2023 COASTAL MASTER PLAN

PREDICTIVE MODELS TECHNICAL ADVISORY COMMITTEE (PM-TAC) REPORT

ATTACHMENT C1

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COASTAL PROTECTION AND
RESTORATION AUTHORITY
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COASTAL PROTECTION AND RESTORATION AUTHORITY

This document was developed in support of the 2023 Coastal Master Plan being prepared by the Coastal Protection and Restoration Authority (CPRA). CPRA was established by the Louisiana Legislature in response to Hurricanes Katrina and Rita through Act 8 of the First Extraordinary Session of 2005. Act 8 of the First Extraordinary Session of 2005 expanded the membership, duties, and responsibilities of CPRA and charged the new authority to develop and implement a comprehensive coastal protection plan, consisting of a master plan (revised every six years) and annual plans. CPRA's mandate is to develop, implement, and enforce a comprehensive coastal protection and restoration master plan.

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- Courtney K. Harris – Virginia Institute of Marine Science, Department of Physical Sciences
- Wim Kimmerer – San Francisco State University, Estuary and Ocean Science Center
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Portions of this report were drafted with the assistance of ChatGPT.

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LIST OF ABBREVIATIONS

CEJST ..... CLIMATE AND ECONOMIC JUSTICE SCREENING TOOL
CLARA .....COASTAL LOUISIANA RISK ASSESSMENT MODEL
CPRA ..... COASTAL PROTECTION AND RESTORATION AUTHORITY
CRMS ..... COASTWIDE REFERENCE MONITORING SYSTEM
EADD.....EXPECTED ANNUAL DAMAGE IN DOLLARS
EASD ..... EXPECTED ANNUAL STRUCTURAL DAMAGE
FEMA .....FEDERAL EMERGENCY MANAGEMENT AGENCY
HSI ..... HABITAT SUITABILITY INDEX
ICM .....INTEGRATED COMPARTMENT MODEL
OMAR .....ORGANIC MATTER ACCUMULATION RATES
PM-TAC.....PREDICTIVE MODELS TECHNICAL ADVISORY COMMITTEE

1.0 INTRODUCTION

The goals and objectives of the Louisiana Coastal Master Plan center around supporting Louisianans by reducing land loss and flood risk. To this end, the Coastal Protection and Restoration Authority of Louisiana's (hereafter CPRA) planning process relies on predictive computer models to project how the coast changes in response to climate change and other factors to support regional project prioritization and decision-making. In developing the 2023 Coastal Master Plan, the master plan team made use of a suite of vetted and scientifically sound models to project future land change, ecological processes, coastal flooding and risk to infrastructure and people. The reader is referred to Chapter 3 of the 2023 Coastal Master Plan (and related appendices) for additional details on the predictive models (CPRA, 2023).

In 2019, a six-member Predictive Models Technical Advisory Committee (PM-TAC) was established by CPRA to support CPRA's development of Louisiana's 2023 Coastal Master Plan. The PM-TAC's role was to provide expert guidance and recommendations to CPRA's team of scientists, engineers, and planners throughout the 2023 planning cycle. Collectively, PM-TAC members' expertise spans the physical, biological and social sciences and engineering. PM-TAC members, their affiliations and their expertise are given in Table 1.

Table 1. PM-TAC Members and Expertise

Name	Affiliation	Expertise
Jennifer L. Irish (Chair)	Virginia Tech. The Charles E. Via, Jr. Department of Civil & Environmental Engineering and Center for Coastal Studies	Coastal engineering, coastal flooding, nature-based infrastructure, disaster resilience
Samuel Brody (served from 2019-2021)	Texas A&M Galveston. Department of Marine & Coastal Environmental Science	Coastal environmental planning, flood mitigation, disaster relief
Courtney K. Harris	Virginia Institute of Marine Science. Department of Physical Science	Sediment transport, numerical modeling of continental shelves and estuaries.
Wim Kimmerer	San Francisco State University. Estuary and Ocean Science Center	Aquatic ecosystems, estuarine biology, ecology, physical-biological interactions
Matthew Kirwan	Virginia Institute of Marine Science. Department of Physical Science	Wetland geomorphology and ecology. Coastal response to sea level rise.
A.R. Siders (served from	University of Delaware. Disaster Research Center	Climate change adaptation policies, managed retreat,

Name	Affiliation	Expertise
2021-2023)		community adaptation, governance
Mark Stacey	University of California Berkeley. Department of Civil & Environmental Engineering	Coastal and estuarine fluid mechanics, sea level rise in estuaries, human infrastructure and resilience

Between May 2019 and May 2023, the PM-TAC and CPRA held biannual primary meetings (8 meetings). These primary meetings were generally one-day and in person, except when COVID-19 travel precautions warranted a virtual format. In preparation for the primary meetings, the master plan team provided pre-meeting materials and discussion questions. Primary meetings typically comprised both presentations by the master plan team and time for the PM-TAC and CPRA to discuss challenges and opportunities. Primary meetings also included a closed-door PM-TAC only session to provide time for the PM-TAC to prioritize and further discuss key recommendations. In addition, the primary meetings were supplemented by virtual meetings. These secondary virtual meetings typically occurred once prior to each primary meeting.

Following each primary meeting, the PM-TAC developed a written report. These written reports were organized according to the CPRA-provided discussion questions and included bullet points summarizing PM-TAC members' observations and recommendations.

The purpose of this final PM-TAC report is threefold. First, this report highlights PM-TAC recommendations related to the 2023 planning process, the resulting advances to the predictive modeling and planning process, and final PM-TAC reflections. This section also highlights key recommendations made that were not implemented in the 2023 cycle due to staffing constraints, lack of observational data and/or the COVID-19 pandemic. Second, the PM-TAC offers recommendations and opportunities for the 2029 planning cycle. Finally, the PM-TAC provides feedback on the PM-TAC process for the 2023 planning cycle and identifies opportunities to enhance the PM-TAC process in the future planning cycles.

2.0 PROGRESS IN PREDICTIVE MODELING

Throughout the PM-TAC's engagement with CPRA, the talent and commitment of the master plan team to develop the predictive modeling framework and provide useful planning guidance were evident. The master plan team acknowledged room for improvement and welcomed PM-TAC feedback. This section highlights key recommendations from the PM-TAC, made between 2019-2023, aimed at enhancing predictive modeling activities during the 2023 planning cycle. It considers recommendations made in the areas of risk modeling, landscape modeling, future scenario selection, and communication.

2.1 RISK MODELING

To support project selection, CPRA models risk using the Coastal Louisiana Risk Assessment (CLARA) model. CLARA estimates flood depth exceedances, direct economic damage exceedances, and expected annual damage in Louisiana's coastal zone (see Appendix E: Overview of Improvements to Risk Modeling [ADCIRC+SWAN, CLARA] for 2023). CLARA uses outputs from high-resolution hydrodynamic simulations of storm surge and waves, and applies Monte Carlo simulation to assess risk across various assumptions about future conditions and with/without different projects. CLARA outputs were used within the Planning Tool to guide project selection.

GROUNDBREAKING ADVANCEMENT IN EQUITABLE EXPECTED DAMAGE ASSESSMENT

During the 2023 planning cycle, CPRA introduced a new risk metric called expected annual structural damage (EASD). EASD quantifies annualized structural damage as a proportion of its replacement cost. EASD thereby represented a significant step toward equally valuing lower-income and marginalized communities in the project selection process.

In its fifth report in August 2021, the PM-TAC commended CPRA for the novelty of EASD and praised their forward thinking in developing it to promote equitable decisions. The PM-TAC observed that the development of EASD by CPRA was a direct response to past criticism of the equity implications of using monetary value as the sole metric for assessing risk. The PM-TAC noted that EASD falls between a Social Vulnerability Index-dependent approach and an expected annual damage in dollars (EADD)-dependent approach. Because it made a compromise between these methods, the PM-TAC concluded that EASD did not represent either extreme, but instead struck a balance between traditional and progressive viewpoints.

Combining EASD and EADD would have required implicit or explicit weighting, but no justification for such weighting existed. The PM-TAC thus discouraged CPRA from merging both risk metrics into a

single metric. Instead, the PM-TAC stressed the importance of presenting both separately. In its 2023 planning, CPRA adopted the PM-TAC's recommendations and relied on both EASD and the traditional EADD jointly for project selection. The PM-TAC thought CPRA's use of census data after project selection, to verify that the priority suite of projects did not protect only privileged groups, was a valuable verification measure.

PM-TAC REFLECTIONS

The implementation of EASD in coastal resilience policy marked a groundbreaking advancement in project prioritization. Although widely recommended in scientific literature, the use of non-monetary or income-weighted damage assessments in practice has been rare. The development of the EASD metric therefore highlights CPRA's strong commitment to incorporating the best available social science and ensuring equitable community benefits. The joint use of EADD and EASD in project prioritization thus shifted paradigms. The development of EASD was a significant recommendation and successful addition to the 2023 planning cycle, addressing concerns regarding inequitable weighting based on dollar values alone, and contributing to equitable decision-making by considering the number and types of structures protected, including residential and commercial assets.

While the adoption of EASD represented a groundbreaking advancement, considering a more progressive damage metric in the next planning cycle would further prioritize investments in areas where damage had the potential to significantly disrupt lives and livelihoods. The impact of $10k in damage or the destruction of a building varies by family, as demonstrated by Howell and Elliott's (2019) work on the correlation between disasters and wealth inequality. EASD, while not progressive by this measure, is not regressive like EADD. Yet, the PM-TAC understands CPRA's need to continue reporting EADD alongside equity-centric metrics and reiterates that adoption of EASD within the 2023 planning process is a groundbreaking step forward in the promotion of equity in decision-making.

KEY ADVANCEMENT IN EVALUATING CRITICAL INFRASTRUCTURE RISK ASSESSMENT

During its initial meetings, the PM-TAC emphasized the significance of incorporating critical infrastructure and facilities into the master planning process. In their fourth report (February 2021), the PM-TAC recommended being more inclusive regarding critical infrastructure types and understanding the importance of different data types for stakeholders, design, and implementation. CPRA implemented these recommendations by adopting a more comprehensive inventory of critical assets and by aggregating risk to critical infrastructure in a variety of ways, depending on intended audience and interpretation needed during project selection.

Upon reflection, the PM-TAC emphasizes the importance of including the criticality of sites and access to critical infrastructure in capturing the varying degrees of damage. CPRA's consideration of critical infrastructure moves towards a more nuanced understanding of risk and acknowledgement that damage to certain structures can have far-reaching and devastating impacts on communities. CPRA's

motivation to continue advancements in this area is evident, which suggests it as an area for further exploration in the 2029 planning cycle. Continued advancements are particularly needed if CPRA adopts a more detailed evaluation of nonstructural options.

2.2 INTEGRATED COMPARTMENT MODEL (ICM)

CPRA uses a coastwide landscape model called the Integrated Compartment Model (ICM) to project land change (see Appendix D: Overview of Improvements to Landscape Modeling [ICM] for 2023). The ICM considers hydrology, water quality, morphology, and vegetation, and integrates the Habitat Suitability Index (HSI) models (see Attachment D5: ICM-HSI Model Improvements). The HSI models project habitat for more than ten fish, shellfish and wildlife species.

KEY ADVANCEMENTS

DE-EMPHASIZING MODELING OF BARRIER ISLANDS

In its sixth report (April 2022), the PM-TAC acknowledged CPRA's significant advancements in understanding the role of barrier islands within the planning process. Given that the available barrier island model did not meet CPRA's planning needs – namely that further improvements to the barrier island model would not alter conclusions regarding risk and project prioritization – the PM-TAC recommended against further model development or sensitivity testing. As a result, CPRA halted any further development of barrier island modeling for the remainder of the 2023 planning cycle. On reflection, the PM-TAC underscores the minimal influence of refining barrier island models on project prioritization. As a result, CPRA's decision to de-emphasize barrier island modeling is viewed by the PM-TAC as a prudent allocation of resources.

VARIABLE WETLANDS ORGANIC MATTER ACCUMULATION RATE

In their second report (January 2020), the PM-TAC advised comparing average observed Organic Matter Accumulation Rates (OMAR) in basins with varying land loss rates, as a positive correlation could indicate the significance of allochthonous carbon input. Though observational data is incomplete, CPRA implemented the recommendation by assigning different OMAR values based on subsidence rates along different portions of the Louisiana coast, with higher OMAR values allocated to the active Mississippi River Delta.

Upon reflection, the PM-TAC emphasizes that OMAR play a crucial role in wetland accretion, particularly in basins lacking significant mineral sediment inputs. It is well-known that OMAR increases with inundation in other regions (Rogers et al., 2019; Gonneea et al., 2019; Herbert et al., 2021). Thus, without the 2023 update to variable OMAR, the ICM potentially would lead to overestimated marsh loss with sea level rise. CPRA's solution for 2023 planning strikes a balance by considering expected process-level feedbacks while acknowledging the limitation on available observational data which must be overcome to develop a more dynamic relationship. The PM-TAC recommends that CPRA

continue to examine the OMAR relationship in the future, making necessary adjustments to the model as the Coastwide Reference Monitoring System (CRMS) data matures.

COUPLING ONE-DIMENSIONAL CHANNEL MODEL

In their third report (October 2020), the PM-TAC acknowledged the impressive progress in the development and integration of components within the ICM, particularly highlighting the advancements made in the nested one-dimensional (1D) channel modeling. On reflection, the PM-TAC notes that nesting the 1D channels smartly balanced accuracy and speed. As discussed in the PM-TAC's sixth report (April 2022), the computational load can be substantially decreased by retaining only those 1D channels that have the potential to exert a significant influence on ICM projections, and thus have the potential to influence project selection.

TABLED OPPORTUNITY TO CHARACTERIZE HABITAT SUITABILITY INDEX UNCERTAINTY

In its third report (October 2020), the PM-TAC recommended analyzing and presenting output based on impact rather than associating these impacts with specific points in time. This approach would entail scenarios reaching the same sea levels and conditions but differing in the timing. Instead of selecting scenarios, the PM-TAC's suggestion was to choose points along a trajectory. The PM-TAC acknowledged that the barrier to accomplishing such an analysis would not be computer time but rather the personnel time required for thorough data analysis. By focusing on impacts rather than trajectories, the complexity of the problem could be reduced, though this should be complementary to a time-based approach rather than a replacement. Due to staffing and schedule constraints, CPRA was unable to execute this uncertainty analysis as part of the 2023 planning cycle but is considering implementing this analysis as part of the upcoming 2029 planning cycle.

On reflection, the PM-TAC emphasizes that the ever-evolving nature of landscape features, independent of climate change effects, eliminates the possibility of a direct substitution of time for impact. However, if a specific part of the landscape is projected to be submerged under certain future conditions, the temporal aspect becomes less significant. Consequently, for the 2029 planning cycle the PM-TAC suggests maintaining an impact-based approach alongside CPRA's existing analytical methods, rather than replacing them entirely. Additionally, the use of artificial intelligence/machine learning techniques might be explored as a potential tool to alleviate the analytical burden associated with this approach.

2.3 KEY ADVANCEMENT IN DEFINING FUTURE ENVIRONMENTAL SCENARIOS

In its third report (October 2020), the PM-TAC recommended using two sea level rise scenarios instead of three to avoid stakeholders' focus primarily on the middle scenario. CPRA implemented this by

utilizing two environmental scenarios in the 2023 planning process (see Appendix B: Scenario Development and Future Conditions). In its fifth report (October 2021), the PM-TAC supported CPRA's decision to consider sea level rise and subsidence jointly in these two environmental scenarios, noting that explicitly considering different combinations of these factors was not a priority since their impacts were similar. Using two environmental scenarios ensured that the master plan's diverse audience engaged in critical thinking and careful interpretation of the results while at the same time ensuring that the scenarios considered encompass the likely range of future outcomes. Upon reflection, the PM-TAC acknowledges the significant benefits of focusing on two future scenarios in the 2023 planning process. This approach enhances planning efficiency and improves stakeholder communication.

2.4 TABLED OPPORTUNITIES FOR ENHANCED COMMUNICATION

CO-DEVELOPMENT OF HIGH-FREQUENCY FLOODING SCENARIOS WITH COMMUNITIES

In its second report (January 2020), the PM-TAC recommended that CPRA engage communities early in the planning process to help define the high tide flooding effort. If engaged early, communities can engage in co-production of storylines and potential consequences, as they think about them differently. Due to the COVID-19 pandemic, CPRA was unable to engage with communities early in the 2023 planning cycle. However, CPRA plans to implement this recommendation during the 2029 planning cycle. On reflection, the PM-TAC emphasizes the importance of co-development with communities, across multiple elements of the planning process, to ensure success of the master plan's implementation.

COMPLEMENTARY PRESENTATION OF PROJECTIONS IN TERMS OF RANGE OF YEARS TO IMPACT

In its fifth report (September 2021), the PM-TAC recommended a complementary approach to presenting model projections that could aid in communication. Specifically, the PM-TAC recommended that certain projections be presented in terms of the range of years during which a specific level of impact (such as land loss or economic risk) is anticipated to occur under different combinations of scenarios and projects. With only two environmental scenarios being evaluated in the 2023 planning cycle, CPRA found it challenging to present results from this complementary viewpoint. CPRA plans to explore implementing this recommendation in the 2029 planning cycle.

On reflection, the PM-TAC emphasized the communication advantages of presenting results in terms of a range of years to impact. This approach would provide affected individuals with a more practical framework for decision-making. For instance, if a neighborhood is projected to remain safe from flooding for the next 20-30 years, residents may make different choices regarding relocation compared to choices made when interpreting a gradual change in flooding over time.

3.0 KEY RECOMMENDATIONS FOR THE 2029 COASTAL MASTER PLAN

Many of the models designed to predict the natural evolution of the coastal landscape are fairly mature in their development. In contrast, there is a critical need to better integrate elements of the human system within the predictive modeling framework, and the PM-TAC recognizes this is the area in need of greatest attention during the 2029 planning cycle. In this section, the PM-TAC offers its recommendations for improving predictive modeling and project selection during the 2029 planning cycle.

3.1 EMBED EQUITY AS A MASTER PLAN PRINCIPLE

The Louisiana Coastal Master Plan aims to preserve coastal Louisiana's culture, ecosystems, and resources threatened by land loss and flood risk, with the goal of serving all Louisianans. The PM-TAC recommends adopting equity as an explicit guiding principle prior to initiating the 2029 planning cycle. The PM-TAC further recommends enhancing public communication and engagement by reviewing and re-classifying certain Objectives as Principles. Rather than funding museums or historical societies, which would be examples of specific objectives, CPRA follows the guiding principle of considering cultural heritage in project recommendations. Similarly, the master plan's focus on equity would not be reflected in direct investments in affordable housing or schools, but rather as a guiding principle for project selection. CPRA should incorporate equity to ensure fairness and avoid perpetuating inequality. Specifically, during the project selection phase an equity guiding principle would prevent the selection of a project suite that inequitably benefits some types of communities over others.

3.2 INTEGRATE ADAPTIVE PATHWAYS PERSPECTIVE INTO PROJECT PRIORITIZATION PROCESS

The PM-TAC recommends that CPRA integrate an adaptive pathways perspective into the 2029 project prioritization process to effectively manage future uncertainty. Here, adaptive pathways differ from adaptive management and do not imply the decommissioning of existing projects. The PM-TAC recommends that the master plan team dedicate time to this integration early in the 2029 planning cycle. The focus is on forward-looking actions and understanding the conditions that warrant specific actions or project initiation, reducing the need for decommissioning concerns. Given the 6-year cycle of the master planning process, regular check-ins can be incorporated to evaluate immediate actions, assess demographic shifts, and identify areas with varying levels of subsidence.

3.3 EXPAND FUTURE SCENARIOS

Future change is complex and is driven by human behavior as much as by natural phenomena. In addition to its use of environmental scenarios, the PM-TAC recommends that CPRA integrate scenarios of projected ranges of population growth and development in the 2029 planning cycle. Consideration of future socio-economic scenarios alongside future environmental scenarios will lead to a more robust assessment of future change and related uncertainty. The current population model assumes growth based on historical patterns, but these assumptions could be criticized. By using multiple shared socio-economic pathways, CPRA can explore different growth and degrowth scenarios and demonstrate the dependence of risk on factors such as population influx, location of new construction, and building construction types – or loss of public services and infrastructure investment associated with population declines (Bastien-Olvera et al., 2023). While land use currently falls outside CPRA's authority, CPRA already models land use based on existing codes, assuming continuity in policies. However, it is essential to acknowledge that local governments have significant control over population growth and its impact on overall risk. Even if land use is not directly included within the models, CPRA is urged to directly acknowledge the impact of local government decisions on future outcomes as a significant source or projection uncertainty.

To further enhance risk assessment and planning, the PM-TAC also recommends that CPRA explore different funding and policy scenarios that have the potential to impact project implementation. By considering factors like the continuity of federal financial support or potential policy changes, such as the introduction of a disaster deductible or increased damage threshold, CPRA can better evaluate the level of risk associated with each project. This broader perspective allows for more informed decision-making and helps stakeholders prepare for different future scenarios.

The PM-TAC recommends that the master plan team dedicate time early in the 2029 planning cycle to determining how best to integrate these additional elements into future scenario selection.

3.4 IMPLEMENT MORE PROGRESSIVE EQUITY METRICS

Socio-economic metrics are a key driver of project prioritization within the master plan framework. The PM-TAC encourages CPRA to continue evolving the metrics used to evaluate projects to maximize the master plan's potential to lead to equitable outcomes. The 2023 planning team evaluated projects based on land area and economic metrics, with the use of EASD in the plan being a significant step forward. Incorporating metrics that consider the societal impact of land and habitat loss would be beneficial, moving beyond pure land loss and property values. It is crucial to assess the overall societal impacts of projects mitigating the impacts of sea level rise. To address historical injustices, progressive measures of equity can be pursued, such as utilizing the White House's Climate and Economic Justice Screening Tool (CEJST) tool to identify disadvantaged communities or prioritizing areas that historically received less CPRA investment. The CEJST index and the Federal Emergency Management Agency's (FEMA) National Risk Index provide relevant metrics, although they have their

own weaknesses and critics. The PM-TAC recommends that the master plan team dedicate time early in the 2029 planning cycle to evaluate and select appropriate equity metrics.

3.5 CHARACTERIZE SOCIO-ECONOMIC IMPACTS OF HIGH-FREQUENCY FLOODING

The PM-TAC recommends that CPRA develop a socio-economic impact analysis for high-frequency (i.e., "nuisance") flooding that encompasses the economic consequences of losing access to essential services such as grocery stores, schools, and daycares, in addition to the consequences for property values. This broader perspective will provide a comprehensive understanding of the impacts and help identify those regions where people's daily lives are most impacted by high-frequency flooding. The PM-TAC recommends that the master plan team dedicate time early in the 2029 planning cycle to evaluate data sources and determine approach.

3.6 EXPAND RANGE OF NONSTRUCTURAL MEASURES

The PM-TAC recommends that CPRA expand the modeling scope to include a wider range of nonstructural measures and then assess these measures at a more granular scale. Currently, the model evaluates the costs and benefits of building elevation, floodproofing, and voluntary acquisition at a community level, but there is considerable variation within communities that could influence the relative performance of nonstructural measures and thus should be considered. This ties into recommendations to assess "bounds" for building elevation and acquisition (e.g., to assess extreme scenarios in which all or no homes are elevated or all or no homes are acquired as a way of bounding the potential effect of the measure), recognizing that levels of community participation in nonstructural measures will vary. Variation could explore varied rates in community participation, application of the measures to different types of buildings (e.g., only to multifamily or commercial buildings), or different ways the measures might be applied (e.g., different elevation heights). The PM-TAC recommends the master plan team establish a portfolio of nonstructural measures, including measures beyond elevation and acquisition, and consider methods for within-community analysis of those measures, prior to the 2029 cycle's project identification phase.

3.7 INCREASE PREDICTIVE MODEL EFFICIENCY

The PM-TAC urges CPRA to dedicate time early in the 2029 planning cycle towards enhancing the efficiency of its predictive models to enable consideration of additional environmental and socio-economic scenarios and to better characterize uncertainty in projections and project prioritization. In addition, increased model efficiency has the potential to allow CPRA staff time to focus more effort on other planning tasks. The master plan relies on various modeling techniques and components to integrate environmental forcing, engineering projects, and societal processes. With each component considered relatively mature, the time seems right to assess the overall efficiency of the modeling

process and workflow. Can certain model components be executed more efficiently? Can the workflow be streamlined? Are there computationally intensive components that can be simplified without compromising overall results? In terms of the Habitat Suitability Index (HSI) models, the focus should be on those species and life stages that hold both value and sensitivity to anticipated changes. Across multiple modeling components, the PM-TAC recommends that CPRA further take advantage of high-performance computing technologies, to facilitate quality control and analysis of large simulation sets. The PM-TAC recommends that the master plan team identify and prioritize model efficiency opportunities early in the 2029 planning cycle, then implement the prioritized efficiencies according to when the modeling component needs to be available to support the planning process.

3.8 UNCERTAINTY

CHARACTERIZE PREDICTIVE MODELING UNCERTAINTY

CPRA faces a grand challenge of constraining uncertainty in projections using the master plan's predictive modeling suite (including but not limited to the ICM, CLARA, and population model). The PM-TAC recommends that CPRA advance uncertainty characterization during the 2029 planning cycle by considering ensemble modeling approaches and assessing uncertainties through hindcasts and sensitivity tests. Propagation of uncertainty in future scenarios should be explored. Additionally, accounting for uncertainties in project outcomes is crucial. The PM-TAC recommends that CPRA concurrently develop its approach to characterizing uncertainty while improving model efficiency, perhaps with the assistance of machine learning and other data science techniques. This is because model efficiency will determine the number of simulations feasible within the constraints of staff and computational resources.

COMMUNICATE PROJECT IMPLEMENTATION UNCERTAINTY

Moreover, it is crucial to clearly and consistently communicate the uncertainty associated with implementing selected projects. Factors such as funding availability, political challenges, participation rates, and federal permitting requirements can influence the feasibility and success of these projects. The PM-TAC recommends that CPRA identify and communicate these uncertainties in the 2029 Coastal Master Plan, as it empowers readers to adapt and take appropriate measures. By presenting a comprehensive understanding of the potential obstacles and uncertainties, the master plan would encourage proactive decision-making and ensure a realistic assessment of the projects' likelihood of implementation.

3.9 IMPROVE SIMULATION OF INFLUENTIAL PROCESSES

The planning team has made significant progress in predictive modeling to support project prioritization, but there are opportunities for further expansion and enhancement to further ensure sound project prioritization. Early in the 2029 planning cycle, the PM-TAC recommends that CPRA

evaluate and prioritize those model improvements with the most potential to impact project selection. In its evaluation, the PM-TAC recommends that CPRA also evaluate how the various modeling components are used to support project selection and adjust if warranted.

While the PM-TAC appreciates that CPRA often is on the leading edge of bringing science to practice, the PM-TAC recommends that CPRA primarily implement model improvements in areas where the scientific understanding and methods are relatively mature. At the same time, the PM-TAC believes that CPRA plays a crucial role in advancing predictive capacity beyond the 2029 cycle by identifying weaknesses in the underlying predictive models and recommending areas for research funding based on those weaknesses. Understanding the causes of land loss, particularly in the context of coastal Louisiana, will contribute to more robust modeling. Hindcast simulations and sensitivity tests can provide valuable information about areas where process representation is crucial.

The following subsections highlight known opportunities for advancement.

COMPOUND FLOODING

One important area of focus is projecting compound flooding and compound risks, which should be a priority in the next planning cycle. Coordinating with the Louisiana Watershed Initiative will be necessary to accurately project the kind of flood events experienced by residents.

SHALLOW SUBSIDENCE

Modeling shallow subsidence rather than considering it solely as a boundary condition is recommended. Recent research shows that shallow subsidence increases with sediment deposition, and models based on accretion alone may underestimate marsh vulnerability (Saintilan et al., 2022; Jankowski et al., 2017). Accounting for shallow subsidence is particularly important near diversions and riverine sediment sources.

MARSH MIGRATION

Another crucial aspect is addressing conversion of uplands to wetlands. The sea-level driven conversion of uplands to wetlands is not currently considered, but recent projections estimate that the area of saline wetlands created by inundated uplands is similar to the total amount of existing saline wetlands (Enwright et al., 2016; Borchert et al., 2018; Osland et al., 2022). This suggests that marsh loss can potentially be balanced by marsh formation elsewhere, which has significant implications for the overall master plan.

MODELED VEGETATION RESOLUTION

Refining the ICM vegetation grid resolution is also a top priority for the 2029 planning cycle, aligning the vegetation projections with the resolution of other data and models being used. This will improve the accuracy and compatibility of the models employed.

Together, these recommendations aim to improve the accuracy, comprehensiveness, and applicability of the planning process, ultimately enhancing decision-making for the preservation of coastal Louisiana. The PM-TAC recommends that CPRA develop a model improvement schedule that enables model developments to be completed in time to meet major planning milestones.

3.10 PRIORITIZING LAND BUILDING BY LOCATION

Additionally, the PM-TAC suggests considering objective functions for the modeling framework that go beyond land area, and prioritizing land-building efforts based on location, with the Barataria diversion being well-suited due to the relative ease in diverting water and sediment from the Mississippi River. The PM-TAC recommends that CPRA dedicate time early in the 2029 planning cycle to determine approach.

3.11 STATUS AND IMPACT OF PAST PROJECTS SELECTED AND CONSTRUCTED

The PM-TAC recommends expanding the project-selection framework to incorporate valuable information from previous plans, U.S. Army Corps of Engineers studies, public solicitations, and regional workgroups. Understanding the status of projects recommended in previous master plans is important. It is vital both to assess whether past recommended projects are still under consideration, funded, or already in place and to assess the performance of previously implemented projects. This knowledge helps inform how previously selected projects should be accounted for within the 2029 predictive modeling framework.

3.12 CRITICAL CPRA STAFFING NEEDS

The PM-TAC acknowledges the magnitude of the planning effort undertaken by the master plan team and continues to be highly impressed with the outstanding quality of the team's work. This is particularly notable given that the master plan team is under-resourced. Principally, there is a dangerous lack of redundancy in staff expertise. The PM-TAC recommends that, prior to initiating the 2029 planning cycle, CPRA expand its team to include more predictive modelers and implement cross-training so that multiple team members are versed in each modeling component.

4.0 THE PM-TAC PROCESS

4.1 REFLECTIONS ON 2023 PM-TAC PROCESS

The PM-TAC process seemed highly effective during the 2023 planning cycle. The addition of a social scientist with relevant expertise was especially valuable. The social scientist's discipline and breadth of knowledge played a central role in several aspects of the process.

The PM-TAC wants to ensure that the input they provide is relevant and impactful to CPRA's modeling processes. Towards that end, the use of question prompts appeared effective in guiding PM-TAC discussions and ensured relevant recommendations for CPRA. However, the focus questions sometimes seemed to lack clarity and missed the opportunity to explicitly highlight the areas where CPRA sought feedback. The PM-TAC appreciated receiving concise, streamlined pre-meeting materials. One successful aspect of the in-person meetings was the short breakout discussions with relevant CPRA team members to address specific questions and topics. This approach facilitated focused discussions and thorough examination of key issues. Another successful aspect was dedicating time to closed-door PM-TAC discussion.

The post-meeting reporting approach used for all but the final primary meeting, where CPRA provided concise notes that PM-TAC adapted into bullet points, proved highly efficient. This method allowed for timely responses to clarifying questions and was more practical than writing lengthy narrative reports. Likewise, the development of the document comparing the PM-TAC Recommendations Matrix with CPRA Responses was highly valuable, providing early feedback on relevant recommendations. On the other hand, this final narrative required substantially more effort to prepare than anticipated; this level of effort may remain appropriate if the PM-TAC final report in this format proves useful to CPRA.

Midway through the cycle, gaining insights into the project prioritization approach was helpful in terms of understanding the full scope of the planning effort and how the predictive models supported project prioritization. Likewise, the field trip at the last meeting was excellent and provided a much-needed opportunity for the PM-TAC to appreciate the challenges and significant benefits of the master plan. Scheduling these two activities earlier in the planning cycle would have been even more impactful.

IMPACT OF COVID-19 PANDEMIC

The COVID-19 pandemic necessitated a pivot to a virtual meeting format for several of PM-TAC's primary meetings. The master plan team deftly navigated this challenge. The use of pre-recorded presentations followed by virtual breakout discussions proved to be the most effective virtual format and is one that could be adopted in the 2029 cycle to supplement, but not replace, in-person meetings. PM-TAC members noted, however, that it was difficult to maintain focus during those virtual meetings that spanned multiple hours. Likewise, the interaction between the master plan team and

PM-TAC was not as rich and productive over the virtual format as it was in the in-person format. Another negative impact of the pandemic was the need to postpone the field trip from 2020 to 2023.

4.2 ENSURE 2029 PM-TAC PROCESS MEETS CPRA NEEDS

The PM-TAC is concerned that the negative impact of CPRA's increased workload to prepare for PM-TAC meetings may outweigh the meeting benefits. CPRA should reflect and assess the value added by its engagement with the PM-TAC and if needed adjust the PM-TAC scope to ensure there is a substantial benefit without causing the team to be overworked.

For example, CPRA may determine that the PM-TAC's primary value does not lie in developing new ideas or approaches, but rather in the review and approval of approaches identified and chosen by CPRA. In that case, PM-TAC engagement might be limited to an annual meeting where the master plan team presents their work and inquires whether the work is acceptable for informing project prioritization.

The following sections offer recommendations for the 2029 PM-TAC process under the assumption that the 2023 and 2029 PM-TAC scopes are the same. Some of these recommendations may not apply if the 2029 PM-TAC scope is changed.

4.3 RECOMMENDED 2029 COMMITTEE COMPOSITION

In assessing the 2029 PM-TAC membership, CPRA should reconsider the committee size and range of disciplinary expertise needed to inform 2029 predictive modeling and project prioritization. A well-balanced mix of natural, engineering, and social sciences within the committee is essential, with an emphasis on filling expertise gaps within CPRA staff. The 2023 PM-TAC benefited from the added social science perspective alongside natural scientists and engineers. Understanding human behavior, particularly migration patterns and responses to interventions, emerged as a critical uncertainty, highlighting the importance of including a demographer and a sociologist/policy expert. It will be crucial for CPRA to identify the type of social science expertise needed (e.g., demographics, policy, resource economics, equity). Additional areas of focus could include resource economics and non-monetary economics, as well as expertise in disaster response and utilizing modeling predictions for anticipatory measures. To maintain continuity, retaining a few members from the 2023 PM-TAC for the 2029 cycle is advisable. Likewise, the 2029 PM-TAC could benefit from including someone with a local background in the proposed engineering projects. Unless significant HSI revisions are expected, specific expertise on HSIs may not be necessary for the 2029 PM-TAC.

4.4 RECOMMENDED 2029 PM-TAC INTERACTION

The 2029 PM-TAC should be engaged as soon as possible to allow their input to help shape the initial

steps of the 2029 planning process. If the PM-TAC scope remains the same – namely that the PM-TAC continues to play a role in identifying and steering modeling approaches – more frequent interaction with the master plan team would be advisable, especially during critical development phases of the planning cycle. Namely, frequent brainstorming will be more important early in the planning cycle and less important late in the cycle such that meetings might be more frequent in early years and less frequent in later years. More frequent meetings would enable PM-TAC members to remain actively engaged throughout the planning process and would minimize the need for review during meetings. The PM-TAC reiterates, however, that CPRA would need to evaluate whether the benefit of more frequent meetings justifies the additional work required of CPRA staff to prepare for meetings.

The PM-TAC agrees that in-person meetings play a crucial role in developing relationships between the master plan team and PM-TAC members, provide an opportunity for informal discussion, and are more productive than virtual meetings. But short, focused virtual meetings are an efficient and cost-effective option, particularly in the context of increasing meeting frequency. During the 2023 cycle, virtual meetings proved most effective when the PM-TAC was asked for specific advice and meeting time was dedicated to discussion. Regardless of format, the PM-TAC recommends that most meeting time be dedicated to discussion, where discussion time should be maximized by providing CPRA updates as pre-meeting material (e.g., in the form of concise summaries, pre-recorded presentations, etc.).

The PM-TAC recommends that the first meeting of the 2029 PM-TAC include a field trip and an overview of the full planning process.

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