

Ecological Management

ECOLOGICAL MANAGEMENT ACTION PLANS

The Action Plans included under **Habitat Management** address the three most critical Priority Problems identified for the BTES - *Hydrologic Modification, Reduced Sediment Flows* and *Habitat Loss/Modification*. As such, they are considered by many to be the most important portion of the CCMP. Underlying these actions is the need for coordination with various other initiatives which have been created to address these critical problems, such as the Coastal Wetlands Planning, Protection and Restoration Act (CWPPRA), and the state's LEAP 2000 program. Of particular importance is the CWPPRA program, as it will provide much of the federal funding required to implement the actions described in this section. Two feasibility studies - one for barrier island restoration, and the other for freshwater and sediment diversions - are presently being conducted in association with CWPPRA, and will significantly impact the specific implementation of these actions. Therefore, it is of the utmost importance that the recommendations included in this CCMP be considered in conjunction with CWPPRA and the other initiatives.

Several efforts have been initiated by the BTNEP in order to broaden the scientific knowledge of these issues, as well as to demonstrate the effectiveness of certain strategies. The BTNEP-sponsored report, *Current Status and Historical Trends of Hydrologic Modification, Reduction in Sediment Availability and Habitat Loss/Modification*, characterizes the current status as well as the spatial and temporal trends of the three Priority Problems. The data produced by this report has been incorporated into the CCMP, as well as the individual action plans. In addition, BTNEP has sponsored two modeling efforts: a landscape simulation model, which will help predict large-scale habitat changes in the BTES; and a hydrologic model, which will help to increase the understanding of water movement in the estuaries. BTNEP has also sponsored a demonstration project using donated Christmas trees to encourage marsh formation in abandoned canals.

In developing these action plans, the Ecological Management Alliance of the Management Conference produced two working documents: the *Phase One Document: Common Ground Strategy for Managing Coastal Wetlands, Barrier Islands and Adjacent Bay Habitat of the Barataria-Terrebonne Basins*; and, the *Phase Two Document: Plan Formulation and Implementation*. The first document identifies the strategies, or "tools" which can be used in habitat management, while the second applies these tools to the specifics of the BTES, including the incorporation of selected CWPPRA projects. These two documents form the basis for the seven Habitat Management Action Plans.

The **Water Quality** action plans directly address three Priority Problems identified by the BTNEP: *Eutrophication, Pathogen Contamination* and *Toxic Substances*. In addressing these problems, Alliance members were aware of the need to tie these actions in with the ongoing efforts of existing agencies, such as the Louisiana Department of Environmental Quality's Nonpoint Source Program, Water Quality Inventory, Water Pollution Control Program, and Toxics Release Inventory; the Louisiana Department of Natural Resources' Coastal Nonpoint Pollution Control Program; and, the Environmental Protection Agency's National Pollutant Discharge Elimination System. The focus of this effort was to work with these programs, avoiding duplications, to ensure that the specific needs of the BTES were addressed.

To support the work being done in this area, the BTNEP has sponsored several initiatives. A report entitled *Characterization of the Current Status and Historical Trends of Eutrophication, Pathogen Contamination and Toxic Substances in the Barataria and Terrebonne Estuarine Systems* was prepared to analyze current and historical data and literature on the three Priority Problems and provide additional data for the Action Plans. Additional studies were sponsored regarding fecal coliform monitoring and mapping of storm water drainage stations. Finally, a demonstration project was initiated to identify alternative agricultural practices which would reduce sediment runoff. A special Task Force on Water Quality was assembled in order to provide the specific experience needed to develop

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action plans in this area. The Task Force included members of the Alliance, as well as scientists from various universities and agencies who had expertise in a specific water quality issue. This collective effort produced seven action plans.

The **Living Resources** action plans address the Priority Problem of *Changes in Living Resources*. The actions proposed in this area not only serve to protect the living resources of the BTES, but also address the need to protect the estuaries from the negative impacts caused by certain species, such as zebra mussels and exotic vegetation. A related plan, addressing nutria herbivory, can be found in the Economic Growth section (plan *EG-3, Nutria Market Development*). Again, Alliance members worked towards integrating these actions into ongoing programs, rather than duplicating efforts. To provide the scientific foundation for the actions in this area, BTNEP sponsored a study, *Status, Trends, and Probable Causes of Change in the Living Resources of the Barataria-Terrebonne Estuary System*. In addition, BTNEP sponsored such projects as oyster grounds mapping and the formulation of a management plan for migratory birds. A Task Force of Alliance members, scientists and agency representatives was assembled to produce the Living Resources action plans.

The BTNEP publication, *Status, Trends and Probable Causes of Change in Living Resources in the Barataria-Terrebonne Estuarine System*, focused on a broad spectrum of species and animal groups within the estuaries. Selected invertebrates, finfish, amphibians, reptiles, birds and mammals are profiled in this document. A recurring management recommendation in the document was the importance of quality habitats, land and water, for a species' survival and for the sustainment of commercial considerations of the estuaries' harvestable aquatic resources. Quality habitat is a recurring statement of need in many of the action plans discussed here; including the action plan for migratory and resident birds (*EM-15*).

The absence of specific action plans for the many species profiled within the *Status and Trends* document is not a reflection of lesser importance than the three action plans included in this CCMP. To the contrary, many of the species profiled within the *Status and Trends* document are part of ongoing monitoring and assessment actions by state and federal agencies and reflect the longstanding importance of those species. The BTNEP endorses and encourages the continuation and expansion of these efforts.

The final plans in this section, **Accessible and Compatible Data Sets**, address the BTNEP Goal, *Create an accessible, comprehensive data base with interpreted information for the public*. In response to this goal, the BTNEP sponsored a study to assess the feasibility of a Data Information and Management System (DIMS) for the BTES. Such a system would establish information management tools and data formats that will best meet the needs of those managing the estuary.

EM-1 Hydrologic Restoration

OBJECTIVES

1. To restore the hydrology of the estuary in order to effectively use the fresh water, sediments and nutrients that already reach the basin marshes and to ameliorate the impacts of local hydrologic modifications.

DESCRIPTION

Hydrologic restoration is the use of plugs, weirs, culverts, shore stabilization and levee management to restore wetland hydrology to a state that more closely reflects hydrologic conditions prior to human alterations. The

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inclusion of specific structures and/or strategies depends upon the specific hydrologic alterations to be addressed by the project.

This action will create flow regimes which effectively use the freshwater, sediments, and nutrients that already reach the basin marshes. In areas where there is little or no freshwater, hydrologic restoration will be used to ameliorate the impacts of local hydrologic modifications. This will also be done in conjunction with freshwater and sediment diversions as "outfall management". In Terrebonne Basin, projects will focus on improved utilization of water and sediments from the Atchafalaya River. A saltwater barrier or lock in the Houma Navigational Canal is being considered. In the Barataria Basin, a major focus will be the control of tidal exchanges between the marshes of the upper and lower basin. Hydrology of the fringing marshes along the Mississippi River and Bayou Lafourche will also be improved.

BACKGROUND/MAJOR ISSUES

Hydrologic restoration projects are usually suggested for implementation in fresh, intermediate, brackish and saline marsh types, and are frequently recommended for cypress-tupelo swamps.

Hydrologic restoration projects use artificial means to restore artificially altered hydrologic regimes. The goals are to improve coastal marsh productivity, water quality and reduce land loss. In this case, artificially altered regimes include wetland areas which have been impacted by canal dredging and levee placement. Hydrologic restoration projects do not normally address alterations to marsh hydrology caused by levees on the Mississippi or Atchafalaya Rivers. These hydrologic problems are addressed by the actions described in Action Plan *EM-2, Freshwater and Sediment Diversions*.

Outfall management and the techniques used to achieve this management play a vital role in achieving the maximum gain from fresh water diversion projects. The approach to outfall management is to slow water velocities and to circulate diverted flows to bathe wetlands as much as possible with oxygenated, nutrient-rich, freshwater in the upper reaches of the project area and allow it to slowly flow through the estuary diluting ambient salinities. It is not an effort to impound water, but rather to incorporate retention measures for better water control, and to retard the rapid drainage typically enhanced by various types of man-made channels.

Some unavoidable impacts may include reduced access for recreational and commercial fishing, and potential for reduced ingress and egress of estuarine organisms. Plugs can eliminate access to some areas; and weirs and culverts can reduce access to varying degrees, depending on structural design. However, innovative approaches are being utilized in project design to facilitate passage of aquatic organisms and boats in all hydrologic restoration projects. Altered hydrologic exchange may reduce the amount of suspended sediment import to brackish marshes but this potential impact may be offset where suspended sediments are retained longer in the marsh, where there is no sediment source, or where marsh soils are largely organic and the requirement for sediment input is reduced.

Hydrologic restoration should be carefully implemented to avoid or address concerns regarding backwater flooding, potential impacts on infrastructure or landowners, adverse impacts on oyster leases and submerged aquatic vegetation, potential for water quality changes including eutrophication, increased duration of flooding on the marsh surface, adequate drainage for already flooded areas, and alterations to navigation.

BENEFITS

The primary benefit of hydrologic restoration projects is improved marsh productivity. This is achieved by increased freshwater retention within fresh and brackish marsh areas, enhanced nutrient and sediment retention in marshes, and

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reduced tidal exchanges. Reductions in tidal exchange and turbidity may also benefit submerged aquatic vegetation. Increased productivity of existing marshes is essential because of the high rates of coastal land loss and habitat change being experienced within the Barataria and Terrebonne basins.

IMPLEMENTATION SCHEDULE

This plan recommends that the Barataria-Terrebonne Management Conference (BTMC) and the citizens of the estuary support the implementation of hydrologic restoration as an ecological management tool wherever it is appropriate, economically feasible and conforms with the broader strategies for the coastal zone laid out in the *Louisiana Coastal Wetlands Restoration Plan* (also referred to as the CWPPRA plan). Specific recommendations are as follows:

Barataria Basin

This plan recommends CWPPRA projects which affect large areas of the basin, such as L'Ours Ridge restoration, which will plug the breaches in the ridge which allow north-south tidal flows; Central Basin Tidal drag, which will slow the opening of the central part of the basin and provides a stabilized ridge; GIWW to Clovelly, which will slow water level fluctuations; and, Little Lake Oil and Gas, which will restore hydrology in a heavily impacted area.

Terrebonne Basin

One of the biggest problems in the Penchant Sub-Basin is high water levels caused by excessive flooding from the Atchafalaya River and Lake Verret area, and insufficient drainage. The primary strategy to improve marsh conditions in this basin is to improve drainage from the basin, especially in the southern and eastern directions. Therefore, projects similar to the Upper Bayou Penchant Watershed Management, as described in the CWPPRA plan, are critical to improving this area. This improved drainage should also help marshes outside of this sub-basin.

In the Lake Boudreaux area of the Timbalier Sub-Basin, projects of secondary importance include the installation of Flap-gated culverts under Louisiana Highway 57 between Dulac and Louisiana Highway 56 and the installation of a structure having a large boat bay in Robinson Canal near Highway 56. The importance of culverts under Highway 57 is to allow for the flow of water north-to-south under the highway and to relieve ponding in this portion of the basin. The structure in Robinson Canal will reduce tidal fluctuations and saltwater penetration in the Lake Boudreaux area. The Lake Boudreaux Wetland project is also recommended.

While small-scale projects could be accomplished with a short-term time frame (0-3 years), the larger projects outlined above require careful design and planning. Short-term plans for this action include:

- S 1.00 BTMC support for the implementation of small-scale hydrologic restoration projects in areas where these are feasible, ecological benefits can be obtained, and funding is available.
- S 2.00 The BTMC should work to ensure that some of the specific projects recommended above are selected for CWPPRA funding.

Medium-term plans (3-6 years) are as follows:

- M 1.00 Projects approved for CWPPRA funding in the short-term should undergo planning, design and implementation phases within 5 years.
- M 2.00 The BTMC and citizens of the estuary should work to maintain interest in the ecological problems of the estuary and identify new areas where hydrologic restoration could be an effective ecological management tool. If such potential project sites can be identified, members of the BTMC should ensure that the projects

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are added to the CWPPRA Restoration Plan in order that they may be considered for future funding by that program.

Long-term plans (6 years and beyond) are as follows:

- L 1.00 The BTMC should ensure that implementors of hydrologic restoration projects constructed in the short- and medium- terms conduct necessary maintenance and monitoring of projects.
- L 2.00 Monitoring data should be evaluated by the Technical Committee of the BTMC to ensure that implemented projects are meeting their goals and not causing adverse impacts (e.g., prolonged flooding of the marsh surface).
- L 3.00 The BTMC should review the need for existing and future hydrologic management projects in the context of the findings of the Mississippi River Diversion feasibility study, and develop recommendations for any necessary changes in system management at all spatial scales.

LEAD AND SUPPORT IMPLEMENTORS

Small scale projects may be implemented in entirety by local land owners and parish governments. The lead implementor of the larger hydrologic restoration projects recommended in this action plan is more likely to be the CWPPRA Task Force which includes the U. S. Army Corps of Engineers, U. S. Fish and Wildlife Service, National Marine Fisheries Service, Natural Resource Conservation Service, Environmental Protection Agency, the State of Louisiana, and the implementing state agency. The cooperation of local landowners and parish governments will continue to be essential to the successful implementation of any hydrologic restoration project.

Support implementors may include the State's Coastal Wetlands Conservation and Restoration Task Force which includes the Governor's Office of Coastal Activities, Louisiana Department of Natural Resources, Louisiana Department of Environmental Quality, Louisiana Department of Wildlife and Fisheries, Louisiana Department of Agriculture, and the Louisiana Department of Culture, Recreation, and Tourism.

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COSTS AND ECONOMIC CONSIDERATIONS

Table EM1-1 provides estimated costs for short- and medium term activities specified in this plan. It includes lead agencies and costs for short- and medium-term activities. Costs are broken down into those considered “new” (a direct product of CCMP recommendations) and “existing” (where plans coincide with existing responsibilities/activities). Acceptance of this plan by the agencies or entities listed as lead or support implementors does not commit that agency or entity to implement the plan. At a later date, parties identified as potential plan implementors will work with the Program Office, the BTMC and other plan implementors to formalize all commitments concerning implementation.

Table EM1-1. Cost Estimates.

	ACTION DESCRIPTOR	LEAD	EXISTING/ NEW	SUBSUME	Y 1-3 COSTS (Short Term)	Y 3-6 AVG COSTS (Medium Term)
EM-01					\$756	\$189
EM-01S1.00	<i>MC support: implem.</i>		E	PI-2	\$0	\$0
EM-01S2.00	<i>MC support: funding</i>				\$756	\$0
EM-01S2.01	<i>funding support</i>	USACOE	E		\$84	\$0
EM-01S2.02	<i>funding support</i>	USEPA	E		\$84	\$0
EM-01S2.03	<i>funding support</i>	USFWS	E		\$84	\$0
EM-01S2.04	<i>funding support</i>	USDA	E		\$84	\$0
EM-01S2.05	<i>funding support</i>	NOAA/ NMFS	E		\$84	\$0
EM-01S2.06	<i>funding support</i>	LDWF	E		\$84	\$0
EM-01S2.07	<i>funding support</i>	LDNR	E		\$84	\$0
EM-01S2.08	<i>funding support</i>	BTPO	E		\$84	\$0
EM-01S2.09	<i>funding support</i>	USNRCS	E		\$84	\$0
EM-01M1.00	<i>plan; design; implementation</i>	CWPPRA	N: no estimate			
EM-01M2.00	<i>additional site identification</i>					\$189
EM-01M2.01	<i>site identification</i>	USACOE	E			\$21
EM-01M2.02	<i>site identification</i>	USEPA	E			\$21
EM-01M2.03	<i>site identification</i>	USFWS	E			\$21
EM-01M2.04	<i>site identification</i>	USDA	E			\$21
EM-01M2.05	<i>site identification</i>	NOAA/ NMFS	E			\$21
EM-01M2.06	<i>site identification</i>	LDWF	E			\$21
EM-01M2.07	<i>site identification</i>	LDNR	E			\$21
EM-01M2.08	<i>site identification</i>	BTPO- EQS	E			\$21

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EM-01M2.09	site identification	USNRCS	E				\$21
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FUNDING STRATEGY

Total Funding Necessary (Years 1-5): \$1,500
Total Funding Existing (Years 1-5): \$1,500
Total New Funding Necessary (Years 1-5): \$0

Summary of new funding strategy: Existing funding for this action plan for the next five years has been identified and will come from department budgets, grants, and volunteer time. No new funding source is required.

EVALUATION METHODS

The monitoring strategies outlined below are related to implementation of the CCMP action plan only and do not apply to actions by others.

Components of Plan

1. Improved utilization of Atchafalaya water and sediments in Terrebonne.
2. Control of tidal exchanges between marshes of upper and lower Barataria.
3. Improve hydrology of fringing marshes along the Mississippi River and Bayou Lafourche.

Interrelationships Among Components

BTMC supports implementation where feasible, ecologically beneficial and funding is available, and works to ensure that recommended projects are selected for CWPPRA funding. BTMC also needs to work to identify new projects in the medium term and ensure they are added to the CWPPRA plan. BTMC reviews monitoring data to ensure projects are meeting their goals and examines projects in the context of the findings of major Feasibility studies concerning Barataria-Terrebonne coastal marshes.

Documentation of Plan Implementation

CCMP Action Plan implementation

The following criteria will be used to determine if CCMP Action Plan implementation steps were accomplished:

1. BTMC passes motions/resolutions in support of hydrologic restoration projects that meet criteria laid out in Action Plan.
2. BTMC nominates supported projects at CWPPRA public meetings.
3. BTMC revises the list of hydrologic restoration projects recommended in the Action Plan.
4. BTMC reviews monitoring data for CWPPRA funded projects and provides comments to CWPPRA.
5. BTMC Technical Committee attends public meetings re. Mississippi River Diversion feasibility study and provides comments re. the feasibility study and existing CWPPRA Restoration Plan concerning hydrologic restoration projects recommended in the CCMP.

The following criteria will be used to evaluate the effectiveness of individual hydrologic restoration projects in meeting CCMP Action Plan objectives. Specific criteria may vary depending upon the characteristics of individual projects.

1. Coastal marsh productivity improves.
2. Freshwater retention in fresh and brackish marshes is increased.
3. Tidal exchanges are reduced.
4. Nutrient and sediment retention in marshes is enhanced.
5. Rates of land loss are reduced.

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6. Access for recreational and commercial fishing is maintained.
7. Ingress and egress of estuarine organisms is maintained.
8. Maintain or increase flushing in forested wetlands.
9. In brackish marsh areas where total suspended solids input is both required and available, total suspended solids input is maintained.
10. There are minimal adverse impacts:
 - a. on oyster leases;
 - b. on SAV;
 - c. on infrastructure or landowners;
 - d. related to backwater flooding;
 - e. caused by increased duration of marsh flooding;
 - f. or on navigation.

Methods

Measurable parameters

CCMP Action Plan Implementation - The activities of the BTMC as outlined in the above criteria will be monitored by an independent Third Party.

Sampling design and statistical methods

CCMP Action Plan Implementation - There are no relevant sampling design or statistical analyses for the evaluation of plan implementation.

Cost estimates

CCMP Action Plan Implementation - The cost estimate is based upon attendance at approximately 6 meetings per year and appropriate reporting. The level of effort is estimated at 80 person-hours and costs including salary, fringe benefits, overhead and associated expenses are approximately \$4,000.

Recommendations and Feedback to Program/Implementor

Monitoring of CCMP Action Plan implementation will be undertaken by an independent Third Party. This independent Third Party will review project monitoring products prepared by CWPPRA and others. They will develop a report which outlines progress made towards accomplishment of CCMP Action Plan objectives. The CCMP Action Plan implementation monitoring reports will be submitted not less than 15 days prior to a regularly scheduled meeting of the BTMC and the independent Third Party will appear at the meeting to discuss the report. Monitoring reports concerning CCMP Action Plan effectiveness will also be provided to the agencies or institutions funding project construction, operation, maintenance, and/or monitoring as well as landowners.

Quality Assurance/Quality Control

Plan implementation

The Quality Assurance Plan involves the following components:

1. Clear identification of effectiveness criteria (as outlined above).
2. Use of qualified and experienced personnel to collect and report (monitor) information on CCMP Action Plan implementation status (to be determined and assessed annually by BTMC).
3. Review of monitoring data and reports by BTMC (as outlined above).
4. Reporting of significant problems identified during the monitoring period to the BTMC before the next report is due.
5. Maintaining a semi-annual schedule for reporting on BTMC activities (as outlined above).

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MONITORING STRATEGIES ASSOCIATED WITH EXISTING PROJECTS OR PROGRAMS

EVALUATION METHODS

The following monitoring strategies are intended to serve as a statement of the most comprehensive and effective mechanisms to assess the effectiveness of projects implemented under the CCMP Action Plans. These strategies should only be used as a guide, not as a requirement. It must be recognized that the monitoring strategies outlined here will be expensive to implement and that, because all levels of government and much of the private sector currently have severe funding restraints, they may not be affordable without significant modification. It must also be recognized that these strategies are not intended to suggest that regulatory agencies require a higher level of monitoring by permit applicants than is currently required.

The monitoring strategies outlined here do not override or replace project monitoring that would be done by an agency related to specific agency-sponsored projects. For example: the monitoring currently being done by LDNR in conjunction with CWPPRA projects would not be replaced by monitoring described in any particular CCMP Action Plan.

Methods

Steyer and Stewart (1992) list variables which may be measured to monitor hydrologic restoration projects implemented under CWPPRA. It is recommended that this model be followed, whether or not any particular project is funded by CWPPRA. Measurable parameters identified by Steyer and Stewart (1992) have been prioritized by Steyer et al. (1995) into Essential Variables or Additional Variables or Substitutions as shown in Table EM1-2. These have been assigned a priority for monitoring under the CCMP Action Plan. The priorities have been assigned based upon the broader mission of the CCMP compared to CWPPRA (restoration, creation or enhancement of vegetated wetlands is not necessarily the primary goal of CCMP Action Plans) and the objectives of the projects as described in the Action Plan. However, priorities for monitoring variables may vary based upon the characteristics, objectives and design of individual projects.

Table EM1-2. Steyer et al. (1995) classification of monitoring variables for hydrologic restoration.

Essential Variables	BTNEP Priority	Additional Variables or Substitutions	BTNEP Priority
Habitat Mapping	1	Fisheries	6
Salinity	2	Accretion/Elevation Change	4
Water Level	3	Water/Sediment Quality	None^a
Vegetation	5		

^a For forested wetlands, where the main objective is to increase flushing and water circulation, it is recommended that monitoring of water level fluctuations and dissolved oxygen be given high priority.

In addition to the parameters in Table EM1-2, it is recommended that the following parameters be measured to ensure that there are minimal adverse impacts associated with project implementation:

1. Productivity on adjacent oyster leases.
2. Coverage of SAV.

These measurements should be given lower priority than those in Table EM1-2. The other criteria concerning potential adverse impacts (e.g., impacts on landowners and backwater flooding) should not or cannot be measured directly but BTMC should be made aware of any complaints that are received by the implementing agency concerning these issues that directly relate to the project.

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Data collection methods

This section provides guidance on the types of data collection methods which are currently available and appropriate for monitoring these types of projects. There may be alternative existing or new techniques which could be adopted as long as they conform to the data quality objectives described under QA/QC.

Habitat Mapping - The procedures and methods outlined by Handley (1992) and Steyer et al. (1995) should be followed.

Salinity - The procedures and methods outlined by Powell (1992) and Steyer et al. (1995) should be followed. At least one continuous recording salinity gauge should be installed at each project and reference site.

Water Level - The basic procedures and methods outlined by Powell (1992) and Steyer et al. (1995) should be followed with the following detailed recommendations. At least one continuous water level gauge should be installed at each project and reference site. These gauges should be sufficiently accurate to record changes in water level of 1 cm and pressure transducers should be vented to allow for automatic correction of changes due to atmospheric pressure. If unvented transducers are used, data must be corrected for changes in barometric pressure.

Vegetation - As the monitoring criterion addresses coastal marsh productivity, rather than the abundance of species or communities, the recommendations of Steyer (1992) concerning aboveground biomass and of Steyer et al. (1995) concerning biomass measurements should be followed for assessment of emergent vegetation. For SAV, species composition can be obtained by transect sampling (USEPA, 1993) using an airboat-rake method (Chabreck and Hoffpauir, 1962) to collect the samples. The frequency of occurrence of individual species should be recorded. The methods described by USEPA (1993) for estimating density of SAV in beds can also be used, depending upon water clarity.

Fisheries - Minello (1992) provides details of high gear-efficiency techniques for fisheries sampling which are appropriate for hydrologic restoration projects and these are recommended. Sampling methods should focus on identification of density, size and biomass of nekton (Steyer et al., 1995). Enclosure devices are the most appropriate gear to be used and care should be taken to control for variations in water level both between sampling periods and between samples on a given day, as this can greatly impact catch efficiency (Minello, 1992). If long-term data sets already exist for the project area using other gear, these techniques should be considered in the development of individual monitoring plans. Sampling of oyster leases is also addressed by Minello (1992) and a variety of techniques are discussed. In this case, the monitoring goal is to identify any adverse impacts on adjacent oyster leases and the Nestier tray and Butler plate techniques recommended by Minello (1992) should be used to examine survival of existing oysters and settlement of oyster spat on appropriate leases.

Accretion/Elevation Change - As the goal of the project is to maintain or enhance contemporary rates of marsh accretion, the feldspar marker horizon technique may be most appropriate. This method is described in detail by both Reed (1992) and Steyer et al. (1995). Feldspar marker measurements should be combined with measures of soil bulk density and organic content (Reed, 1992) to allow for the calculation of organic and inorganic accumulation. However, sediment-erosion table techniques (Boumans and Day, 1993; Reed, 1992; Steyer et al., 1995) are appropriate for long-term measurements of the response of marsh elevation to accretionary processes. These should be employed where the marsh environment is appropriate (i.e., attached marshes) and where sampling design includes comparison with a reference area.

Water Quality (Dissolved Oxygen) - Dissolved oxygen sensors should be cross-calibrated using the Winkler titrametric method (Rabalis et al., 1995). In addition, care should be taken to ensure that measurements at one location are always taken at the same time of day to account for daily variability in dissolved oxygen which has been identified in most estuaries (Summers and Engle, 1992).

Sampling design and statistical methods

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The sampling design for monitoring project effectiveness must include comparison of the project area with an appropriate reference area. Monitoring projects without the use of a reference area can lead to misinterpretation of monitoring data through the lack of a comparative site to identify natural interannual changes in marsh processes, and/or other difficulties (Steyer et al., 1995). It is necessary to ensure that reference and project areas are comparable. Both project and reference areas should be divided into marsh habitats and replicate samples randomly selected within each habitat type. Comparison between project and reference areas should then be based at the sub-area or habitat scale (e.g., brackish marsh sub-area in project is compared to brackish marsh sub-area in reference area). If it is impossible to select a suitable reference area, then either pre-project monitoring or baseline monitoring (Steyer et al., 1995) may be adopted as an alternative. Both of these approaches reduce the validity of the monitoring results as the monitoring then fails to account for natural interannual variability in marsh processes.

The size of the project area, the number of habitats included in the area, and heterogeneity of those habitats determine the number of samples which need to be taken and the validity of the statistical analyses. Steyer et al. (1995) describe appropriate procedures for the determination of sample size within the project area. The use of parametric (e.g., ANOVA, Student's t-test) or non-parametric (e.g., Mann-Whitney U-test, Kolmogorov-Smirnov test) statistical procedures will depend upon the character of the datasets. If data are not normally distributed, as may frequently be the case with the collected data (e.g., salinity in a fresh or intermediate marsh), then transformations, such as logarithmic and square root transformations, should be applied and the transformed data tested for normality. If a normal distribution cannot be achieved in this manner, non-parametric tests should be used. The most basic statistical design for project evaluation is a two-tail test of whether the mean value for a measurable parameter within the project areas is equal to the mean for the reference area. If inequality is identified, further analyses can then determine if the effect of the project is to increase the parameter or decrease the parameter.

Cost estimates

Estimated costs for evaluating hydrologic restoration projects have been developed for CWPPRA by Steyer and Stewart (1992). The actual costs depends upon the size of the project and the number of stations sampled/samples collected. These estimates have been revised where possible in consideration of the recommendations presented here regarding measurable parameters and data collection methods. Ranges are presented for cost estimates on an annual or per sample basis (Steyer and Stewart, 1992) in Table EM1-3 and are compared with monitoring costs associated with the final CWPPRA monitoring plan for the Jonathan Davis Hydrologic Restoration project.

Table EM1-3. Cost estimates for monitoring hydrologic restoration projects.

Parameters	Est. Cost (Steyer and Stewart, 1992)	Cost Basis	BA-20 Jonathan Davis Est. Cost per year over 20 year
Habitat Mapping	\$12,250-18,600	Annual per project	\$8,934
Water Level & Salinity	\$23,600-96,400	Annual per project	\$14,841
Accretion - Feldspar	\$450	Per sample	Included w/vegetation
Elevation Change	\$250	Per measurement	Not monitored
Vegetation	\$2,250-6,750	Annual per project	\$594
Fisheries	\$150-200	Per sample	Not monitored

For hydrologic restoration projects implemented by CWPPRA, average annual monitoring costs shall not exceed \$25,875. This amount is pro-rated according to project size (Steyer et al., 1995) as follows: less than 1000 acres - 60%; 1000-5000 acres - 70%; 5000-15,000 acres - 80%; and greater than 15,000 acres - 100%. These requirements have constrained the development of monitoring plans for CWPPRA projects to below ideal levels which are more realistically reflected in the cost estimates of Steyer and Stewart (1992).

CCMP Part Three - The Technical Supplement: Barataria-Terrebonne Action Plans

Quality Assurance/Quality Control

The Quality Assurance Plan involves the following components:

Project Description - (as provided in Action Plan).

Project Organization and Responsibility - (to be prepared by lead implementor).

Data Quality Objectives - For the measurable parameters recommended in this monitoring strategy, Table EM1-4 presents these objectives as determined by Steyer et al. (1995).

Sampling Procedures - The data collection methods are as described above.

Sample Custody - Collected samples will be in the custody of the monitor from collection to sample processing. Should contractors be utilized for sample processing, written documentation of sample transmission and receipt shall be maintained by the monitor.

Calibration Procedures - Routine calibration of field and laboratory equipment will be undertaken in accordance with manufacturer's instructions or at least annually. Written documentation of the calibration procedures and records shall be maintained by the monitor.

Analytical Procedures - The procedures described by Steyer et al. (1995) and references therein will be followed for analysis of the identified measurable parameters.

Data Review, Validation and Verification - The general procedures described by Steyer et al. (1995) and references therein will be followed. Data will be entered into a DIMS compatible database. Statistical analysis done for the BTMC will follow procedures agreed to by the BTMC and the lead implementor.

Problem Identification - Any significant problems identified during the monitoring period, either with monitoring procedures or project effectiveness, will be identified and made available to the BTMC.

Table EM1-4. Data Quality Objectives for identified measurable parameters (Steyer et al., 1995).

Type of Measurement	Units	Accuracy Goal	Precision Goal	Completeness Goal	Expected Range
Habitat Mapping					
Photointerpretation	habitat	7%	NA	100%	NA
Photoregistration	m	15 m	NA	NA	NA
Water Level	cm	1.0 cm	1.0 cm	85%	-50-200
Salinity	ppt	0.75 ppt	0.5 ppt	85%	0-36
Soil/Sediment Sampling					
Percent Organic Matter	%	10%	15%	85%	0-100
Bulk Density	g/cm ³	01. g/cm ³	15%	85%	0.01-0.90
Vertical Accretion					
Feldspar marker	cm	0.1 cm	30%	85%	0-2
Sediment-Erosion	cm	0.1 cm	30%	85%	0-2
Table					
Veg. Biomass - clip plots	g/m ²	20%	20%	85%	0-2,000
Fisheries Sampling					
Taxonomic ID	species	10%	NA	85%	NA
Organism Counts	numbers	10%	NA	85%	NA
Size	mm	1 mm	1 mm	85%	NA
Dissolved Oxygen	mg/l	0.1 mg/l	0.1 mg/l	85%	0-12

Action Plan EM-1:
Hydrologic Restoration