RISK REDUCTION IN LOUISIANA'S COASTAL MASTER PLAN: LAKE PONTCHARTRAIN BARRIER

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The State of Louisiana (LA) Coastal Protection and Restoration Authority (CPRA) conducts extensive analytical modeling and project evaluations across an expansive coastal region along the Gulf of Mexico as part of updates to the State's Comprehensive Master Plan for a Sustainable Coast (also known as Coastal Master Plan; CMP) on 5-year recurring intervals. The 2017 CMP includes a combination of 45 risk reduction and 79 coastal restoration projects with projected construction and implementation over a 50-year period through 2065 at a projected cost of $50 billion dollars. Risk reduction includes 13 structural and 32 non-structural projects. Structural risk reduction projects consist of continuation of new construction and maintenance of an extensive system of earthen levees, flood walls, flood gates, and pump stations. Non-structural projects consist of a combination of acquisition, elevating, and flood-proofing of residential and commercial structures within projected coastal storm flood risk areas. The Lake Pontchartrain Barrier structural risk reduction project has projected one of the highest cost-effectiveness (CE) values of all CMP projects. This paper will focus on hydrodynamic and risk reduction modeling performed to evaluate a series of conceptual design alternatives for the Lake Pontchartrain Barrier (LPB).

Keywords: risk reduction; hydrodynamic modeling; risk reduction project alternative analysis and modeling

INTRODUCTION

The Louisiana coastal zone, highlighted in Figure 1 by the dashed line, has one of the highest land loss rates in the world. Land elevations are extremely low and highly vulnerable to destructive impacts from tropical storms and hurricanes. Extensive efforts and resources have been expended over the past 10 plus years in response to the high land loss and flood risk.

Figure 1. Location map of Louisiana Coastal Zone.

Louisiana Coastal Master Plan

The map in Figure 2 highlights projects constructed, under construction, and planned since 2007 after identification and evaluation through the State's CMP. Project funding is generally split evenly between risk reduction projects and restoration projects. The CMP analysis process for evaluating potential protection and restoration projects for inclusion into the Plan consists of a complex integrated

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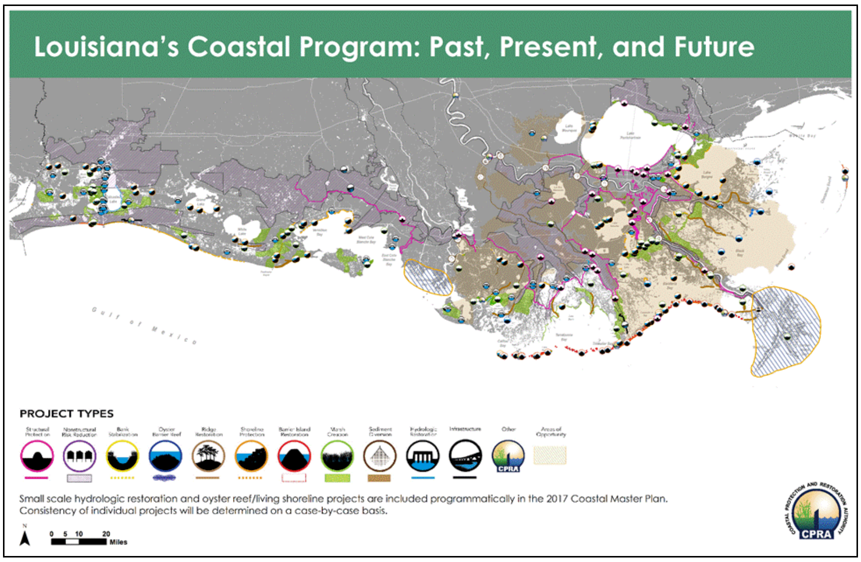

Figure 2. Cumulative map of Louisiana coastal restoration and risk reduction projects since 2007.

modeling system of physical and environmental processes across the State's entire coastal zone.

The map in Figure 3 shows existing and proposed structural risk reduction projects. Orange lines are existing structural risk reduction projects including Federally-constructed levees to prevent flooding along the Mississippi and Atchafalaya Rivers and extensive levee systems encircling the City of New Orleans. The magenta lines are proposed structural risk reduction projects included in the 2017 CMP, both new construction and maintenance, and including flood gates shown in black.

Figure 3. Existing and proposed structural risk reduction projects including planned Lake Pontchartrain Barrier.

Lake Pontchartrain Barrier Project Evaluation

The remainder of this paper will look at a proposed Lake Pontchartrain Barrier structural risk reduction project east of New Orleans along what is known as the New Orleans East Land Bridge. The project location is highlighted in Figure 3 with Lake Pontchartrain to the west and Lake Borgne which opens into the Gulf of Mexico to the east.

A more detailed view of the East Land Bridge is shown in Figure 4 depicting a narrow, low strip of land separating Lake Borgne from Lake Pontchartrain which provides land-based corridors for U.S. Highway 90 and a CSX railway line. Two tidal inlets cut through the Land Bridge connecting Lake Borgne and Lake Pontchartrain, Pass Rigolets shown in the upper right in Figure 4, and Chef Menteur Pass shown in the lower left.

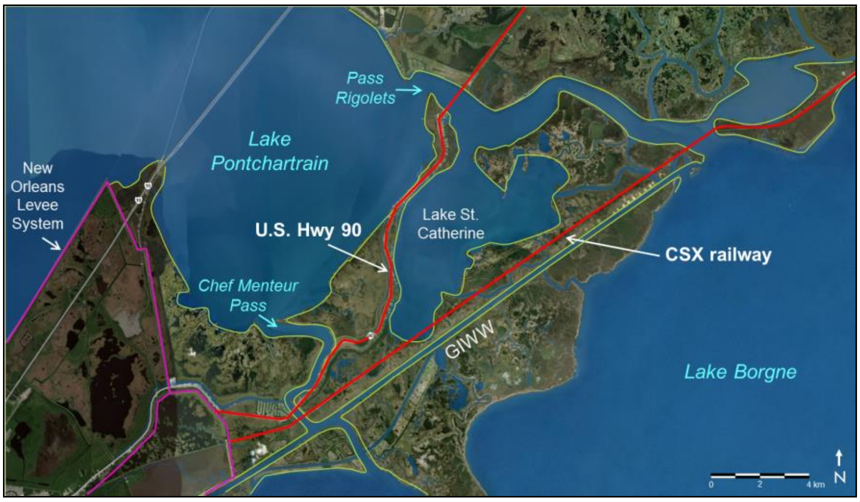

Figure 4. LPB study area site location along the New Orleans East Land Bridge.

Consideration and studies for a flood barrier across the Land Bridge by the U.S. Army Corps of Engineers go as far back as the late 1960's, as shown in Figure 5, and then in more earnest following Hurricane Katrina in 2005.

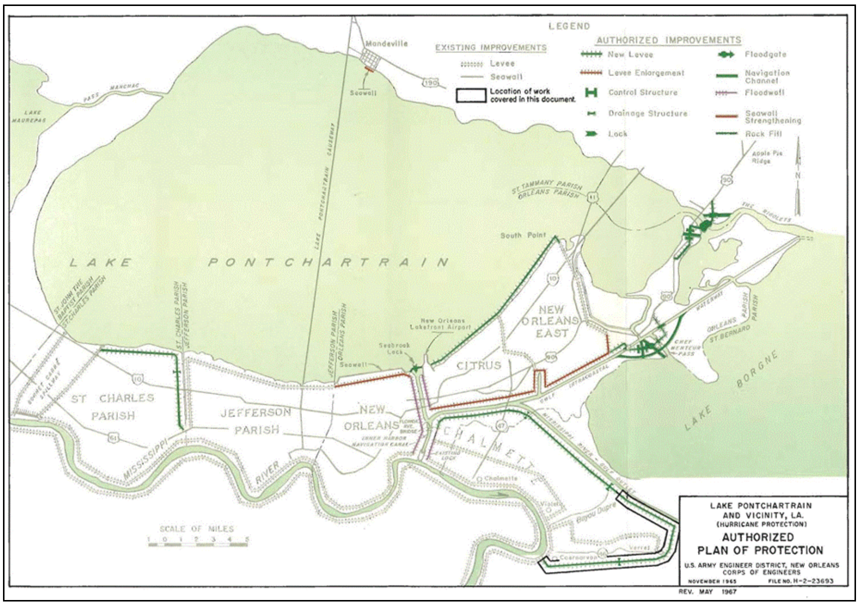

Figure 5. Proposed 1965 protection plan by U.S. Army Corps of Engineers along N.O. East Land Bridge.

The State of Louisiana looked at two possible Lake Pontchartrain Barrier alternatives in the 2012 CMP, both along the Highway 90 corridor, including 7.5m and 10m high alternatives. Both ranked high in terms of cost effectiveness, so the 2012 plan approved further analysis to see if a lower levee height could provide significant risk reduction to development surrounding Lake Pontchartrain, including New Orleans, while minimizing induced flooding to areas outside the barrier within Louisiana and to coastal areas within the State of Mississippi to the east.

MODELING AND PROJECT ALTERNATIVE ANALYSES

Hydrodynamic and Risk Reduction Modeling

Preliminary studies for the 2017 CMP included hydrodynamic modeling with the ADCIRC and SWAN models by ARCADIS and risk and damage reduction modeling with CLARA, which is the Coastal Louisiana Risk Assessment model, by the RAND Corporation. LPB project-specific analyses included detailed regional storm surge and wave simulations obtained from coupled ADCIRC-SWAN modeling driven with a subset of selected synthetic storms. Projections of potential Future With Project (FWP) performance results were compared to Future Without Action (FWOA) projections over a 50-year study period. Two phases of the modeling included, first, optimization/sensitivity runs with ADCIRC and SWAN to screen a relatively greater number of alternatives with a smaller number of storms, and secondly, production runs with fewer selected alternatives and a larger number of storms, and with flood risk and damage output from CLARA.

Storm selection for optimization runs included 10 storms from the Federal Emergency Management Agency (FEMA) 446 synthetic storm suite used for the 2012 CMP which produced 100-year storm surge and wave conditions in the New Orleans East Land Bridge area. The production runs included 77 storms for developing storm statistics for the CLARA model and providing more variety of wind speeds, pressures and track directions.

The upper map in Figure 6 depicts the expanded CLARA model domain for 2017 in blue compared to the 2012 model domain shown in purple. Higher resolution grids were developed for ADCIRC, SWAN, and CLARA for the 2017 CMP, as well as higher resolution asset information for the CLARA model shown in the lower map in Figure 6.

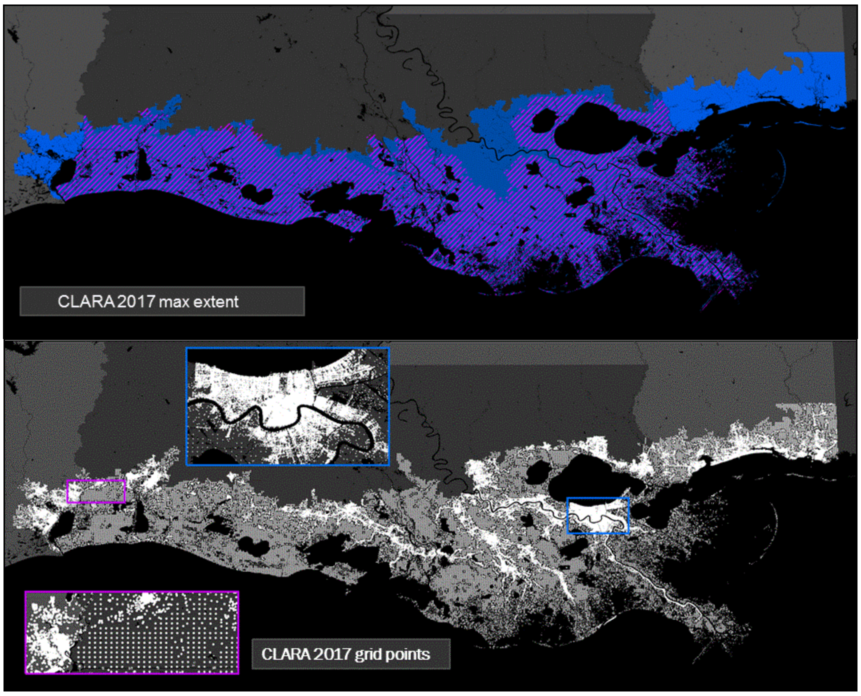

Figure 6. Map of 2017 CLARA model domain (in blue) vs. 2012 (in purple) (top); map of 2017 asset grid for CLARA model (bottom).

Initial Project Alternative Screening

The initial screening ADCIRC-SWAN model runs included a FWOA alternative and 12 project alternatives following two potential alignments, along Highway 90 and the CSX railway, and a range of flood gate heights at the two tidal passes and barrier heights listed in Table 1. The screening alternatives all connected to existing New Orleans levee systems to the west with various connections to the east, including connections to existing levees at the City of Slidell shown in Figures 7 and 8.

Table 1. Initial LPB Modeled Alternatives including Future Without Action plus 12 Project Alternatives.

Alternative ID	Location	Gate Hts	Barrier Hts
1.FWOA	NA	NA	No Change
2.HWY90	Highway90	4m	No Change
3.HWY 9010	Highway90	4m	3m
4.HWY90 MP	Highway90 toMP	4m	3m
5.HWY90Slidell	Highway90 to Slidell	4m	3m
6.HWY90G2	Highway90	0.6m	No Change
7.HWY90G4	Highway90	1.2m	No Change
8.HWY90G6	Highway90	1.8m	No Change
9.HWY90G10	Highway90	3m	No Change
10.CSX	CSX Railway	6m; 5m	No Change
11.CSX10	CSX Railway	6m; 5m	3m
12.CSX10Low	CSX Railway	3m	3m
13.CSXSlidell	CSX Railway-Slidell	6m; 5m	3m

Figure 7. Map of potential Highway 90 LPB alignment with ties to existing New Orleans and Slidell levees.

Figure 8. Map of potential CSX railway LPB alignment with ties to existing New Orleans and Slidell levees.

Surge and wave changes for each screening alternative versus FWOA were compared as plan view difference maps as shown on the lower left plot in Figure 9, with flood reduction in blue and increase in yellow to red. Comparison of flood reduction along a transect inside the East Land Bridge along the south shore of Lake Pontchartrain, as depicted on the map in the upper right of Figure 9, is shown for each alternative versus FWOA in the graph on the middle right in Figure 9. Comparison of LPB-induced flood increase along a transect outside the East Land Bridge and extending eastward along the coast of Mississippi, also depicted on the map in the upper right of Figure 9, is shown in the graph on the bottom right of Figure 9. As shown, the LPB-induced flood increase rapidly decreases from the Louisiana-Mississippi state boundary at the Pearl River Basin eastward along the coast of Mississippi. Flood increase ranges from 0.1 to 0.2m at the Pearl River/state boundary location and shows rapid decrease eastward with corresponding 100-year storm flood increase of approximately 3% compared to FWOA at the state boundary dropping rapidly eastward.

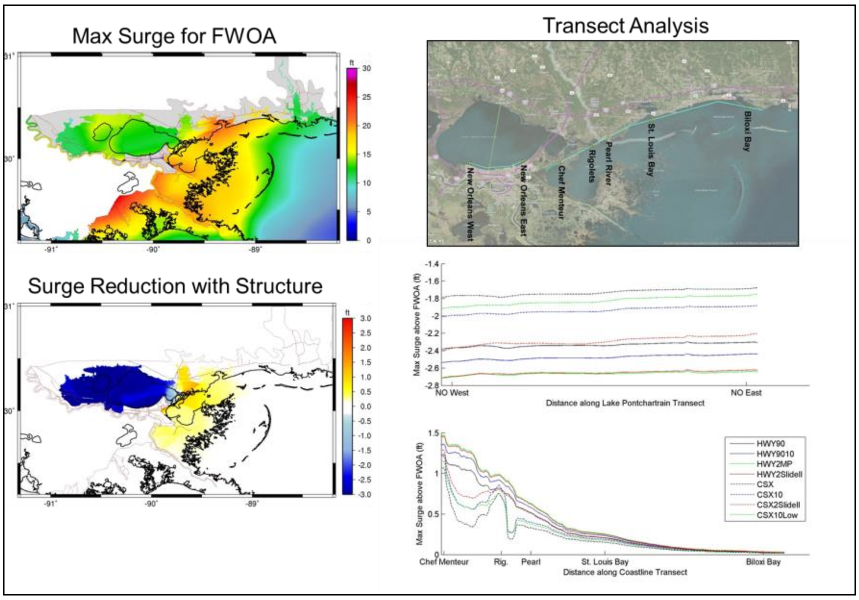

Figure 9. Examples of plan view difference map and transect analyses of LPB alternative screening.

Final Project Alternative Modeling and Analyses

Five final project alternatives plus FWOA listed in Table 2 were compared in production model runs including four alternatives along the Highway 90 alignment previously shown in Figure 7 and one alternative along the CSX alignment previously shown in Figure 8. Project alternatives along Highway 90 include a low alternative with 0.6m gates only, a high alternative with 7.5m gate and barrier heights, and two moderate alternatives with 3m barrier heights but only one with gates, at 3m height. The alternative along the CSX alignment includes moderate barrier and gate heights of 3m.

Table 2. Final LPB Modeled Alternatives including Future Without Action plus 5 Project Alternatives.

Alternative ID	Location	Gate Hts	Barrier Hts
1.FWOA	NA	NA	No Change
2.HWY90 Low	Highway90	0.6m	No Change
3.HWY90 High	Highway90 to Slidell	7.5m	7.5m
4.HWY90 Mod	Highway90 to Slidell	3m	3m
5.HWY90 NoG	Highway90 to Slidell	NoGates	3m
6.CSX Mod	CSX Railway-Slidell	3m	3m

Comparison of the 5 final project alternatives is shown in Figure 10 as flood depth difference plots vs. FWOA, shown on the upper left. A surprising outcome shown in the top middle plot is the significant flood reduction with the "low-gates only" alternative and the low induced flooding outside the Land Bridge. Conversely, the "high barrier and gates" alternative on the upper right shows much greater flood reduction inside the barrier, but very high induced flooding outside the barrier. The two moderate barriers on the bottom left and bottom right show similar more moderate results. The moderate “no-gates” alternative shown in the bottom middle was dropped as ineffective.

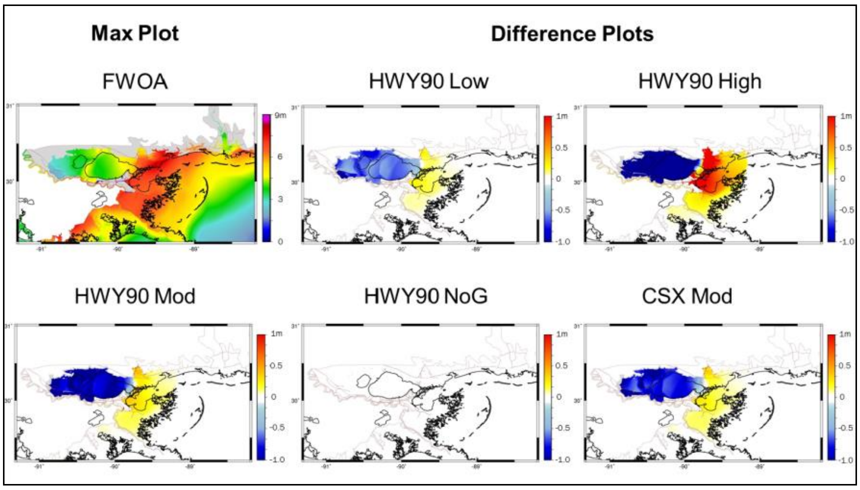

Figure 10. Flood elevation difference plots for 5 LPB final alternatives vs. FWOA.

Storm Damage Risk Reduction Modeling

Parishes in Louisiana and three coastal counties in Mississippi are shown in Figure 11 for which flood depths and asset damages from the CLARA risk reduction assessment model were compiled for comparison of alternatives.

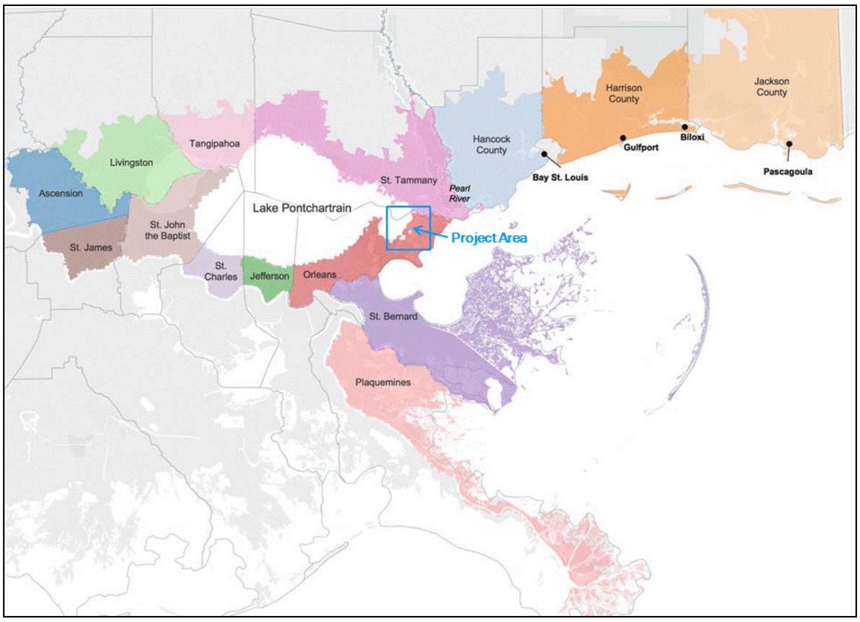

Figure 11. Parishes in Louisiana and counties in Mississippi included in CLARA modeling analyses.

The CLARA model analyses included statistical analyses to obtain flood depths for specific storm return intervals. A map depicting 100-year return period storm flood depths for FWOA from the CLARA model for the study region is shown in Figure 12 with lower depths in blue color shades and higher depths in red shades. The four remaining FWP alternatives, minus the “no-gates” alternative, were selected for risk reduction modeling with the CLARA risk reduction assessment model. Difference maps depicting 100-year return period storm flood depths for each of the four final FWP alternatives versus FWOA flood depths are shown in Figure 13. Areas of net flood reduction are shown in green shades while project-induced flood increases are shown in red shades. The “low gates only” alternative is shown on the upper left, the “high barrier and gates” alternative is shown on the upper right, and the two moderate alternatives are shown on the bottom left for the Highway 90 alignment and on the bottom right for the CSX alignment.

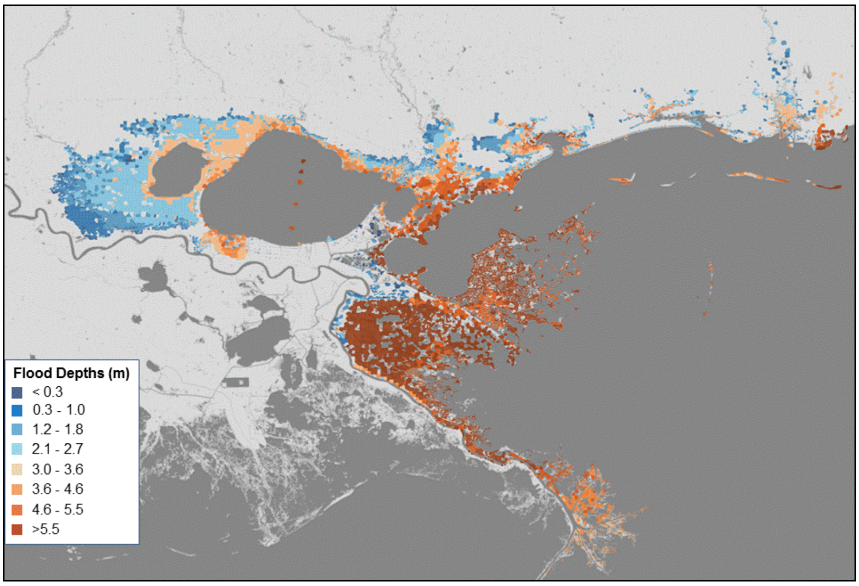

Figure 12. Flood depths for 100-year storm return period conditions for the CLARA modeling study region.

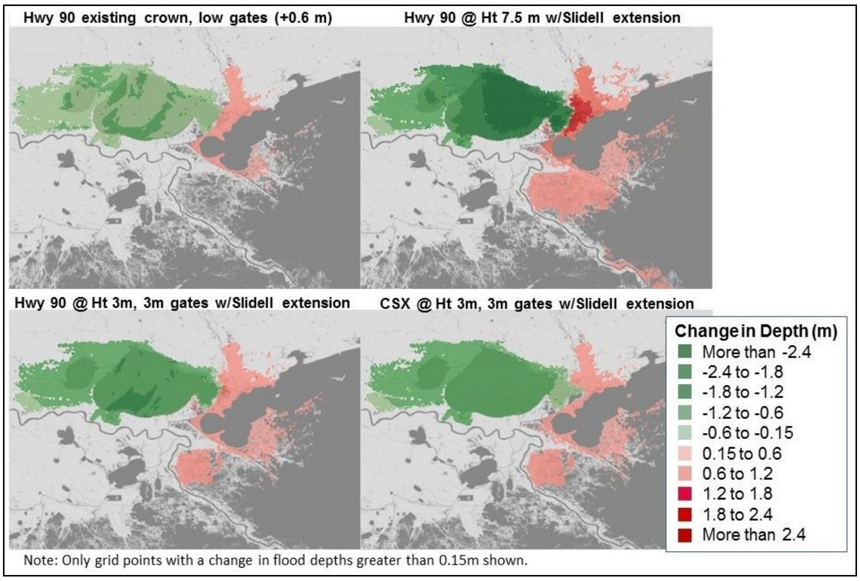

Figure 13. Difference map comparison of flood depths for the final four project alternatives vs. FWOA from the CLARA model.

Comparison of expected annual damages (EAD) for Louisiana parishes within the study region is shown in Figure 14 for FWOA, on the left in Figure 14, and the final 4 alternatives. Reduction in EAD is observed for each of the project alternatives compared to FWOA. Induced flooding damages have been included in the EAD computations for each project alternative, so net damage reduction is shown here.

Again surprisingly, the “low gates only” alternative, 2nd from the left, shows significant damage reduction, essentially the same as or very similar to the other three higher alternatives. The EAD for the “low gates only” alternative is shown to be \$2.0 billion compared to \$3.2 billion for FWOA, an EAD reduction of \$1.2 billion. Color differences shown for FWOA and the four project alternatives in Figure 14 are for different regional locations around Lake Pontchartrain.

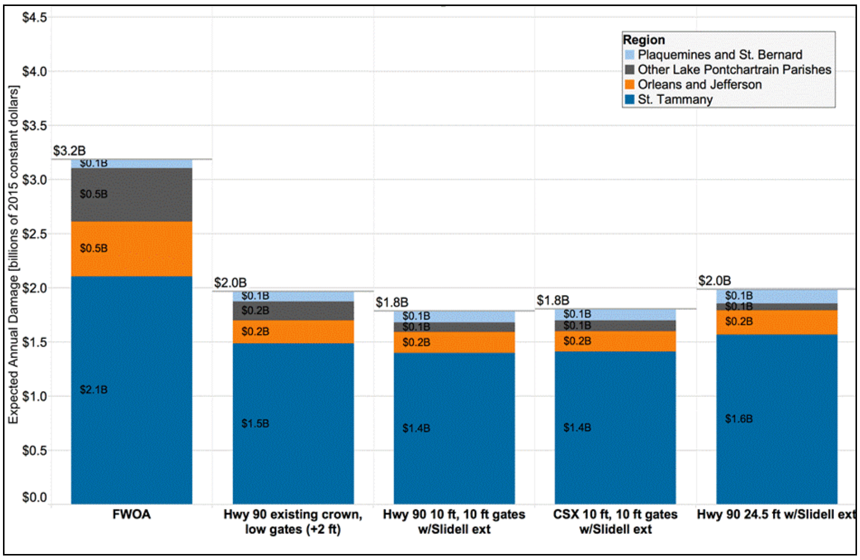

Figure 14. Comparison of expected annual damage (EAD) for the four final project alternatives vs. FWOA from the CLARA model for Louisiana parishes within the study region.

Further comparison of EAD reduction for the final 4 alternatives for the LA parishes around Lake Pontchartrain is shown in Figure 15. Shown from top to bottom on the graph are parishes including St. Tammany Parish, located east of Lake Pontchartrain where the highest damage reduction is seen, Orleans and Jefferson parishes combined, and then all other parishes surrounding Lake Pontchartrain, except for Plaquemines and St. Bernard parishes combined showing net EAD increase at the bottom.

The “low gates only” alternative is shown as the tan bars and, again, is shown to compare very well with the other three, with the combined EAD reduction of $1.2 billion dollars. The “high barrier and gates” alternative is shown as the blue bars and shows essentially the same combined EAD reduction as the “low gates only” alternative, lower than expected as a result of offsetting induced flooding damages.

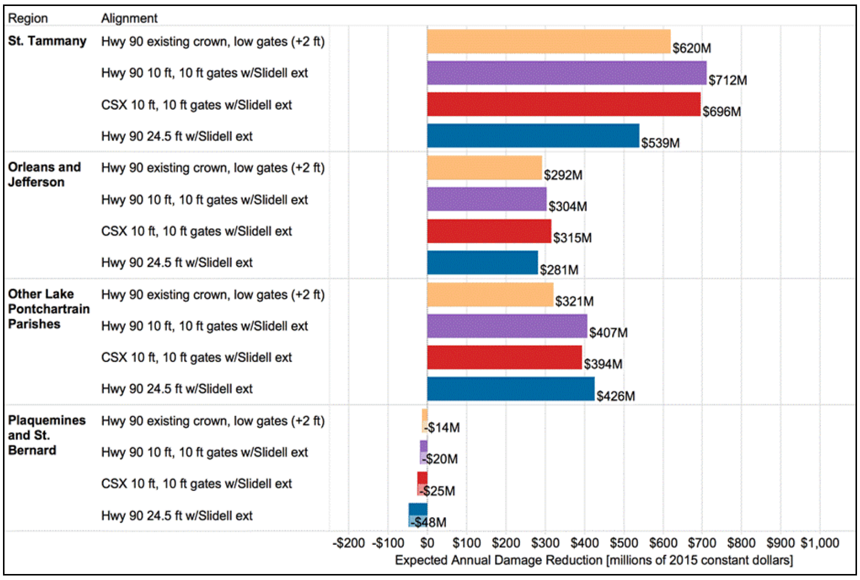

Figure 15. Comparison of expected annual damage (EAD) reduction for the four final project alternatives vs. FWOA from the CLARA model for Louisiana parishes within the study region.

Comparison of EAD increases for the three coastal counties in Mississippi is shown in Figure 16, with the top graph portion being the western-most county closest to Louisiana and the middle and bottom graph portions extending further eastward. It is noted that the horizontal scale in Figure 16 is

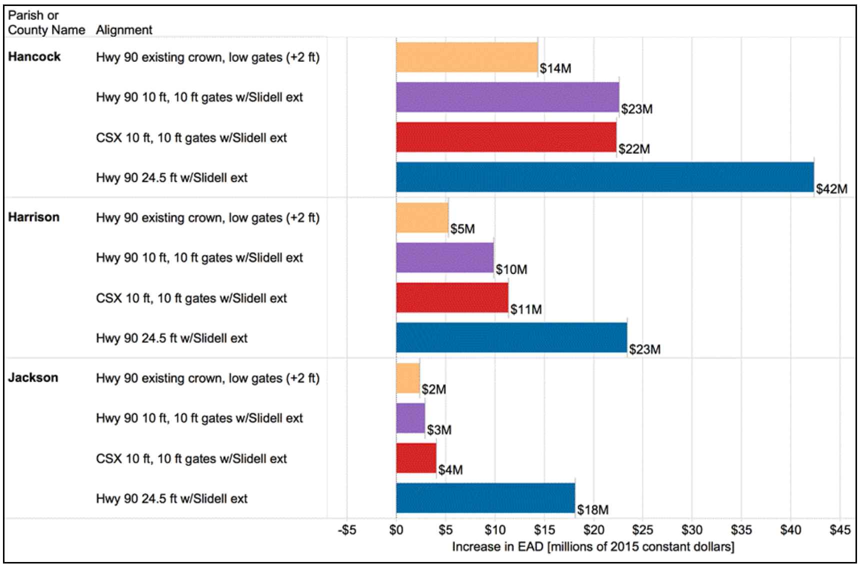

Figure 16. Comparison of expected annual damage (EAD) increase for the four final project alternatives vs. FWOA from the CLARA model for the 3 Mississippi coastal counties within the study region.

in millions of dollars versus billions of dollars shown in Figure 15. This clearly shows the lowest induced damages from the "low gates only" alternative in tan with a combined EAD increase of $21 million. The highest induced damages are seen from the "high barrier and gates" alternative in blue with a combined EAD increase of $83 million.

CONCLUSIONS

The State of Louisiana has conducted extensive hydrodynamic and risk reduction modeling in conjunction with the State's 2017 Coastal Master Plan to identify a cost-effective Lake Pontchartrain Barrier project alternative with the highest risk reduction and lowest project-induced flooding impacts. Based on results of these modeling studies, the "low gates only" alternative ranked highest in terms of damage risk reduction benefits versus potential induced damage risk impacts and was moved forward for inclusion into the 2017 CMP. Implementation scenarios and available funding will determine next steps for moving into more detailed feasibility analysis, and if favorable, engineering & design.

ACKNOWLEDGEMENTS

The authors acknowledge support and funding from the State of Louisiana's Coastal Protection and Restoration Authority of Louisiana for the study work presented in this paper .

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