NAOMI FRESHWATER DIVERSION (BA-03)
State Funded

I. INTRODUCTION

I.1. Project Description

The BA-03 Naomi Project, also known as LaReussite, is a cost shared project by the state of Louisiana (75%) and Plaquemines Parish (25%). The project comprises an area of about 13,000 acres (5,261 ha) of brackish and intermediate marsh, located in the northeast Barataria Basin in Plaquemines and Jefferson Parishes. The area is bound to the north by Bayou de Fleur and a pipeline canal, on the east by a forced drainage system and a storm protection levee, to the west by the Pen, and to the south by the Bayou Dupont ridge (Figure 1).

Freshwater is re-introduced into the project area through a set of 8 separate siphons, each consisting of a steel pipe 6 feet (1.8m) in diameter and 2600 ft. in length, which cross over the west levee of the Mississippi River at Naomi, Louisiana. This corresponds to a position on the river of Mile 64 above Head of Passes, about 18 miles south of New Orleans. The quantity of flow passing through the siphons depends on the relative elevations of the river and tailwater, but the design flow at normal high water exceeds 2,000 cubic feet per second (cfs). River water discharges from the siphons into an armored ponding area and distributed through a single channel, 30 ft. wide and 3,300 ft. long, which is located along the west side of the back-levee and flows southward.

The Naomi siphons system became operational on February 3, 1993. The project was designed by Prescott Follette & Associates, assisted by conceptual studies conducted by the Natarual Resources Conservation Service (then Soil Conservation Service) and by Brown and Root, Inc. The completed project differed somewhat from the original design, notably in the configuration of the ponding area and outfall channel. Changes were necessary to accommodate landrights conflicts.

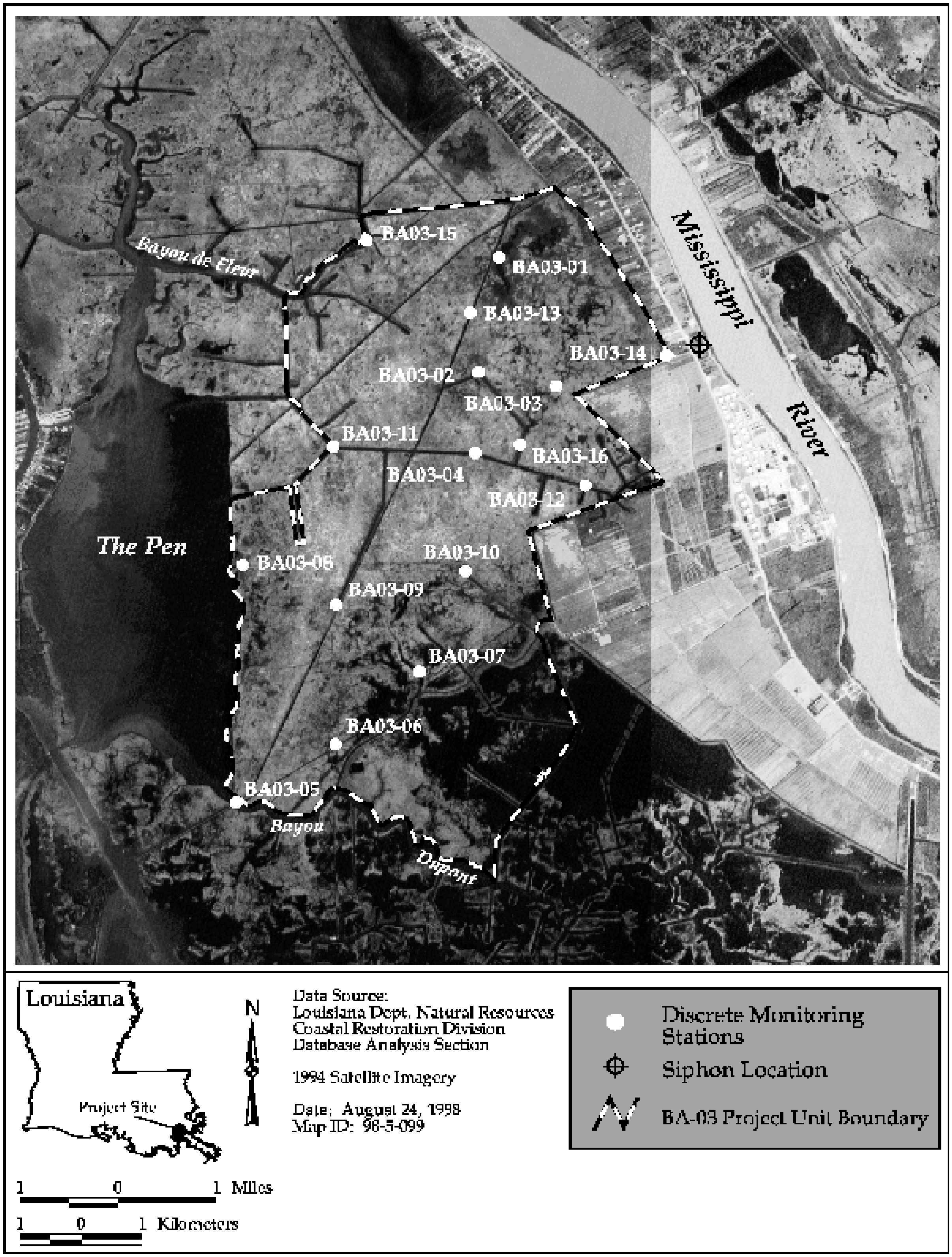

Figure 1. Locations of discrete monitoring stations at the Naomi Freshwater Diversion Project.

I.2. Project Personnel

Project Phase	Name	Position	Organization
Conceptual/Planning	Ken Faust	Engineer	Brown & Root, Inc
Conceptual/Planning	Faye Talbot	Resource Conservationist	NRCS
Conceptual/Planning & Design	Prescott Follette James Tocho	Engineer Engineer	Prescott Follett & Associates
Conceptual/Planning	Gerry Duszynski	Administrative	DNR
Construction	-------	------	T.L. James, Inc.
Const. Oversight	James Tocho	Engineer	Prescott Follett & Assoc.
Const. Oversight	Carrol Clark	Engineer	DNR
Operations Planning	Dr. David Vigh	Engineer	Brown & Root, Inc.
Operations Planning & Operations	Greg Steyer Van Cook	Biologist Engineer	DNR
Operations Planning & Operations	JoAnn McMichael	Administrator	Plaquemines Parish
Operations	Pete Jones Lonnie Serpas Albertine Kimble	Operations Staff	Plaquemines Parish
Operations	Vickie Caridas	Administrator	Plaquemines Parish
Operations and Monitoring	Ed Haywood	Biologist	DNR
Monitoring	Bill Boshart	Biologist	DNR

II. PLANNING

II.1. Causes of Loss

What was assumed to be the major cause of land loss in the project area?
Past research indicated that a contributing cause of freshwater wetland loss in the Barataria Basin was saltwater intrusion (Sasser et al. 1986), and this was assumed to be the major cause of land loss in the project area (Brown and Root 1992).

What were assumed to be the additional causes of land loss in the project area?
Other causes were lack of sediment input, increased tidal exchange and volume, soil erosion, nutria herbivory, and tropical storms (USDA SCS 1991). Most of the loss was attributed to various human activities in the estuarine zone (USDA SCS 1991). This included the construction of the Mississippi River levees, which cut off the area from annual flooding of freshwater and sediment. Construction of the Texaco Pipeline canal through the natural ridges in the project area caused an increase in daily tidal exchange. In addition, construction of other oil field channels and slips increased tidal volume and exchange, resulting in erosion of fragile soils in the project area.

II.2. Background

Freshwater re-introductions are intended to replace some of the ecological functions supported by periodic over-bank flooding that occurred prior to the placement of the flood-control levee system. Re-introductions may be controlled, e.g. siphons and direct diversions, or uncontrolled, e.g.intentional breaches in the levee system.

The first controlled freshwater re-introduction was built at Bayou Lamoque in 1956 to divert freshwater into lower California Bay in the Breton Sound Basin to enhance oyster production (Bowman et al. 1995). Other diversions into the Breton Sound included White's Ditch, the Violet Siphon, and the Caernarvon diversion. Controlled diversions into the Barataria Bay system include West Pointe a la Hache, which became operational in 1992, and the Davis Pond freshwater diversion project (Coastal Environments 1995), which became operational in July, 2002. Several additional controlled re-introduction projects are in various stages of planning.

Uncontrolled re-introduction projects tend to be located on the lower Mississippi River below Venice, Louisiana, where there is little likelihood of damage to property or infrastructure. Planned projects include West Bay and Benny's Bay, which are each expected to have a capacity of up to 50,000 cfs.

II.3. Project Goals and Objectives

The goals and objectives from all parties involved for this project from the planning documents to the final monitoring plan are presented below:

Feasibility Report (NRCS 1991), goals and objectives:

1. Increase sediments and nutrients in the project area.
2. Increase freshwater into the area.
3. Stabilize salinity.
4. Control erosion and reclaim eroded areas to emergent vegetation. Areas that could be reclaimed are those with water depths from marsh level to 1.0 ft. below marsh level.
5. Encourage growth of submergent vegetation especially in the deeper (1.0 ft below marsh level and deeper) open water areas.
6. Allow ingress/egress of marine organisms to the extent possible without compromising the integrity of the management system.
7. Enhance habitat conditions for wildlife and fisheries
8. Provide optimum growing conditions for increased densities of the target vegetation (marshhay cordgrass).
9. Maximize the distribution of freshwater through overland flow.
10. Maintain adequate means of accessibility.
11. Regulate water fluctuations.

12. Improve water quality.

Operation, maintenance and monitoring plan (Brown and Root 1992):
<u>Goals</u>
1. Protect the area from continued degradation
2. Increase and maintain vegetative composition.

<u>Objectives</u>
1. Increase freshwater into the area and
2. Increase land to water ratios.
3. Provide optimum growing conditions for fresh to intermediate marsh
4. Restore more favorable salinity regimes

Monitoring Plan (LDNR 1992):
<u>Goals</u>
1. Increase marsh to open-water ratio
2. Reduce and stabilize mean salinity.
3. Improve growing conditions for and increase relative abundance of fresh to-intermediate marsh species.

<u>Objectives</u>
1. Protect the project area from continued degradation by introducing into the area freshwater from the west bank of the Mississippi River
2. In doing so the project also seeks to increase the inflow of sediment and nutrients into the project area and to improve growing conditions for the target plant species.

How were the goals and objectives for the project determined?
The goals for this project were determined in the planning phase and were based on projected or desired effects that the freshwater diversion would primarily have on the dominant marsh and secondarily on fish and wildlife productivity. Due to budget constraints, it was not feasible to monitor every goal. Therefore, goals and objectives were reduced in number or altered from the original feasibility study to the final monitoring plan developed by LDNR.

Are the goals clearly stated and unambiguous?
Overall, the goals were ambiguous and could have been improved by setting a range of (quantifying) targets within each goal. For example, the goal to "reduce mean project area salinity" could have been given target salinities in the range of 5 to 15 ppt isohaline to attain for a given location within the impacted marsh as predicted by the TABS2 model. The model was tested in the planning phase and was used to predict the effect that the project would have on salinities at a given volume through the siphons (Brown and Root 1992). It should be noted that the TABS2 model was not calibrated during its use (Rasi 1992).

Are the goals and objectives attainable?
The goals and objectives are attainable. However, they can be improved (i.e., more meaningful) by adding targets as discussed above. The goals partially address the causes of land loss. The diversion attempts to mimic historic over-

bank flooding in the estuary to counter saltwater intrusion, lack of sediment input, and soil erosion. However, the project cannot completely ameliorate the effects of herbivory and the dredged oil field canals, which caused increased tidal exchange and volume.

III. ENGINEERING

III.1. Design Feature(s)

The structural components of the La Reussite project consisted of a battery of eight steel pipes that draw river water over the mainline Mississippi River levee to a ponding area on the marsh side of the flood protection levee and an outfall area designed to transmit water to the marsh. Engineering activities for the project consisted of design, construction, and operation and maintenance of these structural components.

What construction features were used to address the major causes and additional causes of land loss in the project area?
As designed, the project consisted of a siphon piping system, a vacuum system for creating and maintaining the siphoning action, an armored discharge pond, and a conveyance system of one outfall channel 15 feet wide and 3300 feet long.

Although a diversion structure passing straight through the levee, such as at Caernarvon or Davis Pond, would be more hydraulically efficient than a siphon, the risks associated with compromising the mainline levee prohibited this approach. As a result, eight identical steel pipes, each six feet in diameter, draw river water from an invert elevation of 4ft. NGVD, transport river water over the top of the levee and under Highway 23, and discharge the water into an armored channel to an invert elevation of 8ft. NGVD, which leads to a ponding area (Prescott & Follette 1990).

The siphons are primed using a manifold piping system that allows a trailer-mounted vacuum pump to draw a vacuum at the crest of each pipe. That same pump then draws a vacuum from the storage tank. This tank and an associated system of float valves and check valves, was designed to maintain the siphoning action by drawing off dissolved gases that can accumulate at high-points in piping systems. The need for a vacuum-maintenance system was identified by the designer, Prescott Follette. Prescott Follette & Associates designed the White's Ditch and Violet siphons and observed that at low river levels, existing siphons at White's Ditch and Violet tended to lose their prime. The vacuum maintenance system was an attempt to extend the operational schedule of the siphons into lower-flow stages of the river.

What kind of data was gathered to engineer the features and what engineering targets were the features trying to achieve?
Flow through the siphons depends on the head differential between the river and ponding area. The range of anticipated flows through the system was expected to be from about 1,200 cfs in October to about 2,100 cfs in April. The average discharge during annual high Mississippi River stage was expected to exceed 2,400 cfs (Brown & Root 1992).

Once discharged into the ponding area, river water is distributed to the project area through a single conveyance channel and by sheet flow over the marsh. Design criteria for the channel included maintaining velocities high enough to keep sediments in suspension, generally considered to be in the 2.0 to 3.0 feet per second range, but not so high as to create erosive conditions in the channel, in excess of about 3.5 feet per second (Chow, 1957). Modeling studies of the channel design indicated velocities in the range of 2.7 feet per second if the structure is operating at about 2,100 cfs (Brown & Root, 1992). Thus, erosion was not considered a threat, but some siltation could occur and dredging may have to be proposed.

Another design concern was excessive marsh inundation due to high water levels in the vicinity of the outfall. A modeling study by Brown & Root (1992) consisting of HEC-2 water surface modeling of the outfall channel, linked with TABS-2 modeling of the entire study area, indicated that an increase in water surface elevation of 26 inches would occur at the discharge pond, with over 10 inches of increase in water surface elevation a mile from the discharge pond (Brown & Root, 1992). As a result, Brown & Root recommended an operational scheme that provided for full operation of the structure (all 8 pipes operating) only during the fall and winter, when marsh plants would not be as sensitive to higher water levels.

Concerns regarding water surface elevation proved to be unwarranted. Monitoring data collected during siphon operation indicated that water levels were only significantly higher due to the siphon at the monitoring station nearest the outfall structure. Mean water levels at that location (Site 14) did indicate that at high flow (>1,000 cfs) water levels were an average of about 22 inches above mean water levels for no-flow conditions (Boshart, 1998). Water surface elevations dissipated, however, rapidly with distance from the discharge area and mean water levels for the remaining monitoring stations were not significantly different at high-flow and no-flow conditions. The operational significance is that year-around operation was not likely to be problematic for marsh inundation.

III.2. Implementation of Design Feature(s)

Were construction features built as designed? If not, which features were altered and why?
Piping and related structural elements were constructed and operated as designed; however significant modifications were made to the outfall system. The original design specified three outfall channels radiating from the discharge pond. Landrights conflicts prevented access to certain areas of the marsh. As a result, the multiple-channel design was replaced with a single channel 30 feet wide and 3300 feet long.

III.3. Operation and Maintenance

Were the structures operated as planned? If not, why not?
Plaquemines Parish Government (PPG) has conducted all operation and maintenance of the siphon in accordance with the operational scheme developed in 1992 by Brown & Root and revised in 1993 by PPG and the Louisiana Department of Natural Resources, Coastal Restoration Division (LDNR/CRD). The revised operations plan calls for the structure to have all eight pipes operating for all months except March and April when only two pipes are to be in operation.

In practice, operations fell short of the planned amount of freshwater to be re-introduced into the project area (Figure 2 – operations) due to several constraints: marine fisheries, low river stages, tropical storms, oil spills, maintenance problems, and staffing limitations within PPG. Marine fisheries limitations were in the form of lawsuits brought about by the commercial oyster industry, and concern in the first year of operation regarding over-freshening during critical life-stage development of brown shrimp. Both of these concerns resulted in shutdown periods of the structure.

Maintenance problems seldom resulted in a complete shut down of the structure, but often resulted in lower flows. Valve corrosion and problems with the vacuum system resulted either in loss of prime or complete inoperation of some of the siphon pipes, even in the early years of operation. Moreover, maintenance problems with the siphons resulted in an increased need for PPG personnel to check, and often reprime, the siphons. This resulted in additional down time. As a result of the limited capability to deliver design flows, the operational plan was abandoned, and instead PPG operated all available siphon pipes whenever river stage allowed operation.

The operation scheme developed during the planning stages proposed an operations schedule based on the average monthly Mississippi River stage (Brown and Root 1992). This plan included increased flows (>1000 cfs) during the first half of the month and reduced flows (<550 cfs) during the second half of the month. However, this schedule was reduced for the months of April and June. In 1993, PPG and the Louisiana Department of Natural Resources, Coastal Restoration Division (LDNR/CRD) revised the operations schedule, which calls for the structure to be operated at full capacity (8 pipes) for all months except March and April when it is to be operated at 25% capacity (2 pipes).

Actual operation and siphon discharge differed greatly from the planned operation (Figure 2). The siphons were operated inconsistently, with very little flow in some years. In addition, March-April discharge exceeded May-February discharge three out of the nine years of operation. The planned average output per year was 801 cfs; however, only 560 cfs was achieved per year through 2001. As illustrated in figure 2 (dotted line), significantly higher flows were attained when all eight siphons were operated during the May – February time frame, and significantly lower flows were realized when only two siphons in operation in the months of March-April.

Are the structures still functioning as designed? If not, why not?
Was maintenance performed?
Because of the numerous problems keeping the siphons primed, the original valves and vacuum piping were replaced with improved valves and new vacuum piping in 2001. The benefit of the maintenance work, however, was substantial as it has enabled the siphon system to be operated at or near full capacity during normal river stages. Operation of the siphons at very low river stages continues to be problematic due to loss of prime.

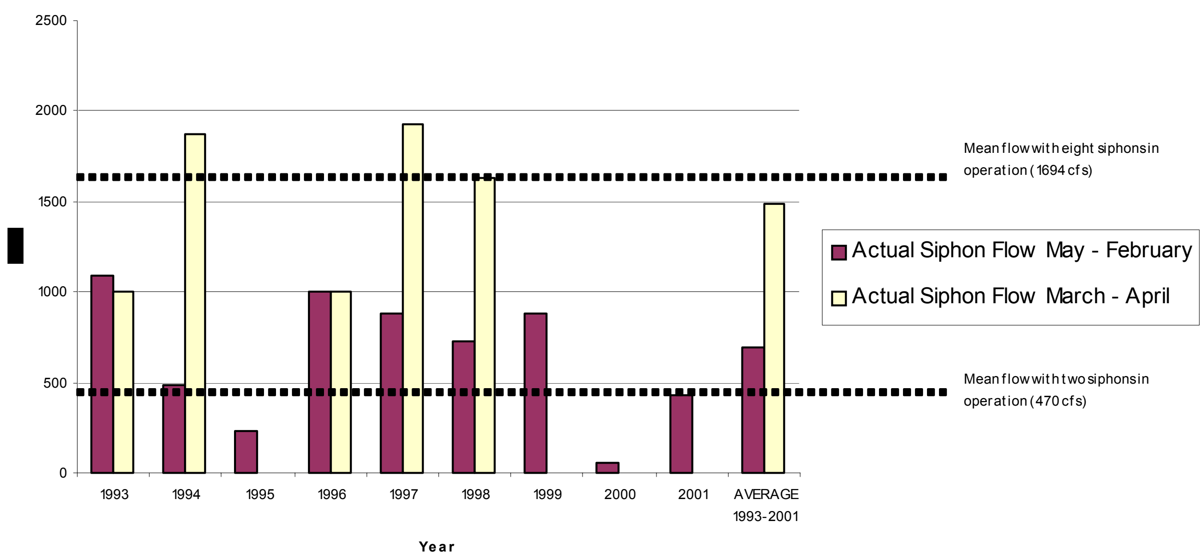

Figure 2. Average siphon flow for two operation time periods from 1993 through 2001. AVERAGE represents the average of all years. Dotted lines represent average flow over all years when only two or eight siphons were in operation (i.e., planned operation).

PHYSICAL RESPONSE

IV.1. Project Goals

Do the monitoring goals match the project goals and objectives?
The goals and objectives for physical response variables that were addressed in the LDNR monitoring plan were to 1) increase marsh to open-water ratio, 2) reduce and stabilize mean salinity (LDNR 1992). These goals are fewer in number and do not match verbatim those listed in the project planning documents (listed in section II.1). However, the monitoring goals capture the meaning of multiple goals and objectives listed in the planning references. For example, the monitoring goal of reducing mean salinity can be translated into the project goal of increasing freshwater into the area, regulating water fluctuations (salinity spikes?), and restoring more favorable salinity conditions. As discussed earlier in this document, all goals and objectives were somewhat ambiguous and could have been improved with quantification of the goals.

IV.2. Elevation

The primary function of a freshwater diversion is to re-introduce freshwater to the project area to control salinity. Moreover, the addition of sediments to the project area, via the diverted river water, is a secondary benefit. Thus, if the siphons are operated as planned, the area should not only freshen up, but it should also accrete enough sediment to help the marsh maintain or increase in elevation. Therefore, even though no target elevation was planned, one of the goals was to the increase the land-to-water ratio of the project area.

What is the range of elevations that supports healthy marshes in different marsh types? Does the project elevation fall within the range for its marsh type?
Average marsh elevation was determined in 1997 in near stations 5, 15, and 16 (figure 1). Elevation ranged between 0.23 and 1.14 ft (NAVD88) among the stations (unpublished data, LDNR/CRD). This elevation range is similar to elevations in other marshes (e.g. BA-04 project area) in the area.

Did the project meet its target elevation?
No target elevation was set for this project.

What is the subsidence rate and how long will the project remain in the correct elevation range?
Local subsidence rates relative to sea level rise are estimated to be 1.1 - 1.29 cm/yr (Penland et al. 1988). If the diversion is operated to as planned, it is expected that the project will gain elevation. (i.e., increase land to water ratio).

IV.2.2 Hydrology

What is the hydrology that supports healthy marshes in different marsh types?
Before the siphons were built, the main source of freshwater input to the area was from rainfall events that resulted in overland flooding. Due to the lack of freshwater input, marine and meteorological forces had a stronger influence on the area's hydrology thus salinity remained high in the northern part of the coastal estuary. In addition, dredging of oil and gas access canals changed the hydrology in the area by providing conduits for saltwater into interior marshes. The BA-03 project changed the hydrology of the area by restoring the link between the Mississippi River and surrounding marsh, thereby restoring the opportunity for periodic over-bank flooding that occurred prior to the placement of the flood-control levee system on the river.

Does the project have the correct hydrology for its marsh type?
The project area has many marsh types. The hydrology that is desired is to have the diverted freshwater periodically over top the marshes and to keep salinities low enough to maintain a fresh-intermediate marsh community.

Even though water level at station 14, which is located in the immediate outfall area, was significantly affected by siphon discharge, the siphons had little effect on water levels within the greater project area (figure 3). Water level recorded at stations 1, 3, and 16, which were closest to the diversion siphon, showed only slight (and not statistically significant) increases in water level resulting from increases in siphon discharge. However, water level at stations 6, 10, and 11, which were located farthest from the outfall, was not influenced by the diversion. The project area contains a number of canals, many with continuous spoil banks. These spoil banks can impede sheet flow and limit it to smaller areas. Also, once the diverted waters enter these canals through gaps in the spoil, the water can be captured within the channel and quickly dispersed, instead of allowing sheet flow across the marsh. This was like some reasons that water levels in the southern end of the project were unaffected by siphon operation. The minimal variation in water level that was observed at these southern stations was potentially due to effects of wind and tidal events.

What were the hydrology targets for the project and were they met?
The targets were to achieve a given flow through the siphons for a given time of year (see section III.3 for details). No target was given as to the frequency and duration of flooding in the project area.

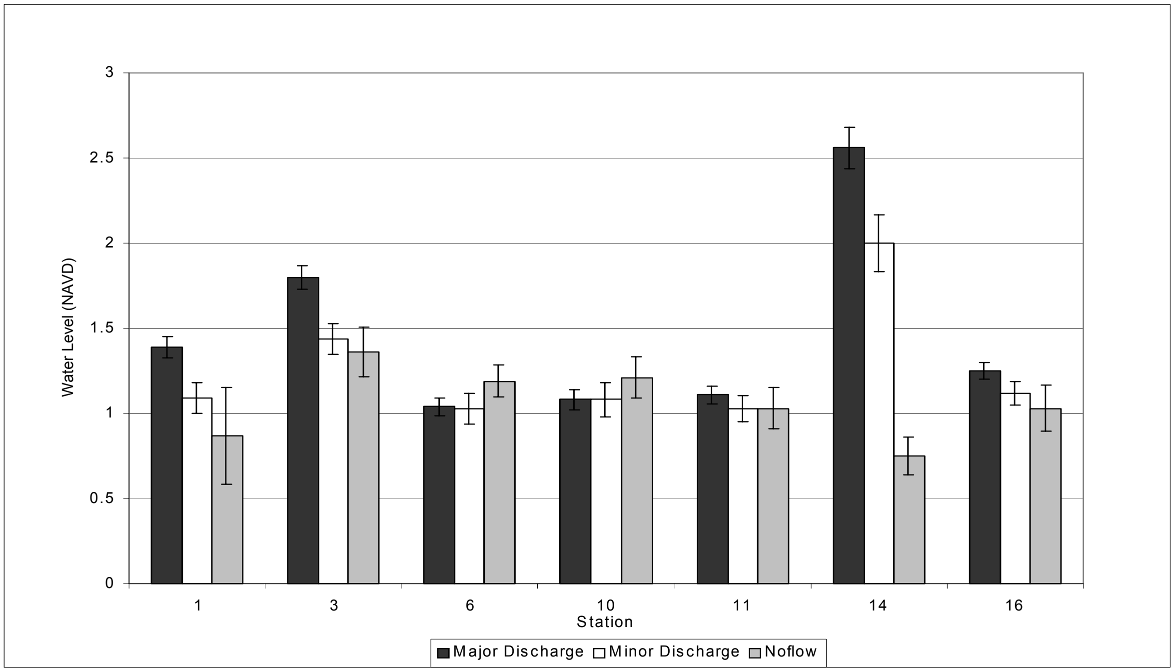

Figure 3. Mean water level (± SE) comparisons (NAVD) of the three operation categories at the seven staff gauges within the Water levels (NAVD) comparisons among major >1072 cfs, minor 0-1072 cfs and noflow 0 cfs discharge at Naomi project area from 1993-1998.

IV.2.3 Salinity

What is the salinity regime that supports healthy marshes in the different marsh types? Does the project have the correct salinity for its marsh type? What were the salinity targets and were they met?

With the exception of "to reduce and stabilize mean salinity", no specific target was given. Average salinity for the project area was significantly lower during periods of siphon operation than during periods of no flow. Salinity stations 5, 6, 7, 8, 9, and 10 exhibit the greatest mean salinity in each phase of siphon operation, and with the exception of station 10, these stations also exhibit the greatest reduction in mean salinity as a result of siphon operation (Figure 4). These stations are located in the southern portion of the project area, which is influenced by saltwater entering the area via Bayou Dupont and the Barataria Bay Waterway (BBW). Therefore, data indicate that freshwater from the siphon affected mean salinity, even at the most southern portion of the project area.

Seasonal variance in salinity within the estuary should be considered when interpreting the direct effects of the siphon discharge on mean project area salinity. The prevalence of months of major discharge (20 of the 22) coincide

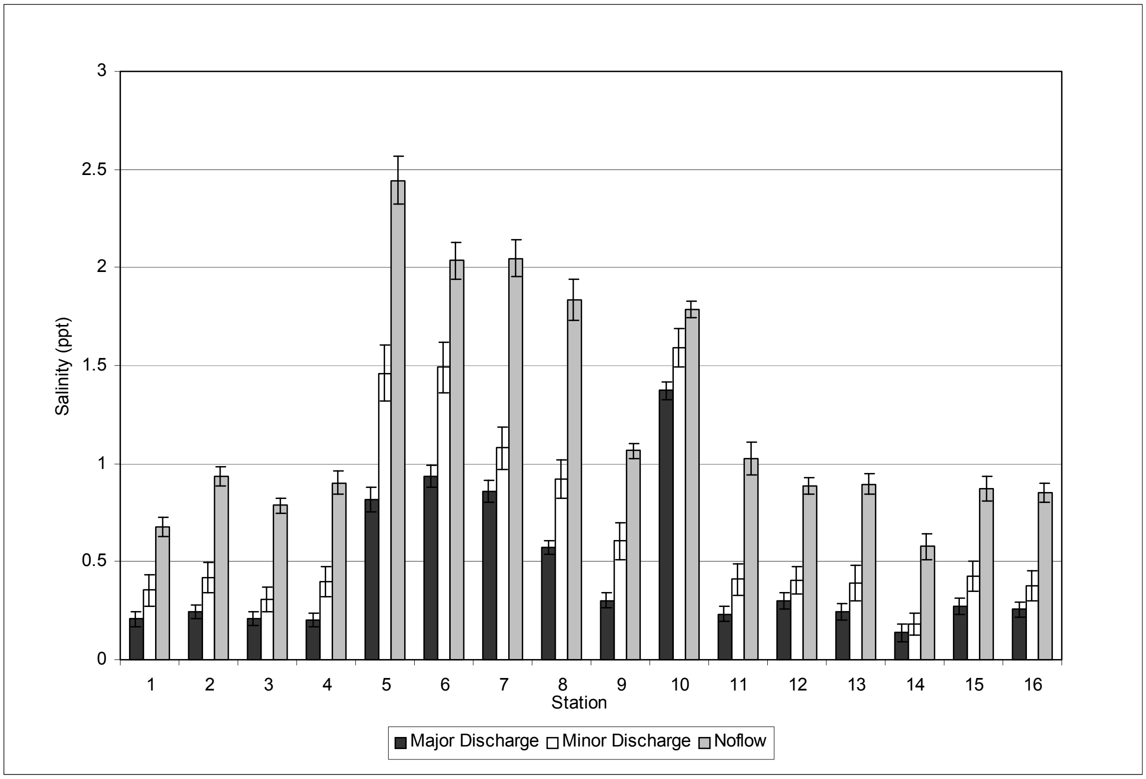

Figure 4. Mean salinity (±SE) for three operational categories at the 16 discrete monthly hydrologic stations (Major discharge > 1,072 cfs [30cms]/month; Minor discharge, 0-1,072 cfs [30cms]/month; Noflow, 0 cfs [0cms]/month) from 1993-1998.

with periods of high river stages (winter - mid summer). This is a characteristic of the project design, because sufficient head differential between river stage and marsh stage is necessary for proper operation of the siphons. However, the Barataria estuary is naturally fresher during this time of the year, because of the Mississippi River's influence on the estuary (Swenson and Swarzenski 1995). Similarly, 13 of the 22 months of noflow occurred between August and December, when there was low river stage and thus insufficient head differential to operate the siphons. The low river stages at this time of the year have historically resulted in higher salinities in the estuary (Swenson and Swarzenski 1995).

The ability to operate the siphons during lower river stages would be advantageous during drought years when freshwater was needed the most. In 1999-2001 the siphons were operated very little, and as combined with the effects of the ongoing drought, salinity in the project area was the highest experienced in a decade (figure 5). Gated diversion structures, such as the one at Caernarvon, can divert water at lower river stages and have that advantage over siphons.

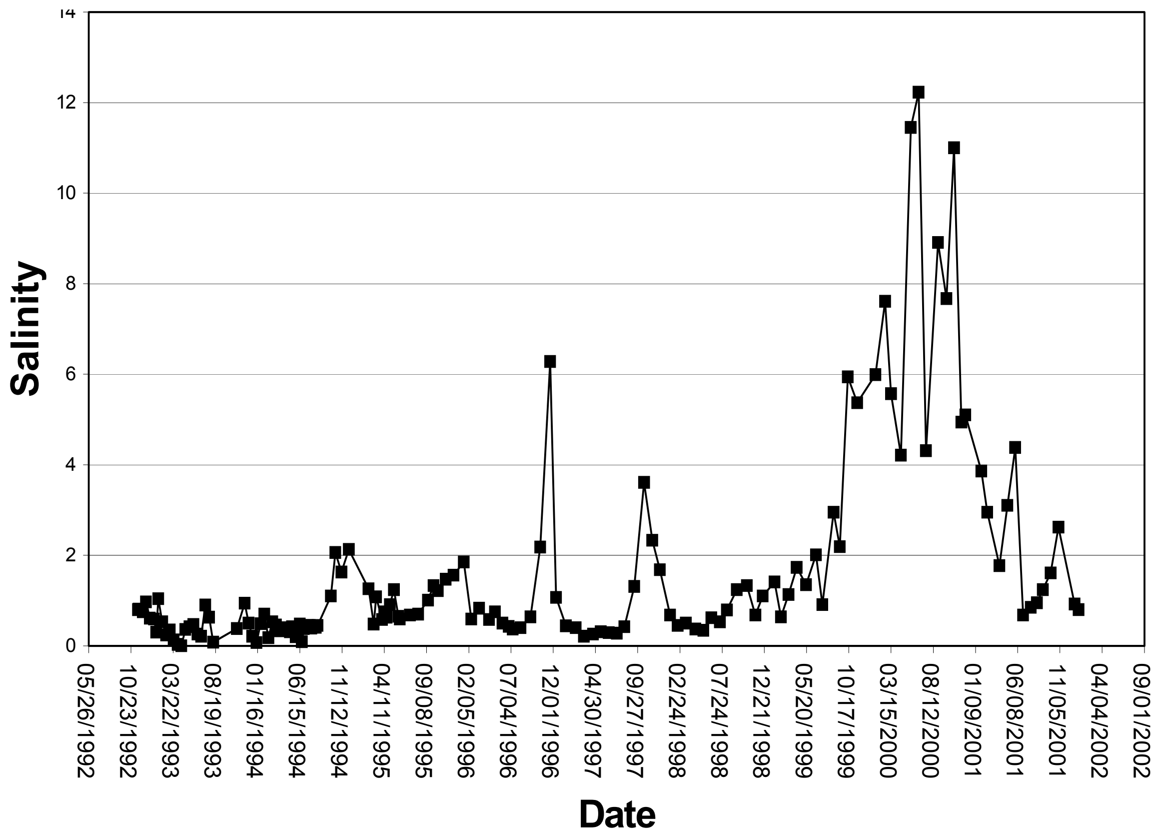

Figure 5. Salinity by month for Naomi Freshwater Diversion Project.

IV.2.4 Soils

What is the soil type that supports healthy marshes in the different marsh types? Does the project area have the correct soil type for its marsh?

The soils of the area consist of the Barbary, Allemands, Kenner, and Lafitte muck types (Soil Conservation Service 1983). The Barbary series is found mainly along the Mississippi River in a narrow band and is characterized as level, very poorly drained, semi-fluid mineral soil formed in clayey alluvium from the Mississippi River deposited in water. The Allemands series is found in the immediate outfall area adjacent to the siphon discharge pond. It is characterized as level, poorly drained organic soil formed in moderately thick accumulations of decomposed herbaceous materials. The Kenner series is found in a narrow band that follows a northwest to southeast path through the project area. It is also characterized as level, very poorly drained, semifluid organic soil formed in herbaceous plant material in freshwater marshes. The Lafitte series is found throughout the remaining southern portion of the project area and is characterized by a thick surface layer of semifluid saline muck with underlying semifluid, saline clay and silty clay loam. The surface layers of all the soils within the project area are organic and very susceptible to erosion especially when not protected by vegetation. The soils are also prone to compaction when allowed to dry (U.S. Soil Conservation Service 1991).

IV.2.5. Other

Describe any other physical characteristics of the project that have bearing on the projects' success.
To introduce more sediment to the project area, a method (dredging?) of adding more sediment to the siphon outflow needs to be implemented. A CWPPRA project (MR-11) has already been approved to address this concept.

IV.3. Suggestions for physical response monitoring

Are there other variables that could be monitored to substantially increase the ability to understand the results of the project?
Soil salinity should be collected throughout the project area in conjunction with vegetation surveys. Soil salinities would provide a better measure of salinity in the marsh and better explain changes in marsh vegetation.

BIOLOGICAL RESPONSE

V.1. Project Goals

Specific goals pertaining to the biological response were to improve growing conditions for and increase relative abundance of fresh to-intermediate marsh species.

V.2.1. Vegetation

Does the project have the correct species composition and cover for its type?
Pre-construction surveys by the USDA-SCS (1991) and Ensminger (1992) indicated that fresh/intermediate marsh comprised the northeast portion of the project area while brackish marsh dominated the remainder. The dominant species included *Sagittaria lancifolia* L. (bulltongue), *Scirpus americanus* Pers. (three-square bulrush), and *Spartina patens* (Ait.) Muhl. (marshhay cordgrass) (figure 6). The post-construction survey conducted in 1997 indicated minor changes in vegetation community structure (Boshart 1998). *S. lancifolia* still dominated the upper northeast portion of the project area, whereas the southern and western portions of project area were still dominated by *S. patens*. However, a large number of species indicative of intermediate or low-salinity brackish marsh was found at the stations in the southern and western areas as well (Boshart 1998). This suggests that the marsh in this portion of the project area is turning

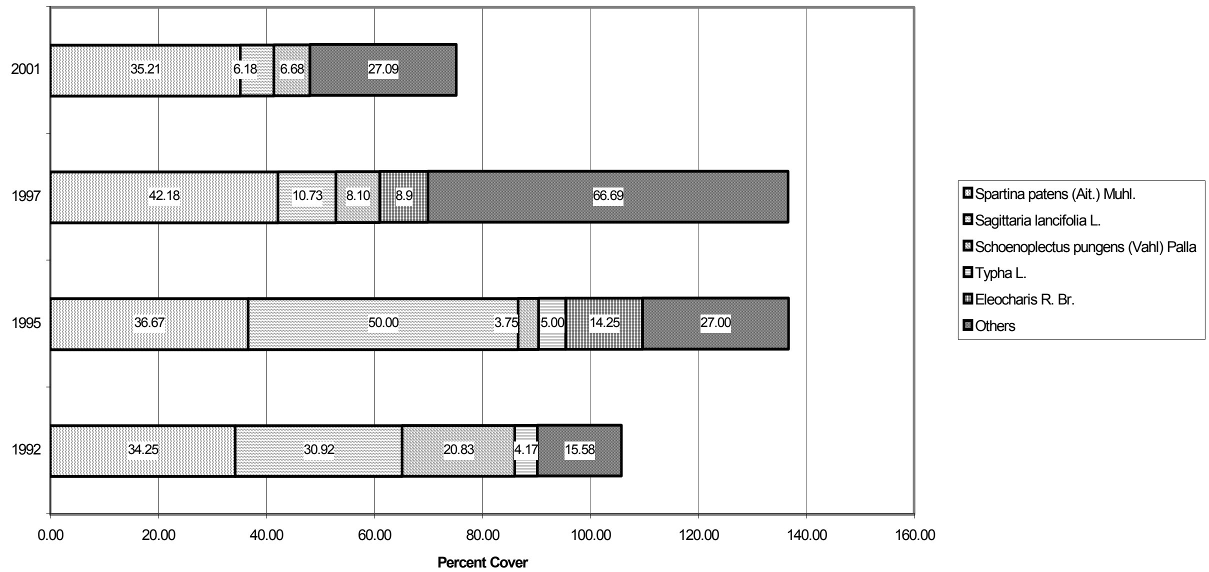

Figure 6. Mean cover (%) for dominant vegetation species for 1992, 1995, 1997, and 2001 surveys.

fresher. The vegetation survey in 2001 indicated that some of the stations reverted back towards more saline conditions (figure 6) which was likely the effect of drought and little output from the siphons.

V.2.2 Landscape

Is the project changing in the direction of the optimal landscape? If not, what is the most likely reason?
Historical loss rates for the project area taken from the Naomi Quadrangle were as follows: 0.32%/yr between 1932-1956, 1.20%/yr between 1956-1974, 0.69%/yr between 1974-1983, and 1.38%/yr between 1983-1990 (Dunbar et al. 1992).

In 1956, the area was classified as fresh marsh with 600 acres (243 ha) of open water. Approximately 2,500 acres (1,012 ha) of marsh converted to open water from 1956 to 1978 and an additional 4,000 acres (1,619 ha) converted to open water from 1978 to 1984 (U.S. Soil Conservation Service 1991). Future aerial photographs and subsequent land-to-water analyses are scheduled for this project (LDNR 1992) and will aid in determining changes in the project area at the landscape scale.

V.2.3. Suggestions for biological response monitoring

Are there any other variables that could be monitored to substantially increase the ability to understand the results of the project?
To measure large-scale changes in marsh communities, habitat analysis should be included with the land water analysis. Also, more frequent photography should be flown and analyzed.

VI. ADAPTIVE MANAGEMENT

VI.1. Existing improvements

What has already been done to improve the project?
Most importantly, an outfall management plan was developed by the NRCS to redirect flows in the BA-03 project area to distribute more water into the marsh and retain water in the marsh for longer periods (NRCS 1999). Also, installation of an improved valve and small vacuum piping system in 2001 increased the efficiency and sustainability of the siphons. In addition, a coastwide nutria control project is being developed to significantly increase harvest of nutria (*Myocaster coypus*) in the hopes of controlling herbivory damage to coastal marshes across Louisiana, including the BA-03 project area (LDNR 2002).

VI.2. Project effectiveness

Are we able to determine if the project has performed as planned? If not, why? And what should be the success criteria for this project?
The goals, from project planning through monitoring, were not quantified and could have been improved (i.e. more meaningful) by including specific targets. The example given earlier in this document (section II.3), illustrates that to set a target salinity for a given location in the project area (e.g., 5 ppt isohaline) would have been more meaningful than to "decrease mean salinity". In this case, effectiveness could have been clearly decided by determining the average salinity at the proposed 5ppt isohaline. This lesson seems to have been learned, because operation of the Davis Pond diversion will be based on this same type of scenario (Brady Carter, LDNR/CRD Monitoring Manager, pers. comm.). An example of well-written, quantified goals is found in the monitoring plan for the Bayou LaBranche Wetland Restoration Project (LDNR 1998). Those goals quantify the planned acres of land to create and the marsh to open water ratio for a given time frame.

Not only is the absence of quantifiable goals in CWPPRA and state projects a chronic problem and hindrance to determining project effectiveness, the continuing mind set that project benefits are realized "overnight" also seems to be a hindrance to evaluation of project effectiveness. In many instances, projects are labeled a success or failure three years after construction, when in reality; it will take many years of data collection to determine if the project was effective or not.

In the case of the BA-03 project, 9 years of data collection is most likely sufficient to determine if the desired physical and biological responses are being achieved. However, data sets such as aerial photography are still small, and without more frequent data, it is impossible to show the compete picture of changes in the landscape.

VI.3 Recommended improvements

What can be done to improve the project?

1. Maintenance had been very poor until recent installation of the new valving and piping system discussed above. A preventative maintenance system needs to be in place.
2. An improved security system needs to be implemented. There is virtually none at the present time. The siphon is at the mercy of anyone who wants to vandalize it.
3. An automated priming system needs to be installed to allow the individual pipes to be quickly placed back in service when they loose prime. Output from the siphon would be increased substantially. Also, the siphon would then be available for service during much of the low river season when they are often not available. It should be noted that DNR has retained an engineering firm to provide recommendations on installation of such a system and on installation of instrumentation on the siphons. The firm will also provide recommendations regarding the feasibility of enriching the water intake stream with additional fine sediment.
4. Instrumentation such as flow meters and gauges possibly online should be installed to actually measure the flow values rather than the calculated spreadsheet values that are currently used to generate data. Current calculations are based on values from a logbook kept by Plaquemines Parish Government (PPG) personnel and then mailed to DNR. The details of the logs are inconsistent. Records are entered only when PPG personnel visit the siphons.
5. The current plan (no documentation) for operations is to run siphons at all times except when conditions such as lose of prime, oil spills, and tropical storms prohibit flow. A consistent plan for operation of the siphons operations is needed.

VI.4. Lessons learned

1. The effectiveness of siphon systems in mimicking the action of the river's overbank flooding was shown.
2. Concerns over soil erosion from such a system apparently did not materialize. This had been a major concern during the conception stage.
3. Need for a maintenance plan has again proven to be necessary.
4. Need for a security system is recognized from severe vandalism that has occurred at other projects. At present, serious vandalism has not occurred at the Naomi siphons but is possible without safety measures. One instance of

moderate vandalism recently occurred when someone closed all eight-siphon pipes thereby shutting the siphon system down.

5. Politics have a very important role in operations. Concern about lawsuits involving this and other diversion projects contributed substantially to the failure to implement a maintenance plan as both the State and Parish were reluctant for a period of time to be involved with the project. It certainly shows how lawsuits can detrimentally affect decision-making.
6. Project goals should be quantified as much as possible to aid evaluation of project effectiveness.
7. A range of flow i.e. quantifiable should be used in modeling not just with or without flow.
8. Consider outfall management from the beginning planning stages.
9. Reference areas were not included during the project planning or developmental stages but could be addressed in the future with the Coastwide Reference Monitoring System (CRMS).
10. Gated structures provide for greater flexibility in operations and should be the preferred technique for freshwater diversions.

VII. SUPPORTING DOCUMENTATION

Boshart, W. M, 1998 Monitoring Series No. BA-03-MSTY-1098-1. Naomi Freshwater Diversion BA-03. Louisiana Department of Natural Resources, Baton Rouge, La. 21pp.

Bowman, P. E., W. S. Perret, and J. E. Roussel 1995. Freshwater introduction and implications for fisheries production in Louisiana. Baton Rouge, LA: Department of Wildlife and Fisheries.

Brown and Root, Inc. 1992. LaReussite (Naomi) freshwater diversion siphon. A management, operation, and monitoring plan. Unpublished final report prepared for Plaquemines Parish government, Department of Health and Hospitals. Belle Chasse, LA.: Brown and Root, Inc.

Coastal Environments, Inc. 1995. Project plan and environmental assessment for Caernarvon diversion outfall management BS-03a Plaquemines Parish, Louisiana. United States Department of Agriculture. Natural Resources Conservation Service

Chow, Ven Te; Open Channel Hydraulics; In Mcgraw-Hill, New York, 1959.

Dunbar, J. B., L. D. Britsch, and E. B. Kemp III 1992. Land Loss Rates Report 3: Louisiana Coastal Plain. Technical Report GL-90-2. Vicksburg, Miss. U.S. Army Corps of Engineers. 65 pp.

Ensminger, A. B. 1992. Vegetative delineations for the Naomi freshwater diversion outfall area project No. BA-03. Unpublished final report prepared for the Louisiana Department of Natural Resources/Coastal Restoration Division. Belle Chasse, LA.: Wetlands and Wildlife Management Co.

Louisiana Department of Natural Resources (LDNR) 1993. Bayou La Branche (PO-17) Monitoring Plan. Unpublished monitoring plan. Baton Rouge: Coastal Restoration Division, Biological Monitoring Section. 7 pp.

Louisiana Department of Natural Resources (LDNR) 1996. Naomi Freshwater Diversion (BA-03) Unpublished monitoring plan. Baton Rouge: Coastal Restoration Division, Biological Monitoring Section. 8 pp.

Louisiana Department of Natural Resources (LDNR) 1999. Naomi Siphon Outfall Management Project (BA-03C) Barataria Bay Waterway East Bank Protection Project (BA-26) Unpublished monitoring plan. Baton Rouge: Coastal Restoration Division, Biological Monitoring Section. 15pp.

Sasser, C. E., M. D. Dozier, J. G. Gosselink, and J. M. Hill. 1986. Spatial and temporal changes in Louisiana's Barataria basin marshes, 1945-1980. Environmental Management 10:671-680

Penland, S., K. E. Ramsey, R. A. McBride, J. T. Mestayer, and L. A. Westphal, 1988. Relative Sea-Level Rise, Delta Plain Development Subsidence, and Wetland Sedimentation in the Teche and Lafourche Delta Complexes: Terrebonne Parish Region, Louisiana. Coastal; Geology Bulletin Number 2, Louisiana Geological Survey, Baton Rouge, Louisiana, 130p.

Swenson, E. M., and C. M. Swarzenski 1995. Water levels and salinity in the Barataria-Terrebonne Estuarine System. In D. J. Reed, ed. Status and Historical Trends of Hydrologic Modification, Reduction in Sediment Availability, and Habitat Loss/Modification in the Barataria and Terrebonne Estuarine System. BTNEP Publ. No. 20, Barataria-Terrebonne National Estuary Program, Thibodaux, Louisiana.

U. S. Department of Agriculture - Soil Conservation Service. 1983. Soil Survey of Jefferson Parish. 95 pp. Plus maps.

U. S. Department of Agriculture – Natural Resource Conservation Service 1999 Project Plan and Environmental Assessment for Naomi Siphon Outfall Management Project (BA-3c) Barataria Bay Waterway East Bank Protection Project (PBA-12b) Unpublished Plan USDA Natural Resource Conservation Service Alexandria Louisiana 24pp. plus appendices.

U. S. Soil Conservation Service 1991. Feasibility Report for Project No. BA-3: Naomi (LaReussite) Diversion Siphon, Plaquemines Parish, Louisiana. Unpublished report prepared for the Louisiana Department of Natural Resources/Coastal Restoration Division. Alexandria, La.: U.S. Department of Agriculture, Soil Conservation Service. 34 pp.

APPENDIX A: INFORMATION CHECK SHEET

Project Name and Number: BA03 Naomi
Date: March 8, 2002

INFORMATION TYPE	YES	NO	N/A	SOURCE
Fact Sheet		X		State Restoration Plan/ NRCS Feasibility Study/ Brown and Root Report/ Outfall Management Report
Project Description		X		State Restoration Plan/ NRCS Feasibility Study/ Brown and Root Report/ Outfall Management Report
Project Information Sheet		X		State Restoration Plan/ NRCS Feasibility Study/ Brown and Root Report/ Outfall Management Report
Wetland Value Assessment		X		State Restoration Plan/ NRCS Feasibility Study/ Brown and Root Report/ Outfall Management Report
Environmental Assessment		X		State Restoration Plan/ NRCS Feasibility Study/ own and Root Report/ Outfall Management Report
Project Boundary	X			DNR Monitoring Plan/ DNR GIS/ Brown and Root Report
Planning Data		X		Prescott-Follett/ Brown and Root Report/ Plaquemines Parish/ HNTB Report
Landrights		X		DNR Correspondence/ Plaquemines Parish
Preliminary Engineering Design		X		Prescott-Follett/ Brown and Root/ Plaquemines Parish
Geotechnical		X		Prescott-Follett/ Brown andRoot/ DOTD
Engineering Design		X		Prescott-Follett/ Brown and Root/ Plaquemines Parish
As-built Drawings		X		DNR/ Plaquemines Parish
Modeling Output		X		Brown and Root
Construction Completion Report		X		Brown and Root/ Prescott-Follett
Engineering Data		X		Brown and Root/ DNR/ Fenstemaker
Monitoring Plan	X			DNR Monitoring Plan
Monitoring Reports	X			
Supporting Literature	X			DNR/ CEI/ MRSNFS/ Day/ Visser
Monitoring Data	X			Swenson Isohaline Report/ Lane SET/ Day/ Aerial Photo/ DNR
Operations Plan	X			Brown and Root/ DNR/ Plaquemines Parish/ Meeting Notes Steyer Plan Changes
Operations Data	X			Plaquemines Parish Operational Log/ DNR
Maintenance Plan	X			Inspection Reports/ Brown and Root/ DNR Valve Repair
Maintenance Data		X		Correspondence/ Haywood/ Emails
O&M Reports		X		
Other				DHH / Plaquemines Parish Fecal Coliform/ HAB Occurance/ USGS Water Quality/ DNR Rasi Sediment/ Cultural Resources NRCS/ Endandered Species LDWF
Oysters	X			DNR GIS/ LDWF
Permits	X			DNR / Plaquemines Parish