Science and Engineering Plan:

An Applied Research Plan for the Coastal Protection and Restoration Authority of Louisiana

September 18, 2012

THE WATER INSTITUTE
OF THE GULF

Contents

Overview

The Water Institute of the Gulf is a not-for-profit, independent research institute dedicated to advancing the understanding of coastal and deltaic systems and to applying scientific and technological solutions for the benefit of society. The Water Institute was founded in 2011 to build collaboration with public, private, and academic partners to preserve and protect the US Gulf Coast environment, a major source of natural, human, and industrial resources. The Institute is also designed to develop and share cutting edge technology in order to advance water management efforts worldwide.

The Institute's first efforts will focus on Louisiana, and specifically, how the state can most effectively address its coastal land loss and flooding crisis. This document identifies the principles, goals, and priorities that will govern the Institute's initial work for the state. The document was prepared pursuant to a Cooperative Endeavor Agreement between The Water Institute and the Coastal Protection and Restoration Authority of Louisiana.

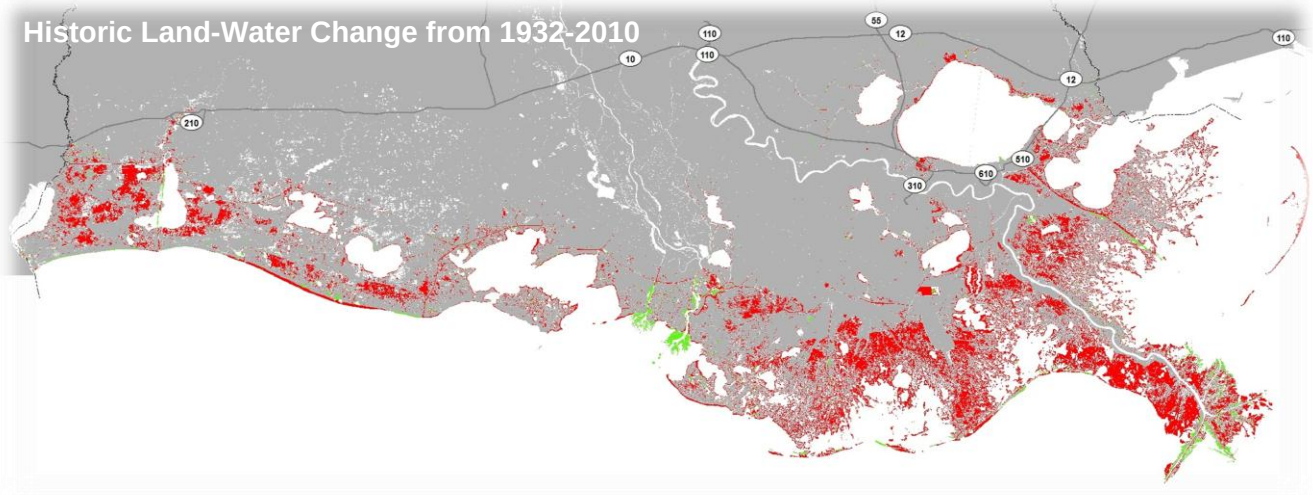
Louisiana's Coastal Crisis

Louisiana's coast includes one of North America's most productive wetland ecosystems, hosts five of the nation's largest ports, and provides more than 90 percent of the nation's offshore energy supplies. In addition, the coast is home to nearly half of Louisiana's population. All of these resources and communities are at risk from coastal land loss. According to the US Geological Survey, Louisiana has lost approximately 1,900 square miles of land since 1932. This extensive land loss not only harms priceless natural systems, it makes towns and cities more vulnerable to flooding. The same flooding risks also threaten nationally important infrastructure, such as navigation channels and energy supply systems that are critical to the nation's economy. As Louisiana continues to lose land, jobs, and communities it has become clear that saving the coast is not an option—it is an imperative.

The State Response

In recent years, the State of Louisiana and the Louisiana Legislature have taken bold action to protect and restore the coast. This progress is embodied in the establishment of a constitutionally protected trust fund for coastal projects, the formation of the Coastal Protection and Restoration Authority (CPRA) to oversee and manage Louisiana's coastal protection and restoration program, and the development of Louisiana's Comprehensive Master Plan for a Sustainable Coast. These efforts complement other state and federal investments in the coast, such as the Coastal Wetlands Planning, Protection and Restoration Act; the Coastal Impact Assistance Program; the Louisiana Coastal Area Program; and the Greater New Orleans Hurricane Protection System.

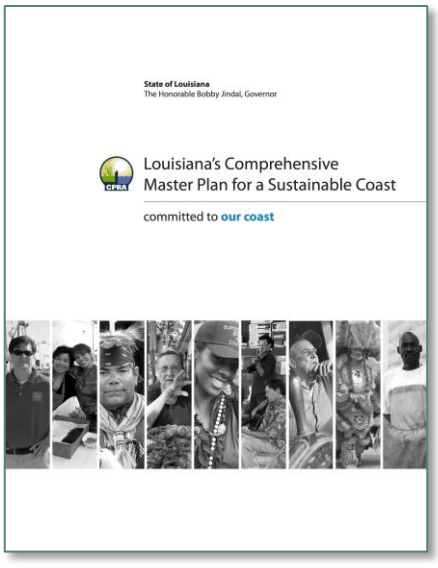
As these and other activities have taken shape, we have learned that protecting and restoring the coast requires a holistic, system wide approach. Piecemeal, uncoordinated efforts cannot stop the root causes of land loss and flooding. Recent events in coastal Louisiana have driven home the need for this coordinated action. Four major hurricanes between 2005 and 2008 battered south Louisiana, changing life forever in many communities. In 2010, the Deepwater Horizon oil spill brought more challenges to the coast.
Meeting these challenges is no easy task, but hardships for Louisiana residents are



Couvillion, B.R., Barras, J.A., Steyer, G.D., Sleavin, William, Fischer, Michelle, Beck, Holly, Trahan, Nadine, Griffin, Brad, and Heckman, David, 2011, Land area change in coastal Louisiana from 1932 to 2010: U.S. Geological Survey

mingled with opportunities. Billions of new dollars in coastal protection and restoration projects are already or will become available as part of ongoing hurricane and flood protection efforts. Other projects will be implemented thanks to state and federal recovery efforts related to the oil spill, including projects associated with the RESTORE Act.

Recognizing how much there is at stake, both in terms of problems to be addressed and opportunities to be wisely used, the Louisiana Legislature unanimously adopted Louisiana's 2012 Comprehensive Master Plan for a Sustainable Coast. The plan was based on a two-year analysis involving some of the state's best scientists and engineers as well as national and international experts. The state used this analysis to select 109 high performing projects that could deliver measurable benefits to our communities and coastal ecosystems over the coming decades. The plan showed that if these projects were fully funded, at a cost of $50 billion, the state could substantially increase flood protection for communities and make great strides toward creating a sustainable coast.



The 2012 Coastal Master Plan was unanimously approved by the Louisiana Legislature in 2012.

The Need for Coordinated Scientific Capacity

The world class science and engineering incorporated in the 2012 Coastal Master Plan will guide policy decisions as the state continues to intensify its commitment to project construction. This level of progress has highlighted other areas where advancement is needed. As Louisiana's coastal program grows and more funds become available to fund large-scale efforts, Louisiana needs commensurate improvements in the way it coordinates and manages coastal science and engineering. For example, implementation of the master plan will require regular upgrades in research capacity and better use of the knowledge that has already been gained. A focus on applied science and engineering must continue to guide the program if we are to achieve a sustainable coast.

The need for this level of applied research has been well documented in the last decade, and the state has laid the foundation for positive change. The CPRA established a program focused on applied coastal engineering and science and it provided support along with the Louisiana Coastal Area's Science and Technology Program, and other efforts, including those of private industry.

In addition, at least three university led consortia for coastal science and engineering have been created and are operating today. Multiple scientists and engineers now focus on water and coastal issues throughout Louisiana.

The value of Louisiana's scientists and engineers—state, federal, private, and university based—is without question. Increased coordination of their work and its increased application to the urgent problems facing south Louisiana will expand knowledge at a time when the

state's expanded coastal program requires more knowledge than ever before.

For all of these reasons, the state needs a central point of science and engineering capacity, one that can help the state build better projects more quickly. This center of innovation must work with academic and private sector experts to maximize the applied knowledge available to decision makers.

The Water Institute of the Gulf

The Water Institute of the Gulf was created to meet these needs. The Institute is a not-for-profit, independent research institute dedicated to advancing the understanding of coastal and deltaic systems and to applying scientific and technological solutions for the benefit of society. Founded in 2011, The Water Institute of the Gulf will build collaboration with public, private, and academic partners to preserve and protect the US Gulf Coast environment, a major source of human, natural, and industrial resources, while developing and sharing cutting edge technology with the goal of advancing water management efforts worldwide.

By serving as a vehicle for collaboration among the best scientists and engineers in the world, The Water Institute will drive innovation in coastal restoration and hurricane protection, building world class expertise in these areas. This expanded capacity will not just inform federal and state efforts in Louisiana, it will eventually create a center of science and engineering excellence that can serve communities throughout the Gulf Coast and beyond.

Intrinsic to this effort is the need to use public and private resources in new ways, such as bringing together university and private scientists and engineers who might not otherwise collaborate. Fostering these kinds of exchanges will allow The Water Institute to capitalize on the depth of expertise that already exists but has not yet been used to maximum combined effect. The Institute's funding will come from a variety of competitive and non-competitive grants provided by both public and private sources across the Gulf Coast and the nation.

Guiding Principles

The principles below describe how The Water Institute will approach its mission.

Strengthen independent and credible science and engineering used by decision makers. The Water Institute's work will provide insight into key Gulf Coast projects and processes. The Institute's findings will be governed strictly by the outcomes produced by scientists and engineers using high quality, technically sound methods and tools.

Collaborate and coordinate with multiple entities to focus science and engineering inquiries and their application. Although The Water Institute will house scientists and engineers in cornerstone disciplines, the Institute will not itself employ all of the scientists and engineers with which it works. Instead, as a nonprofit entity, the Institute will serve as a catalyst for partnerships among universities, NGOs, government agencies, and the private sector, identifying expertise and focusing it on crucial challenges. In this way, the Institute will coordinate existing efforts so they can be readily applied. The Institute will also identify where new expertise is needed and build these areas of knowledge.

Use a system-based approach to Gulf Coast restoration and community resiliency. The Water Institute will deepen

understanding of the complex and dynamic systems at work in the Gulf Coast, including environmental, social, and economic factors.

Build capacity to achieve long-term goals. Addressing the Gulf Coast's challenges will require a focused effort over the next several decades. To support this effort, The Water Institute will invest in the tools and partners needed to provide value over the coming decades.

Leaders and Advisors

The Water Institute of the Gulf is led by founding President and CEO Charles "Chip" Groat, Ph.D., a globally recognized expert on earth sciences, energy, resource assessment, groundwater issues, and coastal studies. The Institute's Board of Directors, chaired by Kevin Reilly Jr., represents a diverse group of individuals, all highly regarded within their fields, including experts on federal program management.

To support the quality of the Institute's efforts, a Science and Engineering Advisory Council was formed. The council's members have expertise in a variety of technical disciplines, and are familiar with the challenges facing the Gulf Coast. The council's charge is to outline an overall strategic plan for the Institute, including program elements, priorities, and staffing needs. The council will also be responsible for providing an annual report card based on an evaluation of the previous year's efforts.

Science and Engineering Advisory Council Members

Greg Baecher, PhD, PE, University of Maryland

Virginia Burkett, PhD, United States Geological Survey

Tony Dalrymple, PhD, PE, Johns Hopkins University

Margaret Davidson, JD, National Oceanographic and Atmospheric Administration

Jos Dijkman, MSc, PE, Dijkman Delft

Shirley Laska, PhD, University of New Orleans

Rick Luettich, PhD, University of North Carolina

Fred Sklar, PhD, South Florida Water Management District

Science and Engineering Plan: Background

The independent science and engineering conducted under the auspices of The Water Institute will support the restoration of Gulf Coast communities - both human and natural. Initial efforts will include a Louisiana focus, with the understanding that lessons learned may be applicable to other gulf regions. At the same time, knowledge from other areas will be applied to Louisiana issues. In this way, the Institute's work in Louisiana will both support critical state initiatives and pave the way for expanded activities gulf wide.

Act No. 604 of the 2012 Regular Session of the Louisiana Legislature provided the authority for the CPRA to use the science and technology capacity of The Water Institute to improve the knowledge of baseline conditions in the coastal area and to develop technologies, models, and methods to carry out the state's coastal activities. In so doing, the legislature affirmed the urgent need for expanded knowledge that can help Louisiana build improved projects with greater speed.

In concert with the legislature's initiative, the CPRA has provided initial funding for The Water Institute. A Cooperative Endeavor Agreement is the mechanism for implementing the funding; the agreement outlines how the Institute will implement a focused science and engineering program.

To more precisely define the activities that will be undertaken for the CPRA as part of the Cooperative Endeavor Agreement, The Water Institute developed this Science and Engineering Plan in consultation with the Science and Engineering Advisory Council. The plan describes the areas of focus and activities to be undertaken in the agreement's first few years. The plan also outlines how these activities help to fulfill Louisiana's needs for sound coastal science and engineering.

The Science and Engineering Plan covers a diverse body of work that will provide important value to the State of Louisiana and build the capacity of The Water Institute. This plan includes long term initiatives that will significantly boost the success of Louisiana's coastal program. The plan also includes exploration of near term, specific priorities.

Although it may be amended in the coming years to reflect new areas of emphasis, this plan provides an initial roadmap that will govern how The Water Institute will support the CPRA's need for high quality science and engineering.

In developing this document, Water Institute staff, in consultation with its technical advisors and the CPRA, identified four goals. Because they capture the primary challenges facing Louisiana as it seeks to address land loss and flooding, these goals helped drive the selection of specific priorities in this plan.

Improve understanding of system dynamics. All science and engineering efforts for Louisiana's coast take place within a system governed by humans and their interactions with the natural environment. This environment includes rivers; gulf tides and storms; and other natural processes, such as sediment compaction and subsidence. Climate change is an overarching part of this system as well, particularly its effects on water levels, weather, and various species.

The Water Institute will undertake activities to help the State of Louisiana more fully understand how all of these elements interact, particularly as new projects are implemented as part of the 2012 Coastal Master Plan. To achieve this goal, the Institute will provide information about outcomes, including how the coast will change if projects are not built. The Institute will also consider how the construction of projects will influence communities and land building, along with fisheries and other ecosystem services.

Optimize project performance.
The projects in the 2012 Coastal Master Plan were chosen because they will deliver crucial value to the state. However, in order to implement these projects effectively, the state needs information about how to complete construction on time and within established budgets. The state also needs to ensure that projects deliver their projected benefits. The Water Institute will work to provide the best possible information about these issues so that projects can move forward most efficiently.

Design approaches that support sustainable communities and renewable natural resources.
The landscape, fisheries, and wildlife of Louisiana's coast are among our nation's most precious natural assets. They represent the essence of what makes Louisiana a world renowned Sportsman's Paradise; these natural resources also sustain thousands of jobs related to eco-tourism, as well as fisheries and other harvests. In support of these resources, and the environmental, economic, social

and cultural importance they hold, The Water Institute will synthesize existing information to make it readily available and conduct targeted new research and modeling. These efforts will expand the state's understanding of how to be an effective steward of the natural resources so central to the identity of south Louisiana.

Support Louisiana's Working Coast. As has often been stated, Louisiana's coast is not a pristine wilderness but a global center of commerce and industry that provides thousands of jobs for coastal residents. The Water Institute will explore how economic uses of the coast can best be integrated with projects to be implemented as part of the 2012 Coastal Master Plan. The Institute's initiatives will seek to support a diverse range of activities coast wide. Emphasis will be placed on identifying win-win approaches that can both strengthen the state's economic base and support the coast's long term sustainability.

Science and Engineering Priorities

The goals above are, by necessity, quite broad. Understanding that The Water Institute had to focus its activities more narrowly in the near term to accommodate budget and timing requirements, the Institute's scientists and engineers, in concert with the CPRA and the Science and Engineering Advisory Council, identified the priorities below.
These priorities address many of the state's most pressing needs for scientific and engineering knowledge that can be applied to the coast. In addition, these priorities work to achieve multiple goals, providing interdisciplinary knowledge that will be important to long term success in confronting Louisiana's coastal crisis. For these reasons, under the activities governed by the Cooperative Endeavor Agreement, The Water Institute will make investigation of the priorities below its first order of business.

As part of its work on these eight priorities, The Water Institute scientists and engineers will work closely with the CPRA, state and federal agencies, and other researchers to avoid duplication of effort, coordinate as appropriate to gain the most information from limited funds, and ensure that the best skills are being applied to the problems at hand.

Sediment Availability and Management. Given the 2012 Coastal Master Plan's emphasis on sediment diversions and marsh creation, it is essential that the state more precisely understand how much sediment is available throughout the coast, the characteristics of this sediment, and how best to use it.

Three primary sources of sediment can be used to help restore Louisiana's coastal wetlands: riverine sediment; in-system sediment from coastal bays and channels; and offshore sediments, including sand, that can be used for restoring barrier islands. The Water Institute's work on this priority will seek to determine the level at which these sediment resources can be exploited for restoration and protection without causing other adverse ecological or economic consequences. Accordingly, the Institute will also examine the renewal rate for sediment resources.

What this inquiry will provide. A clearer understanding of the availability and dynamics of the state's limited sediment resources is a prerequisite for restoring our coast. The Institute's work, in conjunction with previous and ongoing work in this area, including ongoing CPRA efforts, is vital for implementing the projects in the 2012 Coastal Master Plan.

For example, better understanding of sediment transport pathways within the coastal system will enable more efficient use of sediment for restoration and improve estimates of project construction and maintenance costs.

Subsidence. Subsidence is a natural characteristic of deltaic environments and has been the subject of much research in Louisiana. In recent years, improved methods for measuring land surface elevation using GPS technology and the application of geophysical modeling have advanced our understanding of potential subsidence rates and mechanisms. However, the rates of future subsidence and their spatial distribution remain controversial and uncertain. We do know that subsidence remains a key driver of coastal land loss, a potential constraint on restoration success, and a source of risk for Louisiana communities. Rising sea levels will only exacerbate the problem.

The Water Institute's focus in this area will synthesize ongoing research in order to capture the state of our knowledge on subsidence.

What this inquiry will provide. Improved information on this issue will strengthen our understanding of subsidence mechanisms and how they vary across the coast and through time. This will allow better predictions of subsidence rates and more accurate design of flood protection and restoration projects.

Vegetation and Climate Change. As a low lying deltaic area, Louisiana's coast is among the most vulnerable regions in the world to the effects of climate change. Native coastal vegetation, including that associated with coastal marshes, dunes, mangrove forests, and swamp forests will be exposed to multi faceted effects as a result of climate change. Estuaries will become more saline, and shorelines will retreat as sea level rises and coastal landforms adjust to the changing environment. The cumulative and interactive effects of these changes have enormous implications for ecosystem restoration in coastal Louisiana.

The Water Institute will examine and synthesize data on a number of factors associated with climate change, including sea level rise, higher temperatures, changes in rainfall patterns and runoff, and increased carbon dioxide. The aim will be to learn how these and other climate change drivers affect coastal plant communities and landforms. Specific questions to be examined include the effects of climate change on coastal plant productivity, vertical accretion rates, plant decomposition rates, and carbon sequestration rates in various wetland types. In future years The Water Institute will work to improve simulation of how coastal landforms, such as barrier islands and inlets, will respond to changes in climate and sea level and, more specifically, how the success of individual projects may be influenced by climate change and associated stressors.

What this inquiry will provide. This information will allow the state to implement protection and restoration measures in ways that take into account the stressors introduced by climate change. Doing so will help make these projects more resilient, delivering more value per dollar spent. The issue of plant productivity could also become an important economic consideration as the market for carbon mitigation grows.

Fisheries. Given the importance of this priority to the economy and culture of south Louisiana, coastal land loss impacts on fisheries are a topic of much discussion, as are the possible effects of protection and restoration projects. However, there are few definitive studies

of how coastal landscape change will affect commercially and recreationally important species. Uncertainty in this area hinders decision making and delays implementation of important coastal initiatives.

To shed more light on this crucial subject, The Water Institute will examine historical change, both naturally occurring and human induced, as well as current natural variation in the abundance and distribution of fish species. The aim is to better understand species' resilience to changes in coastal conditions and what the future holds for fisheries given the impacts of climate change (e.g. acidification, temperature changes), land loss, restoration efforts, and other impacts, such as the effects of levees and flood gates. The Institute's work will focus on native estuarine and marine dependent species of commercial and recreational importance.

What this inquiry will provide. Many discussions of fisheries focus on the past: where species were located and how people's livelihoods have been affected as these species moved or changed. By providing knowledge about how fisheries are predicted to shift in coming years, The Water Institute's work on fisheries predictability will help inform decision making and provide reasonable expectations about the future dynamics of key species. This knowledge will also help the state design future projects with an eye toward maintaining robust fisheries coast wide.

Community Resilience and Adaptation. The importance of the culture and economic activity of coastal Louisiana is unquestioned. As coastal conditions change due to natural cycles and human activities, we need sound information about how communities will be affected. Because adaptation to our dynamic coast has been such a hallmark of Louisiana history, we also need to understand how communities have adapted to coastal change in the past.

While it is only one of the mechanisms of coastal change in Louisiana, examining how climate change affects communities and developing options for the future are both key parts of this priority, particularly given the need to assess local needs and concerns and include them in coastal planning efforts. The Water Institute will consider factors such as increasing incidence of droughts and high temperatures, the changing availability of fresh water, and higher sea levels. This information will inform decision making at the state and local levels and within the communities themselves. In addition to examining these environmental factors, the Institute will also consider the economic and societal impacts of coastal projects.

What this inquiry will provide. The Water Institute's work on this priority will provide coastal communities with improved information about the kinds of changes they can expect and what they can do to prepare. By creating a climate adaptation plan that identifies a range of possible future changes and options, The Water Institute's work will augment the nonstructural investments identified in the 2012 Coastal Master Plan.

Innovative Engineering for Coastal Management. The need for action is great, but resources are limited and time is short. In order to expedite action that makes the most of limited resources, The Water Institute will spur the progression of restoration and protection engineering, generating new ideas and using approaches that have worked well in other areas but have yet to be applied in Louisiana.

Some of the questions to be explored will be large in scope, such as “Where are the major sources of uncertainty in project implementation?" Other questions will focus more narrowly on specific project types, such as designing structures that maximize sediment capture or designing flood protection structures that can readily be adjusted to account for subsidence or sea level rise.

What this inquiry will provide. As a center for innovation in coastal engineering, The Water Institute will help ensure that state coastal investments employ the most effective technologies and serve as models for the application of sound engineering throughout the world.

Models and Data Management for Real Time Forecasting. For years, models that simulate coastal processes have been the basis for understanding current and future system dynamics. Predicting conditions decades into the future has thus become a cornerstone of project planning. In addition, using specially designed models in concert with a growing network of real time coastal monitoring stations could enable near real time forecasting of coastal conditions. To date, however, links between monitoring data and models is restricted to defining boundary conditions, validating models, and refining how the models work together.

The Water Institute will more fully integrate monitoring data into models to allow near real time forecasting of coastal conditions. Doing so will make it easier to discern short term changes in coastal conditions, such as the effects of wind and changes in freshwater inflows. Easy access to real time and archived data is a key part of integrating models with data collection; meeting this challenge will be an important part of The Water Institute’s work.

What this inquiry will provide. Models that represent hypothetical future conditions are useful for planning but not for operational decisions, which are essential to continued management of our coastal system. The Water Institute will use ongoing data collection and specially designed modeling tools to support decisions that are being made all the time, such as how the state operates structures during non-storm conditions. The Water Institute envisions using this capability to eventually develop public interfaces that will allow residents to have near real time views of water, weather, and fisheries patterns. This work will allow both the state and its citizens to reap the benefits of the extensive data collection that has been undertaken in recent years, while informing project design and construction.

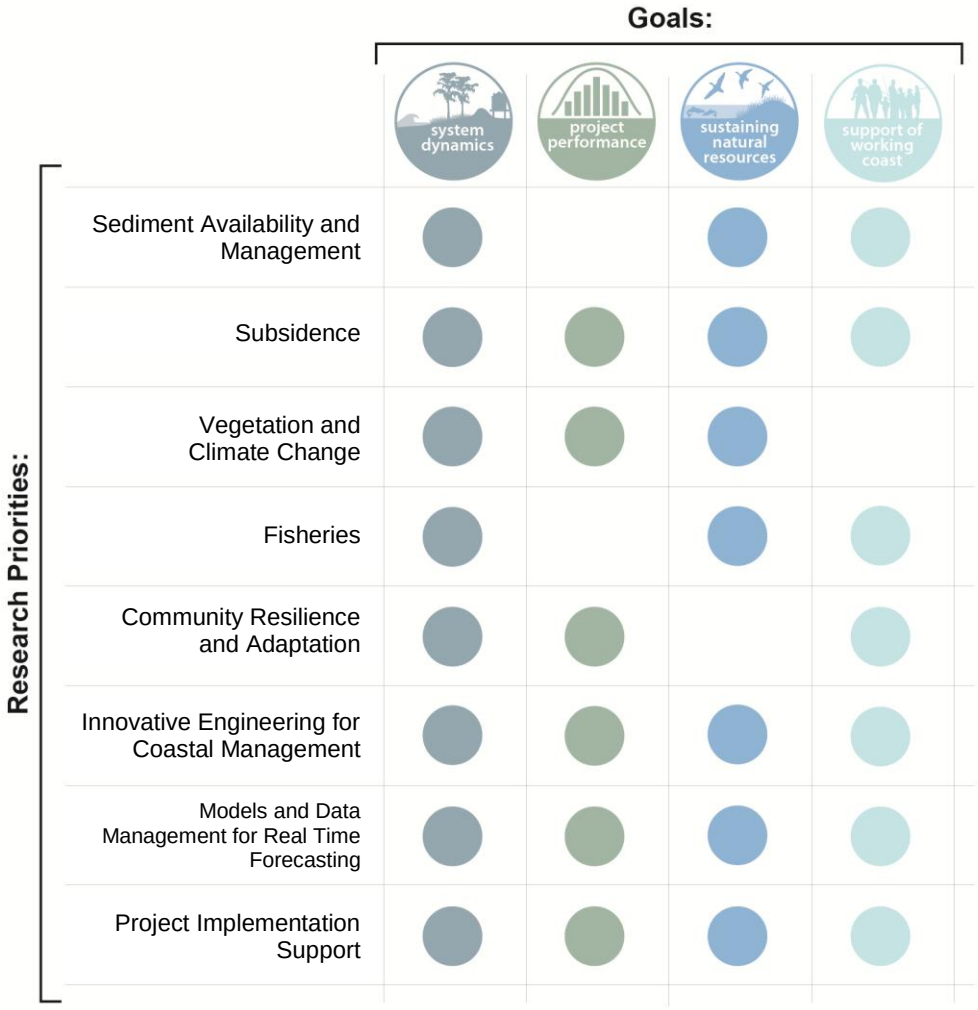
Project Implementation Support. Selecting and implementing the actions necessary to achieve the sustainability of coastal Louisiana requires decision making at a variety of levels. The 2012 Coastal Master Plan has identified the suite of projects that will be moved forward, but the design and implementation of these projects and their re-evaluation as conditions change will require adaptive management that must be informed by science and engineering knowledge. The Water Institute will support these decisions not just by compiling and producing data, but also by making the implications of these data easier for decision makers to understand and apply.

This research priority focuses on understanding, and where possible reducing, the uncertainty associated with implementing projects; for example, how costs could change, how long construction could take, and how reliable the projects’ outcomes are likely to be.

For example, the Institute will develop an approach for assessing flooding risk that

considers uncertainties in project design and implementation. This knowledge will help decision makers better understand the sources of uncertainty in protection projects and how those risks may be reduced. A similar approach will be developed for restoration projects. Workshops, test cases, and other activities will also present the results of Water Institute work to broader audiences, both technical and non-technical.

What this inquiry will provide. These tools will ensure that The Water Institute's efforts are directly applied to the decisions made as part of Louisiana's coastal program. In addition, the tools will help support ongoing program improvements through lessons learned.



The eight science and engineering priorities match multiple goals. As such, they respond to the key challenges facing Louisiana's coast.

Providing Additional Value to the State of Louisiana

In addition to the broad activities outlined in this Science and Engineering Plan, The Water Institute is undertaking tasks that support more immediate delivery of services for the State of Louisiana. These tasks include, but are not limited to:

Model Maintenance. Continue to maintain and improve the state's coastal modeling capabilities, building upon the 2012 Coastal Master Plan modeling effort and expanding where necessary.

Coastal Innovation Program. Administer a program designed to find answers to problems that the 2012 Coastal Master Plan identified as significant but for which solutions do not yet exist. In so doing, identify cost effective and sustainable ways to address the coastal crisis.

Multi-Dimensional Modeling for the Louisiana Coastal Area (LCA) Mississippi River Hydrodynamic and Delta Management Study (MRHDM). Help generate a suite of multi-dimensional modeling tools that can simulate the hydrodynamic and transport processes and pathways governing the behavior of the lower Mississippi River. These tools can then be used to make sound management decisions regarding proposed modifications to the river system.

Metrics for Assessing Model Predictive Performance for the LCA Mississippi River Hydrodynamic and Delta Management Study. Develop metrics to assess the predictive performance of the numerical models applied in this study. This assessment will ensure transparency in the models' performance evaluation. The assessment will also provide objective, quantifiable measures for evaluating the models' performance to minimize subjectivity in the performance assessment.

Data Management. Provide for verification, organization, storage, and access to the key input and output data files associated with the models used for the 2012 Coastal Master Plan.

Adaptive Management. Help the CPRA more fully develop the state's adaptive management framework.

Project Management and Modeling Support for the LCA Mississippi River Hydrodynamic and Delta Management Study. Serve as the technical lead for the CPRA in this effort. Dr. Ehab Meselhe will fill this role, advising the state on all technical issues related to the MRHDM Study including coordination of technical tasks and use of sound science in all analyses.

Support for the Southwest Coastal Louisiana Feasibility Study. Lead and coordinate modeling for the Southwest Coastal Louisiana Feasibility Study and provide assistance to the CPRA in the form of model runs for: a) existing conditions, b) future without project conditions, and c) future with project conditions to meet the requirements of the study.

Peer Review of 2012 Coastal Master Plan Model Technical Reports. Conduct a peer review process for the Master Plan project level model reports. This process will examine the models' documentary record and generate expert feedback regarding potential model improvements.

Appendix 1: A Detailed Look at the Science and Engineering Priorities

The Coastal Protection and Restoration Authority (CPRA) has provided initial funding for The Water Institute. The Cooperative Endeavor Agreement is the mechanism for this funding, and the agreement outlines how the Institute will implement an applied research program. The knowledge and tools developed through the Cooperative Endeavor Agreement will expedite the design and implementation of the large scale projects required to establish a sustainable coast for Louisiana and the nation. This appendix details the activities to be undertaken by The Water Institute of the Gulf during the first 24 months of the Cooperative Endeavor Agreement. The budget for these activities is $4.45 million.

In developing this document, the Institute's scientists and engineers, in collaboration with the CPRA and the Science and Engineering Advisory Council, identified eight science and engineering priorities. These priorities address the state's most pressing needs for scientific and engineering knowledge about the coast. In addition, these eight priorities target interdisciplinary knowledge that will support the state as it confronts its coastal crisis. The following pages outline near term tasks and products for each research priority.

These tasks will build on and compliment existing and ongoing efforts, such as the technical analyses and modeling conducted for the 2012 Coastal Master Plan. In addition, the Water Institute will undertake specific work for the CPRA through task orders including multi-year efforts in areas such as modeling support and data management. In all of its operations, The Water Institute's scientists and engineers will work closely with the CPRA, state and federal agencies, and researchers to avoid duplicative efforts, coordinate as appropriate to leverage the most information from limited funds, and ensure the team applies the best skills to the problems at hand. The Institute will remain cognizant of key schedules, including those of the Louisiana Coastal Area Mississippi River Hydrodynamic and Delta Management Study and the 2017 Coastal Master Plan.

Much of the cooperative endeavor agreement initiated science and engineering is expected to continue in future years; therefore conclusive findings in all areas within the first two years of this agreement are not anticipated. However, some early findings and progress will help improve implementation of the 2012 Coastal Master Plan and support the development of the 2017 Coastal Master Plan.

The dollar amounts associated with the eight science and engineering priorities are estimates; it is possible that funds may shift across priorities to accomplish tasks over the first 24 months. Progress in each of these areas is crucial. Accordingly, the amount of funding allocated to each priority area is not a reflection of that priority's importance. Funding is allocated solely based on two factors: the current state of knowledge within each priority area, and an estimate of what is achievable within the next 24 months to advance the state of our knowledge.

Sediment Availability and Management

Budget: $1,000,000

Rationale: Restoration of coastal Louisiana's wetlands depends on sediment availability and the effective management of sediment resources, including riverine sediment, in-system sediment from coastal bays and channels, and offshore sand that can be used for restoring barrier islands and wetlands. Understanding the availability and dynamics of these very limited resources is key to restoring Louisiana's coast.

Research is needed to determine the level at which sediment resources can be exploited for restoration and protection without causing adverse ecological or economic consequences. We also need to understand the renewal rate of riverine and estuarine sources.

Increased understanding of sediment transport pathways within the coastal system will enable more efficient use of sediment for restoration and improved estimates of project construction and maintenance costs.

Tasks	Products	Timeline
Barrier shorelines and offshore: • Apply sediment budget methodologies to shorelines where data are available • Identify data needs for the development of predictive sediment management tools	• Assessment of historic sediment budget • Summary of sediment management data needs	• 18 months • 12 months
Rivers: • Review existing and ongoing sediment availability and management studies; supplement with field studies as necessary • Initiate the development of a pilot sediment budget for an uncontrolled diversion/delta splay • Initiate development of a land-building model that incorporates mineral and organic accumulation building based on previous work and informed by ongoing research	• Summary assessment of information on river sediment availability • Progress report on research findings • Model framework and testing report	• 6-12 months • 18 months • 24 months
In estuary: • Explore methodologies for geotechnical techniques to characterize sediment properties • Summarize the environmental benefits and consequences of using estuary and lake bottom sediments for restoration projects in the context of coastal bay evolution and change • Initiate development of a "sediment recharge" model for in-estuary borrow using existing data	• Summary of findings and recommendations for further work • Assessment report • Model framework and testing report	• 12 months • 12 months • 24 months

Subsidence

Budget: $350,000

Rationale: Subsidence is a natural characteristic of deltaic environments and has been the subject of extensive research in Louisiana. In recent years, improved methods for measuring land surface elevation, use of GPS technology and the application of geophysical modeling have advanced the understanding of potential rates and mechanisms of subsidence. However, the rates of future subsidence and their spatial distribution remain topics of great uncertainty and controversy. Subsidence coupled with sea level rise is a key driver of coastal land loss, a potential constraint on restoration success and a source of risk for coastal communities. This research priority aims to update synthesis of ongoing research in order to present decision makers with the state of the science, bring focus to the research agenda, and initiate modeling to support incorporate of subsidence processes into coastal decision-making. The overall goal is to reduce uncertainty and provide tools for exploring the role of different subsidence drivers in determining overall rates.

Tasks	Products	Timeline
Update synthesis reports from recent years to reflect recent research	• Synthesis report	• 9 months
Assemble an expert panel to reflect upon the likely role of various future subsidence drivers in coastal Louisiana, measurement issues, and contribution rates relative to space and time. Includes: • Review of existing reports and data that have been generated on the issue • Identification of key near term research needs	• Workshop summary and findings	• 9 months
Convene a workshop of national and international experts on subsidence modeling to gather recommended approach(es) for simulating potential future subsidence	• Workshop summary and findings	• 15 months
Undertake preliminary subsidence modeling for different geophysical settings representative of coastal Louisiana to test concepts and utility of existing data	• Model skill assessment summary	• 24 months
Develop long term research plan	• Research plan	• 24 months

Vegetation and Climate Change

Budget: $700,000

Rationale: As a low lying deltaic area, Louisiana's coast is among the most vulnerable regions in the world to climate change. One of The Water Institute's long-term goals is to understand how all aspects of the coastal system are affected by climate change. A first step toward this goal is to increase understanding about the effects of climate change on vegetation. Because the effect of climate change on native coastal vegetation, including coastal marshes, dunes, mangrove forests, and swamp forests, is multifaceted, research is necessary to answer the following types of questions: How productive are coastal plant communities under the combined influences of increased carbon dioxide, higher temperatures, and altered inundation and salinity regimes? How will climate change factors impact the ability of coastal plants to contribute to vertical accretion? How will decomposition rates change, and how will those rates affect organic matter and soil development? How will changes in coastal vegetation influence other aspects of the ecosystem, including fisheries resource dependent or coastal vegetation communities?

Tasks	Products	Timeline
Synthesize state of knowledge and identify information gaps in understanding how specific climate change factors (e.g. drought effects such as changing runoff, precipitation, and evapotranspiration) affect economically important biological plant and animal communities	• Synthesis report on findings	• 6 months
Initiate field and laboratory research to explore climate change effects on key coastal plant species and interactions among species	• Research plan • Research design and early results	• 9 months • 24 months
Launch preliminary modeling to assess changes in coastal plant communities under various climate change scenarios and link to models dealing with fisheries' productivity	• Calibrated model	• 24 months

Fisheries

Budget: $450,000

Rationale: The effects of coastal land loss on the natural resource base, including fisheries, are the topic of much discussion, as are the potential effects of restoration and protection projects. However, there are few definitive studies of how coastal landscape change will affect commercially and recreationally important fishery species. Uncertainty in this area hinders decision making and delays implementation of coastal restoration and protection projects. This research priority will examine historical change, both naturally occurring and human induced, as well as current natural variation in the abundance and distribution of native resident and estuarine dependent species. The aim is to better understand species' resilience to short or long term perturbations in coastal conditions. Existing research on diversions will be considered to ensure that this research embraces a broad range of conditions and/or project effects. With a modeling component, this research priority will be geared toward providing reasonable expectations of the future dynamics of key species.

Tasks	Products	Timeline
Synthesize state of knowledge and identify data gaps in the current and historic distribution and abundance of key native estuarine-dependent species and important food resources	• Synthesis report on findings	• 6 months
Review available models, including those not previously applied in Louisiana, that could be used to predict the distribution and relative abundance of key species including the evaluation of data requirements and availability, spatial and temporal resolution, and ease/complexity of implementation	• Model review report	• 12 months
Initiate preliminary (local) modeling to assess potential future fisheries' conditions for select representative restoration and protection projects	• Model skill assessment and recommendations on future use of models	• 24 months

Community Resilience and Adaptation

Budget: $450,000

Rationale: The importance of the culture and economic activity of coastal Louisiana is unquestioned. As coastal conditions change due to natural cycles and human activities, we need sound information about how communities will be affected. Because adaptation to our dynamic coast has been such a hallmark of Louisiana history, it is important to understand how communities have adapted or changed in the past. There is also a strong need to develop more effective ways of assessing the concerns of local residents and stakeholders and including their ideas in coastal planning.

In other coastal areas, the threat of climate change and sea level rise has stimulated planning for coastal adaptation and the development of measures to increase community resilience. Although climate change is only one of the mechanisms of coastal change in Louisiana, lessons can be learned from other areas and new approaches identified.

This research priority seeks to generate a climate adaptation plan that would complement the 2012 Coastal Master Plan.

Tasks	Products	Timeline
Develop both historical and current regional profiles of coastal communities in Louisiana: characterize how demographics, commercial foci, key aspects of cultural heritage, economics, and social dependencies have changed over time	• Approach to profile development • Profile completed for ~50% of communities	• 9 months • 12 months
Review research and climate adaptation strategies used in other coastal areas with similar characteristics and develop a "toolbox" of approaches for potential application.	• Climate adaptation "toolbox" draft • Climate adaptation "toolbox" final	• 18 months • 24 months
Initiate "pilot" resilience and adaptation planning for two to three coastal communities with different profiles.	• Scope for resilience and adaptation plans • Progress reports	• 18 months • 24 months
Explore approaches to interagency, independent organization, and community collaboration on planning and resiliency enhancement, including nonstructural measures in coastal Louisiana	• Options document	• 18 months

Innovative Engineering for Coastal Management

Budget: $500,000

Rationale: The need for action on protection and restoration is great but resources are limited and time is short. In order to make the most of limited resources, the state needs increased effectiveness and efficiency when building projects. Louisiana must take advantage of new ideas and approaches that have succeeded in other areas but have yet to be applied in our state. This research priority will explore innovative and large scale approaches to coastal restoration and protection by characterizing the benefits of and challenges to project design and implementation.

Tasks	Products	Timeline
Summarize new developments in restoration and protection project designs, concepts, and technologies with potential application to Gulf Coast environments and problems	• Synthesis report on findings	• 12 months
Initiate research to elucidate key technological or design assumptions and/or limitations that currently introduce high levels of uncertainty to project design or cost projections	• Progress report on findings	• 24 months
Convene an expert panel to explore approaches to sediment diversion structure design and lower river redesign in order to maximize sediment capture and minimize negative impacts on navigation and salinity regimes	• Workshop summary and report on findings	• 12 months
Initiate research identified by the expert panel to supplement sediment diversion structure design and maximize sediment capture and retention	• Progress report on research findings	• 24 months

Models and Data Management for Real Time Forecasting

Budget: $650,000

Rationale: For years, models that simulate coastal processes have served as a cornerstone for understanding current and future system dynamics. Predicting conditions decades into the future has become a cornerstone of project planning. However, using specially designed models in concert with the growing network of real-time coastal monitoring stations could enable near real time forecasting of coastal conditions. These forecasts would take into account short term changes in coastal conditions such as the effects of wind and changes in freshwater inflows. Such an approach could not only provide insight into coastal conditions at any given time, it could also improve response to unexpected coastal events, such as oil spills and storms.

The availability of and access to real time and archived data is crucial to forecasting coastal conditions, assessing project performance. Meeting this challenge will be an important part of this research priority.

Tasks	Products	Timeline
Develop spatial and temporal inventory of existing monitoring stations and the variables collected to identify the most promising area or basin for the development of a pilot data assimilation - modeling study	• Summary report on findings	• 9 months
Initial development of a pilot forecasting model for near real time modeling of estuarine current, salinity distribution, and select water quality variables. To include model set-up, development of data streams for model forcings, boundary conditions, tools/metrics for skill assessment and for accessing/evaluating/communicating model results	• Approach • Progress report on model development	• 12 months • 24 months
Plan for a comprehensive Coastal Louisiana Data and Modeling Center in coordination with other data management/modeling entities. Focus on: • Quality review/control • Data collection consistency • Standardization of the data sets used by various groups • Model support and development Explore options for inclusion of a human dimensions component	• Plan for Data and Modeling Center	• 16 months

Project Implementation Support

Budget: $350,000

Rationale: Selecting and implementing the actions necessary to achieve sustainability of coastal Louisiana requires decision making at various levels. The 2012 Coastal Master Plan has identified a suite of priority projects, but the design and implementation of these projects and their re-evaluation as conditions change entails additional decisions that must be informed by science and engineering knowledge. This research priority focuses on understanding, and where possible reducing, the uncertainty associated with implementing projects – how could costs change, how long could it take to construct, and how reliable are the outcomes? Specific tasks consider methods and workshops to consider uncertainties, new knowledge, integration and monitoring to support decision-making and project implementation for restoration and coastal protection.

Tasks	Products	Timeline
Inventory existing assessment approaches and develop an assessment approach to consider uncertainties in project design and implementation that highlight potential outcomes	• Summary of available assessment approaches • Draft approach for coastal Louisiana	• 12 months • 18 months
Initiate the development of a coastal restoration project management support system that acknowledges uncertainties, incorporates knowledge from previous projects, and identifies key performance metrics based on the uncertainties	• Summary assessment of available tools • Workshop (and summary of findings) to consider applicability of existing tools in coastal Louisiana • Progress report of tool development	• 12 months • 18 months • 24 months
Initiate development of a coastal protection project management support system that acknowledges uncertainties, incorporates knowledge from previous projects, and identifies key performance metrics based on the uncertainties	• Summary assessment of available tools • Workshop (and summary of findings) to consider applicability of existing tools to coastal Louisiana • Progress report on tool development	• 12 months • 18 months • 24 months
Explore methods for applying Integrated Water Resource Management in a coastal context	• Summary report on findings	• 12 months