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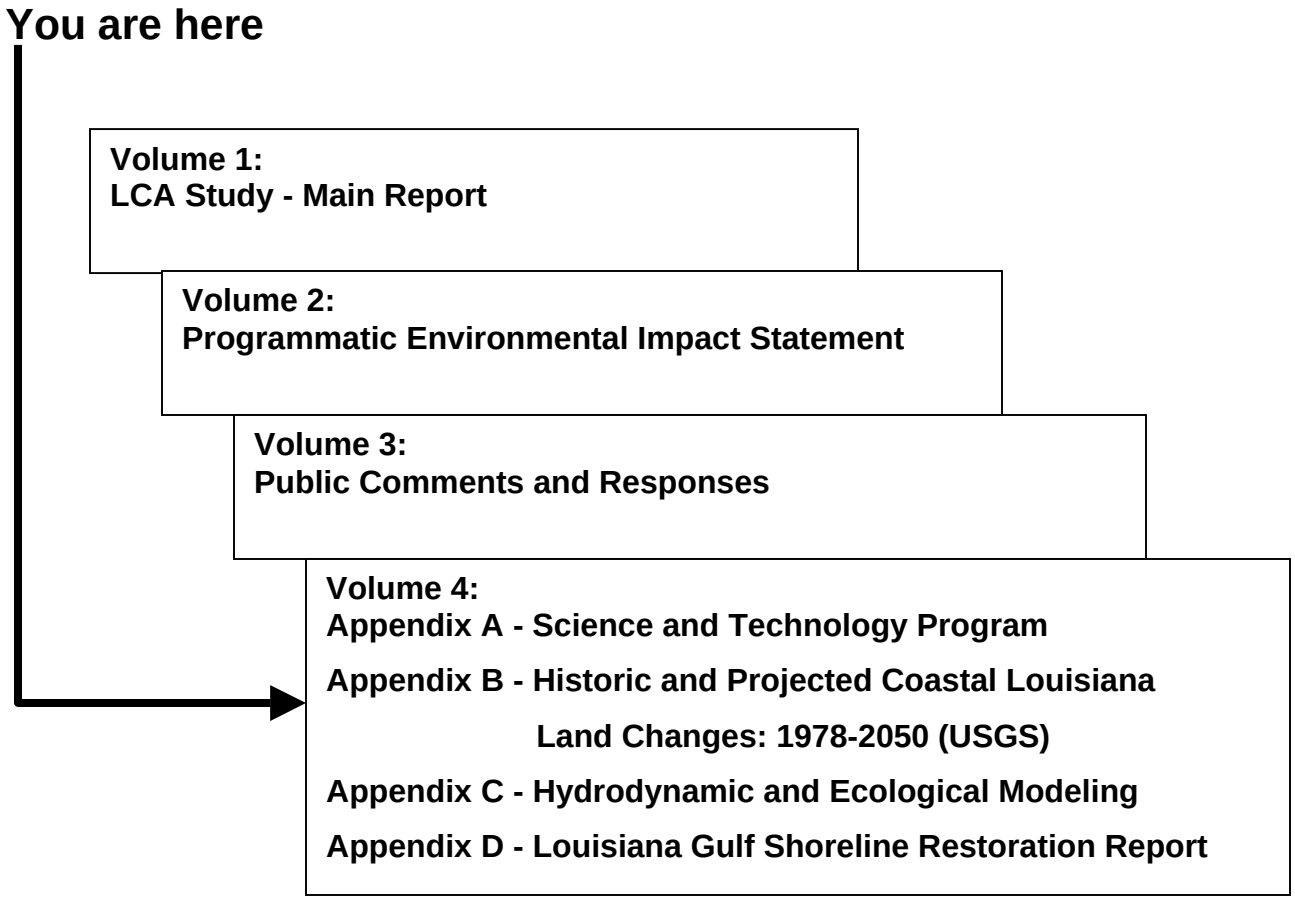
New Orleans District

Louisiana Coastal Area (LCA), Louisiana

# Ecosystem Restoration Study

November 2004
Final
Volume 4:
Appendix A – Science and Technology Program
Appendix B – Historic and Protected Coastal Louisiana Land Changes: 1978 – 2050
Appendix C – Hydrodynamic and Ecological Modeling
Appendix D – Louisiana Gulf Shoreline Restoration Report

## This Report Contains 4 Volumes

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Cover picture is a Live Oak tree on the eastern shoreline of Lake Salvador.

*Picture provided by Lane Lefort of the U.S. Army Corps of Engineers, New Orleans District.*

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# Ecosystem Restoration Study

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**Appendix A – Science and Technology Program**

**LOUISIANA COASTAL AREA (LCA), LOUISIANA**

**ECOSYSTEM RESTORATION STUDY**

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## Science and Technology Program

# 1.0 INTRODUCTION

The science of ecosystem restoration is evolving rapidly through theoretical and applied research. The body of scientific data and knowledge for coastal Louisiana has advanced sufficiently to provide a sound basis for implementation of restoration projects incorporating a number of technological and engineering solutions with continuous learning and method improvement. However, certain aspects require increased monitoring, modeling, and research and experimentation to decrease uncertainties, especially in the area of predicting ecosystem response to the restoration projects. The Science and Technology (S&T) Program supports the restoration efforts. It also supports the opportunity to perform restoration projects in the near-term and thus slow overall coastal degradation while concurrently pushing forward the cutting edge of restoration science, to reduce uncertainty, and rapidly improve the effectiveness of all future restoration activities.

The goal of the S&T Program is to provide the necessary science and technology to effectively address coastal ecosystem restoration needs. The S&T Program would provide analytical tools and recommend to Program Management Team appropriate studies to ensure that current issues of uncertainties can be reduced by sound scientific investigations.

A fundamental relationship exists between this S&T Program and the LCA Program Execution Team (PET) and other coastal protection activities at the state, local, and Federal level. This S&T Program reaffirms the need for close and continuing coordination among the scientific community, and state and Federal coastal resource managers to ensure integration of coastal protection activities occurring throughout coastal Louisiana.

## 1.1 Background

Scientists have long recognized the importance of the Louisiana coastal area for fish and wildlife habitat (Coalition to Restore Coastal Louisiana, 1989; Keithly, 1991; Herke, 1993; Michot, 1993), estuarine productivity (Morris, et al., 1990), and ecological sensitivity to human disturbances (Templet and Meyer-Arendt, 1988; McKee and Mendelssohn, 1989; Reed, 1989). This recognition has resulted in considerable efforts to investigate and understand the complex physical (Morris, et al. 1990), chemical (Mendelssohn et al., 1981; Morris, 1991), and ecological (Montague, et al. 1987) processes that drive the system, providing Louisiana with a rich history of scientific studies. Studies on understanding relationships between different habitats and different aquatic species (Minello and Zimmerman, 1991) have been conducted due to the importance of the Louisiana coast's support to numerous estuarine dependent fish and its ability to provide important nursery habitat for diverse fish communities. The coastal areas have also been important for wintering waterfowl with several studies conducted to understand

relationships between waterfowl use and habitat conditions. Oil and gas exploration and production have prompted numerous studies on subsurface geologic conditions (Wallace, 1966). Additional geologic conditions have been investigated to aid in understanding deltaic processes that have shaped the Louisiana coast (Fisk, 1944; Kolb and Van Lopik, 1958; Frazier, 1967; May, 1984; Smith et al., 1986; Penland et al., 1988; Dunbar et al., 1994; 1995). Studies on the Atchafalaya River and delta have also contributed to our understanding of deltaic processes (U.S. Army Corps of Engineers, 1951; Fisk, 1952; Shlemon, 1972; Wells and Roberts, 1984; Smith et al., 1986). In addition, numerous studies performed in other ecosystems are applicable to some degree in understanding the ecology and function of the Louisiana coastal area. The results of these investigations provide considerable understanding of the physical, chemical, and biological processes underway within the Louisiana coast. The numerous State-sponsored studies generated from the Coastal Wetlands Planning, Protection, and Restoration Act (CWPPRA) program have developed basic trend information over the last ten years. Studies funded by the National Science Foundation and others have aided in understanding impacts and provided recommendations for improved operations for some existing large water diversion projects.

Although many studies have been conducted in the Louisiana coastal area, most were limited in geographic extent or technical scope. Therefore, while much has been learned from previous efforts, many scientific and technical uncertainties remain. The LCA Plan builds upon a sizable knowledge base, but additional investigations to further reduce the scientific and technical uncertainties and to enhance the likelihood of projects successfully meeting restoration goals would be necessary during later LCA Plan implementation. The LCA Project Delivery Team (PDT) reviewed annual reports based on the monitoring results that are part of the CWPPRA process prepared to assess previously constructed CWPPRA projects. These efforts to identify lessons learned from the many CWPPRA projects, past and future, would also serve as a valuable assessment to help in determining what worked and why. Identification of reasons why some projects did not meet project goals would also be very beneficial in reducing potential uncertainties associated with future projects.

Louisiana natural resource managers have also long recognized the magnitude of coastal degradation (Dunbar et al. 1992; Barras et al. 1994; Barras et al. 2003) and have undertaken substantial efforts to address this problem. Advocacy groups have been formed for wetland protection and restoration. Federal and state statutes authorize and finance wetland restoration efforts throughout coastal Louisiana (Boesch, et al. 1994). Small-scale restoration projects proliferated throughout the 1990's, as scientists inside and outside of government continued to press for measures to address the land-loss problem regionally, as well as the related issues of offshore eutrophication and hypoxia (Coalition to Restore Coastal Louisiana, 1989).

In spite of these efforts, wetland losses have continued at a significant rate, computed to be 23.9 $mi^2$ (61.9 $km^2$) during the last 10 years (See Appendix B for more details.) Now more than ever, sound science is needed to support broader, systems-level, integrated coastal restoration to implement the LCA Plan.

## 1.2 Science and Technology Program Organization

This S&T Program appendix consists of five sections. Section 1 provides a short background on the problems and challenges of the LCA Plan. It also includes the objectives of the S&T Program, addresses why science is an integral part of the LCA Plan, discusses lines of communication between the S&T Office, Program Management Team, and the PET, and finally provides general guiding principles of the S&T Program. Section 2 discusses the concepts of Adaptive Environmental Assessment and Management (AEAM) and strategies for integration of science into the LCA Plan. Section 3 discusses the organizational structure of the S&T Program, its components, and relationship to the LCA Plan. Section 4 identifies some of the scientific uncertainties associated with many of the potential near-term courses of action. Those uncertainties provide the focus of the S&T Office, particularly during the early years of the S&T Program. This section also provides some examples of potential demonstration projects and the uncertainties to be addressed with those projects. Section 5 of this appendix identifies the assumptions and objectives considered to execute the S&T Program, a general strategy for Program development, and more specific tasks to be executed during the first three years of the S&T Program.

The first four sections of this appendix collectively provide the foundation for the LCA S&T Program and are not expected to change dramatically from year to year. However, Section 5 would be reviewed and refined annually to reflect lessons learned during program planning and execution. It would continuously be reviewed within the S&T Office to build upon our understanding of ecosystem processes and responses and to constantly reduce scientific uncertainties associated with operation of ongoing projects and planning and execution of future projects. This AEAM process would be integrated throughout the LCA Program, and would be integral to effective and responsive execution of the S&T Program.

## 1.3 Objectives of the Science & Technology Program

The objectives of the S&T Program are to provide a strategy, organizational structure, and processes to facilitate integration of science and technology into the decision-making process with Program Management Team, the PET and the S&T Program . Implementation of this S&T Program would ensure that the best available science and technology integrated into the design, construction, and operation of LCA Plan projects. This S&T Program incorporates AEAM by employing an iterative approach for improving science information and inserting it into management decisions (**figure A-1.1**). Therefore, as decisions are implemented based upon best available science, a structure and process must be in place to acquire better information and adjust the implemented actions accordingly to improve the probability of achieving the goals and objectives for implementation of the LCA Plan. Such a process requires the development of key tools, such as sound baseline data and monitoring over time and space, models, data management, and continued research – to provide managers and users with updated information for planning restoration and on the effects of management actions designed to achieve restoration. By participating in and providing information for restoration efforts, scientists can help define and measure the progress of restoration and the success of individual restoration projects and plans.

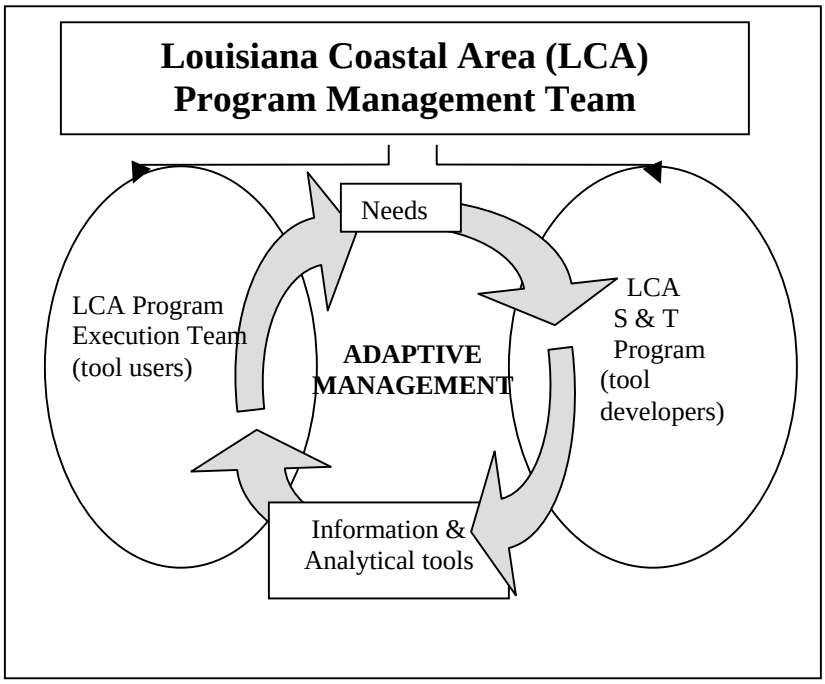


**Figure A-1.1. Louisiana Coastal Area (LCA) Program Management Team. The Program Execution Team would implement the LCA Plan with technical support from the LCA S&T Program. Communication between the Program Execution Team and the S&T Program would be achieved using an AEAM strategy.**

An effective S&T Program should perform the following:

- Work with LCA Program Management Team and the LCA PET to review and assess goals, objectives, and key documents of the LCA Program;
- Identify S&T needs to assist the LCA Plan in meeting those goals and objectives;
- Establish and maintain independent science and technology advisory and review boards;
- Manage and coordinate science projects for (1) data acquisition and monitoring, (2) data management, (3) modeling, and (4) research to meet identified scientific needs of the LCA Plan;
- Coordinate with other research efforts, such as the CREST program; the Louisiana Governor's Applied Coastal Research and Development Program, and other state and federal R & D entities;
- Incorporate lessons learned and experiences (pros and cons) of other large-scale ecosystem restoration science and engineering programs such as the Everglades, Chesapeake Bay, and Calfed;
- Conduct scientific evaluations, assessments and peer reviews to assure that the science implemented, conducted or produced by the S&T Program meets an acceptable standard of quality, credibility, and integrity;
- Establish performance measures for restoration projects and monitor and evaluate the performance of program elements;

- Improve scientific understanding of coastal restoration issues within the context of AEAM, and infuse this improved information into planned or future restoration planning, projects and processes conducted by the PET; and
- Prepare scientific documents including a periodic Science and Technology Report and conduct technical workshops and conferences.

In performing these activities, the S&T Program would maintain continual dialog among scientists, the Program Management Team, and the PET. Priorities for science and technology are established to meet program objectives and would be responsive to programmatic, coast wide issues, as well as project-specific issues.

## 1.4 Role of Science in Ecosystem Rehabilitation and Restoration

The need for a solid scientific foundation to support system-scale ecological restoration has been broadly recognized through similar programs and in statements of agency leaders. Restoration actions are frequently initiated because of societal perceptions rather than in response to a clear, scientifically defined, environmental concern. In the past, restoration managers often relied upon professional opinion to design, implement and manage projects but today's managers realize the value of a continual flow of science information to guide planning, construction, management, and monitoring of restoration projects. The credibility of complex ecosystem restoration programs and the ultimate success of the restoration effort require that science information be made available in a timely fashion and in useful formats to decision makers. An early and fundamental role for science is to provide an understanding of system functions as the basis for determining what processes and attributes need to be restored or managed.

The role for science then is not to make the restoration and management decisions but to:

- Improve coastal restoration decision-making, by identifying science issues to be addressed and develop science information for restoration managers;
- Provide scientific data, analysis, and interpretation that are critical to the planning, design, construction and operation of restoration projects;
- Develop tools, methods, and protocols for system and project-level restoration planning and assessment;
- Minimize uncertainties about the system or system components, which limit restoration planning and execution;
- Assess the immediate and long-term effectiveness of restoration actions in meeting program goals; and
- Provide information and synthesis in a timely manner and useful formats.

There is also growing recognition that restoration efforts simply would not succeed without a sound scientific foundation. This foundation includes: (1) placement of the science and technology program in the organizational structure so that its products may be used for decision-making, (2) development of relevant science information delivered to managers in a timely manner and useful format, and (3) a commitment to continuous review of monitoring data from restoration projects to adapt their operation and development, as well as the design of future

projects, based upon system responses. The LCA Plan approach is based on using the best information in an AEAM setting, and the S&T Program would assist in overcoming these challenges as the LCA Plan is implemented.

### 1.4.1 S&T Program Structure

There are five primary components in the S&T Program and each component has a different emphasis and requirement. These include: (1) S&T Information Needs, (2) Data Acquisition and Monitoring, (3) Data and Information Management, (4) Modeling and AEAM, and (5) Research. Determining S&T needs requires a continuous process in place that solicits such needs from the Program Manager, the PET, and scientists. Data Acquisition and Monitoring require standard operating procedures and rigorous adherence to those standards. Data and Information Management requires standards and procedures to assure data can be shared or compiled from a variety of sources. Modeling and AEAM requires broad interactions among scientists, Program Management Team, and the PET. Research requires clear hypothesis testing and a substantial degree of scientific independence but close coordination with the PET. A systematic process will be established to provide minimum standards for data quality and data management for information received and used by LCA.

#### 1.4.1.1 Science Information Needs

The S&T Program, working closely with LCA Program Management Team and the PET, would develop processes to determine science needs. The S&T Program would also assure that both scientists and the PET are involved in establishing needs, ranking the importance of each need, and determining feasibility. This is envisioned as a continuous process that is repeated each year for the coast as a whole and more often for solving specific problems. While the emphasis on coastal restoration is an integration of science disciplines, this process must also determine science needs while ranking importance and feasibility on a discipline-by-discipline basis. Broadly this includes disciplines such as:

- Hydrology (flows in rivers, open water and bays, salinity, sediment loads and flows, water quality, nutrients, and storm effects);
- Biology and ecology (mapping habitats and trends, ecological processes and functions and values, species and habitat requirements and restoration, invasive species);
- Geography (base maps, satellite maps, aerial photography, land loss trends, elevation, and bathymetry);
- Geology (barrier island processes, sand sources, faulting, subsidence processes, coastal processes);
- Oceanography (hypoxia, and oceanic processes);
- Meteorology (weather and storm patterns and intensity);
- Sociology (Cultural change and trends);
- Economics (Effective costs or savings of restoration); and
- Information technologies (Computer systems, geographic information systems, communications, data storage and retrieval, and standards).

#### 1.4.1.2 Data acquisition and monitoring

To be effective in providing data and information to Program Management Team and the PET, this S&T Program would consider data needs in a geographic hierarchy for the purposes of restoration planning, construction, management and maintenance, and monitoring the relative success of projects. Project success would be measured, not only on a project-by-project basis, but also on its contributions to both basin or sub-basin levels, and entire ecosystems (e.g. Mississippi Deltaic Plain or Chenier Plain). To accomplish this, the S&T Program would strategically develop, as needed, monitoring systems and collect data within the different ecosystems and integrate this effort with the other ongoing monitoring systems like the CWPPRA Coastwide Reference Monitoring System for Wetlands as appropriate.

#### 1.4.1.3 Data and information management

The data and information available through numerous agencies and organizations include historic coastal Louisiana datasets, ongoing monitoring collections, and new data collections generated from new restoration projects and science programs. A data and information management system is needed to provide scientists and project managers with decision-support tools to compare historic trends and management strategies with current restoration techniques. This network of geospatial and scientific data would allow project managers to incorporate lessons learned and adjust restoration strategies to best achieve management goals. The data and information framework may 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.

#### 1.4.1.4 Monitoring and Adaptive Environmental Assessment and Management

Implementation of AEAM prescribes a management process wherein future actions can be changed by observing the efficacy of past actions on the ecosystem through the use of monitoring and modeling. The AEAM approach recognizes that uncertainty is unavoidable in managing large-scale ecological systems. However, when it is properly planned and maintained, the feedback element can be used to sequentially improve management actions so that future system conditions become more consistent with program goals and objectives than past actions. AEAM allows development of an iterative and flexible approach to management and decision-making.

#### 1.4.1.5 Research

There are many kinds of science needs that must be pursued through a research and hypothesis or experimental testing process. Therefore, it is imperative that the S&T Program is guided by the needs articulated by the Program Manager, but allowing for opportunities within the S&T Program for creative studies or testing of new technologies that may have utility for future projects. The role of research in the S&T Program would be to lower costs and risks associated with new restoration techniques, and to provide new analytical tools for assessment of ecological processes and project performance. In general, research projects have a variety of possible outcomes and often a substantial amount of uncertainty, and as a result require a great

deal of scientific independence. This includes restoration demonstration projects, field or laboratory projects, new technology demonstration projects, characterizations of project areas, or improving our understanding of natural and human caused processes that affect restoration and answer scientific uncertainties.

## 1.5 Communication

While scientific understanding of restoration issues has improved, significant gaps remain in the scientific information and AEAM tools needed for large-scale coastal restoration. Program Management Team, the PET, and the S&T Program (**figure A-1.2**) would coordinate to ensure that the objectives of the LCA Plan are achieved using the best available science. The PET and the S&T Program are generally interconnected as follows: the LCA PET, representing those needing and using the science information and are the tool users; and the S&T Program, representing those providing the S&T information and are the tool developers as indicated in **figure A-1.1**. Scientific information would be provided in the AEAM framework, through monitoring and periodic interpretation, model analysis, and continual improvement in knowledge and methods by supporting research, and interaction between scientists and restoration managers. The framework also provides mechanisms for periodic independent peer review to ensure high standards of scientific investigation. The S&T Program establishes a framework in which study components are integrated to ensure that sound science is utilized in making appropriate restoration choices and long-term environmental sustainability.

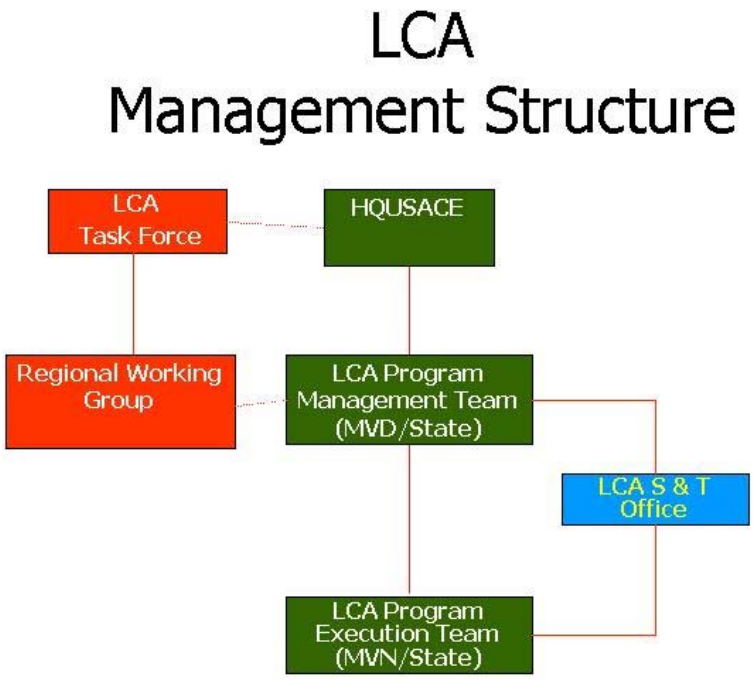


**Figure A-1.2. LCA Management Team Structure.** This figure presents the lines of communication between the LCA Management Team Structure and the S&T Office.

The S&T Program, executed through the LCA S&T Office (**figure A-1.2**), provides mechanisms of coordination that are necessary to ensure timely information transfer to both decision-makers and the PET, and to identify resource needs required to provide the scientific information necessary to implement the LCA Plan. The S&T Program ensures data management and synthesis processes will facilitate information sharing and periodic reporting. An important component of coordination is the timely and accurate identification of data gaps that would be addressed through hypothesis testing. Subsequently, the S&T Program incorporates independent, technical review committees and advisory boards, and periodic reviews of existing data through coordination meetings and conferences. The S&T Program would be reviewed annually and updated as part of the AEAM strategy.

## 1.6 Science & Technology Program Approach

### 1.6.1 Science & Technology Program Development Process

Formalization of a science-based program for the LCA Plan and the institutional framework for management of a mission-directed program of data acquisition/monitoring, research, and modeling, model development, and assessment requires an interdisciplinary and interagency approach. Moreover, successful management of these efforts requires the clear articulation of science and management needs, and ultimately, the agreement of how those needs are organized, prioritized, and accomplished. Therefore, an early step taken to construct the S&T Program was to conduct a workshop for scientists from Louisiana and across the nation to provide suggestions that could be used by the Corps and State to identify data gaps and enhance development of a science-based AEAM Decision-Support System. Additionally, a review was conducted of other similarly large ecosystem restoration programs (i.e., Everglades, CALFED, and Chesapeake Bay) to assess lessons learned and to provide direction for development of the S&T Program proposed herein. The review was an opportunity to examine lessons learned by others and to build upon the strengths of those programs to develop and implement the AEAM strategy presented in this S&T Program. Subsequently, several additional meetings were held with representatives from Federal and state agencies and academia to discuss the goals and objectives of such a S&T Plan and to develop an overall strategy and organizational structure for the S&T Program. Representatives from the meetings prepared draft sections of this S&T Program.

#### 1.6.1.1 Strategy

A basic premise of the S&T Program is that it would be based on AEAM (See Section 2 of this appendix for a more detailed discussion.). All work covered by this S&T Program would be both scientifically defendable and relevant to the overall program needs of the LCA Plan. This means that all scientific activities would be conducted in a manner true to scientific principles and methods, with recognition of the practical and applied destination of the results. This S&T Program would be implemented in close coordination with LCA Program Management Team and the PET to cover all scientific studies: investigations, data collection, simulations, analysis, modeling, and evaluations sponsored either directly through the LCA Plan or conducted in support of the program by coordinating partners. Work conducted through this

S&T Program would comply with generally recognized *Scientific Guiding Principles* and be directed, executed, and reported through a well-defined *S&T Program Structure*.

#### 1.6.1.2 Scientific guiding principles

All work would be conducted in compliance with the following Guiding Principles:

(1) All scientific work would be ***Responsive*** to and prioritized according to the LCA Plan ***needs.***
(2) A strategy of ***Science Leadership and Engagement with the Program Execution Team in Adaptive Environmental Assessment and Management*** would continue to be integrated throughout execution of the LCA Plan and the S&T Office.
(3) ***Clear lines of Communication*** would be established and maintained between all members of the scientific team, LCA Program Management Team, the LCA PET, external advisors, and the public as appropriate through a coordinated effort.
(4) Scientific activities would promote ***Multiple Discipline Integration*** to optimize synergy and early resolution of potential technological conflicts.
(5) The scientific process would be ***Transparent*** with all steps, assumptions, and products available for professional and public scrutiny.
(6) All science work would be based upon the ***First Principles***, i.e., incorporate the fundamentals of biology, physics, and chemistry while maintaining temporal and spatial-scale relationships among all variables and comply with the scientific method.
(7) Work would be conducted within the context of ***Building Institutional Learning and Scientific Capabilities*** that would provide continuing future technological benefit to the Louisiana coastal area and the study partners.
(8) The current ***State of the Technology*** would be applied and transferred into application, but advances in technology would continuously be examined and integrated as appropriate.
(9) ***Resources would be Leveraged*** across the various agencies and study partners to promote fiscal responsibility.
(10) A ***Peer Review*** process would be established and followed to include research proposal evaluations, in-progress review, and product quality assessments.
(11) All members of the S&T Program would be ***Accountable*** for the integrity, quality, ethics and appropriateness of their work.