MISSISSIPPI RIVER AND TRIBUTARIES
MISSISSIPPI DELTA REGION, LOUISIANA
SALINITY CONTROL STRUCTURES

CAERNARVON FRESHWATER DIVERSION STRUCTURE

DRAFT HYDROLOGIC, WATER, AND SEDIMENT QUALITY DATA ACQUISITION PROGRAM REPORT

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I. Introduction.

The Corps of Engineers New Orleans District report entitled "Louisiana Coastal Areas, Louisiana - Freshwater Diversion to Barataria and Breton Sound Basins" was released September 1984. This four-volume feasibility study report explored possibilities and potentialities associated with diverting freshwater from the Mississippi River to the Barataria and Breton Sound estuaries. Appendixes H (Section 12) and K of the report stressed the need for continuing acquisition of environmental data as an integral element of freshwater diversion projects intended to enhance fish and wildlife resources. Freshwater will be diverted from the Mississippi River to the Breton Sound estuary via a control structure constructed near Caernarvon, Louisiana. This freshwater diversion structure is one of several authorized under the Mississippi River and Tributaries - Mississippi Delta Region, Louisiana Project.

Some aspects of network design, i.e., station locations, sampling variables, and sampling frequency were proposed at a program development workshop held at Grand Terre Island, Louisiana October 9-11, 1984. Details of the program development discussions are outlined in the workshop memorandum-for-record (Attachment 2 of the Biological Monitoring Program Draft Report).

Data needs, as identified in the feasibility report and at the program development workshop, are amplified here. This document outlines the rationale, scope, objectives, and cost estimate for the hydrologic, water, and sediment quality data acquisition component of the freshwater diversion project. While sample collection, laboratory analyses, data handling and analysis, and information utilization are important components of the overall data acquisition program, these topics are not addressed in detail in this document.

II. Data Acquisition Needs and Rationale.

In general, data acquisition requirements rest in three principal areas: (1) describing baseline conditions; (2) developing effective freshwater diversion structure operating procedures and controlling diversion structure operation; and (3) documenting the nature and rates of induced change to environmental systems. The rationale for and scope of data acquisition efforts with respect to these three areas of need are discussed briefly in the following paragraphs.

A. Establishment of Baseline Conditions

Why document baseline conditions? Quite simply, the effects of the project on the estuary's marsh acreage and the estuary's ability to support wildlife, finfish and shellfish are expected to be significant. It is anticipated that diversion of nutrient and sediment rich freshwater will rejuvenate existing marsh, significantly reduce dependence on local rainfall and runoff as the principal source of freshwater input to the estuary, and attenuate peak salinity values and induce more regularity in the seasonal pattern of measured salinities. Achieving and maintaining consistently high levels of fish and wildlife production is the ultimate benefit envisaged by accomplishing these goals. Documenting the pre-freshwater diversion characteristics of the estuary is essential for accurate measurement of the extent to which the stated goals are realized during the project life. Ideally, this documentation of baseline conditions and characteristics should be in quantitative terms and in as much detail as practical.

Presently a significant data gap exists for documenting pre-freshwater diversion general water quality characteristics on seasonal and spatial bases. Several state agencies currently measure bacteria density and salinity in the Breton Sound estuary. Water quality assessments in terms of these two characteristic parameters are made regularly for many locations, principally in support of regulatory functions. However, continuing accumulation of relatively long-term records of an extensive suite of water quality parameters is only occurring for two locations in the estuary. These two locations - Lake Petit West Shore and Bay Gardene at Bayou Lost - are part of the Basic

Water Monitoring Network sampled by the Louisiana Department of Environmental Quality (LDEQ). Water samples are, in general, collected monthly at the two locations; data for about 28 characteristic parameters are provided to describe water quality. Public access to and statistical analyses of these data are facilitated by storage onto the US Environmental Protection Agency's STORET data base as well as LDEQ's own computer system. Significantly broader sampling coverage of the estuarine area is imperative if an accurate description of baseline characteristics is to be formulated. Chemical analyses for a suite of water quality parameters comparable to that of the two currently active sampling locations is proposed for six additional locations in the estuary. Time series data for the proposed six additional sampling locations will help to better define the spatial distribution of baseline water qualities. The proposed eight location baseline water quality data acquisition network is shown on Figure 1.

No data are available on sediment quality in the estuary. Baseline data are required to characterize the quality of submerged surficial sediments in areas where deposition of sediment suspended in diverted freshwater might occur. It is anticipated that most of the suspended sediment in the diverted freshwater will be removed from the water column in Big Mar. Finely divided silt and clay particles which escape deposition in Big Mar might be deposited in the proposed west and south flow way areas and in Lake Lery. The quality of bottom sediments in these areas will be characterized by analyses of random samples collected immediately prior to initiating diversions of freshwater.

B. Development of Diversion Structure Operating Procedures

Operation of the diversion structure will be based on estimates of freshwater discharge rates required to impose seasonally dependent upper limits on salinities realized at specific estuary locations. Elements of operating procedures will include the following: (1) desired seasonal target salinities for specific locations; (2) the capability to measure salinities at the target locations; (3) an algorithm to update a current freshwater discharge rate; and (4) a practical

FIGURE 1. Tentative locations of in situ monitoring stations.

frequency, based on system response time and limitations of data gathering methods, for observed versus target salinity comparisons and discharge rate adjustments.

The estimate of optimal salinity regime for oyster production developed by Louisiana Department of Wildlife and Fisheries personnel (Chatry, et. al) can represent seasonal target salinities. This estimate is the average of eight averages of calendar-month salinity measured at three locations over the estuary's public reefs during four years that preceded good seed oyster production. The standard errors (standard deviations of the sample averages) of the mean salinities can be used to define a range of desirable mean salinity for each calendar month. A seasonally dependent band of target salinity can be represented by linear interpolation between the discrete estimates of monthly mean $\pm$ standard error values. Conceivably, other salinity regimes (targets), deemed optimal for other purposes and measured at other locations, could be adopted.

Measurements of salinities realized at the target locations will be the primary input data for control of the operation of the freshwater diversion structure. These data can be conveniently and cost-effectively obtained using in-field salinity recorders.

Salinity variation with time at a particular location is a continuous hydrologic process. Continuous recordings of variables which measure continuous hydrologic processes contain maximum information about the structures of the processes. Transformation from continuous recording to discrete data sequence (digitizing) results in a loss of information. The larger the interval between each observation in the discrete series the greater the information loss relative to a continuous recording. Intuitively, a monthly average salinity value derived from four observations taken at one week intervals will be less accurate than an average of 30 daily values. Similarly, average salinity computed from many individual observations well distributed over an area should be more representative than the average of a few measurements taken at one location. Presently available salinity data, for all but a very few estuary locations, consist of single observations taken at intervals of a week to a month. Salinity data have been accumulated intermittently for many locations in the estuary; however, relatively long high temporal density data records are extremely rare. In general, presently available data appear to be less than optimal for meeting the particular information demands of the freshwater diversion project. This should not be surprising since these data were generated by different agencies for divergent purposes.

An algorithm for calculating required freshwater discharges must be developed to guide initial structure operations. However, the relatively poor spatial distribution and temporal density of available data make them inadequate for formulation of a reliable algorithm for freshwater discharge rate adjustments. Several iterations of the algorithm development process will be required. One formulation of the algorithm has been completed making best possible use of available data. The process will be repeated using data from hydrologic time series accumulated in a three-year period prior to initiating freshwater diversion. Time series of concurrent observations of salinity at several estuarine locations, wind velocity, rainfall, gulf tide ranges and levels, and estimates of evapotranspiration and freshwater inflows willl be required. The procedure for calculating freshwater discharge rate adjustments, developed with data accumulated during the pre-diversion period, will be used to guide initial operation of the diversion structure.

The mathematical procedure, as currently envisaged, will consist of two basic components: (1) target salinities, as previously described; and (2) a multivariate function that relates expected salinty in a future time period to observed past salinity, current environmental conditions, and current freshwater discharge rate. The future pattern, location, and quantities of freshwater introduced into the estuary will be different from current conditions. Therefore, it is required that a function be developed that has incorporated within its good approximations of factors that will be operative during post-diversion conditions. An approach to developing a multivariate function with the required attributes has been proposed by Dr. William McAnally of the Waterways Experiment Station. The recommended procedure involves use of the Corps' two-dimensional numerical modeling system, TABS-2. A schematic TABS-2 numerical model of the estuary will be developed and applied with zero salinity assumed at all inflow boundaries and 34 ppt salinity at the gulf boundary. Observed estuary salinity patterns, represented by the multi-location hydrologic time series previously discussed will be reproduced by calibrating the model's time-varying dispersion coefficients. Reproduction of observed salinity time series by trial and error will, in effect, produce sample concurrent time series of dispersion coefficient estimates. These sample series of dispersion coefficients will be a function of hydrologic, hydraulic, and climatic conditions during the period of observation. Analytical expressions will be developed which relate the generated series of dispersion coefficient estimates to the observed series of tide range, gulf level and wind velocity data. These analytical functions will be used to estimate dispersion coefficients applicable to various combinations of tide, gulf, and wind conditions specified in subsequent TABS-2 model runs. The TABS-2 model will be run through various scenarios of boundary conditions, including a range of tides, gulf levels, hydrologic conditions, and freshwater discharge rates. Finally regression or cross- spectral correlation analyses of the results of the multiple TABS-2 runs will be used to define the required relationship between expected salinity, and observed salinity, environmental conditions, and freshwater discharges. This multi-variate function when combined with the seasonally dependent target salinities will constitute the algorithm for discharge rate adjustments. The algorithm will subsequently be refined using data obtained from the initial four years of diversion structure operating experience. Required hydrologic data will be obtained using in-field instrumentation capable of recording instantaneous observations for several parameters at intervals of two to six hours. Sampling locations for hydrologic data are indicated on Figurie 1.

C. Documentation of Induced Environmental Change

Water and sediment quality data indicative of the nature and rates of changes induced in the estuary's aquatic environments will be required. Expected modifications of the general water chemistry of the estuary were delineated in the freshwater diversion feasibility report and environmental impact statement. While the probability of negative environmental impact resulting from diversions of Mississippi River water is low, the potential for negative impact does exist. A comprehensie program of water and sediment analyses must continue as an integral project element if undesirable effects are to be exposed and remedied as expeditously as possible.

III. Cost Estimate

A. Hydrologic Data Collection

1. Materials and Equipment

a. Five locations equipped at $10,000 per site	$50,000
b. Three locations equipped at $12,000 per site	36,000
c. Eight equipment shelters at $1,000 per site	8,000
	$94,000

Cost estimate includes instrumentation for automatic logging of salinity, stage, and water temperature data on cassette tape for each location and precipitation and wind velocity at three locations. The useful life (in terms of reliability and economy of maintenance) of the hydrologic data collection instrumentation is assumed to be seven years; consequently, $94,000 is assumed to be a recurring cost at seven-year intervals throughout the life of the project.

2. Field Installation

a. Instrumentation packages with shelters setup in the field $2,100 per site	$16,800

Field installation costs are also assumed to be recurring at seven-year intervals throughout the life of the project.

3. Instrumentation Maintenance

   a. Labor: Labor requirement is estimated as two persons for two days every two weeks or 104 man-days per year. Labor includes cleaning probes and retrieving data tapes at two-week intervals, replacing probes and circuit boards as necessary, and collecting water samples for laboratory analysis at monthly intervals.

      Labor: $19,000/y

   b. Replacement Components: The replacement components allowance is taken as 3% of labor cost (compounded) for the six years after initial installation of the instrumentation packages. That is, $600 for the first year after installation, $1150 for year 2, $1750 for year 3, $2400 for year 4, $3050 for year 5, and $3700 for the last year before the instrumentation is replaced.

B. Sediment and Water Quality Data Collection

1. Sediment Sampling and Analysis

   a. Pre-diversion: One-time sediment sampling in Big Mar, the proposed West Flowway area, the proposed South Flowway area, and the Lake Lery area. Twenty samples are to be collected in each of the four areas (80 samples total).

      Analysis cost is estimated at $550 per sample

80 (550) =	$44,000
Sediment sample collection is estimated to require two days at $1000 per day =	2,000
Total sediment sampling and analysis =	$46,000

   b. Post Construction and Long-Term Sediment Sampling and Analysis: Sediment sampling and analysis as described above once per three years of freshwater diversion. Assuming that freshwater would be diverted each year, $46,000 would be expended at three year intervals.

      Total sediment sampling and analysis: (Avg) $15,334/y

2. Water Analysis

Ambient water samples are to be collected at eight locations monthly for analysis. Analysis cost is estimated at $575 per sample.

Water analysis cost: 8(12)(575) = $55,200/y

3. Data Base Maintenance

The cost of screening and preprocessing field data stored on cassette tape and storage of those data onto the STORET data base is estimated as $10,000/yr.

C. Structure Operation Model Development

1. Pre-diversion

a. In-house (labor and equipment)	$52,000
b. Consultation Fee (WES)	25,000
c. Computer time	1,000

2. Post-construction

a. In-house labor	45,000
b. Consultant Fee (WES)	5,000
c. Computer time	1,000

D. Cost Summary

The cost estimate is conservative in that the same level of sampling effort is assumed for the 53 years of monitoring. It is likely that a reduction in sampling effort will be affected when more knowledge of the estuary's behavior is acquired. Since the entire cost of the long-term phase of the program will be borne by the non-Federal sponsor, they will play the major role in scoping the magnitude of this effort.

TABLE 1

LIST OF PROPOSED SEDIMENT PARAMETERS

Sediment Parameter	Estimated Cost
Ammonia	$30.25
Arsenic	35.00
Cadmium	16.50
Chemical Oxygen Demand	33.00
Chloride	20.00
Chlorinated Hydrocarbons or TOX scan	115.00
Copper	20.00
Cyanide	40.00
Lead	20.00
Mercury	35.00
Nickel	20.00
Nitrate	16.50
Nitrite	12.00
Total Kjeldahl Nitrogen	30.25
Phenols	36.50
Total Phosphorus	12.50
Zinc	20.0
Sample Digestion	50.00
TOTAL	$562.50
	Use $550/sample

TABLE 2

LIST OF PROPOSED SURFACE WATER PARAMETERS

Water Parameter	Estimated Cost
Ammonia	$30.25
Arsenic	35.00
Cadmium	16.50
Chemical Oxygen Demand	33.00
Chlorinated Hydrocarbons or TOX scan	115.00
Copper	20.00
Cyanide	40.00
Fecal Coliform Bacteria	45.00
Lead	20.00
Mercury	35.00
Nickel	20.00
Nitrate	16.50
Nitrite	12.00
Total Kjeldahl Nitrogen	30.25
Phenols	36.50
Suspended Solids	13.00
Turbidity	6.00
Zinc	20.00
TOTAL	$544.00
	Use $575/sample

TABLE 3
SUMMARY OF ESTIMATED ANNUAL COST

		HYDROLOGIC DATA ACQUISITION			WATER AND SEDIMENT QUALITY DATA ACQUISITION			OPERATION MODEL DEVELOPMENT				
Phase	Year	Material & Equipment	Field Installation	Sampling & Equipment Maintenance	Sediment Sampling & Analyses	Water Analyses	Data Base Maintenance	Computer & In-House Labor/Equip	Consultant Fees (WES)	Annual Total	Phase Total	Cumulative Cost
	1	94,000	16,800	19,000		55,200	10,000	22,400	8,300	225,700		
Pre-Diversion	2			19,600		55,200	10,000	15,400	8,300	108,500		
	3			20,150	46,000	55,200	10,000	13,200	8,400	154,950	489,150	489,150
	4			20,750		55,200	10,000	11,500	1,250	98,700		
Post Construct.	5			21,400		55,200	10,000	11,500	1,250	99,350		
	6			22,050	46,000	55,200	10,000	11,500	1,250	146,000		
	7			22,700		55,200	10,000	11,500	1,250	100,650	444,700	933,850
	8	94,000	16,800	19,000		55,200	10,000			195,000		
	9			19,600	46,000	55,200	10,000			130,800		
	10			20,150		55,200	10,000			85,350		
	11			20,750		55,200	10,000			85,950		
	12			21,400	46,000	55,200	10,000			132,600		
	13			22,050		55,200	10,000			87,250		
	14			22,700		55,200	10,000			87,900		
	15	94,000	16,800	19,000	46,000	55,200	10,000			241,000		
	16			19,600		55,200	10,000			84,800		
	17			20,150		55,200	10,000			85,350		
	18			20,750	46,000	55,200	10,000			131,950		
Long-Term	19			21,400		55,200	10,000			86,600		
	20			22,050		55,200	10,000			87,250		
	21			22,700	46,000	55,200	10,000			133,900		
	22	94,000	16,800	19,000		55,200	10,000			195,000		
	23			19,600		55,200	10,000			84,800		
	24			20,150	46,000	55,200	10,000			131,350		
	25			20,750		55,300	10,000			85,950		
	26			21,400		55,200	10,000			86,600		
	27			22,050	46,000	55,200	10,000			133,250		
	28			22,700		55,200	10,000			87,900		
	29	94,000	16,800	19,000		55,200	10,000			195,000		
	30			19,600	46,000	55,200	10,000			130,800		

TABLE 3 (CONTINUED)

Phase	Year	HYDROLOGIC DATA ACQUISITION: Material & Equipment	Field Installation	Sampling & Equipment Maintenance	WATER AND SEDIMENT QUALITY DATA ACQUISITION: Sediment Sampling & Analyses	Water Analyses	Data Base Maintenance	OPERATION MODEL DEVELOPMENT: Computer & In-House Labor/Equip	Consultant Fees (WES)	Annual Total	Phase Total	Cumulative Cost
	31			20,150		55,200	10,000			85,350		
	32			20,750		55,200	10,000			85,950		
	33			21,400	46,000	55,200	10,000			132,600		
	34			22,050		55,200	10,000			87,250		
	35			22,700		55,200	10,000			87,900		
Long-	36	94,000	16,800	19,000	46,000	55,200	10,000			241,000		
Term	37			19,600		55,200	10,000			84,800		
	38			20,150		55,200	10,000			85,350		
	39			20,750	46,000	55,200	10,000			131,950		
	40			21,400		55,200	10,000			86,600		
	41			22,050		55,200	10,000			87,250		
	42			22,700	46,000	55,200	10,000			133,900		
	43	94,000	16,800	19,000		55,200	10,000			195,000		
	44			19,600		55,200	10,000			84,800		
	45			20,150	46,000	55,200	10,000			131,350		
	46			20,750		55,200	10,000			85,950		
	47			21,400		55,200	10,000			86,600		
	48			22,050	46,000	55,200	10,000			133,250		
	49			22,700		55,200	10,000			87,900		
	50	94,000	16,800	19,000		55,200	10,000			195,000		
	51			19,600	46,000	55,200	10,000			130,800		
	52			20,150		55,200	10,000			85,350		
	53			20,750		55,200	10,000			85,950	5,418,200	4,352,
Totals				1,985,450			4,237,600		129,000			4,352,

i = .08625 PW=4,472,
A= 128,