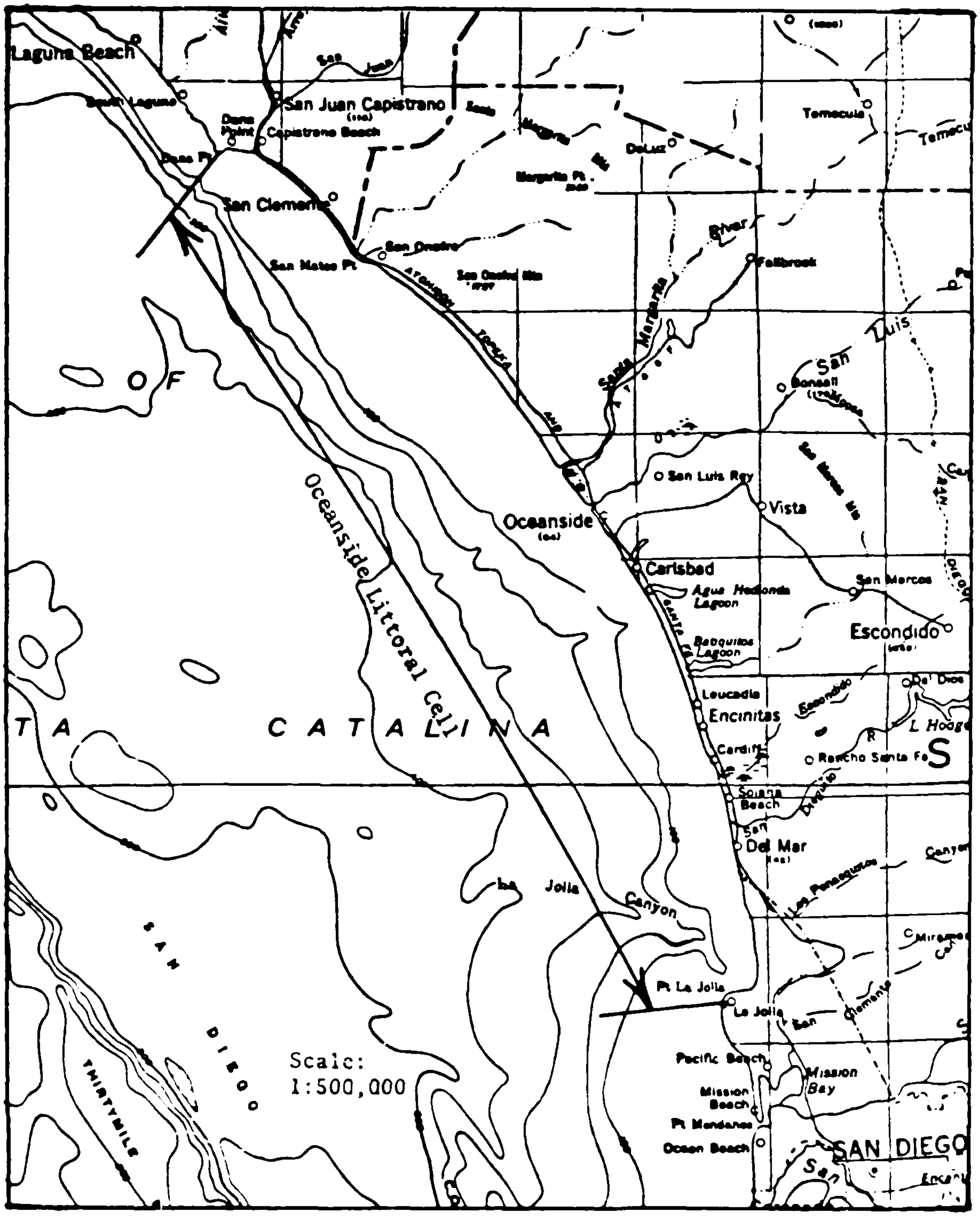


FIGURE 5. OCEANSIDE, CALIFORNIA, LITTORAL CELL

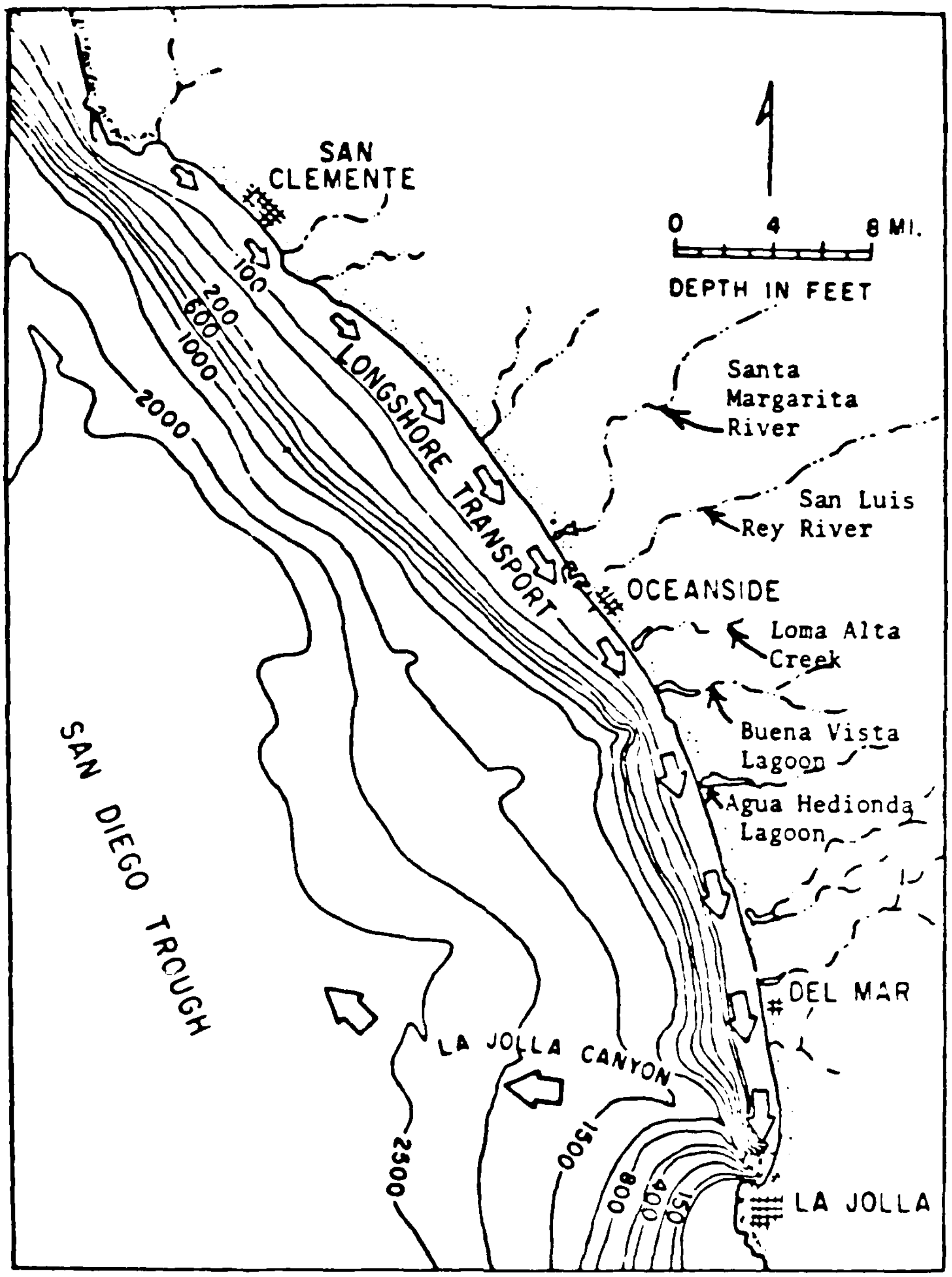


FIGURE 6. THEORETICAL OCEANSIDE, CALIFORNIA, LITTORAL CELL (showing probable direction of net longshore transport (after Inman))

Coastal processes studies conducted in the Oceanside area in the past have shown the potential for longshore transport by sea and swell to be on the order of 640,000 cu yd south and 540,000 cu yd north, with a net annual transport of about 100,000 cu yd to the south (Table 1).

The harbor at Oceanside, located approximately at the middle of the Oceanside littoral cell, can be considered a sediment "sink," as sand moving along the coast is trapped at the harbor jetties and entrance channel. The main northern breakwater traps sand moving to the south, piling sand on its north side until the shoreline realigns so that sand can move around the breakwater and into the harbor. South of the harbor, sand moving northerly is trapped as it moves upcoast and into the harbor. Once in the harbor, this sand is lost to the littoral system, as the harbor is sheltered from wave action and littoral currents. This sand can only be returned to the system by means such as dredging. Dredging records indicate that approximately 360,000 cu yd of material is lost to the harbor annually. On a regional scale the "sink" effects of the harbor are only slightly significant, but at Oceanside, just downcoast of the harbor, its effects are well recognized.

ALTERNATIVE SOLUTIONS AND DEVELOPMENT OF THE SAND BYPASS CONCEPT

The Oceanside Harbor complex today includes the Del Mar Boat Basin and the Oceanside small-craft harbor which was constructed in 1963. While the Del Mar Basin is used exclusively for military purposes, the small-craft harbor and downcoast beach are used primarily for recreation. Today the harbors are protected by a 4,350-ft-long north jetty and a 1,330-ft-long south jetty. Presently a 920-ft-long groin is located at the mouth of the San Luis Rey River, about 1/2 mile south of the harbor. A chronological summary of the harbor's development is shown in Figure 7.

From 1962 to 1981 the Federal government has dredged nearly 9 million cubic yards of sand from the Oceanside and Camp Pendleton harbors and placed the material on Oceanside's beaches. Despite this nourishment, the downcoast beaches have continued to erode. Further renourishment efforts were tried in 1982, with approximately 1 million cubic yards of sand from the San Luis Rey River being truck-hauled to Oceanside. This sand was lost, along with most of the original existing beach, to the large storms of the winter of 1983.

In 1967, Congress authorized a review study of the beach erosion at

TABLE 1
SUMMARY OF POTENTIAL LONGSHORE TRANSPORT COMPUTATIONS
OCEANSIDE, CALIFORNIA*

	Sea		Northern Swell		Southern Swell		Sum		Net		
Month	+ North	- South	+ North	- South	+ North	- South	+ North	- South	+ North	- South	Gross
Jan	35,501	25,281	1,741	9,148	0	0	37,242	34,429	2,813		71,671
Feb	26,188	25,188	3,544	8,759	0	0	29,732	33,947		4,215	63,679
Mar	9,788	63,737	5,977	8,080	0	0	15,765	71,817		56,052	87,582
Apr	2,993	61,542	1,735	6,896	0	0	4,728	68,438		63,710	73,166
May	88	90,521	180	8,265	61,979	0	62,247	98,786		36,539	161,033
Jun	34	99,024	0	9,852	36,889	0	36,923	108,876		71,953	145,799
Jul	9	57,129	0	7,804	112,906	0	112,915	64,933	47,982		177,848
Aug	0	42,133	8	6,105	84,664	0	84,672	48,238	36,434		132,910
Sep	63	33,445	375	3,472	89,151	0	89,589	36,917	52,672		126,506
Oct	1,307	27,342	43	2,970	35,147	0	36,497	30,312	6,185		66,809
Nov	10,389	16,595	1,127	6,541	0	0	11,516	23,136		11,620	34,652
Dec	17,244	15,418	1,546	7,841	0	0	18,790	23,259		4,469	42,049
Annual	103,604	557,355	16,276	85,733	420,736	0	540,616	643,088	146,086	248,558	1,183,704
Net		453,751		69,457	420,736			102,472		102,472	

* In cubic yards

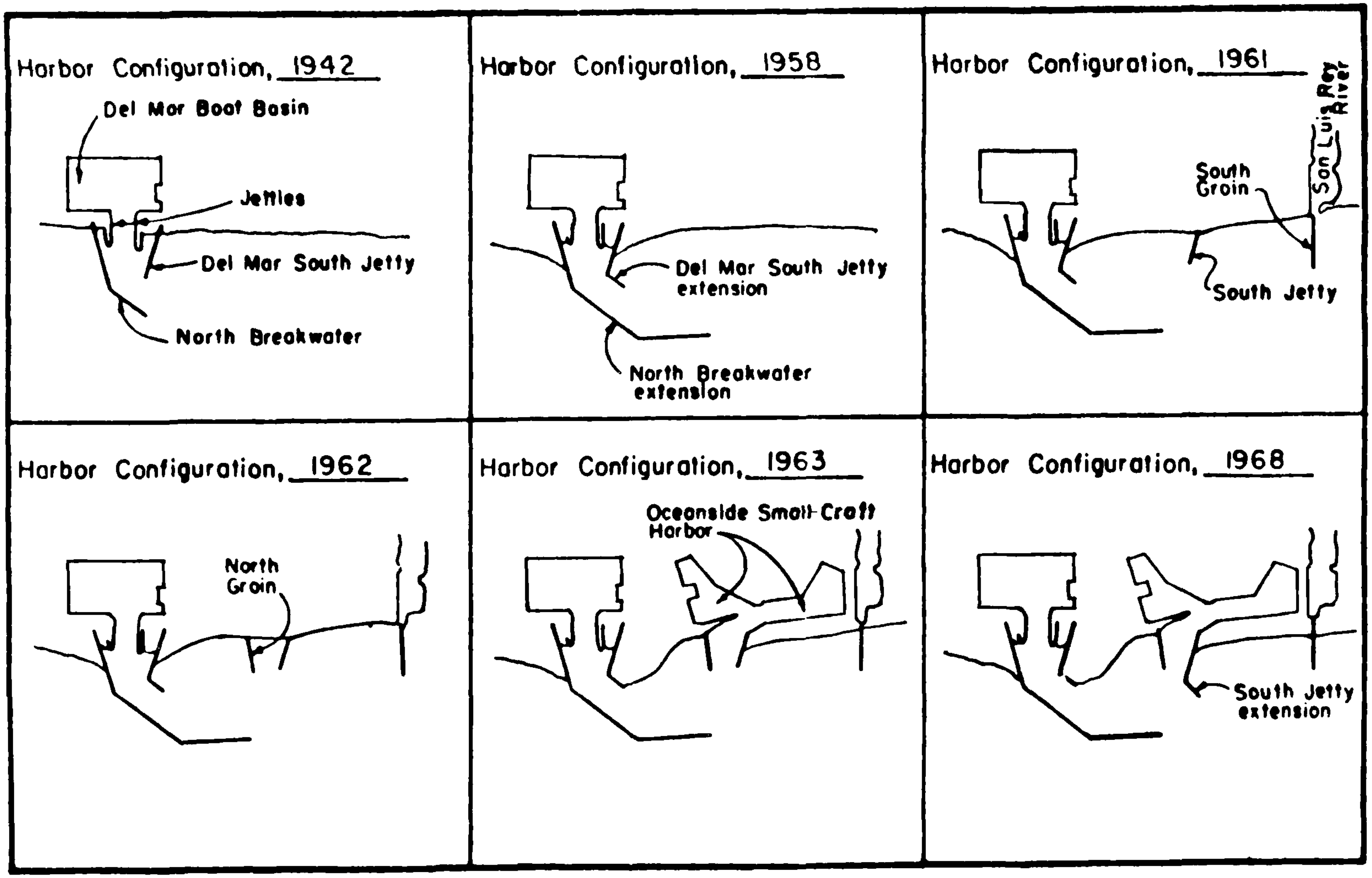


FIGURE 7. CHANGES IN HARBOR CONFIGURATION, 1942--1968

Oceanside. Little progress was made toward an erosion solution during the 1970's. For the most part, this was due to a lack of information about and understanding of the problem.

In 1978, model studies of various proposed solutions were conducted at the US Army Engineer Waterways Experiment Station in Vicksburg, Mississippi. The studies were conducted to gain a better understanding of the effects of proposed structural and beach stabilization measures. The model studies concluded that a proposed five-groin plan was not effective in preventing erosion and recommended instead a combination of an offshore submerged breakwater-groin system for controlling beach erosion. A survey report was prepared by Curren and Chatham (1980) which included the breakwater recommendation and proposals for other erosion solutions. Although the groin plan had local community support, the breakwater plan did not. Reaction to the offshore breakwater proposal was universally negative. Beachfront property owners, surfers, and downcoast local and State agencies were all opposed. The only erosion solution which received universal local support was a sand bypass system.

DESCRIPTION OF THE SAND BYPASS SYSTEM

The Sand Bypass System was originally conceived in the US Army Corps of Engineers' (Corps') 1980 Survey Report on Beach Erosion Control. The proposed bypass consisted of a series of fixed jet pumps placed in the harbor entrance. By mechanically bypassing sand from in and around the harbor, the natural littoral transport which was interrupted by the original construction of the harbor breakwaters theoretically could be restored. The survey report acknowledged that a bypass system was the environmentally preferred solution, but it could not conclude that the proposed system would totally correct the erosion problem.

In 1982, as part of the Corps' Operation and Maintenance Program for Oceanside Harbor, authorization was given to proceed with the design and construction of an experimental sand bypass system. This authorization came through the 1982 Energy and Water Development Appropriation Bill in which Congress appropriated $700,000 for the bypass design.

The first phase of the Sand Bypass System development consisted of data collection and analysis. As part of this study effort, local and technical committees assisted the Corps in developing and evaluating sand bypass concepts (Moffatt and Nichol Engineers, 1983a). The final recommendation comprised (1) an array of fixed jet pumps on the south side of the channel entrance at the south harbor jetty and (2) fluidizers that feed sand to jet pumps on the north side of the north fillet at the north end of the harbor. Discharge was to be at various points along the beach, the last point being at Wisconsin Avenue approximately 2 miles south of the harbor.

Subsequent studies included the development of the system hydraulics and drive components and later the development of the final concept and design (Figure 8) (Moffatt and Nichol Engineers, 1983b and 1984). The basic components of the jet pump system are a clear water supply with intake pump, a clear water supply line, a jet pump, and the jet pump discharge line.

The jet pump is a "Y"-shaped pipe that utilizes the basic principles of fluid dynamics to 'vacuum' sand from the ocean bottom. Supply water is forced through a nozzle where the large increase in velocity is compensated for by a large decrease in pressure. Sand is vacuumed up through the jet, creating a crater in the sand deposit where the jet pump is positioned (Figure 9a).

Fluidizers will also be employed as part of the Sand Bypass System. These devices will force sand into suspension, allowing more sand to be drawn toward the jet pump crater and thereby widening the effective area of the jet pump (Figure 9b).

A fluidizer is a manifold pipe with several perforations. After water is pumped through the pipe, it flows out of the holes at high velocity. The high velocity of the water "fluidizes" the sand which then flows toward the jet pump.

The ultimate bypass system will have a bank of 10 jet pumps on the south side of the harbor channel entrance. These pumps are intended to intercept sand moving into the harbor from the south. On the north side of the channel entrance two jet pumps fed by three fluidizers will intercept sand moving around the harbor from the north. The north fillet system consists of a single jet pump that can be moved about by a hinge. This pump is intended to collect sand that would otherwise migrate around or through the north breakwater into the harbor.

Fixed riser structures, or platforms, will be constructed on each of the jetties. The north fillet platform and equipment are represented in Figure 10. These platforms will be used to interface the subsea jet pumps and

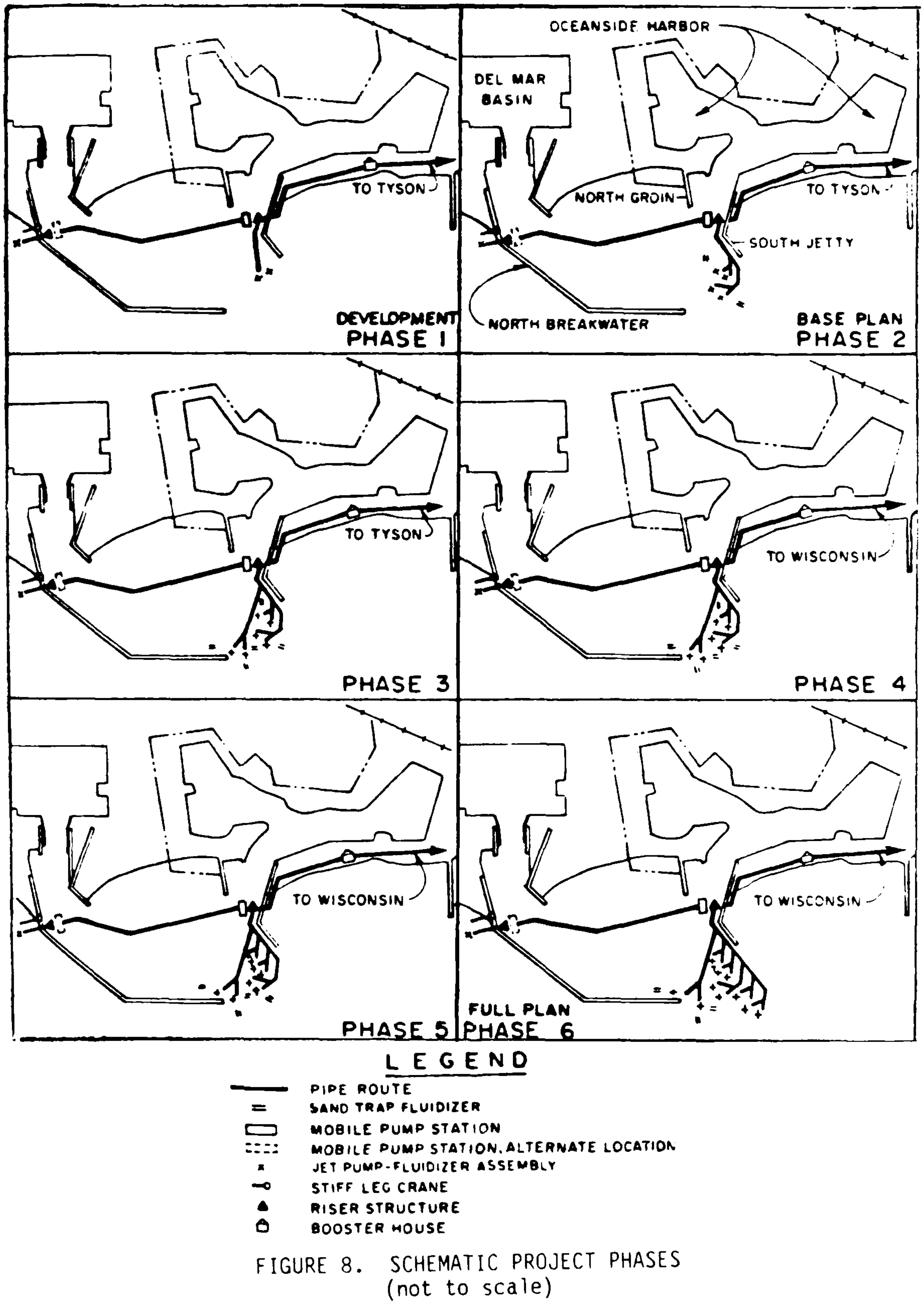
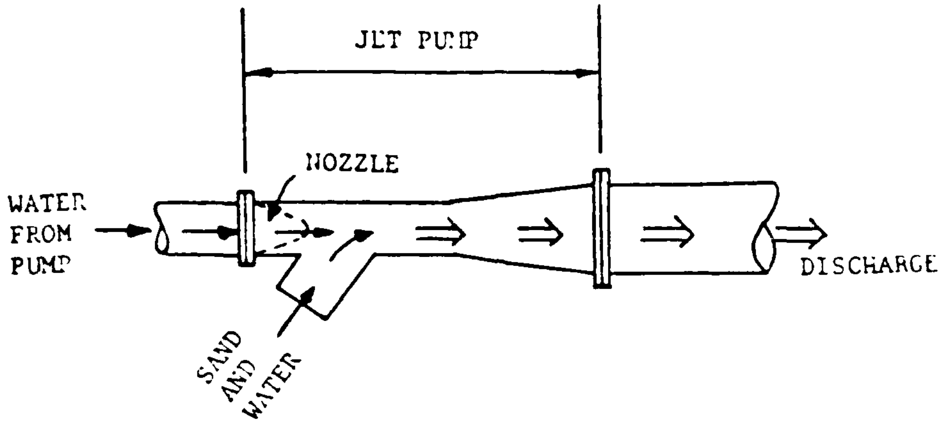
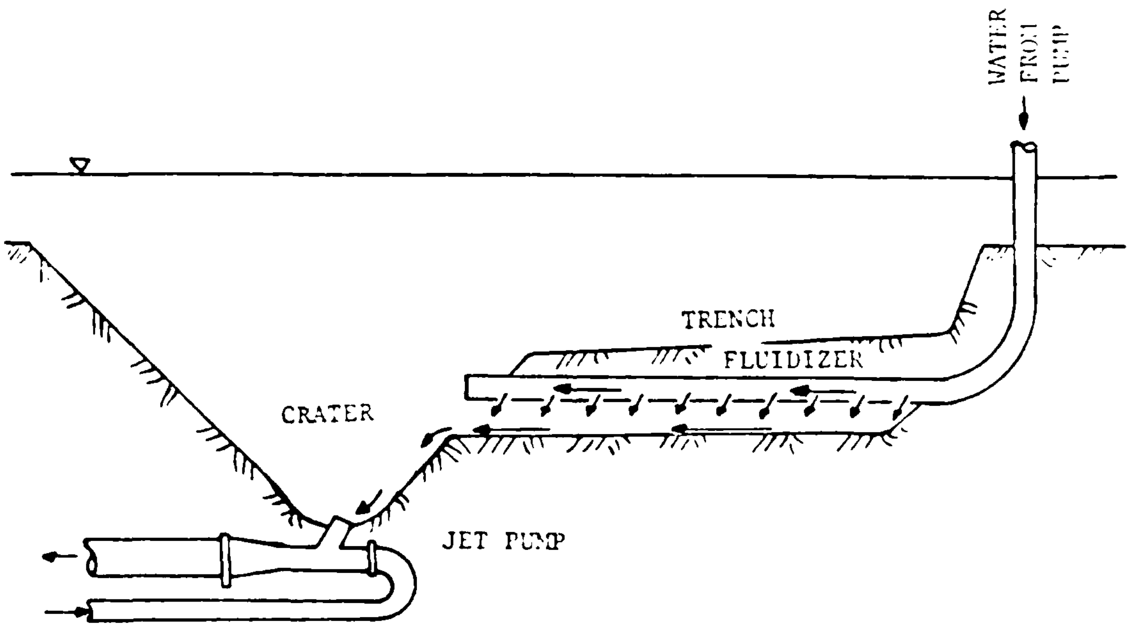


FIGURE 8. SCHEMATIC PROJECT PHASES
(not to scale)



a. Jet Pump Operating Principle



b. Fluidizer/Jet Pump Combination

FIGURE 9. FLUIDIZERS FOR THE SAND BYPASS SYSTEM

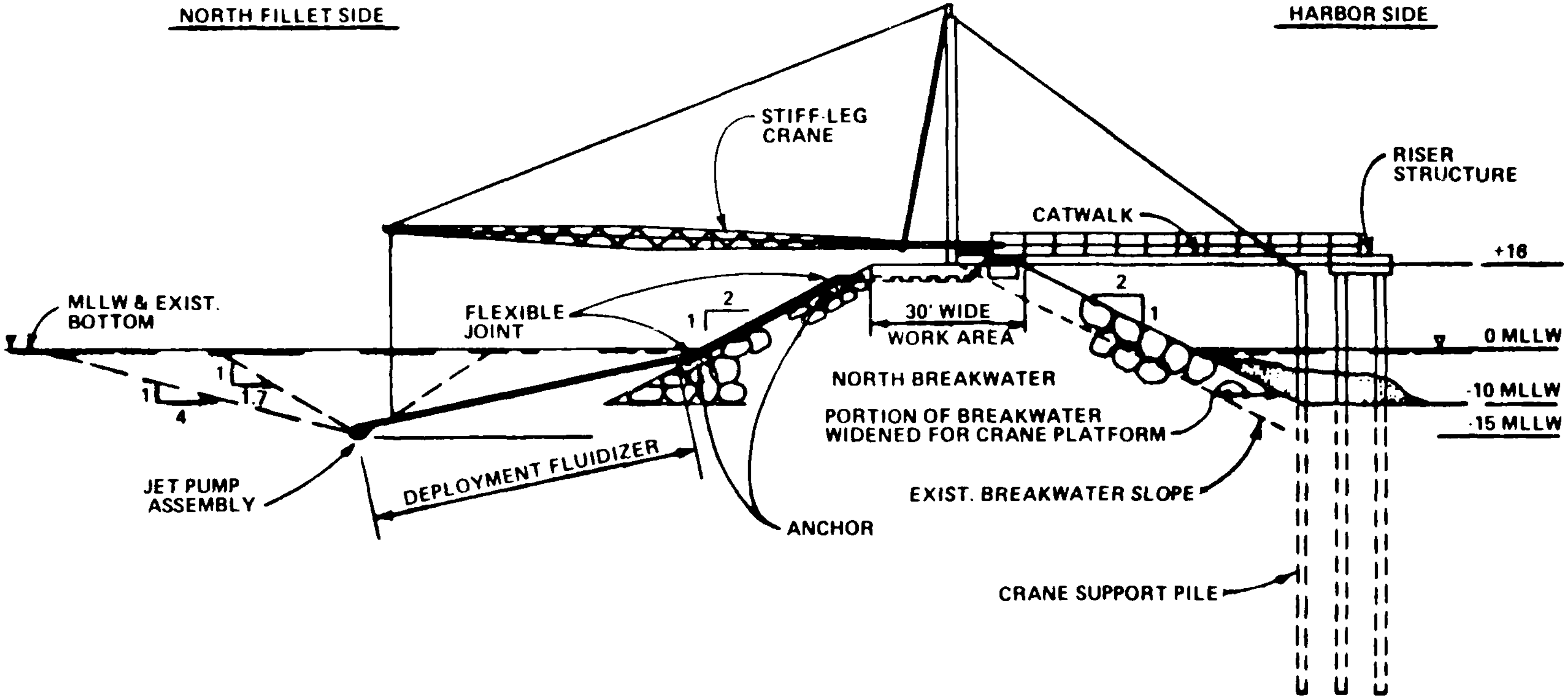


FIGURE 10. NORTH FILLET PLATFORM AND EQUIPMENT

piping system to a mobile pumping platform. The mobile pumping platform is a barge with jack-up capability which will be positioned at either the south or north jetty riser structure depending on the season.

Power to drive the pumps on the mobile barge will be supplied by diesel engines, while an intermediate system booster pump, located near the south jetty, will be driven by an electric motor. Other auxiliary equipment includes small cranes on the north fillet and barge to deploy and recover the jet pumps, piping and service equipment, a work boat for servicing, and a crew boat.

The installation of the beach discharge pipeline was completed in early 1985. When completed, the jet pump system will be joined to the discharge pipeline to facilitate the discharge of sand removed from the harbor entrance and north fillet to the beaches of Oceanside.

The north fillet system is intended to operate during the winter months when the littoral transport is to the south. The entrance channel system will work during the summer months when littoral transport is to the north. Only two jet pumps would operate at any one time in the entrance channel. Each of the 4-in. entrance channel pumps is capable of pumping 100 cu yd per hour, while the 6-in. north fillet pump has a pumping capacity of 200 cu yd per hour. The ultimate system is expected to bypass about 400,000 cu yd of sand annually to the downdrift beach.

Sand bypassing on this scale has not been attempted on the West Coast and, consequently, is considered to be an experiment. Because the exact littoral transport quantities and paths are not well documented, and because of the experimental nature of the system technology, the bypass system will be constructed in phases. Phasing will allow for construction of incremental portions, monitoring of that portion's operation, and for refinement and implementation of future stages based upon prior system performance and experience.

The first phase is known as the development plan. It includes the construction of the north fillet jet pump system and the installation of two fixed jet pumps at the south jetty of the harbor entrance. Since the system is designed to have only two jet pumps operating at any given time, these two initial jet pumps will be capable of pumping the design capacity of the system, provided that sand is available in sufficient quantities and that clogging of the jet pumps does not become a problem. The development plan includes the construction of a booster pump on Harbor Beach. Sand slurry removed by the jet pumps will flow through the booster pump, downcoast through the discharge pipeline (14-in. HDPE) for about 1 mile, to its discharge location at Tyson Street.

The initial development phase should be operational by the summer of 1986. The Corps intends to operate the system for about 1 year before evaluating and then possibly adding to the system. Future construction will depend on the success of the initial system's performance (Figure 8).

If the development plan is successful and a need is demonstrated for the expansion of the system, two more jet pumps and two fluidizers will be constructed in the south entrance channel. If the fluidizers also prove successful, the north entrance channel system will be added. Following that, the remaining jet pumps will be constructed in the south entrance channel, and the discharge pipeline will be extended to Wisconsin Street (about 2 miles south of the harbor).

MONITORING

The performance of the sand bypass system and its effects on the physical and biological environment will be monitored during its installation and during the 5-year experimental period. Biological monitoring will include studies of the effects of the project on infauna, fish, plankton, grunion, and other marine habitats.

Performance monitoring will be accomplished by a computer-based Supervisory Control and Data Aquisition (SCADA) system. This system is an integrated hardware and software package that provides the capacity of both controlling and monitoring the sand bypass system (US Army Engineer District, Los Angeles, 1985). The SCADA system is designed to monitor, record, and process data for sand quantities pumped, fuel and electricity consumed, operating time, and such processes as engine start/stop status, valve open/close status, and fluid temperature and pressure status.

A physical monitoring program has also been implemented. This monitoring includes semiannual beach profiles to a depth of -40 ft, harbor surveys, wave measurements, and sand sample analysis.

The inner harbor surveys are conducted using a conventional fathometer. Wave measurements are obtained using the existing S_{xy} gauge located off the end of Oceanside pier. Sand samples will be collected at predetermined locations by diving.

The beach profiles are obtained by a system that utilizes a lightweight towed sled with a high mast carrying reflectors for a shore-based laser survey system. The sled is pulled along the rangelines by the Lighter Amphibious Resupply Cargo (LARC) vessel (Figure 11) from the US Army Engineer District, Los Angeles. The survey system locates the sled's reflectors both horizontally and vertically, reads the data values, and stores the values immediately on a computer-readable data module. The data obtained from the monitoring program will be used to gain an understanding of local littoral and harbor dynamics and to recommend changes to the system's operation.

A major benefit of the experimental sand bypass system will be the opportunity for scientists and engineers to learn more about the littoral processes at Oceanside and to develop new technologies for harbor maintenance and beach erosion control. By simulating the continuous flow of sand along the coast through the use of the bypass system, it is believed that the bypass will be more effective in stabilizing the beach than periodic dredging, which creates a "bulge" of sand that is subject to accelerated erosion.

Dredging costs are expected to be reduced also once the bypass technology is developed and refined. Costly mobilization will be eliminated, and through the use of energy efficient jet pumps, the bypass has the potential for significant savings over conventional dredging.

The contract for the development phase of the bypass system has been awarded to Maecon Construction Company, Inc., of Irvine, California. The cost of the development plan construction was bid at $5.5 million. Construction is expected to be completed by early summer 1986, with system start-up to follow.

The sand bypass system is important to the Corps as well as to the local community of Oceanside because its successful operation could result in a significant reduction in the erosion problems Oceanside has experienced. The Corps looks forward to advancing harbor dredging technology through the development of this experimental system which is consistent with the current government trend in identifying and developing reliable means of minimizing long-term government expense related to harbor maintenance.

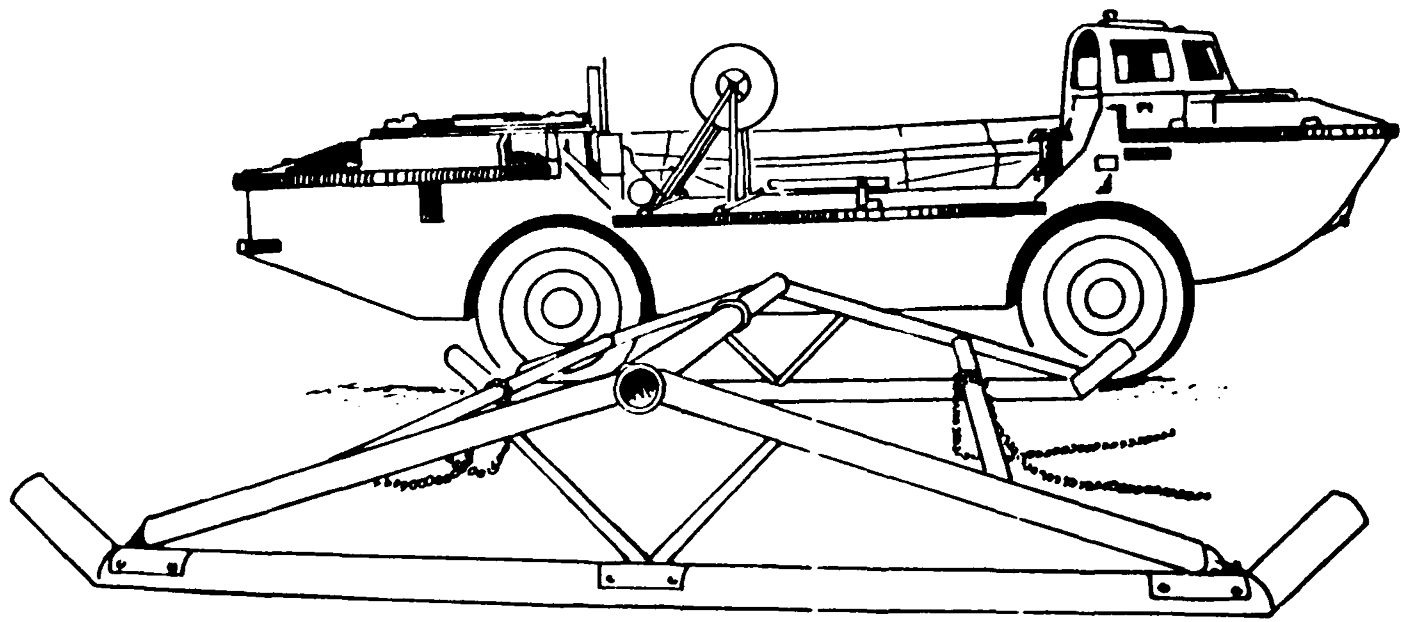


FIGURE 11. SURVEY SLED WITH AMPHIBIOUS VEHICLE, LARC
(Survey sled mast not shown)

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RESEARCH AND DEVELOPMENT NEEDS FOR SOUTH PACIFIC DIVISION

CERB Proceedings

Mr. Achiel E. Wanket, Chief
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South Pacific Division

ABSTRACT

The US Army Engineer Division, South Pacific (SPD), has important interests in the general research areas of Wave Information, Shore Protection and Restoration, Coastal Structures, and Harbor Entrances and Channels. SPD is participating jointly with the Coastal Engineering Research Center and the Office of the Chief of Engineers in a number of research, monitoring, and demonstration projects and investigations to partially address US Army Corps of Engineers and SPD research needs, including (1) measurement of prototype forces on dolosse, (2) the Coastal Data Information Program, (3) monitoring of completed coastal projects, (4) Coast of California Storm and Tidal Waves Study, (5) Oceanside Sand Bypassing System, and (6) Coastal Remote Sensing Demonstration Program. SPD supports the continuation of these collaborative efforts and the addition of appropriate supplementary items of both general interest and specific utility to our West Coast projects and activities.

INTRODUCTION

Thank you for the opportunity to briefly present the research needs of the South Pacific Division (SPD). In so doing, I will discuss and emphasize the importance of our current research and development (R&D) activities and the way in which they relate to the research interests of the Coastal Engineering Research Center (CERC) and other US Army Corps of Engineers (Corps) laboratories.

These current efforts include research and related activities funded by the Office of the Chief of Engineers (OCE), with funding contributions from various programs, including R&D, Coastal Field Data Collection, and Operations and Maintenance (O&M). CERC serves as the technical monitor. I will also discuss some current research activities on general topics which are of special interest to SPD and some suggestions for expanded activities and future work.

SPD has significant interests in all of the four major coastal R&D programs carried on by CERC for the Corps--specifically (1) Coastal Flooding and Storm Protection (including wave information programs), (2) Shore Protection and Restoration, (3) Coastal Structure Evaluation and Design, and (4) Harbor Entrances and Coastal Channels.

There are a number of ongoing activities in which SPD is involved which contribute to these programs. Some of them are stand-alone research/ demonstration efforts; others are in conjunction with our ongoing projects. All are deserving of continued support and completion.

We recognize that the limited funding support currently available for many programs such as the Coastal Field Data Collection Program makes across-the-board progress in many different research areas more difficult. This means that expeditious completion of previously undertaken work assumes even greater importance and, if necessary, priorities should be examined accordingly to assure that past efforts are completed.

This preface is intended to emphasize the importance to SPD of continuing your support of currently programmed work at a high level. I'm not saying, however, that we don't have a "wish list" of added work. We certainly do, and I will discuss this list later.

CURRENT R&D-RELATED PROJECTS INVOLVING SPD

Measurement of Prototype Forces on Dolosse

This important project involving dolosse, which General Palladino noted in his overview, is now under way at Crescent City in conjunction with our rehabilitation of a damaged reach of dolos armor units on the outer breakwater. It has also been discussed in some detail at prior Coastal Engineering Research Board (CERB) meetings. Casting of new dolosse is under way, and CERC is preparing to instrument 20 of these units with strain gages to obtain internal forces. Some will be instrumented to obtain velocities of motion. Hydrodynamic pressures on and within the breakwater will be obtained also, along with offshore and nearshore wave observations to correlate observed forces with wave conditions. Interesting technical problems of placement of the instrumented dolosse, development of rugged data acquisition equipment, and measurement of thermal stresses on the dolosse during casting are also being addressed.

This O&M-funded program is planned for 3 years of observations. When it is completed, in combination with other studies planned by CERC, we are optimistic of thereby improving our understanding of armor unit responses and of producing specific design procedures for improved armor unit performance.

Coastal Data Information Program

In May 1976, SPD, in cooperation with the California Department of Boating and Waterways, began a wave gaging program with Waverider buoys and pressure gages to record continental shelf and nearshore waves using central computing facilities at Scripps Institute of Oceanography. The implications of this idea--notably provision of basic wave data for engineering, planning, and design purposes--are great. With the support and assistance of OCE and CERC, the program was expanded statewide from its genesis in southern California and later to a larger area which now includes gages in Oregon, Washington, Hawaii, and the Field Research Facility pier at Duck, North Carolina. Currently, about 20 gages are operating, and six of these are index gages to be operated and maintained by OCE and CERC's Field Data Collection Program funds allowing, hopefully, for a period of up to 30 years. The remaining gages are supported by specific projects and project studies of SPD, US Army Engineer Division, North Pacific (NPD), and other organizations.

Continuance and, indeed, expansion to all of the Nation's coastline of the Coastal Data Information Program are desirable goals. The monthly and yearly statistical reports produced by Scripps are of considerable value to SPD coastal planners and engineers and others including the National Weather Service (NWS) which uses 3- and 6-hr reports on a daily basis in its broadcasts to mariners. We are aware also of the value of long-term wave data to numerous work units within CERC's coastal programs.

Monitoring Completed
Coastal Projects (MCCP)

The MCCP program, an OCE/CERC Corps-wide program to collect data on the performance of existing Corps coastal works, has only recently come into play within SPD. As noted earlier, a monitoring program has been approved for the Imperial Beach breakwater program, and we will, as Mr. Thuet indicated, be developing a detailed proposal during fiscal year 1986 (FY 86) for Fisherman's Wharf Harbor monitoring after the breakwater construction. We see these individual studies as essential to us and the Corps in evaluating our project performance and preparing for improved future efforts.

Benefits to CERC's and the US Army Engineer Waterways Experiment Station's (WES's) research programs are also evident. For example, at Imperial

Beach the program should assist CERC in verifying and calibrating ongoing numerical littoral transport models and related work units planned in its Shore Protection and Restoration Program.

Oceanside Sand Bypassing

An O&M-funded effort, the Oceanside Sand Bypassing System, will contribute information to benefit the overall Corps dredging mission. The intensive monitoring effort here is also being closely coordinated with other data collection efforts in the vicinity under our Coast of California Storm and Tidal Waves study and the planned Coastal Remote Sensing Demonstration effort, which I will discuss later. This coordinated monitoring will be of assistance also to CERC in developing its littoral transport models.

The Coast of California
Storm and Tidal Waves Study (CCSTWS)

The CCSTWS, which was presented at a briefing for the civilian CERB members--including Dr. Bernard Le Méhauté and Dr. Dag Nummedal (and retiring CERB members Professor Robert Wiegel and Mr. Willard Bascom)--last July in Los Angeles, is a broad ranging general investigation to define coastal processes on the California coast. The first reach being investigated in depth is in the San Diego County area. As indicated by Mr. Daniel G. Parillo in his geomorphological presentation, we are also beginning to look at the Monterey Bay area.

We believe this study, when coordinated with other studies I have just indicated, has a potential not only for improving our understanding of coastal processes but also for predicting the effects of proposed structures and manmade changes. This may come about through the further development of CERC's littoral transport models to which I've previously alluded--specifically, the so-called Regional Coastal Processes Numerical Model to predict effects of proposed structures on a regional scale and another separate, finer grid model to study local effects of structures.

The Remote Sensing
Demonstration Program

The Remote Sensing Demonstration Program is being funded by O&M dollars to demonstrate coastal data acquisition methods with potential to reduce O&M costs and improve the gathering of coastal wave and survey information. SPD is looking forward to serving as a demonstration site for airborne laser mapping and the X-Band and Coastal Ocean and Dynamics Applications Radar (CODAR) technologies. The CODAR coastal demonstration, which is now in the advanced planning stage, will begin at Point Mugu later this year and then at Oceanside in late 1986. SPD and our Districts are looking forward to use of this advanced wave and current sensing system to provide unique synoptic-scale information on storm wave directional spectra. We see this as a likely means to fill the wave information gaps between our widely spaced nearshore wave gages so that we can develop a more unified picture of longshore transport variability between gages. Also, it will ultimately help us determine the effects of island sheltering on southern California which is still a difficult-to-assess problem.

OTHER ONGOING DIVISION AND DISTRICT PROJECTS

The foregoing efforts and program involvement of SPD are certainly not new to the staff of CERC nor, for that matter, to the staff elements at the Chief's office. We have been meeting and speaking frequently on these efforts for the last several years agonizing with them over the details and difficult problems of time, staff, equipment, and materials. The one thing that impresses us, as diverse as these individual work elements are, is how they all seem to interact so that each little "building block" of information that we gather will fit together and that the assistance and participation of SPD in these research efforts will help strengthen the foundations and practice of coastal engineering everywhere.

This "building block" metaphor also applies to other ongoing District and Division coastal projects and related activities, some of which have also been discussed, or will be discussed, during the course of this meeting and the West Coast Regional Coastal Design Conference which takes place after the CERB meeting.

These project activities include the follow g:

(1) San Francisco Bay Disposal Management Program with its important implications for dredging project work.

(2) Coastal Storm Observer Program, which, as Mr. Domurat indicated, is an innovative, low-cost pilot program in cooperation with the State of California to document extreme beach changes during winter storms.

(3) Geomorphological components of the CCSTWS.

(4) Recently upgraded function and operation of the San Francisco Bay-Delta Model which promises continuing usefulness, not only for

Corps navigation and project studies but also for larger Statewide water quality and water resource management problems.

(5) Other numerous SPD project studies, including hydraulic model and computer-based wave studies in which we are, or have been, collaborating with CERC. The Noyo and Fisherman's Wharf models are excellent examples, but we could similarly describe modeling efforts for the Crescent City rehabilitation, the Buhne Point breakwater, Mission Bay, San Pedro, and Los Angeles-Long Beach and navigation simulation studies for the San Francisco Bay ports in concert with WES's Hydraulics Laboratory. Also of note is a series of "lessons learned" analyses, prepared with CERC's assistance, of the damaging effects of the 1982-1983 storms on our coastal structures. These reports are designed to be useful in an ongoing Division-wide program to develop detailed O&M manuals for monitoring and repair of the structures. Each of these activities, among others, has, I believe, contributed its own "building block" to the practice of coastal engineering and allied disciplines of which we are pleased to be a part.

After this generalized presentation of SPD's current and close relationship with CERC, I would like to present our more specific research needs. I will indicate some areas of increased emphasis in existing program efforts and some new ideas as well.

DISCUSSION OF SPECIFIC RECOMMENDATIONS

Wave and Other Environmental Information

General

In the technical area of wave data and other environmental information, we fully support continued expansion and strengthening of the programs, within necessary funds constraints, with the goal of improving the basic environmental information (primarily consisting of a statistically significant wave data base) needed by our design engineers.

In early August the coastal Districts and Divisions met with CERC and OCE at the Kingman Building to discuss and make specific recommendations for the Coastal Field Data Collection Program and related wave data projects of the Corps. I understand that over a dozen recommendations emerged from that meeting, several of which came from a Pacific area work group of SPD, NPD, and the US Army Engineer Division, North Pacific. Repetition of all the recommendations here is unnecessary since I expect that CERC will be supplying them directly to you as information, but there are some recommendations of particular interest to SPD which bear repeating.

Directional Gages

Where possible, we believe it necessary to upgrade index gages to provide added deepwater directional information for both deepwater and nearshore sites. This effort will be important in verifying and calibrating CERC's numerical littoral transport models.

Hindcasts

It is also necessary to extend Wave Information Study (WIS) hindcasts for the North Pacific (which currently encompass 1956-1975) to include an additional 10 years through 1985 to provide SPD with wave parameters at nearshore locations. This information will provide us, and NPD, with new facts on the especially damaging storm waves and general wave climate of the 1978-1979 and 1982-1983 seasons; furthermore, it will allow CERC to verify its WIS parameters through comparison with the prototype wave information gathered by the Coastal Data Information Program since the late 1970's.

Compilations

In a related matter, we wish to request the preparation of the statistical compilations (return periods, etc.) from the appropriate Coastal Data Information Program gages after 10 years of data have been collected at the index sites. This preparation could begin as early as 1987-1988 for some sites, and it could measurably assist us in choosing appropriate design waves for our coastal structures.

Hindcasting of Storm Events

Also related to this is the ability to hindcast storm events in a near real-time mode. In SPD this capability would allow us to quickly obtain new information on damaging storms for use in planning and design and for quick correlation with the results of our Coastal Storm Observer Program.

Regional and National Wave Gaging Networks

As was discussed in a CERC paper at the last CERB meeting, the current Coastal Data Information Program--consisting of Corps Field Data Collection Program index gages, SPD and NPD Corps project gages, and other government and nongovernment gages--is envisioned by CERC and the Corps as the nucleus of a nationwide wave gaging system with obvious long-range benefits to all Corps coastal interests, both field and laboratory.

SPD, which helped pioneer the program, continues to support CERC research and development to this end. We do recognize the funding constraints, and we appreciate and support the understandable desire of other Divisions to participate. For example, the efforts of NPD in Alaska and US Army Engineer Division, South Atlantic, in Florida to expand wave gaging are to be commended; but we also ask that changes be incremental, with an eye to carefully expanding the system as we go without dismantling or neglecting that which has already been built up. I know that CERC is sensitive to this concern, but it should always be kept in mind.

One thing we have learned about the Coastal Data Information Program is that it has synergistic effects with other users extending far beyond the Corps mission. Notable among these is the use by NWS of near real-time data from the program gages in combination with National Oceanic and Atmospheric Administration and Department of Interior buoys, ship reports, and satellite data to produce forecasts for the public and maritime industry. This development was discussed briefly by an NWS representative in a late August user's workshop here at the Bay Model. We do believe that this usage is a dimension of the gaging network which needs to be fully recognized, indeed exploited, as a support for National Wave Gaging system expansion. I, thus, would like to suggest that CERC staff follow up on this to more fully inform the CERB and OCE of this NWS activity. Perhaps a short report or discussion of current NWS procedures, potential for national usage, and so forth, could be presented at a future CERB meeting.

Other Wave and Environmental Information Needs

Coastal Storm Observer Program

The first additional environmental information need is the Coastal Storm Observer Program which, as Mr. Domurat stated, is a pilot effort specifically responsive to concerns, raised at the 41st CERB meeting in Seattle by members of the CERB, about inadequate monitoring of the 1982-1983 coastal storms both during and immediately after the storm events. As indicated by General Palladino, these were major storms, probably the greatest of the century in California.

We do believe that this program deserves close attention by CERC and possible future support since it closely resembles a national research need--the ultimate provision of instruments and techniques to measure changes in the surf zone during storm events.

Sea Level Change

A second need is sea level change research. This topic is of significant interest to SPD, especially here in the San Francisco Bay Area and Delta where we have thousands of square miles of low-lying areas, some well below sea level. The periphery of the Bay is ringed with an elaborate network of levees which are in need of upgrading to provide adequate storm and flood protection, irrespective of any future sea level changes. This problem is being addressed by SPN in the San Francisco Bay Shoreline Study. The plight of levees in the Delta area upstream is even more serious and well known and has been thoroughly studied by the US Army Engineer District, Sacramento (SPK) which proposed solutions including levee upgrading and island consolidation.

Furthermore, the Environmental Protection Agency and a National Academy of Sciences (NAS) work group recently projected large sea level rises based on the results of world climatic models responding to "greenhouse" effects. These projections are certainly in advance of any detectable change in rates of sea level change and at this time are speculative. Mr. Roger Revelle, former director of Scripps, believes, for example, that we will be well into the 1990's before any confirming trends can be detected if they do, in fact, occur. Still, since large changes would have such serious results both in SPD and elsewhere, we continue to urge increased studies by the Corps on the subject, not only strengthening the current WES participation in studies by the Marine Board of the NAS but also in developing and carrying out appropriate supporting in-house work units.

Shore Protection and Restoration

In the Shore Protection and Restoration Program area, as I mentioned earlier, the development of predictive shoreline change models to evaluate the effects of man-made modifications is needed to assist us in coastal planning and engineering.

Essentially then, CERC must continue development of its Regional Coastal Processes Numerical Model System as well as numerical models to assess local project effects. We certainly urge continuance.

We would like also to recommend that the wave transformation (refraction/diffraction) model contained in the Regional Coastal Processes Model be improved to handle complex bathymetry such as that occurring in the vicinity of submarine canyons, several of which are in southern California and in central California where the Monterey Bay Submarine Canyon, an enormous geographical feature comparable to the Grand Canyon, is a case in point.

Coastal Structures

In the technical area of coastal structures, we wish to reaffirm the need for a rational structural design procedure for dolosse and other armor units. Again, we appreciate the important prototype dolosse monitoring effort at Crescent City and hope that will aid us in improving designs for concrete armor units in general, both in shape and reinforcement. We support, of course, its continuance and completion and, as appropriate, physical hydraulic modeling commencing in 1987 or 1988 to extend and generalize the information from the prototype study. In this latter regard, we urge special attention to related model tests by other investigators.

Incidentally, at our upcoming Coastal Design Conference in Oakland, members of the SPN and SPL staffs will be presenting pertinent, related, papers--one on the Crescent City dolos monitoring and the other on steel-fiber reinforcement of dolosse. Also, there will be a poster presentation by Dr. William Baird of Ottawa, Canada, on his firm's work and findings on hydraulic and numerical modeling of internal concrete armor unit stresses.

Monitoring

Imperial Beach

As far as the MCCP monitoring proposals are concerned, we believe that the Imperial Beach monitoring effort is of widespread interest because of the unique opportunity to study the effects of a submerged barrier on coastal processes, including circulation as well as structure design criteria and construction. It is also complementary to recent and planned CERC research on low-crested, reef-type, breakwaters.

Fisherman's Wharf

As indicated, our Districts will be receiving funds ($10,000) this fiscal year to develop a detailed plan primarily to monitor the changed wave environment inside the protected area to verify our design, including CERC model study results. At the time that the monitoring concept was approved, we also proposed that water quality be included, but we were informed that water quality parameters are not part of the MCCP program. However, this matter is still important. Project effects on tidal circulation and water quality were studied by our Districts, which, in cooperation with the Hydrologic Engineering Center, carried out comprehensive preproject prototype measurements and numerical water quality modeling to demonstrate that the project would not have negative effects on water quality. Water quality monitoring, as well as the approved wave-related monitoring, is desirable, offering broad benefits in advancing the state of the art of coastal water quality modeling beyond the benefits to SPD alone. Ideally, monitoring should be carried on in a coordinated or combined manner with the wave monitoring, during a 4- to 5-year period. Our SPN and SPD staffs have been informally discussing available authorities and programs to do this with the staffs of OCE and WES but without success to date. However, we do believe that water quality monitoring should be a part of our continuing evaluation program and suggest that the CERB may wish to address this policy matter.

Bodega Bay Harbor

Besides Imperial Beach and Fisherman's Wharf, we have also proposed a 5-year monitoring program for Bodega Bay Harbor--specifically, the concrete baffle breakwater at Spud Point to include wave measurements, bathymetric and structural surveys, and water quality surveillance. The Spud Point breakwater construction, which protects a fishing-boat marina against local wind waves, presents a significant opportunity to advance technical knowledge of baffle breakwaters through monitoring. The structure is a Corps design, but it was constructed by local interests. Although not currently part of the Corps Bodega Harbor project, it is being considered for operation and maintenance by the Corps, probably on a cost-shared basis. In any event, we see this monitoring as an important research opportunity and hope that it can be included in the program.

Other Projects

We also believe that the MCCP program could beneficially be expanded to some of our other projects. Overall, we enthusiastically support its vigorous application to coastal projects, Corps-wide.

Other Coastal-Structure Research Needs

We also propose three general-interest items for pursuit by CERC in laboratory and field studies.

Uplift Wave Forces

The first item relates to uplift wave forces. With reference to Fisherman's Wharf, our structural design originally included a massive concrete cap of rectangular cross section topping the vertical concrete sheet piles and the supporting batter piles which comprise the breakwater. A concern was raised about possible damages from excessive wave uplift and shock pressures acting upon the horizontal underside of the bayside of the cap; consequently, beveling the underside was suggested.

This concern was thought provoking. In the end, we decided to bevel the underside since a sizable quantity of concrete could be saved with a major cost reduction. This change will also substantially reduce wave slap and uplift wave forces, although we were able to satisfy ourselves that the original design was amply adequate to withstand design wave forces.

We determined that fact through our calculations, consultation with CERC, and some quick studies by Professor Wiegel at the University of California, Berkeley, and Ben Gerwick. However, in so doing, we did discover that there is a lack of information in the literature, and there appears to be a need for added research to accurately determine uplift and shock forces on horizontal surfaces for wave-impacted structures. We would urge CERC to undertake this research to improve the state of the art.

Detached Segmented Breakwaters

A second suggestion, related to the long-standing interest of SPD, concerns the promising use of detached segmented breakwaters for large-scale coastal stabilization and concomitant expansion of beach recreation potentials, especially in heavily populated southern California. In order for this suggestion to be acceptable, however, we need all the information and accumulated prototype experience that are available to satisfy ourselves and involved government and private interests about their effects. We understand that CERC is monitoring and evaluating a number of United States sites, including certain Corps projects, and has plans for further evaluation research, if necessary. Because of the limited number of sites available in this country, we would urge inclusion of foreign experiences in this technical area, focusing on developing this concept into a widely used design tool.

Berm Breakwater

A third suggestion, and one that seems to be widely discussed--it was touched on last year in Chicago by Zane Goodwin in his presentation of US Army Engineer Division, North Central, research needs--is the need to develop alternative breakwater design procedures, notably, the berm breakwater concept mentioned by Zane which has been used in a number of locations in Europe and North America, generally with success. We believe that the concept merits intensive study by CERC in both laboratory and field studies since it offers the possibility of cost reductions through use of a thicker outer layer with smaller armor units, a wider use of quarry output, and construction simplicity.

Harbor Entrances and Coastal Channels

General

In the technical area of Harbor Entrances and Coastal Channels, we hope that the ongoing Oceanside Sand Bypassing Experiment will assist the Corps in its present studies of sand bypassing.

Here in the protected waters of San Francisco Bay, wave action is generally not the predominant concern in the operation of our major harbor entrances and channels which are designed for deep-draft commercial vessels. Instead, channel dimensions and geometry, tidal currents, and shoaling are of primary interest. We have had some recent involvement with WES's Hydraulics Lab in ship navigation simulation for the deepening of the J. F. Baldwin approach channel into Chevron's Long Wharf oil pier at Richmond and will be working with them on further simulations of deepening projects at the Inner Richmond Harbor and at Oakland Harbor.

Parenthetically, I should mention that both SPK and the WES Hydraulic Lab staff will be making explanatory presentations at the Thursday session of the West Coast Regional Coastal Design Conference in Oakland.

The subject of navigation improvement and navigation simulation for large commercial vessels is one that is under continuous research and development at WES and elsewhere, and we understand that several more items on channel geometry and navigation simulation are under way which may be ultimately helpful to us in Bay and Delta navigation design.

Small-Craft Harbor Simulation

There is, however, a need to consider the development of navigation simulation for smaller vessels which use our small-craft harbor projects on the open-ocean coast. Simulation of vessel behavior under wave attack in hypothetical traverses of proposed alternative entrance channels would be most helpful in supplementing information that we currently receive from vessel operators.

Noyo Harbor is a case in point. It is a narrow entrance with frequent periods of high wave action and possible trade-offs involved between adequately protecting the entrance for fishing vessels, while yet maintaining a sufficiently straight and safe approach for the Coast Guard and other users. At this stage, we don't know if such simulation is practicable; however, we do believe it to be an important need which should be investigated by WES.

OTHER RESEARCH NEEDS

As to other coastal-related research needs, I've previously alluded to our hopes for the Remote Sensing Demonstration Program and our plans to cooperate with CERC and OCE during FY 86 and beyond in developing the CODAR tool to improve our wave data gathering capabilities. We also look forward to future tests of the X-Band radar and the airborne laser mapper.

SUMMARY

In closing, I wish to present a summarized list of SPD research interests and needs from the mass of materials just presented as follows:

(1) Wave and Other Environmental Information.

- (a) Add directional gages.
- (b) Extend WIS hindcasts.
- (c) Compile Coastal Data Information Program statistics.
- (d) Hindcast storm events.
- (e) Participate in the Coastal Storm Observer Program.
- (f) Provide full support and incremental expansion of the Coastal Data Information Program and Coastal Field Data Collection Program.
- (g) Investigate NWS-related wave gaging activities.
- (h) Expand sea level change studies.

(2) Shore Protection and Restoration--Provide continued development of littoral transport models.

(3) Coastal Structures.

- (a) Continue prototype dolos monitoring.
- (b) Develop rational structural design procedures for armor units.
- (c) Address monitoring needs: Imperial Beach, Fisherman's Wharf, and Bodega Bay Harbor.
- (d) Study uplift wave forces on horizontal surfaces.
- (e) Develop use of detached-segmented breakwaters.
- (f) Develop berm breakwater concept.

(4) Harbor Entrances and Channels--Provide small-craft harbor entrance simulation.

(5) Other Needs--Improve remote sensing, including CODAR, X-Band, and laser mapping.

I appreciate use of this time to present our research views and needs to the Board. We trust it will be helpful and that some of these ideas will prove useful "building blocks" for the future. Members of our staff and I will be available to work with you and members of the CERC staff in discussing specifics and developing work units, if appropriate.

NEW ENGLAND DIVISION'S COASTAL RESEARCH NEEDS

CERB Proceedings

Mr. Charles J. Wener, Chief
Hydraulics and Water Quality Section
New England Division

ABSTRACT

The coast of New England encompasses five states with approximately 4,350 miles of open shoreline. The New England Division has constructed and is currently studying many coastal improvements related to navigation, beach erosion, and flood protection. This presentation will address relevant research needs which include (1) wave overtopping of coastal seawalls, (2) protection from rising sea level, (3) determination of extent and amount of beach sand movement, and (4) estimation and verification of wave parameters in partially sheltered waters.

INTRODUCTION

The New England Division (NED) is involved in many projects related to navigation, beach erosion, and flood control along our varying 4,350 miles of shoreline. Although my experience is principally in the area of flood control, this presentation will deal with the common research needs of all participating disciplines.

COASTAL PROCESSES

NED is unique in many ways, as typified by our varying coastline. We have long sandy beaches such as those along the southerly shore of Massachusetts and the easterly shore of Cape Cod. Also we have small pocket beaches nestled between headlands on the rocky shore of Maine. Of the approximately 4,300 miles of coastline, only a small segment of the coast is directly subjected to open ocean driven waves. Wind driven waves generated over unlimited fetch distances by frequent northeast storms are not unusual. However, because many areas are sheltered, these open ocean waves attack only limited areas. Serious erosion damage can result in these limited locations as evidenced by Gay Head Cliff in Martha's Vineyard, Massachusetts. Many of our authorized beach erosion studies are in the small projects category (Section 103 Authority) and are located in sheltered areas or areas partially protected by offshore islands or other geological features.

Sheltered areas of New England, i.e., those with limited fetch distances and extremely high tides such as Maine and Connecticut, frequently suffer damages from very frequent coastal storms as well as rare and extremely severe northeasters or hurricanes. These storms produce locally generated short-period waves and swells that impact beaches and shore structures. Because of the nature of these small semiprotected areas, it is very difficult to predict wave heights and directions which in turn relate directly to the volumes of sand material being lost and the places to which it eventually will be deposited. Federal, state, and local environmental, Fish and Wildlife, and other concerned organizations are questioning the results of our sediment transport predictions in these protected areas.

The need exists in New England to develop a short-term research plan which includes the research experience of the US Army Engineer Waterways Experiment Station (WES) and the Coastal Engineering Research Center (CERC) early in the planning stage. The plan should include a pre- and postconstruction sediment budget program. Project funds are not available to analyze in sufficient detail, on a project basis, all of the avenues that we feel would be necessary to address this serious problem.

We at NED feel out of the mainstream of the research community. We are unique with our irregular shoreline and unusual offshore bathymetry. This is a real challenge for us; therefore, we at NED are proceeding with a plan which we hope will give us backup data on wind generated waves in the vicinity of our projects. This would include placing anemometers at strategic locations along the New England coast. Sediment budgets to estimate movement of material on- and offshore and alongshore are then predicted based on wind speed and fetch distance as well as resulting wave heights and direction. The ideal condition would be to have several wave gages at various locations along the coast as part of a long-term detailed monitoring program. This is not feasible with existing project funds in the small projects program.

We have also proposed the "Coast of New England Tide, Wave, Storm, and Erosion Control Effects Study." This fiscal year we are planning to hold a series of meetings with state officials to discuss in detail a three-phase study effort which would involve input for the states. This study, which is similar to the California and Florida studies, could hopefully address coastal problems on a regional basis.

COASTAL FLOOD CONTROL

Several studies involving coastal flood protection are under way in NED. The most advanced is the Roughan's Point Project located in eastern Massachusetts, a few miles north of Boston. Here wind driven waves during northeast storms overtop an existing seawall and cause flooding to a confined, densely developed residential area (Figure 1). Most memorable is the great blizzard of 1978 which was about a 100-year event. NED has used project funds to conduct physical and mathematical models at WES to quantify the frequency of wave overtopping and resultant interior flood levels and to optimize project design. Our efforts have been supplemented by research money from the Office of the Chief of Engineers. It became apparent through these studies that determining the frequency of wave overtopping is a very complex problem. Work at Roughan's Point only begins to address the problem. Much generalized research is needed for use in small project and planning studies where modeling funds are not available. Other investigations involving wave overtopping are now under way at Revere Beach proper, Point of Pines, and, a new addition, the Lynn Bulkhead.

FIGURE 1. PHYSICAL MODEL OVERTOPPING MEASUREMENT

RISING SEA LEVEL

In the New England area sea level is rising relative to the land at a rate of about 0.1 ft per decade (Figure 2) (Hicks and Crosby, 1975; Hicks, Debaugh, and Hickman, 1983). Preliminary WES results from physical modeling of wave overtopping indicate that wave overtopping is exponentially related to the relative freeboard between the stillwater level of the sea and the top of the seawall. The following equation expresses this relationship:

$$Q = e^{C_0 + C_1 f'}$$

where

Q = wave overtopping rate

C_0 = coefficient

C_1 = coefficient

$$f' = \frac{\text{freeboard}}{\left(H_{m_0}^2 L_p\right)^{1/3}}$$

H_{m_0} = spectral significant wave height

L_p = peak spectral wave length

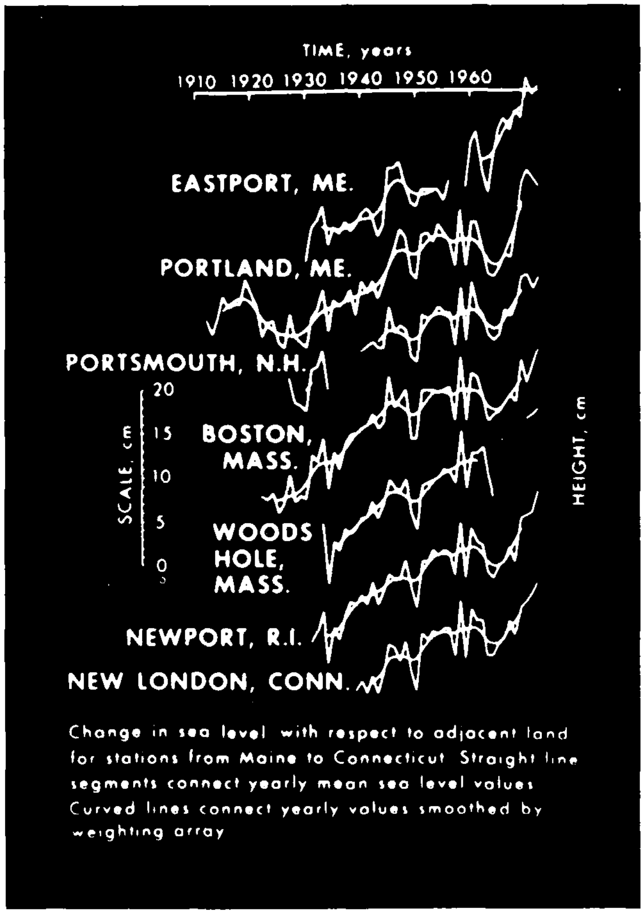


FIGURE 2. CHANGE IN SEA LEVEL WITH RESPECT TO ADJACENT LAND

This means that a small increase in water level generates much additional overtopping. If sea level rise continues, it can be expected that the US Army Corps of Engineers will be asked to investigate improvements to many previously constructed non-Federal projects where overtopping has become a problem. Research needs to be done to identify improvements to limit wave overtopping which can be made to existing structures within the limits of small projects authority.

SUMMARY

New England Division research needs can be summarized as follows:

(1) Determination and verification of wave parameters in partially sheltered waters.

(2) Determination of extent and amount of beach sand movement in sheltered and partially sheltered waters.

(3) Determination of the frequency of wave overtopping of coastal structures.

(4) Determination of methods to curtail wave overtopping of existing structures.

It should be emphasized that much of our work at NED is in the small projects area where money for site-specific research is not available. Therefore, it is only through OCE-sponsored research that most of our needs can be met.

ACKNOWLEDGEMENT

The preliminary wave overtopping relationship mentioned in this paper was developed by John Ahrens, CERC/WES, in his current model investigations for the Roughan's Point Coastal Flood Protection Project.

REFERENCES

HICKS, S. D., AND CROSBY, J. E. 1975. "Trends and Variability of Yearly Mean Sea Level, 1893-1972," National Ocean Survey, Rockland, Maryland.

HICKS, S. D., DEBAUGH, H. A., AND HICKMAN, L. E. 1983. "Sea Level Variations for the United States, 1855-1980," National Ocean Survey, Rockland, Maryland.

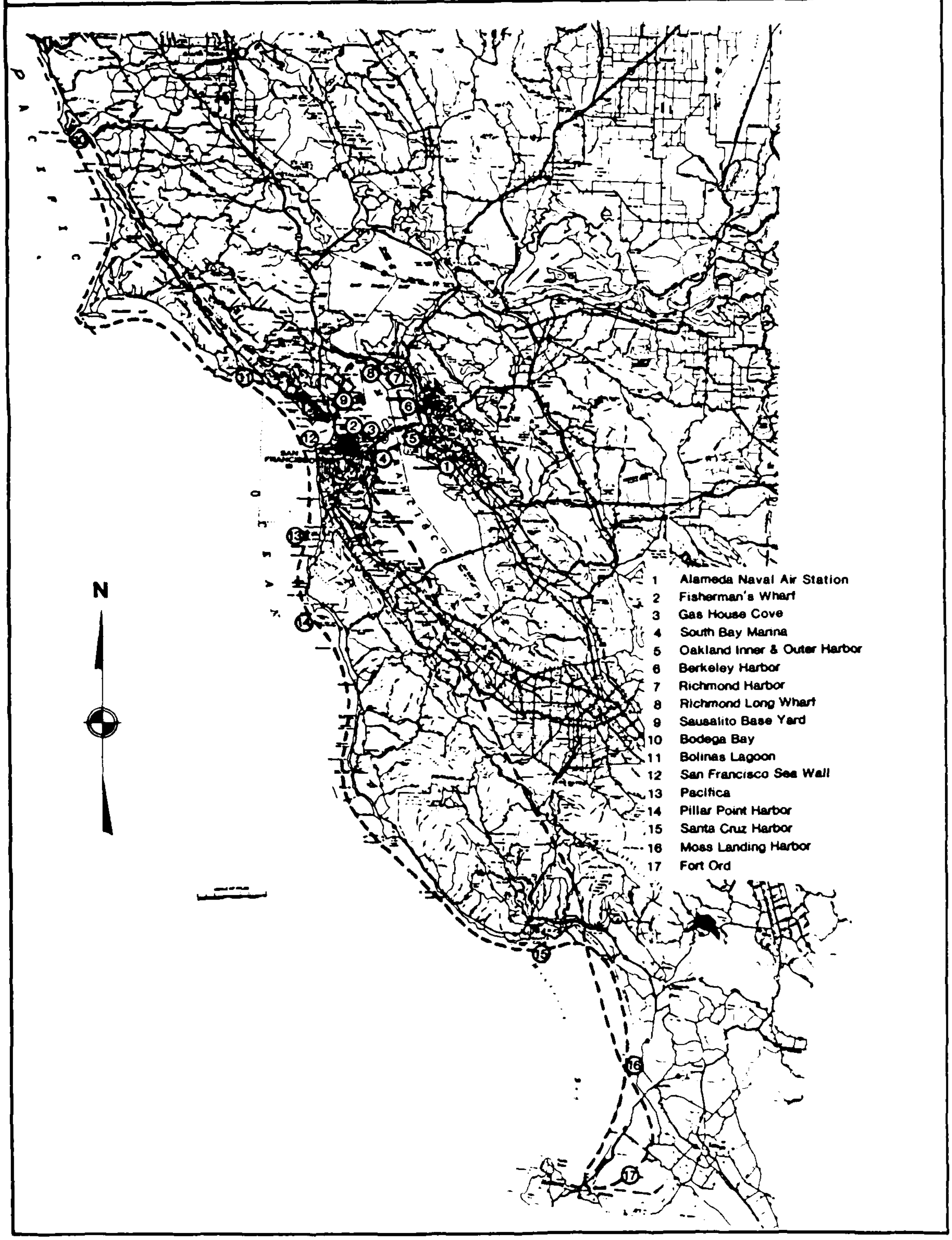
44TH COASTAL ENGINEERING RESEARCH BOARD MEETING

FIELD TRIP ITINERARY FOR FLIGHT GROUP

5 NOVEMBER 1985

7:00	Weather check
8:15 - 8:30	Depart Hyatt Regency Oakland for Alameda Naval Air Station
8:30 - 10:00	Board helicopters and tour North San Francisco Bay (including Fisherman's Wharf, Gas House Cove, South Bay Marina, Oakland Inner and Outer Harbor, Richmond Harbor, Richmond Long Wharf, and Sausalito Base Yard) and proceed to Bodega Bay Coast Guard Station
10:00 - 11:30	Ground tour and briefing of Bodega Bay
11:30 - 1:15	Lunch
1:15 - 2:45	Board helicopters and travel south along the coast (overflying Bolinas Lagoon, San Francisco Seawall, Pacifica Seawall, Pillar Point Harbor, Santa Cruz Harbor, and Moss Landing) to Fort Ord
2:45 - 3:15	Briefing at Fort Ord on Monterey Submarine Canyon
3:15 - 4:30	Return to Alameda Naval Air Station via helicopter
4:30 - 4:45	Return to Hyatt Regency Oakland

44th Coastal Engineer Research Board Meeting



Flight Tour Map

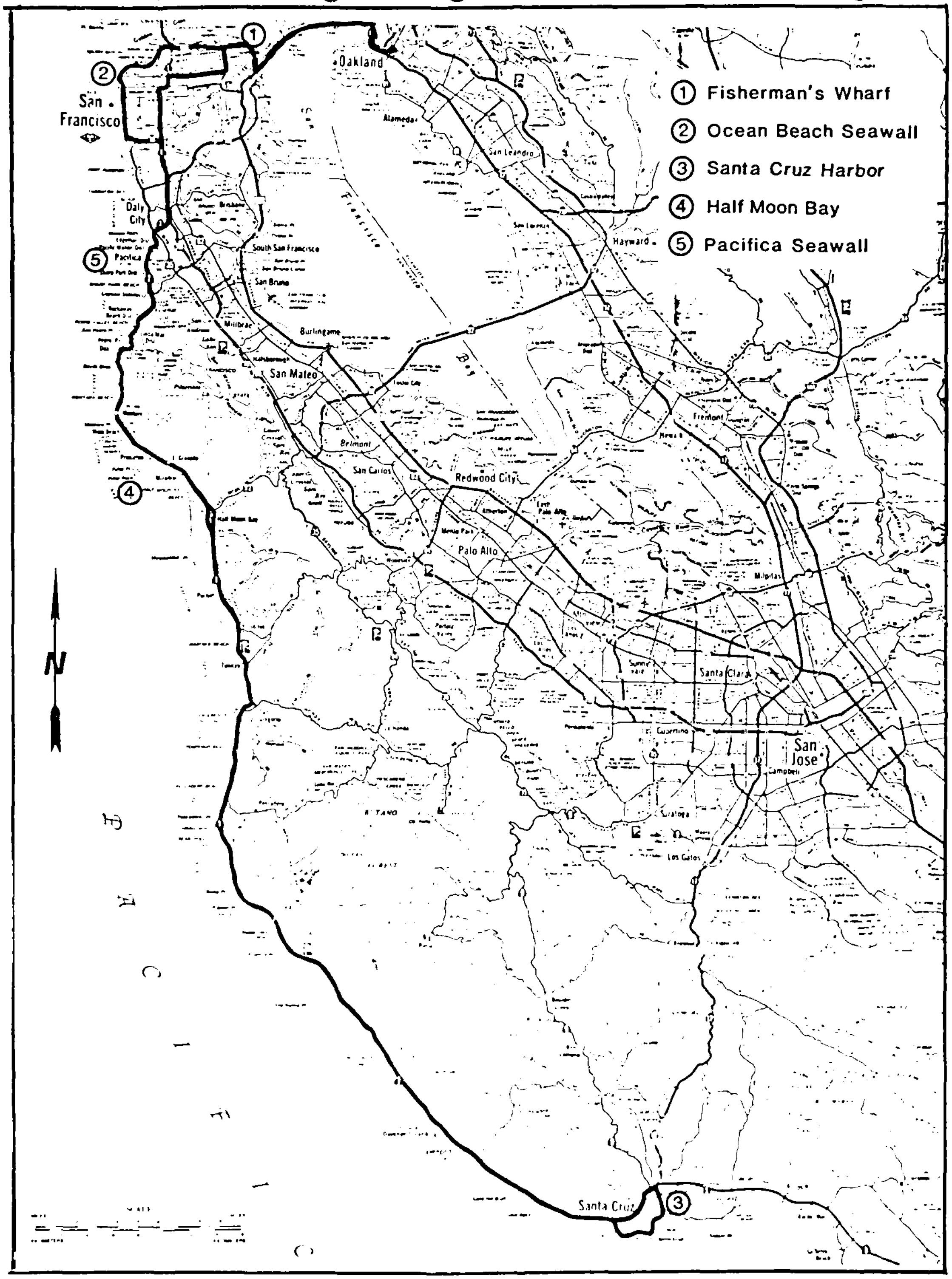
44TH COASTAL ENGINEERING RESEARCH BOARD MEETING

FIELD TRIP ITINERARY FOR BUS GROUP

5 NOVEMBER 1985

7:30 - 8:00	Depart Hyatt Regency Oakland and arrive at Fisherman's Wharf
8:00 - 8:45	Fisherman's Wharf briefing from the decks of the Eureka
8:45 - 9:15	Drive to Ocean Beach
9:15 - 10:00	Briefing on the existing Ocean Beach Seawall and the proposed San Francisco Seawall
10:00 - 12:00	Drive to Santa Cruz
12:00 - 1:30	Lunch and briefing of the Santa Cruz Harbor
1:30 - 2:30	Drive to Half Moon Bay
2:30 - 3:00	Briefing at Half Moon Bay
3:00 - 3:30	Drive to Pacifica
3:30 - 4:00	Briefing at Pacifica
4:00 - 5:15	Return to Hyatt Regency Oakland

44th Coastal Engineering Research Board Meeting



Bus Tour Map

DESCRIPTION OF SITES VISITED

FISHERMAN'S WHARF

Fisherman's Wharf Area is located on the San Francisco Bay on the northern waterfront of the City of San Francisco. The project under construction will provide protection for commercial navigation (fishing) vessels and the historic fleet owned by the Golden Gate National Recreation Area as well as provide additional recreation in the area. The project features consist of a 1,509-ft-long solid breakwater enclosing the area between Hyde Street Pier and Pier 45, a 250-ft-long segmented breakwater on the west side of Pier 45, and a 150-ft-long segmented breakwater in the abandoned ferry slip at Pier 45. Construction was initiated during October 1985, with a total contract cost of $7,887,000.

GAS HOUSE COVE (EAST HARBOR FACILITY, SAN FRANCISCO MARINA)

Gas House Cove is a small-craft harbor located at the east end of San Francisco Marina. Wind, waves, and surge have created very hazardous conditions for moored boats in the harbor area. These problems were solved by a 117-ft concrete sheet-pile breakwater connecting two existing breakwaters. Construction was completed in 1975 at a Federal cost of $180,000. Local interest cost was about $154,000.

SOUTH BEACH HARBOR

This marina, currently under construction by the San Francisco Redevelopment Agency as a part of a larger neighborhood redevelopment project, will consist of a south breakwater extending from shore, a north breakwater extending from the existing Pier 40, and a main breakwater parallel to the shore and in 30 ft of water. All breakwaters are of reinforced concrete sheet-pile construction, and fishing access will be provided to the public on the north and south breakwaters, around Pier 40, and along the shore. Pier 40 will contain small boat support facilities, such as restaurants and chandleries. Construction of the 683 slips/moorings is scheduled to start in December 1985, and the entire project is due to be finished by August 1986. The slips range from 26 to 50 ft in length, with most in the 30- to 34-ft range. Of the 683 spaces, 400 are already spoken for. Federal funds were used for planning and design (US Army Engineer District, San Francisco, having done some preliminary planning), while construction was funded by $26 million in Redevelopment Agency bonds and a $12 million California Department of Boating and Waterways loan. The breakwaters were designed against wave heights to 6 ft from the southeast.

OAKLAND INNER AND OUTER HARBOR

Oakland Harbor is a major west coast seaport. It is located on the east side of San Francisco Bay and consists of entrance and access channels; inner and outer harbor; a tidal canal; and appurtenant channels, turning basins, and jetties. Controlling depths range from 18 to 35 ft. Improvements that ultimately became part of this harbor complex were first authorized for Corps of Engineers construction in 1874. They consisted of jetties along the entrance to Oakland Estuary. These jetties are now part of the inner harbor because of extensive land fills that have been made behind them. The existing outer harbor, which serves the Oakland Army Terminal, is located just south of the Oakland approach to the Bay Bridge. Oakland's main commercial waterfront is along the inner harbor.

BERKELEY HARBOR

Completed in 1965, this small navigation project consists of a detached rubble-mound breakwater, 725 ft in length, protecting the entrance channel of Berkeley Harbor. Federal cost was about $160,000, including aids to navigation provided by the US Coast Guard. The cost of meeting requirements of local cooperation for construction was also $160,000.

RICHMOND HARBOR

Richmond is the site of extensive commercial petroleum refining and handling facilities and a Department of the Navy fueling depot. Richmond Harbor, which is north of San Francisco harbor and east-northeast of Oakland Harbor, serves these petroleum and fueling facilities as well as general commercial shipping. In general, the harbor complex comprises approach, entrance, and inner harbor channels; turning basins; a maneuvering area; and a training wall.

Project channel dredging was started in 1918 and carried on intermittently until 1940. The project was completed in 1957 except for dredging West Richmond Channel and enlarging and deepening the maneuvering area off Richmond Long Wharf. Federal cost for completed work was about $3,000,000. Local interest cost amounted to $4,000,000.

SAUSALITO BASE YARD

To reduce hazards to navigation and seaplane operations, a project for collecting and removing drift from San Francisco Bay was authorized in the 1950 River and Harbor Act. However, funds for constructing floating plant and other equipment have not been provided, and the project is classified "inactive." Since 1950, floating debris has been collected and removed from bay waters as maintenance work under the San Francisco Harbor Project. A tugboat and two Navy YSD's (with bow modifications to hold collection nets) are being used by the Corps of Engineers to collect debris, which is disposed of by landfill methods.

Also, to reduce the volume of debris floating in San Francisco Bay, the Corps inspects known dumping grounds and waterfront construction areas and investigates all reports of illegal disposal of materials. Backed by Federal law against polluting navigable waters, legal action has been brought against offenders. Recent urbanization of shoreline areas and abandonment of antiquated facilities and derelict vessels have increased quantities of drift and debris entering the bay.

BODEGA BAY

Bodega Harbor is a triangular shaped coastal lagoon situated at the northern end of Bodega Bay, about 55 miles north of San Francisco. Improvements completed in 1943 consist of a bulkhead to retain a sand spit, two jetties, entrance and navigation channels, and three turning basins. Controlling depth of the harbor is 12 ft. Federal cost of improvements was about $700,000. Local interests contributed $52,000. Major rehabilitation of the channels and south jetty was accomplished in 1961. During advance engineering and design the authorized project was reformulated and approved by the Office of the Chief of Engineers to construct a baffled concrete pile breakwater at Spud Point and an access channel from the existing Federal channel to a proposed local marina. Plans and specifications were completed; however a funding agreement could not be reached. Thus the inner breakwater was constructed with 100 percent local contributions.

Bodega Harbor is the only improved harbor in the 140-mile reach between San Francisco Bay and Noyo Harbor. It serves as an important harbor of refuge and as the home port for a small commercial fishing fleet.

BOLINAS LAGOON

In earlier years, Bolinas Lagoon was studied as a possible harbor of refuge. Situated in a favorable location, about 12 miles upcoast from San Francisco, it provides substantial relief from the hazards of wind and weather facing fishing and recreational vessels along this coastal reach. Since the lagoon is a placid place and the habitat for diverse wildlife species, its preservation as well as its use as a harbor had to be considered. Rather than allow natural and human processes to accelerate conversion of the lagoon into a marshy meadow, a preventive management program needed to be devised to assure continued enjoyment of the area in its natural state. A study of the lagoon to develop an ecologically sensitive land and water management plan that would meet human needs without destroying environmental quality was authorized in 1976. Local interest in natural resources offers the opportunity to make Bolinas Lagoon a model or demonstration project in environmental conservation.

OCEAN BEACH SEAWALL

Ocean Beach is located south of the entrance to San Francisco Bay. Between the Cliff House and Fort Funston, Ocean Beach has required protective structures at various locations to save the bluffs and the Great Highway from erosion and to improve the beach for recreational purposes. The most substantial structure was the 4,300-ft-long O'Shaughnessy Wall under construction from 1915 to 1922 along the northern portion of the beach. Erosion and storm events periodically necessitate the placement of rubble on the slopes of the beach where the Great Highway has been damaged or endangered along the southern portion of Ocean Beach. Highway closures, which are frequent due to blowing sand, add to the costs and problems of maintaining the area. To mitigate these problems the design of an O'Shaughnessy-type wall from Lincoln Way to Sloat Boulevard has been authorized with construction to be undertaken in phases based on available funding, beginning with the areas where it is most needed in the 11,000-ft-long project area. Construction has not yet been scheduled.

BEACH BOULEVARD SEAWALL

Located in the City of Pacifica approximately 10 miles south of the San Francisco County line, Beach Boulevard parallels Sharp Park State Beach. This straight north-south beach often experiences heavy seas and high wind-driven tides. With an estimated annual erosion rate of 1 to 2 ft per year, Beach Boulevard and extensive public utilities were in imminent danger. The two-phase project consists of 1,356 linear feet of seawall composed of 31,138 tons of armor rock and 14,756 square feet of reinforced earth wall capped with a concrete wave deflector. Phase I of the joint project, which is shared among the City of Pacifica, the California Department of Boating and Waterways, and the California Coastal Conservancy, is in the final stages of construction. Phase II of the seawall project is scheduled for construction during the summer of 1986.

PILLAR POINT HARBOR

Located in Halfmoon Bay about 15 miles south of San Francisco, the project consists of two breakwaters that form a protected harbor for commercial fishing vessels and recreational craft. It was authorized by the 1948 River and Harbor Act and completed in 1961. As a remedial measure to alleviate surge, construction of a 1,050-ft extension of the west breakwater was completed in 1967. The minimum depth of the 245-acre harbor is 6 ft. The total construction cost is $8,598,700.

SANTA CRUZ HARBOR

Santa Cruz Harbor is located at the northern end of Monterey Bay, about 65 miles south of San Francisco. The project is in Woods Lagoon in the eastern part of the City of Santa Cruz. It consists of entrance channel jetties, an inner harbor channel, and a turning basin. Controlling depths range from 10 to 20 ft. These improvements were completed in 1963 at a cost of $2,900,000, of which $1,800,000 was the Federal portion. The harbor had slips for 363 vessels. The harbor has since been extended by the local interests. Construction of an authorized sand bypassing system to improve project maintenance has not yet been completed. A cooperative agreement between the port district and the US Army Corps of Engineers has been reached regarding the joint procurement of a dredge design specifically for operation at Santa Cruz.

MOSS LANDING HARBOR

Moss Landing Harbor is on Monterey Bay about midway between Santa Cruz and Monterey. The project consists of harbor entrance jetties, a 1,900-ft entrance channel, a 3,200-ft lagoon channel, and a turning basin. Controlling depth is 15 ft. Completed in 1947 at a Federal cost of $340,000, the harbor is maintained by the US Army Corps of Engineers. Local interests provided a rights-of-way and disposal areas for harbor construction. The economy of Moss Landing is sustained by commercial fishing and by offshore handling of petroleum products by pipeline and barge.

DISCUSSION OF CHALLENGES TO BOARD
BY GENERAL HEIBERG

The following is a synthesis of comments and discussions by those present at the Coastal Engineering Research Board (CERB) meeting on the morning of 6 November. The discussion centered on the charges given to the Board by GEN Heiberg when he opened the 44th meeting of the CERB on 4 November.

BG KELLY

BG Kelly opened the session with a review of GEN Heiberg's charges to the Board. The Chief asked the Board to develop a long-term plan for coastal engineering with recommendations in the following fiscal and technical areas:

(1) New funding sources.

(2) Shift from basic to applied research.

(3) Coastal engineering education.

(4) Regional coastal studies.

(5) Highly advanced and large scale national laboratory facilities.

NEW SOURCE OF FUNDING

BG PALLADINO

BG Pallandino stated that organizations like the National Science Foundation (NSF) and others which have an interest in research and who offer certain criteria and suggestions for research could perhaps in some coordinated way work with the Corps.

DR. NUMMEDAL

Dr. Nummedal noted that the NSF does have a program that encourages joint research between Federal agencies and/or industry and NSF. He said NSF's budget has been increasing under the current administration. That increase has specifically gone into all kinds of interdisciplinary programs, other than grants to individual investigators, "so that clearly the philosophy of NSF is to get involved in exactly what the Board is talking about here." Dr. Nummedal went on to say that "if we look for upgrading of facilities also, it should be coordinated with either the National Research Council or NSF." The Corps of Engineers (Corps) should get input from those agencies as to what they perceive are "the needs for a coastal engineering center."

DR. LE MÉHAUTÉ

Dr. Le Méhauté said that American companies who have to do investigations do not come to the Corps because by law the Corps is not allowed to work for them. They are not going to private industries because private industry does not have the economic base to invest in installation of test facilities which will compete with laboratories such as Delft, Trondheim, Wellingford, etc. The result is that these American companies go to foreign countries. A solution to this problem suggested by Dr. Le Méhauté would be a solution "a la Thatcher." She privatized Wellingford and said, "You are on your own now; find your own business." Dr. Le Méhauté went on to say that in France "many industry and research organizations are nationalized, and the government allows the nationalized organizations to compete in foreign countries." He feels strongly that the Corps, perhaps through some adaptation of the law, should market its skills to foreign countries.

MR. PFEIFFER

Mr. Pfeiffer suggested, as a means of acquiring sources for research, "piggybacking on District projects in the coastal areas" such as construction, planning, and design projects.

DR. MEI

Dr. Mei strongly supported Dr. Le Méhauté's philosophy that perhaps the Coastal Engineering Research Center (CERC) can open up its capabilities and resources "to larger markets and therefore bring in larger revenue." Also, Dr. Mei wondered whether with the Corps' prestige and influence if there were some "high level contact to be made with the National Oceanographic and Atmospheric Administration (NOAA)" in order to see whether a joint effort could be initiated with emphasis on coastal studies. If beach erosion is of such concern to recreational activities in American life, he thought perhaps the Department of the Interior or the Park Service ought to be contacted to see whether it can somehow support some of the activities in beach erosion research. Another organization mentioned by Dr. Mei was the Office of Naval Research (ONR). He said, "I think perhaps a high level contact initiated by the Corps of Engineers can influence ONR from the top in order for them to emphasize coastal studies." Dr. Mei stated further that NSF does not have any visible program on coastal studies. His feeling was that their "industrial university liaison" is a program they would like to expand, and if Corps activities could be regarded as industrial by NSF, "this would be a useful avenue for industrial university research and expanding collaborations between the Corps and universities as well."

DR. LE MÉHAUTÉ

Dr. Le Méhauté felt that the Corps should take the leadership in establishing a commission of Federal agencies to coordinate research in coastal engineering. He felt "it is time to regroup and think of the program on a Federal scale."

DR. WHALIN

Dr. Whalin supported this idea. He went on to say that all involved in coastal research do in fact "talk to one another but at a low level, a small scale." He said the Corps does not "really coordinate things from the top."

BG ROBERTSON

BG Robertson mentioned as sources of funding the Corps' regulatory functions and the petroleum industry. He said, "The oil companies are putting all kinds of money into mitigation for onshore and nearshore activities."

DR. NUMMEDAL

Dr. Nummedal suggested the Army Research Office might be contacted as a source of coastal research funds.

BG KELLY

BG Kelly brought up the fact that Corps Operations and Maintenance (O&M) programs are greater than the Corps Construction General and that "there's a tremendous potential out there in O&M that we really haven't even looked at, not just O&M in the Corps but other agencies."

SHIFT FROM BASIC TO APPLIED RESEARCH

DR. MEI

Dr. Mei said that the distinction between basic and applied research is very vague and that he would like to see the Corps emphasize the need of coastal problems, and "whether it's basic or applied is not terribly important."

MR. CALHOUN, BG KELLY, AND MR. PFEIFFER

All addressed the point that it is more a question of semantics and packaging. The Corps is getting in trouble because it keeps referring to basic research. A better term is "fundamental" research or knowledge. All agreed that it is important to package the research correctly, and this should be done by "guiding the research towards problem solving."

BG ROBERTSON

At this point BG Robertson quoted a statement made by the Chief concerning research and development (R&D). He said, "Look for areas of payoff; R&D is not a winner." BG Robertson said the Chief was speaking in a budgetary sense, and he is looking for ways to go out and get cost sharing, get somebody else to come on board." The Corps can market a payoff which comes from applied research to solve specific problems better than it can market basic research.

DR. NUMMEDAL

Dr. Nummedal said, "I agree with everything that has been said, and maybe a term that we can use to express this would be the concept of technology transfer." Dr. Nummedal went on to say that the Corps is in the process of generating knowledge. That is what research is. There is a very diffused border between basic and applied research. But once the Corps generates that knowledge, how is it using it? the Corps needs to "transfer the knowledge and transfer the technology" both to the Corps Districts and the private sector.

DR. MEI

Dr. Mei noted that "there are certain areas which could be readily handled by the Corps and at CERC which are now regarded as outside the authority of CERC." He gave as an example the motion of ships inside large harbors. Dr. Mei wondered whether, in view of the capabilities of the Corps, the Corps should be more aggressive and "expand its horizon rather than stop at some sort of official boundary." He suggested expanding coastal engineering into other areas "as long as it has something to do with coastal engineering." Dr. Mei went on to say that perhaps the emphasis need not be placed so much on beach erosion alone. He said, "Right now I think beach erosion is the leading thing, the highlight of activities at CERC and perhaps in the Corps; but coastal engineering can be much broader than that if we can slightly shift emphasis a little bit."

BG PALLADINO

BG Palladino said that the pure basic research which is essential to the training and the education of coastal engineers can be done at universities throughout the country. If the Corps could provide assistance to universities "through the facilities and/or capabilities of the Federal labs," then relatively small sums of money will produce a very good product.

COASTAL ENGINEERING EDUCATION

DR. LE MÉHAUTÉ

Dr. Le Méhauté would like to see the "American know-how" radiate to foreign countries by having the Corps in collaboration with faculties from American universities offer courses to students in foreign countries. These would be "international courses in coastal engineering which could take place at Delft and in places competing with Delft." He felt that foreign students would prefer to come to the United States for these courses.

DR. MEI

Dr. Mei seconded the idea and said that the program can be made more effective if "CERC takes the leadership and pulls the resources from various university faculties in order to make this a very highly visible program."

DR. NUMMEDAL

Dr. Nummedal said that Ph. D's who have been out of school for the past 10 to 15 years "are not using very much of those particular facts that we learned in school anymore. We are using the new facts that have been generated as a result of research over the last few years." To overcome this education deficit he recommends an extensive in-house education program tied closely to universities. Dr. Nummedal went on to say, "One way this continued education within the Corps might be very effective and very closely tied in with the universities is if, in fact, the Corps could act to coordinate or become essentially a funding source for the universities." This would allow the investigators at various universities to work on research contracts together with colleagues at CERC and jointly design a variety of effective programs. He recommended also an exchange of researchers between Federal labs and universities. He said this is a very effective training tool.

DR. MEI

Dr. Mei supported this idea and recommended establishing fellowships or internships that would encourage the flow of faculty members to work at CERC for short periods of time. He brought up the fact that "CERC now has the best facilities for coastal engineering laboratory research in the United States and that it would be good to have a reasonably formal and highly publicized program to encourage university people to use the facilities in conjunction with CERC research projects but with the blessing of the CERC people."

BG ROBERTSON

BG Robertson asked, "Has the Corps made any attempts to enter into joint associations with specific universities whereby we can make our research facilities available to the guys working on their Ph. D. dissertations?"

DR. WHALIN

Dr. Whalin answered that a mechanism already exists to do this but is not advertised, and "it's very loose, very general." This is an agreement that says NSF researchers can use government and Corps facilities in their R&D projects.

COL GRUM

COL Grum added that the US Army Engineer Waterways Experiment Station (WES) employees conduct courses for Mississippi State University and that there are a number of IPA's working at WES.

REGIONAL COASTAL STUDIES

BG PALLADINO

BG Palladino brought up the point that the key to success of regional programs is having a close relationship with the states involved, getting a strong endorsement of the studies by the states, and getting the states to commit some of their own resources. He said it is important to develop some type of cooperative effort so that "it does not become a Corps isolated effort but becomes one that has a strong demand base from the local governmental institution."

BG ROBERTSON

BG Robertson strongly supported the need for cooperative studies. He indicated that not only the states but also agencies such as the Environmental Protection Agency (EPA), National Marine Fisheries, and Fish and Wildlife Service have to be tied in with these large-scale studies.

MR. PFEIFFER

Mr. Pfeiffer interjected a caution here by saying, "The states are kind of poor, and it is something we are going to have to market very well to make it work to get any dollars out of the states."

BG KELLY

BG Kelly stated that in this new era of local participation "We're going to have to get the states more involved."

DR. NUMMEDAL

Dr. Nummedal suggested Louisiana as an example whereby "the Corps could come in and do a tremendous amount of good." He said the State is committed to do a large-scale coastal restoration project but cannot handle it because "there is no coastal engineering program in the State of Louisiana. There is no agency within the State that is logically structured to manage coastal engineering." He felt the Corps should move on this relatively soon.

BG ROBERTSON

BG Robertson suggested that this, in fact, be a specific effort proposed to the Chief. He thought it "would probably take legislation to do this," but it should be a big payoff.

MR. OLIVER

Mr. Oliver interjected a caveat that these cooperative studies are dependent on Corps policy and competition with others. He said the Corps needs "general policy guidance on how we go about involving ourselves with these studies within the given set of laws that we work with at this point in time."

BG KELLY

BG Kelly concurred and stated that one of the items the Board needs to examine closely is "present authorities and policies."

MR. CALHOUN

Mr. Calhoun indicated that the Board should also examine the policy as to "how we separate our military and civil functions, primarily manpower."

NATIONAL LABORATORY FACILITIES

DR. LE MÉHAUTÉ

Dr. Le Méhauté felt that the United States is lagging behind "foreign country national laboratory facilities." He said it is not a matter of "duplicating what other countries are doing. It is a matter of creating a unique facility which corresponds to the US needs." He stated that the area where the "biggest payoff could be" is dredging. He felt that a unique large facility--a dredge research facility--with modern equipment dedicated to studies of tidal inlets would lead to a "breakthrough in understanding the mechanism of tidal inlets, in how to channelize" and how to do channel maintenance.

MR. CALHOUN

Mr. Calhoun brought up the fact that the Navy is experiencing severe problems in dredging and that the Corps may get support for research from the Navy.

DR. NUMMEDAL

Dr. Nummedal noted that ONR some years ago was involved in funding research related to tidal inlets, but as they moved into deeper water "that sort of has been left behind." He feels the Corps needs to move into that area.

BG PALLADINO

BG Palladino mentioned that in reference to all these areas being discussed by the Board there is really no agreement among all the parties as to exactly what the market is. "Who is the customer?" He went on to say, "I'm not sure that we have a clear definition and understanding of the market within the coastal engineering and research arena, and that probably ought to be done as a high priority."

BG KELLY

At this point BG Kelly divided the five areas that were discussed into two broad categories. One category he identified as Funding and Big Payoffs and the second as Research, Education, and a National Laboratory Facility. He formed two task groups to address these categories. The following individuals were assigned to the two groups:

Funding and Big Payoffs	Research, Education, and National Laboratory Facility
BG Donald Palladino	BG Patrick Kelly
BG George Robertson	BG Paul Kavanaugh
Dr. Bernard Le Mehaute	Dr. Chiang Chung Mei
Dr. Dag Nummedal	Dr. Bernard Le Mehaute
Dr. Robert Whalin	Mr. Jesse Pfeiffer
Mr. John Mikel	COL Allen Grum
Mr. John Housley	Mr. Charles Calhoun
Mr. William Murden	Mr. John Lockhart

BG Kelly suggested that the two task groups meet sometime in January 1986 and spend the day addressing these areas. He said he would like to have some definite suggestions by the time the next Coastal Engineering Research Board formally meets.

THE SAN FRANCISCO BAY-DELTA TIDAL HYDRAULIC MODEL

CERB Proceedings

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ABSTRACT

This paper discusses the theoretical foundation for the design and construction of physical estuarine hydraulic models. It introduces the San Francisco Bay-Delta Tidal Hydraulic Model and describes the most recent technical upgrade of the model. The paper concludes by discussing the potential applications of this state-of-the-art research tool in assisting other agencies with their water resource planning and policy decisions.

MODELING THEORY

The goal of estuarine hydraulic modeling is to produce flow and mixing conditions within the model that reasonably reproduce those observed in the prototype. The primary concern is not that the model exactly resemble the prototype in appearance but that it accurately reproduce those parameters that affect its intended uses. Once these uses have been determined, the hydraulic engineer is guided by the principles of hydraulic similitude.

Similitude

There are three basic types of similitude: geometric, kinematic, and dynamic. All must be attained if complete similarity is to exist between model and prototype fluid phenomena. Geometric similarity occurs when flow fields and boundary geometry of model and prototype have the same shape and corresponding length ratios. If the corresponding velocity and acceleration ratios between model and prototype are the same throughout the flow field, the two flows are said to be kinematically similar. Finally, dynamic similarity is achieved when the forces acting on corresponding fluid masses are related by ratios having the same value at all points of correspondence between the two flows.

Departure from geometric similarity frequently must occur during construction of estuarine models for physical and economic reasons. This departure results in a distorted model. Although geometric similarity is sacrificed, the goal of reproduction of prototype flows and mixing conditions can still be achieved in the model by fulfilling the requirements of kinematic and dynamic similarity, as long as accelerations (as with waves or surf) are not of concern.

Kinematic Similarity

Kinematics is the study of motion without reference to the masses or forces acting on a moving body. In other words, kinematic similarity can be achieved even if the kinetics of the two systems differ.

According to Newton's 2nd Law of Motion (F = ma), the kinetic reaction of a given volume of fluid is equal to the sum of the forces acting on it. The principal forces that may affect a flow field are those of gravity, pressure, inertia, viscosity, elasticity, and surface tension. The dominant force in an estuarine model is gravity; other forces are small or negligible by comparison.

Therefore, the model and prototype will be kinematically similar if the ratio of kinetic reaction, velocity, and acceleration of a volume of fluid in the prototype to the gravitational force acting on it is equal to the ratio of the kinetic reaction of scaled-down volume in the model to the gravitational force acting on it.

Dynamic Similarity

The conditions for dynamic similarity require that the flows be kinematically similar and, furthermore, that they have mass distributions such that the ratio of density at corresponding points of the flow has the same value for all sets of points. Mass distribution is a function of inertia, a flow field and the forces acting on it. The only force being considered is gravity since gravitational forces are predominant in tidal flows.

The ratio of the inertial force to the force of gravity is termed the Froude number. This dimensionless number (V^2/gL, where V is the velocity, g is the gravitational acceleration, and L is the depth of water) is central to the Froude Model Law which states that the model and prototype will be dynamically similar if the Froude number is the same in both systems.

Thus, dynamic similarity can be achieved simply by scaling the velocity of flow by a factor equal to the square root of the geometric scaling factor. The velocity of water within a hydraulic model is scaled by scaling the frictional resistance of the bed to the flow field. In a distorted model, agreement with the Froude Model Law is obtained by making the model bed rougher than the prototype. By mathematical manipulation of the Manning equation (an equation that relates flow to frictional resistance in an open channel), the roughness scaling coefficient or hydraulic roughness is found.

Application

The application of the above theoretical considerations to the construction of an estuarine hydraulic model is achieved by replicating the bathymetric geometry of the prototype in the model. Furthermore, through application of the Froude Model Law and trial-and-error method, the hydraulic roughness is attained in a distorted scale model. The bathymetry is determined using hydro-survey data for the estuary being modeled. The data are scaled depending on the selected horizontal and vertical scaling factors, and the bottom configuration (defined by templates) may be formed in concrete. To achieve the required degree of roughness, vertical metal strips are implanted in the model bed. Thereafter, the model is calibrated using hydraulic and salinity field data to duplicate the prototype's behavior under a selected set of boundary conditions.

Although hydraulic modeling theory is rigorously applied in design and construction of a model, the flow and mixing conditions found in the model must be compared with the prototype. This is termed verification and may be conducted in two stages. In the first stage, hydraulic verification, the tidal elevations and arrival times as well as current velocities are compared to the prototype's behavior under a similar set of boundary conditions. The second stage is salinity verification, during which salinity gradients in the prototype for a given set of boundary conditions are compared to the data obtained from the model's simulation of similar conditions. When the model passes the verification tests, it is then ready to fulfil its intended use(s).

EVOLUTION OF THE BAY-DELTA MODEL

Original Model

San Francisco Bay is, by definition, an estuary, a closed embayment where fresh and salt water mix. The area of the Bay is about 400 square miles at mean lower low water and 460 square miles at mean higher high water. The Bay is generally shallow, with two-thirds of the Bay less than 18 ft deep and only 20 percent greater than 30 ft deep. The saltwater system is driven by the tides. The tides at the Golden Gate are typical west coast semidiurnal mixed tides with two unequal highs and lows each day. The average tidal range is about 4-1/4 ft with extreme ranges of up to 12 ft during winter storm events. Once inside the Golden Gate, the tide bifurcates with a standing wave moving into the south bay in-phase with the Golden Gate and a progressive wave moving into the north bay system. The Delta lies to the east in the area where the Sacramento and San Joaquin Rivers converge to discharge over 40 percent of the total runoff from the State of California into San Francisco Bay. The Delta consists of some 60 islands formed by 1,100 miles of levees and 700 miles of waterways. Fresh water passes through the Delta to withdrawal points for agricultural use and for export from the Delta for use in central and southern California.

As previously discussed, a tidal hydraulic model provides a means of reproducing the pheonomena that occur throughout a large, complex estuary in a manageable scale. In accordance with the laws of similitude, most measurements made in a scale model are proportional to the corresponding prototype quantities. It is therefore possible to measure water levels, velocities, salinity, dispersion of pollutants, and other factors which cannot reliably be computed or estimated by other means.

The San Francisco Bay-Delta Tidal Hydraulic Model is one of the largest estuarine models in the United States. The original Model was constructed during 1956-1957 and represented about 326 square miles of the Pacific Ocean and the San Francisco Bay System. The Delta portion, which includes all reaches of the Sacramento and San Joaquin Rivers subject to tidal influence, was added to the Model during 1966-1969. The scaling ratios of model to prototype are as follows:

(1)	horizontal	1:1,000
(2)	vertical	1:100
(3)	time	1:100
(4)	velocity	1:10
(5)	discharge	1:1,000,000
(6)	salinity	1:1

The Model has been verified (US Army Engineer District, San Francisco (SPN), 1976) and its repeatability tested (SPN, 1984).

Until recently, data acquisition has been manual, i.e., by discrete sampling. Furthermore, tidal control was accomplished by a mechanical electrical cam system. Water level was determined by use of point gages. Salinity was determined from water samples collected from a predetermined depth. Samples were then analyzed on a Beckman Conductivity Meter. Velocity was measured by counting the revolutions of a pigmy meter. Direction was determined by observing the flow of dye.

Regardless of how well the Model was designed or constructed, the necessity to depend on manual collection of discrete samples and data reduction limited the potential information that could be gleaned from Model operation. Furthermore, both the manual data collection and cam-controlled tide generation resulted in system noise. To improve data collection abilities and reduce system noise, SPN together with the US Army Engineer Waterways Experiment Station embarked on a comprehensive program to upgrade the technical capability of the Model. The upgrade included computer-controlled data acquisition and tide control as well as instrumentation to measure conductivity-temperature, current velocity and direction, and water level elevation. The upgrade did not eliminate the need for discrete sampling (still used for verification of instrument readouts), but it has greatly enhanced the amount of data that can be collected and reduced the delay in its evaluation. These improvements have increased the Model's sensitivity and ability to detect small changes in salinity. Furthermore, the upgrade has provided greater knowledge and understanding of model performance.

Model Upgrade

Data Acquisition System

Data acquisition is accomplished by a Hewlett-Packard 1000/65 minicomputer. The system functions as an on-line process control system, outputting control signals, collecting data, processing data, and providing on-line monitoring of model operations. System capabilities also include report quality graphics, narratives, and tables. Backups of all software programs and raw data are on magnetic tape.

The Hewlett-Packard system combines real-time data gathering capability with a secure multiuser operating environment. Events or processes requiring real-time response are given guaranteed priority in scheduling and execution of programs. During testing, the data acquisition task is given highest priority, with all other users sharing the remaining computational resources on either a priority or time-slice basis.

The minicomputer system is made up of the HP 1000/65 mainframe containing the central processing unit, the operating system, system memory, and the necessary interfaces with all peripheral devices. The system supports FORTRAN, PASCAL, and BASIC high-level languages along with all software needed to create, edit, compile, load, and execute programs. Peripheral devices on the system include a 16-megabyte disk drive for system operations programs, a 64-megabyte disk drive for all user programs and data, 9-track magnetic tape drive for data/program backups, and 4 control processors for signal input/output. Other devices include a matrix line printer, letter-quality daisy wheel printer, graphics plotter, remote terminals, and system control.

Model test data are acquired by two Hewlett Packard Model 2250 measurement and control processors. The HP 2250's send and receive all signals through special function cards which allow analog input, analog output, digital output, and various counting functions. All model data collection is accomplished by one HP 2250. Data are obtained from all stations at approximately 22-sec intervals, stored in a data buffer until requested by the HP 1000, and then stored on magnetic disk. The HP 2250's are used also to store discrete sample analysis data from Beckman Conductivity Meters for the HP 1000. These data are also placed on disk files.

Model Instrumentation

Model parameters currently acquired by the HP 1,000 system include water level elevation, X-Y components of current velocity, electrical conductivity, and temperature of the water. The conductivity/temperature sensors used at the Bay Model were developed and manufactured by the Montedoro-Whitney Corporation. They were designed to minimize disturbances to the flow field. The sensor consists of two electrodes excited with a constant AC voltage. The water path between the electrodes acts like a variable resistance dependent on the value of the water conductivity. The signal is output to the front LED display panel and to the computer. Simultaneously, measurements of water temperature are obtained via a linearized thermistor. A software program converts temperature and conductivity into salinity in parts per thousand (ppt) for the calibration curve on each instrument.

The water velocity sensors were also designed and manufactured by the Montedoro-Whitney Corporation. These sensors operate on the principle that water flow distorts an electromagnetic field set up by the electrodes and yields a measure of the flow intensity. Transaxial placement of two sets of electrodes gives a measure of the flow in two directions. Output is the magnitude of the north/south and east/west components of flow velocity. Vector addition is used to obtain the resultant magnitude and direction of the tidal flow.

Water level changes in the model are recorded using a device that converts distance into DC voltage. The electrical capacitance formed between the probe and the water surface is held constant. Internal electrodes maintain this constant capacitance so that a change in the water level elevation appears as a DC voltage change at the output.

Data Analysis

Software is available to retrieve data, convert raw data to prototype equivalent, and compute basic statistics such as mean, standard deviation, percent deviation, minimum/maximum values, and lunar day averages. Future statistical analysis routines will include harmonic and spectral analysis, analysis of variance, and a variety of curve fitting programs.

Plotting software has been developed to give a visual presentation of salinity, flow velocity, and water level time histories for all stations. Other software includes storage and retrieval of discrete sample data, word processing, and comparisons of data from various tests.

Tide Generation

The upgrade also included converting the tide generator from control by mechanical cams to control by the minicomputer. This was accomplished in February 1984. The mechanical system was limited to reproducing only repetitive tides. The upgrading of the computer controls will permit generation not only of the repetitive tides but also of seasonal and storm variations. Computer analysis of data from three water level detectors located at the ocean area model boundary direct the computer to make incremental changes in the position of two motorized gate valves. A 14-in. valve controls the continuous inflow of salt water (having an ocean salinity of 33 ppt) supplied by a 75-hp pump. A slide gate valve controls the gravity outflow return to the primary sump. The new tide generator system has reduced certain operating costs; it has resulted in more consistent generation of the repetitive tide and has the capability to reproduce variable tides.

MODEL STUDY CAPABILITIES AND USES

During the past 30 years, the San Francisco Bay-Delta Tidal Hydraulic Model has proven to be a valuable scientific research tool used by engineers and water resource planners. It has assisted decision makers in providing answers to complex hydrodynamic problems associated with proposed plans of improvement in the estuary. Investigators have performed model studies to provide engineering data to evaluate the possible impact of proposed projects on the Bay system. These studies include hydraulics, observation of surface current flow patterns, surface and subsurface tracers, and ocean salinity intrusion caused by deepening deep-draft navigation channels including mitigation schemes, dispersion of wastewater discharges from sewage treatment plants and thermal discharges from power plants, shoaling in navigation channels, and tests of remedial measures. These measures include the use of dikes, training walls, channel/realignments, circulation of dredged material disposal in Bay waters, and reclamation of tidal and submerged lands in the estuary. In addition, studies have been conducted of Delta water transfer schemes and water releases to flush the estuary, schemes to reduce saltwater intrusion into the Delta, and the impact of levee failures in the Delta on salinity intrusion. The model is used also in emergency situations, at the request of the US Coast Guard, to predict the movement of major oil spills and to assist search and rescue missions in San Francisco Bay.

Over the past decade engineers, planners, and decision makers have expressed the need for more precise data from model investigations. Water resource planners have turned to numerical models for these data--the tools at hand--as an alternative to physical models since present physical model construction and operating costs would be excessive if borne by only a few users. However, with the continual improvement of the Bay Model, to keep pace with today's data requirements, it evolves and continues to perform an important role for studying water related problems in the Bay system. Also, it can contribute a greater service to the State of California in the management of their major water resources. Furthermore, it is envisioned that numerical modelers will find greater use of the physical model to augment their findings through less costly hybrid applications.

SUMMARY

In conclusion, it is a giant evolutionary step from model theory to physical hydraulic model reproduction of an estuary. The the San Francisco Bay-Delta Tidal Hydraulic Model, built on site by SPN, has provided an invaluable resource for the general public, the educator, and the scientist--a tool available to the State and Federal agencies, private agencies, and the public to perform studies at minimal costs. The Model must keep pace with the changing technology and will continually strive to improve data reliability in order to meet the demands of today's engineers, water resource planners, and decision makers. The San Francisco Bay-Delta Tidal Hydraulic Model is successfully meeting this goal and looks forward to an active future as a state-of-the-art research tool.

REFERENCES

US ARMY ENGINEER DISTRICT, SAN FRANCISCO. 1976. "San Francisco Bay-Delta Model, Model Verification and Results of Sensitivity Tests," Technical Memorandum No. 1, San Francisco, Calif.

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PUBLIC COMMENT

BG KELLY: This a time that we have reserved, and it is prescribed in our charter that we have it reserved for comments by anyone from the public in the given area wherever we hold the meeting to render any thoughts or comments that they might have.

BG KELLY: *I'll open it up at this time. Do we have anybody from the public who would like to make a statement?*

(No response.)

CERB Proceedings

NATIONAL OCEANOGRAPHIC AND ATMOSPHERIC ADMINISTRATION
SEA LEVEL MONITORING

Mr. Paul M. Wolff
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Ocean Services and Coastal Zone Management
National Oceanic and Atmospheric Administration

ABSTRACT

The National Oceanic and Atmospheric Administration's National Ocean Service has responsibility for maintaining historical and predicted water levels in the Nation's coastal areas. The mechanical gages of this 175-station network are being replaced by acoustic instruments with satellite data collection system. Traditionally these gages have been located in harbors, but the present trend is to place new stations on the open coast. This new water level system also has applications in the modeling and prediction of ocean and estuary current systems. Recent attention to the predicted "greenhouse effect" warming of the earth's atmosphere has lent new impetus to a measuring system of ocean basin wide water levels. The geodetic location of the stations is available from two surveying techniques. The objective of the system would be to detect the first few centimeters of general sea level rise if ice melting is occurring. The geodetic observations, in combination with the tidal measurements, will yield a determination of whether the land is subsiding or sea level rising over a specified spatial domain. The warming could cause an increase in sea level by melting of ice caps and glaciers and by expansion of the water in the world's oceans accompanying a temperature increase. This would cause changes in the mass distribution of the earth and affect its rotation. The Very Long Baseline Interferometry measurements of changes in the rotation parameters could well provide the first warnings of such a global warming.

INTRODUCTION

Historically, the National Oceanic and Atmospheric Administration (NOAA) and the US Army Corps of Engineers (Corps) have had many cooperative projects in the Nation's harbors and coastal and inland waterways. In the future, in the area of predicting and dealing with the consequences of potential sea level rise, NOAA and the Corps must again join forces and combine our respective expertise.

SIGNIFICANCE OF SEA LEVEL RISE

The amount of carbon dioxide in the earth's atmosphere is definitely increasing on a worldwide basis. Whether this will increase or decrease air temperature at the earth's surface or the ocean's temperature is not known precisely. The magnitude of the consequences for coastal communities if the so-called "greenhouse effect" does occur is indeed serious. The physical consequences of sea level rise will include permanent flooding, higher storm wave flooding, erosion, barrier island migration, and losses in freshwater aquifers. Table 1 indicates the potential impacts in terms of coastal areas flooded and dollar losses from property damage with a hypothetical 15-ft rise in sea level.

TABLE 1

IMPACT OF SEA LEVEL RISE*

Top Ten by Area Flooded	Percentage	Top Ten by Market Value	Dollars (in billions)
Louisiana	27.5	Florida	33.4
Florida	24.1	New York	22.0
Delaware	16.0	Texas	14.3
D. C.	15.0	California	7.3
Maryland	12.3	Louisiana	6.5
New Jersey	9.5	New Jersey	6.2
N. Carolina	7.9	Virginia	4.1
S. Carolina	6.7	Massachusetts	2.2
Rhode Island	3.5	Pennsylvania	2.0
Virginia	3.1	S. Carolina	1.6

* US only, 15-ft case.

Because of these potential losses and damages it is very important now to study the problem and begin making preliminary measurements.

ROLE OF NOAA

NOAA, the appropriate entity for this study of monitoring sea level rise, has the legal responsibility for safe navigation and determination of maritime boundaries. The agency is currently carrying out a number of research efforts into the related physical and chemical processes. The

Subtropical Atlantic Climate Studies (STACS) program investigates heat transport in the northern subtropical Atlantic Ocean. NOAA's program to measure background concentrations of CO_2, ozone, and other atmospheric constituents, and to measure solar radiation, is referred to as Geophysical Monitoring for Climatic Change (GMCC). The Radiatively Important Trace Species (RITS) program supports research and monitoring to understand the behavior, trends, sources, and consequences of substances such as nitrous oxides, methane, and trophospheric ozone. In its geodesy program, NOAA is developing processing capability for application of satellite altimetry to measure temporal variations of ocean dynamic heights. All of these efforts related to monitoring sea level rise are tied also to NOAA's development of ocean current models.

SCOPE OF MONITORING EFFORT

In order to monitor sea level rise it is necessary to measure on a consistent, long-term basis on both sides of a given ocean basin. An El Nino event, for example, which resulted in a 1-m increase in sea level in the eastern portion of an ocean basin would be accompanied by a 1-m decrease on the western side. Therefore, the integrated effect basin wide is the key knowledge we are seeking.

Water levels would rise both because of the melting of polar ice and because of the expansion of the water at higher temperatures. Ultimately, a sea level rise of 1 to 2 m is sometimes predicted. A rise of several millimeters or 1 or 2 cm could be an indication of an establishing trend. Early detection is critical in order to conduct the necessary studies and coastal planning and protection to deal with the problem of rising sea level.

NEW MEASUREMENT TECHNOLOGIES

Quantifying sea level rise is now possible because of new measurement technologies. For vertical leveling, the innovative use of Very Long Baseline Interferometry (VLBI) and Global Positioning Systems (GPS) will yield a geodetic reference system with precision of ±1 cm. Figure 1 is a schematic of how GPS links the tide gages to the global VLBI network. Differential use of VLBI and GPS will enable us to calculate absolute sea level instead of relative, for the first time. Existing measurements cannot account for the

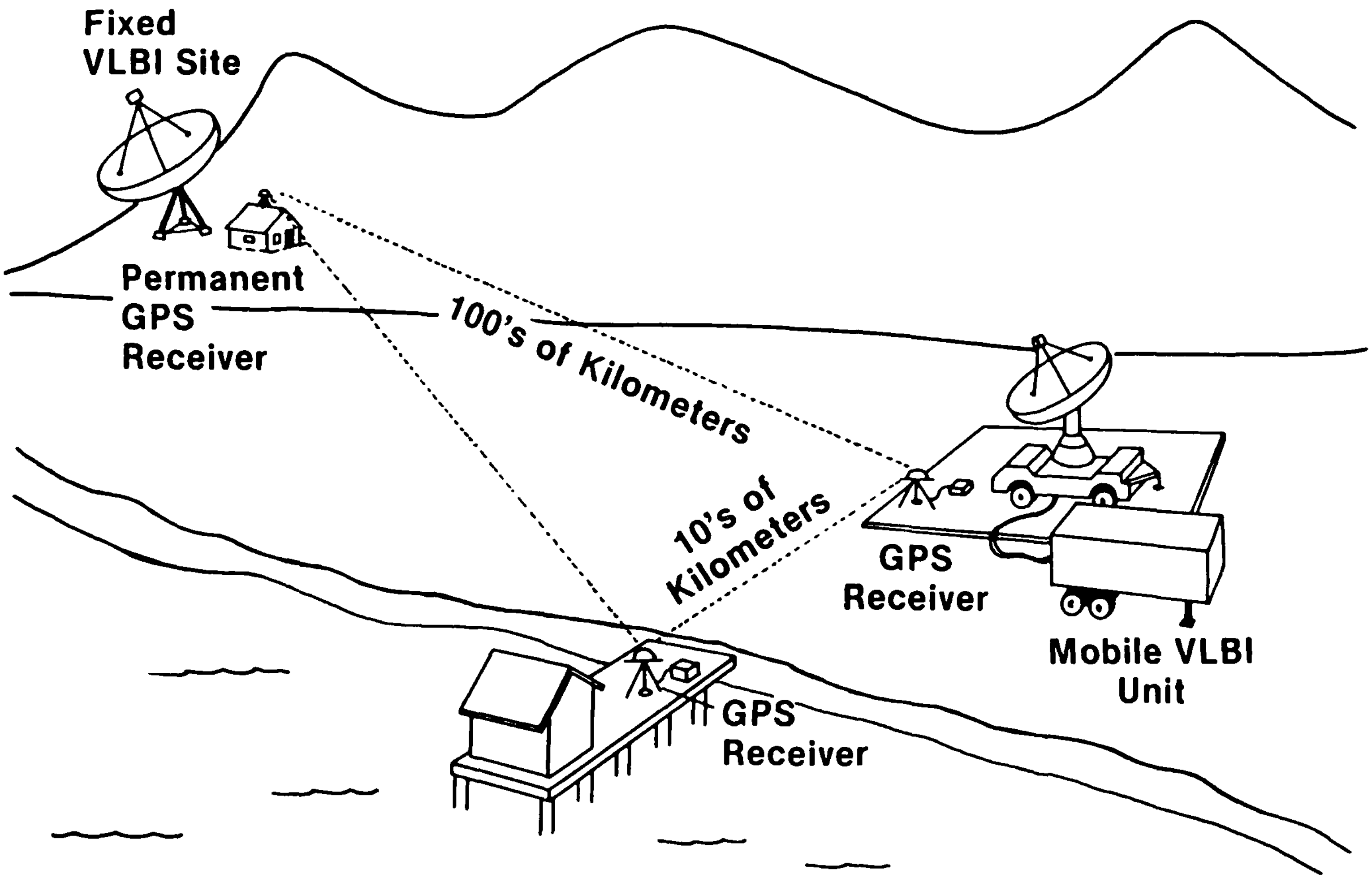


FIGURE 1. GPS LINKAGE OF TIDE GAGE TO GLOBAL VLBI NETWORK

vertical movement of the land surface. Essentially, we need to know whether sea level is rising or the land is sinking.

For water level measurement, NOAA's National Ocean Service (NOS) is in the process of installing a "next generation" system. The old gages, designed in the 1920's, are mechanical; they have a complex stilling well, require daily calibration, and use a paper tape for data collection which is mailed in monthly. The new gages will use a noncontact acoustic sensor with an open stilling well and no moving parts, and data collection will be via the Geostationary Operational Environmental Satellite with a central recording system. The replacement gages will be installed at 150 stations in the US, with 100 deployed worldwide. NOAA also plans to relocate or place additional water level measurement stations along the open coastline. This will produce a signal which does not contain interference from the movement of the water in harbors or estuaries. The Next Generation Water Level Measurement System will be in place in the next 5 years.

PROPOSED COOPERATIVE PROJECT

In a cooperative effort with the COE, NOAA is proposing to conduct a limited concept demonstration on the east coast. NOAA will provide the basic operating funds for geodetic, water level measurement (tides), and research efforts. The COE is being requested to provide additional support for capital equipment and operations. Table 2 lists the proposed East Coast "Master" Stations that would become part of the demonstration project. Table 3 provides a summary of NOAA contributions and the funds requested from the COE for the first year of this 2-year program.

TABLE 2

EAST COAST MASTER STATIONS

Location	Gage/Data Collection Platform	Auxiliary Sensors
1. Miami, FL	NOS	NOS
2. Lake Worth, FL	NOS	NWS/C-MAN*
3. Charleston, SC	**	**
4. Duck, NC	NOS	NOS/COE
5. Hampton Roads, VA	**	**
6. Atlantic City, NJ	NOS	**
7. New York, NY	**	**
8. Newport, RI	**	**
9. Boston, MA	NOS	NOS
10. Portland, ME	**	**
11. Eastport, ME		

* Coastal Marine Automated Network.
** Funding yet to be provided; COE support requested.

TABLE 3

NOAA CONTRIBUTIONS

Geodesy	Tides	Research
3 VLBI Observatories ($3M)	65 East Coast Tide Stations ($1M)	Island Gages
3 GPS-Fixed at VLBI Observatory ($450K)	5 Next Generation Systems ($100K)	Gulf Stream Transport ($300K)
3 WVR*-Fixed at VLBI Observatory ($600K)	4 Auxiliary Sensor Packages ($60K)	0
Operational Support ($400K)	Operational Support ($800K)	0
	COE REQUEST	
2 GPS-Mobile ($300K)	6 New Generator Systems ($120K)	0
2 WVR-Mobile ($400K)	7 Auxiliary Sensor Packages ($105K)	0
Operational Support ($200K)	Operational Support ($150K)	0
	Analysis ($150K)	0

* Water vapor radiometer.

DISCUSSION

BG KELLY: *What is RITS?*

MR. WOLFF: I do not recall what the acronym stands for. However, it is related to the fact that in addition to CO_2 there are a number of trace gases increasing in the atmosphere that have considerable heat capacity in certain spectral windows and that may significantly affect the basic heat transfer and retention properties of the atmosphere.

MR. PFEIFFER: *Will the Global Positioning Systems (GPS) station be used full-time for your uses or part-time with time available for other uses?*

MR. WOLFF: We are dedicated to shared use. You can have access, when available, to any equipment you purchase.

BG ROBERTSON: *Was your earliest data point on sea level rise for the year 1910?*

MR. WOLFF: Yes sir, 1910 is the earliest year. However, I would trust the data only since about 1930. We installed new gages in the 1920's, and the old gages had accuracies of feet rather than centimeters. The best evidence of sea level rise is the motion of the coastline, since it is difficult to resolve millimeter sea level rise signals. The National Ocean Service of NOAA has data on coastline recession.

BG ROBERTSON: *Is there sufficient information to know whether there has been an acceleration in sea level rise? One of your last charts seemed to indicate there has been no acceleration, but you have indicated great concern.*

MR. WOLFF: An acceleration in rise has not been detected. Since climatic variations can cause sea level variations on the order of a meter, they can mask the signal on the order of a centimeter for which we are searching. If an accelerated increase is occurring and we do not detect it in the first two centimeters, we are not going to have time to take actions which will ameliorate probably a third to half the damage.

DR. MEI: *Your last slide showed a total budget of close to $10 million. Is this a one time, 1-year budget?*

MR. WOLFF: It is a continuing budget of $9 million for base funding in geodesy. We cannot get authority to buy certain equipment we need for this effort because when the equipment is a new technology it is very difficult to convince NOAA, the Department of Commerce, Office of Management and Budget (O&M), and Congress. GPS is here now, and it will revolutionize all of geodesy, including surveying and water level change. It opens many doors and is worth the effort it will take to get to use it.

DR. MEI: Your initial estimate was that it would take 500 years for sea level to rise 1 m.

MR. WOLFF: Yes. At the current rate it would take 500 years, but if the CO_2 effect is real, the rate will accelerate. I mentioned the rise is a sine curve with a very slow movement now, but a sine curve has a segment of very rapid rise.

DR. NUMMEDAL: *Is this acceleration and shape of the rise curve established or speculation?*

MR. WOLFF: Processes in the atmosphere tend to be nonlinear, and if the CO_2 warming begins to occur, the rate will increase. This is an intuitive feeling, and I cannot prove it.

DR. MEI: But a nonlinear process can go either way. It can go down or up.

MR. WOLFF: That is right. We know CO_2 is increasing. What the effect will be, we do not know. However, if we do not detect the first centimeter in an increased rate of rise, then increased water levels will be on us before we can act.

BG KELLY: *Has Congress been supportive of this program?*

MR. WOLFF: The staffs have been unanimously supportive, but we have had problems with OMB and the Department of Commerce.

DR. NUMMEDAL: The best estimate of the projected rate of sea level rise is the one produced by a committee of the National Research Council chaired by Roger Revelle, Scripps Institution of Oceanography. The committee has estimated a rise in the eustatic component of sea level over the next century of 70 to 80 cm. The Environmental Protection Agency has estimated a rise of 40 cm to 2.5 m. Revelle's estimate is the one people are accepting as the most likely.

Sea level rise is certainly an important topic. The National Research Council has established another committee to consider engineering implications of sea level rise. I am on this committee which is chaired by Dr. Robert Dean, University of Florida. The committee is due to release a report by April 1986. I suggest we invite Dr. Dean to a future meeting in about 6 months to 1 year to give a review of the findings of the committee.

DR. WOLFF: Dr. Revelle is familiar with the study we are proposing. In addition, our study would fit in well with the world ocean climate experiment which is an international effort to determine the ocean circulation.

DR. NUMMEDAL: One of the key benefits of the study you have discussed is it will separate the true eustatic sea level rise from localized land subsidence. This is what is needed to establish whatever signal is due to carbon dioxide warming.

MR. PFEIFFER: *I attended a meeting last week concerning a holistic study of the globe over a 10-year period including the atmosphere, ocean, and biosphere. Does your program interface with this program?*

MR. WOLFF: I know of the program, but I work on a 2-year basis and cannot get excited about something that may start in 1990. There are always many of these studies proposed and few funded. I am interested in long-term monitoring. The open water stations we would place would be there indefinitely. If this does not meet longer range research objectives, I will leave that problem to other groups.

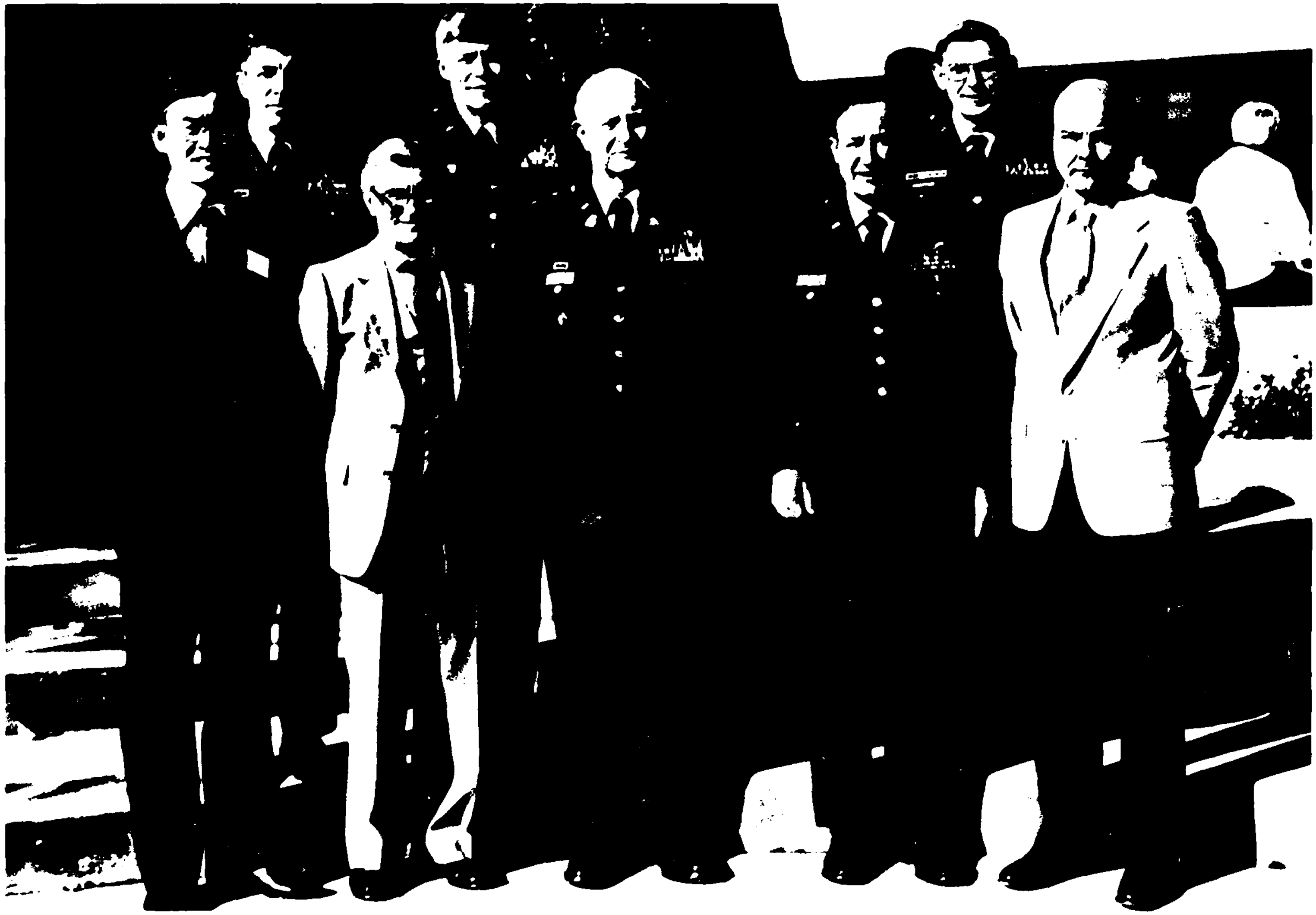
MR. LOCKHART: *Will your proposed network of tide gages establish a survey base that can be used to establish a datum several miles from shore?*

MR. WOLFF: That is within the reach of the new technology. The new technology will establish an accurate datum on land, and there is no reason this could not be extrapolated as much as 200 miles out to sea. The altimeter data will be unclassified in 11 months and has precision of 5 cm. If we can determine one datum on each, the satellite can measure the relative height between two points.

MR. LOCKHART: *Are you storm proofing the open ocean gages? We have worked in cooperation with NOAA on hardening several gages in the Gulf.*

MR. WOLFF: They will not be hurricane proof, but I expect them to be storm proof. I cannot afford to build structures. I will use any structures I can.

DR. WHALIN: Paul, I appreciate your coming and talking with us. It was a very apropos topic. We have been working in the Corps to develop multiagency support to meet common goals.



COASTAL ENGINEERING RESEARCH BOARD
44TH MEETING, 4-6 NOVEMBER 1985
SAN FRANCISCO BAY-DELTA TIDAL HYDRAULIC MODEL
SAUSALITO, CALIFORNIA

OPEN DISCUSSION BY COASTAL ENGINEERING RESEARCH BOARD (CERB) MEMBERS

Below is a synopsis of questions and comments by members of the Board. Appendix C contains letters from Dr. Bernard Le Méhauté, Dr. Chiang C. Mei, and Dr. Dag Nummedal.

BG ROBERTSON: I propose that the CERB annually review coastal research needs, prior to going to the Civil Works Research Needs Board, with a view toward suggesting priorities and exploring tie-ins with existing or proposed research at other agencies, universities, etc.

MR. LOCKHART: Stewardship of the research needs program has been turned over to the Research and Development (R&D) Directorate.

MR. PFEIFFER: We have periodically briefed the CERB in the past on the entire R&D program, which is a good idea. We are continually looking for joint funding opportunities. Don't expect 100 percent yield; 10-20 percent is more realistic.

MR. YUEN (private contractor): We should explore tie-ins or joint ventures with private companies that have basic research funds. Honeywell is an example in water resources.

DR. MEI: the 1984 National Science Foundation/Office of Naval Research (NSF/ONR) workshop at Oregon State University developed a document identifying research needs in coastal and ocean engineering. A similar workshop was held 2 years ago at the University of Hawaii.

DR. WHALIN: I will send CERB a copy of the workshop proceedings.

BG KELLY (to Pfeiffer): *How does coastal engineering fare in the Corps R&D program?*

MR. PFEIFFER: It follows the average trend. The problem is that the entire R&D budget is heading downward toward a point in the future where it will not be meaningful.

BG PALLADINO: *Are the Division presentations of research needs worthwhile? If so, do we structure our R&D program accordingly?*

DR. WHALIN: The presentations are worthwhile, but the reaction is not clear. For example, every presentation for the last 3 years has stressed the need for continued and expanded wave data acquisition. Despite this, the Corps has not been successful in increasing the wave data collection budget. Continued level funding means that in a few years we will be at a decision point for the whole program. Another example is the hurricane presurge anomaly study which was a direct result of the CERB meeting.

BG KELLY (to Whalin): *Have we analyzed past research needs presentations to extract common needs?*

DR. WHALIN: No. But we probably should.

MR. LOCKHART: Most of the common needs are being addressed. We try to do things such as add R&D dollars to a model study to gather new data.

BG Kelly: *How do the CERB's comments get incorporated?*

DR. WHALIN: For the last 2-3 years, CERC has reviewed the transcript and extracted the significant questions and discussions. We then develop responses or plans of action and report on them at the next meeting. We don't yet have a good mechanism in place for action items on subjects such as the budget.

BG PALLADINO: CERC and other participants in the CERB meetings have been effective in following up. As an example, we will arrange to meet with CERC and Dr. Nummedal to discuss concerns raised at this meeting about Imperial Beach. The R&D community should attend events such as the upcoming West Coast Regional Design Conference to ascertain user design needs.

DISCUSSION OF DATE AND PLACE OF NEXT MEETING

BG KELLY: We will now discuss where we would like to hold the next Board meeting and the general time frame. I believe we have some offers.

BG ROBERTSON: I would like to repeat the offer I made in Chicago. John Oliver has done a great job in checking out all the possibilities and in checking out the opportunity to accept my invitation to go to Alaska.

I would like to ask you and the Board to give me a month to check legal and funding potential possibilities, and at that point I would still invite you to return to Seattle. But I think we probably will have other invitations and a "lady in waiting" that might be a better offer. Then maybe in another year we can make it to Alaska. I still want to emphasize we do want to host the Board in Alaska in June 1986.

BG KELLY: *Was there one other offer we had earlier?*

MR. DEBRUIN: We reextend our offer to have the Board meet on the Texas Gulf Coast, either in fall 1986 or spring 1987. Our choice of location will be Corpus Christi. And we're willing to wait on the North Pacific Division (NPD) for a month.

BG ROBERTSON: I would like to accept that backup. And if we can't get the legal and the financial questions answered within a month, I don't think we should hold up Galveston that long. I do appreciate their willingness to wait for us and back us up, if the Board will so indulge us.

BG ROBERTSON: *I would like to ask a question of the Board, just to help us. We traditionally meet in May and October or early November. I would recommend, if it is not too inconvenient, for the Board, as far as Alaska is concerned, that we slip into June. Any problems with that?*

DR. MEI: I think it might be more convenient for people from the universities, i.e., for the civilian Board members. In May, or at the end of May, we generally have examinations.

DR. NUMMEDAL: We finish very early. I'm done with exams by mid-May.

BG KELLY: Well, George, your offer is accepted and subject to further analysis, both legal and financial. We'll accept Galveston, then, and we'll try to resolve this thing here witnin the next month.

CLOSING REMARKS BY COASTAL ENGINEERING RESEARCH BOARD PRESIDENT

Well, first of all, I wish to just summarize some of the things that I have seen so far. This is the first Coastal Engineering Research Board (CERB) meeting that I have attended, and I am very pleased with what I have seen so far. I think the interchange was tremendous, both on Monday and today. We never lost a minute; it was productive the entire time. Yesterday's tour and the weather as well as all the projects that we saw in the morning and afternoon--both in the northern part of the area and the southern part of the area--were tremendous. We saw all sorts of things that are unique to the California coastline and its problems.

I think the mood was set with the Chief's presentation very early in the program when he, in essence, threw out the gauntlet to the Board and said, "Okay. Now, here are some things you ought to take a look at." We are trying to address those. And, by the way, his concluding comment, I thought, was very interesting. He said basically to be objective, and "I promise to be objective when I look at what your recommendations are." So, I think that kind of set the proper stage. We have reviewed the next meeting time, the June time frame, either in Alaska if we can solve the problems there or in Galveston as a backup.

I would like to single out, in particular, a whole bunch of people. And I just think it is worthy that I do single them out because the support has been tremendous from both the South Pacific Division, San Francisco District, and the US Army Engineer Waterways Experiment Station (WES) in getting this whole conference ready. And, in particular, I would like to single out from the Division, of course, Don. The hospitality that you and your entire staff have offered and the various presentations that were made--which took a lot of time to get ready--have been tremendous. Ace Wanket and Hugh, especially, I think your role has been tremendous. If I mispronounce some of the names, please excuse me, but Dick Dibuono, Jaime Merion, George Domurat, Diane Hayson, Will Prior, Donna Willet--of course, we trained her in Tennessee--and Florene Kent have done a great job. And from the District side, of course, I wish to thank COL Andy Perkins and his entire staff; MAJ Steve Thomas, who waited through the wee hours of the morning last night to retrieve the lost bus driver; MAJ Ken Clow, who I might point out was one of my former students in physics at the Military Academy; Bill Burke; Mark Dettle; Frank Rezac; Bill

Prout; Sal Polito; Dennis Thuet; Les Tong; Judy Zaitlin; and Tom Denes.

Then we had the Bay Model tour. That is why we are here. What a beautiful scenery. Daphne Dervin and Tom Wakeman gave a tremendous briefing and tour this morning as well as John Marting and Ed Griggs. From the Los Angeles District we had Doug Diemer who was prepared to give two talks on Monday, and unfortunately we just ran out of time and could not get him in. But we want to thank him for doing that.

Now, the WES staff and the Coastal Engineering Research Center (CERC) staff who have supported the Board have just been tremendous. COL Al Grum gave us a good dissertation on his role and what he is doing and his support. But there are two ladies who really are the unsung heroes, and they are Sharon Hanks and Harriet Hendrix. Then there are Andy Szuwalski and Shirley Hanshaw who is the editor. Shirley, I met her for the first time last night, is taking all this down and is going to put it all together.

RESPONSE TO RESEARCH NEEDS OF US ARMY ENGINEER DIVISION, SOUTH PACIFIC (SPD), AND US ARMY ENGINEER DIVISION, NEW ENGLAND (NED)

SPD'S NEEDS

SPD has extensive needs to improve the body of wave and other coastal processes information available, including support and incremental expansion of field wave gaging with the addition of directional gaging offshore, development of 10-year statistics from the gage information, extension of the wave information study hindcasts for an additional 10-year period, and expanded study of sea level changes. Participation in the Coastal Storm Observer Program is sought.

The US Army Corps of Engineers (Corps) and the Nation have need of a significantly expanded wave gage program to be used in verifying models, improving forecasts, and developing wave climates. Both the Corps and National Oceanographic and Atmospheric Administration (NOAA) have programs to attempt this, neither of which is adequately funded. Although small incremental funding will help, a massive funding level perhaps three to five times what is now spent is needed. Until such funding is available, The Coastal Engineering Research Center (CERC) is trying to work with SPD and other Divisions to optimize placement of gages and to coordinate the program with project studies, as well as with other Federal, state, and local efforts. To get local support, the Districts and Divisions are the Corps' primary liaison, and CERC needs their help to assure that local funds can be used to add gages to the system. SPD has been particularly successful in this approach. CERC has worked with NOAA and SPD to obtain a directional gage offshore in California, but more are needed. Our involvement with the Coastal Ocean and Dynamic Applications Radar (CODAR) wave radar was generated by the need on the Pacific coast to obtain directional wave data offshore. We expect this system to allow collection of a larger amount of directional data more reliably than now possible with gage installations.

CERC has proposed funding of 10 years of additional hindcasts and has scheduled it in the Field Data Collection Program documentation. This program too has funding limits, and the proposed effort does not begin until after completion of the Great Lakes efforts. The 10-year hindcasts for the Pacific Ocean would be most useful because a considerable body of wave data collected under the Field Data Collection Program and the Coast of California Tidal Wave Study during this period can be used to verify and improve the hindcasts. The basic model used at CERC in the hindcasts can be used for quick response hindcasts for a particular storm. CERC is investigating the feasibility of using NOAA or Navy products to initialize and drive the model which would allow detailed hindcasts soon after an event. The nesting grid interface technique now used will allow hindcasts to be made in shallow water and on a fine grid resolution as soon as the bathymetric data can be entered into the model and the wind data obtained. CERC is also developing an interface to the NOAA digital bathymetric data set that should allow rapid generation of bathymetric files and software that would allow interface with gage data to help drive the model.

CERC maintains liaison with most NOAA wave efforts. Provision of Corps gage data to the National Weather Service (NWS) is seen as a valuable assistance to their efforts. However, the Corps receives no funding from NOAA for this effort. The Corps may also need to study the Corps' liability position as a result of NOAA's use of these data.

The problem of changes in climate go beyond sea level rise. If the climate changes sufficiently to make sea level rise a problem, significant changes in the probability of severe coastal storms and rainfall flooding may also change. CERC continues to work with other agencies on this problem. We are proposing to the Office of the Chief of Engineers (OCE) a study to investigate the effect of climate change on storm patterns, wave conditions, flooding, erosion, sea level change, and the attendant effects on Corps structures (completed and proposed). At this point it is not possible to forecast what change will occur. We do think it critical, however, that the Corps investigate different levels of change, estimate their impact, and recommend strategies to cope with the problems created. In this way, the Corps can be in a better posture to cope with the changes should they occur.

The Coastal Storm Observer Program is an innovative program to obtain information about the effects of storms. CERC will seek improved liaison with this effort to define ways in which CERC can help.

SPD encourages the continued development of littoral transport models.

CERC views development of regional scale coastal models capable of simulating littoral transport with and without structures as one of its most important goals. Achievement will mark a significant advance for the coastal engineering field. CERC continues to work on the problem and plans to test the model first in Southern California. CERC is looking at its entire research program to see where research on other topics can improve the basic parts of the model already in place. Essential to the model's successful evaluation and use will be high quality sets of coastal hydrodynamic and morphological information as well as personnel experienced in the region under study. The Coast of california Storm and Tidal Waves Study can be a critical contributor to the effort by providing high caliber data for the model. SPD's Coastal Storm Observer Program can also provide valuable information.

SPD wants continued monitoring of the prototype dolosse at Crescent City with the results incorporated into a rational structural design procedure for armor units. Additional needs are studies of uplift wave forces on horizontal structures, use of detached segmented breakwaters, and the berm breakwater concept.

CERC is monitoring prototype dolosse at Crescent City. The Prototype Dolosse Test Working Group will consider possible extension of the data collection period. SPD, US Army Engineer District, Los Angeles (SPL), US Army Engineer District, San Francisco (SPN), CERC, and the US Army Engineer Waterways Experiment Station (WES) are represented on the Test Working Group and will be involved in the technical discussion. CERC presently does not have a recommendation on extension of the monitoring program but will develop one based on results from the first year of data collection and analysis. The objective goal of this research is to develop a structural design procedure for dolosse. The Crescent City Prototype Study is a necessary and important first step.

CERC considers the detached breakwater to be a very promising structural technique for the control of beach erosion. Both design guidance and field experience are needed to develop a properly engineered detached breakwater project. CERC has recently prepared a technical report titled "Detached Breakwaters for Shore Protection," which is undergoing final editorial review.

It is a qualitative assessment of the state of the art. Under the "Evaluation of Navigation and Shore Protection Structures" research work unit, several detached breakwater projects are being monitored. These prototype monitoring and evaluation programs provide a qualitative service record and data which can be used to identify the significant design parameters, define empirical relations, and test design tools. Under the "Numercial Modeling of Shoreline Response to Coastal Structures" work unit, methods for numerically simulating the shoreline response to a particular structure configuration are being developed. Another work unit, "Lab and Scale Effects in Movable Bed Models," is developing the technology for physically modeling sediment transport.

The search for more economical designs and assurance of safe performance requires studies of uplift forces on horizontal structures. This search has become a significant concern to all Corps field offices and extends beyond the needs of SPD. Nearly every coastal District and Division has to design and construct and/or approve structures such as decked piers, wharves, walkways, and seawalls with horizontal extensions or overhangs. The wave forces on such structures are complicated to predict and very little or, in some cases, no directly applicable design data exist to aid the field offices. CERC's research work and experimental studies in this area are practically nil, and more effort should be made to provide generalized design data. Site-specific physical model studies are the most appropriate tool at this time, but the cost of such studies is often prohibitive for small projects. CERC has already introduced in the Coastal Structure Evaluation and Design Program a proposed research work unit to develop wave force and wave pressure design criteria for various types of coastal structures. The wave uplift forces on horizontal structures could and should become a part of that work unit.

The need for design guidance on the sacrificial berm breakwater is universal throughout the Corps. Continuing efforts to economize the design and construction of major breakwater structures require the Corps to seek new and innovative design concepts. The sacrificial berm concept, although not new, has been promoted by others over the last few years as an economical alternative to the more conventional design presently used by the Corps. Certainly this concept has its place, but even its promoters recognize that it has weeknesses and unknowns.

The sacrificial berm concept was originally introduced in Denmark on structures that could readily be maintained by dumping more stone as the onslope protection was gradually degraded. This allows a lower first cost, but since the stones move and adjust to the wave environment, higher maintenance may be required. This type of design must be engineered very closely because it is potentially dangerous to design for armor movement for the following reasons: selection of the design event becomes more critical, and replenishing of the slope material must be planned. This concept should not be used on breakwater heads, and if the stone breaks apart, freezes, and thaws the average stone size may be reduced. The armor then becomes underdesigned and moves even more than originally intended. The Corps has not used this type of structure as major breakwater protection, but several field offices have inquired about its use. CERC has not done any research on the concept. With all of its uncertainties, this concept should be addressed thoroughly before field use is allowed.

SPD recommends an effort to understand and predict the navigation problems associated with small craft entering harbors.

The problem of handling small craft in harbor channels and entrances is of potential concern in every Corps coastal Division. CERC's efforts under way include research at predicting waves and currents in the entrances of inlets and rivers. In order to improve our ability to design small-craft harbors and navigation channels, a systematic approach is needed that is based on the hydrodynamic requirements of small craft. CERC has proposed a three-phase, joint research initiative with the WES Hydraulics Laboratory on "Small Boat Harbor Design." This research proposal is not scheduled for funding until fiscal year 1988 (FY 88). In the meantime, CERC is aware of the need and is conducting research in several related areas, including the development of more accurate physical and numerical simulation technology for both harbor configuration and structure cross-section design and documentation of "marginal" small-craft harbors as we become aware of them.

SPD emphasized interest in remote sensing: CODAR, x-band radar, and laser mapping.

CERC has worked with OCE and the field to develop programs to test promising remote sensing techniques in the field. Our efforts have been largely to monitor developments in remote sensing that are conducted by others to find those techniques sufficiently proven for evaluation as practical tools. The demonstration program proposed in california is our first large-scale effort.

NED's NEEDS

The New England coastline has a wide variety of coastal morphological types. Many areas are complex and are affected by waves generated locally. They also are partially or completely sheltered from open ocean wave attack. Many coastal engineering projects are in the small project category (Section 103 Authority) and cannot fund investigations, data collection, or model studies needed to address the problems in sufficient detail. The Division needs a short-term research plan that includes WES and CERC research experience early in the planning. Because of the irregular shorelines and unusual bathymetry, the Division's research needs seem outside the mainstream of the research community.

Small projects in complex settings are not unique to NED. They occur in most Corps Divisions, particularly in Alaska, the Pacific Islands, estuarine areas, lakes, and reservoirs. Often the complexity of the site and problem could require detailed planning and study of alternatives more difficult and relatively more costly than for more expensive projects in uncomplicated settings. As a result, such problems often do not get the attention that the technical issues themselves warrant because of cost. As the Corps of Engineers enters a fiscal climate where funding of the planning stage of projects may be cost shared with local governments, the pressure will be to further reduce the cost of technical studies. The NED need for tools to improve the planning and engineering of small project studies reflects this trend.

Many Corps programs address broad areas or issues. The Field Data Collection Program is building a national wave climate, but it emphasizes large reaches of coasts. The research programs have primarily emphasized studies of processes in less complicated areas so that better understanding of the process can be deduced. The goal, of course, is to develop methods, models, or procedures that unite the understanding of several different processes and can be used in complex cases. CERC has under development many numerical models that can be of use in studies of the complex areas under question. However, their use can be relativley costly if small scale variations in topography, etc., are important and must be resolved. CERC has historically conducted hydraulic model studies to produce general design curves for manuals and continues to do so. Many problems that arise in the small project studies require customization of a design that requires detailed knowledge not normally produced in a generic study. In any study, large or small, it would be desirable to have all needed information available in a nomogram or manual. This is not practical, and there must be some limit where project studies are appropriate. The need at CERC is the development of less expensive methods to perform small site-specific studies. CERC's assistance should be requested as early as possible so that our experience can be used to quickly customize a project plan of study. CERC will work toward development and generalization of our models so that they can be more economically applied while yielding a minimum degradation of the technical results. CERC sees the need to improve methods for the planning and design of small projects attempting to maximize technical quality for the given resources. CERC has proposed a new research program on reservoir harbor and shore protection to OCE to address special needs in the reservoir environment, including the need for predicting waves in enclosed water bodies with irregular shorelines and bathymetry. This effort would be complementary to NED's need.

NED needs improved methods for predicting wave conditions in partially sheltered waters and the extent and amount of beach sand movement.

NED has taken a significant step toward prediction of the wave conditions in partially sheltered waters by the plan to emplace anemometers in areas where wave conditions will be needed. In highly complex areas, broad scale wind patterns that can be determined from weather maps are not particularly accurate. CERC can investigate regional scale wind models that account for topography and roughness in these studies. Such models coupled with a limited set of local measurements may provide a significant increase in the accuracy of wind and wave estimates.

CERC has wind wave models that can be simplified to simulate wave conditions in sheltered areas and that could accept input of ocean wave conditions at a boundary. For deepwater conditions the models can be simplified. For shallow-water conditions this is difficult. CERC is currently conducting research on the applicability of current wave models to narrow fetch cases. We can broaden that investigation to develop a simplified model that can be used in the partially sheltered case and on lakes, reservoirs, estuaries, and fjords. The proposed new research program on reservoir harbor and shore protection mentioned earlier would help meet this objective.

Coupling of a regional wind model with faster wave calculations would address NED's problems and similar problems in other Divisions. Determination of the extent and amount of beach sand movement would improve by improving the wave information available.

NED needs improved methods for determining the frequency of wave overtopping of coastal structures and for curtailing overtopping of existing structures.

CERC has conducted overtopping tests, and the ones recently conducted for NED at Roughans Point have been extended by OCE funding to help generalize their results. The complexity of the interaction of individual structures with breaking waves can be fairly specific to a structure and site. Improved knowledge is needed for determining the overtopping vulnerability of different types of designs, but very specific results may still require a scale model study. One goal should be to develop methods to decrease the costs of such studies. Development of numerical models of this problem are being pursued outside of CERC and may offer advantages in the future.

If sea level rise does become significant, the problem of improving older structures will become a very important topic. As discussed earlier for SPD needs, CERC has formulated a proposed program to look at the effects of sea level rise and climate change.

SPEAKERS

ROBERT R. BOTTIN, JR.

Mr. Bottin is a civil engineering technician in the Wave Processes Branch, Wave Dynamics Division, Coastal Engineering Research Center, US Army Engineer Waterways Experiment Station (WES). He has been employed at WES since 1972 and has progressed to a project manager position for physical hydraulic model investigations. Mr. Bottin manages model investigations involving wave action (both long- and short-period), river discharges, tidal flows, and/or the movement of sediment. He has authored or coauthored over 25 publications and has been the recipient of numerous awards, including the WES Herbert D. Vogel Technician Award in 1984. Mr. Bottin is a graduate of the University of Southern Mississippi with a B.S. degree in industrial technology. He is also an Engineer Officer with the US Army Reserves.

THOMAS A. DENES

Mr. Denes is a civil engineer in the Environmental Branch of the US Army Engineer District, San Francisco. Since starting work in May 1985, he has been involved with identifying aquatic disposal sites in San Francisco and the Gulf of the Farallones as well as identifying the paths of sediment transport within the bay. He was formerly employed with the Coastal Engineering Research Center assisting in the development of prototype oceanographic instrumentation. He graduated from the University of Wisconsin in 1979 with a B.S. degree in civil and environmental engineering continuing with an M.S. degree in marine sciences in 1983. Mr. Denes is a member of the Oceanic Society.

DOUGLAS J. DIEMER

Mr. Diemer is a civil engineer in the South Coast Section, Coastal Resources Branch, US Army Engineer District, Los Angeles (SPL). He has been employed with SPL for 4 years, in which time he has been involved in the coastal planning and design of various military and civil works projects. Design experience includes work on the Imperial Beach Breakwater project, Coronado Naval Amphibious Base Beach Renourishment Project, and Oceanside Sand Bypass. Mr. Diemer graduated from Loyola Marymount University in Los Angeles in 1980 with a B.S. degree in civil engineering. Presently he is enrolled part-time in the M.S. degree program at the University of California, Los Angeles. Mr. Diemer is a registered professional engineer in the State of California.

GEORGE W. DOMURAT

Mr. Domurat is an oceanographer in the Navigation and Coastal Planning Branch of the US Army Engineer Division, South Pacific (SPD). He received a B.S. degree in oceanography from Stockton State College in 1974 and an M.S. degree in oceanography from Old Dominion University in 1977. Mr. Domurat started with the US Army Engineer District, San Francisco, in 1977 and has been involved in channel and harbor design, shoreline erosion and protection studies, various coastal planning studies, development of field data collection programs, and data collection at the San Francisco Bay-Delta Tidal Hydraulic Model. Since joining SPD in August 1984, Mr. Domurat has acted as program manager for coastal studies within SPD. He is a member of the Marine Technology Society, the Coastal Society, a director of the American Shore and Beach Preservation Association (ASBPA), and vice-president of the California Chapter of ASBPA.

STANLEY S. FUJIMOTO

Mr. Fujimoto is a civil engineer in the South Coast Section, Coastal Resources Branch, US Army Engineer District, Los Angeles (SPL). He has been employed with SPL for 2-1/2 years—1 year as an engineer-intern and the other 1-1/2 years with the South Coast Section. Mr. Fujimoto graduated from California State Polytechnic University, Pomona, in 1983 with a B.S. degree in civil engineering. Presently he is enrolled part-time in the M.E. degree program at California State Polytechnic University, Pomona.

ROBERT A. HOLMAN

Dr. Holman is an associate professor in the marine geology group of the College of Oceanography, Oregon State University (OSU). Prior to moving to OSU, he was at Dalhousie University where he received his Ph. D. in physical oceanography in 1979. Dr. Holman's interests center on the dynamics of infragravity band wave motions in the surf zone and their influence on sediment transport to form natural sandbar systems.

JAMES R. HOUSTON

Dr. Houston is chief of the Coastal Engineering Research Center (CERC) of the US Army Engineer Waterways Experiment Station (WES). Prior to becoming chief of CERC, he served as chief of the Research Division. Dr. Houston has worked at WES *since 1970 on numerous coastal engineering studies dealing with explosion 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. in engineering mechanics from the University of Florida.*

WARDELL D. JOHNSTON

Mr. Johnston joined the US Army Engineer District, San Francisco, in 1955. His primary responsibilities were to: (1) plan and supervise the prototype hydraulic-salinity data collection program for verification of the San Francisco Bay hydraulic model under construction, and (2) assist in planning, design, and supervision of model construction. Mr. Johnston developed new construction techniques and procedures for forming model slabs and planned the installation of instruments and equipment to operate the model. In 1966, he planned, designed, and supervised the extension of the original model to include the Sacramento-San Joaquin Delta. He planned and executed five additional prototype surveys to obtain data to verify the Delta. For over 20 years he directed and actively participated in the operation of the model to conduct most complex hydraulic, salinity, sedimentation, reclamation, water pollution, and flood flow studies. Most recently, he was instrumental in the design and construction of Delta model slabs to form Delta Islands and conducted model studies for evaluating the salinity impact of levee failure flooding of Delta Islands. He assisted in the authorship and authored technical papers and reports presenting the results of the model and prototype investigations.

NICHOLAS C. KRAUS

Dr. Kraus is a research physical scientist in the Coastal Processes Branch, Research Division, Coastal Engineering Research Center (CERC), US Army Engineer Waterways Experiment Station. He joined CERC in September 1984 and is presently involved with numerical modeling of beach evolution; fundamentals of sand transport, including windblown sand; and finite amplitude wave theory. Previously he was a senior research engineer at the Nearshore Environment Research Center in Tokyo, Japan. Dr. Kraus received a B.S. degree in physics from the State University of New York at Stony Brook and a Ph. D. degree in physics from the University of Minnesota. He is a member of the

American Society of Civil Engineers, Japan Society of Civil Engineers, and American Geophysical Union.

CURTIS MASON

Mr. Mason has been chief of the Field Research Facility, Coastal Engineering Research Center (CERC), US Army Engineer Waterways Experiment Station, since 1979. He began work at CERC in 1971 as program manager for the Corps' General Investigation of Tidal Inlets and was chief of the Coastal Processes Branch from 1978 to 1979. Prior employment was as a research physicist for the Naval Ship Engineering Center and the Naval Oceanographic Office. He received a B.S. in general science from Oregon State University in 1964, and an M.S. in oceanography from Texas A&M University in 1971. His career research interests relate to developing an improved understanding of real-world coastal processes.

DOUGLAS G. OUTLAW

Mr. Outlaw is chief of the Wave Processes Branch, Wave Dynamics Division, Coastal Engineering Research Center (CERC), US Army Engineer Waterways Experiment Station (WES). He has been employed at WES since 1972 and was transferred to CERC in July 1983 from the WES Hydraulics Laboratory. He has been involved with coastal studies of harbor protection, harbor resonance and sediment transport, wave and tide data acquisition and analysis, and tidal circulation. Mr. Outlaw received a B.S. degree in civil engineering and an M.S. degree in hydraulic engineering from the Georgia Institute of Technology. He also is an Engineer Officer with the US Army Reserves.

DANIEL G. PARRILLO

Mr. Parrillo is chief of the Geotechnical and Materials Branch, US Army Division, South Pacific (SPD). Prior to his coming to SPD, he was Division Geologist for US Army Engineer Division, North Atlantic. Before entering government service, Mr. Parrillo worked with the New Jersey Geological Survey and various consulting firms in the private sector. He also owned a geological consulting business at one time. He holds an M.S. degree in geology from Rutgers University and is a registered professional geologist and engineering geologist.

DENNIS W. THUET

Mr. Thuet is a civil engineer in the US Army Engineer District, San Francisco (SPN), where he has worked in both planning and construction. Presently he is the construction engineer for the Fisherman's Wharf project working at the San Francisco resident office. While in planning, his main responsibility was project manager for the Fisherman's Wharf project, through both Planning and Advanced Engineering and Design, which provided a unique oppportunity for him to experience the full cycle of events leading to completion of a Federal project. He received a B.S. degree in civil engineering from the University of Utah in 1966. He is a registered professional engineer in the State of California.

LESTER TONG

Mr. Tong is a biologist in the Environmental Branch, Planning/Engineering Division, US Army Engineer District, San Francisco (SPN). He has been employed with SPN for 13 years, in which time he has been involved with numerous flood control and navigation Civil Works projects. His responsibilities include determining input with the Fish and Wildlife Service, endangered species consultations, environmental statements, dredged material bioassays, and water quality analyses. Navigation planning experience includes Fisherman's Wharf breakwater and improvements for Richmond and Oakland Inner Harbors. He graduated from the University of California at Berkeley in 1969 with a B.A. degree in zoology. He was awarded Planner of the Year by the US Army Engineer Division, South Pacific, in 1985 and is a member of the American Fisheries Society.

THOMAS H. WAKEMAN

Mr. Wakeman originally joined the US Army Engineer District, San Francisco (SPN), in 1970. He initially worked in the Regulatory Section and later moved on to the Waterways Maintenance Section. During this period, he became involved with dredging activities. Subsequently, he participated in SPN's Dredged Disposal Study. At the completion of that study in 1976, he was selected for long-term training and chose to attend the University of California (UC) at Davis. In 1979, he returned to work in the Navigation and Coastal Planning Section until joining the Regulatory Functions Branch in late 1980. In 1982, Mr. Wakeman left SPN to continue his research in hydrodynamics at UC. While in Davis, he also worked in the Research Branch at the Hydrologic Engineering

Center; started his own consulting firm, "EARTH DOCTORS"; and worked as a wastewater engineer for Moldenhauer Engineering Company. Presently, he is the Model Director at the San Francisco Bay-Delta Tidal Hydraulic Model. Tom's undergraduate studies were in marine biology and mechanical engineering at California State Polytechnic University in San Luis Obispo. He earned the masters degree in marine biology with a minor in geology from San Francisco State University. Presently, he is a Ph. D. candidate in civil engineering at UC, Davis, where he is studying the hydrodynamic behavior of secondary clarifiers in wastewater treatment plants.

ACHIEL E. WANKET

Mr. Wanket is chief of the Engineering Division, US Army Engineer Division, South Pacific, a position he has held since January 1975. Prior to assuming this position, he served as the assistant chief, Engineering Division. Mr. Wanket has also served in engineering positions of progressive responsibility in the US Army Engineer District, Detroit. He received a B.S. degree in civil engineering from the University of Detroit in 1951 and an M.A. degree in business administration from the University of Michigan in 1957. Mr. Wanket is a registered professional engineer, a member of the Senior Executive Service, and a member of the US Committee on Large Dams (Chairman, Publications Committee), the US Committee on Irrigation, Drainage, and Flood Control, the American Society of Civil Engineers, the Society of American Military Engineers, the Commonwealth Club of California, the American Public Works Association, and the Engineering Criteria Review Board of the San Francisco Bay Conservation and Development Commission.

CHARLES J. WENER

Mr. Wener holds a B.S. degree in civil engineering from the University of Vermont and has completed all course requirements for an M.S. degree in Water Resources/Environmental Engineering at Northeastern University. He has been a hydraulic engineer in the Hydraulics and Water Quality Section at the US Army Engineer Division, New England (NED), for 11 years and has been section chief since 1984. Coastal experience includes hydrodynamic and wave modeling, establishing storm tide frequency relationships, design of coastal flood protection projects to prevent wave overtopping, analysis of local wind data to establish wave heights in sheltered waters, flood hazard analysis for Coastal Flood Insurance Studies, and evaluation of coastal and estuarine water quality conditions and impacts. He is the NED member on the Corps Water Quality Committee.

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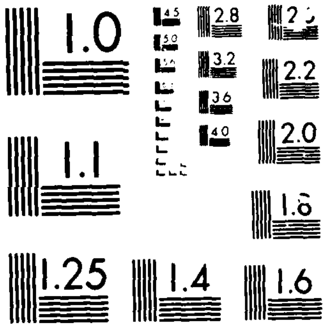
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PAUL M. WOLFF

Mr. Wolff was appointed assistant administrator for Ocean Services and Coastal Zone Management in December 1983. A retired Navy captain, he has specialized in applying numerical methods in oceanographic and marine weather analyses and prediction. He founded the US Navy Fleet Numerical Weather Central in 1959 and commanded it until 1970. He has designed marine weather services for Saudi Arabia and Iran, created a computer weather service used by 15 nations, and served as a consultant to the National Aeronautics and Space Administration in its SEASAT program. He has undertaken extensive ocean investigation to determine areas where thermal structure is favorable for ocean thermal energy conversion plants. After retiring from the Navy, Mr. Wolff was president of a private meteorological company—Global Weather Dynamics. He has been active in international projects of the World Meteorological Organization and the Intergovernmental Oceanography Commission. He graduated from Wittenberg University in Springfield, Ohio, and received an M.S. degree in meteorology from the Navy's Postgraduate School. He attended postgraduate study programs at the University of Chicago. During his naval career, he served as senior naval officer to the Joint Numerical Weather Prediction Unit at Suitland, Maryland and as a weather officer on nine ships. He has received the Navy Oceanographer's Award, the Marine Technology Society Award, and the American Society of Naval Engineers Solberg Research Award. A Fellow of the American Meteorological Society, he has been widely published in scientific and technical journals.

JODY A. ZAITLIN

Ms. Zaitlin is a marine biologist in the Environmental Branch, US Army Engineer District, San Francisco (SPN). She began work with SPN in 1978. She has worked on water quality evaluations under Section 404 of the Clean Water Act and is currently developing physical, chemical, and biological testing criteria for the aquatic disposal of dredged material in San Francisco Bay. Ms. Zaitlin graduated from the University of California, Berkeley, in 1977 with a B.A. degree in environmental studies. She is currently in the M.A. program in marine biology at California State University, San Francisco. Ms. Zaitlin is a member of the American Society of Fisheries Research Biologists and the Western Society of Naturalists.

APPENDIX A

REVISED INTERIM MANAGEMENT POLICY FOR DREDGED MATERIAL DISPOSAL IN SAN FRANCISCO BAY AND ENVIRONS

APPENDIX A

SAN FRANCISCO DISTRICT, CORPS OF ENGINEERS INTERIM MANAGEMENT POLICY FOR DREDGED MATERIAL DISPOSAL IN SAN FRANCISCO BAY AND ENVIRONS

July 1985

I. HISTORICAL OPEN-WATER DISPOSAL SITES IN SAN FRANCISCO BAY, DESIGNATED FOR CONTINUAL USE

A. Water Quality Protocol - Retain guidance per Public Notice 78-1

B. Guidelines on use of Designated Sites

1. Alcatraz (SF-11)
    a. Only dredged material in compliance with water quality protocol
    b. Permits and Corps of Engineers maintenance projects directed to use western half of site
    c. No restriction on quantities or annual amounts for existing permits or Corps of Engineers maintenance projects
    d. For all new work (dredging in areas and to depths not dredged for 20 or more years) aquatic disposal projects of greater than 10,000 cubic yards (yd^3), grain size analysis will be performed. If the material contains greater than 20% fine material:
        (1) Hydrometer analysis will be required, as well as Atterberg limits and in-place moisture content.
        (2) If sediment test results indicate potential for mounding (liquidity index of the material is less than 4.5), slurry (a homogeneous mixture of water and sediment with a liquidity index of 4.5 or greater) disposal will be required.
    e. No restriction on timing either tidal or seasonal

f. COE new work projects:

(1) Disposal of slurry will be required and may be restricted to certain locations in the disposal site.

(2) No more than 500,000 yd^3 per month shall be disposed.

(3) Periodic bathymetric monitoring will be required.

2. San Pablo Bay (SF-10)

a. No disposal during the period of May through June

b. For new work dredging projects of greater than 100,000 yd^3, which contain greater than 20% fine material;

(1) Hydrometer analysis will be required as well as Atterberg limits and in-place moisture content.

(2) If sediment test results indicate potential for mounding (as above), slurry disposal will be required.

c. Bathymetric monitoring will be performed in conjunction with maintenance dredging.

3. Carquinez Strait (SF-9)

a. No restrictions on timing.

b. For all new work aquatic disposal projects of greater than 100,000 yd^3 which contain greater than 20% fine material:

(1) Hydrometer analysis will be required, as well as the in-place moisture content and Atterberg limits of the material.

(2) If sediment test results indicate potential for mounding (as above), slurry disposal will be required.

c. Bathymetric monitoring will be performed in conjunction with maintenance dredging.

II. OPEN-WATER DISPOSAL SITES IN SAN FRANCISCO BAY, NOT DESIGNATED FOR DREDGED MATERIAL DISPOSAL

A. Basis for proposing new sites per PN 78-1 and 40 CFR 230

B. Limitations for use of any proposed new open-water site in S. F. Bay include:

1. No more than 30,000 yd^3 per activity per year
2. No more than 50,000 yd^3 per year cumulative
3. Restrictions on dredging or disposal methodology determined on a project specific basis.
4. Restrictions on timing determined on a project specific basis.

III. OFF-SHORE DREDGED MATERIAL DISPOSAL SITES

A. OCE policy:

1. Undesignated ocean dumpsites (e.g., sites which are not either interim-approved or final designated) will not under normal circumstances be used.

2. Under unusual circumstances, utilization of non-designated sites may be necessary. In such cases, the District Engineer will explain the circumstances and document the need for the non-designated site and forward findings to Chief of Engineers, attention Water Resources Support Center for projects and DAEN-CWO-N for permits. The Chief of Engineers will instruct the District of further action.

B. Availability of Designated Off-shore Sites

1. The once interim-designated 100-fathom ocean disposal site has not been extended (Federal Register, dated 7 February 1983, interim final rule)

2. The interim-designation San Francisco Channel Bar site has been extended until final rulemaking is completed or until 31 December 1988 whichever is sooner (Federal Register, dated 19 February 1985, interim final rule) to provide acceptable disposal of dredged material essential for navigation. To date, use of the site has been exclusive for dredged material from the San Francisco Bar Channel, which has been mainly sand.

C. <u>On-going Study</u>. Consideration of a replacement site for the once interim-designated 100-fathom site was initiated in fiscal year 1983. Field surveys has been completed on two sites in the Gulf of the Farallones.

IV. RECORDING

A. Each permit applicant will provide before and after dredging bathymetric surveys of the project site, and computation of the quantity dredged. The applicant will provide monthly totals of the quantity of clamshell and slurry disposal.

B. Regulatory Functions Branch will compute the total disposal (in cubic yards) for each method of disposal at each site monthly for permited projects.

C. Construction-Operations Division will compute the totals of Corps of Engineers maintenance dredging disposal for each of the disposal sites on a monthly basis.

D. The discharge total will be forwarded to Environmental Branch for reporting purposes.

APPENDIX B

SUPPLEMENTAL REGIONAL PROCEDURES FOR EVALUATING DISCHARGE OF DREDGED OR FILL MATERIAL INTO WATERS OF THE UNITED STATES

DEPARTMENT OF THE ARMY
SAN FRANCISCO DISTRICT, CORPS OF ENGINEERS
211 MAIN STREET
SAN FRANCISCO, CALIFORNIA 94105

SPNCO-R

30 July 1979

PUBLIC NOTICE NO. 78-1 (FINAL)

TO WHOM IT MAY CONCERN:

1. The U.S. Army Corps of Engineers, San Francisco District has finalized the supplemental regional procedures for evaluating discharges of dredged or fill material into waters of the United States (Inclosure 1). Public review of the draft procedures were made available by Public Notice No. 78-1 issued on 27 November 1978. These procedures will supplement the Corps' present regulations for evaluating such discharges (33 CFR 323, published in the Federal Register on 19 July 1977) and the EPA's 404(b) guidelines (40 CFR 230, published in the Federal Register on 5 September 1975).

2. Data and test results generated by these procedures are not the sole factors used in deciding whether a permit should be issued or denied by the District Engineer. Data gathered herein would supplement information that we would receive through our public notices on Section 404 discharges. All relevant information that we have would be used to determine whether any given discharge is or is not in the public interest.

3. We would like to emphasize that these procedures are relevant only to waters of the U.S. under the jurisdiction of the San Francisco District, and the testing procedures primarily pertain to discharges of dredged or fill material at open-water disposal sites. Other types of proposed discharge sites (upland, behind-dikes, intertidal areas, etc.) will continue to be evaluated by the regulations cited in paragraph 1.

4. As a result of the comments we received on PN 78-1 of 27 November 1978, announcing proposed changes to our evaluation procedures for Section 404 discharges, and subsequent meetings with various Federal and State agencies, and other interested groups, we have made some modifications to the procedures initially described in PN 78-1 of last November. Some of the changes are: (1) deletion of the liquid phase bioassay; (2) addition of a solid phase bioassay for disposal sites that are low energy areas; (3) use of applicable State water quality objectives (EPA criteria would be used if there are no State objectives); (4) elaboration of the elutriate test; and (5) consideration of modifying the testing procedures for dredged material discharges not exceeding 10,000 cubic yards per activity at any one of the historical open-water disposal sites designated for continual use.

SPNCO-RS
PUBLIC NOTICE NO. 78-1 (FINAL)

5. The Corps recognizes that most applicants and commercial chemical laboratories are not familiar with these testing procedures since the procedures substantially differ from those that we and other agencies have been using. To insure reasonable time for all those that might be affected by these new procedures, we are allowing a twelve-month "familiarization" period (beginning with the date of this public notice), whereby the Corps in its evaluation of the test results, will take into consideration such factors as laboratory quality assurance, unfamiliarity of the procedures, testing protocol, etc. This twelve-month period will also allow us to work out unforeseen "bugs" in the procedures, and allow the commercial laboratories time to maximize their quality assurance and accuracy of the test results.

6. These supplemental regional procedures for evaluating Section 404 discharges will remain effective until such time they are revised by the Corps, or are superseded by the promulgation of the U.S. Environmental Protection Agency's final Section 404(b) guidelines. Additional details or answers to questions concerning these procedures can be obtained by contacting Mr. Calvin Fong of our Regulatory Functions Branch (telephone 415-974-0416), or by writing to the District Engineer, at the address at the head of this public notice.

1 Inclosure
As stated

John M. Adsit
JOHN M. ADSIT
Colonel, CE
District Engineer
San Francisco District

SUPPLEMENTAL REGIONAL PROCEDURES FOR EVALUATING DISCHARGES OF DREDGED OR FILL MATERIAL INTO WATERS OF THE UNITED STATES

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APPENDIX C
RECOMMENDATION LETTERS FROM CERB MEMBERS

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December 31, 1985

General Patrick. J. Kelly
President CERB,
Office of the Chief of Engineers
Department of the Army
20, Massachussetts Ave, NW
Washington D. C. 20314-1000

Dear General Kelley,

It was a most fruitful meeting of CERB in Oakland last month. I appreciated the opportunity to become acquainted with the vast responsibilities and deep commitment of the Corps to the coastal problems in our country.

May I summarize my thoughts as a result of the discussions and of the speech by General Heiberg.

I. <u>On Fostering Coastal Engineering Education</u>.

Measured by the magnitude of coastal engineering works the Corps handles, the number of Corps personnel formally trained in coastal engineering appears to be small. Most of your engineers learn on the job . This is related to the small number of identifiable programs in our universities. If a program has to involve at least three faculty members, then I can only think of MIT, Berkeley, Florida, Miami, and Delaware. From these places a large fraction of our graduates are foreign and most of them end up either in the oil industry or US and foreign universities. We need greater effort devoted to the education of coastal engineers <u>for the Corps</u>. Possible avenues include the following.

1. Establish cooperative programs with some universities so that engineers may work for Master's or Engineer's degrees in 1 to 2 years. These programs can indirectly stimulate the growth of undergraduate programs at these places, I believe. For many years now Navy sends 30 officers to study ship engineering at MIT; so, there are precedents in the armed forces.

2. How about starting coastal engineering courses at the Military Academy? This would certainly prepare some young cadets for a challenging career in the Army. At the beginning all you need is to hire one assistant professor. Visiting Professorships can further attract talents from outside. Annapolis has a good ocean engineering program. It has lab facilities which are the envy of any civilian university and also visiting professorships. Being in charge of our coast lines, there is much justification to introduce a coastal engineering program at the West Point.

II. <u>On Research and Funding</u>

The need for more coastal engineering research is recognized by us all. The Corps and in particular CERC are at the forefront of translating basic research into real world, mission-oriented applications. There are also applied research of more general and less mission-specfic type. I feel that researchers in academia are doing a lot more on the latter. But both to facilitate the latter and to enhance its rapid transfer to the former, close collaboration between the Corps and the academia is necessary. As the leader of the coastal engineering profession, the Corps can carry the flag to the Congress, to the private sector, etc. in order to achieve policies and framework for steady funding. On the other hand, it is also advantageous for the Corps to explore smaller measures which may bear immediate benifits to its own immense missions. Specific step may include:

1. Aggressive pursuit with universities joint projects with emphasis on the use of CERC facilities including the Duck Pier. Limit to projects that are of direct interest to the Corps. Can the Corps underwrite the cost of experiments? At the CERB meeting every one was talking about seeking external funding outside the Corps or even the Federal Government. Is internal funding totally out of the question? The annual budget of the Fluid Mechanics and Hydraulics Program at NSF is 5.4 million, and I don't know of a single grant in our field. In comparison, CERC has an annual budget of 6 million for in-house research. Even a fraction of this will put the Corps ahead of NSF for our profession. Many topics now being studied at CERC are of the type also of interest to the academia and can be enriched by such partnership. In this mode the Corps is not funding the universities. It is just a different way of spending the same amount of research dollar for broader gains.

2. Each Corps District may initiate its own contract research programs unique to its own operational needs. From the CERB meeting I learned that the budget of each Corps District is on the order of a few hundred million. Are there no coastal problems which might benifit from a deeper solution beyond existing wisdom or strictly model tests? If there are, could the investment of 100 K per year by each District save the Corps more in the long run?

My views are clearly biased by my own professional affiliation and these suggestions may fall into the category of controversial approaches. Nevertheless I hope we can discuss them further at the January meeting.

With best wishes for the new year,

Sincerely yours,

Chiang C. Mei
Professor of Civil Engineering
Member CERB

14 November 1985

Brigadier General Patrick J. Kelly
President, Deputy Director of Civil Works
U.S. Army Corps of Engineers
20 Massachusetts Avenue, N.W.
Washington, D.C. 20314-1000

Sir:

I have much enjoyed the opportunity to get acquainted with you during our last meeting in San Francisco. I am convinced that under your leadership the CERB will be most effective, as it has been under Brigadier General C.E. Edgar III.

Following the consolidation of CERC after the move from Ft. Belvoir, and the momentum which presently exists, the time has come to throw new ideas in order to not only keep the momentum going, but to keep establishing CERC as a true leading international center of excellence in coastal engineering.

In the following, I will summarize some ideas presented in San Francisco and I will give further afterthoughts.

1) In view of the shrinking research dollars in coastal engineering, I suggest that the U.S. Army Corps of Engineers take the initiative and leadership in establishing a Federal Commission for Coastal and Ocean Engineering Research (FCCOER) which would include representatives of NCEL, ONR, NSF, FEMA, NOAA.... The purpose of this commision will be to pool resources, coordinate research programs and eventually unite to solicit research fundings, based on the large constituancy that these agencies represent. Initially, a meeting can then be organized to define these goals, and assess the response of potential participants.

2) In our past meetings, we have alreay discussed research in dredging, and it is my understanding that a program is now implemented from OCE. Dredging research has three components:

- environmental inpact (done very competently by WES in the past)
- dredging technology (hydromechanics...)
- operations

The Corps is now spending over one billion dollars per year on dredging operations without much research. Therefore it would seem that if there is a domain where research can be cost effective, it should relate to dredging operations in addition to dredging technology. A 10% savings in the dredging operations is 100 million dollars. This easily justifies a major research effort. Therefore, I suggest the creation of a dredging research center for the study of dredging technology and operation. This may include the construction of a major unique large laboratory and field facilities for the study of tidal inlets and harbor entrances, since most of the dredging cost is around tidal inlets.

This facility can be conceived as a national center, with collaboration and support from the FCCOER (see above). It should be conceived as a center of international prominence, unique in the world and open to all concerns. It could eventually be supported by a fund from the dredging allocation (0.5% would amount to 5 million dollars each year).

3) My third point deals with marketing. It is a fact that W.E.S. has a quasi monopoly of experimental work in coastal engineering in the U.S. Therefore, the investment by private industries in laboratory installations has always been marginal due to the lack of a domestic market. As a result, not only the U.S. has been unable to attract the foreign market in experimental research, but the domestic market not controlled by the federal government (offshore industries, utility companies) have had a tendency to export to foreign laboratories such as Delft, Grenoble, Wellingord.... A number of changes are suggested.

The idea of privitizing WES (a la Thatcher, like the Wellingford lab.) is not realistic. Authorizing WES to go after the nongovernmental and foreign market in competition with private industry, besides being forbidden by law, may also create an uproar. But, the opening and renting (and advertising) of the WES facilities to private companies is certainly possible, as it is done presently with universities. Also allowing the WES personnel to help private companies (in operating the facilities to begin with) should be allowed. (For example, I know for a fact that the Navy has rented in the past the David Taylor Model Basin to Global Marine.) Needless to say that for succeeding along these lines, this would require WES to operate, like private industries, on a different time scale, based on short deadlines, overtime when needed, cutting red tape, etc..., all of which I would consider as being rather beneficial! For this, additional incentive may have to be given to the personnel. Eventually a parallel non-profit or profit organization located at Vicksburg can result from this opportunity. I have more specific ideas on how all this could be implemented, but it would be premature to go into details without giving CERB the opportunity to assess whether this (r)evolution is feasible within the present political context.

I am looking forward to discussing further these suggestions and will depend heavily on your guidance in this regard.

Sincerely,

Bernard Le Mehaute
Professor
Division of Applied Marine Physics

Department of Geology
LOUISIANA STATE UNIVERSITY AND AGRICULTURAL AND MECHANICAL COLLEGE
BATON ROUGE · LOUISIANA · 70803-4101

January 7, 1986

Mr. Patrick J. Kelly, Brigadier General
President, Coastal Engineering Research Board
U.S. Army Corps of Engineers
20 Massachusetts Ave. N.W.
Washington, D.C. 20314-1000

Dear General Kelly,

I should, of course, have written this letter a long time ago yet I still hope it will reach you before our CERB meeting at Ft. Belvoir.

The challenges presented by General Heiberg in his remarks at the San Francisco CERB meeting address the entire spectrum of coastal engineering research within the Corps. I am very pleased that the Chief wants to undertake this wholescale assessment of our research efforts. I am also pleased to observe that the present board under your leadership has a large amount of enthusiasm and creativity, ensuring the generation of a multitude of ideas to improve research effectiveness.

A. In terms of big payoffs it appears that improved dredging effectiveness is the leading candidate. As Dr. Le Mehaute already has pointed out, the total annual dredging budget is about $1 billion. Moreover, those of us who regularly carry out coastal fieldwork have observed numerous occasions where substantial amounts of money could be saved by using sophisticated dredging methods rather than "brute force". Specifically, some of these approaches include (a) utilizing the natural sand-bypass pathways of tidal inlets, (b) fluidization or enhanced scour of the channel bed during ebb flow (current Navy experiments), (c) design of stabilized channels such as to minimize sand wave growth after completed dredging, (d) better monitoring of contractor compliance using modern surveying techniques such as high-resolution side-scan sonar, (e) high-resolution reflection seismic surveys to identify sources and sinks of sand prior to initiation of a dredging program, etc.

These are just a few improvements in tidal inlet maintenance which can be implemented. Clearly there is room for development in the technology of the dredge, in the hydrodynamic modeling of inlet flow and related subjects. To address these subjects the establishment of a Dredging Research Lab is one possibility. This is a long-term solution, and definitely worth pursuing. We should discuss whether such a lab should be part of CERC/WES or located at a coastal site; perhaps associated with a university with related research capabilities (U. Fla., Texas A&M, UC San Diego, MIT, Old Dominion, etc.).

On a shorter time frame I would like to propose that we consider initiating, right now, a multi-institutional, multi-disciplinary study of tidal inlet hydraulics and sedimentation. The program structure I have in mind is something along the lines of the National Sediment Transport Study (NSTS) conducted some 5 years ago. Scripps Institution organized the effort, but at least half-a-dozen other institutions participated. Not only is it logical for the Corps to sponsor such a program in view of its enormous dredging expenditures; a tidal inlet study of this type is also a logical continuation of CERC's program on General Investigations of Tidal Inlets (GITI) conducted in the 70's.

B. My next point deals with a subject that many would consider being outside the field of pure coastal engineering. Yet, it is an undeniable fact that no engineering project is ever done without a thorough economic analysis to complement the technical design work. Therefore, we need to take a close look at the methodology used in the computation of benefit-cost ratios. The quality of the nation's future coastal engineering works will depend as much on the economic analyses as on the technical expertise. It is particularly important that the benefit-cost analyses for coastal engineering projects be evaluated in light of the current tendency to encourage "soft" designs in coastal erosion mitigation. Such solutions have very different ratios between cost of initial construction and long-term maintenance than do traditional structural ("hard") solutions.

C. At the CERB meeting in Vicksburg in May, 85, Dr. Whalin asked whether the Corps should establish a National Center of Excellence in Coastal/Ocean Engineering. I think the question should be answered in the affirmative and we should proceed to evaluate possible structures of such a center. One model that comes to mind is the National Center for Atmospheric Research (NCAR) which, over the last 15 years or so, clearly has made the U.S. the world's leader in atmospheric research. It is a highly successful national laboratory center with great computer facilities and equipment for experimental and field data collection. At the same time, it has become a focal point for academic research programs. The "GALE" project, scheduled for January 15th to March 15th, 1986 is an excellent example of how their research is typically conducted.

I hope you will find these thoughts and observations useful. I look forward to continuing this work to enhance the nation's coastal engineering research capabilities.

Sincerely

Dag Nummedal
Professor of Geology

cc: Col. A.E. Grum, WES
DN/ljs

APPENDIX D

MEMORANDUM FOR THE CHIEF OF ENGINEERS

FROM BG C. E. EDGAR III

DEPARTMENT OF THE ARMY

SOUTH ATLANTIC DIVISION, CORPS OF ENGINEERS
510 TITLE BUILDING, 30 PRYOR STREET, S.W.
ATLANTA, GEORGIA 30335-6801

REPLY TO
ATTENTION OF:

SADDE

28 OCT 1985

MEMORANDUM FOR THE CHIEF OF ENGINEERS.

SUBJECT: Role of the Coastal Engineering Research Board (CERB)

1. The 43rd Meeting of the CERB was hosted by the Waterways Experiment Station in Vicksburg on 22-24 May 1985. The Board's final report of that meeting was published in August. At that meeting, representatives from each major Corps headquarters element with a coastal engineering function made a presentation on their organization's responsibilities, research needs, and future directions. A list of the presenters is attached (Encl 1). I requested the senior OCE and WRSC-D staff to make the presentations to insure that the CERB was exposed to the major policy and technical issues confronting the Corps as envisioned by our senior civilian leaders in their respective areas of responsibility. I chose this course of action because I and members of the Board believe the CERB should be an active, dynamic, and integral part of the Corps family and provide you with innovative, visionary and sound recommendations concerning the future focus and direction of coastal engineering in the Corps, the nation, and the world. The timely relocation of the Coastal Engineering Research Center (CERC) to WES and the great capability enhancement derived from the other four WES laboratories makes this introspective action even more essential. I asked the CERB members to review the role of the Board, given our charter, taking into consideration the information conveyed at this meeting to determine if modifications to our current operating procedures were necessary. The Board has had a long, distinguished, and unique history in the Corps of Engineers. Through the Board's guidance, CERC has become synonymous with excellence in coastal engineering worldwide. The Shore Protection Manual is the "bible" of coastal engineering throughout the world. That is past and the Board has a similar, valuable role to play in the future. The Board believes strongly that we must change the present span of overview if CERB is to be an active proponent for coastal engineering both to be consistent with changes in the Corps and to have an impact on the future. In addition, the coastal engineering research arena and the profession face critical, immediate and long-term challenges the Board must consider as a part of its Charter if it is to provide you its best advice and recommendations to help shape that future. This memorandum summarizes what transpired at the meeting, the members thoughts regarding the issue and my recommendations to you for future action.

2. A copy of the CERB Charter is attached (Encl 2). The Board's objectives and scope are outlined in paragraph B. The Board was established primarily to advise you on coastal engineering research; however, paragraph B-4 gives you the authority to ask the CERB to perform additional functions. Consequently, no change in the Charter is required for the Board to expand its existing or traditional role if you choose it to do so. The CERB initiatives are in no way intended nor is it desired to encroach upon the Board of Engineers for Rivers and Harbors' responsibilities for project review.

3. The CERB is comprised of four senior Corps officers and three world-renowned civilian experts in coastal engineering. The make-up of the Board provides strong expertise to advise you on policy and technical matters. The Board receives the necessary support from the Director of WES and the staff of CERC. The military members also receive support from their own staffs. I recommend no changes be made to the Charter concerning composition of or support for the CERB.

4. By way of general background, the Coastal Engineering R&D Program is guided by the following six general policies. It must:

a. Be mission oriented to support civil works.

b. Have close user interaction with the field (Districts and Divisions) and OCE.

c. Exploit new technology to benefit Corps missions.

d. Emphasize user application and technology transfer.

e. Maintain/enhance Corps technical credibility through high quality, useful R&D.

f. Maximize benefit to Corps from mission support programs.

The coastal engineering R&D program is mission oriented to support Civil Works. The R&D Directorate, through the laboratories, provides a technical support service to the Districts, Divisions, and OCE. There is a close user interaction among the Districts, Divisions, OCE, and the R&D community. The majority of CERC activities consist of applied research and development with a firm goal to benefit Corps missions. CERC does not perform very much basic research. Emphasis is on user application and technology transfer throughout the Corps and to the private sector. There is a tremendous synergism between our military and civil works coastal engineering research programs which needs to be exploited to the maximum.

5. In line with the theme of the Vicksburg meeting, ten questions for future direction of coastal engineering R&D were posed to the Board by the Chief, CERC. A summary of the members' responses are attached (Encl 3). As you might imagine, there was not unanimity in all responses, but there was a common thread and a very strong feeling by each member that the CERB can and should be more active in order to maximize its service to the Corps.

6. The following points were discussed during the meeting at WES:

a. This highlighted the Corps special role historically in the coastal engineering field and the responsibilities attendant with this role. Unlike other engineering professions (e.g. structural, environmental, and geotechnical engineering), there is no significant funding for coastal engineering R&D from sources outside the Corps. The Corps of Engineers has sole responsibility for advancing coastal engineering technology in the United States, and the Corps must recognize its unique role to this profession and respond accordingly in its budgeting process. The Board should provide the Chief of Engineers with specific recommendations (both fiscal and technical) on long-term directions for coastal engineering. This is a critical responsibility of the Board, since future technological advances for solving coastal engineering problems will not be provided by spinoffs from R&D funded by others in the United States.

b. The lack of basic or fundamental research funding poses a present and serious problem for coastal engineering. Funding of basic research in coastal engineering, mostly accomplished by universities, can support the innovation necessary to dramatically reduce the cost of doing business in the Corps. The Board should investigate both an increase in traditional General Investigations (GI) funding for the Coastal Engineering area (Dr. Blakey estimated during the 43rd Board meeting that Corps projects in coastal regions constituted nearly half of the total future Corps work) and funding from other appropriate areas (O&M, CG, etc.). The Director of Civil Works should assist the Board in this endeavor and the opportunity for cost sharing by states, universities, and other non-Federal entities needs to be taken into account.

c. The Board should address training of Corps personnel in coastal engineering. This is extremely important since the Corps must, to a large extent, grow its own professionals in coastal engineering. The Board should consider innovative solutions to this problem, such as establishing a program where CERC and a university system join to provide academic training with the necessary associated laboratory facilities.

d. The lack of sufficient highly advanced and large-scale laboratory facilities for coastal research should be addressed by the Board. A dialogue has been initiated with the Marine Board, National Research Council and the National Science Foundation (NSF) on the establishment of national laboratory facilities available to both the Corps and the academic community. The potential benefit and cost effectiveness of national laboratory facilities available to both the Corps and NSF would provide the mechanism necessary for the Corps and academia to jointly make a quantum leap in the science and practice of coastal engineering.

e. Since establishment of the Board, dramatic changes have occurred in the type of work and funding sources for Corps coastal engineering activities. For instance, the O&M portion of Civil Works budget has increased from approximately 15 percent to over 50 percent during the past few years. This change in emphasis of the Corps operational priorities has produced R&D needs that have transcended the traditional Board role to review only the GI funded coastal engineering R&D program. Today, new R&D thrusts funded from the O&M budget, such as the Repair, Evaluation, Maintenance, and Rehabilitation (REMR) Program have significant coastal engineering components. Field demonstrations (i.e., Floating Breakwater Prototype Tests (Puget Sound), Dolosse Prototype Tests (Crescent City, CA), and Field Verification Program (New England) have been developed in recent years and are primarily coastal engineering demonstrations. The major economic payoff potential for R&D in dredging has been discussed in recent Board meetings. Regional coastal studies are underway in Los Angeles and Jacksonville Districts, and similar studies may soon be initiated in other districts. The expertise of the CERB in addressing difficult technical issues in these and other coastal studies is available and could be used to advantage. The Board has been briefed in many of these areas (i.e., field demonstrations, REMR, regional coastal studies, dredging, etc.) but only in a passive manner. The Board should provide systematic advice and recommendations to the Chief that span the breadth of coastal engineering over the various funding appropriations of the Corps.

f. The Board should give high priority to addressing methods of increasing the identity and visibility of coastal engineering in the Corps. Most Corps work involves activities along the coast, yet the USACE coastal engineering community does not have an organizational identity (such as Geotechnical Branch, Structures Branch, Hydraulics and Hydrology Branch) within most coastal districts, divisions, or OCE. In order to grow our own coastal engineers, there must be a clear organizational element (from district to division to OCE) dealing with coastal issues to which Corps personnel can gravitate and for which a career ladder is apparent. Such an element would serve as a conduit where the coastal engineer could advance and be properly recognized for professional achievements.

g. If the Corps is to gain substantive benefit from the CERB, OCE and other decision makers throughout the Corps must accept the responsibility to both consider and seek the Board's recommendations, take appropriate action on those recommendations, and provide feedback. Without substantive action of Board recommendations (whether supporting or not) and/or a lack of feedback on the response taken, an activist role by the CERB is not possible. For example, the CERB has raised a significant item which for various reasons, OCE has been unable to deliver. The CERB strongly recommended that the FY 87 budget include sufficient funds ($2.6 M) to expand Coastal Field Data Collection (CFDC) so that data base can fulfill its intended role as a critical national program. Accurate, reliable, continuous wave data are the single most urgent immediate requirement in coastal engineering. This issue has been articulated by the Board at the last four meetings. Up to this point, the best we have been able to do is level fund CFDE. To fulfill a commitment to leadership for coastal engineering's future, we must dedicate ourselves to action on this program.

8. Given the foregoing and the Corps unique role in the Coastal community, I believe there is an opportunity for the Corps to show the way. In August 1988, the 22nd International Coastal Engineering Conference will be held in Madrid. If we have been successful in husbanding our resources and providing focus and progress through implementation of the CERB initiatives, we should be poised to make some significant advances in Coastal Engineering. This would be an appropriate forum for you to call on others to follow the Corps lead by declaring that 1990-2000 will be targeted by the Corps as "The Decade of the Coast" and suggesting that others do the same. By that time CERC programs/budgets will have had the opportunity to be focused and an all out effort can be made for making real far-reaching advances in the basic and

applied research necessary to revolutionize the accuracy and reliability of coastal engineering practice. This long-term plan should give us sufficient time to influence budgets and mobilize State and federal agencies with an interest in coastal engineering to make sustained cooperative advances for the profession. The upcoming joint meeting of CERB and ASCE in San Francisco suggests that seeds are already planted.

9. I recommend you take the following actions:

a. The CERB should be directed to take an active role in providing you advise and recommendations across the total span of the Corps coastal engineering responsibilities regardless of the funding source (i.e., GI, CG, O&M, etc.).

b. The Corps of Engineers bears sole responsibility for funding basic and fundamental research in coastal engineering, which is the only engineering discipline where other agencies/organizations are not and will not fund a significant amount of basic research. The present Corps coastal engineering R&D program contains insufficient basic research. The Board should be directed to provide recommendations (both fiscal and technical) on long-term directions for the Corps program.

c. CERC and the Board should be directed to pursue novel and innovative mechanisms for funding new, large, high technology laboratory research facilities.

d. CERC and the Board should be directed to pursue innovative mechanisms for training (jointly between CERC and some academic institution) the coastal engineers of the Corps.

e. The CERB should be directed to address methods of increasing the identity and visibility of the Corps' coastal engineers. The Chief of Engineers can support this by declaring that the coastal engineering function and professional coastal engineers must be given an identity in the Corps commensurate with their peers in other engineer functions and their importance to the Corps mission. Our coastal districts and divisions, and OCE should be systematically organized to contain a coastal engineering element as appropriate (i.e., such as Sections, Branches, Divisions for Geotechnical, Structural, Hydraulics and Hydrology, etc.).

f. Corps budgets submitted to OMB must contain sufficient funds for Coastal Field Data Collection so this program has the fiscal resources necessary to achieve its goals.

g. The Chief of Engineers pronounce 1990-2000 as "The Decade of the Coast" at some appropriate forum (22nd International Coastal Engineering Conference in August 1988 in Madrid) to demonstrate Corps leadership, commitment and acceptance of responsibility in the only mission area where the Corps stands alone for advancing both state of the art and engineering practice.

10. I thank you for the opportunity to serve as President of the CERB. It has been an exciting three years, the Board is motivated to make a difference and the new members should provide an added dimension. I believe I leave this assignment at a time when CERB and CERC are in a dynamic and healthy posture, ready to meet the challenges ahead and to contribute their share in providing "Leadership in Customer Care."

Ernie

C. E. Edgar III
Brigadier General, USA
Former President, CERB

END

DTIC

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