State of the Science Regarding River Diversions

Coastal Protection and Restoration Authority of Louisiana

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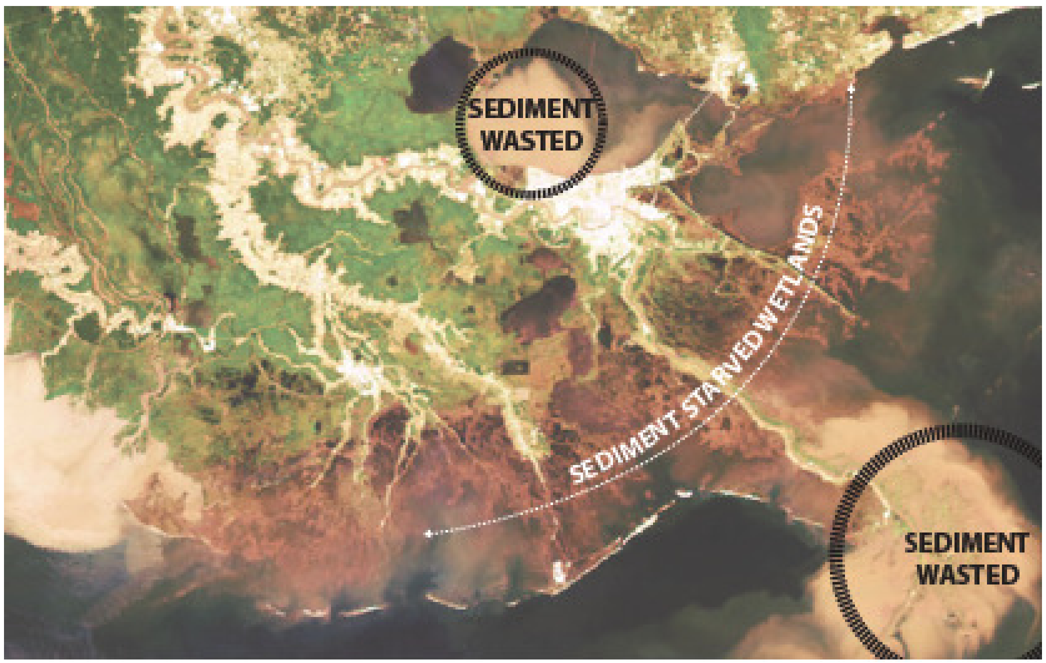
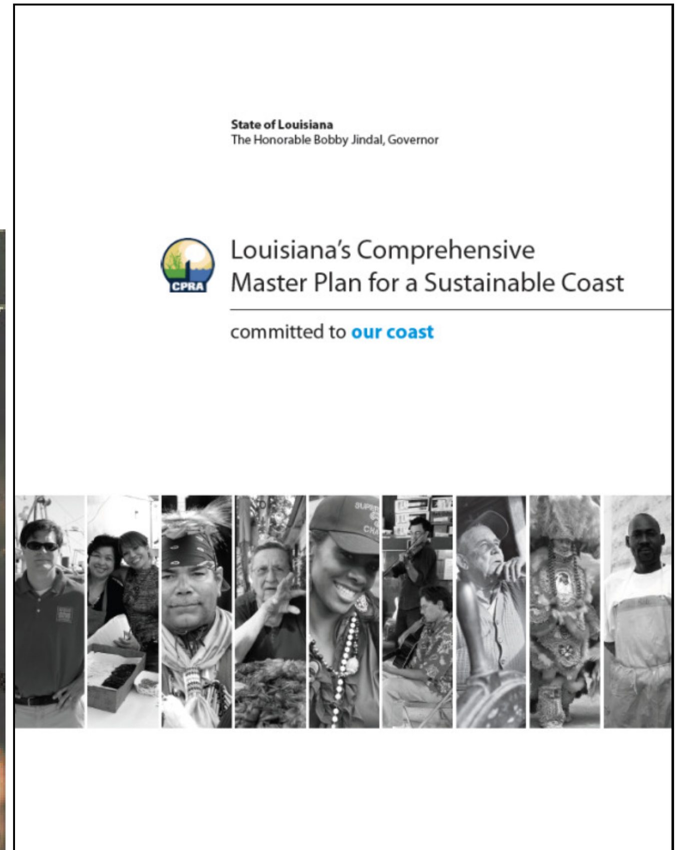
Presentation at the Meeting of the Board of the Southeast Louisiana Flood Protection Authority – East

Jefferson Parish Council Chambers, Harahan, Louisiana
19 April 2012

Objectives

- Describe the state of the science and technical investigations regarding the benefits, uncertainties, and risks associated with diversions.
- Describe diversions as a component of the 2012 revision of the State's Coastal Master Plan





Outline of This Presentation

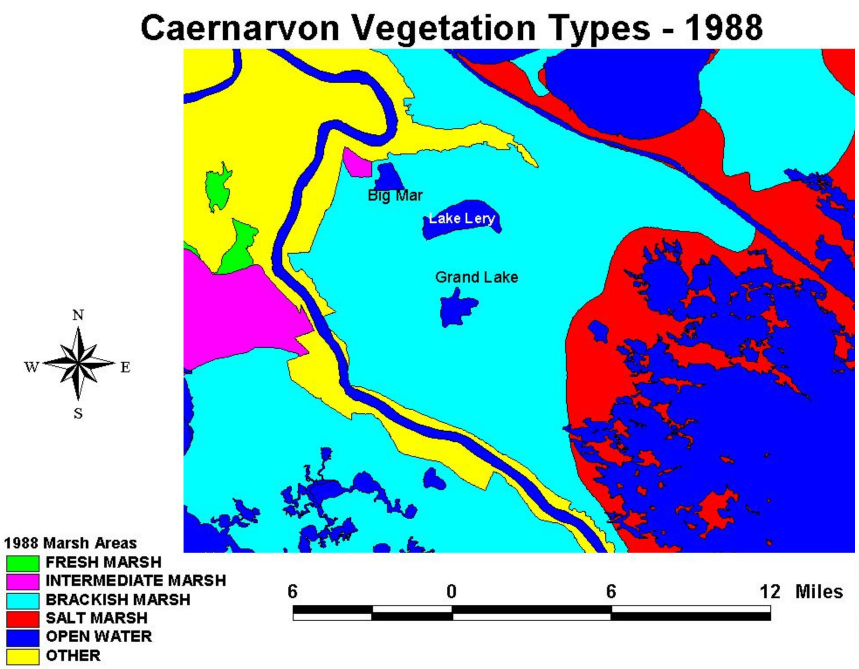
- Objectives
- State of the Science of Diversions
  - Priority Topics and Ongoing Activities
    - "Riverside"
      - Sediment and Freshwater Availability
      - Induced Shoaling Potential
    - "Bayside"
      - Sediment Transport and Land-Building
      - Response of Wetland Soils and Vegetation
- Diversions in the 2012 Master Plan
  - List of Projects
  - Operational Assumptions and Considerations
- Summary

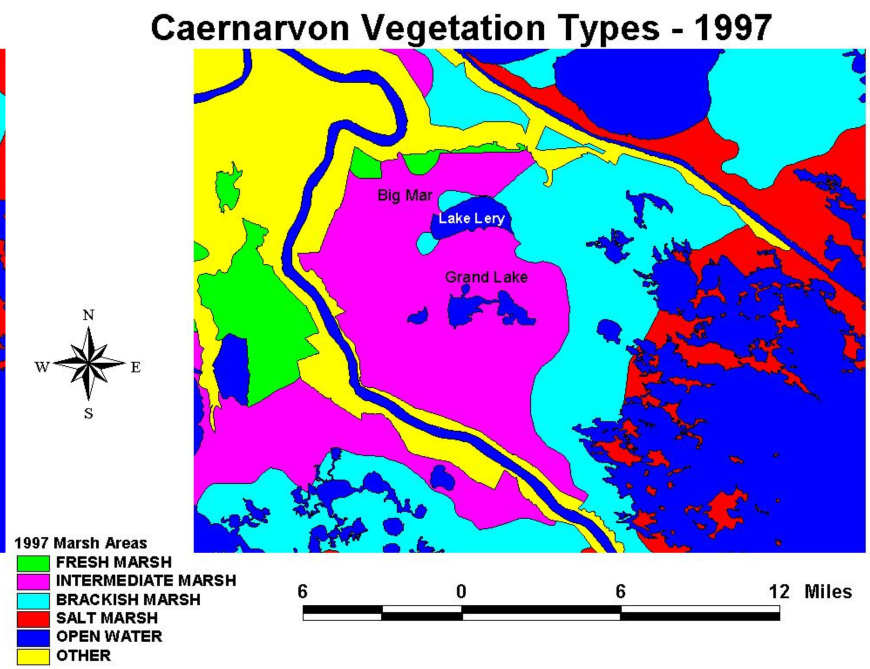
The State of the Science of Diversions

Priority Topics and Ongoing Activities

Priority Technical Topics

- **Diversions WILL change the physical and biological environments of rivers and receiving basins.**
- **Best understanding of these effects is critical to inform stakeholder and management decision-making regarding diversion structure site location and operation.**





The State of the Science of Diversions

Priority "Riverside" Technical Topics

Sediment and Freshwater Availability

Priority “Riverside” Technical Topics
Sediment and Freshwater Availability

Questions

- **How much freshwater can we remove from the river, and when?**

- **Is the Mississippi River transporting enough (especially coarse-grained) sediment to meet land-building goals?**

- **When and where is that sediment accessible?**

Priority "Riverside" Technical Topics
Sediment and Freshwater Availability

State of the Science

- **How much freshwater can we remove from the river, and when?**

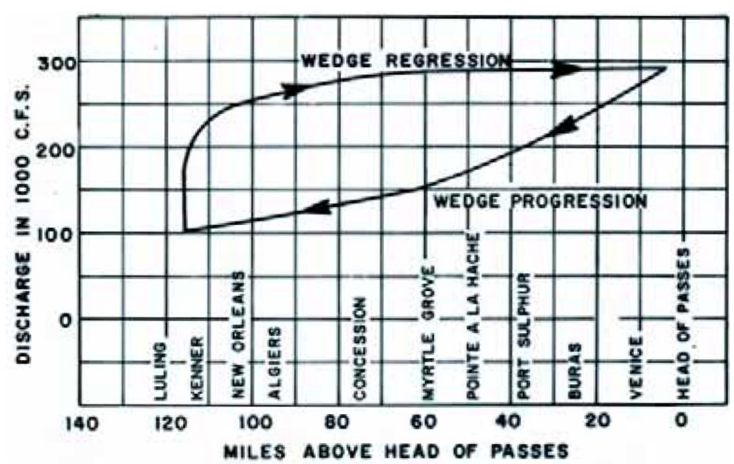


Figure 4 - Position of toe of saltwater wedge above Head of Passes versus flow in the Mississippi River (from Soileau et. al., 1989).

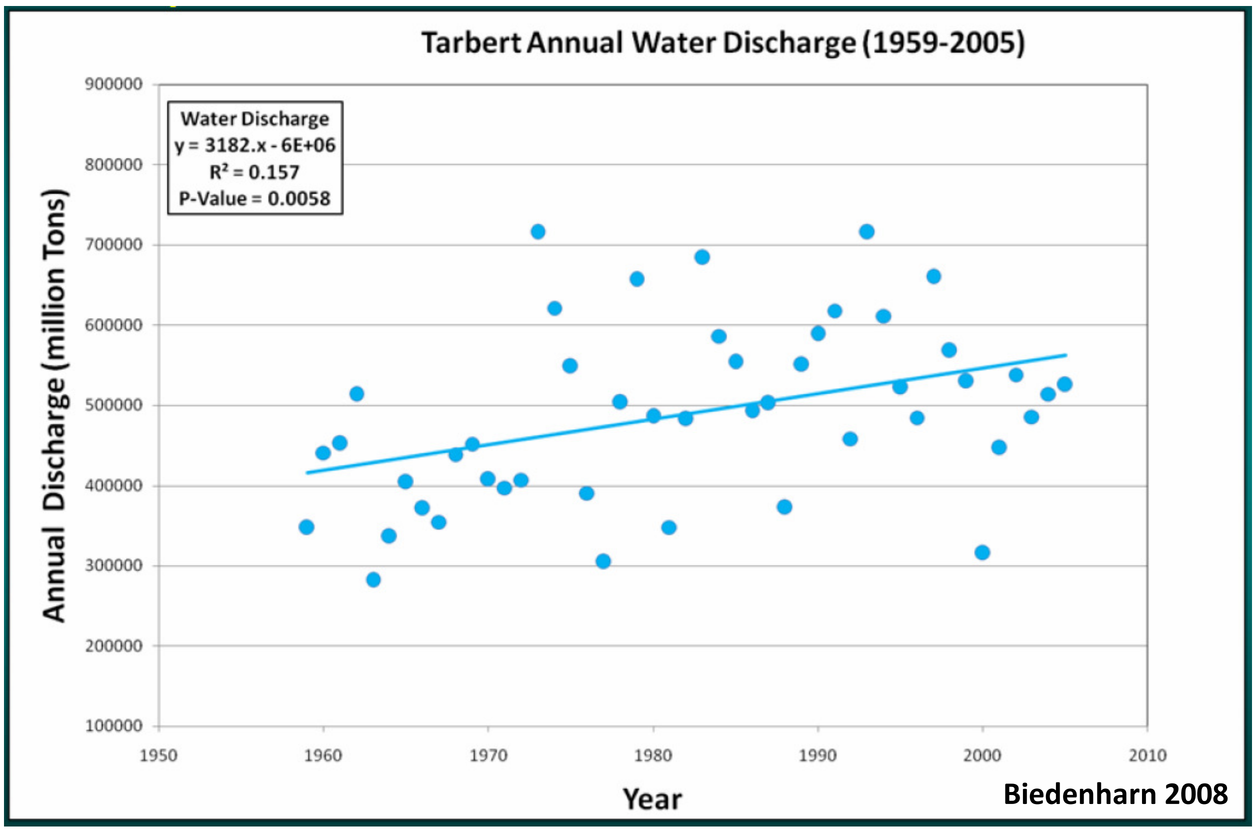
Winer 2011

- **Minimum flows needed to ensure stakeholder activities can continue**
  - **Industrial freshwater supplies**
  - **Municipal drinking water supplies**
  - **Navigation needs**
- **Most guidelines (Coast Guard, Master Plan, etc.) assume a minimum flow from which we could not divert between 200,000-300,000 cfs as**

Priority “Riverside” Technical Topics
Sediment and Freshwater Availability

State of the Science

- **How much freshwater can we remove from the river, and when?**



Priority "Riverside" Technical Topics

Sediment and Freshwater Availability

State of the Science

- **Research on riverine sediment supply have highlighted the degree to which Mississippi River sediment loads have been altered by human activities in the past century.**

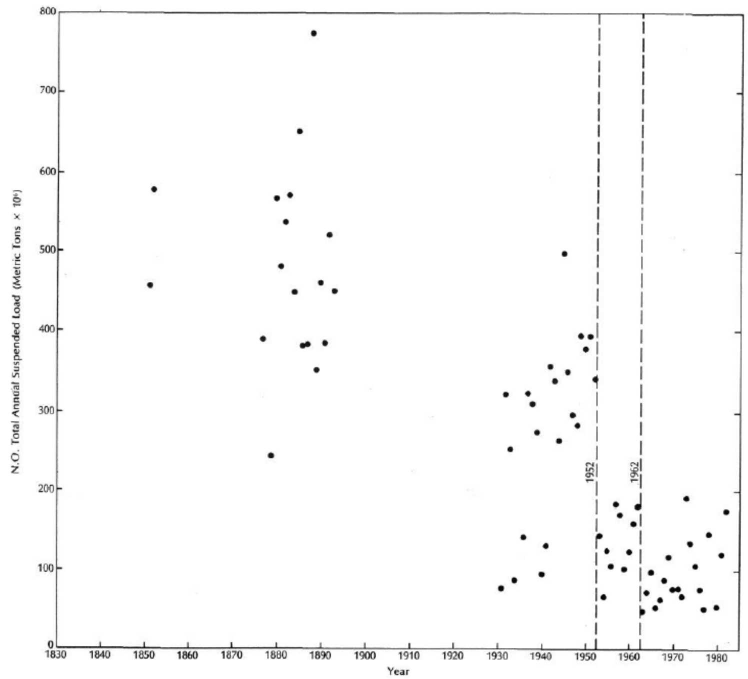
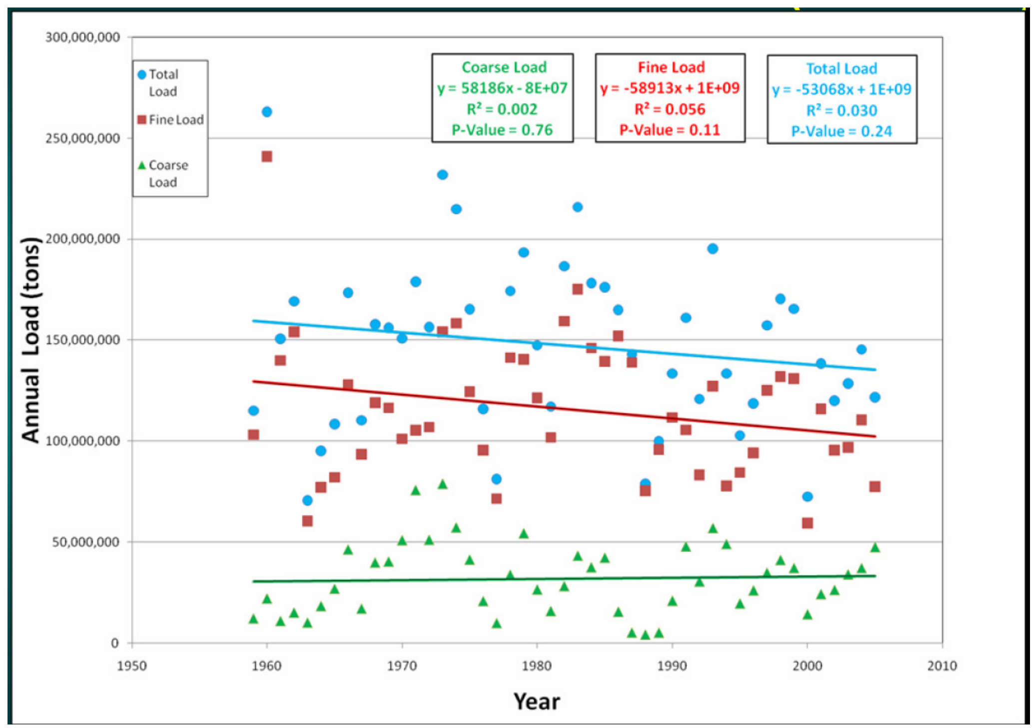


Figure 3. Total annual suspended load for the Mississippi River below New Orleans based on data from Humphreys and Abbott, 1851; Quinn, 1879 to 1893; and New Orleans Water and Sewage Board, 1930 to 1982.

Kessel 1988



Biedenharn 2008

Priority "Riverside" Technical Topics
Sediment and Freshwater Availability

State of the Science

- **When and where is that sediment accessible?**
  - **Most sediment (especially larger-grained, land-building sediment) is transported in the river on a rising hydrograph (typically in the spring as the river is rising).**

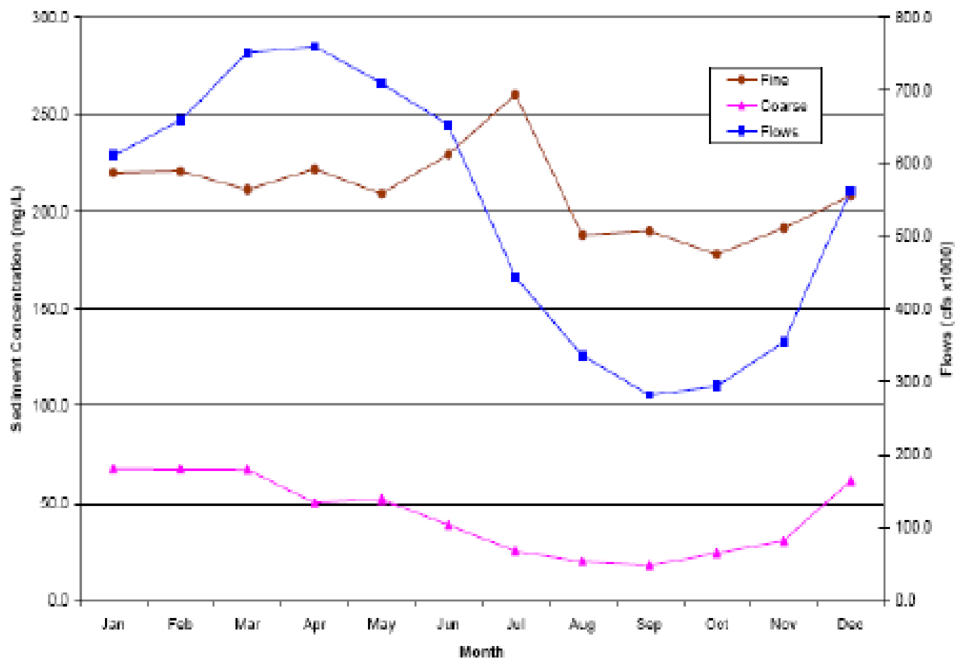
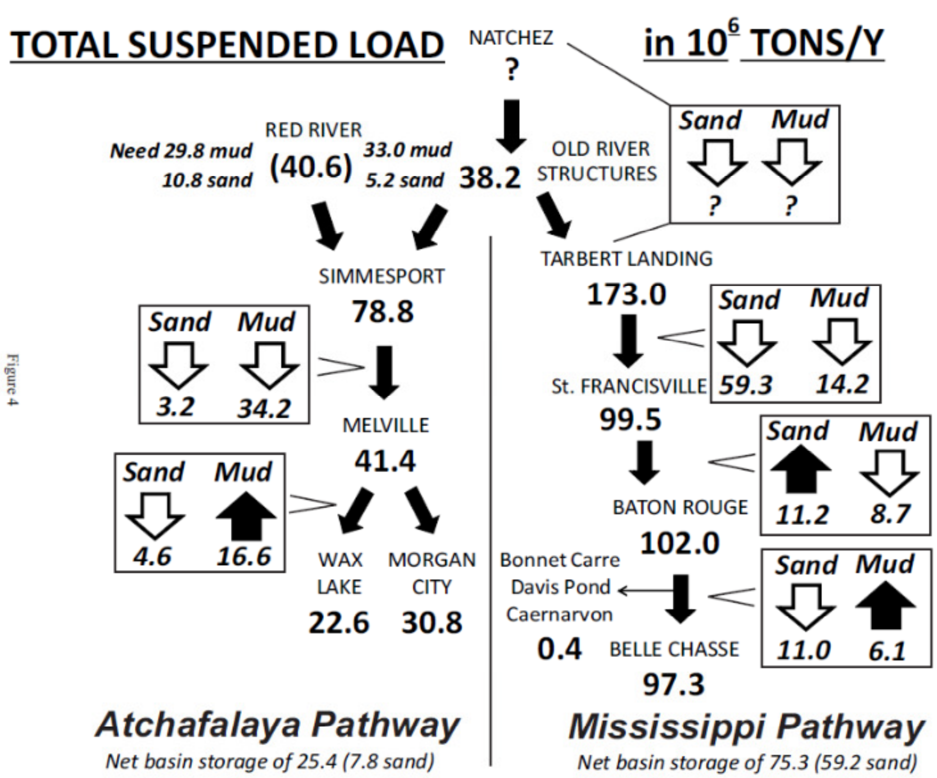


Figure 2.6 Composite annual hydrographs for sediment and discharge at Tarbert Landing are shown

Priority "Riverside" Technical Topics
Sediment and Freshwater Availability

State of the Science: Mississippi and Atchafalaya River Sediment Budget

- **When and where is that sediment accessible?**



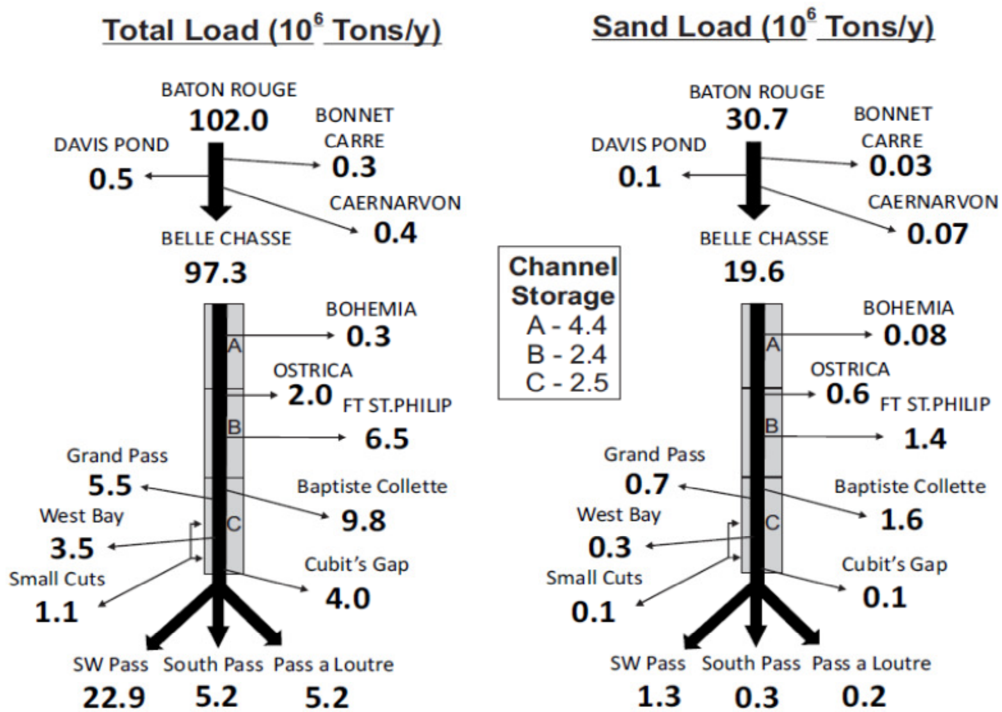
Allison et al. 2012

- **Division of suspended sediment at ORC differs from the 70:30 water split of Mississippi and Red River discharge due to the distinct Red River suspended sediment load.**
  - **Sand is apportioned between the lower Mississippi and Atchafalaya pathways at a 83:17 ratio, and fines at a 60:40 ratio.**

Priority "Riverside" Technical Topics
Sediment and Freshwater Availability

State of the Science: Mississippi and Atchafalaya River Sediment Budget

- **When and where is that sediment accessible?**

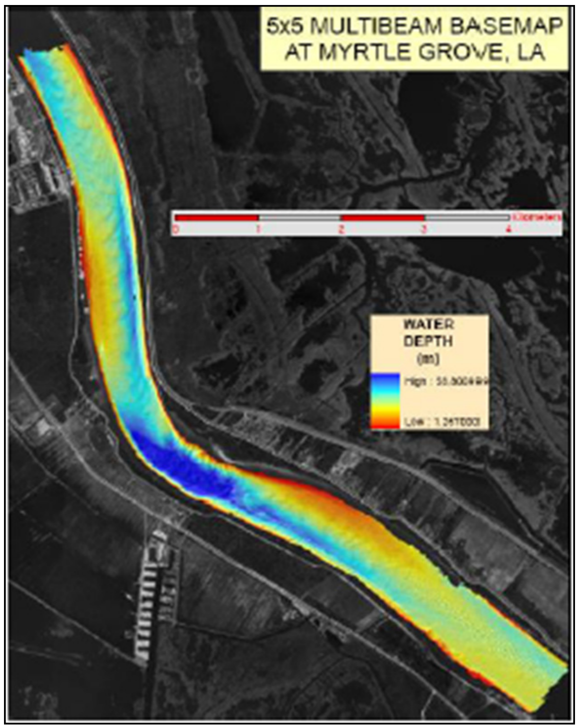


- **An examination of water:suspended sediment ratios of individual water exits downriver of Belle Chasse indicates that there is a progressive downstream reduction in the efficiency of these channels in passing sediment.**

Allison et al. 2012

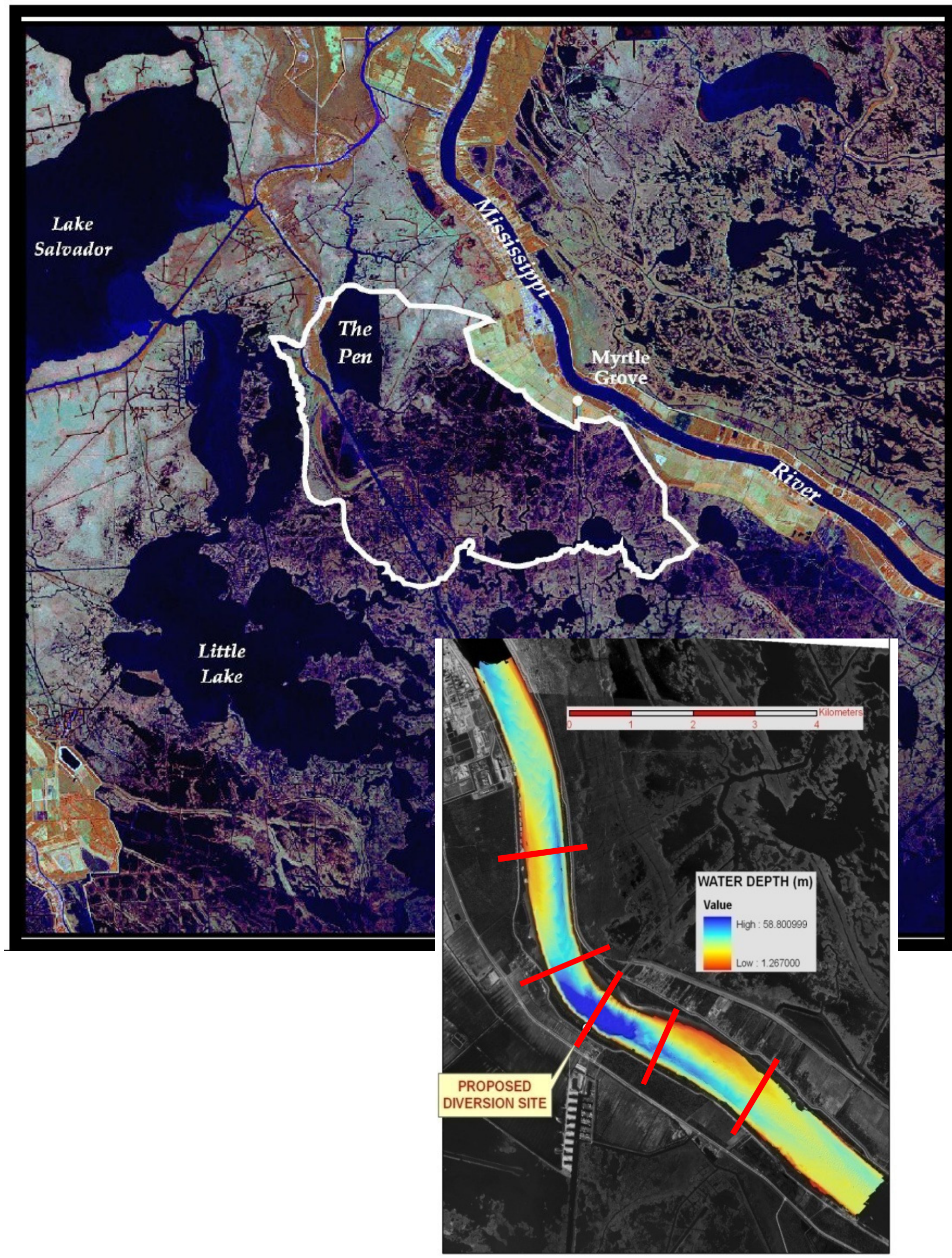
Priority "Riverside" Technical Topics
Sediment and Freshwater Availability

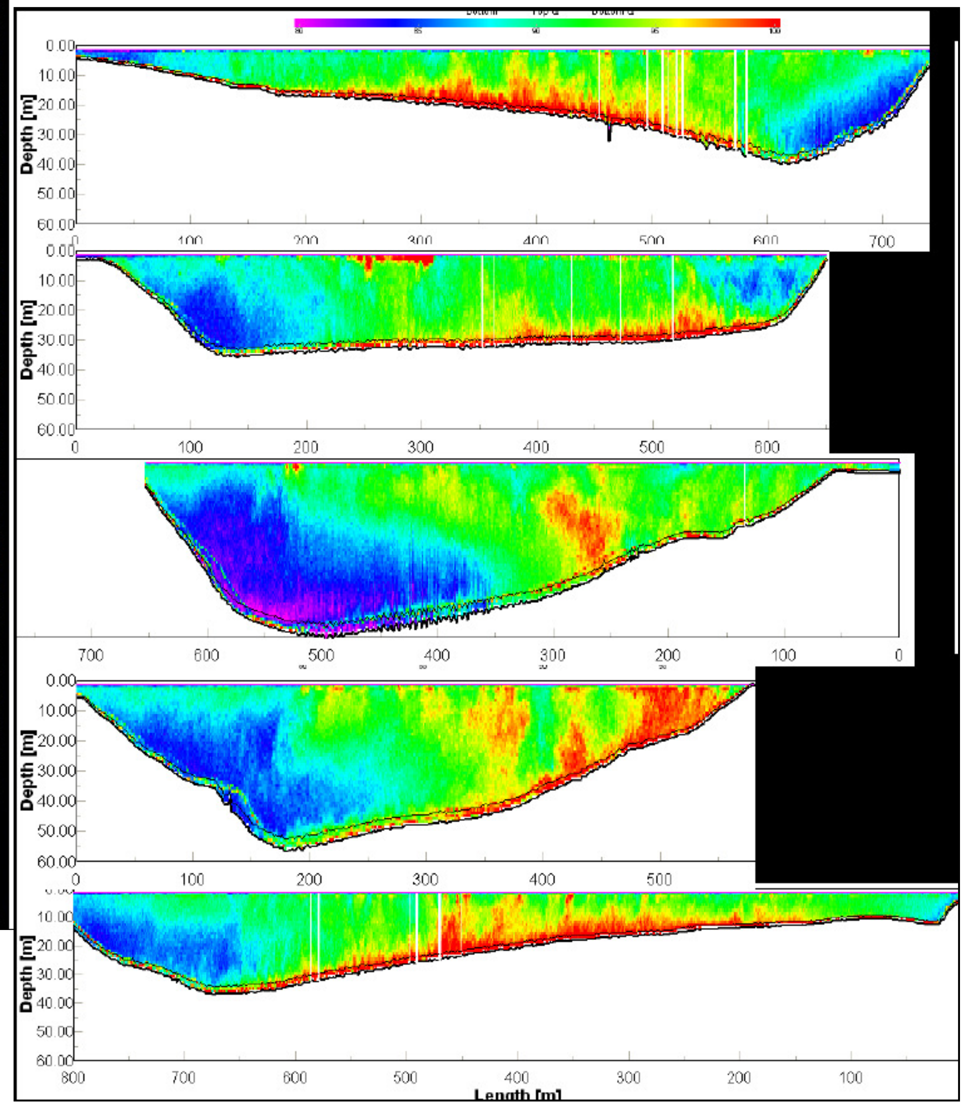
Ongoing Activities: Medium Diversion with Dedicated Dredged at Myrtle Grove Feasibility Study



- **Designing the structure to maximize sediment transport per unit water, minimizing potential shoaling and over-freshening**
- **Initial work prior to the cost-share performed cooperatively between CPRA and Environmental Defense Fund**

Medium Diversion with Dedicated Dredged at Myrtle Grove Feasibility Study





ADCP Backscatter Intensity
(Surrogate for sediment load)

Priority "Riverside" Technical Topics
Sediment and Freshwater Availability

Ongoing Activities: LCA Delta Hydrodynamic and Delta Management Feasibility Study

- **Developing a calibrated hydrodynamic and sediment management model to predict changes in depositional patterns across the system and inform dredging and sediment management**
- **Five-year, $25M cost-share between CPRA and USACE (MVD and MVN)**
- **Initial river hydrodynamic steps include**
  - **River hydrodynamic and sediment transport data collection**
  - **Geomorphic analysis**
  - **One-dimensional river hydrodynamic and sediment modeling**
  - **Multi-dimensional river hydrodynamic and sediment modeling**
  - **Data management**
- **Basically, Myrtle Grove on steroids**

Priority "Riverside" Technical Topics
Sediment and Freshwater Availability

Topic Summary

- **We can likely only divert river water and sediment when flows exceed 200,000-300,000 cfs**
  - **Those flows are available most of the year**
  - **Long-term trends support expectation of adequate availability, especially higher in the system**
- **Adequate sand is being transported for immediate needs – issue is more access to available material than adequate amount of material**
- **Progressive downstream reduction in the efficiency of distributary channels in passing sediment favors the location of diversions further upriver and above existing Balize Delta water exits.**
- **Estimated amount of sediment available from the River**
  - **145 million tons per year (Meade and Moody 2010)**
  - **200 million tons per year (MS River Delta Science and Engineering Special Team)**

The State of the Science of Diversions

Priority “Riverside” Technical Topics

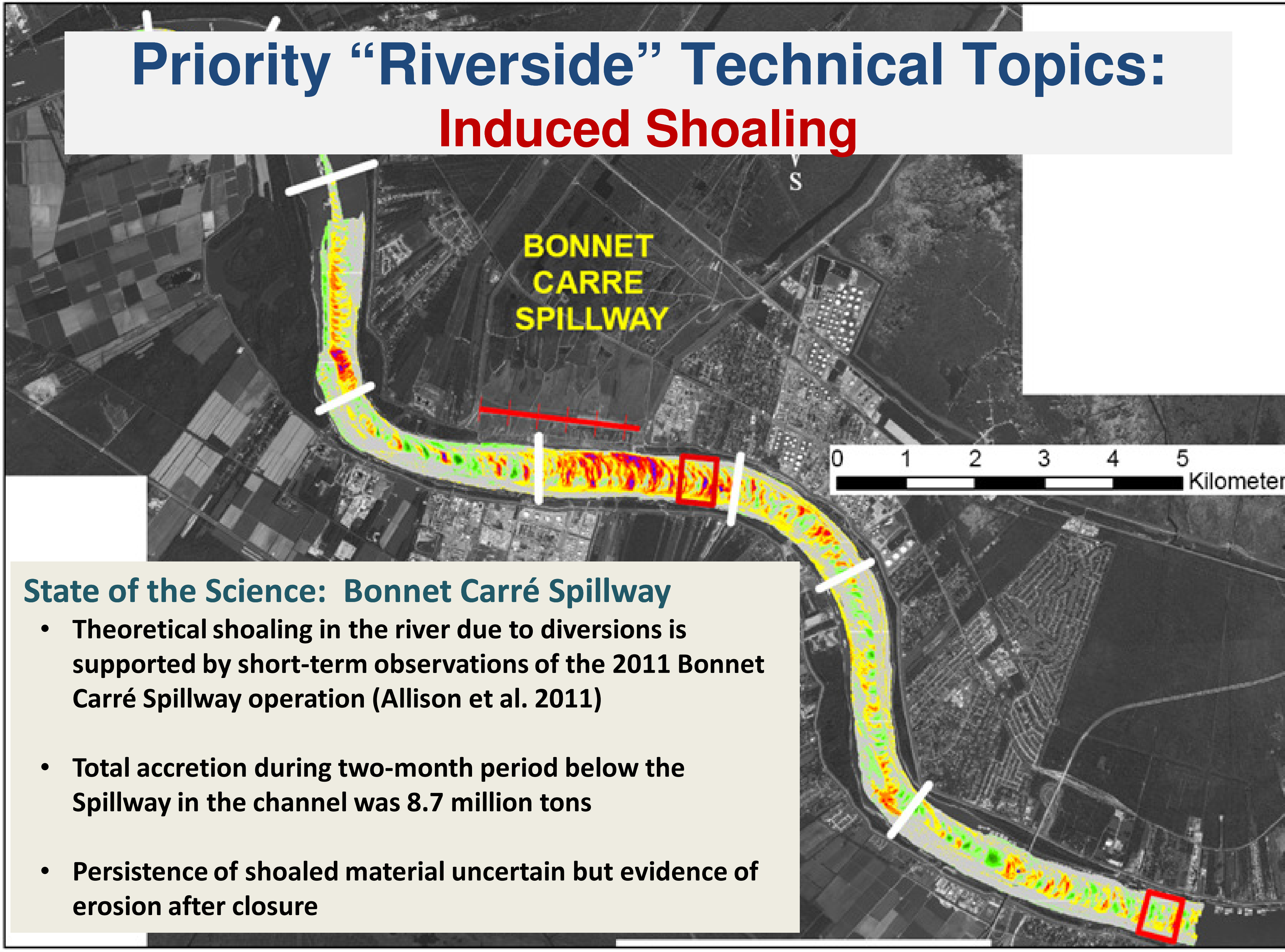
Induced Shoaling

Priority “Riverside” Technical Topics
Induced Shoaling

Question

- Does the removal of large amounts of freshwater from the river lead to downstream deposition of suspended sediment?

Priority "Riverside" Technical Topics:
Induced Shoaling

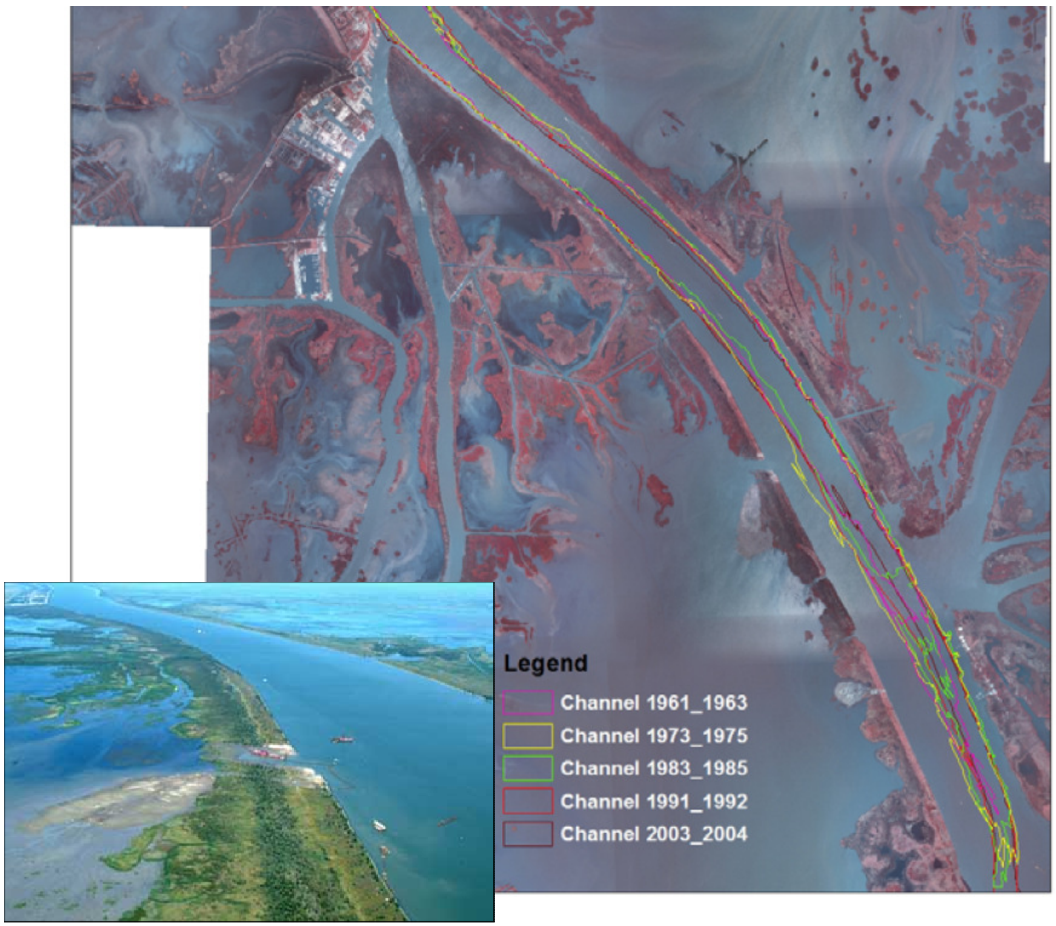


State of the Science: Bonnet Carré Spillway

- Theoretical shoaling in the river due to diversions is supported by short-term observations of the 2011 Bonnet Carré Spillway operation (Allison et al. 2011)
- Total accretion during two-month period below the Spillway in the channel was 8.7 million tons
- Persistence of shoaled material uncertain but evidence of erosion after closure

Priority "Riverside" Technical Topics
Induced Shoaling

Ongoing Activities: CWPPRA West Bay Sediment Diversion Study



- The West Bay Sediment Diversion Effects study suggests the diversion may cause 10-40% of observed shoaling in the Pilottown Anchorage Area
- The majority of shoaling in this area is thus due to continuation of a historically aggrading lateral bar unrelated to the diversion project (Little et al. 2012)
- Final project analysis is forthcoming

Priority "Bayside" Technical Topics
Induced Shoaling

Ongoing Activities: LCA Science Board Review of Diversion Land-Building

- **"Given the diversity of factors that can influence shoaling, even in the absence of diversions, predictions to establish cause-effect relationships must be recognized as a challenge."**

Priority "Riverside" Technical Topics
Induced Shoaling

Topic Summary

- Future medium and large diversions must be designed to remove proportionally more sediment than freshwater and be coupled to robust sediment management to recognize opportunities for beneficial use if downstream shoaling occurs.

- Shoaling should be viewed as a potential opportunity for accessing riverine sediment

The State of the Science of Diversions

Priority "Bayside" Technical Topics

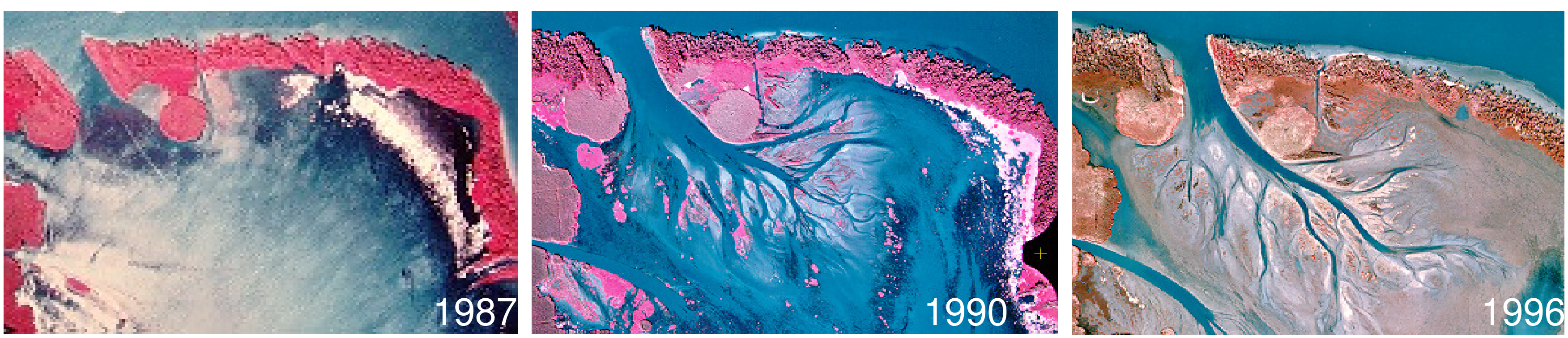
Land-building Potential

Priority “Bayside” Technical Topics
Land-building Potential

Question

- **Can diversions build land at rates fast enough to offset coastal land loss?**
- **Can we identify the best locations in the river to build diversions to maximize project success?**

Pass-a-Loutre Crevasse

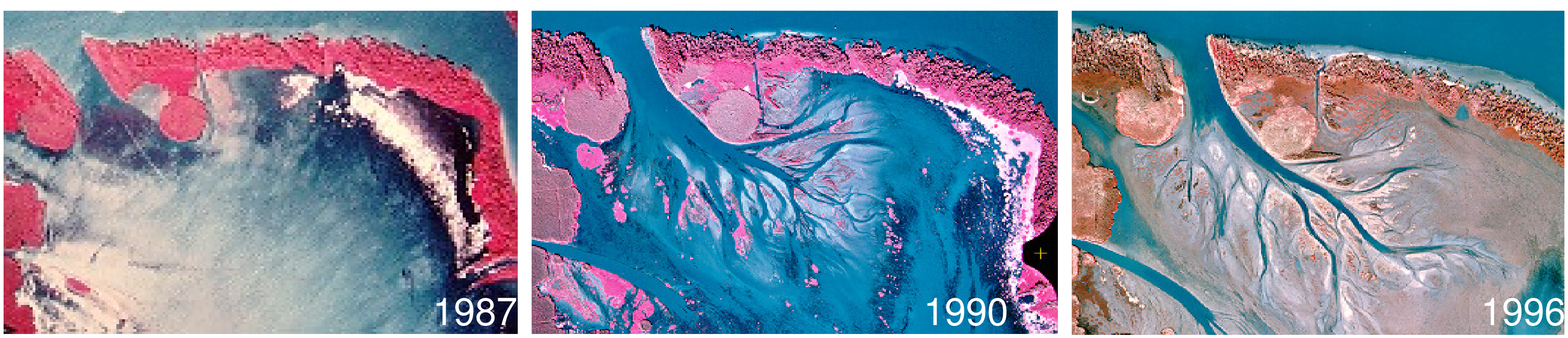


Priority "Bayside" Technical Topics
Land-building Potential

State of the Science

- **Sediment diversions must fill the subaqueous portion of the receiving coastal embayment before subaerial expression**
  - **Filling may not be visually noticeable during early stages**
- **Land-building is slow and episodic, but more energy efficient than wetland creation via dredged sediment placement**
- **Expectations for diversion-related land building can be informed by a robust understanding of river sediment dynamics and monitoring of past projects**

Pass-a-Loutre Crevasse



Priority "Bayside" Technical Topics
Land-building Potential

State of the Science: West Bay Freshwater Diversion

- Sediment accumulation in the West Bay receiving area prior to the 2011 flood was less than the rate of subsidence (Kolker, in preparation)
- Study was conducted prior to the 2011 Mississippi River flood, which deposited large amounts of coarse-grained sediment in West Bay and created approximately four acres of subaerial wetland.
- Anticipating significant 2009-2011 West Bay infilling from West Bay final report

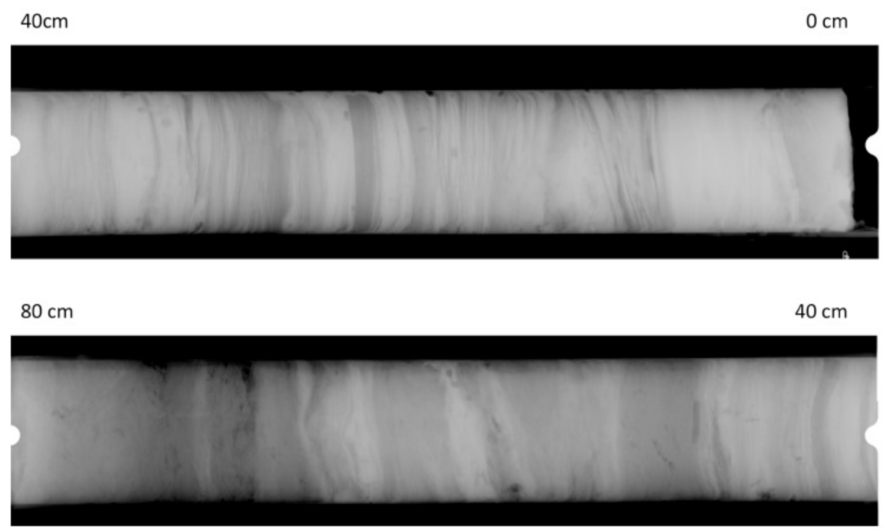


Fig. 4. X-radiograph of core WB S09 - 36, showing strong and distinct sediment laminations.

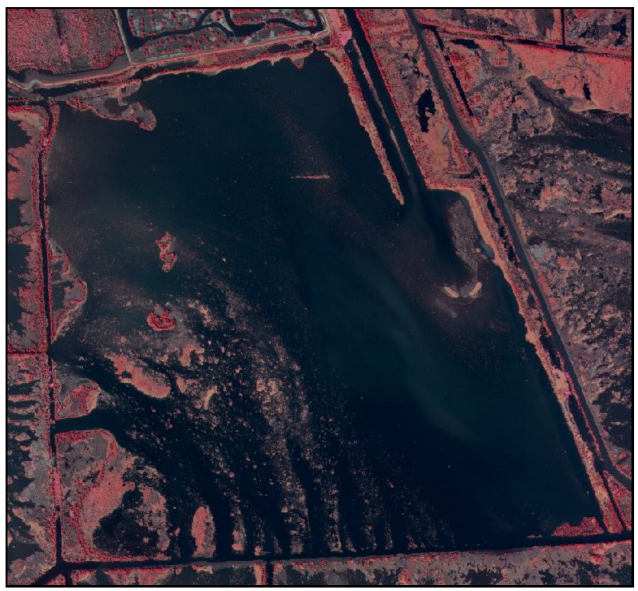
Kolker in prep.

Priority "Bayside" Technical Topics
Land-building Potential

State of the Science: Big Mar, Caernarvon Freshwater Diversion (Henkel et al. 2011; Couvillion et al. 2011)

- 344-600 acres of growth 1998-2010 (29-50 acres/yr), most since 2004
- Able to build land even though Caernarvon was originally built as a 'freshwater water diversion' instead of a 'sediment diversion' and the diversion has been under-operated.

1998: LDNR SONRIS



2005: LDNR SONRIS

2012: Google Map

Priority “Bayside” Technical Topics
Land-building Potential

State of the Science: West Point a la Hache Siphon

- **Sedimentation and elevation maintenance seen even in small diversion projects**
  (Lane et al. 2006)

Priority "Bayside" Technical Topics
Land-building Potential

Ongoing Activities: LCA Science Board Review of Diversion Land-Building

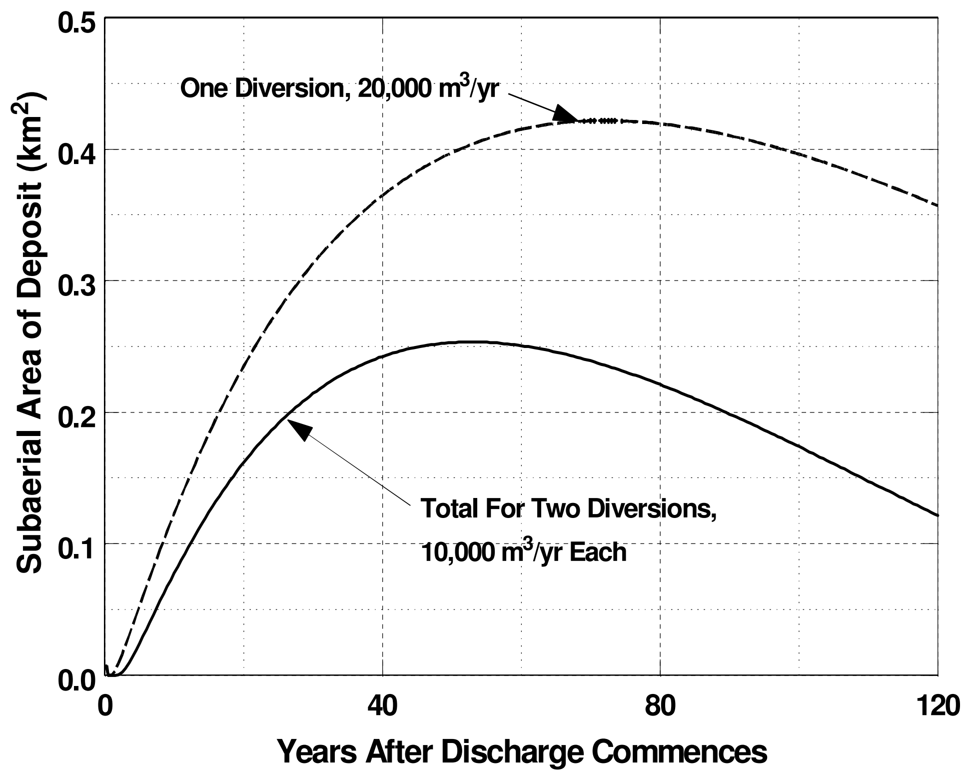
- **An upcoming report by the LCA Science Board will summarize the science of delta land-building and provide an authoritative guidance document to assist in the selection, planning and performance predictions of future diversions.**

- **Draft recommendations for maximizing success include:**
  - **Select sites that are in areas of low subsidence**
  - **Select sites that have relatively thin Holocene stratigraphic sequences**
  - **Select sites that are likely to have very high trapping efficiency**
  - **Select sites that do not exceed 2 meters in depth**
  - **Select sites that have very low bottom gradients**

Priority "Bayside" Technical Topics
Land-building Potential

Are Fewer Larger Diversions Better than Multiple Smaller Diversions?

- **LCA Science Board model predicts that while two diversions could transport same volume of sediment as large diversion, predicted subaerial land area is much greater for single diversion**



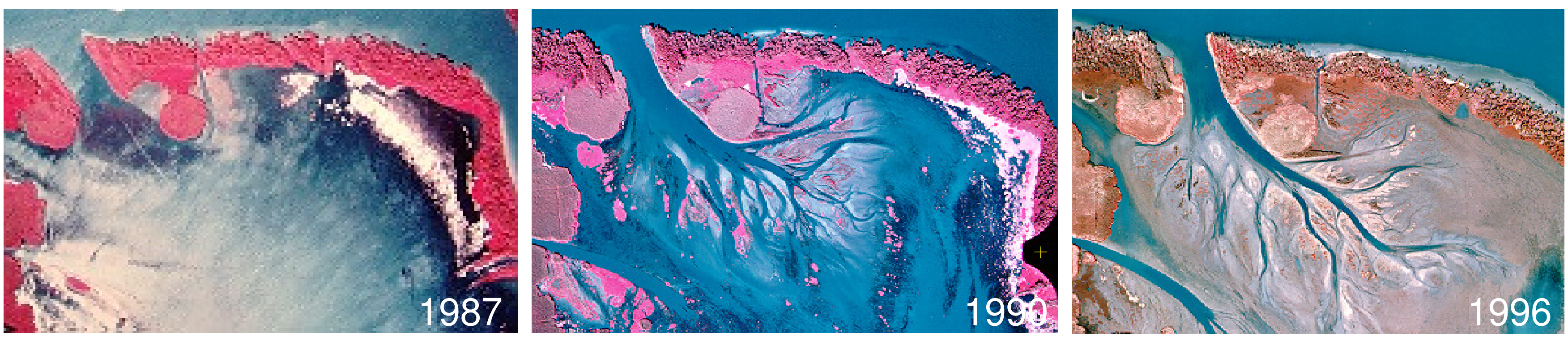
Dean et al. draft report

Priority “Bayside” Technical Topics
Land-building Potential

Topical Summary

- **Land-building is slow and episodic**
- **Widespread evidence that diversions can build land**
  - **Holds even for small projects and projects not intended as sediment diversions**
- **Criteria for successful project location reinforces discussion from look at river sediment transport data that “higher up in the system” is the better place to locate future projects**

Pass-a-Loutre Crevasse



The State of the Science of Diversions

Priority "Bayside" Technical Topics

Response of Wetland Soils and Vegetation

Priority "Bayside" Technical Topics
Response of Wetland Soils and Vegetation

Question

- **To what extent are the freshwater, nutrients and sediments in diversion flows beneficial and/or detrimental to wetland soils and vegetation?**

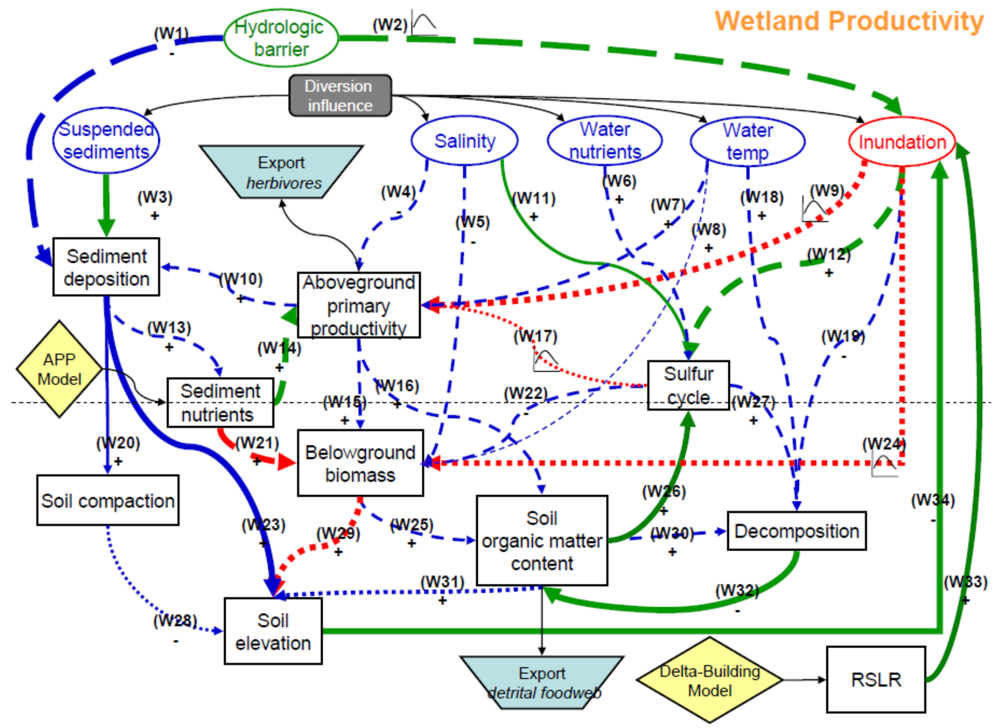


Figure 10.2. Conceptual diagram of wetland productivity as influenced by freshwater diversion into Barataria Basin, Louisiana.

Nuttle et al. 2009

Priority “Bayside” Technical Topics
Response of Wetland Soils and Vegetation

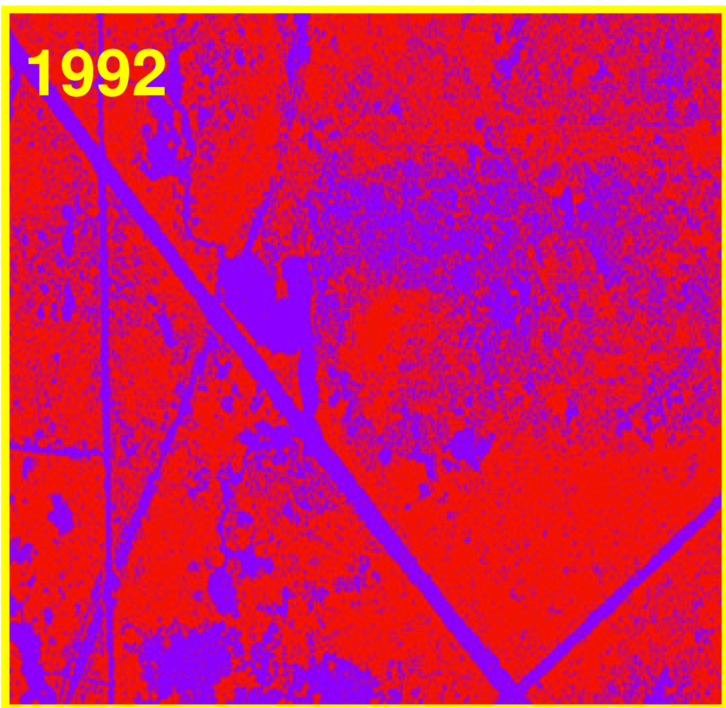
State of the Science

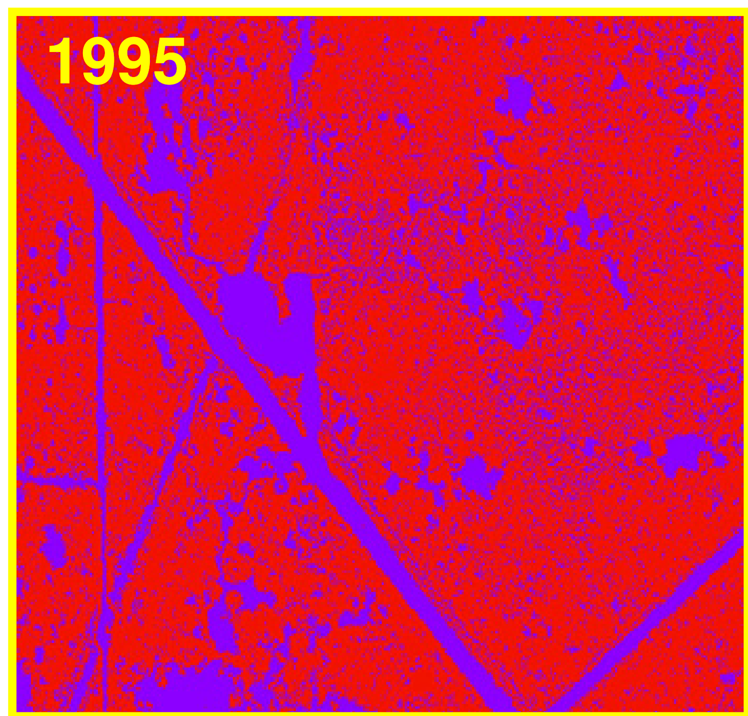
- **Diversions improve wetlands by**
  - **Providing freshwater to alleviate saltwater intrusion,**
  - **Providing nutrients for plant growth, and**
  - **Providing mineral sediments to increase soil strength and structure.**

Priority "Bayside" Technical Topics
Response of Wetland Soils and Vegetation

State of the Science: Pre-hurricane land/water analysis at Caernarvon

- **Pre-Katrina land loss in Caernarvon influence area had stopped and reversed in localized areas**
  - **406 acres in 9 sampled areas**
  - **18% land gain in 3 years (1992-1994): 5.9 % land gain per year**





Priority "Bayside" Technical Topics

Response of Wetland Soils and Vegetation

State of the Science: Pre-hurricane land/water analysis at Caernarvon

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Estuarine, Coastal and Shelf Science 58 (2003) 653–662
ESTUARINE COASTAL AND SHELF SCIENCE

Impact of Mississippi River freshwater reintroduction on enhancing marsh accretionary processes in a Louisiana estuary

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Received 24 October 2002; accepted 27 May 2003

Abstract

To counteract extensive wetland loss a series of diversion projects have been implemented to introduce freshwater and sediment from the Mississippi River into Louisiana coastal wetlands. To keep pace with increases in water level due to subsidence Louisiana coastal marshes must vertically accrete through the accumulation of both organic matter and mineral sediment. The impact of Mississippi River freshwater diversion on enhancing vertical marsh accretion (mineral and organic matter accumulation) was examined in Breton Sound estuary, a coastal wetland experiencing marsh deterioration as result of subsidence and salt water intrusion. Using ^{137}Cs dating and artificial marker horizons, increases in the rate of vertical marsh accretion were measured at marsh sites along a spatial gradient which has been receiving diverted water from the Mississippi River (Caernarvon diversion) since 1991. Vertical accretion and accumulation of mineral sediment organic matter and nutrients in the marsh soil profile, increased at marsh sites receiving freshwater and sediment input. Iron and manganese content of the marsh surface sediment were shown to be an excellent signature of riverine sediment deposition. Soil extractable phosphorus was higher and extractable sodium was lower at sites nearest freshwater and sediment input. Results demonstrated that freshwater diversion through sediment input and lowering of salinity will enhance marsh accretion and stability, slowing or reversing the rate of wetland loss.

Keywords: coastal restoration; Mississippi River; river diversion; marsh accretion; sedimentation; Gulf of Mexico

1. Introduction

The stability of coastal marshes is governed by many processes. Subsiding marshes must vertically accrete through organic matter and sediment accumulation to keep up with relative sea level changes (Kennish, 2001). Relative rates of vertical accretion and coastal submergence determine the long-term stability of coastal marshes (Mitsh and Gosselink, 2000). For every marsh there is an optimal water depth and an optimal rate of relative sea level rise at which the marsh community is most productive (Morris et al., 2002). These conditions vary regionally with the difference in nutrient and sediment, flooding, vegetation, tidal, range, and climate.

One of the most critical problems facing deltas throughout the world is a high rate of sea level rise associated with global warming. In deltas, subsidence results in a relative sea level rise that is greater than eustatic sea level rise alone. Because of higher relative sea level rise, delta marshes will likely be affected first by acceleration in eustatic sea level rise (Day et al., 1995).

Along the Louisiana Coast marsh accretion due to subsidence has generally not been rapid enough to balance relative sea level rise (Boesch et al., 1994; Callaway et al., 1997; Reed, 1989; DeLaune et al., 1978;

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doi:10.1016/S0272-7714(03)00177-X

- **Sediment captured by the Caernarvon Freshwater Diversion was adequate in maintaining elevation against subsidence & sea level rise (Cable et al. 2007; Delaune 2008) when in combination with organic matter accumulation.**

Priority "Bayside" Technical Topics
Response of Wetland Soils and Vegetation

State of the Science

- **Diversions improve wetlands by**
  - Providing freshwater to alleviate saltwater intrusion,
  - Providing nutrients for plant growth, and
  - Providing mineral sediments to increase soil strength and structure
- **Several authors have suggested that the introduction of nutrients**
  - Increases decomposition of organic matter in fresh marsh soils (Swarzenski et al. 2008) and
  - Changes biomass allocation in vegetation (Darby and Turner 2008),
  - Leading to marshes that are more susceptible to hurricane-induced conversion to open water (Howes et al. 2010)
- **Although consistent with general ecological theory, caveats in those studies limit broad application of those results.**
  - The State is pursuing a broader body of investigations to inform this issue.

Priority "Bayside" Technical Topics
Response of Wetland Soils and Vegetation

State of the Science / Ongoing Activities

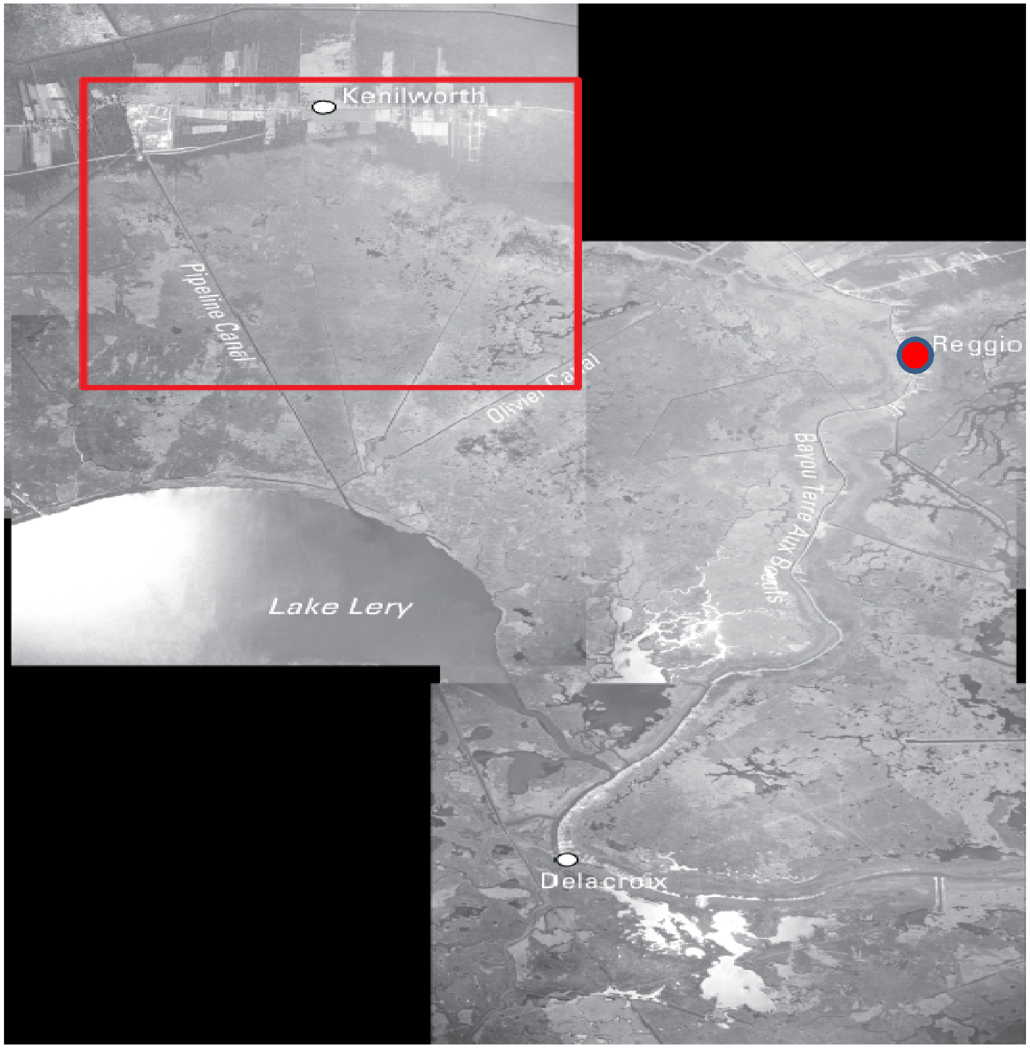
- **Debated Point**
  - Howes et al. (2010) suggested that diversion outflows, by weakening soils and altering plant growth, made the Caernarvon marsh more susceptible to hurricane-wave-induced shear stress. The study also concluded that all freshwater soils are inherently weaker and thus more vulnerable to storm damage. The study was criticized for
    - Not accounting for a defined mineral sediment layer in the soil from the 1927 flood,
    - Not structuring the study to separate the effects of the diversion inflows,
    - Not structuring the study to study multiple freshwater soil types, and
    - Assuming similar wave stresses between the "diversion" and "non-diversion" sites.
  - CPRA has commissioned a study by LSU to measure shear strength at 39 CRMS-Wetlands monitoring stations across 13 marsh types to better survey shear-strength variability across marsh types and address the indictment of diversion-associated fresh marsh soil strength without spatial or temporal coverage to justify claims. Study results are due in December 2012.

Priority "Bayside" Technical Topics
Response of Wetland Soils and Vegetation

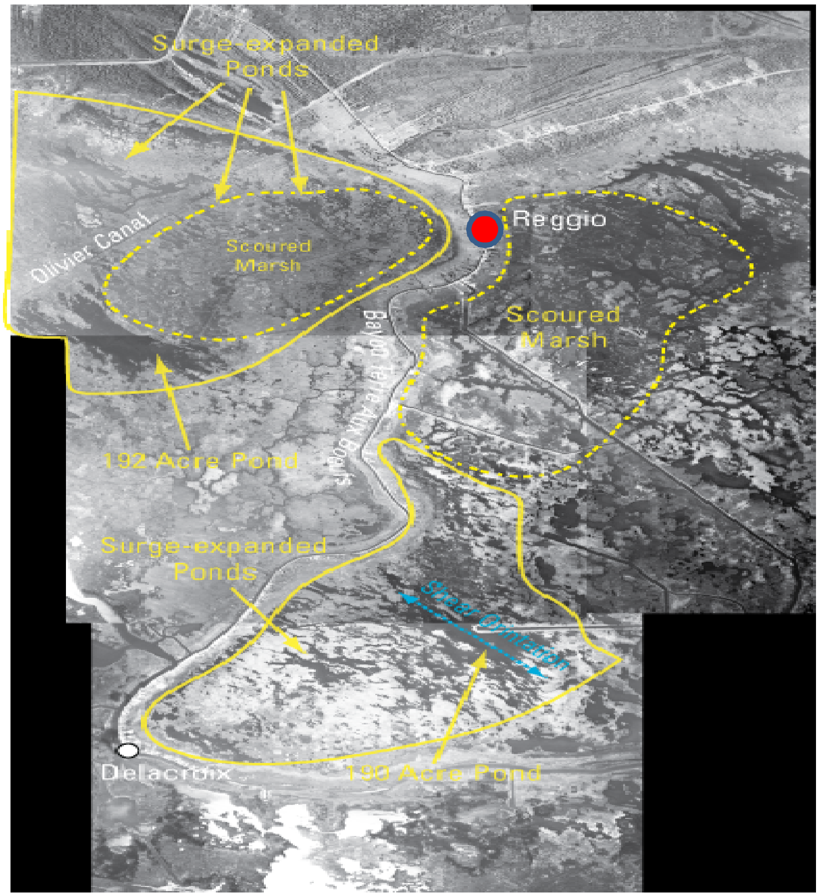
State of the Science

- **Debated Point**
  - Kearney et al. (2011) took data from both Darby &Turner (2008) and Howes et al. (2010) to help explain observations of greater marsh loss within the Caernarvon area as evidence that diversion inflows are detrimental to the marsh. The study was criticized for
    - Comparing the Caernarvon area to Myrtle Grove and West Point a la Hache on the west side of the river, on the assumption that storm surge stresses were similar in the three area
    - Not accounting for previous studies that have discussed inherent vulvnerability of the Caernarvon area to storm stress due to spatial orientation
  - The USGS Northern Gulf of Mexico Ecosystem Change and Hazard Susceptibility project has documented hurricane-induced marsh loss on both sides of Bayou Terre aux Bouefs that pre-dates construction of the diversion structure.

Historical Caernarvon Storm Damage



April 28, 1965 Pan Photography



March 29, 1967 Pan Photography

Historical photography shows that hurricane induced shear of wetlands in the Caernarvon basin was occurring 25 years before the construction of the diversion

Shear Damage After Katrina/Rita Was Not Confined to Caernarvon Fresh Marshes

Priority "Bayside" Technical Topics
Response of Wetland Soils and Vegetation

Ongoing Activities

- **An expert panel of academic and government researchers associated with a February 2011 LCA Science & Technology Program / NOAA workshop is preparing an external review of the response of wetland soils and vegetation to diversion flows. Preliminary conclusions include**
  - **"Delivery of nutrients or lowering of salinity may stimulate plant production but may also increase rates of organic matter decomposition leading to elevation loss. Studies on diversion effects on elevation have provided some insights but have not rigorously tested the relations."**
  - **"There is no clear answer to the question of whether river diversions reduce soil strength through degradation of peat soil, or are they a positive influence, promoting plant growth and peat accretion with no impact on organic soil strength?"**
  - **"Conditions vary considerably from site to site so data from one site are not necessarily useful at another."**

Priority “Bayside” Technical Topics

Response of Wetland Soils and Vegetation

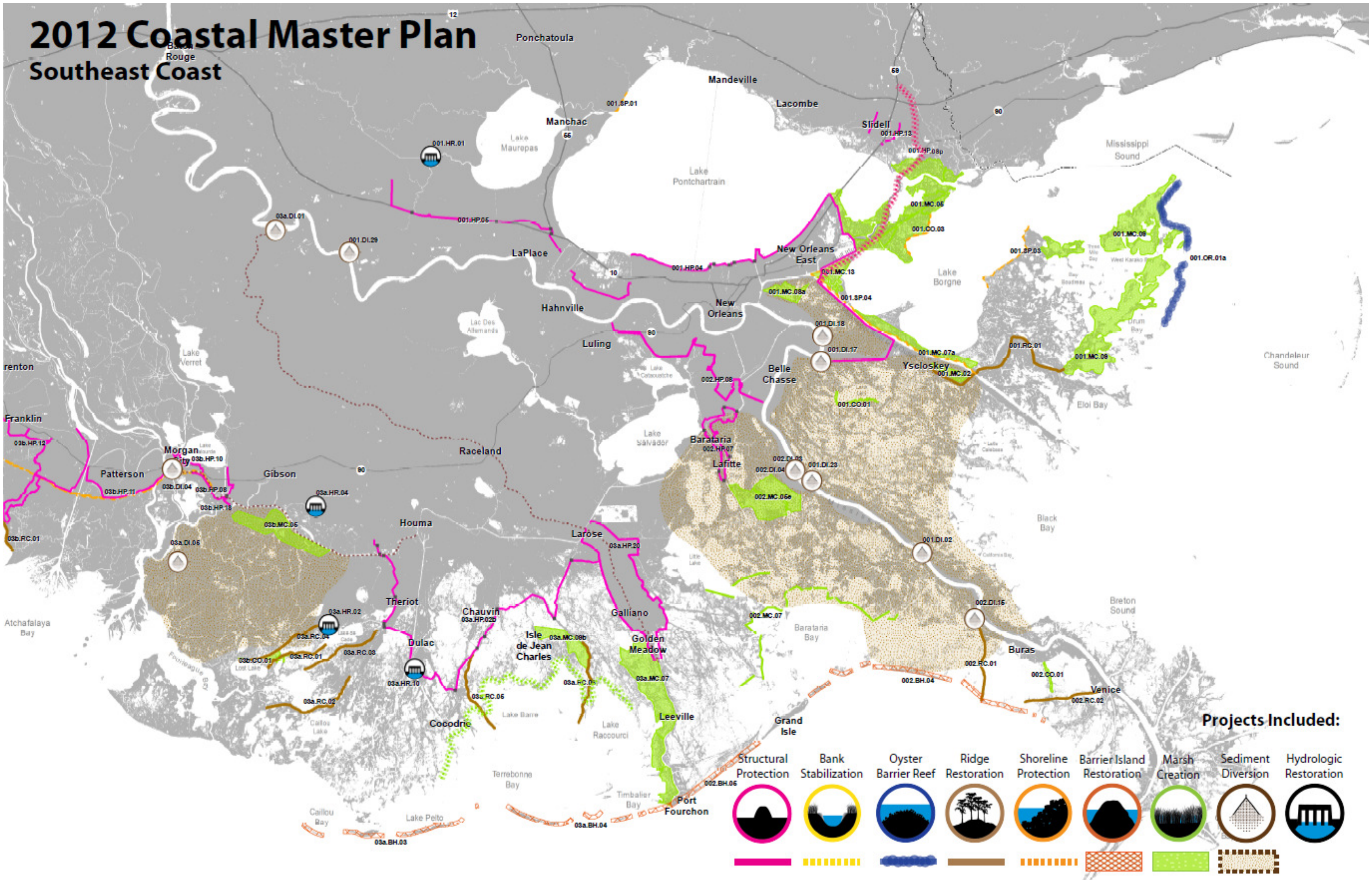
Topical Summary

- The available data is sometimes contradictory on this topic.
- The individual studies held up both in support of and against diversions need to be closely examined for caveats in study design and extrapolation of results.
- CPRA will continue to pursue more comprehensive studies to address this topic.
- Some aspects of this debate also go beyond data comparisons and involve stakeholder policy preferences.

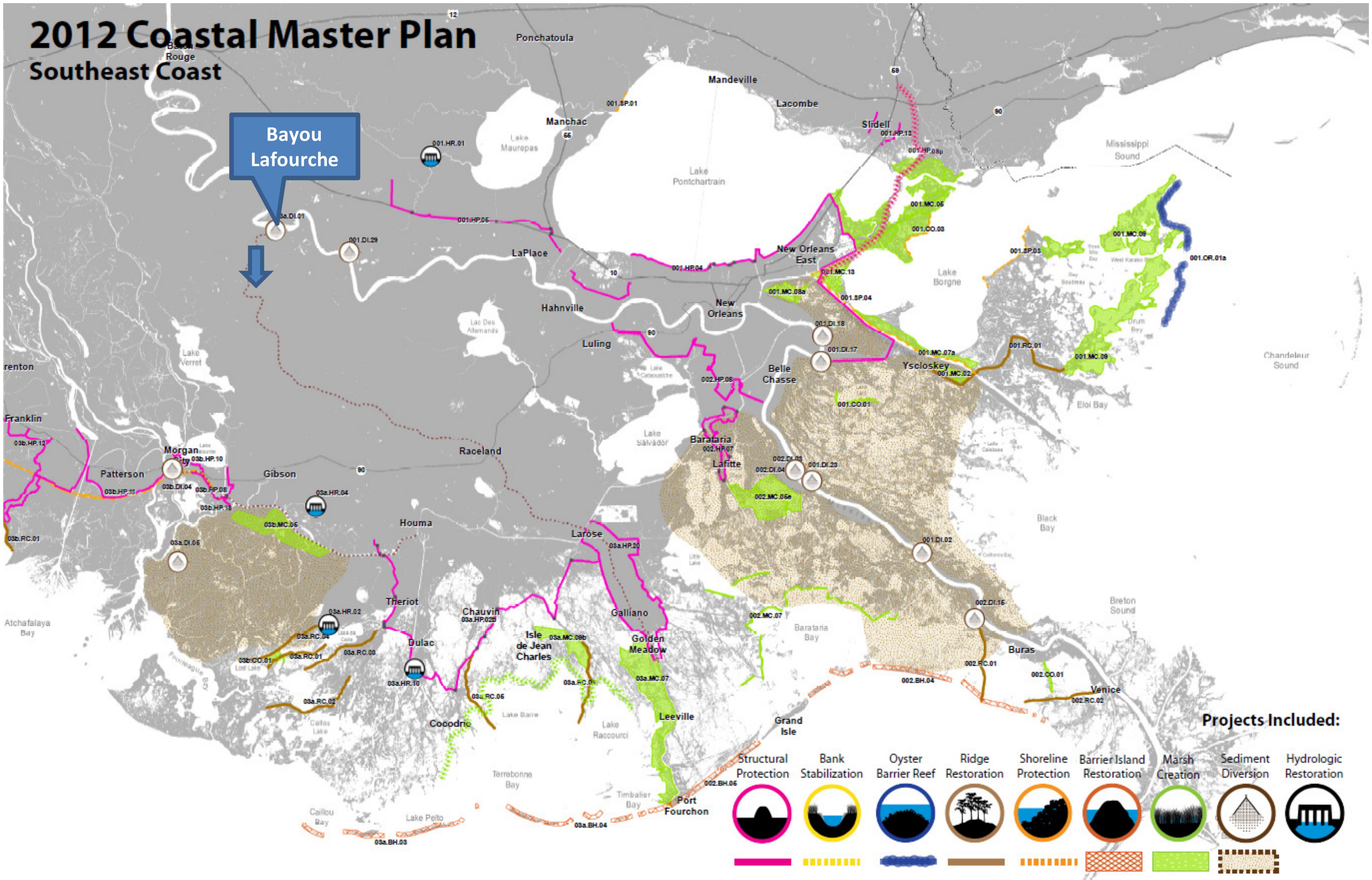
Diversions in the 2012 Master Plan

List of Projects

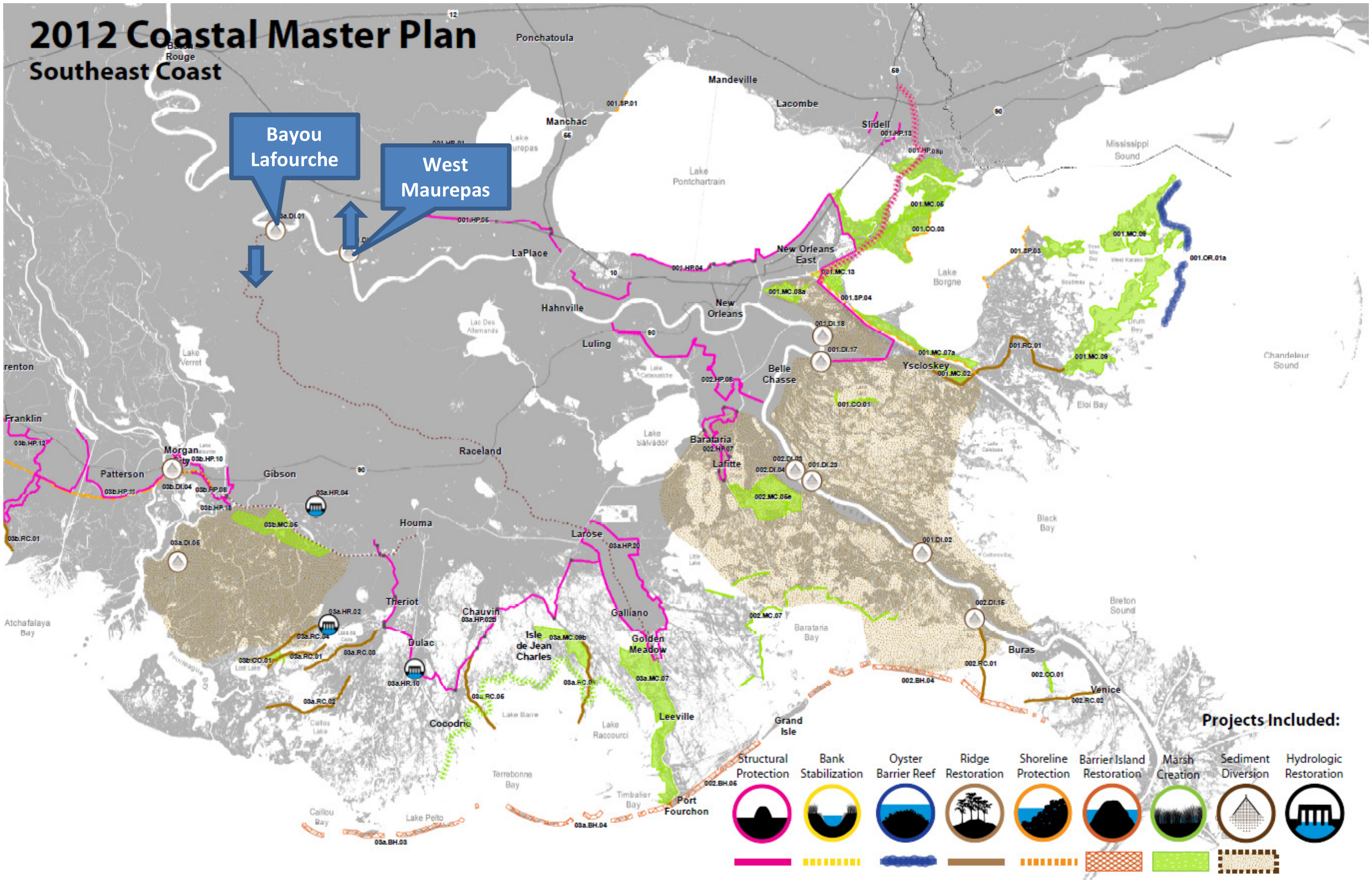
Diversions in the 2012 Coastal Master Plan



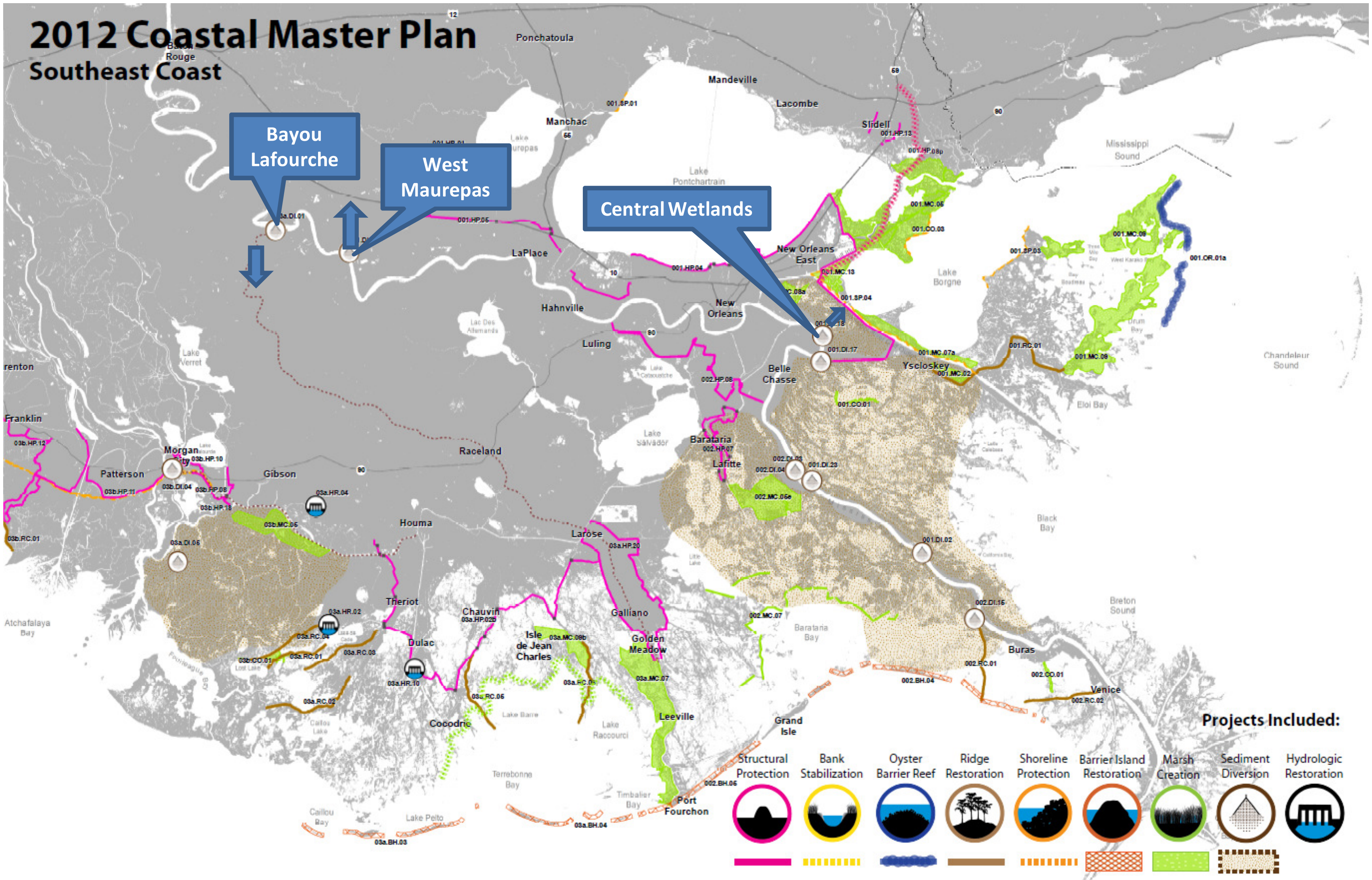
Diversions in the 2012 Coastal Master Plan



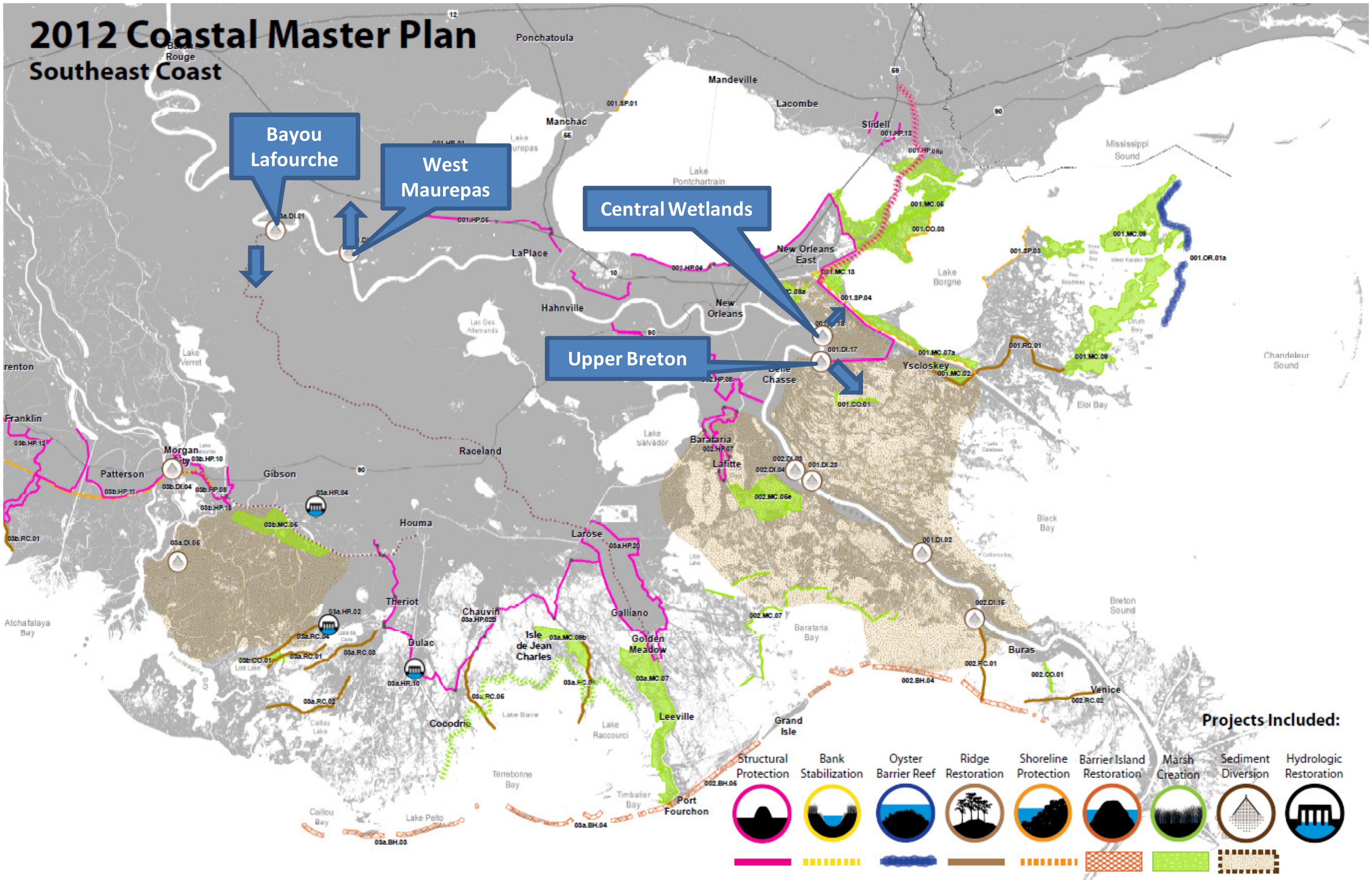
Diversions in the 2012 Coastal Master Plan



Diversions in the 2012 Coastal Master Plan



Diversions in the 2012 Coastal Master Plan



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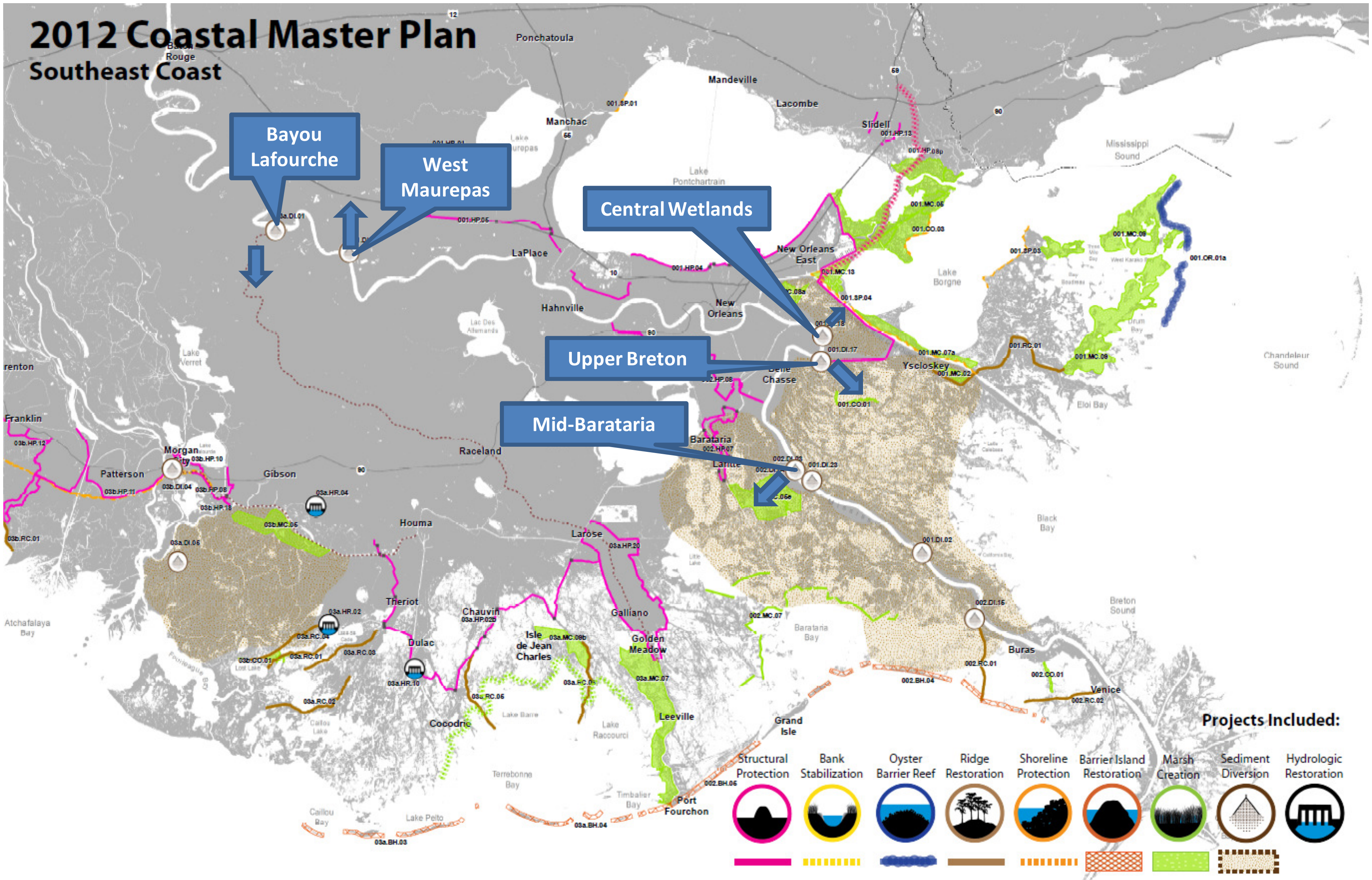
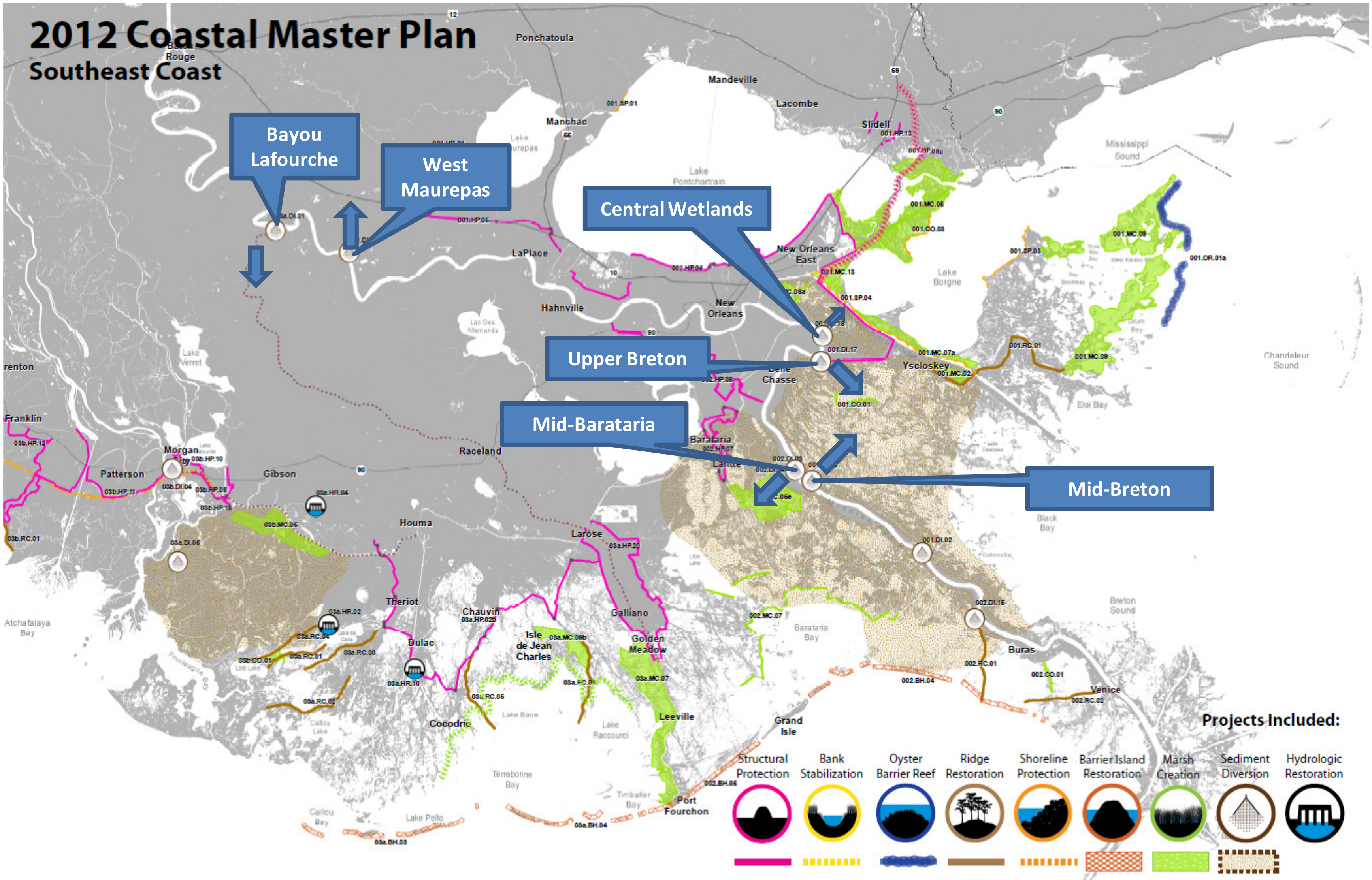
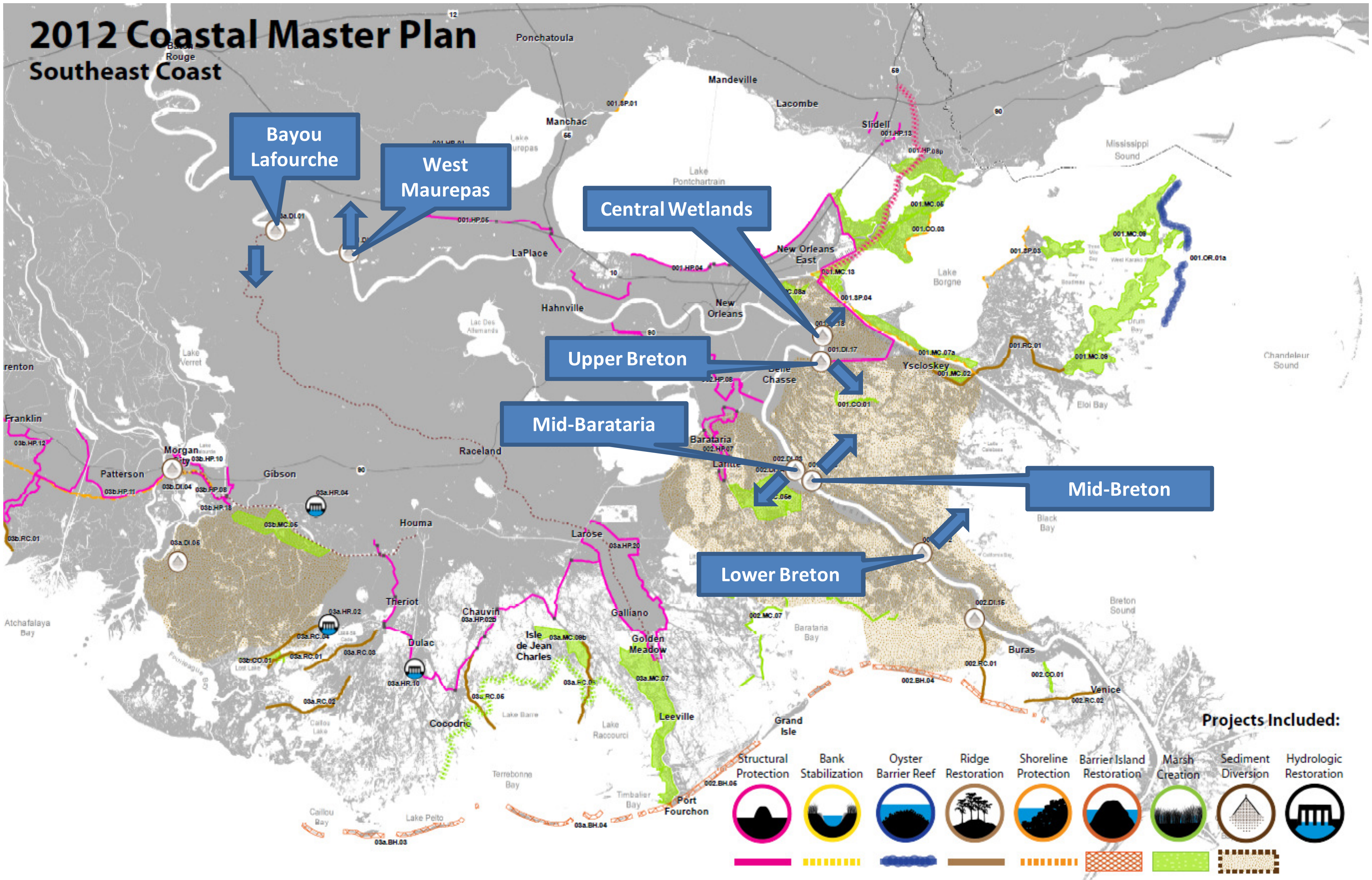


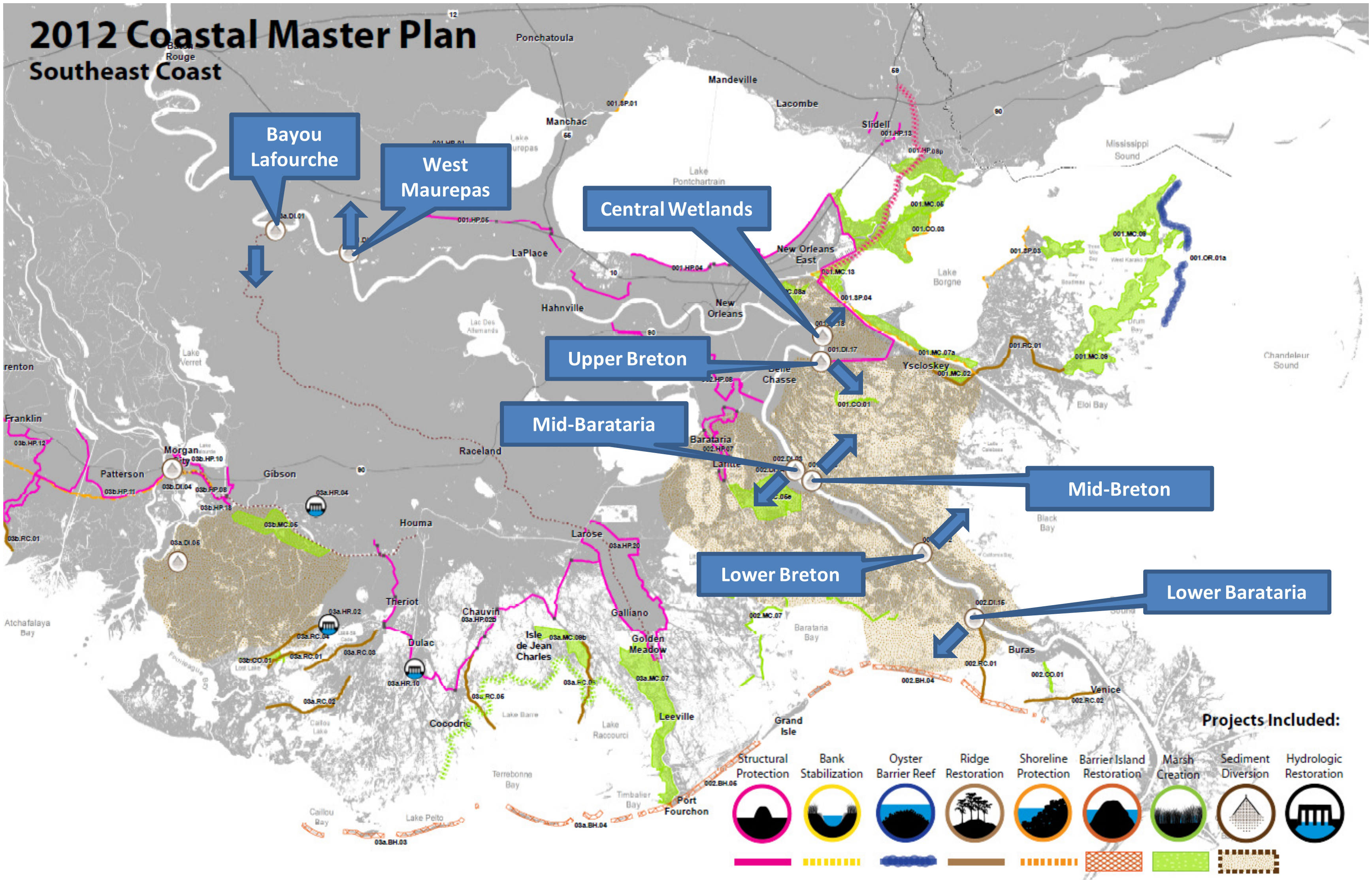
Diversions in the 2012 Coastal Master Plan



Diversions in the 2012 Coastal Master Plan



Diversions in the 2012 Coastal Master Plan



Diversions in the 2012 Master Plan

Project	*2012-2031*		*2032-2061*	
	Discharge Capacity	*Cost*	*Discharge Capacity*	*Cost*
Bayou Lafourche Diversion	**1,000 cfs**	**$189 M**	**-**	**-**
West Maurepas Diversion	**Small**	**$127 M**	**-**	**-**
Central Wetlands Diversion	**Small**	**$189 M**	**-**	**-**
Upper Breton Diversion	**Large**	**$885 M**	**-**	**-**
Mid-Barataria Diversion	**Medium**	**$275 M**	**Large**	**$820 M**
Mid-Breton Diversion	**Small**	**$123 M**	**-**	**-**
Lower Breton Diversion	**Medium**	**$212 M**	**-**	**-**
Lower Barataria Diversion	**Medium**	**$203 M**	**-**	**-**
Total		**$2.203B**		**$820 M**
Grand Total				**$3.023 B**

Existing Diversions
(not including emergency spillways)

Diversion	*Discharge Capacity (cfs)*
Bayou Lafource Siphon	300
Caernarvon Freshwater Diversion	8,000
Channel Armor Gap	2,500
Coquille Siphon	250
Davis Pond Freshwater Diversion	10,000
Naomi Siphon	2,100
Violet Siphon	300
West Pointe a la Hache Siphon	2,100
West Bay Sediment Diversion	20,000
White's Ditch Siphon	250

TOTAL PRESENT DISCHARGE CAPACITY:
45,800 cfs (1297 m^3s^{-1})

Diversions in the 2012 Master Plan

Operational Assumptions and Considerations

Diversions in the 2012 Master Plan

Operational Assumptions in Master Plan Modeling

- **Large diversions described in the Master Plan as**
  - Flow of 250,000 cfs when river discharge exceeds 900,000 cfs,
  - Flow of 50,000 cfs when river discharge 600,000-900,000 cfs,
  - Flow of 8% of river discharge between 200,000-600,000 cfs,
  - Not flowing at river discharge below 200,000 cfs

- **Medium diversions described in the Master Plan as**
  - Flow of 50,000 cfs when river discharge exceeds 600,000 cfs
  - Flow of 8% of river discharge 200,000-600,000 cfs
  - Not flowing at river discharge below 200,000 cfs

- **Small diversions described in the Master Plan as**
  - Low of 5,000 cfs when river discharge exceeds 200,000 cfs
  - Not flowing at river discharge below 200,000 cfs

Diversions in the 2012 Master Plan

Operational Assumptions and Considerations

Exact maximum capacities and locations will be determined through feasibility-level investigations

Diversions in the 2012 Master Plan
Operational Assumptions and Considerations

Exact maximum capacities and locations will be determined through feasibility-level investigations

We anticipate operating the suite of diversions as a system

- **All of the diversions will NOT be open all of the time**
- **All of the diversions will most likely NOT be open all at the same time**
- **Many of the diversions may NOT be open MOST of the time**
- **Will prevent over-freshening**
- **We are developing tools to help us consider the collection of individual projects as a system**

Diversions in the 2012 Master Plan

Operational Assumptions and Considerations

Ongoing Activities: Small Scale Physical Model Update

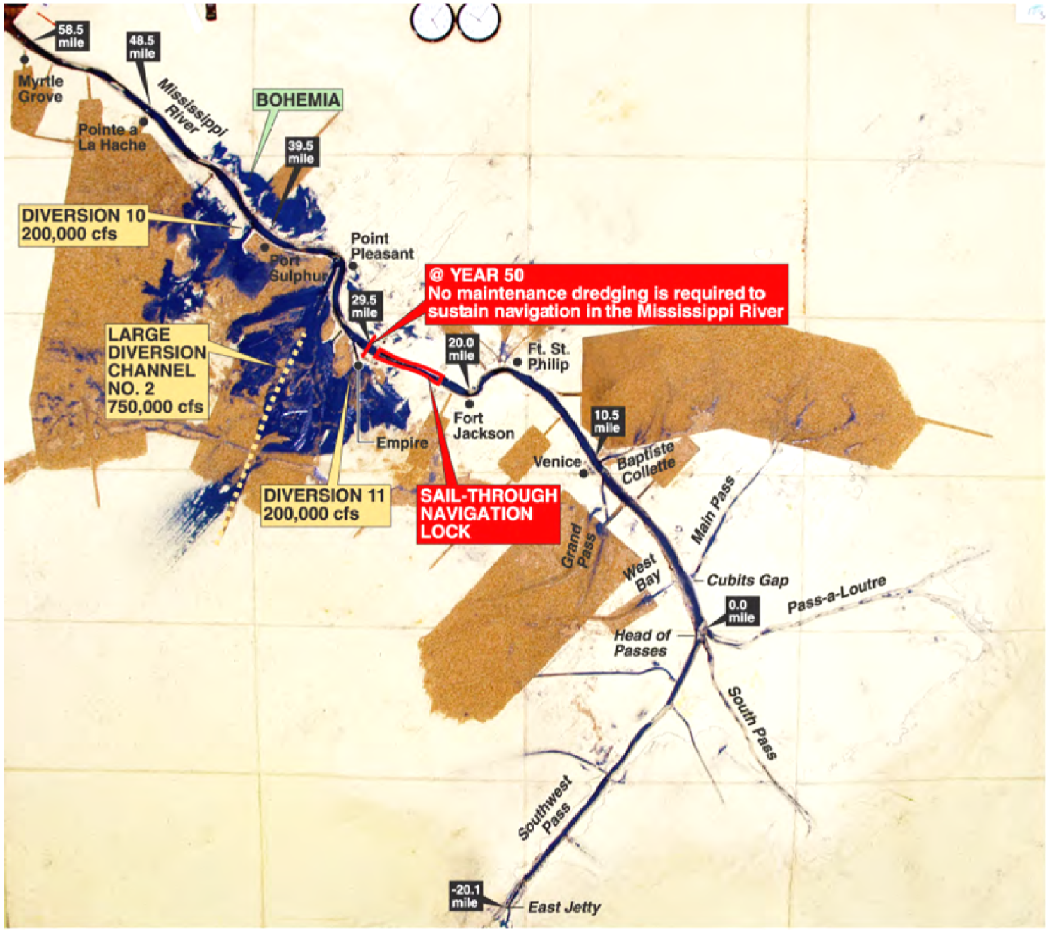


PHOTO NO. 9:
LARGE DIVERSION CHANNEL NO. 2
State of Sedimentation after 50 years of operation

- **Investigates the effectiveness of potential locations for sediment diversions along the lower Mississippi river**
- **Determines the relative effectiveness of different diversion designs**
- **Aids in planning for the operations of multiple diversions**

Shown in blue are sand deposits at Bohemia, Large Diversion Channel No. 2, and small-scale Diversion Channels No. 10 and 11 after 50 years of operation.

Diversions in the 2012 Master Plan

Operational Assumptions and Considerations

Exact maximum capacities and locations will be determined through feasibility-level investigations

We anticipate operating the suite of diversions as a system

Operational details will be project specific to maximize benefits

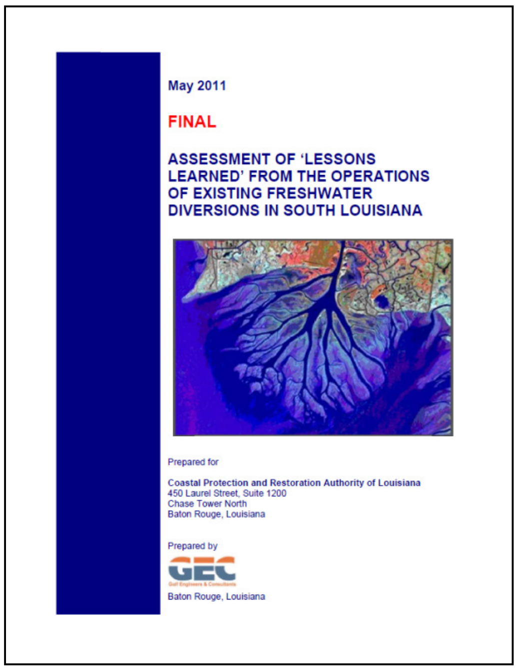
- **E.g. the benefits of diversions are greatest when water, sediments, and nutrients get on the marsh surface.**
  - **For the Caernarvon Freshwater Diversion Project, 3,500 cfs necessary for sheet flow (pre-Katrina, Snedden 2006).**

Summary

- **Diversions have been recognized as a critical component of most recent comprehensive coastal restoration plans**

Summary

- Diversions have been recognized as a critical component of most recent comprehensive coastal restoration plans
- We have learned much information during past decade that will improve diversion use outcomes


May 2011

FINAL

ASSESSMENT OF 'LESSONS LEARNED' FROM THE OPERATIONS OF EXISTING FRESHWATER DIVERSIONS IN SOUTH LOUISIANA

Prepared for

Coastal Protection and Restoration Authority of Louisiana
450 Laurel Street, Suite 1200
Chase Tower North
Baton Rouge, Louisiana

Prepared by

GEC

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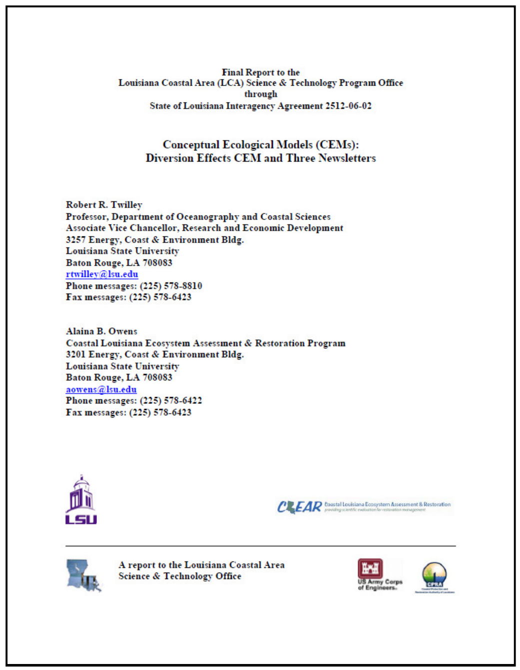
Final Report to the
Louisiana Coastal Area (LCA) Science & Technology Program Office
through
State of Louisiana Interagency Agreement 2512-06-02

Conceptual Ecological Models (CEMs):
Diversion Effects CEM and Three Newsletters

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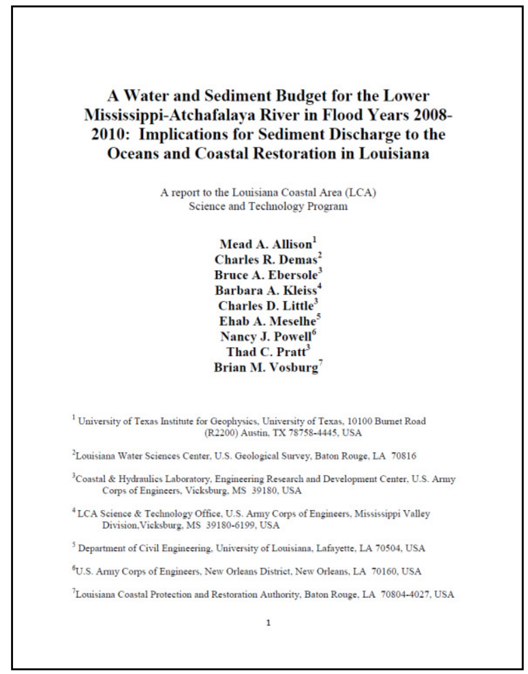
A report to the Louisiana Coastal Area Science & Technology Office


A Water and Sediment Budget for the Lower Mississippi-Atchafalaya River in Flood Years 2008-2010: Implications for Sediment Discharge to the Oceans and Coastal Restoration in Louisiana

A report to the Louisiana Coastal Area (LCA) Science and Technology Program

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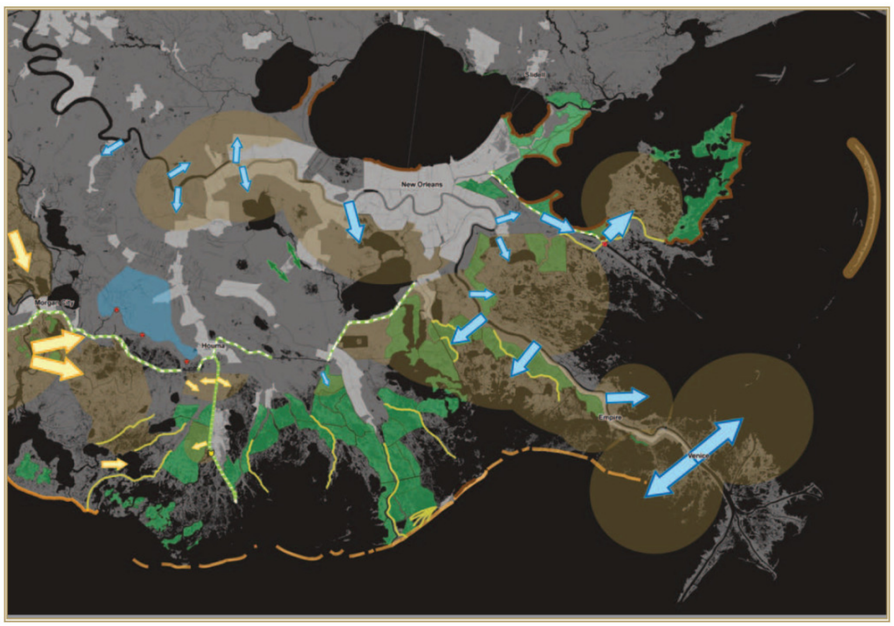
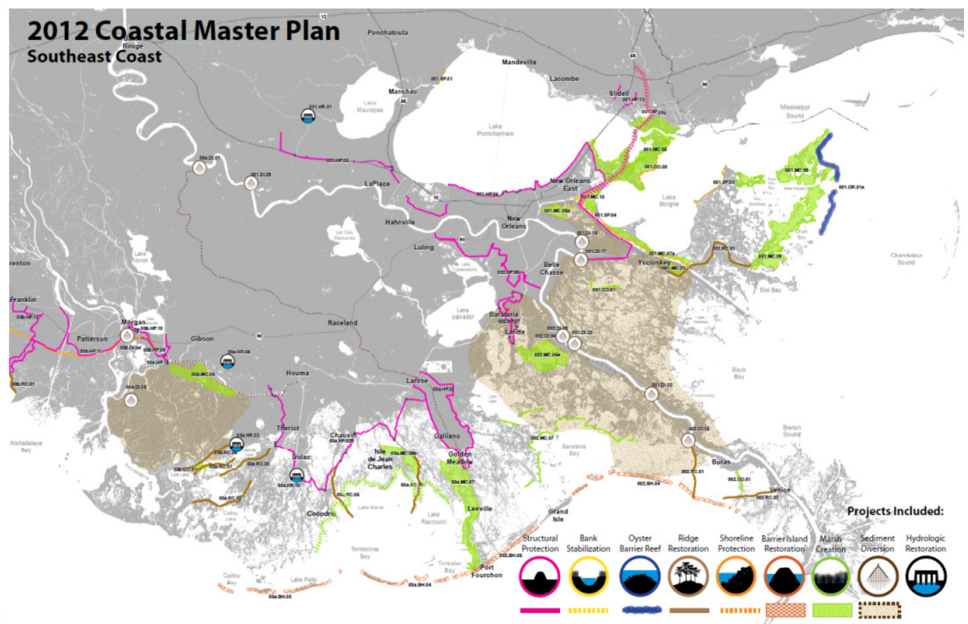
Summary

- Diversions have been recognized as a critical component of most recent comprehensive coastal restoration plans
- We have learned much information during past decade that can be applied to our use of diversions
- We have become more strategic in the location and operation as a system of planned diversions





Summary

- **Diversions have been recognized as a critical component of most recent comprehensive coastal restoration plans**
- **We have learned much information during past decade that can be applied to our use of diversions**
- **We have become more strategic in the location and operation as a system of planned diversions**
- **"Adaptive management is active management"**
  - **Urgency to act to achieve a sustainable coastal zone requires a certain amount of learning while doing**

Summary

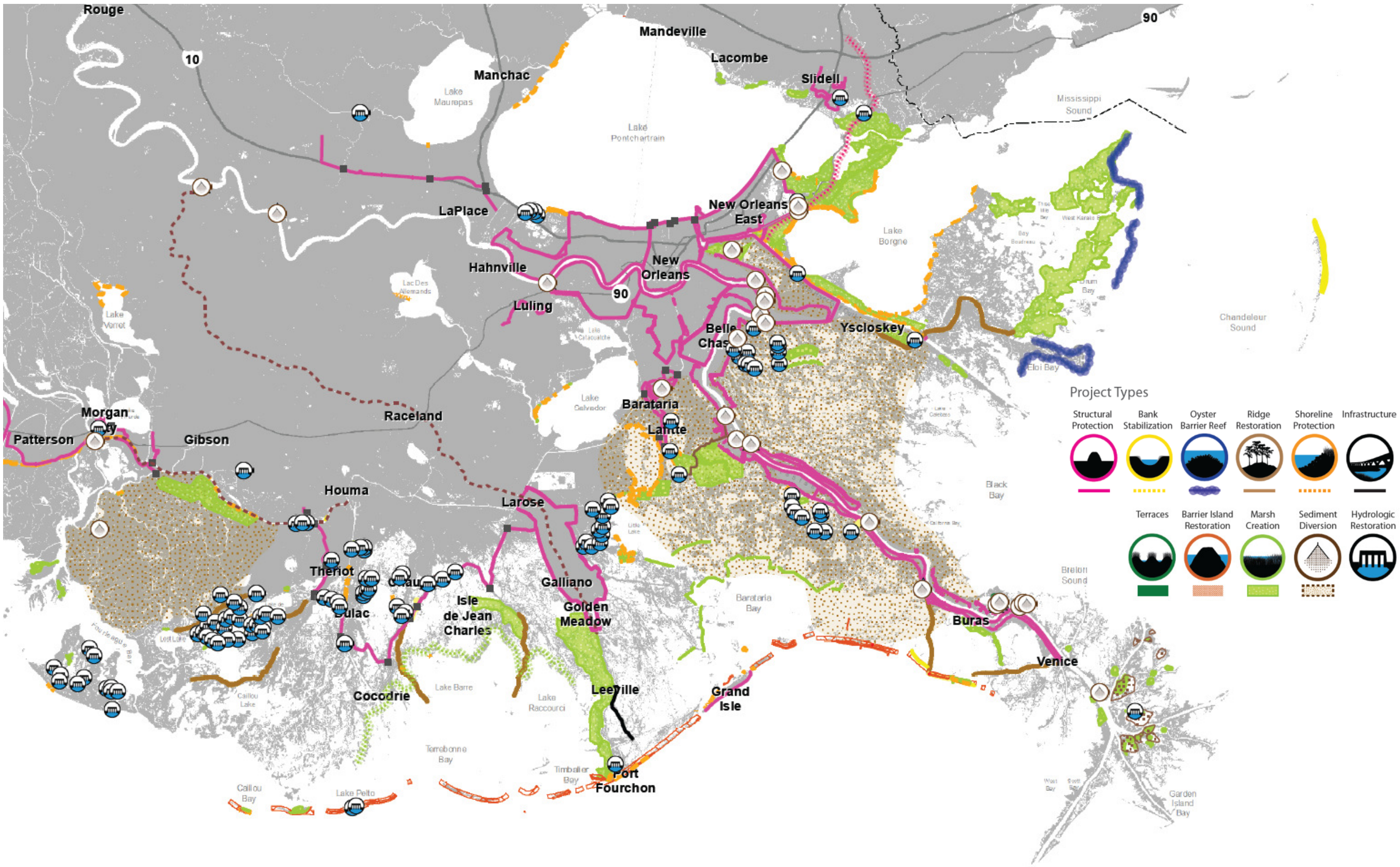
- **Diversions have been recognized as a critical component of most recent comprehensive coastal restoration plans**
- **We have learned much information during past decade that can be applied to our use of diversions**
- **We have become more strategic in the location and operation as a system of planned diversions**
- **"Adaptive management is active management"**
- **There are 47 marsh creation projects proposed**
  - **There is likely an adequate amount of sand available for these projects**

Summary

- **Diversions have been recognized as a critical component of most recent comprehensive coastal restoration plans**
- **We have learned much information during past decade that can be applied to our use of diversions**
- **We have become more strategic in the location and operation as a system of planned diversions**
- **"Adaptive management is active management"**
- **There are 47 marsh creation projects proposed**
- **There are 8 sediment diversion projects proposed**
  - **Difficult to calculate amount of sediment needed/available**
  - **Characteristics of the specific area where diversions are located need to be taken into account**
  - **Diversions not only build land but also add nutrients and mineral soils that can help build land by increasing plant productivity**

Diversions in the 2012 Coastal Master Plan

Current and Future Projects Combined



Thanks for Your Time!

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- **Questions?**