LOUISIANA COASTAL PROTECTION AND RESTORATION
FINAL TECHNICAL REPORT

ADAPTIVE MANAGEMENT APPENDIX

June 2009

U. S. Army Corps of Engineers
New Orleans District
Mississippi Valley Division

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Purpose

The Louisiana Coastal Protection and Restoration (LACPR) Technical Report has been developed by the United States Army Corps of Engineers (USACE) in response to Public Laws 109-103 and 109-148. Under these laws, Congress and the President directed the Secretary of the Army, acting through the Chief of Engineers, to:

- Conduct a comprehensive hurricane protection analysis and design in close coordination with the State of Louisiana and its appropriate agencies;
- Develop and present a full range of flood control, coastal restoration, and hurricane protection measures exclusive of normal policy considerations for South Louisiana;
- Consider providing protection for a storm surge equivalent to a Category 5 hurricane; and
- Submit preliminary and final technical reports.

The purpose of this appendix is to reinforce the requirement and application adaptive management for LACPR, which is discussed in the main Technical Report.

Introduction

Protection and restoration in Louisiana is a commitment over many decades. Therefore, potential changes in social, political, and environmental conditions over this time, coupled with improvements in science and engineering supports the need for an adaptive management framework to guide program and project management.

Adaptive management (AM) is a "learning by doing" management approach which promotes flexible decision making that can be adjusted in the face of uncertainties as outcomes from management actions and other events become better understood (National Academy of Sciences 2004). It is used to address the uncertainties that can impede successful implementation of large scale projects such as those contained within the LACPR final array of alternatives. In AM, a structured process is used so that the "learning by doing" is not simply a "trial and error" process (Walters, 1986). Although most commonly used to resolve ecosystem issues, AM is equally useful in resolving engineering, policy, socio-economic issues and interactions, and other processes by reducing uncertainties and improving understanding in these areas and their interrelationships.

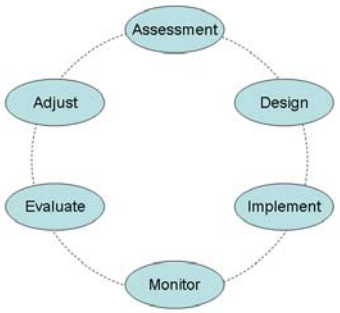
As we more forward with long-term restoration and protection plans through detailed planning and design, components of LACPR amendable to AM will be further identified and a specific AM process will be defined. Incorporation of AM will allow projects to move forward even if data is incomplete or if there is uncertainty with scientific understanding. It is critical that AM principles be integrated throughout project and program development and implementation through project planning, engineering/design, construction, operation and maintenance, while promoting updates to account for changes

in future conditions. There must be clear linkages and continuity across all facets of the program to ensure that the required feedback and learning is applied to decisions and management actions. If appropriately applied the science /management linkages would support improved decision making, management actions, and operations at multiple scales.

To help to ensure program success, LACPR may also implement a program-wide AM strategy. The purpose of this appendix is to begin to lay out a framework for that strategy. This strategy could be crucial for ensuring that the program remains true to its basic objectives while also integrating valuable new information and allowing necessary shifts in priorities. In addition, using a comprehensive systems approach while employing AM would ensure collaborative engagement among stakeholders for the implementation of the program.

Adaptive Management Process

The basic elements of an AM process are: (1) Assess; (2) Design; (3) Implement; (4) Monitor; (5) Evaluate; and (6) Adjust (**Figure 1**). The processes associated with each element may vary depending on if it is program or project level AM or if the project is structural or nonstructural in nature. In practice, AM is implemented in a non-linear sequence, but in an iterative way, starting at various points in the process and repeating steps based on improved knowledge:



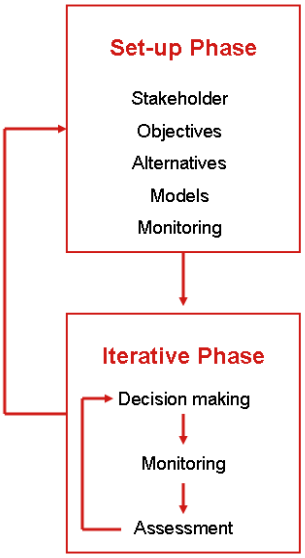
Source: Nyberg, B. 1999.

Figure 1. Components of Adaptive Management: One iteration of the learning wheel

A comprehensive strategy for AM of LACPR would be developed in consultation with stakeholders and participating local, state, federal, and tribal governments. The discussion below suggests a potential path for an AM Program structure and includes essential components of a successful strategy.

Application of AM should occur in two phases as suggested by the *Adaptive Management: U.S. Department of the Interior Technical Guide (2007)* (**Figure 2**). A set-up phase would involve the development of key components and an iterative phase would link these components in a sequential decision process. Elements of the set-up phase

include: stakeholder involvement, defining management objectives, identifying potential management actions, identifying or building predictive modeling tools, specifying performance measures and/or risk endpoints, and creating monitoring plans. In addition, values for the monitored measures that would trigger AM should be determined in this phase. The iterative phase uses these elements in an ongoing cycle of learning about system structure and function, and managing based on what is learned. The elements of the iterative phase include decision making, follow-up monitoring, and assessment.



Source: Williams, B.K., R.C. Szaro, and C.D. Shapiro. 2007.

Figure 2. Two-phase learning in adaptive management.

There are many advantageous opportunities for applying AM in large scale projects and programs (**Figure 3**). The LACPR AM strategy should start by inventorying what is "known" and "unknown" about each system and its response to hurricane risk reduction and restoration activities. This inventory would promote focusing on important uncertainties that must be addressed so that AM processes can work to resolve them.

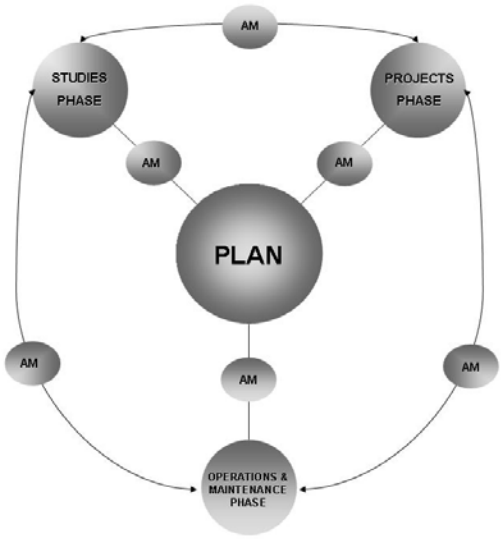


Figure 3. Key adaptive management utilization opportunities within planning and project implementation.

Program Adaptive Management

At the Program level, the key to successful AM is the framework for implementation (**Figure 4**). This framework promotes effective communication between stakeholders, project teams, a Science and Technology (S&T) program, an Adaptive Planning and Management (AP&M) Team, Federal and State Governments, and LACPR Program Management (for a complete description of the framework see Section 17 of the main report). At this level, AM is achieved by the incorporation of new information and technology into new and existing projects as it becomes available, adjusting or modifying projects as changes are made to other projects (comprehensive system approach), and by the assimilation of lessons learned as new projects are developed.

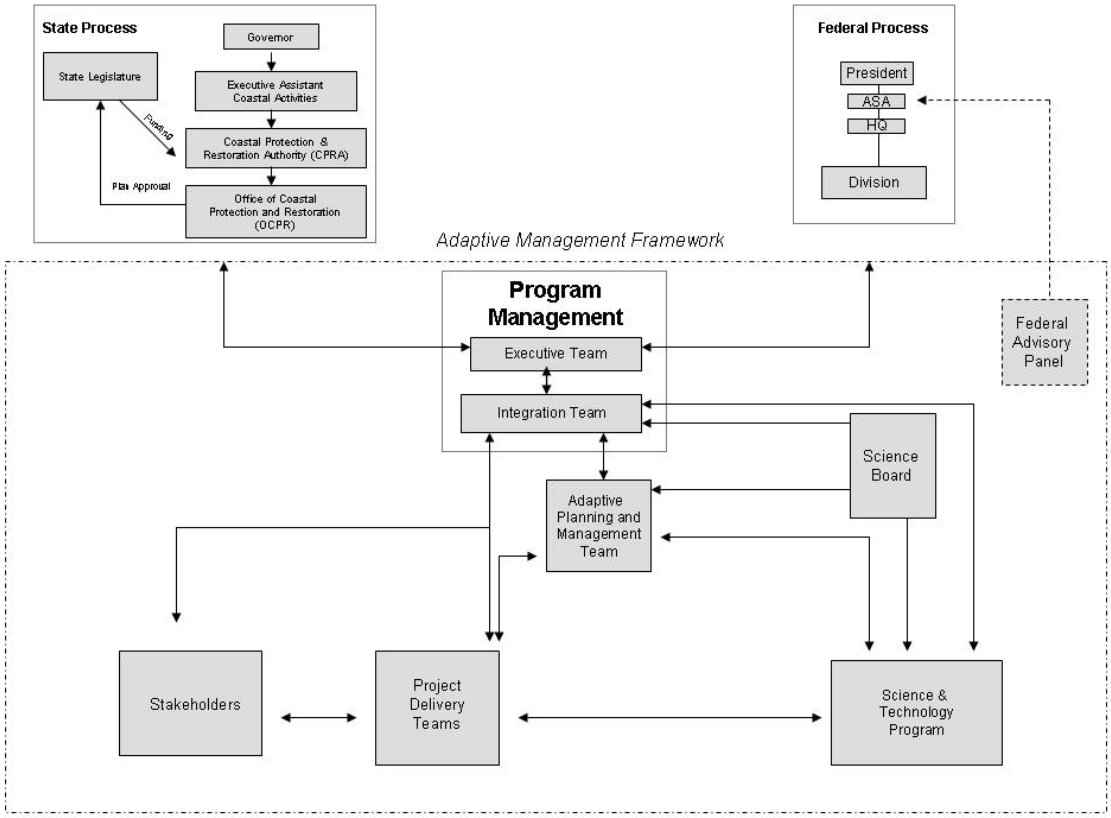


Figure 4. Proposed communication and collaboration framework

Adaptive Planning and Management Team

An AP&M Team could provide essential support to LACPR in meeting its goals and objectives through the application of a system-wide perspective to the planning and implementation. The Team should consist of a multi-agency (State and Federal) staff from the appropriate disciplines, including engineering, planning, environmental science, economics, sociology, modeling, and resource management. The Team may also include members from the S&T Program and the Project Delivery Teams (PDTs) to ensure interactions and relevance with all aspects of the program. The AP&M Team would develop decision–making processes to be used in AM and would work closely with, S&T Office, as well as the Integration Team in order to fully implement these processes.

Working with the Program Management Team (PMT) and PDTs, an AP&M Team would be primarily responsible for developing recommendations for refinements or improvements to the comprehensive plan throughout implementation by using monitoring results and assessment tools to continually evaluate the plan to make sure the program goals and objects are being met. In short, they would make sure that the projects are contributing to the overall plan as intended, and if they are not, the AP&M Team will recommend to the PMT that changes in the plan should be considered. If they concur, the PMT will direct the project PDT to reformulate.

This AP&M Team would work closely with the PDTs and S&T Program to make sure the right questions are being addressed in a structured format and that the process for answering them and disseminating the information is collaborative and transparent. An AP&M Team would provide guidance to and support for project level AM.

In addition, an AP&M Team would provide a structure to ensure that decisions are based upon best available science, technology, and socio-economic data, and that a process is in place to acquire and incorporate new or better information as it becomes available. The AP&M Team would work with project teams to set up project level AM plans including a conceptual framework for AM decisions, make recommendations for improving project plans, and adjust implemented actions based on new or improved information, to increase the probability of achieving the goals and objectives of the plan. Such a process requires the development of key AM components, such as sound baseline data and monitoring, models, data management, and continued research. The AP&M Team could work closely with project teams to define these needs and with the S&T Program to develop the necessary tools or tasks.

Science and Technology Program

Although the body of data and knowledge for coastal Louisiana has advanced sufficiently to provide a sound basis for implementation of restoration and hurricane risk reduction projects, certain aspects require increased analyses, monitoring, modeling, and research and experimentation to decrease uncertainties, especially in the area of predicting ecosystem and socio-economic response to the restoration and hurricane risk reduction projects.

A Science and Technology (S&T) Program was established under Louisiana Coastal Area (LCA) by the USACE and the non-Federal sponsor to effectively address coastal ecosystem restoration needs, and to provide a strategy, organizational structure, and process to facilitate integration of science and technology into the decision making process (USACE, 2004). The LCA S&T program can be utilized to ensure that the best available science and technology are integrated into planning, design, construction, and operation of LACPR projects.

In order to be most effectual for LACPR, the LCA S&T Program would need to be modified to not only provide the necessary environmental and engineering science, but would also include social and economic science and analyses, to completely and effectively address coastal restoration and hurricane risk reduction needs. The program would provide analytical tools and recommend to the Project Teams the appropriate modeling, monitoring, research, and/or experimentation to ensure that current issues of uncertainty can be addressed. In addition, it would be responsible for implementation of a monitoring and assessment plan, including the collection of baseline and project performance data. The S&T Program would conduct data mining, identifying data gaps, and collect new data where needed as directed by the Project, AP&M, and Integration Teams. It would also be responsible for setting up a system–wide database to house and

manage all scientific data for coastal Louisiana and include a systematic approach for coordination with other ongoing and planned related research and monitoring activities and to make sure sufficient information is obtained to address critical questions and to support AM.

The S&T Program would execute programs under broad tasks directed by the Executive Team to include Decision Support, Assessment, Modeling and Evaluation, and Data Management (Figure 4). In addition, the S&T Program would assist in the development and monitoring of demonstration projects designed to resolve critical areas of scientific or technical uncertainty and to advance coastal restoration plans by improving the planning, design and implementation of full-scale restoration and hurricane risk reduction projects. In general, the S&T Office coordinates, administers, and reports on monitoring and science activities conducted as part of coastal restoration planning and implementation efforts in order to provide the Integration and Executive Teams, project managers and other execution teams the best available science and technology support to plan, construct, operate and adaptively manage sound coastal restoration and hurricane risk reduction projects.

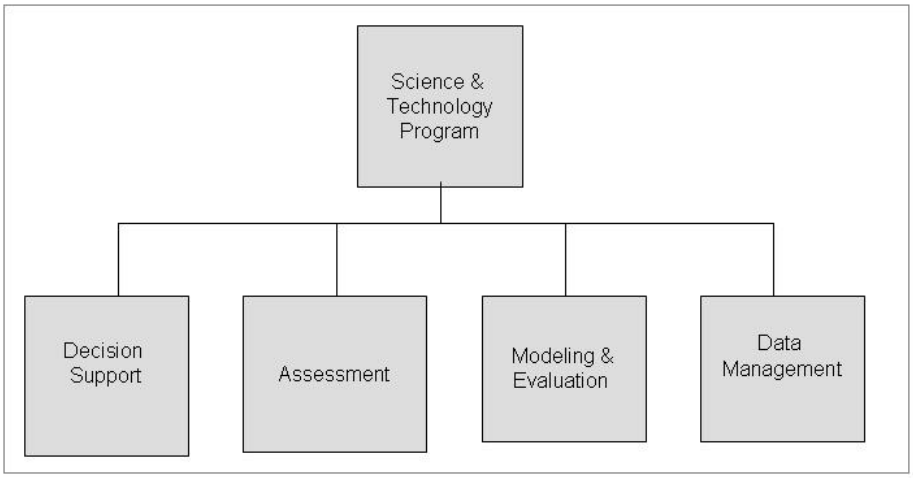


Figure 4. Science and Technology Program Structure.

Decision Support

The Decision Support Team would work with project teams and the AP&M Team to identify their technical needs and seek to develop scientific investigations, studies, literature reviews, and workshops in order to make the best scientific and technical knowledge available to guide the project manager's decision making process. Information from these efforts would be provided to project teams and program management, in addition to being disseminated through websites, technical notes, and reports. The Decision Support Program would provide rapid direct environmental and

engineering technical support to address a wide range of simple or short-term problems associated with coastal restoration efforts.

Assessment Team

The Assessment Team would consider data needs in a geographic hierarchy for the purposes of restoration planning and hurricane risk reduction. In order to measure project success on not only on a project-by-project basis, but also on its contributions to both basin or sub-basin levels, and entire ecosystems or planning units, the S&T Assessment Team would work with project teams to develop monitoring systems and collect data within the different ecosystems or planning units. Data would be integrated with the other ongoing monitoring or data management systems as appropriate. Baseline data would improve conceptual and predictive models and working hypotheses, and are essential to monitor changes in socio-economic or ecosystem processes affected by coastal restoration and hurricane risk reduction projects. In addition, data would facilitate the adaptive management of projects in response to unexpected outcomes or events.

An Assessment Team would be responsible for interpreting project performance based on the analysis of information obtained from the S&T program, including research, monitoring, and modeling. They would work closely with the program and project management teams to create, refine, and provide documentation for a set of conceptual models for the planning area and create, refine, and monitor a set of attribute-based performance measures, and design and review the system-wide monitoring and data management program.

Modeling and Evaluation Team

The Evaluation Team would be primarily responsible for the management of the tools used to forecast the performance of the plans and the designs relative to desired objectives. They would support the S&T Team in the development and refinement of these tools which include predictive models and a Multi-Criteria Decision Support (MCDA) tool. Additionally, they would apply these tools to the evaluation of system-wide planning activities and provide guidance to the PDTs regarding alternative evaluation for project level adaptive planning. In addition, this team would assist PDTs with the development and refinement of regional evaluation performance measures, review project-level goals, objectives, and performance measures from a system wide perspective.

Data Management Team

The coastal restoration and hurricane risk reduction process would include data collection, development of modeling and assessment tools, development of higher-level decision support tools for evaluating project alternatives, and publishing data, analyses, and plans for end-users in and out of government. The volume of data collected and generated in these areas would be daunting. It would, at least initially, come in different formats from different organizations and must be organized and integrated into formats

that are widely accessible and useable. For the restoration and risk reduction processes to be successful, it is critical that scientists, economists, sociologists, engineers, and managers from a variety of disciplines and organizations be able to operate in a collaborative environment. A well-conceived computing and information framework is essential to this success.

The Data Management Team would facilitate the management of data and information available through numerous agencies and organizations, including historic coastal Louisiana datasets, ongoing monitoring collections, and new data collections generated from new restoration and hurricane risk reduction projects and develop a system for storing and organizing this information. This network of data would allow the AP&M Team, program management, and project managers to incorporate lessons learned and adjust restoration and hurricane risk reduction strategies and to best achieve management goals. The computing and information framework would be a collaborative effort involving government and private organizations. The end product would be a distributed network of data centers sharing common data structures and standards.

Stakeholder Involvement

Stakeholder engagement and the use of a collaborative approach to problem solving are critical components to ensure the success of LACPR. Because of the size and complexity of LACPR, it is important that stakeholders are not just involved, but actively engaged in problem-solving at the program and project levels. Engaging stakeholders in project planning, design, implementation, and evaluation has many benefits including: (1) building better understanding among stakeholders; (2) promoting relationships and trust as well as establishing lines of communication; (3) providing an opportunity for cooperative learning (i.e., issues that may be confusing, unclear, or unknown at the initiation of the project); (4) providing a mechanism to identify and address key issues and concerns; (5) creating networks for "honest dissemination of new understanding as the project/program unfolds; (6) enabling development of creative solutions that address the unique mix of stakeholder interests; and (7) increasing the likelihood of program/project success (USACE, 2007). The LACPR team recognizes that all organizations, entities, and individuals have interests and is committed to addressing these interests proactively within the context of the project/program in order to reduce the likelihood of delay and to help remove any obstacles.

Goals and Objectives

Clearly focused and quantitative goals and objectives are essential to AM. They should be logically linked to management actions, action agencies, indicators/metrics, monitoring activities, and ecosystem or risk reduction services. LACPR goals and objectives were identified at the beginning of the planning process. These goals and objectives will be critical elements of the LACPR AM process. They address stakeholder interests, where possible, in order to ensure stakeholder involvement and clearly link the problems to opportunities and solutions. If Congress or the Administration directs further

development of LACPR, then the current goals and objectives would be refined to ensure that program/project components are very specifically focused to support AM needs to ensure restoration or protection goals are achieved. These would clearly reflect refined program resolution and additional stakeholder input.

In addition, clear goals and objectives can be used to guide the development of conceptual models, an AM tool used to identify stressors, working hypotheses, and key uncertainties, used to guide the process of selecting assessment performance measures and indicators, and evaluation performance measures/metrics.

Managing Risk

A function of AM is to increase learning to continuously assess and reduce risk. Managing risk related to project or program performance will help to assure that restoration and protection goals are more likely to be achieved. Doing so from the outset can ensure smoother delivery over the life of a project/plan. Risk arises because of limited information and uncertainty about the future. By identifying uncertainties early in the planning process, and creating Project Management Plans (PMPs) that manage for or reduce the uncertainties, risk is reduced

Identify Uncertainties

A key to AM is the identification and reduction of uncertainties. Uncertainty can stem from many sources. For example, for scientists, there is uncertainty in assessing the effects of sea level rise on the coastal ecosystems; for stakeholders, there is uncertainty about wetland impacts if certain hurricane risk reduction features are constructed; and for engineers, there may be uncertainty associated with levee design. Often the most difficult uncertainties to deal with are those associated with political or sociological elements.

Once identified, uncertainties should be listed to describe what is known and not known regarding the proposed risk reduction or ecosystem restoration action/plan. An approach to address the uncertainties should be identified as well as the priority of when they should be addressed to focus planning and monitoring activities.

Conceptual Models

Working closely with the PDTs and the AP&M Team, the S&T Program would design and use conceptual models that would help drive monitoring and quantitative modeling efforts and identify areas of uncertainty. These conceptual models can provide hypotheses of human and system response to management actions over various spatial and temporal scales. The conceptual models guide the identification of performance measures and ultimately, provide a framework for targeting variables and tracking the status of human and system responses. More specifically, the variables that get targeted would be those that can be incorporated back into decision-support tools to test the working hypotheses that drive management actions. Furthermore, as conceptual models

are developed and enhanced throughout the life of the program, the monitoring strategies would subsequently be improved, data gaps identified, and critical uncertainties addressed, enhancing the ability of the decision-support tools to produce successful restoration and protection alternatives.

Performance Measures/Metrics

Performance measures would be used during two AM processes: plan evaluation (evaluation performance measures and metrics) and assessment of actual plan performance (assessment performance measures). In many cases, these processes would be the same, allowing predictions to be compared to actual responses. In other cases, tools may not be available for project evaluation. However, if the measure is important enough, or shows a strong enough linkage to proposed hurricane damage risk reduction or restoration activities, then it should be monitored (assessed) to track project effects. Additionally, for each assessment performance measure (to be identified in the conceptual model process), interim goals, hurricane risk reduction, and restoration targets would be established. The progress towards risk reduction and restoration would be assessed at regular intervals as LACPR is implemented.

Monitoring Plans (Assessment)

Monitoring programs are a key component of AM. Monitoring provides feedback between decision making and system response relative to management goals and objectives. An essential element of AM is the development and execution of a scientifically rigorous monitoring and assessment program to analyze and understand system response to project/program implementation.. It is recognized that project level monitoring would be limited by cost and duration based on current regulations and that project level AM plans would need to be designed to reflect this constraint. Program (regional) monitoring should however be long term for Program AM with funding from a S&T program.

The Assessment Team, under the S&T Program, would provide leadership and guidance for all monitoring and assessment efforts for LACPR. This team would design monitoring programs to collect data essential for the development of decision-support tools (i.e., models, etc) and to assess the overall goals and objectives of LACPR. Working closely with the other teams in the S&T Program and the AP&M Team, data standards, monitoring guidelines, and assessment criteria would be clearly set so as to better track hurricane risk reduction and coastal restoration efforts. In addition, the AP&M Team would also ensure that project-specific monitoring plans and system-level monitoring strategies clearly describe desired conditions such that management actions throughout the life of LACPR could be optimized.

The monitoring and assessment effort will only be successful if the data collected meet the needs of the AP&M Team, the PDTs, and all the teams under the S&T Program. Communication among the teams would be essential, requiring well defined data delivery and feedback mechanisms to support program management decisions. The S&T Program

would ensure that the monitoring plans are implemented and that the monitoring data are utilized to assess project and program progress and evaluate and improve models. In addition, monitoring data would be used to evaluate potential changes to management actions under the AP&M Team. Once the feedback mechanisms are defined, understood and reiterated throughout the life of the program, uncertainties would be reduced and better management decisions could be made.

The monitoring and assessment approach would utilize and build upon data availability through existing monitoring systems such as CWPPRA's Coastwide Reference Monitoring System. An assessment would be initiated of all available data collection conducted by existing monitoring and modeling programs. This assessment could then be compared with the project and program needs of the LACPR to support optimized monitoring and assessment planning.

Report Cards

Report cards would be developed periodically and after a significant event, such as a hurricane, by the AP&M Team and the S&T Assessment Team to inform decision makers, stakeholders, and the public about the condition of the Louisiana coastal ecosystem and the hurricane risk reduction system. The report card should provide a way to interpret the results of the monitoring in a concise, easy-to-understand format, should compare values of selected indicators/metrics over time, and provide decision makers, stakeholders, and the public a clear summary of the progress toward restoration and risk reduction goals and objectives.

Multi-criteria Decision Support

A multi-criteria decision support tool can be utilized as a component of the AM strategy during plan implementation. Existing program level performance measures would be maintained where appropriate and new measures may be recommended as deemed necessary for AM. The multi-criteria decision support tool could also be used to guide project level planning and AM although a new set of performance measures may be used depending on project specific goals and objectives.

Demonstration Projects

Demonstration projects may be used to resolve critical areas of scientific or technical uncertainty in order to advance programs or projects, such as new technologies for building levees, floodwalls, or armoring, or the application of technologies. For instance, the Dutch proposed a mix of flood risk reduction and landscape stabilization measures based on proven technology and innovative concepts (see discussion of the Dutch Perspective in the main report). However, proven technology suited for the typical Dutch environment will need validation for the characteristics of the environments in the Louisiana coastal zone. In addition, there may be opportunity to improve upon current technology. Therefore, pilot projects should be designed and implemented as a means to

improve upon or validate the Dutch or other engineering solutions, to reduce uncertainties, and to fill in information gaps.

Both full-scale restoration opportunities and large scale studies may depend upon results from demonstration projects to advance their planning and analysis of alternatives. In order to be responsive to program needs, demonstration projects must also have the ability to be implemented within 1-3 years and provide meaningful results in a relatively short timeframe.

Working with the other programs, S&T Program Management would determine the most appropriate way to address areas of uncertainty and reduce implementation risks. Resolution of uncertainty and timeliness of construction would be given great consideration in the formulation process. While resolution of an uncertainty may require that an entirely new project be built, projects currently in the engineering and design phase, as well as existing restoration and risk reduction projects may be examined for their suitability in addressing the uncertainty. Additionally, opportunities to resolve multiple uncertainties within one well-designed demonstration project would be sought. Once approval by the Program Management Team to pursue demonstration concepts is given, the S&T Office would work to develop necessary documentation to justify implementation.

The S&T Program Management would ensure that demonstration projects are sequenced to evaluate, refine, and reduce uncertainty related to early actions in the program and that data collection and analyses within demonstration projects are aimed at hypothesis testing. Experimentation should be built into demonstration projects, as well as existing projects as appropriate; however, collection and analysis of data would be carefully focused to ensure that the targeted uncertainty is adequately addressed.

The Implementation Team would be responsible for design and implementation of demonstration projects. The S&T Office would be directly involved in the engineering and design phase of demonstration project implementation to ensure that the project design is appropriate to address the uncertainty. The S&T Office would evaluate results and develop a report for each project of the findings with recommendations to the Executive Team.

Potential Required Future Actions

Depending on the authorities and accompanying directions, potential future actions may require the confirmation and implementation of the proposed communication and collaboration framework and the development of a comprehensive AM strategy including the refinement of goals and objectives; confirmation or further identification of uncertainties and opportunities for learning; and identifying the responsibilities, processes, communication, and coordination requirement to make it functional. This may include decision frameworks, monitoring and assessment and reporting.

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