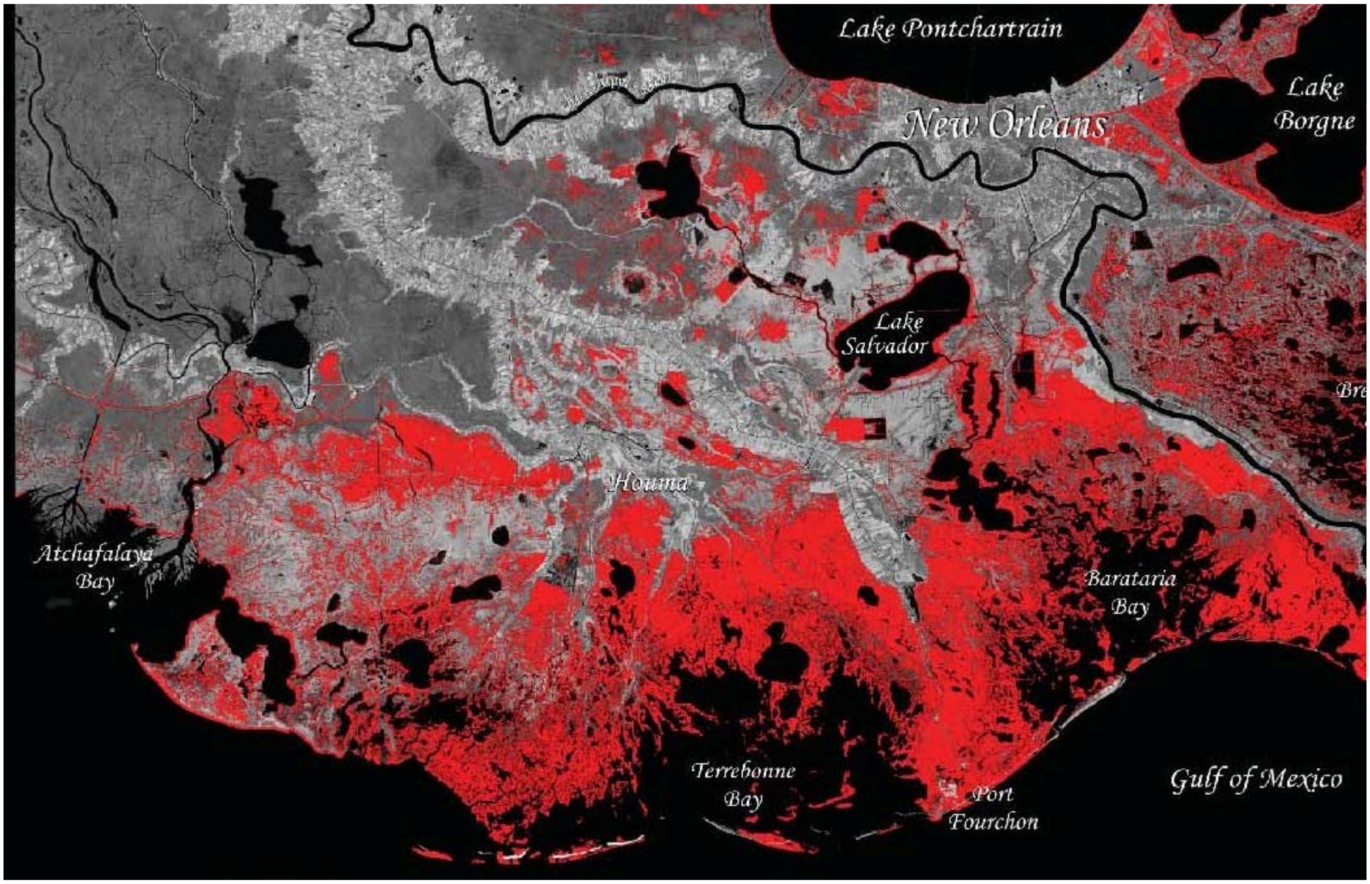
APPENDIX H

VALUE ENGINEERING REPORT

Value Engineering Study Report



Terrebonne Basin Barrier Shoreline Restoration
Multipurpose Operation of Houma Navigation Lock
Convey Atchafalaya River Water to Northern Terrebonne Marshes

CEMVN-VE-09-04

June 2009

Prepared by

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Date: July 8, 2009

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Subject: Value Engineering Study Report – Final
Terrebonne Basin Barrier Shoreline Restoration
Multipurpose Operation of Houma Navigation Lock
Convey Atchafalaya River Water to Northern Terrebonne Marshes

Mr. Vicidomina:

Value Management Strategies, Inc. is pleased to transmit 15 paper copies and 25 copies on CD of the Final Value Engineering Study Report.

This report summarizes the results and events of the study conducted May 5 – 8, 2009, in New Orleans, Louisiana.

We enjoyed working with you and are looking forward to continuing our efforts to assist the New Orleans District U.S. Army Corps of Engineers in its value engineering efforts.

Sincerely,

VALUE MANAGEMENT STRATEGIES, INC.

Mark Watson, PE, CVS
VE Study Team Leader

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E. Louisiana Sand Management Working Group Meeting Minutes, 2 February 2005

F. Information on Relative Sea-Level Rise as prepared by Kevin Knuuti, P.E., Chief, Engineering Division, U.S. Army Corps of Engineers, Sacramento, CA

G. Multi-Pit Breakwaters, *Journal of Waterway, Port, Coastal, and Ocean Engineering*, William G. McDougal, A. Neil Williams, and Keizo Furukawa, January/February 1996

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EXECUTIVE SUMMARY

INTRODUCTION

This Value Engineering (VE) Study Report summarizes the events of the VE workshop conducted May 5 – 8, 2009 for the U.S. Army Corps of Engineers (USACE), New Orleans District, by Value Management Strategies, Inc. The subject of the study was the Terrebonne Basin Barrier Shoreline Restoration project, the Houma Navigation Gate Operations Plan, and the Convey Atchafalaya River Water to Northern Terrebonne Marshes project.

This study was conducted at the Feasibility Scoping Report/Preliminary Draft EIS, an early stage of project development, and as such is the beginning of plan formulation.

VE STUDY RESULTS

The VE team developed 38 alternative concepts which are intended to assist the USACE in better formulating plans to carry forward into the next phase of development.

These recommendations are categorized per subject project as well as those that pertain to general plan formulation.

Major findings of the workshop are summarized as follows:

Terrebonne Basin Barrier Shoreline Restoration

The natural processes of subsidence and erosion have combined with human-caused effects leading to significant shoreline retreat and land loss along the Terrebonne Basin barrier island chain. As such, the system is in a continuous need of sediment. The current project plans and budget only allow for a single renourishment after about five years, which means the sustainability of the project is in doubt. Furthermore, the availability of suitable sediment from Ship Shoal to restore and maintain the barrier islands may be limited. Finally, the barrier island chain forms a complex system of ecological, physical, chemical, and social processes, which interact in a highly involved and, at times, dynamic fashion.

Key VE alternatives identified to address these issues are as follows:

- Sustain Barrier Island System
  - Obtain a clear definition of the project objectives regarding sustainability
  - Establish permanent trust fund for renourishment costs
- Provide Sediment for Renourishment
  - Use Minerals Management Service (MMS) to regulate Ship Shoal quantities to various projects needing sediment
  - Construct a permanent pipeline from Ship Shoal to the east end of East Timbalier Island

- Utilize Dynamic Coastal Systems
- Utilize sand recycling/backpassing for barrier island nourishment
- Consider coastal geomorphic processes for sediment placement
- Construct new barrier island chain closer to new shoreline

♦ Protect Sediment

- Install inverted breakwaters and use excavated material to construct/replenish back marsh
- Fix barrier islands in their current location, eliminating or minimizing island roll over, by incorporating a "hard" core or allow surface armoring

Multipurpose Operation of Houma Navigation Lock

The Houma Navigation Canal (HNC) lock and floodgate were planned over a decade ago. The possible addition of a year-round significant freshwater flow into the HNC from the proposed Atchafalaya River Diversion Project would significantly affect the operation of the lock and floodgate and perhaps even warrant reconsideration of the facility design. The lock and gate complex will have to balance the impacts to navigation with the necessity of protecting the interior from tidal surge and salinity. Finally, the potential future global sea level (GSL) rise impacts what type of facility should be constructed.

Key VE Alternatives identified to address these issues are as follows:

♦ Optimize holistic system by balancing HNC flow rate capacity with gate and lock design and operation plan

♦ Develop a set of guidelines for when gate will be shut and install monitors and controls to automatically close gate

♦ Configure proposed 250-foot floodgate such that an additional gate could be added in the future in order to upgrade to a lock to accommodate a possible higher than expected future sea level

Convey Atchafalaya River Water to Northern Terrebonne Marshes

Issues with this project are that freshwater and sediment has poor delivery to the wetlands due to 1) alterations in natural hydrologic flow (canals, etc.), 2) constrictions in the Gulf Intracoastal Waterway (GIWW) that reduce freshwater flow to the subunit, and 3) freshwater delivered to the HNC bypasses adjacent wetlands and delivers to the Gulf of Mexico. The project is also having to identify where the freshwater needed should be derived from and how it should be delivered to the areas that need it.

Finally, seasonal differences in the need for freshwater and nutrients, and the locations from which freshwater can be recruited and distributed, may have conflicting parameters (i.e., freshwater is particularly needed during periods of low flow in the rivers).

Key VE alternatives identified to address these issues are as follows:

- GIWW Constriction at Houma
  - Louisiana Department of Transportation and Development (LADOTD) to build a high-rise bridge and take the tunnel out of service
  - Install a channel section through the Twin Span bridge
- Address Freshwater Quantity Limitations
  - Alter Old River Control Structure to divert more than 70/30 allocation
  - Develop a seasonal freshwater management plan
  - Install wicker gates on HNC cuts into the marsh
- Address Freshwater Source and Transport
  - Use Bayou Lafourche to convey freshwater to the northern Terrebonne marshes

General/Plan Formulation

- Develop Plan Strategies that account for much higher levels of GSL rise

  One issue addressed by the VE team spans all three projects and has ramifications throughout the Louisiana Coastal Area (LCA) program. All three projects are currently assuming a minimum amount of relative sea level rise (combination of sea level rise and subsidence). Currently, work is underway by the USACE, National Oceanic and Atmospheric Administration (NOAA), and United States Geological Survey (USGS) to investigate the glacial melt contribution to future GSL rise. Project benefits depend upon habitats maintained above sea level. Consequently, benefits beyond the 50-year planning horizon will be lost if subsidence and GSL rise exceed the current assumptions. The rate of GSL rise in the future is currently unknown, but could be much greater than the current assumptions. As such, the projects should develop specific Plan Strategies that consider the range of possible future GSL rates.

SUMMARY OF VE ALTERNATIVE CONCEPTS

The table that follows summarizes all of the alternative concepts developed by the VE team. The items in **red** text were identified by the VE team as items of particular note and key recommended strategies for the Project Development Team (PDT) to consider.

SUMMARY OF VE ALTERNATIVE CONCEPTS

Terrebonne Basin Barrier Shoreline Restoration, Multipurpose Operation of Houma Navigation Lock, Convey Atchafalaya River Water to Northern Terrebonne Marshes

Number	Description
Terrebonne Basin Barrier Shoreline Restoration	
T-1	**Install inverted breakwaters and use excavated material to construct/replenish back marsh**
T-2	**Obtain a clear definition of the project objectives regarding sustainability**
T-3	**Establish permanent trust fund for renourishment costs**
T-4	**Construct a permanent pipeline from Ship Shoal to the east end of East Timbalier Island**
T-5	Conduct offshore sediment analysis to identify alternative sources of barrier island renourishment sediment
T-6	Consider wind-powered fixed dredged sediment supply
T-7	**Use MMS to regulate Ship Shoal quantities to various projects needing sediment**
T-8	**Consider coastal geomorphic processes for sediment placement**
T-9	**Utilize sand recycling/backpassing for barrier island nourishment**
T-10	**Fix barrier islands in their current location, eliminating/minimizing island rollover, by incorporating a "hard" core (e.g., buried sand-filled Geotubes, revetments) or allow surface armoring (e.g., revetments, rock, concrete)**
T-11	Construct groins and/or breakwaters with prefilled sediment
T-12	**Construct new barrier island chain closer to new shoreline**
T-13	Establish an environmental dredging fleet
T-14	Prioritize project components based on marsh loss factors
T-15	Add Plan Strategy that addresses habitat needs in excess of budgetary limitations
T-16	Implement oil/gas industry outreach program regarding future sediment management
T-17	Change the term "non-structural" in project documents to "soft structural"
Houma Navigation Gate Operations Plan	
H-1	**Optimize holistic system by balancing HNC flow rate capacity with gate and lock design and operation plan**
H-2	**Develop a set of guidelines for when gate will be shut and install monitors and controls to automatically close gate**
H-3	**Install flow control on HNC cuts into the marsh**
H-4	**Configure proposed 250-foot floodgate such that an additional gate could be added in the future in order to upgrade to a lock**

Number	Description
H-5	Extend utilization of temporary barge gate and defer construction of new sector gate
H-6	Consider using a floatable barge gate in lieu of a sector gate
H-7	Construct concrete sector gates or utilize other maintenance-favorable materials
Convey Atchafalaya River Water to Northern Terrebonne Marshes	
A-1	**Address flow constrictions in the GIWW at Houma**
A-2	**Operate the Old River Control Structure to optimize flow split outside of the 70/30 mandate in non-flood conditions**
A-3	**Use City of Houma wastewater effluent to replenish cypress forests**
A-4	Pump flow from Davis Pond Diversion from Company Canal
A-5	**Use Bayou Lafourche to convey freshwater to the northern Terrebonne marshes**
A-7	Ensure that local fishing interests are fully informed of project alternative impacts
A-6	Construct mini-Woody's Ditch east of Houma and west of Bayou Lafourche connecting the Mississippi River to Lake Fields
A-8	Require oil companies to plug canals connecting to GIWW
A-9	Install nutria fencing along GIWW and birth control measures throughout project area
General/Plan Formulation	
G-1	**Develop Plan Strategies that account for much higher levels of global sea level rise**
G-2	**Develop a seasonal freshwater management plan**
G-3	Create federal advisory committee
G-4	Identify and incorporate the effects of subsidence from fluid withdrawal in the project analysis and design; utilize water injection to minimize the impacts of fluid withdrawal-induced subsidence
G-5	Consider alternate procurement methods for construction

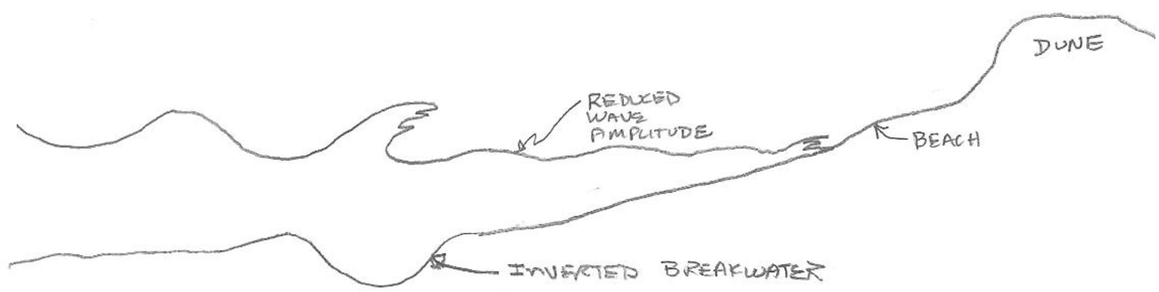
VE ALTERNATIVE CONCEPTS

TERREBONNE BASIN BARRIER SHORELINE RESTORATION

T-1 Install inverted breakwaters and use excavated material to construct/replenish back marsh

This project faces a severe shortage of suitable material for island/dune construction as well as the back marsh. A potential good source of back marsh material may exist just offshore of the barrier islands on the Gulf side. This material can easily be dredged and placed on the land side of the island as the base for the back marsh. With this excavation comes another advantage, the construction of an inverted breakwater on the Gulf side in front of the island.

The construction of inverted breakwaters parallel to the beach is a simple concept that could prove to be very cost effective as well as physically effective for normal wave activity. They could even be constructed in tandem with offshore shoals. The concept is depicted in the sketch below.



The argument against inverted breakwaters is that the inverted breakwaters may trap some of the sand eroding from the beach, and thus negatively impact the littoral drift. However, the current littoral drift carries minimal sediment so the effect downdrift should also be minimal.

The advantage of this approach is the potential for obtaining sediment close to points of placement at a lower cost to the project. In addition, the initial wave heights will be diminished by the inverted breakwater, reducing impact energy along the shoreline and allowing more time for stabilization of plantings. Over time it is probable that movement of sediment will fill in the inverted breakwater because, at this location, there is a decrease in wave energy and the trench acts as a sediment trap. But this could be seen as a benefit as these trenches would become excellent locations for material needed in future maintenance dredging to renourish and sustain the program.

A paper published in the *Journal of Waterway, Port, Coastal, and Ocean Engineering* (January/February 1996) entitled *Multi-Pit Breakwaters* by William G. McDougal, A. Neil Williams, and Keizo Furukawa assessed the benefits of a submarine depression used as a breakwater. They found that the appropriate selection of depression (pit) dimensions and placement may lead to a significant reduction in wave height behind these structures. The shadow region behind the pits can reduce the wave heights by 10% to 20% of the incident wave height. This paper provides guidance on the selection of pit (inverted breakwater) geometries and placement for optimal breakwater performance. A copy of this paper is provided in Appendix G.

These features would not be very effective in reducing significant storm surges, in the same manner that offshore rock breakwaters would not be effective either. Further modeling and/or test reaches are recommended to assess their applicability to this project.

T-2 Obtain a clear definition of the project objectives regarding sustainability

The first environmental operating principle of the USACE states that the USACE should, "Strive to achieve environmental sustainability, and recognize that an environment maintained in a healthy, diverse, and sustainable condition is necessary to support life." The sixth item listed in the "12 Actions for Change" indicates that the USACE should "focus on sustainability." It is clear from these principles and actions that sustainability is important to the USACE and, consequently, should be incorporated into USACE activities. However, the April 2009 Feasibility Scoping Meeting Report (FSMR) does not contain any mention of how sustainability will be considered in plan formulation. Moreover, there is no definition of sustainability provided in the FSMR. A clear definition of sustainability is needed in order to make sustainability a meaningful project objective.

Such an objective may be established as follows:

- Sustainable with resources within the LCA up to the Year 2100 based on a range in relative sea level rise (e.g., extrapolation of historical rates of sea level rise, accelerated rate of sea level rise per NRC-low I, and accelerated rate of sea level rise per NRC-high III) no matter what the cost.

T-3 Establish permanent trust fund for renourishment costs

GSL rise at the highest rates combined with subsidence could be a net rise of nearly 6 feet by Year 2100 and thus inundating the project area. If the LCA projects are not cancelled by Congress for these reasons, then an alternative concept requires repeated fill and restoration efforts to keep pace with both GSL rise and subsidence. This is not a sustainable condition, but demands continuous repeated beach renourishment and marsh platform fill in perpetuity. Placing fill at the rate that equals the combined faster rate of GSL rate based on this current science, and the known subsidence rates, in perpetuity will be vital for restoration success. Consequently, episodic (e.g., every five years) marsh platform fill and barrier island sand nourishment is essential for ecological restoration success. Project renourishment needs based on just the National Ecological Restoration (NER) process using cost-effective incremental cost accounting (CEICA) justification cannot provide for perpetual ecological needs.

Congress typically chooses not to undertake financial obligations requiring future funding for perpetual costs. But Congress may appropriate funds to establish a permanent trust fund and the interest accrued would provide for perpetual costs. While such costs may be included as operations and maintenance (O&M) costs provided by state, not federal, funding, then only state assets, not national assets, are accessible. However, support is growing in Congress for certain permanent trust funds, for residential housing for example, that would build on successful trust fund models by states and tribes. By far the largest is the $26 billion Alaska Permanent Fund.

A possible example for a beach renourishment permanent trust fund: A multi-variant analysis of the costs to assure dredging and placement of sand from Ship Shoal to the Terrebonne barrier islands based on the above various rates of GSL rise is performed to determine the projected range of perpetual funding needed. If, for example, an annual beach renourishment cost of $5 million is required to keep pace with the accelerated rate of GSL rise, then a permanent beach renourishment trust fund of $166 million yielding 3% annually would be needed. *(Should this trust fund yield exceed renourishment requirements, the trust fund may grow or alternatively annual net excess can be returned to the U.S. Treasury.)*

References: NOAA, Sea Levels Online. http://tidesandcurrents.noaa.gov/sltrends/sltrends.shtml

T-4 Construct a permanent pipeline from Ship Shoal to the east end of East Timbalier Island

One of the potential methods for barrier island construction and renourishment being considered by the PDT is to create "feeder beaches" that may erode into the littoral drift transferring sand to be deposited on barrier islands to the west. The primary location for such a "feeder beach" would be the east end of East Timbalier Island. Typically, this would involve periodically bringing in a dredge to Ship Shoal, laying a pipeline, and transferring sand to the "feeder beach".

If the design team determines that there is benefit to identifying a permanent location for deposition of renourishment sand at East Timbalier Island, it may be possible to lay a permanent pipeline for the dredge to hook up to. The pipeline could terminate on land, though this may create an issue with excessive accumulation of sand in a small area that might plug the pipe and prevent full deposition of the desired volume of sand. It may be preferable to terminate the sand within the littoral drift current itself rather than on dry land so that the sand begins its journey to the west immediately after it exits the pipe. A key concern would be siting the pipeline to avoid or minimize impacts to existing oil and gas facilities located between Ship Shoal and East Timbalier Island.

A further refinement of this idea would be to construct a permanent dredging plant at Ship Shoal to feed this pipeline. This dredge could be powered by "green" technologies (wind, solar) as discussed in another proposal.

T-5 Conduct offshore sediment analysis to identify alternative sources of barrier island renourishment sediment

The PDT has indicated that a major constraint in achieving the project objectives is the availability of suitable sediment to restore and maintain the barrier islands. Although Ship Shoal was identified as a sediment source with known reserves of sand, there are numerous projects in the LCA that are planning to utilize these sediment resources. In addition, Ship Shoal is between 50 and 100 miles from the barrier islands depending on the exact location within Ship Shoal and the island that is being restored with sand from this sediment source. Consequently, the cost of restoring the islands could be reduced significantly if alternative sediment sources closer to the islands were utilized for restoration activities. These sources may consist of sand layers located beneath the top sections of near-shore bottoms.

It is suggested that an offshore sediment source investigation be conducted to identify alternative sources of barrier island restoration and nourishment sediment. The investigation would focus on the area in the immediate vicinity of the islands and on the side towards the Gulf of Mexico. It might be possible to tap into the oil/gas industry for geological information (e.g., seismic recordings, geological logs, and sediment borings) to assist in conducting this investigation, thereby reducing the costs of the investigation. In addition, this recommendation could be used to suggest funding for the MMS to conduct this investigation for the purpose of mapping the sediment resources in the area since MMS is the federal agency responsible for managing these offshore resources.

T-6 Consider wind-powered fixed dredged sediment supply

Dredging from Ship Shoal to the Terrebonne Islands will be by periodic use of hopper dredges mobilized and demobilized every five to ten years.

This alternative concept involves the permanent placement of a cutter head pipeline dredge at Ship Shoal with the pipeline terminus on East Terrebonne Island. Sand deposited here sub-tidally is expected to accrete to the barrier islands by long shore displacement.

Two booster pumps (either kinetic or positive displacement) are needed to supplement the dredge pump due to the distance the sand slurry can be pumped without pipe sedimentation. Two booster pumps would be installed to form a series spaced equidistant from the dredge site to the disposal site. A displacement booster pump used in combination with a centrifugal dredge pump would require a booster pump holding facility because it is difficult to match positive displacement pumping rates to centrifugal pumping rates.

Offshore Louisiana has potential for wind energy development according to two reports prepared for the Department of Energy in 1979. Offshore areas west of the Mississippi River offer a high Class 3/low Class 4 wind energy resource. (Class 7 being maximum and Class 3 is the threshold for feasible wind power development.) In 2005, the Louisiana legislature approved authority for the State Mineral Board to lease state lands and water bottoms (i.e., areas within three miles of shore) for the production of wind energy.

To power these slurry pumps, three 1.5 MW capacity wind turbines and towers would be installed: one at the Ship Shoal cutter head and two others to power the booster pumps. Wind power supply is interruptible. Cut in wind speed, when power is produced, begins at 3.5 m/s (8.4 mph). Because the wind-powered electric pumps would shut down when the wind is below the cut in speed, a flap valve at each booster station would be installed to drain the slurry to prevent sediment build up in the pipe.

The installed price for each 1.5 MW wind turbine and tower is estimated at $17.5 million according to the Danish Wind Industry Association. General Electric produced over 10,000 1.5 MW capacity wind turbines successfully operating since 1996 and are manufactured at GE's Pensacola, Florida plant.

References:

Coastal Zone Wind Energy, Part II: Frequency Distribution of Winds by Direction for East and Gulf Coast Stations, Final Report, DOE/ET/20274-77/78/79-8, prepared by Michael Garstang and others, University of Virginia, Charlottesville, VA, under contract for U.S. Department of Energy; May 1979.

Design Study and Economic Assessment of Multi-Unit Offshore Wind Energy Conversion Systems Application, Vol. 1: Executive Summary, WASH-2330-78/4 (Vol. 1), prepared by Westinghouse Electric Corporation, Advanced Systems Technology, East Pittsburgh, PA, under contract for U.S. Department of Energy; June 14, 1979.

Danish Wind Industry Association, http://www.windpower.org/en/tour/econ/econ.htm

General Electric's 1.5 MW Wind Series: 1.5xte and 1.5ste,
http://www.gepower.com/prod_serv/products/wind_turbines/en/15mw/index.htm

Louisiana HB 428 (Act 481), July 12, 2005.

Note: The peak capacity of 4.5 MW for these three wind turbines, produced when wind speeds exceed 12 m/s, compares to the 10,400 horsepower main engine – equivalent to 8 MW of power – on the hopper dredge WHEELER operated by the USACE. These wind turbines, with 82.5-meter rotor length, can produce $400,000 annually in electric power revenue -- based on 8 cents per kWh and 30% operating efficiency. At some additional cost, these wind turbines could be installed to provide electric power revenue to the project when the power produced is not needed for dredging operations.

***T-7* Use MMS to regulate Ship Shoal quantities to various projects needing sediment**

The proposed concept is to use the MMS to regulate the use of Ship Shoal sediments for use by various projects, in particular coastal barrier island restoration. Included in the idea is the thought to have MMS evaluate the actual quantities of available sediment at Ship Shoal and determine appropriate locations for its use.

BACKGROUND: Following a request by the USACE to be a Cooperating Agency in the LCA Barataria Basin Barrier Shoreline Restoration, the MMS has been working with the USACE and other federal and state natural resource agencies regarding the use of Ship Shoal and other sand bodies under their jurisdiction for use as sand sources for coastal restoration projects. Working as a Cooperating Agency for the LCA Barataria Basin Barrier Shoreline Restoration, the MMS determined the need for intensive coordination and management of offshore sand resources for use in coastal Louisiana restoration projects. In May 2003, Mr. Barry Drucker with the MMS established the Louisiana Sand Management Working Group (LA-SMWG) with the intent and purpose of bringing together various federal and state natural resource agencies, as well as potential sand resource users (see Appendix E). S. Jeffress Williams, U.S. Geological Survey (Coastal and Marine Geology Program, 384 Woods Hole Rd., Woods Hole, MA 02543, email: jwilliams@usgs.gov) provided a compelling summary of the problems and opportunities at the meeting:

1. Need for long-term sand requirements: Use of offshore sand for nourishment and coastal restoration in Louisiana, as well as many other regions, has longer term implications than just 20 to 30 years. The USACE projects are typically authorized for 50 years. For several projects suitable and economical sand resources have not been identified for 50 years of initial fill and periodic O&M fills. In my judgment, we need longer term planning for compiling sand needs. At minimum 50 years, 100 years is best.

2. Need for sediment database/Seafloor maps: For Louisiana in particular, a great deal of data and information is available from very disparate sources on sand body location, sand quality, and quantity. What is needed is a comprehensive computer-based sediment database. The usSEABEDsystem is one start in this direction, but it needs further development to incorporate subbottom data, i.e., cores, borings, and seismics. Also, at least for premier sand bodies like Ship Shoal, Tiger Shoal, etc., we need complete map coverage of the seafloor using digital mosaic side-scan and multi-beam technologies that have recently become available. Such base maps are critical for not only accurately delineating the sand bodies, but also important for mapping essential fish habitats and infrastructure to avoid, such as pipelines.

3. Permit streamlining: Plans for large scale barrier nourishment are well advanced in Louisiana, potentially requiring ~100 CY meters of sand. An efficient permitting process by the USACE and MMS needs to be in place.

4. Science studies/monitoring: Important questions arise on sediment transport processes associated with dredging and nourishment, such as: What is the traditional engineering "close-out depth" for a

particular coast and how close to shore can you dredge without exacerbating erosion of the adjacent coast? What is the importance of ebb-tide shoal sediments for the Louisiana sediment budget and can they be mined without causing downdrift erosion? What is the optimum spatial and temporal design for dredging so as to minimize environmental harm? How long do dredge holes remain open? What is their short and long-term effects on marine habitats, wave refraction, etc.?

In May 2003, the MMS provided in the Federal Register a notice to prepare a multi-project environmental assessment to evaluate the potential environmental impacts associated with the removal of sand resources from Ship Shoal (see Appendix D). Meetings were conducted over the ensuing years with MMS funding scientific efforts to investigate the potential impacts associated with removal of sand resources from Ship Shoal.

IMPLICATIONS FOR CREATIVE IDEA: The MMS is the regulatory agency with jurisdiction to manage the Ship Shoal and other offshore federal sand bodies. They have been conducting investigations over the past several years. There have been several studies funded by the MMS that have determined the extent of sand and other mineral resources on Ship Shoal. The MMS has funded and will likely continue to fund studies regarding potential impacts of removing these sand resources from Ship Shoal on aquatic organisms, as well as on wave dynamics. However as described in the attached minutes of the May 2003 meeting, the MMS does have authority to make decisions on suitability or priority of sand use; however, the MMS would prefer consensus on these decisions. Hence the creation of the LA-SMWG.

Most recently (see email below), Ms. Stacie Merritt of the MMS notified intent to conduct a meeting for the LA-SMWG this Summer in New Orleans, Louisiana. The intent of the meeting is to discuss issues associated with accessing federal sand and gravel resources for projects along the Louisiana coast.

-----Original Message-----
From: Merritt, Stacie [mailto:Stacie.Merritt@mms.gov]
Sent: Thursday, May 07, 2009 4:36 PM
Subject: Louisiana Sand Management Working Group Meeting - Summer 2009

The Minerals Management Service, Marine Minerals Program is planning a meeting for the Louisiana Sand Management Working Group this Summer in New Orleans, Louisiana. The intent of the meeting is to discuss issues associated with accessing Federal sand and gravel resources for projects along the Louisiana coast. Below is a draft list of meeting topics:

1. *A Marine Minerals Program Case Study: Pelican Island*
2. *Gulf of Mexico Significant OCS Sediment Resources NTL (http://www.gomr.mms.gov/homepg/regulate/regs/ntls/2009NTLs/09-g04.pdf)*
3. *Need for OCS Mineral Resources*
4. *Geological and Geophysical (G&G) Authorization Requirements*
5. *Methodology and Potential for Submerged Cultural Resources in Borrow Pit Areas*

We invite you to comment on the above list of topics and to suggest additional topics you would like covered at the meeting. Comments/suggestions should be sent to Stacie Merritt at stacie.merritt@mms.gov by June 5, 2009.

We would also like you to provide input on the dates for the meeting. We are currently considering holding the meeting during the August 3 – August

28, 2009 time period. Please go to the following link to enter your dates of availability. Make sure you scroll to the right to see all of the days.

http://www.doodle.com/6rkmyvkiswfugkm6

If none of these days will work for you, please provide other dates for consideration. Dates of availability and proposed alternative meeting dates are due by June 5, 2009.

Once we have an idea of how many people are interested in attending and how extensive is the list of topics, we will be able to determine the specifics on when it will be held and where.

If you know of anyone who should be added to this mailing list (or deleted), please send their contact information to Stacie Merritt (stacie.merritt@mms.gov); their name will be added to future mail outs.

We look forward to your participation in this meeting.

Thanks,
Stacie

Stacie M. Merritt
Marine Minerals Program Coordinator
Minerals Management Service
Coastal Program Section
504-736-3276

VE Alternative follow-up:

In June 2007, MMS sent a letter to all stakeholders (Federal, State, and other) requesting information on potential projects using outer continental shelf (OCS) sand and gravel resources in the next five years. Based upon MMS resources and stakeholders' responses regarding project timelines, a maximum of two projects per quarter were scheduled.

Most recently, MSS sent another request in April 2009 to update the calendar; responses were due June 1, 2009. Their intent is to publish the responses in the Federal Register in the third quarter of 2009. It is anticipated that MMS will continue to schedule a maximum of two projects per quarter.

An email from Stephanie M. Gambino with MMS is provided in the appendices of this report. The email provides information regarding MMS' management of OCS deposits, as well as material resource evaluations and studies specific to Ship Shoal.

T-8 Consider coastal geomorphic processes for sediment placement

The configuration and manner in which sediment will be placed on the barrier islands was not presented in the April 2009 FSMR. It appears that the PDT is leaning towards placement of most sediment (sand on the Gulf side and mud on the bay side) on the downcoast side of the islands, which is the western end of each island. This preliminary decision is apparently based on the fact that the longshore transport moves sediment from east to west. Likewise, from a cross-shore standpoint it does not appear that much consideration has been given yet to how the sediment would be placed from the beach across the dune and into the back-bay marsh.

It might be possible to increase the longevity of the placed sediment by considering the coastal geomorphic processes in developing and/or refining the configuration and manner of sediment placement.

Instead of placing sand in equal amounts along the entire length of the island or in larger volumes at the western end of each island, the PDT should consider constructing the east end of each island wider than the west end. Utilizing this configuration for the beach restoration and nourishment activities would allow the eastern beach area to serve as a feeder beach providing a sediment source to nourish downcoast (western) beaches as the longshore transport moves the sand from east to west. Prior to implementation, a coastal processes analysis should be conducted to determine the maximum beach width in each area to avoid overbuilding the beach in the eastern portions of each island. An overbuilt beach could push the sand into deeper waters and/or result in overly steep beach slopes, both of which could increase the rate of erosion.

Another consideration in the placement of sediment for island restoration is the aspect ratio of each barrier island. The aspect ratio is the length of each island divided by the width and it can be calculated as a mean or at regular intervals (e.g., every quarter mile) along the entire length of each island. There has been some research conducted to estimate the optimum aspect ratio for the barrier islands and this information should be considered in the development of sediment placement configurations (volumes and locations).

T-9 Utilize sand recycling/backpassing for barrier island nourishment

Beach restoration and beach nourishment are presented in the April 2009 FSMR as two management measures that will be carried forward for future consideration in the formulation of project alternatives. Beach restoration is defined in the FSMR as the (initial) placement of beach-suitable sediment (sand) within the beach profile from the dune out to the depth of closure, while beach nourishment is defined as the periodic placement of sand in the same location. Beach restoration basically restores the shoreline and beach to historical conditions, while beach nourishment keeps pace with future erosion to maintain the restored condition. Ongoing beach nourishment activities will require the identification and dredging of additional sources of sand in the future. Based on existing information and data, sand is already limited in availability and there is a lot of demand for that sand for this project as well as other projects in the LCA. Therefore, the retention and efficient use of existing and future sand resources will be an important factor in cost-effectively meeting project objectives.

One way to make more efficient use of existing and future sand resources is to utilize sand recycling/backpassing to replace and/or augment beach nourishment activities. In the Terrabonne Barrier Islands, the net longshore transport is from east to west, meaning that sand is driven by the waves from east to west. Sand recycling would consist of dredging sand at the western end of the barrier islands and placing it on the eastern end. This would help reduce the quantity of new sand needed for future nourishment activities. The effectiveness of sand recycling can be improved through the construction of terminal groins or breakwaters at the downcoast end of the barrier islands to capture as much sand as possible before it is lost to the bay area and/or Gulf of Mexico. Prior to implementation, coastal processes analyses should be conducted to make sure that sand from an upcoast island (i.e., to the east) is not providing a substantial source of sand to a downcoast island, otherwise the sand recycling program might result in increased erosion to the downcoast barrier island. Sand recycling has been used with success along Peninsula Beach, which is located in Long Beach, California.

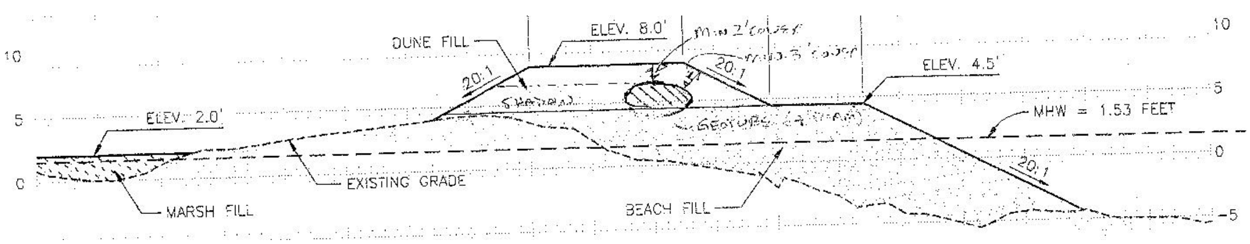
T-10 Fix barrier islands in their current location, eliminating/minimizing island rollover, by incorporating a "hard" core (e.g., buried sand-filled Geotubes, revetments) or allow surface armoring (e.g., revetments, rock, concrete)

The natural geomorphic development of barrier islands is to allow them to rollover where the dune field progresses landward overriding the back marsh as the beach face erodes. This is currently the preferred design as presented by the USACE PDT. In order for this approach to be successful, periodic renourishment (typically every five years) is required over the 50-year life of the project to maintain both the barrier island and the back marsh. However, the current project plan and budget only allows for a single renourishment after about five years, which means the sustainability of the project is in doubt.

An alternative approach is to fix the islands in place and minimize the amount of renourishment required. This is not a "natural" geomorphic process for barrier islands as it limits rollover and migration of the barrier island landward. However, there are agencies in the state, as well as members of the general public, who would prefer this approach as a more positive means of providing storm surge and salinity intrusion protection. Fixing the location of the islands with a corresponding reduction of renourishment needs may improve sustainability within the available budget for the project. It would also reduce the amount of material needed, which is a considerable general project concern.

One alternative installs a buried "hardscape" that draws a "line-in-the-sand" on the shoreline. The sand-filled Geotube (using sand already earmarked for beach and dune restoration) would resist erosion of sand along with storm surge-related breaches in a more cost-effective manner than, say, offshore breakwaters. In most cases these Geotubes can replace the offshore breakwaters, or be used in tandem with the breakwaters (such as inverted breakwaters proposed above) in critical areas.

Since the Geotubes are not exposed most of the time, they will not experience deterioration from sunlight or vandalism. If damage to the Geotubes occurs from storm surge activity, they can be replaced or repaired. Erosion of the sand in front of the Geotubes and on top will likely occur over time requiring renourishment of the dunes approximately every ten years. A sketch of this concept is shown below:



In lieu of Geotubes, other hardened materials such as revetments or rock can be buried in the core to increase the "hardness" of the island. Further, surface hardening can be considered through the use of surface revetments, concrete, or rock; however, this approach may not be preferred over the "hardened" core concept as it would take away from the sand beach surface that may be preferred nesting areas for birds. In addition, surface hardening would be considered to be less aesthetic than exposed sand surfaces, and would be less capable of supporting stabilizing vegetation.

T-11 Construct groins and/or breakwaters with prefilled sediment

The use of groins and breakwaters to trap sand on the barrier islands were identified as potential management measures to be carried forward through the plan formulation phase. Based on the information presented in the April 2009 FSMR, it appears that groins and breakwaters would be implemented without the use of prefill. The implementation of groins and breakwaters without prefill can lead to erosion of adjacent shorelines and beaches as indicated in the FSMR. This erosion is caused by the trapping (or retention) of sand in the fillet of the groins, as well as the salient (or tombolo if the salient touches the shoreline) of the breakwaters.

The addition of prefill should be considered to address the potential impact of erosion attributed to the implementation of groins and breakwaters. For groins, the use of prefill would entail estimating the volume of sand that would be trapped in the fillet and then placing this volume of sand in the fillet as part of the initial groin construction project. In the case of the breakwaters, the use of prefill would consist of estimating the volume of sand that would be trapped in the salient and then placing that volume of sand in the salient as part of the initial breakwater construction project. The use of prefill mitigates for impacts to adjacent beaches while the retention structure (i.e., groin or breakwater) provides a wider, more stable beach. Prior to implementation of prefill for a breakwater, a coastal processes analysis should be conducted to assess the potential impact of the salient itself on longshore transport.

T-12 Construct new barrier island chain closer to new shoreline

There is high probability that maintaining the existing barrier islands beyond the 50-year planning horizon will not be possible due primarily to increasing rates of sea level rise, future subsidence, and resources constraints (e.g., sediment supply and funding). Given the value of the habitat on the islands, as well as the important role these islands play in protecting bayside resources, it still makes sense to expend resources in restoring and maintaining the islands from now and into the immediate future (e.g., 50 years). However, it also makes sense to begin thinking now about the long-term sustainability of the entire ecosystem in the LCA.

It is suggested that consideration be given to the design and construction of a new barrier island chain. This would include the identification of a new “fallback” shoreline that would be used to guide the location of the new barrier island chain. This new shoreline and barrier island chain would form the second line of defense, with the first line of defense being the restoration and protection of the existing barrier islands. The new barrier island chain could be constructed in areas of the existing LCA that are relatively high in elevation and free of oil and gas wells and pipelines to minimize construction costs associated with fill placement and construction access. In addition, this strategy could be implemented through an adaptive management framework such that lessons learned from restoration and maintenance of the existing barrier islands could be used to improve the design, construction, and maintenance of the new barrier island chain.

T-13 Establish an environmental dredging fleet

The amount of sediment needed to renourish the barrier island system will far exceed the available dredge fleet in and beyond the region. While private industry will respond to this need by manufacturing additional dredges as projects progress, it is likely that such plant development will severely lag project demand. Private industry will not likely produce more than is needed at any given period, as they will perceive a risk of over supplying intermediate need. Such projected constant shortages will likely limit bid completion and raise prices substantially.

A possible means of avoiding this problem may be government partnerships with private industry to fabricate new dredges in advance of individual project need. For example, the government could build the needed fleet and lease the equipment to industry; the government could finance industry to build their fleet; or industry could build the fleet on their own and lease equipment to the government. There are a number of "lease/purchase" and other innovative procurement options that balance risk and optimize financial advantages between the government and industry. In general, the government can secure capital at relatively low cost and industry can take tax advantages of ownership via depreciation deduction. Such advance fabrication of dredges could help in achieving adequate resource supply to meet projected demand.

T-14 Prioritize project components based on marsh loss factors

The PDT indicated that some type of system would be needed to prioritize restoration activities. However, it does not appear that such a system was developed or applied during preparation of the information contained in the FSMR. The PDT was asked if an estimate had been developed that represents the percentage of marsh loss due to the various causes of erosion. For example, how much of every 100 acres of marsh loss is attributed to sea level rise, fluid withdrawal-induced subsidence, sediment compaction-induced subsidence, wind-wave erosion, storm-induced erosion, vegetation loss attributed to salinity changes, and herbivore activity. Note that a cursory review of the figure in Attachment F of the April 2009 FSMR suggests a relationship between oil and gas extraction (as represented by oil and gas wells) and marsh loss (as represented by open water areas). It is important to develop an estimate of the importance of these various loss factors because a primary stated objective of the barrier island restoration is to protect and preserve the marsh to the north of the islands. If sea level rise and fluid-induced subsidence are of equal or greater importance than wind-wave erosion and storm-induced erosion, then restoration of the barrier islands may not achieve this objective.

One way to address this issue would be to conduct an analysis to determine the amount of marsh loss attributed to sea level rise, fluid withdrawal-induced subsidence, sediment compaction-induced subsidence, wind-wave erosion, storm-induced erosion, vegetation loss attributed to salinity changes, and herbivore activity. The results of this analysis could then be used to prioritize project components, thereby giving the PDT a planning tool for the prioritization task that they will have to undertake. The results might also suggest that it is not possible to meet some of the project objectives or that the objectives themselves need to be prioritized in order to select the appropriate restoration activities. Concern about the possible findings of this analysis should not be used as a reason not to conduct it since the results will merely inform the decision making process. For example, even if the results indicate that sea level and/or subsidence are primary contributors to marsh loss, it does not mean that barrier island restoration should not be implemented, rather, it means that barrier island restoration would probably not be effective in meeting the project objective related to marsh protection from wind-wave erosion and storm-induced erosion.

T-15 Add Plan Strategy that addresses habitat needs in excess of budgetary limitations

The Plan Strategies identified for the project are intended to produce a full spectrum of alternative plans as required by National Environmental Policy Act (NEPA) and USACE planning guidance in ER 1105-2-100. Alternative Plan Strategies were designed to be significantly different from one another and to represent the entire range of solutions to identified problems within the study area. This VE alternative concept is intended as a check to the PDT that Plan Strategy E, increase of current configuration and functional geomorphology, be the Plan Strategy that addresses habitat needs above and beyond the budgetary limitations set by the project authorization. During the NEPA alternative evaluation process, this consideration is needed regardless if the funds will be available to ever make the alternative feasible. If Plan Strategy E is not intended to satisfy this part of the alternative evaluation, suggest developing an additional Plan Strategy that does address the "best case" scenario regarding habitat creation and sustainment.

T-16 Implement oil/gas industry outreach program regarding future sediment management

The PDT indicated that the oil/gas industry (industry) might redistribute sediment placed on the islands following restoration activities. The industry has a longstanding practice of redistributing sediment to protect oil/gas infrastructure. For example, the industry redistributes sediment via dredging to bury pipelines that have become exposed following storm and hurricane activity. Consequently, the PDT expressed concern that the industry would utilize the newly placed sediment for this purpose upon completion of restoration activities, thereby decreasing the effectiveness of restoration activities and undermining project success.

An outreach program could be implemented to proactively address this issue. The outreach program would explain the various restoration components to the industry. It would include a description of the natural sediment processes and how those processes would benefit the natural habitat and resources, as well as how those processes would benefit the industry. A description of acceptable sediment management practices would be included in the outreach program to minimize negative practices and maximize positive practices since it might be possible to work with the industry to help maintain and/or improve the islands upon completion of restoration activities. Finally, the outreach program would have to be developed in careful consideration of the target group that is to receive the information to make sure the right people in the industry are getting the message and that it is tailored to those people. This will help ensure that the right message is getting to the right people.

T-17 Change the term "non-structural" in project documents to "soft structural"

The project documents use the following definition of terms: *"A management measure is a feature (a structural element that requires construction or assembly on-site) or an activity (a non-structural action) that can be combined with other management measures to form alternative plans."* The term "non-structural" is commonly used in USACE flood control and hurricane protection projects. It has a very specific meaning that includes options such as floodproofing property, raising buildings above flood elevations, purchasing property and/or relocating or removing the property from the area of risk, and prohibition of further development in areas of risk. However, for this project, the term is to refer to restoration activities that include:

- Dune restoration
- Marsh creation
- Beach restoration
- Beach nourishment
- Subtidal sediment placement
- Addition of sediment into near-shore environment to supplement littoral drift
- Beach closure
- Small marsh island construction on bayside for bird habitat
- Vegetative planting
- Herbivory control

- Biological bio-engineered oyster reefs
- Spit creation
- Canal backfilling

In order to avoid confusion with a generally accepted definition, the VE team recommends that the term “non-structural”, as used in the project documents, be changed to “soft structural”.

MULTIPURPOSE OPERATION OF HOUMA NAVIGATION LOCK

H-1 Optimize holistic system by balancing HNC flow rate capacity with gate and lock design and operation plan

The HNC lock and floodgate were planned over a decade ago. The possible addition of a year-round significant freshwater flow into the HNC from the proposed Atchafalaya River Diversion Project would significantly affect the operation of the lock and floodgate and perhaps even warrant reconsideration of the facility design.

The lock and floodgate have multiple purposes and functions (reference "*Coastal Impact Assistance Program Application – Houma Navigation Canal Lock, May 22, 2006; Terrebonne Levee Conservation District",* included as Appendix A). First and foremost is providing a barrier to tidal (hurricane) flooding as an integral part of the proposed Morganza to the Gulf levee system. The second function is to block excessive saltwater intrusion into the basin. High saltwater levels adversely affect marsh habitat and potable water supply for the City of Houma. As result of providing a barrier in the HNC, accommodations to minimize impacts to navigation are incorporated in the design of the closure facility. A 250-foot-wide (200 feet wide prior to recent change) gate will allow safe passage of oil rig components and the 110-foot lock would allow normal vessel traffic during prolonged periods of closure.

The required operating frequency and duration of the 110-foot lock may be greatly affected by the amount of water (and consistency of this supply) that the proposed Atchafalaya River Diversion Project can produce. **The very need for a lock should also be re-evaluated and balanced with the formulation of this project.**

It may be determined that adequate freshwater flow can be supplied to the HNC, negating the need for saltwater intrusion gate/lock closure. This could minimize lock operation frequency to an average of 20 days per year (usually non-continuous) due to historical flood events. The question arises as to whether or not such minimal closure time warrants the need for vessel passage during such events as there are alternate (albeit lengthy) alternative routes to the Gulf of Mexico.

On the other hand, significant freshwater flow in the HNC may be distributed out from the channel into adjacent marsh if a relatively small hydraulic head is artificially maintained by means of closing the gate and lock. This would require a lengthy (perhaps full-time, all the time) operation of the lock.

The recommendation is to budget for full-time lock operation (about $1.2 million per year) and integrate Atchafalaya River Diversion alternative selection with HNC lock operation, design, and perhaps necessity. If this is done, it may be determined that the Atchafalaya River Diversion may be efficiently maximized with a resulting minimization of lock total life cycle cost. This may indicate that the set diversion project pre-authorization amount of $221 million be exceeded to achieve overall system cost-effectiveness with a reduction in HNC Lock life cycle costs. This could be complicated given two separate funding authorizations.

It should be noted that the HNC lock and floodgate complex is part of the Morganza to the Gulf, Hurricane Protection Project. The "parent" project authorization is currently in abeyance pending approval of a Post Authorization Change (PAC) report. This report is required due to an official project cost increase in excess of 20%. The PAC is currently being developed, but its scope is limited to only "level of risk reduction" (levee and structure height) and not broader project parameters. Given the above mentioned significant existing and possible future conditions changes relative to plan formulation criteria of a decade ago, the entire design of the proposed lock and floodgate should be re-evaluated. A summary list several significant outstanding questions pertinent to the lock and gate complex is as follows:

- Would the introduction of a significantly higher flow of freshwater down HNC negate the need to provide a barrier for non-flood event saltwater intrusion?

- If higher flows are introduced down HNC, would closure result in beneficial distribution of freshwater upstream of the facility (additional purpose/reason for a lock structure)?

- If soon to be published USACE-sanctioned predictions of net sea level rise is faster and higher than previously anticipated, would it then be prudent to build a single-wide (250 foot) lock versus a wide floodgate and smaller (110-foot) lock combination?

- The local sponsor apparently has requested a permit to construct a temporary standalone barge gate as part of their levee construction plan. Can this serve for a longer period of time and defer construction of an expensive sector gate? Also, if a single gate closure is (now) apparently acceptable to the local oil and gas industry, why does the federal plan (still) require a lock and gate combination?

- Does the cost estimate reflect, and is it consistent with, ongoing construction of large sector gates for the IHNC East Closure and for the current design of the GIWW West Closure Complex?

H-2 Develop a set of guidelines for when gate will be shut and install monitors and controls to automatically close gate

The flood gate on the HNC is proposed to be closed for flood and salinity control. If the gate is closed, marine traffic will be required to use the lock, thus resulting in possible delays to navigation.

Given the importance of the gate to safe navigation on the HNC as well as to the marshlands, and that these two factors may compete against one another regarding whether the gate should be closed or not, an automatic system should be considered that would close the gate at specific, pre-determined levels of tidal surge, salinity, and canal flow. This would serve to eliminate the possibility of one function of the gate superseding the others.

H-3 Install flow control on HNC cuts into the marsh

The Central – Lake Boudreaux Area problems and opportunities include major hydrologic alterations through the presence of the GIWW and the HNC. However, one of the primary concerns within this study unit is the altered hydrology and distribution of freshwater and sediment. Freshwater and sediment that reaches the Central Study Area has poor delivery to the wetlands. If the project increases freshwater flow down the HNC and cuts are made through spoil banks, it may be prudent to also install flow control at these openings. By installing wicker-type gates or other backflow preventer, the freshwater would not quickly drain back into the HNC as flow diminishes. This alternative would allow control of freshwater returning into the HNC as flows subside in that channel. Freshwater would then be available to drain out slowly through inter-marsh pathways.

H-4 Configure proposed 250-foot floodgate such that an additional gate could be added in the future in order to upgrade to a lock

If significant sea level rise becomes a reality, HNC closure will be required throughout the year. This may negate the ability to safely pass platform structures through a single floodgate. It then may be warranted to upgrade the proposed 250-foot floodgate to a full lock with the addition of a second gate. Placement and configuration of the initial floodgate should accommodate such a possible future modification. Navigation approach reaches would be a primary factor to consider.

H-5 Extend utilization of temporary barge gate and defer construction of new sector gate

The state and local levee district has plans to construct a "temporary" 250-foot barge gate as well as a system-wide reduced height levee. The height of the gate would not provide desired 0.01 annual storm probability containment, but still be on the order of 0.02 to 0.04. The subsequent federal project will increase this protection to the 0.01 level. However, a very costly component, the 250-foot floodgate (new sector gate) could be left as a last order of construction or even be deferred for several years. The protection obtained by the temporary gate would only allow wave over-wash during peak hurricane hours and the vast storage of the protected area could easily accommodate such inflow without any significant property damage. It would therefore appear prudent to extend the service of the temporary floodgate until major maintenance is needed.

An estimated break-out cost for the 250-foot floodgate from URS Task Order 5, May 2008, is about $150 million. Estimated major maintenance cost would be about $5 million in ten years. Annual interest savings of first cost and ten-year maintenance costs at the current federal discount rate of 4-5/8% would be approximately $7 million per year of deferral**.**

H-6 Consider using a floatable barge gate in lieu of a sector gate

In the initial project planning 10+ years ago, the premise was that a 200-foot-wide sector gate was a favorable choice versus a barge-type gate given easier and faster operation. VE studies then, and since that time, have challenged this premise given the unproven performance of such a large sector gate. Major maintenance, when the gate must be removed, is a significant concern for large sector gates. The USACE has chosen a 150-foot complementary barge gate design for the east GIWW closure current under design-build construction. It is still believed that a floating barge gate may be more appropriate, both in initial cost and long term costs, for the now 250-foot HNC gate. Several conceptual floating barge gate designs are illustrated in Appendix B.

H-7 Construct concrete sector gates or utilize other maintenance-favorable materials

The standard gate material is steel protected by sacrificial anodes for corrosion resistance. The USACE conducted an extensive value analysis assessment of the use of differing materials to construct gates (sector, miter, tainter) along with techniques to reduce corrosion. This study was initiated after the recognition that typical steel gates eroded easily and were difficult and expensive to repair and maintain. The results of this study were published on August 13, 2004 in a value engineering report entitled *Improving Life Cycle Costs of Construction/Operations/Maintenance of Gate Structures.* It is worth noting that South Florida Water District is now utilizing all stainless steel gates. Presented below are some of the advantages and disadvantages of several different gate materials:

ADVANTAGES

Stainless Steel Gates:

- Stainless steel has excellent corrosion resistance.
- Stainless steel gates would not need to be painted.
- The maintenance cycle would be greatly increased.
- The duration of the maintenance event would be reduced.
- Potentially lighter gates.

Aluminum Gates:

- Aluminum has excellent corrosion resistance.
- Aluminum gates would not need to be painted.
- The maintenance cycle would be greatly increased.
- The duration of the maintenance event would be reduced.
- Potentially lighter gates.

Concrete Gates:

- Concrete does not have the same corrosion problems that steel has.
- Concrete gates would not need to be maintained as often as steel gates.
- Concrete can be designed to be impact resistant.
- Lightweight concrete can be used in conjunction with normal weight concrete to lighten the overall weight.
- Compartments can be cast to increase buoyancy.
- Left and right gates would use the same formwork.

DISADVANTAGES

Stainless Steel Gates:

- Stainless steel has the same stiffness as structural steel.
- Stainless steel is more difficult to weld than structural steel.
- Stainless steel material costs much more than structural steel (about three times the cost on a per weight basis).
- Potential corrosion issues at connection points (hinge, pintle, drive mechanism).

Aluminum Gates:

- Aluminum is only 33% as stiff as steel.

- Welded aluminum is about 66% the strength of steel.
- Aluminum is difficult to weld.
- Aluminum costs much more than structural steel (about two times the cost on a per weight basis).
- Aluminum does not have an endurance limit, making fatigue a concern.
- Potential increased corrosion of attached hardware (hinge, drive mechanism, pintle).

Concrete Gates:

- Concrete can crack; cracks would eliminate water tight properties.
- Replacement of individual members would be difficult.
- Reinforcing steel may corrode under certain conditions (epoxy coated bars should be used).
- Concrete structures are typically heavier than steel structures.
- Attachment of hardware may present problems.
- Spreader bar needed for lifting.
- Required floor of gate structure may adversely affect operation problems caused by debris.
- Long-term data on fiber reinforced plastic (FRP) reinforcing bars is only available for roughly ten years.

Lock and floodgates, constructed of steel, require maintenance to address issues that include corrosion (rusting, pitting), seal deterioration, cracking, and impact damage. Each gate is unique in dimension and weight to the lock or floodgate it serves. The maintenance cycle is usually about every 10 to 12 years; however, this timeframe is often delayed by budgetary constraints, or accelerated by some form of impact damage that makes a gate inoperable. For a lock, a complete maintenance event is usually done in two consecutive years, where one set of gates will be pulled/rehabilitated at an optimal time of the year, then repeated for the other set of gates the following year. A typical example of a maintenance cycle is the Port Allen Lock where completion of the cycle would take about 90 days, but has been accelerated to 45 days through the use of a spare set of gates. The length of closure of the lock has been about 6 to 9 days total to facilitate maintenance. Depending on location, a maintenance cycle closure can impact users at a cost in excess of $6 million (pre-Hurricane Katrina). Tables 1 and 2 illustrate the economic impact to navigation current (2004) maintenance cycles have at its most significant location, Calcasieu Lock, and where least effects are encountered, Harvey Lock.

Cost of 8 Day Closure at Calcasieu Lock and Harvey Lock

Calcasieu Lock	
Year 2001 Tons	38,680,000
8 Days of Tons	847,781
Cost of Waiting Per Hr/Ton	0.08
Cost of 8 Day Closure	**6,510,957**
(Use 4 Day Avg or 96 hrs)	

Harvey Lock	
Year 2001 Tons	2,094,000
Avg Delay/Tow (hrs)	0.98
Algiers Lock	
Year 2001 Tons	22,879,000
Avg Delay/Tow (hrs)	3.37
Algiers Lock with Harvey Traffic	24,973,000
Estimated Avg Delay per Tow if Harvey Traffic diverts to Algiers Lock	7.13
Annual Cost of Delay Without Diversion	8,220,298
Annual Cost of Delay With Diversion	14,240,079
Incremental Annual Cost of Diversion	6,019,781
Incremental 8 Day Cost of Diversion	**131,940**

Table 1: Cost of 8-Day Closure

PRESENT WORTH OF ECONOMIC IMPACT OF MAJOR MAINTENANCE CLOSURES @ CALCASIEU AND HARVEY LOCKS			
		Present Worth of Impact to Navigation	
Year	Present Worth Factor @ 5.5%	Calcasieu Lock $ 6,511,000 per maint. event	Harvey Lock $ 132,000 per maint. event
10	0.585	$ 3,808,935	$ 77,220
11	0.555	$ 3,613,605	$ 73,260
20	0.343	$ 2,233,273	$ 45,276
21	0.325	$ 2,116,075	$ 42,900
30	0.201	$ 1,308,711	$ 26,532
31	0.19	$ 1,237,090	$ 25,080
40	0.118	$ 768,298	$ 15,576
41	0.112	$ 729,232	$ 14,784
	Total:	$ 15,815,219	$ 320,628

Table 2: Present Worth of Navigational Benefits

Representatives from the USACE report that several significant components to maintenance exist. These include pulling the gate, which requires a substantial number and/or capacity of cranes as each gate can weigh from 30 to 200 tons, and sand blasting and painting, which comprise the greatest amount of maintenance/restoration time. They further report that sector gates are more durable and exhibit less structural deterioration than miter gates. These observations may be the reason that all currently proposed new control structures are being planned or designed with sector gates.

The results of the 2004 VE Study may be summarized as follows:

- The USACE New Orleans is currently very successful in operating and maintaining their gate and lock structures. Current practices allow for virtually uninterrupted service for generally 10 years or more between major maintenance cycles. However, the cost of performing major maintenance and more importantly, the economic impact to navigation when critical structures are temporarily put out of service, are significant. There is the potential that even marginal improvements may produce large benefits.

- The 2004 VE Study produced a number of recommendations that appear to be economically justified. Most require additional upfront investment cost that will lengthen the time between required major maintenance events. Proposals address both changes that can be immediately implemented at relatively low cost (add cathodic protection, change coating system) and changes to future gate design and material selection (stainless steel, aluminum, concrete, etc.).

- A number of the recommendations cite field-proven design/maintenance practices that should have a high level of confidence for successful implementation. Others suggest investigating something completely new, and some degree of further research, development and analysis must be performed prior to full-scale application.

- Most of the recommendations are cost effective purely on the basis of potential direct maintenance cost savings that may be realized by lengthening the time between required major maintenance events. It should be particularly noted that the potential economic benefits for improving maintenance cycle length at locations where maximum marine traffic impacts occur are enormous. Maximizing major maintenance cycles at these locations will be highly leveraged, justifying even very high first cost investment. For example, the use of stainless steel gates appears to produce a benefit to cost ratio of over 5:1 if used in lieu of regular structural steel at such a critical location. Please refer to the three Summary of Alternatives tables on the following pages; but note that the costs shown are pre-Hurricane Katrina estimates. The overall benefit should still remain.

- In considering the recommendations of the 2004 VE Report, USACE New Orleans should include such factors as available funds, short and long-term implementation, and relative criticality of structure service in further developing and prioritizing future maintenance actions.

SUMMARY OF ALTERNATIVES RANKED ACCORDING TO POTENTIAL LIFE CYCLE COST SAVINGS NOT INCLUDING BENEFITS TO NAVIGATION (PRE-HURRICANE KATRINA)		
Alternative Number	**Alternative Title**	**Total Estimated Present Worth of Life Cycle Cost Savings *Not* Including Impacts to Navigation**
SET 1	***Changes to Maintenance***	
4	Use metal flame-sprayed coating instead of paint	$1,200,000
2	Use 100% solids coating for paint	$600,000
1	Use galvanic anode cathodic protection in addition to paint	$500,000
3A	Apply ceramic or cementitious coating to steel – existing gates	$200,000
6A	Replace existing gates with stainless steel	($600,000)
SET 2	***Alternative Materials and Design***	
8A	Build sector gates out of concrete; pre-tension or post-tension concrete	$1,600,000
8B	Build sector gates out of concrete; pre-tension or post-tension concrete, use FRP reinforcement instead of steel	$1,400,000
7	Build gates out of aluminum	$1,100,000
9	Build FRP gates	$300,000
5	Use tubular members where possible; eliminate/reduce complex corners designing for corrosion resistance	$250,000
3B	Apply ceramic or cementitious coating to steel – new gates	$50,000
6B	Build gates out of stainless steel	($125,000)
10	Build sector gates out of ultra high molecular weight polyethylene (UHMWPE) plastic or cast/molded urethane or polyethylene, or equivalent; with stainless steel wearing edges and corners	($4,000,000)

Alternative Number	Alternative Title	Total Estimated Present Worth of Life Cycle Cost Savings Including Minimum Impacts to Navigation
SET 1	***Changes to Maintenance***	
4	Use metal flame-sprayed coating instead of paint	$1,400,000
2	Use 100% solids coating for paint	$800,000
1	Use galvanic anode cathodic protection in addition to paint	$700,000
3A	Apply ceramic or cementitious coating to steel – existing gates	$250,000
6A	Replace existing gates with stainless steel	($300,000)
SET 2	***Alternative Materials and Design***	
8A	Build sector gates out of concrete; pre-tension or post-tension concrete	$1,900,000
8B	Build sector gates out of concrete; pre-tension or post-tension concrete, use FRP reinforcement instead of steel	$1,600,000
7	Build gates out of aluminum	$1,300,000
9	Build FRP gates	$600,000
5	Use tubular members where possible; eliminate/reduce complex corners designing for corrosion resistance	$300,000
6B	Build gates out of stainless steel	$125,000
3B	Apply ceramic or cementitious coating to steel – new gates	$100,000
10	Build sector gates out of UHMWPE plastic or cast/molded urethane or polyethylene, or equivalent; with stainless steel wearing edges and corners	($3,600,000)

Alternative Number	Alternative Title	Total Estimated Present Worth of Life Cycle Cost Savings Including Maximum Impacts to Navigation
SET 1	***Changes to Maintenance***	
6A	Replace existing gates with stainless steel	$12,000,000
1	Use galvanic anode cathodic protection in addition to paint	$11,100,000
4	Use metal flame-sprayed coating instead of paint	$11,100,000
2	Use 100% solids coating for paint	$7,100,000
3A	Apply ceramic or cementitious coating to steel – existing gates	$3,000,000
SET 2	***Alternative Materials and Design***	
8A	Build sector gates out of concrete; pre-tension or post-tension concrete	$14,900,000
8B	Build sector gates out of concrete; pre-tension or post-tension concrete, use FRP reinforcement instead of steel	$14,600,000
7	Build gates out of aluminum	$13,500,000
9	Build FRP gates	$12,800,000
6B	Build gates out of stainless steel	$12,400,000
10	Build sector gates out of UHMWPE plastic or cast/molded urethane or polyethylene, or equivalent; with stainless steel wearing edges and corners	$11,900,000
3B	Apply ceramic or cementitious coating to steel – new gates	$2,800,000
5	Use tubular members where possible; eliminate/reduce complex corners designing for corrosion resistance	$1,900,000

The primary cost benefits arise when the impacts to commercial operations are taken into consideration. Reduced downtime and improved corrosion resistance translates to considerable life cycle cost savings if alternate materials and cathodic protection techniques are utilized to construct gates. It appears that concrete gates offer the most promise in long-term cost savings. Significantly increased cycle time between maintenance events coupled with reduced downtime for each maintenance activity translates into highly improved reliability, maintainability, and navigational benefits.

CONVEY ATCHAFALAYA RIVER WATER TO NORTHERN TERREBONNE MARSHES

A-1 Address flow constrictions in the GIWW at Houma

There are two apparent flow constrictions in the GIWW at Houma: the "Houma Tunnel" and the "Twin Span" (see location map below). These items will prevent desired proposed Atchafalaya River diversion flow from going to the eastern Terrebonne Basin. The current planning rationale views this flow limitation as a planning constraint given the belief that the tunnel cannot be removed (this also makes any possible flow improvement to the Twin Span non-effective). It has been recently discovered, however, that LADOTD plans to build a high-rise bridge and take the tunnel out of service. See below excerpt from the Tri-Parish news service in Houma:

> *The new high-rise bridge over the Intracoastal Waterway that will be built to replace the Houma tunnel should be located where a railroad bridge now crosses the waterway close to Bayou Black, audience members said at a meeting last week in Houma.*
>
> *The state Department of Transportation and Development formally kicked off the project with the meeting, intended for Terrebonne residents to suggest a variety of sites to build the bridge and to air their views on the project.*
>
> *But the railroad bridge location near the south end of Dunn Street was the only site that was brought up by audience members.*
>
> *R. Gary McClure, an engineer with the Baton Rouge firm Shread-Kuyrkendall & Associates who is studying the project, acknowledged that the railroad bridge site was being considered, as did a DOTD official at the meeting. The environmental impact of the new bridge would be minimal, according to McClure.*
>
> *The tunnel, completed in 1961, is currently having 10 pumps replaced at a cost of $1.9 million and needs around $2 million worth of new lighting. McClure and the DOTD official said the tunnel experiences frequent traffic congestion.*
>
> *State Sen. Reggie Dupre of Houma said the idea of replacing the tunnel has been around since the late 1990s. He said the three tunnels existing in the state - in Houma, Harvey and Belle Chasse - "are maintenance nightmares."*

Once the replacement bridge is constructed, the tunnel can be removed. It may be necessary, however, to accelerate this bridge project to accommodate the LCA schedule.

If the tunnel can indeed be removed, it would then appear to be practical to improve gravity flow across the Twin Span and eliminate the entire GIWW flow constriction through Houma. This may be accomplished by installing a channel section through the next bridge bent on the east side (see below map). An all earthen channel with rock and/or steel sheetpile protection of the bridge foundation or an earthen channel in combination with multiple concrete culverts under the bridge structure proper can create an adequate flow section. This would, however, require the purchase of an estimated 15 to 20 developed residential properties to the north and a partial vacant (industrial?) tract to the south. While politically undesirable, such real estate purchase is possible and does not appear to be cost prohibitive.

If only limited property can be obtained, an alternative would be to pump through the same bridge bent, utilizing a pump station to the south and several large diameter forcemains discharging to the north. This would be both a more expensive initial cost option as well as require significant future O&M cost.

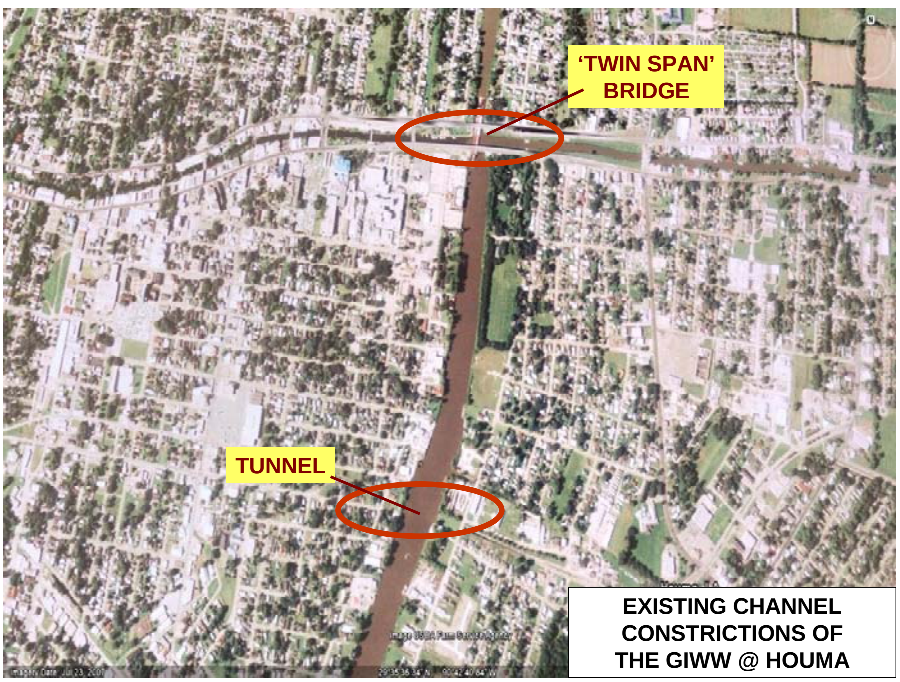
A rough cost estimate for removing the tunnel, purchasing property, and installing a gravity conveyance through the bridge is in the range of $7 to $12 million; removing the tunnel with a pumping option through the bridge would be on the order of $20 to $35 million. Estimated cost of items as follows (design, management and contingencies included):

Gravity Conveyance

Removal of tunnel	$1-$2 million
Real estate total acquisition costs	$2 -$4 million
Channel cut with culverts under bridge	$4 -$6 million
Total:	$7 -$12 million

Pumped Conveyance

Removal of tunnel	$1-$2 million
Real estate total acquisition costs	$1 -$3 million
Pump station (1,500 CFS) and forcemains	$18 -$30 million
Total:	$20 -$35 million



A-2 Operate the Old River Control Structure to optimize flow split outside of the 70/30 mandate in non-flood conditions

The Old River connects the Red, Atchafalaya, and Mississippi Rivers. In the 1890s, the Atchafalaya River was expanding and would have allowed the Mississippi River a shorter outlet to the Gulf of Mexico. By the 1950s, it was apparent that Atchafalaya River could capture the entire Mississippi River flow. In 1954, Congress authorized the USACE to construct the Old River Control Project to prevent the Mississippi River from changing course. This legislation obligated the flow between the Mississippi River and the Atchafalaya River to remain at its then current rate, a 70/30 split.

It appears possible that the Old River Control Structure has the capability to alter this flow split during low flow conditions. During periods of low river flow, this 30% allocation may be less than needed in the Atchafalya River to supply the desired quantity of freshwater flows into the GIWW. The ability to alter this flow ration may be imperative to achieving the project goal of providing freshwater to the entire Terrebonne Basin when it would be needed.

Such a change would require a change in federal law. The 70/30 split would be retained, unaltered, during non-low flow to avoid adverse affects. Over time, frequent and prolonged deviation from the 70/30 split at low flow could possibly change the river bottom configuration enough to affect flood condition performance. Further evaluation would therefore be required before this change in operation would be implemented. Allowing flexibility to route more than 30% into the Atchafalya River would become an adaptive management strategy to meet project salinity reduction purposes.

A-3 Use City of Houma wastewater effluent to replenish cypress forests

A process recently utilized and planned in several localities is the use of secondary treated wastewater plant effluent to feed newly planted cypress stands. Such a system accelerates tree growth and treats secondary effluents to tertiary standards (as well as reduces effluent discharge to receiving waterways). This system is currently being considered for inclusion in the LCA program in the Missouri River Gulf Outlet (MRGO) Ecosystem Restoration Project (St. Bernard Parish).

Passing effluent through natural or man-made vegetation has been shown to significantly improve the quality of the effluent. This alternative measure would allow the effluent to flow over and through the vegetation in the marshland, creating a filtering effect that would enhance water quality and add nutrients to the biotic system.

The science addressing Contaminants of Emerging Concern is still in its infancy. Should such contaminants (e.g., pharmaceuticals, byproducts of plastics and heavy metals) be present in the treated effluent, they may be retained in the effluent; however, since this is not part of the drinking water supply, the issue may be insignificant. In fact, by diverting the effluent to the marsh rather than to the river, improvements to the drinking water supply in this respect may be improved.

It is not known what the current wastewater treatment system status is for the City of Houma (centralized plant, numerous privately run package plants, etc.), but this may be a possible consideration if a target cypress planting area (or existing stand) is relatively close to a wastewater treatment site(s). This can be a "win-win" alternative that results in lower wastewater treatment costs and habitat creation/enhancement.

A-4 Pump flow from Davis Pond Diversion from Company Canal

A possible means of delivering freshwater produced by the Davis Pond Diversion westward into Bayou Lafourche (and indirectly into the Terrebonne Basin target area) may be by inducing westward flow in Company Canal via pumping at the old lock location. This concept was developed in a previous VE Study – *"Bayou Lafourche Siphon Restoration Project, July 2001; Proposal C-1"* (see Appendix C). Cost and hydraulic considerations may limit this flow to less than 1,000 CFS but this may be a beneficial supplement to proposed freshwater flow that may originate from the west (Atchafalaya River Diversion).

A-5 Use Bayou Lafourche to convey freshwater to the northern Terrebonne marshes

In lieu of or complementary to conveying Atchafalaya River water to the northern Terrebonne marshes, this proposal suggests transferring freshwater through Bayou Lafourche from the Mississippi River in the vicinity of Donaldsonville approximately 55 miles to Company Canal, thus replacing the proposed transfer of freshwater from the Atchafalaya River. Freshwater would be removed from the river by constructing a control structure. Freshwater would also enter the GIWW further south of this location.

Bayou Lafourche, a former distributary of the Mississippi River, was closed for flood protection purposes in 1905. Bayou Lafourche had a channel capacity of approximately 11% of Mississippi River flows prior to closure. Under the 1899 Rivers and Harbors Act, the USACE was ceded, i.e., acquired in perpetuity, flowage easements for navigation purposes along this and other delta bayous. The sketch below shows a conceptual control structure at the Mississippi River near its confluence with Bayou Lafourche to transfer 15,000 cubic feet per second (CFS) down Bayou Lafourche to its confluence with the Company Canal.

A flow of perhaps as high as 15,000 CFS will inundate residential yards and docks, but not permanent residences located along the top of the natural levee. Property owners would be compensated for dock and yard structure replacement costs, but not property easements or rights-of-way for their inundated land as these privately owned parcels have encroached the navigational flowage easement held by the federal government.

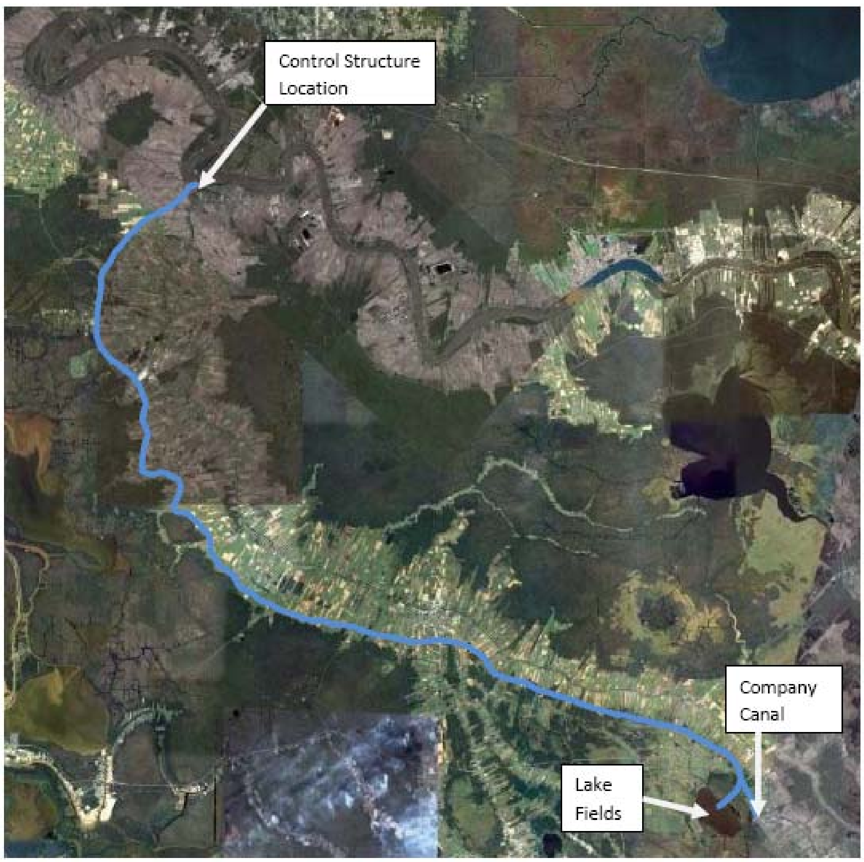
In an effort to estimate a rough, order-of-magnitude cost for this proposal, the following assumptions are made:

- The bayou may support up to 15,000 CFS without channel modification (or less flow up to the amount needed to support the unaltered restriction at Houma).
- The transfer will require ~1,000 feet of four 12-foot by 12-foot buried culverts.
- The following unit costs are assumed:
  - Residential dock and yard structure replacement costs of $10,000/property, with an average residential lot size along the Bayou of 200-foot width
  - Mississippi River control structure of $27 million
  - Utility relocations and roadway work of $5 million
  - GIWW shoreline improvements as proposed in the current design plan estimated at $10 million
  - Culvert construction cost of $3,000 per linear foot for combined four culverts
  - Engineering and Design allowing 15%
- Contingencies allowing 40%.

Based on these assumptions, the approximate cost of this proposal is estimated in the $100 million range.

A-6 Construct "mini-Woody's Ditch" east of Houma and west of Bayou Lafourche connecting the Mississippi River to Lake Fields

This proposal suggests constructing a water transfer feature consisting of an open-air canal plus, where appropriate, buried culverts that will move freshwater from the Mississippi River in the vicinity of Donaldsonville approximately 60 miles to Lake Fields, thus replacing the proposed transfer of freshwater from the Atchafalaya River. This feature would parallel Bayou Lafourche on the south side and would run through primarily agricultural land (to avoid marsh areas) at the back of the property avoiding as many structures as possible. Freshwater would be removed from the river by constructing a control structure. Once the water reaches Lake Fields, it can be distributed to desired areas primarily through existing canals, ditches, and bayous that emanate from the lake. Water would then be allowed to enter the GIWW for distribution into the desired project restoration areas. A suggested alignment is shown on the following map.



Idealized location of proposed mini-Woody's Ditch

In an effort to estimate a very rough, order-of-magnitude cost for this proposal, the following assumptions are made:

- The feature will be ~60 miles long.
- The feature will carry up to 15,000 CFS.
- Approximately 90% will be open canal and 10% will consist of four 12-foot by 12-foot buried culverts.

- The cross section of the canal will be 10 feet deep with a 25-foot bottom width, and 3 horizontal:1 vertical side slopes.

- 25-foot wide access roads will be provided on each side of the canal.

- The following unit costs are assumed:

  - Land acquisition and mitigation costs of $10,000/acre
  - Mississippi River control structure of $30 million
  - Utility relocations and roadway work of $25 million
  - Canal construction cost of $7.50 per cubic yard
  - Culvert construction cost of $3,000 per linear foot (for combined four culverts)
  - Engineering and Design allowing 15%
  - Contingencies allowing 40%

Based on these assumptions, the approximate cost of this proposal is estimated at $315 million.

A-7 Ensure that local fishing interests are fully informed of project alternative impacts

The introduction of any significant freshwater into a currently brackish or saltwater regime will undoubtedly change fish occurrence patterns in that area. There are probably thousands of sport and commercial fisherman that utilize the project area inland waters. Saltwater fish are the prized catch and any major change to water salinity will move these fish to other locations. It is therefore imperative that all sport and commercial fishing interests are made fully aware of potential impacts and changes to fishing as a result of project alternatives. This should go beyond the required "public meeting" forum. Failure to do so may result in severe political backlash that could ultimately affect the success of this project.

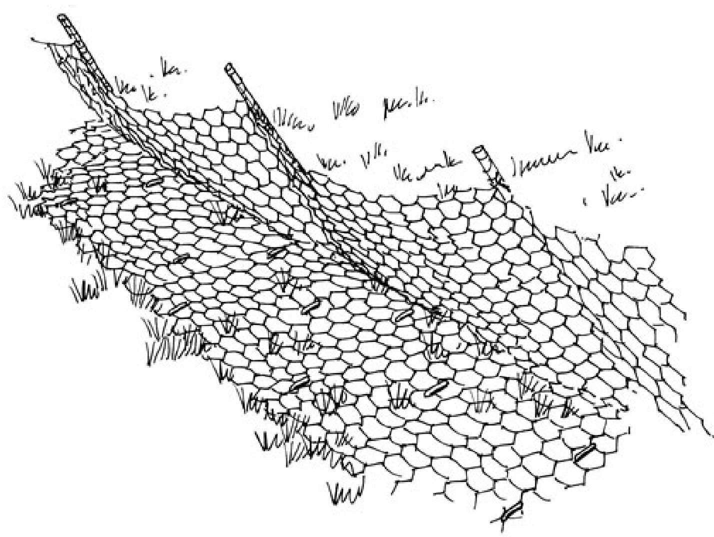
A-8 Require oil companies to plug canals connecting to GIWW

The Atchafalaya River Diversion Project proposes to raise the stage on GIWW sufficient to cause water to flow toward the HNC. However, there are many points along the GIWW that will serve as diversion points for the water, thus affecting a sort of "line loss" for the freshwater that is needed to the east of Houma. Many of these diversion points result from where old and unused canals intersect the GIWW. The canals were built by oil companies to access oil and gas deposits. The original concept proposes to plug these canals, thus limiting the amount of line loss in the system. However, consideration should be given to requiring the oil and gas companies that originally built the canals to plug them instead of using project costs. In addition, justification under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) guidelines may allow the taxing of the oil/gas industry to provide funds for backfilling of canals.

A-9 Install nutria fencing along GIWW and birth control measures throughout project area

The proposed plan includes nutria (*Myocastor corpus*) control by trapping and hunting. Nutria cause plant damage, erosion, land loss, and will interfere with vegetative recovery.

Because nutria are not climbers, fencing will prevent access. A nutria fence consists of a mini floppy fence constructed of 1-inch mesh wire or plastic at least 2 feet high and staked so that it is wobbly. The fence should not be pulled tight between the stakes, but rather have some “give” so that when the nutria tries to climb the fence, it will wobble, discouraging further climbing. Constructing the fence so that it leans slightly toward the nutria’s side will increase its effectiveness. To prevent nutria from digging under the fence requires either 1) a 2-foot wide wire apron on top of the ground on the animal’s side of the fence or 2) an apron buried 6 to 12 inches.



Birth control chemicals in sweet potatoes or carrots can be used to keep a nutria population under control. The birth control program needs to assure that non-targeted mammals will not be affected. Such programs have to be continuous because nutria that die without reproducing are replaced by others moving into the vacant habitat due to fencing failure. For control in the Terrebonne barrier islands, consider placing a continuous nutria fence along the north shore of each island. For the Atchafalaya to Terrebonne marshes, consider placing a continuous fence along the GIWW and Bayou Lafourche or along the Morganza to the Gulf levee. Vegetable bait would be delivered by air. Augmentation of the kill by hunting and trapping would be beneficial.

GENERAL/PLAN FORMULATION

G-1 Develop Plan Strategies that account for much higher levels of GSL rise

The purpose of this ecological restoration is to achieve a sustainable solution, but the project must respond to the combined rates of subsidence and GSL rise. GSL rise consists of two factors: 1) eustatic rise due to density warming and 2) land-based glacial melt rise. Eustatic sea level rise during the next 50 years is expected to be approximately 4 inches (IPCC 4th Assessment Report, 2007). The IPCC has not yet projected the portion of sea level rise due to land-based glacial melt. Under the 2007 IPCC "business as usual" scenario, eustatic GSL is projected to be 0.75 feet to 1.5 feet by 2100. At that time, no significant acceleration of GSL rise had been detected. New research published this year indicates that GSL rise could be 3 to 4 feet by 2100, which is much higher than IPCC 2007 predictions (Niels Bohr Institute, published in the journal *Climate Dynamics*). The great uncertainty in the rate of GSL rise regards how quickly the ice sheets on land will melt.

The subsidence rate in the Mississippi River delta planning area ranges from 1 to 3.5 feet by 2100. The relative sea level rise (i.e., the eustatic portion only of GSL rise and the delta's subsidence rates) used for the LACPR for the next 50 years are 1.3 to 2.6 feet, or 2.6 to 5.2 feet by the end of the century.

Twentieth century rise in sea level from observed data was about 1.8 mm/year as result of long-term response to the end of the last ice age. Since 1992, however, satellite data have recorded an accelerated rate of GSL rise of 3.0 mm/year, but this is not sufficiently long to determine if this rate will be prolonged or is a short-term change.

Project benefits depend upon habitats maintained above sea level. Consequently, benefits beyond the 50-year planning horizon will be lost due to subsidence, GSL rise, and storm-induced habitat loss. Long-term melting of the Greenland ice sheet during subsequent centuries of warming could result in complete melting over several thousand years, eventually resulting in a GSL rise of 22 feet (7 meters).

As the rate of GSL rise in the future is unknown, the project should develop specific Plan Strategies that consider the range of possible future GSL rates, and check to see how sensitive the project design is to those different scenarios. Those future scenarios include:

1. A low level that is based on an extrapolation of the historic rate assumes GSL rise will be linear in the future and will not accelerate.

2. A medium level that assumes GSL rise of 0.5 meters by 2100.

3. A high level that assumes a greater future acceleration of GSL rise of 1.5 meters by 2100.

However, as noted above, current science projecting an accelerated rate of land-based glacial melt has huge ramifications for project viability or perpetual cost obligations. Future GSL rise rate based on this science must wait on future work by the IPCC and U.S. agencies to be completed by late 2009. This work is based on recent, and increased, rates of observed GSL rise using satellite data, previous historic rates of sea level rise during past glacial melt. Currently, work is underway by the USACE, National Oceanic and Atmospheric Administration (NOAA), and USGS to investigate the glacial melt contribution to future GSL.

G-2 Develop a Seasonal Freshwater Management Plan

Wetlands in the project area are deteriorating as a result of subsidence, lack of sediment and nutrient deposition, saltwater intrusion and erosion. Deterioration will continue unless action is taken to resolve the causative factors. Sustainable protection and enhancement of the wetlands in the project area is dependent on providing a hydrologic regime that minimizes the physiological stress to wetland vegetation.

Seasonal differences in the need for freshwater and nutrients, and the locations from which freshwater can be recruited and distributed, should be optimized. For example, the quantity of water that can be diverted from the Atchafalaya River to the GIWW is somewhat limited due to infrastructure restrictions: traffic tunnel in Houma and the Houma twin bridge abutments are two examples. Freshwater could also be diverted into the GIWW system at the Harvey Lock and Algiers Lock. In addition, freshwater is being diverted into Bayou Lafourche and Davis Pond. Each of these is an individual site at which important resources can be introduced into the wetlands; however, quality and quantity of freshwater could be enhanced with coordination and planning treating these sources as a supply network.

Opportunities exist to naturalize the distribution of freshwater and, to a limited extent, the deltaic forming sediments, improve distribution of freshwater, and to reduce the negative impacts of Gulf storm events. Seasonal Gulf events have an intensive impact on the remaining marsh areas. Opportunities exist through freshwater supply and distribution to create a healthier marsh which will be more resistant to the normal range of events.

Cost to develop a management plan is minimal. Implementing the management plan would likely require instrumentation and communication equipment.

G-3 Create federal advisory committee

Public participation will be achieved through the NEPA process involving federal and state cooperating agencies, public review, and public and legislative hearings. This can be augmented by developing a formal multi-state committee. A federal advisory committee can be comprised of both government and non-governmental stakeholders along the Mississippi flyway, including Canada. The Federal Advisory Committee Act (FACA, PL 42-463) governs the establishment and behavior of federal advisory committees. There are now approximately 1,000 such committees. FACA was an attempt by Congress to curtail the "locker-room discussion" that had become prevalent in administrative decisions and obligates transparency in the process.

For example, a federal advisory committee may include the Missouri and Mississippi State River Basin Commissions, and national and Canadian environmental organizations. This would expand national interests to support Congressional intent, but will add additional administrative burden to the USACE.

Example FACA Committee: The National Park Service, Georgia, Big Cypress National Preserve Off-Road Vehicle (ORV) Advisory Committee.

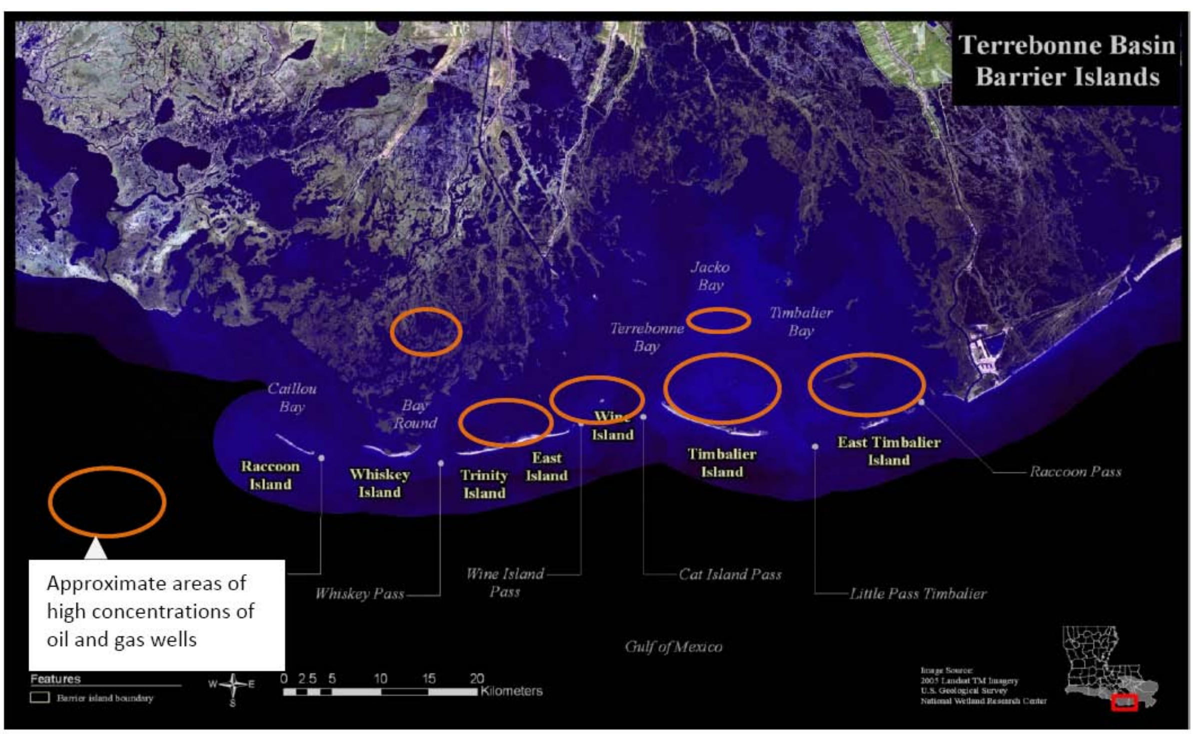
__*G-4 Identify and incorporate the effects of subsidence from fluid withdrawal in the project analysis and design; utilize water injection to minimize the impacts of fluid withdrawal-induced subsidence*__

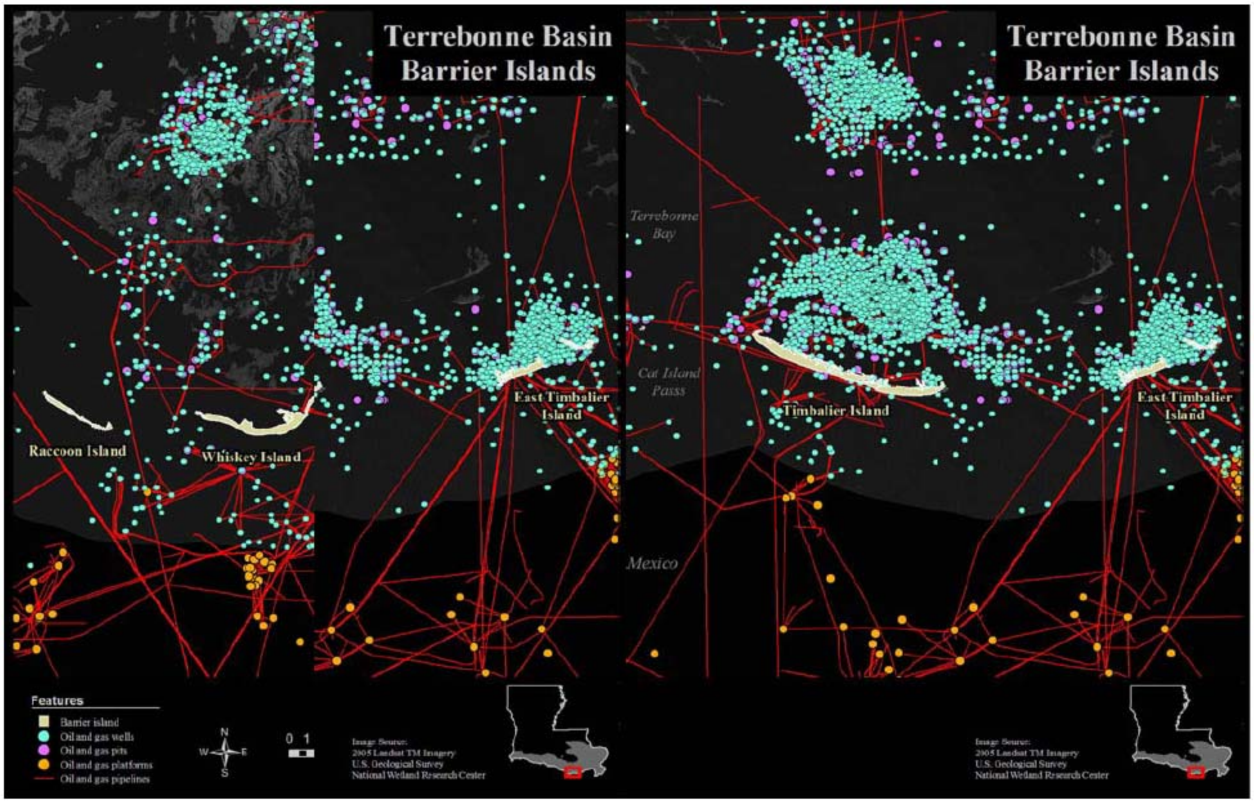
The Principal of Effective Stress is a well known geotechnical engineering principal applied to the consolidation of sediments and rock when there is a net change in interstitial pressure in the system. Principally, this can be described as an increase in stress between particles resulting from a reduction of pore fluid pressure that causes the solid particles in the mass to move closer together. Once this consolidation of mass occurs, it cannot be reversed. The reduction in fluid pressure happens when the fluids are permanently removed from the system (that is, through the pumping or mining of groundwater, oil, and gas). The consolidation of the solids produces general settlement (or subsidence) of the ground surface.

Significant ground surface subsidence (sometime associated with fault development) as a direct result of fluid withdrawal has been documented worldwide. Well known cases exist in Houston, south central Arizona, North Las Vegas, and central California. In the Long Beach, California area, from about 1920 to 1960, 29 feet of surface subsidence occurred that was directly related to the removal of oil and gas.

The current documents do not fully address time-dependent subsidence in the project area due to oil and gas withdrawal, a process which is ongoing in the area. The amount of such subsidence has not reportedly been documented to date. It is recommended that surface subsidence due to fluid withdrawal in the project area, and its future impacts on project sustainability, be assessed and included in the project design and documents.

There may be some visual evidence of a correlation of open water in the project area with the concentrated location of oil wells. It could be interpreted that some of this open water resulted, in part, from subsidence associated with the withdrawal of oil and gas from these concentrated well areas. This visual comparison can be seen in the two maps below.





As was mentioned above, from about 1920 to 1960 in the Long Beach, California area, 29 feet of surface subsidence occurred that was directly related to the removal of oil and gas. Once this problem was identified, the petroleum industry elected to inject saltwater into the subsurface to replace the withdrawn oil and gas as a mechanism of recharge that would maintain the internal pressures, thus minimizing the change in effective stress. As a result of this effort, additional subsidence has been limited to about 1 foot to date.

An added benefit of saltwater recharge has been the ability to increase the extraction of petroleum from the reserve. Such recharge has become a standard practice in the industry. If this is not already being done within the project area, the USACE is encouraged to open discussions with the oil industry to see if the technique can be implemented. This would reduce the amount of future subsidence due to fluid withdrawal, extending the life of the project and its sustainability.

<u>G-5 Consider alternate procurement methods for construction</u>

Given the complexities associated with identifying sources of material for renourishment of the barrier islands, transport and placement of the material, and preservation of the material, as well as limited specialized contractor availability, use of alternate procurement methods should be considered. Examples of some of these methods include CM-at-Risk and using Habitat Units as the pay items.

CM-at-Risk procurement, also known as Integrated Design-Bid-Build or Earlier Contractor Involvement, involves selecting a contractor and separate designer during the design phase. Both parties work together under separate contracts with the government with the objective of developing a design that is most efficient. The government then negotiates and awards construction packages to the contractor. If negotiations are not successful, the government reserves the option to bid the work on the construction open market.

The process calls for the selection of a construction contractor (based on qualifications only) early in the design phase. This contractor and the designer collaborate in developing a design most suitable for the specific contractor while meeting all performance requirements (such as maximizing the number of Habitat Units created). In this arrangement, the government has the option to either negotiate a subsequent construction price with the previously selected contractor or bid the job on the open market. Such a procurement plan would help assure a constructible design that meets the relatively complex requirements of this project.

PROJECT ANALYSIS

SUMMARY OF ANALYSIS

The following value analysis tools were used to study the project:

- Key Project Factors
- Function Analysis / FAST Diagram

KEY PROJECT FACTORS

The first day of the study included meetings with the project stakeholders. The following summarizes key project issues and concerns identified during these sessions.

PROJECT ISSUES

The following are some of the issues and concerns associated with the Terrebonne Basin Barrier Shoreline Restoration Project:

- Lack of sediment for barrier island renourishment. The demand for sediment from various projects exceeds the supply at Ship Shoal.
- Project authorization requires signed Chief's Report by December 2010.
- There is a limit to the number of dredges available to the project to supply sediment for barrier island renourishment.
- Absolute sea level rise threatens the project's justification and sustainment.
- Key navigation routes through the project limits must be maintained.
- Project funds do not provide for future renourishment requirements.

The following are some of the issues and concerns associated with the Convey Atchafalaya River Water to Northern Terrebonne Marshes Project:

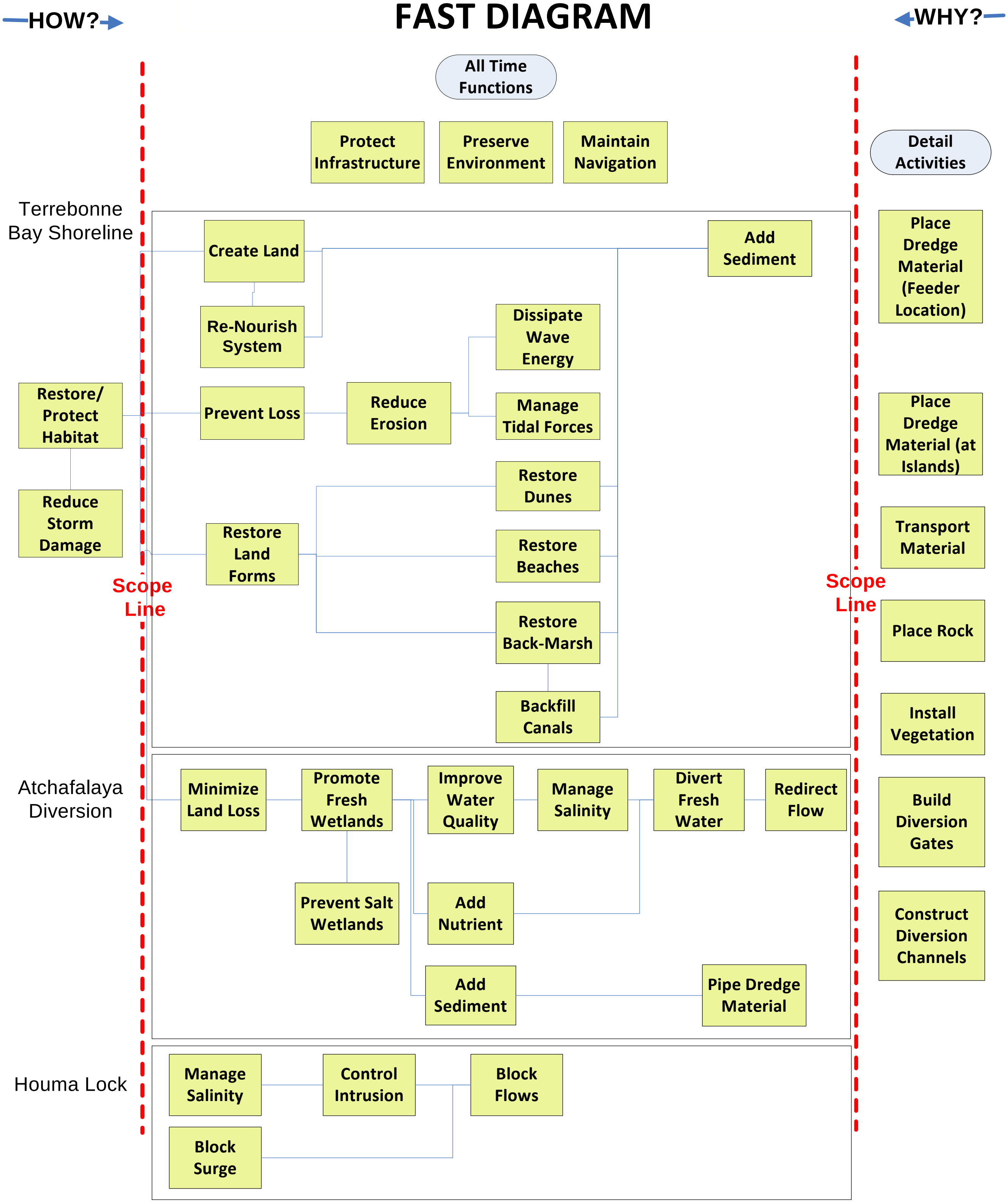
- Project authorization requires signed Chief's Report by December 2010.
- Existing tunnel and Twin Span bridge in Houma creates restriction to GIWW flow rates (maximum 2,600 CFS).
- The availability of water during low flow times may limit the amount of freshwater needed to counteract salinity levels.
- Flow between the Mississippi River and the Atchafalaya River is legislated to remain at a 70/30 split.
- Project raises the 100-year flood plain along the GIWW.
- Project lacks hydrology and hydraulics data to determine necessary flows from Atchafalaya River to HNC and impacts to existing systems.
- Multiple private land owners present issue for gaining permissions for accessing project sites.

FUNCTION ANALYSIS / FAST DIAGRAM

Function analysis was performed and a FAST Diagram was produced, which revealed the key functional relationships for the project. This analysis provided a greater understanding of the total project and how the project objectives and specific project activities are related.

Terrebonne Bay Shoreline, Atchafalaya River Diversion, Houma Gate Operations

FAST DIAGRAM



PROJECT INFORMATION

PROJECT INFORMATION

INTRODUCTION

The program goal of the coast-wide LCA Ecosystem Restoration Plan is to reverse the current trend of degradation of the coastal Louisiana ecosystem by maximizing the use of restoration strategies to reintroduce historic flows of water, nutrients, and sediment to coastal wetlands, and to maintain the structural integrity of the coastal ecosystem.

PROJECT BACKGROUND

Title VII of the Water Resources Development Act (WRDA) of 2007 authorizes the LCA program. The authority includes requirements for comprehensive coastal restoration planning, program governance, project modification investigations, a Science and Technology (S&T) program, restoration project construction, a program for beneficial use of dredged material, feasibility studies for restoration plan components, and other program elements.

Specifically, Section 7006(e)(3) requires the Secretary of the Army to submit one feasibility report to Congress on six elements by December 31, 2008 and a Chief's Report by December 31, 2010. The six elements are:

1. Multipurpose Operation of Houma Navigation Lock
2. Terrebonne Basin Barrier Shoreline Restoration
3. Convey Atchafalaya River Water to Northern Terrebonne Marshes
4. Small Diversion at Convent/Blind River
5. Amite River Diversion Canal Modification
6. Medium Diversion at White Ditch

This study focused on the first three elements.

PROJECT DESCRIPTIONS

Terrebonne Basin Barrier Shoreline Restoration

The natural processes of subsidence, habitat switching, and erosion, combined with human activities, have caused significant adverse impacts to the Northern Terrebonne Marshes, including accelerated wetland loss and ecosystem degradation.

The project proposes to reverse the continuing degradation and deterioration of the Isles Dernieres (Raccoon Island, Whiskey Island, Trinity Island, East Island, and Wine Island) and Timbalier Islands (Timbalier Island and East Timbalier Island) to achieve a sustainable coastal ecosystem that can support and protect the environment, economy, and culture of southern Louisiana and thus the nation.

Project objectives include:

- Prevent habitat conversion and future land loss where predicted to occur.
- Protect vital socioeconomic resources, including cultures, community, infrastructure, business and industry, and flood protection.
- Restore and maintain characteristics of natural marsh hydrology.
- Reduce salinity levels in project area.
- Increase sediment and nutrient load to surrounding wetlands.
- Increase residence time of freshwater.
- Sustain existing fish and wildlife habitat.

Management measures were developed to address study area problems and to capitalize upon study area opportunities. Management measures were derived from a variety of sources, including prior studies, the Conceptual Ecological Model, the NEPA public scoping process, and the multidisciplinary, interagency PDT.

Alternative Plan Strategies will be used to identify combinations of management measures to achieve the outputs represented by each strategy. The strategies were identified and developed to produce a full spectrum of alternative plans as required by NEPA and USACE planning guidance in ER 1105-2-100. Alternative Plan Strategies are designed to be significantly different from one another and to represent the entire range of solutions to identified problems within the study area.

The management measures evaluated can be grouped into the following two categories:

Hard Structural

- Breakwaters
- Groins
- Terminal groins
- Sand fencing
- Barges/Ships
- Sheet pile
- Pass closures
- Canal plugs

Non-Structural

- Dune restoration
- Marsh creation
- Beach restoration
- Beach nourishment
- Subtidal sediment placement
- Addition of sediment into near-shore environment to supplement littoral drift
- Beach closure
- Small marsh island construction on bayside for bird habitat
- Vegetative planting
- Herbivory control
- Biological bio-engineered oyster reefs
- Spit creation
- Canal backfilling

The initial array of alternative Plan Strategies developed by the PDT includes:

- Plan Strategy A: No Action
- Plan Strategy D: Maintain island geomorphology and ecological function
- Plan Strategy E: Increase of current configuration and functional geomorphology
- Plan Strategy F: Maximize the allocated and available resources for the barrier island restoration

Two Plan Strategies (B and C) were eliminated from further study prior to the VE Study.

A signed Chief's Report is due to congress by December 31, 2010. Authorized costs for the project from WRDA of 2007 (Public Law 110-114) are $124,600,000.

Multipurpose Operation of Houma Navigation Lock

A lock complex is proposed to be constructed in the HNC as part of the Morganza, Louisiana to the Gulf of Mexico Hurricane Protection Project to provide flood protection, drainage, environmental benefits (i.e., salinity control), and navigational passage. The HNC Lock would be located in Dulac, Louisiana near the confluence of the HNC and Bayou Grand Caillou. The lock complex will consist of a 250-foot wide floodgate, a 110-foot wide by 800-foot long lock chamber, and the associated necessary improvements to the site, all built in a realigned channel just west of the existing HNC. The 250-foot wide floodgate is designed to allow for continued use of the channel by the offshore fabrication industry located in Houma, 20 miles to the north.

The HNC Lock Complex, including the large floodgate, will be operated under tidal flow and salinity conditions and possibly to retain upstream freshwater.

Convey Atchafalaya River Water to Northern Terrebonne Marshes

The purpose of the proposed action is to reverse the current trend of degradation of the Terrebonne marshes resulting from subsidence, erosion, saltwater intrusion, and lack of sediment and nutrient deposition. The project proposes to accomplish this by utilizing freshwater, sediments, and nutrients from the Atchafalaya River and the GIWW.

The project study area comprises approximately 1,000 square miles (660,000 acres) in southern Louisiana in the vicinity of the City of Houma and Terrebonne Parish. The study area is bound to the west by the Lower Atchafalaya River, to the east by the Bayou Lafourche ridge, to the north by the Bayou Black ridge, from the Lower Atchafalaya River Water to the City of Houma, and by the GIWW, from the City of Houma to the Bayou Lafourche ridge. The southern boundary of the project lies along what would have historically been the transitional area from fresh to brackish marsh. Due to the magnitude of the 1,026 square mile project area, the entire project area was divided into three subunits labeled as West - Bayou Penchant Area, Central - Lake Boudreaux Area, and East - Grand Bayou Area.

The objective of the project is to provide additional freshwater, nutrients, and fine sediment to the area. The introduction of additional freshwater could facilitate organic sediment deposition, improve biological productivity, and prevent further deterioration of the marshes. Specific project objectives include, but are not limited to the following:

- Prevent, reduce, and/or reverse future wetland loss.

- Protect vital socioeconomic resources, including cultures, community, infrastructure, business and industry, and flood protection.

- Achieve and maintain characteristics of sustainable marsh hydrology.

- Reduce salinity levels in project area.

- Increase sediment and nutrient load to surrounding wetlands.

- Increase residence time of freshwater.

- Sustain productive fish and wildlife habitat.

The study is currently considering the following alternative Strategic Plan concepts as part of the initial array:

1. **ARTM 1: No Action.** Alternatives developed under this strategy will include no measures from this project. The future condition will include sea level rise, subsidence, and other projects that are under construction or are likely to be constructed.

2. **ARTM 2: Utilize Existing Flow and Management Measures to Maximize Restoration Efforts.** Alternatives developed under this strategy will focus on modifying the interior portions of the project area. They will not actively attempt to introduce additional freshwater carrying sediments and nutrients from other sources.

3. **ARTM 3: Utilize Increased Flow from the Atchafalaya River and Management Measures to Maximize Restoration Efforts.** Alternatives developed under this strategy will focus on increasing supply from the Atchafalaya River to introduce additional freshwater carrying sediments and nutrients. Preliminarily, the focus of introducing additional flow from the Atchafalaya River consists of implementing an opening through Avoca Island to increase flow into the GIWW.

4. **ARTM 4: Utilize Increased Flow from Locations East of the Project Area and Management Measures to Maximize Restoration Efforts.** Alternatives developed under this strategy will focus on attempting to draw water from outside the project area to the east along with modifying the interior portions of the project area. Preliminarily, the focus of introducing additional flow from locations east of the project area consist of diverting additional flow from Davis Pond.

5. **ARTM 5: Utilize Increased Flow from the Atchafalaya River and Locations East of the Project Area and Management Measures to Maximize Restoration Efforts.** Alternatives developed under this strategy will focus on maximizing flow inputs from both the Atchafalaya River and locations east of the project area along with modifying the interior portions of the project area.

INFORMATION PROVIDED TO THE VE TEAM

The following project-related information was provided to the VE team for their use during the study:

- Terrebonne Basin Barrier Shoreline Restoration, Louisiana Coastal Area, Feasibility Scoping Report, dated April 2009

- Convey Atchafalaya River Water To Northern Terrebonne Marshes (Artm), Louisiana Coastal Area, Feasibility Scoping Meeting Report, dated April 2009

- Coastal Impact Assistance Program Application, Houma Navigation Canal Lock, dated May 22, 2006

- Value Engineering Study Report, Houma Navigation Canal Lock, dated January 2001

IDEA EVALUATION

IDEA EVALUATION

INTRODUCTION

All of the ideas generated by the VE team were recorded and evaluated with project-specific attributes applied to each idea to ensure an objective evaluation.

PERFORMANCE ATTRIBUTES

Performance attributes represent those aspects of a project's scope and schedule that may possess a range of potential values (as opposed to performance requirements which represent essential, non-discretionary aspects). The VE team developed the following list of performance attributes to act as criteria for considering the value potential of the creative ideas:

Terrebonne Performance Attributes

- Coordination with natural/coastal processes
  Includes sustainability of barrier island system
- Functionality of habitat
  Includes acres of habitat and quality of habitat
- Degree of protection to interior marsh
- Schedule

Houma Lock Performance Measures

- Impacts to navigation
- Ability to control salinity
- Maintainability

Atchafalaya Performance Measures

- Impacts to water quality
- Impacts to existing infrastructure
- Maintainability
- Impacts to navigation
- Coordination with other projects
- Schedule
- Flood control reliability during high water event
- Construction impacts (including minimizing impacts to navigational operations or downtime)

EVALUATION PROCESS

The VE team, as a group, generated and evaluated ideas on how to best perform the various major components or functions of the project. The goal of the evaluation was to select the best ideas that would produce a high level of performance at an acceptable level of cost. The evaluation used the key criteria listed above and the function analysis performed by the VE team.

Given the relatively early level of project development at the time of the VE Study (i.e., no original design), the team evaluated each of the ideas with respect to each of the key evaluative criteria to determine whether it was better than, equal to, or worse than the other feasible alternatives. The team then reached a consensus on the idea's development status.

Readers are encouraged to reconsider all ideas generated by the VE team, as previously rejected ideas may prove to be feasible as the project development proceeds beyond the scope of the VE Study.

IDEA EVALUATION

All of the ideas that were generated during the creative phase were recorded and each idea was discussed individually and the advantages and disadvantages of each were discussed.

The Idea Evaluation Summary Table containing all of the ideas, and the rating applied to each idea, is presented on the following pages. The ideas were assigned a recommendation for development as follows:

Develop	=	Develop into VE Alternative Concept
ABD	=	Being Done or Part of Original Scope
Eliminate	=	Idea Rejected or Outside Project Scope
Comb w/ No.	=	Idea Combined with Another Idea

No.	Idea Description	Development Status
Houma Lock and Gate		
H-1	Eliminate Houma Lock	Develop
H-2	Close Houma floodgate and lock traffic all the time	Comb w/ H-1
H-3	Optimize holistic system to consider HNC flow rate and need/operation of lock	Comb w/ H-1
H-4	Optimize improvement of Houma GIWW restriction with need/operation of lock	Eliminate
H-5	Divert water through Houma constriction (Twin Span bridge)	Comb w/ A-2
H-6	Eliminate restriction at Houma by replacing tunnel	Develop
H-7	Budget for maximum lock operation	Comb w/ H-2
H-8	Consider extended utilization of temporary barge gate	Develop
H-9	Relocate Gulf Island Fabrication out of Houma to eliminate gate	Eliminate
H-10	Consider dawn and dusk lock-through for continuous lock operation	Comb w/ H-2
H-11	Consider Gulf Island Fabrication traffic to be west-only and eliminate gate	Eliminate
H-12	Consider Gulf Island Fabrication traffic by road to Port of New Orleans	Eliminate
H-13	Increase lock length to 1,200 feet for continuous operation	Comb w/ H-2
H-14	Construct 250-foot lock and construct closure dam on HNC in lieu of gate (accounts for high sea level rise)	Develop
H-15	Use a barge gate for floodgate	Develop
H-16	Construct concrete sector gates or other maintenance-favorable materials	Develop
H-17	Use air curtain to block saltwater intrusion in lieu of gate	Eliminate
H-18	Implement adaptive management plan for Houma Lock	Comb w/ H-2
H-19	Install wicker gates on HNC cuts into marsh	Develop
H-20	Perform parametric analysis of project alternatives accounting for sea level rise	Comb w/ G-5
H-21	Install adjustable sill to block saltwater wedge	Eliminate
H-22	Defer construction of 200-foot gate and use local-sponsored barge gate	Comb w/ H-8
H-23	Install a salinity monitoring system on HNC to automatically close gate	Develop
H-24	Canal around bridge over GIWW to introduce more water to HNC	Comb w/ 5
Atchafalaya River Diversion		
A-1	Pump around Houma restriction	Comb w/ H-5
A-2	Address flow constrictions in the GIWW at Houma	Develop
A-3	Eliminate Houma restriction by constructing bridge and demolishing tunnel	Comb w/ H-6
A-4	Increase GIWW capacity at Houma restriction by exposing bridge abutments	Eliminate
A-5	Install permanent dredge plants at Atchafalaya Bar channel for sediment for marsh building	Eliminate

IDEA EVALUATION

Terrebonne Basin Barrier Shoreline Restoration
Multipurpose Operation of Houma Navigation Lock
Convey Atchafalaya River Water to Northern Terrebonne Marshes

No.	Idea Description	Development Status
A-6	Alter Old River Control Structure to divert additional water to Atchafalaya River as needed (70/30 congressional mandate)	Develop
A-7	Construct drawbridge in lieu of permanent bridge for tunnel replacement	ABD
A-8	Include pipeline to provide sediment to marsh areas	ABD
A-9	Assess impacts of altering ORCS flow ratio on Mississippi, Atchafalaya, Old, and Red Rivers	Comb w/ A-6
A-10	Pump Davis Pond flow from Company Canal	Develop
A-11	Construct mini-Woody's Ditch east of Houma and west of Bayou Lafourche	Develop
A-12	Raise elevation of canal south of Lake Salvador to induce flow westward	Eliminate
A-13	Incorporate effects of subsidence from fluid withdrawal into project analysis	Comb w/ G-6
A-14	Introduce saltwater re-injection to limit impacts of fluid withdrawal	Comb w/ G-6
A-15	Incorporate latest sea level rise data into project analysis	Comb w/ G-5
A-16	Require oil companies to plug canals connecting to GIWW	Develop
A-17	Expand CERCLA to tax oil/gas industry to provide funds for backfilling of canals	Comb w/ A-16
A-18	Increase federal excise tax on gas to provide funds for ecological rehabilitation projects	Eliminate
A-19	Exercise federal floodway rights in Bayou Lafourche	Develop
A-20	Deepen GIWW in lieu of raising water elevation	Eliminate
A-21	Convert brackish marshes to saltwater marsh	Eliminate
A-22	Ensure local fisheries are informed of project impacts	Develop
A-23	Limit study area to levee line of Morganza Levee Project	Eliminate
A-24	Use City of Houma wastewater effluent to replenish cypress forests	Develop
A-25	Install nutria fencing along GIWW and birth control measures throughout project area	Develop
A-26	Use Algiers and Harvey Lock as source for freshwater to HNC	Develop
A-27	Construct channel diversion south of Houma to connect to GIWW to the east	Develop
Terrebonne Basin Barrier Shoreline Restoration		
T-1	Install inverted breakwaters and use fill for replenishing back-marsh	Develop
T-2	Calculate renourishment rates required to sustain barrier islands accounting for absolute sea level rise	Develop
T-3	Use a given planning horizon (i.e., 50-year) for renourishment requirements based on a range of sea level rise	Comb w/ T-2
T-4	Obtain a clear definition of the sustainability project objective	Develop
T-5	Include renourishment costs in project costs	Develop
T-6	Establish federal trust fund for renourishment costs	Develop
T-7	Construct new barrier island chain closer to new shoreline	Develop

IDEA EVALUATION

Terrebonne Basin Barrier Shoreline Restoration
Multipurpose Operation of Houma Navigation Lock
Convey Atchafalaya River Water to Northern Terrebonne Marshes

No.	Idea Description	Development Status
T-8	Relocate Timbalier Islands to the north using existing islands as sediment source	Eliminate
T-9	Incorporate a hard core into barrier islands	Comb w/ T-10
T-10	Fix barrier islands in current location; Harden islands to reduce rate of roll over	Develop
T-11	Divert Mississippi River to provide sediment for littoral drift (“Feed the Beast”)	ABD
T-12	Prioritize which barrier islands should be saved	ABD
T-13	Use East Timbalier as a feeder island for other islands	Eliminate
T-14	Utilize sand recycling/back-passing for barrier island renourishment	Develop
T-15	Allow revetments	Comb w/ T-10
T-16	Use buried revetments	Comb w/ T-10
T-17	Use Geotubes for dune core	Comb w/ T-10
T-18	Utilize concrete armor units in lieu of rock	Comb w/ T-10
T-19	Procure environmental dredging fleet	Develop
T-20	Use C-rock for barrier island hardening and relocate as necessary to allow roll over	Eliminate
T-21	Evaluate a retreating strategy for relocating barrier islands closer to marshes	Comb w/ 7
T-22	Utilize congressional action to allocate Ship Shoal sands	Eliminate
T-23	Evaluate actual quantities of available sediment at Ship Shoal and determine appropriate locations	Comb w/ T-42
T-24	Design alternatives for future tidal prism	ABD
T-25	Close Wine Island Pass; connect East Island to Wine Island	Eliminate
T-26	Construct east end of each island wider than west end to act as sediment source; ensure islands have sufficient aspect ratio for coastal geomorphic processes	Develop
T-27	Change the term “non-structural” in project documents to “soft structural”	Develop
T-28	Utilize water injection to minimize impacts from fluid withdrawal-induced subsidence	Comb w/ G-6
T-29	Connect the two pieces of East Timbalier Island and close the pass in between	Eliminate
T-30	Prioritize project components based on habitat loss factors	Develop
T-31	Investigate additional Mississippi River diversions to provide sediment for barrier islands	ABD
T-32	Implement oil/gas industry outreach program regarding future sediment management practices	Develop

No.	Idea Description	Development Status
T-33	Conduct off-shore sediment analysis to identify alternative sources of barrier island renourishment sediment; provide MMS sufficient funds to map sediment sources	Develop
T-34	Consider variable habitat types on barrier islands	ABD
T-35	Construct permanent pipeline from Ship Shoal to the east end of Timbalier Island	Develop
T-36	Consider alternate procurement methods for construction	Develop
T-37	Construct groins and/or breakwaters with pre-filled sediment	Develop
T-38	Run dredges using green technologies in lieu of diesel	Comb w/ T-35
T-39	Add Plan Strategy that addresses habitat needs in excess of budgetary limitations	Develop
T-40	Develop Plan Strategies to evaluate differing renourishment requirements and island hardening alternatives	ABD
T-41	Use birth control agents to control nutria	Comb w/ A-25
T-42	Use MMS to regulate Ship Shoal quantities to various projects needing sediment	Develop
T-43	Relocate pipelines crossing Ship Shoal to increase sediment capacities available	Eliminate
T-44	Use abandoned pipelines at Ship Shoal for sediment transport	Eliminate
T-45	Utilize back-bay material for renourishment of barrier islands	Eliminate
General/Plan Formulation		
G-1	Use upwelling ram pumps to bring cold water to ocean surface to reduce hurricane intensities	Eliminate
G-2	Use ram pumps to power sediment transport piping	Eliminate
G-3	Develop a seasonal freshwater management plan	Develop
G-4	Create federal advisory committee to represent the migratory bird interests (FACA)	Develop
G-5	Perform parametric analysis of project alternatives accounting for the three levels of sea level rise	Develop
G-6	Identify and incorporate effects of subsidence from fluid withdrawal into project analysis	Develop

VE TEAM AND PROCESS

VE TEAM AND PROCESS

The SAVE International VE Job Plan was followed to analyze the criteria/functions of the project and the issues of concern, create and evaluate ideas for change, and develop and present alternatives to the project team and stakeholders.

VE TEAM AND PROCESS

This four-day VE Study was performed during the period of May 5 – 8, 2009. The study was facilitated by Mark Watson, a Professional Engineer and Certified Value Specialist with Value Management Strategies, Inc. The VE team members and key project contacts are listed below.

The VE Team included:

David Cannon	Everest International Consultants	Coastal Engineer
Ron Tanenbaum	Value Management Strategies, Inc.	Geotechnical Engineer
Frank Vicidomina	USACE-New Orleans District	Co-VE Team Leader
Wes Wilson	Environmental Protection Agency	Environmental Engineer
Chester Watson	Biedenharn Group, LLC	Hydraulics Engineer
Mark Watson	Value Management Strategies, Inc.	VE Team Leader

A complete list of all study participants is documented on the subsequent pages at the end of this section

The SAVE International VE Job Plan was followed to analyze the criteria/functions of the project and the issues of concern, create and evaluate ideas for change, and develop and present alternatives to the project team and stakeholders.

Value Engineering is a strictly adhered to process that follows specific steps and procedures. The specific steps in the VE process are as follows:

Step 1: Preparation – Developing a basic understanding of the client's/user's needs and requirements, specific goals, and current costs, with an agreement on the scope of the study.

Step 2: Information – Which is gathered prior to and during the study, and is reviewed and discussed with the team. A summary of project constraints, critical issues, and observations from field inspection can be found in the *Project Analysis* section**.**

Step 3: Function Analysis – Defines the functions of the project through an organized use of the Function Analysis System Technique (FAST) diagram that shows how the functions are related to one another. One FAST diagram was developed for this study and is shown in the *Project Analysis* section.

Step 4: Speculation – Also known as creativity, it is the application of brainstorming techniques to develop a large quantity of ideas rather than focusing on the quality of ideas. A complete list of workshop ideas can be found in the *Idea Evaluation* section.

Step 5: Evaluation – Reduces the large quantity of ideas to a few high quality ideas.

Step 6: Development – The concepts identified in the evaluation phase are developed into specific VE alternatives that have been technically validated and quantified as much as possible.

Step 7: Report – Containing the VE team's recommendations and a presentation to the project stakeholders to receive their approval of these recommendations.

Step 8: Implement and Audit – Tracking the implementation of alternatives and auditing the results measures the effectiveness of the VE effort.

MEETING ATTENDEES
Terrebonne Basin Barrier Shoreline Restoration
Multipurpose Operation of Houma Navigation Lock
Convey Atchafalaya River Water to Northern Terrebonne Marshes
VALUE ENGINEERING STUDY

NAME	ORGANIZATION	POSITION	PHONE/CELL	EMAIL
Mark Watson	Value Management Strategies, Inc.	VE Team Leader	(816) 206-0067	mark@vms-inc.com
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Pam DeLoach	USACE-New Orleans District	Engineering Team Leader	(504) 862-2621	pamela.a.deloach@usace.army.mil
Aaron Bass	SJB Group	Coastal Scientist	(225) 769-3400	abass@sjbgroup.com
Carol Parsons Richards	LA Office of Coastal Project & Restoration	Coastal Resources Supervisor	(225) 342-9430	carol.richards@la.gov
William Klein	USACE-New Orleans District	Biologist	(504) 862-3540	william.p.klein@usace.army.mil

APPENDICES

APPENDICES

The following documents are provided as reference material to the results of this VE Study.

A. Coastal Impact Assistance Program Application – Houma Navigation Canal Lock, May 22, 2006; Terrebonne Levee Conservation District

B. Conceptual floating barge gate designs

C. VE Study – Bayou Lafourche Siphon Restoration Project, July 2001; Proposal C-1

D. Preparation of a Multi-Project Environmental Assessment to evaluate the potential environmental impacts associated with the removal of sand resources from Ship Shoal, offshore Central Louisiana

E. Louisiana Sand Management Working Group Meeting Minutes, 2 February 2005

F. Information on Relative Sea-Level Rise as prepared by Kevin Knuuti, P.E., Chief, Engineering Division, U.S. Army Corps of Engineers, Sacramento, CA

G. Multi-Pit Breakwaters, *Journal of Waterway, Port, Coastal, and Ocean Engineering*, William G. McDougal, A. Neil Williams, and Keizo Furukawa, January/February 1996

H. MMS Management of Outer Continental Shelf Material Deposits and related information

Appendix A

Coastal Impact Assistance Program Application

Houma Navigation Canal Lock
May 22, 2006

Project Title - Houma Navigational Canal Lock

Nominating Agencies – This project is a joint nomination from the following agencies:

Terrebonne Levee and Conservation District
Terrebonne Parish Consolidated Government

The project is supported by the following entities via the attached resolutions of support:

Terrebonne Cons. Waterworks District No. 1
Lafourche Waterworks Dist. No. 1
South Lafourche Levee District
Bayou Lafourche Fresh Water District
Terrebonne Parish Coastal Zone Advisory Board
Terrebonne Port Commission
Lafourche Parish Government
North Lafourche Levee District
Houma Terrebonne Chamber of Commerce

Point of Contact:

The point of contact for this project is:

Mr. Jerome Zeringue, Executive Director
Terrebonne Levee and Conservation District
220 Clendenning Road
Houma, La. 70361

jzee@tlcd.org

Total CIAP Funds Requested:

As outlined in the guidance for the application process as dictated by DNR, as well as the preliminary guidance issued by the Minerals Management Service, the nominating agencies have worked to find other cost sharing funding sources for the HNC Lock. The nominating agencies have identified four other sources that are available and applicable to the lock project. They are as follows:

Terrebonne Parish CIAP Funding	$ 10 Million	6 %
State CIAP Funding	100	55
Local Sales Tax Dollars	20	11
State Capital Outlay	20	11
Federal Appropriations	30	17
Total	**180**	**100 %**

The ongoing design and environmental impact analysis of the lock complex, described below, has been funded by a combination of the local sales tax, state capital outlay, and federal appropriations. With the addition of the CIAP funding, the project can be constructed.

Infrastructure Funds Requested:

$ 0

The Houma Navigation Canal Lock will provide both environmental and flood control benefits. The lock complex, including the large floodgate, will be operated for an average of 90 days each fall to prevent salt water intrusion. This time period is clearly identifiable on the attached enclosures. Enclosure 1 depicts the number of days over the past 60 years that the salt content in the water (as measured at the Houma Water Treatment Plant) has exceeded 250 mg/l. This is the standard used by the Consolidated Water District in Houma to decide when the Houma Navigation Canal/Intracoastal Waterway are too salty to use for potable water. Enclosure 2 depicts the mean number of days that this standard is exceeded in a given year, distributed over the various months of the year. This data demonstrates that salt water intrusion occurs primarily during September, October, and November, on average. This information was also the basis for the calculation of salt water reduction benefits in the Final Feasibility Study and Environmental Impact Statement for the Morganza to the Gulf Project (2002).

It will also be operated for an equal amount of time in the spring during periods of high Atchafalaya River flow to encourage freshwater diversion. Based on historical flows, the high flows usually occur in the months of March, April, and May. These high river stages usually exist for approximately 90 days.

By comparison, the lock complex will most likely be operated only for a few days per year (20 on average) for storm surge prevention. This number is based on the average days of closure over the last 4 years at the existing Bayou Terrebonne and Bayou Little Caillou Floodgates. Even on those days, the lock complex will provide significant salt water intrusion benefits as well.

Based on these operational criteria, the lock will be operated approximately 90% of the time (180 days out of 200 total days) in an average year for environmental benefits, primarily marsh conservation and preservation. Using this rational, any funds dedicated for the lock should be considered non-infrastructure in nature.

This characterization may seem contradictory since the lock complex is a large project both in size and cost; however, every coastal restoration/preservation project from the smallest to the largest, consists of physical improvements (water control structures, levees, pumps, etc) that would be considered infrastructure in another setting. A water control structure can be used for wetland preservation as well as infrastructure improvements in the right setting. The Houma Navigation Canal setting, and the resulting onshore OCS impacts, merely requires a larger solution than other locations.

Description/Location of Project

The Houma Navigation Canal Lock would be located in Dulac, Louisiana, near the confluence of the Houma Navigation Canal and Bayou Grand Caillou. Enclosure 3 and 4 are a vicinity map and project sketch. The lock complex will consist of a 200' Wide flood gate, a 110' wide by 800' long lock chamber, and the associated necessary improvements to the site, all built in a realigned channel just west of the existing Houma Navigation Canal. The project also includes a closure dam across the existing channel once the new structure and channel are built. The new lock and floodgate will be built primarily on an existing maintenance dredging spoil disposal area on the west bank of the existing channel. The project will be built in this method to allow for continued, uninterrupted navigation in support of OCS activities through the channel during construction.

The 200' wide floodgate is designed to allow for continued use of the channel by the offshore fabrication industry located in Houma, 20 miles to the north. It allows for use of the channel by structures up to 250' wide through innovative design techniques.

The lock chamber is a key component of the complex because it will allow for continued use of the waterway during periods of salt water intrusion and fresh water management. During those periods, the flood gate will be closed, and smaller navigation will be routed through the lock chamber. Also during those periods, but much less frequently, the larger flood gate will have to be opened for a short period of time to allow for passage of the larger structures. These passages will usually only require a 12 hour opening of the large floodgate.

Project Type

The project fits the characteristics of several project types as outlined in the CIAP legislation, but most accurately fits category (1), conservation, restoration and protection of coastal areas, including wetlands. As described above, the lock will be operated for approximately 90% of the time to manage salt water intrusion and fresh water distribution. Operation in this manner will conserve and protect vast amounts of wetlands within the Terrebonne Basin. The remaining operational time will be for storm surge protection, which also provides significant salt water prevention benefits.

Project Justification

The project justification will be provided in a format corresponding to the evaluation criteria as outlined on the DNR CIAP application guidance.

1) Is the project free of issues that may impact timely implementation of the project?

This project can be implemented (begin construction) by December 2007. There are no projects of a similar size and scope that can be implemented in such a short time frame. This project can be implemented in this time frame because it has been the subject of a detailed engineering and environmental planning process for the last six years. The lock complex has been in design since 2000, with a 50% design deliverable recently submitted and reviewed. The design costs to date total $8 Million, with and additional $2 Million needed to complete the design. URS, Corp., as the design firm on the project, will complete final design by December, 2007.

Concurrent with the design process, the Corps of Engineers (COE) is performing an Environmental Impact Statement on the lock complex at a cost of approximately $100,000 (to date). This EIS is in process, and will include an analysis of the immediate and secondary environmental impacts and benefits of the lock complex, including affects on freshwater flows both near and detached from the structure.

The design and EIS are supported by both a numerical and physical model, at a cost of $ 1 Million (to date). The numerical model, referred to as the system wide model, will analyze freshwater distribution throughout the Terrebonne Basin. The physical model will help identify design issues, freshwater flows, and navigation concerns.

Notably, both the design and the EIS have been conducted in a collaborative fashion, with input from the following agencies and interested parties:

La. DNR	TLCD
La. DOTD	US EPA
US ACE	US FWS
NMFS	La. DWF
La. DEQ	Terr. Parish School Board

The result of this process is a project that has been, and will continue to be, fully analyzed and critiqued from multiple perspectives. This is the only major coastal project that has been subject to this level of review and analysis, and is ready to be implemented. As a result, the issues that may affect implementation of the project have been identified, In the LCA Study, the Houma Navigation Canal Lock is one of the ten short term projects. This study effort also included many of the same parties involved in the Coast 2050 effort. In both studies, the Houma Navigation Canal Lock is identified as the most important project in the Terrebonne Basin and the project which could have the greatest systemic effects in that basin.

The lock complex also meets the goals and objectives of Action Plans EM-1 (Hydrologic Restoration), EM-2 (Freshwater and Sediment Diversion) and EM-7 (Marsh Management) of the Barataria-Terrebonne National Estuary Program (BTNEP).

In summary, the construction of the Houma Navigation Canal Lock has been recommended in 3 separate comprehensive reports on the most important restoration measures for the Terrebonne Basin.

In addition, the Houma Navigation Canal Lock can be used to improve the operation of other proposed coastal restoration projects. The Lake Boudreaux Freshwater Introduction Project and the Grand Bayou Freshwater Introduction Project are CWPPRA projects which rely on freshwater distribution out of the Houma Navigation Canal and the Gulf Intracoastal Waterway, respectively. Both projects have been approved based on using the currently available freshwater resources in those waterways. When the Houma Navigation Canal Lock is operated for freshwater distribution, it should encourage more flows into those areas, thereby increasing the effectiveness of those projects. Additionally, the Falgout Canal Marsh Management Project should have greater effectiveness when the Houma Navigation Canal Lock is used to reduce saltwater intrusion.

3) Does the proposed project protect health, safety, or infrastructure of national, state, regional or local significance?

This proposed project protects many types of infrastructure of extreme importance. The project will protect the economic vitality of Lafourche and Terrebonne Parishes by protecting the freshwater drinking resources of both communities. The Houma Navigation Canal is the primary conduit for saltwater intrusion in the Terrebonne Basin. It affects the main water plant in Houma. The water plant in Houma provides the majority of the drinking water for Terrebonne Parish. It is routinely affected by saltwater intrusion every fall (Enclosure 1 & 2).

The Lafourche Waterworks District No. 1 in Lockport is also negatively affected by saltwater intrusion. The saltwater travels down the Intracoastal Waterway to the Company Canal and up the Company Canal to Lockport. This plant produces the water for the majority of central and southern Lafourche Parish, including Port Fourchon. These waterways provide the potable water for over 200,000 persons in the heart of the oil and gas industry in south central Louisiana. When drought conditions exist, as they have earlier this year, our citizens literally taste coastal erosion in their drinking water. This drinking water benefit was valued at $193,000 per year over the 50 year project life, The saltwater intrusion benefits were calculated in the Morganza to the Gulf Hurricane Protection Project Study. The benefits to the potable water supply in Terrebonne and Lafourche Parishes was outlined in preceding paragraphs. The habitat benefits of preventing salt water intrusion were analyzed in an April, 1997, report by the COE. In that study, it was calculated that the lock complex would benefit approximately 188,000 acres of habitat over the project life, primarily by reducing salinities.

The benefits of managing the freshwater resources of the area are currently being analyzed in the system wide model. This model is being run by the Corps of Engineers at the request of the state and federal resource agencies associated with the Morganza to the Gulf Study. As described earlier, the purpose of this model is to determine the changes to the distribution of freshwater resources throughout Terrebonne Parish by building and operating the Houma Navigation Canal Lock. This model has been constructed and the model runs will be completed this summer.

The system wide model will be used in conjunction with a physical model of the lock complex. This physical model has been constructed by the Corps of Engineers in Vicksburg. This model will also be used to insure, among other things, that navigation will not be negatively affected by the lock.

As discussed above, this feature is currently the object of a 6 year, $8 Million design effort, and a 2 year, $1 million physical and numerical model effort. This project has been analyzed to a greater extent than any other project on the coast of Louisiana, and the benefits associated with it are as certain as any project could be.

6) Does the proposed project address an area of critical conservation/ restoration need or a high loss area?

The project addresses an area of critical conservation or restoration need in a very high loss area of Louisiana. The Terrebonne Basin has historically been one of the highest loss areas in central Louisiana, averaging 10 square miles per year in loss over the last 40 years. At the same time, the Terrebonne Basin, particularly the east side of the Terrebonne Basin, has had very few options for significantly restoring wetlands. This project is the only project that can provide **systemic** benefits in the near term. This is the reason why this project was a part of the Coast 2050, BTNEP, and LCA efforts. It has been clearly recognized as the lynch pin of the restoration of the Terrebonne Basin.

7) How sustainable are the benefits of the proposed project?

The benefits of this project are sustainable for 50 years. The design life of the Houma Navigation Canal Lock is 50 years. The Houma Navigation Canal Lock is also unique in that there is an existing, fully funded local sponsor with the capability of operating and maintaining the lock. The TLCD has already committed, in association with the La.DOTD, to be the local sponsor for the Morganza to the Gulf Hurricane

Protection Project, including the lock. The local sponsor has the primary responsibility within that project for operation and maintenance of the project features, including the lock complex. The TLCD has the capability and the funding stream, in association with the La.DOTD, to operate and maintain this feature for its design life. There are very few other similarly situated coastal protection projects in the State of Louisiana.

Project Cost Share

As outlined in the guidance for the application process as dictated by DNR, as well as the preliminary guidance issued by the Minerals Management Service, the nominating agencies have worked to find other cost sharing funding sources for the HNC Lock. The nominating agencies have identified four other sources that are available and applicable to the lock project. They are as follows:

Terrebonne Parish CIAP Funding	$ 10 Million	6 %
State CIAP Funding	100	55
Local Sales Tax Dollars	20	11
State Capital Outlay	20	11
Federal Appropriations	30	17
Total	**180**	**100** %

The ongoing design and environmental impact analysis of the lock complex, described below, has been funded by a combination of the local sales tax, state capital outlay, and federal appropriations. With the addition of the CIAP funding, the project can be constructed.

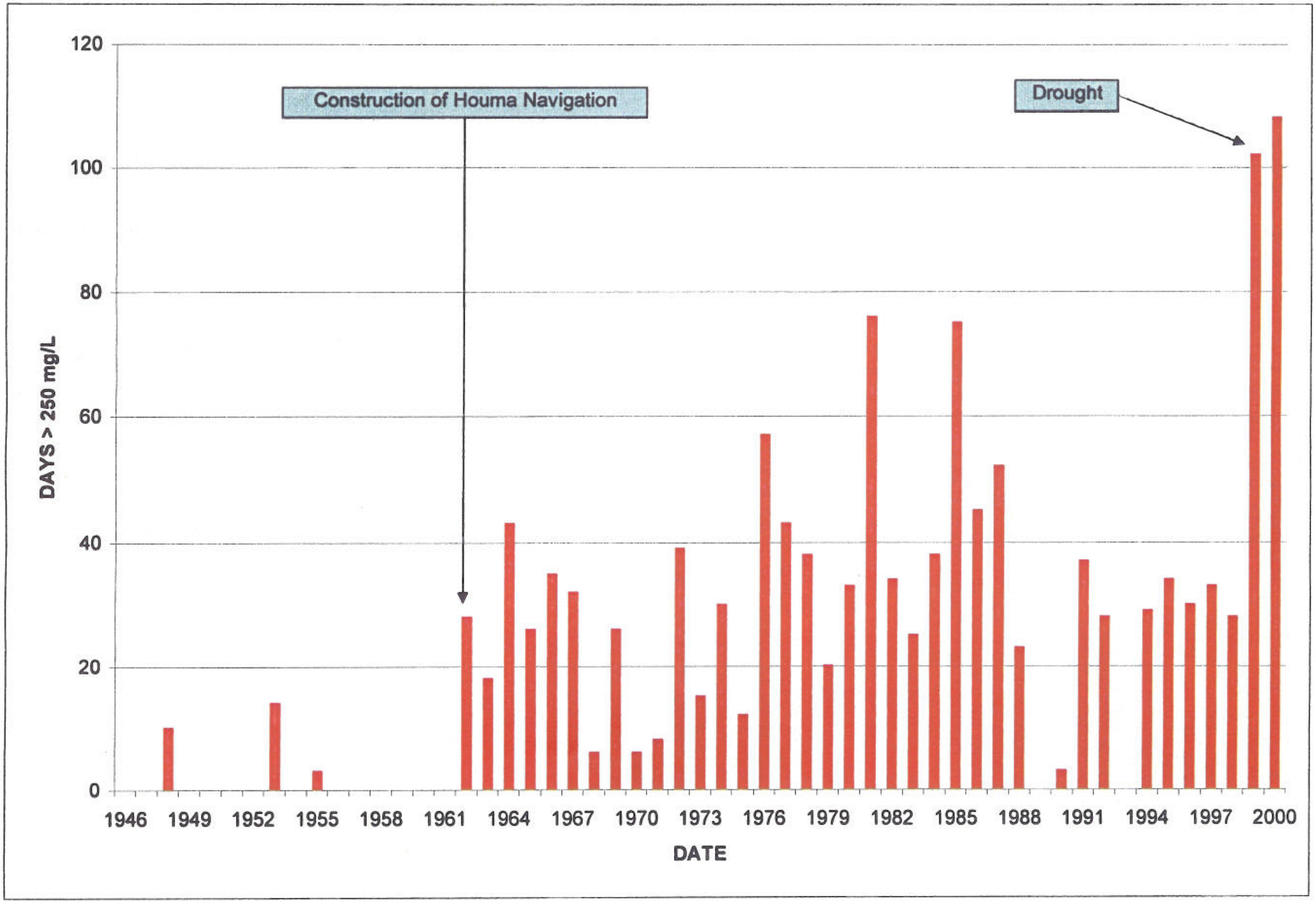


Figure 9. Days per year that chlorides measured > 250 mg/L at the Houma Water Treatment Plant on the Intracoastal Canal near its confluence with the Houma Navigation Canal.

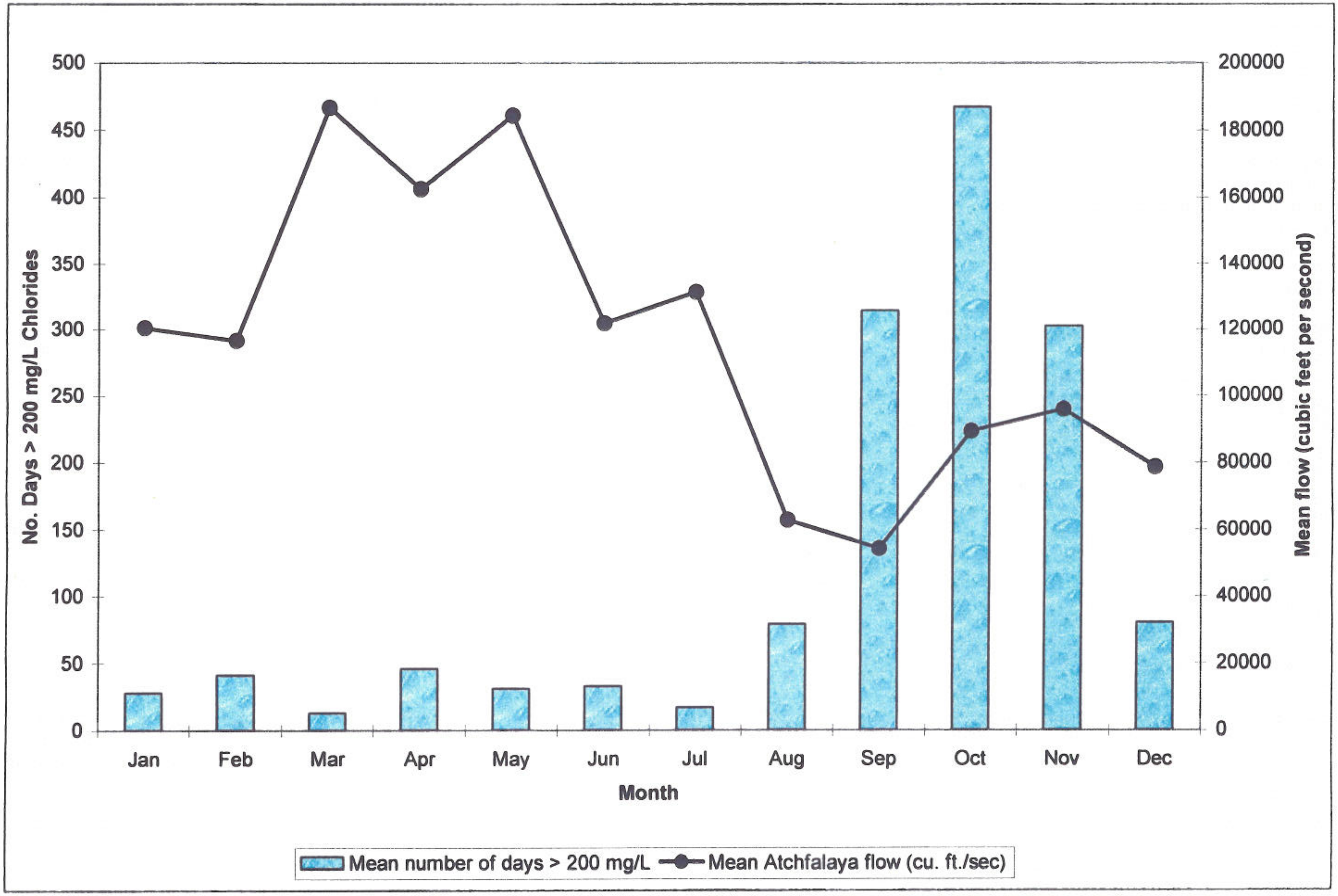
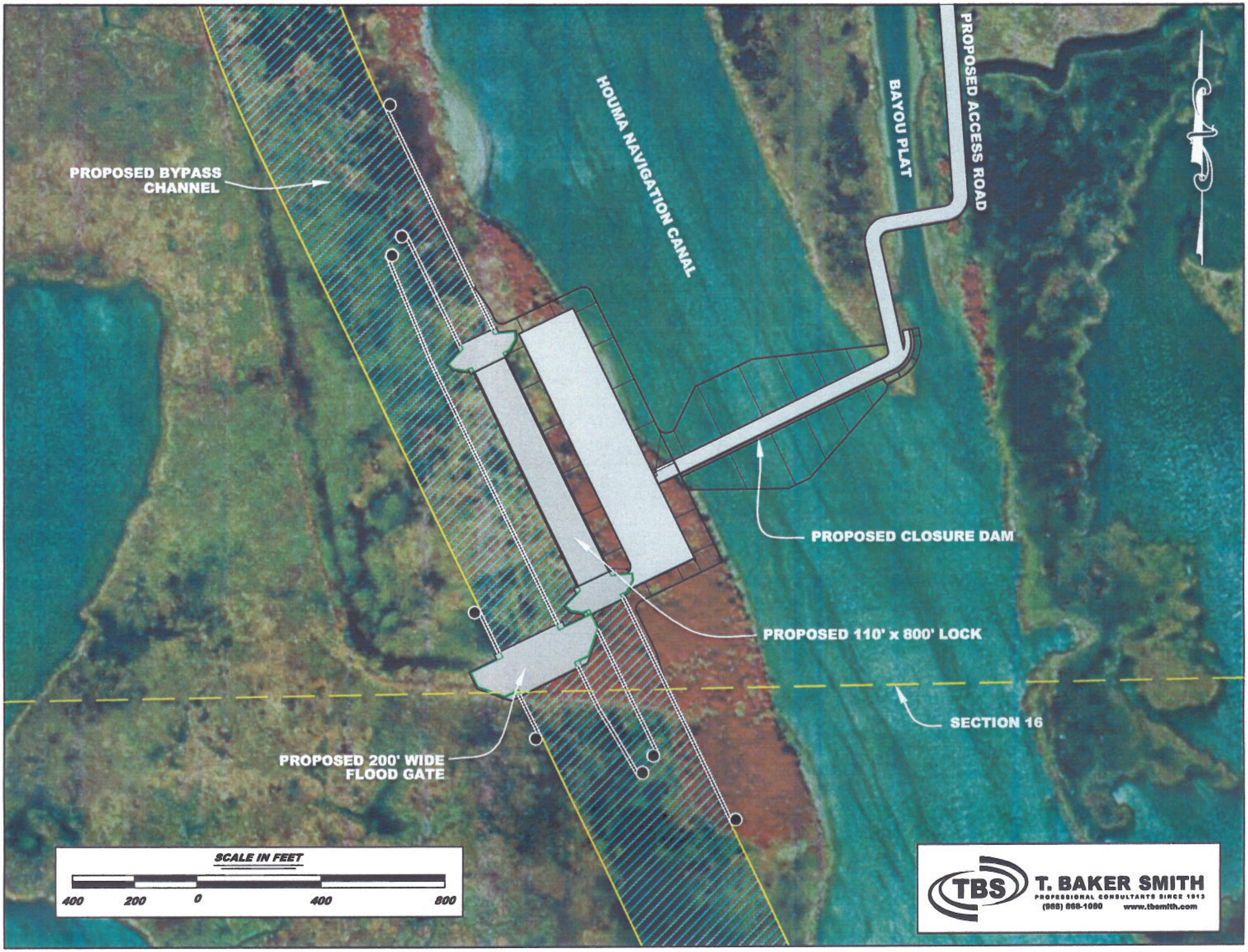


Figure 10. Mean monthly days at the Houma Water Treatment Plant with chlorides > 200 mg/L compared to mean monthly flow of Atchafalaya River at Morgan City.


PROPOSED ACCESS ROAD
BAYOU PLAT
HOUMA NAVIGATION CANAL
PROPOSED BYPASS CHANNEL
PROPOSED CLOSURE DAM
PROPOSED 110' x 800' LOCK
SECTION 16
PROPOSED 200' WIDE FLOOD GATE
SCALE IN FEET
400 200 0 400 800
TBS
T. BAKER SMITH
PROFESSIONAL CONSULTANTS SINCE 1913
(985) 868-1050 www.tbsmith.com

VICINITY MAP

**PROPOSED HOUMA NAVIGATION CANAL LOCK
FOR THE
MORGANZA TO THE GULF, HURRICANE PROTECTION SYSTEM**

Appendix B

DOD SERVICE: USACE
CONTROL NO: CEMVN-VE-01-05
VALUE ENGINEERING OFFICER: Frank Vicidomina, PE, CVS

Value Engineering Study on the

HOUMA NAVIGATION CANAL LOCK

JANUARY 2001
U.S. Army Engineer District, New Orleans

VALUE ENGINEERING FIRM NAME: OVEST
ADDRESS: 100 W. Oglethorpe Avenue
Savannah, Georgia 31401
PHONE: (912) 652-5448

VALUE ENGINEERING STUDY TEAM LEADER: WARREN WITHERS
(912) 652-5958

VALUE ENGINEERING STUDY TEAM MEMBERS:

Frank Vicidomina
Meredith Godoi
Ron Tanenbaum
Eara Merritt
Rick Gangloff
John Burnworth
Jason C. Merritt
Warren Withers
Charles Claghorn

DESCRIPTION: Use Hinged Barge Gate (200'-250') with 84'x750' Lock

ORIGINAL DESIGN:

The current plan requires the construction of a 200-foot wide by 1,200-foot long multi-purpose lock structure on the Houma Navigation Canal (HNC). The lock bottom elevation is –20. (See Drawing No. 1).

PROPOSED DESIGN:

This proposal recommends that a 200-foot wide hinged barge gate structure (bottom elevation of –20) and an 84-foot wide by 750-foot long lock structure (bottom elevation of –15) be constructed on the HNC in lieu of the 200-foot by 1,200-foot lock structure. The gate would be a hinged barge gate with cut-off walls to close the remainder of the Houma Navigation Canal. The barge would pivot about a hinge until either closed or completely opened. The barge would be pumped out to raise and float in into position with thrusters, then sunk into its opened or closed position. (See Drawing No. 2).

ADVANTAGES:

1. Significantly reduces project costs.
2. Less disruption to traffic.
3. May be more reliable than sector gates for this size structure.
4. Reduced O&M costs.
5. Allows for passage of large structures (through gate) during certain periods of time.
6. Can be floated to a yard for maintenance.
7. Reduces required depth of lock structure.
8. Allows reduction of lock width and length.

DISADVANTAGES:

1. Siltation could be more of a problem than with sector gate.
2. Secure closure under possible reverse head conditions must be considered in design.
3. Possible longer time to open/close required.

JUSTIFICATION:

This proposal will provide similar storm surge protection, salt water control, and lockage functions of the current design at a substantially reduced cost. A hinged barge gate could be more reliable than sector gates for structures of this size. The barge could be completely removed when not needed to accomplish maintenance in a yard off-site.

JUSTIFICATION (continued):

Separation of the 200-foot gate from the lock would appear to warrant both width and length reduction of the lock given the apparent traffic consisting of primarily crew and fishing boats. Sector gates have been the preferred choice for smaller applications. It should be noted, however, that there is a geometric divergence in the total structure size of a sector gate relative to other "bar-type" or "door-type" alternatives. There are significant concerns with possible (unknown) operational problems of sector gates of this size. Siltation problems, alignment of drive systems, and other currently unforeseen difficulties appear to warrant concern. Maintenance, particularly that of the removal of such large gates, also appears to be an issue.

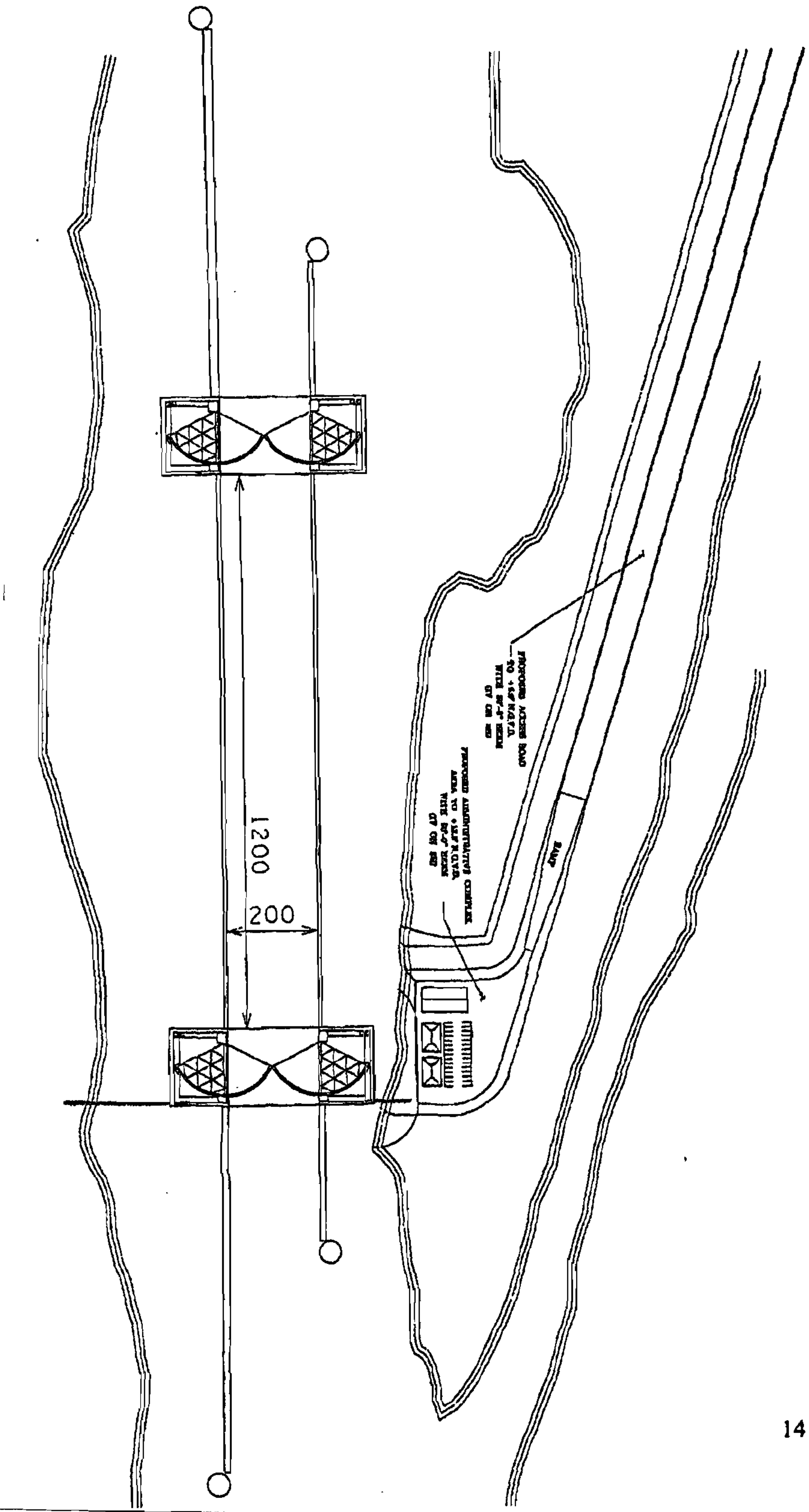
Conversely, there are certain concerns with the proposed change. There are currently two large gates in operation in the Terrebonne Flood Protection System (Bayou Delarge and Petit Caillou). Some problems have been encountered with closure under flowing water conditions. It appears that such problems could be solved through further engineering. Reverse operating head criteria, currently shown at 5.0 feet for the lock structure, appears to be overly conservative for the gate portion of the system since some waiting on more favorable tide conditions can be done. A reverse operating head of about 2.5 feet would appear justified.

Although this type of gate may take longer to open and close, it is not believed that any significant salt water intrusion volume would occur, especially if operation (to pass a rig) is coordinated with tide change.

Given the unique large size of these gates and the probable known and unknown problems to be encountered, the further detailed evaluation of alternative gate types appears to be warranted.

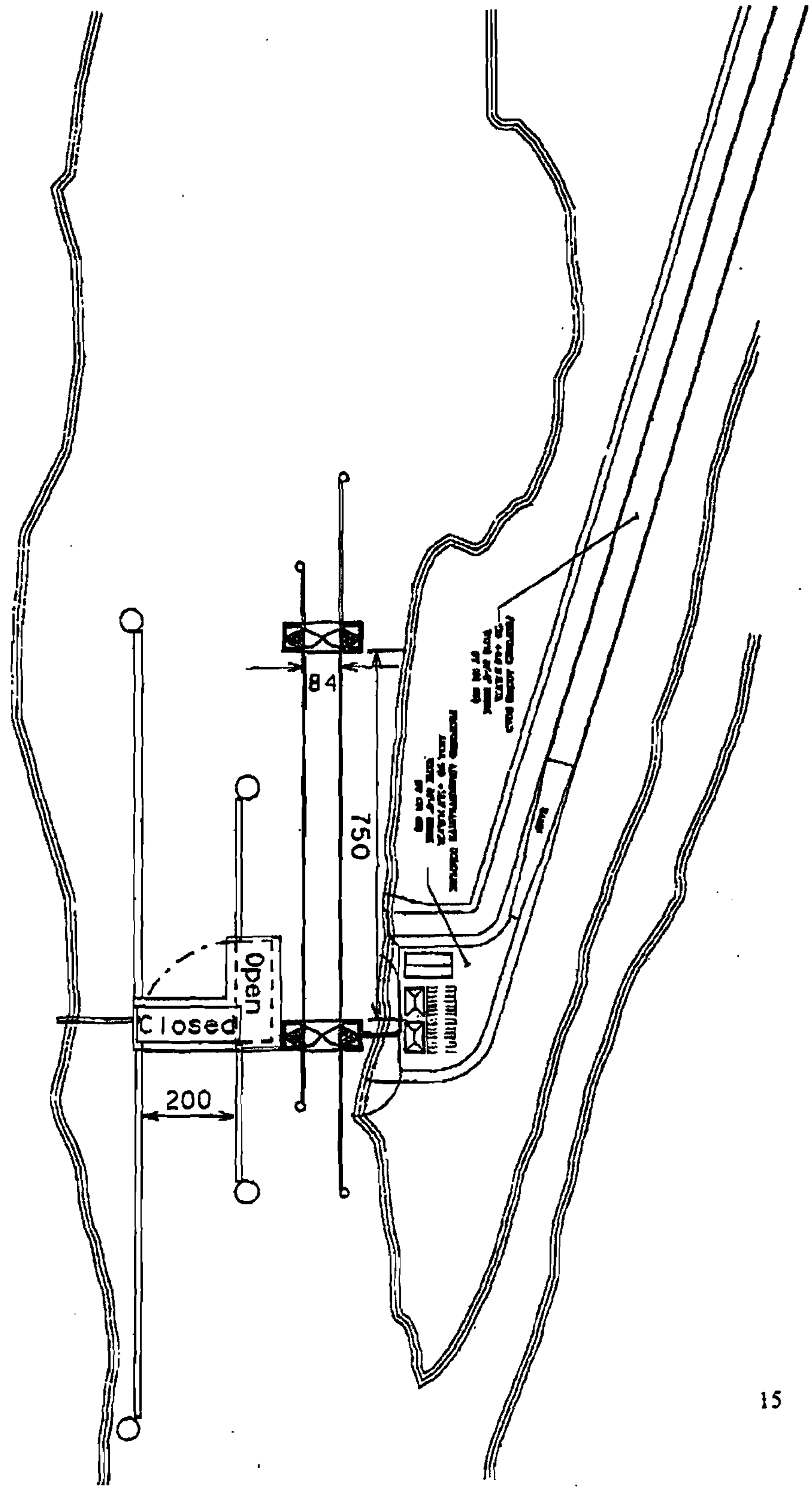
DRAWING NO 1:

EXISTING DESIGN WITH 200'x1200' LOCK



DRAWING NO 2:

PROPOSED DESIGN WITH 200' HINGED BARGE GATE AND 84'x750' LOCK



DRAWING NO 2:

CALCULATIONS

SCALE-UP CALCULATIONS:

200' Floodgate On HNC (200'x28') **(Feasibility Study)**	**=**	**$51,500,000**
Change to 38' height x 38/28	**=**	**$69,900,000**
x 2 gatebays	**=**	**$139,800,000**
Add chamber (+$23,600,000)	**=**	**$163,400,000**
Raise chamber (375 x 1,200 x 2 x 5) = $4,500,000 **(elevation 28 to 33) (elevation –20 to –10)**	**=**	**$167,900,000**
Appurtenant structures = $2,600,000 **(from Englewood Lock)**	**=**	**$170,500,000**

COST ESTIMATE WORKSHEET

PROPOSAL NO.: C-1 Use Hinged Barge Gate (200'-250') with 84'x750' Lock

DELETIONS

ITEM	UNITS	QUANTITY	UNIT COST	TOTAL
200'x1200' lock with cut-off walls	LS	1.00	$170,500,000	$170,500,000
(See attached scale-up calculation)				$0
				$0
				$0
				$0
				$0
				$0
				$0
		Total Deletions		$170,500,000

ADDITIONS

ITEM	UNITS	QUANTITY	UNIT COST	TOTAL
84'x750' lock with cut-off walls	LS	1.00	$46,400,000	$46,400,000
200' gate structure (hinged barge gate)	LS	1.00	$22,500,000	$22,500,000
				$0
				$0
				$0
				$0
				$0
				$0
				$0
				$0
		Total Additions		$68,900,000
		Net Cost Decrease		$101,600,000
		Mark-ups	0.00%	$0
		Total Cost Decrease		$101,600,000

VALUE ENGINEERING PROPOSAL

PROPOSAL NO: C-4 PAGE NO: 1 OF 5

DESCRIPTION: Use a Balanced Swing Gate with 84'x750' Lock

ORIGINAL DESIGN:

The current plan would construct a 200-foot wide by 1,200-foot long multi-purpose lock structure with sector gates on the Houma Navigation Canal (HNC). (See Drawing No. 1).

PROPOSED DESIGN:

This proposed design recommends two floating swing gates for flood control plus a smaller 84-foot wide by 750-foot long lock structure. (See Drawing No. 2). (See Appendix E, Supporting Information).

ADVANTAGES:

1. Significantly reduces project costs.
2. Reduced forces acting on the balanced structure.
3. Gates can withstand storm forces with less calculated stress (less possibility of damage).
4. Reduced O&M costs.
5. Allows for passage of large structures (through gate) during certain periods of time.
6. Can be floated to a yard for maintenance.
7. Allows for depth, width and length reduction of lock.

DISADVANTAGES:

1. Gates are large and have not been modeled by computer.
2. Lack of familiarity with this type of gate structure (operation and maintenance).

JUSTIFICATION:

The justification for this proposal is the cost reduction of a smaller lock and swing gate for flood control when compared with large sector gates. Smaller swing gates have been built with success. The theoretical reduction of operating forces should also decrease the time between maintenance periods which will further reduce costs. Balanced gates should function efficiently.

JUSTIFICATION (continued):

Separation of the 200-foot gate from the lock would appear to allow depth, width and length reduction of the lock given the apparent traffic consisting of primarily crew and fishing boats. Sector gates have been the preferred choice for smaller applications. It should be noted, however, that there is a geometric divergence in the total structure size of a sector gate relative to other "bar-type" or "door-type" alternatives. There are significant concerns with possible (unknown) operational problems of sector gates of this size. Siltation problems, alignment of drive systems, and other currently unforeseen difficulties appear to warrant concern. Maintenance, particularly that of the removal of such large gates, also appears to be an issue.

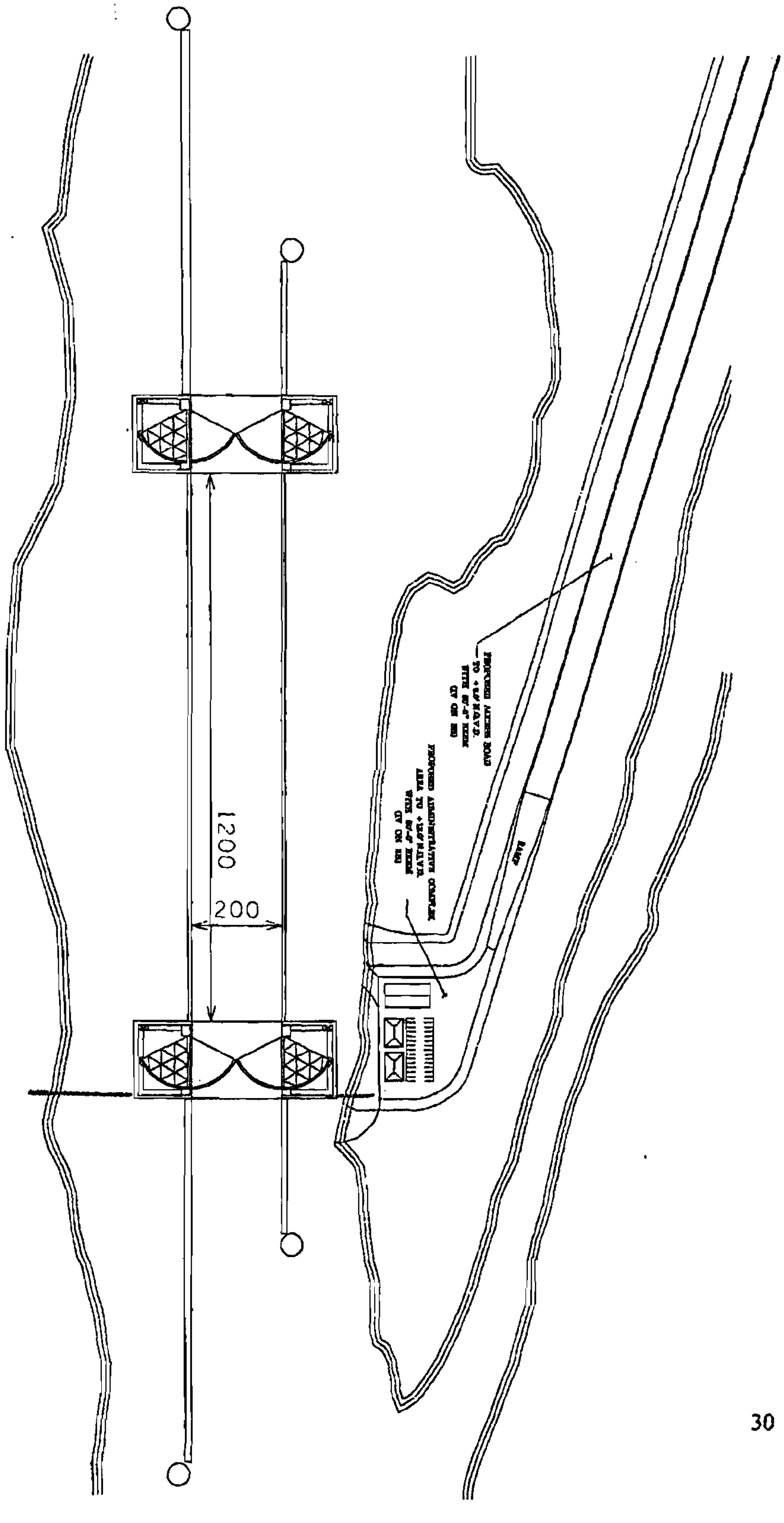
Conversely, there are certain concerns with the proposed change. It appears that such problems could be solved through further engineering. Reverse operating head criteria, currently shown at 5.0 feet for the lock structure, appears to be overly conservative for the gate portion of the system since some waiting on more favorable tide conditions can be done. A reverse operating head of about 2.5 feet would appear justified.

Although this type of gate may take longer to open and close, it is not believed that any significant salt water intrusion volume would occur, especially if operation (to pass a rig) is coordinated with tide change.

Given the unique large size of these gates and the probable known and unknown problems to be encountered, the further detailed evaluation of alternative gate types appears to be warranted.

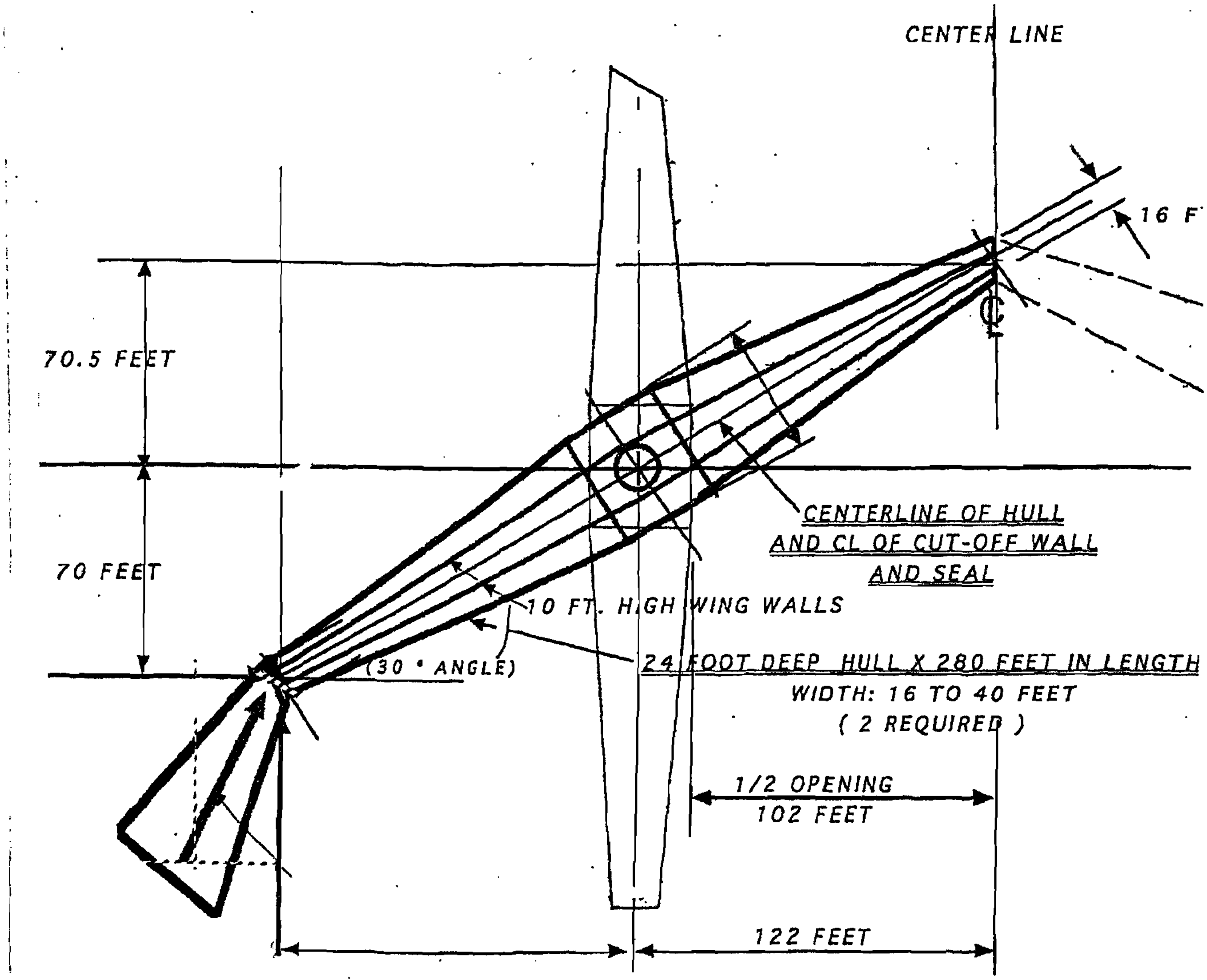
DRAWING NO 1:

EXISTING DESIGN WITH 200'x1200' LOCK



DRAWING NO 2:

PROPOSED DESIGN WITH BALANCED SWING GATE



	COST ESTIMATE WORKSHEET				
	PROPOSAL NO.: C-4 Use a Balanced Swing Gate				PAGE 5 OF 5
	DELETIONS				
	ITEM	UNITS	QUANTITY	UNIT COST	TOTAL
	200'x1200' lock (with sector gates)	LS	1.00	$170,500,000	$170,500,000
					$0
					$0
					$0
					$0
					$0
					$0
					$0
			Total Deletions		$170,500,000
	ADDITIONS				
	ITEM	UNITS	QUANTITY	UNIT COST	TOTAL
	84'x750' lock	LS	1.00	$46,400,000	$46,400,000
**	Swing gates, controls, misc.	LS	1.00	$24,100,000	$24,100,000
					$0
					$0
					$0
					$0
					$0
					$0
					$0
					$0
			Total Additions		$70,500,000
			Net Cost Decrease		$100,000,000
			Mark-ups	0.00%	$0
			Total Cost Decrease		$100,000,000
**	See estimate in Appendix E, Supporting Information (minus contingency).				

SUPPORTING INFORMATION

Balanced Swing Gate (Proposal C-6)

BALANCED SEGMENTED ARCH FLOODGATE: 200 FOOT CHANNEL:

The balanced segmented arch floodgate (BSA-Floodgate) has the following advantages over other proposed large-span floodgates, as follows: (280 x 24 ft x 40-16 ft. width):

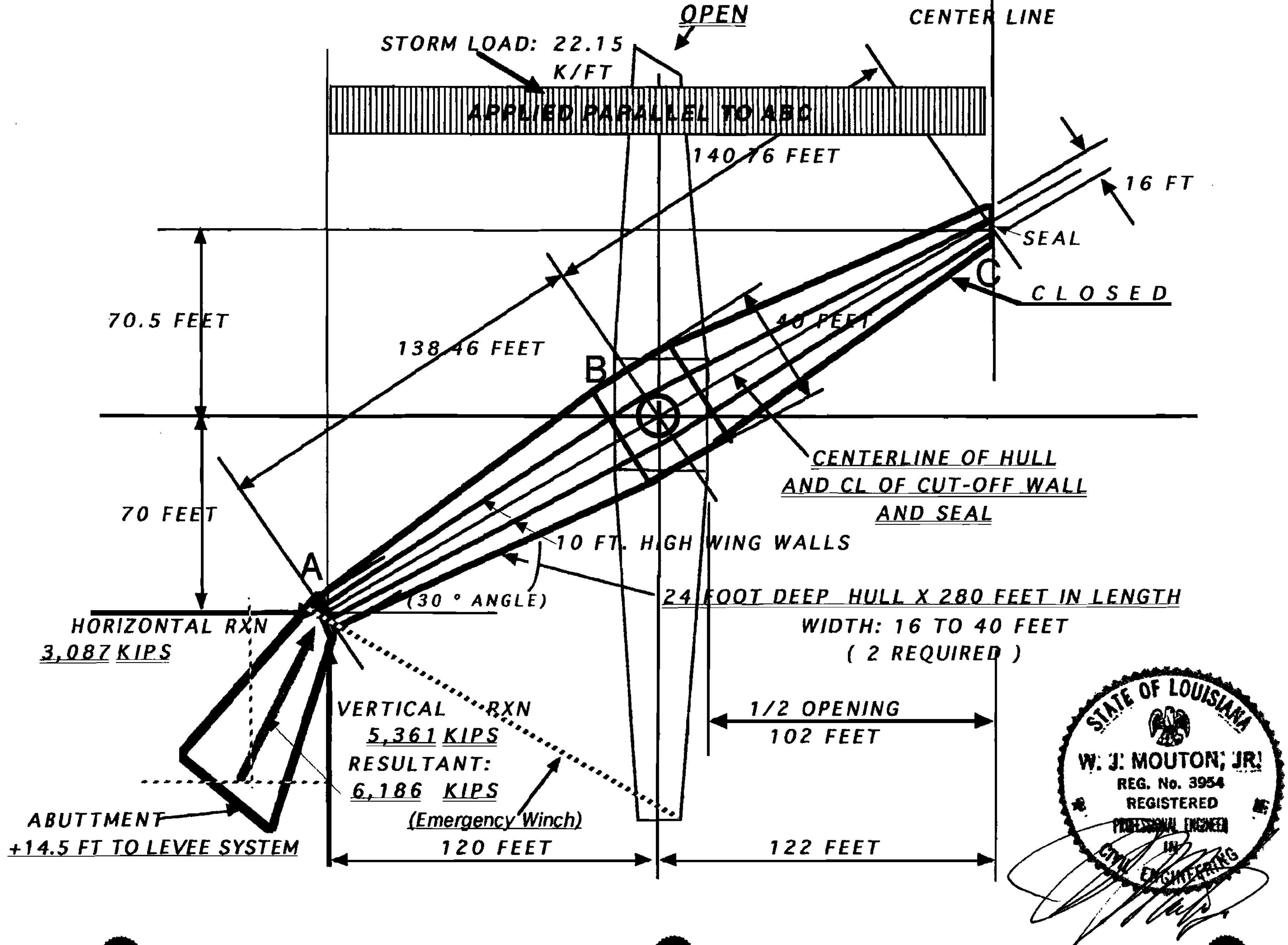
1. *50 % cost reduction over proposed float-in sector gates.*
2. *No reduction in stream cross-section at opening, with no major increase in channel flow during operation.*
3. *Possible unrestricted opening of channel width by removal of de-ballasted segmented floating sections.*
4. *Simplified construction of massive cut-off bearing walls by twin sheet-pile walls with tremie grout or float-in, grouted precast, prestressed bottom bearing elements.*
5. *Elimination of "De-Watering": by floating out twin segments to shipyards, and by inspecting and repair of 20 foot sections of massive cut-off wall bottom bearing by 24 foot portable repair caissons.*
6. *Minimal opening and closing force required of balanced 280 foot arch segments: channel side to be only 2 feet longer for positive closure pressure under storm surge.*
7. *Several means of operation: winch cables on shore or on segmented units, rack and pinion drive available on outer channel sides, or units can be closed with ballast pumps acting as bow thrusters: one forward, one aft, reversible.*
8. *Controlled buoyancy by means of free-flooded sections at - 4 feet elevation.*
9. *No serious overturning moment with vertical storm surcharge at top of hull due to set-back of 10-12 foot high wingwalls.*
10. *No uplift due to lack of de-watering and arch-type of structural reaction of storm forces on abutments.*
11. *Most major storm force reactions taken by massive end abutments.*
12. *Center vertical axle does not take storm loading. Hydraulic lifting of center axle for segmental unit maintenance at ship -yard.*
13. *Segmental units take 5 ft. pool depth reverse heads by equalized horizontal cantilever reactions by center axle.*
14. *Construction of 3/4" plate steel, with three vertical bulk-heads at storm-side, pool-side, and centerline. Draft: 5 Ft.*
15. *Alternate Construction: Precast prestressed units: 12 inch SLWT exterior walls and bottom with 8 inch interior walls. 50 foot maximum width: Draft: Maximum 15 feet empty.*

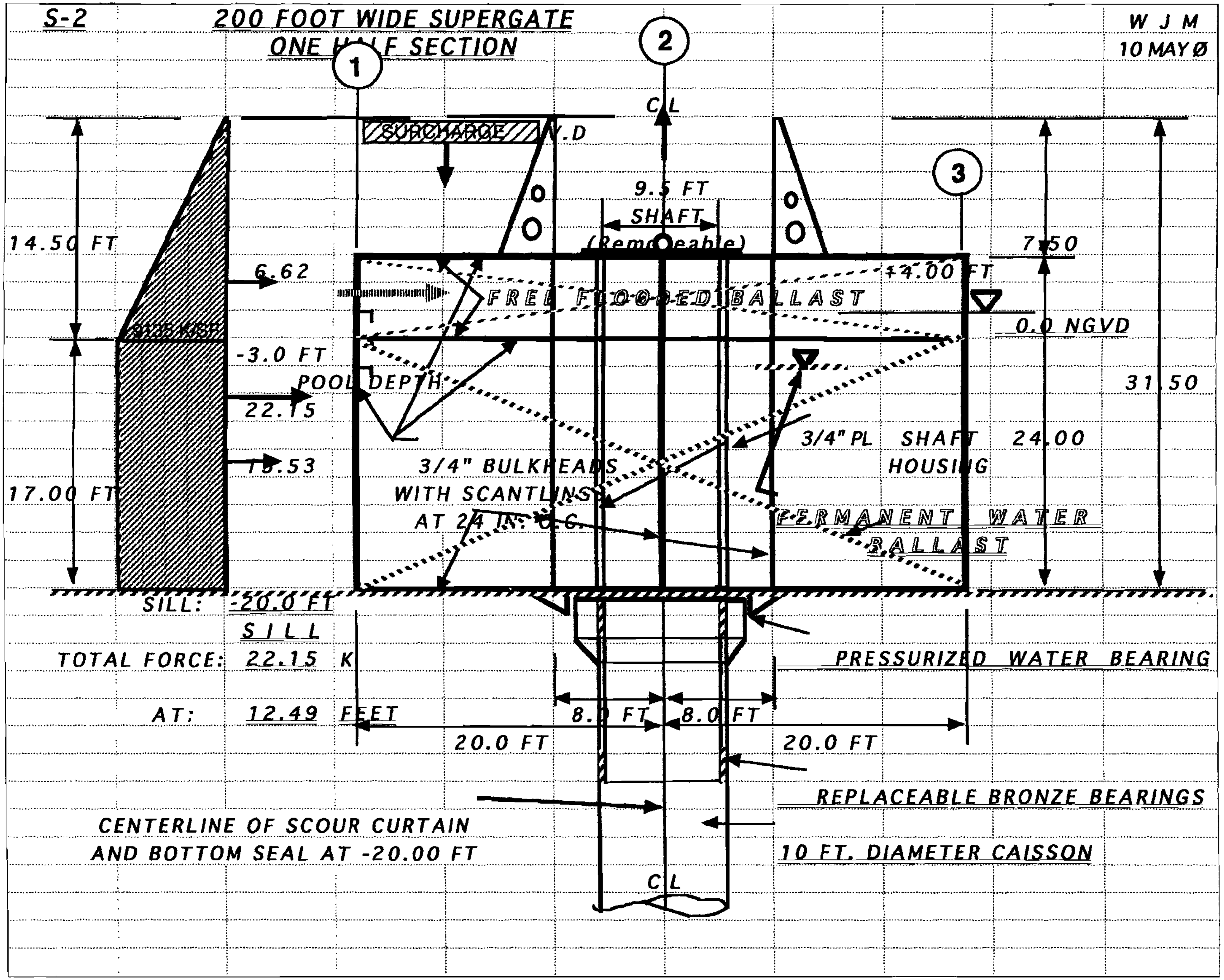
W. J. Mouton, Civil Engineer, CEEC 20 May 2000

(May also be used as H20-44 Highway BRIDGE)

S-1 **200 FOOT WIDE SUPERGATE ONE HALF SECTION**

C.E.E.C. W J M
10 MAY Ø

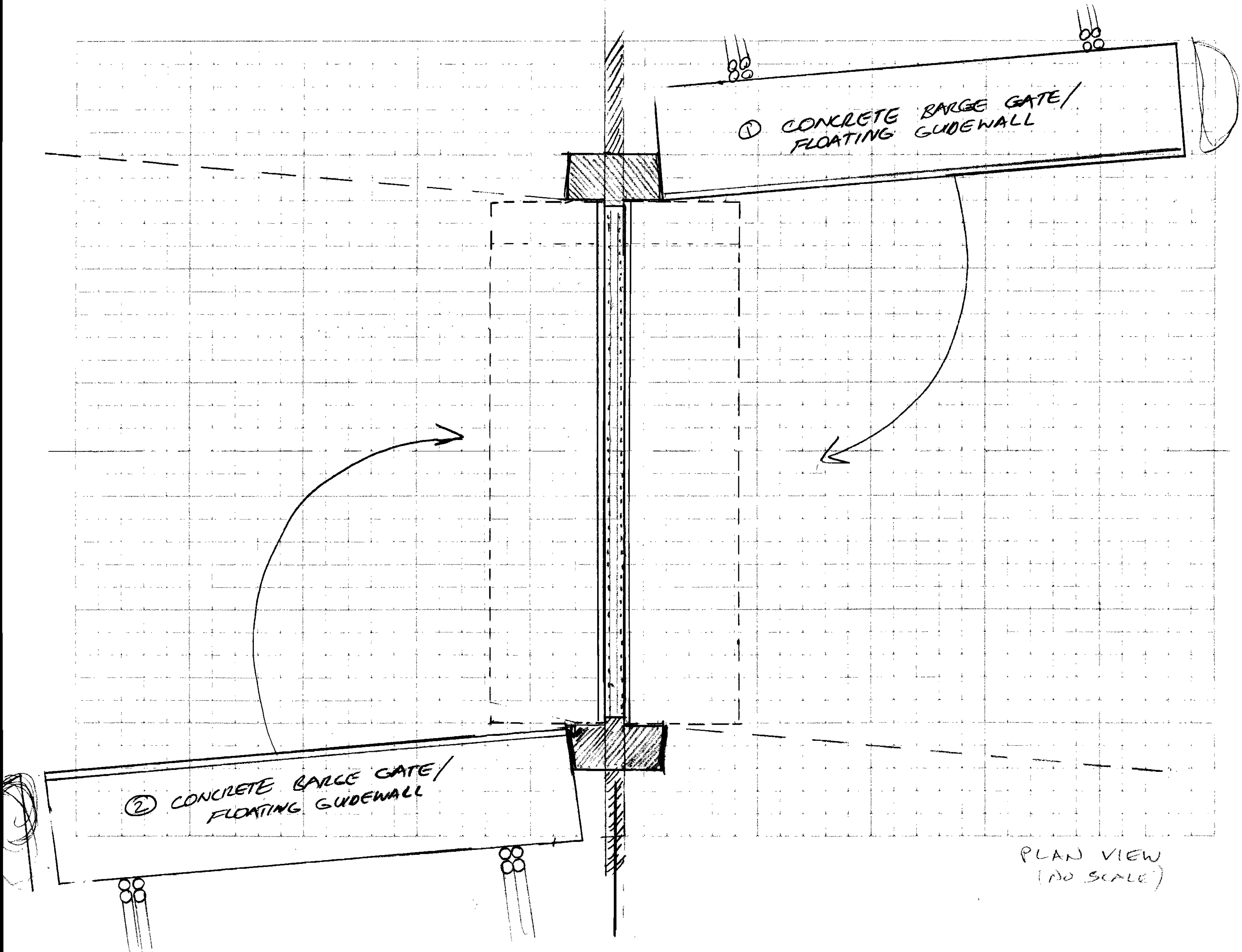


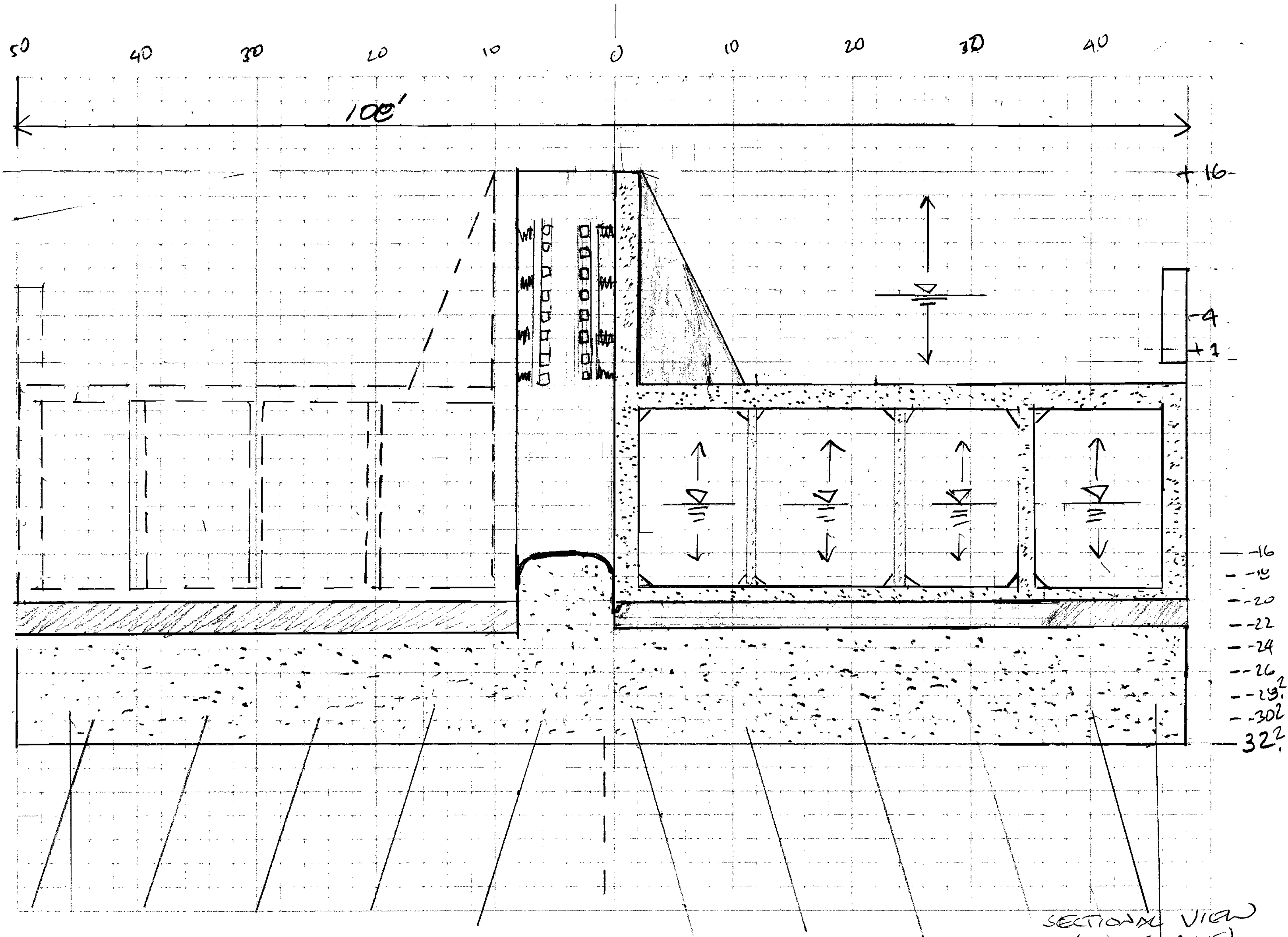


S-2
200 FOOT WIDE SUPERGATE
ONE HALF SECTION
W J M
10 MAY Ø
1
2
3
C L
SURCHARGE
9.5 FT
SHAFT
(Removeable)
14.50 FT
6.62
FREE FLOODED BALLAST
14.00 FT
7.50
0.0 NGVD
-3.0 FT
POOL DEPTH
22.15
31.50
3/4" PL
SHAFT
HOUSING
24.00
3/4" BULKHEADS
WITH SCANTLINS
AT 24 IN. O.C.
17.00 FT
PERMANENT WATER
BALLAST
SILL: -20.0 FT
S I L L
TOTAL FORCE: 22.15 K
PRESSURIZED WATER BEARING
AT: 12.49 FEET
8.0 FT
8.0 FT
20.0 FT
20.0 FT
REPLACEABLE BRONZE BEARINGS
CENTERLINE OF SCOUR CURTAIN
AND BOTTOM SEAL AT -20.00 FT
10 FT. DIAMETER CAISSON
C L

S-3		200 FOOT WIDE SUPERGATE							C.E.E.C.	W J M
		ONE HALF SECTION			STRUCTURAL ANALYSIS					10 MAY Ø
SOLVE FOR REACTIONS:						PRELIMINARY				
V PARALLEL TO CHANNEL										
	22.15	X	242.00	.=.	5360.87	KIPS		RESULTANT:		
OR:	22.15	X 279.22	X.8666=		5360.67	KIPS		6186.39	KIPS	
H NORMAL TO CHANNEL:			Σ M AT C:							
	22.15	X	279.22	^2/2 =	-863,542	FT KIPS				
		HULL CL LENGTH								
	5360.87	X	242.00	.=.	1,297,332	FT KIPS				
		SUM MOMENTS AT CL "C" :			433,790	FT KIPS				
		DIVIDED BY DEPTH:			140.50	FEET				
		HORIZONTAL =			3087.47	KIPS				
SUM OF MOMENT AT B							MOMENTS AT 1/4 PT:			
W	22.15	X	138.46	^2/2 =	-212,343	FT KIPS			-106,172	
V	5360.87	X	120.00	.=.	643,305				321,652	
H	3087.47	X	70.00	.=.	-216,123				-108,062	
				Σ MOMENTS	214,838	FT KIPS			107,419	FT KIPS
24 FT HULL:		MOMENT OF INERTIA & SECTION MODULUS AT "B"								
PLATE	NUMBER	THICK	H OR L	AREA	d'	bd^3/12	A d'^2	MOM I	c	S= I/c
SIDES	2	0.75	286.50	429.75	143.25	20.14	17,637,423	17,637,444	143	123,124
HOR. B,T, M	3.00	0.75	480.00	1080.00		20,736,000	0	20,736,000	143	144,754
									SUM S: IN^3	267,877
24 FT HULL:		MOMENT OF INERTIA & SECTION MODULUS AT 1/4 PT: A/B								
PLATE	NUMBER	THICK	H OR L	AREA	d'	bd^3/12	A d'^2	MOM I	c	S= I/c
SIDES	2	0.75	286.50	429.75	119.25	20.14	12,222,573	12,222,594	143	85,324
HOR. B,T, M	3.00	0.75	336.00	756.00		7,112,448	0	7,112,448	143	49,651
									SUM S: IN^3	134,974
		SUMMARY OF STRESSES								
ON HULL	V	H	R	A STEEL	P/A	MOMENT	SECT. MOD	M x 12/S		fa/Fa+fb/Fb
A	5361	3087	6186	861.75	7.18	0		0	P/A+M/S	7.18
A/B	4021	3087	5069	1185.75	4.28	107,419	267,877	4.81	Fy=50 Ksi	9.09
B	2680	3087	4089	1509.75	2.71	214,838	134,974	19.10	Fb=25Ksi	21.81
C	0	3087	3087	861.75	3.58			0	with -17%	3.58

S-4	200 FOOT WIDE SUPERGATE						C.E.E.C.	W J M
	ONE HALF BALANCED GATE X 280 FEET							20 MAY Ø
1/2 HULL	NUMBER	WT/SF	L	W	WEIGHT	3/4" PL + 3.5 x 6 x 3/8 L at 24"O.C.		
TOP, BOTT &		KSF		AVG.	KIPS		36.15	PSF" USE
UPPER CMPT	3	0.038	140.00	29.71	474.24			38 PSF
VERT. SIDES:	2	0.038	142.00	24.00	259.01			
WT CMPT X 7	8	0.038	24.00	29.71	216.80	WT CMPT AT 20 FT.O.C.		
NT CMPT X 7	7	0.015	24.00	29.71	73.38	TRUSSWORK:VERTICAL		
NT HOR + 8.5	1	0.015	140.00	29.71	61.15	TRUSSWORK: HORIZONTAL		
ABUT AT A,C	2	0.060	24.00	16.00	46.08			
REINF AT B	1	0.040	24.00	40.00	38.40			
10 FT. SLEEVE	0.5	0.070	24.00	16.00	13.44			
WATER BRGS	0.5	0.150	2.00	16.00	2.40	24" WIDE WATER BRGS		
UP WING WALLS	2	0.025	142.00	7.50	53.25			
MANIFOLDS	7	0.035	142.00	1.00	34.79			
HATCH, LADDERS	16	0.300	1.00	1.00	4.80			
	SUM ONE/HALF HULL WEIGHT				1,278	KIPS		
BUOYANCY	1	0.063	140.00	29.71	262.08	K/FT		
				DRAFT:	4.88	FEET		
ESTIMATE OF PROBABLE COST							ESTIMATED COSTS:	
				QUANTITY		UNIT COST	DREDGING EXCLUDED	
HULL	2		4 x 1,278 =	5,111	KIPS $	$2,350		$12,010,736
PUMPS & MACH.	8			LENGTH		$75,000		$600,000
Center Caissons	2	0.032	31.5	100	201.6	$4,200		$846,720
Cut Off Wall+Cap	4	0.03	40	135		$2,750		$1,782,000
ABUTT PILING	60	36" Ø		140	400 TON	AT $250/FT		$2,100,000
BATTER PILES	60	36" Ø		150	400 TON	AT $250/FT		$2,250,000
SHT PILES	2		160 LF	60		AT $35/SF		$672,000
CONCRETE CAPS	2	40	60	10	1800 CY	AT: 240/CY		$432,000
ELECTRICAL	2					$150,000		$300,000
CONTROL HOUSES	2					$150,000		$300,000
			ENGINEERING & SUPERVISION AT 13.0%					$2,768,149
	ONE COMPLETE FLOODGATE				CONTINGENCY AT 20%			$6,015,401
	WITH BUTTRESS & WING WALLS					SUM TOTAL:		$30,077,006


① CONCRETE BARGE GATE/
FLOATING GUIDEWALL
② CONCRETE BARGE GATE/
FLOATING GUIDEWALL
PLAN VIEW
(NO SCALE)



SECTIONAL VIEW
(NO SCALE)

Appendix C

US Army Corps
of Engineers

Office of the Chief of Engineers
Value Engineering Study Team

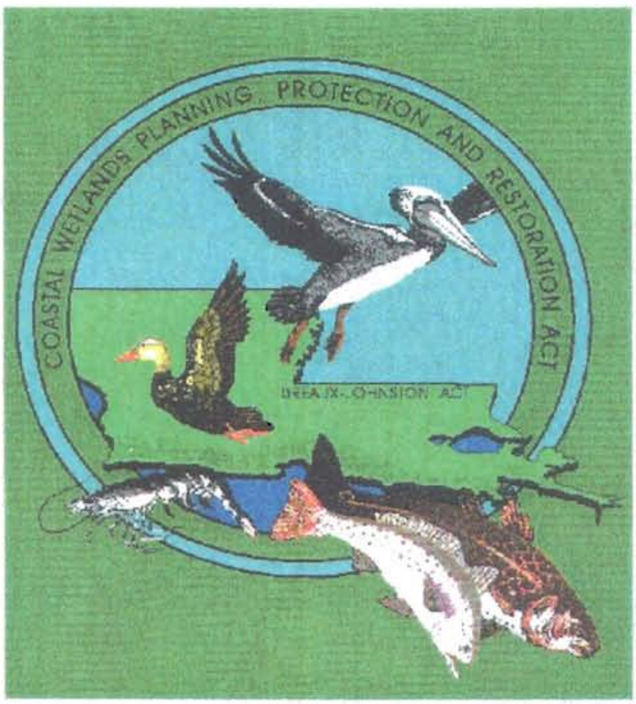
OVEST

VALUE ENGINEERING TEAM STUDY

Final Report

Bayou LaFourche Siphon Restoration Project

Southern Louisiana



Sponsored By:
U.S. Army Engineer District, New Orleans

July 2001

VALUE ENGINEERING PROPOSAL

PROPOSAL NO:	C-1	PAGE NO: 1 OF 12
DESCRIPTION:	Combine 200 CFS from Mississippi with 800 CFS from Davis Pond	

ORIGINAL DESIGN:

The current project plan provides upgrading of the existing pump station and siphon to 340 CFS, and construction of a new pump station with siphon rated at 660 CFS to provide a total diversion into Bayou Lafourche of 1,000 CFS. Bayou Lafourche would be dredged to accommodate 1,000 CFS flow without increasing water levels.

PROPOSED DESIGN:

Restore the existing pump station at the Mississippi River to a practical 200 CFS capacity; (existing water levels in Bayou Lafourche will not change); and construct a new pump station near Bayou Lafourche on Company Canal to redirect 800 CFS from Lake Salvador. The diversion will be from the Davis Pond Project through Lake Salvador via an enlarged Company Canal to Bayou Lafourche.

Company Canal will be enlarged to accommodate the required 800 CFS. Due to the limited number of crossings and obstructions, a cutterhead dredge using hydraulic disposal is recommended. Relatively large diameter lines can be used to pump dredged material to the western and southern edges of Lake Salvador (Restoration of these areas are designated CWPPRA projects). By using these disposal sites new marsh is crated and the project benefits are increased.

A pump station is required to move water from Lake Salvador to Bayou Lafourche because the natural hydraulic gradient is very minor. The head induced by the pump station will draw down the water in Company Canal and possibly affect the water levels in adjacent areas. To prevent this, weirs may be constructed across all intersecting waterways.

ADVANTAGES:

1. Immediate creation of over 400 acres of new (restored) marsh.
2. Eliminates all disruptive work along Bayou Lafourche.
3. Upgrading an existing canal simplifies construction.
4. Faster construction time.

DISADVANTAGES:

1. Some beneficial flow may be diverted from the Davis Pond Project.
2. Removes approximately 68 acres of bank along the Company Canal.
3. Operation limitations of this scheme under prolonged high tide conditions may be less effective than current plan.
4. Possible water draw-down in areas immediately along Company Canal may require additional water management operations.

JUSTIFICATION:

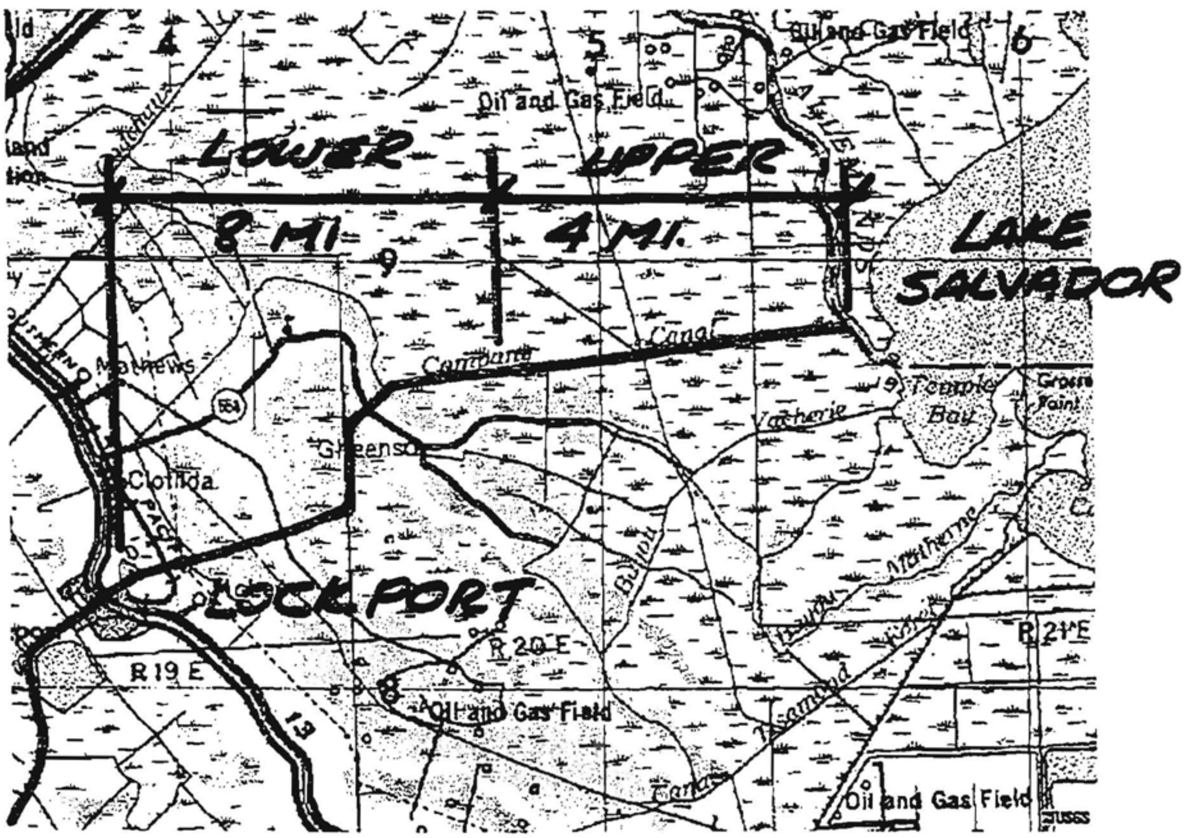
The current project redirects 1,000 CFS from the Mississippi River through 55 miles of Bayou Lafourche before reaching the desired areas. Throughout this reach, the dredging and shoring necessary to improve the channel without raising water levels will disrupt the local community. In addition, disposal of the dredged material is complicated, as well as egress through the Bayou. A number of low bridges block the passage of dredging equipment and the shallowness of the channel limits the size of such equipment. Because of these issues, construction will be difficult and lengthy, delaying implementation of any benefits.

In contrast, redirecting 800 CFS from Lake Salvador only requires improving 12 miles of an existing canal that cuts through undeveloped land. Access to the existing canal is simple and the dredged material can be pumped to beneficial use areas. Construction is both quicker and easier and benefits will be realized sooner. Flow re-directed from the Davis Pond Diversion Project may be non-beneficial if, and when the full 10,000 CFS is needed. During most diversion events, however, less than 10,000 CFS diversion is anticipated. The additional 800 CFS could likely be 'made-up' just by a slight flow increase without adverse effect. There may likely be an opportunity to create new marsh with the disposal from dredging Company Canal. It is estimated that over 400 acres of nearby open water could be filled to immediately create/restore marsh from the 68 acres of cut.

The utilization of river flow supplied by the Davis Pond Diversion and conveyed via Company Canal appears to be a far more cost-effective means of achieving project goals.

DRAWING NO. 1

EXISTING DESIGN FOR COMPANY CANAL



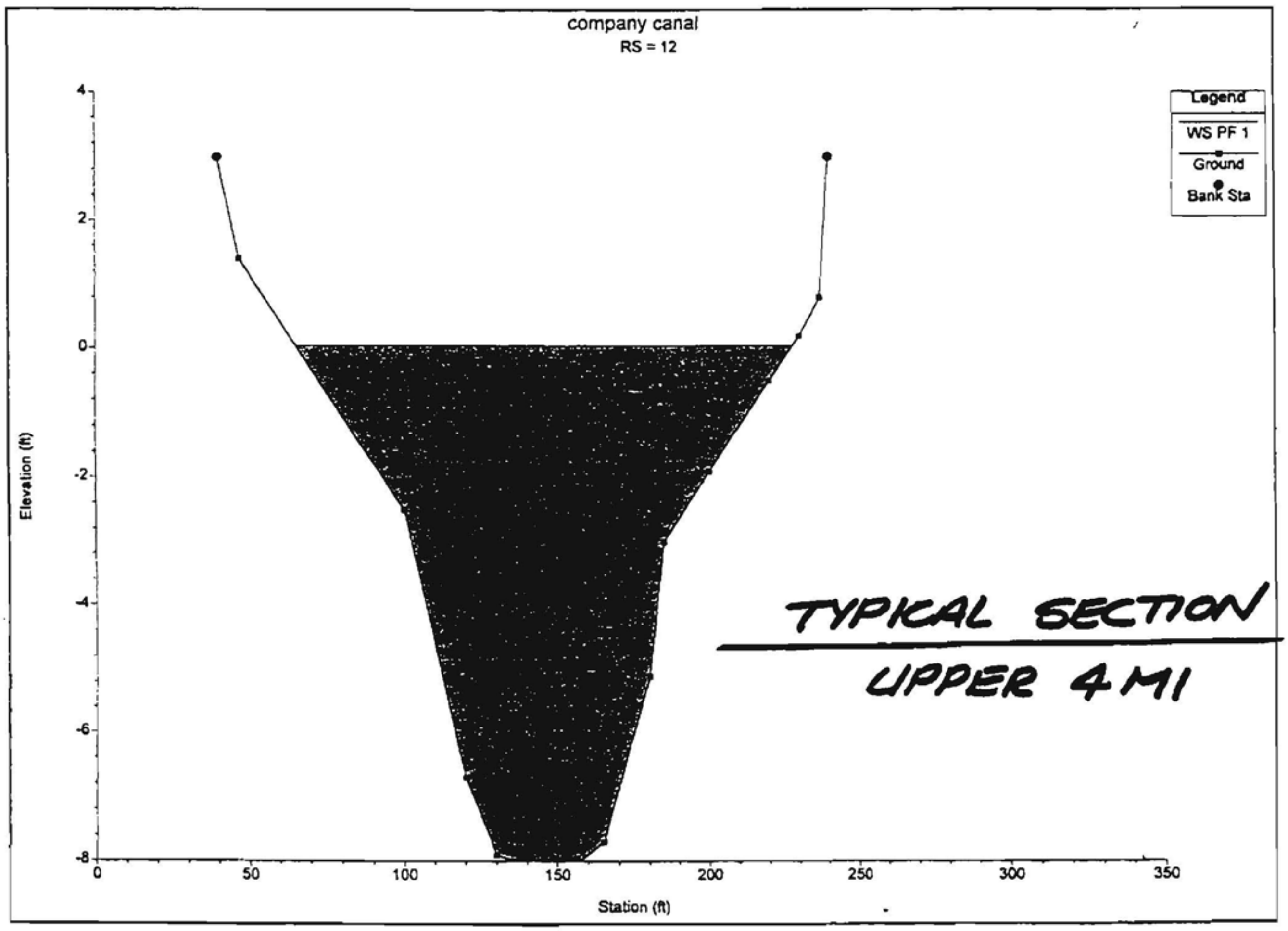
EXISTING COMPANY
CANAL

VALUE ENGINEERING PROPOSAL

PROPOSAL NO: C-1 PAGE NO: 4 OF 12

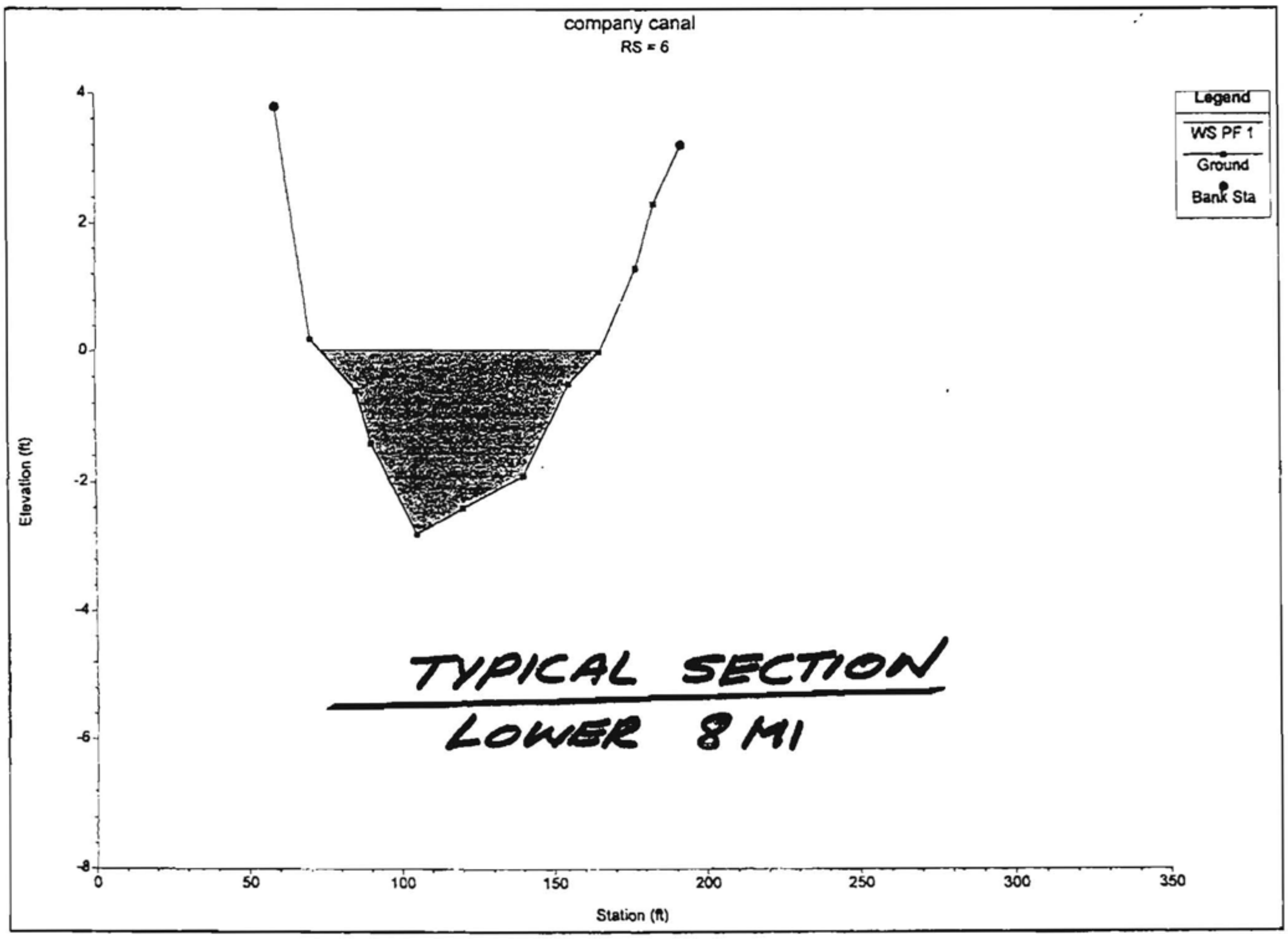
DRAWING NO. 2

EXISTING DESIGN SECTION UPPER 4 MILES



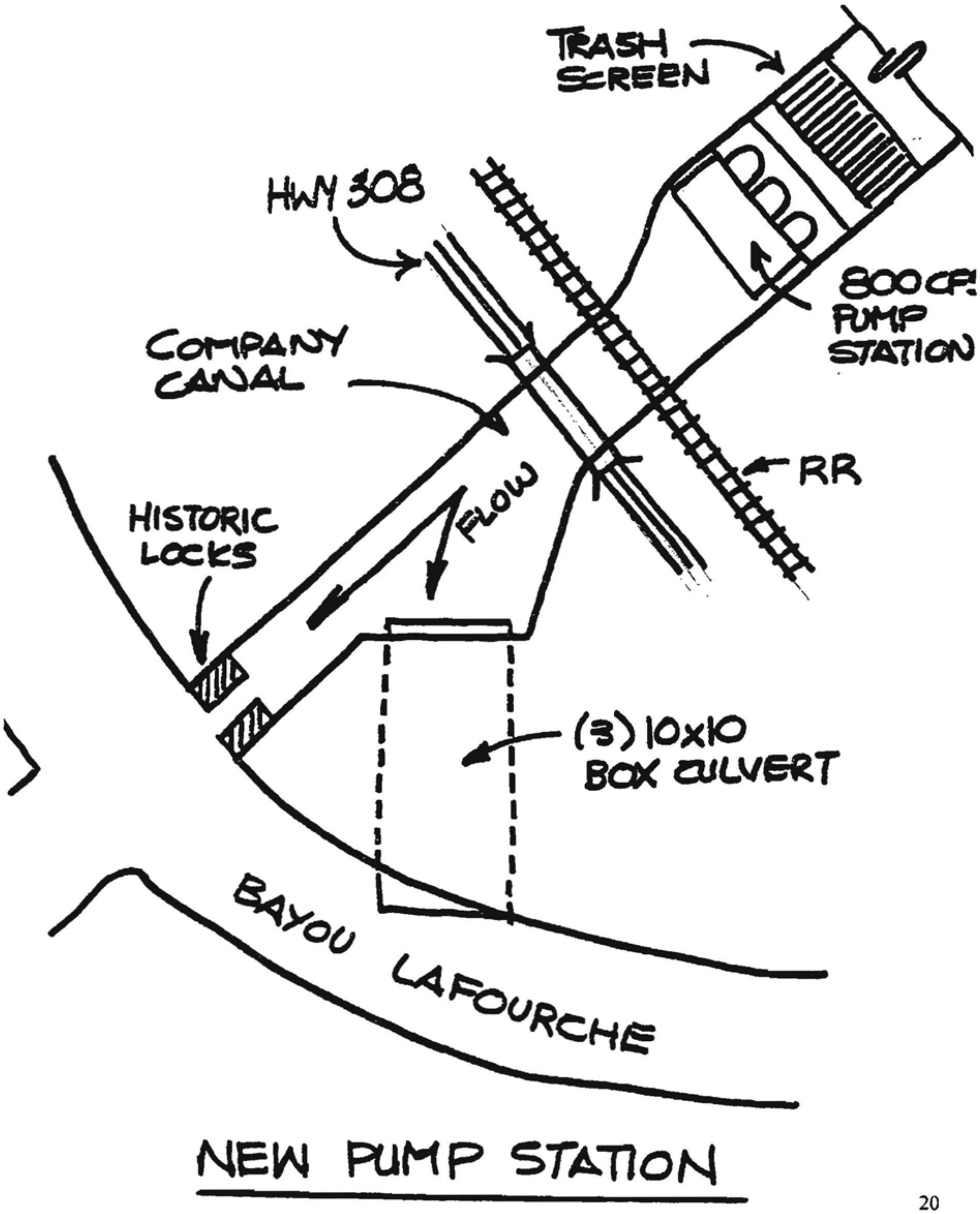
DRAWING NO. 3

EXISTING DESIGN SECTION LOWER 8 MILES



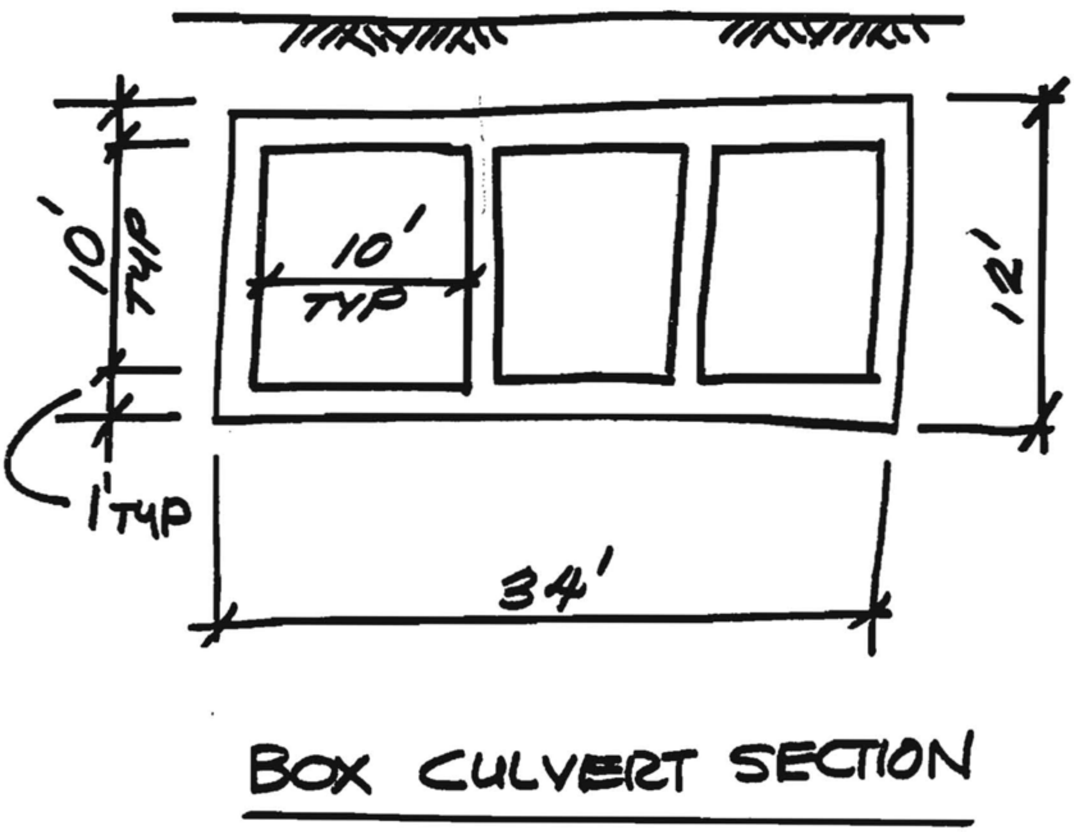
DRAWING NO. 4

PROPOSED DESIGN FOR NEW PUMP STATION



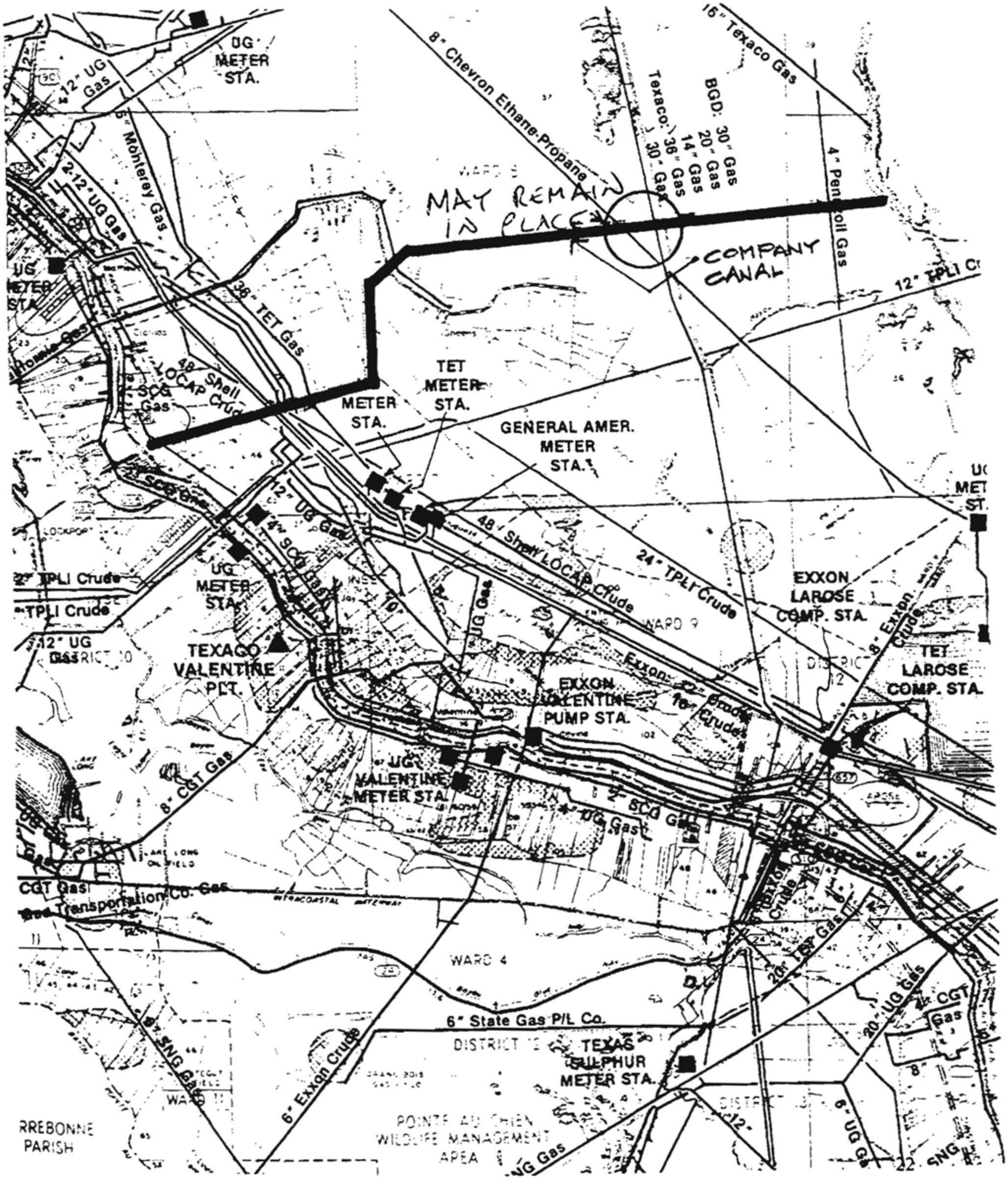
DRAWING NO. 5

PROPOSED DESIGN BOX CULVERT



DRAWING NO. 6

PROPOSED DESIGN



CALCULATIONS/ESTIMATES

Hydraulic Design (re: HYDRAULICS SECTION – COE)

Preliminary hydraulic analysis has indicated that a 150-foot top width channel with 1 on 3 side slopes and an approximate depth of 8 feet will require a 3-foot head to convey 800 CFS. This cross section will apply to the lower 8 miles near Bayou Lafourche. The upper 4 miles will not need dredging.

Disposal/Dredging (re: DREDGING SECTION – COE)

Hydraulic modeling calculated an estimated 1.4 million cubic yards of dredging is required to develop the required cross-section. This material will be pumped an average of 12 miles to reach the restoration areas. The estimated cost is $3.00 per cubic yard.

Real Estate (re: EPA REPORT)

For the lower 8 miles, the existing channel is approximately 80 feet across the top and must be widened to 150 feet. This results in the removal of approximately 68 acres of surrounding marsh. The entire channel covers approximately 150 acres assuming an 80-foot width for the lower 8 miles and a 150-foot width for the upper 4 miles. The cost is assumed to be $5,000/acre for the property and $2,500/acre for acquisition.

Marsh Reclamation (re: EPA REPORT)

Dredging will remove approximately 1.4 million cubic yards of material from Company Canal and place it along the edges of Lake Salvador. Assuming that these areas are 2 feet deep on average, the disposal will create approximately 434 acres of new marsh. Credit for the reclamation is $1.50/ cubic yards.

CALCULATIONS/ESTIMATES (continued)

Relocations (re: COE VE)

Underground Lines:

(1) 2" gas	-	$10,000
(1) 6" gas	-	$50,000
(1) 8" gas	-	$50,000
(2) 12" gas	-	2 x $100,000 = $200,000
(1) 36" gas	-	$500,000
(1) 48" oil	-	$500,000
Sub-total	-	$1,310,000

Roads and Bridges:

(1) Railroad Bridge	-	$250,000
(2) Hwy 308 Bridges	-	2 x $200,000 = $400,000
(2) Private Bridges	-	2 x $100,000 = $200,000
Sub-total	-	$850,000

Construction (re: COE VE)

(1) New 800 CFS Pump Station	-	800 CFS x $8,000 = $6,400,000
(1) Restored 200 CFS Pump Station	-	200 CFS x $4,000 = $800,000
(20) Sheetpile Weirs	-	20 x $50,000 = $1,000,000
(3) 10 x 10 Concrete Culverts	-	3 x 300 feet x $2,500 = $2,300,000

Operation & Maintenance

$$HP = \frac{\text{DESIGN FLOW} \times \text{DESIGN HEAD} \times \text{WEIGHT of WATER}}{550 \times 0.7}$$

and

$$KW = HP \times 0.746$$

800 CFS Pump Station:

Energy	-	580 x 24 x 365 x $0.04/kwh = $203,712
Maintenance	-	$150,000

200 CFS Pump Station:

Energy	-	(See VE Comment 29) $65,000
Maintenance	-	$50,000

FIRST COST ESTIMATE

(ORIGINAL DESIGN)

ITEM	U/M	QTY	UNIT COST	TOTAL
ENTIRE PROJECT	LS	NA	NA	$89,979,073
TOTAL COST				$89,979,073

(PROPOSED DESIGN)

ITEM	U/M	QTY	UNIT COST	TOTAL
NEW PUMP STATION	CFS	1	$8,000	$6,400,000
REHAB. PUMP STATION	CFS	1	$4,000	$800,000
DREDGING	CY	1,400,000	$3.00	$4,200,000
RELOCATION	LS	NA	NA	$2,200,000
WEIRS	EA	20	$50,000	$1,000,000
CULVERTS	LF	900	$2,500	$2,300,000
MOB/DEMOB DREDGING	LS	NA	NA	$800,000
SOIL REP. & SURVEY	LS	NA	NA	$1,000,000
REAL ESTATE	AC	218	$5,000	$1,100,000
ACQUISITION	AC	652	$2,500	$1,600,000
NEPA	LS	NA	NA	$700,000
SUB-TOTAL COST				$22,100,000
CONTINGENCIES 20%				$4,400,000
SUB-TOTAL COST				$26,500,000
E&D, S&A 20 %				$5,300,000
TOTAL COST				**$31,800,000**
INITIAL SAVINGS				**$58,200,000**
MARSH CREATION CREDIT	CYD	1,400,00	$1.50	**$2,100,000**
TOTAL SAVINGS				**$60,300,000**

OPERATION & MAINTENANCE

(ORIGINAL DESIGN)

ITEM	U/M	QTY	UNIT COST	TOTAL
ENTIRE PROJECT	LS	NA	NA	$1,400,000
TOTAL COST				$1,400,000

PROPOSED DESIGN

ITEM	U/M	QTY	UNIT COST	TOTAL
NEW PUMP STATION ENERGY, MANPOWER AND REPAIR	LS	NA	NA	$354,000
REHAB.PUMP STATION ENERGY, MANPOWER AND REPAIR	LS	NA	NA	$115,000
CHANNEL MAINTENANCE	LS	NA	NA	$55,000
CWPPRA MONITORING	LS	NA	NA	$29,000
SUB-TOTAL COST				**$553,000**

ANNUAL SAVINGS **$847,000**

50-YEAR PRESENT WORTH (LIFE-CYCLE) SAVINGS: 15 x $647,000 = **$12,705,000**

TOTAL LIFE-CYCLE SAVINGS = $60,300,000 + $12,705,000 = $73 million

Appendix D

United States Department of the Interior

MINERALS MANAGEMENT SERVICE
Washington, DC 20240

MAY 28 2003

Mr. Raymond A. Mosley
Director, Office of the Federal Register
7th Floor, Suite 700
800 North Capitol Street, N.W.
Washington, D.C. 20001

Dear Mr. Mosley:

Enclosed are three signed copies and a Microsoft Word disk copy of the notice, "Preparation of and Environmental Assessment," for publication in the Federal Register.

I hereby certify that the disk, labeled as "Prep-EA.doc," is a true copy of the signed documents.

Please notify our Federal Register Liaison Officer, Denise Johnson in Washington D.C., telephone (202) 208-3976, of the date that this Notice will be published.

Sincerely,

Thomas A. Readinger

Certifying Officer

4 Enclosures

Barry

BILLING CODE: 334010LBH

DEPARTMENT OF THE INTERIOR

Minerals Management Service (MMS)

Preparation of a Multi-Project Environmental Assessment to evaluate the potential environmental impacts associated with the removal of sand resources from Ship Shoal, offshore Central Louisiana

AGENCY: Minerals Management Service, Interior.

ACTION: Preparation of an environmental assessment.

SUMMARY: MMS is preparing an environmental assessment (EA) to examine the potential effects on the marine and coastal environments of using sand from Ship Shoal, a sand shoal located approximately 10 miles south of Isle Dernieres, offshore the central coast of Louisiana. Geological and geophysical studies of Ship Shoal have determined that the shoal's sand is an ideal source of material to place on the rapidly eroding Louisiana barrier islands. Several coastal restoration and storm protection projects that propose to use sand from Ship Shoal are already in the planning stages. The Louisiana Department of Natural Resources (LDNR), the U.S. Environmental Protection Agency (EPA), and the U. S. Army Corps of Engineers (USACE) are assisting during development of the EA. We will publish an announcement in the Federal Register when the EA has been completed and is available to the public.

PUBLIC COMMENT: MMS requests interested parties to submit comments specific to the environmental issues related to the removal of sand resources from Ship Shoal. Comments should be sent to Chief, Leasing Division, Minerals Management Service, 381 Elden Street, Mail Stop 4030, Herndon, Virginia 20170. In addition, comments may be sent by e-mail to barry.drucker@mms.gov. Your comments should be submitted on or before July 1, 2003.

FOR FURTHER INFORMATION CONTACT: Minerals Management Service, Leasing Division, Sand and Gravel Unit, 381 Elden Street, Mail Stop 4030, Herndon, Virginia 20170, Mr. Barry Drucker, telephone (703) 787-1296, email: barry.drucker@mms.gov.

SUPPLEMENTARY INFORMATION: Louisiana's coastal land loss problem continues at a rate of more than 30 square miles per year severely affecting the storm buffering capacity and the protection that nearshore barrier islands provide to human populations, oil and gas infrastructure, inland bays, estuaries, and wetlands. The bays inshore of the islands are huge estuaries where freshwater and saltwater mix and most of Louisiana's commercial and recreational fish depend on them during parts of their life cycle. Without barrier islands, coastal fisheries will experience significant adverse impacts. The entire Isle Dernieres chain in offshore central Louisiana, a critical component of the Louisiana barrier island system, is projected to be lost by the year 2010. A study by the Coastal Wetlands Planning, Protection and Restoration Act task force recommended returning Isles Dernieres and the Timbalier Islands to 1992 conditions (pre-Hurricane Andrew), which would require adding sand to build them to a width of about 1,230 feet wide and 8-9 feet above sea level. The current overall strategy is to restore the island chains to a condition suitable for providing coastal protection and for maintaining the integrity of the estuarine system.

Geological and geophysical studies of Ship Shoal indicate that very significant similarities exist among the properties of Ship Shoal and the nearby barrier islands. Ship Shoal sand is considered ideal material for use in restoration and nourishment projects along the Louisiana coast within the Terrebonne and Barataria Basins. Resource estimates for the volumes of sand comprising the Ship Shoal structure are 1.2 billion cubic meters.

MMS has already been notified by LDNR and EPA that they will seek leases for the use of Ship Shoal sand for planned projects at Whiskey Island and New Cut, Louisiana. In addition, USACE is considering using Ship Shoal sand as a base for the levee system for the Morganza to the Gulf Hurricane Protection Project. Besides these efforts, MMS anticipates that Ship Shoal will serve as a long-term source of material for further Louisiana coastal restoration efforts well into the future.

Public Law 103-426, enacted October 31, 1994, gave MMS the authority to convey, on a noncompetitive basis, the rights to Federal sand, gravel, or shell resources for shore protection, beach or wetlands restoration projects, or for use in construction projects funded in whole or in part by or authorized by the Federal Government.

Thomas A. Readinger

Thomas A. Readinger
Associate Director for
Offshore Minerals Management

5/12/03

Date

Appendix E

Louisiana Sand Management Working Group Meeting
AGENDA - 2 February 2005
Lindy C. Boggs International Center, University of New Orleans

09:00 Open Session

I. Introductions, Housekeeping Items, Review of Agenda

II. Environmental Issues Update

A. Utilization of Benthic Communities by Fish Populations on Ridge and Shoal Features – Allen Brooks, USGS Coastal Ecology and Conservation Research Group, Gainesville, FL
B. Environmental Investigation of the Long-Term Use of Ship Shoal Sand Resources for Large-Scale Coastal Restoration in Louisiana – Greg Stone, LSU [Handout No. 1]
C. Baseline Biological Studies (Shrimp and Seatrout) of Ship Shoal – Richard Condrey, LSU [Handout No. 2]

III. LCA Comprehensive Plan Status – Tim Axtman, USACE New Orleans District

IV. Resource Issues Update

A. MMS/La DNR Cooperative Agreement – Syed Khalil, La DNR
B. MMS Position Paper on Establishing Project Priorities – Tim Redding, MMS [Handout No. 3]
C. Louisiana Virtual SeaBed: UNO, USGS, INSTAAR – Shea Penland PIES-UNO

12:00-13:00 Lunch

V. Multiple Use Issues Update

A. Impacts of Hurricane Ivan on oil and gas infrastructure – Alex Alvarado, MMS GOM Region
B. Update on MMS Study on Ship Shoal Oil & Gas Infrastructure Stability – Rob Nairn, Baird & Associates [Handout No. 4]

VI. Review of Proposed Projects

A. Whiskey Island/West Flank – Brad Crawford/Chris Williams, EPA/DNR
B. Pelican Island, Rachel Sweeney, NOAA [Handout No. 5]
C. Morganza to the Gulf Hurricane Barrier – Bill Maloz, USACE New Orleans District

15:00 Closed Session (Federal, State, and Local Agencies Only)

VII. Action Items

A. Assignments and Deliverables
B. Schedules

VIII. Wrap-up, Summary, and Adjourn

MEETING MINUTES

I. Introductions, Housekeeping Items, Review of Agenda

II. Environmental Issues Update

A. Utilization of Benthic Communities by Fish Populations on Ridge and Shoal Features

Allen Brooks presented the study design and initial results for this study of Ship Shoal. They are using both stable isotopes and gut content analyses to establish baseline data on the benthic communities that are important components of fish diets on Ship Shoal. Stations are located in proposed dredging areas, control areas, and “off-bank” areas that are north of Ship Shoal and in deeper water. Cruises were conducted in January and December 2004 and planned for April/May 2005. He also announced three reports of interest:

1) USGS Report 2004-5198. Literature search on benthic communities. Published.
2) Analysis of 18 years of SEAMAP data on fish utilization of shoals in the Gulf of Mexico (Sabine, Heald, Tiger, Trinity Shoals) that will be published soon.
3) Two-year study of the demersal fish on Ship Shoal, a landscape study of utilization. Study should be completed after one more year of field data collection.

There was discussion about how the study results will be used, whether as baseline for pre-/post-dredging monitoring of impacts or for EIS. MMS has already prepared an EA for dredging. It will be important to have data on which benthic communities are important prey for fish, so that guidelines for dredging could be developed to minimize impacts to these communities. Coordination and exchange of samples/data/information between the USGS cruises and the LSU biological cruises was also discussed.

B. Environmental Investigation of the Long-Term Use of Ship Shoal Sand Resources for Large-Scale Coastal Restoration in Louisiana

Greg Stone presented information on the status of the physical tasks, which include Quantification of local and regional hydrodynamics for statistically significant meteorological conditions, pre-dredging. He also discussed the instrumentation and new buoy that will fill some gaps and provide real time data for Ship Shoal. The study also includes a biological component that was discussed by Richard Condrey in the presentation, which followed.

C. Baseline Biological Studies (Shrimp and Seatrout) of Ship Shoal

Richard Condrey of LSU presented an update on this study. He has been joining SEAMAP cruises (July, Sept, Dec 2004) to collect additional data on Ship Shoal. Plans are for field data collection cruises in August and October 2005 and March 2006.

III. LCA Comprehensive Plan Status

Tim Axtman gave an update on the LCA Plan with a lot of detail. The Near-term Plan was based on projects that are highly cost effective and achievable in a relatively short period of time. The current plan consists of (at a cost of $2 billion):

1) 15 near-term critical projects
2) Science and technology program including demonstration projects
3) Increased beneficial use
4) Modification of selected structures
5) Large-scale long-term concepts

The 2005 Work Plan will include:

1) Completion of the barrier island feasibility study
2) Science and technology program development (hire director, support will be through funds from individual studies)
3) Develop the long-range beneficial use program
4) Conduct studies to modify/improve the Davis Pond and Caernarvon diversions
5) Long-distance sediment transport demonstration project
6) Third delta and Acadiana Bays studies
7) LCA Plan future development

IV. Resource Issues Update

A. MMS/La DNR Cooperative Agreement

Syed Khalil of DNR reported on the status of the study being conducted under the MMS/DNR MOU to assess offshore sand sources off the Louisiana coast and create a geospatial database (geological, environmental, and associated data) for better evaluation of the sand sources. They have conducted detailed geophysical and geotechnical surveys of Ship Shoal blocks 88/89 and Sandy Point. DNR estimates that 51 million cubic yards of OCS sand will be needed through 2010. DNR recommends:

1) Regional geological/geophysical surveys in other blocks of Ship Shoal and other shoals
2) Phased operation of such evaluations, consisting of:
   a. Reconnaissance geophysical surveys
   b. More detailed surveys in high potential sand areas
   c. Vibracores where needed to confirm sand volumes
3) Continue coordination with other agencies in database design and development
4) Continue data input into database
5) Develop protocol for geophysical data collection

Barry Drucker of MMS made a comment that the results of DNR's work would be incorporated into the proposed FY 06 MMS LA site-specific environmental study to evaluate other areas besides Ship Shoal.

B. Louisiana Virtual SeaBed: UNO, USGS, INSTAAR

Mark Kulp of UNO presented an update on the joint USGS/UNO effort to create a geospatial data warehouse and on-line user interface for geological and geophysical data for coastal Louisiana (including onshore and offshore). The URL for the visualization tools will be distributed to the LaSMWG as soon as it is available.

V. Multiple Use Issues Update

A. Impacts of Hurricane Ivan on oil and gas infrastructure –

Alex Alvarado gave a presentation on the extent of damage to oil and gas infrastructure during Hurricane Ivan, which was extensive. MMS is planning a study to determine where the mudslides occurred.

B. Update on MMS Study on Ship Shoal Oil & Gas Infrastructure

Rob Nairn of Baird & Associates, Inc. presented some interim results of their MMS-funded study to determine appropriate buffers around oil and gas infrastructure. The study included re-bathymetric surveys of the Holly Beach dredge pits specifically for this project. Data from other sites were presented as well. In summary, the interim results indicate that pit morphology evolution processes include:

Slope stability adjustment – soil type is a factor
Pit infilling (due to both regional/local sources of turbidity)
Pit margin adjustment
Berm evolution for multiple pits

The study deliverables will include recommendations for estimating buffers for different conditions. There will not be a single buffer but guidance on how to calculate buffers for different site conditions off Louisiana.

There was extensive discussion of the interim buffer of 300 m by DNR who are concerned over the size of the setback/buffer which might reduce the overall extent of some borrow sites and want the setback justified by credible scientific investigation/methodology.

VI. Review of Proposed Projects

A. Whiskey Island/West Flank

Brad Crawford of EPA provided an update of the proposed dredging of Ship Shoal for sand placement on the West Flank of Whiskey Island. They expect to need 4 million cubic yards of sand. They asked if stipulations would be required in the lease concerning how the sand should be removed from the borrow site. They want to give as much leeway to the dredger to keep the costs as low as possible. The project is now planned for initiation in Spring 2006; it has been modified and the sand volume needed increased to protect some marsh area east of the flank.

B. Pelican Island

Rick Hartman of NOAA gave a brief update. They received $60 million for the project last year. DNR has worked on the oyster lease issues, but there are still some delays. They had to get an ocean dumping permit from the USEPA/ACOE. They are also working internally on sea turtle issues. They continue to discuss the lease agreement with MMS. NOAA is collecting additional vibracores in the southern area to get total thickness of sand since the northern area is inaccessible because of the 300 m buffer around pipelines. They will be bidding out the project as either hopper barges or cutterhead dredging. They expect construction to begin in 2006.

C. Morganza to the Gulf Hurricane Barrier

Bill Maloz of the ACOE provided an update on this project, which consists of:

72 miles of earthen levee
12 sector gate structures for flood control
12 environmental water control structures
Houma Navigation Canal Lock Complex

First construction is scheduled for Jun 2005. Total construction is estimated at 16 years - 2021 (assumes immediate start, steady funding stream & continuous construction) at a total cost of $740 million. They want to use sand for the levee base following reasons: lower costs than all earthen levee; greater stability, less time to consolidate; and it will require a smaller footprint so there are environmental benefits. They looked at several sand sources: Ship Shoal, Cat Island Pass, Bayou Sorrel, Horseshoe Channel, sand from Alabama disposal sites, Bonnet Carrie spillway, and Mississippi River sediment traps. They have identified several sand stockpile areas along the levees. Their current focus is on the sand from maintenance dredging of Cat Island Pass, which is the closest source, therefore, sand from Ship Shoal will most likely not be accessed for this project. They are working with DNR on modeling of the potential impacts of using this inshore sand source.

VII. MMS Position Paper on Establishing Project Priorities

The discussion of the December 2004 version of the priorities paper included the following questions, which focused on how to reduce impacts of oil and gas infrastructure on access to OCS sand off Louisiana:

1) What are the MMS requirements for abandoned wells and pipelines? The suggestion was that MMS should require removal of abandoned facilities so they will not interfere with sand access. MMS stated that the current regulations allow abandonment in place, as long as it does not pose conflicts with other uses of the seafloor. There was discussion about who would pay if the operator was defunct or could not be found. MMS agreed that they needed to discuss policy guidelines for oil and gas abandonment in good sand areas.

2) Has MMS considered designating pipeline corridors through sand areas? The State reviews all new well requests on land to determine if it is feasible to cluster them, to reduce the footprint of their impacts. Does MMS have this kind of authority? MMS

currently cannot officially set-aside areas for sand access. In deep water, wells are clustered around platforms because of the costs. However, MMS has guidelines for protection of certain features or resources, such as cultural resources. They agreed to consider access to sand as a resource that should be protected, to be incorporated into the plan review process. They requested that lease blocks of critical interest for sand be identified.

3) The issue of whether MMS could set aside areas for sand access on other shoals was raised. MMS did issue an Information to Lessees (see detailed discussion in the Priorities Paper that was distributed prior to the meeting) that included the following:

   Stipulation No. 9 - Sand Dredging Operations: Limitation on Use of Leased Area
   The Minerals Management Service (MMS) is evaluating use of sand resources from the area covered by this lease (the "leased area") for nearby levee and barrier island restoration projects. As a result, the MMS may enter into non-competitive, negotiated sand and gravel leases with a third party during the term of this lease.
   Dredging of sand from within the leased area and the associated presence of an ocean-going dredge vessel may conflict with Lessee's oil and gas operations. Prior to construction or placement of any structure for exploration and development on the leased area, including, but not limited to, anchoring, well drilling, and pipeline and platform placement, Lessee shall notify in writing and consult with the Chief, MMS Leasing Division, regarding such planned activities.
   The MMS will determine whether the planned activities conflict with ongoing or planned sand dredging operations. If MMS determines that Lessee's planned activities conflict with sand dredging, the MMS will require Lessee to conduct its operations in a manner to avoid such conflicts. In addition, MMS will coordinate all activities of the dredge vessel(s) and service vessel(s) in order to minimize conflicts with lessee's planned activities.

MMS said that it would consider developing more detailed language that would specify the types of requirements that could be included in priority sand areas, such as pipeline corridors.

STATUS OF RECOMMENDATIONS FROM THE MAY 2003 LA SMWG MEETING

Recommendation	Status
MMS will distribute to the La SMWG the final multi-project Environmental Assessment that should be completed by the end of March 2004	**Done**.
The La SMWG will be notified of any proposed changes to the current hazard and archaeological survey requirements.	No proposed changes to date.
The La SMWG will provide MMS comments on the draft prioritization process paper by 15 May 2004	**Done**. A new draft dated December 2004 was presented at the February 2005 meeting.
As the USGS and UNO continue work on the US.Seabed project in Louisiana, they should work on estimating the uncertainty in the sand volume estimates being generated.	**On-going**.
It is important for DNR to look for sand sources inshore, including in the major river channels, in addition to the offshore sand shoals.	**On-going**.
The issue of buffers around oil and gas infrastructure is of great concern. Work should continue to identify risks and mitigation strategies.	**On-going**. Reported interim results of current study at the February 2005 meeting.
Work should continue on strategies to reduce the potential conflict between access to sand borrow sites and oil and gas leasing and infrastructure.	**On-going**. New action items were identified at the February 2005 meeting.

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40. Jacqui Michel	Research Planning, Inc. (PC on behalf of MMS)	jmichel@researchplanning.com

Appendix F

PLANNING FOR SEA LEVEL RISE: U.S. ARMY CORPS OF ENGINEERS POLICY

Kevin Knuuti[1], M.ASCE

Abstract: The U.S. Army Corps of Engineers (Corps) was involved with billions of dollars worth of hurricane and storm damage prevention, ecosystem restoration and other coastal engineering projects in 2001. Current public policy demands that the Corps evaluate the economic benefits and costs of its projects over a projected fifty-year life span. With the current trend in global warming and the resulting rise in eustatic sea level, public awareness of the importance of sea level change considerations has increased dramatically. Corps policy on how to assess and apply sea level change to coastal engineering projects is critical to proper economic analysis of projects as well as to project success.

Recognizing that relative sea level change is potentially more important to coastal engineering projects than eustatic sea level change, the Corps bases its policy on an assessment of the risk of accelerated sea level rise as compared to observed historic trends. It applies these considerations to "every coastal and estuarine (as far inland as the new head of tide) feasibility study that the Corps undertakes." In accordance with suggestions in the National Research Council's 1987 report on sea level change, Corps feasibility studies consider which design alternatives are most appropriate for a range of possible future rates of rise. The feasibility studies then use risk/sensitivity analysis to quantify the benefits and costs of design alternatives. These design alternatives should include those based on the observed historic trend in sea level change and those based on various possible accelerated rates of change.

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INTRODUCTION

Engineers design all of their projects for specific life spans. The design life typically includes an assessment of structural durability as well as potential changes in a project's use, in the development of the area around the project, and also in local environmental conditions. While it is common practice to consider how human-induced changes will affect design considerations, it is not as common to properly account for potential environmental changes. This is partially due to our inability to predict the future but is also due to a general failure to recognize the significance of slowly occurring changes that do not have sudden consequences. It is easy, for example, to make someone understand the importance of designing a structure for a potential earthquake when earthquakes happen periodically and result in immediately obvious and disastrous damages. It is much more difficult to convince someone to account for a slow creep in the rise of sea level that is due to a combination of global warming, regional rebound of the earth's crust, and local tectonic activity.

The U.S. Army Corps of Engineers (USACE or Corps) has established a policy on how to account for changes in sea level in the planning, design, and management of its projects. With its policy, the Corps attempts to balance the potential for an acceleration in the current rate of eustatic sea level rise with the historically documented rate of relative mean sea level change for specific project areas (USACE, 2000). Unfortunately, very few people and very few Corps Districts are aware of the Corps' policy and the policy is thus not widely followed. This paper describes the basis for the Corps' sea level rise policy and the procedures associated with that policy. While the policy only applies to Federal projects in which the Corps is involved, it is based on sound scientific and economic principles and would benefit almost all engineering and ecosystem restoration projects in the coastal zone.

SEA LEVEL CHANGE

Mean sea level change is a difficult concept to quantify. The local rate of change varies dramatically around the country and around the world due to a variety of factors. People generally recognize that global warming is resulting in an eustatic rise in sea level, due primarily to melting polar ice caps and thermal expansion of water. There is, however, a great deal of controversy associated with the concept of global warming and a great deal of difficulty associated with quantifying the effect of global warming on eustatic sea level rise. This controversy, and its effect on peoples' acceptance of the importance of mean sea level rise, is exacerbated by the fact that the relative rate of mean sea level rise varies from location to location. People in Portland, Maine, for example, where there is an 88-year record of tide gauge data showing a steady, 1.91 mm/year (Zervas, to be published), rise in relative mean sea level, might be quick to conclude that eustatic sea level is rising at a steady rate. Conversely, people in Neah Bay, Washington, where there is a 66-year record of tide gauge data showing a linear trend of relative mean sea level dropping at a rate of 1.41 mm/year (Zervas, to be published), might conclude that eustatic sea level is dropping. In all likelihood, neither would be correct.

Eustatic Sea level Rise

Scientists studying the earth's geology, climate, ice packs, and atmosphere generally agree on the legitimacy of the concept of global warming. Many also agree that the rate of global warming is accelerating. Quantifying these two values, however, has proven quite difficult. In establishing its current policy, the Corps has chosen to follow the recommendations of the National Research Council (NRC), as described in the publication *Responding to Changes in Sea Level: Engineering Implications* (NRC, 1987). This publication assumes three possible scenarios for eustatic sea level rise to the year 2100. These scenarios are described by the equation

$$E(t) = 0.0012t + bt^2 \qquad (1)$$

in which t represents years, starting in 1986, b is a constant, and $E(t)$ is the eustatic sea level rise, in meters, as a function of t. For the three scenarios proposed by the NRC, b is equal to 2.854E-5 for Curve 1, 6.770E-5 for Curve 2, and 1.069E-4 for Curve 3 resulting in eustatic sea level rise values, by the year 2100, of 0.5 meters, 1.0 meters, and 1.5 meters, respectively. These three eustatic sea level rise scenarios are depicted in Figure 1.

Relative Mean Sea level Change

Relative mean sea level change can be due to many factors, depending on location. These factors include eustatic sea level rise; crustal subsidence or uplift (includes glacial rebound); tectonic activity; human-induced subsidence from structural loading or groundwater, oil, or natural gas extraction; auto-subsidence from consolidation of native sediments; and climatic fluctuations such as El Nino-Southern Oscillation (ENSO). While people sometimes determine past changes in relative mean sea level by examining geologic records, it is more common to determine recent changes by examining the records at long-term tide stations.

Records at long-term tide stations are often used to determine the rates of relative mean sea level change around the United States and in other parts of the world. Although these records appear to yield more precise records of relative mean sea level change than do geologic records, it is important to examine as much information as possible for a specific area before applying the results obtained from one specific tide station to all projects in the area. One example of the difficulty associated with determining relative mean sea level change from tide station records can be found in San Francisco Bay.

The longest continuously recording tide gauge in North America is located on the Presidio of San Francisco, near the entrance to the Golden Gate. This tide gauge (NOAA tide gauge number 941 4290) has been recording since 1854 and is frequently used to describe the rate of relative mean sea level change near San Francisco over the last 147 years. When the data from this tide gauge is examined along with that of other gauges in the San Francisco Bay area and in Northern

California, however, it becomes apparent that the rate of relative mean sea level change associated with the Presidio gauge is questionable (see Table 1).

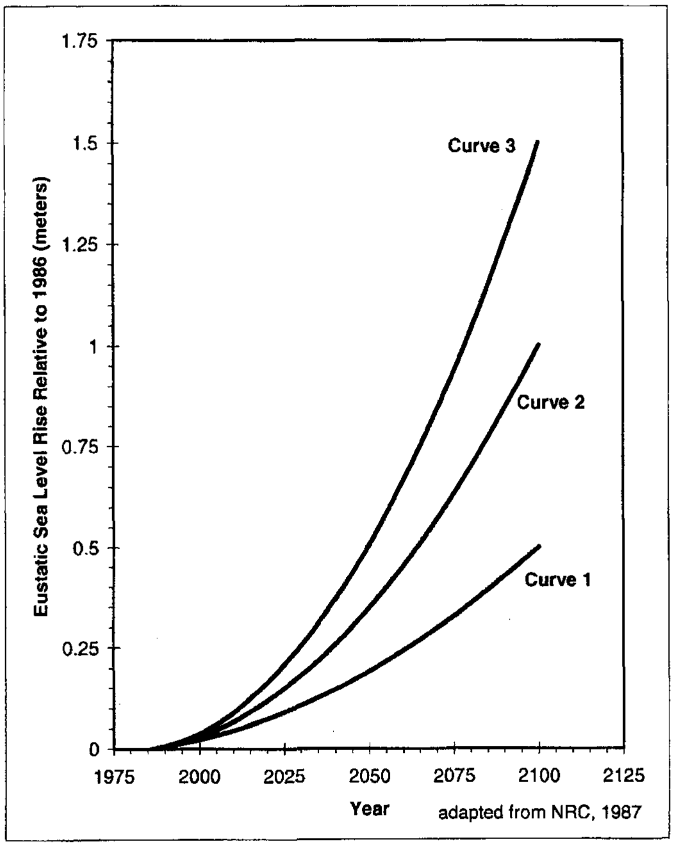

Figure 1. National Research Council Scenarios for Eustatic Sea Level Rise

The full 146-year record for the Presidio gauge shows a (linear) relative mean sea level rise trend of 1.41 mm/year. Closer examination, however, reveals that the record for the same gauge, from 1906 (post San Francisco earthquake) to the present, shows a (linear) relative mean sea level rise trend of 2.13 mm/year. While there does not appear to have been a sudden vertical shift in the gauge in 1906, the apparent increase in the relative mean sea level rise rate appears to be significant. Determining which rate is appropriate to use for long-term analysis is subjective and suggests that determining the rate of relative mean sea level rise at other locations in the bay may be useful.

Table 1. Linear Trends in Relative Monthly Mean Sea Level for the San Francisco Bay Area and Northern California*

Station Name	NOAA Tide Gauge Number	Years of Record	MSL Trend (mm/year)	Standard Error (mm/year)
Presidio	941 4290	146	1.41	0.08
Presidio (pre 1906 earthquake)	941 4290	52	1.12	0.35
Presidio (post 1906 earthquake)	941 4290	94	2.13	0.14
Alameda	941 4750	61	0.89	0.32
Monterey	941 3450	27	1.86	1.09
Point Reyes	941 5020	25	2.51	1.27
Crescent City	941 9750	67	-0.48	0.23

* Trends are for all data up to 1999 (Zervas, to be published)

The second longest recording tide gauge in San Francisco Bay is the Alameda gauge (941 4750), which has been recording since 1939 and is approximately 30 kilometers from the Presidio gauge. The Alameda gauge shows a (linear) relative mean sea level rise trend of 0.89 mm/year. This rate is significantly less than that of the Presidio gauge, possibly indicating that either the Alameda gauge or the Presidio gauge (or both) is moving vertically and may not be accurately recording relative mean sea level change. While it may seem reasonable to assume that the Presidio gauge is slowly sinking, relative to the Alameda gauge and a fixed vertical datum, this is not necessarily so and is not supported by measurements taken from local tidal benchmarks. The alternative would seem to be that the Alameda gauge, which is based over a thick layer of unconsolidated bay mud, is slowly rising. This is also not necessarily so, indicating that a complete releveling of each of these tide gauges may be necessary before concluding that either one provides an accurate estimate of local relative mean sea level change.

In an attempt to assess the possibility of vertical tectonic movement affecting the tide gauges in the San Francisco Bay area, the Corps also examined the records for the National Geodetic Survey (NGS) global positioning system (GPS) continuously operating reference station (CORS) located on Angel Island in San Francisco Bay (NGS station designation PBL1). The NGS reports that this station has recorded a vertical velocity of 0.4 mm/year, +/- 1.0 mm/year, downward over the last seven years and interprets this to mean that there has been no significant steady vertical crustal motion at this location over the last seven years (Soler, 2001). While this lends credibility to the trends in relative mean sea level change calculated for the Presidio gauge, it does not help resolve the discrepancy between the trends at the Presidio gauge and the Alameda gauge. It is also important to note that assuming the vertical velocity at CORS site PBL1 applies to the bedrock around the Presidio gauge or the area around the Alameda gauge may not be appropriate, given the proximity of active geologic faults in the area.

The different possible relative mean sea level rise rates at the Presidio gauge and the smaller relative mean sea level rise rate at the nearby Alameda gauge combine to demonstrate the difficulty that can be associated with trying to determine a historically supported local rate for relative mean sea level change. In San Francisco Bay, the Corps' practice is to base an estimate for local relative mean sea level change on the trends at a variety of local tide gauges, taking into consideration the geology around those gauges, and attempting to err (if necessary) on the conservative side with a rate close to the post San Francisco earthquake rate for the Presidio gauge. Relative mean sea level trends for other locations around the United States, as calculated by NOAA, are listed in Table 2.

Table 2. Linear Trends in Relative Monthly Mean Sea Level for Various Locations around the United States*

NOAA Tide Station Name	First Year of Record	Years of Record	MSL Trend (mm/year)	Standard Error (mm/year)
Bermuda	1932	68	1.83	0.30
Eastport, Maine	1929	71	2.12	0.13
Bar Harbor	1947	53	2.18	0.16
Portland	1912	88	1.91	0.09
Boston	1921	79	2.65	0.10
Montauk	1947	53	2.58	0.19
The Battery	1856	144	2.77	0.05
Philadelphia	1900	100	2.75	0.12
Baltimore	1902	98	3.12	0.08
Charleston, SC	1921	79	3.28	0.14
Fernandina Beach	1897	103	2.04	0.12
Key West	1913	87	2.27	0.09
Pensacola	1923	77	2.14	0.15
Galveston Pier 21	1908	92	6.50	0.16
San Diego	1906	94	2.15	0.12
Los Angeles	1923	77	0.84	0.16
Astoria	1925	75	-0.16	0.24
Ketchikan	1919	81	-0.11	0.16
Juneau	1936	64	-12.69	0.26
Cordova	1964	36	6.97	0.60
Anchorage	1972	28	2.76	1.16
Honolulu	1905	95	1.50	0.14
Hilo	1927	73	3.36	0.21
Guam	1948	52	0.10	0.90
Pago Pago	1948	52	1.48	0.56

* Trends are for all data up to 1999; this table is adapted from Table 3 in the NOAA Technical Report *Sea Level Variations in the United States, 1854-1999* (Zervas, to be published)

U.S. ARMY CORPS OF ENGINEERS

Relevance to Coastal Engineering Projects

The Corps is actively involved with a variety of types of coastal engineering projects. These projects include, but are not limited to, traditional shoreline protection and erosion control projects, navigation improvement and maintenance projects, beach nourishment projects, and ecosystem restoration projects. The effect of a rise in relative mean sea level is readily apparent for most coastal structures projects. An increase in relative mean sea level could result in larger wave heights near structures, higher wave runup, more erosion and less protection. The effect of a change in relative mean sea level on coastal and estuarine ecosystem restoration projects may, however, be less obvious.

For tidal wetland restoration projects in San Francisco Bay, the Corps designs its projects for an optimum mix of tidal and seasonal wetlands. This mix is determined by local biologists along with members from several state and Federal resource agencies. Because tidal datums have a direct effect on sedimentation levels and the resulting plant communities that develop, failure to account for relative mean sea level change in a tidal wetland restoration project could lead to decreased habitat area for target (threatened and endangered) species. It could also lead to inadequate transition zones between the tidal and seasonal wetlands and a less than optimum mix of tidal and seasonal wetlands, both of which would have adverse effects on habitat area. Some of these projects are so sensitive to tidal datums and relative mean sea level that failure to account for relative mean sea level change could result in project failure twenty, thirty or forty years into the future.

Former and Current Policy

In 1986 the Corps policy for including sea level rise in planning, design, and monitoring of its projects was to consider only local historical data, with extrapolation as necessary (USACE, 1986). More recently, the Corps has changed its policy to that described in its *Planning Guidance*, Engineering Regulation 1105-2-100, Appendix E, Section IV.E-24.k (USACE, 2000). The current policy clearly states that the Corps will address the risks and uncertainty associated with both historically determined and future estimates for sea level rise rates. Specific guidance from the Corps regulation states:

- *Potential relative sea level change should be considered in every coastal and estuarine (as far inland as the new head of tide) feasibility study that the Corps undertakes.*

- *A sensitivity analysis should be conducted to determine what effect (if any) changes in sea level would have on plan evaluation and selection. The analysis should be based, as a minimum, on the extrapolation of the local, historical record of relative sea level rise as the low level and Curve 3 from the NRC report as the high level.*

- *If the plan selection is sensitive to sea level rise, then design considerations could allow for future modification when the impacts of future sea level rise can be confirmed* [adaptive management].

- *Feasibility studies should consider which designs are most appropriate for a range of possible future rates of rise. Designs that would be appropriate for the entire range of uncertainty should receive preference over those that would be optimal for a particular rate of rise but unsuccessful for other possible outcomes.*

The policy also states that Corps projects should consider three different methods to include the possibility of sea level rise in a project:

1. Adaptive management. Allow for future modifications to the project after the effects of sea level rise can be confirmed.

2. Facilitating future modifications. Design projects for current mean sea level but incorporate features that will help facilitate future structural changes (this could also be considered a form of adaptive management).

3. Design for the future. Base current design on the estimate of mean sea level at some point in the future.

CASE STUDY, U.S. ARMY CORPS OF ENGINEERS PRACTICE

The *Ocean Beach Storm Damage Reduction Feasibility Study* (USACE, 1996) provides a good case study for examining how to apply the Corps' sea level rise policy. This feasibility study was initiated in the mid-1990s, stopped in 1996 due to a lack of funding from the local cost-sharing partner, and reinitiated in 2001. The feasibility study addresses the problem of severe shoreline erosion along the southern end of Ocean Beach in San Francisco. In the original feasibility study, the Corps considered the following alternatives as potential solutions to the problem: no action, a rubble-mound revetment, seawall type 1, seawall type 2, dune nourishment, and beach nourishment. The following two sections describe how the Corps incorporated its former (1986) policy on sea level rise in the original feasibility study and how it could apply its current (2000) policy to the same alternatives as the recently reinitiated study progresses.

Former (1986) Policy

The Corps examined the economic benefits and costs of each of the six alternatives and, in accordance with its former sea level rise policy (which was in place at the time of the initial feasibility study), applied a (then) historically supported local relative mean sea level rise rate of 1.8 mm/year for the fifty-year design life of the project alternatives. The Corps applied this sea level rise rate to the existing local mean sea level and used the resulting water level(s) for all calculations and numerical modeling for wave transformation, wave height, wave runup, longshore and cross-shore currents, littoral transport, and shoreline erosion. For the hard structure alternatives, the revetment and the two types of sea walls, the Corps multiplied the relative mean sea level rise rate by the fifty-year design life of the structures and applied the result as a single value to determine the maximum water level for design purposes. For the no action alternative and the soft structure alternatives, the dune and beach nourishment, the Corps applied the relative mean sea level rise rate as an annual increase to local mean sea level for the fifty-year design life of the project. This resulted in fifty different values for local mean sea level, each of which was used for an iteration in the numerical models for erosion and littoral transport. The Corps then calculated economic benefits and costs for each of the design alternatives.

Current (2000) Policy

While it is likely that the Corps will consider different alternatives in its current (reinitiated) feasibility study for Ocean Beach, this paper will apply the current Corps policy on sea level rise only to the alternatives proposed in the 1996 feasibility study. Under current policy, the Corps will address each of the design alternatives in a very different manner than it did in 1996. Initially the Corps will determine the sea level rise rates that would represent the lower and upper bounds for consideration. Assuming that the mean sea level record at the Presidio tide gauge, since the 1906 earthquake, accurately represents the local historic trend in relative mean sea level change, the Corps would set the lower bound for sea level rise at 2.13 mm/year or 0.107 meters over the fifty year design life of the project. Using Curve 3 from the NRC publication as the maximum possible rate, the Corps would set the upper bound for sea level rise by manipulating equation (1), with b equal to 1.069E-4. Manipulating equation (1) to account for the fact that it was developed for eustatic sea level rise starting in 1986, while the project will be starting at some date after 1986, results in equation (2)

$$E(t_2) - E(t_1) = 0.0012(t_2 - t_1) + b(t_2^2 - t_1^2) \qquad (2)$$

where t_1 is the time between the project start time and 1986 and t_2 is the time between the end of the fifty-year project life and 1986 (or $t_2 = t_1 + 50$). If t_1 and t_2 in this example are defined as

$$t_1 = 2001 - 1986 = 15 \qquad \text{and} \qquad t_2 = 2051 - 1986 = 65$$

the total rise in eustatic sea level, as calculated using Curve 3, between the start date of the project and the end of its fifty-year design life would be 0.49 meters. To determine intermediate rates of sea level rise for consideration, the Corps would use Curves 1 and 2 from the NRC publication. Again using equation (2), with t_1 and t_2 defined as above and the appropriate constants for Curves 1 and 2, intermediate values for sea level rise after fifty years would be 0.17 meters (Curve 1) and 0.33 meters (Curve 2).

For the hard structure alternatives, the Corps would then follow a three-step procedure. First, the Corps would determine whether or not the alternatives were sensitive to sea level rise (in this case the answer would be *yes*). Second, the Corps would consider the three methods previously listed for incorporating sea level rise into project design and would choose one or more methods for each structural alternative. This could lead to each alternative being expanded into two or three alternatives, one based on adaptive management, a second based on facilitating future modifications, and a third designed for the fifty-year value of sea level rise. Third, the Corps would evaluate the new alternatives to determine which would be the most appropriate for the complete range of sea level rise rates and which would be the most economical (highest benefit:cost ratio). Designs that would be appropriate for the complete range of sea level rise rates would receive preference over those that maximized the benefit:cost ratio for one rate of sea level rise but failed to accommodate other possible rates of rise. This criteria, whether or not a design alternative accommodates the complete range of sea level rise rates, could be used as an initial screening mechanism at this stage of the evaluation to limit the number of alternatives that would need a full economic analysis.

For the soft structure alternatives the procedure would be similar but would include additional steps. Erosion of the existing and proposed beach, dunes, and bluff would occur at different rates throughout the life of the project, depending on which sea level rise scenario the Corps chose. In order to properly evaluate this, the Corps would have to evaluate erosion, project conditions, and environmental conditions on an annual basis, with a constant rate of sea level rise for the historically-based scenario and accelerating rates of sea level rise for the three NRC-based scenarios. The Corps would then evaluate the benefit:cost ratios for each of the soft structure alternatives by summing the individual benefits and costs associated with each yearly increment of the fifty-year project life. The results of this portion of the analysis could be summarized in a table such as Table 3.

As described previously, during its final evaluation process the Corps would consider all alternatives with a benefit:cost ratio greater than or equal to 1.0:1 but would give preference to designs that would be appropriate for the entire range of uncertainty.

CONCLUSIONS

Corps of Engineers policy clearly states that all Corps studies will address the risks and uncertainty associated with historically determined and future estimates for sea level rise rates. Studies are to address the uncertainty associated with determining a sea level rise rate by using the local historic relative mean sea level rise rate as the lower limit and Curve 3 from the NRC's 1987 publication as the upper limit for its analysis. It is the responsibility of each Corps District to determine the appropriate historic relative mean sea level rise rate for each study or project location.

By evaluating each design alternative over the full range of possible sea level rise rates, and by giving preference to design alternatives that adequately accommodate the full range of sea level rise uncertainty, Corps studies should result in designs that are successful throughout their fifty-year project lives and possibly beyond. While this procedure may seem overly conservative, in that it addresses and accommodates potential sea level rise rates that some people view as extreme, the Corps of Engineers feels that it is a prudent and fiscally responsible design method, given the uncertainty associated with future sea level rise.

Table 3. Alternative Evaluations for Varying Rates of Local Mean Sea Level Rise (Example)

	Accommodates Sea Level Rise/Benefit:Cost Ratio			
Alternative	Historical rate*	Curve 1 rate*	Curve 2 rate*	Curve 3 rate*
1(a) Revetment (adaptive mgmnt)	Yes / 1.40:1	Yes / 1.38:1	Yes / 1.19:1	Yes / 1.02:1
1(b) Revetment (facilitates future modifications)	Yes / 1.23:1	Yes / 1.09:1	No / 0.99:1	No / n/a
1(c) Revetment (designed for 50-year sea level rise value)	Yes / 1.27:1	Yes / 1.17:1	Yes / 1.03:1	No / 0.92:1
2(a) Seawall 1				
2(b) Seawall 1				
2(c) Seawall 1				
3(a) Seawall 2				
3(b) Seawall 2				
3(c) Seawall 2				
4(a) Beach nourishment				
4(b) Beach nourishment				
4(c) Beach nourishment				
5(a) Dune nourishment				
5(b) Dune nourishment				
5(c) Dune nourishment				
6 No action				

* Benefit:cost ratios and the determination of whether or not alternatives accommodate the specified rates of relative mean sea level rise are completely hypothetical and are not related, in any way, to actual alternatives for the Ocean Beach Storm Damage Reduction Feasibility Study.

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Appendix G

Multiple-Pit Breakwaters

By William G. McDougal,[1] A. Neil Williams,[2] and Keizo Furukawa[3]

Abstract: Linearized shallow-water wave theory is used to investigate the interaction of surface waves with multiple rectangular submarine pits in water of otherwise uniform depth. The solution is obtained by a boundary element technique using a two-dimensional Green's function. It is shown that appropriate selection of pit dimensions and placement may lead to a significant reduction in wave heights behind these structures. Numerical results have been presented that illustrate the influence of the various pit characteristics on the diffracted wave field. Two pits can provide a shadow region in which wave heights are reduced to 10–20% of the incident wave height. The shadow region, with wave heights reduced to 30% of the incident wave height, is approximately the width of the pits and five wavelengths long. Guidance is given on how to select pit geometries and placement for optimal breakwater performance. An example is also presented that shows how to select a pit to reduce wave heights in a navigation channel.

INTRODUCTION

Breakwaters are commonly used as a means of providing coastal facilities and shorelines protection from wave attack. Whether submerged or surface piercing, fixed or floating, most breakwaters occupy a portion of the water column and provide protection through reflection and/or dissipation of the incident wave energy. In the present paper, an alternative form of breakwater configuration is considered in which submarine depressions are used. Williams (1990) used linear shallow-water wave theory to study the interaction of waves with a single rectangular pit. This analysis was later extended to three dimensions by Williams and Vazquez (1991). In both cases it was shown that a significant shadow zone may develop in the lee of a rectangular depression. It is possible to exploit this characteristic further using multiple depressions (or pits) to provide an increased degree of protection from wave attack. This idea in particular is the topic of the present paper. As intuitively expected, Williams (1990) and Williams and Vazquez (1991) found that the influence of the pit on the incident wave field is most pronounced in shallower water and, therefore, in the present study, only long waves are considered.

The theoretical solution presented herein is based on a boundary element approach. The fluid domain is divided into multiple regions: interior regions whose boundaries consist of the projection of the outline of the pits and an exterior region consisting of the remainder of the fluid domain. Application of Green's second identity using an appropriate Green's function in each region (interior and exterior) leads to a set of simultaneous integral equations for the velocity potential and its normal derivative on the imaginary fluid interfaces between the interior and exterior regions. These integral equations may then be discretized and the resulting systems of algebraic equations solved by standard matrix techniques. Using the values of the velocity potential and its derivative on the imaginary fluid boundaries, a reapplication of Green's identity allows the potential, and hence surface elevation, at any point in the fluid to be determined.

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Numerical results are presented that illustrate the influence of the various pit characteristics on the wave field for several example geometries. It is shown that appropriate selection of pit dimensions and placement may lead to a significant reduction in wave heights behind these structures. Guidance is given on how to select pit geometries and placement for optimal breakwater performance. An example is also presented that shows how to select a pit to reduce wave heights in a navigation channel.

THEORETICAL DEVELOPMENT

A train of regular surface waves of height H and angular frequency ω propagate over N rectangular pits of width a_j and length b_j, $j = 1, 2, \ldots, N$ as shown in Fig. 1. The interior water depth within pit j is denoted by d_j, and that of the exterior fluid region is denoted by h. Cartesian coordinates are employed with the x- and y-axes in the horizontal plane and the z-axis pointing vertically upward from an origin at the still-water level. One corner of each pit may also be taken as the origin of a local coordinate system (x_j, y_j, z), $j = 1, 2, \ldots, N$. The incident waves propagate at an angle θ to the positive x-axis.

The fluid is taken to be inviscid and incompressible and the flow irrotational. Furthermore, it will be assumed that

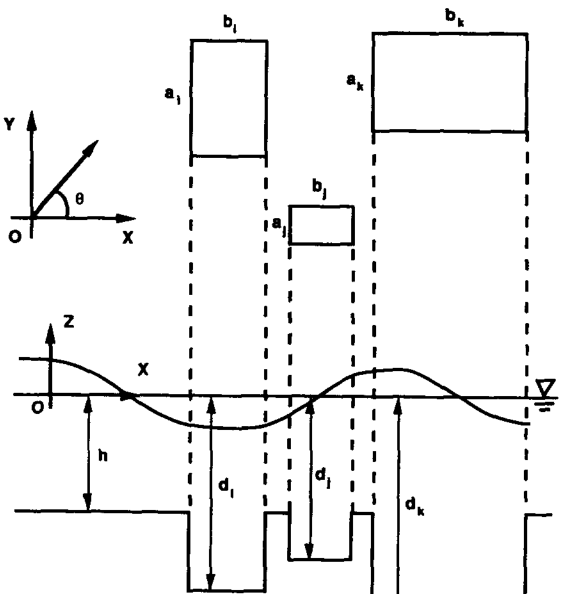

FIG. 1. General, Multiple-Pit Configuration

wave heights are sufficiently small and that the wavelength to water depth ratios are such that linearized shallow-water wave theory is applicable. Subject to the aforementioned restrictions and assumptions the fluid motion may be described in terms of a depth-averaged velocity potential $\phi(x, y, t) = \text{Re}[\Phi(x, y)e^{-i\omega t}]$. The fluid domain is divided into $N + 1$ regions (Fig. 1), N interior regions defined by $0 \le x_j \le b_j$, $0 \le y_j \le a_j$, $-d_j \le z \le 0$, $j = 1, 2, \ldots, N$, and an exterior region ($N + 1$) consisting of the remainder of the fluid domain. The governing equations in each of the fluid regions may be written

$$\frac{\partial^2 \Phi_j}{\partial x^2} + \frac{\partial^2 \Phi_j}{\partial y^2} + k_j^2 \Phi_j = 0; \quad j = 1, 2, \ldots, N + 1 \qquad (1)$$

where the wave numbers k_j are defined by

$$k_j = \frac{\omega}{\sqrt{(gd_j)}}; \quad j = 1, 2, \ldots, N \qquad (2)$$

$$k_{N+1} = \frac{\omega}{\sqrt{(gh)}} \qquad (3)$$

and g = acceleration due to gravity.

Continuity of mass flux and pressure across the fluid interface between the interior and exterior regions requires the following conditions be satisifed there:

$$d_j \frac{\partial \Phi_j}{\partial n} = h \frac{\partial \Phi_{N+1}}{\partial n}; \quad \text{on } \Gamma_j \qquad (4)$$

$$\Phi_j = \Phi_{N+1}; \quad \text{on } \Gamma_j \qquad (5)$$

where Γ_j denotes the interface contour (Fig. 1), and n the normal to Γ_j directed from region j, $j = 1, 2, \ldots, N$ into region $N + 1$. The theoretical basis for (1)–(5) may be found in Stoker (1957).

Finally the scattered component of the fluid potential in the exterior region must satisfy an appropriate radiation condition at large radial distances r from the pit, namely

$$\lim_{r \to \infty} \sqrt{r} \left\{ \frac{\partial}{\partial r} - ik_{N+1} \right\} (\Phi_{N+1} - \Phi_{N+1}^I) = 0 \qquad (6)$$

where Φ_{N+1}^I = the complex amplitude of the incident potential and is given by

$$\Phi_{N+1}^I(x, y) = \frac{-igH}{2\omega} e^{ik_{N+1}(x\cos\theta + y\sin\theta)} \qquad (7)$$

Suitable Green's functions $G_j(\bar{r}, \bar{r}')$, $j = 1, 2, \ldots, N$ and $G_{N+1}(\bar{r}, \bar{r}')$ may now be defined for the interior and exterior regions, respectively as (Lee 1971)

$$G_j(\bar{r}, \bar{r}') = \frac{i\pi}{2} H_0^{(1)}(k_j R); \quad j = 1, 2, \ldots, N \qquad (8)$$

$$G_{N+1}(\bar{r}, \bar{r}') = \frac{i\pi}{2} H_0^{(1)}(k_{N+1} R) \qquad (9)$$

where $H_0^{(1)}$ is the Hankel function of the first kind of order zero; $\bar{r} = (x, y)$, $\bar{r}' = (x', y')$ and $R^2 = (x - x')^2 + (y - y')^2$. The above Green's functions satisfy the respective governing equations in the fluid regions except at $\bar{r} = \bar{r}'$, where they each exhibit a logarithmic singularity. In addition, $G_{N+1}(\bar{r}, \bar{r}')$ satisfies the radiation condition, (6). Applying Green's second identity to Φ_j and G_j over region j (interior to pit j) yields

$$\varepsilon_j \pi \Phi_j(\bar{r}') + \int_{\Gamma_j} \left\{ \Phi_j(\bar{r}) \frac{\partial G_j}{\partial n}(\bar{r}, \bar{r}') - G_j(\bar{r}, \bar{r}') \frac{\partial \Phi_j}{\partial n}(\bar{r}) \right\} d\Gamma = 0;$$
$$j = 1, 2, \ldots, N \qquad (10)$$

where $\varepsilon_j = 2$ if $\bar{r}'$ is inside Γ_j; $\varepsilon_j = 1$ if $\bar{r}'$ is on a smooth portion of Γ_j; and $\varepsilon_j = 1/2$ if $\bar{r}'$ is a corner point of Γ_j. Similarly, applying Green's second identity to Φ_{N+1} and G_{N+1} over the exterior region ($N+1$) results in the following integral equation:

$$\sum_j^N \int_{\Gamma_j} \left\{ \Phi_{N+1}(\bar{r}) \frac{\partial G_{N+1}}{\partial n}(\bar{r}, \bar{r}') - G_{N+1}(\bar{r}, \bar{r}') \frac{\partial \Phi_{N+1}}{\partial n}(\bar{r}) \right\} d\Gamma$$
$$+ 2\pi \Phi_{N+1}^I(\bar{r}') = \varepsilon_{N+1} \pi \Phi_{N+1}(\bar{r}') \qquad (11)$$

where $\varepsilon_{N+1} = 2$ if $\bar{r}'$ is outside Γ_j (i.e., inside the exterior fluid domain); $\varepsilon_{N+1} = 1$ if $\bar{r}'$ is on a smooth portion of Γ_j and $\varepsilon_{N+1} = 3/2$ if $\bar{r}'$ is a corner point on Γ_j, $j = 1, 2, \ldots, N$.

Restricting $\bar{r}'$ to lie on Γ_j and applying the interface matching conditions, (4) and (5), leads to the following integral equations:

$$\varepsilon_j \Phi_{N+1}(\bar{r}') + \frac{1}{\pi} \int_{\Gamma_j} \left\{ \Phi_{N+1}(\bar{r}) \frac{\partial G_j}{\partial n}(\bar{r}, \bar{r}') - \frac{h}{d_j} G_j(\bar{r}, \bar{r}') \frac{\partial \Phi_{N+1}}{\partial n}(\bar{r}) \right\} d\Gamma = 0; \quad j = 1, 2, \ldots, N \qquad (12)$$

$$\varepsilon_{N+1} \Phi_{N+1}(\bar{r}') - \frac{1}{\pi} \sum_{j=1}^N \int_{\Gamma_j} \left\{ \Phi_{N+1}(\bar{r}) \frac{\partial G_{N+1}}{\partial n}(\bar{r}, \bar{r}') - G_{N+1}(\bar{r}, \bar{r}') \frac{\partial \Phi_{N+1}}{\partial n}(\bar{r}) \right\} d\Gamma = 2\Phi_{N+1}^I(\bar{r}') \qquad (13)$$

which link the values of Φ_{N+1} and $\partial \Phi_{N+1}/\partial n$ on $\Gamma = \Sigma\, \Gamma_j$.

The preceding integral equations may be solved by discretizing the integration contour Γ into a number of small line segments and assuming the potential and its normal derivative to be constant in each and equal to their respective values at the segment midpoint (node). This procedure results in a set of simultaneous matrix equations for the fluid potential and its normal derivative at the segment nodes that may be solved by standard matrix techniques.

Having obtained the potentials and normal derivatives at the interfaces the potentials at any point in the fluid may now be calculated using (10) or (11) with the appropriate value of ε_j, $j = 1, 2, \ldots, N + 1$. The free-surface elevations in each region may be obtained from the corresponding potentials using

$$\eta_j = -\frac{1}{g} \frac{\partial \phi_j}{\partial t}; \quad j = 1, 2, \ldots, N + 1 \qquad (14)$$

where $\eta_j(x, y, t) = \text{Re}[\Delta_j(x, y)e^{-i\omega t}]$, $j = 1, 2, \ldots, N + 1$. Finally, the diffraction coefficient K is defined as the ratio of the magnitude of the free surface elevation to the incident wave amplitude. It is this parameter that is of primary interest in the present work.

NUMERICAL RESULTS AND DISCUSSION

A computer program has been developed to implement the above theory and to illustrate the relationship between the various wave and geometrical parameters in the problem. In obtaining the results presented herein the interface contour Γ_j of each pit, $j = 1, 2, \ldots, N$, was discretized into 80–120 line segments.

Single-Pit Configuration

Because of the complexity of the multiple-pit problem, the single pit is first examined in some detail. Although numerical results for a single pit have been obtained by Williams (1990), the parameter range considered herein and the focus of the

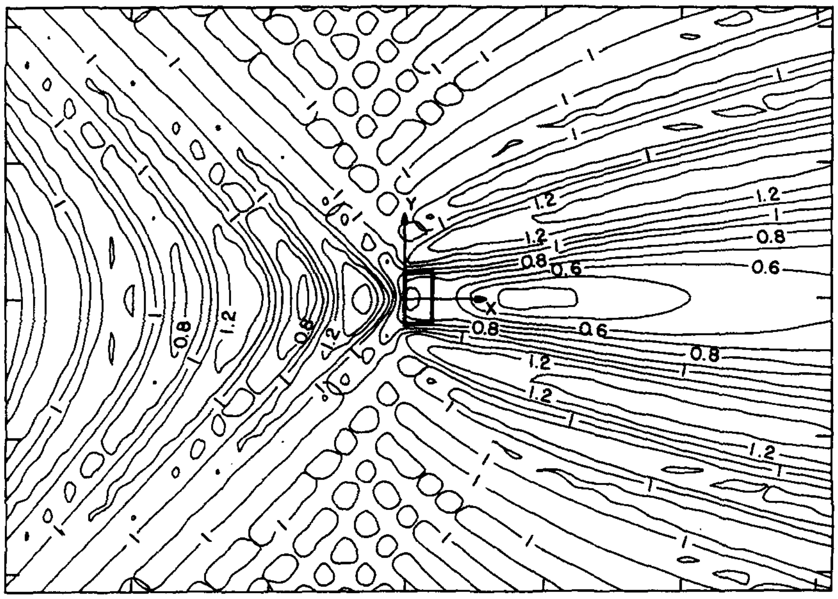

FIG. 2. Contours of Diffraction Coefficient for Single Pit with a/L = 1.0, b/L = 0.5, d/h = 3, κh = 0.167, and θ = 0°. Region Shown Is 4L Upstream and 8L Downstream Measured from the Front of the Pit, and ±4L in the Transverse Direction Measured from the Pit Center

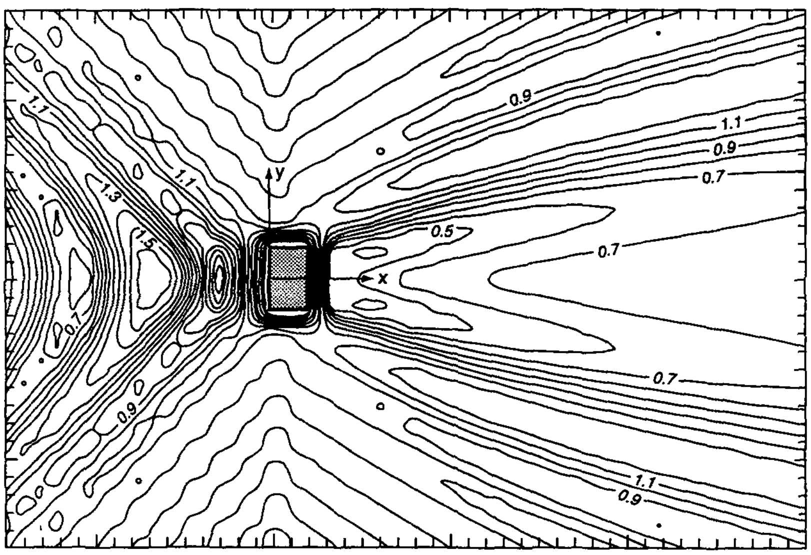

FIG. 3. Contours of Diffraction Coefficients for Conventional, Bottom-Founded, Surface-Piercing Breakwater with a/L = 1.0, b/L = 0.5, κh = 0.167, and θ = 0°. Region Shown Is Identical to that in Figure 2

present discussion are completely different. The results are presented in terms of dimensionless pit width, length, and depth parameters a/L, b/L, and d/h, where a, b, and d denote the single pit width, length, and depth, respectively, and L is the incident wavelength in the exterior region. It is noted that the diffraction pattern in the vicinity of the pit may be quite complex. Fig. 2 shows the diffraction pattern for the case of a single pit with $a/L = 1.0$, $b/L = 0.5$, and $d/h = 3$, for an incident wave direction $\theta = 0°$. The dimensionless wave frequency $\kappa h = 0.167$, where $\kappa = 2\pi/L$. The location of the pit is shown in the figure. The contour lines indicate the values of the diffraction coefficient. It can be seen that in front of the pit a partial standing wave system develops, while in the lee of the pit a shadow zone exists in which wave heights are reduced. In this shadow region diffraction coefficients of $K = 0.4$ are achieved. This single pit provides a level of protection in long waves that exceeds that achieved by many types of floating breakwaters. In fact, the performance is superior to a rigid, impermeable full-depth breakwater of comparable dimensions (see Fig. 3). It is this characteristic that will be exploited in developing the multiple-pit breakwater concept.

The above parameter combination, namely $a/L = 1.0$, $b/L = 0.5$, $d/h = 3$, and $\kappa h = 0.167$, will be taken as the reference case for the single-pit configuration. Variations in the various parameters about this reference case now examined. First, the sensitivity to a/L, the dimensionless pit width, is considered. Fig. 4 shows that for values of $1.0 \leq a/L \leq 5.0$, and all other parameters equal to their reference values, the minimum diffraction coefficient in the lee of the pit is of the order of 0.25. Also shown in Fig. 4 are the dimensionless distances x_f/L and x_b/L from the rear of the pit to the front and back of the $K = 0.5$ zone. It can be seen that the location of this "acceptable" shadow zone is strongly dependent on a/L. For a pit breakwater of width equal to the incident wavelength, acceptably low values of the diffraction

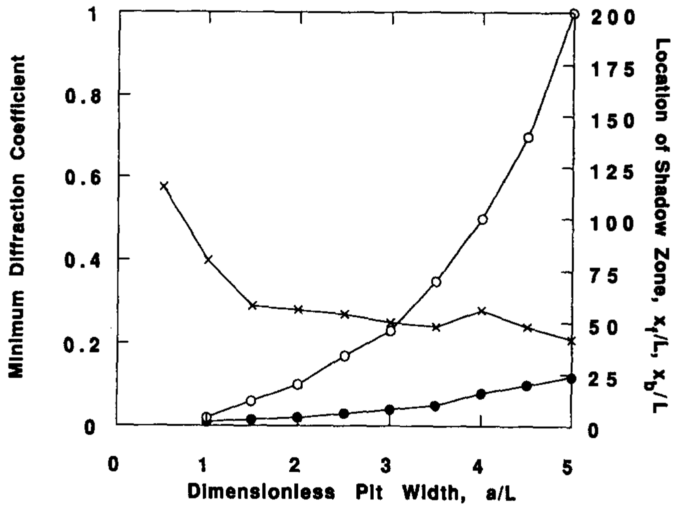

FIG. 4. Variation of Minimum Diffraction Coefficient and Location of Shadow Zone ($K < 0.5$) with Dimensionless Pit Width a/L for Single Pit ($b/L = 0.5$, $d/h = 3$, $\kappa h = 0.167$, and $\theta = 0°$) (Notations: × = K; ● = x_f/L; ○ = x_b/L)

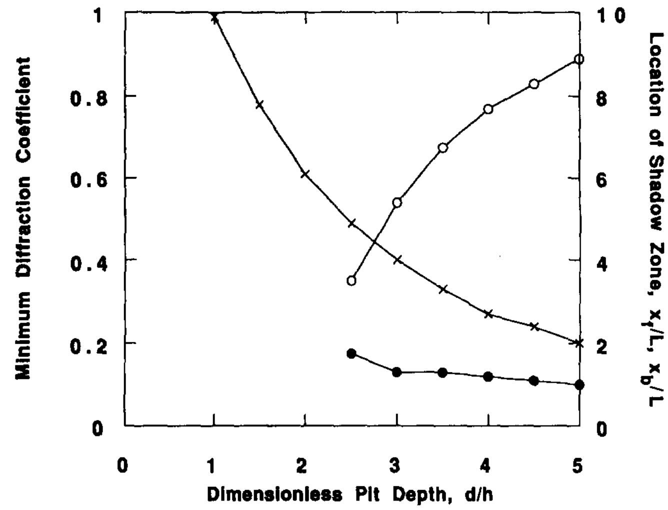

FIG. 6. Variation of Minimum Diffraction Coefficient and Location of Shadow Zone ($K < 0.5$) with Dimensionless Pit Depth d/h for Single Pit ($a/L = 1.0$, $b/L = 0.5$, $\kappa h = 0.167$, and $\theta = 0°$) (Notations: × = K; ● = x_f/L; ○ = x_b/L)

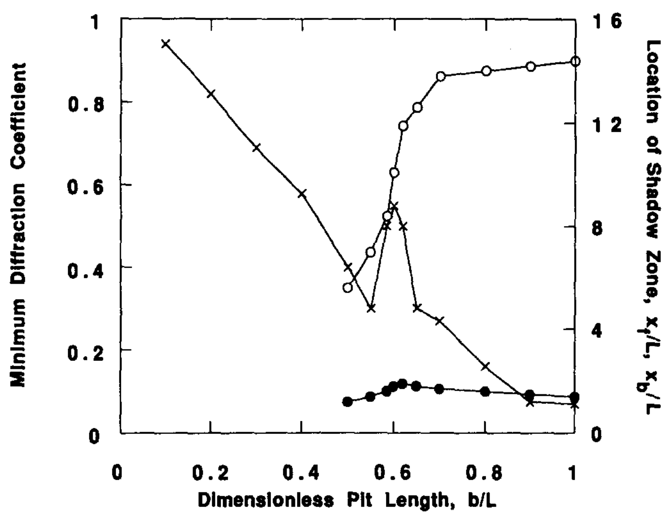

FIG. 5. Variation of Minimum Diffraction Coefficient and Location of Shadow Zone ($K < 0.5$) with Dimensionless Pit Length b/L for Single Pit ($a/L = 1.0$, $d/h = 3$, $\kappa h = 0.167$, and $\theta = 0°$) (Notations: × = K; ● = x_f/L; ○ = x_b/L)

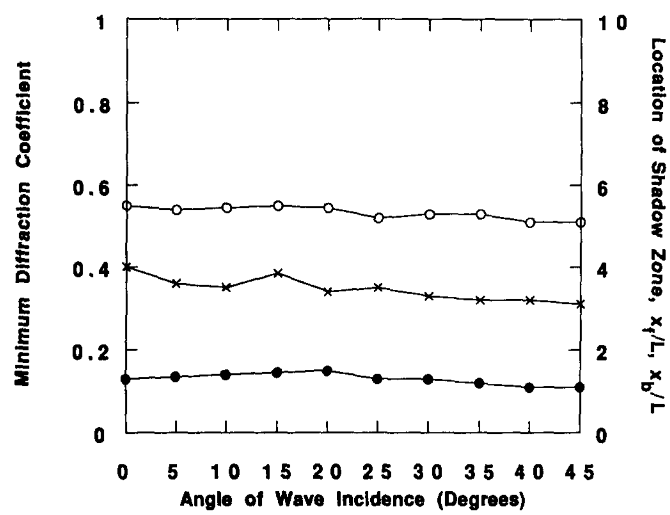

FIG. 7. Variation of Minimum Diffraction Coefficient and Location of Shadow Zone ($K < 0.5$) with Angle of Wave Incidence θ for Single Pit ($a/L = 1.0$, $b/L = 0.5$, $d/h = 3$, and $\kappa h = 0.167$) (Notations: × = K; ● = x_f/L; ○ = x_b/L)

coefficient ($K < 0.5$) occur over a region approximately one to six wavelengths behind the structure. However, for a pit with a width of three wavelengths, the low values of the diffraction coefficient occur over a region from approximately seven to 50 wavelengths behind the structure. From Fig. 4, it is concluded that in order to provide a reasonable level of protection, the pit width should be at least one wavelength. However, for pits with a dimensionless width $a/L > 3.0$, the acceptable shadow zone is located a large distance behind the structure. For very wide pits, the minimum diffraction coefficient approaches a constant value. This value is much lower than that for the two-dimensional case of an infinitely long trench (Lee and Ayer 1981; Kirby and Dalrymple 1983; Furukawa 1991). This may be explained by observing that the finite-width pit results in a refraction divergence in the lee of the structure. Although increasing the pit width causes the shadow zone to occur further leeward of the structure, this divergence still exists.

The second geometrical consideration is the length of the pit, as measured by the dimensionless parameter b/L. The dependency of the minimum diffraction coefficient on b/L is shown in Fig. 5. All other parameters are taken equal to their reference values. It can be seen that for $b/L > 0.5$, the diffraction coefficient $K \leq 0.4$. Also, since little protection is afforded for $b/L < 0.5$, the value $b/L = 0.5$ represents a minimum dimensionless pit length for acceptable breakwater performance.

Fig. 6 shows the dependency of the minimum diffraction coefficient on the pit depth, as measured by the relative water depth d/h. Again, all other parameters are taken equal to their reference values. As intuitively expected, as the value of d/h increases, the level of protection provided by the pit also increases. From the figure it appears that a reasonable range of values is $3 \leq d/h \leq 4$.

From the above investigation of the diffraction characteristics of a single pit, the following geometric conditions appear to optimize wave protection in the lee of the structure for the wave condition considered: $a/L \geq 1.0$, $b/L \geq 0.5$, $d/h = 3$. These values are optimum in the sense that they yield maximum protection with minimum excavation.

In the preceding discussion, it was assumed that the waves are normally incident on the pit, that is, $\theta = 0°$. Fig. 7 shows the influence of wave direction on the minimum diffraction coefficient for the reference pit geometry. The results are

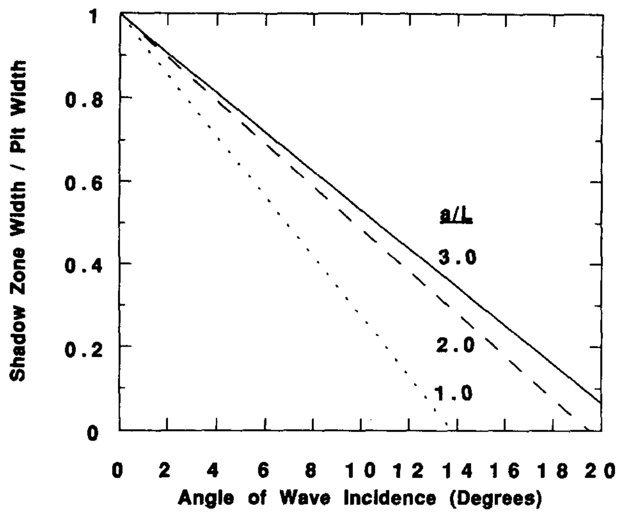

FIG. 8. Variation of Width of Shadow Zone ($K < 0.5$) with Range of Angle of Wave Incidence $\pm\theta$ for Single Pit ($b/L = 0.5$, $d/h = 3$, and $\kappa h = 0.167$)

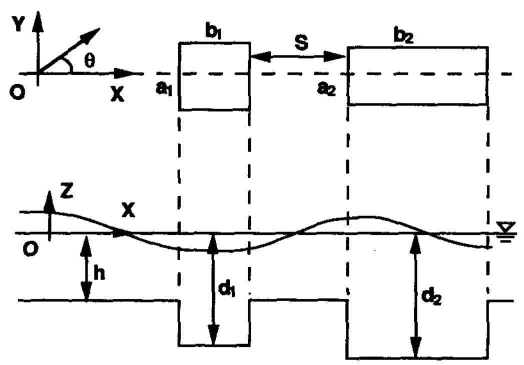

FIG. 9. Dual-Pit Configuration

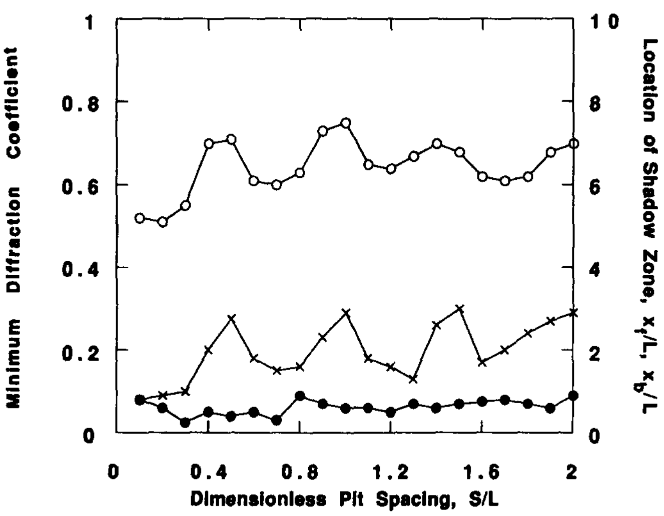

FIG. 10. Variation of Minimum Diffraction Coefficient and Location of Shadow Zone ($K < 0.3$) with Dimensionless Pit Spacing S/L for Dual-Pit Configuration ($a_j/L = 1.0$, $b_j/L = 0.5$, $d_j/h = 3$ for $j = 1, 2$, $\kappa h = 0.167$, and $\theta = 0°$) (Notations: × = K; ● = x_f/L; ○ = x_b/L)

similar to those for normal incidence and, generally, show a lack of sensitivity to wave angle. However, the diffraction shadow zone is now offset from the centerline of the structure and the width of the shadow zone is now approximately 80% of the projected width of the pit.

For waves incident on the pit at an angle θ, the shadow zone behind the structure will be offset by the same angle. A similar situation occurs for waves incident from an angle $-\theta$. The overlap of these two shadow zones is the area protected for waves incident from any angle in the sector $\pm\theta$. Obviously, the greater the variation in incident wave angle, the smaller the protected area. The width of the region defined by $K \leq 0.5$ is shown as a function of incident wave angle variation for different values of a/L in Fig. 8. The width of the overlap region is nondimensionalized by the pit width. It can be seen that the smaller width pits ($a/L = 1.0$) provide greater relative overlap for a given wave angle, since the distance between the pit and the acceptable shadow region increases with increasing pit width. For $a/L > 4$, the distance from the pit to the acceptable shadow zone is so large that only very small variations in θ overlap. This suggests that pit breakwaters are only effective for protecting coastal facilities and shorelines when the variation in wave direction is relatively small. However, since the pits are in shallow water, significant refraction will occur. Therefore, the deepwater incident wave angle variation may be much greater.

Multiple Pit Configuration

The diffracted wave field due to a pair of submarine pits is now studied. The geometry for the dual-pit configuration is defined in Fig. 9. A variety of pit locations have been examined (Furukawa 1991), including placing the second pit in the diffraction shadow of the first, and having both diffraction shadows overlap. It was observed that the case of overlapping shadows was most effective in reducing wave heights and also required considerably less space across the shoreline. Guidance for the pit geometries follows from the single-pit response. A dimensionless pit spacing parameter S/L, where S is the spacing between the pits (Fig. 9) is defined. Fig. 10 shows the influence of this parameter on the minimum diffraction coefficient for the case where $a_j/L = 1.0$, $b_j/L = 0.5$, $d_j/h = 3$ for $j = 1, 2$, $\kappa h = 0.167$, and $\theta = 0°$. It can be seen that there is a lack of sensitivity of the minimum diffraction coefficient to S/L. Although somewhat lower diffraction coefficients are obtained at certain spacings, this variation is rather minor and, in general, the diffraction coefficients are very low. Also shown in Fig. 10 are the dimensionless distances x_f/L and x_b/L from the rear of the second pit to the front and back of the $K \leq 0.3$ zone. It can be seen that the location of this shadow zone is relatively insensitive to S/L. However, for values of $S/L < 0.5$, the shadow zone tends to appear as two side lobes in the lee of the structure, while for $0.5 < S/L < 1.0$ the shadow zone is elliptical. A typical result for the diffraction pattern for the dual-pit configuration is shown in Fig. 11.

The numerical model was also used to study a three-pit configuration (Furukawa 1991). A number of placement schemes were considered. Pits were located such that their shadow zones all overlapped at a given location. The two rear pits were also placed so that each was in the shadow zone of the previous one. A rather surprising feature was that the performance of the dual-pit system was not significantly improved by adding a third pit. Therefore, it was concluded that only two pits are required; the third pit provides little improvement in performance for the additional costs associated with excavation.

Navigation Channel—An Example

The pit breakwater concept can be used in a variety of applications. Using the guidelines discussed, a pit is to be selected to protect a dredged navigation channel from long swell waves having a period of 18 s. The channel is 100 m wide, 1,000 m long, and 12 m deep. The adjacent, undredged

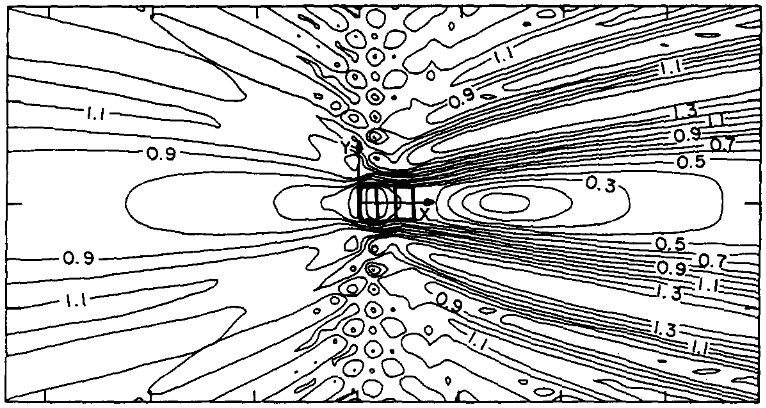

FIG. 11. Contours of Diffraction Coefficient for Dual-Pit Configuration with $a_j/L = 1.0$, $b_j/L = 0.5$, $d_j/h = 3$ for $j = 1, 2$, $\kappa h = 0.167$, and $\theta = 0°$. Region Shown Is 10.66L Upstream, 8L Downstream, and ±5.33L in the Transverse Direction. All Distances Are Measured from the Center of the Upstream Pit

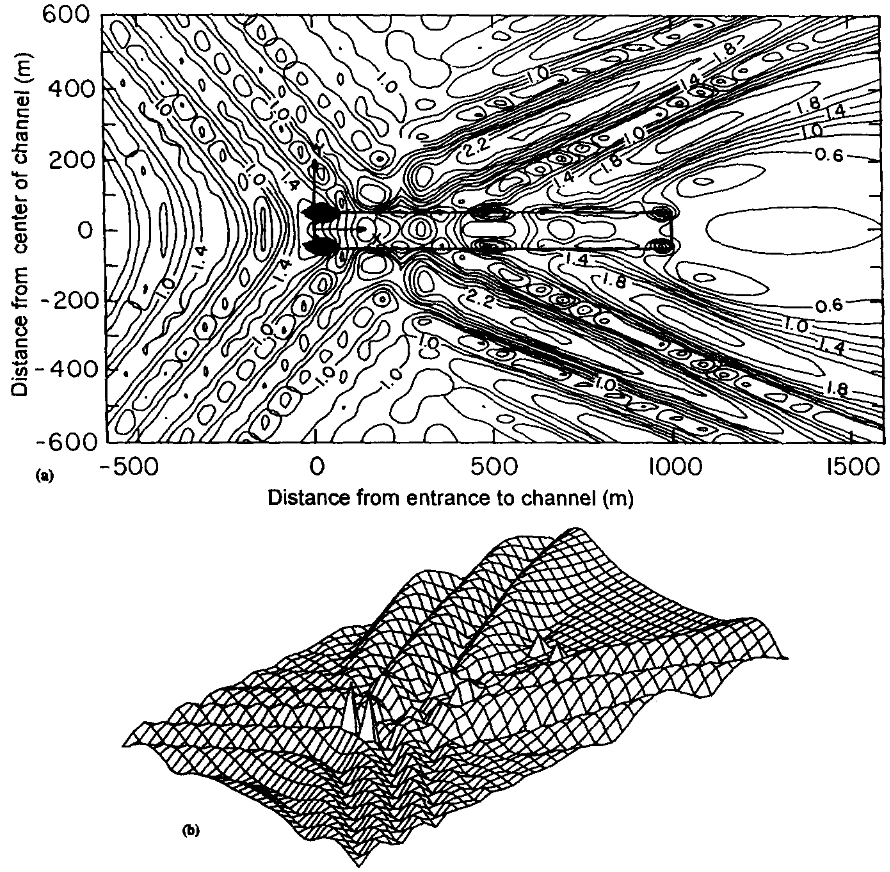

FIG. 12. Diffraction Coefficients for Unprotected Navigation Channel: (a) Contours; (b) Surface Projection

water depth is 6 m. Fig. 12 shows a contour map and a surface projection of the diffraction coefficient for the unprotected channel. At the seaward end of the channel, the incident wave height is increased by more than 40% due to interactions with the channel walls. There are also several locations within the channel where wave heights are amplified.

To reduce wave heights within the navigation channel a pit is excavated at its seaward end. It is noted in Fig. 12 that the seaward 50% of the channel experiences the worst wave conditions, therefore it is necessary to select a pit that has an acceptable shadow zone approximately 500 m long. From Fig. 4 it is estimated that the pit width need only be as great as that of the channel and that the pit should be located approximately 200 m seaward of the channel end. The dimensionless pit length corresponds to $b/L \approx 0.5$ and the relative depth $d/h = 2$. The resulting diffraction coefficients with the pits in place are shown in Fig. 13. Again, both a contour map and a surface projection are shown. It can be seen from Fig. 13(a) that the wave heights in the channel have been significantly reduced. Fig. 13(b) shows how the shadow zone falls on the channel. The result is a region of low wave amplitudes at the navigation channel location.

CONCLUSIONS

Linearized shallow-water wave theory was used to investigate the interaction of surface waves with multiple rectangular submarine pits in water of otherwise uniform depth. The solution is obtained by a boundary element technique

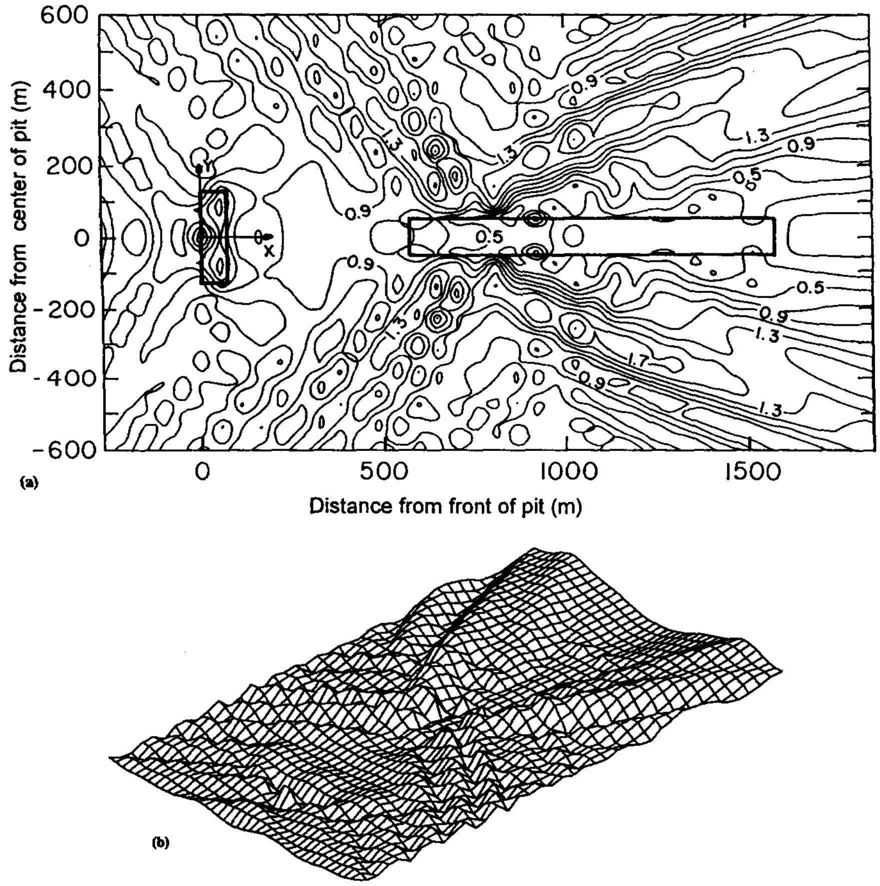

FIG. 13. Diffraction Coefficients for Navigation Channel with Offshore Pit: (a) Contours; (b) Surface Projection

using a two-dimensional Green's function. It is shown that appropriate selection of pit dimensions and placement may lead to a significant reduction in wave heights behind these structures. Numerical results were presented for a pair of pits that illustrate the influence of the various pit characteristics on the wave field for several example geometries. Guidance was given on how to select the pit geometries and placement for optimal breakwater performance. Increasing the number of pits beyond two did not lead to a significant further reduction in wave heights. Finally, a numerical example was presented that illustrates how to select pit geometries to reduce wave heights in a navigation channel.

APPENDIX I. REFERENCES

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APPENDIX II. NOTATION

The following symbols are used in this paper:

a_j, b_j = dimensions of pit j, $j = 1, 2, \ldots, N$;
d_j = water depth in pit j, $j = 1, 2, \ldots, N$;
g = acceleration due to gravity;
$G_j(\bar{r}, \bar{r}')$ = Green's function in regions j, $j = 1, 2, \ldots, N + 1$;
H = incident wave height;
h = water depth in exterior region;
$H_0^{(1)}$ = Hankel function of first kind of order zero;
i = $\sqrt{-1}$;
K = diffraction coefficient;
k_j = wave numbers in region j, $j = 1, 2, \ldots, N + 1$;
L = incident wavelength;
n = normal to Γ_j, $j = 1, 2, \ldots, N + 1$;
R = $(x - x')^2 + (y - y')^2$;
r = radial coordinate;
$\bar{r}, \bar{r}'$ = field and source points;
t = time;
x, y, z = Cartesian coordinates;
Δ_j = spatial component of surface elevation in region j, $j = 1, 2, \ldots, N + 1$;
ε_j = see (10), (11), $j = 1, 2, \ldots, N + 1$;
η_j = surface elevation in region j, $j = 1, 2, \ldots, N + 1$;
θ = incident wave direction;
κ = incident wave number;
Γ = total interface contour, $\Gamma = \Sigma\, \Gamma_j$;
Γ_j = interface contour of pit j, $j = 1, 2, \ldots, N$;
Φ_j = spatial components of potential in fluid region j, $j = 1, 2, \ldots, N + 1$;
ϕ_j = potential in fluid region j, $j = 1, 2, \ldots, N + 1$;
Φ_{N+1}^I = spatial component of incident potential; and
ω = wave frequency.

Appendix H

From: Gambino, Stephanie [mailto:Stephanie.Gambino@mms.gov]
Sent: Monday, June 08, 2009 6:14 PM
To: Klein, William P Jr MVN
Cc: Gambino, Stephanie; Stacie Merritt
Subject: RE: VE creative idea MMS regulate Ship Shoal

Bill

The MMS Marine Minerals Program manages sand and gravel resources on the Federal outer continental shelf (OCS) via a 5 year rolling calendar. We believe the rolling calendar allows us to allocate our limited funding and personnel resources in a way which balances stakeholders' needs and provides adequate and timely information on those offshore areas where sand would likely be needed first.

In June 2007, we sent a letter to all stakeholders (Federal, State, and other) requesting information on potential projects using OCS sand and gravel resources in the next 5 years. Based upon MMS resources and stakeholders' responses regarding project timelines, a maximum of 2 projects per quarter were scheduled.

Most recently, we sent another request in April 2009 to update the calendar; responses were due June 1, 2009. We intend to publish it in the Federal Register (FR) in the third quarter of 2009. It is anticipated that we will continue to schedule a maximum of 2 projects per quarter.

If information on a project is not submitted prior to our publishing the calendar in the FR, the project will not be included on the calendar and will likely not be able to be completed according to the negotiated agreement requestor's desired timeline. Further, if a scheduled project can not be undertaken within the agreed upon timeframe, there is the possibility that the project will be moved to the next open slot on the calendar, which could potentially lead to significant delays in project completion. The MMS plans to publish the OCS sand and gravel rolling calendar twice a year.

Sand and gravel resource evaluations and studies specific to Ship Shoal can be found at:

Ship Shoal Resource Evaluation:
http://www.mms.gov/sandandgravel/MarineMineralResourceEvaluation.htm#Louisiana

Ship Shoal Studies:
http://www.mms.gov/sandandgravel/MarineMineralStudies.htm#Louisiana

All MMP Resource Evaluations can be found at:
http://www.mms.gov/sandandgravel/MarineMineralResourceEvaluation.htm

All MMP studies can be found at:
http://www.mms.gov/sandandgravel/MarineMineralStudies.htm

Lastly, the FY 2010 proposed budget does have some money allocated for sand and gravel resource evaluation and studies, but not necessarily at Ship Shoal.

If you need any additional information, please let me know.

Regards,

Stephanie M. Gambino
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