Systemic analysis of the tradeoffs associated with management strategies for natural and built Mississippi River outlets

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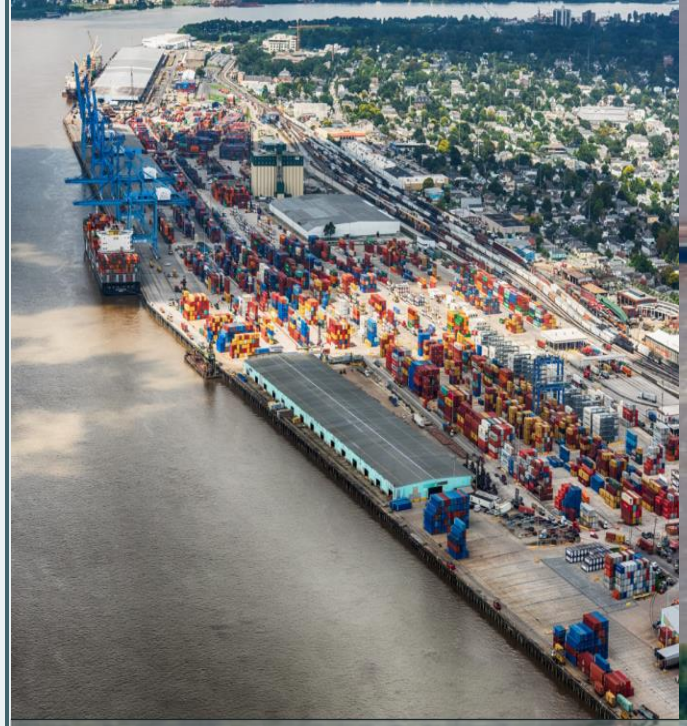
Tulane University
State of the Coast – May 20, 2025



Natural Resource Management Decision Making

What are the tradeoffs? How do we quantify them? How do we find the right balance?

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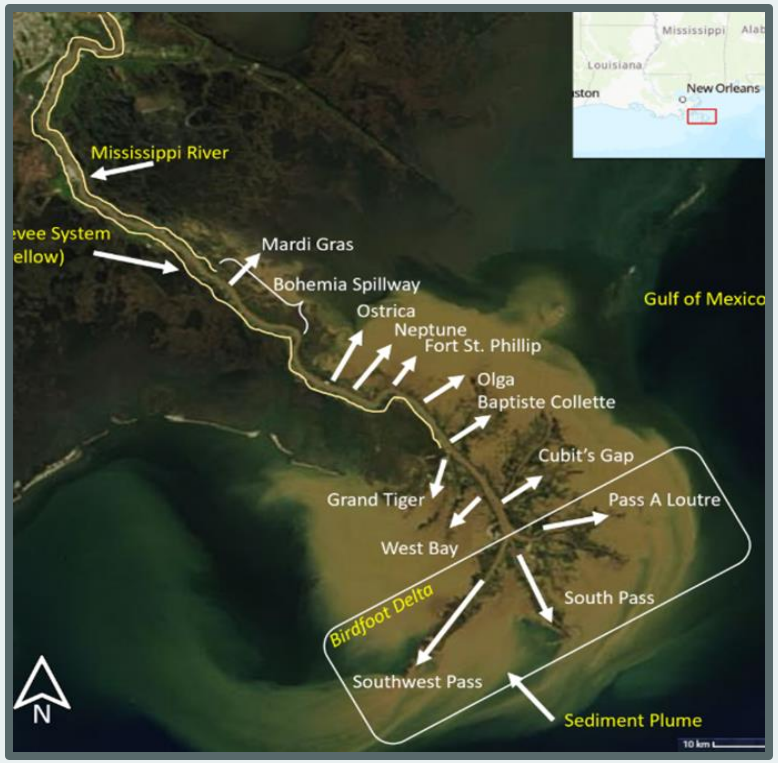
Lower Mississippi River = valuable natural resource

What if the Mississippi River flood risk management features were operated differently?

How will new diversions affect the already highly managed ecosystem?



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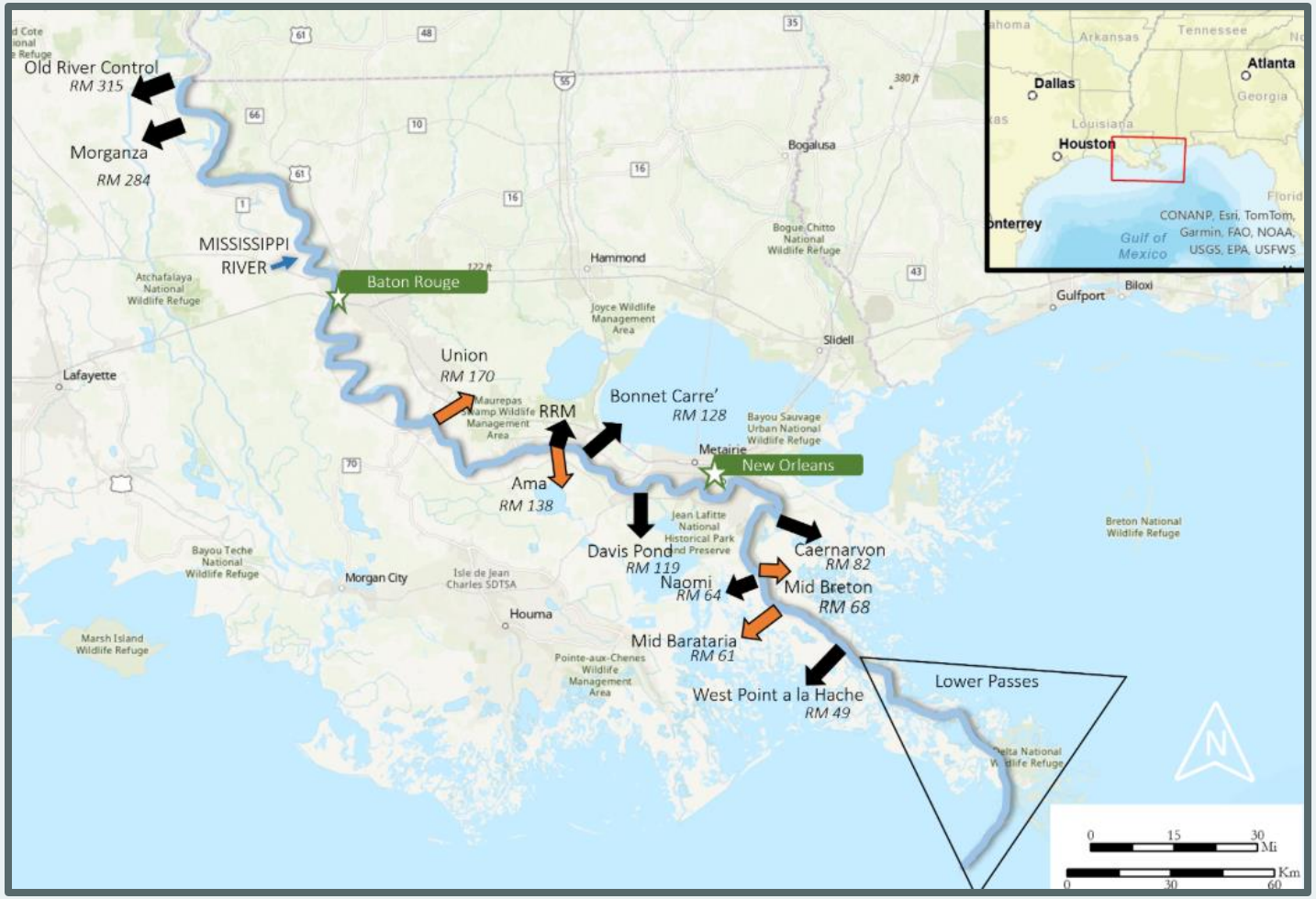
Study Area

- Lower Mississippi River *below* Old River Control Structure
- Existing and Proposed Diversions
- Natural Passes below levee system
- Basins: Maurepas/Pontchartrain, Mississippi Sound, Breton, Barataria, Delta



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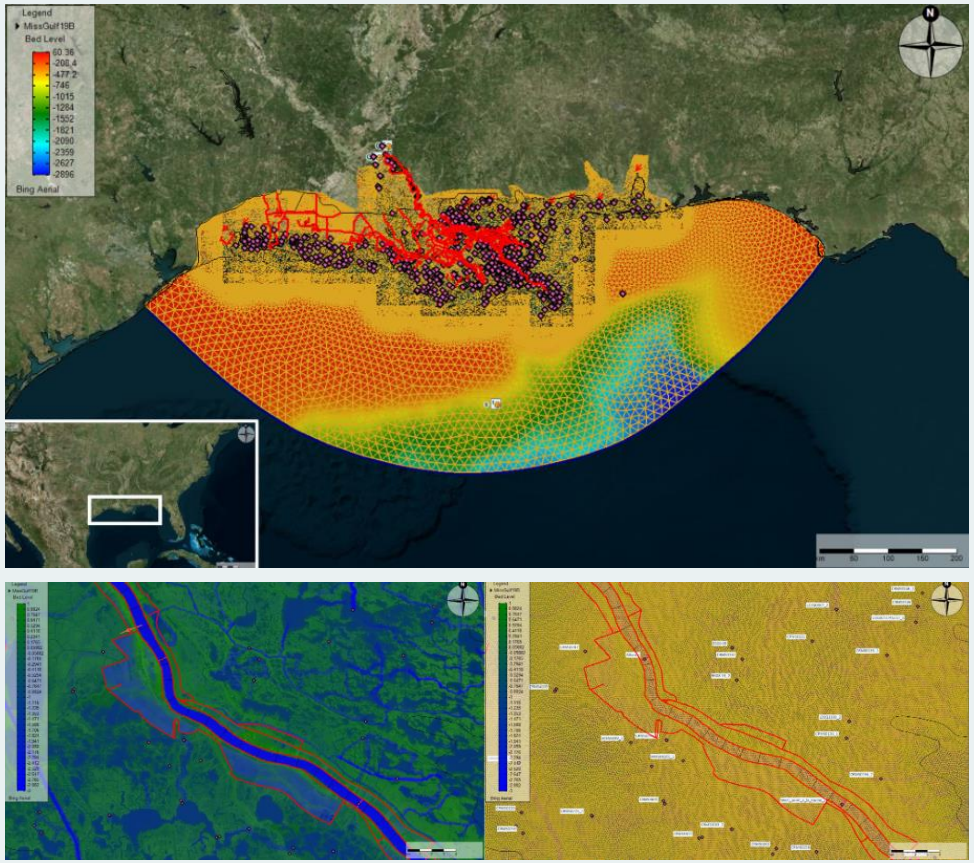
Model Details



- Delft3DFM model engine
- Resolution 17km – 90m
- 4.3 million elements
- USGS NLCD and USACE bathymetric surveys
- USGS and USACE river discharge
- Nested coastal water level boundary from Gulf Atlantic Model
- 3 dimensional with 7 sigma layers
- Hydrodynamic, Salinity, and Temperature transport
- GFS-NCEP Atmospheric forcings: wind, air pressure, air temp, humidity, cloud coverage
- Run Time: 960 cores, 1yr sim, 3-5 days

Calibration Curious? Scan Here!

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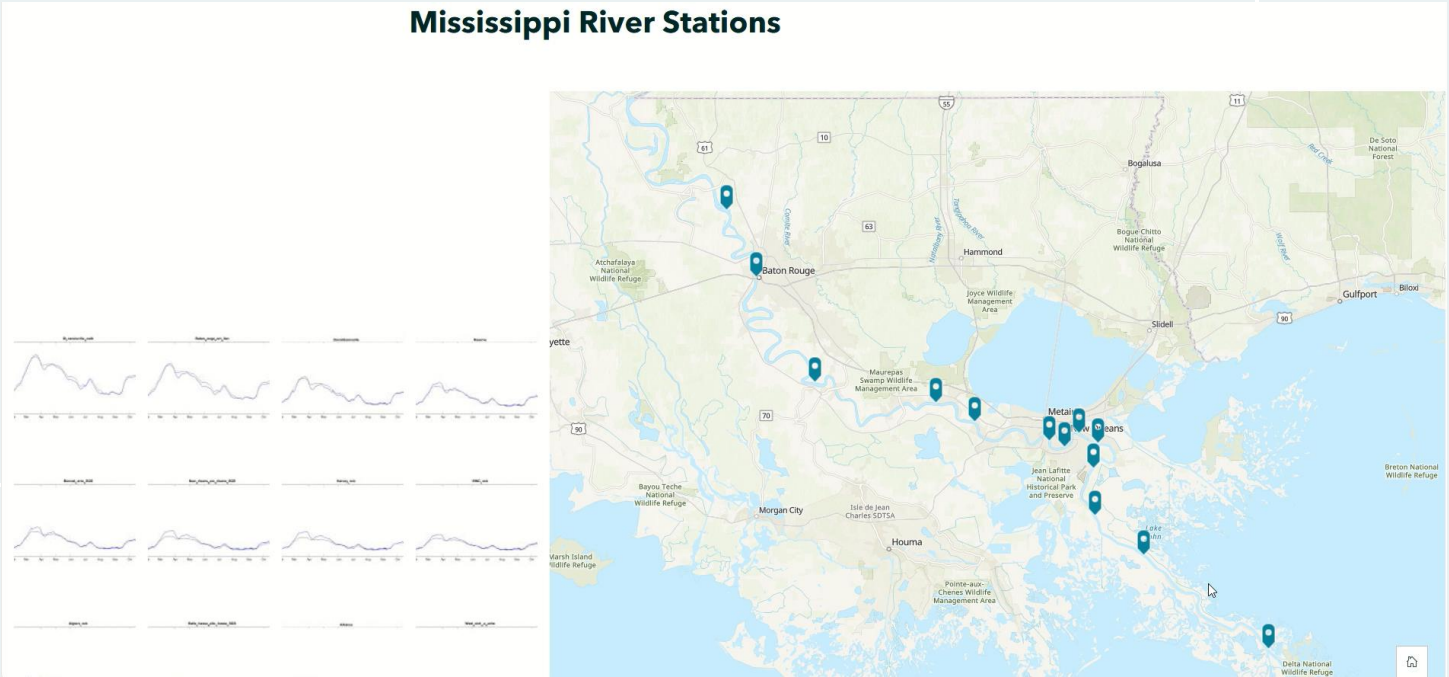
Want to see my calibration?

Scan Here!

Calibration and Validation

2018 & 2019
Hydrodynamics
Salinity
Temperature



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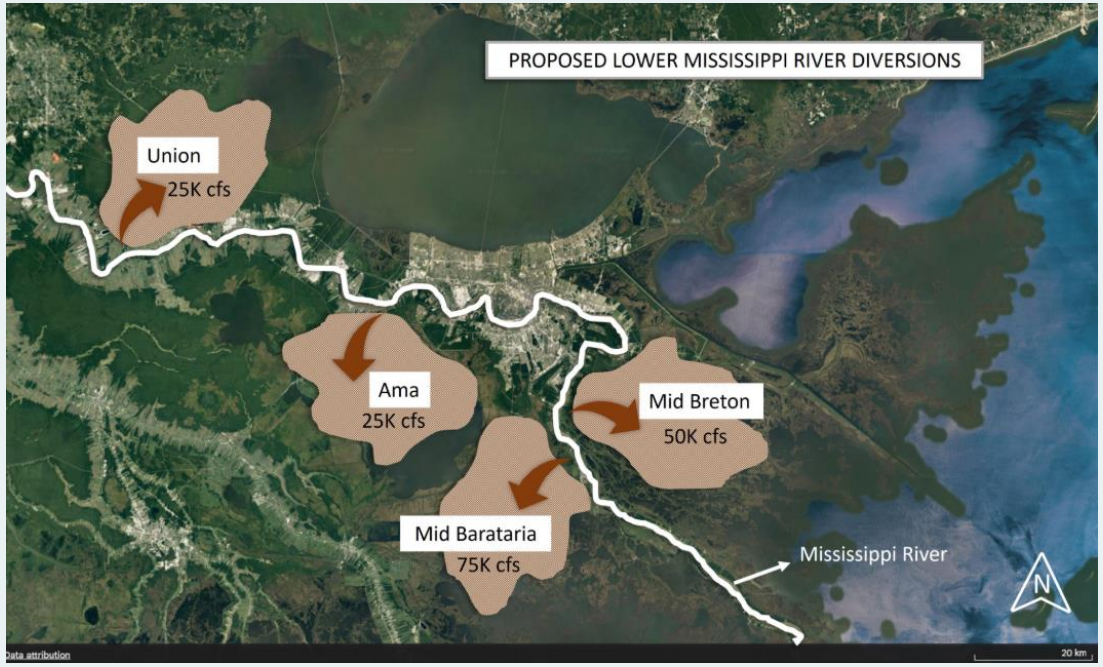
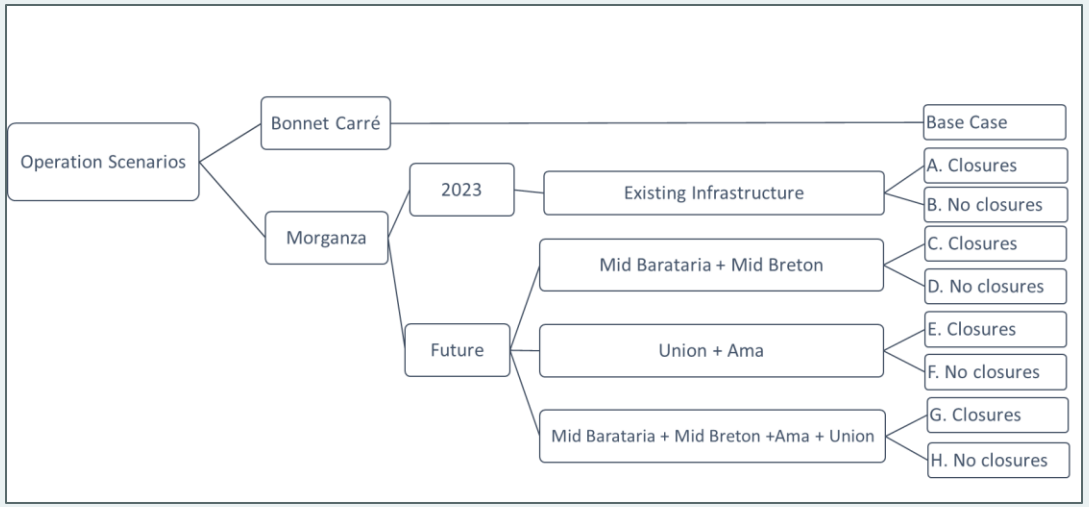
Operational Scenarios





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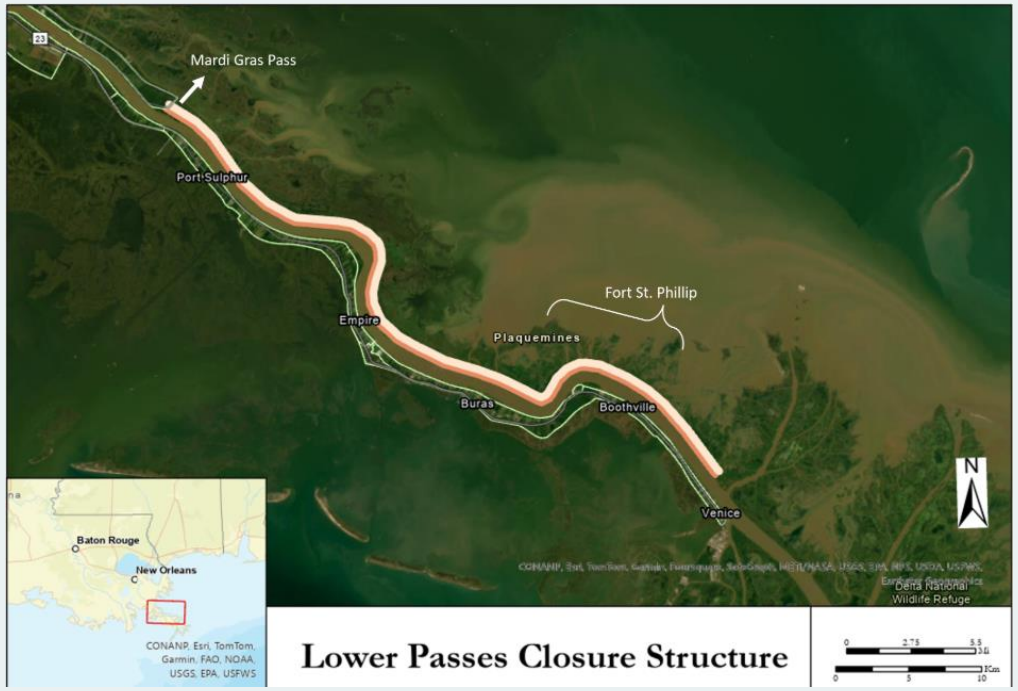
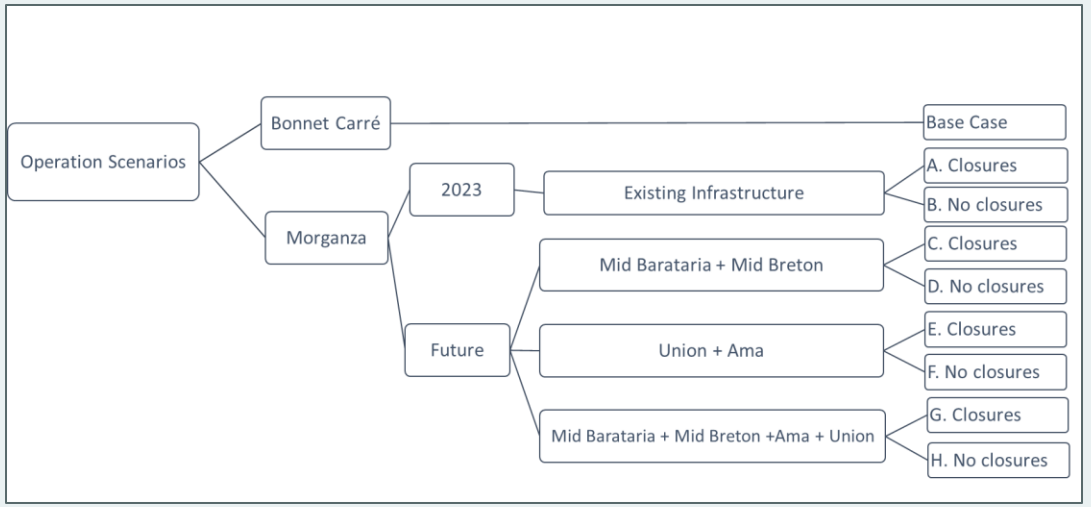
Operational Scenarios





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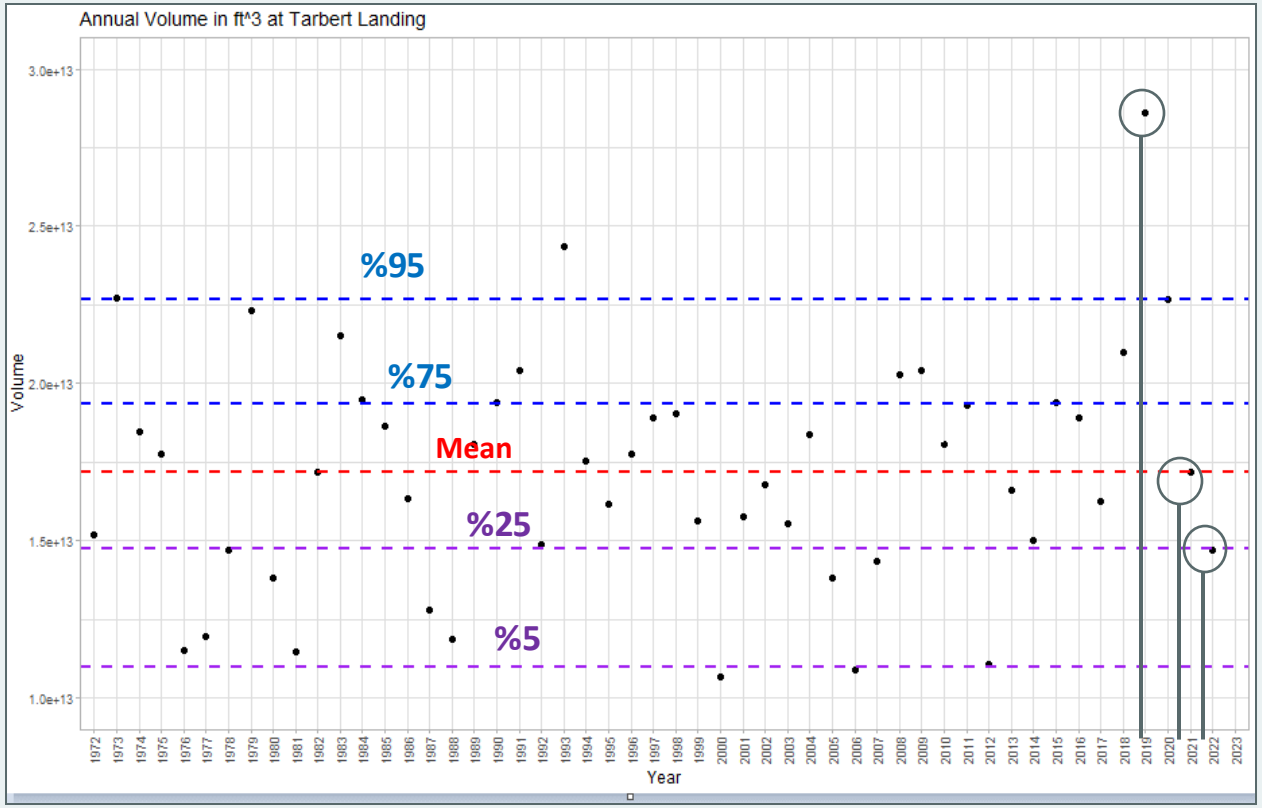
Operational Scenarios



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Scoring Approach

Metric	Define Criteria Considerations	Target Value
Flooding communities (days)	Considered flooded day if water depth exceeds zero at access points (ex. Road, levee, driveway, etc.) to select vulnerable location per basin: ○ Venice Marina ○ Lower Lafitte Playground ○ University of New Orleans research facility ○ Amite diversion canal neighborhood ○ Delacroix	Zero days flood.
Marsh inundation (acreage)(CPRA, 2017, 2023; Gough & Grace, 1998; Mossa, 1996; Peyronnin et al., 2017b; Snedden et al., 2015)	Unstressed marsh is any cell that has an Annual Inundation Depth < the Inundation Threshold Depth (based on the mean annual salinity)	Acreage of available unstressed marsh in base conditions.
Sediment Delivery (tons/year)(Allison & Meselhe, 2010; Snedden et al., 2007)	Sediment delivery in tons per year is calculated as the daily discharge through the diversion multiplied by the Mississippi River sediment concentration at the diversion location to produce the sediment load delivery. Sediment concentrations were based on the sediment rating curves from the Baton Rouge and Belle Chasse gaging stations.	Maximum delivery assumes that the only diversions open are those entering the basin of interest.
Eastern Oyster Suitability (acreage)(CPRA, 2012, 2017, 2023; Wang et al., 2017)	Coastal Master Plan 2023 Habitat Suitability Index formula.	Acreage with >0.5 HSI in base conditions within the Louisiana Department of Health designated oyster harvest areas.
Marine Mammal Suitability (acreage)(Garrison et al., 2020; McClain et al., 2020; Meselhe et al., 2019; White et al., 2018)	Meselhe et al. (2019) 'longest streak' formula applied to Bottle Nose Dolphins (compatible with the Environmental Impact Study for the Mid Barataria Sediment Diversion)	Acreage with <45 days salinity streak in base conditions
Navigation (metric ton/year) (Allison et al., 2012c; Nittrouer et al., 2008; Ramirez & Allison, 2013)	Bedform Transport Rate analysis $y = 146.3e^{1.77E-4*x}$	Bedform transport rate equivalent to base condition

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$$\frac{Actual\ Value}{Target\ Value} * 100\% = \%Target_{scenariox}$$

$$\%Target_{scenariox} - \%Target_{Base} = \%from\ Base$$

Simulate the Scenarios

*run model +process output

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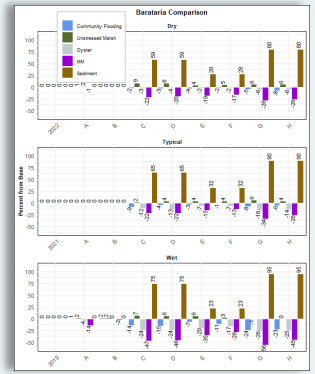
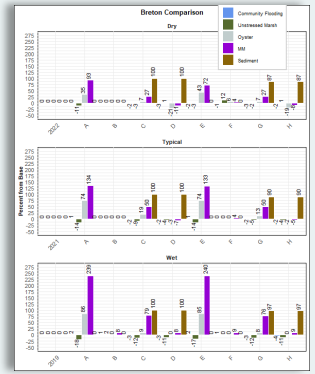
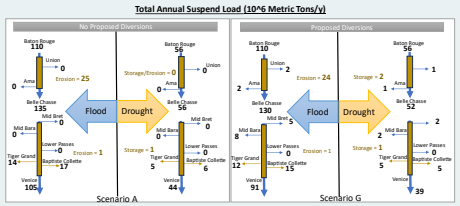
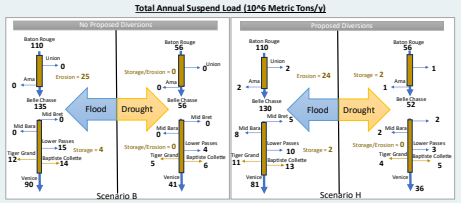
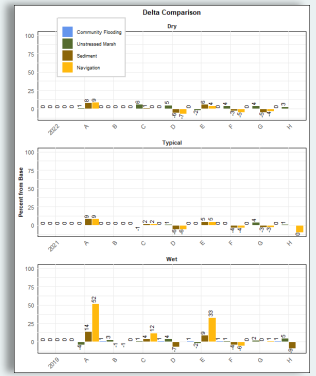
Results: Database

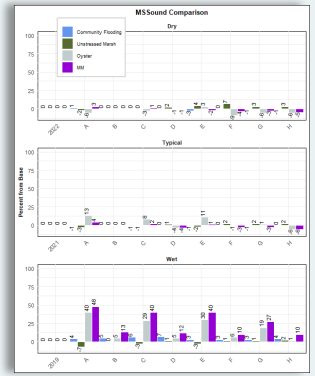


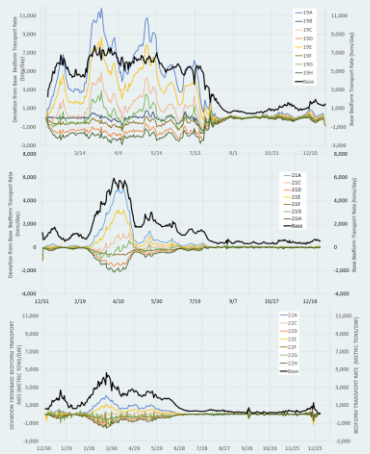












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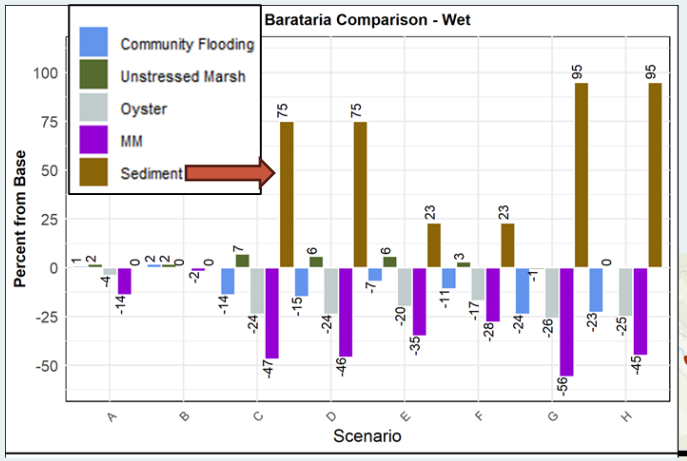
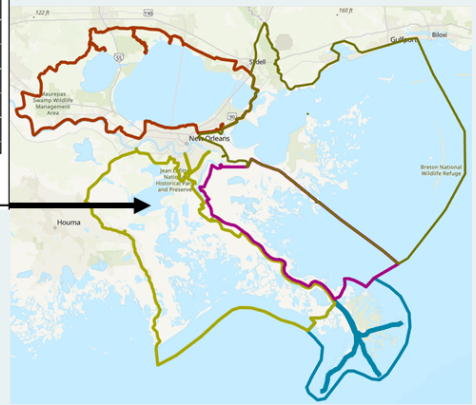
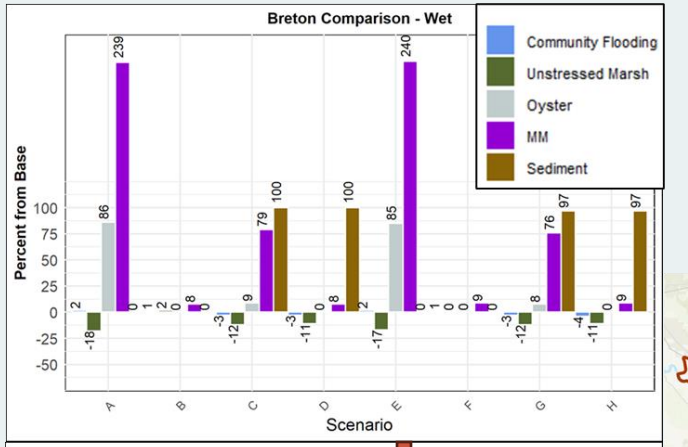
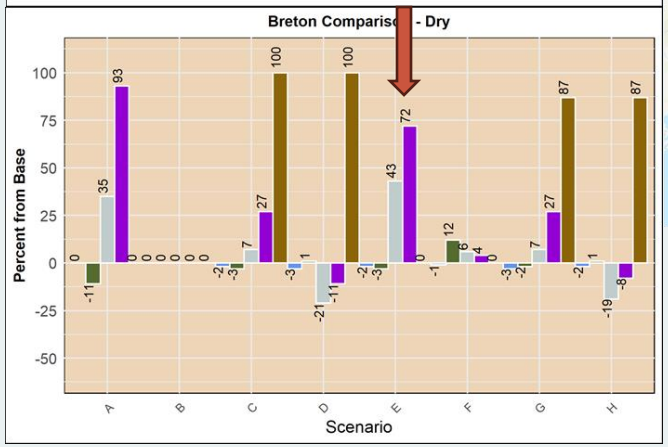
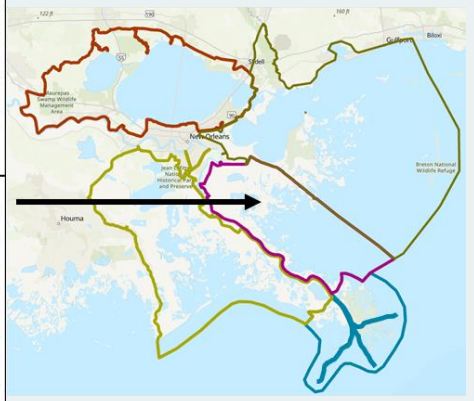
Results % deviation from BASE CASE



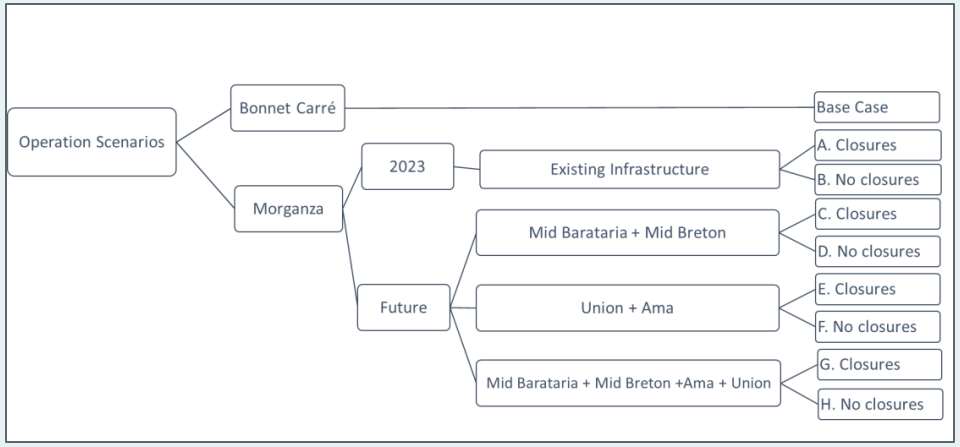








Tradeoff example: Scenarios with proposed diversions operating introduces 2(Ama) to 10 (Ama and Mid Barataria) tons/yr of sediment and decreases oyster suitability 15%(Ama) -23%(Ama and Mid Barataria)



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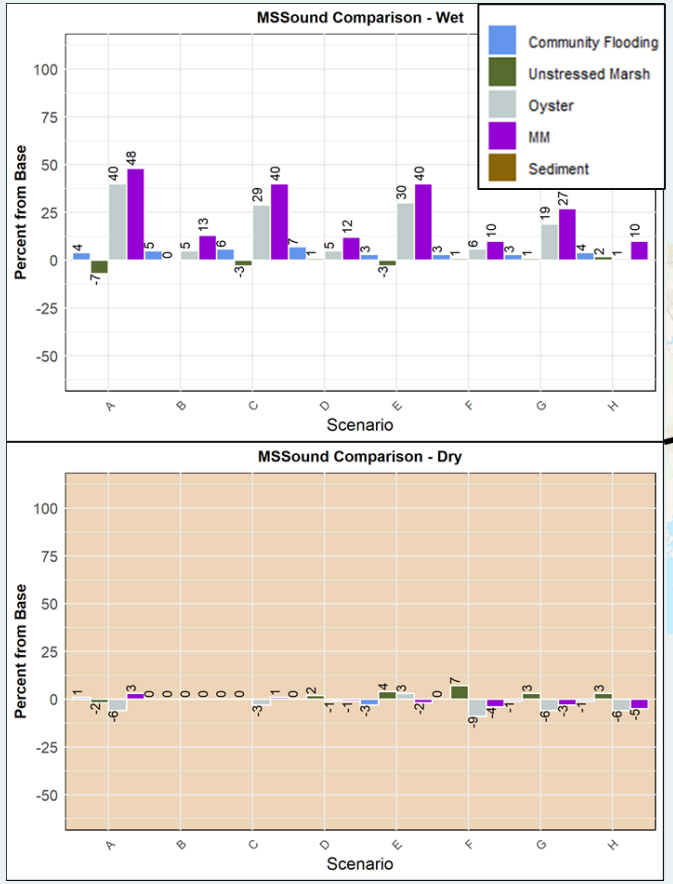
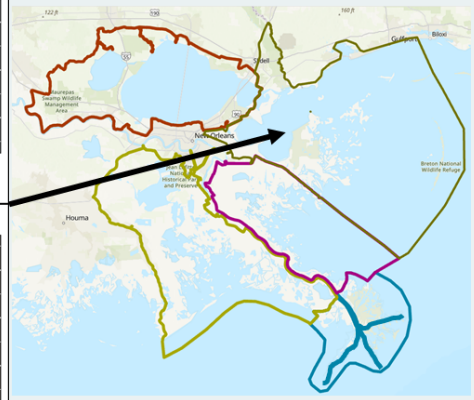
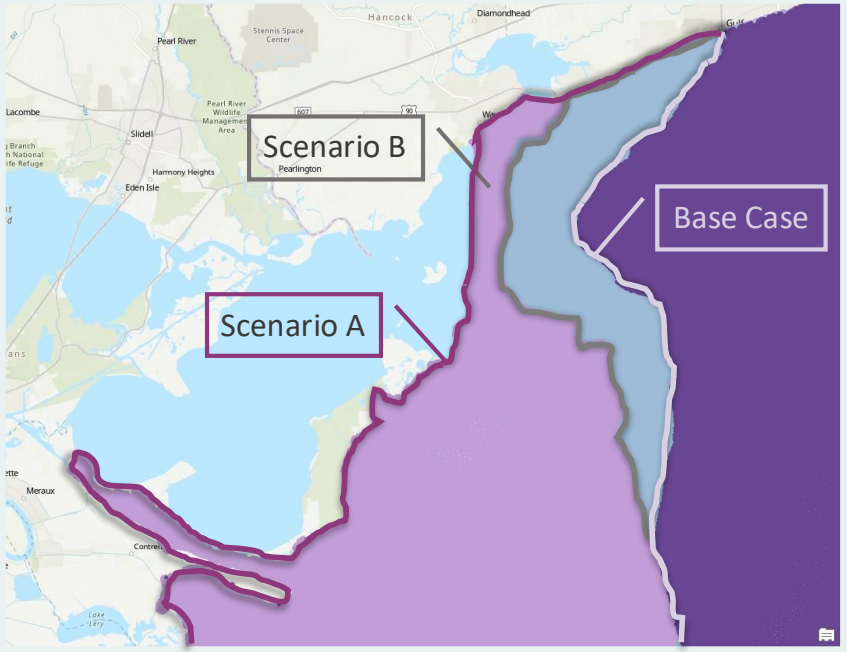
Results







Wet Year Marine Mammal Suitability

Scenario B (Morganza): with ~ 115,000 more acres equating to 13% improved from base case

Scenario A (Morganza +Lower Pass Closure):~ 430,000 more acres equating to 48% improved from base case.

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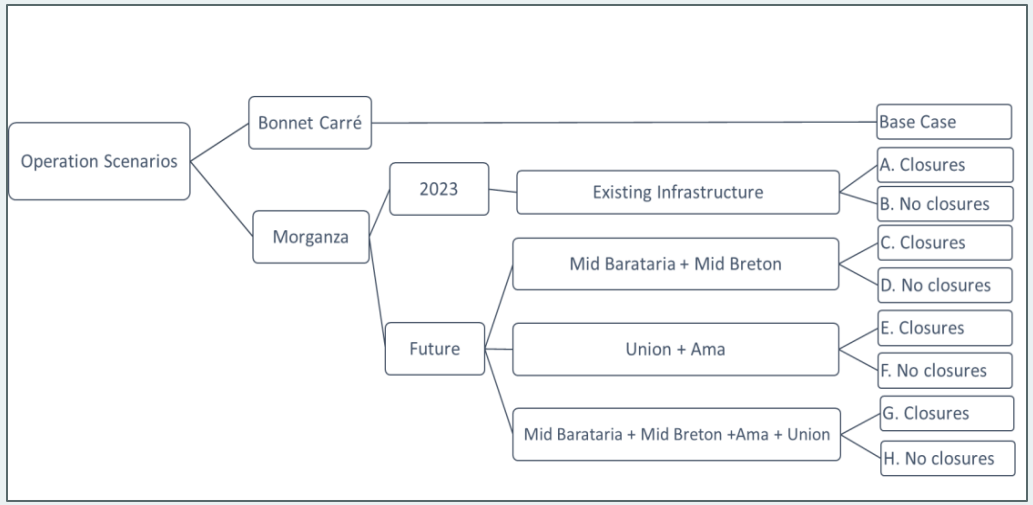
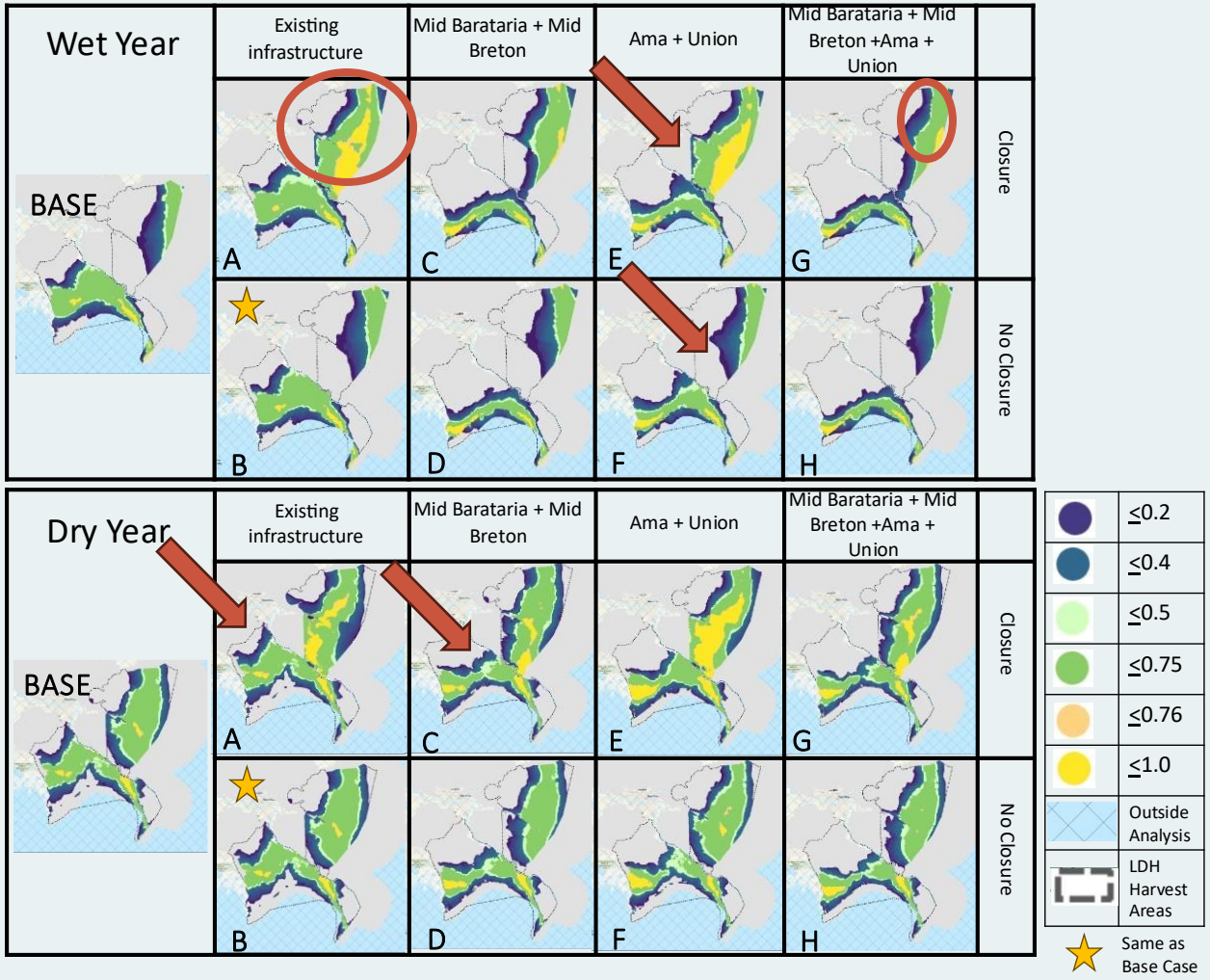
Results



Change in suitable area

- Shape (expanded/squeezed)
- Acreage (quantity)
- Location (inland/gulfward)



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Results

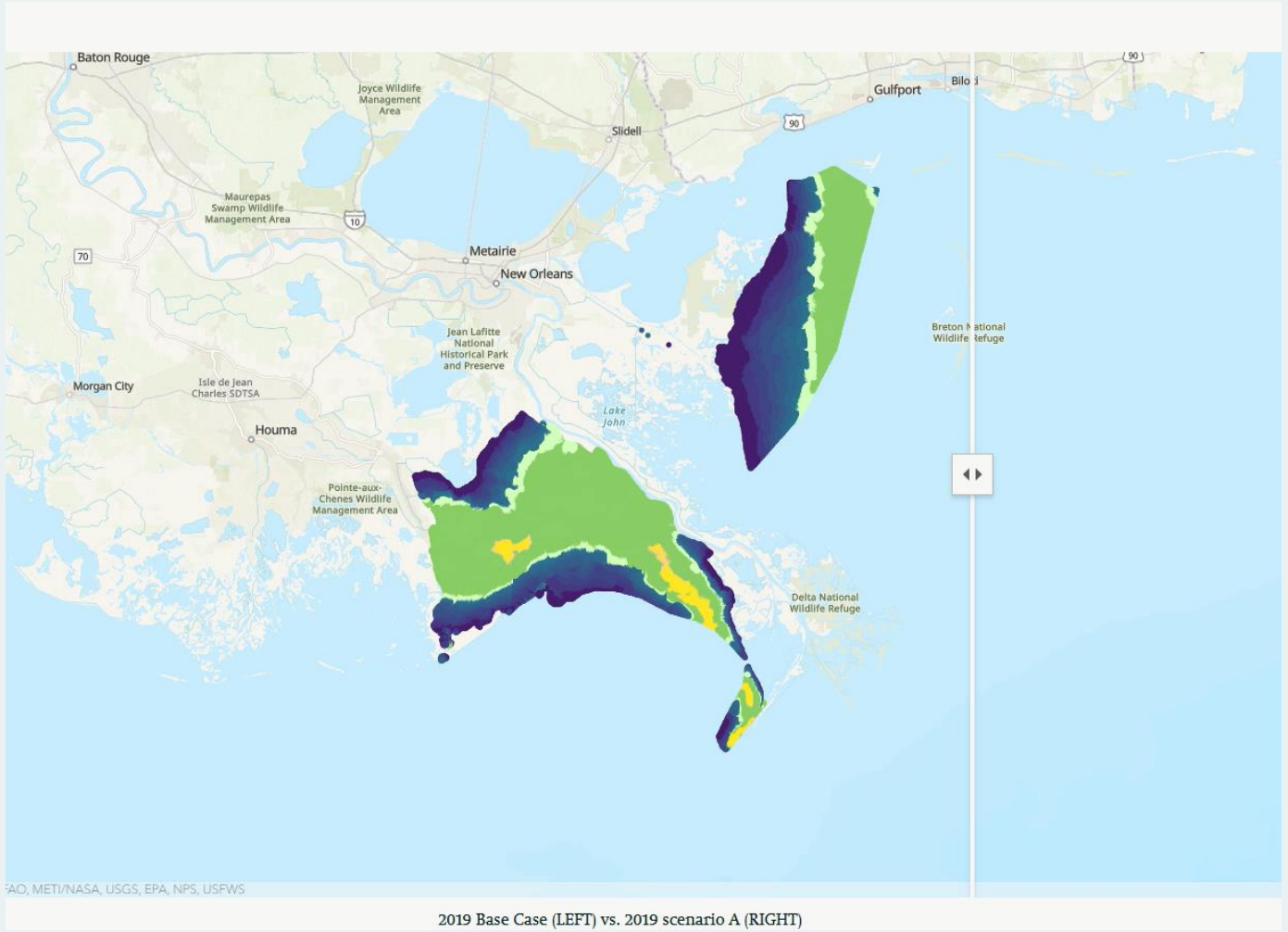
Wet Year Oyster HSI

Base Case

vs

Morganza + Lower Pass Closure

- Change in suitable area
  - Shape (expanded/squeezed)
  - Acreage (quantity)
  - Location (inland/gulfward)



2019 Base Case (LEFT) vs. 2019 scenario A (RIGHT)

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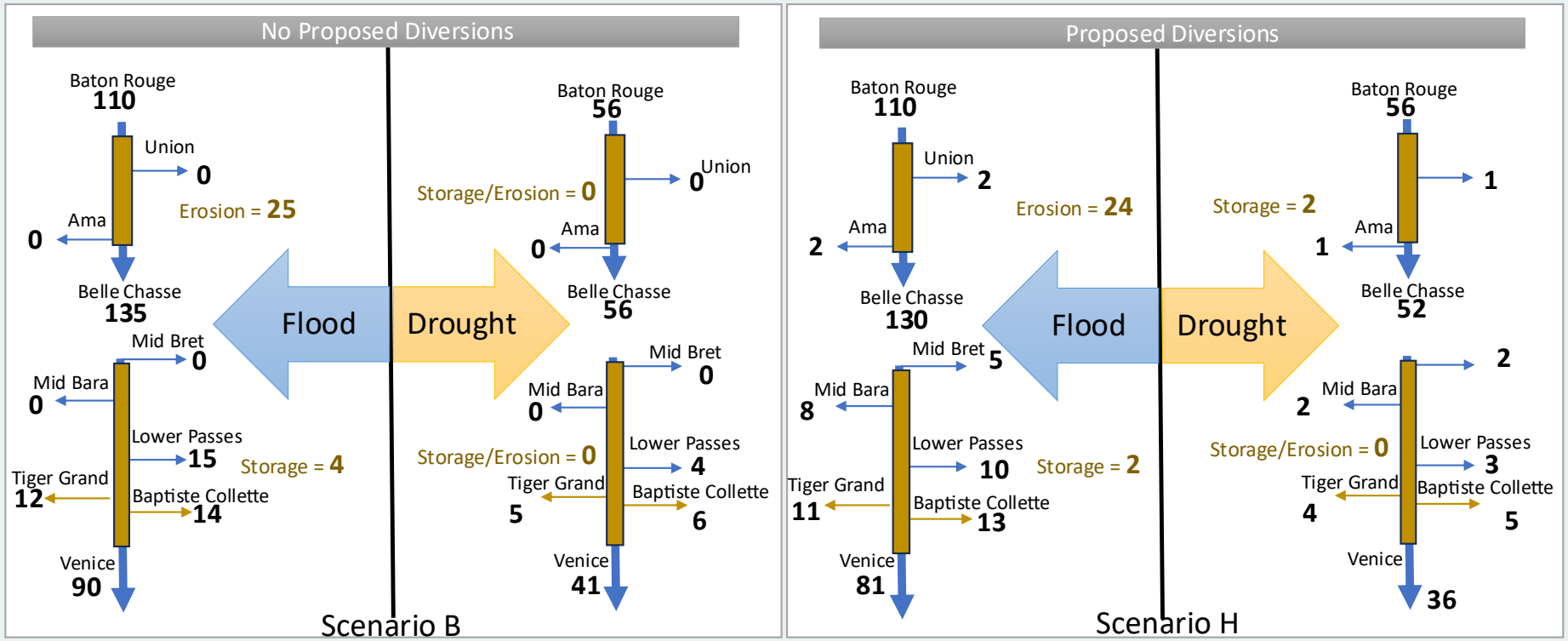
Results

Total Annual Suspend Load (10^6 Metric Tons/y)



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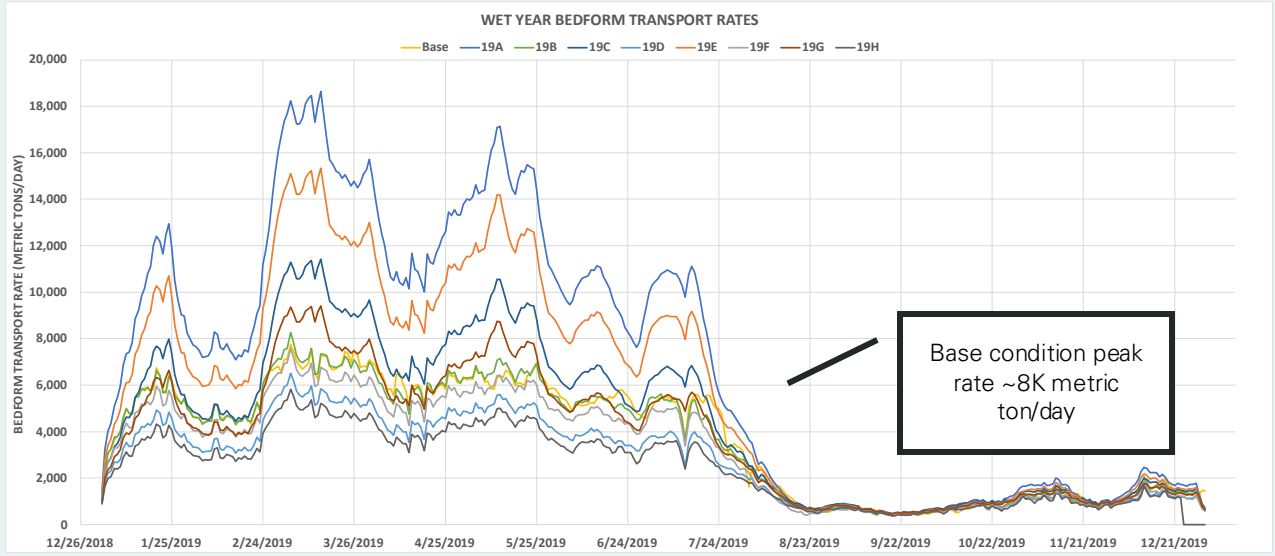
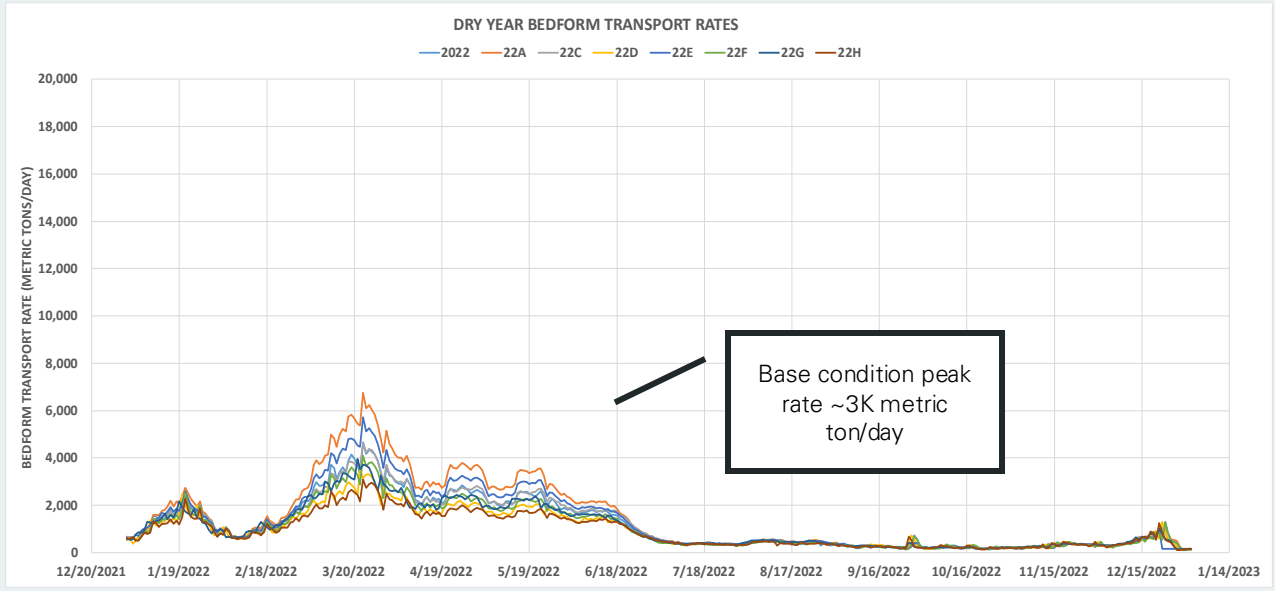
Results

- Most extreme cases (scenario H) decrease transport rate by ~35% for the wet year hydrographic conditions
- In scenario G (red), with all proposed diversions operating and an entire closure of natural passes on the river's east side, the hydraulics conditions revert to the base-case(yellow) conditions.





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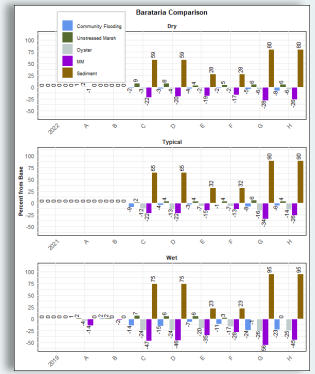
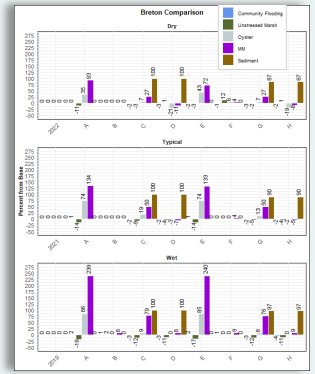
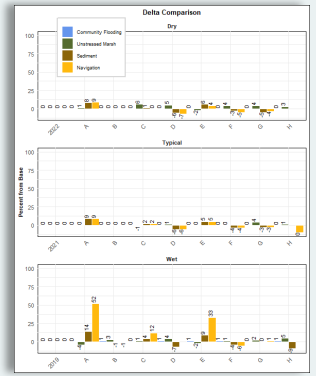
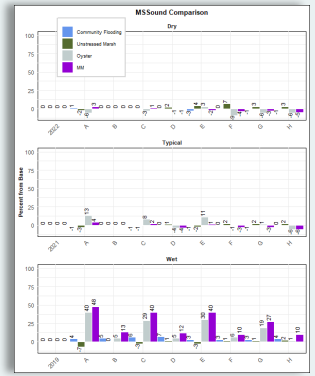
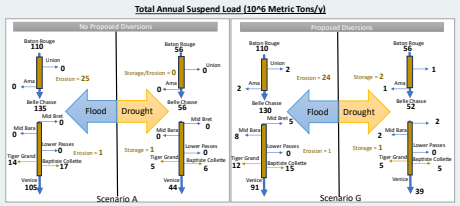
Results: Database

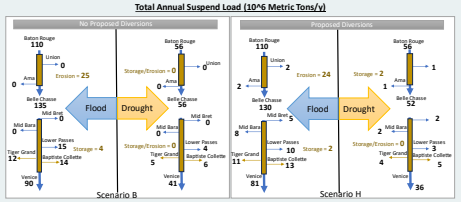


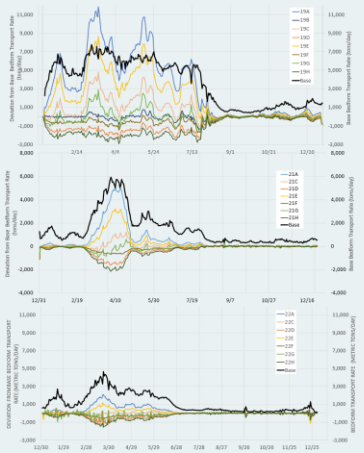












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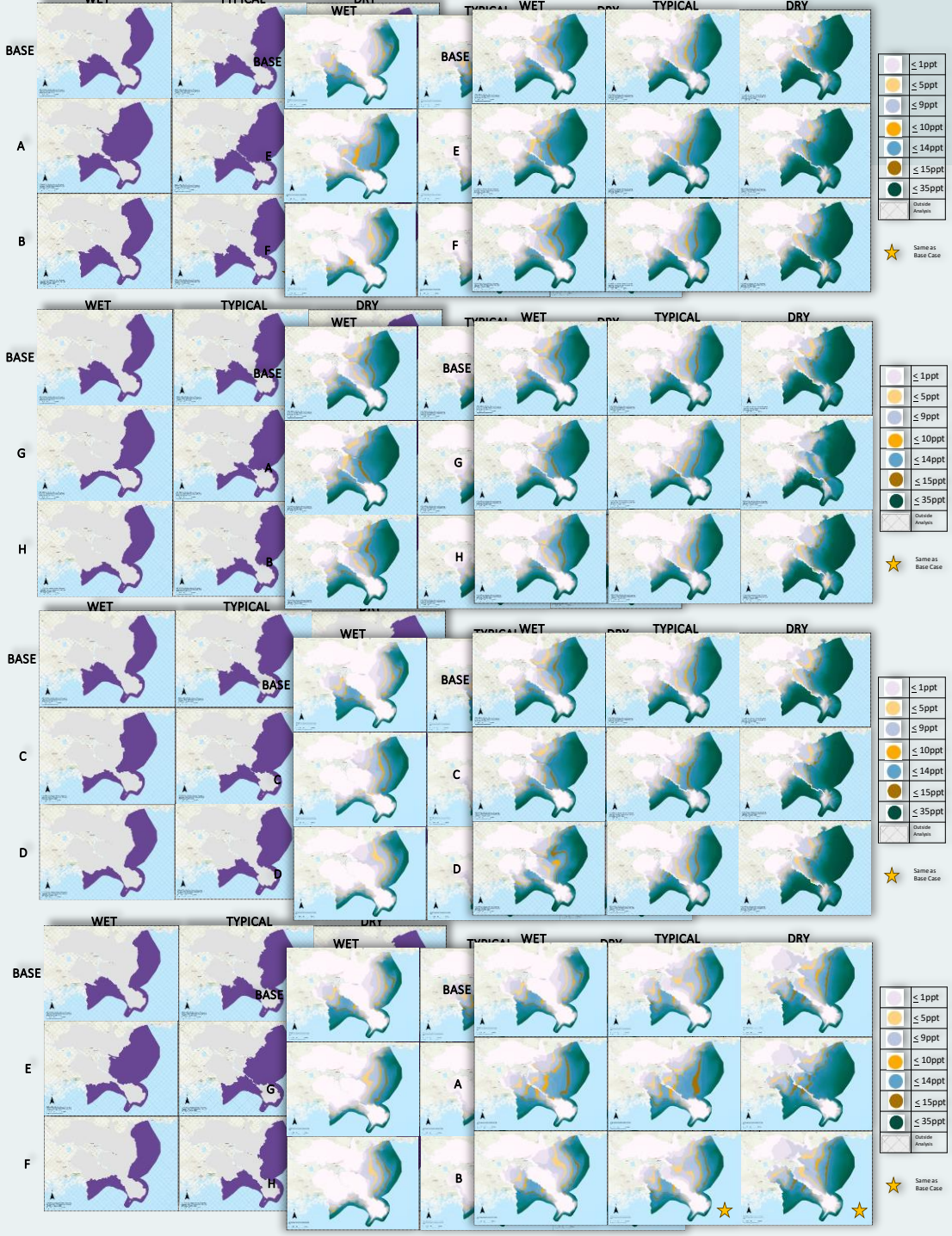

Story map of study →

What did we learn?

1. Natural Hydrology primary factor in basin conditions
2. Achieve similar response in scored metrics with different operational tactics
3. Big Picture Tool to turn knobs
4. Upper diversions “soak the sponge” with reduced gulf signal
5. Diversions for multiple uses
6. Formalized adaptive management of diversion structures
7. Increase monitoring on east side passes

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Future Research

Does this study provide direction for future research to continue our understanding of a "system" of diversions on the Lower Mississippi River?

- Investigation of Atchafalaya basin response to varying Morganza Spillway operations
  - Modeling partial closure strategies
  - Modeling pulsed diversion strategies
  - Modeling varying diversion capacities
- Refinement of multidisciplinary scoring approaches

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Thank you!

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