Participatory modeling

Connecting local knowledge and scientific understanding

THE WATER INSTITUTE OF THE GULF

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THE WATER INSTITUTE OF THE GULF®

Louisiana is getting smaller.

Between 1932 and 2010, Louisiana's coastal area lost more than 1,800 square mile of land through a variety of means including erosion, subsidence, lack of sediment nourishment from the Mississippi River, canal dredging, and much more. The land loss represents a complex mixture of natural and human-induced causes where every potential solution comes with pros and cons that often require compromise.

The compromises are not limited to merely ecological responses or the moving of dirt to build new land. Louisiana's coast is a "working coast," with residents relying on their proximity to the wealth of coastal resources - from fisheries and tourism to oil and gas production and related petrochemical industries. What happens to the coastal landscape has real and measurable impacts to the quality of life, culture, and economy of more than two million Louisiana residents who call the coastal area home.

Although Louisiana researchers, government agencies, non-profits, and private citizens have been battling land loss for decades, a real change came about after the 2005 hurricane season that saw hurricanes Katrina and Rita bring devastation to the entire coastline.

The Louisiana legislature passed Act 8 in December of that year to form the Coastal Protection and Restoration Authority (CPRA) and tasked it with coming up with a Coastal Master Plan that would include the state's restoration and protection vision for the next 50 years. Updated every five, and now six, years, this science-based plan evaluates hundreds of projects to find the best suite of projects to pursue for long-term sustainability.

One vital component of this evaluation utilizes computer modeling to run numerous scenarios both for individual projects and how groups of these projects could interact over time.

Although CPRA has held hundreds of public meetings to generate feedback on their science-based plans and have made adjustments to incorporate suggestions, it has been a struggle to incorporate the vast local knowledge and experience into what is essentially a computer model-based cost-benefit analysis.

This project tested an approach that could prove useful in not only better incorporating local knowledge into the coastal planning process, but also increasing public understanding and confidence in the modeling process.

During five meetings in 2018, representative community members in St. Bernard Parish were involved in a fact-finding and participatory modeling activity. Areas of risk were identified, and potential natural and nature-based solutions were tested through modeling. The models were adjusted based on the community group's feedback.

This summary outlines how this project moved forward, what was discovered through this new process, and if the community found value in the approach.

Competency sub groups discuss project selection and model development.

Competency group

In March 2018, a group of six St. Bernard community members and several Institute staff met for the introductory meeting in what would end up being five meetings over a six-month period.

In all, there were eight community members, and four Institute modelers who made up the "competency group," to share ideas between numerical modeling and community experience. These members were joined by Institute social scientists who facilitated the meetings and discussion.

The goal of the community/researcher collaboration was to co-design a computer model representing the hydrology and ecology of Breton Sound Estuary and then use the model to test different nature-based restoration and protection projects.

The meetings built upon one another with the first focusing mainly on introductions, outlining the project and getting community input on priorities for coastal and ecological resiliency. The next two meetings in April and May focused on co-designing and calibrating a computer model of Breton Sound Estuary while also addressing questions about model assumptions. The June meeting focused on selection of nature-based solutions such as sediment diversions, marsh creation, and building and/or restoring coastal ridges.

The fifth, and final meeting, was held in early October and was a chance for the competency group to review the model results from projects selected by the competency group. A total of nine reports were presented, many of which combined multiple projects.

In a survey filled out by competency group members, both residents and researchers, the

Competency group informal discussion before and after meetings.

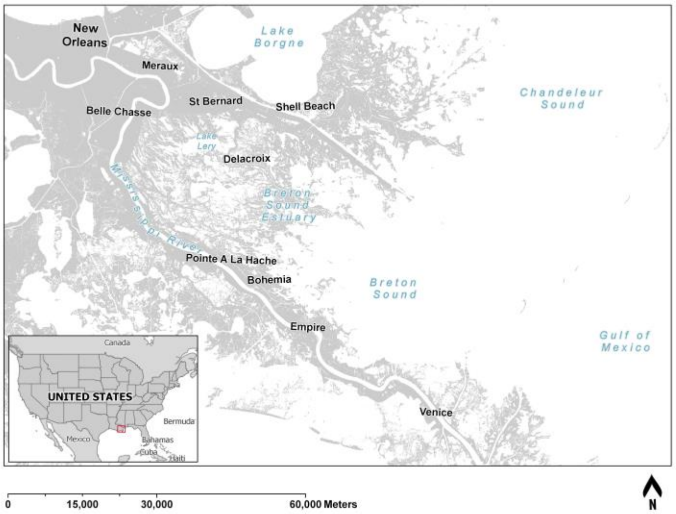
process was rated highly, as was the desire to see the process used more widely in coastal planning efforts. Most of the nine surveys that were completed talked about the value of being heard and being involved in the development of the projects and model in the very beginning instead of commenting on an end product.

Many participants also wanted to see the results of the project shared with groups including Coastal Zone Management boards, state agencies, nonprofit organizations – either as it pertains to specific projects or to the possibility of applying the process to future project development.

Participatory modeling

Modeling efforts in support of restoration and protection activities in coastal Louisiana are traditionally based only on the observation and analysis of natural processes. Although the state held more than 170 briefings with the public, community groups, local officials, advisory groups and others in the 2017 Coastal Master Plan development process, it's been difficult to directly incorporate those comments into modeling efforts.

Despite its scientific rigor, this process fails to account for the knowledge, experience, and priorities of communities that adds value to final



Competency group discussion focused on the Breton Sound estuary.

decision making. While extensive public input is gathered in developing Louisiana’s Coastal Master Plan including stakeholder group meeting during development and public meetings for comment on draft iterations of the plan, methods to directly integrate these comments into a modeling process has not been developed.

The goal in this project was to test a potential solution to this disconnect that not only improves final outcomes due to community buy-in but also increases public confidence in the planning process itself. To support the project, a modeling tool was developed based on the competency group’s input and used to test nature-based projects selected by the community members. Through this effort, community input and scientific knowledge could be integrated to determine the impact certain projects would have to ecology and to local communities, such as flood protection.

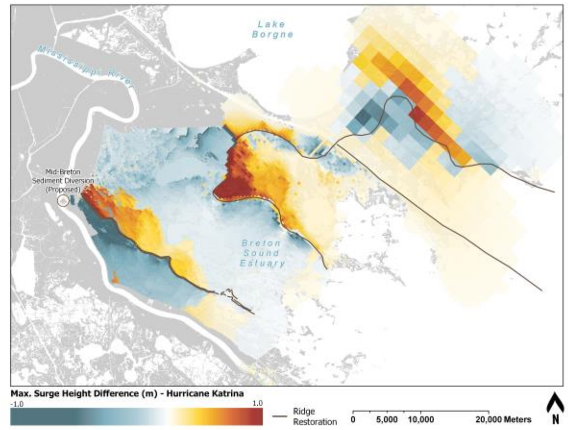
As part of the process, the group was divided into five sub groups containing community members and researchers with a goal of fleshing out the proposed projects for consideration.

Each group was asked to describe a project they were interested in seeing built, identify where the project would be, list the desired outcomes of the project, identify what modeling results could help quantify the outcomes, and identify benefits and challenges of building the project.

Two models were adapted to test the identified projects. The Integrated Compartment Model, referred to as the “fast model,” covers the lower Mississippi River and estuary receiving basins south of New Orleans. The “slow model,” combined an existing Delft3D model to test projects at a finer scale and was also used with a wave model known as Simulating Waves Nearshore (SWAN).

At the center of this project was the development of models that could better reflect community knowledge, concerns, and desirable outcomes from a selection of projects chosen by the group. Computer models as predictive tools are used widely to study coastal and deltaic systems around the world and have been used extensively to evaluate the effectiveness of nature-based restoration and protection strategies. CPRA does have a well-developed outreach and engagement plan, but the process doesn’t have a mechanism to directly integrated community experience into the modeling efforts that are used to prioritize projects.

However, local communities often have limited input in the project proposal and screening process, or in the evaluation of these nature-based projects and are not involved enough in the development or application of these modeling tools. Modeling used in this project successfully reproduced the trends of flooding, rate of shoreline erosion, salinity pattern changes, and the presence or absence of preferable habitat conditions for key species like brown shrimp or oysters.



Model output showing maximum surge height difference during a Hurricane Katrina scenario.

While these qualitative measures are not a substitute of well-established rigorous and quantitative model performance assessment approaches, they substantially increase the acceptance of landscape predictive tools by local communities.

Gaining such acceptance is critical and would increase the likelihood of human communities to comply with flood warning and support environmental restoration and protection strategies because what may seem best scientifically may not incorporate the willingness of community members to make the tradeoffs necessary to make purely scientific solutions feasible or doable.

Ecosystem

The close connection between people, communities, economy, and culture in southeast Louisiana fosters a special concern from residents for the preservation and restoration of ecosystems and the services they provide. Engaging coastal community members about using nature-based solutions to not only provide flood protection, but to support important ecosystem functions such fisheries habitat, helps bridge scientific knowledge with local experience.

Within the participatory modeling project, researchers wanted to know about possible nature-based solutions, such as marsh creation and ridge restoration, and evaluate the effectiveness, such as flood protection for communities and available habitats for the ecosystem.

To help answer these questions the team of community members and researchers developed a set of tools, primarily modeling tools, to evaluate proposed projects on things like how much nutrients the wetlands could absorb, how much carbon could be stored in the soil, and what the potential impact would be on fisheries habitat.

Looking at two of the primary nature-based solutions – marsh creation and the restoration of ridges – the team found that by adding created marshes to an ecosystem, the nutrient loads that can be removed from the water because of the additional marsh area increases slightly.

In addition, marsh creation will likely improve and increase fisheries habitat as well as the amount of carbon that can be stored in the soil. The restoration of ridges in the coastal wetlands showed an ability to reduce storm surge in some areas.

Competency sub group meeting in St. Bernard Parish.

Outcomes

A total of eight projects ideas were evaluated with marsh creation and ridge restoration being the most common suggestions for nature-based solutions.

Projects:

Marsh creation: Four locations around Breton Sound including terracing in Mid-Breton diversion outfall area (P001), central wetlands and Hopedale region (P009), downstream outlet of Bayou Gentilly (P011), and around Lake Lery (P012).

Main Findings: Both the fast model and slow model showed increases in sediment accretion and water level on the diversion side of the terraces (P001). The newly created marshes are largely sustained at the end of year 20 in all environmental scenarios. However, a net land loss was found in the Mid-Breton outfall area , primarily due to inundation caused by back-up water locally.

Rock jetty: Built at Baptiste Collette channel (P003) and at the end of the Mississippi River Gulf Outlet in Lake Machias (P020).

Main Findings: Both the fast and slow models showed sediment capture in the project area for rock jetty at the Baptiste Collette (P003) channel at year 20.

Ridge restoration: Built south of Big Mar (P004), west of Lake Lery (P005), along old river channels (P006), along Oak River, Bayou La Loutre, and Terre aux Boeufs (P007).

Main Findings: Models used Hurricane Katina storm surge to evaluate how ridge restoration might impact the water levels. The models indicated that they would help areas deemed important to the community.

Living shorelines: Build shoreline protection using vegetation mats along the north shore of Lake Coquille (P008).

Main Findings: Modeling indicated that the shoreline was preserved at year 20.

Shoreline protection: Use rock breakwaters in Lake Lery (P010) in an attempt to reduce wetland erosion from waves and preserve the shoreline.

Main Findings: Modeling indicated that the shoreline was preserved at year 20.

Fill pipeline canals: Fill in pipeline canals that run north to south from the Mississippi River Gulf Outlet to Pointe a la Hache (P016).

Main Findings: Working group suggested future investigation should use the slow model for better resolution and accuracy.

Marsh creation: Using 1932 historical locations of marsh and islands as a blueprint, build a series of marsh creation projects (P017).

Main Findings: Modeling indicated slightly higher water levels in the northern sound and sediment accretion was concentrated along the coast and less in the marsh interior. The majority of the newly built land was sustained by year 20 although land loss occurred in the northern end of the system because of elevated water levels.

Removal of the Mississippi River Gulf Outlet rock dam: With a goal of reconnecting Lake Borgne and the Gulf of Mexico (P018)

Main Findings: Models indicated a slight reduction in the average yearly salinity downstream of the removed structure. Working group suggested to update the slow model and perform additional evaluation for the salinity intrusion.

Caernarvon modification: Convert the current freshwater diversion at Caernarvon into a sediment diversion by increasing the flow to 35,000 cubic feet per second (P021).

Main Findings: Modeling indicated elevated water and increased sediment accretion would occur in the diversion outfall area, but overall wetland loss would occur due to elevated water levels and the impact that would have on wetland vegetation.

Acknowledgement

This project was supported by the Science and Engineering Program of The Water Institute of the Gulf with funds from the Louisiana Coastal Protection and Restoration Authority and the Baton Rouge Area Foundation. Thank you to the Los Islenos Center for hosting the five meetings and to the community members for taking time out of their busy schedules to discuss coastal hazards and nature-based solutions.

Project Fact Sheets

Modeling Nature-based Restoration Projects in Breton Sound Estuary

Restoration Project Summaries

PROJECT GOALS

This project brings residents living in Breton Sound Estuary and social and natural scientists working in coastal Louisiana together as an environmental competency group (hereafter "the working group") to test different natural and nature-based restoration and defense options. Over the course of 2018, the group of 16 met five times to develop ideas for different possible restoration projects in the Breton Sound Basin and to discuss priorities for setting-up model domains and scenarios for testing potential projects. The goal of the meetings was to collaboratively develop possible restoration projects and define modeling scenarios to reflect the questions and interests of all group members. Members of the Water Institute of the Gulf helped facilitate meetings where all members shared ideas, knowledge, questions, and priorities for what projects for restoration to examine and how to use numerical models to investigate the potential results of different natural and nature-based restoration projects.

NATURAL AND NATURE-BASED SOLUTIONS

Natural solutions are those that consider conserving existing habitats such as salt marshes or mangrove forests and nature-based solutions are those created by humans, such as oyster reefs, created marshes, restored ridges, and beach nourishment. These nature-based solutions can be used in natural habitat settings or the urban environment to adapt and mitigate the impacts from climate change as well as improve human health and well-being.

RESTORATION PROJECT MODELING

The project summaries provided in this document summarize the results of model simulations of natural and nature-based defense projects designed and selected by the working group. Long-term project effects were modeled over a span of 20 years into the future. The hydrologic conditions of the Mississippi River for the 20 years simulations were taken from historic hydrographs from 1964 to 1983, post the construction of the Old River Control Structure. This approach reflects the modeling efforts in the 2017 Louisiana Coastal Master Plan [1]by the Coastal Protection and Restoration Authority, which used the 1964 to 2013 Mississippi River hydrograph as the 2015 to 2064 hydrograph. Some projects were modeled together to evaluate the impacts collectively, as indicated in each summary.

ENVIRONMENTAL SCENARIOS FOR PROJECT MODELING

All projects were modeled in two ways: First, with "fast model" also known as the Integrated Compartment Model (ICM) that is used as a planning-level model. Second, with the “slow model” also known as the Delft3D Integrated Biophysical Model that is a project-level or detailed model that has smaller grid cells and takes a longer amount of time to run.

The fast model is a planning level model. It focuses on project impact on the landscape in a large spatial and temporal scale (e.g. Louisiana’s coastal zone for the next 50 years). It enables us to run projects more

[1] Louisiana Coastal Protection and Restoration Authority. (2017). *Louisiana’s Comprehensive Master Plan for a Sustainable Coast*. Baton Rouge, Louisiana: Louisiana Coastal Protection and Restoration Authority.

quickly because it is less computationally complex, therefore ideal for narrowing down project options for more in-depth analysis. The slow model is a project level model. Compared to the fast model, the slow model is more detailed with finer grid cells and takes a longer time to run. It is a more time consuming and expensive tool compared to the fast model. The fast model can provide insight onto the long-term impacts of a project to large-scale morphological and ecological conditions, such as habitat. In contrast, the slow model can show detailed flow patterns and sediment distribution in the project vicinity.

The three environmental scenarios used in the 2017 Coastal Master Plan were adapted in this study.[2] These environmental scenarios include rates for projected sea level rise, subsidence, precipitation, and evapotranspiration. A summary of the sea level rise and subsidence for the three scenarios is listed below:

Low: 1.4 (ft/50yr) global mean sea level rise, 20% range for subsidence
Medium: 2.1 (ft/50yr) global mean sea level rise, 20% range for subsidence
High: 2.7 (ft/50yr) global mean sea level rise, 50% range for subsidence

Due to the high cost and time for running the slow model, projects selected for model runs with the slow model were only simulated under the medium environment condition described above.

Additionally, all projects were modeled assuming the construction of the Mid-Breton Sediment Diversion on the landscape per the 2017 Coastal Master Plan. The one exception – restoration of historical ridges - is noted in the project summaries.

RESTORATION PROJECT SUMMARIES

Each project summary lists the following:

Project description: This includes the type of restoration project (including project number) proposed by the working group, its location, and its intended function. In some cases, multiple restoration projects with the same type were modeled together.

Map description: Maps describe the location of the project and the kind of metric used as the primary indicator to denote project performance. Difference maps were the main approach to evaluate project impact when compared to the baseline conditions. Some difference map examples include land change difference maps and salinity difference maps. The former calculates the land gain, land sustained or land loss when compared to the baseline conditions at certain years. The latter represent the annual averaged salinity difference between the landscape with project and baseline conditions without the project.

Modeling comments: Modeling comments describe the main results of the model runs for the projects and decisions the modeling team made during the modeling process.

[2] This was decided by the modeling team to provide a more comprehensive evaluation of the projects. It is not a request from the working group.

Scenarios considered: Specifies which environmental scenarios were used to test the proposed restoration projects.

Estimated project costs: Estimates from the 2017 Coastal Master Plan for projects in the Breton Sound Basin were used to approximate average unit costs for each project type. The size of the modeled projects was multiplied by these average unit costs to determine an approximate project cost. These estimates are for generalization only and do not reflect actual project costs.

Breton Sound Marsh Creation

Marsh Creation

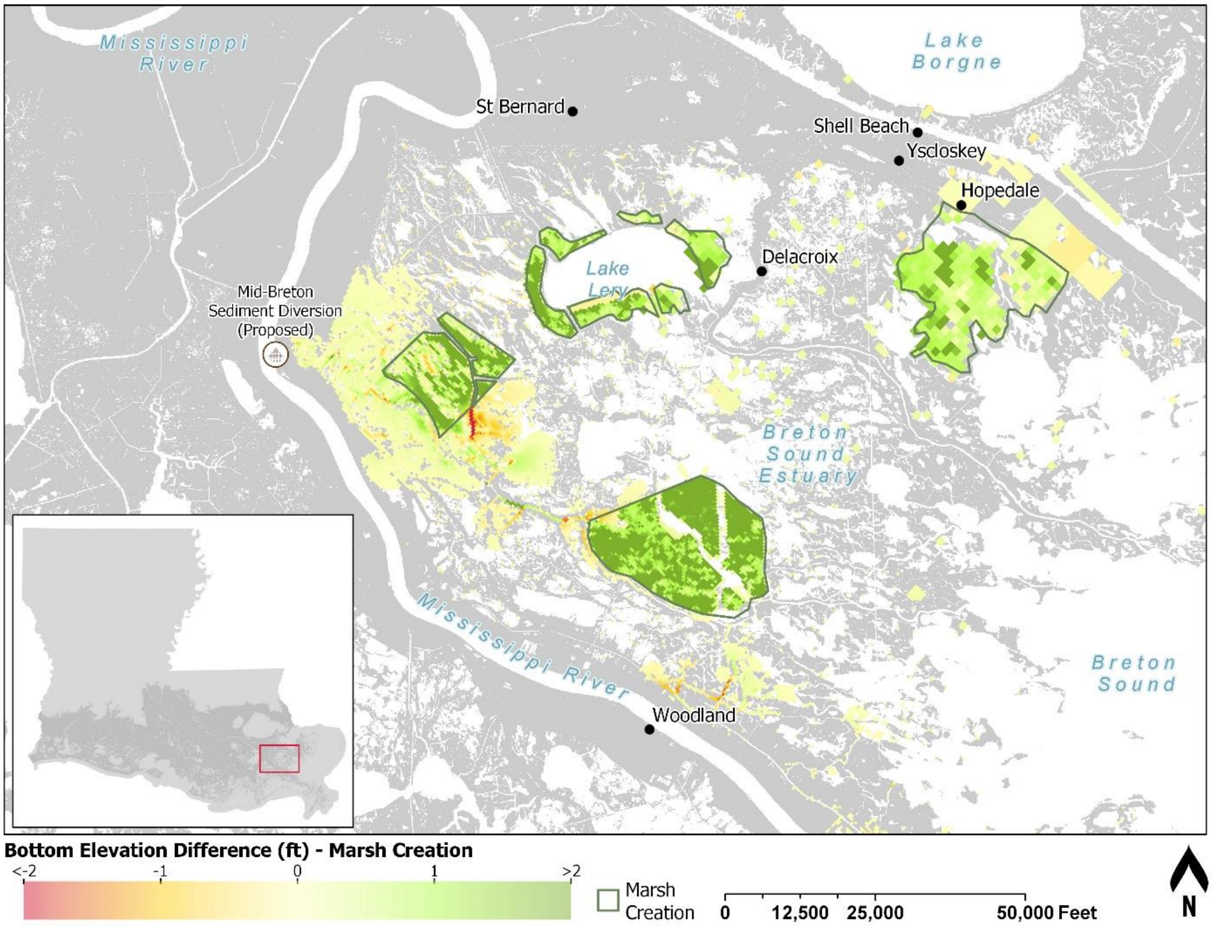
Project Number: P001, P009, P011, and P012

PROJECT DESCRIPTION

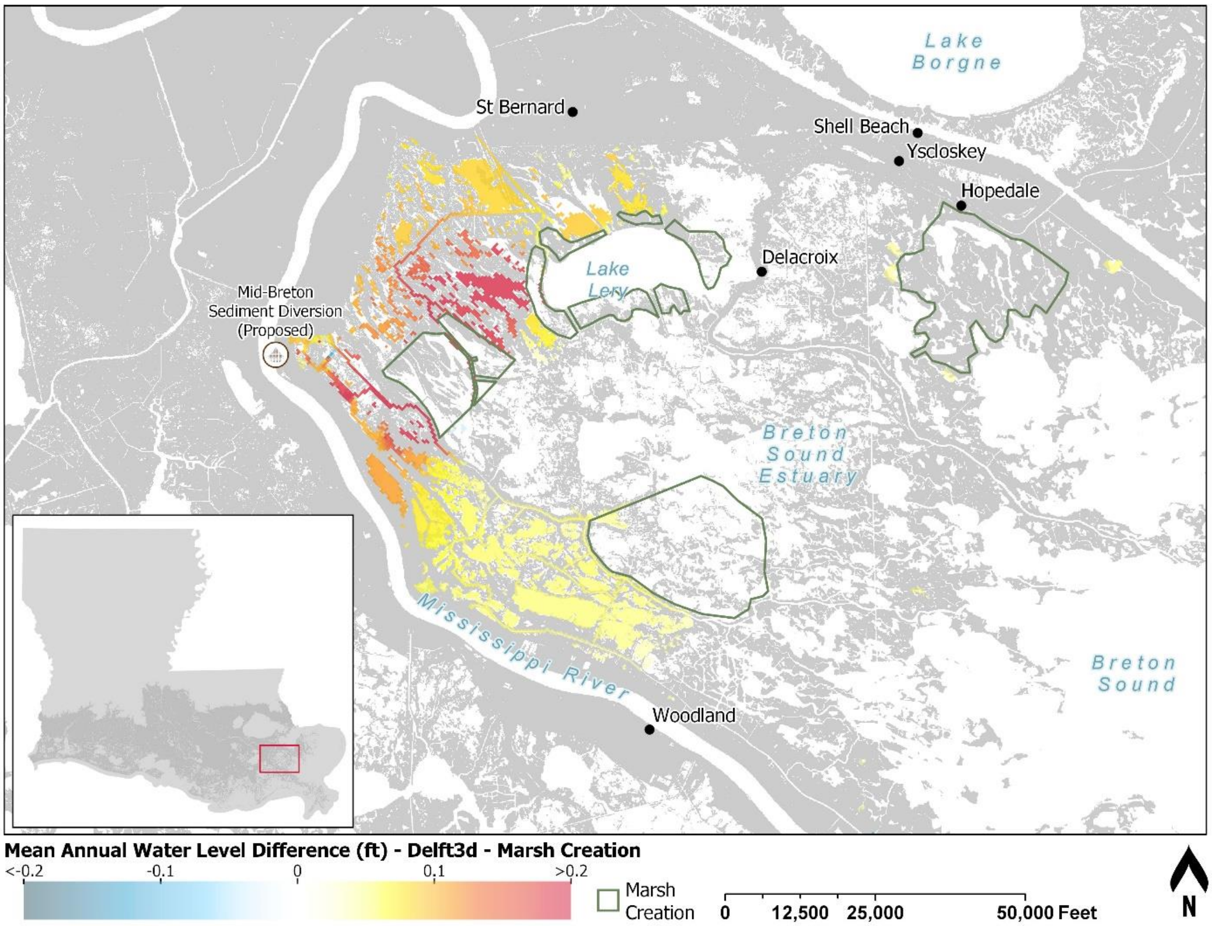
The working group recommended several marsh creation projects for Breton Sound Estuary. Four marsh creation projects aimed at making new wetland habitat and restoring degraded marsh were modeled. These include:

1) Terracing in proposed Mid-Breton Sediment Diversion outfall (P001);
2) Marsh creation in the central wetlands and Hopedale region (P009);
3) Marsh creation downstream of the Bayou Gentilly outlet (P011);
4) Marsh creation around Lake Lery (P012).

These projects were intended to create new wetland habitat and restore degraded marsh. The project was implemented in model year 4 of 20 at an elevation of 1.3 ft. (0.4 m NAVD88).



This map depicts predicted bottom elevation difference with the terracing and marsh creation projects at year 20 under the medium environmental scenario when compared to the baseline condition in the slow model. The terracing and marsh creation projects were modeled together in this model run (solid dark green line). Positive differences are in green colors (higher bottom elevations) and negative differences are in red colors (lower bottom elevations).



This map depicts predicted mean annual water level difference with the terracing and marsh creation projects at year 20 under the medium environmental scenario when compared to the baseline condition in the slow model. The terracing and marsh creation projects were modeled together in this model run (solid black green line). Positive differences are in red colors (higher water levels) and negative differences are in blue colors (lower water levels).

MODELING COMMENTS

Each of the four marsh creation projects was modeled in separate simulations under low, medium, and high environmental scenarios with the fast model for initial project evaluation. Two additional simulations were conducted for the marsh creation downstream of the Bayou Gentilly outlet (P011) in low and high subsidence rates to evaluate project sensitivity to assumed subsidence rate in the Breton Sound. Initial project evaluation using the fast model shows increases in both sediment accretion and water level on the diversion side of the terraces (P001) over the simulation period. A net land loss on the diversion side of the terraces (P001) at year 20 was predicted in the fast model due to higher water levels in adjacent marshes that stress wetland vegetation and cause it to collapse and subside. At the same time, no significant impact on main hydrological conditions (mean water level, salinity, sediment accretion) was found for the three other marsh creation projects (P009, P011, and P012). No significant impact was found with both low and high subsidence assumptions in the 20 years simulation for project P011.

After modeling the marsh creation projects separately with the fast model, the four marsh creation projects were then simulated collectively in the slow model. The slow model results showed that the newly created marsh was sustained at year 20 as the fast model predicted. There was some land gain locally on the diversion side of the terraces (P001) at proposed Mid-Breton Sediment Diversion outfall from additional sediment retention. There was, however, some land loss on the backside of the terraces due to the reduction of sediment supply from the diversion. There were no significant impacts to water level and salinity when all four marsh creation projects were combined.

The newly created marsh could help sustain wetlands in the Breton Sound Estuary. The marsh creation projects examined in both the fast and slow models are largely sustained at the end of year 20 in all environmental scenarios. The terraces in the proposed Mid-Breton Sediment Diversion outfall area could retain more sediment, however, could also potentially cause water to back up and inundate the wetland locally, thus the projects may have a negative impact in the near future (<20 years).

These results are preliminary and are part of a participatory modeling pilot project. They do not represent an endorsement by The Water Institute of the Gulf.

SCENARIOS CONSIDERED

Fast model: low, medium, and high environmental scenarios (P001, P009, P011, P012); low and high subsidence rates (P011);
Slow model: medium environmental scenarios

APPROXIMATE PROJECT COST: ~$1.2 BILLION

Cost is estimated from the average unit cost of marsh creation projects located in the Breton basin that were included in the 2017 Coastal Master Plan; the average cost was $52,400 per acre. These project unit costs do not account for any site-specific elements, sediment volumes required, nor account for other project constraints.

Rock Jetty

Sediment Steering and Trapping

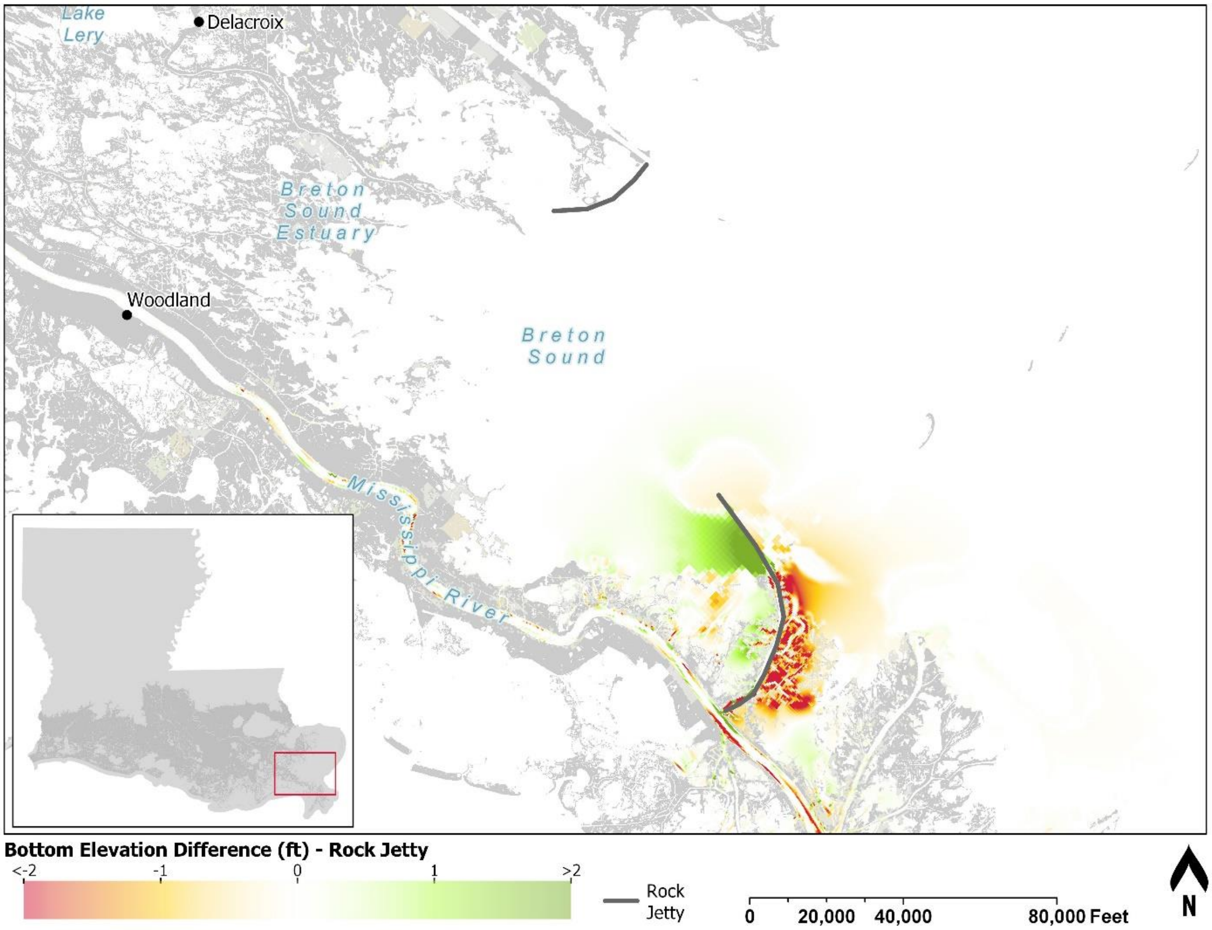
Project Number: P003 and P020

PROJECT DESCRIPTION

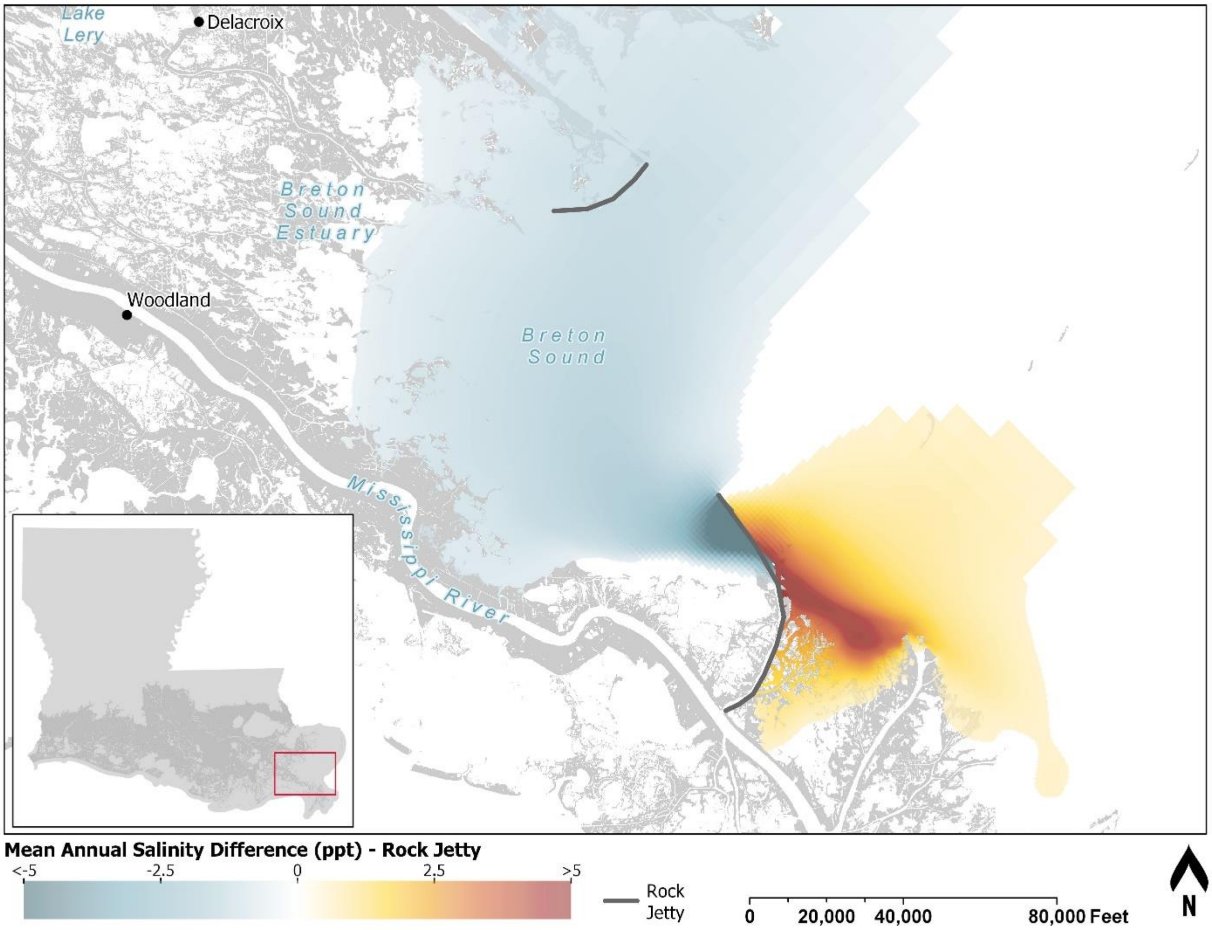
The working group wanted to model two rock jetties in order to facilitate land creation and stabilized marsh in adjacent project areas. The two projects include:

1) Rock jetty at the Baptiste Collette channel (P003);
2) Rock jetty at the end of MRGO (P020).

These projects were intended to direct and constrain the plume of sediment in the area and capture the flow of suspended sediment to enhance land creation and stabilize marsh. In lieu of using rock jetties, the model was set-up to model SREDS (sediment retention enhancement devices) as the best analog to examine the potential impacts of rock jetties.



This map depicts predicted bottom elevation difference with the rock jetty projects at year 20 under the medium environmental scenario when compared to the baseline condition in the slow model. The two rock jetty projects were modeled together in this model run (solid black line). Positive differences are in green colors (higher bottom elevations) and negative differences are in red colors (lower bottom elevations).



This map depicts predicted mean annual salinity difference with the rock jetty projects at year 20 under the medium environmental scenario when compared to the baseline condition in the slow model. The two rock jetty projects were modeled together in this model run (solid black line). Positive differences are in red colors (higher salinities) and negative differences are in blue colors (lower salinities).

MODELING COMMENTS

Initial project evaluation using the fast model shows increased sediment deposition in the project area at year 20 for the rock jetty at the Baptiste Collette (P003) channel. In addition to this, slightly elevated water level and salinity differences were found in this (P003) project area due to the fresh water redistribution. There was no significant impact on main hydrological conditions (mean water level, salinity, sediment accretion) found for the rock jetty at the end of MRGO (P020) in the fast model runs.

Project evaluation with the slow model shows the same trend as the fast model rock jetties (P003 and P020). A maximum net sediment deposition near the Baptiste Collette channel rock jetty (P003) at year 20 was found up to 6.5 ft. Most of sediment deposition, however, was limited to near the rock jetty. Even though some areas showed high sedimentation rates, the sedimentation in the project (P003) area was not enough to break the water surface and become land in the 20-year simulation. On the east side of the jetty (P003), a net erosion was predicted due to the reduced sediment supply outside the jetty. There was no significant impact on sediment deposition found for the rock jetty at the end of MRGO (P020) due to the limited flow and sediment supply through the MRGO.

Impact on salinity was also found in the Baptiste Collette channel rock jetty project (P003). Due to redistribution of fresh water with the rock jetty, salinity in the lower Breton Basin was reduced up to 2 ppt. The impacted area extended into the Breton Sound estuary.

As predicted by the model, the rock jetty at the Baptiste Collette channel could potentially increase sediment deposition in the Breton Sound estuary, while the rock jetty at the end of MRGO did not show promising results in both fast and slow model. Both fast and slow model results also show salinity changes might occur in the project area for the rock jetty at the Baptiste Collette channel.

These results are preliminary and are part of a participatory modeling pilot project. They do not represent an endorsement by The Water Institute of the Gulf.

SCENARIOS CONSIDERED

Fast model: low, medium, and high environmental scenarios (P003 and P020); with the 2017 Master Plan in the fast model (P020);
Slow model: medium environmental scenarios

APPROXIMATE PROJECT COST: ~$140 MILLION

Cost is estimated from the average unit cost of shoreline protection projects located in the Breton basin that were included in the 2017 Coastal Master Plan; the average cost was $2,145 per foot of protected shoreline. These project unit costs do not account for any site-specific elements and are provided solely to provide a rough frame of reference. The depth of water at the project location was not taken into consideration

Ridge Restoration

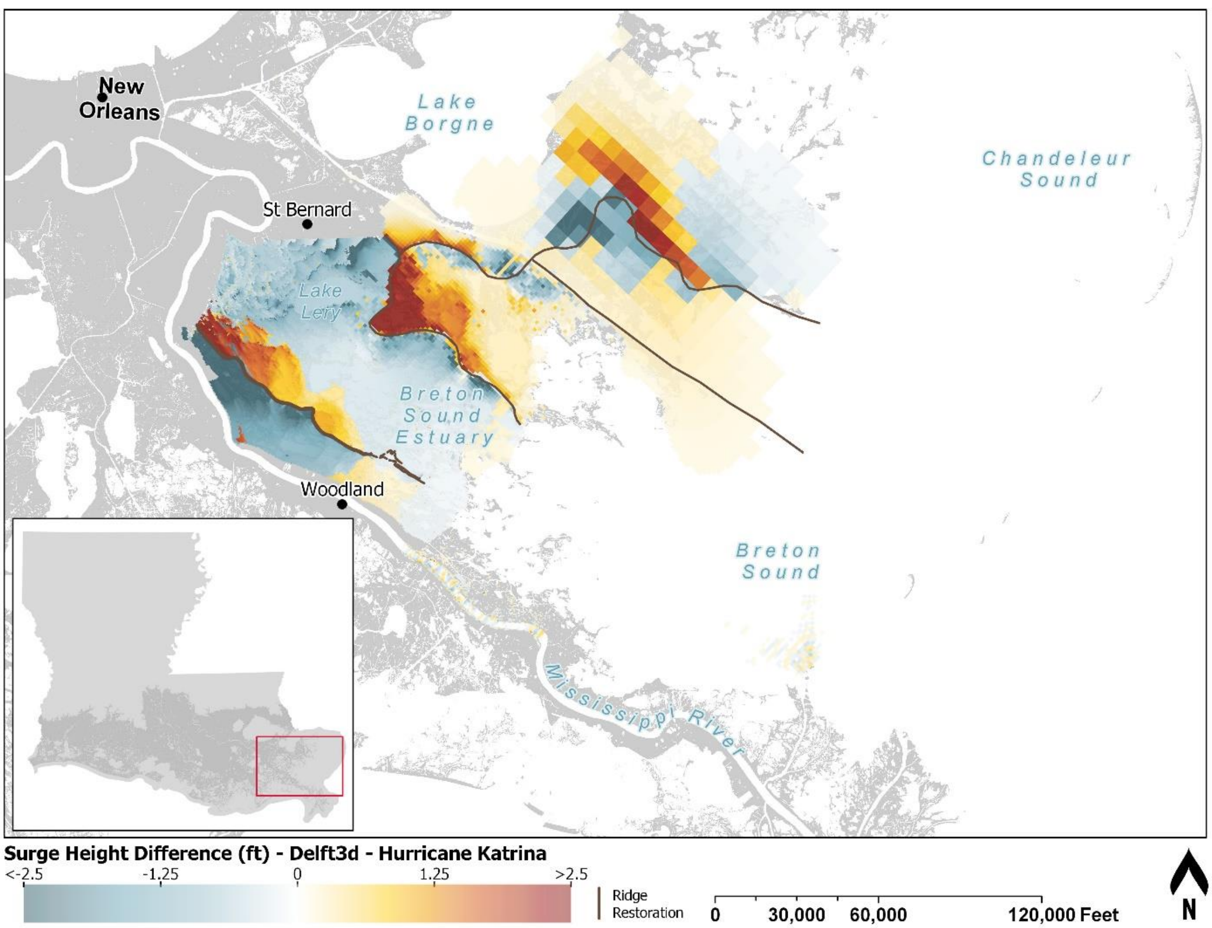
Project Number: P004, P005, P006, and P007

PROJECT DESCRIPTION

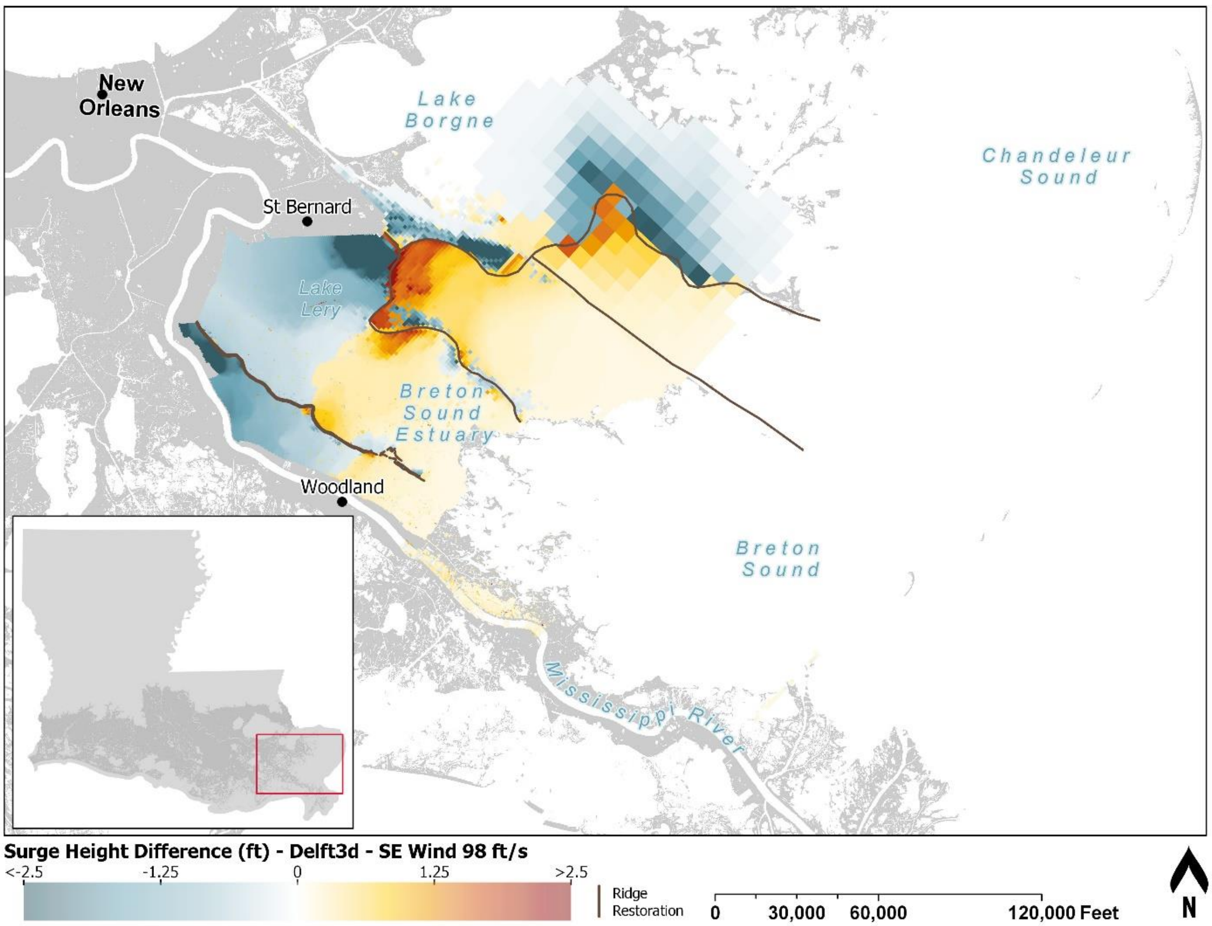
This model run examined suggested restoration of historical ridges posited by the working group in four areas:

1) Ridge restoration south of Big Mar (P004);
2) Ridge restoration west of Lake Lery (P005);
3) Ridge restoration of old river channels (P006);
4) Ridge restoration of Oak River, Bayou La Loutre and Terre aux Boeufs (P007).

These projects were intended to restore coastal upland habitat, natural hydrology, and provide wave and storm surge attenuation. Due to the limitation of the fast model in simulating surge impact, only the slow model was used to conduct project evaluation for the proposed ridge restoration ideas. Compared to other projects, this model run did not include the Mid-Breton Sediment Diversion from the 2017 Coastal Master Plan. Due to relatively short-term impacts of storms, no sea level rise or subsidence was considered. The sediment, water quality, and vegetation dynamics were also not included in the surge attenuation modeling. The bathymetric-topographic elevation data used for the simulations represented the landscape (as predicted with the slow model) in the year 2020.



This map depicts predicted difference in surge height (maximum water level) with the ridge restoration projects under Hurricane Katrina when compared to the baseline condition in the slow model. The four ridge restoration projects were modeled together in this model run (solid black line). Positive differences (ridges result in higher water levels) are in red colors and negative differences (ridges result in reduced water levels) are in blue colors.



This map depicts predicted surge height (maximum water level) difference with the ridge restoration projects under constant southeasterly wind conditions when compared to the baseline condition in the slow model. The four ridge restoration projects were modeled together in this model run (solid black line). Positive differences (ridges result in higher water levels) are in red colors and negative differences (ridges result in reduced water levels) are in blue colors.

MODELING COMMENTS

The ridges (assumed to be constructed to 5 ft NAVD 88) were created based on historical ridge footprint. Two scenario runs were tested to evaluate the effect of ridge restoration on surge attenuation: 1) Hurricane Katrina and 2) constant southeasterly wind at 98 ft/s, which is a strong tropical storm-force wind.

Hurricane Katrina (2005) was selected to evaluate the effect of the ridge restoration efforts on the surge attenuation. The wind fields for Hurricane Katrina were reconstructed using the National Hurricane Center (NHC)'s best rack data (https://www.nhc.noaa.gov/data/#hurdat). The simulation was conducted for 3 days (Aug. 28th - 30th, 2005). The evaluation of the ridge restoration projects in the slow model showed that ridge restoration can reduce local surge heights up to 4 ft. The ridges, however, can also trapped surge flow, resulting in delay drainage and increases of surge height up to 5 ft at some locations. The protection effects highly depend on wind direction, the path of the hurricane, and orientation of ridges.

To evaluate ridge impacts under constant southeasterly wind condition, the historical wind timeseries data (year 2010 to 2017) from NOAA station at Shell Beach, LA (CO-OPS 8761305) were used to determine the typical cold and warm front wind speed. It was found that the typical wind speed during cold front was about 32 ft/sec lasting for 2 to 4 days. The wind speed from a warm front was weaker than the wind speed from a cold front. By considering the orientation of the Breton Basin and proposed ridges, a worst scenario of a constant 98 ft/s southeasterly wind for 3 days was determined which would create a significant wind set-up in the basin during the simulated period. The model results show that water levels on the leeward side of ridges were reduced (up to 2.6 ft) at some locations when compared to model results without the ridge restoration projects until the point when water levels reached the ridge top elevation. It is worth noting that the existence of ridges could also increase the local water elevation (up to 2.3 ft) due to the ridges impacting water flow pathways. The local impacts from the proposed ridges are highly dependent upon the wind direction and the orientation of the ridges.

Overall, the model suggests that restoration of historic ridges can reduce surge heights in several areas but can also trap surge flow in other locations. This is highly dependent on wind speed/direction and the path of the hurricane.

These results are preliminary and are part of a participatory modeling pilot project. They do not represent an endorsement by The Water Institute of the Gulf.

SCENARIOS CONSIDERED

Slow model: 1) Hurricane Katrina and 2) constant southeasterly wind at 98 ft/s for 3 days
the following effects were not considered in this project evaluation: 1) sea level rise, 2) subsidence, 3) proposed sediment diversion operation

APPROXIMATE PROJECT COST: ~$140 MILLION

Cost is estimated from the average unit cost of shoreline protection projects located in the Breton basin that were included in the 2017 Coastal Master Plan; the average cost was $2,145 per foot of protected shoreline. These project unit costs do not account for any site-specific elements and are provided solely to provide a rough frame of reference. The depth of water at the project location was not taken into consideration.

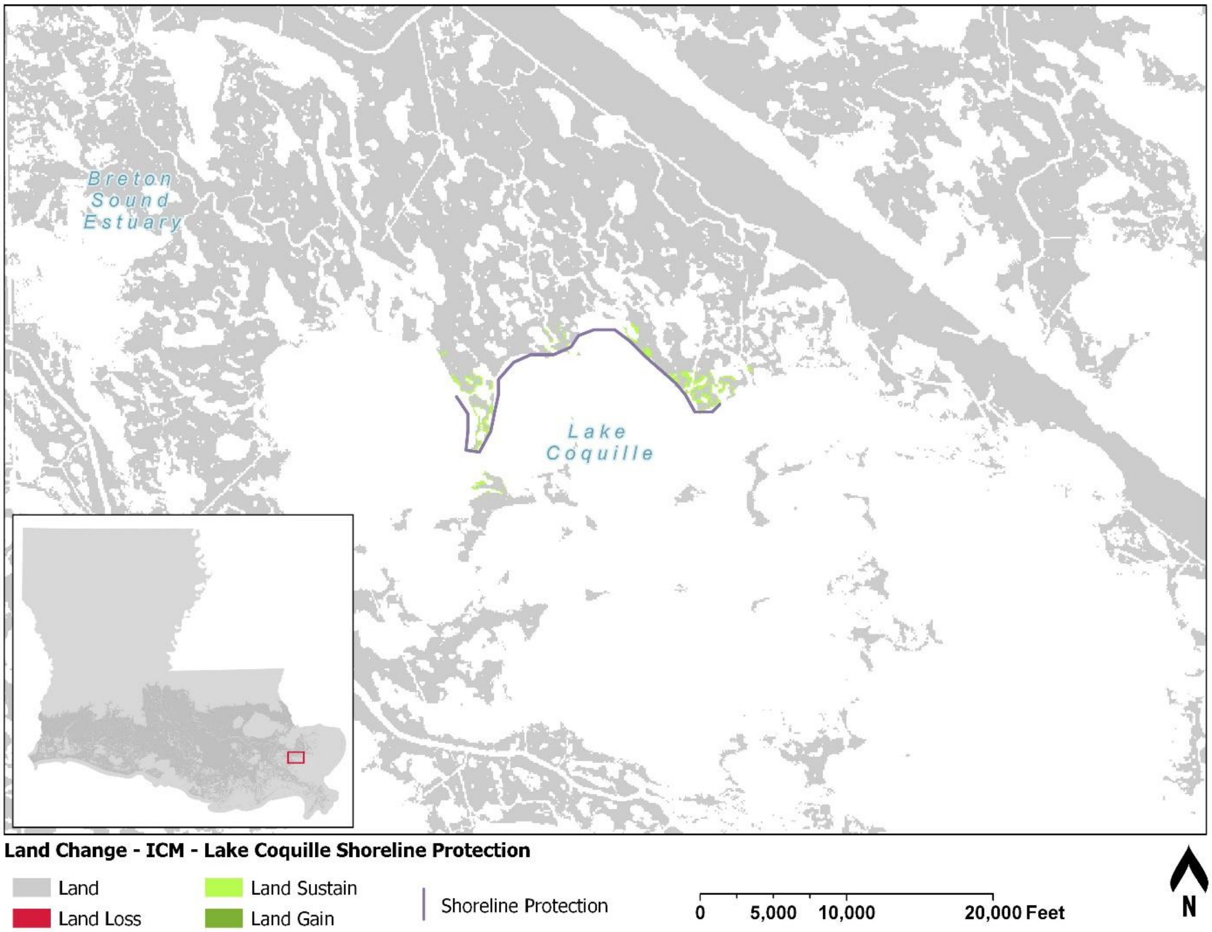
Lake Coquille Shoreline Protection

Living Shorelines

Project Number: P008

PROJECT DESCRIPTION

Shoreline protection through vegetation mats along the north shore of Lake Coquille (P008) reaching to Lake Jean Louis Robin to preserve shoreline integrity and reduce wetland degradation from wave erosion. Members of the group also felt vegetation mats could withstand high salinity well.



This map depicts predicted land difference with the Lake Coquille shoreline protection project at year 20 under the low environmental scenario when compared to the baseline condition in the fast model. The shoreline protection project is shown as purple line in the map. Light green region is land sustained with the project.

MODELING COMMENTS

The shoreline restoration project was initiated in year 1 of the model run and examined through year 20 under the low environmental scenario. The model showed that the project area was preserved after 20 years. Since the project footprint does not overlay with any major water flow pathways, the project does not impact hydrological conditions (mean water level, salinity, sediment accretion) in the project area.

Model results suggest that the project is valuable for restoring the historical shoreline and strengthen the bank against erosion and future sea level rise but might not induce benefits farther away from the project in the Breton Sound Estuary. Only project impacts under the low environmental scenario were evaluated to investigate the maximum project effects. The project was not evaluated in the slow model due to the limited impact.

These results are preliminary and are part of a participatory modeling pilot project. They do not represent an endorsement by The Water Institute of the Gulf.

SCENARIOS CONSIDERED

Fast model: low environmental scenario

APPROXIMATE PROJECT COST: ~$6 MILLION

Cost is estimated from the average unit cost of marsh creation projects located in the Breton basin that were included in the 2017 Coastal Master Plan; the average cost was $52,400 per acre. These project unit costs do not account for any site-specific elements, sediment volumes required, nor account for other project constraints. Marsh creation cost was used instead of shoreline protection costs to account for the vegetated mats proposed here.

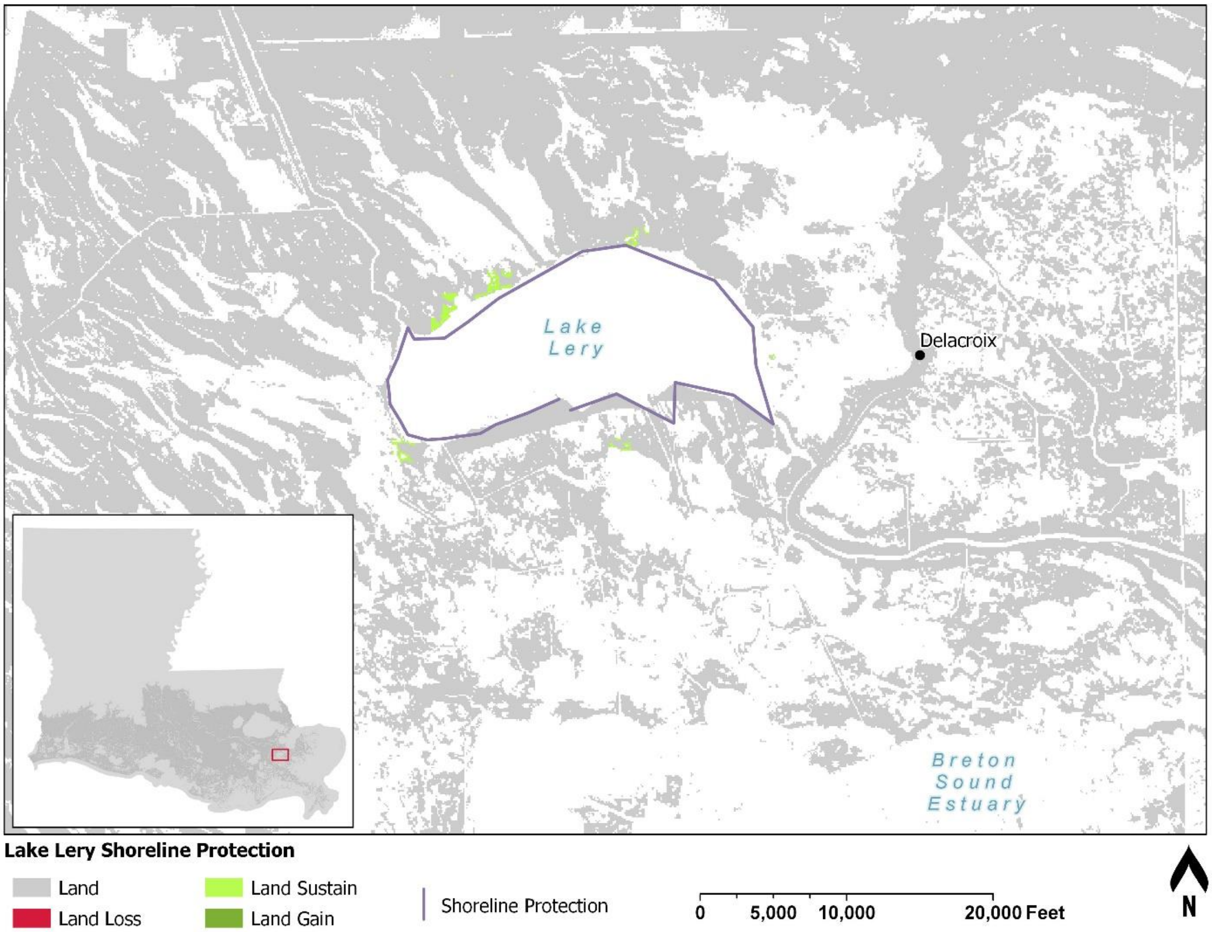
Lake Lery Shoreline Protection

Shoreline Protection

Project Number: P010

PROJECT DESCRIPTION

This project uses rock breakwaters as shoreline protection along the entirety of Lake Lery to preserve shoreline integrity, hydrological conditions, and reduce wetland degradation from wave erosion.



This map depicts predicted land difference with the Lake Lery shoreline protection project at year 20 under the low environmental scenario when compared to the baseline condition in the fast model. The shoreline protection project is shown as purple line in the map. Light green region is land sustained with the project.

MODELING COMMENTS

Project evaluation using the fast model shows the bank line region in the project area (implemented at year 1) was preserved in year 20 under the low environmental scenario. Since the project footprint does not overlay with any major water flow pathways, the project does not impact any hydrological conditions (mean water level, salinity, sediment accretion) in the project area.

Model results suggest that the project may have value in restoring the historical shoreline and strengthening the bank against erosion from future sea level rise. The project might not induce far field benefits in locations further from the project site. Only project impacts under the low environmental scenario were evaluated to investigate the maximum project effects. Projects were not evaluated in the slow model due to the limited impact.

These results are preliminary and are part of a participatory modeling pilot project. They do not represent an endorsement by The Water Institute of the Gulf.

SCENARIOS CONSIDERED

Fast model: low environmental scenarios

APPROXIMATE PROJECT COST: ~$150 MILLION

Cost is estimated from the average unit cost of shoreline protection projects located in the Breton basin that were included in the 2017 Coastal Master Plan; the average cost was $2,145 per foot of protected shoreline. These project unit costs do not account for any site-specific elements and are provided solely to provide a rough frame of reference.

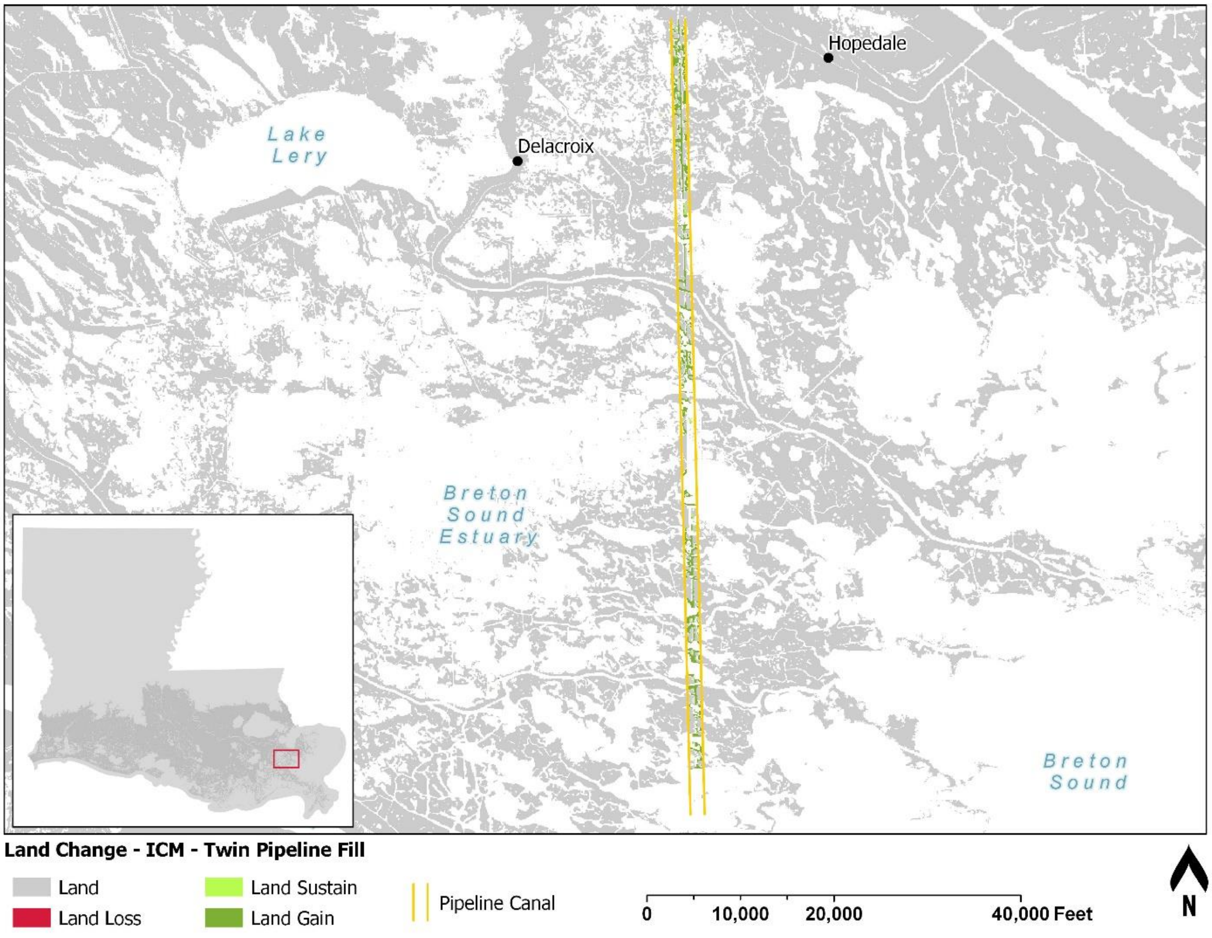
Filling Pipeline Canals

Marsh Creation

Project Number: P016

PROJECT DESCRIPTION

The group suggested filling in the twin pipeline canals (P016) that run north-south from MRGO to Pointe a la Hache as a created marsh using the historic land/water map from 1932 to restore the historical hydrology and topography. Deep water with a depth more than 2.5 ft were left as open water based on previous marsh creation assumptions in the Breton Sound Estuary.



This map depicts predicted land difference with the filling pipeline canals project at year 20 under the medium environmental scenario when compared to the baseline condition in the fast model. The pipeline canals are shown as yellow lines in the map. Light green and dark green regions are land sustained and land gain with the project, respectively.

MODELING COMMENTS

Initial evaluation of the project using the fast model shows no significant impact on the hydrological conditions in the pipeline canal area when filled in for marsh creation. Since the major flow paths along and crossing the twin-pipeline canals have a depth more than 2.5 ft, they were not filled in therefore the hydrodynamics, salinity, and sediment accretion were not significantly altered in the project area.

Further discussion with the working group suggested that additional filling is needed for all deep channels which would potentially create a bigger impact to the project area. The suggested model update efforts were not carried out in this study due to time limitations. It was also suggested that future investigations should use the slow model for better resolution and accuracy.

These results are preliminary and are part of a participatory modeling pilot project. They do not represent an endorsement by The Water Institute of the Gulf.

SCENARIOS CONSIDERED

Fast model: low, medium, and high environmental scenarios

APPROXIMATE PROJECT COST: ~$40 MILLION

Cost is estimated from the average unit cost of marsh creation projects located in the Breton basin that were included in the 2017 Coastal Master Plan; the average cost was $52,400 per acre. These project unit costs do not account for any site-specific elements, sediment volumes required, nor account for other project constraints.

Historic Breton Sound Estuary Landscape

Marsh Creation

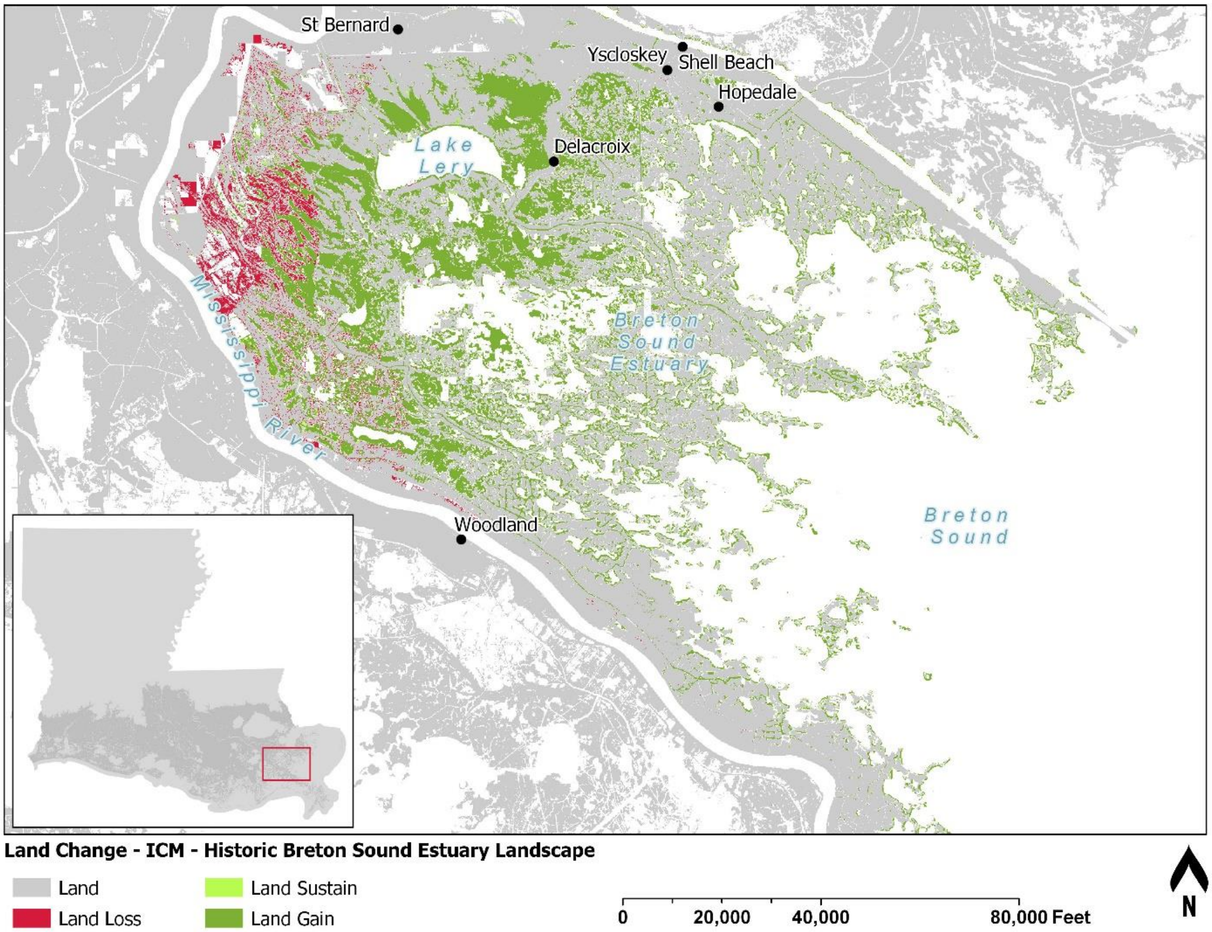
Project Number: P017

PROJECT DESCRIPTION

This project (P017) utilizes the historic locations and areas of marsh and small islands located in Breton Sound Estuary from a 1932 land/water map as a guide for extensive marsh creation projects throughout the estuary that can restore the historical hydrology and topography. Deep water with a depth more than 2.5 ft were left as open water based on previous marsh creation assumptions in the Breton Sound estuary.

MAP DESCRIPTION

Modeled project area shows land gain and land loss across Breton Sound after 20 years in the model. Land loss is concentrated in areas in the upper, western part of the estuary with land growth concentrated present-day shallow water areas in the more interior areas of the estuary.

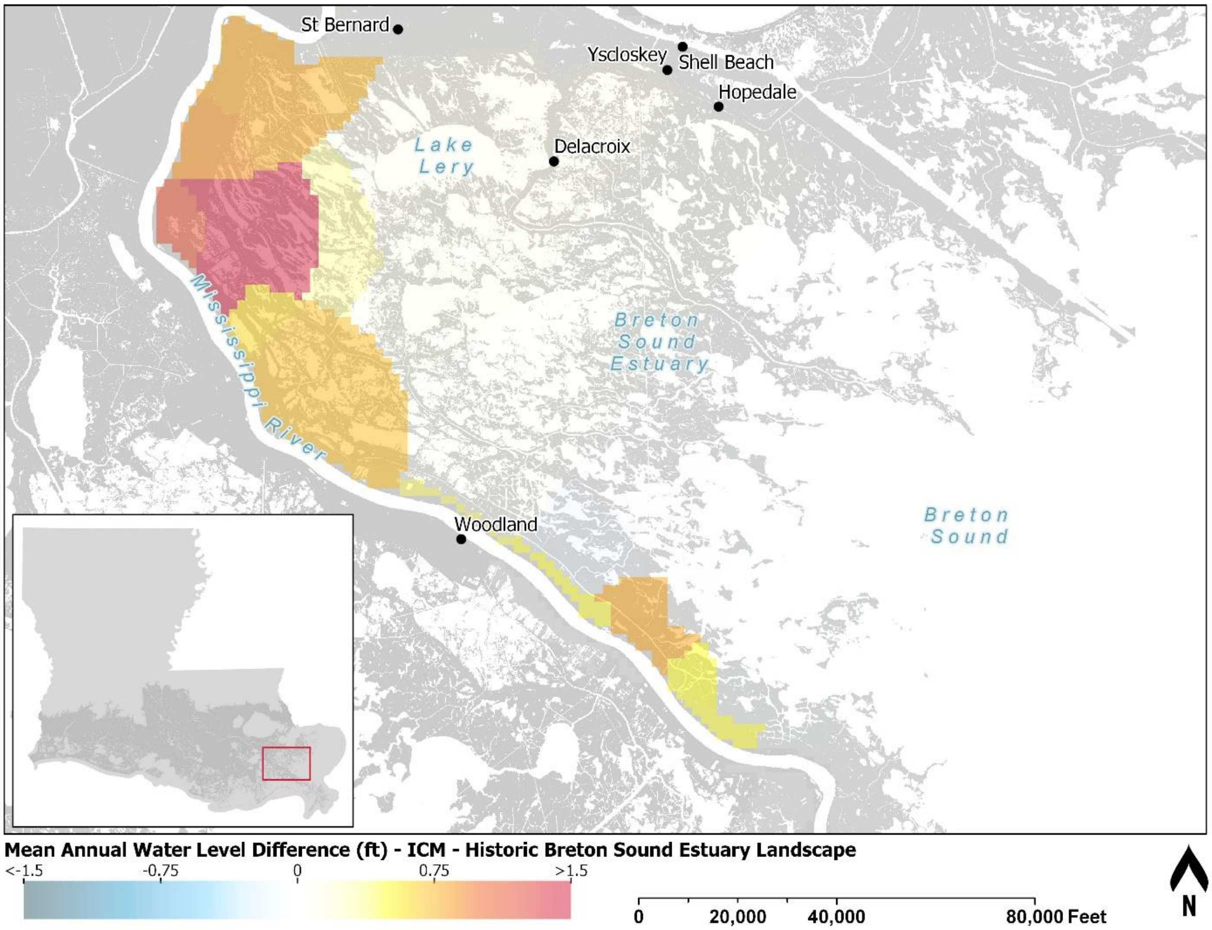


This map depicts predicted land difference with the restoration of historic Breton Sound Estuary landscape project at year 20 under the medium environmental scenario when compared to the baseline condition in the fast model. Light green and dark green regions are land sustained and land gained with the project, respectively. The red region is additional land loss with the project.

Historic Breton Sound Estuary Landscape

Marsh Creation

Project Number: P017

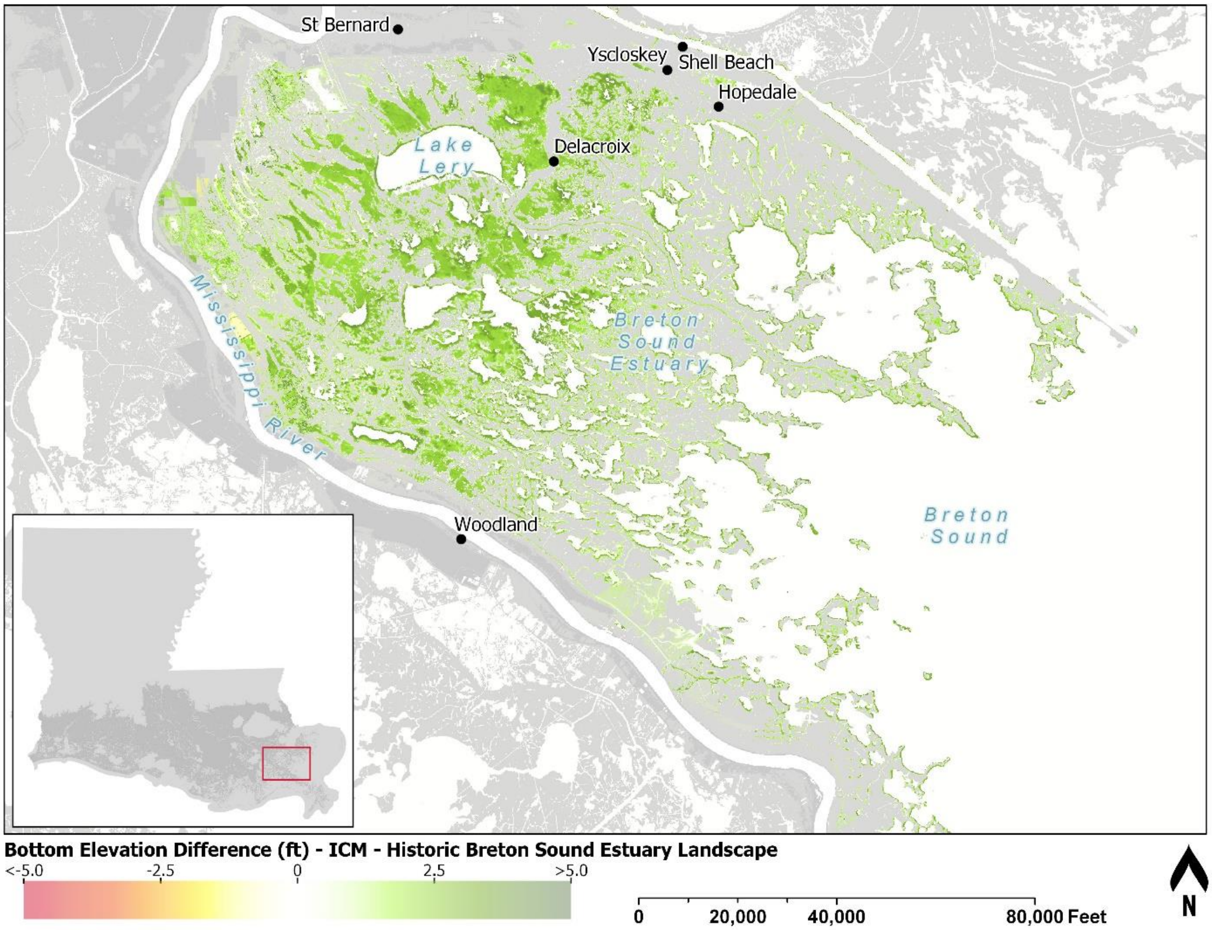


This map depicts predicted mean annual water level difference with the restoration of historic Breton Sound Estuary landscape project at year 20 under the medium environmental scenario when compared to the baseline condition in the fast model. Positive differences are in red colors (higher water levels) and negative differences would be in blue colors (lower water levels); however, only net increases in mean water levels are seen.

Historic Breton Sound Estuary Landscape

Marsh Creation

Project Number: P017



This map depicts predicted bottom elevation difference with the restoration of historic Breton Sound Estuary landscape project at year 20 under the medium environmental scenario when compared to the baseline condition in the fast model. Positive differences are in green colors (higher bottom elevations) and negative differences are in red colors (lower bottom elevations).

MODELING COMMENTS

When the full suite of marsh restoration projects was evaluated with the fast model at year 20, the model showed slightly elevated water levels in portions of the Breton Sound Estuary. This is a result of reduced flow paths for water as a result of newly created marsh. Sediment deposition increased along coastal marsh systems while decreasing in the interior marsh system. The majority of the new built land was sustained by year 20 (as shown in the map), however some land loss occurred in the costal side of the basin due to the increased water level. Despite this, the estimated costs make it a challenge to implement.

These results are preliminary and are part of a participatory modeling pilot project. They do not represent an endorsement by The Water Institute of the Gulf.

SCENARIOS CONSIDERED

Fast model: low, medium, and high environmental scenarios

APPROXIMATE PROJECT COST: ~$6 BILLION

Cost is estimated from the average unit cost of marsh creation projects located in the Breton basin that were included in the 2017 Coastal Master Plan; the average cost was $52,400 per acre. These project unit costs do not account for any site-specific elements, sediment volumes required, nor account for other project constraints.

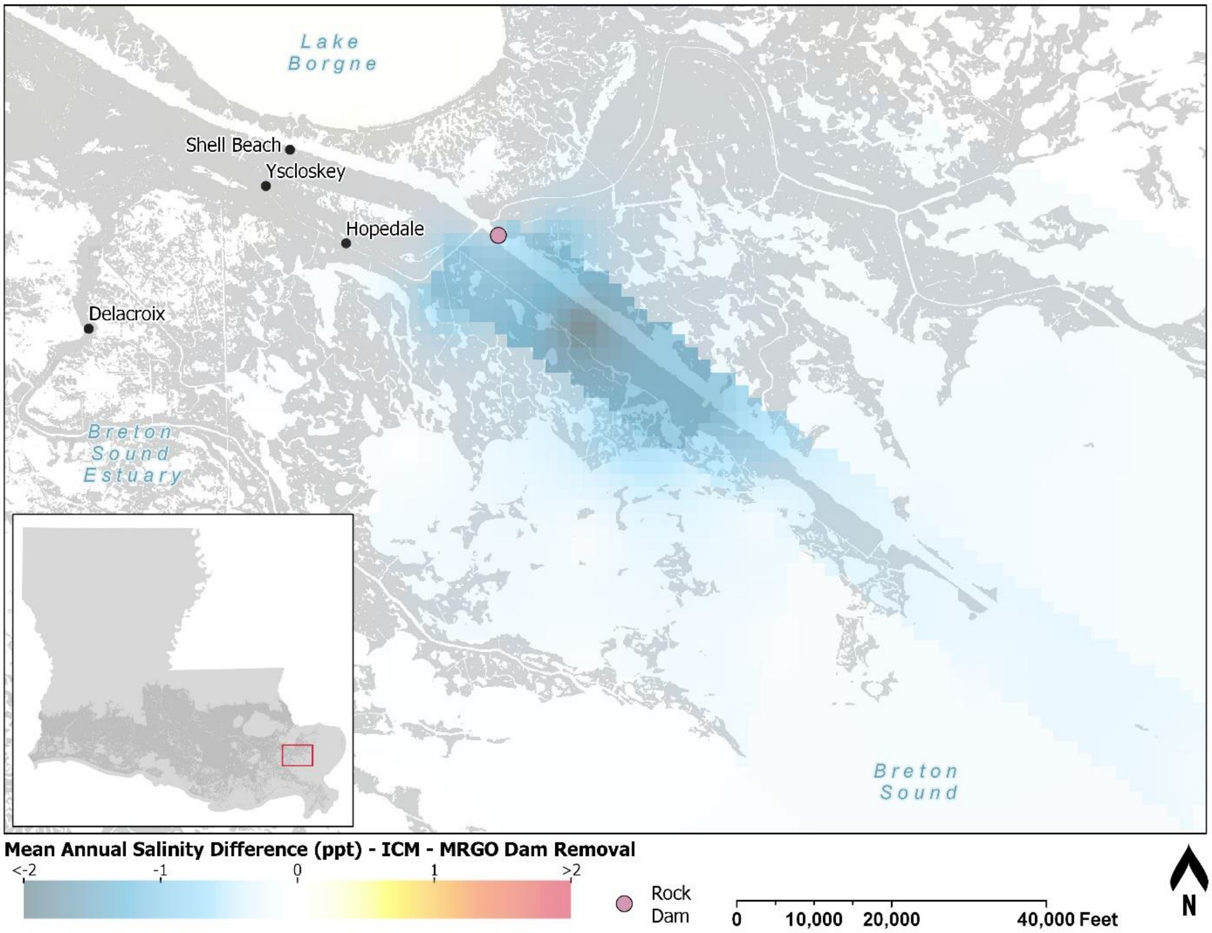
MRGO Rock Dam Removal

Ridge/Hydrologic Restoration

Project Number: P018

PROJECT DESCRIPTION

Members of the group suggested the removal of the MRGO rock dam (P018) to reconnect the movement of water between Lake Borgne and the Gulf of Mexico via the Mississippi River Gulf Outlet (MRGO). The project goal was to evaluate the salinity impact on Lake Borgne under the projected future conditions.



This map depicts predicted mean annual salinity difference with the MRGO Rock Dam Removal projects (red circle) at year 20 under the medium environmental scenario when compared to the baseline condition in the fast model. Positive differences are in red colors (higher salinities) and negative differences are in blue colors (lower salinities).

MODELING COMMENTS

The existing MRGO Rock Dam was removed from the model and then re-connected with a link connecting the upstream and downstream compartments. Project evaluation using the fast model predicts a slight annual average salinity reduction downstream of the removed structure, as shown in the map, for year 20. Since the MRGO was not well represented in the fast model due to the coarse grid resolution, the impact of the project is likely under-predicted. No significant impacts on salinity was found in Lake

Borgne. It was also noticed by the modeling team that the MRGO located near the boundary of the slow model domain, which would limit the model predictive capability in this area due to the boundary effects. After further discussion with the working group, it was suggested that the project should be evaluated with an updated slow model which has an extended model domain that covers the entire project region. The suggested model update efforts were not carried out in this study due to time limitations.

These results are preliminary and are part of a participatory modeling pilot project. They do not represent an endorsement by The Water Institute of the Gulf.

SCENARIOS CONSIDERED

Fast model: low, medium, and high environmental scenarios

APPROXIMATE PROJECT COST: N/A

Costs were not estimated due to a lack of similar projects in the 2017 Coastal Master Plan.

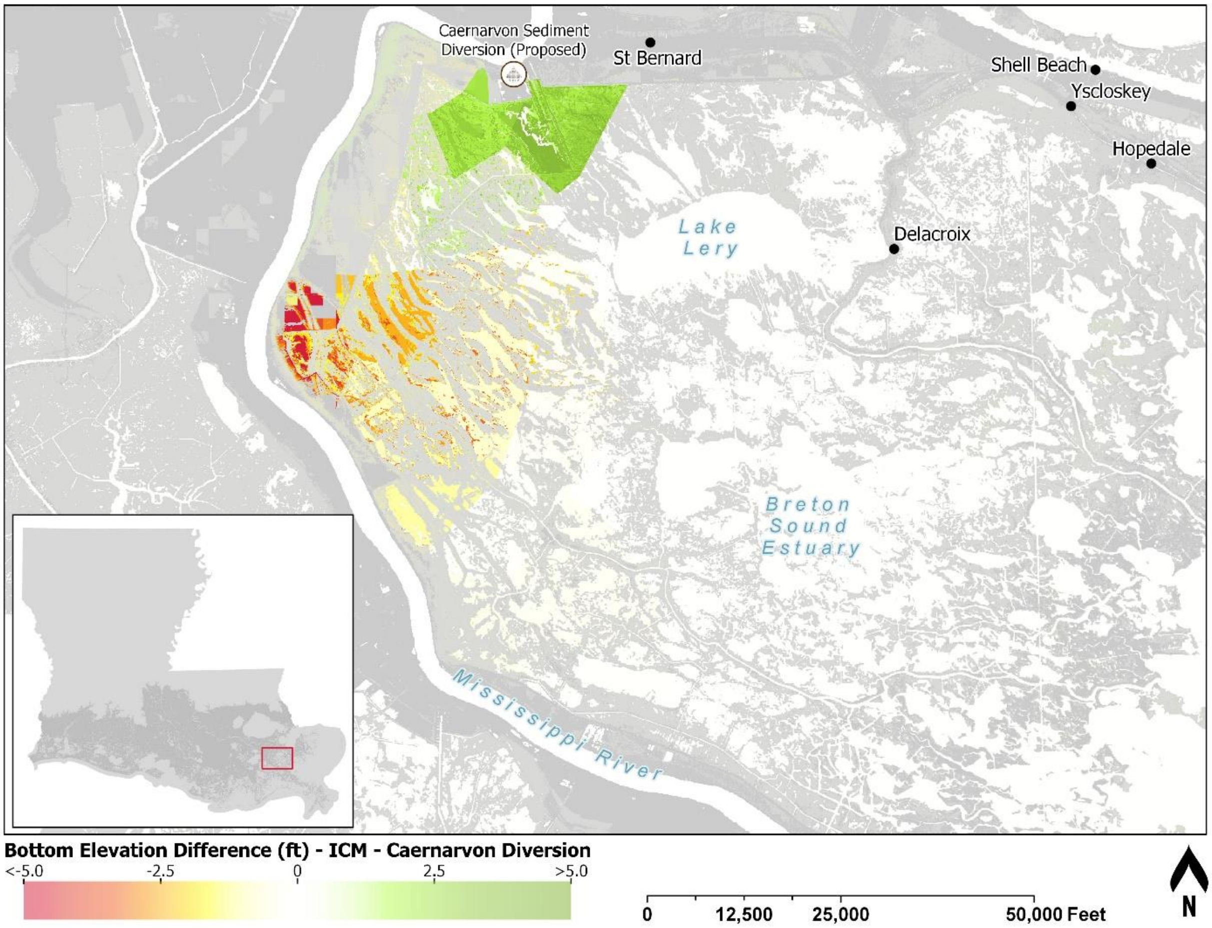
Caernarvon Sediment Diversion

Sediment Diversion

Project Number: P021

PROJECT DESCRIPTION

The working group proposed converting the freshwater diversion at Caernarvon (P021) into a sediment diversion by increasing its flow rate capacity to 35,000 cfs and by redesigning the structure to build and maintain land. At the same time, the proposed Mid-Breton Sediment Diversion was closed to compare the benefit between the two diversion locations.

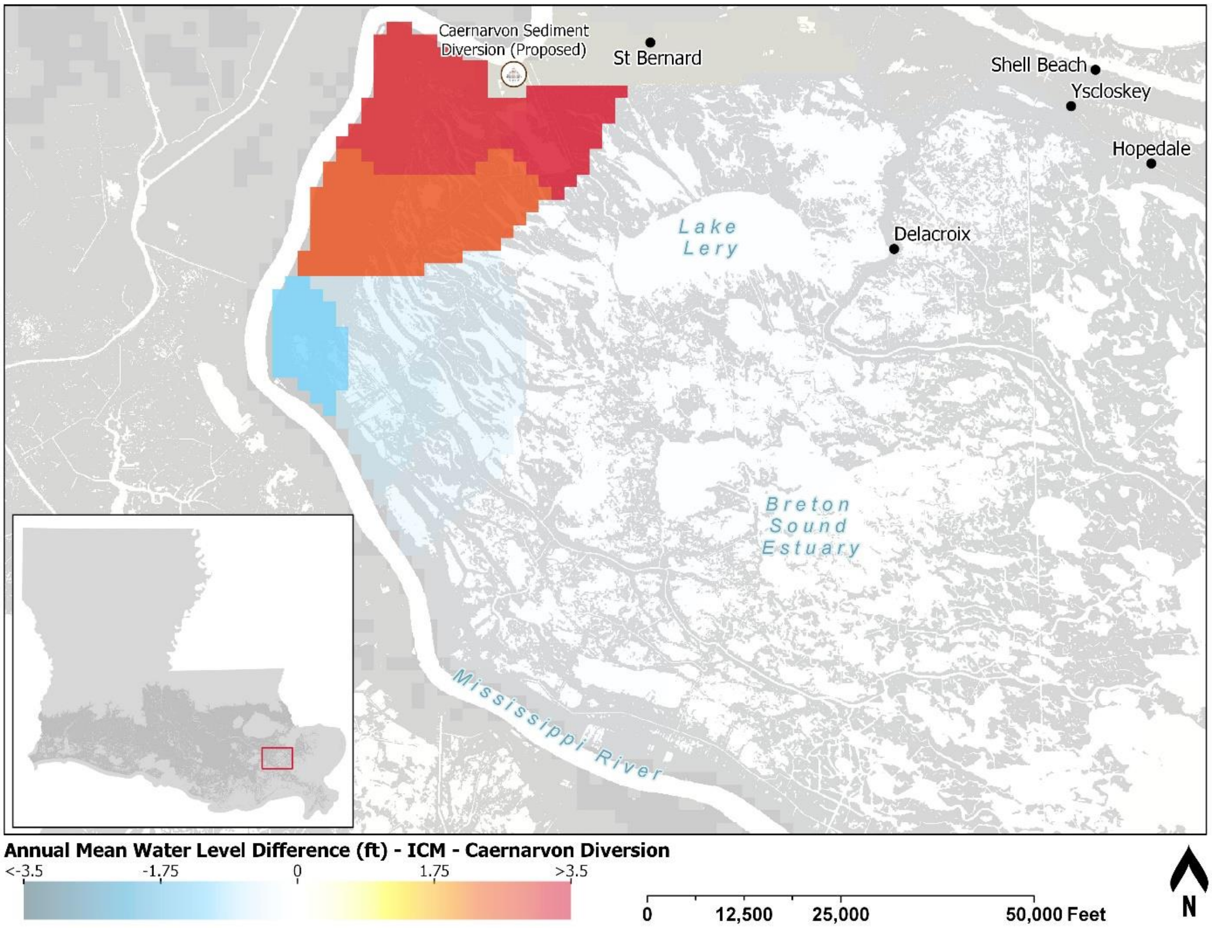


This map depicts predicted bottom elevation difference when operating the Caernarvon diversion as a sediment diversion while closing the Mid-Breton Sediment Diversion at year 20 under the medium environmental scenario when compared to the baseline condition in the fast model. Positive differences are in green colors (higher bottom elevations) and negative differences are in red colors (lower bottom elevations).

Caernarvon Sediment Diversion

Sediment Diversion

Project Number: P021



This map depicts predicted mean annual water level difference when the Caernarvon diversion is operated as a sediment diversion while closing the proposed Mid-Breton Sediment Diversion at year 20 under the medium environmental scenario when compared to the baseline condition in the fast model. Positive differences are in red colors (higher water levels) and negative differences are in blue colors (lower water levels).

MODELING COMMENTS

The Caernarvon diversion was modeled at 35,000 cfs when the Mississippi River flow equals 1,000,000 cfs. Flow rates were calculated using a linear function for river flow from 200,000 cfs to 1,000,000 cfs; flows variable above 1,000,000 cfs with 5,000 cfs minimum flow maintained when Mississippi River flow is below 200,000 cfs. Project evaluation using the fast model predicts an elevated water level and an increased sediment deposition in the vicinity of the project outfall at year 20. Due to the shallow basin in the coastal side of Breton Sound Estuary, the elevated water overwhelmed the benefit from the sediment deposition in the near future. An overall wetland loss was predicted by the model at year 20 due to higher water levels in adjacent marshes that stress wetland vegetation and cause it to collapse and subside in the model. Results suggest that an optimized operation plan would be needed to balance the impact to the water level and sediment deposition in the project area.

Caernarvon Sediment Diversion

Sediment Diversion

Project Number: P021

These results are preliminary and are part of a participatory modeling pilot project. They do not represent an endorsement by The Water Institute of the Gulf.

SCENARIOS CONSIDERED

Fast Model: low, medium, and high environmental scenarios

APPROXIMATE PROJECT COST: ~$400 - $500 MILLION

Cost is estimated from the proposed Mid-Breton Sediment Diversion project cost in the 2017 Coastal Master Plan which was $480 million. This is an approximate estimate and is provided solely to provide a rough frame of reference.