3. PRINCIPLES OF PROJECT DESIGN AND OPERATION

3.1 OVERVIEW OF CHAPTER 3

Several of the studies performed as part of EPA's project evaluation, and listed in Table 1.3-1, provided information regarding the conceptual design and operation of a diversion project at Donaldsonville, and the improvement of the downstream channel. The studies typically considered more than one diversion size (e.g., 660 cfs, 1,000 cfs, 2,000 cfs).

Chapter 3 of the evaluation report summarizes study results that are generally applicable independent of the ultimate size of the project that is selected. These results are, in effect, the principles upon which any diversion project could be designed and operated. The provision of such general information here allows subsequent discussions of particular alternatives to focus narrowly on the specific features of individual project concepts.

Chapter 3 is organized as follows.

- Section 3.2 summarizes principles for design and operation of diversion works, i.e. a siphon system, and/or a pumping station. The discussion includes right-of-way considerations, and a hypothetical schedule of water diversions.
- Section 3.3 discusses design concepts with respect to the area immediately below the diversion facilities in Donaldsonville, including two bayou crossings, and a prospective sand trap that could be constructed as part of a diversion project.
- Section 3.4 presents the basis for design of a dredging program that would be applicable to any alternative requiring extensive channel improvements. Information is presented on the criteria used in conceptual design of the project, including a "reference profile" that reflects conditions during the period when the bayou was clogged with vegetation, and representative

templates for dredging of an improved channel. Section 3.4 also describes the methods and equipment to be used for dredging the channel so that future water levels will not exceed the reference profile, presents a proposal for disposing of dredged material, and discusses maintenance dredging.

- Section 3.5 provides information related to the water management features of the project, including: removal of the Thibodaux weir; installation of two deployable weirs; outfall control structures in wetlands areas; bank protection and stabilization measures; ongoing vegetation management; bayou monitoring stations; water management plan; and wetlands monitoring.

- Section 3.6 discusses aspects of project development that relate to implementation, such as possible cost-share arrangements with the FWD and others; environmental and permitting requirements; and specific issues such as oyster leases and legal responsibility.

3.2 DESIGN AND OPERATING CONSIDERATIONS FOR DIVERSION WORKS

Most of the alternatives evaluated in Sections 5 and 6 of this report would divert water from the Mississippi River to Bayou Lafourche by siphons or a pump-siphon combination. (Alternatives such as a controlled spillway structure are not considered practical at this location.) Basic features of a diversion works that are common to the various alternatives are discussed here in Section 3.2.1 (siphons) and 3.2.2 (pumps). The alternatives also face common issues with respect to the right-of-way for the diversion works (Section 3.2.3), a likely operations schedule for a pump-siphon combination (Section 3.2.4), and responsibility for project operations and maintenance (Section 3.2.5).

Except as otherwise noted, information in this section is taken primarily from Pyburn and Odom (1997c; see citation in Table 1.3-1 and abstract in Appendix A). In turn, Pyburn and Odom benefited from formal and informal input from the U.S. Army Corps of Engineers.

3.2.1 Siphons

Information on siphons is taken primarily from a USACE report (Shadie, 1997; see citation in Table 1.3-1 and abstract in Appendix A).

Siphons are pipes that use atmospheric pressure to draw water from one place (where elevation is high) to another (where elevation is less), in a setting where there is an intervening point that is even higher than the intake. The rate at which water can be siphoned at Donaldsonville, from the Mississippi River into Bayou Lafourche, depends on: 1) river stage; 2) friction loss (which in turn is primarily a function of pipe material, size and configuration); and 3) the head in the Bayou Lafourche receiving water. The levee crown for a siphon center-line at

Donaldsonville is about 40.3 feet, and the practical limit on siphon lift is 26 feet. Consequently, siphoning is possible only when the Mississippi River stage is 14.3 feet or higher.

The chart below indicates the amount of Mississippi River that would be siphoned to Bayou Lafourche in a single 72-inch diameter steel pipe, if the bayou tailwater elevation is 8 feet NGVD (Shadie, 1997).

River stage (ft NGVD)	**Flow per pipe, cfs**
34	534
30	491
28	468
26	444
24	419
22	392
20	363
19	347
18	331
17	314
16	296
15	277

Larger pipes would provide greater capacity, and vice-versa; siphon capacity would be reduced if bayou water levels are higher. Siphon capacity is less than above if the siphons are part of a pumping plant. (See next section for a description of the pipe configuration in such a plant.) The existing FWD facility is able to siphon when river stages are 15.7 feet or higher. The required stage is lower than shown in the chart because the existing facility uses smaller pipe diameters (48-inches), and because the facility experiences additional head losses because the siphoning occurs within a pumping station pipe configuration.

A siphon diversion at Donaldsonville would be built by constructing a screened intake structure in the river so that the intake is always submerged, laying pipes over the top of the flood control levee, and constructing a discharge structure at the head of the bayou. The lower end of the pipes would be buried. Note that an alternative to laying pipes over the levee crest would be to cut the siphons into the levee. However, it has been assumed here that this option would be difficult to implement, due to the need to maintain levee integrity. Also, in low water periods the level of the River is often below the level of the outfall in Bayou Lafourche, so that direct gravity flow to the bayou could not occur.

Siphons are comparatively inexpensive to construct, because there is little excavation and no need for extensive control structures. In the early 1990’s, Plaquemines Parish built a diversion at West Pointe a la Hache, where maximum river stages are lower than at Donaldsonville. Eight 72-inch siphons (about 2,000 cfs total capacity) were constructed for a cost of less than $6 million. Higher costs may be expected where there are right-of-way conflicts for the siphons and/or outfall. If not equipped with vacuum pumps to initiate siphoning, siphons require no energy to operate and there is little cost for maintenance.

3.2.2 Pumps

Pumps use energy to physically lift water, in this case from the Mississippi River to the top of the levee; the water then flows by gravity to Bayou Lafourche. The following description of pumping alternatives should be read in conjunction with Figure 3.2-1, which is a schematic profile for a new pumping station located at Donaldsonville. In most respects, the schematic is identical to the existing pumping station.

A pump diversion at Donaldsonville would be built by constructing a screened, pile-supported intake structure in the river, sufficiently deep to always be submerged. Buried pipes would extend from the intake structure to a pump pit. Sluice gates in the pump pit at the end of the intake pipes would provide for regulation of flow, and allow for dewatering of the pits when necessary for pump maintenance.

At the pump pit, a formed suction intake would channel the water from a horizontal flow to the vertical pump lines. This type of intake, along with an increased pipe size, is one of the design improvements upon the existing station. The CWPPRA engineering work group has recommended that there be an evaluation of the final design by pump-station specialists, such as those at the USACE Waterways Experiment Station in Vicksburg, MS.

Pumps would lift water from the pit to the levee top. The water would then flow by gravity through buried pipes to a discharge basin at the head of the bayou, where energy would be dissipated. The discharge pipes would be sloped upwards near their terminus, in order to retain water when a diversion is stopped. This would keep most of the pipe full of water, making it less difficult to restart siphoning or pumping.

Smooth wall steel pipe would be used throughout. The pump platform would be covered and equipped with an overhead crane for handling of the pumps; it would contain a small office and machine shop and be connected to the existing pump station by a catwalk.

The facility would operate by siphoning during high river stages, and by pumping at lower stages. A facility that combines siphon and pump operations in a single set of pipes will experience additional head loss during siphon periods. As a rough approximation, siphon rates for 72-inch pipes that are configured as shown in Figure 3.2-1 would be about 81% of the rates tabulated above, and siphoning could not occur once the river level dropped much below 15 feet. The minimum river stage for siphoning would be intermediate between the 14.3 feet that is required for pure siphons (no head loss through a pumping plant) and the 15.7 feet that is required for the present pumping plant (with smaller-diameter pipes).

The Donaldsonville site requires relatively small lifts and short-distance transport. The assumed design is that a new pump station would be equipped with vertical mixed flow column pumps having a capacity of 100,000 gpm (223 cfs) each. These would be powered by variable-speed electric motors in order to allow reduction of flow in small increments down to about 60% capacity, which would provide flexibility to manage the system for relatively small changes in pumping rate at any given time. The facility also would be equipped with vacuum pumps to remove air from the system and help initiate siphoning. Vacuum pumps also would aid in start-up of pump operations.

Pump diversion facilities are more expensive to build than siphons, not only because of the costs of the pumps and associated facilities, but because of the need for deep excavations for the intake pipes. Pumps are also more expensive to operate, due to power costs and the need for ongoing maintenance. What is gained from pumps is the ability to operate year-round. This is an important consideration for Bayou Lafourche, where saltwater intrusion typically occurs at times when siphons would be inoperative.

3.2.3 Rights-of-way

About 10 feet of right-of-way width is needed for each installed pipe. Additional right-of-way would be required in order to provide for trench walls, construction access and set-backs.

The following discussion of right-of-way issues should be read in conjunction with Figure 3.2-2, which is an air photograph and plan view of a specific alternative that has been assessed in this evaluation. The following issues are representative of any construction of new diversion facilities at Donaldsonville: need to acquire land; need for relocations; need for cultural resources coordination.

The right-of-way owned by the FWD is shown in Figure 3.2-2, along with the prospective location of new facilities. Note that the existing FWD property limits near the river are undefined. The alignment for new facilities suggested in the figure would go outside the FWD right-of-way. Thus, additional right-of-way may need to be acquired.

The prospective facilities would require cuts across two existing roadways, including LA 22. Discussions with the Louisiana Department of Transportation and Development have indicated that there should be no unusual problems with the crossings. It would be necessary to relocate a small seafood restaurant on Mississippi Street that is not always operational, and a water intake shed at the head of Bayou Lafourche (this is the freshwater source for Donaldsonville). Two residential structures shown on the figure have been removed since the air photo was taken. A cultural resource property exists at the diversion site: Ft. Butler, site of a Civil War battle. Cultural resources issues associated with this property are discussed in Section 3.6.

The preliminary location and right-of-way requirements shown on Figure 3.2-2 were based on fitting the facilities between the presumed outer limit of Ft. Butler (so as to avoid or minimize cultural resource impacts) and the American Legion structure shown on the map (to avoid relocation of this relatively large building). The available space is less than 80 feet wide, which is sufficient for several new pipes, but which provides little flexibility in alignment.

3.2.4 Operations schedule for pump-siphon combination

Table 3.2-1 provides data on Mississippi River stages and interprets these data with respect to their effect on the operations schedule for the existing 340 cfs facility, and for a new 660 cfs facility (with three 72-inch pipes). The data for the new facility would be proportionally larger or smaller for larger or smaller facilities. For three hydrologic conditions, Table 3.2-1 indicates the time when a diversion would need to operate by pumping (shown by the letter “P” in the table), rather than by siphoning (“S”). The classification into these two categories, and the estimates of diversion rates, are intended to be approximate and illustrative.

- One condition represents typical (median) river stages. The data indicate that for a new facility, river stages are sufficiently high to support siphoning in about seven months of the year, December-June. New siphons would not be expected to operate in the remaining months. In December, the median river stage is probably not sufficient to maintain siphoning in the existing (less efficient) facilities.

- A second condition represents high-river stages, defined here as occurring in the wettest three years of ten. In these years, the winter and spring stages of the river are higher than average, and the rate at which siphons operate will increase accordingly. However, the period when siphoning can occur is still typically limited to December-June.

- The third condition represents low-river stages, defined here as occurring in the driest three years of ten. In these years, river levels allow siphoning to be sustained only in March-April.

The data in Table 3.2-1 indicate that in a spring with higher than average river stages, a facility that is rated at 660 cfs for pumping could divert 1,000 cfs or more by siphoning. The fact that additional capacity exists when siphons operate, rather than pumps, should not be taken to indicate that a CWPPRA project would divert more than 1,000 cfs when the river is high.

3.2.5 Responsibility for project operations and maintenance

Because a diversion would need to be integrated with FWD facilities, it is assumed that FWD would be responsible for day to day operations of the diversion works. As discussed in Section 3.5.6, it is assumed further that operations would be in accordance with a formal operations plan that is developed with extensive public input and that has oversight from the State of Louisiana and local governments, as well as EPA. The potential allocation of operations costs among the various entities is discussed in Chapter 5, for the optimized project.

Figure 3.2-1. Diversion facility profile.

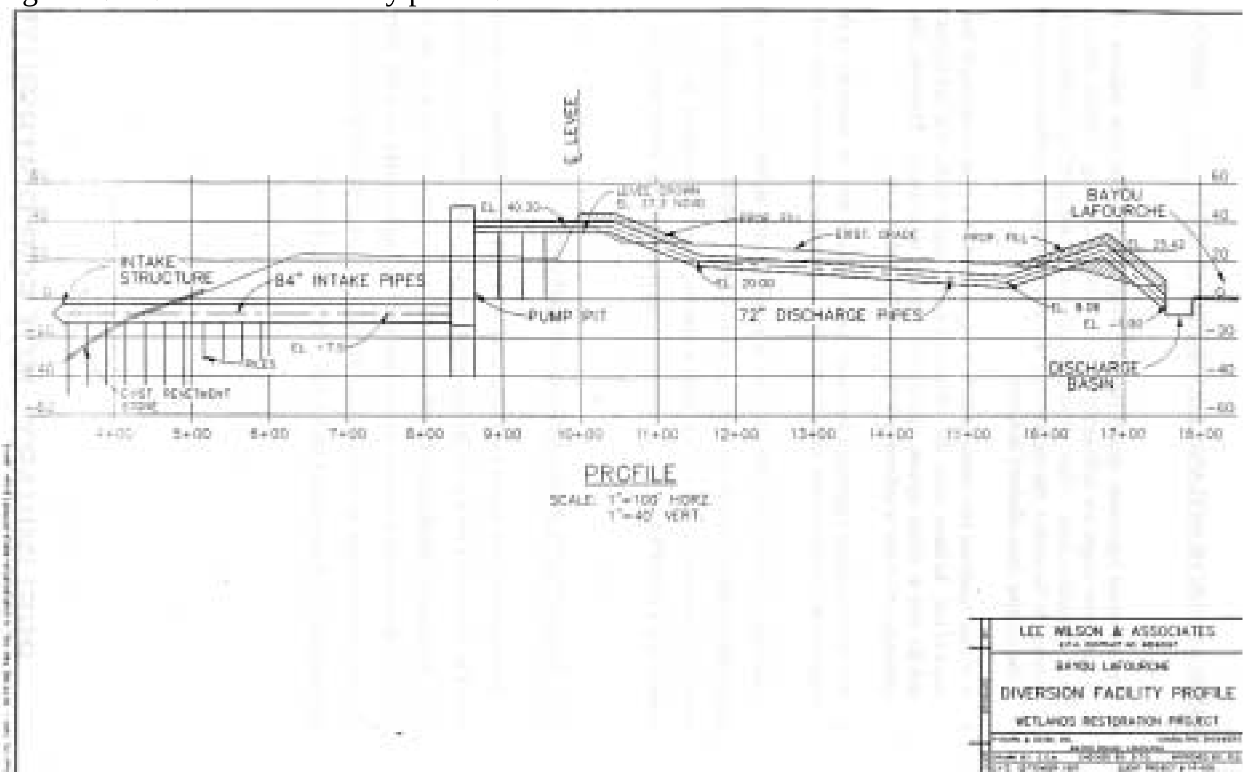


Figure 3.2-2. Diversion facility plan.

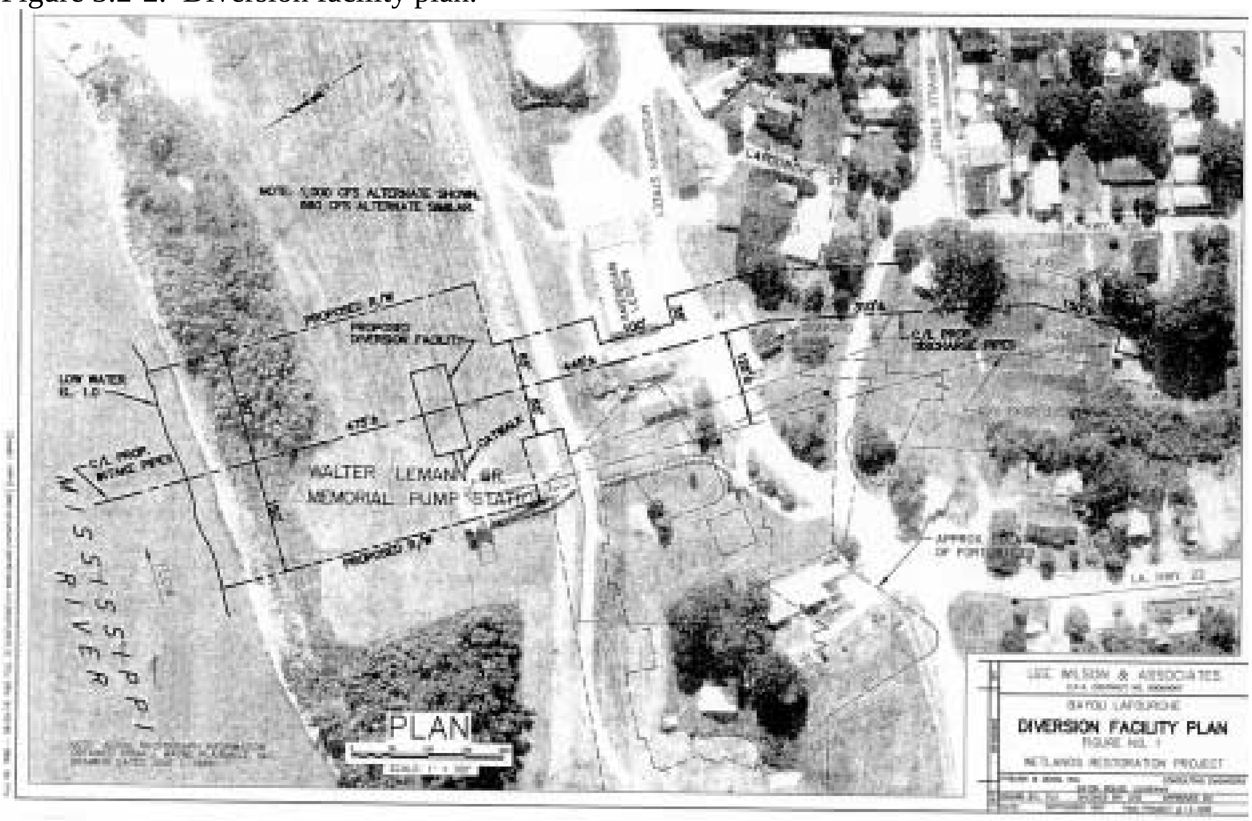


Table 3.2-1. Operational capability for a Bayou Lafourche Diversion.

Example assumes 1,000 cfs nominal capacity, made up of a new 660 cfs facility and the existing 340 cfs capacity. Actual operations would not exceed 1,000 cfs.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
MEDIAN YEAR												
River stage	14.8	16.7	20.1	21.9	20.3	18.5	10.0	6.8	5.5	5.4	7.1	16.1
Mode of operation	S/P	S	S	S	S	S	P	P	P	P	P	S
New plant, cfs	576	690	856	932	865	782	660	660	660	660	660	656
Old plant, cfs	340	207	257	280	260	235	340	340	340	340	340	197
Total, cfs	916	897	1113	1212	1125	1017	1000	1000	1000	1000	1000	853
HIGH RIVER												
River stage	18.5	19.7	23.2	25.1	24.9	21.7	13.8	8.3	6.2	7.3	9.6	19.7
Mode of operation	S	S	S	S	S	S	P	P	P	P	P	S
New plant, cfs	782	838	984	1054	1047	924	660	660	660	660	660	838
Old plant, cfs	235	251	295	316	314	277	340	340	340	340	340	251
Total, cfs	1017	1089	1279	1370	1361	1201	1000	1000	1000	1000	1000	1089
LOW RIVER												
River stage	10.9	13.0	16.8	18.9	13.9	12.2	8.1	5.3	5.1	4.7	5.3	8.5
Mode of operation	P	P	S	S	P	P	P	P	P	P	P	P
New plant, cfs	660	660	695	801	660	660	660	660	660	660	660	660
Old plant, cfs	340	340	209	241	340	340	340	340	340	340	340	340
Total, cfs	1000	1000	904	1042	1000	1000	1000	1000	1000	1000	1000	1000

S = SIPHONS OPERATING. P = PUMPS OPERATING. S/P = NEW PLANT SIPHONS, OLD PLANT PUMPS.

MEDIAN YEAR = 50% RECURRENCE INTERVAL. HIGH RIVER = 30% RECURRENCE INTERVAL. LOW RIVER = 70% RECURRENCE INTERVAL

3.3 DESIGN AND OPERATING CONSIDERATIONS FOR DIVERSION OUTFALL AREA

The diversion outfall area is the initial mile or so of Bayou Lafourche that lies immediately downstream of the outlet works shown in Figure 3.2-2. This reach contains two potential obstructions to flow, in the form of earthen embankments known as the “highway crossing” (Section 3.3.1) and the “railroad crossing” (Section 3.3.2). At present water is conveyed through culverts beneath each embankment. The downstream area also includes a reach in which batture right-of-way is owned by the FWD, and where a sand trap could be constructed (Section 3.3.3) and maintained (Section 3.3.4).

The following discussions are based on Pyburn and Odom (1997c; see citation in Table 1.3-1 and abstract in Appendix A), and on information that EPA developed and submitted to the CWPPRA Engineering Work Group.

3.3.1 Highway crossing at LA 3089

Louisiana State Highway 3089 crosses Bayou Lafourche approximately one-half mile downstream of the existing diversion outfall. Figure 3.3-1 (bottom) illustrates the features of this crossing. At a flow of 340 cfs (the current maximum), the existing drop-box weir structure at the inlet of the highway embankment culverts causes 1.0 to 1.5 feet of pooling. This results in the diversion outfall having a stage in the range 8.6 to 9.1 NGVD. Slightly lower gradients across the weir and culverts occur at the more common lower flows.

At a flow of 2,000 cfs, this crossing would need to be replaced with a bridge. A smaller flow of 1,000 cfs could be passed by a combination of the existing culverts, and two additional 6-foot diameter pipes that could be installed without affecting road traffic; those structures are shown on the drawing in Figure 3.3-1. Preliminary project designs developed during this evaluation had assumed the structures would be constructed, at a cost of approximately $0.5 million; see discussion in Pyburn and Odom (1997c, abstracted in Appendix A).

However, in 1998 information was obtained from the Louisiana Department of Transportation and Development that, for reasons of highway safety, the crossing will be replaced by a bridge. The bridge will be constructed on pipe piles and will be 25 feet long and 52 feet wide (letter from Thomas W. Aymond to Katherine Vaughan, April 1, 1998). EPA has coordinated with LDOTD to ensure that the bridge will safely convey flows up to 1,000 cfs. The Department has advised EPA that bridge construction will commence by August, 1999, or sooner.

Based on assessments of other bridges along Bayou Lafourche (e.g. Section 3.4.7), a new bridge would eliminate any constraint to flow (for diversions up to 2,000 cfs, or larger) at the Highway 3089 location. Therefore, the improvements shown on Figure 3.3-1 are no longer proposed as part of any diversion alternative.

3.3.2 Railroad crossing

Approximately 600 feet downstream of the LA 3089 is a crossing of the Union Pacific Railroad. Figure 3.3-1 (top) illustrates the features of this crossing. There are three existing culverts through this embankment. Two of these are 9-foot diameter corrugated metal pipes, and one is a 5 ft x 6 ft reinforced concrete box. The culverts can pass the current maximum flow of 340 cfs, and in fact the existing diversion facility is operated such that the water level often is kept just below the top of the culverts beneath the railroad embankment.

At a flow of 2,000 cfs, this crossing could need to be replaced with a bridge, in order to prevent backwater flooding upstream. However, computer simulations indicate that the culverts will pass 1,000 cfs if the upstream water level is about 1.75 feet higher than the downstream level. EPA has coordinated with Union Pacific and confirmed that conveyance of this flow will not cause a problem. The higher water above the railroad crossing will occur in proximity to a low spot in LA 308, which dips down to go beneath the crossing at this location; the elevation of the water at about 9.5 feet would be lower than the road, which is above 10 feet NGVD. Construction of a protective berm could be considered during project design, to ensure that high water does not impact the highway. EPA is coordinating with LDOTD in this matter.

3.3.3 Sand trap concept

As discussed in Section 2.9, Bayou Lafourche has a tendency to silt in over time. Of diverted sediments, it is primarily the clays that would be expected to be transported through the bayou to the wetlands. Sediment deposition in the bayou has the potential to reduce the channel cross-section, limit the conveyance capacity of the channel, and require ongoing maintenance dredging. In order to minimize maintenance costs, the conceptual designs for a new diversion project have included a sand trap facility. This facility would concentrate the area in which sedimentation of coarser materials occurs, and thus concentrate the area in which ongoing dredging is needed.

One simple design for causing sedimentation is to hold water in a given area for a long enough time that coarser particles will settle out. A natural holding area will occur in the reach above the railroad crossing, where water will be partially impounded behind the crossing culverts. This holding area can be enlarged by dredging. An additional holding area could be constructed by dredging in the reach just below the railroad crossing, which is sometimes known as the boat-launch area. The FWD owns right-of-way along the large, grassy batture in this reach.

The minimum design for a sand trap is based on a desired retention time of at least 15 minutes, which is sufficient to allow settling of sand and some silt. For a flow of 1,000 cfs, this retention time requires a holding area with a volume of 900,000 cubic feet. Such capacity could be created, for example, by dredging a 1,000 foot long channel that is 120 feet wide and 10 feet deep, with 1:3 side slopes; the flat center section is then 60 feet wide. The average flow through the channel would be 1.6 feet per second. A larger sand trap would increase retention time and trap-efficiency, but would increase the initial dredging requirement.

The conceptual design of a sand trap is illustrated as follows: Figure 3.3-2 is a map showing a possible trap location above the railroad crossing; Figure 3.3-3 is a map showing a possible trap location in the boat launch reach; Figure 3.3-4 provides cross-sections for one dredging concept (the examples given are above the railroad crossing); and Figure 3.3-5 provides a different conceptual cross-section (this one below railroad crossing). The differences in concepts relate primarily to width: the location below the railroad bridge allows for a wider trap than the one above the location shown Figure 3.3-4.

Note that in the boat launch reach, neither channel bank is developed, and thus the sand trap could be even larger than illustrated.

Two alternatives are available for disposal of dredged material from a sand trap located in or above the boat launch reach. The primary alternative would be to lay a discharge pipe back to the FWD pump station, and over the levee for discharge to the Mississippi River; this is a common practice along the river. A secondary alternative would allow for placement of material on the batture, where it could be then sold as commercial fill. The second alternative would be considered only to the extent the material is determined to be marketable. That determination would be made during the design phase of the project, when core holes along the bayou would provide a basis for assessing the characteristics of the material.

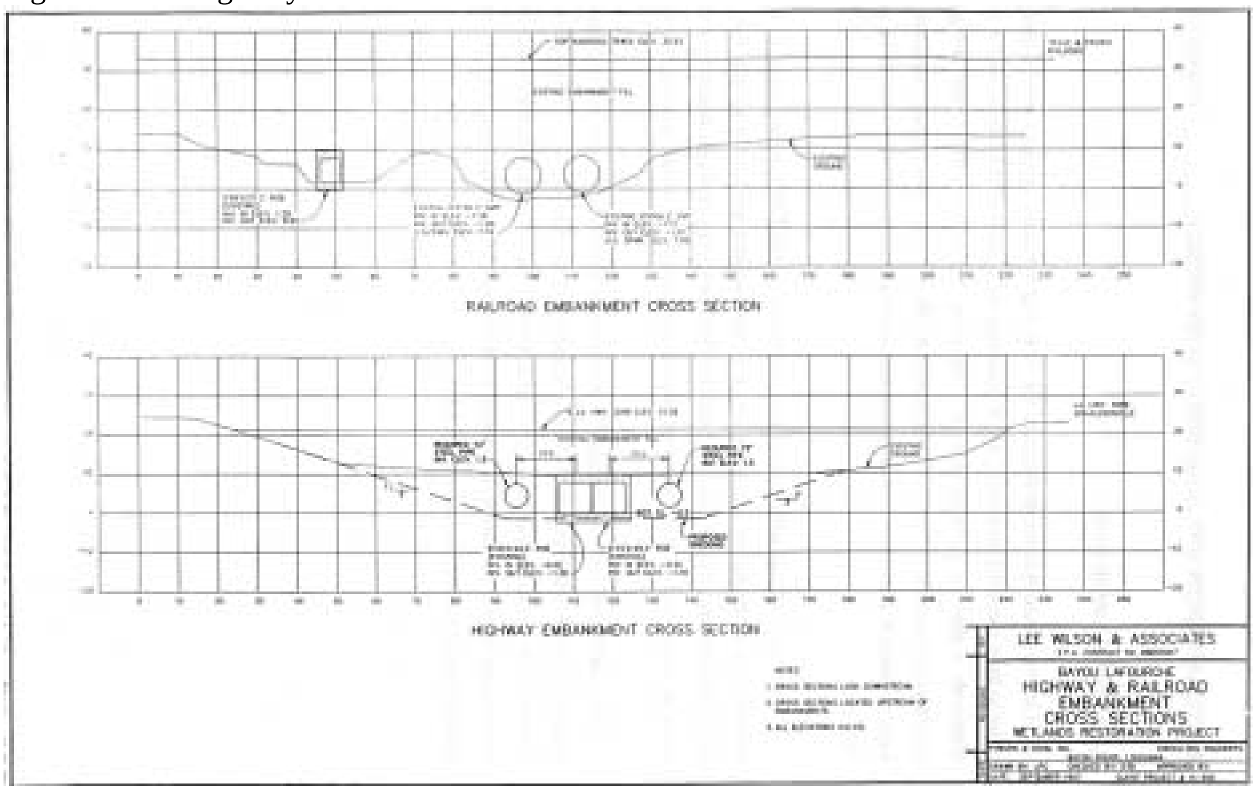
3.3.4 Sand trap maintenance

It is anticipated that maintenance of the sand trap would be required several times a year, in order to keep the sump area open, and to maintain the volume of the trap so that it will function effectively in allowing sediment to settle. Therefore, it is expected that a small dredge would be permanently available to the sand trap area (e.g. via a routine maintenance contract, long-term lease or outright purchase). An above-ground pipeline for river disposal would be permanently installed.

A material handling facility could be constructed on the FWD batture (next to the widened channel) if it is determined that a portion of the maintenance sediment is suitable for commercial sale. As with any sales of material from the initial dredging, revenues would be used to offset dredging costs. To be conservative, subsequent analyses give no credit for such revenues.

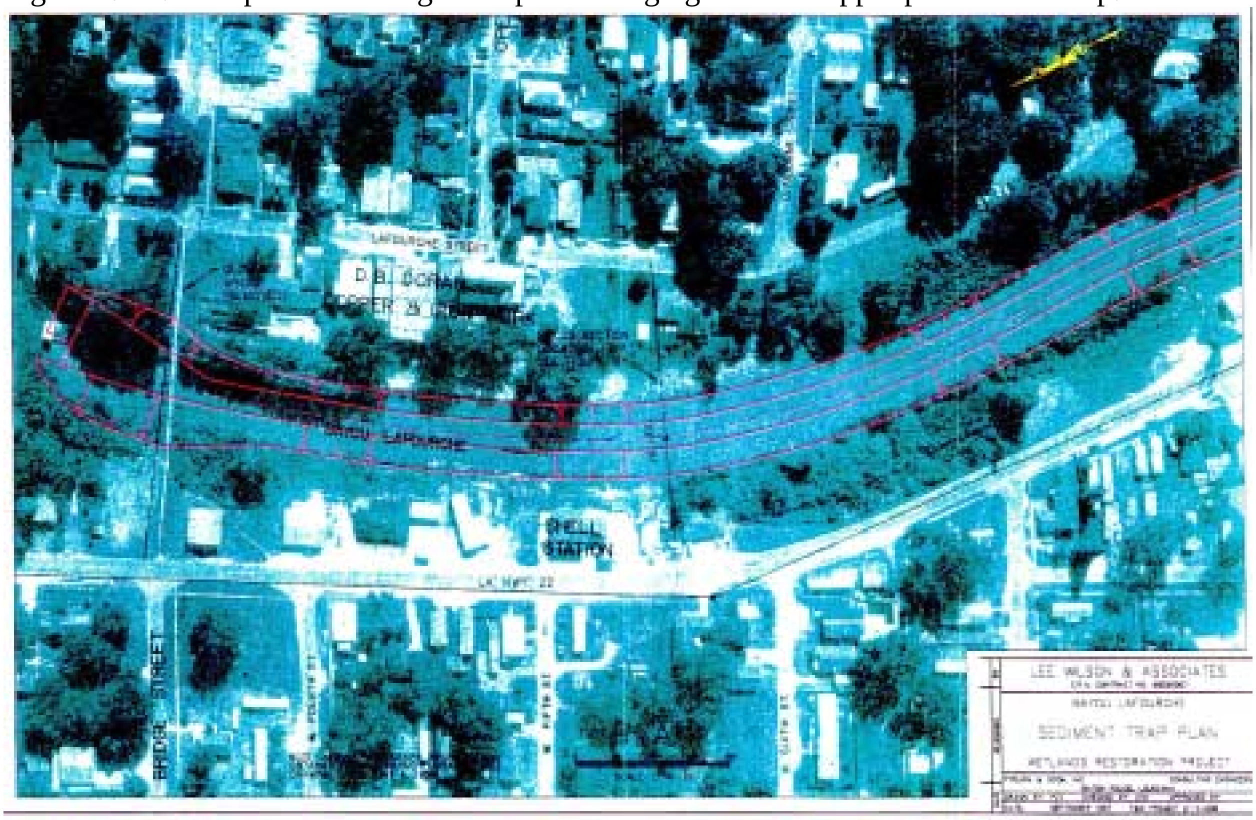
The quantity of material dredged for maintenance would depend on the total volume of the sand trap (which determines its relative efficiency) and the size of the diversion (hence the total quantity of sediment introduced at the bayou head). The calculation method used to determine maintenance dredging quantities is described in Section 4.3; the application of the method to a specific project is illustrated in Section 5.3.3.

Figure 3.3-1. Highway and railroad embankment cross-sections



PRELIMINARY: DRAFT

Figure 3.3-2. Air photo showing conceptual dredging limits of upper part of sand trap.



PRELIMINARY: DRAFT

Figure 3.3-3. Air photo showing conceptual dredging limits of upper part of sand trap.

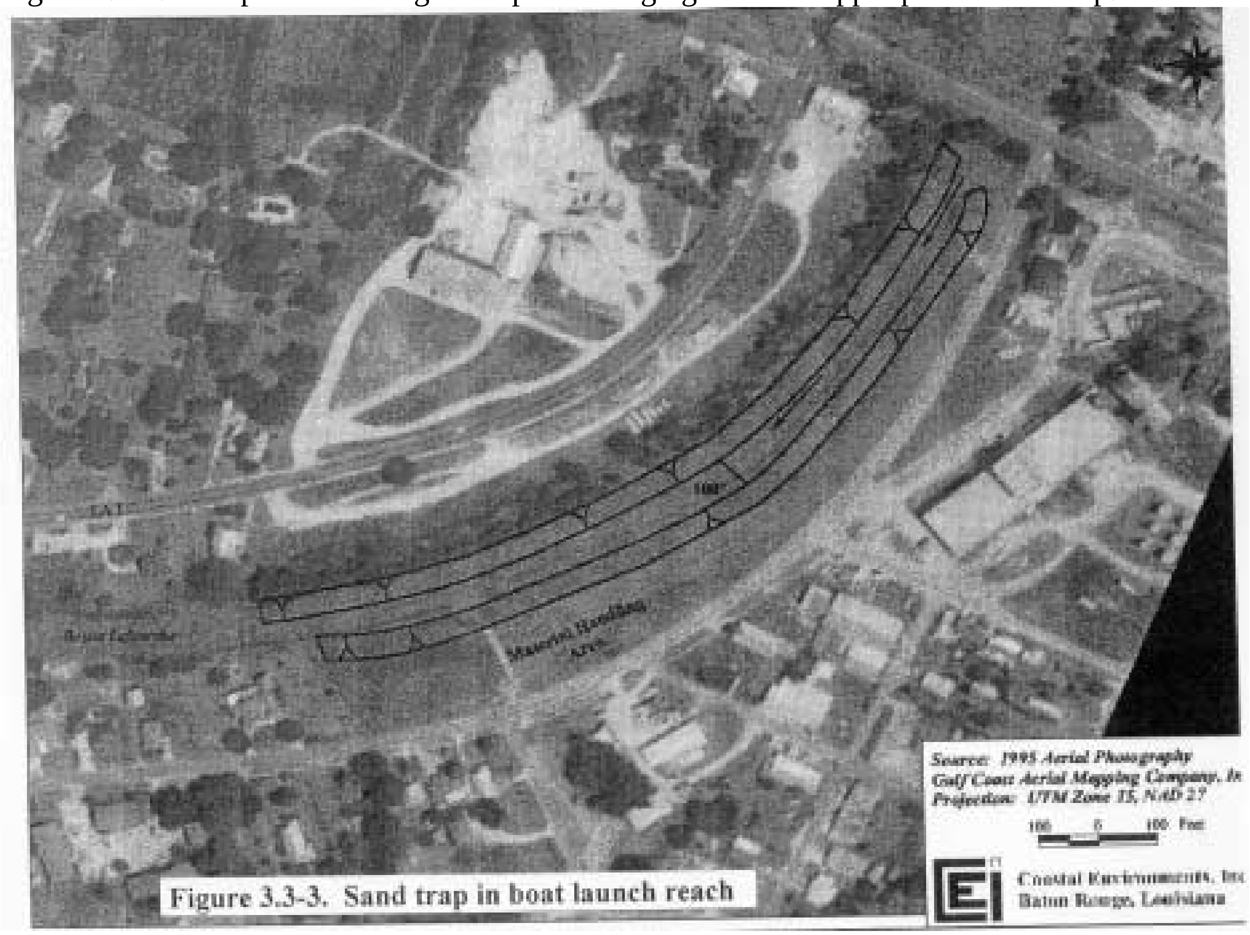


Figure 3.3-3. Sand trap in boat launch reach

Figure 3.3-4. Cross-section to illustrate sand trap concept above the railroad crossing (above La. 3089)

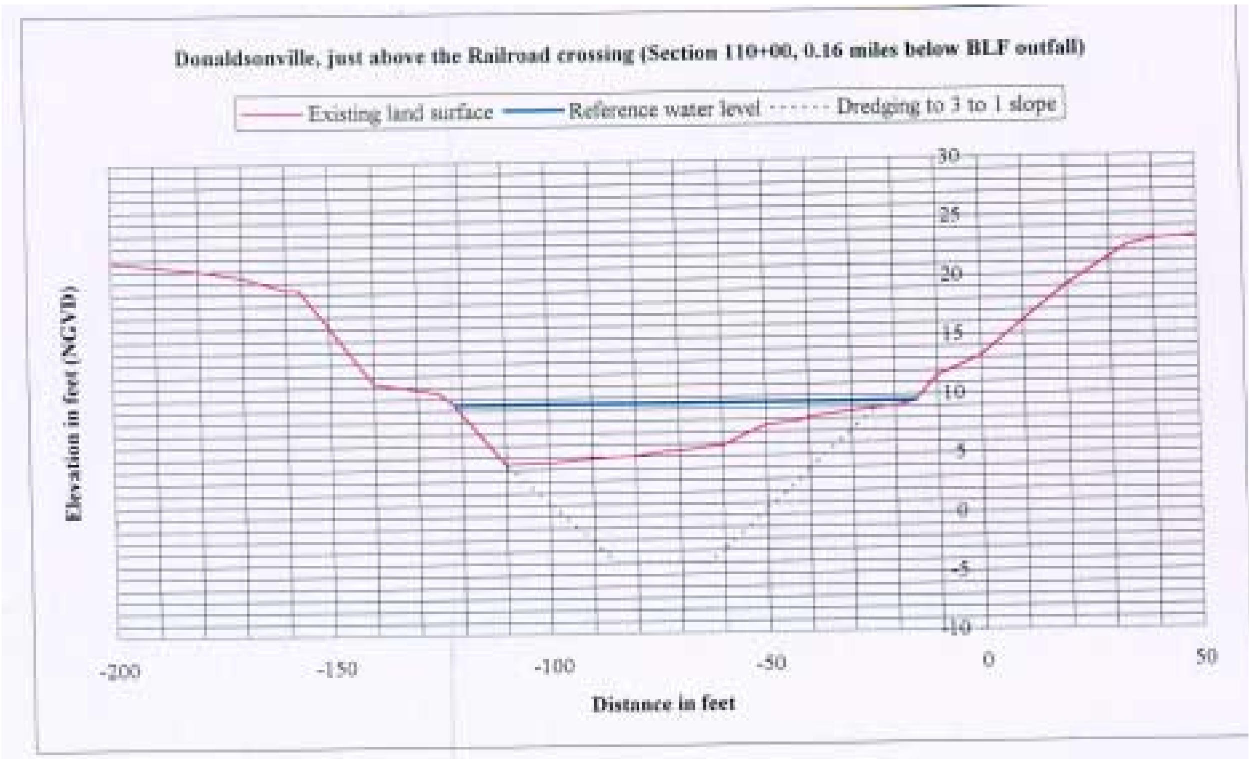
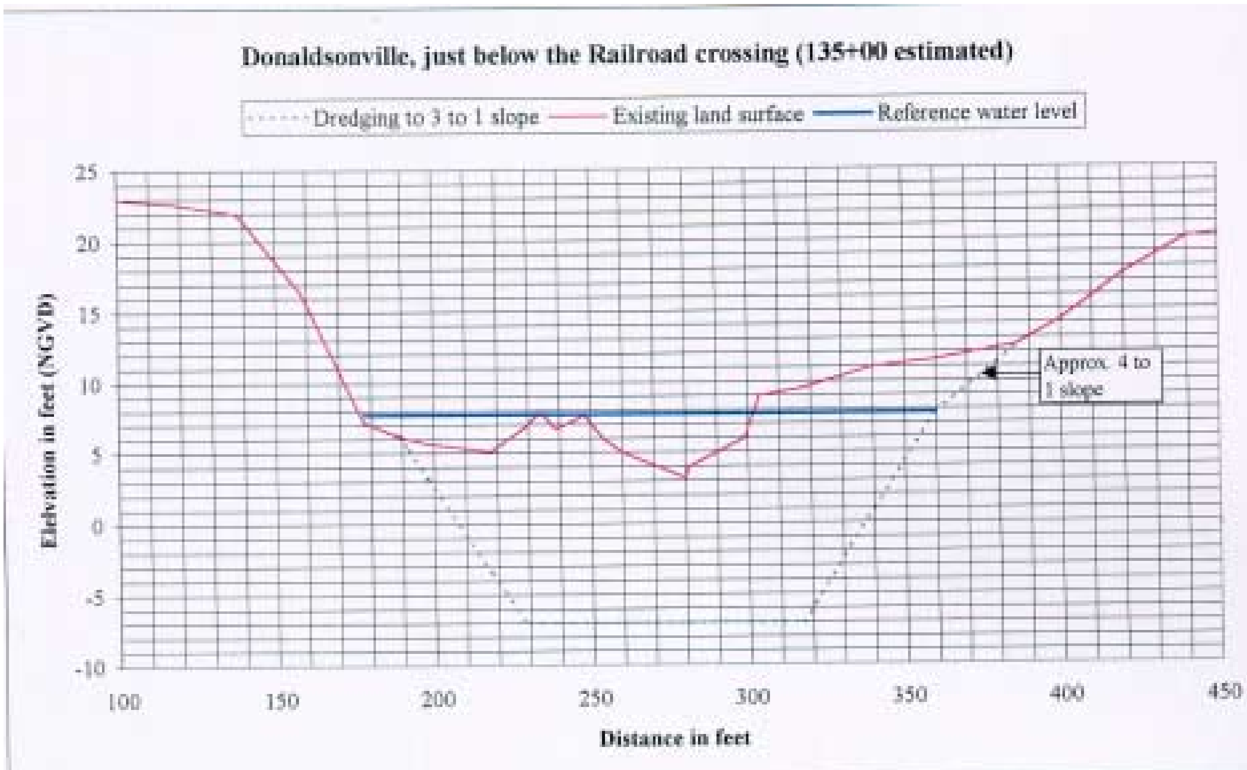


Figure 3.3-5. Cross-section to illustrate sand trap concept in boat launch reach.



3.4 DESIGN PRINCIPLES FOR DREDGING TO INCREASE BAYOU CAPACITY

The diversion project selected for the 5th CWPPRA Priority List provided for relatively limited dredging of Bayou Lafourche. In its evaluation of the project, EPA has given extensive consideration to an alternative design concept, by which channel capacity would be substantially increased through dredging. The evaluation of the concept has involved many considerations, which are discussed as follows.

- Section 3.4.1 introduces the issues associated with the conveyance capacity of Bayou Lafourche, and outlines how dredging can address concerns about the original project.
- Section 3.4.2 presents reference water-level profiles that have been used as a basis for judging the effects of alternative dredging programs and diversion rates.
- Section 3.4.3 explains EPA's approach to defining a dredging template, i.e. standard cross-sections for the improved channel.
- Section 3.4.4 reviews the bank stability evaluations of the dredging templates.
- Section 3.4.5 reviews dredging methods.
- Section 3.4.6 discusses the prospective disposal of dredged material.
- Section 3.4.7 provides information related to the need to replace or protect bridges as a consequence of increased diversions and/or increased dredging.
- Section 3.4.8 summarizes information regarding protection and relocation of utility lines that cross beneath the bayou.

3.4.1 Overview of the channel conveyance problem

Key issues. At the 1996 scoping meetings, the concern most frequently and vocally expressed by the public was that a diversion of 2,000 cfs down Bayou Lafourche would flood batture properties and also block drainage from back-bayou areas. This issue was raised, at least in part, because the original Project PBA-20 involved relatively little improvement to the channel, but instead relied almost entirely on a rise in water levels (hence increased depth of flow, channel gradient and velocity) to carry 2,000 cfs.

The increase in water levels in Donaldsonville from the original project was projected to be more than five feet, which would nearly double the difference in elevation between the head of the bayou and Lockport when compared to current conditions. The increase was about 2 feet at Thibodaux. For practical purposes, water levels substantially below Raceland were not impacted very much, as conditions there are dominated by water levels in the GIWW rather than by the amount of flow in the bayou.

A large increase in water levels in the middle and upper bayous would submerge the lowest part of the batture and, in some locations, could overtop structures that are built within the batture (such as docks, decks, kennels, storage areas). Any runoff draining to the bayou from the two highway corridors would further increase water levels and related effects during storm periods. It would be necessary to close any at-grade canals that are now open, and there would be no possibility of relieving area flooding problems through drainage to Bayou Lafourche.

A related public concern was that, because the original project involved only siphons, each year there would be a large increase in bayou levels when diversions began, and a large decrease when they ceased. These large fluctuations in water level in the bayou could lead to sloughing of some banks along the bayou.

EPA has carefully considered these issues in its evaluation of the project. One factor that has been considered is that under Louisiana law, it can be argued that batture lands provide an easement for the passage of high water. If so, then a legal entitlement arguably exists to build a project that would cause the impacts described above. If this legal argument is not valid, or if the argument were withheld for reasons of policy, the alternative exists to compensate impacted property owners, as by purchasing or condemning flowage easements.

EPA has not undertaken in-depth investigation of the legal and other issues associated with flowage easements, whether obtained as a matter of law or through compensation. Rather than pursue a project that would flood the batture and possibly require easements, EPA has evaluated alternatives to modify the project so that it does not cause increased water levels along Bayou Lafourche. This approach is intended to address public concerns, reduce controversy, and avoid costly delays as have occurred with other CWPPRA projects that have experienced land rights problems.

Diverting more water without increasing water levels. If water levels are to be maintained at or below historic conditions, then whatever water is diverted at Donaldsonville must be conveyed to Lockport and beyond along the existing, rather flat flow gradient. This gradient, of no more than 1 foot per 10 miles, is on the same order as that of the Mississippi River, a channel that obviously carries a huge quantity of water. The capacity of the Mississippi River results from the large cross-section of the channel, and especially its great depth, which extends far below sea level. Increasing the cross-section of Bayou Lafourche would similarly increase the capacity for conveying water diverted at Donaldsonville.

An increased cross-section of Bayou Lafourche requires dredging of a deeper channel. A wider channel would be beneficial, but widening is constrained by the presence of development along the bayou sides. Widening could be an option primarily in reaches where width is severely restrictive to flow, and there is no unacceptable conflict with bayou-side development. No specific reaches where widening could be considered were identified in this study, except for the boat launch area.

The criteria used to conceptually design the dredging program included a reference water level profile (Section 3.4.2) and a standard dredging template (Section 3.4.3).

Addressing the problem of water-level variations. A project that includes pumps as well as siphons would not result in the large seasonal fluctuations in water levels that would occur with a siphons only project. Existing causes of water-level change would be unchanged with such a project. These causes include storm runoff, and fluctuations that result when spills of hazardous chemicals occur in the Mississippi River, and it becomes necessary to shut down diversions at Donaldsonville. The principal method for dealing with these changes is not dredging, but use of weirs; see Section 3.5.

3.4.2 Reference water level profile

Given the conceptual design objective that water in the bayou should not rise above historic levels, it is necessary to characterize past water levels, in order to obtain public input as to what constitutes an acceptable water level for the future. There is great variability in past water levels, as illustrated in Figure 2.4-4 (which compares conditions in 1990, 1996 and 1998) and Figure 2.4-5 (which compares numerous profiles collected during the past two years).

In order to simplify the comparison of project water levels to historic levels, EPA started with the bayou water level measured by the U.S. Geological Survey on a single date, November 21st,

1996. See Figure 3.4-1a. This represents historic water-level conditions in the bayou for a time of dry weather, but when water levels were comparatively high. A second profile, provided only for comparison, illustrates current wet weather conditions and demonstrates that the November data are well below recent experience.

Reference profile. A reference profile has been plotted which represents "historic high water levels". Plotted as a solid line in Figure 3.4-1b (also shown in red in color copies), the reference profile represents conditions on November 21st, with some adjustments described below. The reference profile was selected to approximate 1996 conditions because that when EPA held its public meetings and was told that water levels were already high at virtually all locations along the bayou. The reference profile is not being presented as "acceptable"; but as an indication of water levels that should not be reached by a new project. Judgments about the project can be based on an understanding that "water levels will be lower than was observed during the high water period of late 1996".

Within 1996, the November date was selected because it was among the higher levels surveyed by USGS, yet no storm runoff had impacted the bayou for several weeks prior to that date, so that the bayou was primarily carrying diversion water. The main reason for the high water levels was vegetative clogging, as described in Section 2.6.

The reference profile has been adjusted to depart from actual conditions on 11/21/96 in the following ways.

- Historically, water levels above the Thibodaux weir have been a few feet higher than below the weir, so that there has in effect been a "waterfall" over the weir. The weir must be removed as part of any project to increase diversion rates. Therefore, the drop of water levels over the weir has been eliminated from the reference profile shown in Figure 3.4-1. The effect of this adjustment is that just below the weir, the profile is a few inches higher than observed during the peak of the vegetation clogging problem. Within a few miles the difference between the reference line and historic conditions is essentially zero.

- Although the backwater effects from tides extend up to the weir (and will extend farther upstream if the weir is removed), the main reach of Bayou Lafourche that is impacted by tides (and other aspects of Gulf of Mexico water levels) is below Raceland. Tidal effects are apparent on 11/21/96. The tidal effect dominates flow conditions in this part of the bayou. It is not practical to consider enlarging the lower channel to the point that water can be conveyed against the highest tides. The water level profile for Raceland has been adjusted to reflect considerations of tidal effects. Specifically, the reference line water level for Raceland is set at 2.8 feet NGVD; this is the value that corresponds to a high tide of 2 feet NGVD at Larose. Values this high and higher were measured at Raceland by USGS during the 1996 vegetation event, and subsequently (see Figure 2.2-5).

- The effects of vegetation do not appear to have extended to the upper, narrow reach of the bayou, and it is not clear that 11/26/96 represents an unusually high water level in that area, when compared to prior and subsequent events. Therefore, the line drawn in the figure reflects the highest of the surveyed data obtained by USGS.

As noted above, the use of the solid (red) line in Figure 3.4-1 is to provide a reference against which to judge water levels that are expected to result from an increased future diversion. EPA anticipates that the solid (red) line shown in Figure 3.4-1 will receive considerable attention during the public review that will follow distribution of this report. A key issue in the review will be to determine if it is correct that, if the project water levels are below the line shown in the figure, then there will be no flooding impacts to batture properties. If actual flooding is determined to be likely, then the project concepts set forth in Chapter 5 may need to be revised, or one of the smaller alternatives described in Chapter 6 would need to be considered. A similar revisiting of concepts and alternatives will be appropriate if it is determined that the project water levels are acceptable, but that the dredging needed to accomplish them is not viable (e.g. because of bank stability concerns, or because a hypothetical modeled cross-section might actually encroach on the batture).

An important purpose of the reference profile is to avoid the potentially complex legal issues associated with easements and ownership of the batture, and the consequent cost and delay of legal proceedings. Simply put, by designing a project so that future water levels would be at or below historic ones, EPA intends to remove any threat of increased flooding that might trigger legal concerns.

The subsequent discussion of a dredging program for Bayou Lafourche is based on deepening the channel so that flows can be conveyed without exceeding the profile shown in Figure 3.4-1. As discussed in Chapter 5, a large volume of channel sediments must be dredged to achieve this objective. It is this channel deepening (along with removal of the weir at Thibodaux), that is key to EPA's judgment that the channel can convey an increased quantity of water while keeping water levels below the reference line; and it is the cost of providing this channel capacity which has led to an increase in the estimated cost of the project.

Comparison profile of 1/7/98. The dashed line in Figure 3.4-1a (also shown in blue in color copies) was measured by the U.S. Geological Survey on January 7th 1998, at a time of major storm runoff (with flows of 1,000 cfs or greater); see discussion in Section 2.5.3. The importance of this profile is to illustrate that the solid line in the figure (11/21/96) is substantially below what already happens during "ordinary high water" storm events.

3.4.3 Template for dredging cross-section

The objective of the dredging program would be to create a cross-section in Bayou Lafourche through which increased amounts of diversion could flow. The following are the conceptual design criteria for a template, or standard shape, of the dredged cross-section. This criteria reflect engineering judgment and experience. Figure 3.4-2 illustrates a cross-section that conforms to the criteria.

- Each cross-section was constrained to remain within the limits of existing top banks of the active channel. That is, there was no widening of cross-sections. In practice this means that the upper limit of dredging can be no higher than the reference profile shown by the solid line in Figure 3.4-1. (The sand trap discussed previously is an exception to this design. The difference is because that part of the channel would be designed to catch sediment, and not just convey water; and because there is no development on the bank owned by the FWD, and minimal development on the opposite bank.
- The cross-section needs to be stable, so that channel banks will not have a tendency to slough into the bayou. For purposes of general analyses, bank stability was considered to require a side-slope of no steeper than 3H:1V, i.e. along the channel margin there needs to be no more than 1 foot of vertical change in channel bed elevation for at least each 3 feet of horizontal channel width.
- It is desirable to have a flat center section of the channel, in order to maintain flow and limit the impacts of siltation on channel depth. (I.e., a V-shaped channel will lose depth from silt more quickly that a flat-bottomed channel. A flat-bottomed channel is more consistent with the natural shape of the bayou.) The minimum desired width of the flat bottom was set at 25 feet.
- Flow velocities during dry weather conditions should not exceed 2.5 feet per second, which is the threshold at which the natural sand banks of the channel could begin to be eroded.
- No constraint was placed on the depth of dredging. In effect, this represents an assumption that existing pipelines and bridges are not a barrier to building the project. Such structures may require protection or relocation as part of a dredging project; see Sections 3.4.7 and 3.4.8. Note that as a practical matter, the criteria given above (no widening of the channel; relatively flat side-slopes; relatively wide bottoms) limited dredging depth to no more than several feet below the existing channel bottom.

3.4.4 Evaluation of bank stability

Approach. As noted above, the conceptual design was based on the assumption that the banks of a dredged channel would be stable if they did not exceed a slope of 3H:1V. This assumption was evaluated using a simplified geotechnical analysis (Pyburn and Odom, 1998; see citation in Table 1.3-1 and abstract in Appendix A). The analysis was based on soils data obtained from soil borings made by LDOTD in association with bridge construction, on slope profiles of the type shown in Figure 2.3-1, and on dredge templates comparable to Figure 3.4-2.

The borings indicated that in some locations, (e.g. LA 70 Spur bridge) there are very soft to soft silty clays and loams at depth. The analysis determined that in settings where the existing banks are very high and steep, and the soft materials are found at the toe of the dredged slope, a 3H:1V side-slope for a dredged channel may not be stable. Stability conditions would be more favorable in situations where subsurface material is substantially stronger and/or the existing banks place less load on the slope (as often occurs where the batture flattens out near the bayou, or there is a bench in the channel next to the bank).

In the upper bayou, slopes steeper than 1:1 are found, and some 30% of the channel banks above Thibodaux have a steepness of 3:1 or greater. The presence of high, steep natural slopes may be an indicator of reasonably firm subsurface material. The height and steepness of natural slopes decreases down-bayou, which may indicate an increasing occurrence of weak subsoil’s. Thus, it is not at all certain that there are extensive areas where weak subsoil’s occur in the same locations where banks are very high and steep; if such occurrences are rare, then concerns over bank stability would be much less than if such occurrences are common. The funding for the current study did not permit detailed soil sampling and stability analyses for the dredging program, as that would be part of project design. Thus the extent to which an actual stability problem exists was not determined.

Three alternative dredging templates were studied, for potential use if actual stability problems occur. These are illustrated in Figure 3.4-3.

- Based on the geotechnical studies, a dredged channel with 4H:1V was determined to be stable even if subsoil's are weak and banks are high. When compared to 3H:1V, this template would reduce dredging costs, but also reduce the channel cross-section. If stability problems require use of this template, channel capacity would be less than for the optimized project discussed in Chapter 5.
- Use of sheet piles for bank stabilization purposes presumably would stabilize banks even in the presence of otherwise adverse conditions, and without adverse effects on channel capacity. However, assuming the structure extended from +6' to -15' NGVD, the option illustrated in the figure would cost at least $500 per linear foot to install, plus mobilization and rights-of-way. This cost is so high that, at most, bank stabilization could be used only to a very limited degree as part of an expanded diversion project.
- A template with a broken slope (or bench) was considered, to help support the weight of the existing high banks. This is likely to be stable under most conditions, and may have less of an adverse impact on channel cross-section than a 4H:1V slope. It is possible that the combined use of a 3H:1V template in areas of strong subsoil, and a benched template elsewhere, would allow for channel enlargement sufficient to carry a flow approaching 1,000 cfs, without increasing water levels above the reference profile.

In summary, if it turns out that there are locations along the bayou where high and steep natural slopes coexist with weak material at depth, then there will be concerns about the stability of a 3H:1V dredging template. The available alternatives would be to use a benched (broken slope) template and/or a 4H:1V template; bank stabilization would be considered only to a very limited extent. The effect of these alternatives would depend on the extent to which stability concerns occur. If the extent and length of problem-sections is limited, there would likely be minimum impact on project design and effectiveness. Indeed, there are many reaches where dredging quantities could be reduced without an unacceptable impact on project performance; thus some use of 4H:1V and benched cross-sections is expected to be appropriate for a project that will carry 1,000 cfs.

However, if the alternative templates need to be used extensively, the expected outcomes would be to reduce dredging costs and ultimate channel conveyance capacity, when compared to the 1,000 cfs optimized project alternative discussed in Chapter 5.

3.4.5 Dredging method

The development of a dredging plan is described in CEEC (1997c; see abstract in Appendix A). Key elements of the plan include determining the type of dredge that is most suitable for the bayou and defining the operational features of the dredging activity. Disposal of the material is a separate issue; see Section 3.4.6.

Dredge type. Several factors are important to selecting the best type of dredge for use in Bayou Lafourche.

- Some reaches of the channel are relatively narrow (70 feet or less) and shallow (4 feet or less). This suggests the need to use a relatively small dredge.
- There are benefits to a dredge that can be easily disassembled in order to be more easily moved around bridges.
- There may be areas of the bayou that contain debris. Debris can cause damage to certain dredge types (e.g. hydraulic cutterhead dredges), which can increase down-time due to maintenance. If a cutterhead is used, it would be appropriate to conduct a magnetometer survey of the bayou before dredging begins, to identify areas of major metallic debris.
- It would be beneficial to have a dredge that can produce a relatively precise cross-section, in order to ensure that banks are not steeper than the design, and also to provide for dredging around structures such as water intakes and docks. A bucket dredge (or small cutterhead) would be best for this purpose.
- It may be beneficial to slurry the sediment with a high solids content, in order that the material will contain relatively small amounts of water. This will result in smaller quantities of water to drain from disposal areas, and a quicker drying time for deposited material.

- Factors such as costs (which in turn can be impacted by the duration of dredging and the size of the dredge) must be considered.

CEEC presented information on various types of dredges. Their recommended alternative was to use a bucket dredge in combination with a slurry pump. The bucket dredge and ancillary equipment would set on a barge constructed from inter-connecting floatation units. The bucket would extract material from the bayou and drop it onto a screen where gross debris would be removed. The material would fall through a hopper to a slurry processing unit which would pump material with high solids content to the disposal area. It is expected that such a pump could move material for a distance of 1.5 to 2 miles before an additional booster pump wold be needed.

In order to complete dredging within a reasonable timeframe, it would be necessary to use a dredge with at least 200 cubic yard per hour capacity; or multiple units with smaller capacity. Figure 3.4-4 illustrates a 50 cubic yard/hour unit in operation in New Orleans.

For purposes of project planning, dredging has been assumed to be accomplished by a 24-hour operation. In addition to operators of the equipment, there would be supervisory and support personnel, and a team to handle the disposal operations. The dredge is assumed to be diesel fueled. Consumables such as pipe fittings would be purchased.

The dredge would use anchor spuds to maintain its position in the bayou. For moves within a reach, one or more of the spuds would be lifted and the bucket would push or pull the barge to a new location. There would need to be an access point in each reach where the equipment could move from the bayou banks onto the barge (or vice-versa), with assistance of a crane if necessary. Most commonly, access would be at a bridge, with the crane being placed on the bridge approach; this would block traffic at times.

It is expected that the inter-connected flotation units could be disassembled and navigated beneath most bridges. The typical move would be to disassemble the dredge at one access point; move the equipment by crane (and by truck if necessary) to the next access point; disassemble and float the barge to the next access point; and reassemble the barge and dredge.

3.4.6 Disposal of dredged material

Three alternatives have been identified for disposal of dredged material.

- In the Donaldsonville area, material can be discharged to the Mississippi River.
- Along the bayou, there may be areas on or near the batture where landowners would desire the material be placed as a fill.
- If the above options are not available, material could be piped into cane fields located up to a mile from the bayou, and deposited in order to elevate the cultivated land.

Figure 3.4-5 illustrates the basic disposal concept. Material would be pumped in plastic pipe that would pass through culverts beneath Highway 308. (The concept also would work on the Highway 1 side, but the distance to the back of the alluvial ridge is much farther.) More than four hundred culverts have been identified that could be used for this purpose. For planning purposes, it is assumed that actual culverts to be used would be approximately one mile apart; thus the dredge would never be more than one-half mile from a culvert. The discharge pipelines would be pulled out of culverts during storm events.

Beyond the highway, the discharge lines would pass through drainage ditches or overland, and would discharge to containment areas that would be about 500 ft wide with 24 inch earthen levees. Water draining from the containment areas would seep to the nearby wetlands. Runoff from fields would be routed around the containment dikes, which would be breached once the material had dewatered. It would take up to two years for the material to dry to the point that the land could be used. This disposal practice is considered a beneficial use of dredged material.

Maximum transport distances in most instances would be one-half mile within the bayou (to the culvert), one-half mile to the back-level disposal area, and one-half mile to the farthest location within the confinement area. This distance of 1.5 miles or less would not require a booster pump. If disposal areas are farther away from the bayou, a booster pump could be required.

Landowner willingness to accept dredged material was investigated by holding meetings attended by persons owning or representing owners of agricultural lands. The concept of obtaining dredge material appeared to be well received. Some individuals indicated a preference for sites near the bayou and/or highway; others preferred placement at the back side of their properties closest to the marsh. Most had questions of the type that can only be answered during project design. Specific commitments to allow disposal have not been requested, but at least fourteen candidate tracts of land -- including several that measure hundreds or thousands of acres -- have been identified along the length of the potentially dredged reaches. On each tract, owners/operators have represented themselves as being favorable to the location of spoil disposal sites on their properties, at minimal cost provided that damages (if any) are compensated. A formal program for obtaining land commitments and easements would be an essential, early component of any project design.

All disposal locations would be located outside of existing wetlands. No permits would be required pursuant to Section 404 of the Clean Water Act, or other Federal/State statutes. Based on present information, the expectation is that both the sediment itself and the decant water would be of good quality. Formal testing of the material and water would be undertaken as part of project design.

3.4.7 Bridge and road modifications

Conditions near the outlet works in Donaldsonville were discussed in Section 3.3. Further downstream, four issues regarding bridges and roads were assessed as part of overall project planning: need to replace bridges because they impede water flow; ability to dredge at bridge locations; protection of bridges from increased flow; and flooding of roadways.

Bridge replacement. Application of the HEC computer model described in Section 4.3 was used to determine that it is not necessary to replace any existing bridge in order to convey a flow up to 1,000 cfs; see Section 4.3.3.

Dredging at bridges. EPA has coordinated with LDOTD regarding the impacts of channel dredging on bridges. As a rule of thumb, LDOTD has indicated that bridge stability is not expected to be impacted if the bridge pilings reach at least 20 feet below the channel bottom. The agency is evaluating their records to determine if concerns may exist. For bridges where the criteria is not exceeded, there should be no need for further evaluations. Bridges investigated to date have been determined to have piling depths of 30 feet or more.

If there are bridges with pilings of unknown depth or condition, special surveys may be required during the design of a diversion project. If information were to indicate that piling depth would be less than 20 feet beneath the channel after dredging, then a site-specific stability assessment could be needed. At this time, EPA has no information to indicate that such surveys will be needed, or that they would lead to a need to make bridge modifications.

Scour protection at bridges. EPA's coordination with LDOTD has included exchange of information regarding flow velocities in a dredged channel. The existing information indicates that these velocities would be too low to cause a scour problem. The issue should be revisited during project design. If scour were to be a concern at a particular location, then the final design could include special bridge protection measures, such as rip-rap.

Flooding of roadways. If a diversion project does not increase water levels compared to historic levels, there would be no increase in the high-water flooding of LA 308 at Lafourche Crossing, thus no incremental impacts to traffic, including emergency vehicles or hurricane evacuation. Currently, the weir at Thibodaux isolates the crossing area from any hydrologic changes caused by pump shut-down. This would change if the weir is replaced by a deployable structure (see Section 3.5). With such a structural change in the bayou, the potential to manage water levels in the bayou would substantially increase. For example, during a hurricane the diversion project could be shut down, the weir partially deployed, and water levels gradually lowered. This would reduce the existing risk of flooding at the crossing.

3.4.8 Utility protection and relocation

Utility lines that cross beneath Bayou Lafourche -- such as oil and gas pipelines, water and sewer lines, and communications cables -- must be protected against the direct and indirect effects of dredging, or relocated.

Protection and relocation concepts. Pressurized pipelines typically must be placed out-of-service at the time of actual dredging, to eliminate any risk of accidents. More permanent protection of utility lines can be considered where, after dredging, the line would be at risk of being ruptured by channel scour, boat anchors or other causes. In 1971, the State of Louisiana, Department of Public Works issued a requirement for a minimum of five feet of cover for pipelines crossing waterways. Part 195, Title 49, CFR requires 48-inches of cover for liquid pipelines crossing water bodies at least 100 feet wide between high water marks. These values of 4-5 feet can be used as a guideline to indicate when dredging comes close enough to a pipeline or cable such that protection or relocation should be evaluated.

Figure 3.4-6 illustrates how utility lines that have their cover significantly reduced by dredging could be protected or relocated. The lowest cost action would be to cover the line with rip-rap. Flow velocities in the bayou are low, and are not expected to reach scouring levels after dredging (see, for example, discussion of HEC model in Section 4.3). Given this fact, and also because heavy-duty anchors are not in use in reaches where dredging is likely to occur, rip-rap protection may be adequate for many cable crossings or water lines where dredging will reduce mud cover to only a few feet.

Where dredging would reduce cover over a pressurized hydrocarbon lines to three feet or less, a relocation may be needed. Typically relocation would involve removal of the existing line and replacement with a deeper line that is slightly offset. Lowering of existing pipelines in place is not recommended because of potential damage to the pipeline, safety hazards, and interruption of service.

Inventory of lines. The potential need to protect and/or relocate utility crossings was studied by Pyburn and Odom (1998; see abstract in Appendix A). P&O searched relevant archives to identify locations where Bayou Lafourche is crossed by a buried pipeline or cable. A field reconnaissance also was performed. Based on this inventory, EPA sent a questionnaire to owners of the lines, requesting additional information. The information obtained from the archival survey, field reconnaissance and questionnaire is summarized in Table 3.4-1. The table is keyed to maps that show line locations and many other features of the bayou; see Figure 3.4-7.

The first part of the table begins from Thibodaux and works upstream; the second half goes downstream. This division of the table was done because, below the weir at Thibodaux, most if not all pipelines have a federal permit that makes it clear that the costs of line relocation, if done in conjunction with certain types of federal projects, are to be born by the owner of the line.

The inventory of utility crossings may not be complete, especially downstream of the weir where the survey methods used were less comprehensive. Even so, it is clear that several dozen utility lines cross the bayou. Pipeline sizes vary from 1 inch to 36 inches. Some pipelines carry natural gas, others liquid hydrocarbons, and still others are used for water supply. The location of lines is summarized as follows.

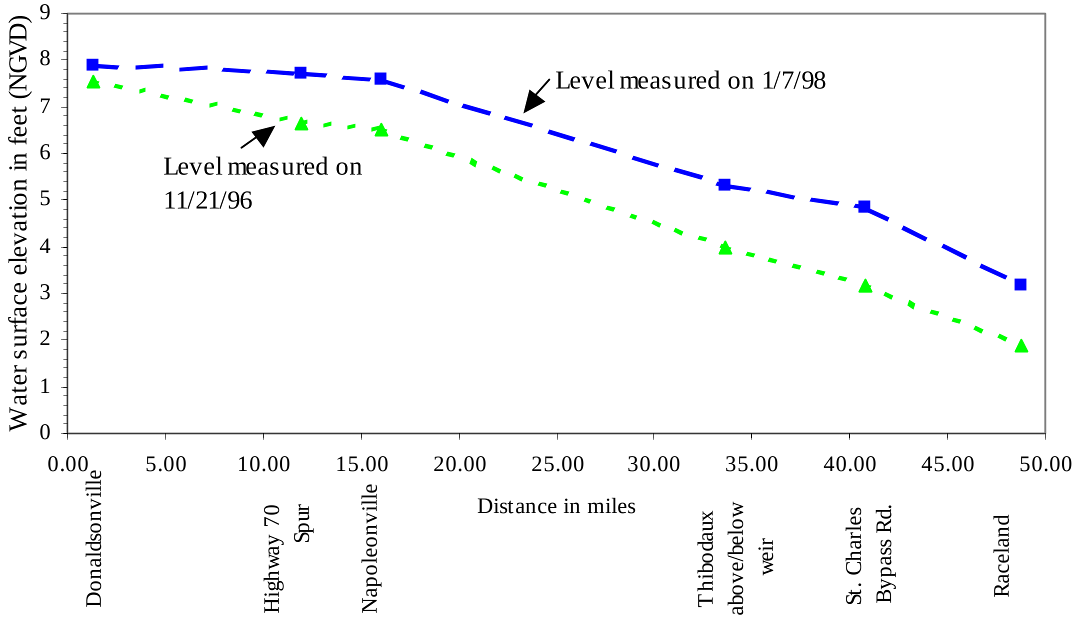
Reach	Length in miles	Locations	Pipelines and cables	Profile info available
Below Donaldsonville through Thibodaux	34	73	86	62
Below Thibodaux through Lockport	21	5	5	Not assessed
Totals	55	78	91	

<u>Coordination and cost-sharing</u>. Placing a pressurized pipeline out of service prior to dredging requires advanced close coordination between pipeline owners and the dredging contractors, and may require payment for lost product. Extensive and effective coordination with utility owners is required prior to a relocation. Beyond the cost of actually providing protection or relocation, costs associated with utility line replacement can include right-of-way, damages, permitting, engineering, environmental investigations and lost product.

EPA has not determined how much, if any, of the pipeline relocation costs would be borne by the project. In some instances, the burden of a relocation may clearly fall on the owner, as a result of permit conditions. This is especially likely for pipelines below the Thibodaux weir. In other cases, the cost of relocation may be voluntarily borne by the owner, as when the owner is a customer of the FWD.

Figure 3.4-1. Reference profile.

a. Water levels measured in Bayou Lafourche on 21 November 1996 and 7 January 1998



b. Water level measured in Bayou Lafourche on 21 November 1996 and Reference Line (maximum project water level)

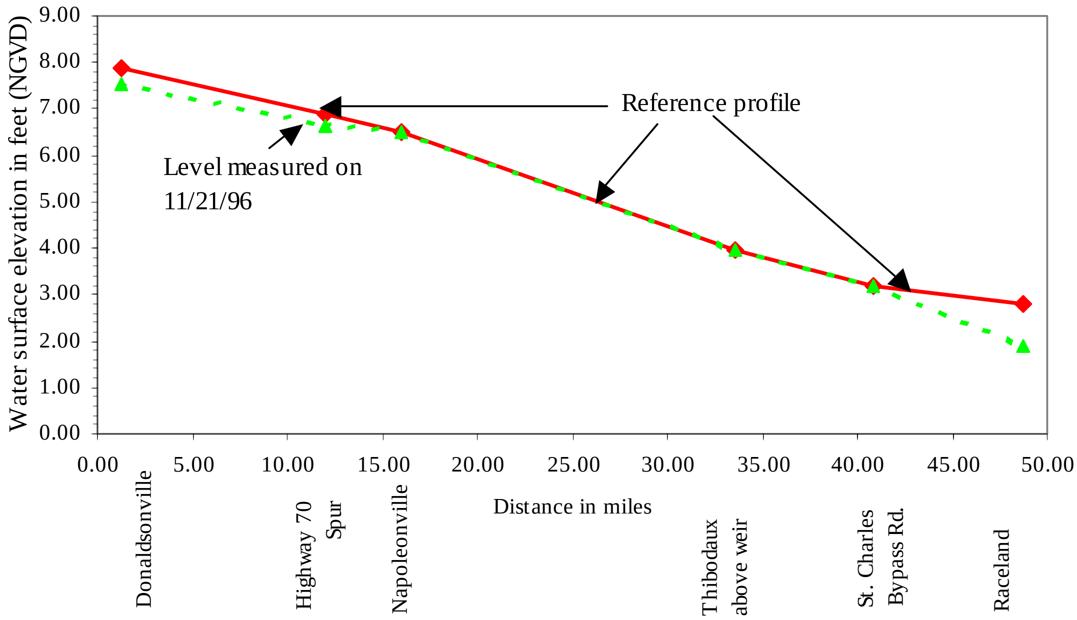


Figure 3.4-2. Representative dredging cross-section

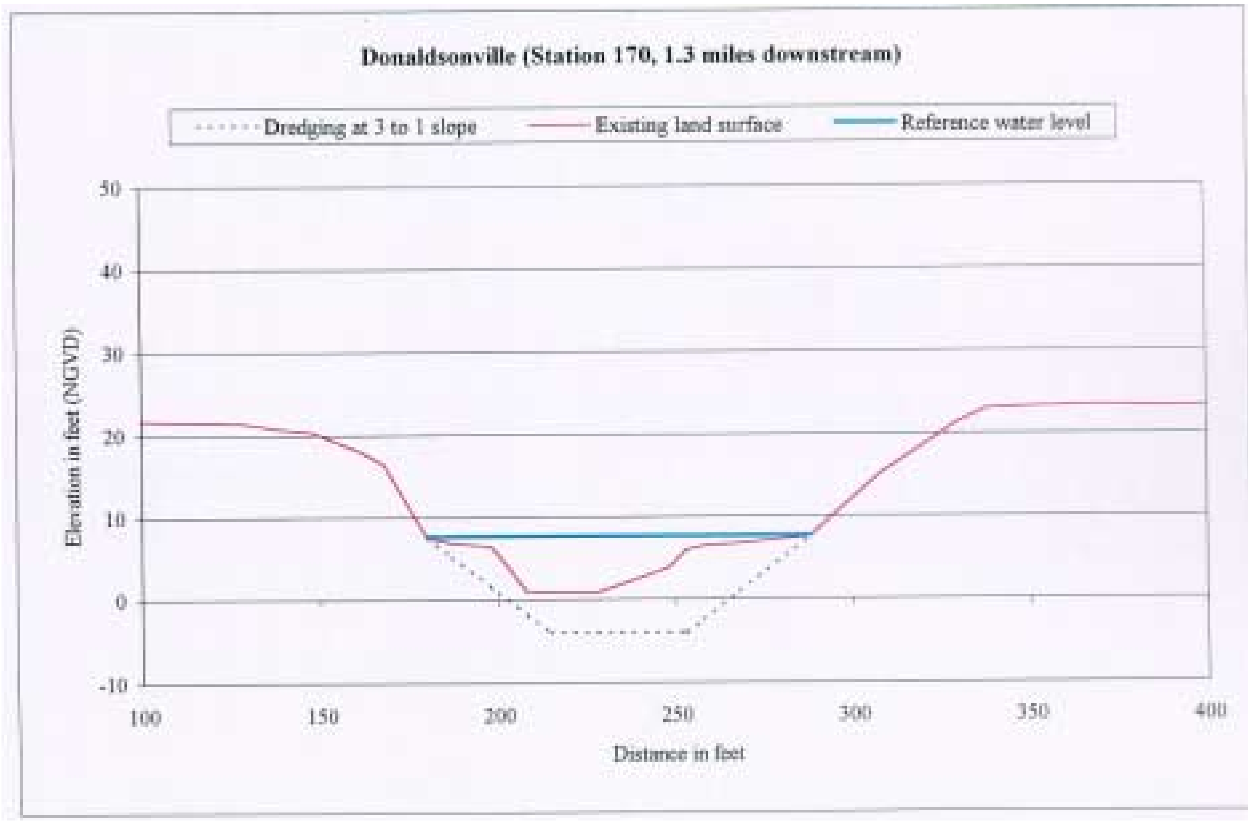


Figure 3.4-3. Dredging options: Donaldsonville example

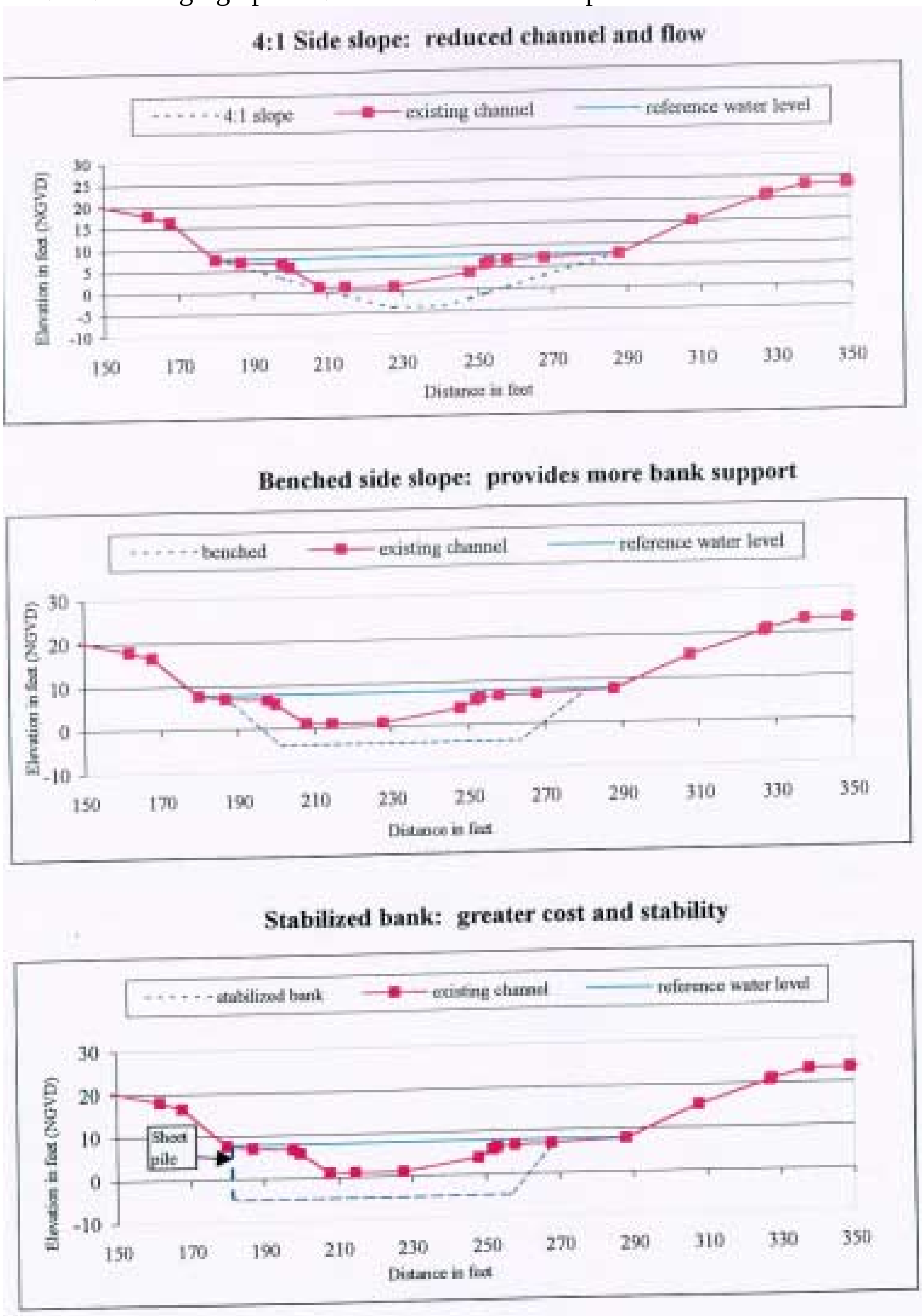


Figure 3.4-4. Photos to illustrate possible dredging operation.

Illustrations are from 1998 Corps of Engineers' Project at Wilson Avenue Canal, New Orleans. Dredging program at that location has both similarities and differences compared to potential dredging of Bayou Lafourche.

a. Barge assembled by shore-based crane. Barge is made up of small, inter-connected flotation units that can be lowered in water to pass beneath bridges.

b. Bucket dredge on barge. Bucket is visible just behind the nearest spud, which is used to help anchor dredge. For Bayou Lafourche, the ramp to shore would be used only at access points where it is feasible to drive the bucket on and off the barge.

Figure 3.4-5. Map to illustrate plan for disposal of dredged material

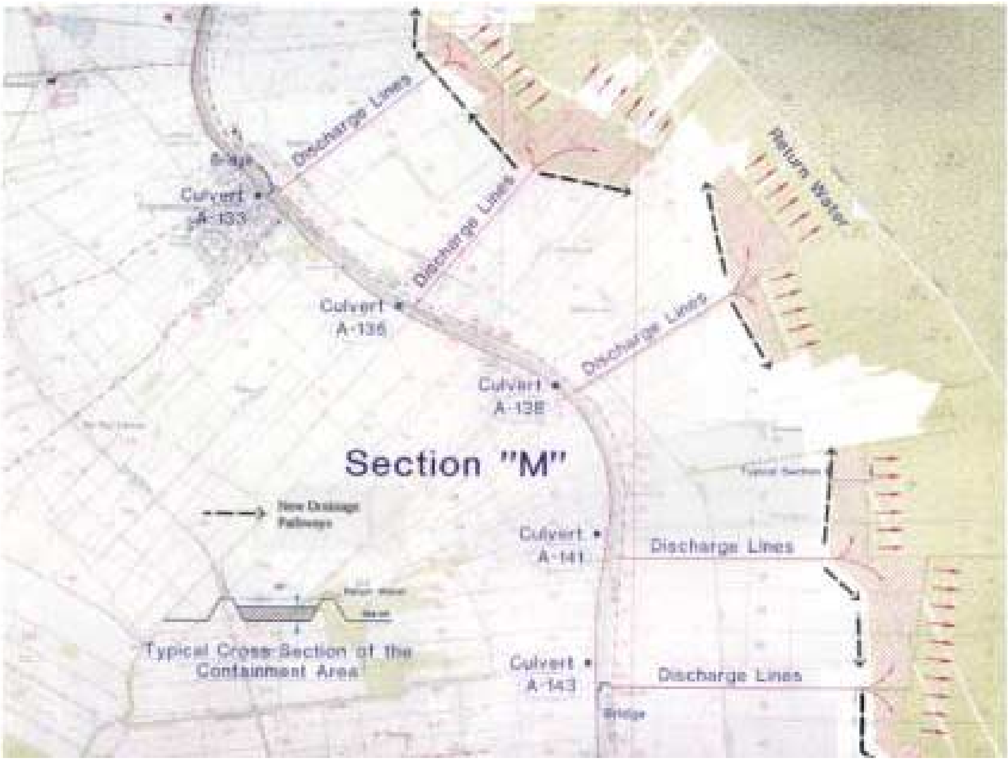
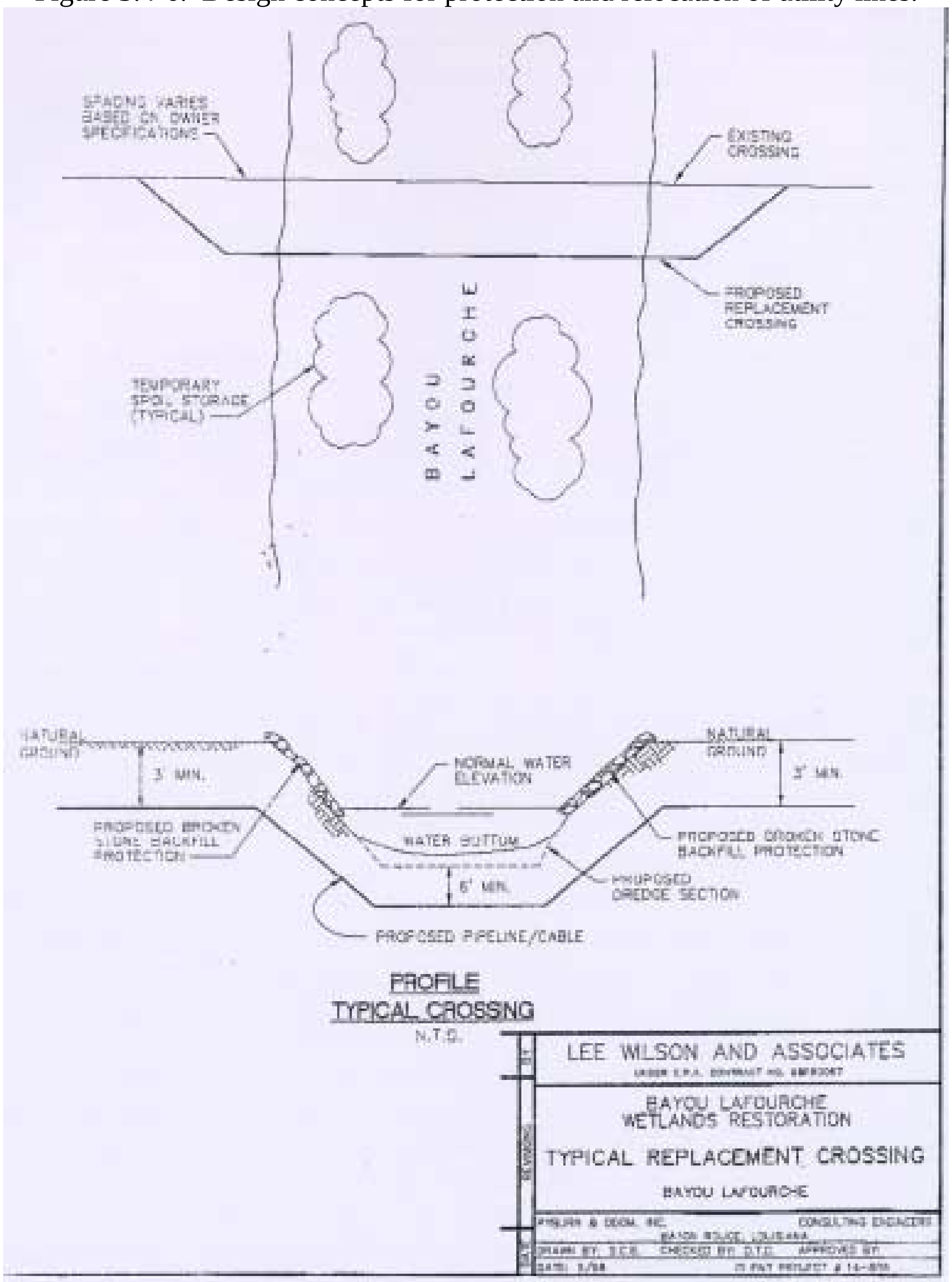


Figure 3.4-6. Design concepts for protection and relocation of utility lines.



.Figure 3.4-7. Location of utility crossings and other features.

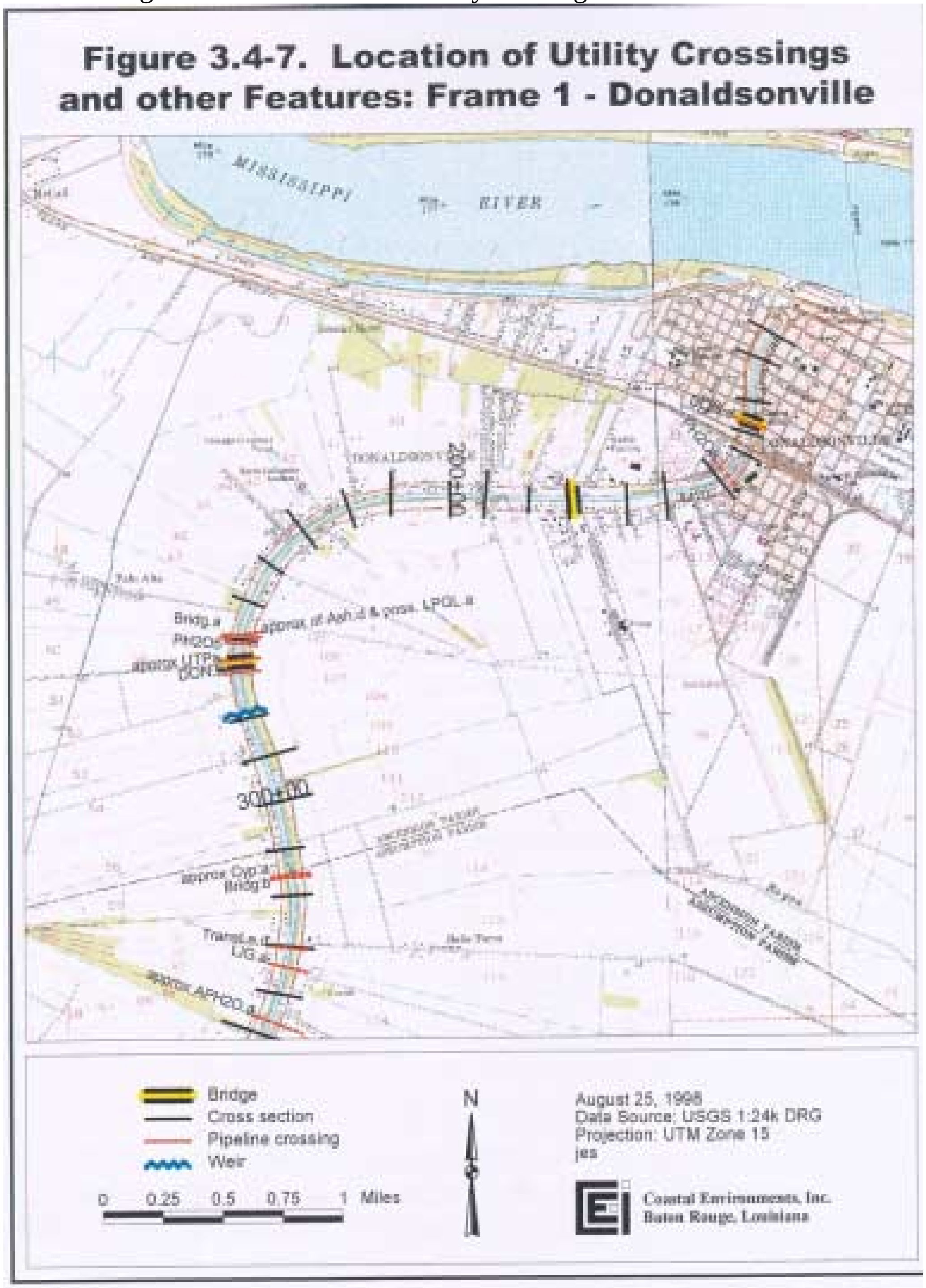


Figure 3.4-7. Location of Utility Crossings and other Features: Frame 2 - Belle Rose

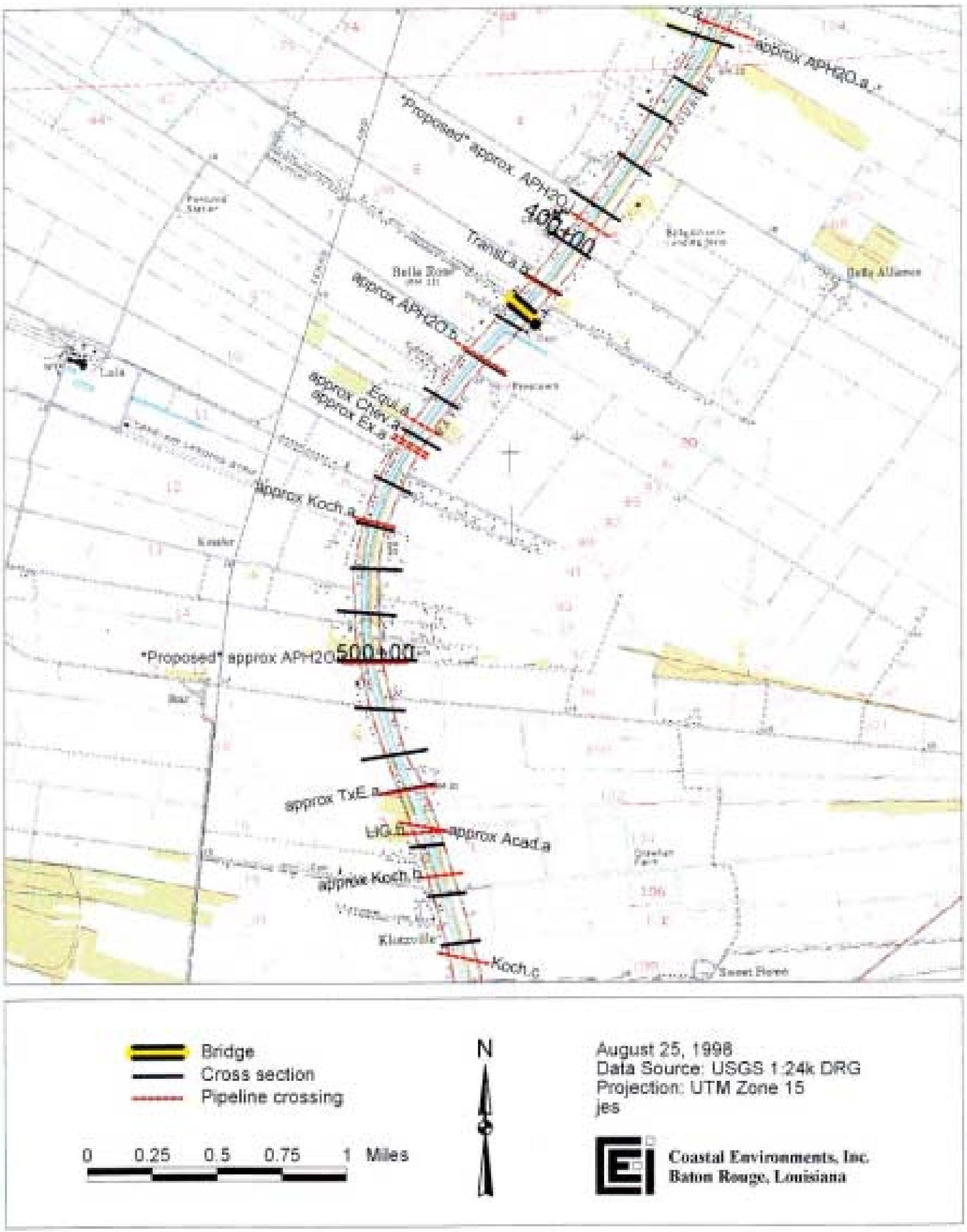


Figure 3.4-7. Location of Utility Crossings and other Features: Frame 3 - Paincourtville

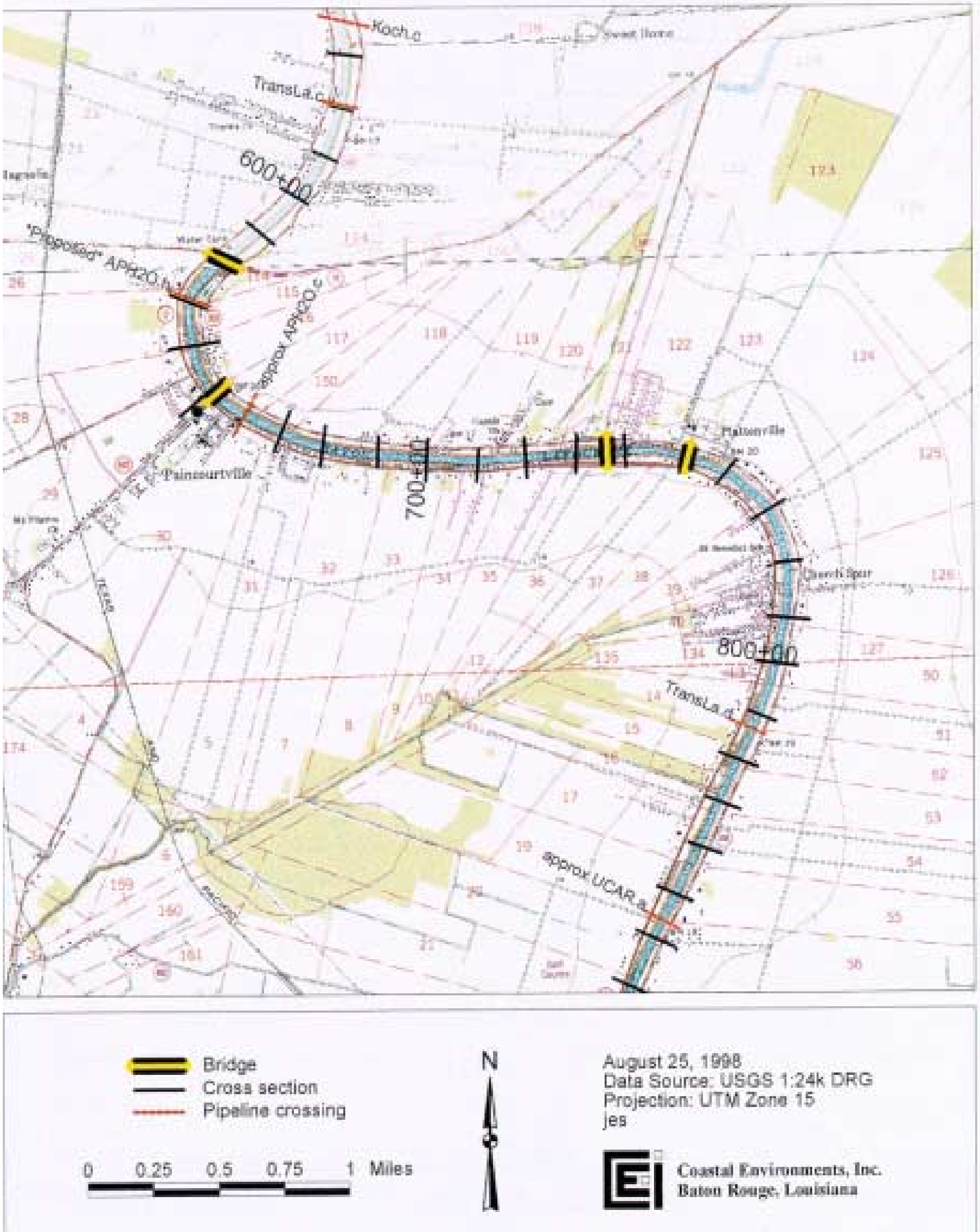


Figure 3.4-7. Location of Utility Crossings and other Features: Frame 4 - Napoleonville

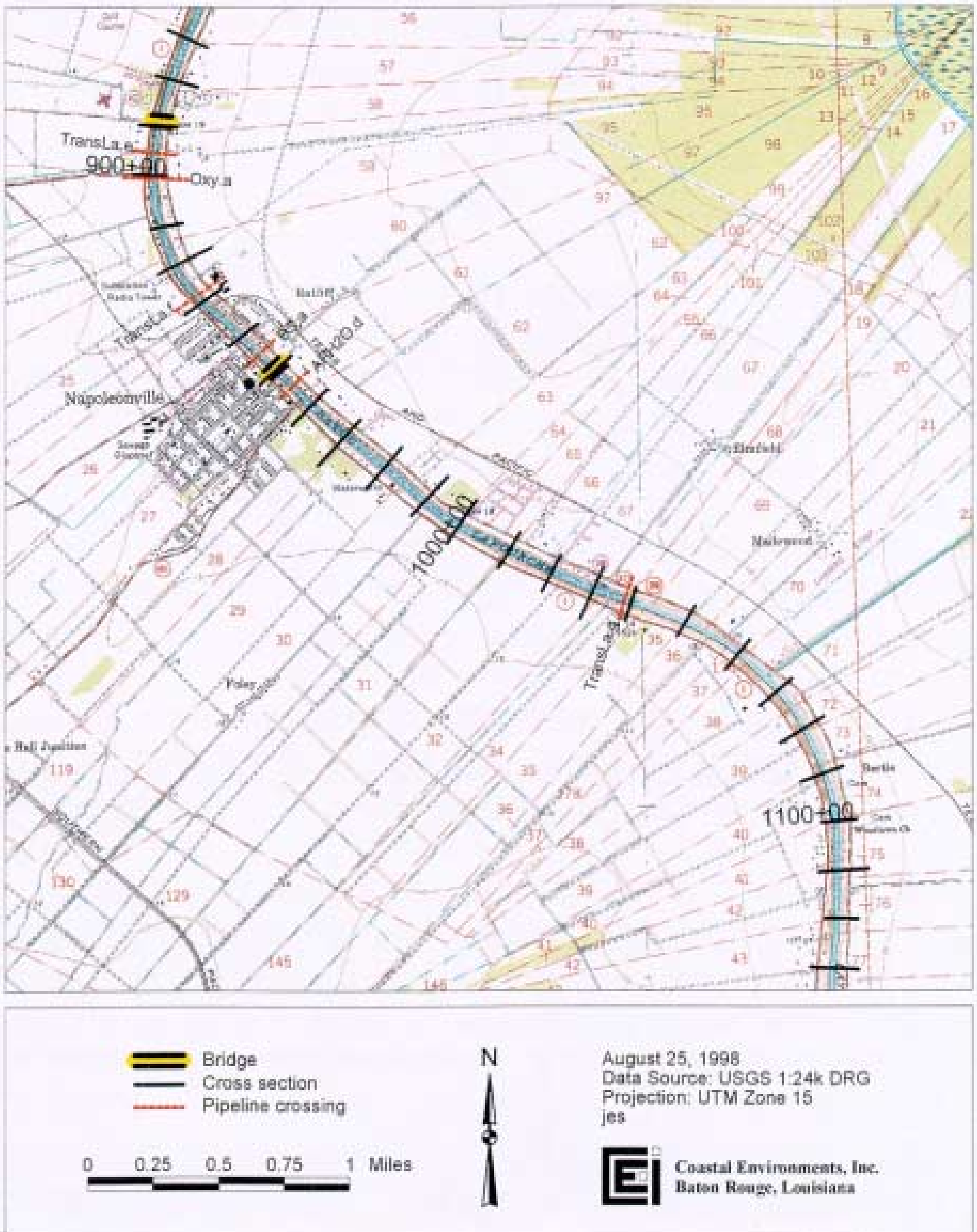


Figure 3.4-7. Location of Utility Crossings and other Features: Frame 5 - Supreme

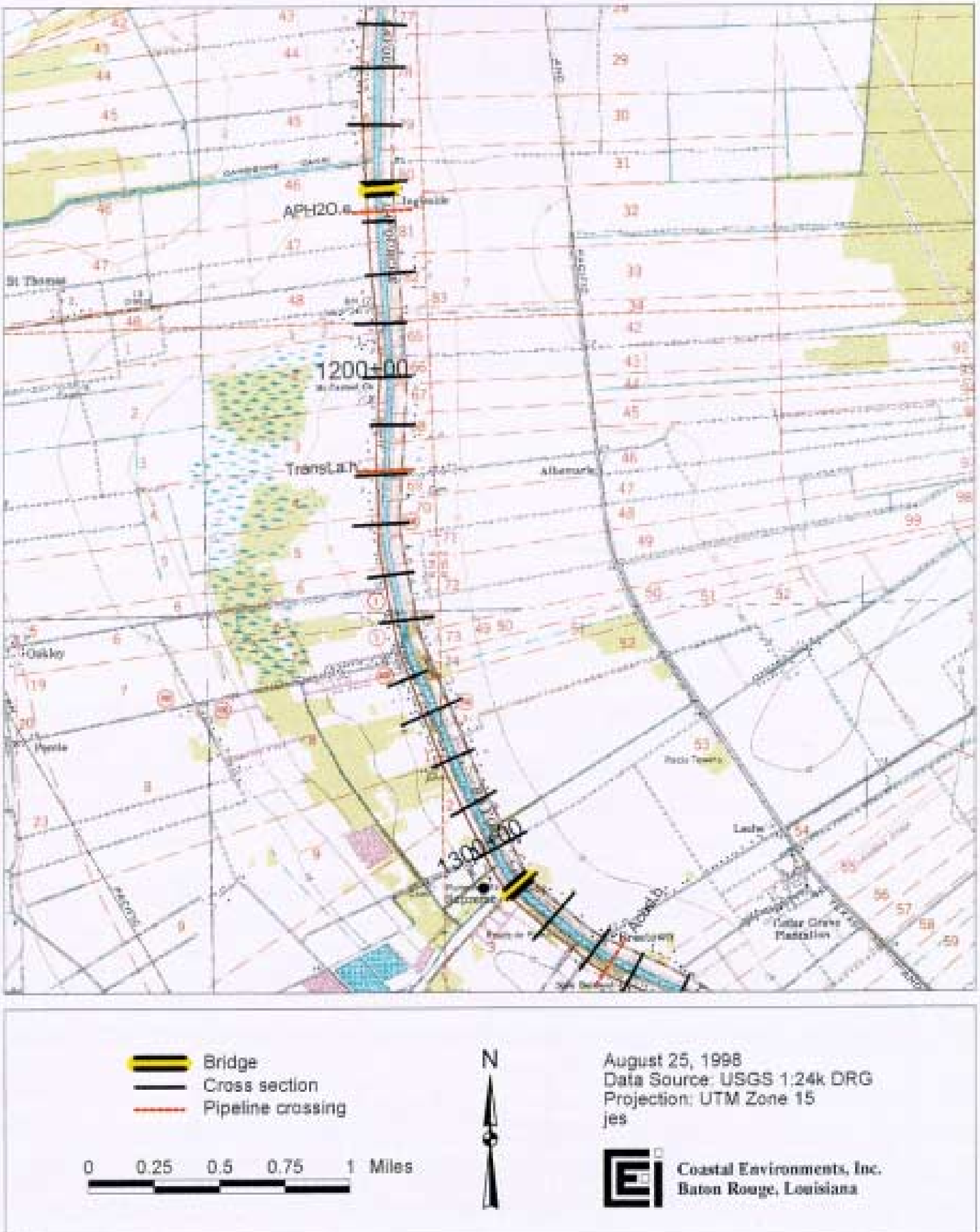


Figure 3.4-7. Location of Utility Crossings and other Features: Frame 6 - Labadieville

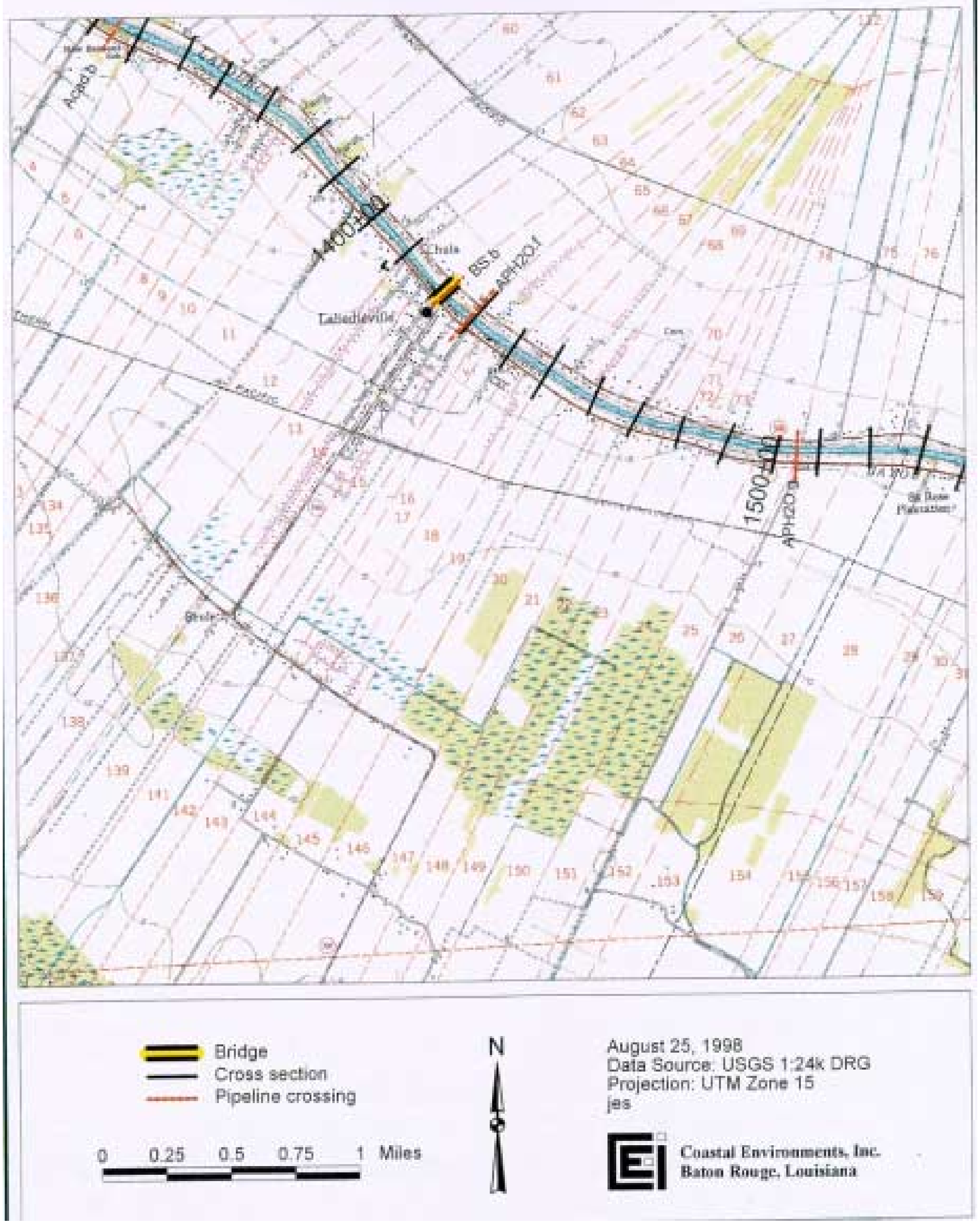


Figure 3.4-7. Location of Utility Crossings and other Features: Frame 7 - Laurel Grove

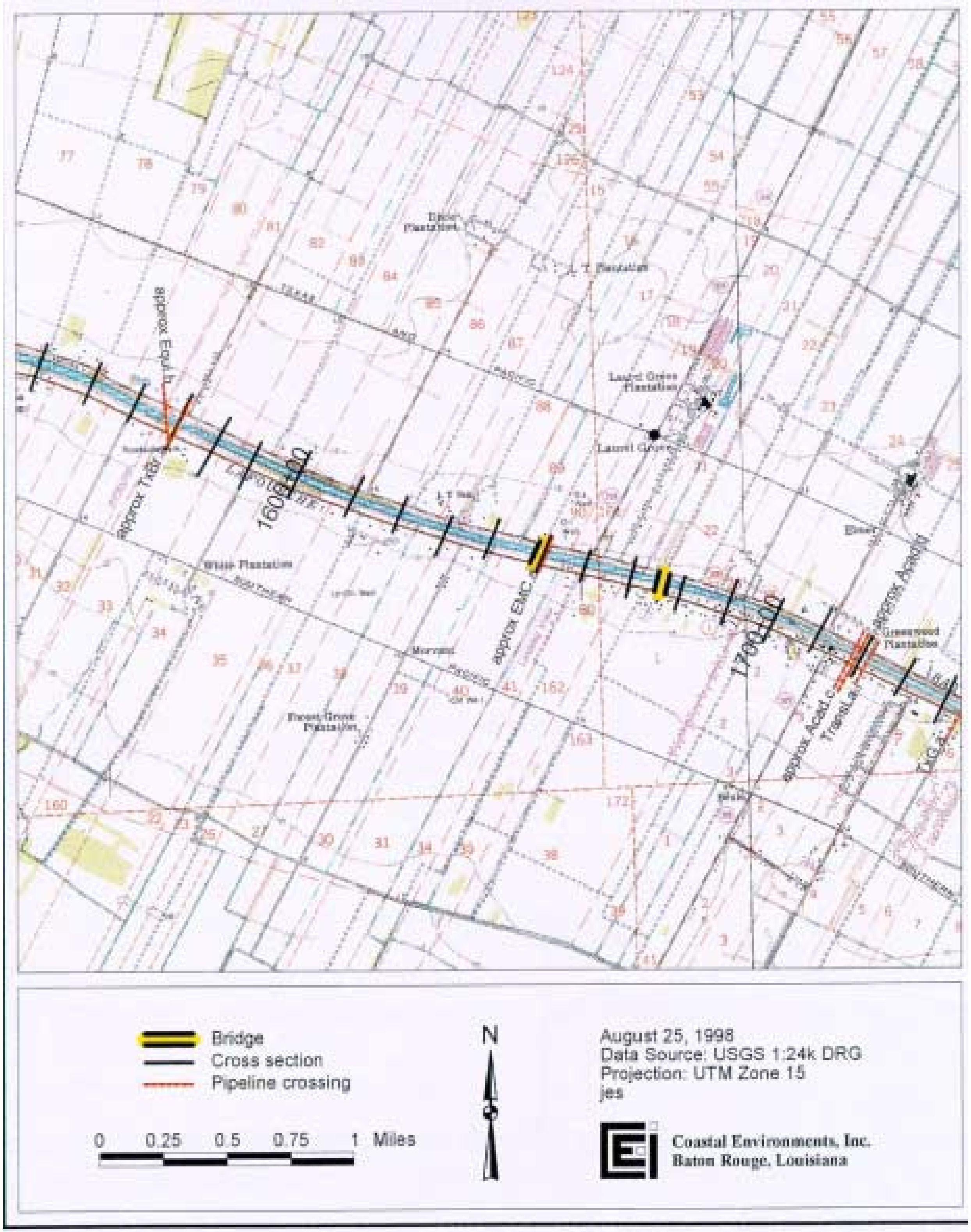


Figure 3.4-7. Location of Utility Crossings and other Features: Frame 8 - Thibodaux

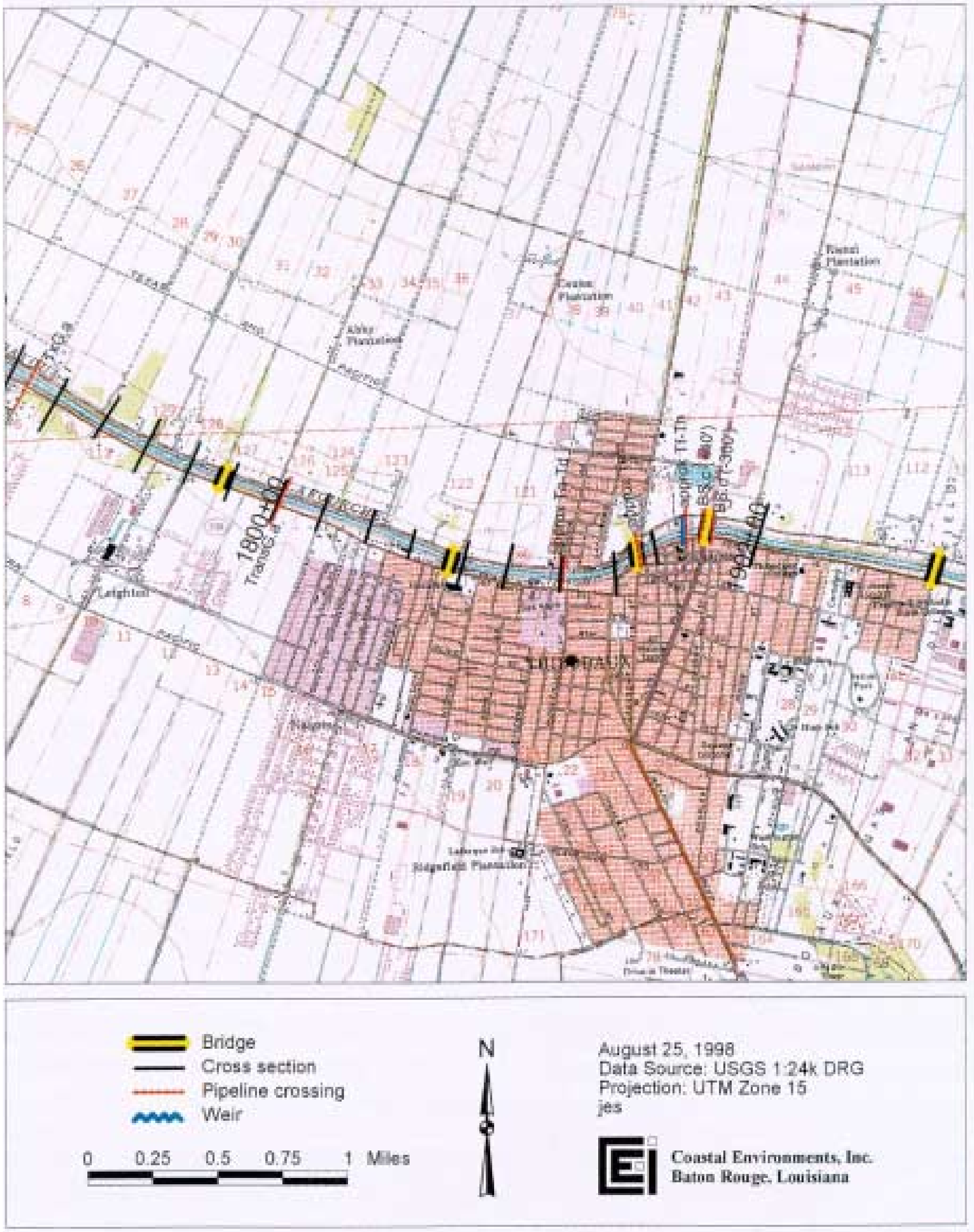


Figure 3.4-7. Location of Utility Crossings and other Features: Frame 9 - Lafourche

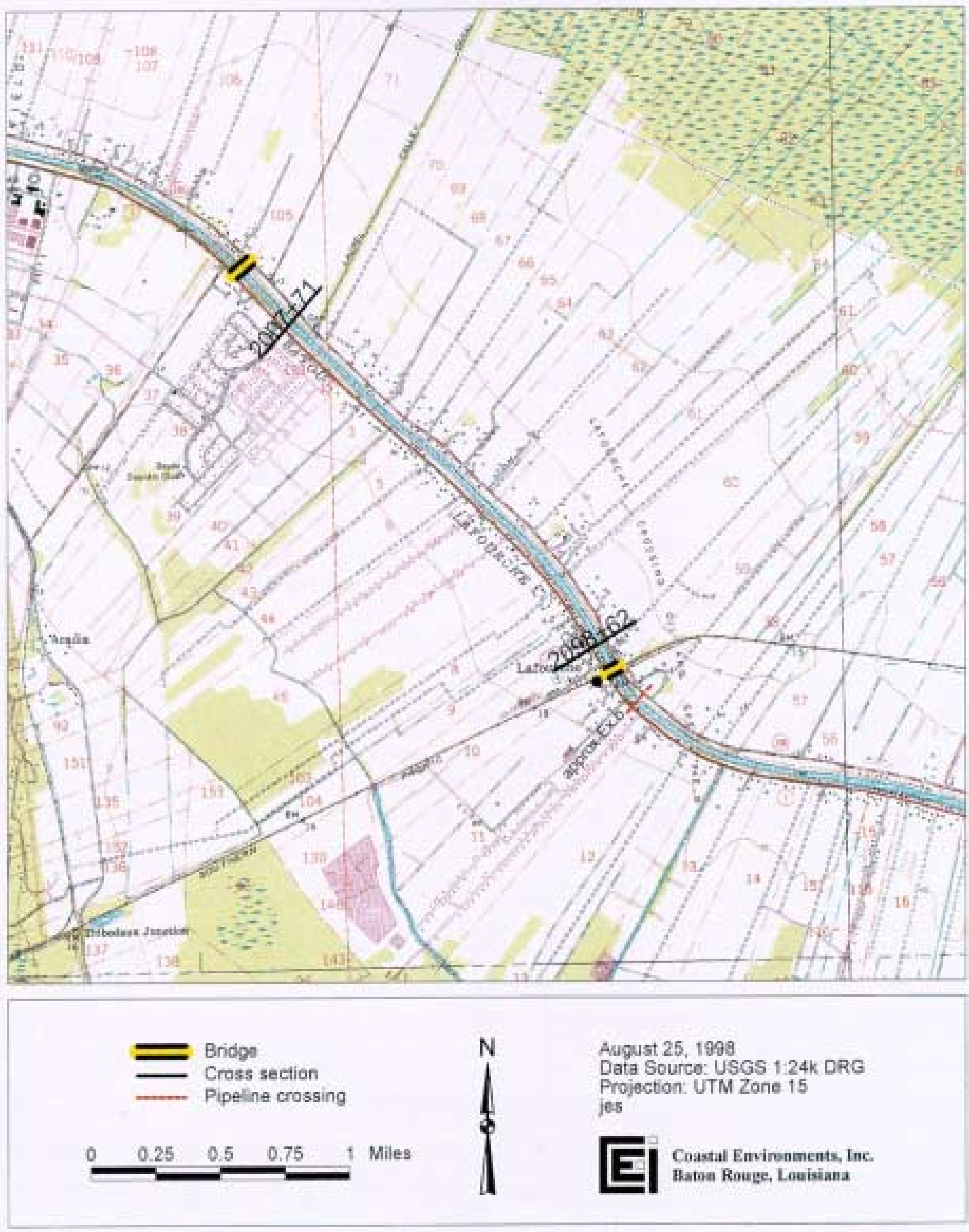


Figure 3.4-7. Location of Utility Crossings and other Features: Frame 10 - Rousseau

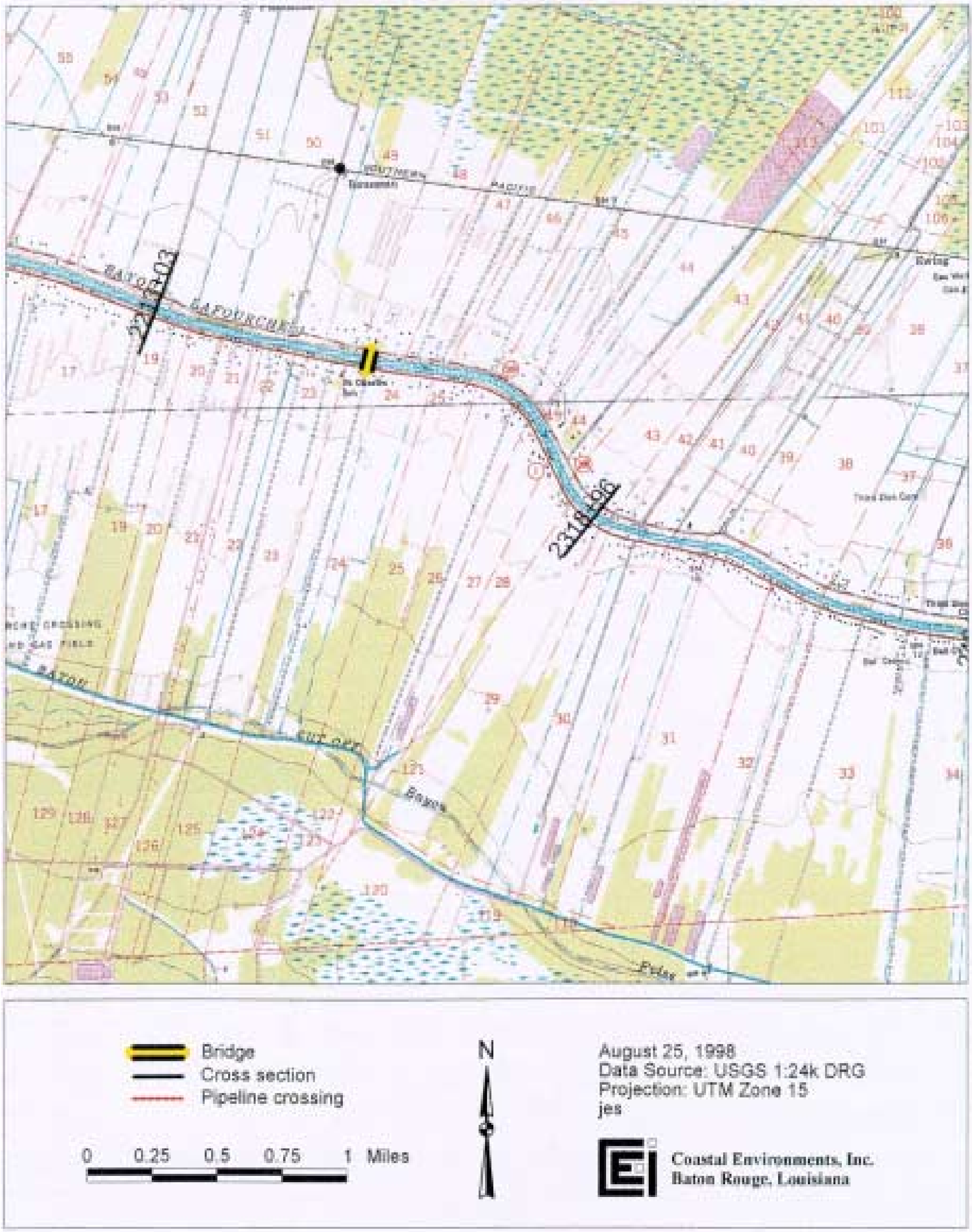


Figure 3.4-7. Location of Utility Crossings and other Features: Frame 14 - Lockport

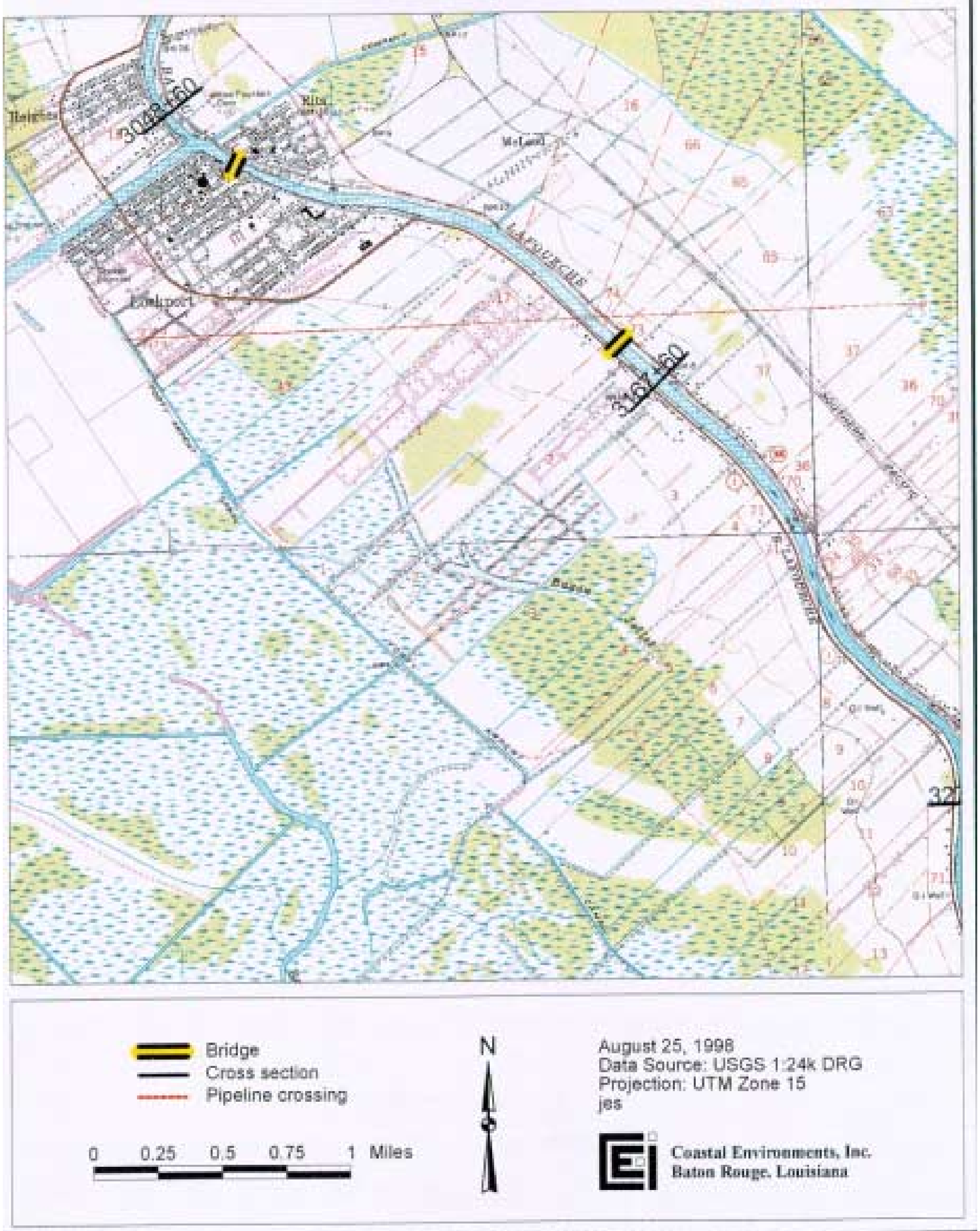


Figure 3.4-7. Location of Utility Crossings and other Features: Frame15 - Valentine

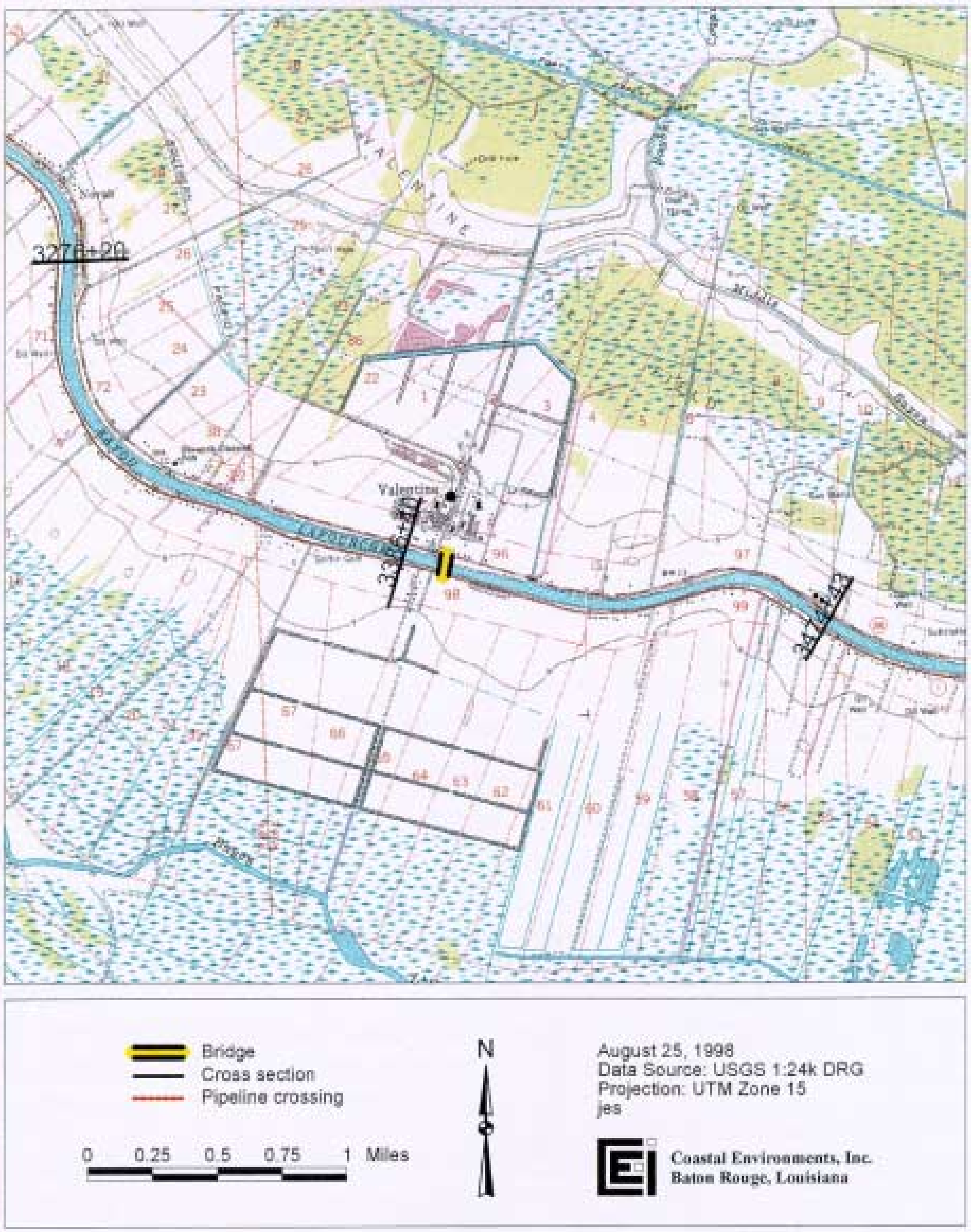


Figure 3.4-7. Location of Utility Crossings and other Features: Frame 16 - Larose

Table 3.4-1a. Preliminary list of utility crossings, Thibodaux to Donaldsonville

Owner/ ntact/Township & Range	Map key (see Fig. 3.4-7	Source of info. other than owner	Date laid (mo/ yr)	Approx. miles from BLF outfall	Brief description	Top of pipe elevation (feet)	Bottom elevation (feet)	Remarks (see Sources)	Remarks from 1/29/98 recon.	Remarks from EPA contact with owner
Exxon Pipeline Company/Muriel Brodie (504) 537-4809 S59, T15S-R17E	Ex.b		1959	-	1 - 6”					• Abandoned in place, filled w/ nitrogen and left dry • 15.3’ blw mud line • Revised 1982 plat and blue line from 1993 inspection
City of Thibodaux/ Coby Nuss (504) 447-4017	T.h		6/52	33.79	1 - 16” water, cast iron					• 3.7’ blw mud line
City of Thibodaux/ Coby Nuss (504) 447-4017	T.g		6/52	33.77	1 - 12” water, cast iron					• 3.7’ blw mud line
City of Thibodaux/ Coby Nuss (504) 447-4017	T.f		6/52	33.77	2 - 10” water, cast iron					• 3.7’ blw mud line
City of Thibodaux		1/29 Rec.	-	33.76	1 - 2" gas	-	-	-	Noted 1/29 recon.	• City has no record of this line
Bell South/ Alice Bourgeois (504) 580-7160.	BS.d	C	1953 & 1963	33.67	2 - steel armor cable (1 - 4”), (1 - 5”)	-11 MLW	-5 MLW	67' between sags	Not noted	• 4” is 6.5’ blw mud line, • 5” is 6’ blw mud line • 1998 topographic survey
City of Thibodaux/ Coby Nuss (504) 447-4017	T.e	F	8/41	33.63	1 - 3" gas, cast iron; 1 - 6" water	-11.8 MSL	-6 +/-	60' between sags	Not noted	• Water line abandoned • 5.8’ blw mud line

Table 3.4-1a. Continued.

Owner/ Contact/Township & Range	Map key (see Fig. 3.4-7	Source of info. other than owner	Date laid (mo/ yr)	Approx. miles from BLF outfall	Brief description	Top of pipe elevation (feet)	Bottom elevation (feet)	Remarks (see Sources)	Remarks from 1/29/98 recon.	Remarks from EPA contact with owner
Bell South/ Alice Bourgeois (504) 580-7160	BS.c	E-1	1939	33.60	1 - 3" steel armor cable	-11.8 MSL	-8.2	67' between sags	Not noted	• 4' blw mud line (?) • Profile and plan provided
City of Thibodaux/ Coby Nuss (504) 447-4017	T.d		12/40	33.35	1 - 3" gas cast iron					• 6.0' blw mud line
City of Thibodaux/ Coby Nuss (504) 447-4017	T.c	H	12/40	33.34	1 - 6" water cast iron	-11.8 MSL	-5.8	60' between sags	Not noted	• 6.0' blw mud line
City of Thibodaux/ Coby Nuss (504) 447-4017	T.b	G	4/55	33.34	1 - 8" sewer, cast iron	-7.5 MSL	-4	60' between sags	Not noted	• 3.5' blw mud line
City of Thibodaux/ Coby Nuss (504) 447-4017	T.a		10/97	33.34	1 - 10" sewer, polyethylene					• 5' blw mud line • 1996 Blue line plan
Transcontinental Gas Pipeline Corp/ Mr. Warren Toups (504) 446-7100	TransG.a	I	9/58	32.26	1 - 24" gas concrete coated steel pipe; 2 - 30" gas	-12.3 MSL	-7	70' between sags	Found	• Location markers on pipelines • 24" is approx 5' blw mud line, 30" approx 7.3' blw mud line • Location map, plan and profile

Texas Gas Transmission Co. Mr. Paul Frederick (acting land manager) (318) 235-9065 RB: S6, T14S-R16E LB: S27, T14S-R16E	TxG.a	P	5/60	31.21	1 - 10.75" gas, steel	-		3.5' cover U shape	Found	• 6.2 blw mud line, per constr. Plan • Bayou Chevreuil – Trahan 10 line • Block valve located approx 2.9 mi. S of bayou crossing • Block valve located approx 7.6 mi N of bayou crossing • 5' blw mud line • Air photo, plan and profile

Table 3.4-1a. Continued.

Owner/ Contact/Township & Range	Map key (see Fig. 3.4-7	Source of info. other than owner	Date laid (mo/ yr)	Approx. miles from BLF outfall	Brief description	Top of pipe elevation (feet)	Bottom elevation (feet)	Remarks (see Sources)	Remarks from 1/29/98 recon.	Remarks from EPA contact with owner
Tejas (Acadian Gas, LLC)/Michael D'Angelo (504) 446-2791/ RB: S4, T14S-R16E LB: S25, T14S-R16E	Acad.d	K	4/60	30.81	1 - 8.625" gas/oil, steel w/ concrete coating on exterior	-14 MLW	-7.3 MLW	60' at or below -14 MLW	Found Acadian	• Acadian notes depth not available • "Monterrey Line" 50' ROW • Location map provided
Long Gas Co., Inc. Tejas (Acadian Gas, LLC)/Michael D'Angelo (504) 446-2791 RB: S3, T14S-R16E LB: S25, T14S-R16E	Acad.c	L	12/40	30.69	1 - 4.5" gas, steel	-11.8 MLW	-6 MLW	60' between sags	Not noted	• "Waverly to Caldwell" • Location map provided
Sugar Bowl Trans Louisiana Gas Company/Thomas Meyers (504) 447-2612	TransLa.i	(UG)	-	30.71	1 - 2" gas, steel	-	-	-	Found Acadian	• Old St. John Bridge
Energy Management Corp. (purchased from Texas Gas Transmission 6/97)/ Ronnie Lewis (601) 969-1122	EMC.a	M *	10/57	29.45	1 - 4" gas, steel	-7.5 MGL	-4.5 MGL	U shape	Found unmarked vents, marked all vents	• 6' below mud line
Gas Distributing Corp. (Thibodaux)		N	6/48	29.38	1 - 2" gas	-7.5 MGL	-4.8 MGL	U shape	Found 2"	

Texas Gas	See last column	(UG)	-	29.22	1 - 20"?	-	-	-	Not noted	• Neither Texas Gas Corporation nor Energy Management Corporation has any knowledge of this line
Shell Pipe Line		2/98 C/E Pub. not.	2/98 Pub. not.	27.87	1 - 20" oil	-9 NGVD (highest)	-1 NGVD	Dir. Drill	Proposed	• Proposed 6’ below mud line

Table 3.4-1a. Continued.

Owner/ Contact/Township & Range	Map key (see Fig. 3.4-7	Source of info. other than owner	Date laid (mo/ yr)	Approx. miles from BLF outfall	Brief description	Top of pipe elevation (feet)	Bottom elevation (feet)	Remarks (see Sources)	Remarks from 1/29/98 recon.	Remarks from EPA contact with owner
Texas Brine Co., LLC/ Kenneth Blanchard (504) 369-6657 RB: S81, T14S-R15E LB: S33, T14S-R15E	TxBr.a	DTC *	1981	27.85	1 - 14" gas or liquid brine solution	-		-	Found	• 6' below mud line • Fax of plat
Equilon Pipeline Company, LLC(previously Shell)/ John Krause (504) 728-4821 RB: S80, T14S-R15E LB: S33, T14S-R15E	Equi.b	O, 1C	12/67	27.83	1 - 20" oil, steel, 20" OD x 0.50 WT + x52 concrete coated	-10 MSL	-4	100' between sags	Found	• "Ship Shoal 20 inch Segment II" • R/W 51-Bayou Lafourche • 6' minimum blw mud line • As-built blue line alignment, plan and profile
Assumption Parish Waterworks District No. 1/ Henry Templet (504) 369-6156	$APH_2O.g$		1984	26.62	1 - 8" water, cast iron ball joint river crossing pipe					• Signs are located on right descending bank (La Hwy 1 side) and all crossings have valves on both sides to isolate crossing from water pipelines paralleling bayou
R.N. Hure, et al		B	1/50	25.51	1 - 2" water	-9.8 MGL	-6.8 MGL	U shape	Not noted	
Assumption Parish Waterworks District No. 1/ Henry Templet (504) 369-6156	$APH_20.f$	1-A-1	10/58	25.14	1 - 6" water, cast iron ball joint river crossing pipe	-10 (No datum)	-6.5	60' between sags	Not noted	• Signs are located on right descending bank (La Hwy 1 side) and all crossings have valves on both sides to isolate crossing from water pipelines paralleling bayou
Lionel Gremillion		R	7/47	25.14	1 - 1.5" gas	-7.5 MGL	-4.5 MGL	U shape	Not noted	
		-		25.13	Labadieville Bridge					

Table 3.4-1a. Continued.

Owner/ Contact/Township & Range	Map key (see Fig. 3.4-7	Source of info. other than owner	Date laid (mo/ yr)	Approx. miles from BLF outfall	Brief description	Top of pipe elevation (feet)	Bottom elevation (feet)	Remarks (see Sources)	Remarks from 1/29/98 recon.	Remarks from EPA contact with owner
Southern Bell Tel & Tel Bell South/ Alice Bourgeois (504) 580-7160	BS.b	S & T	2/39 & 3/55	25.09	2 - cables (2 - 2") both are steel armor cable	-11 MLW	-5 MLW	60' between sags	Not noted	• One cable is 6' blw mud line, the other cable's depth is unknown • Profile and plan
Gas Distributing Corp. (Thibodaux)		V	6/50	25.03	1 - 2" gas	-7.2 MLW	-4.2 MLW	U shape	Not noted	
Lake Long Gas Co. (Acadian) Tejas (Acadian Gas, LLC)/ Michael D'Angelo (504) 446-2791 RB: S4, T14S-R15E LB: S54, T14S-R15E	Acad.b	U & DTC	1/41	23.57	1 - 4.5" gas, steel	-11.8 MLW	-5	60' between sags	Found	• "Cox & Robichaux Line" • Mile 83.25 above the mouth of the waterway • Location map
Gas Distributing Corp. (Thibodaux)		W	9/53	23.08	1 - 2" gas	-	-	2.5' cover U shape	Not noted	
Trans Louisiana Gas Company/Thomas Meyers or Ted Richard (504) 447-2612	TransLa.h			21.16	1 - 1" gas, steel					• 3589 Hwy 1

Assumption Parish Waterworks District No. 1/ Henry Templet (504) 369-6156	APH$_2$O.e	1-A-2	10/58	20.20	1 - 8" water, cast iron ball joint river crossing pipe	-10 (No datum)	-7	60' between sags	Not noted	• Signs are located on right descending bank (La Hwy 1 side) and all crossings have valves on both sides to isolate crossing from water pipelines paralleling bayou • Near LA Hwy 1010 bridge

Table 3.4-1a. Continued.

Owner/ Contact/Township & Range	Map key (see Fig. 3.4-7	Source of info. other than owner	Date laid (mo/ yr)	Approx. miles from BLF outfall	Brief description	Top of pipe elevation (feet)	Bottom elevation (feet)	Remarks (see Sources)	Remarks from 1/29/98 recon.	Remarks from EPA contact with owner
Trans Louisiana Gas Company/ Thomas Meyers (504) 447-2612	TransLa.g	X	10/66	17.99	1 - 2" gas, steel	-6.5 MSL	-3.6	U shape	Not noted	• 4371 Hwy 1
Assumption Parish Waterworks District No. 1/ Henry Templet (504) 369-6156	APH_20.d	1-A-3	10/58	16.19	1 - 8" water 1 - 6" water, cast iron ball joint river crossing pipe	-10 (No datum)	-7	60' between sags	Not noted	• Signs are located on right descending bank (La Hwy 1 side) and all crossings have valves on both sides to isolate crossing from water pipelines paralleling bayou
-		-	-	16.05	Napoleonville Bridge			-		
Trans Louisiana Gas Company/Thomas Meyers or Ted Richard (504) 447-2612	TransLa.f			15.67	1 - 2" gas, steel					• 4847 Hwy 1
Texas Brine Co., LTD		DTC *	1981	15.22	1 - 14"	-	-	-	Not noted	• 6' below mud line
Bell South/ Alice Bourgeois (504) 580-7160	BS.a		1971	15.21	1 - 5" cable, steel armor cable					• No section included in Bell South's pkg for this crossing • Sketch of line
Occidental Chemical Corp (Care of Texas Brine Company, LLC)/ Kenneth Blanchard (504) 369-6657	OXY.a	DTC	1998	15.19	1 - 12" brine, steel	-	-	-	Found line crossing	• 15' below mud line; old line removed • Fax of profile and plat

RB: S24, T13S-R14E LB: S59, T13S-R14E										
E. Sundbery (Napoleonville)		Y	10/41	15.14	1 - 1" gas	-	-	2' cover, 60' between sags	Not noted	

Table 3.4-1a. Continued.

Owner/ Contact/Township & Range	Map key (see Fig. 3.4-7	Source of info. other than owner	Date laid (mo/ yr)	Approx. miles from BLF outfall	Brief description	Top of pipe elevation (feet)	Bottom elevation (feet)	Remarks (see Sources)	Remarks from 1/29/98 recon.	Remarks from EPA contact with owner
Trans Louisiana Gas Company/Thomas Meyers or Ted Richard (504) 447-2612	TransLa.e			15.05	1 - 2” gas, steel					• 4990 Hwy 1
UCAR Pipeline Incorporated/ K.A. McKnight (512) 553-3172	UCAR.a	DTC	1967	14.59	1 - 8" ETH 1 - 8” LPG steel	-	-	-	Found	• 8’ below mud line • Valve for each line located west of bayou (approx. 230’) • Plat, profile and plan from 1990 inspection
Trans Louisiana Gas Company/Thomas Meyers or Ted Richard (504) 447-2612	TransLa.d			13.51	1 - 2” gas, steel					• Plattenville Bridge
Assumption Parish Waterworks District No. 1/ Henry Templet (504) 369-6156	APH$_2$O.c	1-A-4	10/58	10.58	1 - 8" water 1 - 6” water, cast iron ball joint river crossing pipe	-11 (No datum)	-8	U shape	Not noted	• Signs are located on right descending bank (La Hwy 1 side) and all crossings have valves on both sides to isolate crossing from water pipelines paralleling bayou
-		-	-	10.52	Paincourtville Bridge					
-		-	-	10.03	Hwy. 70 Bridge					

Assumption Parish Waterworks District No. 1/ Henry Templet (504) 369-6156 (C.J. Savoie Consult-ing Engineers, Inc.) S114, T12S-R13E	Proposed APH_2O.h			10.01						• Proposed • Map from consulting firm only, no data sheets • At Paincourtvile water tower • Plat provided

Table 3.4-1a. Continued.

Owner/ Contact/Township & Range	Map key (see Fig. 3.4-7	Source of info. other than owner	Date laid (mo/ yr)	Approx. miles from BLF outfall	Brief description	Top of pipe elevation (feet)	Bottom elevation (feet)	Remarks (see Sources)	Remarks from 1/29/98 recon.	Remarks from EPA contact with owner
Trans Louisiana Gas Company/Thomas Meyers or Ted Richard (504) 447-2612	TransLa.c			9.06	1 - 2" gas, steel					• 6408 Hwy 1
Koch Pipeline Southeast, Inc./ Tim Halbrook (504) 369-5000 RB: S20, T12S-R14E LB: S109, T12S-R14E	Koch.c	12/97 C/E Pub. Not.	7/98	8.95	1 - 12" gas liquids, steel	-9.5 NGVD (highest)	-1.5 NGVD	Dir. Drill	Proposed	• 20' below mud line • 1 mi N of Hwy 70 on La. Hwy 1 • Blue line section and plan from 1998, and copy from 1997
Koch Pipeline Company, L.P. (Ammonia Division)/ Kelly Jones (573) 486-5489 RB: S104 T12S-R14E LB: S18, T12S-R14E	Koch.b	1/29 recon.	11/69	8.47	1 - 8" liquid anhydrous ammonia. Welded carbon steel, API 5L, X-42 yield strength	-	-	-	Noted 1/29 recon.	• Koch thinks is same as at 136,500' • Bayou C/L at mile marker 107.52 (along pipeline from Marksville pump station) • E bank block valve 2-1 at mile marker 113.27 (5.75 mi from bayou C/L) • W bank block valve 2-3 at mile marker 104.66 (2.86 mi from bayou C/L) • E bank casing, 12" by 83' • W bank casing • 12" by 83' • Waterbottom casing, NONE, 11 concrete weights

Louisiana Intrastate Gas/Mike Leger (318) 233-8945	LIG.b	P&O (10-8008)	1979	8.42	1 - 36" gas, steel 36" OD x .500 W.T. API 5L x 60	-	-	-	Found	• 9' below mud line • 2 copies of 1980 blue line aerial photo and as-built plan and profile

Table 3.4-1a. Continued.

Owner/ Contact/Township & Range	Source of info. other than owner	Date laid (mo/ yr)	Approx. miles from BLF outfall	Brief description	Top of pipe elevation (feet)	Bottom elevation (feet)	Remarks (see Sources)	Remarks from 1/29/98 recon.	Remarks from EPA contact with owner
Tejas (Acadian Gas, LLC)/ Michael D'Angelo (504) 446-2791 RB: S17, T12S-R14E LB: S104, T12S-R14E	DTC	4/66	8.40	1 - 20" gas, steel with concrete coating	-	-	-	Found	• "Chico 'C' Line" • Location map provided
Texas Eastern Transmission Corp./John Scarbrough (318) 475-4209 S16, T12S-R14E	P&O		8.14	1 - 36" gas, steel	-12 MSL	-2	60' between sags	Found	• Unable to locate plan/profile drawings
Assumption Parish Waterworks District No. 1/ Henry Templet (504) 369-6156 S14, T12S-R14E			7.53						• Map from consulting firm only, no data sheets; plat • At Champ Lane & LA Hwy 308 • C.J. Savoie Consulting Engineers, Inc.
Koch Pipeline Company, L.P./ Mr. Jean Zeringue (504) 265-2112 x226	1/29 recon.	1978	6.97	1 - 8" oil, concrete coated steel	-	-	-	Noted 1/29 recon.	• Currently out of service • 8" block on both sides of bank • Approx 6' blw mud line • Same as Matador line on spreadsheet
Exxon Pipeline Company/Muriel Brody (504) 537-4809 S89, T12S-R14E	DTC	-1953 & 1966	6.96	2 - 16" oil, steel	-	-	-	Found	• 11.8' and 9.8' blw mud line • Revised 1982 plat and blue line from 1996 survey

Chevron Pipe Line Company/Kevin Gaudet (504) 364-2078 RB: S10, T12S R14E LB: S89, T12S-R14E	DTC	1971	6.92	1 - 8" oil, ethylene steel	-7 MSL	-2	75' between sags	Found	• 7' below mud line at installation • Mainline block valves located on each side of bayou • 1970 blue line aerial photo and blue line profile and plan from 1978 survey

Table 3.4-1a. Continued.

Owner/ Contact/Township & Range	Map key (see Fig. 3.4-7	Source of info. other than owner	Date laid (mo/ yr)	Approx. miles from BLF outfall	Brief description	Top of pipe elevation (feet)	Bottom elevation (feet)	Remarks (see Sources)	Remarks from 1/29/98 recon.	Remarks from EPA contact with owner
Equilon Pipeline Corporation, LLC (previously Shell)/ John Krause (504) 728-4821 RB: S9, T12S-R14E LB: S87, T12S-R14E	Equi.a	P&O(10-8008)	1979	6.74	1 - 36" oil, steel 36" OD x 0.312" WT & x52 concrete coated	-		-	Found	• 6' below mud line • "Red Stick 36" Line" • Previously DOE's "Bayou Choctaw to St. James Line" • As-built blue line alignment, plan and profile
Assumption Parish Waterworks District No. 1/ Henry Templet (504) 369-6156	APH_2O.b	1-A-5	10/58	6.22	1 - 6" water, cast iron ball joint river crossing pipes	-9 (No datum)	-6	U shaped	Not noted	• Signs are located on right descending bank (La Hwy 1 side) and all crossings have valves on both sides to isolate crossing from water pipelines paralleling bayou
Trans Louisiana Gas Company/Thomas Meyers or Ted Richard (504) 447-2612	TransLa.b			5.86	1 - 2" gas, steel					• Belle Rose
Assumption Parish Waterworks District No. 1/ Henry Templet (504) 369-6156 S5, T11S-R14E	Proposed APH_2O.j			5.56						• Map from consulting firm only, no data sheets • At Belle Rose Middle School • Plat provided
Assumption Parish Waterworks District No. 1/ Henry Templet (504) 369-6156	APH_2O.a		1984	4.66	1 - 8" water, cast iron ball joint river crossing pipes					• Signs are located on right descending bank (La Hwy 1 side) and all crossings have valves on both sides to isolate crossing from water pipelines paralleling bayou

Table 3.4-1a. Continued.

Owner/ Contact/Township & Range	Map key (see Fig. 3.4-7	Source of info. other than owner	Date laid (mo/ yr)	Approx. miles from BLF outfall	Brief description	Top of pipe elevation (feet)	Bottom elevation (feet)	Remarks (see Sources)	Remarks from 1/29/98 recon.	Remarks from EPA contact with owner
Louisiana Intrastate Gas/Mike Leger (318) 233-8945	LIG.a	DTC	1976	4.65	1 - 24" gas, steel,	-	-	-	Found	• At least 7' below mud line • 2 copies of blue line aerial photo plan and profile from 1976 • 24" OD, 0.375" W.T., API 5Lx 6R x-60 coated w/ somastic & concrete to 1.15 s.g.
Trans Louisiana Gas Company/Thomas Meyers or Ted Richard (504) 447-2612	TransLa.a			4.36	1 - 2" gas, steel					• 7456 Hwy 1
Monterey Tejas(Cypress Gas, LLC, c/o Acadian Gas, LLC)/Michael D'Angelo (504) 446-2791 RB: S59, T11S-R14E LB: S95, T11S-R14E	Cyp.a	DTC *	11/85	3.17	1 - 20" gas, steel	-	-	-	Found	• "BR-S No. 55 Line" • Location map provided
Bridgeline Gas Distribution LLC/ Mike Cary (504) 758-0217	Bridg.b	DTC *	9/68	3.16	1 - 12" gas, steel 1 - 20" gas, steel	-8	-1	100' between sags	Found	• 6' below mud line • Location map and profile provided
Peoples Water Service of Donaldsonville/ Norbert Redmond (504) 473-7603	PH_2O.b	-	1982	3.09	1 - 6" potable water, PVC yellomine	-	-	-		• 4' - 6' below water bottom • Valves at the top of both banks • Btwn Hwy 943 & 944 • Location map provided

City of Donaldsonville/ Charles Oatis or Spencer Harvey (504) 473-4247	Don.b	1/29 recon.	1972	2.27	1 - 6’”gas, steel	-	-	-	Noted 1/29 recon.	• There is a regulator station on the right descending bank (Hwy 1) • Location map provided

Table 3.4-1a. Continued.

Owner/ Contact/Township & Range	Map key (see Fig. 3.4-7	Source of info. other than owner	Date laid (mo/ yr)	Approx. miles from BLF outfall	Brief description	Top of pipe elevation (feet)	Bottom elevation (feet)	Remarks (see Sources)	Remarks from 1/29/98 recon.	Remarks from EPA contact with owner
Allemania		*	-	2.16	1 - 8"	-	-	-	Not noted	
Union Texas Petrochemicals Corporation/ Mr. Thom O'Brien (713) 968-2970 RB: S50, T11S-R14E LB: S106 T11S R14E	UTP.a	DTC	6/67 6/97	2.10	1 - 6" oil 1 - 6 5/8" ethane,steel	-	-	4' cover U shape	Found	• Data sheet indicates new line (6/97) in same ROW • Location map, plan, and profile provided • 6' below mud line
Ashland Chemical Company/ Mike Lewis (504) 685-3400	Ash.a	*	10/80 8/81	2.06	1 - 8" CO, carbon steel API-5LX Grade x-52	-	-	8' cover	Found	• 8.5' blw mud line • Location map and profile provided
LPGL		DTC	2/83	2.04	1 - 24" gas	-	-	-	Found	• Bridgeline (Bridg.a) map indicates "Louisiana Resources Pipeline" at this location
Bridgeline Gas Distribution LLC/ Mike Cary (504) 758-0217	Bridg.a	*	7/97 1998	2.03	1 - 6" gas, HVL	-22.75	-	(Dir. Drill)	Found Staked Line	• Under construction • Location map and proposed profile

Peoples Water Service of Donaldsonville Norbert Redmond (504) 473-7603	PH_2O.a	*	1989 or 1990	0.66	1 - 12" potable water, PVC yellomine	-	-	-		• 4' - 6' below water bottom • Valves available on both sides of bayou • Hwy 1 S, midway btwn Missouri Pacific RR and Magnolia St., crosses bayou and Hwy 308 to 2nd St. • Location map

Table 3.4-1a. Continued.

Owner/ Contact/Township & Range	Source of info. other than owner	Date laid (mo/ yr)	Approx. miles from BLF outfall	Brief description	Top of pipe elevation (feet)	Bottom elevation (feet)	Remarks (see Sources)	Remarks from 1/29/98 recon.	Remarks from EPA contact with owner
-		-	0.54	Railroad Bridge			-		
City of Donaldsonville/ Charles Oatis or Spencer Harvey (504) 473-4247			0.44	1 - 6" gas polyethylene 1 - 6" water (Missing info on water line)					• Side-by-side pipelines, 3 to 4' below mud line; directly beneath sidewalk on north side of 10th St. bridge. • There is a regulator station on the left descending bank at the intersection of West 10th St. and LA 308 • Location map provided

Sources:
E-1, H, etc. = Corps of Engineers. Alphabetic or alpha-numeric designations are key codes on permits issued by Corps of Engineers, New Orleans District.
DTC = Design Technics Co. (previously Dewitt) (dated 1992)
P&O = Pyburn & Odom files
** = LA State Land Office*
1/29 recon. refers to vehicle trip along Hwys. 1 and 308 on 1/29/98

Table 3.4-1b. Utility crossings, Thibodaux to Larose.

Note: this inventory was done using less comprehensive methods than for Table 3.4-1a.

Preliminary list of utility crossings, Thibodaux (weir) to Larose (GIWW)

Based on review of DTC maps only								
Source of information	Owner	Date installed (Mo./Yr.)	Distance from GIWW in Larose	Brief description	Top of pipe elevation	Bottom elevation	Remarks	Remarks from 1/29/98 reconnaissance.
DTC	BGD	-	0.3 miles	1 - 30" gas 1 - 20" gas 1 - 14" gas	-	-	-	-
DTC	Texaco	-	0.3 miles	1 - 36" gas 1 - 30" gas	-	-	-	-
DTC	Exxon	-	3.8 miles	1 - 6" oil	-	-	-	-
DTC	UG	-	4.6 miles	1 - 4" gas	-	-	-	-
DTC	CGT	-	7.1 miles	1 - 8" gas	-	-	-	-
DTC	UG	-	9.8 miles	1 - 12" gas	-	-	-	-
DTC	TPLI	-	10.0 miles	1 - 24" oil 1 - 12" oil	-	-	-	-
DTC	Chevron	-	14.0 miles	1 - 12" gas	-	-	-	-
DTC	UG	-	15.1 miles	2 - 12" gas	-	-	-	-
DTC	CGT	-	17.7 miles	1 - 12" gas	-	-	-	-
DTC	TPLI	-	18.4 miles	1 - 8" oil	-	-	-	-

DTC	UG	-	18.6 miles	1 - 16" gas 1 - 12" gas 1 - 30" gas	-	-	-	-

Table 3.4-1b. Continued.

Based on review of DTC maps only								
Source of information	Owner	Date installed (Mo./Yr.)	Distance from GIWW in Larose	Brief description	Top of pipe elevation	Bottom elevation	Remarks	Remarks from 1/29/98 reconnaissance.
DTC	Promix	-	21.0 miles	1 - 4" LPG Mix	-	-	-	-
DTC	TPLI	-	29.3 miles	1 - 18" oil	-	-	-	-
DTC	LRC	-	29.5 miles	1 - 16" gas	-	-	-	-
DTC	Exxon	-	29.8 miles	1 - 6" oil	-	-	-	-
DTC	Transcontinental Gas Pipeline Corp.	-	32.2 miles	1 - 8" gas	-	-	-	-

Sources:
E-1, H, etc. = Corps of Engineers. Alphabetic or alpha-numeric designations are key codes on permits issued by Corps of Engineers, New Orleans District.
UG = United Gas Operating Maps (Dated 1978)
DTC = Design Technics Co. (Previously Dewitt) (Dated 1992)
P&O = Pyburn & Odom files
** LA = State Land Office*
1/29 recon. refers to vehicle trip along Hwys. 1 and 308 on 1/29/98
Distances relative to GIWW are approximate only

3.5 WATER MANAGEMENT FACILITIES AND OPERATIONS

In addition to the diversion works and channel improvements discussed above, the conceptual design of a new diversion project would include an extensive program for water management in the bayou. Facilities and operations that are part of this water management program are discussed as follows: removal of Thibodaux weir (Section 3.5.1); installation of deployable weirs (3.5.2); interaction with the Cutoff Canal control structure in the marsh area (3.5.3); vegetation management (3.5.4); installation and operation of water monitoring stations (3.5.5); development of a water management plan (3.5.6); and monitoring of wetlands impacts (3.5.7).

3.5.1 Removal of Thibodaux weir

The weir at Thibodaux (Figure 1.1-2c) represents a barrier to the efficient conveyance of diverted water, especially at flows of 1,000 cfs or less. This is shown by Figure 2.6-1, which illustrates that water levels above the weir are often held 2 feet above the level immediately below the weir. Thus an important step toward conveying more water down the bayou, without increasing water levels, is to remove the weir. A preliminary removal plan is provided in Pyburn and Odom (1998, abstracted in Appendix A).

The weir consists of a sheet pile wall with a reinforced concrete cap; see Figure 3.5-1. A reinforced concrete walkway is structurally supported on top of the concrete cap. The sheet pile length at mid-channel is thirty-feet. The original construction plans indicate rock both upstream and downstream to an elevation of 0.0 NGVD. Additional rock has been added downstream to fill a scour hole which had developed. The concrete of the walkway and cap will need to be removed. The heavy reinforcing steel in the concrete will make this a difficult task. The sheet pile will then need to be pulled. A large crane will be required for this task.

A principal concern in the removal plan is access to position equipment within the channel near the weir structure. The plan assumes that a rock ramp will be constructed along the Hwy. 1 bank and into the channel at a slope flat enough to safely maneuver a large crane. The ramp will flatten out at an elevation just above the water surface at mid channel to provide a working plane. A nearby parking strip is assumed to be available for storage of materials, parking of construction equipment, and access to the ramp. After the sheet pile is removed, the rock ramp and original protection rock within the channel will have to be removed to the final channel bottom elevation (assumed for cost-estimation purposes to be -4.0 NGVD).

The rock removed from the channel bottom can be placed along the portions of bank within reach of the crane. Excess rock, concrete, sheet pile and other debris will have to be hauled off. Note that the timing of weir removal would likely be after construction of the replacement weir (discussed below), so that channel water levels could be managed effectively as soon as the permanent weir is gone.

3.5.2 Deployable weirs

While the fixed weir at Thibodaux is a hindrance to conveyance of diverted water, some type of weir structure will be needed at times when water levels must be stabilized in the bayou. For example, when there is a spill in the Mississippi River, the pumps must be shut down, and water levels (in the absence of a weir) would drop so rapidly as to possibly contribute to bank instability and slumping along the bayou. Holding water levels up at a constant level also is of value to water-supply intakes along the bayou.

For Bayou Lafourche, the appropriate structure is one that has no effect on water flow during normal conditions, but can be put into place quickly during a pump-shut down. It also is desirable that the structure be adjustable, so that varying amounts of flow can be passed depending on the exact nature of upstream and downstream conditions. The term “deployable” is used here to refer to a weir structure that is normally not in use, but capable of being placed into use on short notice.

At least three types of deployable weirs can be considered in association with a Bayou Lafourche diversion project.

- Lifting gates. This structure looks something like a low bridge across the bayou; see Figure 3.5-2. A series of heavy gates between pilings is installed. For normal flow conditions, the gates are raised and the structure has minimum impact. One or more gates can be closed by lowering it to the bottom, thus reducing the channel cross-section and the rate of flow. Although gates may be only partially lowered, this type of operation generally is not desired as it forces flow through a small cross-section near the channel bottom, which may have undesirable effects (e.g. scour). Thus the flows allowed by the structure are decreased (or increased) in discrete steps, depending on how many gates are closed or opened.
- Swing gates. This structure is a dam that can pivot out from a recess along the bank; see Figure 3.5-2. When not in use, it sits within the recess and has no effect on flow. When swung into place, it acts as a flow barrier. The structure can be designed with flap-gates, louvers or other features that allow passage of some flow.
- Inflatable rubber dams. The design concept of this structure is shown in Figure 3.5-3; operations are illustrated in Figure 3.5-4. These structures would lie flat on the channel bottom when not in use, and could be inflated (with water or air) to any height. Water inflation would be by a truck-mounted pump and would be manual. They can be fully deployed in 40 minutes or less and are advertised to be virtually maintenance free. At times of very high water, the structures (if deployed) can be designed to auto-deflate.

3.5.3 Interaction with Cutoff Canal structure

A hydrologic management structure in Cutoff Canal, just south of Grand Bayou, was included on the Fifth CWPPRA Priority List (Project TE-10). Figure 3.5-5 shows the original planned location of the Cutoff Canal structure. Figure 3.5-6 shows the general features and dimensions of the planned Cutoff Canal structure (not to scale). The following discussion reflects initial aspects of the TE-10 project; ongoing revisions to that project may lead to some changes in the discussion that follows.

The structure is intended to control the outfall of increased freshwater flow into the Grand Bayou marshes achieved by enlargement of Bayou l'Eau Bleu, and would function similarly for fresh water diverted by Bayou Lafourche. This structure should thereby increase benefits of a Bayou Lafourche diversion.

Alternative locations are being considered to the south (below the location on the map) to accommodate a variety of local concerns regarding navigational access, potential effects on active shrimping in Cutoff Canal and Grand Bayou, safety issues, and flooding concerns (especially in the Point au Chien area). Further consultation with residential and local government interests as a component of planning and implementation of the TE-10 project will be required to finalize structure location (Ronnie Paille, USFWS; personal communication 4/29/98).

3.5.4 Vegetation management

The recent vegetation clogging of the bayou (see Section 2.6) imposed significant maintenance costs on the FWD. With greater flows of turbid water, and a much deeper channel, the potential for reoccurrence of vegetative clogging may be reduced by an expanded diversion. On the other hand, there is no certainty that periodic mowing of vegetation will continue to be necessary, even without an expanded diversion. In its project evaluation, EPA makes the worst-case assumption that that mowing will in fact be needed, with or without a new diversion, and that this will be part of the normal maintenance program conducted by FWD.

3.5.5 Bayou monitoring stations

With removal of the weir at Thibodaux, and deployable weirs in place, the potential exists to closely manage water levels in the bayou through adjustments of the new weirs, and the new pumps. For this to be practical, it will be necessary to have real-time data on water level and flow conditions along the bayou. Therefore, the conceptual design of a diversion project should include installation of data collection platforms (DCPs) at several locations from Donaldsonville to Larose. Measurements of discharge at such platforms can be obtained through a DCP-mounted flow meter or a more costly Doppler technology, which requires a cable across the bayou on or below the bed.

Water levels are currently monitored at FWD staff gages; in addition, USGS already operates some DCPs along the bayou. These locations would be suitable for an expanded monitoring network. The following chart lists each location, the existing monitoring facilities, and the new facilities that would be desirable to upgrade the system.

Location	Existing facilities	Needs
Donaldsonville (bridge at the Sonic drive-in)	Stage, rainfall, flow (to be provided in immediate future), with real-time data transmittal. Operated by USGS/LDEQ.	None.
Labadieville-Napoleonville reach, e.g. Cancienne Canal	FWD staff gage at Assumption Parish water plant in Labadieville.	Partial DCP: stage, rainfall.
Thibodaux (water plant)	Stage, rainfall, with real-time data transmittal. Operated by USGS/LDEQ. (Stage also is measured below the weir, which allows flow to be calculated).	Add flow meter.
Mathews (Lafourche Parish #2 water plant)	FWD staff gage.	Full DCP: stage, rainfall, flow.
Larose (the GIWW)	Stage, rainfall, and flow. Operated by USGS/COE/EPA for a two-year period.	Extend operation of existing facility for stage and rainfall.

The DCPs would provide digital read-outs that could be retrieved remotely on a real-time basis by USGS. For the existing platforms, as would also be the case for the added platforms, the data base is accessible on the USGS home page, where incoming data are added at 15-minute intervals. The expectation is that a specific management plan would be developed in conjunction with stakeholders along the bayou. For example, if a stage determined to be critical is identified by the DCPs as having been reached, diversion rates could be reduced.

3.5.6 Water management plan

The expectation is that a specific water management plan would be developed and used to direct operation of any new diversion works. The plan would be prepared in conjunction with people who live and work along the bayou, or who are otherwise have a stake in project performance. The plan would specify criteria to be used in determining the rate at which pumps or siphons would be operated, and weirs deployed. Day-to-day operations would be the responsibility of the operators of the pumping plant, the Bayou Lafourche Freshwater District. These operations would be subject to oversight by an advisory committee with members from EPA, Parish governments, special districts and boards, and the State of Louisiana.

Normal operations would divert at full capacity, and natural gradients would be used to convey water down the bayou and through existing channels (including Company Canal and the Gulf Intercoastal Waterway), to degrading wetlands areas. Special operations would be expected if there is a spill in the Mississippi River, or a major storm event.

Because the water management plan would be developed in association with local stakeholders, its details are not now known. The following discussions highlight some of the issues that could be considered in the plan, with respect to the water supply facilities and operations of the Bayou Lafourche Freshwater District, and the flood protection and drainage activities of Parish governments and local levee/drainage districts. Issues of cost-sharing among those who benefit from the plan also are discussed.

Water supply facilities and operations. The existing listed Project PBA-20 was intended to be integrated into the facilities and operations of the FWD, because that agency has authority and staff for such operations. EPA does not envision any option that would set up a new agency to compete with FWD in bayou operations.

The concept for a CWPPRA diversion is to deliver freshwater, sediment and nutrients to the wetlands each day of the year. If sized and operated at 1,000 cfs, this would always provide more flow down Bayou Lafourche than required by the FWD. Therefore, routine operations would always be driven by CWPPRA objectives. A non-routine exception would occur in the event of a toxic spill in the Mississippi River that was detected by the existing Early Warning Network. In this emergency circumstance, a temporary shut-down of the diversion could be required to protect public water supplies served by FWD.

Based on Table 2.8-1, it would be typical that 61 cfs of a diverted flow would be withdrawn from the Bayou for water supply purposes. This impact is expected to increase to 69 cfs as population and water demands grow. Seasonal peak withdrawals will continue to exceed 100 cfs during the sugar-cane refining season. Note that a portion of this withdrawal occurs in Donaldsonville, and could often be met by increasing the rate of diversions, without increasing the amount of downstream flow in the bayou. Most of the rest of the withdrawals occur above Lafourche Crossing. Computer models discussed in Chapter 4 assumed a 1,000 cfs flow, when in fact actual flows would be less because of water-supply withdrawals; therefore these models slightly overstate future water levels in the lower reach of the bayou if a larger diversion project is implemented.

The effect of these withdrawals would be to reduce the quantity of water, nutrients and sediment reaching the wetlands. For a 1,000 cfs diversion, the effect would be in the range of 6 to 7% on average, and 11% at times. An overall adjustment factor of 8% downward has been selected as representative for adjusting estimated wetlands benefits to account for the impact of water-supply withdrawals.

The nature of an expanded diversion project is that it would largely or entirely address two existing needs of the FWD that are discussed in Section 2.8.2: existing pumps need to be overhauled or replaced; and there is a potential need to expand capacity to as much as 780 cfs for the purpose of providing needed salinity control. EPA has considered numerous configurations for new diversion facilities, that would involve retention or abandonment of the existing pumping plant, and/or phased construction of new facilities. Among these configurations, those that are most beneficial to the FWD are ones that provide the most modern and integrated facilities.

Because a diversion project could benefit FWD, the FWD is a potential cost-share partner in a project. However, the extent to which FWD may cost-share in new facilities has yet to be negotiated between FWD and the Task Force. EPA does not expect that FWD must pay for all or even most of the facility, even though FWD may some day require a larger facility to combat future salinity problems that impact water supply. Considerations that may bear on the ultimate cost-share arrangement could include the following.

- In the absence of a CWPPRA project, the costs of upgrading the existing 340 cfs facility and providing new capacity will be born by FWD. However, it could be ten years or more before the FWD would incur these costs on its own initiative.

- Except for the question of ultimate capacity (which could be larger for a CWPPRA project than a simple FWD expansion), the cost of constructing facilities would be the same whether funded by FWD or CWPPRA.
- A modern pumping plant (whether entirely new, or a combination of new and rehabilitated facilities) should be comparatively more efficient and less expensive (per cfs diverted) to operate than the existing FWD plant. For example, energy costs would be less per cfs for a new facility, because of the use of larger pipes (72 inches) and variable-speed pumps.
- Repair costs also should be less, at least initially, because facilities would be new and/or newly rehabilitated.
- A project design that includes a sand trap may decrease long-term dredging costs for the District. Costs of vegetation control also could be less because the bayou would have slightly faster flows of slightly more turbid water, in a much deeper channel; these factors would likely reduce the potential for large-scale growth of vegetation.
- FWD has provided some wetlands benefits by diverting water for salinity control; this water has passed through the bayou to wetlands areas.
- FWD is expected to bear at least some of the day-to-day operational costs of a CWPPRA diversion project.
- FWD may experience both advantages and burdens from its association with a CWPPRA project, which will bring a heavy federal involvement and thus special expertise and also additional bureaucracy.

Drainage and flood control. There are significant existing flood control and drainage concerns in and near Bayou Lafourche, as indicated by the following.

- Areas near the Bayou that now frequently experience flooding (such as the Marais area above Labadieville) or that are in need of flood relief (e.g. the Hospital area in Donaldsonville) were identified in CEEC (1997a; see abstract in Appendix A).
- The USACE is conducting a major study, Morganza to the Gulf, to evaluate flooding problems west of Bayou Lafourche, including the Lake Verret Basin. These problems are sufficiently severe that the study is considering the development of 8,000 cfs of forced drainage capacity for the basin. One flood control alternative is to pump 500 cfs of this to Bayou Lafourche via Cancienne Canal.

- The USACE is about to initiate another major study, Donaldsonville to the Gulf, to evaluate flooding problems east of Bayou Lafourche, e.g. the Barataria Basin above Highway 90.
- Communities and lands in three parishes (Ascension, Assumption and Lafourche) have areas that drain to Bayou Lafourche. Discussions with parish officials as part of EPA's project evaluation have indicated that it would be beneficial to drainage management to maintain or increase the capacity of Bayou Lafourche, and to operate the diversion project to provide a drainage function.

Based on the above considerations, it would be reasonable to consider operating a Bayou Lafourche diversion project so that it provides drainage benefits, along with wetlands benefits. For example, at the onset of a major rainfall event, it would be possible to reduce diversions at Donaldsonville, in order to lower water levels in the bayou. The lower water levels would provide room for the passage of storm water. Compared to historic conditions, the net result would be a decrease in bayou water levels for any given storm, and improved drainage from back-bayou areas. In order for such operations to maintain relatively steady water levels in the bayou, the deployable weirs would be raised or lowered as appropriate.

EPA has not identified any existing flood control or drainage program that has the potential to provide a substantial investment in the dredging of Bayou Lafourche in order to obtain the benefits discussed above. However, cost-share funding from Parishes or other entities may be a possibility for the deployable weirs, monitoring stations and/or operational aspects of the management plan. Note that there is no apparent loss of wetlands benefits from a diversion project if that project is operated to provide drainage benefits, so long as total flows of fresh water to the marsh are not substantially changed.

Summary. The essential features of a management plan would be its development and oversight by bayou stakeholders at local, state and federal levels, its commitment to divert full water supplies to the wetlands whenever possible, and its provisions for two variations on full supply: a reduction in flow to zero cfs under emergency conditions (e.g. barge spill in

Mississippi River); a partial reduction in flows to account for stormwater discharges or other causes of high water in the bayou.

3.5.7 Monitoring of wetlands impacts

Standard practice for all CWPPRA projects is to undertake monitoring in wetlands areas in order to determine whether project impacts are as predicted. A CWPPRA monitoring plan for Project PBA-20 has not yet been prepared. The plan can be expected to focus on photo interpretation and/or field transects of potentially benefited areas, to determine if in fact the project has helped to decrease loss rates (compared to non-benefited areas).

Figure 3.5-1. Drawings of Thibodaux weir

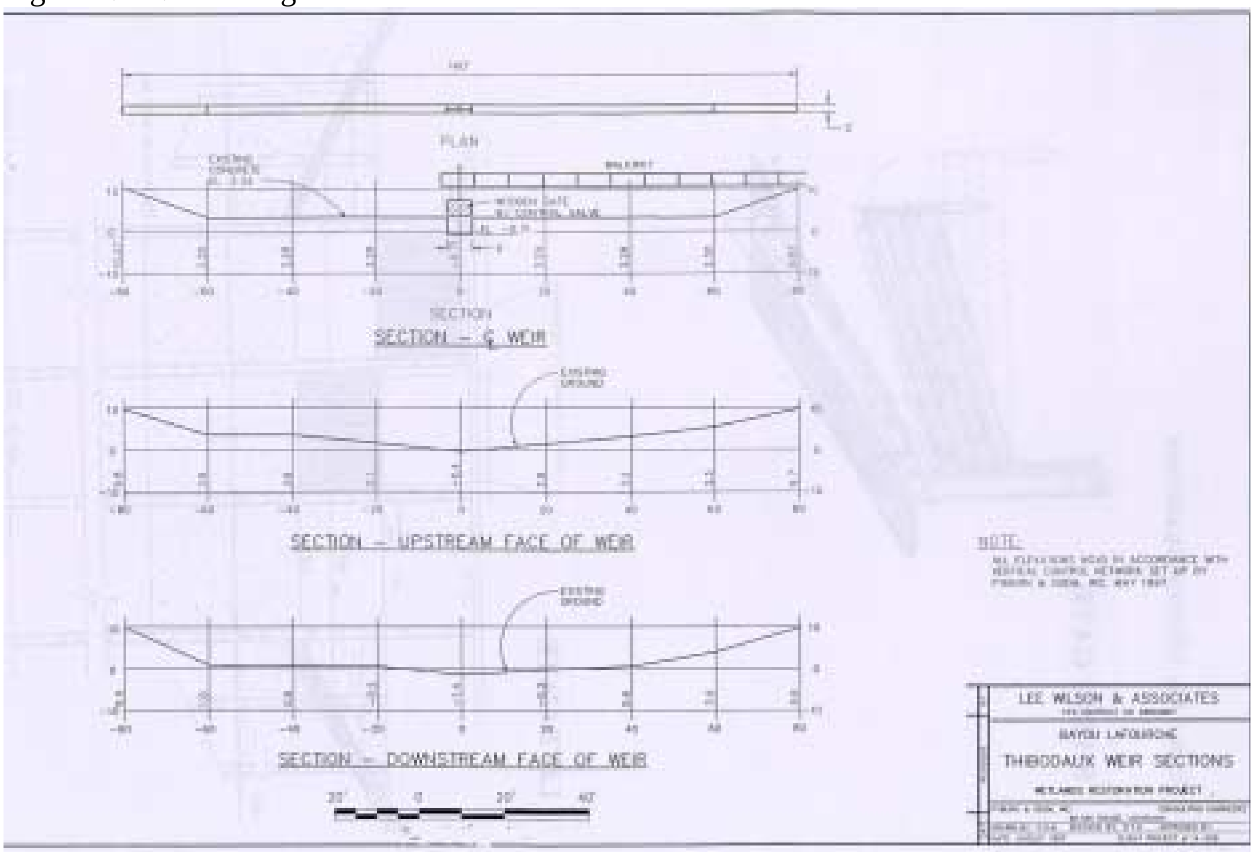


Figure 3.5-2. Lift and swing gate

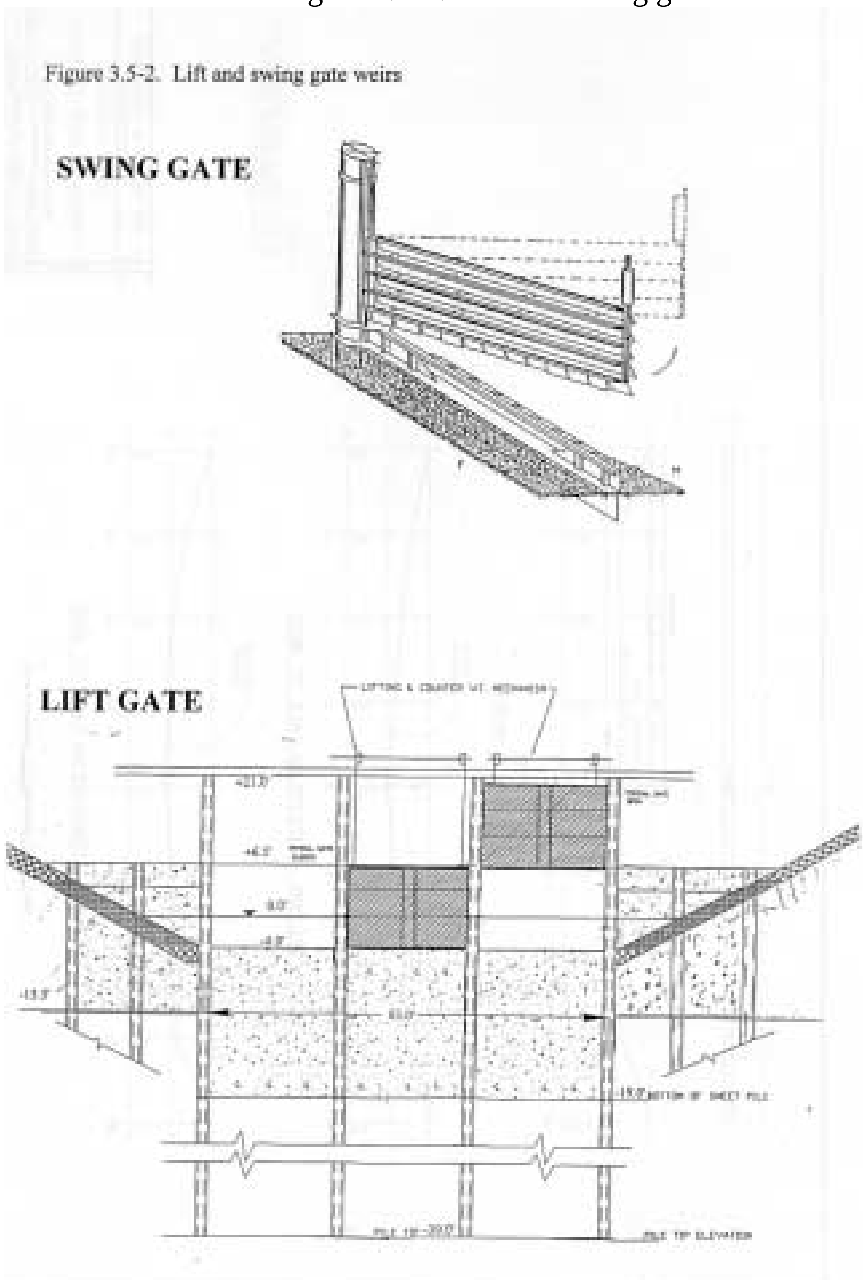


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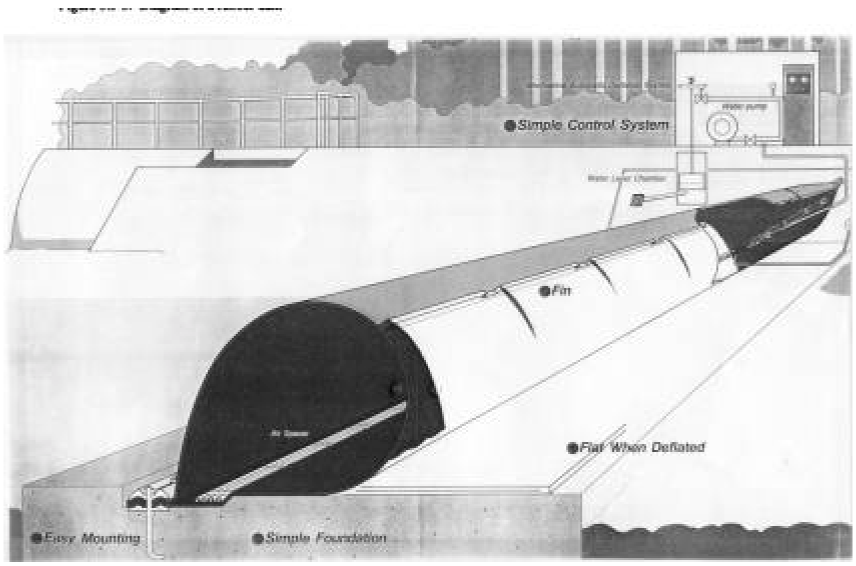
Figure 3.5-3. Diagram of rubber dam



PRELIMINARY: DRAFT

Figure 3.5-4. Rubber dam before and after deployment

Figure 3.5-5. Map of Grand Bayou Project (from Louisiana Coastal Wetlands Conservation and Restoration Task Force, 1996. Fifth Priority Project List Report.).

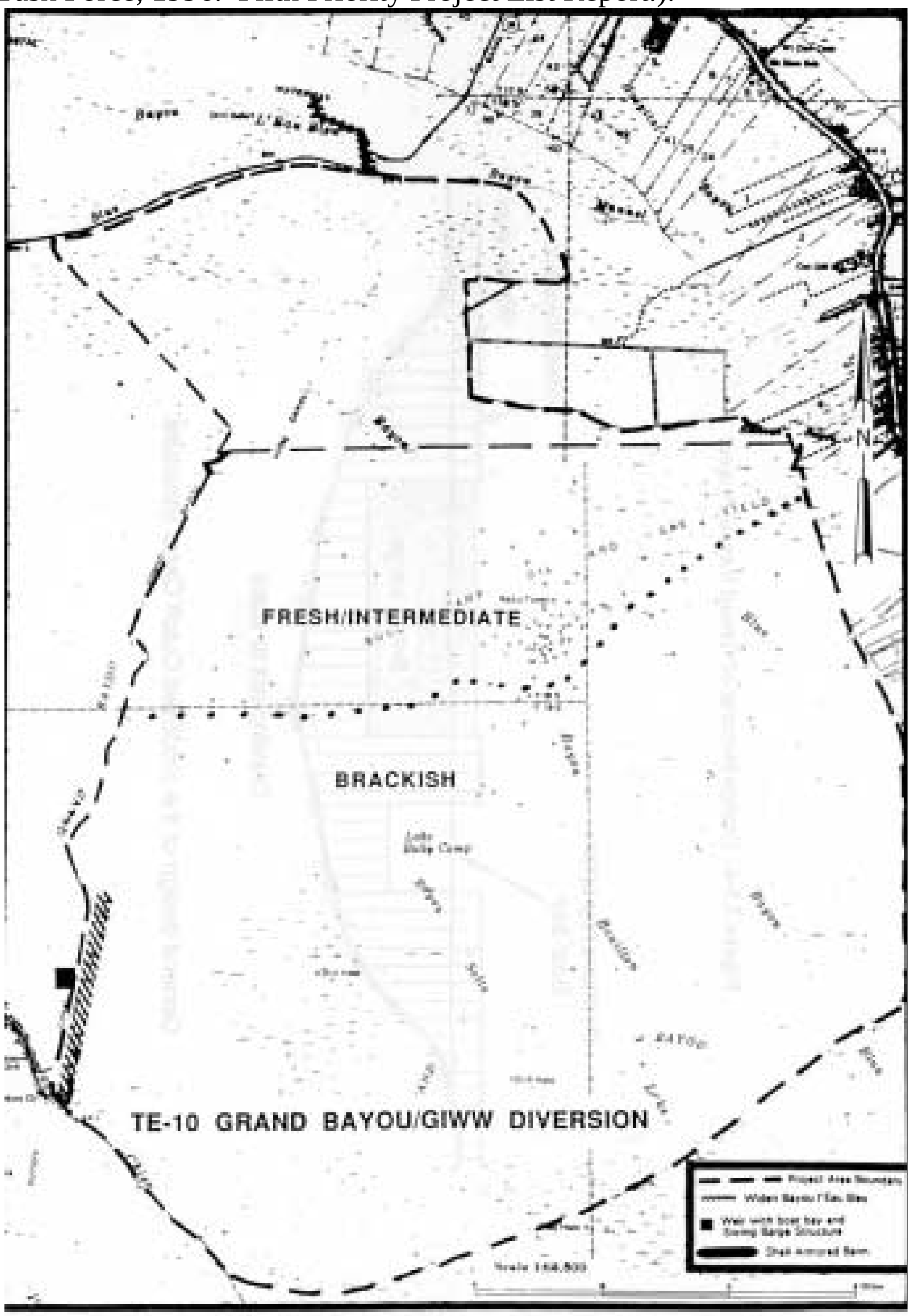
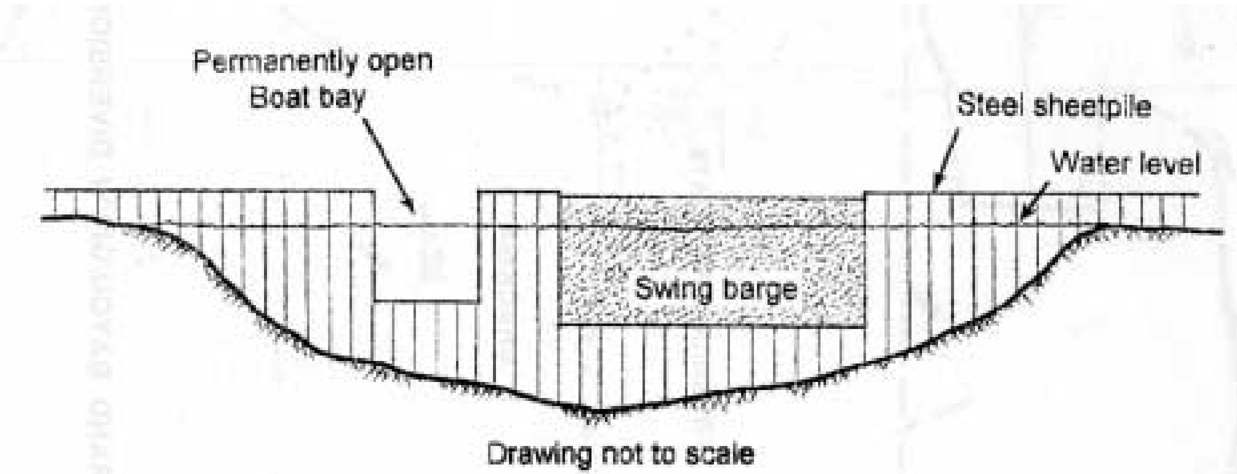


Figure 3.5-6. Design features of Grand Bayou Project.



General design of the proposed Cutoff Canal Structure.

3.6 PROJECT IMPLEMENTATION

EPA's evaluation has noted several activities that will be required prior to construction of a CWPPRA diversion into Bayou Lafourche.

Cost-share negotiations. Initiation of cost-share negotiations with FWD and local governments will be required. This action is contingent upon the public review of this report, and on the decision by the CWPPRA Task Force to proceed with the project.

Permits. Table 3.6-1 identifies potential regulatory approvals for a new diversion project, and identifies general issues commonly associated with each type of regulatory review. The major permit involved would be from the New Orleans District of the U.S. Army Corps of Engineers. The focus of this permitting process is twofold: 1) to mitigate any potential navigation impacts from construction and operation of facilities (Section 10 of the Rivers and Harbors Act), and 2) to mitigate any potential environmental impacts from dredge and fill activities (Section 404 of the Clean Water Act). Note that FWD already holds a permit that would allow dredging in the uppermost part of the channel.

Environmental reviews. All CWPPRA projects are required to be evaluated pursuant to the National Environmental Policy Act (NEPA). Typically, the review is done by the lead federal agency through an Environmental Assessment (EA) of the project, which leads to a Finding of No Significant Impact, or a decision to prepare a more extensive Environmental Impact Statement (EIS). The agency's NEPA review commonly satisfies the NEPA requirements of the Corps Section 10/Section 404 permitting decision.

EPA anticipates that it will use the forthcoming public review of this report to scope the issues that need to be addressed in an EA or EIS, and to provide a basis for determining which type of document to prepare. The information in the report is far more extensive than found in a typical

EA and in many EISs. While some additional assessments may be required, a primary reason for the additional environmental review is to ensure that EPA has full public input to the decision-making process.

Cultural resources coordination. Evaluation of potential impacts to historical and archeological resources is part of the coordination process. Potential sources of cultural resources in the project area include: 1) the site of Ft. Butler, located in the vicinity of the proposed diversion works; 2) water craft and associated relics that might be buried under the silt of the Bayou Lafourche, and which might be affected by dredging operations.

Background research for this report (CEI, 1997a; see Table 1.3-1) provides information on the Ft. Butler site. Archival maps were electronically scanned to produce a series of overlays in order to estimate the location of Fort Butler and other structures which may have been in the project right-of-way. Material from the State Regional Archeologist was also considered. The result is shown on Figure 3.6-1.

In the early 1850s, ten structures stood along the west bank of Bayou Lafourche, including a possible ferry dock. Any traces of the buildings were probably destroyed during construction of a confederate fortification early in the Civil War or of federal Fort Butler in 1863. Any remnant of the confederate structure was probably destroyed or incorporated into Fort Butler.

A portion of an outlying earthen defense embankment and exterior moat probably was located in the proposed project right-of-way. Presumably material would have been pushed into the moat when the fort was destroyed. Apparently the earthworks of the fort and also former levees along the bayou were used to in-fill surviving remnants of the moat and also to dam the bayou. The CEI report states “That pre-Civil-War features survive within the ROW is considered highly unlikely, but can not be completely ruled out”.

No new structures were built in the bayou until after 1940. Existing structures (refer to Section 3.2.3) will need to be examined to determine if they are eligible for the National Register of Historic Places.

Regarding water craft remains in the bayou itself, the currently navigable portion of the bayou was dredged in 1983, but no survey was conducted prior to the work and no finds were reported. Prior to closing of the bayou at Donaldsonville in 1904, the USACE regularly removed watercraft wreck debris from the defined navigation channel. However, “substantial remains” of pre- and post-closing watercraft could exist along the banks, both above and below the currently navigable portions of the bayou (Kelly, 1998).

The preliminary CEI report has been submitted to the Louisiana State Historical Preservation Officer (SHPO). In response, the SHPO has recommended that a Phase I cultural resources survey be conducted prior to construction of the facility (Hobdy, 1998). The Survey would identify potential impacts to: any Ft. Butler remains; any structures listed on or eligible for listing on the National Register of Historic Places; and any cultural resources affected by dredging. The possibility exists that recordation or other mitigation measures could be required.

The SHPO is in the process of nominating Fort Butler to the National Register. This action will assist EPA in NHPA coordination by eliminating the need for EPA to independently determine the eligibility of the site for the National Register.

Oyster leases. Potential conflicts with existing oysters leases must be identified and resolved for successful project implementation. Based on experience with conflicts to project implementation from operation of the Caernarvon diversion, LDNR initiated an effort to develop an approach for dealing with potential project conflicts with oyster leases. This effort has involved extensive interactions with oyster fishermen as well as evaluation of alternatives and planning by specialists within LDNR.

LDNR developed four options to reduce impacts of restoration projects on oysters leases. These are established in the Oyster Lease Relocation Act, passed in 1997, and include: 1) “in kind” exchange of an impacted lease for another, unowned lease outside of influence of the project; 2) lease relocation, which may include placement of cultch in a new area in an amount equal to that which existed at the impacted lease; 3) retention of the lease without compensation, in which the leaseholder assumes all risks of continued operation in an impacted area, but has the right to choose another option at a later time; and 4) purchase of the lease by the State of Louisiana. The fourth option is only used if it is more cost-effective than relocation.

One of the first steps in identifying and addressing potential problems with oyster leases is to identify all surveyed leases within a project’s boundaries. Oyster leases falling within the Bayou Lafourche project areas are listed in Table 3.6-2.

LDNR has reviewed all oyster lease conflicts for CWPPRA projects listed to date, and presented recommendations for resolution to facilitate project implementation (Baker and Clark, 1997). For CWPPRA projects with areas that overlap Bayou Lafourche project areas, the information summarized by LDNR is included in Table 3.6-2.

Figure 3.6-1. Cultural resources features

Modern air photo of Donaldsonville showing the proposed ROW for the new Bayou Lafourche pumping facility (purple), the ROW for the current pumping facility (yellow), and the approximate location of the 1863 Federal Fort Butler.

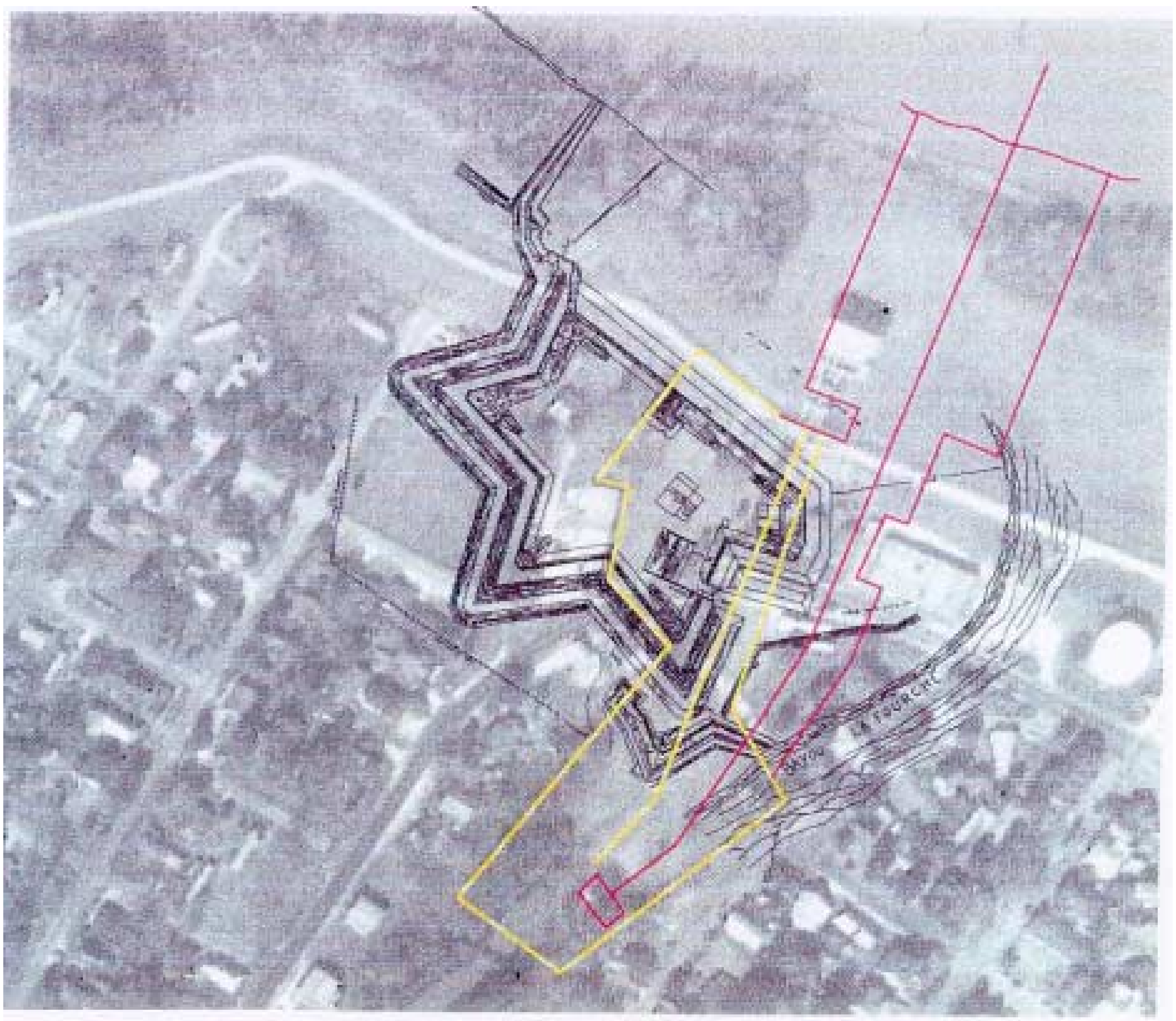


Table 3.6-1. Required regulatory approvals and possible agency concerns

Agency	Permit	Issues addressed, general and specific
Federal		
U. S. Army Corps of Engineers (USACE, or Corps)	**Section 404 Permit** for: 1. placement of dredged material (and possibly dewatering activities) in adjacent and/or offsite wetland areas. 2. Discharge of dredged material to the Mississippi River.	Section 404 & 10 permits are considered together. • Compliance with the National Environmental Policy Act. • Sediment chemistry. • Disposal areas and methods. • Water Quality Certification by LDEQ. • Public input. • State and Federal input.
	Section 10 Permit for: 1. installation of water intake pipes and related appurtenances in the Mississippi River; and, 2. any structures located in the navigable waters of Bayou Lafourche (which are presently considered to be below the weir in Thibodaux). 3. dredging of possible wetlands located in the footprint of the pump stations and appurtenances; 4. dredging in Bayou Lafourche;	
U. S. Coast Guard (USCG)	**"Letters of No Objection" (LNO).** Reviews and comments on issues related to the Corps' Section 10 Permits.	• Waterway safety.
National Marine Fisheries Service (NMFS)	**Review.** Routinely reviews and comments on separate or joint public notices filed by the Corps, LDNR-CMD, and LDEQ. Coordinates on Endangered Species Act.	• Effects of dredging on wetlands. • Effects of dredging on water quality as related to fisheries.
U. S. Environmental Protection Agency (EPA)	**Review.** Routinely reviews and comments on separate or joint public notices filed by the Corps, LDNR-CMD, and LDEQ.	• Compliance with the National Environmental Policy Act.

Table 3.6-1, continued

Agency	Permit	Issues addressed, general and specific
U. S. Fish and Wildlife Service (USFWS)	**Review.** Routinely reviews and comments on separate or joint public notices filed by the Corps, LDNR-CMD, and LDEQ. Coordinates on Endangered Species Act.	• Effects of dredging on wetlands. • Effects of dredging on water quality as related to fisheries.
State of Louisiana		
La. Dept. of Environmental Quality (LDEQ)	**Water Quality Certification.** Required pursuant to Section 401 of Clean Water Act as a prerequisite to issuance of a Department of Army Section 404 Permit	• Sediment chemistry.
La. Dept. of Natural Resources, Coastal Management Division (LDNR-CMD)	**Federal Consistency.** A Federal Consistency Determination is required for federally sponsored project that will directly and significantly impact coastal waters even though the project is located outside of Louisiana's Coastal Zone. Usual fee of $300 is waived for CWPPRA projects.	• Sediment chemistry. • Disposal areas and methods. • Public, State and Federal input.
La. Office of State Lands	**Class C & D Permits.** Class C required for wharves/piers, if included as part of project. Class D required for other structures placed in Bayou Lafourche.	• Structures in the bayou.
La. Dept. of Transportation and Development (LDOTD)	**Permit.** Usually issues permits for projects which may affect state highways (e.g. vehicular safety during construction), but does not in instances when a project is funded entirely or in part by state money.	• Project effects on LA HWY 1 and 308 (e.g., effects on embankments and/or drainage crossings). • Effects on integrity of bridges connecting LA HWY 1 and LA HWY 308.
La. Dept. of Wildlife and Fisheries (LDWF)	**Review.** Routinely reviews and comments on separate or joint public notices filed by the Corps, LDNR-CMD, and LDEQ.	• Effects of dredging on wetlands. • Effects of dredging on water quality as related to fisheries.

La. State Historic Preservation Officer (SHPO)	**Review.** Routinely reviews and comments on separate or joint public notices filed by the Corps, LDNR-CMD, and LDEQ.	• Effects on historically significant sunken vessels, if any. • Effects on historical structures at diversion site and along bayou, including aesthetics (e.g. placement of dredged materials).
La. Dept. of Health and Hospitals (DHH)	**Review.** Routinely reviews and comments on separate or joint public notices filed by the Corps, LDNR-CMD, and LDEQ.	• Effects on individual on-site wastewater systems (e.g., effects on size of drain fields on batture lots).

Table 3.6-1, continued

Agency	**Permit**	**Issues addressed, general and specific**
Local		
Bayou Lafourche Fresh Water District (FWD)	**Permit.** Required from the District for any project that requires a Section 10 permit from the Corps of Engineers.	• Water quantity and quality.
Local governments	**Comment letters.** Local municipalities and parishes have no jurisdictional, regulatory oversight, but may issue letters of support or objection during the public comment period to the Corps, LDNR-CMD, and LDEQ in order to influence permit decisions.	• Effects on local flooding potential. • Effects of flow velocities and water levels as related to recreational safety. • Effects on residential and commercial structures, pipeline and utility crossings (submarine and aerial); remedial actions needed, if any (e.g. relocation). • Effects on rail bridge at Lafourche Crossing.
Water intake facilities	**Comment letters.** No jurisdictional, regulatory oversight, but may issue letters of support or objection during the public comment period to the Corps, LDNR-CMD, and LDEQ in order to influence permit decisions.	• Dredging activities' effects on short-term water quality. • Dredging activities' effects on industrial intakes such as sugar cane mills.

Table 3.6-2. Oyster leases within the boundaries of the Bayou Lafourche Diversion Project.

Bayou Lafourche project area	Lease #	Acreage	Within boundaries of other CWPPRA project	Expected level of effects	LDNR recommendations and status
Grand Bayou marshes	L-34021	199 ac	TE-10/XTE-49	Overlaps only southern tip of project area; effects expected to be minimal	Survey lease, and possible modeling, to be sure of expected project effects. Expected to be addressed by sponsors of TE-10/XTE-49.
Grand Bayou marshes	L-34049		TE-10/XTE-49	Lease extends from southern project boundary into center of project area; most likely to be negatively affected by fresh water from project.	Candidate for Oyster Lease Relocation Program; also survey lease, and possible modeling, to be sure of expected project effects. Expected to be addressed by sponsors of TE-10/XTE-49.
Barataria Basin near Delta Farms	None		BA-2	n/a	n/a
Lake Fields marshes	None		n/a	n/a	n/a
Montegut marshes					
HNC marshes					

PRELIMINARY: DRAFT

Table 3.6-2. Oyster leases within the boundaries of the Bayou Lafourche Diversion Project.

Bayou Lafourche project area	Lease #	Acreag e	Within boundaries of other CWPPRA project	Expected level of effects	LDNR recommendations and status
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Grand Bayou marshes	L-34049		TE-10/XTE-49	Lease extends from southern project boundary into center of project area; most likely to be negatively affected by fresh water from project.	Candidate for Oyster Lease Relocation Program; also survey lease, and possible modeling, to be sure of expected project effects. Expected to be addressed by sponsors of TE-10/XTE-49.
Barataria Basin near Delta Farms	None		BA-2	n/a	n/a
Lake Fields marshes	None		n/a	n/a	n/a
Montegut marshes					
HNC marshes					

4. METHODS USED TO QUANTIFY PROJECT IMPACTS

4.1 OVERVIEW OF CHAPTER 4

A principal objective of EPA's project evaluation was to quantify important impacts of the project, especially: 1) the effects of increased diversions on water levels in Bayou Lafourche; and 2) the amount of fresh water, nutrients and sediment distributed to the wetlands. The quantification methods used in the evaluation are described in Chapter 4, as follows.

- Section 4.2 is a brief introduction to the quantitative methods, using a conceptual model to show how diversions interact with other factors to influence the bayou and the wetlands.

- Section 4.3 describes work done by Louisiana State University using the HEC models, which are the basis for all predictions regarding the effects of increased diversions on flow and water levels in Bayou Lafourche, for existing channel conditions and for future scenarios in which the channel capacity would be increased by dredging and other measures. LSU work also quantified sediment deposition in the channel, and sediment throughput to the marsh.

- Section 4.4 describes work done by the U.S. Army Corps of Engineers using the UNET model, which is the basis for all predictions regarding how water from Bayou Lafourche will be distributed to wetlands through Company Canal, the GIWW, and other channels. The predictions consider effects such as high versus low water in the Atchafalaya basin, and the operation of the Davis Pond Project.

- Section 4.5 describes work done by the U.S. Army Corps of Engineers using the TABS model. This model is the basis for predictions regarding how water from Bayou Lafourche can impact salinity in the wetlands, and for the evaluation of outfall structures.

- Section 4.6 describes the wetlands valuation assessment (WVA) method that is routinely used to quantify the benefits of CWPPRA projects in terms of average annual habitat units. Section 4.6 also summarizes studies (beyond those presented in Sections 4.3-4.5) that help dimension the area impacted by a Bayou Lafourche diversion project, or that use model results to interpret data on salinity, sediment, nutrient and other restoration benefits.

4.2 CONCEPTUAL BASIS FOR ASSESSING DIVERSION IMPACTS

4.2.1 Conceptual model of bayou hydrology

Figure 4.2-1 is a diagram to illustrate a simplified conceptual model for evaluating the impacts of a diversion into Bayou Lafourche. The concepts important to evaluating the bayou include the following.

- There are many sources of water in Bayou Lafourche and the adjoining wetlands beyond that contributed by a river diversion.
- There are many aspects of the stream channel condition and network that are important in determining how water flows through the bayou.
- Therefore, the channel and wetlands can have many different responses to a diversion. The effect that has received most public comment -- a possible water level rise onto the batture -- is but one example. Conditions such as water levels in the bayou will depend on how the various water sources collectively interact with the various channel conditions.
- It is possible to change the channel response to a diversion by means such as channel improvements (in this case, dredging and/or removal of the Thibodaux weir). Similarly, outfall structures can alter the distribution of flow in the downstream channel network.
- There is an interaction between Bayou Lafourche and regional drainage. If Bayou Lafourche is high, runoff from urban lands and agricultural lands along the natural ridge must drain to the swamps of the Barataria and Verret basins, where water levels are already high and drainage potential is limited.
- All of the relationships described above can be different depending on the time frame and location being considered.

4.2.2 Example of system complexity

One example to illustrate the complexity of the real system is provided in Figure 4.2-2. This figure plots the stage or water level measured at the Sonic Bridge in Donaldsonville, as a function of the rate of FWD diversions. The bridge is less than two miles downstream of the existing diversion and, ideally, one would expect water levels there to go up and down consistently with the amount of the diversion.

Figure 4.2-2a plots monthly stage and diversion data for ten years of record (1988-97). Overall, there is a general trend of higher water levels with higher flow, as expected. For the existing channel conditions, the stage increases about 1 foot per 150 cfs. However, there also is substantial scatter in the data, indicating that many factors besides diversion rate are important. Both data sets are measured rather approximately, so that some of the scatter may simply be inconsistencies in the measurements.

One factor that is clearly impacting water level is time of year. Figure 4.2-2b shows two regression lines, one through the monthly data for December-June (1988-97), when diversions are typically by siphoning, and the other for July-November, when diversions are typically by pumping. The lines indicate water levels are higher in siphon periods than pumping periods. This is expected because, during siphon months, the Mississippi River is high and therefore ground water levels near the river are higher than at other times. Consequently, water levels in the bayou rise to some degree independently of diversion rate. Based on the space between the two lines in Figure 4.2-2b, this seasonal effect of ground water rise is about one-half foot. The higher ground water contributes extra flow to the bayou during high-river periods. For this reason, a smaller diversion during high-river will produce the same bayou stage and flow as a larger diversion in low-river.

Collectively, Figures 4.2-1 and 4.2-2 illustrate that the linkage from the Mississippi River to the wetlands through a Bayou Lafourche diversion is complex. One practical significance of this fact is that computer models are required in order to predict how conditions are likely to change in response to increased rates of diversion and to channel improvements. Such models provide approximations of the actual environment. The results can guide the planning and evaluation of a project, as one tool to be used in the application of professional judgment and common sense.

4.2.3 Basis of computer models

Computer models adequate to fully integrate all the factors shown in Figure 4.2-1 are not available. Elaborate models that capture even a substantial part of the complexity of the real system are costly to develop and of limited practical value unless (as is rarely the case) there are extensive data for use in calibration. The approach here is to use relatively simple models that focus on a small number of parameters of greatest significance, namely diversion rate and water flow.

The fundamental relationship embodied in the simple models was briefly described in Section 2.3.1, and is discussed here in quantitative terms. The following equations describe the mass balance (total discharge) in a channel, and the velocity of flow.

*Discharge = cross-sectional area * flow velocity.*

$$\text{Velocity} = \frac{1.5 \; * \; \text{depth}^{2/3} \; * \; \text{gradient}^{1/2}}{\text{roughness}}$$

The following parameters are a reasonable description of Bayou Lafourche near Thibodaux for a period of high diversion rate: depth = 4 feet; width =140 feet; gradient = 1 foot per 19 miles (which is a flatter gradient than often observed in the upper channel); roughness = 0.021. For this situation, the channel cross-section would be 560 square feet, the velocity would be 0.57 feet per second, and the flow would be about 320 cfs. For the same channel deepened to 8 feet (but no other changes), the velocity would be 0.9 feet per second, the cross-section 1120 square feet and the flow 1,008 cfs.

This example is not intended to be a rigorous prediction, but to illustrate the basic point that an increase in channel depth (hence cross-section) can provide for a substantial increase in water flow, without any change to the channel gradient or water levels, and with only a modest increase in velocity. The example also illustrates that the existing gradient of Bayou Lafourche is not so flat as to prevent conveyance of 1,000 cfs or more if the channel is deepened sufficiently. These principles are embodied in the models described in subsequent sections.

The most significant limits to conveying 1,000 cfs occur in the uppermost reach of the bayou, near Donaldsonville. There a channel cross-section of 500 to 600 square feet is needed in combination with a velocity of 1.8 to 2 feet per second, if a 1,000 cfs flow is to be carried. Using a 3H:1V dredge template, a section that large requires a width of at least 80 feet; the bayou appears to be less than 80 feet wide at locations in that reach. In that area, consideration may need to be given to benched templates that have a steeper, deeper center section, so that the flow can be conveyed without widening the bayou or making the banks unstable. Limited use of sheet pile bulkheads also could be considered.

Figure 4.2-1. Conceptual model of diversion impacts Bay Lafourche

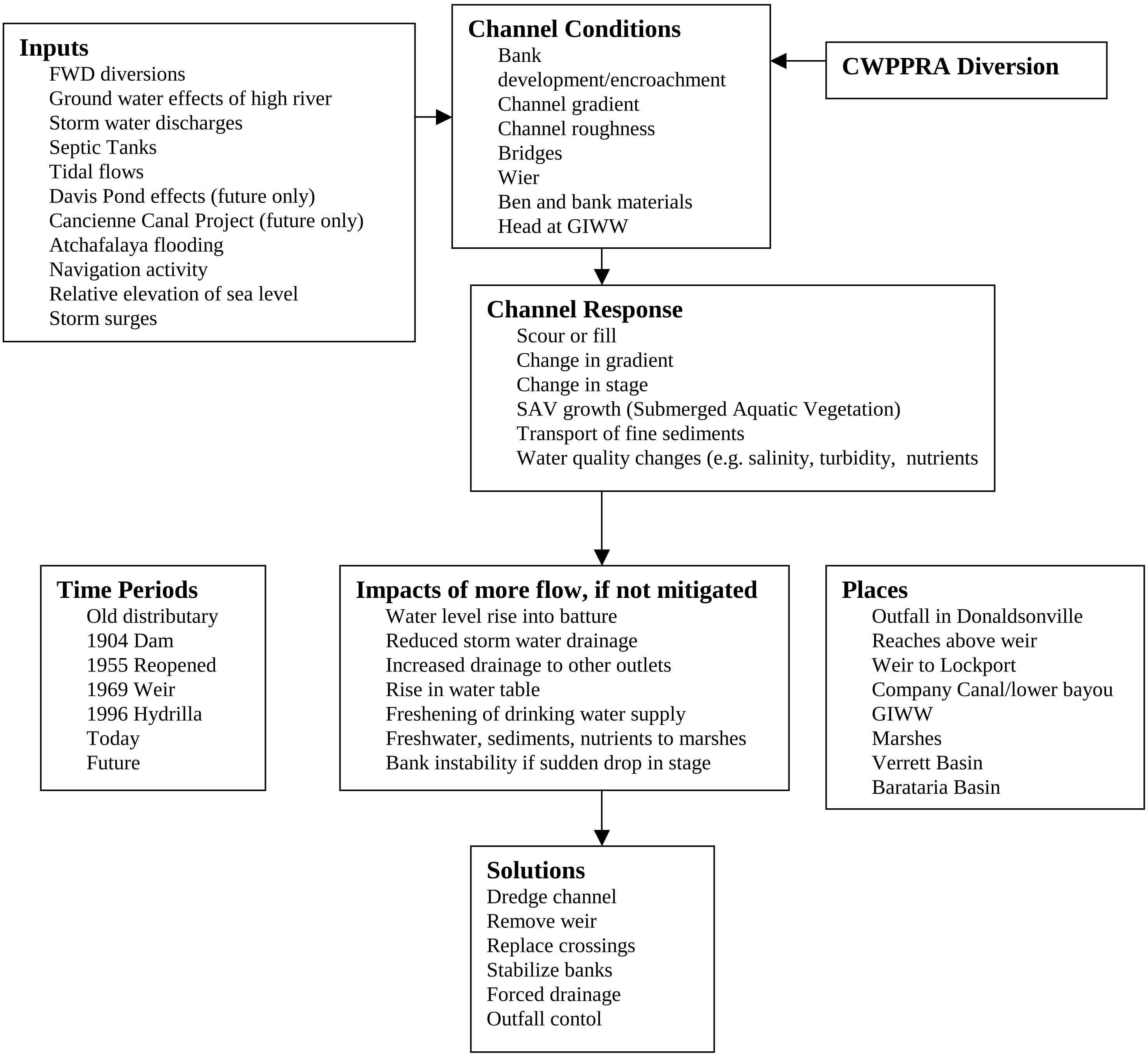
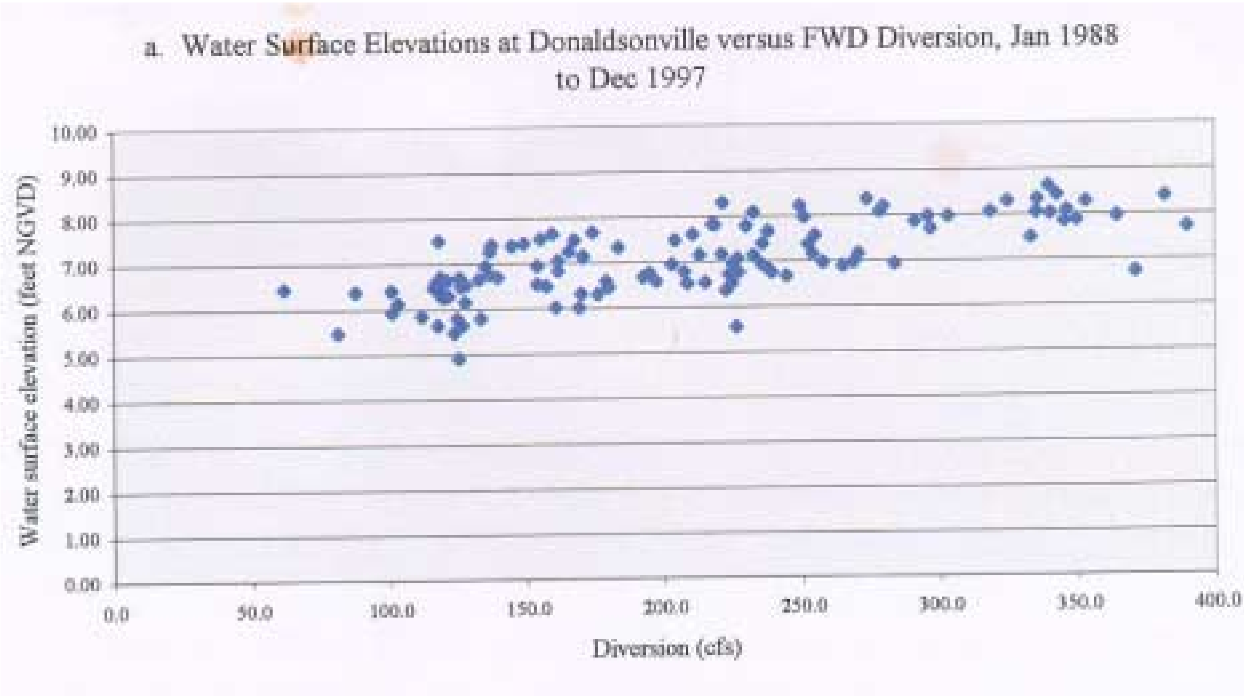
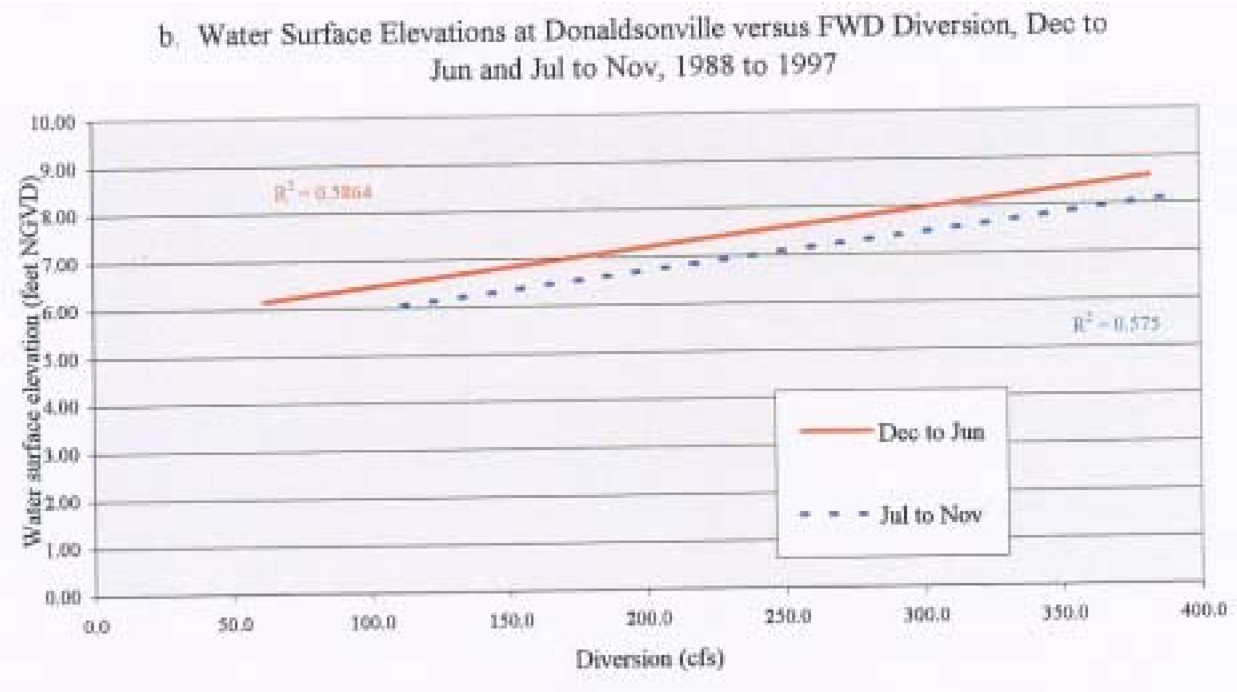


Figure 4.2-2. Diversion-stage relationships in Donaldsonville.




b. Water Surface Elevations at Donaldsonville versus FWD Diversion, Dec to Jun and Jul to Nov, 1988 to 1997
Water surface elevation (feet NGVD)
10.00
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
R^2 = 0.5864
R^2 = 0.575
Dec to Jun
Jul to Nov
0.0
50.0
100.0
150.0
200.0
250.0
300.0
350.0
400.0
Diversion (cfs)

4.3 HEC MODELING

4.3.1 Introduction to the HEC models

For EPA's evaluation of the project, the modeling of flow conveyance and sediment transport through Bayou Lafourche was developed by Hassan Mashriqui, under the direction of Dr. Paul Kemp at Louisiana State University. Refer to Appendix A for abstracts of the Mashriqui and Kemp reports. Portions of the LSU work were funded by the Louisiana Department of Natural Resources, as part of the State's cost-share of the project evaluation.

LSU used the "HEC" models published by the Hydrologic Engineering Center of the U.S. Army Corps of Engineers. For assessing river flow conditions, the principal models used were HEC-2 (version 1.01) and its latest upgrade HEC-RAS (version 1.15). These models calculate one-dimensional water surface profiles for steady-state flow conditions in a simple channel network. The models are particularly well suited to assess changes in water surface profiles due to channel improvements, such as dredging. The models are not expected to be able to accurately simulate stages or velocities in tidal channels that experience time-varying or reversing flows.

Sediment transport and retention were simulated using the HEC-6 open-channel hydraulic model. HEC-6 computes sediment transport by grain size over the long-term (up to 50-years in the runs reported here). HEC-6 follows the Vanoni approach in depositing sediments introduced in suspension (Vanoni, 1975), which is based on reservoir fill studies. Sand, silt and clay fractions deposit at 93, 65 and 30 pounds per cubic ft, respectively, and create a material to be dredged that has a density that is the product of the combined sedimentation. No consolidation occurs until after Year 1. Afterward, the deposit consolidates at a rate consistent with its composition, so that clays consolidate most while sands do not consolidate at all.

Both model types are described in further detail in the LSU reports.

4.3.2 Overview of modeling procedure

The extensive use of HEC-RAS and HEC-2 can be characterized in terms of the background information obtained, and several types of simulations: duplication runs; verification runs; optimization runs; and sensitivity runs. In addition, the HEC-6 model was run to evaluate sediment transport conditions.

Background information. As described in Mashriqui and Kemp (1998), background information was acquired from several sources prior to the initiation of the modeling work.

- Bayou Lafourche cross-section geometry, stage-discharge at several stations, and pump information were obtained from the FWD.
- The current accuracy of cross-section data used was verified with additional surveys performed by Pyburn and Odom.
- The USGS Water Resources Data Report Series for Louisiana provided discharge and stage information for Bayou Lafourche at Donaldsonville and Thibodaux.
- Cross-sections from Thibodaux to the GIWW were obtained from the USACE, as were all input files used in the Corp's HEC-6 work.
- Bridge and weir design data were acquired from the Louisiana Department of Transportation and Development (LDOTD).
- Additional information on Mississippi River stages, and the sediment properties of the Mississippi River and the bayou was obtained from the open scientific and engineering literature, from the personal files of the authors of the LSU report, and from additional unpublished USGS and USACE stage, discharge and water quality measurements.
- Information on downstream boundary conditions at the intersection of Bayou Lafourche and the GIWW was derived from UNET modeling work described in Section 4.4.
- Bed materials were sampled and analyzed by Pyburn and Odom.

- Field investigations were carried out on water and by land to examine the existing Lemann pump facility and outfall area in Donaldsonville, to locate sections where the Bayou is constricted or where bank elevations are low, to note the location and condition of bridges, to identify drainage features, and to identify locations where additional survey work is required.

Duplication runs. The USACE had previously done a HEC-6 model of Bayou Lafourche from the railroad crossing in Donaldsonville to the weir at Thibodaux (USACE, 1994). LSU duplicated this model and then used the channel surveys performed by Pyburn and Odom (see abstract of 1997 survey report in Appendix A) to verify the model cross-sections, and to resolve datum inconsistencies. Cross-sections for the Thibodaux-Larose reach were added in order to allow simulation of weir removal. In total, 174 regular channel cross-sections were used in the model, with average approximate spacing at one-quarter mile intervals. In the reach between Donaldsonville to Thibodaux 133 sections were provided, of which 88 (64%) were spaced 1000 ft apart and 45 were 2000 ft apart. The average distance between cross sections was 1330 ft. Between Thibodaux to Larose there were 41 cross-sections, most at one-mile spacing. The model thus extended over a 67 mile length of the bayou. Additional specialized cross-sections were added for certain bridges, as discussed subsequently.

Verification runs. The concept of calibration is to use real-world data to adjust model parameters so that realistic results are obtained. Data are not available to calibrate a Bayou Lafourche flow model, especially for the high-flow conditions that would occur with a greatly enlarged diversion. The concept of verification is to test model outputs against real-world data to see if reasonable results are obtained; the model is not adjusted in this procedure. Verification of the model was performed by LSU, using the following procedure.

- 22 data sets were selected where a given daily flow rate was observed at Thibodaux, and there was a concurrent staff gage rating of water levels in Donaldsonville. The flow rates ranged from 110 to 1,530 cfs.

- For each data set, the model was run assuming that the flow diverted at Donaldsonville was equal to the flow observed at Thibodaux. The predicted bayou level at Donaldsonville was compared to the actual level.
- The model results showed good agreement between predicted and observed water levels when the assumed rate of diversion into the bayou was close to the actual diversion rate. The predicted stages averaged about 0.3 feet lower than the observed stages.
- For many runs, including most simulations with an assumed diversion greater than about 300 cfs, the model predicted a higher stage than actually observed. This error occurred on dates when the high flow at Thibodaux was the result of runoff below Donaldsonville. Thus, the model assumption that the flow originated as a diversion at Donaldsonville was incorrect, and the result was to over-predict Donaldsonville stages.

Based on these results, the basic structure of the HEC model reasonably represents bayou conditions at existing diversions but has not been demonstrated by use of actual data to be correct for higher diversions. This lack of verification at high flows is inherent in the problem being modeled: there are no real-world data for high rates of diversion into Bayou Lafourche that can be used to verify any bayou flow model.

The lack of actual data for a future high-rate diversion is the primary reason for relying on a model to predict diversion impacts. The LSU model is a reasonable choice for this purpose for the following reasons: 1) the model is reasonably verified for current conditions; 2) the model is based on fundamental principles of channel hydraulics that are clearly applicable to Bayou Lafourche; 3) the model is well-established and frequently relied on for channel evaluations throughout the United States, and indeed the world; and 4) it will be possible to phase in any new diversion by gradually increasing flows, and this will allow the model to be more fully verified before continuous, full-scale operations are initiated.

Optimization runs. The verified model was used to simulate many concepts for modifying the Bayou Lafourche Project. For example, HEC-RAS was used to determine if dredging could meaningfully improve channel capacity while preventing batture flooding. Similarly, the model was used to determine if removal of the Thibodaux weir could substantively impact channel capacity, and to conceptually design the sand trap. The results of such runs were used as background to the more detailed optimization runs described below.

The greatest amount of time spent in the flow modeling was to test different combinations of channel improvements and diversion rates, in the context of different criteria for what could be considered as an acceptable future water level in Bayou Lafourche. A typical example was to assume an overly large amount of dredging throughout the channel and the diversion of a steady water rate, such as 1,000 cfs. The resulting water levels were then compared to the reference profile in Figure 3.4-1. Since the initial dredging had been overly large, there was generally a substantial freeboard between the predicted water level and the reference profile. The dredging cross-sections were then adjusted incrementally to reduce the amount of dredging. As the process was continued, model outputs were inspected to ensure that changes in one part of the channel did not have unacceptable impacts on reaches just upstream or downstream.

These types of model runs were continued until the predicted water level profile was reasonably smooth through the entire length of the bayou, and clearly at or (preferably) below the reference line. The resulting cross-sections thus would represent the minimum amount of channel improvement needed to convey the flow without causing a rise in water levels; and the volume of dredging needed to achieve the cross-sections would represent the basis for determining the costs of improving the channel.

Note that this procedure does not represent a conclusion that a given water level is acceptable. If, for example, it were determined that water levels need to be a specific level lower than the reference line, then for a given amount of specified dredging the total diversion quantity would simply be reduced; or for a specified diversion, the amount of dredging would be increased.

Application of the flow model involved dozens of iterative runs that considered different diversion rates and levels of channel improvements. For example, dredging was simulated in amounts as much as 10 million cubic yards (a level which permits conveyance of 2,000 cfs within the criteria, at substantial expense). Selected results of these optimization runs are discussed in Chapters 5 and 6 of this report.

Sensitivity runs. Channel roughness had been selected by USACE as 0.021, which is a value typical of alluvial channels. The coefficient was not changed in these runs, or in any other simulation except for sensitivity tests done specifically for the purpose of evaluating the effects of roughness. The downstream boundary condition, water level in the GIWW at Larose, was typically +1.5 feet NGVD, but sensitivity runs were made at stages ranging from 0 to +3 feet. (Some runs also used +1.5 feet at Company Canal in Lockport.) Sensitivity tests also were made to assess the extent that the model results were not affected by inclusion or exclusion of bridges. Sensitivity run results are described below; see also the LSU reports.

4.3.3 Effects of channel constraints

Many specific model outputs are discussed in the context of particular alternatives; see, for example, Section 5.6.2. Some more general model results are summarized below to illustrate the role of the flow model in project planning and design. Channel constraints other than cross-sections are discussed in Section 4.3.3; dredging is presented in Section 4.3.4.

General characteristics of the bayou for modeling purposes. The following characterization of the bayou is taken directly from Mashriqui and Kemp (1998).

- For modeling purposes, the free-flowing Bayou starts at the Donaldsonville gage location, immediately below the railroad crossing, about 2,300 ft from the Mississippi River. The rest of the 67 mile reach between Donaldsonville and Larose can be divided into four hydrologically distinct segments.

- The first segment consists of the first 10 miles downstream of the gage. Channel side slopes vary from about 2:1 (horizontal:vertical) to 5:1, but are quite variable. The thalweg for segment 1 drops from +4 to -4 ft.

- The second segment extends 20 miles to Thibodaux. The thalweg in segment 2 has no slope, but varies between -1 and -6 ft, with most values between -3 and -2. Natural bank elevations drop from 24 to 14 ft between Donaldsonville and Thibodaux. Side slopes for this segment show less variation than upstream, generally ranging from 3:1 to 4:1.

- The weir at Thibodaux is currently set to maintain reservoir water levels above 4 ft. It influences stage, flow and sediment deposition in the upper two reaches, exerting most influence under low flow conditions. At 1,000 cfs discharge, it would continue to elevate stage for most of the reach between Donaldsonville and Thibodaux. The Thibodaux weir stabilizes water levels, and thereby limits rapid bank dewatering associated with changes in discharge, so it currently exerts an ameliorating effect on bank stability that must be considered as plans are made to replace this structure.

- The Bayou becomes wider and the thalweg gradually drops to -10 ft in the third segment between the Thibodaux weir and Lockport, about 30 miles downstream. This reach is open to tidal influences from the Gulf of Mexico and to flows from the Atchafalaya River and the Houma Navigation Canal that enter the Bayou through the Company Canal at Lockport and through the GIWW. Side slopes south of the Thibodaux weir are generally in excess of 5:1.

- The fourth segment is approximately 10 miles in length and connects Lockport to Larose. Thalweg is uniform at -10 ft. Stages at the intersection of Bayou Lafourche and the GIWW range from 0 to 3 ft, and average between 1.0 and 1.5 ft, NGVD. Flow from upstream appears to have relatively little influence at present on stage or discharge in the fourth reach. Natural bank elevations drop from 14 to 7 ft between Thibodaux and Larose.

- The Bayou generally flows through only a portion of the old channel cross-section, much of which is now mowed or wooded. The relatively small area currently occupied by water can be contrasted with the level "batture" that is not normally flooded, and the steeper walls of the original channel that flatten off at the level of the roads on either side. Some owners have landscaped the "batture" and others have planted gardens and constructed structures or outbuildings in this area.

Effects of the Thibodaux weir. Figure 4.3-1 shows model output for existing channel conditions, for flows that range from 150 to 340 cfs; the stage in the GIWW is assumed to be 1.5 feet NGVD. It can be seen that the first seven miles of the Bayou are shallower and the thalweg has a steeper slope than anywhere else. Figure 4.3-1 clearly shows how water backs up behind the Thibodaux weir. The effects of the weir are further shown in Figure 4.3-2, which illustrates the flow line for a 340 cfs diversion with the weir, and without it. (In all these simulations, it is assumed that there is no other inflow to or diversion from the channel; thus the 340 cfs passes through to Thibodaux and Lockport.)

The two figures indicate that without the weir, water levels at Thibodaux for a discharge of 340 cfs would be about three feet lower than with the weir. The impact of eliminating the weir is less upstream, but is still several inches even in Donaldsonville. Other model runs, not graphed here, show that the impacts of the weir are significant at flows of at least up to 1,000 cfs. However, at a flow of 2,000 cfs or greater, and in the absence of dredging, the weir would be so submerged that its impact would be comparatively minor. On the basis of these results, removal of the Thibodaux weir is an important component of any project that aims to increase flows in Bayou Lafourche, without increasing water levels.

Effects of bridges. Existing stream crossings in the Donaldsonville area are discussed in Sections 3.3.1 (Highway 3089) and 3.3.2 (railway). The most constrictive of the other bridges is a former railroad bridge that crosses the bayou above Napoleonville, at Assumption High School; see list of bridges in Table 2.3-2. This structure is now permanently closed and used as a footbridge. Because it was designed to pivot, one of the supporting piles blocks considerably more of the channel than is true for any other bridge. Model results indicated that even at 2,000 cfs, the bridge caused a negligible effect on backwater stages; i.e. the increase in stage was a few inches or less for representative flows.

Additional analyses looked closely at the cumulative effect of numerous bridges. Water levels were computed for conditions with and without several bridges; the difference represents the impact of the bridge structures. The typical effect of a pile-supported bridge was modeled as causing a backwater effect of less than 0.01 foot per bridge, at a discharge of 1,000 cfs if the channel were dredged beneath the bridge. Thus the cumulative effect of all bridges is only a few inches. However, the model indicated that if the channel is not dredged beneath the bridges, the backwater effect would be about 0.06 feet per bridge. This effect would accumulate to more than 1 foot (at Donaldsonville). Under the no-dredge scenario, velocities in excess of 2.5 fps were computed at some of the upstream bridge sections, suggesting that the “humps” left might experience scour.

Based on this result, it will be necessary to dredge the channel beneath bridges to depths that are comparable to upstream and downstream channel sections. The 1994 HEC-6 model developed by the USACE did not include engineered features like bridges. The final HEC-RAS model developed by LSU explicitly included five bridges.

Stage in the GIWW. Figure 4.3-3 provides another kind of model result, namely the effect of stage (water level) in the GIWW on stage (water level) in the bayou. These runs represent outputs assuming removal of the weir at Thibodaux, and a diversion of 1,000 cfs. Runs are shown for GIWW stages of 0, 1.5, and 3 feet. As illustrated previously in Figure 2.3-2, except in very unusual conditions, actual stages in the GIWW near Houma are in the 1 to 2 foot range.

The effect of higher stages in the GIWW is to increase stages in the bayou, and vice versa. These effects diminish upstream, so that by Thibodaux (mile 32) the effect of a 3 foot stage difference in Larose is only about 0.5 feet. At Donaldsonville there would be no tidal effect whatsoever, even without the weir in place. Note that simulations of tidal effects and of channel flows below the weir done using the UNET model (Section 4.4) showed very similar results to the HEC model. In all subsequent HEC-RAS runs, a GIWW stage of 1.5 ft. NGVD was assumed.

The use of figures to illustrate the combined effects of very high stage and high discharge are for purposes of showing model results, and do not suggest that a diversion would continue to operate if a storm surge were to effectively block the bottom of the bayou.

Roughness. Mashriqui and Kemp (1998) provide an extensive discussion of the roughness coefficient that is an important determining factor in calculation of water conveyance through a channel. They note that the Manning's roughness coefficient selected by the USACE, 0.021, is typical of a relatively straight earthen channel (Chow, 1959), and is reasonable for reaches of Bayou Lafourche that are not impacted by bed or bank vegetation.

Sensitivity runs were done using values from 0.015 to 0.030. Over most of the reach above Thibodaux, this range of roughness values could cause stages to increase by one foot or more (if the channel is rougher than assumed in the model runs that use 0.021), or to decrease by almost as much if the channel is smoother than assumed.

Qualitative observations of water levels in Donaldsonville suggest that water levels there are higher than might be calculated using model equations that rely on a roughness factor of 0.021. Many causes could explain this observation (see discussions in Section 4.2), but one of them is that the actual channel roughness today is greater than 0.021. Two factors to consider are that channels become more efficient at higher flows, and channel dredging can be expected to produce a smoother, more homogeneous channel than the one existing today. These factors suggest that roughness in a future with the project may be less than it is today. Kemp and Mashriqui concluded that there is currently no empirical basis for changing ‘n’ from 0.021, but that this value should be investigated further during project design.

4.3.4 Effects of channel improvements

As discussed above and in Section 3.4, project design involved configuration of an “optimum” dredging program to deepen Bayou Lafourche so that it can carry more water without causing an increase in water levels. The HEC model was the primary tool used in the actual determination of where dredging is needed, and how much material must be removed from the channel and disposed of safely.

The use of the model for this purpose is illustrated in Figure 4.3-4. The two solid lines represent the channel bottom elevation, before dredging (light, irregular line) and after dredging (heavy, more regular line). This particular example is the model output for the optimized project that is discussed in Chapter 5, and represents more than 3 million cubic yards of dredging. The effect of such dredging is to produce an essentially flat channel bottom at -4’ NGVD above Thibodaux, and at -6’ from Thibodaux to about Raceland. Exceptions in the uppermost reaches reflect the sand trap and railroad culverts. Note that the nature of the model is to extrapolate between dredged sections; thus the dredged line appears to fill in existing deep channel sections, which would not in fact be the expected practice.

Figure 4.3-5 conceptually illustrates the effect of channel improvements, in combination with removal of the weir and continued channel maintenance such as the cutting of *Hydrilla*. The upper dark line reflects flow conditions in the bayou in 1996, when diversion rates were less than 200 cfs. The line just below that line shows flow at 340 cfs with all the improvements. (The channel bottom profiles before and after dredging are shown at the bottom of the graph and are the same as in Figure 4.3-4).

The model runs indicate that for flows that are within the capacity of the existing diversion works, the effect of dredging and removal of the weir would lower water levels near Donaldsonville by up to four feet. The change at Thibodaux would exceed two feet. The effects in the tidal reach of the bayou would be comparatively small.

The difference between the two flow lines represents freeboard, or room for additional flow. This freeboard can be used to convey a larger diversion, or storm flows, or a combination of the two types of water.

Figure 4.3-6 shows water level profiles for the same improved channel as described above, for different rates of diversion ranging from 500 cfs to 1,000 cfs, in 100 cfs steps. These profiles show the extent to which greater flows increase the water level in the bayou. For example, based on the model results, nearly doubling the diversion rate from 500 to 1000 cfs would raise water levels by about 2.5 feet, and would use most of the freeboard created by the channel improvements. The near-constant slope of the flow-line curve is an indication that the weir has been removed, and conveyance improved to uniform conditions along the bayou. The triangles on the graph represent values from the reference profile in Figure 3.4-1 and indicate that 1,000 cfs is about the largest diversion that can be contemplated, for dredging that is on the order of 3 million cubic yards.

Channel improvements that lead to the results shown in these figures are predicted to have relatively minor effects on average velocities predicted by the model. Maximum projected velocities for a 1,000 cfs diversion in an improved channel range between 0.5 and 1.6 feet per second. For comparison, USACE's 1994 study had identified 2.5 feet per second as the velocity above which there could be a risk of channel scour.

The overall results shown here are common sense: 1) all else being equal, the greater the rate of discharge, the higher the water level in Bayou Lafourche; 2) all else being equal, the greater the amount of dredging, the lower the water level in Bayou Lafourche; and 3) the amount of channel dredging needed to maintain the bayou at historic levels increases as the amount of river diversion increases. The value of the model is providing a quantitative basis for optimization, in order to approximate the maximum amount of diversion that may be accomplished without exceeding the reference profile and without causing an unacceptably high dredging cost.

4.3.5 Simulation of sediment transport and retention

The HEC-6 simulations used channel configurations from HEC-RAS plus assumptions about sediment inputs and outputs, to predict the amount of sediment transported through a channel reach, the amount deposited, and the resulting effect of the deposition on bottom elevations. The model's resulting calculations of water levels were not used, as HEC-RAS is considered more appropriate for evaluating water-level conditions (e.g. it can include bridges). Most runs assumed constant sediment and water inputs; some runs also simulated the effects of maintenance dredging. (The latter were done after completion of the 1998 LSU report and are not described in that report; the model results are presented in Chapter 5.)

It was expected that siphoned or pumped discharges can have a sediment load that may be somewhat different than Mississippi River concentrations. Mean sediment concentration and distribution between coarse (sand) and fine (silt and clay) fractions was determined for data collected at biweekly intervals by the USACE and USGS at Tarbert Landing on the Mississippi River north of Baton Rouge between January 1989 and September 1994. Mean concentration averaged 226 ppm for this 5 year period. Sand contributed 26 percent, and clay and silt contributed somewhat higher percentages, between 30 and 40 percent each.

Concentrations at Donaldsonville are expected to be somewhat lower than Mississippi River Tarbert Landing concentrations and the sand content of pumped or siphoned inputs might be quite a bit lower. River water was put into the HEC-6 model with the suspended sediment characteristics shown in Table 4.3-1. The values used by USACE (1994) also are shown in the table. LSU chose a relatively conservative 100 ppm concentration, of which 1 percent is sand, 59 percent is silt and 40 percent is clay. It should be noted that this was five times higher than the 21 ppm selected by USACE. Much of the difference arises from the very small percentage of clay introduced by the USACE modelers. The LSU model also assumed that when deposited, the finer-grained sediment is very fluffy; consolidation occurs over time, as shown in Figure 4.3-7.

Figure 4.3-8 illustrates one result of the sediment modeling. The model output shown in the figure is the quantity of sediment, in cubic yards, either retained within the bayou above Larose, or transported past Larose, in an average year (based on a 50-year model run). The model results indicate that the maximum retention (deposition) rate occurs at a discharge of between 800 and 1,000 cfs. In effect, this reflects the ability of the flow to carry silts. At flows below 800-1000 cfs, velocities are sufficient to carry the clay, but not to carry silt and sand all the way through the bayou. At higher velocities, much more of the silt is transported (along with the clays); but even at the highest flow rates shown, sands remain within the bayou.

The HEC-6 model predicted that, at a 1,000 cfs constant discharge, 50 to 60 percent of clay sediments from the River, about 20,000 tons per year, would pass through the modeled channel, while virtually all of the sand and silt would deposit between Donaldsonville and Larose. At the end of 5 years, 40 percent of all sediment introduced is retained in the first 5 miles. In the absence of a sand trap and channel maintenance, these materials would cause the channel bed to build upward toward the profile that existed prior to dredging; see Figure 4.3-9 which, as in the prior paragraph, assumes a 1,000 cfs diversion. This accumulation would begin at the uppermost part of the channel. Channel maintenance in that area would be required to ensure that deposition on the order of 70,000 tons per year does not unacceptably reduce conveyance.

It should be noted that while the HEC-6 model does balance mass, it does not balance volume, because of the size-dependent consolidation rates. Accordingly, sediment volumes shown entering a given reach do not generally equal the sum of volume passed and volume retained in a deposit on the bed, except for sand. Velocities are so low that scour is not predicted to occur in

Bayou Lafourche. The average annual deposition predicted from a 5 year run adds up to 46,657 cubic yards per year, of which 1 percent is sand, 90 percent is silt and 9 percent is clay.

Figure 4.3-1. Backwater curves for existing channel conditions.

Bayou Lafourche HEC-RAS Model

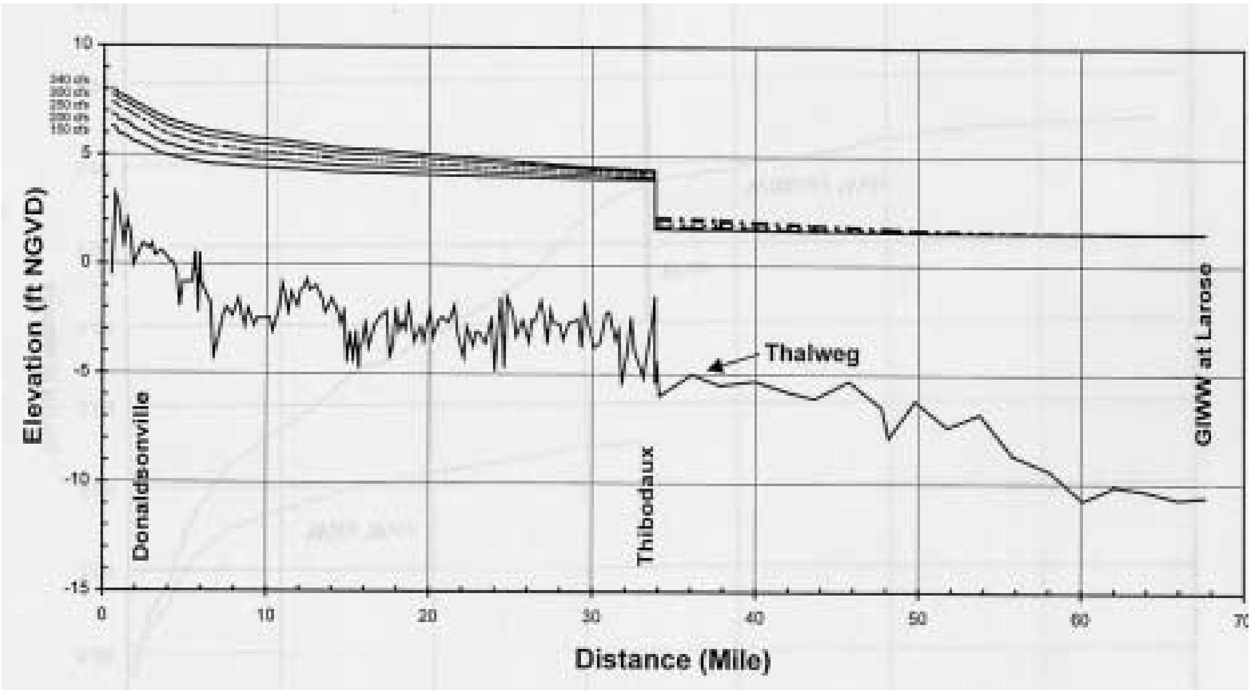


Figure 4.3-2. Effects of removing weir at Thibodaux

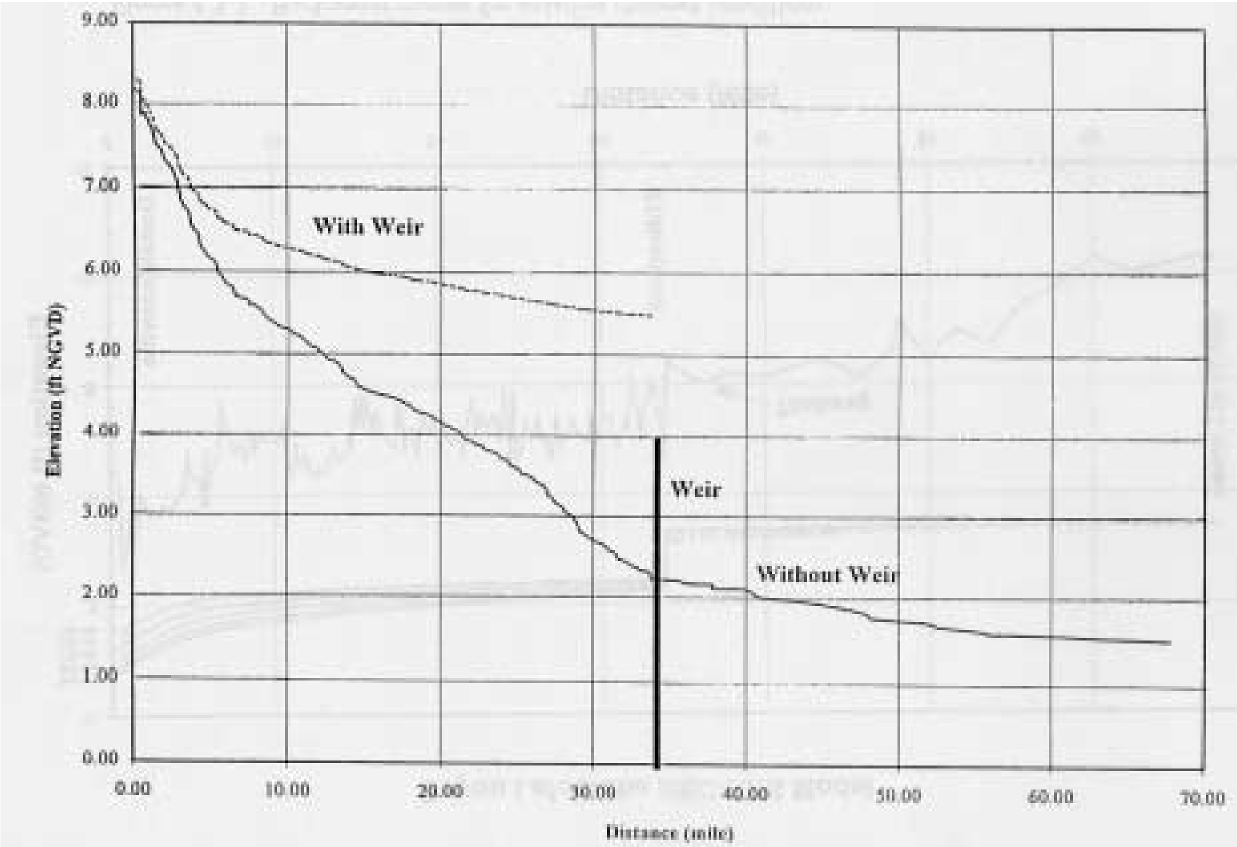
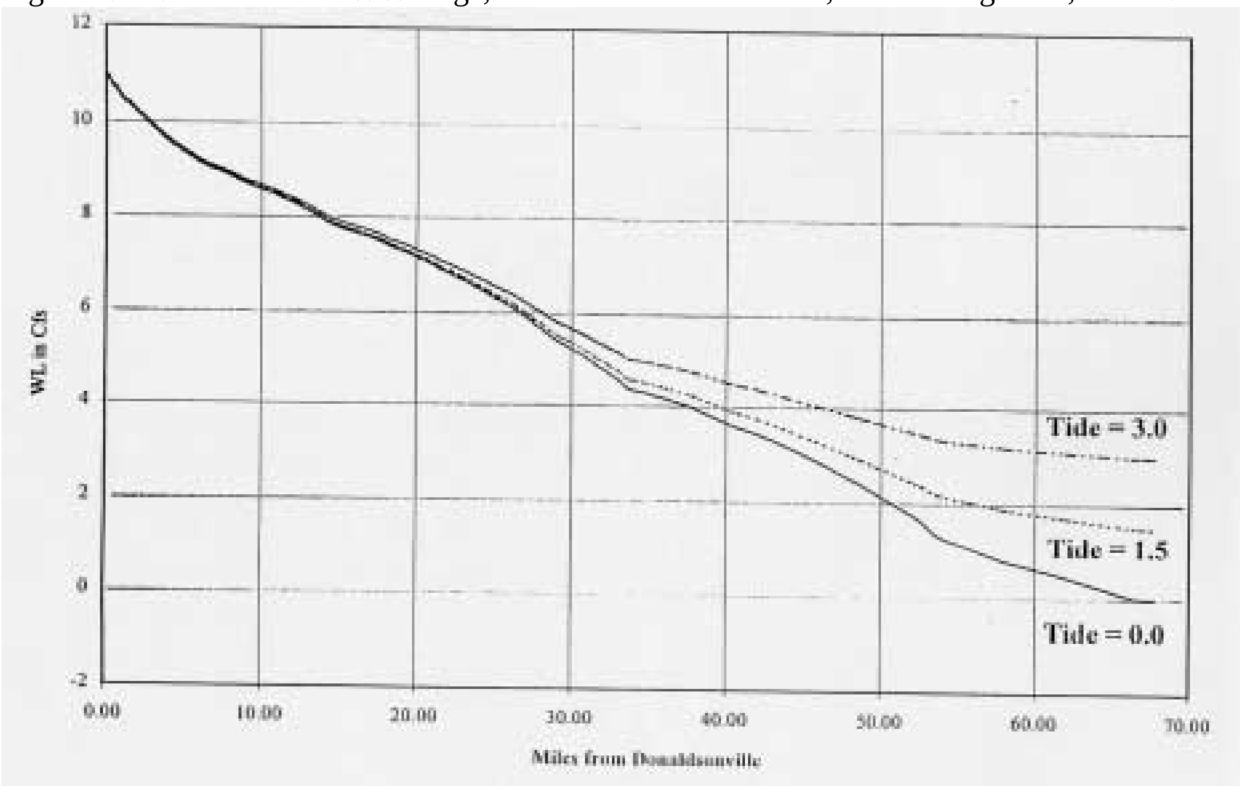


Figure 4.3-3. Effects of GIWW stage, in the absence of the weir, for discharge of 1,000 cfs.



PRELIMINARY: DRAFT

Figure 4.3-4. Effects of dredging on channel bottom in Bayou Lafourche.

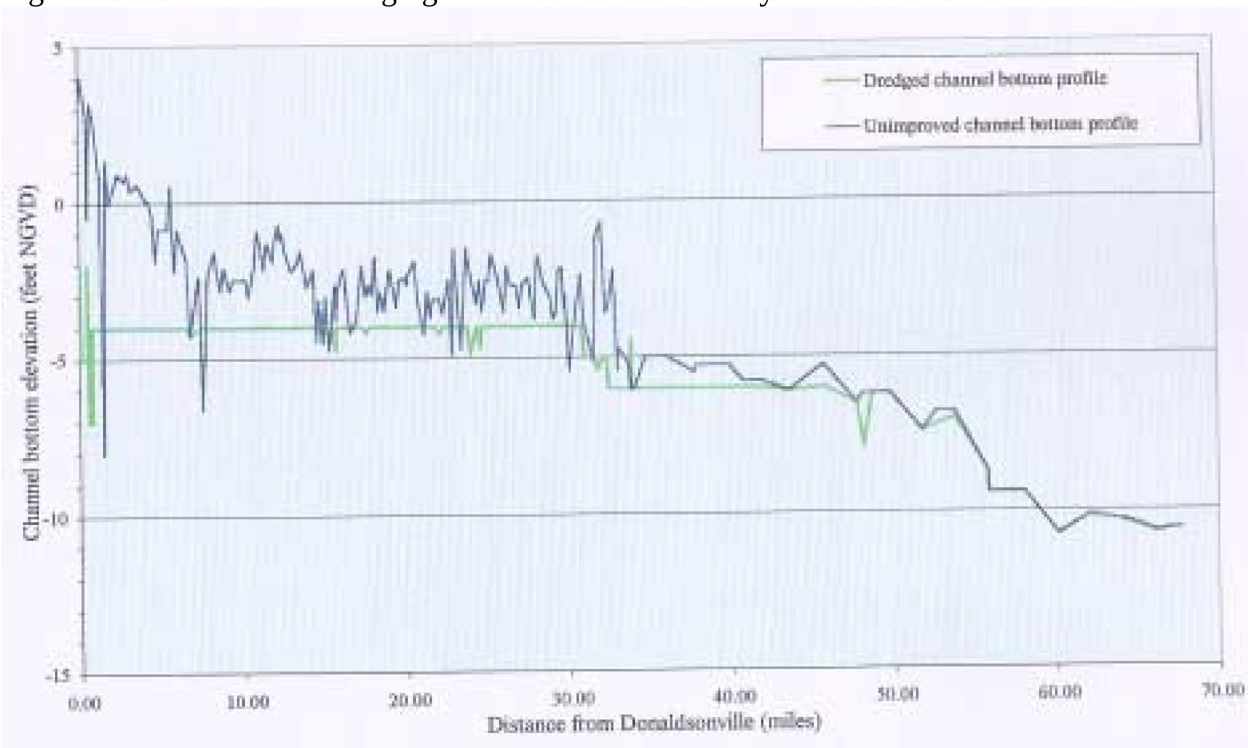
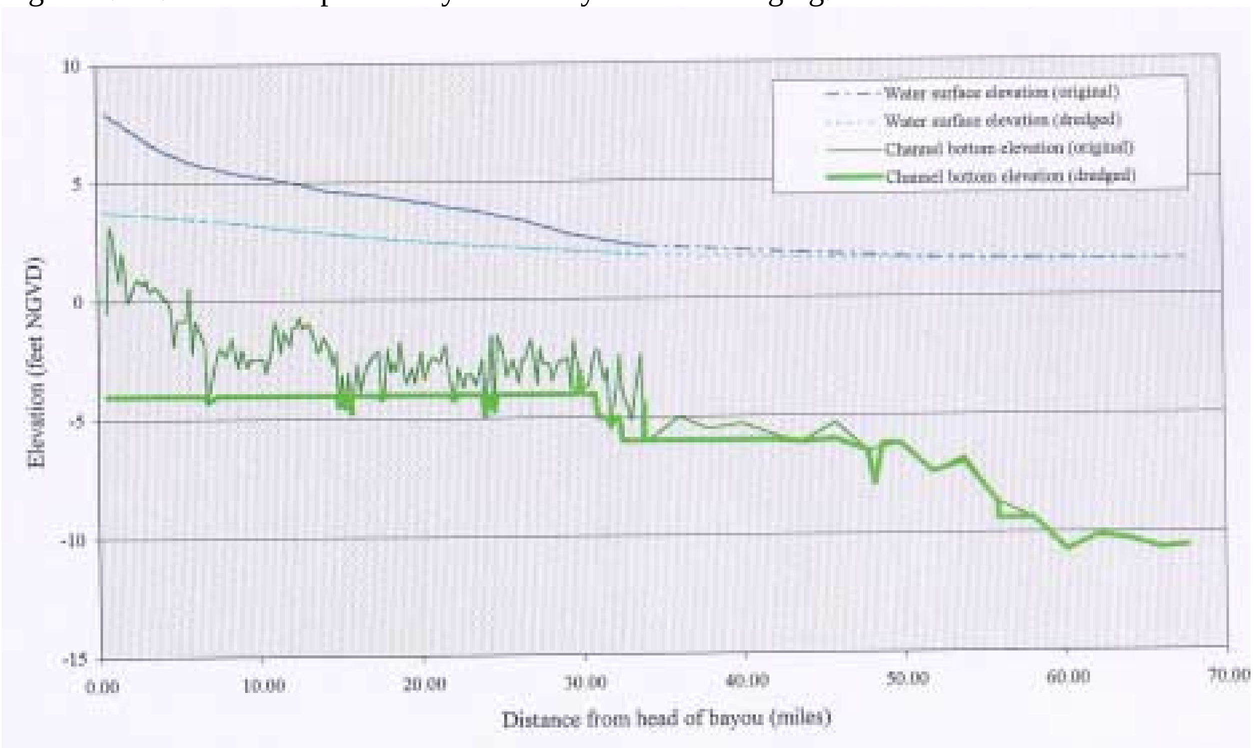
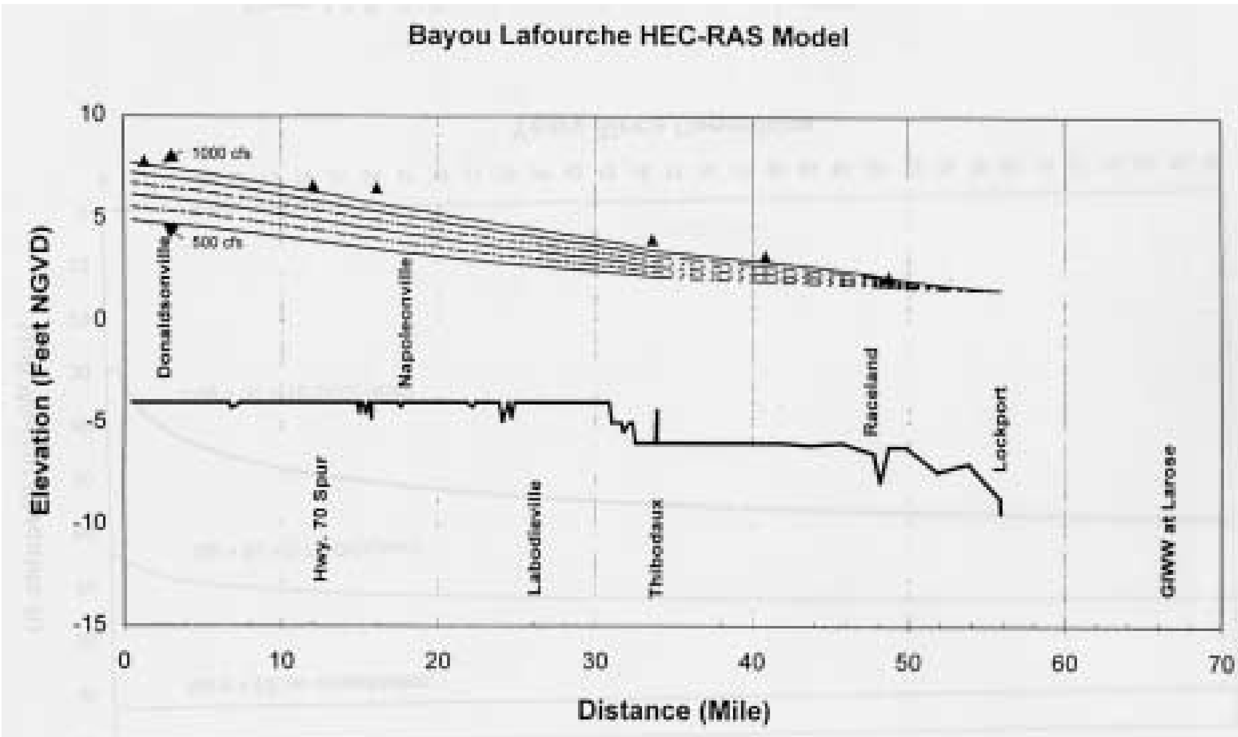


Figure 4.3-5. Freeboard potentially created by channel dredging.



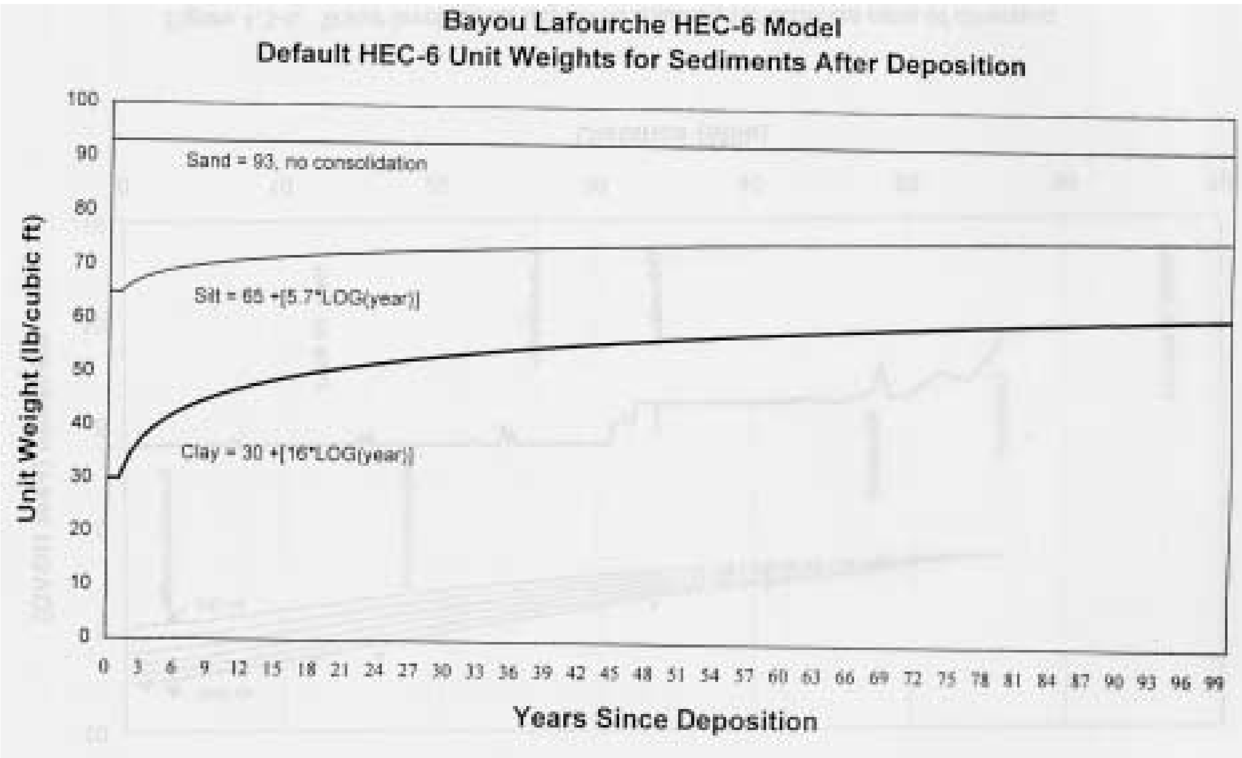
PRELIMINARY: DRAFT

Figure 4.3-6. Water levels in an improved channel, for different rates of diversion.



PRELIMINARY: DRAFT

Figure 4.3-7. Sediment compaction curves used in HEC-6 model.



PRELIMINARY: DRAFT

Figure 4.3-8. Annual sediment retention and yield at Larose.

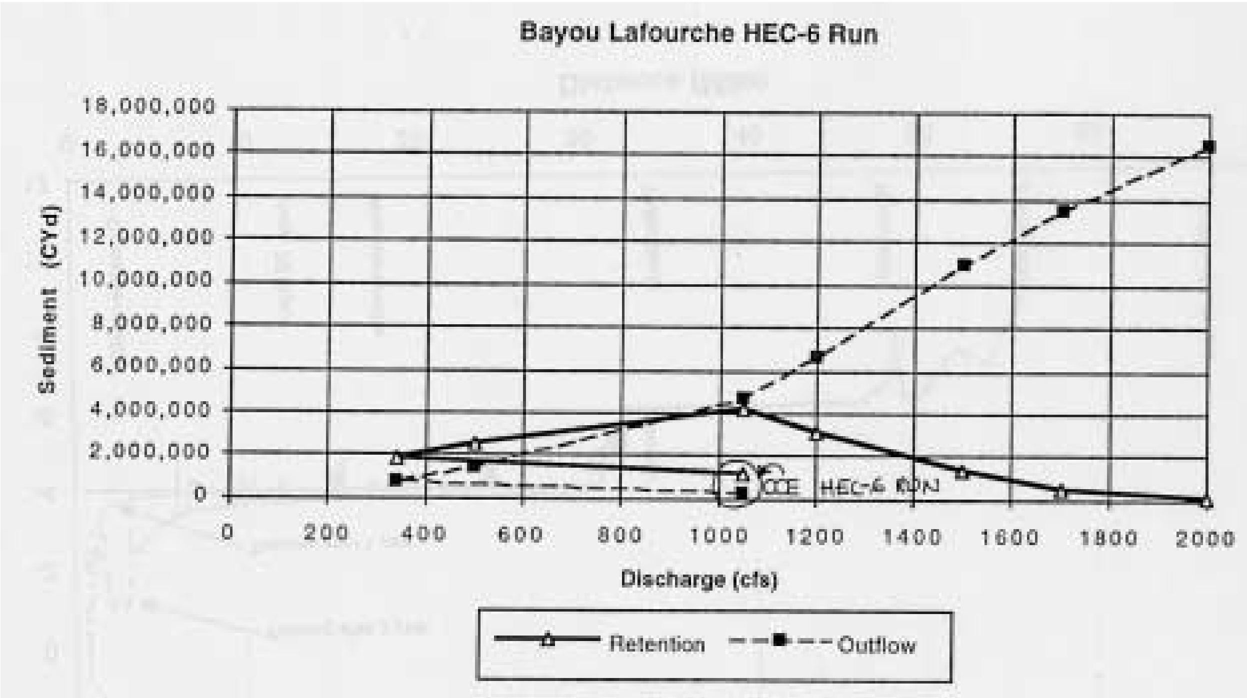


Figure 4.3-9. Channel profiles simulated by HEC-6, in the absence of maintenance dredging.

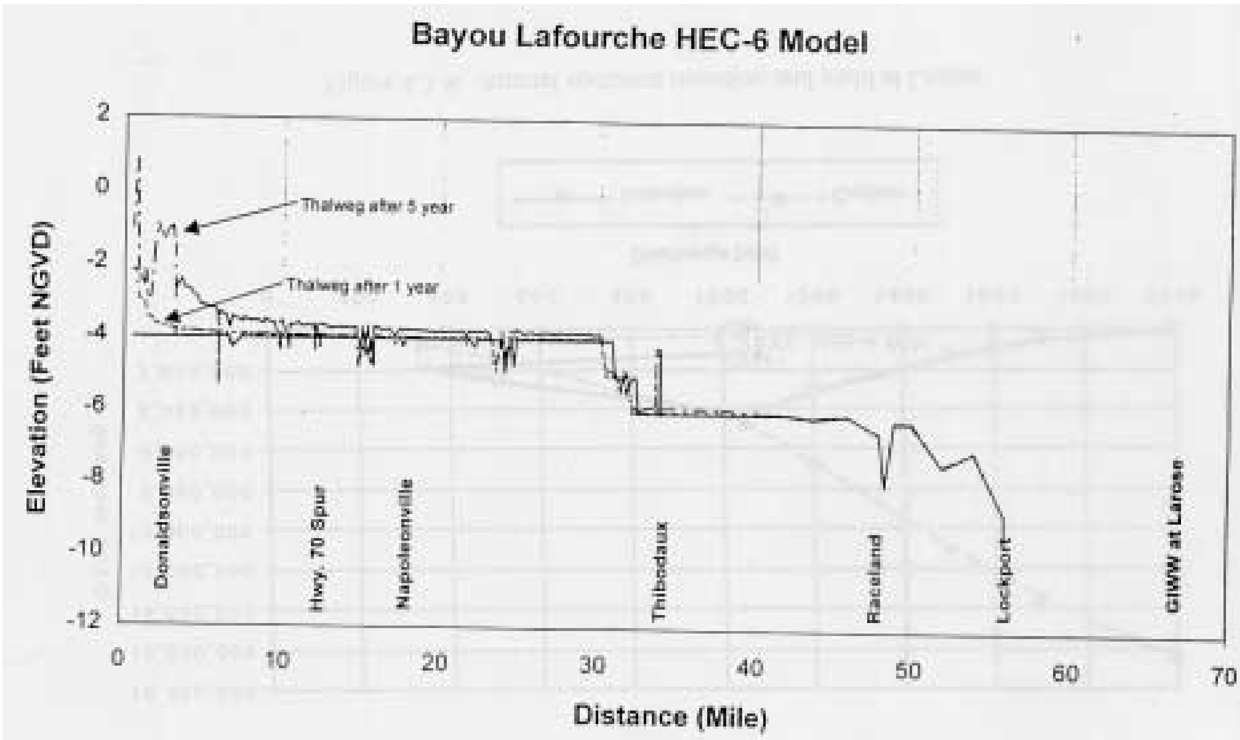


Table 4.3-1. Suspended sediment input characteristics

Name	Grain Type	Percent of the total sediment load input into model: USACE	Percent of the total sediment load input into model: LSU	Mean actual values at Tarbert Landing
Clay	Clay	8.900	40.000	
Silt	Silt 1	22.570	15.000	
Silt	Silt 2	22.570	14.800	
Silt	Silt 3	22.570	14.800	
Silt	Silt 4	22.570	14.800	
Sand	VFS	0.650	0.420	
Sand	FS	0.153	0.174	
Sand	MS	0.17	0.006	
Sand	CS	0.000	0.000	
	TOTAL	100	100	
Sediment Conc. (PPM)		20	100	226
	Clay (PPM) %	8.9	40	
	Silt (PPM) %	90.28	59.4	
	Sand (PPM) %	0.82	0.6	26

4.4 UNET MODELING

4.4.1 Introduction to the UNET model

The goal of the UNET modeling work was to describe the distribution and impacts of diverted water under different existing hydrologic conditions and for a variety of diversion inputs. The UNET model was selected to accomplish this because it simulates flows in multiple channels that are hydrologically linked, which makes a suitable analog for the distributary channels in the Bayou Lafourche study area. The modeling was done by Harley Winer at the U.S. Army Corps of Engineers (USACE). Refer to Appendix A for an abstract of the work, which is cited as USACE (1997a).

4.4.2 Overview of modeling procedure

The two essential components of the UNET model, as configured for this study, are the channel network and the boundary conditions.

Channel network. The areas of interest for the current evaluation are all parts of the region that are hydrologically connected to Bayou Lafourche, and therefore might be affected by a diversion. Since Bayou Lafourche forms the border between Barataria and Terrebonne hydrologic basins, and is hydrologically connected with both basins, the model was structured to include all the major channels between the Barataria Estuary and the Atchafalaya River that are interconnected to Bayou Lafourche, including those connected through the Gulf Intercoastal Waterway (GIWW).

Figure 4.4-1 shows all the channels included in the model, with channel segment numbers and arrows showing the direction of predominant flow. Figure 4.4-1 represents the model grid. Figure 4.4-2 shows the grid superimposed on a regional map so channel locations can be easily identified. Table 4.4-1 defines all the channel reaches in the grid by channel name and beginning and ending points, and also lists the other reaches to which that reach is connected in the model. Note that the model is not structured to handle four-way channel intersections in which two channels flow in and two flow out. At the four-way intersection of Company Canal and the GIWW, a small artificial reach (# 6) was added to the model grid to avoid this problem. Channel cross-sections were taken from existing information. USACE field surveys were undertaken to provide additional sections in critical areas.

The UNET model does not support modeling of overbank flow perpendicular to the channel. USACE considered this to be a modeling concern only for the Penchant region of the model grid, where losses due to overbank flow affect how much water coming in from the Atchafalaya River is captured in Penchant and how much remains in the GIWW to flow past Houma. Channel size and friction were adjusted for some bayous in Penchant to adjust for overbank flow, so that calibration runs of the model fit USGS measurements of flows in the GIWW past Houma.

Boundary conditions. UNET can use tidally-driven boundary conditions (i.e., tidal effects can be evaluated) and time-varying hydrographs (e.g., variations due to storm runoff). However, for the purposes of this study, the UNET model was run in steady state. That is, all boundary conditions were maintained at a constant level for a given run. Each separate model run changed one boundary condition, compared to prior runs. Thus a comparison of different runs identifies the relative effect of a change in a given boundary condition.

Major freshwater inputs to the study area are the Davis Pond Diversion (under construction) into the northeast corner of Barataria Basin, and the Atchafalaya River at the GIWW on the west side of Terrebonne Basin. These inputs are accounted for in the model as steady-state boundary inputs. To mimic the full range of flow conditions to which a diversion into Bayou Lafourche would add, the low, medium, and high flows for each of these major inputs were tested. This gave a total of nine combinations of Atchafalaya plus Barataria flows tested. Average low, medium, and high flows used were 2,000 cfs, 10,000 cfs, and 20,000 cfs respectively for the Atchafalaya River; and 500 cfs, 5,000 cfs, and 10,000 cfs respectively for Barataria.

Another boundary condition was the stage of the gulf, which was set at 0 (zero) NGVD for most runs. Initial runs using a simplified channel network considered gulf stages at half-foot increments up to 3 feet, and determined that flow distributions were not sensitive to this boundary. A run using the complete channel network was done for gulf stage at 1.5 NGVD, to confirm that this boundary is not critical to distribution of Bayou Lafourche flows.

The tested range of diversion flows into the head of Bayou Lafourche included 1 cfs, 500 cfs, 1,000 cfs, 1,500 cfs, and 2,000 cfs. A value of 1 cfs rather than 0 (zero) cfs was used to represent essentially no flow into Bayou Lafourche, because a value of zero would not be handled well by the model equations. These five diversion flows were tested for each of the nine combinations of existing hydrologic conditions, giving a total of 45 model runs.

4.4.3 Overview of model results

Table 4.4-2 shows the magnitude and direction of flow for major channel reaches within the Bayou Lafourche study area for each of the 45 model runs. Positive flow numbers indicate that the direction of flow is in the predominant direction, as shown on the grid map in Figure 4.4-1. Negative numbers indicate that flow was in the opposite direction of predominant flow (i.e., flow was reversed under the conditions of that model run).

To understand how much change a diversion into Bayou Lafourche of a particular magnitude would cause, the differences in flows in the major channels between flow with no diversion (represented by 1 cfs into Bayou Lafourche) and flow with the diversion level of interest must be examined. Estimated flow increases that are predicted in various major channel segments for 1,000 cfs and 2,000 cfs diversions are summarized in Tables 4.4-3 and 4.4-4, respectively.

Charts and maps showing model outputs. A number of graphs illustrate model outputs. Figures 4.4-3 through 4.4-6 illustrate the effects which increasing Atchafalaya flows and increasing Bayou Lafourche discharges have at each level of Barataria flow on flows in various major channel segments throughout the study area. Figures 4.4-7 through 4.4-9 show how increasing flows in Bayou Lafourche affect channel flows for each combination of Atchafalaya plus Barataria inputs.

Model outputs also are illustrated using maps. Figures 4.4-10 through 4.4-13 show the distribution of water for a 1,000 cfs diversion into Bayou Lafourche under various flow conditions. Note that these maps show the distribution of hydrologic effects, not the molecules of water. For example, it is often the case that the effect of Bayou Lafourche on the GIWW near Houma is to partially block the natural eastward flow. With high water in Bayou Lafourche, flow that would have gone east in the GIWW instead is diverted south into the Houma Navigation Canal. The molecules of Bayou Lafourche water flow down Company Canal and turn east, effectively replacing the blocked GIWW water. Hydrologically, it is the Houma Navigation canal that experiences this particular diversion impact.

Figures 4.4-14 and 4.4-15 show how diverted water changes flows in various channels for a 1,000 cfs diversion into Bayou Lafourche under the situation of low-flow at the boundaries, and high flow at the boundaries, respectively.

Sensitivity test. The results of the sensitivity test for gulf stage are summarized in Table 4.4-5. In this test, the UNET model was run using a gulf stage of 1.5 feet, and with Barataria boundary inputs at 500 cfs, Atchafalaya inputs at 2,000 cfs, and flow in Bayou Lafourche at 1,000 cfs. The resulting flows in major channels are compared to those from the model run with the same boundary conditions, but with gulf stage at 0 ft (the stage which was used for all other model runs).

Increasing the gulf stage essentially reduces the overall north-south gradient throughout the grid. Since the gulf boundary (as well as all other boundary conditions and inputs) were included as steady-state conditions, any difference in the way this change in stage would be expected to affect different channels would be primarily related to differences in channel geometry. Only one channel, Company Canal east, showed a difference of more than 20% between runs. Company Canal east is the smallest channel evaluated in detail in the model. The next biggest difference was a 20% increase in flow down Company Canal west. Together, these suggest that reducing the north-south gradient in the model (i.e., using 1.5 ft. gulf stage instead of 0 ft.) reduces flow south in the bayou, with a relative increase in flow east and west. Most of the additional flow west in Company Canal appears to then go east in the GIWW and south in Bayous Terrebonne and l'Eau Bleu.

The sensitivity run shows that each change in boundary conditions results in some changes in distribution of flows among channels. But the overall picture of a regional distribution of diverted water, and the relative proportions of distribution east into Barataria, and west and south into Terrebonne Basin, appear to be reasonably portrayed in the model runs using 0 ft. gulf stage as a boundary condition.

4.4.4 Distribution of diverted water

Low-water conditions. The changes in flow seen in various channel segments for a particular size of Bayou Lafourche diversion vary as the existing hydrologic inputs on the east (Barataria) and west (Atchafalaya) sides of the study area change. In a low-flow condition as may occur in fall (Figure 4.4-10), and with a 1,000 cfs diversion down Bayou Lafourche, almost two thirds of the diverted water is projected to flow west down Company Canal at Lockport. This flow splits at the GIWW. The effects that go easterly in the GIWW interact with the effects that go through Bayou Lafourche from Lockport to Larose. This flow complexity helps illustrate the importance of using a model, as there is no other method to effectively characterize diversion impacts.

Overall, the net distribution of diverted water under low-flow conditions is 37% to the east (Barataria Basin), 35% to the west (much of which flows down the Houma Navigation Canal), and 28% to the south (to the marshes of southeastern Terrebonne Basin).

Effects of higher flow at the boundaries. The effect of higher Atchafalaya River flows is to increase the total flow in the model and to shift flows eastward. For example, for channels conveying water from Bayou Lafourche either east or south, both increases in Atchafalaya flows and increases in Bayou Lafourche diversions progressively increase flow in that channel (see Figures 4.4-7 and 4.4-12.

The effect of higher Barataria flows is similar to the Atchafalaya, but opposite in direction. Thus, increasing flows from the Barataria Basin tend to increase the amount of water from Bayou Lafourche and from the Terrebonne Basin that stays in the Terrebonne Basin (see Figures 4.4-6 and 4.4-13).

When flow conditions in both basins are high (as could occur in the spring, once Davis Pond is operating), the overall impact is a net shift to the east when compared to low-water conditions. This effect is the result of assuming that high water produces twice as much flow at the Atchafalaya boundary as at the Barataria boundary. For high water, a 1,000 cfs Bayou Lafourche diversion is distributed 46% to the east, 31% to the west, and 23% to the south (Figure 4.4-11).

General distribution of effects. Increasing flow into Bayou Lafourche progressively increases southerly or easterly flows in the channels confluent with the bayou, notably Company Canal and the GIWW; and also increases southerly flow in channels confluent with the GIWW, including Bayous Terrebonne and l'Eau Bleu, and lower Bayou Lafourche. Increasing flows in Bayou Lafourche progressively blocks flow (i.e., reduces the magnitude of easterly flow) in the GIWW west of Company Canal (east and west of Houma), and increases flow down the Houma Navigation Canal.

A 2,000 cfs diversion into Bayou Lafourche changes flows in the major channel segments more than a 1,000 cfs diversion does. The difference varies around a two-fold increase; the increase is greater than two-fold in some cases (e.g., Company Canal east and the Houma Navigation Canal under low flow conditions), but more often is slightly less than two-fold. Thus, the proportional distribution of benefits may vary slightly between a 1,000 cfs and a 2,000 cfs diversion, but net benefits would likely be approximately proportional to size of the diversion for this range of diversion sizes.

4.4.5 Proportional impacts of increased Bayou Lafourche diversion

Low-water conditions. Obviously, at low water, flows in all the area channels are lower than at high water. The effect of a 1,000 cfs Bayou Lafourche diversion at such times can be substantial. As shown in Figure 4.4-14, the increase in low-water flow in many of the channels will approximately double if 1,000 cfs is diverted down Bayou Lafourche, when compared to a situation in which there is no Bayou Lafourche diversion. Channels where the increase is roughly two-fold include lower Bayou Lafourche, Bayou l'Eau Bleu and the GIWW east of Bayou Lafourche. The flow increase in Bayou Terrebonne would be almost as high, at 71%. The effects are marked even in the largest channels, such as the Houma Navigation Canal, which would carry 26% more fresh water with a 1,000 BLF diversion than without a diversion. Note that a doubling of flow in low water conditions would be less than the flow increase that occurs in high water conditions; thus there would be no increased flooding effects.

High-water conditions. At high water, the relative changes caused by flows in Bayou Lafourche are, of course, much less (see Figure 4.4-15). The primary reason for operating a Bayou Lafourche diversion at this time of the year would be to provide a small sediment input to the system (and also to reflect the fact that operations are inexpensive, since water can be siphoned). Note that even during high water, flows in the southern receiving channels (e.g., lower Bayou Lafourche, Bayou l'Eau Bleu, and Bayou Terrebonne) are increased by about one-third. These channels are generally large, and the flow increase would be expected to impact water levels by a few inches at most.

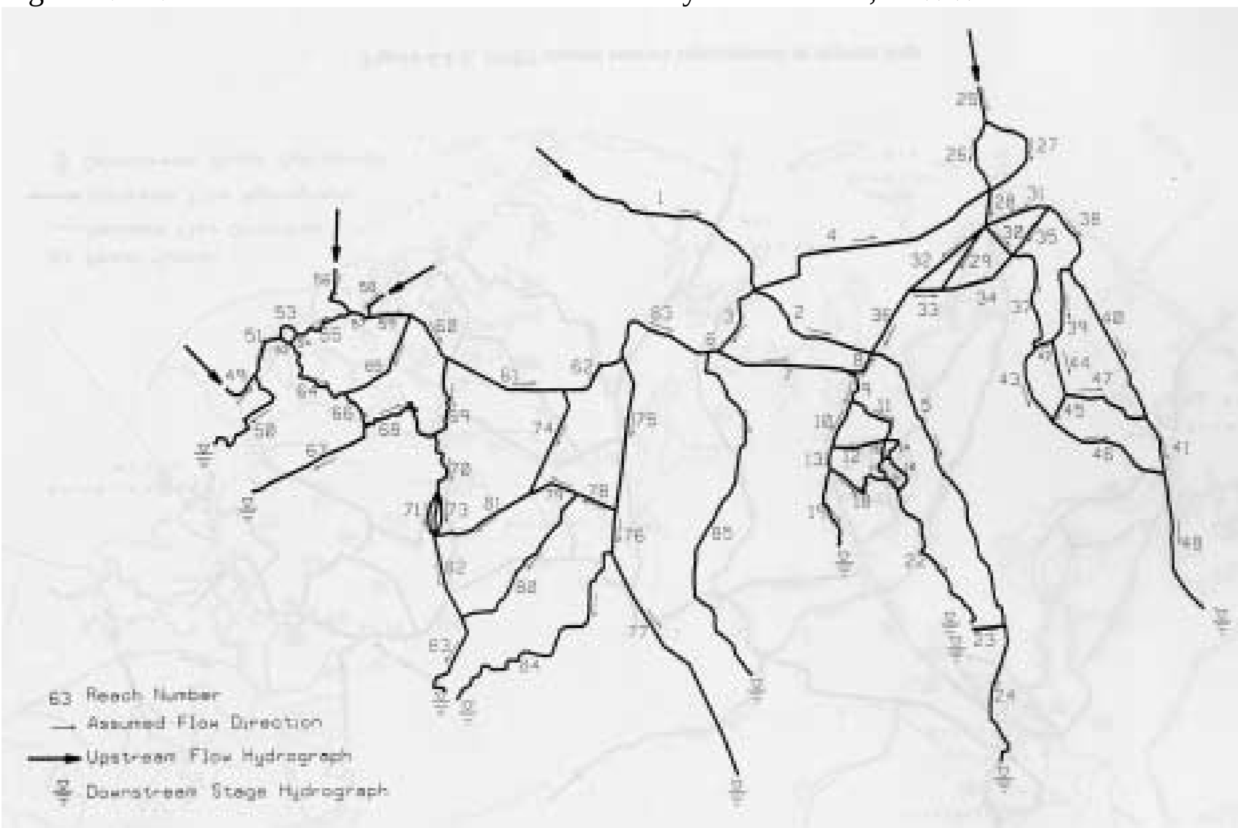
Adjustment for FWD operations. The results presented above cannot be used directly to predict the effects of a given project. Analysis of any specific project would need to account for the average amount of freshwater flow diverted by the FWD. This would include average flows that already reach the target marshes, and presumably contribute to existing loss rates (or lack thereof), as well as the average amount of water removed for consumptive purposes (e.g. industrial and municipal uses).

Since baseline marsh loss rates are calculated from satellite imagery spanning the period from 1983 to 1990, the average existing flows were calculated from FWD pumping data available from the latter portion of this period (1988-90; see Figure 2.4-1).

In addition, since differences in channel flow are evaluated for the low flow period, when contribution of the diversion is expected to have the proportionately most significant benefit, average pumping during the low flow, fall season (September to November) was used. The average fall pumping from 1988-90 is about 185 cfs. It is assumed that only water removed from the bayou for consumptive purposes (e.g., industrial and municipal uses) is unavailable to the marshes. During the fall, this is equal to about 88 cfs. The balance, (185 - 88 =) about 97 cfs, should be contributed to the marshes. The net effect of the two adjustments is that for evaluation of any diversion, a total of (97 + 88 =) 185 cfs should be subtracted from the quantity of water to be diverted at Donaldsonville, to reflect the difference from the existing condition..

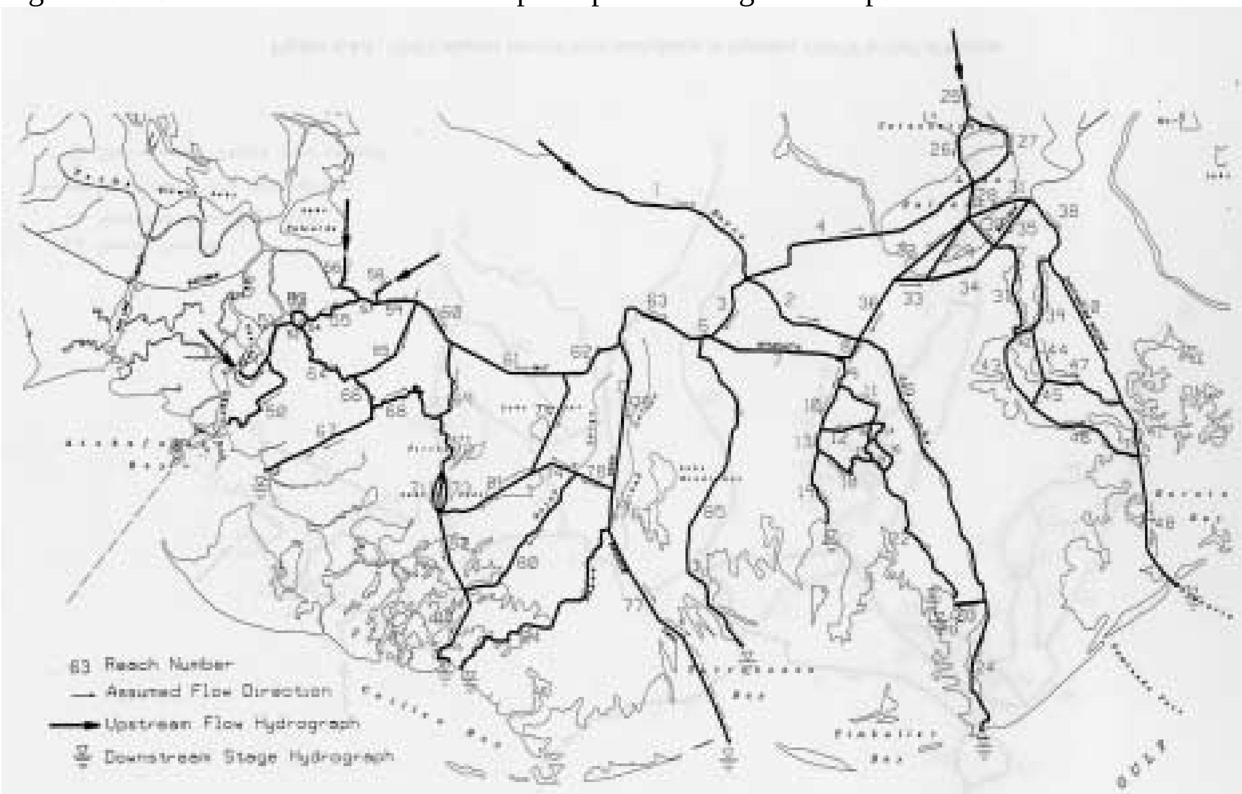
Note that in a fully consistent analysis, HEC-RAS models of bayou water levels in the Raceland area should be adjusted downward to reflect the effect of upstream withdrawals on bayou flow. To be conservative, this adjustment has not been made.

Figure 4.4-1. UNET channel network from Atchafalaya to Barataria, GIWW to Gulf of Mexico



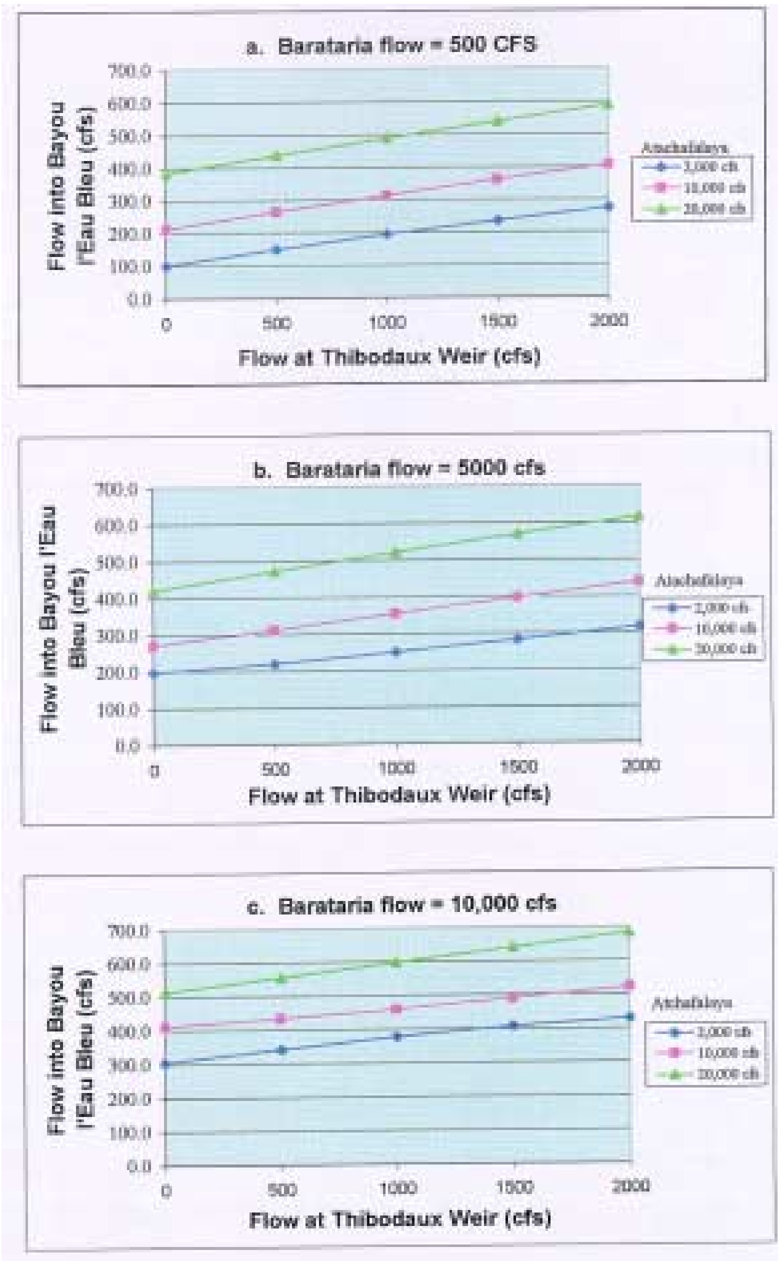
PRELIMINARY: DRAFT

Figure 4.4-2. UNET channel network superimposed on regional map.



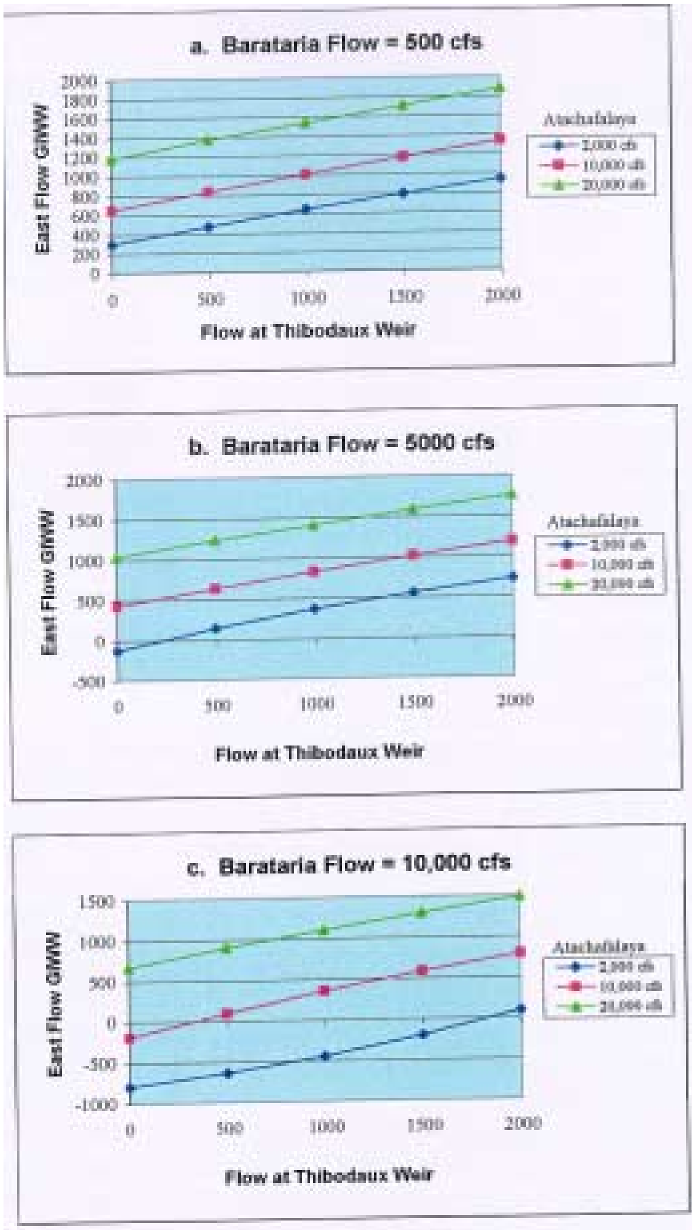
PRELIMINARY: DRAFT

Figure 4.4-3. Flow into Bayou l-Eau Bleu for different boundary conditions.



PRELIMINARY: DRAFT

Figure 4.4-4. Flow in GIWW East of Bayou Lafourche for different boundary conditions.



PRELIMINARY: DRAFT

Figure 4.4-5. Flow into the GIWW east of Houma navigation Chanal for different boundary conditions.

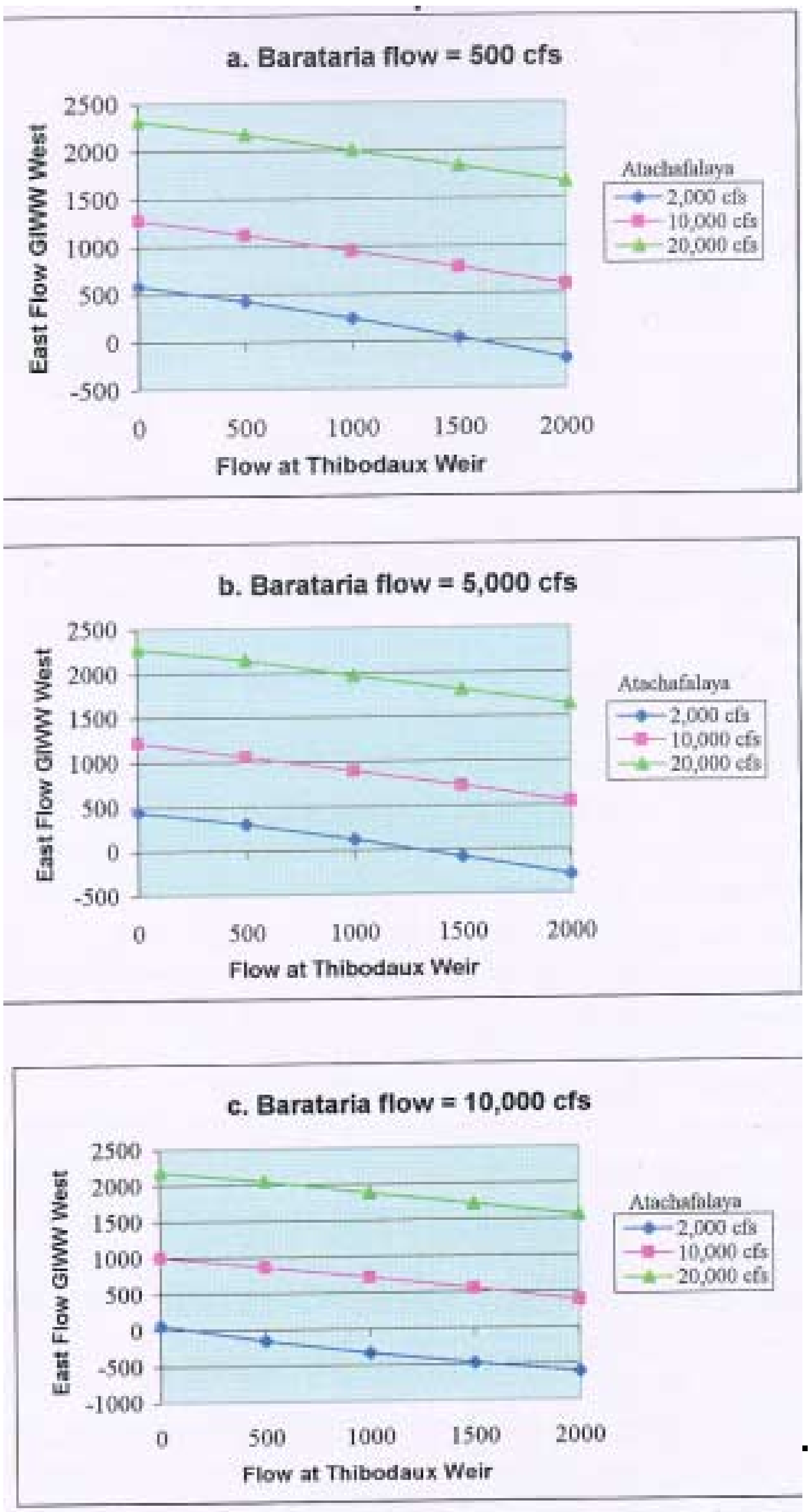


Figure 4.4-6 Flow into Bayou Lafourche South for different boundary conditions.

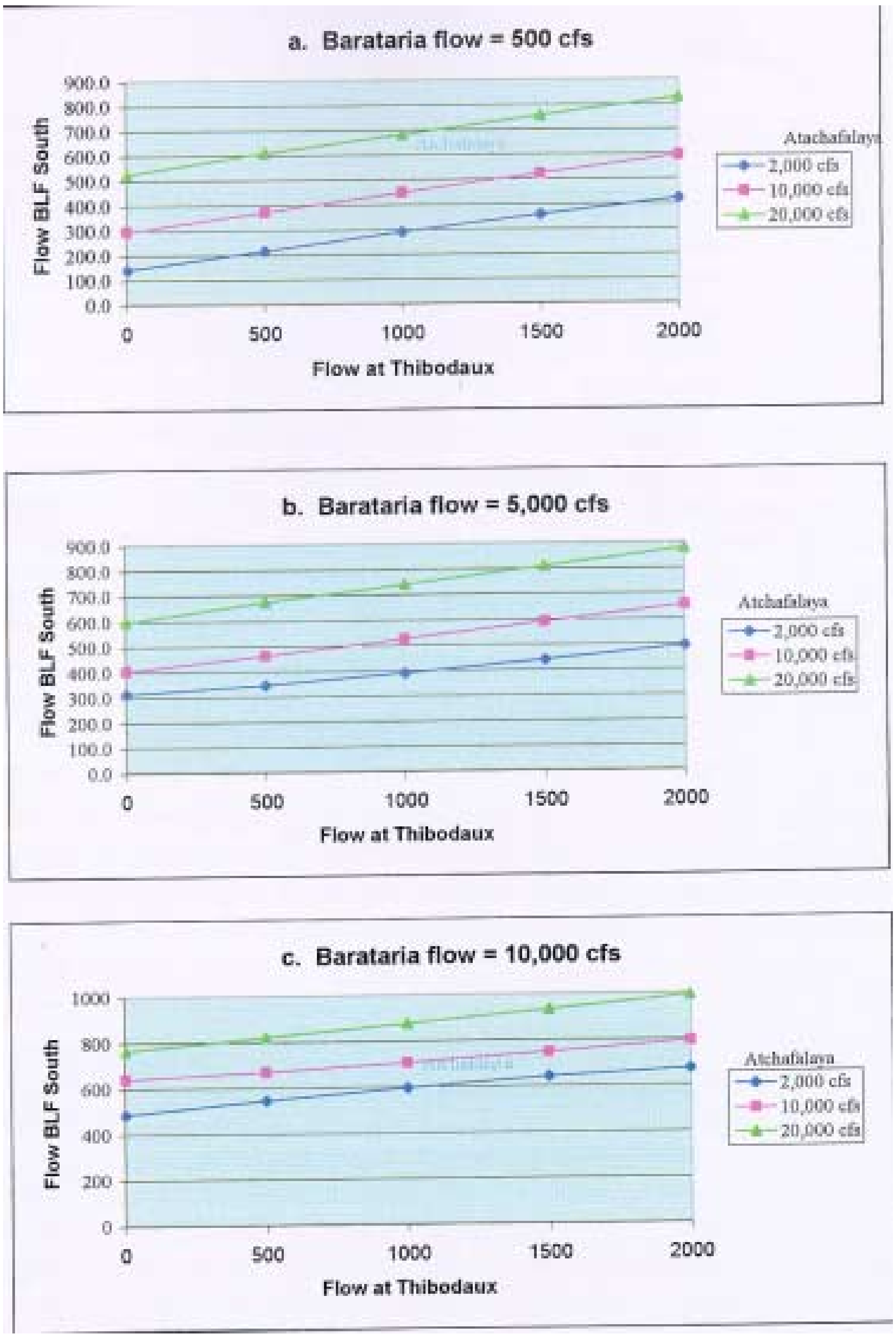


Figure 4.4-7 Changes in flow in four major distributary channels with changes in Bayou Lafourche flow, with low Barataria boundary inputs and varying Atchafalaya inputs.

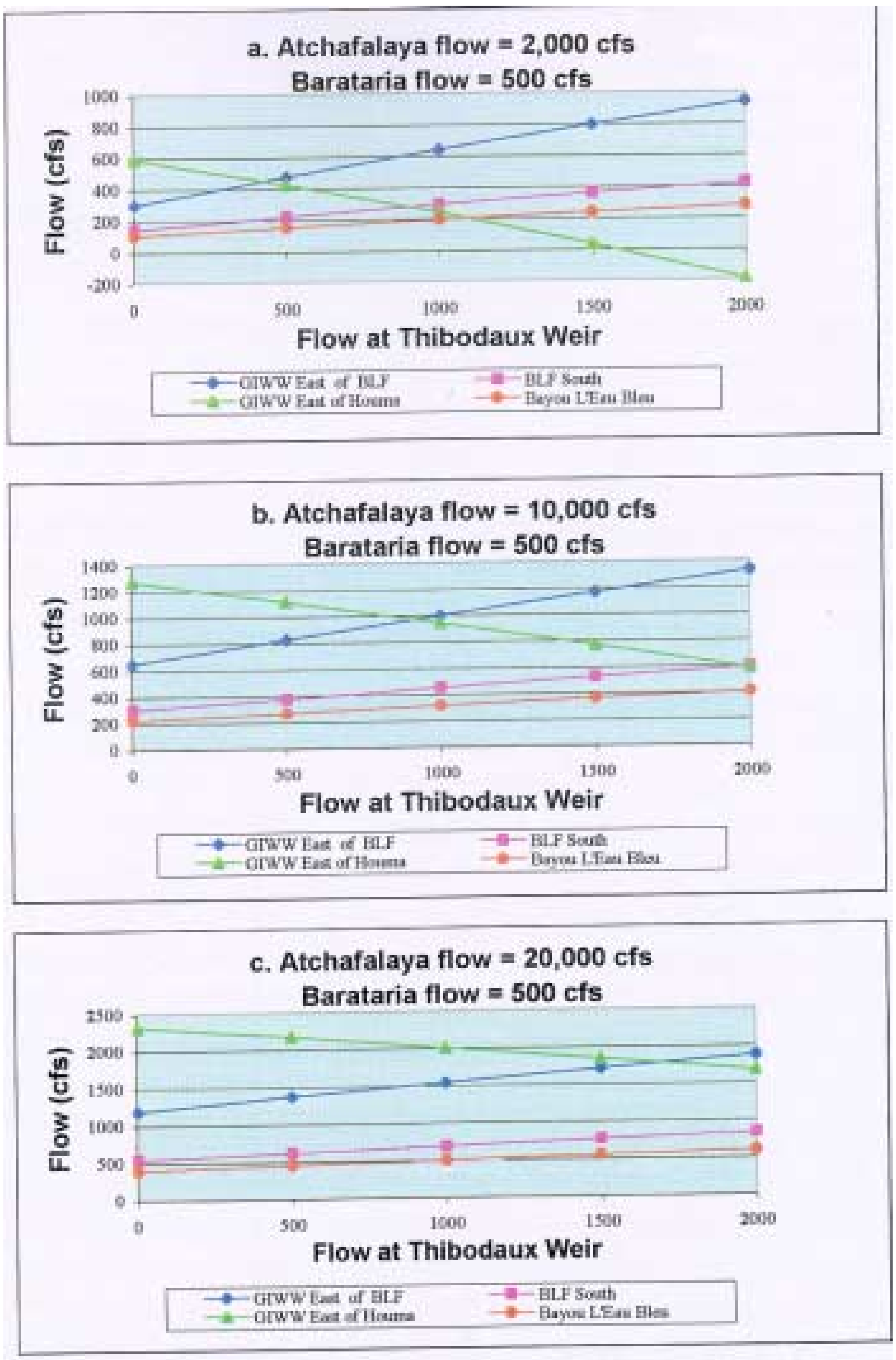


Figure 4.4-8. Change in flow in four major distributary channels with changes in Bayou Lafourche flow, with medium Barataria boundary inputs and varying Atchafalya inputs.

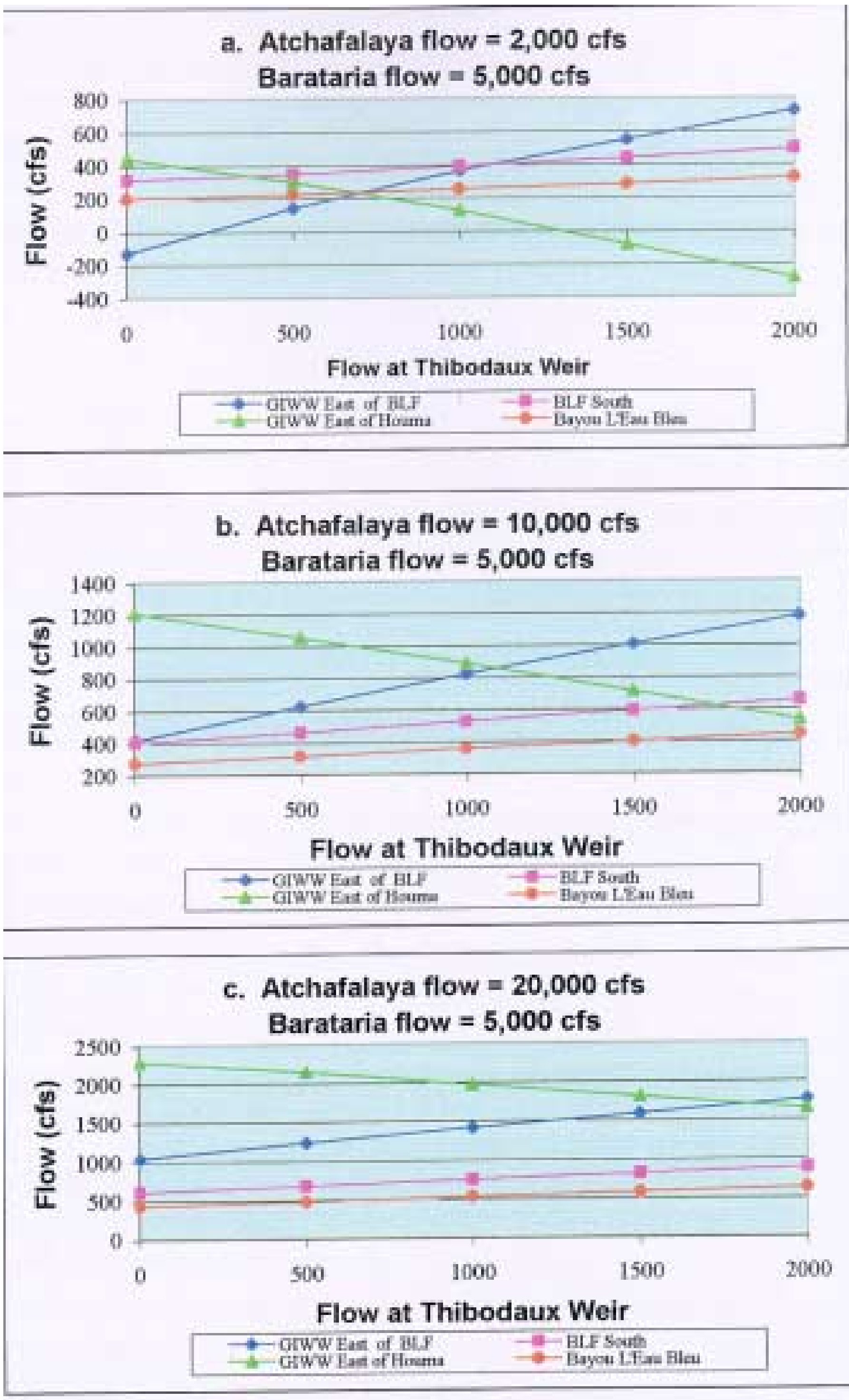


Figure 4.4-9. Changes in flow in four major distributary channels with changes in Bayou Lafourche flow, with high Barataria boundary inputs and varying Atchafalaya inputs.

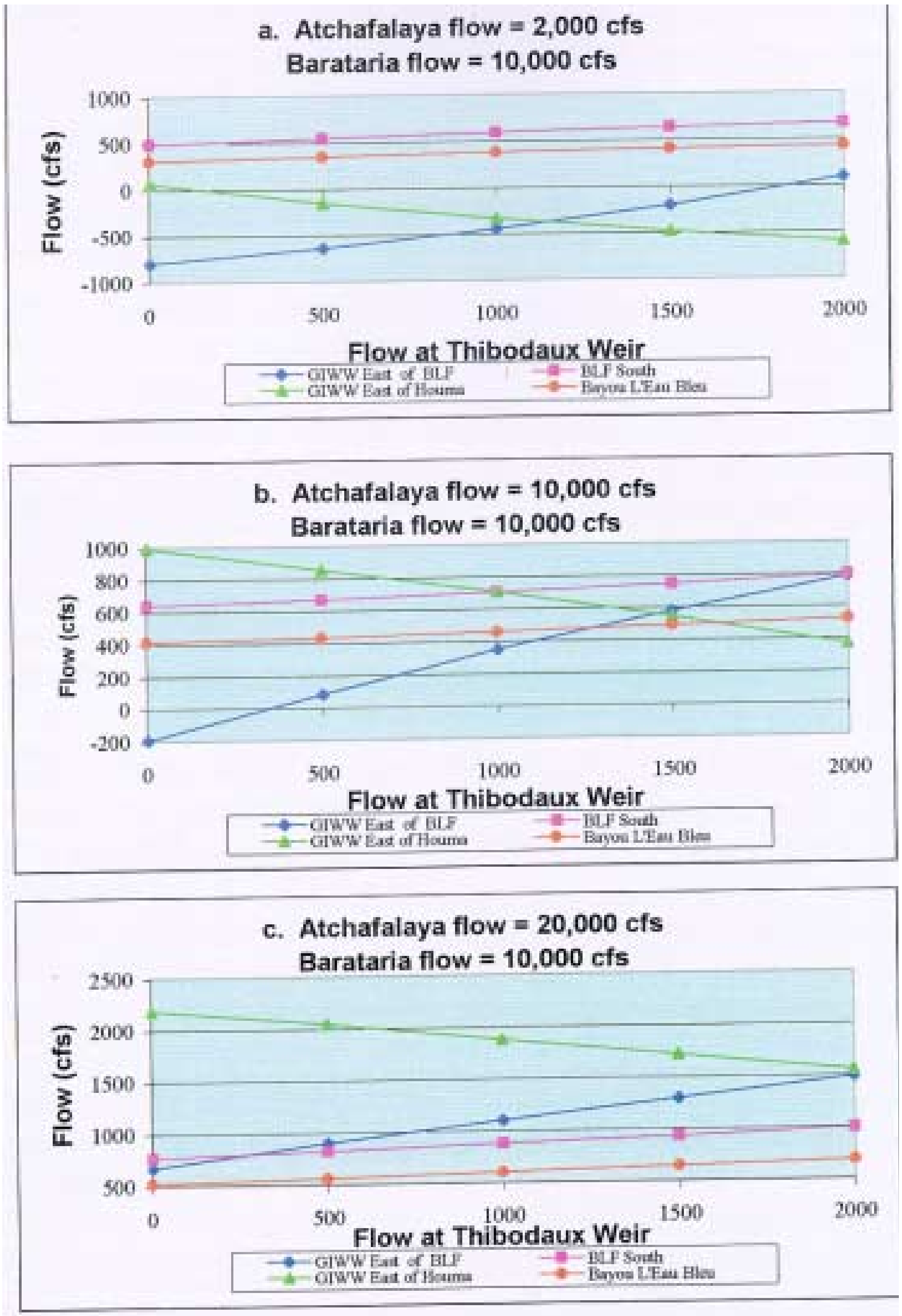


Figure 4.4-10. Flow Distribution, Low Water

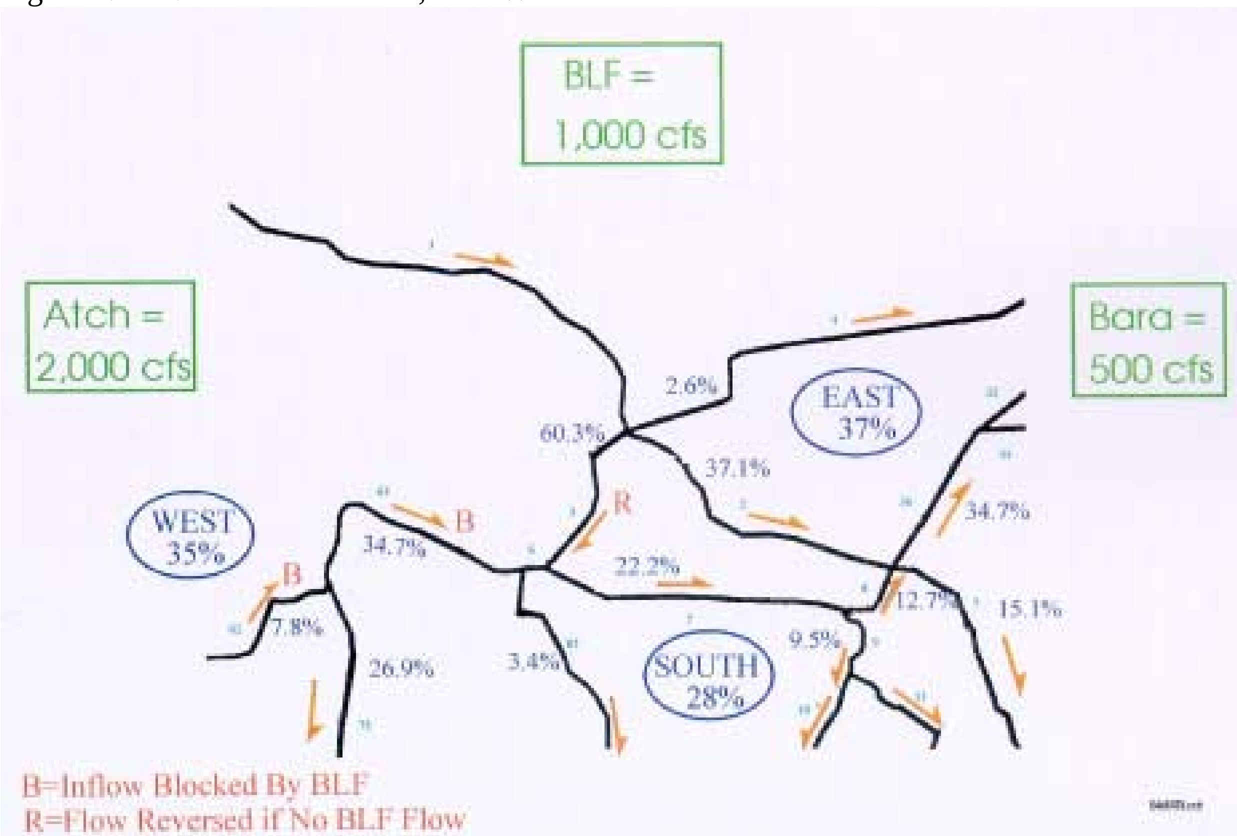
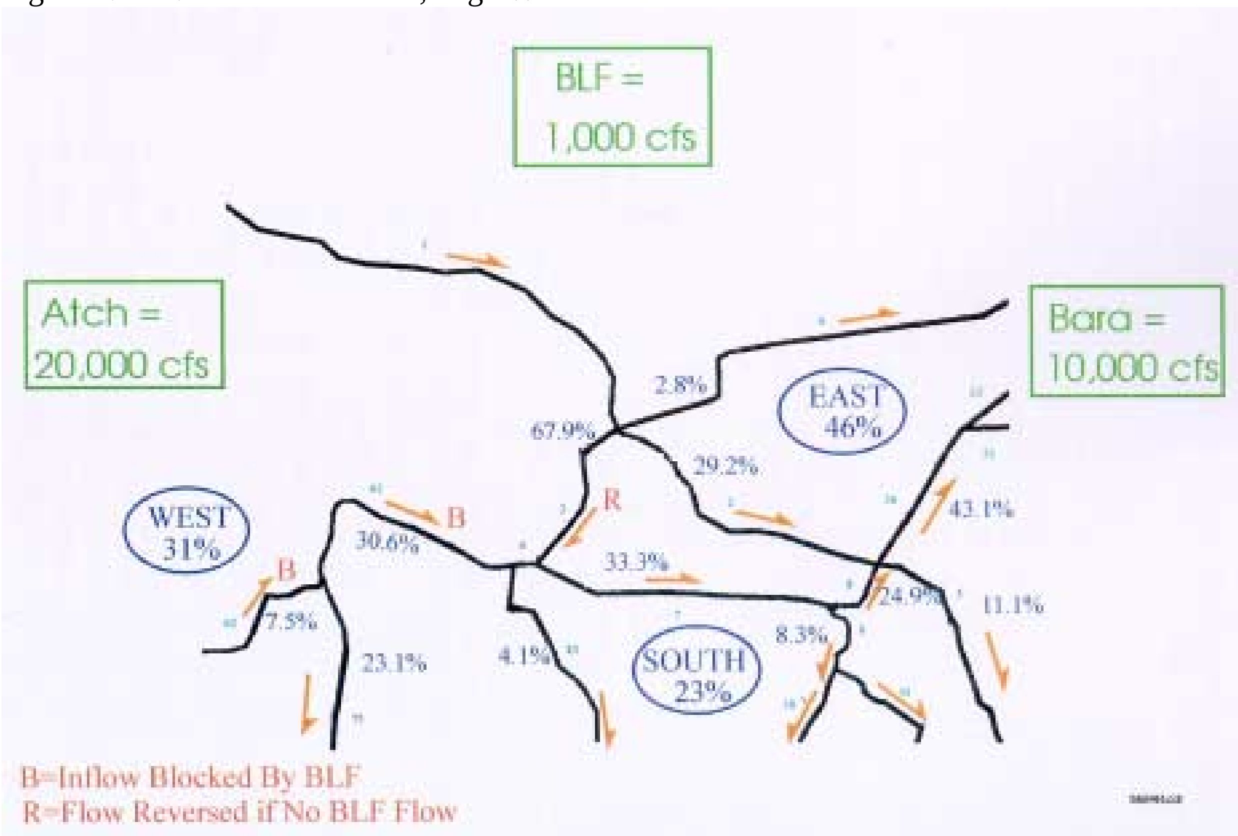


Figure 4.4-11. Flow Distribution, High Water



PRELIMINARY: DRAFT

Figure 4.4-12. Flow Distribution, High Atchafalaya Water

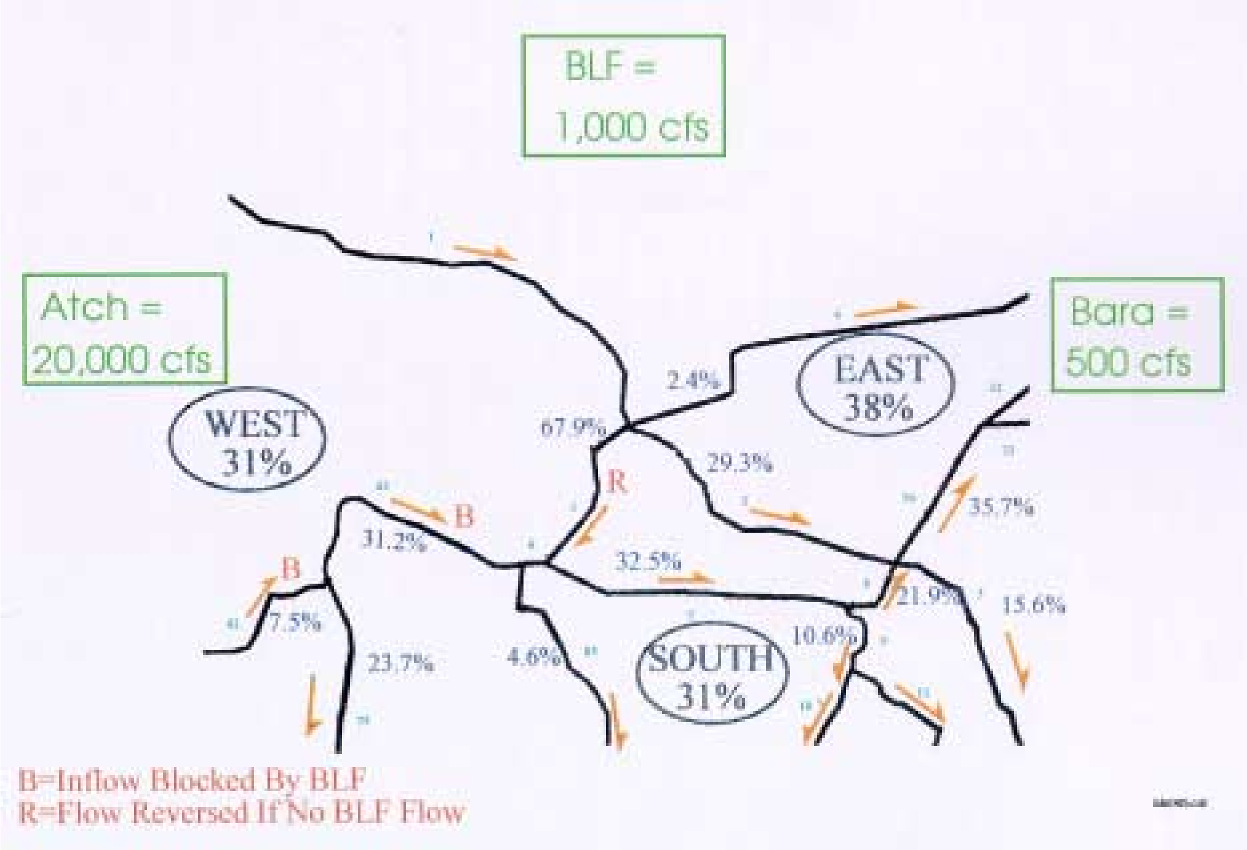
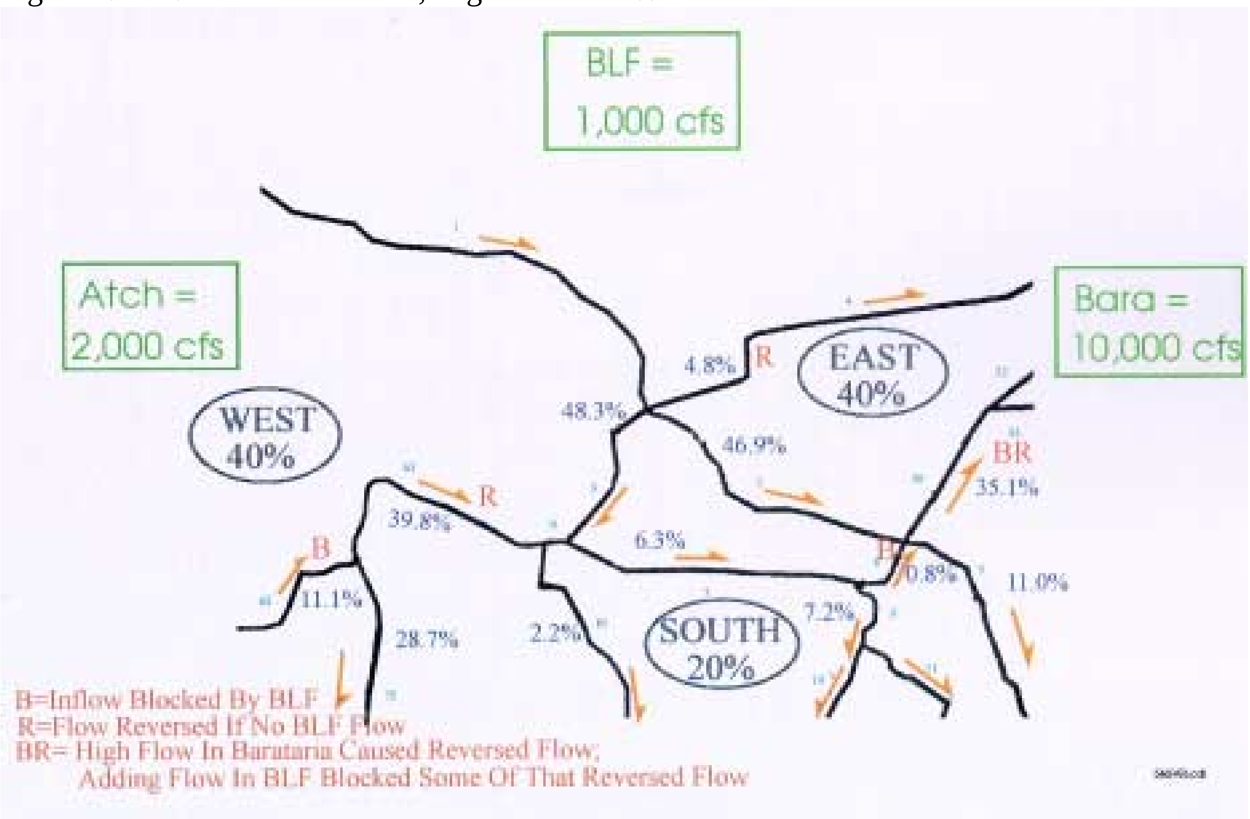
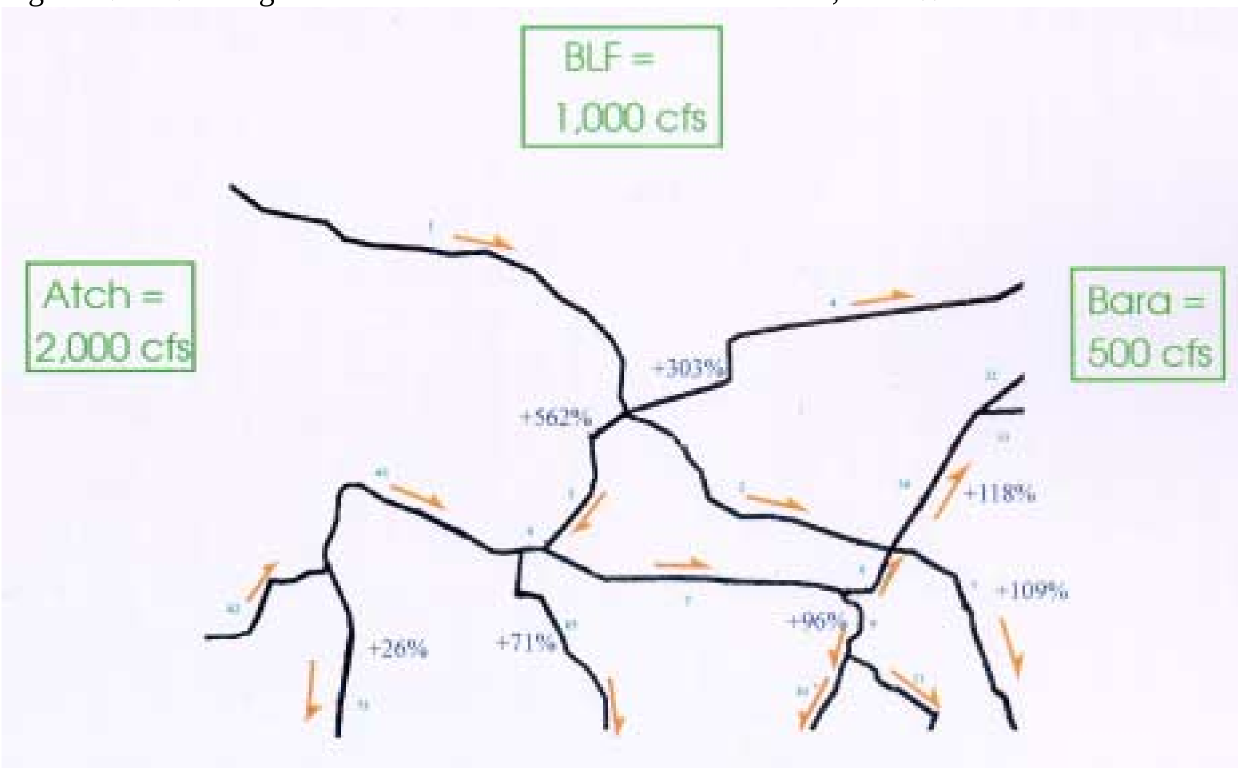


Figure 4.4-13. Flow Distribution, High Barataria Water



PRELIMINARY: DRAFT

Figure 4.4-14. Change in Flow with Addition of 1000 cfs in BLF, Low Water



PRELIMINARY: DRAFT

Figure 4.4-15. Change in Flow with Addition of 1000 cfs in BLF, High Water

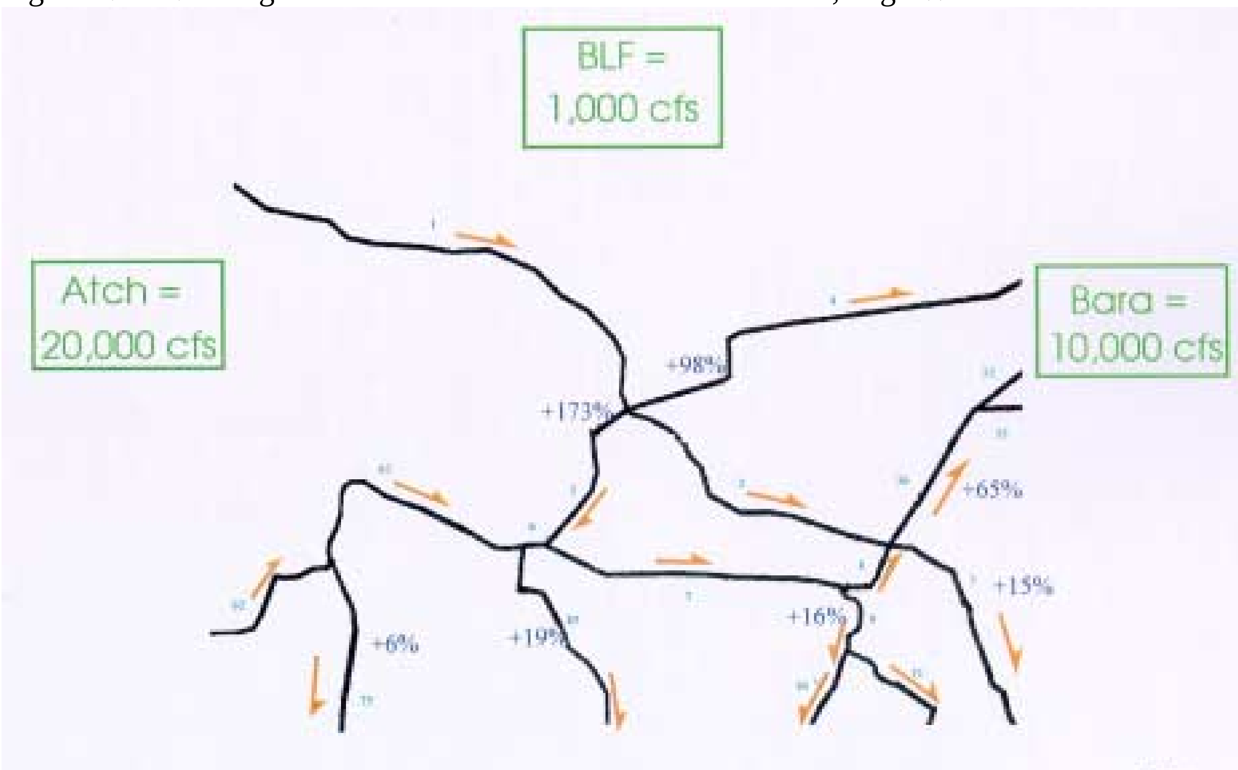


Table 4.4-1. Reach numbering and connection table for UNET model of Bayou Lafourche.

Reach Number	Waterway	From	To	UB	DB
1	Bayou Lafourche	Thibodaux Weir	Company Canal	-	2,3,4
2	Bayou Lafourche	Company Canal	GIWW	1	5
3	Company Canal	Bayou Lafourche	West to GIWW	1	6,7
4	Company Canal	Bayou Lafourche	East to Lake Salvador	1	28
5	Bayou Lafourche	GIWW	Louisiana Canal	2,8,36	23,24
6	GIWW	Company Canal	Bayou Terrebonne	3	85
7	GIWW	Company Canal	Bayou l'eau Bleu	3	8,9
8	GIWW	Bayou l'eau Bleu	Bayou Lafourche	7	5
9	Bayou l'eau Bleu	GIWW	Upper Bayou Blue	7	10,11
10	Grand Bayou Canal	Upper Bayou Blue	Sulfur Mine Canal	9	13
11	Upper Bayou Blue	Grand Bayou Canal	Sulfur Mine Canal	9	12,14,15
12	Sulfur Mine Canal	Upper Bayou Blue	Grand Bayou Canal	11	13
13	Grand Bayou Canal	Sulfur Mine Canal	Grand Bayou	10,12	18,19
14	Middle Bayou Blue	Sulfur Mine Canal	Connection	11	16
15	Bayou Bouillon	Sulfur Mine Canal	Connection	11	17,20
16	Lower Bayou Blue	Connection	Grand Bayou Blue	14,20	22
17	Bayou Bouillon	Connection	Grand Bayou Blue	15	21
18	Grand Bayou	Cutoff Canal	Bayou Bouillon	13	21
19	Cutoff Canal	Grand Bayou	Lake Chien	13	-
20	Connection	Bayou Bouillon	Lower Bayou Blue	15	16
21	Grand Bayou Blue	Bayou Bouillon	Bayou Blue	17,18	22
22	Grand Bayou Blue	Bayou Blue	Little Lake	16,21	-
23	Louisiana Canal	Bayou Lafourche	Little Lake	5	-
24	Bayou Lafourche	Louisiana Canal	Gulf of Mexico	5	-
25	Lake Cataouatchi	Davis Pond	Couba Island	-	26,27
26	Bayou Couba	Lake Cataouatchi	Lake Salvador	25	28
27	Bayou Bourdeaux	Lake Catacuatchi	Lake Salvador	25	28
28	Lake Salvador			4,26,27	29,30,31,32
29	Catahoula Bay	Lake Salvador	GIWW	28	34
30	Bayou Perot	Lake Salvador	GIWW	28	37
31	Bayou Villars	Lake Salvador	GIWW	28	35,38
32	Harvey Canal #2	Lake Salvador	GIWW	28	33,36
33	GIWW	Harvey Canal	Catahoula Bay	32	34
34	GIWW	Catahoula Bay	Bayou Perot	29,33	37
35	GIWW	Bayou Barataria	Bayou Perot	31	37
36	GIWW	Harvey Canal	Bayou Lafourche	32	5
37	Bayou Perot	GIWW	Bayou Rigolettes	30,34,35	43

UB=upstream boundary

DB=downstream boundary

Table 4.4-1. (Continued).

Reach Number	Waterway	From	To	UB	DB
38	Bayou Barataria	GIWW	Bayou Rigolettes	31	39,40
39	Bayou Rigolettes	Bayou Barataria	Harvey Canal #1	38	42,44
40	Barataria Waterway	Bayou Rigolettes	Bayou St. Denis	38	41
41	Barataria Waterway	Bayou St. Denis	Grand Bayou	40,47	48
42	Bayou Rigolettes	Harvey Canal #1	Bayou Perot	39	43
43	Bayou Perot-Little Lake	Bayou Rigolettes	Turtle Bay	37,42	46
44	Harvey Canal #1	Bayou Rigolettes	Turtle Bay	39	45,47
45	Turtle Bay	Harvey Canal	Little Lake	44	46
46	Grand Bayou	Little Lake	Barataria Waterway	43,45	48
47	Bayou St. Denis	Turtle Bay	Barataria Waterway	44	41
48	Barataria Waterway	Grand Bayou	Gulf	41,46	-
49	Avoca Island Cutoff	Atchafalaya River	Little Horn Bayou	-	50,51
50	Little Horn- Deer Island	Avoca Island Cutoff	Atchafalaya River	49	-
51	Avoca Island Cutoff	Little Horn Bayou	First Storage connection	49	52,53
52	Avoca Island Cutoff	First Storage connection	Bayou Penchant	51	54,64
53	Storage Connection	Bayou Penchant	Bayou Penchant	51	55
54	Avoca Island Cutoff	Bayou Penchant	Second Storage connection	52	55
55	Avoca Island Cutoff	Second Storage connection	GIWW-Bayou Boeuf	53,54	57
56	Bayou Boeuf	Amelia	Bayou Chene	-	57
57	GIWW	Bayou Chene	Bayou Black	55,56	59
58	Bayou Black		GIWW	-	59
59	GIWW	Bayou Black	Pipeline	57,58	60,65
60	GIWW	Pipeline	Bayou Copasaw	59	61,69
61	GIWW	Bayou Copasaw	Minor's Canal	60	62,74
62	GIWW	Minor's Canal	Houma Nav Canal	61	63,75
63	GIWW	Houma Nav Canal	Bayou Terrebonne	62	85
64	Bayou Penchant	Avoca Island Cutoff	Pipeline	52	66
65	Pipeline	GIWW	Bayou Penchant	59	66
66	Bayou Penchant	Pipeline	Carrion Crow Bayou	64,65	67,68
67	Palmetto Bayou	Bayou Penchant	Atchafalaya Bay	66	-
68	Bayou Penchant	Carrion Crow Bayou	Bayou Copasaw	66	70
69	Bayou Penchant	GIWW	Bayou Penchant	60	70
70	Bayou Penchant	Bayou Copasaw	South Pipelines	68,69	71,72,73
71	Penchant Pipeline #1	Bayou Penchant	Bayou Decade	70	82
72	Penchant Pipeline #2	Bayou Penchant	Bayou Decade	70	82
73	Penchant Pipeline #3	Bayou Penchant	Bayou Decade	70	82
74	Minor's Canal	GIWW	Lake Decade	61	81
75	Houma Nav. Canal	GIWW	Falgout Canal	62	76,78
76	Houma Nav. Canal	Falgout Canal	Bayou Grand Caillou	75	77,84
77	Houma Nav. Canal	Bayou Grand Caillou	Gulf	76	-
78	Falgout Canal	Houma Nav. Canal	Bayou Dularge	75	79,80
79	Falgout Canal	Bayou Dularge	Lake Decade	78	81
80	Bayou Dularge	Falgout Canal	Bayou Grand Dularge	78	83
81	Lake - Bayou Decade	Falgout Canal-Minor's Canal	Merchant	74,79	82
82	Lake Merchant	Bayou decade	Bayou Grand Dularge	71,72,73,81	83
83	Bayou Grand Dularge	Bayou Dularge	Gulf	80,82	-
84	Bayou Grand Caillou	Houma Nav. Canal	Gulf	76	-
85	Bayou Terrebonne	GIWW	Gulf	6,63	-

UB=upstream boundary

DB=downstream boundary

Table 4.4-2. Flows[1] (cfs) in each channel segment associated with modeled combinations of Atchafalaya, Barataria, and Bayou Lafourche flows.

Atchafalaya Flow	Barataria Flow	BLF Flow	GIWW East of BLF	BLF South	GIWW East of Houma	Bayou L'Eau Bleu	Bayou Terrebonne	BLF below Comp Canal	Company Canal West	Houma Nav. Canal	Company Canal East
2000	500	[illegible]	254.7	138.5	587.8	99.1	47.9	99.7	-107.3	1050.3	8.6
2000	500	500	472.5	215.6	423.4	148.5	67.0	262.1	218.1	1179.2	19.7
2000	500	1000	641.2	289.5	240.9	193.9	81.7	470.2	499.2	1318.8	34.7
2000	500	1500	794.5	356.7	31.4	234.9	93.9	682.9	765.7	1474.9	51.4
2000	500	2000	939.6	420.5	-188.5	274.2	105.3	894.1	1033.8	1634.4	72.1
10000	500	[illegible]	643.5	291.1	1268	210.5	103.2	215.0	-233.0	2240.8	19.0
10000	500	500	824.7	369.6	1110.3	262.0	124.5	362.8	107.8	2362.4	29.5
10000	500	1000	998.3	445.7	940.7	311.1	143.3	532.1	425.7	2491.5	42.2
10000	500	1500	1169.3	520.7	766.8	358.4	159.7	730.2	751.2	2622.2	58.7
10000	500	2000	1331.9	591.9	583.4	403.4	174.7	932.0	986.5	2758.1	81.5
20000	500	[illegible]	1178.8	524.5	2312.4	383.1	191.1	394.0	-428.9	4005.4	33.9
20000	500	500	1368.8	607.6	2175.8	437.2	212.2	583.0	-131.1	4109.6	50.1
20000	500	1000	1535.0	680.1	2000.7	489.1	236.6	686.8	253.2	4242.1	59.9
20000	500	1500	1706.0	754.7	1835.7	539.7	257.2	845.9	576.2	4366.1	78.0
20000	500	2000	1875.6	828.5	1672.0	589.2	276.2	1025.5	871.9	4488.0	102.6
2000	5000	[illegible]	-129.5	311.2	440.6	196.9	65.4	71.1	-67.7	1165.9	-2.5
2000	5000	500	139.5	344.5	298.0	220.0	77.6	247.2	236.5	1275.5	16.4
2000	5000	1000	364.5	388.7	124.0	249.1	89.0	461.7	505.7	1406.5	32.6
2000	5000	1500	548.5	438.0	-82.8	280.7	100.0	676.7	773.2	1558.4	50.1
2000	5000	2000	724.2	492.3	-285.0	315.7	111.1	889.4	1039.0	1703.3	71.7
10000	5000	1	414.7	399.9	1208.2	267.5	131.8	201.9	-216.2	2287.0	15.5
10000	5000	500	625.4	459.1	1051.9	309.4	131.3	348.9	124.4	2407.0	26.6
10000	5000	1000	820.7	522.6	884.7	352.2	148.9	523.8	435.8	2533.7	40.4
10000	5000	1500	1006.1	588.0	711.1	395.0	164.5	723.8	718.6	2663.6	57.5
10000	5000	2000	1178.2	652.2	527.2	436.7	178.9	926.4	992.3	2799.4	81.3
20000	5000	1	1032.2	596.4	2278.4	420.5	196.6	386.5	-419.2	4031.4	33.7
20000	5000	500	1232.7	671.4	2141.0	471.2	217.2	571.6	-120.1	4136.0	48.5
20000	5000	1000	1407.3	738.7	1966.2	520.5	241.0	678.6	262.7	4268.1	58.7
20000	5000	1500	1584.7	808.7	1801.7	569.2	261.4	839.2	583.1	4391.5	77.8
20000	5000	2000	1759.4	878.5	1637.9	617.1	280.0	1019.9	877.5	4513.3	102.6
2000	10000	1	-800.5	485.2	61.9	304.4	92.4	-24.5	44.1	1452.5	-18.6
2000	10000	500	-640.4	542.5	-156.5	341.1	103.5	228.7	274.5	1611.6	-3.2
2000	10000	1000	-489.5	594.6	-335.7	375.9	114.3	444.2	526.9	1739.1	28.9
2000	10000	1500	-204.8	639.0	-486.5	406.3	124.3	663.0	788.3	1844.3	48.7
2000	10000	2000	89.3	670.5	-606.9	428.1	132.8	877.9	1049.8	1927.1	72.4
10000	10000	1	-197.4	637.0	989.4	408.5	138.3	157.1	-360.1	2454.6	4.0
10000	10000	500	83.1	666.4	852.1	430.6	152.0	307.4	172.5	2558.3	20.1
10000	10000	1000	347.2	701.3	705.9	455.9	164.9	500.2	463.3	2667.5	36.6
10000	10000	1500	578.0	746.7	542.5	486.2	177.7	706.0	738.0	2788.2	56.0
10000	10000	2000	782.4	791.7	363.7	518.5	190.1	911.5	1007.5	2918.5	81.0
20000	10000	1	665.8	761.7	2180.3	513.4	211.6	364.9	-392.7	4106.2	28.8
20000	10000	500	896.9	818.0	2044.8	554.5	230.7	545.6	-90.2	4208.9	44.8
20000	10000	1000	1096.5	872.3	1874.7	596.4	252.6	687.0	286.1	4336.9	56.9
20000	10000	1500	1294.8	951.1	1713.8	639.2	271.5	822.6	600.1	4456.9	77.3
20000	10000	2000	1486.2	991.6	1552.0	682.4	289.2	1006.4	891.1	4576.8	102.5
		MIN	-800.5	138.5	-606.9	99.1	47.9	-24.5	-428.9	1050.3	-18.6
		MAX	1875.6	991.6	2312.4	682.4	289.2	1025.5	1049.8	4576.8	102.6

[1]-Positive numbers indicate flow in the direction defined in grid (see Figure1)(i.e., south or east).

Negative numbers indicate flows reversed from defined direction (i.e., north or west).

Table 4.4-3. Increased flows (cfs) due to 1,000 cfs increase in Bayou Lafourche flows.

Increase in Flow in Bayou Lafourche South of Company Canal For nominal 1000 cfs increase in BLF Boundary Flow			
	Barataria=500	Barataria=5000	Barataria=10000
Atchafalaya=2000	371	391	469
Atchafalaya=10000	317	322	343
Atchafalaya=20000	293	292	292

Increase in Flow in Company Canal East For nominal 1000 cfs increase in BLF Boundary Flow			
	Barataria=500	Barataria=5000	Barataria=10000
Atchafalaya=2000	26	35	48
Atchafalaya=10000	23	25	33
Atchafalaya=20000	24	25	28

Increase in Flow in Company Canal West of Bayou Lafourche For nominal 1000 cfs increase in BLF Boundary Flow			
	Barataria=500	Barataria=5000	Barataria=10000
Atchafalaya=2000	603	573	483
Atchafalaya=10000	659	652	623
Atchafalaya=20000	682	682	679

Table 4.4-3 (continued)

Increase in Eastward Flow in GIWW East of Bayou Lafourche For nominal 1000 cfs increase in BLF Boundary Flow			
	Barataria=500	Barataria=5000	Barataria=10000
Atchafalaya=2000	347	494	351
Atchafalaya=10000	353	406	545
Atchafalaya=20000	356	375	431

Increase in Flow in Bayou Lafourche South of GIWW For nominal 1000 cfs increase in BLF Boundary Flow			
	Barataria=500	Barataria=5000	Barataria=10000
Atchafalaya=2000	151	77	109
Atchafalaya=10000	155	123	64
Atchafalaya=20000	156	142	111

Increase in Flow in GIWW West of Bayou Lafourche* For nominal 1000 cfs increase in BLF Boundary Flow			
	Barataria=500	Barataria=5000	Barataria=10000
Atchafalaya=2000	127	181	-8
Atchafalaya=10000	190	207	266
Atchafalaya=20000	219	225	249

*Calculated indirectly as the balance between incoming and outgoing flows at a confluence of major channels.

Table 4.4-3 (continued)

Increase in Flow in Houma Navigation Canal For nominal 1000 cfs increase in BLF Boundary Flow			
	Barataria=500	Barataria=5000	Barataria=10000
Atchafalaya=2000	269	241	287
Atchafalaya=10000	251	247	213
Atchafalaya=20000	237	237	231

Increase in Flow in Bayou Terrebonne For nominal 1000 cfs increase in BLF Boundary Flow			
	Barataria=500	Barataria=5000	Barataria=10000
Atchafalaya=2000	34	23	22
Atchafalaya=10000	40	37	27
Atchafalaya=20000	46	44	41

Increase in Flow in GIWW East of Houma For nominal 1000 cfs increase in BLF Boundary Flow			
	Barataria=500	Barataria=5000	Barataria=10000
Atchafalaya=2000	-347	-317	-398
Atchafalaya=10000	-327	-324	-284
Atchafalaya=20000	-312	-312	-306

Table 4.4-3 (continued)

Increase in Flow in GIWW West of Houma* For nominal 1000 cfs increase in BLF Boundary Flow			
	Barataria=500	Barataria=5000	Barataria=10000
Atchafalaya=2000	-78	-76	-111
Atchafalaya=10000	-77	-77	-71
Atchafalaya=20000	-75	-75	-75

Increase in Flow in GIWW East of company Canal* For nominal 1000 cfs increase in BLF Boundary Flow			
	Barataria=500	Barataria=5000	Barataria=10000
Atchafalaya=2000	222	233	63
Atchafalaya=10000	291	291	313
Atchafalaya=20000	325	325	332

Increase in Flow in Bayou l"Eau Bleu For nominal 1000 cfs increase in BLF Boundary Flow			
	Barataria=500	Barataria=5000	Barataria=10000
Atchafalaya=2000	95	52	72
Atchafalaya=10000	101	85	47
Atchafalaya=20000	106	100	83

*Calculated indirectly as the balance between incoming and outgoing flows at a confluence of major channels.

Table 4.4-4. Increased flows (cfs) due to 2,000 cfs increase in Bayou Lafourche flows.

Increase in Flow in Bayou Lafourche South of Company Canal For nominal 2000 cfs increase in BLF Boundary Flow			
	Barataria=500	Barataria=5000	Barataria=10000
Atchafalaya=2000	794	818	902
Atchafalaya=10000	717	725	754
Atchafalaya=20000	632	633	642

Increase in Flow in Company Canal East For nominal 2000 cfs increase in BLF Boundary Flow			
	Barataria=500	Barataria=5000	Barataria=10000
Atchafalaya=2000	64	74	91
Atchafalaya=10000	63	66	77
Atchafalaya=20000	67	69	74

Increase in Flow in Company Canal West of Bayou Lafourche For nominal 2000 cfs increase in BLF Boundary Flow			
	Barataria=500	Barataria=5000	Barataria=10000
Atchafalaya=2000	1141	1107	1006
Atchafalaya=10000	1220	1209	1168
Atchafalaya=20000	1301	1297	1284

Table 4.4-4 (continued)

Increase in Eastward Flow in GIWW East of Bayou Lafourche For nominal 2000 cfs increase in BLF Boundary Flow			
	Barataria=500	Barataria=5000	Barataria=10000
Atchafalaya=2000	645	854	890
Atchafalaya=10000	686	764	980
Atchafalaya=20000	697	727	820

Increase in Flow in Bayou Lafourche South of GIWW For nominal 2000 cfs increase in BLF Boundary Flow			
	Barataria=500	Barataria=5000	Barataria=10000
Atchafalaya=2000	292	181	185
Atchafalaya=10000	301	252	155
Atchafalaya=20000	304	283	230

Increase in Flow in GIWW West of Bayou Lafourche* For nominal 2000 cfs increase in BLF Boundary Flow			
	Barataria=500	Barataria=5000	Barataria=10000
Atchafalaya=2000	133	216	173
Atchafalaya=10000	270	291	380
Atchafalaya=20000	269	376	409

*Calculated indirectly as the balance between incoming and outgoing flows at a confluence of major channels.

Table 4.4-4 (continued)

Increase in Flow in Houma Navigation Canal For nominal 2000 cfs increase in BLF Boundary Flow			
	Barataria=500	Barataria=5000	Barataria=10000
Atchafalaya=2000	584	537	475
Atchafalaya=10000	517	512	464
Atchafalaya=20000	483	482	471

Increase in Flow in Bayou Terrebonne For nominal 2000 cfs increase in BLF Boundary Flow			
	Barataria=500	Barataria=5000	Barataria=10000
Atchafalaya=2000	57	46	40
Atchafalaya=10000	72	67	52
Atchafalaya=20000	85	83	78

Increase in Flow in GIWW East of Houma For nominal 2000 cfs increase in BLF Boundary Flow			
	Barataria=500	Barataria=5000	Barataria=10000
Atchafalaya=2000	-776	-726	-669
Atchafalaya=10000	-685	-681	-626
Atchafalaya=20000	-640	-641	-628

Table 4.4-4 (continued)

Increase in Flow in GIWW West of Houma* For nominal 2000 cfs increase in BLF Boundary Flow			
	Barataria=500	Barataria=5000	Barataria=10000
Atchafalaya=2000	-192	-188	-194
Atchafalaya=10000	-167	-169	-162
Atchafalaya=20000	-158	-159	-158

Increase in Flow in GIWW East of company Canal* For nominal 2000 cfs increase in BLF Boundary Flow			
	Barataria=500	Barataria=5000	Barataria=10000
Atchafalaya=2000	308	335	297
Atchafalaya=10000	463	460	490
Atchafalaya=20000	575	573	578

Increase in Flow in Bayou l"Eau Bleu For nominal 2000 cfs increase in BLF Boundary Flow			
	Barataria=500	Barataria=5000	Barataria=10000
Atchafalaya=2000	175	119	124
Atchafalaya=10000	193	169	110
Atchafalaya=20000	206	197	169

*Calculated indirectly as the balance between incoming and outgoing flows at a confluence of major channels.

Table 4.4-5. Results of test of sensitivity of the Bayou Laourche UNET model to Gulf stage; flows in selected reaches for 1000 cfs in Bayou Lafourche, 500 Barataria flow, and 2000 cfs Atchafalaya flow.

Reach Number	Location	0.0 Gulf Flow (cfs)	1.5 Gulf Flow (cfs)	Difference cfs	Difference percent
2	BLF-Comp canal to GIWW	470.2	461.8	-8.4	-1.8%
3	Company Canal West	495.2	477.3	-17.9	-3.6%
4	Company Canal East	34.7	60.9	26.2	75.5%
36	GIWW East of BLF	-641.2	-641.0	0.2	0.0%
5	Bayou Lafourche south of GIWW	289.5	271.4	-18.1	-6.3%
63	GIWW west of Company Canal	241.0	289.1	48.1	20.0%
75	Houma Nav Canal south of GIWW	1318.8	1216.9	-101.9	-7.7%
85	Bayou Terrebonne	81.7	95.2	13.5	16.5%
9	Bayou l’Eau Bleu	193.9	220.6	26.8	13.8%

4.5 TABS MODELING

4.5.1 Introduction to the TABS model

The modeling of effects of how increased fresh water from a source such as Bayou Lafourche would impact salinity distribution in the marsh was done by Harley Winer at the U.S. Army Corps of Engineers (USACE). Refer to Appendix A for an abstract of this work, which is cited as USACE (1997b).

A TABS-MD Hydrodynamic and Transport model was used to assess the effects that increased fresh water input via the GIWW and Bayou l'Eau Bleu would have on the distribution of salinities in the Grand Bayou marshes. This marsh area is a significant target marsh for the Bayou Lafourche diversion project. It is also part of the main target area for the CWPPRA TE-10 project, which involves (among other features) enlargement of Bayou l'Eau Bleu to increase freshwater input from the GIWW.

TABS-MD is a two-dimensional hydrodynamic and salinity transport model. TABS uses a finite element grid, in which each element is either a triangle or quadrangle with corner and mid-side nodes. Each node is assigned x-y coordinates and an elevation. From this, TABS uses three separate, sequential programs to calculate water surface elevations, horizontal velocity components, and concentration of constituents. The latter are based on mass conservation equations, and uses the outputs from the hydrodynamic portion of the program.

TABS is particularly well-suited to analyze flows and constituent transport in areas where flows are similar from the surface to the bottom at any one point, and vertical velocities are unimportant. The model therefore does well examining flows in rivers at junctions, flows in tidal plains, tidal exchange in marshes, etc. It is not well-suited to examine near-field problems of flow-structure interactions, or areas of vertically stratified flow. It also does not directly simulate the flow of water over the marsh.

4.5.2 Overview of modeling procedure

The study was based on expansion of an existing TABS grid, which was originally developed by USACE for a study contracted by the Bayou Lafourche Freshwater District, and which included only the marshes south of the GIWW (the Grand Bayou marshes); see USACE (1994). This two-dimensional marsh grid was expanded by adding some major channels within the marsh, including Sulfur Mine Canal, Bayou Blue below Bully Camp, and the connection between Bay Courant and Grand Bayou Blue. In addition, a network was added that included the GIWW, Company Canal, and Bayou Lafourche from Thibodaux to the Gulf of Mexico.

Because there were problems with model verification, the one-dimensional channels were removed from the grid, and the model was run using only the enhanced two-dimensional marsh area plus channels. In this configuration, Bayou l'Eau Bleu was the northern boundary, and the gulf was the southern boundary.

Outputs from the UNET model developed for evaluation of the Bayou Lafourche diversion (see USACE, 1997a) were used to define boundary flows in the GIWW east of Bayou Lafourche and west of Company Canal. A constant tidal range of 1.5 feet at the gulf boundary was used. Initial salinities were the same for all runs. A proposed structure with a boat bay in Cutoff Canal, in the southwest corner of the Grand Bayou marshes, was incorporated in the model. Total closure of this canal also was tested.

The model was verified by comparison to National Ocean Service (NOS) tidal range and phase charts. Synoptic velocity measurements also were compared to model results, especially for Cutoff Canal at the Pointe au Chien ridge, where strong tidal currents (several feet per second) are routinely observed. The model did not produce velocities that approached those observed in the field. This may indicate that tidal prism was not properly represented in the model, which could affect model results regarding salinity. It also could explain why the TABS model did not show large salinity fluctuations that are sometimes observed in the Grand Bayou marshes.

Model runs included two different flows into Bayou l'Eau Bleu - 200 cfs to simulate the existing channel, and 500 cfs to simulate increased flows or an enlarged channel. Runs also included opened, partially closed, and closed conditions for Cutoff Canal in the southwest corner of the study area to simulate a proposed structure.

Model output was the daily average salinity after a 30-day model run, which was recorded for seven locations throughout the Grand Bayou marsh area, shown in Figure 4.5-1.

4.5.3 Overview of model results

The TABS model showed that a 300 cfs increase in flow (from 200 cfs to 500 cfs) into the study area through Bayou l'Eau Bleu would result in a substantial decrease in average salinity, even at the southern perimeter of the study area. The following table illustrates average salinity (ppt) in Grand Bayou Blue, for different flows and presence or absence of a structure in Cutoff Canal.

Bayou l'Eau Bleu Flow	Cutoff Canal Open	Cutoff Canal with Boat Bay	Cutoff Canal Closed
200 cfs	13.6 ppt	14.1 ppt	14.8 ppt
500 cfs	11.3 ppt	11.6 ppt	12.1 ppt

Another illustration of model results is the average salinity (ppt) in Cutoff Canal 1.5 miles south of Pointe au Chien ridge, for different flows and presence or absence of a structure in Cutoff Canal.

Bayou l'Eau Bleu Flow	Cutoff Canal Open	Cutoff Canal with Boat Bay	Cutoff Canal Closed
200 cfs	12.6 ppt	13.3 ppt	13.2 ppt
500 cfs	8.7 ppt	10.4 ppt	12.6 ppt

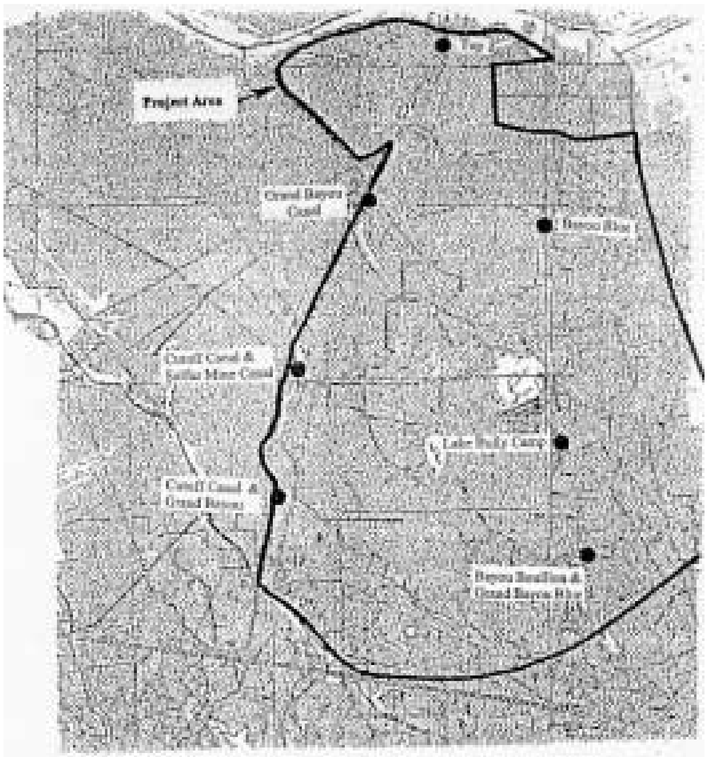
On the southeastern side, in Grand Bayou Blue near Catfish Lake, the modeled flow increase resulted in a decline in salinities of 2.3 ppt to 2.7 ppt (17% to 18%), depending on whether Cutoff Canal was opened or closed. On the southwestern side, in Cutoff Canal near the Pointe au Chien ridge, salinities decreased by 3.9 ppt (31%) with the Cutoff Canal opened, and by 0.6 ppt (4.5%) with the canal closed. Thus, introduction of more fresh water into the study area had a substantial effect on salinities.

4.5.4 Interaction with Project TE-10

This assessment is pertinent to both the proposed diversion into Bayou Lafourche at Donaldsonville, and the Grand Bayou project which involves enlargement of Bayou l'Eau Bleu from the GIWW to the Grand Bayou marshes. One of the issues evaluated for the Grand Bayou project (TE-10) was to assess the effect of an outfall management structure in Cutoff Canal on salinities in the region. Salinities in the northern half of the study area decreased only slightly with the structure or with complete closure of the canal compared to the opened condition. Salinities showed a greater reduction with the structure in the southwestern portion of the study area. However, in the southeastern quadrant, salinities were predicted with the model to be higher with closure of Cutoff Canal than without closure.

The modeled increase in salinity with the structure was explained based on an empirical relationship, developed by USACE, between tidal prism and restriction of cross-sectional area of tidal passes. There is a threshold corresponding to about 30% of the natural tidal pass cross-section, before which there is little or no reduction in tidal prism, but rather a compensatory increase in tidal velocity in the remaining cross-section. Cutoff Canal represents about 50% of the cross-section available into this hydrologic unit of marsh. Therefore, closure would likely only result in increased tidal excursion through the remaining tidal passes, in this case notably Grand Bayou Blue on the eastern side of the study area. The model showed that closure of Cutoff Canal results in increased salinities in the southeastern portion of the study area, an apparent result of the induced increase in tidal excursion. In the southwestern portion of the study area (in Cutoff Canal near the Pointe au Chien ridge), the structure also increases salinities slightly over the open canal condition.

Figure 4.5-1. Location of stations for which TABS-MD model results are reported.



4.6 DETERMINATION OF WETLANDS BENEFITS

4.6.1 Overview of WVA procedures

CWPPRA requires that the most cost-effective restoration projects be selected for funding and implementation. In the CWPPRA framework, "effectiveness" of the project is judged almost entirely on considerations of the quantity and quality of wetlands to be gained or preserved if the project is implemented. The Wetlands Value Assessment (WVA) was developed specifically for this purpose, as a methodology for quantifying expected benefits to wetlands from any type of restoration project. The WVA methodology was developed by the WVA Workgroup, a committee established by the CWPPRA Task Force and composed of representatives of each federal agency and the state as well as academic advisors, with broad participation of other agency specialists and scientists.

The WVA is a specific adaptation of habitat assessment modeling. The emphasis in CWPPRA is on preservation of emergent wetlands. It is an underlying assumption that these wetlands serve multiple uses. Thus, the WVA was developed using a community approach, to reflect potential benefits to a variety of fish and wildlife species. Since the WVA emphasizes value as fish and wildlife habitat, it does not necessarily capture other functional values of wetlands, such as hydrology, water quality, nutrient export, flood water storage, or storm surge protection.

Assumptions. There are two assumptions implicit in applying the WVA model for evaluation of benefits. First is the assumption that quantity of habitat (marsh acreage) alone is not sufficient to capture value. This reflects a general understanding that an acre of degrading marsh would not be equivalent to an acre of healthy marsh; and an acre of newly created marsh may not be equivalent to an acre of established marsh. The model therefore attempted to capture the qualities that differentiate marshes in various conditions with regard to apparent functional value as habitat. The model does this by using a series of variables, so that the model combines estimates of quality as well as quantity.

The second assumption is that there is an optimal marsh habitat condition and it can be characterized. Wetland quality is then determined based on comparison to this assumed optimal condition, and ranked accordingly.

Approach. There are four WVA models, one for each major wetland type encountered along the Louisiana coast: 1) fresh/intermediate marsh; 2) brackish marsh; 3) saline marsh; and 4) cypress swamp. Each model includes a formula to characterize the combined habitat quality of emergent marsh and associated open water areas. The formulas result in a number scaled from 0.1 to 1 that represents the relative value of the habitat, compared to optimal habitat that would receive a ranking of 1. These formulas are a composite of variables that are considered important in characterizing fish and wildlife habitat.

Methodology - brackish marsh example. The approach used for assessing changes in each variable and applying these in the model to estimate benefits will be illustrated using the brackish marsh model as an example. Six environmental variables are used to characterize both marsh and water conditions in the brackish (as well as the other) marsh model(s). The variables are:

- percent of area covered by emergent marsh (V1);
- percent of open water area dominated by submerged aquatic vegetation (SAV) (V2);
- marsh edge and interspersion (V3);
- percent of open water that is shallow (<1.5 feet) (V4);
- salinity (V5); and
- aquatic organism access (V6).

Each of these variables is evaluated with regard to a Suitability Index graph. These graphs show the relationships between values of the variables and habitat quality, and are presented for the brackish marsh model in Figure 4.6-1. It can be seen from these graphs that the Suitability Indices range between 0.1 and 1, where 1 represents optimal habitat. For example, the graph for V1 shows a linear relationship, where 100% marsh gives an optimal habitat suitability of 1, and no marsh (0%) gives the minimal suitability index of 0.1.

If a current value for a variable is known, the current Suitability Index can be obtained from the graph. If a future value for a variable is predicted (e.g., with or without the project), the associated Suitability Index can be obtained from the graphic relationship. The differences in these future Suitability Indices then represent the changes in habitat conditions that are expected from the project, which are compared to what would occur without the restoration project.

Values for the variables included in the WVA models are estimated based on a variety of sources of existing information. These would include: recent satellite imagery (e.g. from which estimates could be made of the percentages of marsh and open water in a project area); aerial photography; field surveys conducted by the WVA workgroup; literature data; existing water quality monitoring stations and other monitoring results; interviews with experts in the field; and experience of the scientists participating in the WVA evaluation process.

The form of each Suitability Index graph reflects assumptions that were made regarding the optimal range of the variable for that marsh type, and how habitat quality would change as the value of that variable changed. As presented above, the graphs for V1 (percent emergent marsh) as well as for V2 and V6 are a simple linear relationship to suitability - the more vegetated marsh (or SAV or organism access) there is, the higher the assumed habitat quality is.

Another variable, V3 (marsh edge and interspersion) is related to suitability in a step function. Even though there is certainly a continuous range of degrees of interspersion, it was not feasible to evaluate degree of interspersion on a continuous scale.

A few variables, such as V4 (percent shallow water) show a more complex linear relationship. In these, an optimal range of suitability is reached at a value less than 100% of the total possible range in values, and then declines as the value of that variable increases beyond that range. For V4, having 100% shallow water (i.e., no water deeper than 1.5 feet) was considered to reflect a lower habitat diversity and to present fewer opportunities for refuges than a combination of shallow plus deeper water.

Using the variable values estimated by the WVA workgroup, a suitability index value is obtained for each variable for existing conditions ("year 0"), for the first year of project implementation (year 1), for the end of the 20-year project life (year 20), and for any "target year" between years 1 and 20 for which a major change in conditions would be expected. These values are then entered into set formulas to calculate overall Habitat Suitability Indices (HSIs) for each target year.

The HSI formula for characterizing habitat quality for brackish marsh is as follows.

$$HSI = [(3.5 * (SI_{V1}^{3} * SI_{V2} * SI_{V6})^{1/5}) + ((SI_{V3} + SI_{V4} + SI_{V5})/3)] \text{ divided by } 4.5$$

The variables are weighted, reflecting judgments on the relative importance of each variable in determining habitat quality for that wetland type. Weightings are accomplished using coefficients, or exponents, or both. So for example, in the first term of the brackish marsh formula, V1 (emergent marsh) is weighted more heavily than V6 (aquatic organism access), because its exponent is 3 compared to 1. The entire first term (including V1, V2, and V6) is weighted more heavily than the second term, because its coefficient is 3.5 compared to 1. Overall, the coverage of marsh (V1) is considered the most important variable.

Because the component suitability indices range from 0.1 to 1, the HSIs range from 0.1 to 1, and are assumed to have a linear relationship to overall ability of the particular wetland area to provide fish and wildlife habitat.

Once HSIs are determined for several time periods (existing conditions and each future target year), for the future with and without the project, the next step in estimating project benefits is to multiply each HSI by the project acres present in each target year. This yields Habitat Units (HUs) of wetland for each target year. Habitat Units can be thought of as acres modified by a quality factor.

HUs are then averaged over the 20-year project life. This gives Average Annual Habitat Units (AAHUs) for the future with the project and the future without the project. AAHUs for future without the project are subtracted from AAHUs for future with the project to estimate net AAHUs for wetland habitat due to the project.

Methodology - other marsh types. The overall process illustrated in the brackish marsh example (above) is the same for fresh/intermediate and for saline marshes. The component variables are also the same. However, the Suitability Index graphs that relate values of each variable to habitat quality differ between marsh types. The Suitability Index graphs for fresh/intermediate and saline marshes are presented in Figures 4.6-2 and 4.6-3, respectively. Differences among the graphs for each variable reflect expected differences in the optimal range for some variables, especially salinity and abundance of submerged aquatic vegetation, between marsh types.

In addition, the formulas used to calculate HSIs in fresh/intermediate and saline marsh differ slightly from those for brackish marsh. The main differences are in the relative weightings of each variable. These differences reflect judgements on how important each variable is in determining habitat quality for that marsh type. For instance, abundant SAVs (V2) are considered more characteristic of fresh marshes than saline marshes. Conversely, the fresher a marsh is, the less influential estuarine organism access is considered to be. The formulas for fresh/intermediate and saline marshes are as follows.

Fresh/Intermediate Marsh:

$$HSI = [(3.5 * (SI_{V1}^{3} * SI_{V2}^{1.2} * SI_{V6}^{0.5})^{1/4.7}) + ((SI_{V3} + SI_{V4} + SI_{V5})/3)]/ 4.5$$

Saline Marsh:

$$HSI = [(3.5 * (SI_{V1}^{3} * SI_{V2}^{0.5} * SI_{V6}^{1.2})^{1/4.7}) + ((SI_{V3} + SI_{V4} + SI_{V5})/3)]/ 4.5$$

4.6.2 Summary of previous analysis

A WVA evaluation of the Bayou Lafourche Diversion Project was originally conducted in October 1995 as part of the overall evaluation for listing the project on PPL5. This WVA assumed project features and operations as described for the original project (see Section 6.3.1). In particular, estimation of benefits assumed a flow of 2,000 cfs delivered by siphon only. This meant that water only would be diverted from approximately December through June, and maximum flow would not be achieved in all months.

Assumed water distribution. For the original WVA, assumptions on the distribution of water were based on minimal available information from the USFWS on flows at Company Canal and

Bayou Lafourche, and at the GIWW and Bayou l'Eau Bleu. This led to the assumptions that: 1) about 70% of the water flowing down Bayou Lafourche would go west/southwest down Company Canal; and 2) about 15% of the water flowing east in the GIWW from Company Canal back toward Bayou Lafourche would go down Bayou l'Eau Bleu and into the Grand Bayou marshes. It was assumed that the diversion would have no hydrologic effects or net marsh benefits west of Company Canal at the GIWW. However, no modeling was employed to predict water distribution or the extent of hydrologic effects of the diversion.

Project areas evaluated. Three areas, shown in Figure 4.6-4, were identified as marshes likely to be benefited from the originally described Bayou Lafourche diversion. The selection of these areas was based on the assumptions of where diverted water would go (described above), and on apparent hydrologic connectedness to the main arteries of water distribution. Size of each area was then limited based on assumptions on the potential magnitude of effects.

These three areas were evaluated separately through the WVA process, with net benefits from each subarea summed to give total project benefits. Characteristics of these subareas determined for application in the WVA were as follows.

Area number	Area name	Marsh type	Total area (acres)	Marsh area (acres)	Loss rate, 1983-90[1]
I	Lake Fields to GIWW	Fresh	13,446	9,104	0.082 %/y
II	Grand Bayou	Intermediate	9,422	7,314	0.749 %/yr
III	Delta Farms	Fresh	5,975	392	3.361 %/yr
TOTALS			28,843	16,810	-

1 - based on information from USACE GIS data base.

Original evaluation of WVA variables. The following discussions explain how V1 through V6 were determined for the original siphons project, which was evaluated in October, 1995.

V1 Percent of project area covered by emergent marsh. The basis for evaluating changes in V1 for the original Bayou Lafourche diversion was the assumption that the diverted water would reduce the rate of marsh loss. Reduction in marsh loss with the project was assumed to be largely through the stimulation of marsh health and organic production by introduction of additional nutrients; and by the moderation of salinity due to the introduction of additional fresh water. Only minimal independent estimates of the magnitude of benefits that might be expected from 2,000 cfs siphon were available for the original WVA. A gross estimate of nutrient loading (as total nitrogen) was made, but there was no basis for estimating how this would be partitioned among areas. Thus, estimates of the magnitude of effects were largely conjecture.

By reducing marsh loss, more marsh acres would remain in an area 20 years in the future with the project than in the without-project future, for which marsh loss was assumed to remain constant. Differences in the degree of reduction in marsh loss among the three subareas generally reflect assumed differences in the degree of effect on the marsh area by the diversion. Future reductions in loss rates estimated for each area was as follows.

Area number	Area name	Loss rate, 1983-90[1]	Acres to be lost in 20 yrs without the project	Assumed reduction in loss rate with the project	Net savings in marsh acres
I	Lake Fields to GIWW	0.082 %/y	149	50%	74
II	Grand Bayou	0.749 %/yr	1,096	25%	274
III	Delta Farms	3.361 %/yr	264	30%	80
TOTALS			1,509		425

1 - based on information from USACE GIS data base.

V2 Percent of open water area dominated by submerged aquatic vegetation (SAV). The original evaluation of V2 for the Bayou Lafourche diversion was as follows (FWOP = future without project; FWP = future with project).

		V2 SAVs		
Area number	Area name	Existing conditions (year 0)	FWOP (20 years)	FWP (20 years)
I	Lake Fields to GIWW	5%	5%	10%
II	Grand Bayou	60%	50%	65%
III	Delta Farms	50%	50%	60%

Changes in abundance of SAV were predicted to occur as a result of stimulation from the addition of nutrients. In Areas I and III, the average abundances of SAVs were expected to remain stable even without the project; thus project benefits accrued from predicted stimulation of SAVs with the project. In Area II, the Grand Bayou marshes, it was assumed that the continued deterioration of these marshes without the project also would lead to some decline in dominance of SAVs. The rationale for this included greater exposure to high energy conditions and possibly to higher salinities. Thus, benefits in this area resulted from protection against this decline as well as from stimulation of growth.

V3 Marsh edge and interspersion. The original evaluation of V3 for the Bayou Lafourche diversion was as follows.

		V3 Interspersion		
Area number	Area name	Existing conditions (year 0)	FWOP (20 years)	FWP (20 years)
I	Lake Fields to GIWW	Class 1 - 25% Class 2 - 25%	Class 1 - 25% Class 2 - 25%	Class 1 - 25% Class 2 - 25%

		Class 3 - 10% Class 4 - 40%	Class 3 - 10% Class 4 - 40%	Class 3 - 10% Class 4 - 40%
II	Grand Bayou	Class 2 - 60% Class 3 - 40%	Class 2 - 50% Class 3 - 50%	Class 2 - 55% Class 3 - 45%
III	Delta Farms	Class 4 - 100%	Class 4 - 100%	Class 4 - 100%

Note that Class 1 is the most solid marsh, while Class 4 is the most opened or deteriorated marsh. This original evaluation of V3 reflects the existence of some relatively healthy marsh in Areas I and II as well as relatively degraded marsh in Area II. It also captured the interspersion of large open water bodies in Area I and III. This variable was predicted to change only minimally, reflecting the extent that marsh deterioration and losses would progress over 20 years without the project and would progress at a lesser rate with the project. V3 was not predicted to change in Area III, where future average loss rates were low and the open water body of Delta Farms dominated the landscape.

V4 Percent of open water that is shallow. The original evaluation of V4 for the Bayou Lafourche diversion was as follows.

		V4 Shallow water		
Area number	Area name	Existing conditions (year 0)	FWOP (20 years)	FWP (20 years)
I	Lake Fields to GIWW	5%	5%	10%
II	Grand Bayou	85%	80%	85%
III	Delta Farms	5%	5%	5%

The distribution of shallow water in Area I (along Lake Fields and the GIWW) was considered small due to the dominance of the lakes. The increase after 20 years with the project was predicted to result from stimulation and accumulation of organic production, especially of SAVs. V4 benefits in Area II were considered to be primarily from prevention of the degradation that would occur without the project. Area III, dominated by the Delta Farms pond, was evaluated as having de minimus shallow water that was not expected to change with the project.

V5 Salinity. The original evaluation of V5 for the Bayou Lafourche diversion was as follows.

		V5 Salinity		
Area number	Area name	Existing conditions (year 0)	FWOP (20 years)	FWP (20 years)
I	Lake Fields to GIWW	0.5 ppt	0.5 ppt	0 ppt
II	Grand Bayou	2 ppt	4 ppt	1.5 ppt
III	Delta Farms	0.5 ppt	0.5 ppt	0 ppt

Changes in salinity reflect the expected freshening from diverting additional fresh water into Bayou Lafourche. However, all salinities were within the optimal ranges for the respective marsh types in the WVA model. Therefore, this variable did not contribute to net project benefits.

V6 Aquatic organism access. The availability to aquatic organisms of marshes within the original Bayou Lafourche project area was considered unrestricted under existing conditions, and would not change with the project. Thus, V6 was evaluated as a 1.0 for all cases.

4.6.3 Project area for modified Bayou Lafourche project

For one alternative, the modified project described in Chapter 5, the WVA Workgroup defined modified project boundaries, representing marsh areas that will be "substantially" benefited by the diversion. This process included identification of locations likely to be influenced by the project, and then definition of the extent of marsh area in each location that would be substantially benefited. Boundaries (and WVA benefits) for the other alternatives were approximated by EPA consultants based on application of the principles established by the WVA Workgroup.

Locations of benefited marshes. Results of UNET modeling, summarized in Section 4.4, were the primary input for identification of target marsh locations for the modified Bayou Lafourche diversion project. This modeling effort provided several results that contributed significantly to selection of target marshes.

- At low flow, almost two thirds of the diverted water flows into Terrebonne Basin, initially via the Company Canal. Of this, about 35% flows west via the GIWW, towards the Penchant Subbasin, and about 28% flows south via the main distributaries from the GIWW, especially the HNC, Bayou Terrebonne, and Bayou l'Eau Bleu. A net one third flows east into Barataria Basin, primarily in the GIWW east of Bayou Lafourche.

- In high flow conditions (e.g., with the Atchafalaya in spring flood on the west, and Davis Pond running at maximum on the east), the distribution of diverted water and/or its hydrologic effects are shifted eastward. Under these conditions, about 46% of the diverted water goes east into Barataria; about 31% goes west, and 23% flows south.

- In low flow conditions, and accounting for the proportion of diverted water that is not used for other purposes and gets out of the bayou, the modified project increases flow south in the HNC by almost 22%; in Bayou Terrebonne by about 40%; in Bayou l'Eau Bleu by about 70%; in Bayou Lafourche south of Larose by almost 79%; and in the GIWW east of Bayou Lafourche by almost 84%. The estimated actual increases in flow are +215 cfs in the HNC; +27 cfs in Bayou Terrebonne; +76 cfs in Bayou l'Eau Bleu; +121 cfs in Bayou Lafourche south of Larose; and +276 cfs in the GIWW east of Bayou Lafourche.

Size of benefited area - comparison to other projects. The extent of marsh included in each area was estimated using input on magnitude of additional flow expected to reach each location, and on hydrologic connectedness to the main arteries of water distribution. Expected nutrient and clay sediment loadings and salinity effects of the diversion were also estimated for each project subarea as input for establishing size of benefited areas.

4.6.4 General considerations regarding benefits of modified Bayou Lafourche project

Methods applied toward quantifying benefits. As in the original WVA, the basis for estimating effects in the WVA evaluation of the optimized project was the assumption that the Bayou Lafourche diversion would reduce marsh loss rates. No marsh building was predicted from the primarily clay sediments that would be delivered with the diverted water to the marshes. The primary mechanisms through which the diversion was expected to impact marsh losses in the target marshes were through the reduction of salinity stress due to the increased freshwater flows; and through the stimulation of organic production in emergent marsh as a result of the introduction of clay sediments and of nutrients. Approaches used to estimate salinity effects, and to estimate inputs of sediments and nutrients are presented in Sections 4.6.5, 4.6.6, and 4.6.7, respectively.

To estimate the magnitude of delivery of additional fresh water and associated resources to the various target marshes, attributable to a new diversion, an estimate first was made of the average magnitude of existing diversions made by the Bayou Lafourche Freshwater District (FWD). Pumping data from the FWD are presented in Figure 2.4-1. Data from 1988 through 1990 were used to calculate average existing discharge rate, because this period is representative of existing conditions that have contributed to any existing marsh benefits within the period from which marsh loss rates are calculated (1983-90). In addition, since evaluation of differences in channel flows emphasize the fall season, when benefits from the year-round diversion of fresh water are expected to be proportionately greatest, average pumping during the fall (September through November) was used. From these data, the average existing discharge is about 185 cfs.

This value includes fresh water, with associated nutrients and sediments, that is actually delivered to marshes from the existing diversion, and thus removes these existing benefits from the estimate of benefits of the new diversion. It also includes any water withdrawn for industrial and residential use that would not be available for transport or contribute benefits to target marshes. Section 4.4.5 summarizes average existing withdrawals plus projections for future growth, giving an estimate of average withdrawal for industrial and residential use of about 88 cfs over the life of the project.

To estimate total delivery of resources (fresh water, sediments, and nutrients) to the target marshes by the modified project, the average existing diversion of water (185 cfs), which includes the amount withdrawn for other uses (88 cfs), was subtracted from the total diversion size of 1,000 cfs. This gave an estimate of 815 cfs of water that could potentially deliver resources to marshes.

Influence of landscape modeling results on assessment of benefits. A landscape model was used to help evaluate the Bayou Lafourche diversion. Specifically, researchers at LSU (White et al., 1997) have developed and published a landscape simulation model for the wetlands of the Barataria and Terrebonne Basins. The model is called CELSS. The hydrologic portion is an overland flow, finite difference, two-dimensional, and vertically integrated model, using a 10 km^2 cell size and 1-hour time steps. Boundary conditions include tide elevation and salinity at the gulf, Atchafalaya River discharge and suspended sediment, and numerous other discharges and pumping station inputs along the perimeter of the basins.

The hydrologic model is coupled with a primary production model that uses 1 km^2 cells and 1-day time steps. Outputs from these models are transferred to a soil generation module and a habitat switching module, which evolve the landscape at a scale of 1 km^2 on an annual basis. In the model, habitat classification is based on salinity and biomass criteria. Calibration and verification of this multi-module model was complex (see White et al., 1997); ultimately the model was validated by comparing outputs to the USACE and USFWS land loss data.

There are numerous limitations associated with the CELSS model. One of the most pertinent in this case is that the hydrologic portion of the model is an overland flow model, and does not incorporate major channels or other hydrologic boundaries or pathways within each basin. In addition, the scale of the model is very coarse. Due to these limitations, output of the CELSS model was only used to provide an independent comparison of the general magnitude and extent of project benefits.

For the WVA process, the calibrated and validated landscape model was run to evaluate a 1,000 cfs diversion into Bayou Lafourche. This was accomplished by putting 700 cfs of water into Terrebonne Basin, and 300 cfs into Barataria Basin, generally consistent with distributions of water expected from the UNET modeling. Based on an estimate of average freshwater input into Barataria Basin of about 7,000 cfs (Swenson and Swarzenski, 1995), and the assumption that freshwater inputs to Terrebonne Basin are similar, a 1,000 cfs diversion represents roughly 7% of the current freshwater input to the combined basins.

Several model outputs were considered for evaluation of extent of marsh effects. Salinity outputs showed small but measurable changes diffused throughout the basin. Thus the model results are probably a realistic representation that the effects of a diversion into Bayou Lafourche will be diffuse and basin-wide.

Changes in marsh elevation, an intermediate model output, were captured to show the extent of marsh areas for which the model predicted that inputs from the diversion would stimulate the marsh not only to keep up with subsidence, by to exceed this by at least 1 cm of net accretion over the 30-year model run. This was taken as an indication of significant changes resulting from a Bayou Lafourche diversion of 1,000 cfs. Figure 4.6-5 shows the cells, as colored squares, that showed an increase in marsh elevation of at least 1 cm for both the Barataria and Terrebonne Basins. These cells were superimposed on recent marsh imagery in GIS. The area of significant effects extend from the HNC east to Lake Salvadore, and encompass about 121 km^2 (about 29,899 acres) in Terrebonne Basin, and about 156 km^2 (about 38,548 acres) in Barataria Basin.

Marsh area lost in 30 years of model simulation with a 1,000 cfs year-round diversion into Bayou Lafourche, and again without a diversion were compared to estimate net benefits of the diversion project. Because entire 1 km^2 cells were either lost to open water or not depending on the final predominance of marsh in the cell, this is a relatively coarse measure, and should not be used to determine exact locations of effects. However, the results can be interpreted as a reasonable order-of-magnitude estimate of the extent of benefits of a 1,000 cfs diversion into Bayou Lafourche. The model output shows that about 5 km^2 (about 1,236 acres) are saved in

Terrebonne Basin with the project over no action, and about 7 km^2 (about 1,730 acres) are saved in Barataria Basin, for a total of about 2,966 acres saved from loss with a 1,000 cfs diversion into Bayou Lafourche.

4.6.5 Assessment of salinity impacts

General salinity effects. Saltwater intrusion is considered a significant cause of marsh degradation and loss in the Barataria and Terrebonne Basins. Thus, moderation of salinity and reduction of saltwater intrusion will be significant benefits of the Bayou Lafourche diversion.

The primary basis for evaluating the extent and magnitude of project effects on average salinity was a study conducted by USACE using the TABS model to evaluate changes in salinity within the Grand Bayou marsh area that would be expected from increased freshwater input via the GIWW and Bayou l'Eau Bleu. The Grand Bayou marsh is the main target area for the CWPPRA TE-10 Project, which involves (among other features) enlargement of Bayou l'Eau Bleu to increase freshwater input from the GIWW. It is also a significant target marsh for the Bayou Lafourche diversion project. A description of the model, methods employed, and results are presented in Section 4.5.

As described in Section 4.5, the TABS model did not reproduce the strong tidal currents observed in the field, particularly in Cutoff Canal at the Pointe au Chien ridge, and thus did not reproduce the large salinity fluctuations that are sometimes observed in the Grand Bayou marshes. This may be a limitation in interpreting the range of salinity effects predicted by the model.

Predicted salinity responses in Grand Bayou marshes. Salinity changes with increasing flow through Bayou l'Eau Bleu for the Grand Bayou marsh locations shown in Figure 4.5-1 are graphed in Figures 4.6-6 to 4.6-9. These locations are at increasing distances south from the point of freshwater input. To interpret these graphs relevant to the Bayou Lafourche diversion project, it is necessary to know that the UNET modeling showed that at low flow, a 1,000 cfs diversion into the bayou with 815 cfs going to the marshes would increase flows in Bayou l'Eau Bleu from about 109 cfs to about 186 cfs.

In the northern portion of the Grand Bayou marsh ("Top", Figure 4.6-6), an increase in flow with no structure in Cutoff Canal (line labeled "open") from 109 to 186 cfs resulted in a decrease in average salinity from slightly less than 1 ppt to slightly more than 0.25 ppt. The relatively small reduction in salinity at the location closest to the source of additional fresh water is primarily a reflection of the very low existing salinities at this location. The next locations moving south from the top of the study area are Grand Bayou Canal on the west and Bayou Blue on the east (Figure 4.6-7). Here, the same increase in flow decreased average salinities by 1.1 to 1.2 ppt (from about 5.6 ppt to about 4.4 ppt on the west, and from about 6.2 ppt to about 5.1 ppt on the east).

In the middle of the study area, at Cutoff Canal and Sulfur Mine Canal on the west and Bully Camp on the east (Figure 4.6-8), the increase in flow estimated to be associated with the Bayou Lafourche diversion resulted in a decrease in salinity of 0.5 ppt to 0.6 ppt (from about 9.8 ppt to about 9.2 ppt on the west, and from about 10.3 ppt to about 9.8 ppt on the east).

In the southern portion of the study area, at Cutoff Canal and Grand Bayou on the west and Bayou Bouillon and Grand Bayou Blue on the east (Figure 4.6-9), the increase in flow from 109 to 186 cfs resulted in a decrease in average salinity of about 0.2 to 0.3 ppt (from about 15.7 ppt to about 15.5 ppt on the west, and from about 13.5 ppt to about 13.2 ppt on the east).

In summary, a 1,000 cfs diversion into Bayou Lafourche during low flow conditions, with 815 cfs going to marshes, can be expected to decrease average salinities in this target marsh area by about 0.2 to 1.2 ppt, even as far south as Bayou Bouillon and Grand Bayou Blue. This is expected to be a minimal estimate, based on the evidence that the TABS model is underestimating salinity maxima in Grand Bayou marshes. This magnitude of decrease in salinities is likely to be biologically significant, especially depending on the marsh type in each area.

The implication of this information for the Bayou Lafourche diversion is that the diversion of 1,000 cfs of fresh water in the fall may have marsh benefits equivalent to or greater than a much larger diversion during high water in the spring. Since the operational plan for the Bayou Lafourche diversion is to siphon and/or pump year-round, this project should have functionally equivalent marsh benefits equal to that of a much larger project that only diverts during high water.

Other estimates of the magnitude of salinity effects. Another approach used to develop an understanding of how much a Bayou Lafourche diversion would affect salinity conditions in target marshes was to relate increased flows from the diversion to rainfall equivalents. This approach is based on drawing analogies with observable changes associated with rainfall, to the extent that there are salinity data from marsh areas for both wet and dry years. One component of this analysis was to characterize a wet year compared to an average year in terms of rainfall in coastal Louisiana. Eleven years of rainfall data from New Orleans are shown in Figure 4.6-10. These data show a mean annual rainfall and standard deviation of 64.5±11 inches/year. Out of the 11 years of data, the two wettest years (i.e., highest rainfalls) had rainfalls equal to or greater than one standard deviation above average. Using this to characterize a wet year suggests that an additional 11 inches or more of rainfall per year could be described as a wet year.

The second component was to estimate how much the increase in rainfall in a wet year would displace the 5 ppt and 20 ppt isohalines compared to their average position. Using information for Barataria Basin, Eric Swenson of LSU estimated that a discharge equivalent to one additional inch of rainfall could move the 5 ppt and 20 ppt isohalines a few tenths of a mile. In the Grand

Bayou marshes, the increase in freshwater input associated with a 1,000 cfs diversion during low flow (about 77 cfs) is equivalent to about 19 inches of rain per year (about 1.6 inches per month) over the 34, 900 ac area. Using a conservative displacement of 0.2 miles per inch of rainfall, the yearly input to the Grand Bayou area could move the isohalines almost 4 miles. Since the Grand Bayou target area is about 4 to 5 miles across, this could represent a freshening of more than 10,000 to 12,000 acres of marsh.

Importance of diversion during the fall low-flow period on marsh benefits. Most diversions operating in or planned for coastal Louisiana marshes divert primarily during high river stage, i.e., early spring through early summer. Such diversions are important for delivering resources needed for marsh maintenance (and reduction in marsh loss), and/or for marsh creation. But while these typical diversions also reduce salinities due to freshwater inputs, they do not operate during periods of greatest salinity increases and occurrence of salinity spikes (evidence of saltwater intrusion). Maximum saltwater intrusion typically occurs in the fall, when riverine inputs are low.

For diversions that operate year-round by using pumps as well as siphons, fresh water will be delivered to target marshes continuously, with the potential to counteract late summer or fall saltwater intrusion, including salinity spikes characteristic of some of the target marsh areas. Some specific evidence is available that suggests that in relatively fresh, peat-forming marshes, control of late-summer/fall salinity spikes may be more important in preserving overall marsh integrity than addition of fresh water during the spring.

In a study conducted in marshes in Jean Lafitte National Historic Park, Hargis and Swarzenski (1998) found that important soil chemistry parameters of redox, porewater sulfide, and salinity were related to proximity of the marsh site to the source of occasional saltwater spikes. That is, in a relatively fresh marsh (average salinity of 2.5 ppt), occasional salinity spikes markedly influenced marsh soil redox, sulfide, and salinity.

These variables appeared to influence species composition of the marshes, with sites of greater influence of saltwater peaks associated with a shift in dominance to species with less root-forming capabilities. The general pattern of change in dominant species was from maidencane to *Eleocharis* to bulltongue to wiregrass with increasing exposure to salinity spikes.

Hargis and Swarzenski concluded that marsh soil redox, sulfide, and salinity have substantial influence on the integrity of peat-forming marshes through the mechanism of influencing degree of root productivity and peat formation. This is expected to have proportionally greater benefits in preservation of marsh integrity than salinity moderation in the spring. This should also contribute to the year-round Bayou Lafourche diversion having functionally equivalent marsh benefits equal to that of a much larger project that only diverts during high water.

4.6.6 Assessment of sediment loading effects

Sediment loading calculations. Sediment input from the Bayou Lafourche diversion is expected to sustain existing marsh and reduce loss rates rather than build marsh acreage. The amount of benefit that can be expected from diverted sediments will be related to the quantity of sediments delivered to the marshes, and the sediment needs of the marshes.

Sediment delivery or "loading" will be related to the concentration of sediment in the diverted water as it reaches the marsh, and how much water reaches the marsh over time. Based on USACE and USGS biweekly sampling of suspended sediments in the Mississippi River at Tarbert's Landing, Mashriqui and Kemp (1996) reported the mean suspended sediment concentration between 1989 and 1994 to be 226 ppm, for a mean discharge of 65,000 cfs. The particle size composition of the suspended sediment at Tarbert's Landing was 26% sand, with silts and clays each between 30% and 40%.

Mashriqui and Kemp (1996) suggested that the suspended sediment concentration in river water at Donaldsonville would be slightly lower than at Tarbert's Landing. Long term (1972-97) LDEQ data for total suspended solids (TSS) in Bayou Lafourche water at Donaldsonville yielded an average of 117 mg/l.

It is expected that the sands and most of the silts in the diverted water will settle within the upper reach of the bayou. This is based on particle dynamics, in which settling rate is related to fall velocity of the particle (which is related to particle size), and velocity of the water, as well as the presence or absence of turbulent flow. It is thus expected that by the time the diverted water reaches Lockport, most of the sediment in suspension will be clays, and that most of these clays will remain in suspension and be delivered to the marshes.

LDEQ data from Lockport (1991-97) gave an average TSS of 34 mg/l. Given the USACE/USGS estimate of the percent of clays in suspended river sediments (see above), this value of TSS seems consistent with the assumption the most of the suspended sediments remaining in Bayou Lafourche water at Lockport are clays, and is the average concentration of clay sediments used in subsequent loading calculations. Annual loading is then calculated as the sediment concentration in the water flowing to the marshes times the rate of flow times the period of time over which the flow occurs.

Capture of sediments by the marshes. Once there is an estimate of loading of clay sediments to each target marsh, consideration must be given to how much of that sediment is probably delivered to the emergent marsh itself, compared to how much remains in associated water bodies and/or passes through the system. This can be thought of as a capture efficiency factor, which would be applied in each target area before estimating potential benefits from sediment delivery.

HEC-6 model results for comparison to sediment loading. Mashriqui and Kemp (1997) used a HEC-6 model to evaluate sediment dynamics in the Bayou Lafourche channel, including an estimate of how much sediment would be exported past Lockport. HEC-6 is a steady-state, one-dimensional open channel flow model supported by the Hydrologic Engineering Center (HEC) of USACE.

The reach of Bayou Lafourche modeled extended from Donaldsonville to Larose. Channel geometry inputs were from the 1993 LDOTD sections, and validated by comparison to sections re-surveyed in 1997. The input suspended sediment concentration used in the model was 100 ppm, of which 40% was assumed to be clays. The model output that will be compared to the sediment loading calculations was an annual volume of sediment exported past Lockport in Bayou Lafourche. It was assumed that this quantity of sediment was that which was available for delivery to target marshes.

Sediment needs of a marsh. There are several studies that have evaluated both inorganic (sediment) and organic accretion in various marsh types. Two assumptions must be made to use these data as an indication of sediment “needs” for a marsh:

- the rate of inorganic plus organic accretion observed in a healthy marsh represents that which is needed to keep up with relative subsidence, and

- the amount of inorganic (sediment) accretion observed represents that which is needed to stimulate organic production as well as directly contribute to vertical accretion.

The following are some study results that could be used to estimate marsh "need" for sediment. Day and Templet (1989) estimated sediment accretion deficits by marsh type:

Marsh Type	Inorganic Areal Accretion Deficit ($g/m^2/yr$)
Fresh	409
Intermediate	1391
Brackish	2476
Saline	960

Templet and Meyer-Arendt (1988) estimated a need of 6 cm/yr to counteract net subsidence in coastal marshes.

Hatton et al. (1983) provided data on vertical accretion of inorganic sediments in different marsh types in Barataria Basin:

Marsh Type	Accumulation Rate ($g/m^2/yr$)
Fresh	
levee	689
back marsh	280
Intermediate	
levee	1634
back marsh	243
Brackish	
levee	2954
back marsh	478
Saline	
levee	2700
back marsh	1740

Nyman et al. (1993) gives data on accretion of inorganic sediments for a variety of saline and brackish/saline marsh sites (only averages presented here):

Marsh Type	Mineral Accumulation ($g/m^2/yr$)
Saline (mean of 11 sites)	1992
Brackish/saline (mean of 4 sites)	724
Overall mean	1629

Nyman et al. (1990) gives the following formulas for mineral sediment requirements for each marsh type (these were the mineral sediment requirements to achieve vertical accretion equal to relative subsidence):

Fresh: $g/m^2/yr$ = 424.27 (submergence rate in cm/yr)
Intermediate: g/m2/yr = 348.18 (submergence rate in cm/yr)
Brackish: g/m2/yr = 1051.89 (submergence rate in cm/yr)
Saline: g/m2/yr = 1797.92 (submergence rate in cm/yr)

If these equations are solved using a relative subsidence rate of 1.2 cm/yr (Day and Templet, 1989), the following estimates of sediment needed to keep up with subsidence are obtained:

Fresh: 509.12 g/m2/yr
Intermediate: 417.82 g/m2/yr
Brackish: 1262.27 g/m2/yr
Saline: 2157.50 g/m2/yr

Need clearly depends on marsh type. Reasonable averages from these numbers seem to be:

Marsh Type	Range	Ballpark Average
Fresh	280-510 $g/m^2/yr$	400 $g/m^2/yr$

Intermediate	240-1390 $g/m^2/yr$	600 $g/m^2/yr$
Brackish	500-2500 $g/m^2/yr$	1250 $g/m^2/yr$
Saline	960-2160	1730 $g/m^2/yr$

Sediment benefits. Sediment benefits for each target marsh area will be estimated by combining the estimates of sediment loading, capture efficiency, and marsh needs to give an acreage of marsh that could reasonably be expected to be fully sustained in each area. These acres would be expected to be saved from loss with the project, and could be compared to existing predictions of acres of loss over the project life to estimate how much the diversion project is expected to reduce marsh loss rates in each target area.

4.6.7 Assessment of nutrient loading effects

Nitrogen loading calculations. Loading of total nitrogen was calculated to estimate nutrient delivery effects, as nitrogen and phosphorus are the major plant nutrients, and nitrogen is typically dissolved in the water column, while phosphorus is typically associated with sediments.

Nitrogen loading will be a product of average concentration in the water and volume of water delivered over time. Nitrogen concentrations were based on long-term (1991-97) LDEQ data for Bayou Lafourche at Lockport, as well as on measurements of total nitrogen concentrations made by USGS during two synoptic surveys conducted for the Bayou Lafourche evaluation. Average nitrogen concentration from the LDEQ data was 1.48 mg-N/l. Average total nitrogen from the USGS data was 1.55 mg-N/l at Lockport. As a result, value of 1.5 mg/l was used for nitrogen loading calculations.

Nutrient capture by the marshes. As for the estimates of sediment delivery, it may be necessary to apply a factor to account for transfer or capture efficiency of the total nitrogen delivered to each target marsh.

Marsh needs for nutrients. There is little information available on “needs” for nutrient delivery, or on how much response the delivery of a certain amount of additional nutrients will produce in a marsh.

Mendelssohn (1979) did a study that related nitrogen fertilization in a salt marsh to standing crop biomass of *Spartina alterniflora*. His results, interpreted from a graph, show that application of 560 kg/hectare of nitrogen resulted in about a 190% increase in biomass. This appeared to be the maximum response.

Nutrient benefits. The estimate of nitrogen loading to each target marsh area will be combined with the estimate of need and approximate marsh response to give an estimate of the acres of marsh that could be substantially affected by the nutrients delivered by the Bayou Lafourche diversion. Overall, stimulation of marsh production resulting from nutrient delivery is expected to contribute to organic vertical accretion and thus help sustain the affected marshes. Some judgement will be required to estimate whether doubling of production is likely to fully sustain the affected marshes, or contribute some portion of full support.

Figure 4.6-1. Suitability index graphs showing relationship of six component variables to habitat quality for the WVA brackish marsh model.

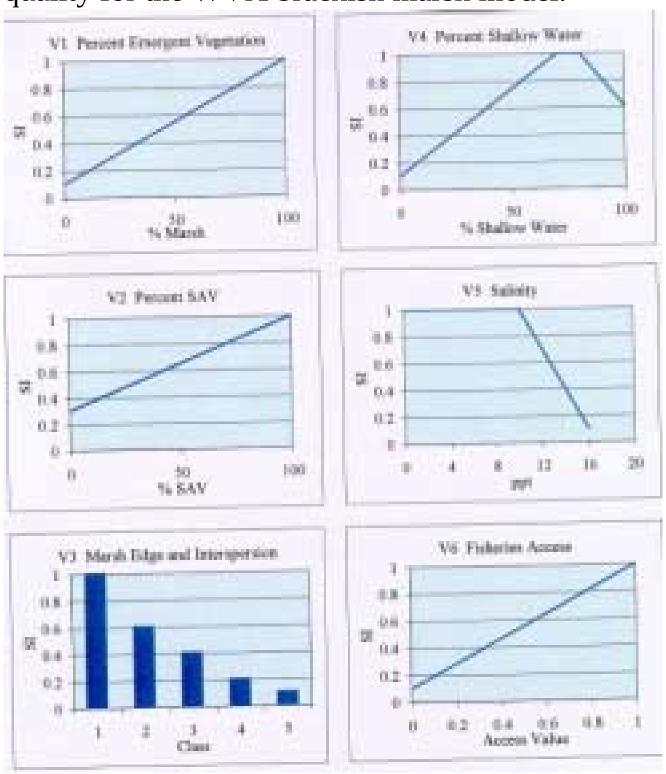


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Figure 4.6-2. Suitability index graphs showing relationship of six component variables to habitat quality for the WVA fresh/intermediate marsh model.

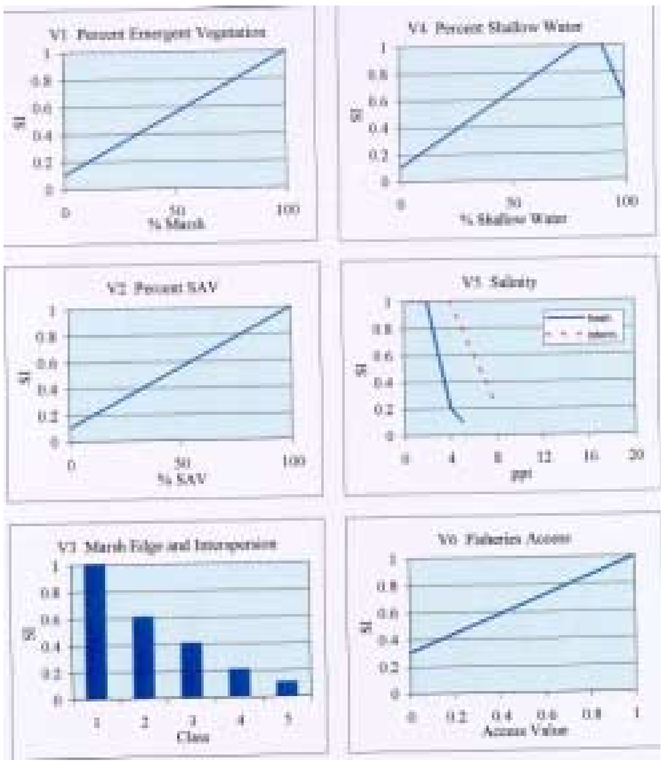
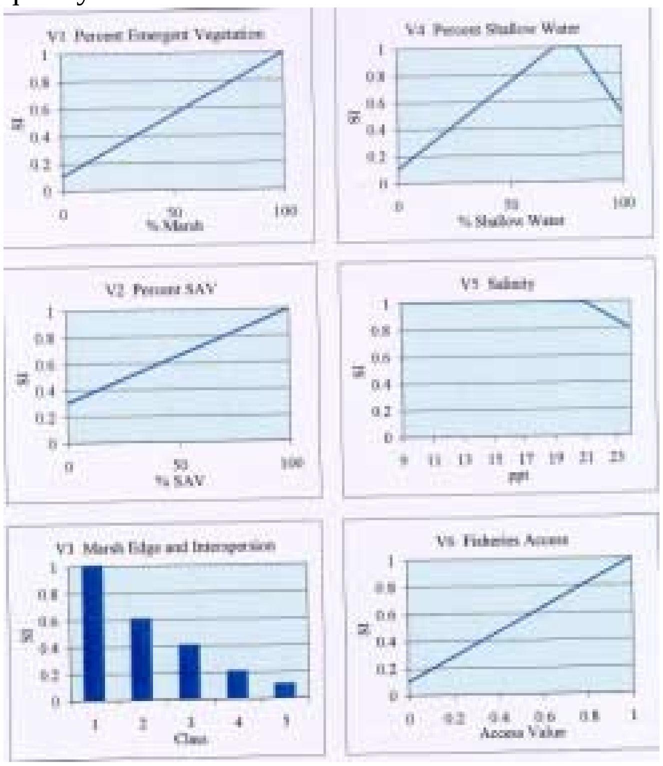


Figure 4.6-3. Suitability index graphs showing relationship of six component variables to habitat quality for the WVA saline marsh model.



PRELIMINARY: DRAFT

Figure 4.6-4. Project area defined for evaluation of WVA benefits for the originally described project.

Figure 4.6-5. Results from the CELSS landscape model showing 1 km^2 cells, as colored squares, that showed an increase in marsh elevation of at least 1 cm for both the Barataria and Terrebonne Basins.

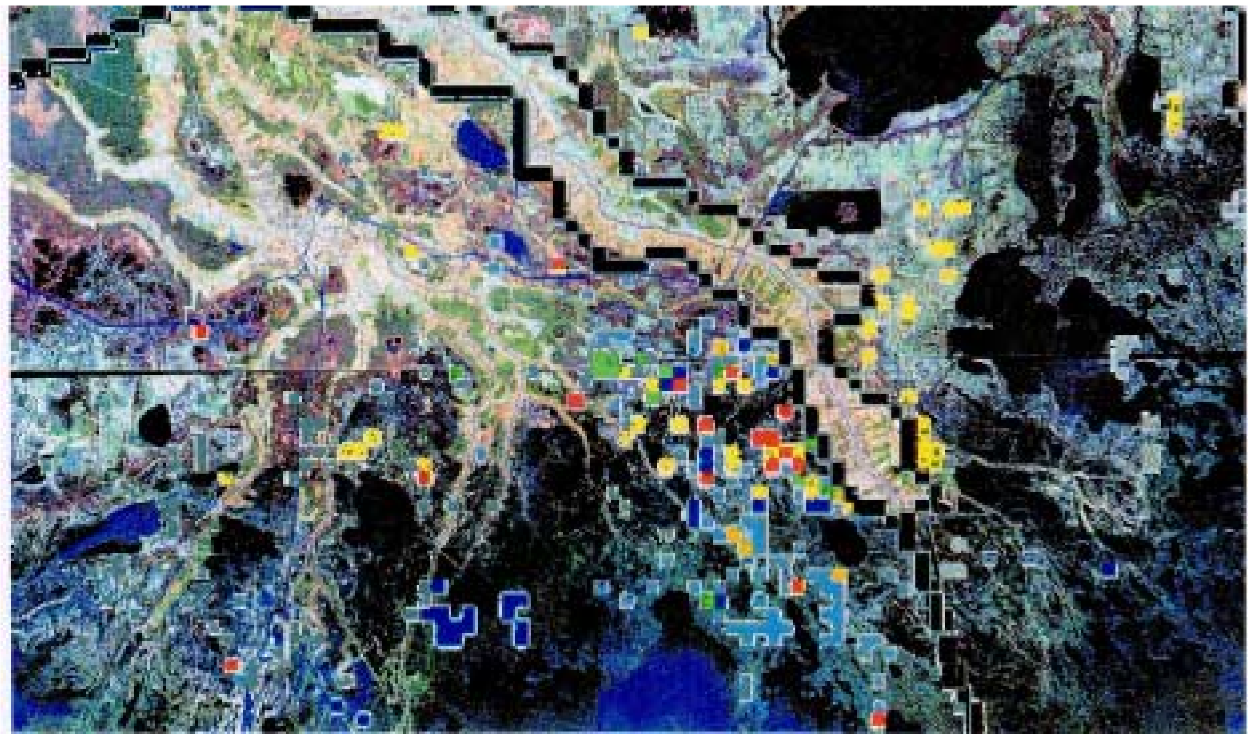


Figure 4.6-6. Salinities (ppt) at the uppermost station reported for TABS ("Top") for conditions with no structure in Cutoff Canal ("open") and with a structure in Cutoff Canal ("closed").

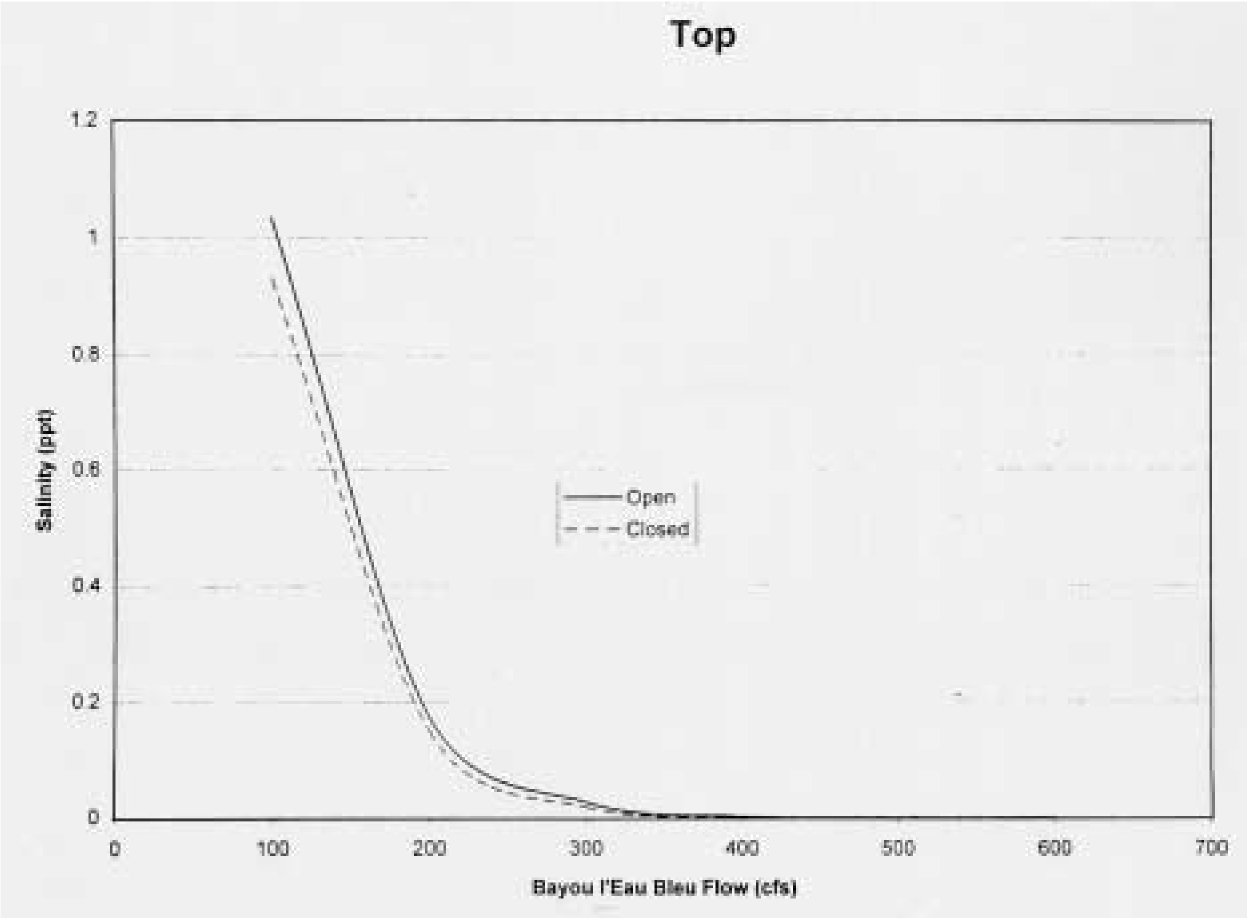


Figure 4.6-7. Salinities (ppt) at stations in the upper one-third of the TABS study area, Grand Bayou Canal on the west and Bayou Blue on the east, for conditions with no structure in Cutoff Canal ("open") and with a structure in Cutoff Canal ("closed").

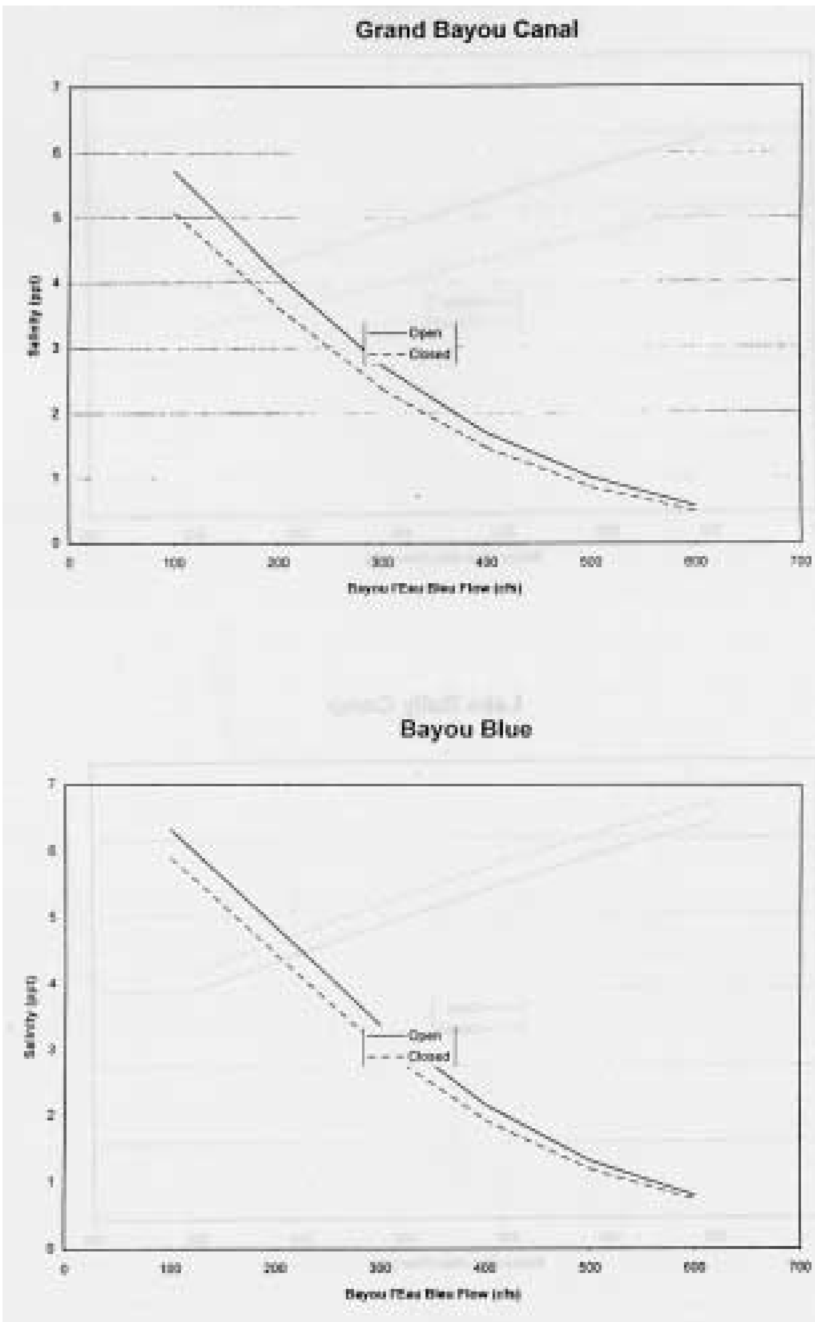


Figure 4.6-8. Salinities (ppt) at stations in the middle of the TABS study area, Cutoff Canal and Sulfur Mine Canal on the west and Lake Bully Camp on the east, for conditions with no structure in Cutoff Canal ("open") and with a structure in Cutoff Canal ("closed").

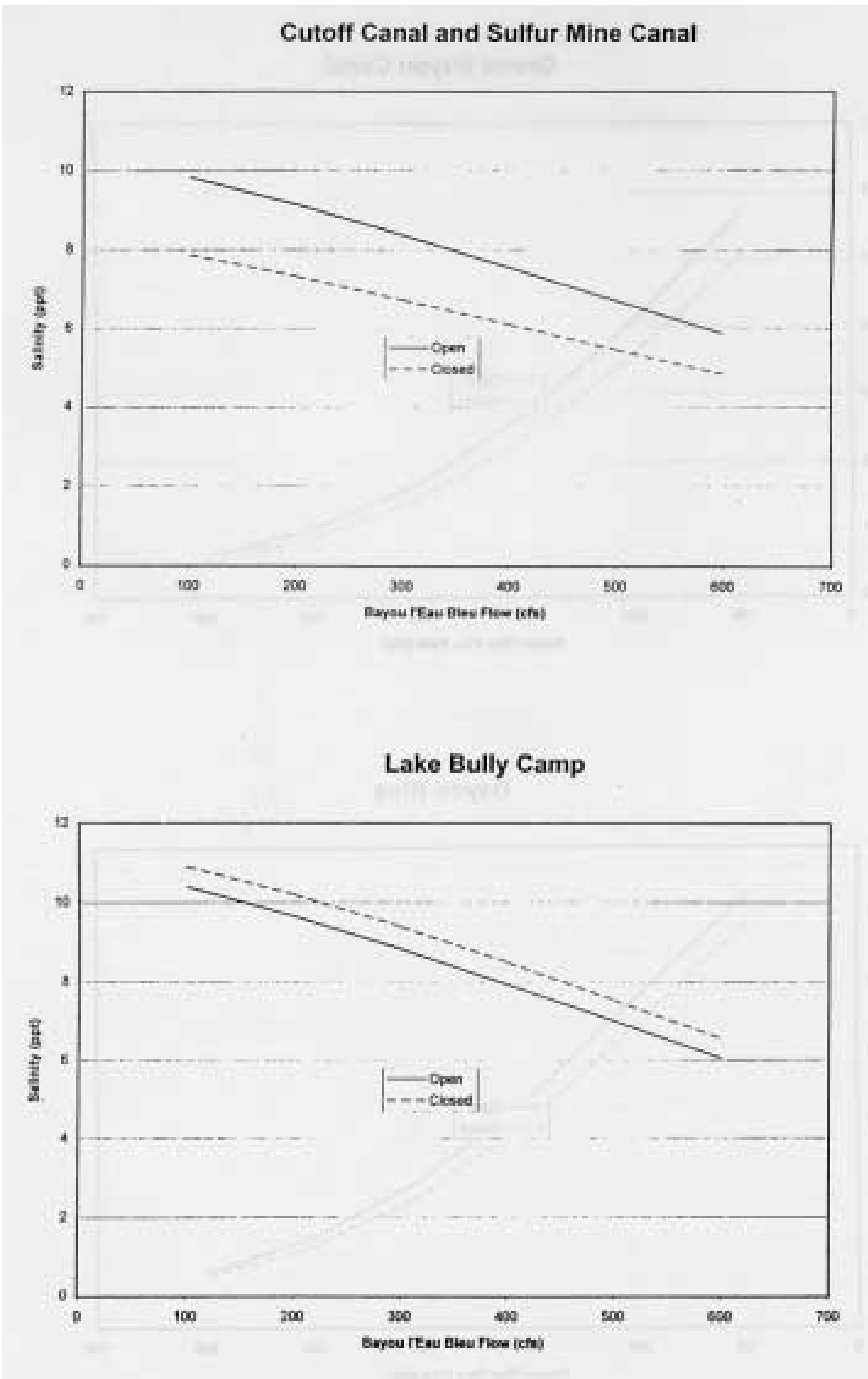


Figure 4.6-9. Salinities (ppt) at stations in the southern portion of the TABS study area, Cutoff Canal and Grand Bayou on the west and Bayou Bouillon and Grand Bayou Blue on the east, for conditions with no structure in Cutoff Canal ("open") and with a structure in Cutoff Canal ("closed").

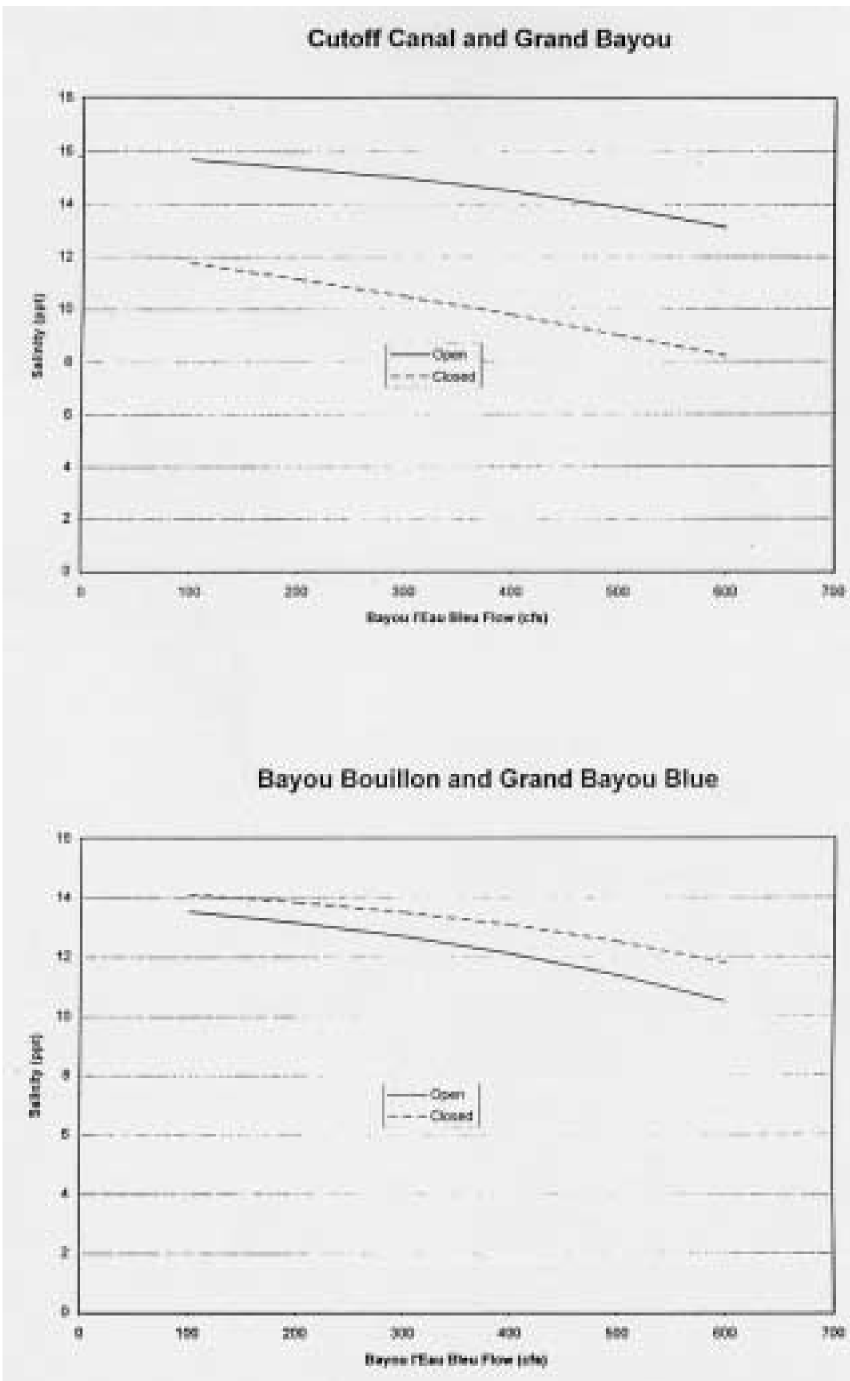
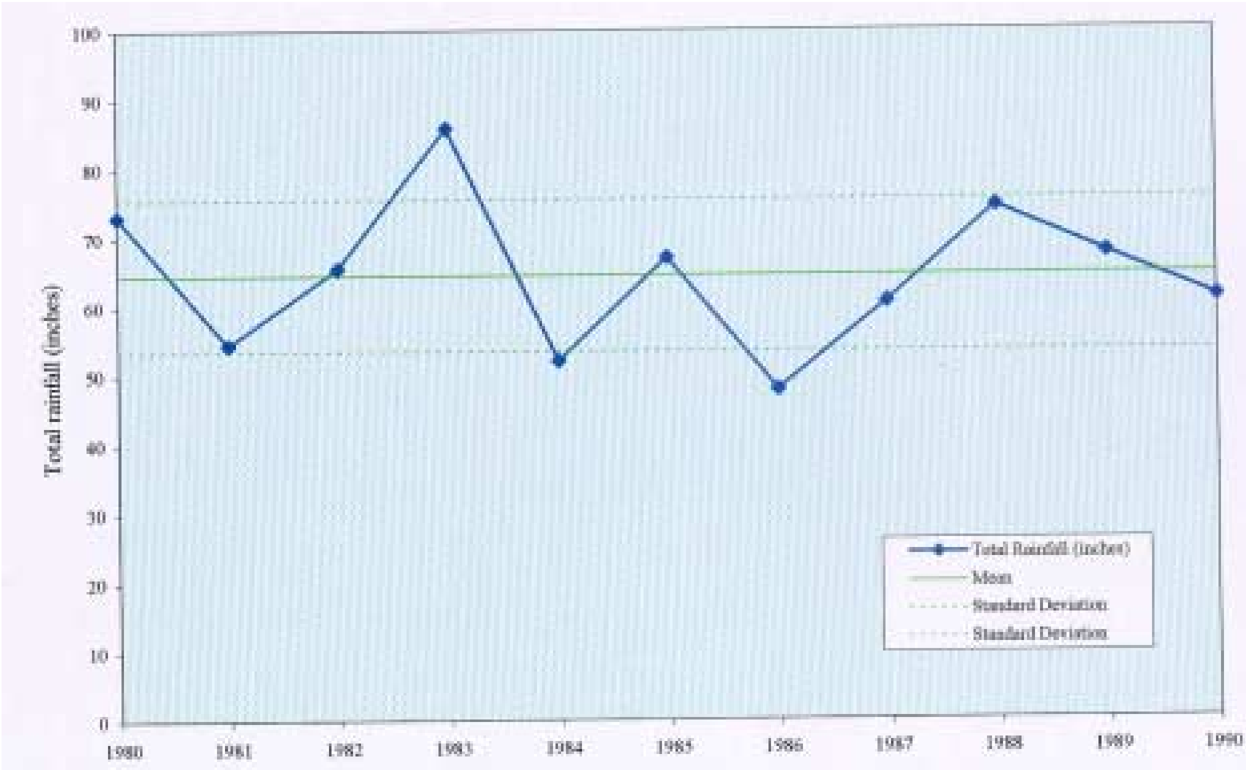


Figure 4.6-10. Total annual rainfall (inches) at New Orleans, 1980-1990.



5. EVALUATION OF THE OPTIMIZED PROJECT

5.1 OVERVIEW OF CHAPTER 5

EPA's evaluation has considered many alternatives for a Bayou Lafourche Diversion Project. Although the alternatives are varied in their approach (see generally the discussion in Chapter 6), three features have figured prominently in one or more of the options studied. In comparison to the original project PBA-20, these features are as follows.

- Most alternatives include pumps in the diversion, in order to maximize fresh water supplies during the fall when salinity problems are the greatest.
- Compared to the original 2000 cfs siphon project, all alternatives investigated in depth have reduced the project size, to reduce costs and impacts.
- A particular focus has been to identify alternatives that use channel improvements and management in order to convey diverted water without significant adverse effects on water levels along the bayou, and without significant adverse effects to drainage from lands on the levee ridge.

EPA has made no final decision regarding the most cost-effective project that would incorporate the features listed above. However, a specific project concept -- referred to as the "optimized project" -- has been selected as the focal point for discussing the costs and important impacts of a diversion which incorporates the features listed above. To be developed in two phases, the optimized project would initially provide facilities to safely convey 340 cfs, and ultimately 1,000 cfs, without a rise in water levels along the bayou, and without rapid declines in the event of a pump shut-down.

In effect, the optimized project would provide the same volume of water to the wetlands as the original project, but the flow would be a year-round supply of 1,000 cfs, instead of a seasonal supply of 2,000 cfs.

The optimized project would have multiple benefits that are expected to far exceed those of the original project. These benefits would be for wetlands, through year-round introduction of fresh water, nutrients and nourishing sediments; to water supply, through a general improvement in facilities and an increased capacity for salinity control in the fall; and to drainage, through increased channel capacity and water management capability.

The features, costs and impacts of the optimized alternative are discussed here, in Chapter 5. Other alternatives are presented in Chapter 6. EPA's final decision regarding the project will not occur until the optimized project, and other alternatives, have received public review and comment, and an environmental review process has been completed.

Chapter 5 is organized as follows.

- Section 5.2 briefly summarizes the features of the optimized project and explains how the project would be phased.
- Section 5.3 describes the construction features of the project, and presents the best current estimate of the cost to build the project.
- Section 5.4 briefly describes how the project will be operated and maintained, and presents the best current estimate of these ongoing costs.
- Section 5.5 presents information on other project costs -- contingencies, design, oversight, permitting and environmental compliance -- along with an estimate of total costs.
- Section 5.6 summarizes the effects of the project on Bayou Lafourche and adjoining properties. It includes results of the computer models that were described in Part 4, with respect to predicting how the optimized project will impact water levels in Bayou Lafourche.

- Section 5.7 summarizes the results of the Wetlands Valuation Assessment of the optimized project.
- Section 5.8 outlines specific steps for implementation of the project, including further public review and regulatory compliance, and gives a schedule for this implementation, along with a schedule for expenditure of funds.
- Section 5.9 discusses EPA's overall evaluation of the project, with respect to cost-effectiveness from CWPPRA and other perspectives.

Throughout Chapter 5 (and 6) of this report, costs are estimated using conventional engineering methods, and represent the amount of money in 1998 dollars that must be made available to build and operate the proposed facilities. As described in Section 5.9.1, cost estimates using this conventional methodology differ somewhat from those using the method adopted for CWPPRA projects. Refer to Section 5.9 for an explanation of the differences and for a statement of all costs in terms that are equivalent to those for other CWPPRA projects. Note that EPA has submitted its cost estimates to the Engineering Work Group and, in response to comments, will make revisions to some of the tables presented in this Chapter. At this time, the known changes are not expected to have a substantial impact on the overall estimate of project cost.

Also throughout Chapter 5 (and 6) of this report, benefits are estimated both with and without consideration of synergistic effects of Project TE-10. The estimates of benefits without TE-10 represent the formal outcome of the WVA process as conducted by the CWPPRA Environmental Work Group. This process excluded TE-10 because when the original WVA for Project PBA-10 was conducted, synergistic interactions with other projects were not considered. Thus the estimated benefits can be compared to those of the original project.

The estimates of benefits with TE-10 represents EPA's adjustments to the formal WVA, based on discussions of the Environmental Work Group; however, they have not been submitted to or approved by that group. EPA has provided such estimates because, for the current priority list, synergistic interactions with other projects are considered. Thus, the benefits of TE-10 need to be counted for any comparison that is made between the Bayou Lafourche diversion project, and other projects being considered for the current list.

5.2 OVERVIEW OF PROJECT FEATURES AND PHASING

5.2.1 Full project

The optimized project would provide facilities for the safe conveyance of 1,000 cfs. The concepts behind the conceptual design of the project are set forth in Chapter 3. The facilities would include the following. Figure 5.2-1 is a map showing the features of the full project.

- Upgrade the existing 340 cfs pump station at Donaldsonville, and construct a new 660 cfs pump/siphon station adjacent to the existing facility. These facilities would provide capacity to divert up to 1,000 cfs into Bayou Lafourche.
- Construct a sediment (sand) trap near the outfall in Donaldsonville. This facility would concentrate sedimentation in a single location where maintenance dredging can be accomplished at comparatively low cost.
- Remove the existing fixed weir at Thibodaux, and install two deployable weirs, one in Thibodaux and one in Donaldsonville. These facilities would provide capability to stabilize or adjust water levels in the bayou as needed.
- Dredge the bayou channel from Donaldsonville to below Raceland. This would substantially increase the conveyance capacity of the bayou. A number of utility lines would be replaced or protected as part of the dredging program. Limited bank stabilization would be included.
- Install additional stations for monitoring of water conditions in the bayou, and install monitoring stations in the marshes that will benefit from the project. These facilities would provide data to be used in evaluation and management of the project.

In addition to the constructed features listed above and shown on the map, the project would provide for development of a water management plan for Bayou Lafourche. This plan would establish criteria for operation of project features (especially the diversion works and the deployable weirs) in order to obtain the maximum wetland benefits, while also ensuring that water supply and drainage (flood protection) needs are met along the bayou.

5.2.2 Phase I

The first phase of the project would provide the initial water management plan and the following facilities for safe conveyance of 340 cfs. EPA anticipates that this phase could be designed and built in two years.

- Upgrade the existing 340 cfs pump station at Donaldsonville, by replacing two old, fixed speed pumps with modern, variable speed pumps.
- Construct a sand trap in the boat launch reach in Donaldsonville. One utility replacement is required at this location.
- Remove the existing fixed weir at Thibodaux, and install the two deployable weirs.
- Do limited dredging of the bayou channel in Donaldsonville, above the Palo Alto bridge. No utility relocations are required.
- Install all monitoring stations.

Figure 5.2-2 is a map showing those project features that would be located in the Donaldsonville area. Facilities downstream of Donaldsonville were shown on Figure 5.2-1.

Removal of the weir at Thibodaux would generally lower water levels by two feet above that point, and by lesser amounts farther upstream. This would allow conveyance of 340 cfs of flow in all areas of the Bayou except Donaldsonville; there, dredging is proposed to provide the necessary capacity. The deployable weirs would provide the ability to stabilize water levels if the diversion works shut down; and some ability to lower water levels during storms (though much less than for the full project).

Figure 5.2-1. Project facilities and effects

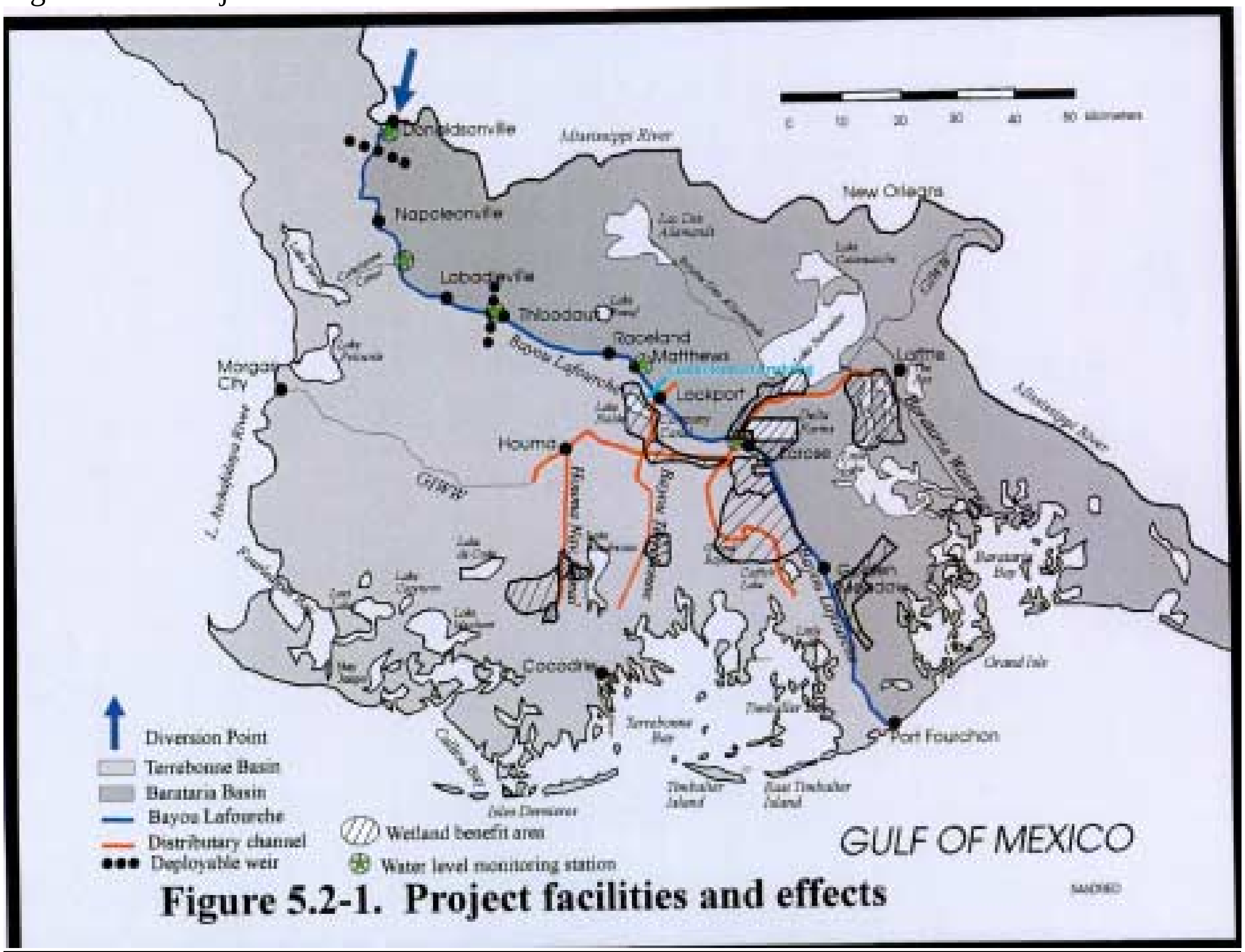


Figure 5.2-1. Project facilities and effects

5.2.3 Phase II

The second phase of the project would refine the water management plan and construct the following facilities for safe conveyance of 1,000 cfs. EPA proposes that this phase be designed at the same time as Phase I is being constructed. Construction would begin after a minimum of one year of safe operation of Phase I, and would require approximately two additional years.

- Build a new 660 cfs pump station at Donaldsonville, using variable speed pumps.
- Do extensive channel dredging from Donaldsonville to below Raceland. This includes extension of channel improvements above railroad bridge in Donaldsonville. Relocate utility lines and protect bridges as needed. Provide limited bank stabilization.

Collectively these facilities would greatly increase the capacity of the bayou to convey water, the capacity of the pumps and siphons to divert water, and the ability of the management plan to adjust water levels.

All the facilities discussed above for both phases are described in more detail in subsequent sections.

Figure 5.2-2. Map of Phase I facilities near Donaldsonville.

5.3 CONSTRUCTION FEATURES AND FIRST COSTS

Project features are described and construction costs are presented as follows.

- Rehabilitation of existing pump station (Phase I): Section 5.3.1.
- Construction of new 660 cfs pump/siphon station (Phase II): Section 5.3.2.
- Construction of sand trap (Phase I): Section 5.3.3.
- Initial dredging and utility replacement (Phase I): Section 5.3.4.
- Primary dredging program (Phase II): Section 5.3.5.
- Utility relocations for primary dredging program (Phase II): Section 5.3.6.
- Weirs (Phase I): Section 5.3.7.
- Monitoring stations (Phase I): Section 5.3.8.
- Bank stabilization (Phase II): Section 5.3.9.

Costs other than the direct expense for constructing new facilities are presented in Sections 5.4 (operations and maintenance) and 5.5 (contingencies, engineering, oversight, permitting). Detailed descriptions of project features and associated estimates of costs were submitted to the CWPPRA Engineering Work Group for review in a series of 4 submittals (EPA, 1998a, b, c, and d). Attachments included within these documents contain detailed backup material for many of the cost estimates provided here and in Sections 5.4 and 5.5. At the time of writing this report, the Engineering Work Group had not yet reviewed the project engineering and cost submittals.

5.3.1 Rehabilitation of existing pump station

In order for the existing diversion works at Donaldsonville to reliably divert a steady 340 cfs, and to have the flexibility to adjust diversion rates during storms, it would be desirable that all four pumps at the station be in good condition, and that at least some of the units be true, variable speed pumps. As indicated in Section 2.8.1, two existing pumps are in need of overhaul. A logical approach to addressing this need, and the need for variable speed capacity, is to replace the two fixed-speed pumps that need overhaul with two new variable speed units. The existing pumps could be retained for spare parts.

Table 5.3-1 presents an estimated cost for replacing two existing pumps with variable speed pumps of the same capacity. The cost reflects informal quotes received from a representative supplier. As discussed in Section 2.8.1, no other rehabilitation needs have been identified at the existing diversion works, and thus no other costs are included in the optimized project.

Note that for alternatives in which a new 660 cfs facility (with variable speed pumps) is constructed prior to upgrade of the existing facilities, then the upgrade of the facilities could simply involve overhaul of existing pumps, rather than replacement with new variable speed units.

5.3.2 New pump station

A new 660 cfs diversion facility would be consistent with the principles for siphon and pump station design that are provided in Section 3.2. Graphics illustrating project features are Figure 3.2-1 (profile) and 3.2-2 (plan). The plan shown on Figure 3.2-2 would accommodate five intake and discharge pipes; the proposed facility involves only three pipes. Particulars of the proposed station are as follows:

- there would be three 84-inch intake lines, three 72-inch outfall lines and three pumps;
- each pump would be variable speed with a rated capacity of 100,000 gallons per minute (220 cfs);
- as discussed in Section 3.2.3, some new right-of-way would be purchased, two structures would be relocated (a seafood restaurant on Mississippi Street and a water intake shed at the head of Bayou Lafourche, which is the freshwater intake for Donaldsonville), and cultural resources investigations would be performed with respect to Ft. Butler.

Table 5.3-2 provides the preliminary cost estimate for the pump station, based on the studies done by Pyburn and Odom (Pyburn and Odom, 1997c; see Appendix A for a summary of the report).

5.3.3 Construction of sand trap (Phase I)

The conceptual design of a sand trap is discussed in Section 3.3.3. The principal considerations in applying the design concept to the specifics of the optimized project related to bank stability, disposal of material, and estimated cost. Construction costs are itemized in Table 5.3-3.

Description. For cost-estimation purposes, the sand trap is assumed to be located in the boat launch reach, just below the UP Railway crossing. The sand trap is illustrated in Chapter 3 on a map (Figure 3.3-3) and cross-section (Figure 3.3-5). The main structure would be 1,000 feet long, with a bottom section at -7' NGVD that would be up to 100 feet wide, and with 3H:1V side slopes. There would be tapered sections at the upstream and downstream ends (shown on the figure as areas where the two banks are not fully aligned). This structure would encroach on the batture at a location already owned by FWD.

Stability of template. Consideration of stability of the generalized dredging template is presented in Section 3.4.4. In summary, the analyses indicate that, for the combination of weak material at depth (cohesionless silts) and high (e.g., 28+ feet) and steep existing slopes (e.g., 1:1), a 3H:1V dredging template is not stable. Stability is improved if stronger material is found at depth, or if the banks are not as high and steep. For a bank only 24 feet high and natural slopes of only 2H:1V, and without any surcharge, the 3:1 template can be excavated and the resulting slope will have a safety factor of 1.4 even if very weak material is found at depth.

No stability analysis specific to the sand trap has been performed. Based on the dredging template shown in Figure 3.3-5, the LA 1 bank at the sand trap would be 29 feet high, but the existing slope is only 3H:1V; the template also provides a small bench. Most important, boring data obtained from LDOTD show that the material at depth is likely to be much better than any that has been assessed in the stability study. A formal stability analysis will be undertaken as part of project design. Existing information is sufficient to justify an assumption of slope stability for planning-level purposes.

Dredging cross-section and volume. Inspection of the template shows that a representative dredging cross-section will require removal of about 2,000 square feet of material. The trap is approximately 1,000 feet long. Adding in an allowance for the tapered sections, it is estimated that approximately 90,000 cubic yards must be dredged.

Dredging method. Because there is comparatively easy access to this site, it is assumed a bucket dredge with a capacity of 200 cubic yards per hour would be used. The cost estimate assumes use of a bucket dredge, disposing to a slurry pump for discharge to the Mississippi River. The bucket would initiate dredging from the bank, until the channel had space to assemble a flexi-float barge. The dredge would then operate from the barge. Material would be placed into a hopper/pump for screening of debris, and then pumped at high-density to the disposal site.

Sediment disposal would be by pipeline back over the levee to the Mississippi River (unless it is determined that the material is marketable). The pipeline would pass beneath the railway crossing in the gap between the bayou and LA 308; and would be along or in the bayou above that point until it reaches the FWD right-of-way at the pump station. Consequently, the disposal concept requires no allowance for rehandling of material, or land costs.

5.3.4 Initial dredging and utility replacement (Phase I)

To convey the 340 cfs of flow associated with Phase I without elevation of average water levels, the reach of Bayou Lafourche that extends from just below the sand trap, at cross-section 150+00, to cross-section 300+00, just below the Palo Alto bridge, would require dredging. Phase I dredging in this reach would be consistent with the dredging concepts described in Section 3.4, except that the need for dredging is so light that it would be possible to use a dredging template with a 4H:1V side slope. Evaluation of stability of the dredging template is discussed in Section 3.4.4, and indicates that this slope would be stable. A site-specific stability analysis would be undertaken as part of project design.

The HEC-2 model described in Section 4.3 was used to estimate the volume of dredging that would be needed to modify the existing channel to the dredging template cross-sections, and to assess how these channel improvements would affect capacity of the channel to convey the 340 cfs associated with Phase I of the optimized project. (Note, these runs were done after completion of the LSU modeling report, and are described in one of EPA’s submittals to the Engineering Work Group; see EPA, 1998b.)

The cross-sections used as input to the HEC model extend from just below the sand trap at cross-section 190+00 (about 1.68 miles downstream of the FWD outfall in Donaldsonville) to cross-section 300+00 (about 3.76 miles downstream of the FWD outfall in Donaldsonville and about 0.58 miles downstream of the Palo Alto bridge). These cross-sections serve the main purpose of allowing quantification of the relationship between dredging volume and water level. The sections are not intended as design drawings. Formal design would look closely at placement of dredging relative to channel and bank features, as well as at optimization of dredge volume.

Evaluation using the HEC-2 model indicates that approximately 150,000 cubic yards of material would be dredged from this reach as part of Phase I. The model indicates that the improved section will convey 340 cfs with water levels that are generally lower than now occur. To illustrate, Figure 5.3-1 compares water levels that were measured in the existing channel on July 8, 1998 when the FWD was pumping about 185 cfs, and water levels estimated by the HEC model for 340 cfs in the channel with Phase I level dredging. The July 8th water levels equal or exceed the predicted water levels with 340 cfs in all parts of this reach.

Dredging is assumed to occur by extension of the sand trap method downstream, i.e. a 200 cubic yard/hour bucket dredge with slurry pumping to the Mississippi River. One dredge move would be required to relocate the dredge from the boat launch reach (where access is readily available) to the reach between the Sonic Bridge and the Palo Alto Bridge (where access is viable at a fire station just above the Palo Alto Bridge on the LA 1 side, or in the open batture just below the Sonic Bridge). A second move would likely be required from above to below the Palo Alto Bridge; bayou access below the bridge would probably be at the site of the new weir. An extra booster pump is assumed to be required for dredging below the Sand Trap, and a third pump is assumed to be required for the lower mile of the dredged channel.

Estimated Phase I dredging costs are summarized in Table 5.3-4. This includes the costs of the dredge plus full support; booster pumps; and the costs of moving the dredge past two bridges that occur within the dredged reach.

5.3.5 Primary dredging program (Phase II)

Quantity. The concept of a dredging program was described in Section 3.4, and the method by which dredging was optimized was described in Section 4.3.2. The optimization procedure determined that the removal of about 3.3 million cubic yards of sediment (of which about 0.25 million cubic yards would be dredged in Phase I) would allow for the conveyance of 1,000 cfs, with no increase in water levels in Bayou Lafourche below the sand trap. The effect of the dredging on water levels is discussed subsequently, in Section 5.6. These results confirm that dredging (along with removal of the permanent weir) would provide extensive improvement to the conveyance capacity of the bayou.

Figure 4.3-4, presented previously, compares the channel bottom (thalweg) profile for present conditions to the profile that would result from dredging of 3.3 million cubic yards. Figure 5.3-2a-e is a series of channel cross-sections, showing current and dredged conditions. As shown in these figures, the optimum channel would have a minus 4.0 foot (NGVD) bottom elevation from Donaldsonville to about the Thibodaux weir. Downstream of this point, the natural channel bottom grade was used as a guide to incrementally step the channel bottom down from a minus 6.0 elevation just below the weir to the end of the dredged section, which is below Raceland.

Figure 5.3-3 is a graph that shows the cumulative dredging volume (i.e., for both project phases) along the bayou, starting at Donaldsonville. Figure 5.3-4 is a plot showing the amount of dredging to be conducted along the channel, per unit length. Both graphs show substantial variability from location to location; that variability is in part a reflection of simplified modeling assumptions and constraints. However, the overall pattern shown is expected to reflect actual dredging conditions, i.e. a typical dredging volume in the range of 5 to 15 cubic yards per foot of channel length. The average is estimated to be 59,000 cubic yards per mile.

Reflecting these data, the dredging program can be characterized in terms of four segments of the bayou, with the following characteristics.

Reach	Miles	Depth of dredging	Cubic yards/foot	Million cubic yards
Donaldsonville	0-5	4-8 feet = 6 ft avg.	15-30 = 23.7 cy/ft average	0.56 in 5 miles
Below Donaldsonville through Thibodaux	5-33	1-3 feet = 2 ft avg.	5-15 = 11.4 cy/ft average	1.78 in 28 miles
Below Thibodaux to below Raceland	33-55	0-1 foot = 0.5 ft avg.	0-10 = 3.6 cy/ft average	0.92 in 22 miles
Below Raceland to Larose	55-67	None	0	0

The most intense dredging is projected for the first five miles. Dredging would be comparatively light below Thibodaux.

As part of Phase II of the optimized project, a segment of the bayou upstream of the railroad bridge in Donaldsonville would be dredged using 3H:1V side slopes. This would increase the capacity of the channel to carry the additional flow, and also would be the initial area for sand deposition, since this reach is the first to see diverted water after the area of immediate discharge. To maximize the utility of this segment as an upstream sand trap, it would be maintained at this depth through maintenance dredging.

Dredging method and disposal. As indicated under Phase I dredging, the cost estimate assumes use of a bucket dredge, disposing to a slurry pump for discharge to the disposal sites. The disposal concept is discussed in Section 3.4.6; disposal would be primarily to cane fields adjacent to the bayou. Specific disposal sites would be identified during project design.

Cost. Phase II dredging costs are estimated in Table 5.3-5.

5.3.6 Utility relocations

General planning and design considerations regarding utility crossings are discussed in Section 3.4.8. A partial inventory of utility crossings that could be impacted by channel dredging was presented in Table 3.4-1. Potential impacts on these crossings were estimated based on the assumption that dredged cross-sections would be as shown in the standard template (Figure 3.4-2), and the channel bottom would be as shown in Figure 4.3-4, discussed above.

Identification of crossings that may require action within the reach to be dredged in Phase I. The pipelines listed in Table 3.4-1a that fall within the upper 3.76 miles of the bayou were reviewed for potential conflicts associated with dredging to the proposed template for Phase I. A summary of the assessment is presented in Table 5.3-6. The only line that crosses the bayou above the Sonic Bridge is a water service line owned by People's Water Service of Donaldsonville that crosses the boat launch reach, where the sand trap will be dredged and maintained. Contacts with the owner indicate that this is a 12-inch PVC line, installed in 1989 or 1990, is about 650 feet downstream of the railroad bridge at a depth of 4 to 6 feet below the mud line. This line clearly must be replaced, by offset into a much deeper alignment.

The remaining reach of the Bayou to be dredged in Phase I, from mile 0.54 down to mile 3.76, contains 10 pipeline crossings. Those with known depths are too deep to be impacted by the proposed dredging. Of the lines with unknown depths, most are large lines that are almost certainly buried quite deeply. Except at the sand trap, the dredging for Phase I is very light, and poses minimal risks to utility crossings. For planning purposes, the evaluation indicates that none of the pipelines listed in the table need to be replaced during Phase I.

Identification of crossings that may require action within the reach to be dredged in Phase II. The assessment of the 73 locations with pipelines that cross the bayou above Thibodaux assumed that Phase II dredging would produce a 25 foot wide channel at minus four feet NGVD above Thibodaux. Reduction of cover to less than 4 feet triggered further review of the potential need for action. Judgments on the types of action needed were based on the extent of dredging expected for each location, the amount of existing cover, and the type of pipeline. A qualitative characterization of the amount of Phase II dredging expected at each pipeline location, and associated assumptions about replacement needs, are as follows.

- No dredging. Existing information suggests no significant change to the channel bottom at the indicated location of the pipeline. No replacement is needed.

- Light dredging. Dredging is expected to lower water bottom by no more than two feet. More importantly, the reach is one in which projected water levels are well below the reference line. Therefore, a reduction in dredging over a short distance (e.g. over the utility crossing) is practical. In general, it is assumed that in such reaches no utility replacements will be needed.

- Moderate dredging. Dredging may lower water bottom by up to four feet; some dredging in reach cannot be avoided. Utility replacements are assumed necessary for lines that are known or expected to be shallow.

- Heavy dredging. Dredging expected to lower water bottom by more than four feet. (If “very heavy”, more than eight feet.) Utility replacements are assumed necessary unless an existing line is known to be buried very deeply.

Based on consistent patterns among lines for which depth information is available, the largest hydrocarbon lines are always deeply buried and at no risk from dredging. Consequently, lines requiring replacement are primarily small to moderate-size hydrocarbon lines where dredging is moderate to heavy.

Results of the assessment, summarized in Table 5.3-6, indicated that Phase II dredging could result in 9 of the crossings (12%) requiring remedial action, including 7 crossings of hydrocarbon lines assumed to be replaced, and 2 crossings of water lines assumed to be protected. The nine crossings identified specifically include the following 11 lines: two large (six-inch) water lines; three large (one eight-inch and two six-inch) oil lines; three large (one six-inch, one twelve-inch, and one twenty-inch) gas lines; and three gas lines of two-inches diameter or less. Note also that the seven hydrocarbon crossings include two locations where there are two lines in the same trench.

A detailed assessment of lines below Thibodaux was not conducted for two reasons. First, dredging in that reach is in the "light" category. Second, most if not all pipelines in that reach are subject to federal requirements such that line relocation costs can be presumed to be born by the owner of the line.

Cost estimates. Costs for utility relocations associated with Phase I are estimated in Table 5.3-7; those for Phase II are presented in Table 5.3-8. Based on experience, construction costs for replacement were estimated at $150,000 for lines up to six inches, $170,000 for lines eight to sixteen inches, and $225,000 for larger lines up to 36 inches in diameter. These represent conventional cut and cover lines relocated next to the original line, as shown in Figure 3.4-6. The cost for protection of a water line is estimated by Pyburn and Odom to be $25,000.

The inventory of replacement costs for utility crossings is:

Gas line at mile 23.08:	small line, \$150,000
Water line at mile 6.22:	protection, \$25,000
Gas line at mile 5.86:	small line, \$150,000
Gas line at mile 4.36:	small line, \$150,000
Two gas lines at mile 3.16, 32" combined diameter:	large line equivalent, \$225,000
Water line at mile 3.09:	protection, \$25,000
Gas line at mile 2.27:	medium line, \$170,000
Hydrocarbon line at mile 2.16:	medium line, \$170,000
Two hydrocarbon lines at mile 2.10, 12" combined diam.:	medium line equivalent, \$150,000
Water line at mile 0.66:	included in Phase I

For the water service line to be replaced in Phase I, the nominal cost estimate for a line of this size of \$170,000 was increased to \$200,000 to account for the extra planned width of the channel at the sand trap, where this line is located. This site has unusually easy access, and is a recent public facility mostly located within FWD property. Therefore, no exceptional charges have been identified, such as special right-of-way, crop damage, need for environmental investigations, or relocation of on-shore facilities.

Within the reach of Phase II dredging, the assumption of conventional replacement appears reasonable for the existing lines, which typically have a substantial cleared right-of-way. Where two lines are adjacent, the assumption has been that costs would reflect the combined pipe diameter.

An estimate of \$7,000 per relocation has been added, to account for right-of-way, damage, permitting, environmental investigations and related matters; this estimate is based on information provided by Michael Rolland, Attorney at Law, formerly with USACE.

EPA has not determined how much, if any, of the pipeline relocation costs would be borne by the project. In some instances, the burden of a relocation may clearly fall on the owner, as a result of permit conditions. In other cases, the cost of relocation may be voluntarily borne by the owner, as when the owner is a customer of the FWD. For purposes of the Phase II cost evaluation, 100% of the relocation costs are included within the project budget. Note that this cost is less than previously estimated; the results of the questionnaire led to a substantial reduction in the count of utility lines that would need to be replaced.

5.3.7 Weirs (Phase I)

General aspects of the removal plan for the weir at Thibodaux were presented in Section 3.5.1; information on deployable weirs that can be used on an emergency or permanent basis was presented in Section 3.5.2.

Removal of weir at Thibodaux. Removal of the existing weir at Thibodaux would be undertaken as part of Phase I of the Bayou Lafourche diversion project. It would likely be accomplished after construction of the deployable weirs, described below, to preserve the ability to control bayou water levels. The cost estimate for removal of the existing weir is presented in Table 5.3-9. This estimate includes cost of removal, plus additional budget for site-specific logistical considerations, including permitting and rights-of-way.

Deployable control structures. Of the several types of bank stabilization problems possible in the bayou, the one considered most likely to occur is slumping in response to rapid dewatering of the bayou, as may occur following an emergency shut-down of the pumps caused by a toxic spill in the Mississippi River. Of the three main options discussed in Section 3.5.2 to maintain stable water levels in this situation, the deployment of inflatable weirs was selected for inclusion in the cost estimate because of their flexibility of operations and relatively low maintenance. The preliminary plan includes deployment of two inflatable bladder-type weirs in the bayou, one at the Thibodaux site and another below Donaldsonville.

The lowest cost option would be relatively light-duty inflatable weirs, which are estimated to cost about $100,000. However, for purposes of cost analysis, it is assumed that the structures would be heavy-duty inflatable weirs on concrete foundations. Costs are estimated in Table 5.3-10.

5.3.8 Monitoring stations (Phase I)

Information concerning the concept and design of the monitoring system was presented in Section 3.5.5. Project plans and costs for installation of data collection platforms (DCPs) along the bayou have been optimized by integration with existing platforms operated by USGS. Accordingly, among the five designated locations for monitoring stations, only two (Mathews, and Cancienne Canal or other location near Labadieville/Napoleonville) require full DCP installation, including flow meters. The existing platform at Thibodaux will require the addition of a flow meter. Table 5.3-11 summarizes estimated costs for installing the monitoring stations. Operation and maintenance costs are discussed separately (see Section 5.4).

5.3.9 Bank stabilization (Phase II)

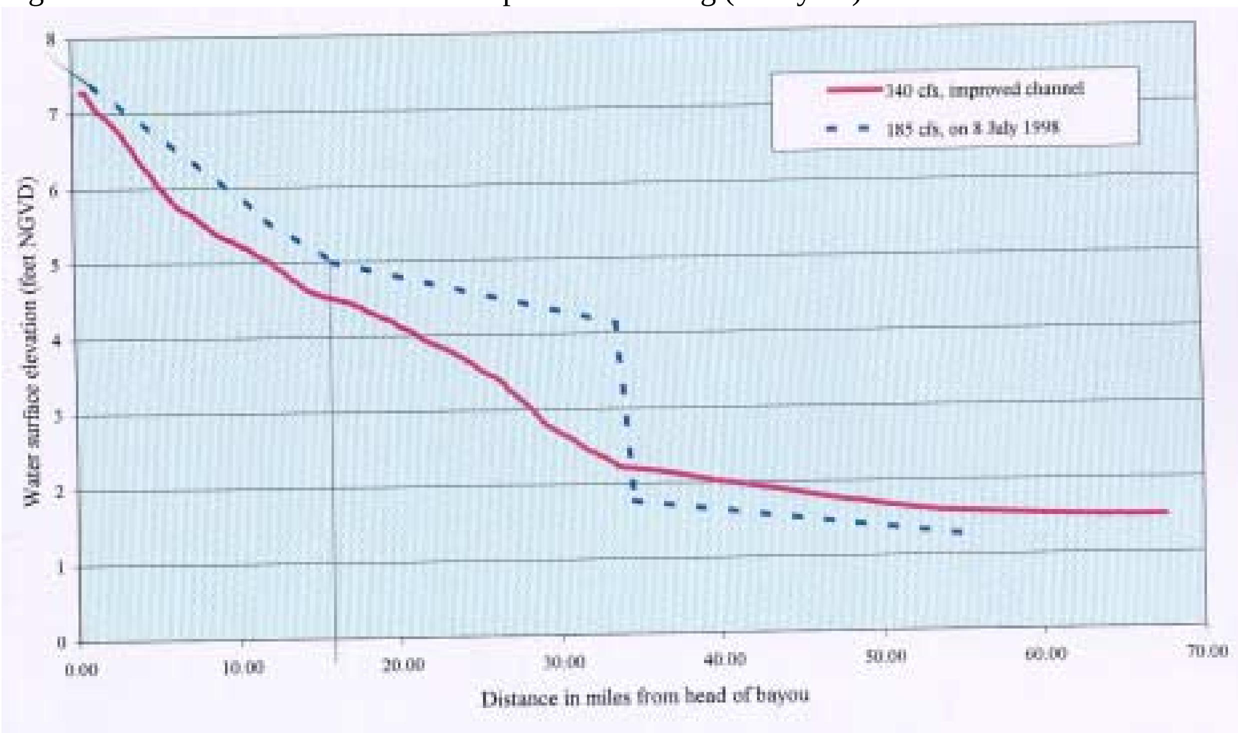
Bank protection and stabilization measures, and the need for them, were discussed in Section 3.4.4. In the preliminary project plan, stability is to be maintained by dredging a 3H:1V side slope for the improved channel, and by using deployable weirs to limit water level fluctuations that are caused by project operations. As summarized in Section 3.4.4, a detailed bank stability analysis will be a component of project engineering and design to determine if there are locations along the bayou where high and steep natural slopes coexist with weak soils at depth, where there may be concerns about the stability of a 3H:1V slope. Some such areas may be addressed by use of 4H:1V bank slopes, or by incorporating a benched profile in the dredged bank, as appropriate. Some locations may require bulkhead protection to assure stability.

Table 5.3-12 provides an estimate of the cost for stabilizing 1,000 linear feet of one bank of the bayou using anchored sheet piling. The estimated cost of $600,000 for 1,000 linear feet is close to the amount of $650,000 included in the original project budget for bank stabilization. This funding amount has been retained for the modified project. It clearly provides for limited structural bank stabilization. Thus, with the cost constraint, the approach could be used only in one or two particularly critical sections of the improved channel, which would likely be within the same reach that is dredged in Phase I.

The budget for bank stabilization does not reflect detailed engineering design analysis, but constraints on available funding. If detailed designs determine that a 3H:1V template is unstable over large reaches of the channel, requiring benched or 4H:1V templates, the project probably would have to be resized to reflect the practical dredging template. At this time, existing project information supports continued planning for a 1,000 cfs project.

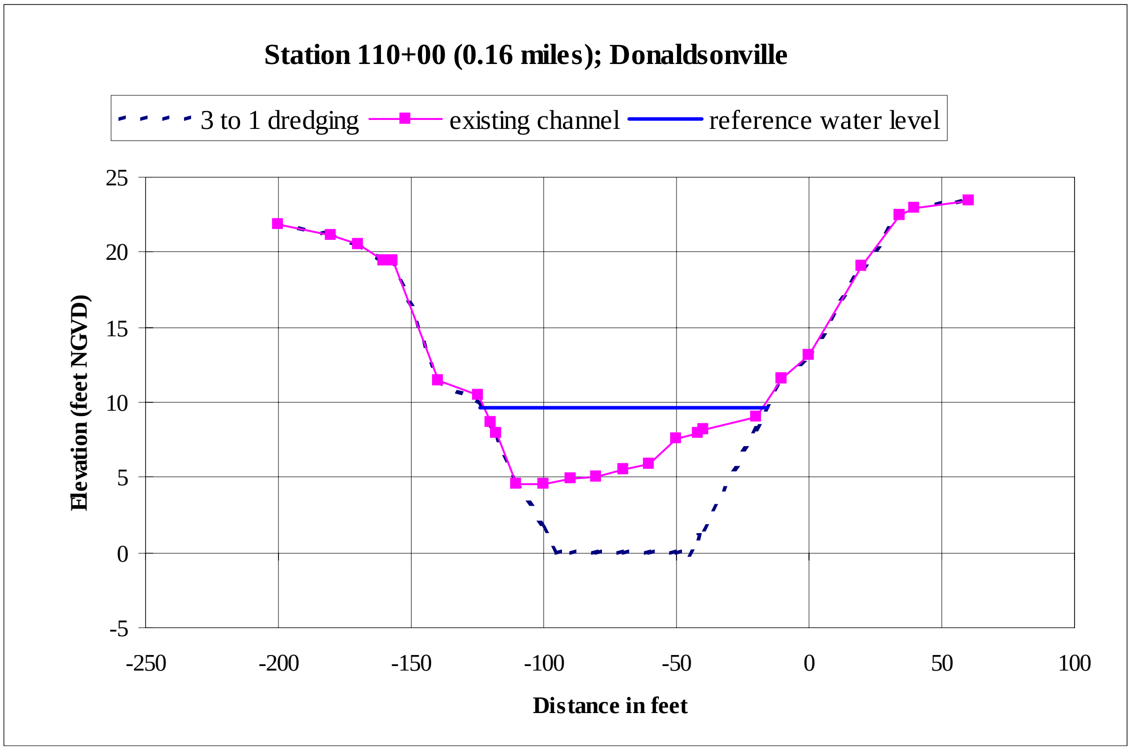
Note that litigation is currently underway regarding the causes of and liability for claimed bank instability problems in the upper bayou. The litigation, to which FWD is a party, presumably will be resolved prior to final project design and its outcome may provide further information for consideration with regard to the stability issue. The existence of this litigation, to which the federal and state governments are not a party, is one reason why the EPA's evaluation has not included a closer look at site-specific claims of problems.

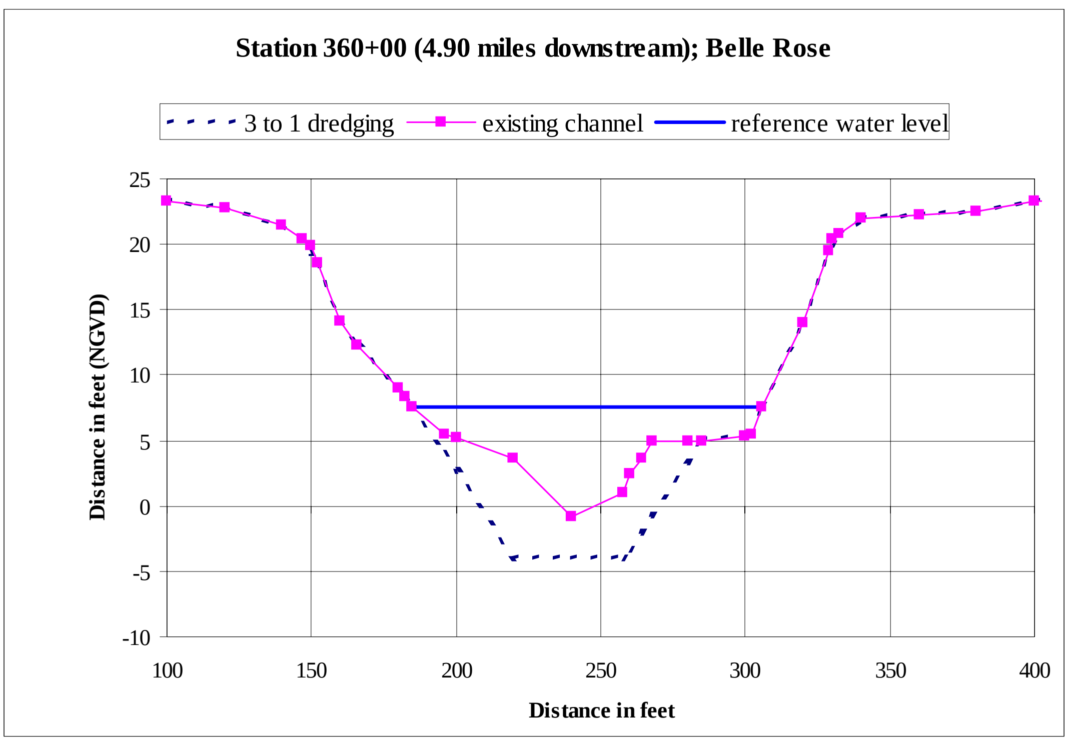
Figure 5.3-1: water levels Phase I compared to existing (8 July 98)



PRELIMINARY: DRAFT

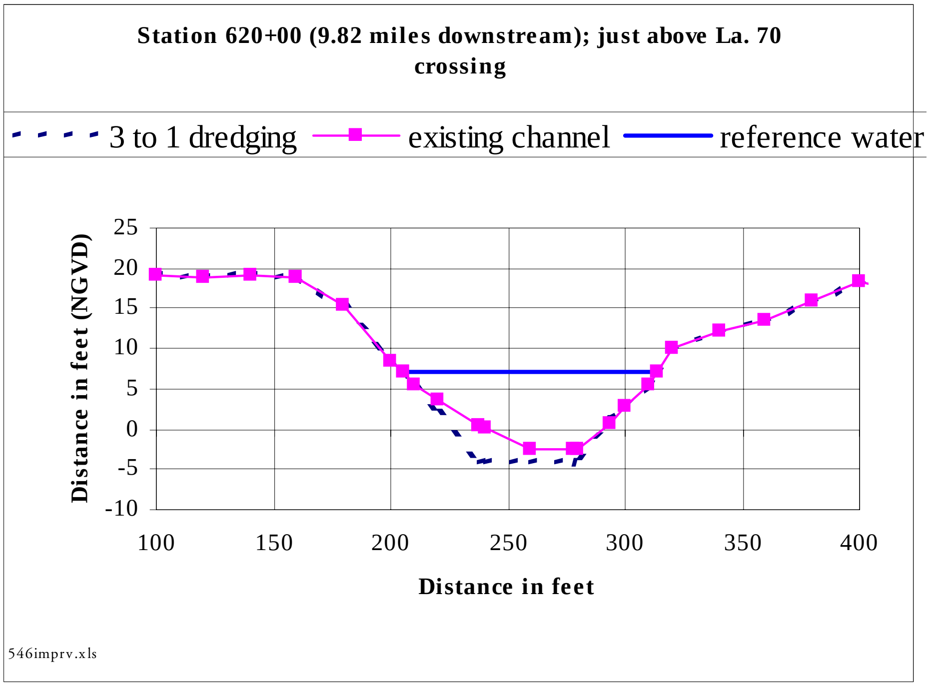
Figure 5.3-2a: dredging cross-sections

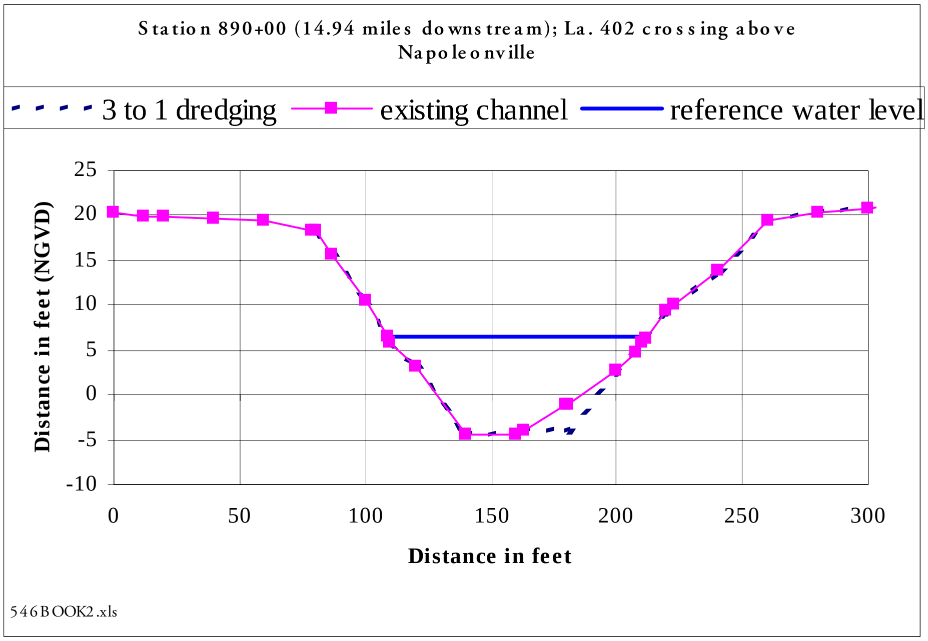




PRELIMINARY: DRAFT

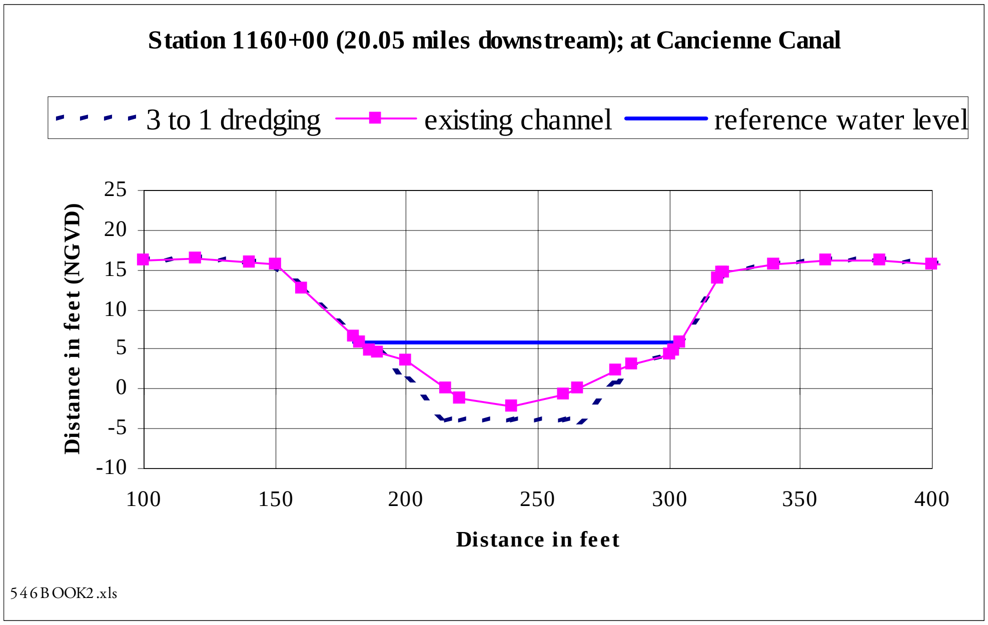
Figure 5.3-2b. Dredging cross-section

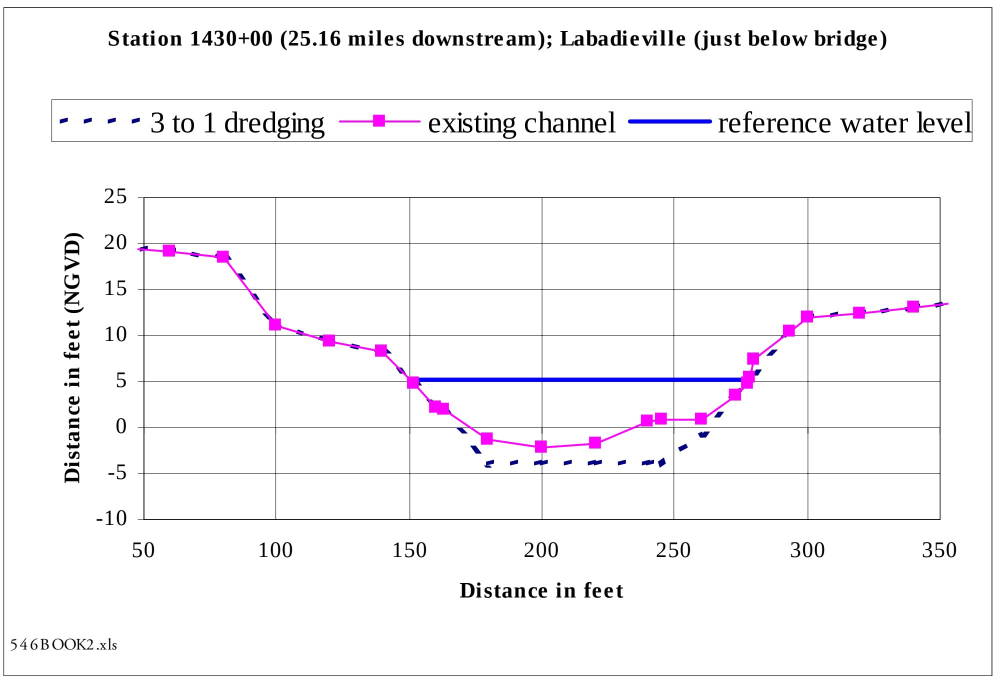




PRELIMINARY: DRAFT

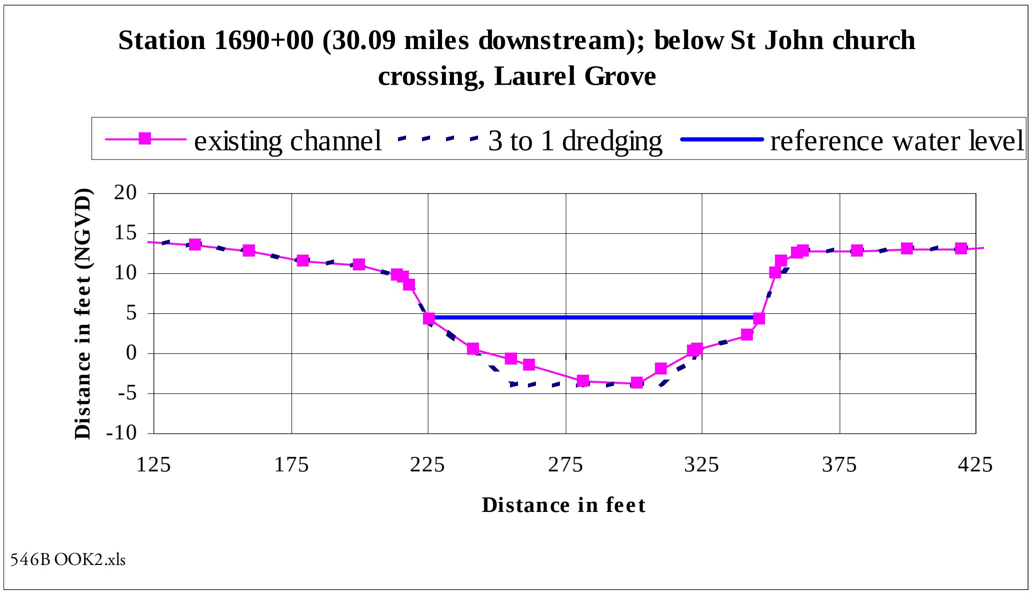
Figure 5.3-2c. Dredging cross-sections.

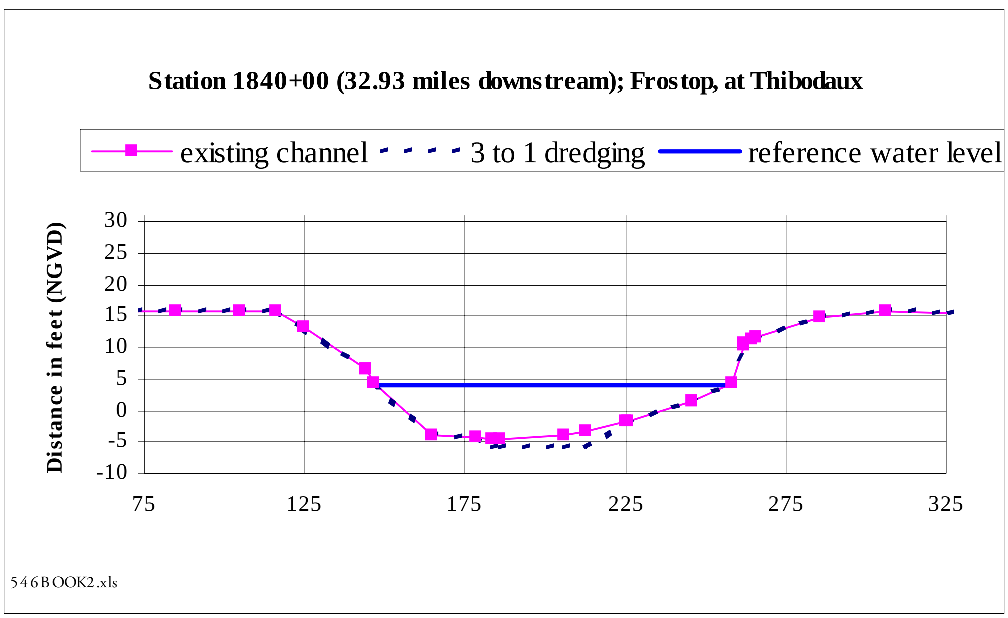




PRELIMINARY: DRAFT

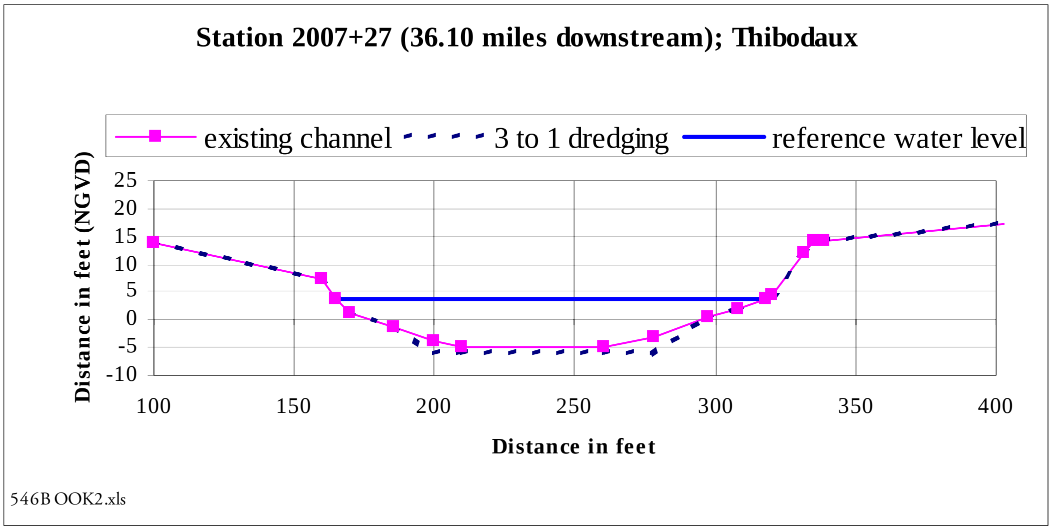
Figure 5.3-2d. Dredgin cross-sections





PRELIMINARY: DRAFT

Figure 5.3-2e. Dredging cross-sections



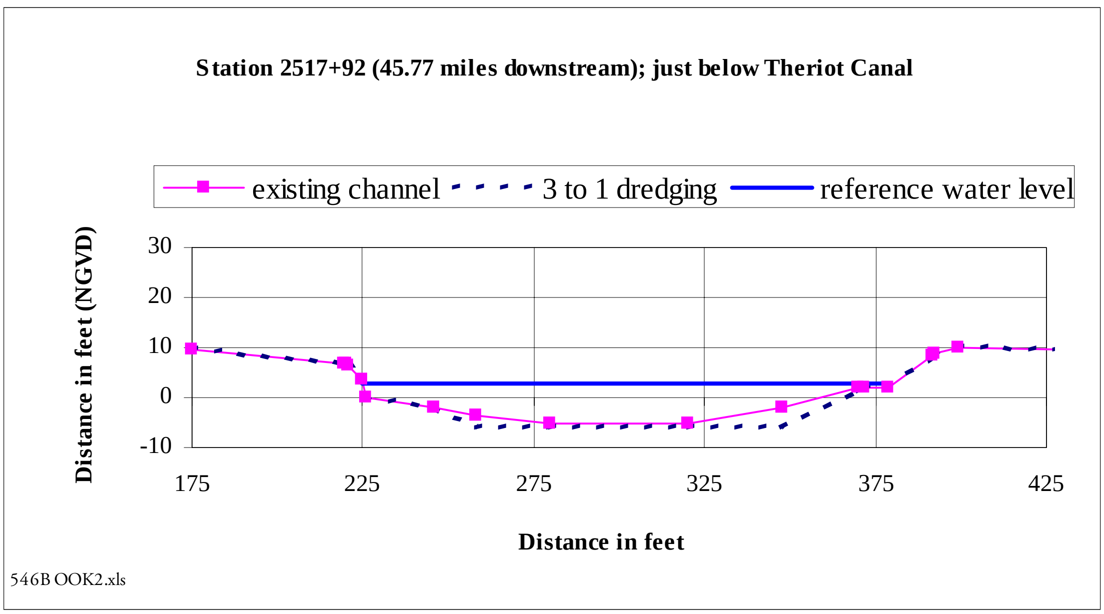
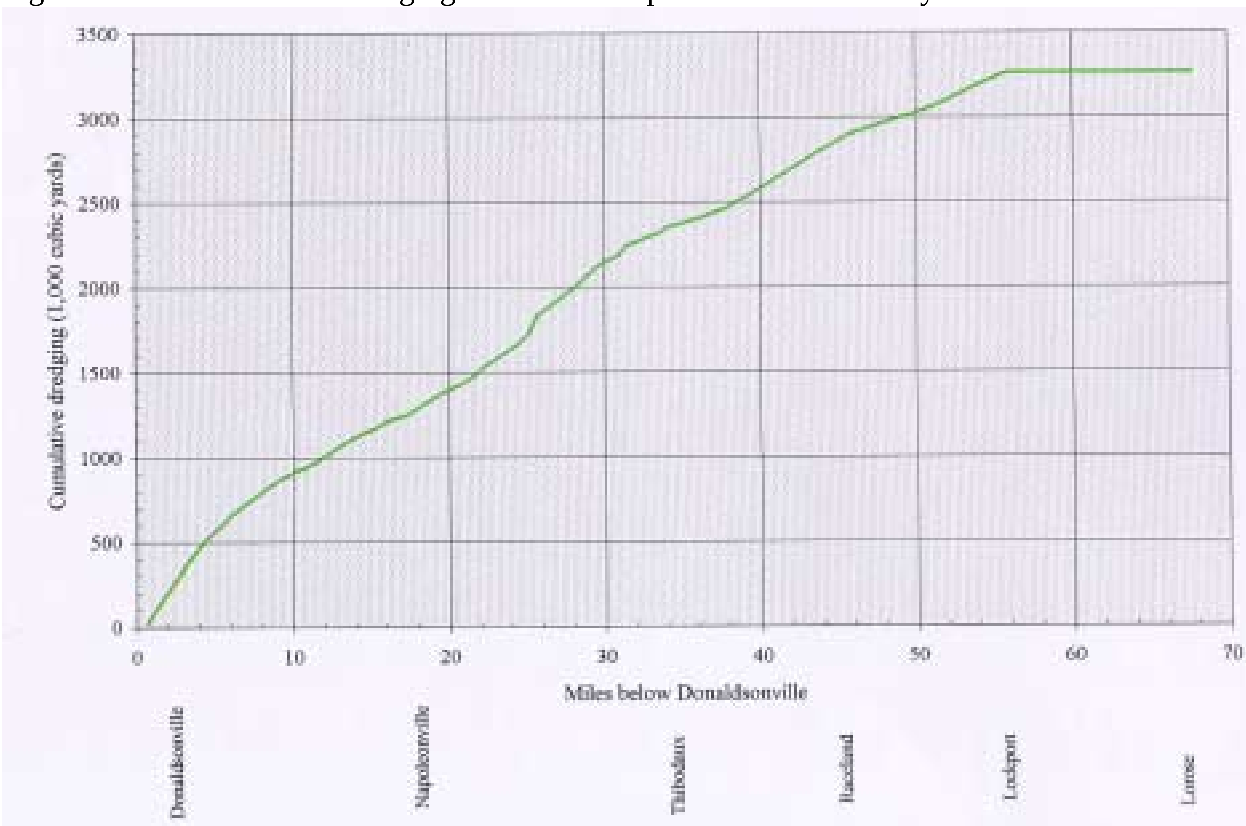


Figure 5.3-3: Cumulative dredging volume for improved channel in Bayou Lafourche



PRELIMINARY: DRAFT

Figure 5.3-4: Dredging volume by location in Bayou Lafourche

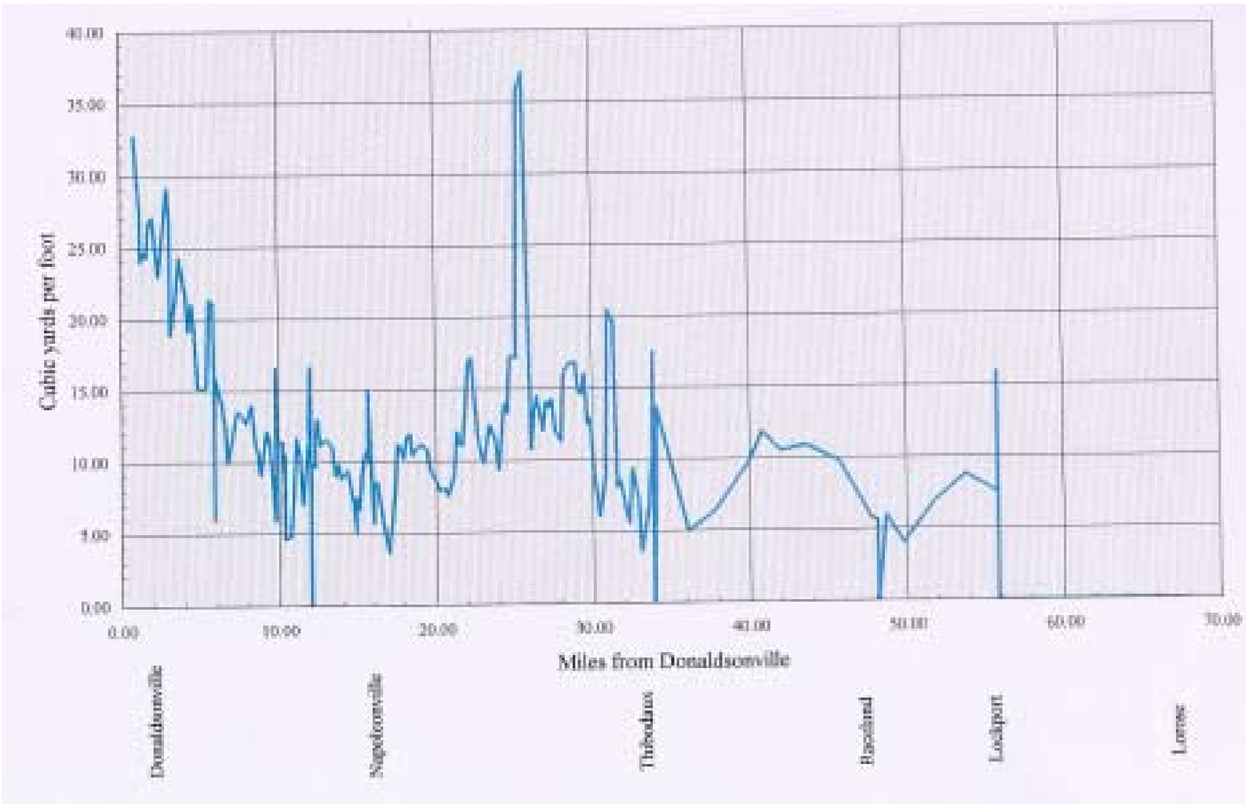


Table 5.3-1. Construction cost estimate for Phase I rehabilitation of existing pump station

Source: Pyburn and Odom, 1998, supported by communication with ITT Fluid Technology Corp.

Replace existing 340 cfs pumps	**Cost**
Two 45,000 gpm variable speed pumps @ $240,000 each	$480,000
Two electric motors @ $100,000 each	$200,000
Installation of pumps and motors @ $20,000 each	$40,000
Total[1]:	**$720,000**

[1] See Section 5.5 for add-on costs, such as contingency and engineering.

Table 5.3-2. Construction cost estimate for diversion facilities, Phase II, optimized project

Source: 1997 engineering report by Pyburn and Odom cited in Table 1.5-1.

New 660 cfs pump station	**Cost**
Site preparation (mobilization, utilities, demolition)	$1,325,000
Intake structure (structure, intake lines, dolphin, revetment repair, excavation)	$1,247,000
Intake lines (dike const., dewatering, pile supports, intake lines, backfill)	$1,548,000
Pump pit structure (cofferdam, dewatering, concrete, building, crane, catwalk)	$1,333,000
Mechanical & electrical (pumps, motors, formed suction intake, vacuum system)	$2,265,000
Discharge pipes (pile supports, excavation, bedding, pipe, backfill)	$1,466,000
Discharge structure (cofferdam, dewatering, excavation, stilling basin, riprap)	$368,000
Subtotal:	**$9,552,000**
Design model (for intake)	$75,000
Right-of-ways	$250,000
Total[1]:	**$9,877,000**

[1] See Section 5.5 for add-on costs, such as contingency and engineering.

Table 5.3-3. Construction cost estimate for installation of sand trap

Source: Based on estimates provided by the USACE, New Orleans, 1998.

Sand trap	**Cost**
Dredging of 90,000 cy (at 200 cy/hr = 450 hours, 12 hours/work day = 37.5 days)	
Dredge rental (bucket dredge, incl. crew, fuel, full support): $272/hr[1]	$122,400
Booster pump (12”, 1,000 hp): $98/hour (includes fuel and support)[2]	$44,100
Subtotal:	**$166,500**
Overhead and profit (25%)	$41,625
Investigations and permitting (lump sum)[3]	$11,000
Right-of-way and clearing (lump sum)[4]	$17,000
Total[5]:	**$236,125**
Cost per cubic yard:	**$2.62**
Cost per day:	**$6,297**

1 Dredge cost per hour derived as dredge-only part of estimate provided by Tom Murphy, NOD COE, for bucket dredge with truck disposal, June 1998

2 Disposal cost per hour derived as booster-only part of estimate provided by Tom Murphy, NOD COE, for cutterhead dredge with pipeline disposal, July 1998

3 Investigations include site-specific geotechnical work; assumed lump sum

4 Right of way needed for minor squaring off of channel, left descending bank

5 See Section 5.5 for add-on costs, such as contingency and engineering.

Work to be accomplished by a bucket dredge working on Flexi-Float sectional barges, 9 sections @ 10' x 40'.

Table 5.3-3. Construction cost estimate for installation of sand trap

Table 5.3-4. Cost estimate for Phase I dredging

Source: Based on estimates provided by the USACE, New Orleans, 1998, unless otherwise indicated.

Phase I dredging (see separate sand trap estimate)	**Cost**
Dredging of 150,000 cy (at 200 cy/hr = 750 hours, 12 hours/work day = 62.5 days)	
Dredge rental (bucket dredge, incl. crew, fuel, full support): $272/hr	$204,000
Three booster pumps (12”, 1,000 hp) at $98/hour (includes fuel, support), with the third pump operating only 250 hours	$171,500
Two moves around bridges (estimate from CEEC, 1997)	$40,000
Subtotal:	**$415,500**
Overhead and profit (25%)	$103,875
Investigations and rights-of-way (lump sum)	$15,000
Total[1]:	**$534,375**
Cost per cubic yard:	**$3.56**
Cost per day:	**$8,550**

[1] See Section 5.5 for add-on costs, such as contingency and engineering.

Work to be accomplished by a bucket dredge working on Flexi-Float sectional barges, 9 sections @ 10' x 40'.

Table 5.3-5. Cost estimate dredging for Phase II dredging

Table 5.3-5. Cost estimate for Phase II dredging

Bucket dredge and pipeline to sugar fields. Source: Based on estimates provided by the USACE, New Orleans, 1998, unless otherwise indicated.

Phase II dredging (3 million cubic yards, 200 cy/hour (net) for 24 hours/day (includes down time) = 15,000 hours, 625 days, 20.55 months)	**Cost**	**Total cost**
Bucket dredge [1]		
3900 dragline (3.5 CY), $90/hr	$1,350,000	
Flexi-floats (complete), $404/day	$252,500	
Tug/tender, $600/day	$375,000	
Tools (3% of labor)	$55,193	
Slurry pump, $70,447/month	$1,447,686	
Total equipment cost:		$3,480,378
Dredge labor [1]		
PEO dragline (2), $20.74/hr	$622,200	
Oiler (2), $12.76/hr	$382,800	
Deckhand (2), $15.95/hr	$478,500	
Foreman (1), $23.75/hr	$356,250	
Total labor cost:		$1,839,750
Supplies [1]		
Safety and misc	$15,458	
Freight (Flexi-floats)	$6,500	
Total supplies cost:		$21,958
Moves around bridges (24 moves at $20,000 each) [2]		$480,000
Pipeline equipment and support (derrick barge, quarter boat, misc. barge, pontoon pipeline, pontoons, ball joints, shore line, submerged line), $10,917/month [3]		$224,344
Pipeline labor [3] (8-hour day shift only; includes 15% for overtime and 50% for benefits)		
Asst. engineer, $17.49/hr	$87,450	
Rodman, $12.63/hr	$63,150	
PEO dozer, $16.83/hr	$84,150	
Laborers (2), $11.47/hr	$114,700	
Total pipeline labor cost:		$349,450

Table 5.3-5. Continued.

Phase II dredging (3 million cubic yards, 200 cy/hour (net) for 24 hours/day (includes down time) = 15,000 hours, 625 days, 20.55 months)	**Cost**	**Total cost**
Pipeline-related fuel and repairs, $8,195/mo [3]		$168,407
Miscellaneous [3]		
Dozer, $20,000/mo	$411,000	
Electronic positioning equipment, $4,000/mo	$82,200	
Total miscellaneous cost:		$493,200
Fixed costs [3]		
Pipeline lay out and pick up, $25,000 x 24 sites	$600,000	
Disposal management, $2,500 x 24 sites	$60,000	
Total fixed costs:		$660,000
Subtotal:		$7,717,488
Overhead and profit (25%)		$1,929,372
Investigations and rights-of-way (lump sum)		$250,000
Easements for disposal areas (1250 acres @ $240/acre)		$300,000
Total[4]:		$10,196,860
Cost per cubic yard:		**$3.40**
Cost per day:		**$16,315**

[1] Based on estimate provided by the USACE, New Orleans, July, 1998

[2] Based on estimate provided by CEEC, 1997, for 4.2 mcy, adjusted to 3 mcy

[3] Based on estimate provided by the USACE, New Orleans, 1998

[4] See Section 5.5 for add-on costs, such as contingency and engineering.

Table 5.3-6. Utility crossings assessment

Part a. Above Thibodaux.

Identification	Map key (see Fig. 3.4-7)	Approx. miles from BLF outfall	Principal considerations	Preliminary determination
Exxon 6"	Ex.b	-	Abandoned	No action
City of Thibodaux	T.h	33.79	Shallow water line; light dredging	Field survey; assume no action
City of Thibodaux	T.g	33.77	Shallow water line; light dredging	Field survey; assume no action
City of Thibodaux	T.f	33.77	Two shallow water lines; light dredging	Field survey; assume no action
City of Thibodaux		33.76	Gas line with no record; light dredging	Field survey; assume no action
Bell South	BS.d	33.67	Two deep cables; light dredging	No action
City of Thibodaux	T.e	33.63	Abandoned water line and deep gas line; light dredging	No action
Bell South	BS.c	33.60	Deep cable; light dredging	No action
City of Thibodaux	T.d	33.35	Deep gas line; light dredging	No action
City of Thibodaux	T.c	33.34	Deep water line; light dredging	No action
City of Thibodaux	T.b	33.34`	Deep sewer line; light dredging	No action
City of Thibodaux	T.a	33.34	Deep sewer line; light dredging	No action
Transcontinental Gas	TransG.a	32.26	Three large, deep gas lines but possibly moderate dredging	Field survey; assume no action
Texas Gas Transmission Co.	TxG.a	31.21	Deep gas line; light dredging	No action
Tejas (Acadian Gas)	Acad.d	30.81	Deep hydrocarbon line; light dredging	No action
Sugar Bowl/Trans LA.	TransLA.i	30.71	Small gas line; light dredging	Field survey; assume no action
Long Gas Co./Tejas …	Acad.c	30.69	Deep gas line; light dredging	No action
Energy Mgt. Corp.	EMC.a	29.45	Deep gas line; light dredging	No action
Gas Distributing Corp.		29.38	Deep gas line; light dredging	No action
Texas Gas		29,22	No records; large line, presumably deep; no dredging	Field survey; assume no action
Shell		27.87	Deep oil line; light dredging	No action
Texas Brine	TxBr.a	27.85	Deep gas or brine line; light dredging	No action

Table 5.3-6. Assessment of utility crossings, continued.

Part a, above Thibodaux.

Identification	Map key (see Fig. 3.4-7)	Approx. miles from BLF outfall	Principal considerations	Preliminary determination
Equilon	Equi.b	27.83	Deep oil line; light dredging	No action
Assumption Parish WW#1	APH2O.g	26.62	Water line assumed deep; light dredging	Field survey; assume no action
Hure		25.51	Deep water line; light dredging	No action
Assumption Parish WW#1	APH2O.f	25.14	Deep large water line; light dredging	No action
Gremillion		25.14	Deep small gas line; light dredging	No action
Southern Bell	BS.b	25.09	One deep cable, one cable unknown depth; light dredging	Field survey; assume no action
Gas Distr. Corp.		25.03	Small gas line, not deep; light dredging	Field survey; assume no action
Lake Long Gas Co.	Acad.b	23.57	Deep gas line; very light dredging	No action
Gas Distr. Corp.		23.08	Small gas line; unknown depth; moderate dredging	Field survey; assume replacement
Trans Louisiana Gas Co.	TransLa.h	21.16	Small gas line, unknown depth; no dredging,	No action
Assumption Parish WW#1	APH2O.e	20.20	Large water line assumed deep; light dredging	Field survey; assume no action
Trans Louisiana Gas Co.	TransLa.g	17.99	Small gas line, not deep; light dredging	Field survey; assume no action
Assumption Parish WW#1	APH2O.d	16.19	Two large water lines; assumed deep; light dredging	Field survey; assume no action
Trans Louisiana Gas Co.	TransLa.f	15.67	Small gas line, depth unknown; light dredging	Field survey; assume no action
Texas Brine Co.		15.22	Large brine line, deep; no dredging	No action
Bell South	BS.a	15.21	Cable, unknown depth;no dredging	No action
Occidental Chem.	OXY.a	15.19	Deep large brine line;no dredging	No action
Sundbery		15.14	Small gas line, unknown depth; light dredging	Field survey; assume no action
Trans Louisiana Gas Co.	TransLa.e	15.05	Small gas line, depth unknown; light dredging	Field survey; assume no action
UCAR Pipeline	UCAR.a	14.59	Two large deep hydrocarbon lines; light dredging	No action
Trans Louisiana Gas Co.	TransLa.d	13.51	Small gas line, depth unknown; light dredging	Field survey; assume no action
Assumption Parish WW#1	APH2O.c	10.58	Two large water lines; assumed deep; light dredging	Field survey; assume no action
Assumption Parish WW#1	APH2O.h	10.01	Proposed line; coordination underway	No action

Table 5.3-6. Assessment of utility crossings, continued.

Part a, above Thibodaux.

Identification	Map key (see Fig. 3.4-7)	Approx. miles from BLF outfall	Principal considerations	Preliminary determination
Trans Louisiana Gas Co.	TransLa.c	9.06	Small gas line, depth unknown; light dredging	Field survey; assume no action
Koch Pipeline	Koch.c	8.95	Large deep hydrocarbon line; light dredging	No action
Koch Pipeline	Koch.b	8.47	Large ammonia line, assumed deep; light dredging	Field survey; assume no action
LA. Intrastate Gas	LIG.b	8.42	Large deep gas line; light dredging	No action
Tejas/Acadian	Acad.a	8.40	Large gas line, assumed deep; light dredging	Field survey; assume no action
Texas Eastern	TxE.a	8.14	Large gas line, assumed deep; light dredging	Field survey; assume no action
Assumption Parish WW#1	APH2O.i	7.53	Proposed line; coordination underway	No action
Koch Pipeline	Koch.a	8.47	Large oil line, assumed deep; light dredging	Field survey; assume no action
Chevron	Chev.a	6.92	Deep oil line; light dredging	No action
Equilon	Equi.a	6.74	Very large oil line, moderate depth; no dredging	No action
Assumption Parish WW#1	APH2O.b	6.22	Large water line, not deep; moderate dredging	Assume protection
Trans Louisiana Gas Co.	TransLa.b	5.86	Small gas line, unknown depth; moderate dredging	Field survey; assume replacement
Assumption Parish WW#1	APH2O.j	5.56	Proposed line; coordination underway	No action
Assumption Parish WW#1	APH2O.a	4.66	Large water line, unknown depth; light dredging	Field survey; assume no action
LA Intrastate gas	LIG.a	4.65	Large deep gas line; moderate dredging	Field survey; assume no action
Trans LA Gas	TransLa.a	4.36	Small gas line, unknown depth; moderate dredging	Field survey; assume replacement
Monterey Tejas	Cyp.a	3.17	Large gas line, assumed deep; moderate dredging	Field survey, assume no action
Bridgeline Gas	Bridg.b	3.16	Two large gas lines, moderate depth; moderate dredging	Assume replacement
Peoples Water Service	PH2O.b	3.09	Large water line, moderate depth; moderate dredging	Assume protection
City of Donaldsonville	Don.b	2.27	Large gas line, unknown depth; heavy dredging	Assume replacement
Allemania		2.16	Large line, assume hydrocarbon, depth unknown; heavy dredging	Assume replacement
Union Texas	UTP.a	2.10	Two large hydrocarbon lines, not deep; moderate dredging	Assume replacement
Ashland	Ash.a	2.06	Large CO line; deep; moderate dredging	Field survey, assume no action

PRELIMINARY: DRAFT

Table 5.3-6. Assessment of utility crossings, continued.
Part a, above Thibodaux

Identification	Map key (see Fig. 3.4-7)	Approx. miles from BLF outfall	Principal considerations	Preliminary determination
LPGL		2.04	Very large gas line, assumed deep; moderate dredging	Field survey, assume no action
Bridgeline	Bridg.a	2.03	Large deep gas line under construction; moderate dredging	Field survey, assume no action
Peoples Water Service	PH2O.a	0.66	Large water line; very heavy dredging (sand trap)	Assume replacement (Phase I)
City of Donaldsonville	Don.a	0.44	Large gas, large water line; not deep; heavy dredging	Replacement with new bridge

Table 5.3-7. Construction cost estimate for utility relocations, Phase I

Source: 1998 engineering report by Pyburn and Odom cited in Table 1.5-1;
5/6/98 report prepared for EPA by Michael S. Rolland, Attorney at Law, formerly with the COE.

Phase I utility line relocation	**Cost**
Construction	$200,000
Rights-of-way (additional acreage)	n/a
Damage (trees, crops, fences)	n/a
Permitting and environmental investigations (404/10, local, state)	n/a
Relocation and restoration of on-shore facilities (on-shore facilities, construction near roadways, exceptional costs)	n/a
Total[1]:	**$200,000**

[1] See Section 5.5 for add-on costs, such as contingency and engineering.

Table 5.3-8. Construction cost estimate for utility relocations, Phase II

Source: 1998 engineering report by Pyburn and Odom cited in Table 1.5-1;
questionaires to owners, distributed by EPA;
confidential legal report prepared for EPA by Michael S> Rolland,
Attorney at Law, formerly with USACE

Phase II utility line relocation	**Cost**
Construction (relocation of lines)	
Three medium lines at $150,000 each	$450,000
Three medium lines at $170,000 each	$510,000
One large line at $225,000	$225,000
Construction (protection of lines)	
Two lines at $25,000 each	$50,000
Rights-of-way (additional acreage), damage (trees, crops, fences), permitting and environmental investigations (404/10, local, state), at $7,000 each location	$63,000
Total[1]:	**$1,298,000**

[1] See Section 5.5 for add-on costs, such as contingency and engineering.

Table 5.3-9. Construction cost estimate for removal of Thibodaux weir, Phase I

Source: 1998 engineering report by Pyburn and Odom cited in Table 1.5-1.

Removal of Thibodaux weir	**Cost**
Construction of a working ramp, piping to maintain flow, and removal of the weir, sheet pile, and various debris	$100,000
Right-of-way, permitting and ancillary costs	$15,000
Total[1]:	**$115,000**

[1] See Section 5.5 for add-on costs, such as contingency and engineering.

Table 5.3-10. Construction cost estimate for installation of deployable weirs, Phase I

Source: Rubber dam estimate provided by Roger Busch, Bridgestone Engineered Products Company, Inc., Huntington Beach, CA.; foundation estimate by Pyburn & Odom.

Part A. Installation of deployable weir at Donaldsonville	**Cost**
Rubber dam (two 50-foot spans, 10 ft high, double anchor; side slopes 1:1). Includes rubber body, all attachment materials, design documents, drawings and manual, and portable pump for inflation/deflation.	$406,948
Installation of embeds and bladders; and operational testing (100 hours x $15/hr)	$1,500
Installation of foundation	
Sheet pile (11,700 sf x $18/sf)	$210,600
Concrete (180 cy x $400/cy)	$72,000
Excavation (450 cy x $5/cy)	$2,250
Fill (130 cy x $10/cy)	$1,300
Cofferdam (temp. sheet pile; 12,500 sf x $11/sf)	$137,500
Rock ramp (500 tons x $35/ton)	$17,500
Misc. (anchor bolts, misc. steel, dewatering, etc.)	$9,650
Mobilization (5% of $450,800 foundation cost)	$22,540
Right-of-way, permitting and ancillary costs	$15,000
Total[1]:	**$896,788**

[1] See Section 5.5 for add-on costs, such as contingency and engineering.

Part B. Installation of deployable weir at Thibodaux	Cost
Rubber dam (two 75-foot spans, 8 ft high, double anchor; side slopes 1:1). Includes rubber body, all attachment materials, design documents, drawings and manual, and portable pump for inflation/deflation.	$376,506
Installation of embeds and bladders; and operational testing (100 hours x $15/hr)	$1,500
Installation of foundation	
Sheet pile (9,350 sf x $18/sf)	$168,300
Concrete (111 cy x $400/cy)	$44,400
Excavation (75 cy x $5/cy, rounded up)	$400
Fill (65 cy x $10/cy)	$650
Cofferdam (temp. sheet pile; 10,200 sf x $11/sf)	$112,200
Rock ramp (370 tons x $35/ton, rounded up)	$13,000
Misc. (anchor bolts, misc. steel, dewatering, etc.)	$9,050
Mobilization (5% of $348,000 foundation cost)	$17,400
Right-of-way, permitting and ancillary costs	$15,000
Total[1]:	**$758,406**

[1] See Section 5.5 for add-on costs, such as contingency and engineering.

Table 5.3-11. Construction cost estimate for monitoring stations, Phase I

Source: George Arcemeaunt, Water Resources Division, U.S. Geological Survey, Baton Rouge, La.

Monitoring stations	**Cost**
One Data Collection Platform (stage, rainfall)	$15,000
One Data Collection Platform (stage, rainfall, and flow)	$21,000
One Flow Meter	$6,000
Total[1]:	**$42,000**

[1] See Section 5.5 for add-on costs, such as contingency and engineering.

Table 5.3-12. Estimated costs for stabilizing 1,000 linear feet of the left descending bank (La. 308 side) of Bayou Lafourche using anchored sheet piling.

Source: Pyburn & Odom (see Cost Evaluation Phase II Construction, Bayou Lafourche Diversion Project; submitted to the CWPPRA Engineering Work Group, September 1998)

Item Description	**Quantity**	**Unit**	**Unit Price**	**Extension**
Sheet Piling (PZ-22)[1]	21,000	Square Feet	$15	$315,000
Wales[2] (Double C10x30)	60,000	Pounds	$1	$60,000
Soil Anchors[2] (10 feet on center)	100	Each	$1,500	$150,000
			Subtotal:	$525,000
			Mobilization (approx. 10%)	$75,000
			Total Cost[3]: (1,000 LF)	**$600,000**

1 - Tip elevation of sheet piling assumed at -15 feet NGVD, based on rough depth of most of the failure circles from stability analysis of benched dredge section at cross-section 230+00.

2 - Assumes bayou levels could be lowered to +5 feet NGVD for installation of wales and soil anchors.

3 - Required excavation assumed to be included in the project dredging quantities.

5.4 PROJECT OPERATIONS AND MAINTENANCE FEATURES AND COSTS

In most respects, the optimized project would mirror the operations of the FWD. The FWD has committed to providing operations and maintenance (O&M) support equivalent to O&M costs in its current budget. Additional O&M costs for diversions that benefit wetlands would require CWPPRA funding, or an additional cost-share contribution. The conceptual design of the optimized project also provides for specialized operations to benefit drainage. It is assumed here that any costs for such operations would be funded outside of a CWPPRA or FWD budget, even though the operations might be the responsibility of FWD or Parish personnel.

O&M costs for Phase I fall into five categories, each of which is discussed below (Section 5.4.1): pumping; water management; water monitoring; other O&M; and CWPPRA monitoring. Two operations costs are added upon completion of Phase II (Section 5.4.2): diversion (pumping) costs associated with the new pump/siphon facility; and channel maintenance costs.

5.4.1 Operations and maintenance costs: Phase I

Component and total costs associated with operations and maintenance of Phase I are summarized in Table 5.4-1. Details of each component are discussed below.

Pumping amounts and costs. Phase I involves diversions at 340 cfs year-round. An operations schedule for the project, showing when the rehabilitated existing facility could siphon and when it would pump to divert up to 340 cfs, is provided in Table 3.2-1. During times of low river, this will require pumping at a rate higher than normally experienced. The incremental cost of pumping, beyond FWD normal pumping rates, is a cost of Phase I.

Based on this schedule in Table 3.2-1, it was assumed that pumping would be required for 5,000 hours per year (about 6.85 months). This would be 20,000 hours for the four pumps. Cost information on FWD pumping is provided in Table 5.4-2 and averages $11.50/hr. Using this value, 20,000 hours of pumping would cost $230,000. The District's existing utility cost is $125,000 per year, so this represents an incremental cost of $105,000. An additional $30,000 has been included in the budget for incremental maintenance costs and materials associated with the higher volume (Table 5.4-1).

Water management activities and costs. The project will use deployable weirs to stabilize channel water levels during pump shut-downs. Expenses associated with this activity include maintenance (assumed to be a low-cost item, as the rubber dams now proposed need only periodic attention and minor repairs); and actual operations (e.g. emergency inflation of dams during a spill, followed by deflation). Any additional costs, associated with fine-tuned management for storm runoff conveyance, are assumed to be covered by separate (non-CWPPRA) funding.

The cost for maintaining and operating the water management facilities has been estimated at $20,000/year (Table 5.4-1), which represents salary, benefits and support for the equivalent of one-half technical-level employee. (The actual work could be done using employees of the three Parishes along the bayou.)

Water monitoring activities and costs. Information on water level and flow conditions from five Data Collection Platforms (DCPs) installed along the bayou would be collected and used to make decisions on operation of the diversion, in order to manage water levels. As described in Section 3.5.5, some of the needed platforms already exist at appropriate locations; these would continue to be operated by USGS, with no additional operational expense to the project. Specifically, the existing platforms at Donaldsonville, Thibodaux, and Larose would continue to be operated by USGS during the Bayou Lafourche diversion project. As a result, project costs only include operation and maintenance of the new platforms at Labadieville/Napoleonville (Cancienne Canal) and at Mathews, and the flow meter to be added to the platform at Thibodaux (see Table 5.4-1). The differences in equipment to be operated and maintained at each of the new platforms is reflected in the differences in operation and maintenance costs shown in the table. The specific O&M budget needs at the five stations are as follows.

- Donaldsonville. All monitoring activities are currently funded. No incremental cost.
- Labadieville-Napoleonville. New station, stage and rainfall only: full costs of monitoring are included in project budget. ($5,000/year.)
- Thibodaux. New flow monitor: incremental costs included in budget, although in practice this may be cost-shared in other ways. ($3,000/year.)
- Mathews. New station with stage, rainfall and flow: full costs of monitoring are included in project budget. ($14,000/year.)
- Larose. Continuation of existing station, stage and rainfall only: Based on discussions with USGS, this level of monitoring is likely to be funded independently. No incremental cost.

Other O&M activities and costs. Except for pumping costs, Phase I involves no substantive change in the O&M responsibilities of the FWD. Maintenance dredging of the sand trap is included in Phase II costs rather than in Phase I, because Phase II operations begin one year later than Phase I, and the greatest sedimentation would be associated with the higher flows of Phase II operations. Consequently, no further O&M costs have been considered for Phase I.

CWPPRA monitoring activities and costs. It is assumed that CWPPRA monitoring would be initiated during Phase I, following standard protocols. A CWPPRA monitoring plan for Project PBA-20 has not yet been prepared. The plan can be expected to focus on photo interpretation and/or field transects of potentially benefited areas, to determine if in fact the project has helped to decrease loss rates (compared to non-benefited areas). For diversion projects of this type, a standardized estimate of monitoring costs is $25,875 per year in 1993 dollars. This value must be inflated, at 2.6 %/year, to the present year, 1998, in which base costs are being estimated. This base value becomes $29,418/year (Table 5.4-1). Monitoring would continue for a total of 20 years, comprising one year of pre-construction and 19 years of post-construction (i.e. operational) monitoring, as is standard for CWPPRA projects.

5.4.2 Operations and maintenance costs: Phase II

Diversion costs for the new 660 cfs station. Diversion costs relate to the energy required to pump 660 cfs of water through the new pump station, and to maintenance of this facility. Based on the operations schedule in Table 3.2-1, it is estimated that the new pumps would need to operate about 4500 hours per year. This reflects most years, when pumping is needed for only 5 months, and low-river years, when pumping is needed for 10 months. The pumping time is less than for the existing plant because the new facility is expected to be more efficient (larger pipes, more efficient intake).

Power costs were estimated by assuming a pump efficiency of 85%, a motor efficiency of 95%, a pump discharge head of 16.63 feet, and 3.8 cents per kilowatt of electricity. These numbers are based on an engineering evaluation of existing FWD facility operations and costs conducted by Pyburn & Odom, and summarized in the fourth submittal to the CWPPRA Engineering Work Group (EPA, 1998d). The result is an estimate of 1.75 million kilowatt hours, or $66,500 per pump per year. The total cost of $199,500 per year for all three pumps was rounded up to $200,000/year and is itemized in Table 5.4-3.

Information provided by the FWD indicates that no increase in staff time would be required for operation of a 1,000 cfs facility, because the new 660 cfs station would be connected to and operated in conjunction with the existing station. The operational expenses that the FWD currently provides are considered to represent part of what FWD would contribute to the project. Consequently, no additional labor and overhead costs have been allocated to the optimized project.

Table 5.4-3 also estimates costs for facility maintenance, including supplies, insurance, and repairs. These estimates also are based on evaluation of and extrapolation from records of existing expenses (see EPA, 1998d). Repair costs are expected to be less than for the existing plant, because the latter pumps substantial sand and has an ineffective intake. The annual cost of $45,000 assumed here is based on expending $150,000 for each pump overhaul, with an assumed two overhauls per pump during the 20-year life cycle of the project.

Channel maintenance and management. Several categories of channel maintenance and management have been identified for the optimized project, and are included in Phase II. Costs for these activities are listed in Table 5.4-3.

The current daily routine of the Freshwater District includes clearing of snags and debris in the channel, mowing of aquatic vegetation, and general surveillance of channel conditions. These activities are considered to be a necessary part of the FWD operation that would be little affected by the project. Therefore, no project-specific cost has been allocated to routine maintenance.

A HEC-6 model was run (see Section 4.3.5 for methods) to estimate the rate and quantity of re-deposition of sediment in the upper 5 miles of the bayou. Maintenance dredging was evaluated assuming operation of the Phase II project (i.e., sediment deposition rate and quantity were modeled for a diversion flow of 1,000 cfs). It is also assumed that most of the deposition occurs within the sand trap, and quarterly dredging only within the boundaries of the sand trap (including the dredged channel above the railway crossing) were modeled. Historically, the rate of siltation over most of the length of Bayou Lafourche has been slow; see, for example, the comparison of 1997 and 1986 cross-sections in Figure 2.3-2. The combined effect of a sand trap and higher flow velocities should reduce the siltation rate compared to historical conditions. Consequently, there is no expectation that maintenance dredging would be required during the 20-year lifetime of the project, except at the sand trap.

It is not considered that HEC-6 model results represent accurate estimates of maintenance dredging needs, due to model limitations discussed in Section 4.3. Monitoring will be required to accurately define requirements for quantity and frequency of dredging. Results are considered adequate for planning-level estimates.

At this planning level, the model indicates that about 40% of the sediments delivered through the diversion would be retained in the upper 5 miles of the bayou. To prevent the sediment from clogging the channel, about 10,000 cubic yards of dredging would be required per quarter within the boundaries of the sand trap, plus the channel above the railway crossing. This dredging would maintain the sand trap at the desired depth, and preserve channel conveyance capacity.

The model also suggests there may be some siltation of the channel below the trap. This model result is at variance with actual historic conditions, in which direct channel surveys in 1997 found no significant infill compared to similar surveys done in 1986 (see Figure 2.3-2).

The cost of the estimated 40,000 cubic yards or dredging that would be needed each year is presented in Table 5.4-3. This estimate is based on the cost per cubic yard estimated for installation of the sand trap of $2.62/cy (see Table 5.3-3). Routine maintenance is expected to be less expensive than one-time dredging. Thus, a unit cost of $2.50/cy has been assumed. This unit cost is considered representative, and includes dredge rental with full support, booster pumps, and overhead plus profit.

Note that discussions with persons knowledgeable about the Bayou Lafourche area indicate that there is a potential that dredged sands from the trap could have commercial value. Possible revenues from sale of such material have not been considered in this evaluation.

Table 5.4-1. Operation and maintenance costs, Phase I

Operation and maintenance	**Unit Cost**	**Annual Cost**
Pumping		
Incremental costs for pumping to 340 cfs	$105,000/year	
Incremental maintenance and materials costs	$ 30,000/year	
Subtotal		$135,000
Operation and maintenance of deployable control structures		$20,000
Data Collection Platforms [1, 2]		
One Platforms for stage, rainfall	$ 5,000/year	
One Platform for stage, rainfall, and flow	$ 14,000/year	
One Platform for flow (added to existing platform)	$ 3,000/year	
Subtotal		$22,000
CWPPRA monitoring [3]		$29,418
Total:		**$206,418**

[1] Source: George Arcemeaunt, Water Resources Division, U.S. Geological Survey, Baton Rouge, LA
[2] Remaining platforms already operated by USGS
[3] In 1998 dollars

Table 5.4-2. Existing energy costs for FWD pumping.

Date	Average river stage	# of pump/hours*	Cost (rounded)	Cost/hour
August 1996	8.26	1/744	$10,800	$14.52
September 1996	4.78	1/720	$ 9,200	$12.78
August 1997	5.82	3/1860	$18,900	$10.16
September 1997	4.81	3/2103	$22,900	$10.88
October 1997	4.90	3/2208	$21,900	$ 9.91
November 1997	5.26	3.03/2145**	$23,600	$11.00
December 1997	6.93	3.06/2304**	$26,000	$11.28
				$11.50 (average)
* Number of pumps operating during month/Actual pump hours				
**Denotes more than three pumps operating during month				

Table 5.4-3. Operation and maintenance costs, Phase II

Operation and maintenance	Unit Cost	Annual Cost
Pumping costs (energy)		$200,000
Maintenance		
Material and supplies	$15,000/year	
Insurance	$30,000/year	
Repairs	$45,000/year	
Subtotal		$90,000
Channel maintenance (sand trap maintenance dredging)		
10,000 cy/qtr for 4 qtrs @ $2.50/cy		$100,000
Total:		**$390,000**

[1] Source: Pyburn & Odom

5.5 TOTAL PROJECT COSTS

There are several normal “add-on” costs in the budget for CWPPRA projects that are (or can be) calculated as a percentage of the project construction budget: a contingency factor (Section 5.5.1); engineering design and supervision (Section 5.5.2); agency oversight (Section 5.5.3); and initial environmental compliance (Section 5.5.4). The total project cost estimate is summarized in Section 5.5.5. Note that several aspects of these add-on costs are to be modified and refined, in accordance with guidance from the Engineering Work Group.

5.5.1 Contingencies

A 25% contingency is commonly applied to construction costs for CWPPRA projects for which little or no detailed evaluation is made. There appears to be comparatively little uncertainty in the cost estimates for Phase I. As a result, a 20% contingency has been applied to Phase I construction costs. While EPA’s evaluation provides more extensive information than is typically available for CWPPRA projects for Phase II as well, a conservative approach was agreed on with the Engineering Work Group in which the same percentage (25%) was applied to the current, provisional cost estimate for Phase II of the project.

5.5.2 Design and supervision

Based on discussions with the CWPPRA Engineering Work Group, the following engineering-related costs have been included in the project budget. First, a cost equal to 7% of the total construction budget is included for engineering and design services; in effect these are the costs incurred getting the project ready for construction. Second, a cost equal to 9% of the total construction budget is included for supervision and administration during the construction period.

5.5.3 Agency oversight

It has been recent practice to provide a budget for administration and supervision equal to 2% of first costs for the federal sponsoring agency, and another 2% for the non-federal agency. Because of the magnitude of the Bayou Lafourche Project, this would lead to a very large allotment for agency supervision. EPA has used a 1% mark-up for its own costs, and (at the request of LDNR) 2% for the non-federal cost.

5.5.4 Environmental compliance

Environmental compliance needs for the project were discussed generally in Section 3.6. These needs include preparation of an environmental assessment, obtaining permits from the New Orleans District of the U.S. Army Corps of Engineers, and cultural resources surveys. Estimated costs for these actions are summarized in Table 5.5-1. To be conservative, a generalized value of 1% of construction cost has been used to account for initial compliance costs.

5.5.5 Total cost

Table 5.5-2 is a summary of the project costs that have been provided above in Chapter 5. Note that the term "first costs" in this table is the simple summation of construction and add-on costs in current dollars; it is not identical to first-costs in the calculation of present worth, because the latter have been adjusted for the time-value of money (see below). However, in simple terms the costs to build Phase I and II respectively are on the order of \$5 million and \$32 million; and the combined operational cost is almost \$0.6 million per year.

Fully funded costs. CWPPRA costs are calculated by taking current costs and applying an inflation factor to account for cost increases that will be experienced by the time an actual project feature is constructed or operated. Tables 5.5-3 and 5.5-4 present schedules of funding for Phases I and II, respectively. Using these schedules, appropriate inflation factors can be applied to estimate fully funded cost.

In conventional financial analyses, a second adjustment is made to account for the fact that when a project is funded, but actual costs are deferred, the funds earn interest until they are spent. In a CWPPRA fully funded cost estimate, this compensating adjustment for growth in money supply through interest payments is not made.

The rationale for this approach is that the income to the trust fund that provides CWPPRA dollars accrues to the fund as a whole, not to the projects for which funds are earmarked. By counting inflation, but not interest, the fully funded method indicates that any deferred investment (such as operations) will become increasingly expensive over time. This effect is particularly great for a project that invests substantially in future operations rather than entirely in present construction. The resulting estimates of fully funded costs reflect the true presumed expenditure of trust fund monies, but not the offsetting benefits to trust fund resources, or the true fiscal impact on society.

Table 5.5-5 presents an estimate of fully funded costs for Phase I of the Bayou Lafourche project, based on the schedule for expenditures presented in Table 5.5-3. The inflation rates applied to CWPPRA projects are calculated according to a formula specified in the Water Resources Development Act (WRDA). An inflation factor of 2.6% per year is the current rate being applied to CWPPRA projects, and has been applied in this analysis. The cost estimates presented here are assumed to be current and applicable through 1999. Thus the initial year of inflated costs is year 2000.

Project operations are assumed to occur for 20 years. Water management and monitoring is initiated a year earlier than operations, and extends through the project lifetime. CWPPRA monitoring also is initiated a year earlier than operations. However, to be consistent with monitoring estimates for other projects, the total monitoring effort is limited to 20 years.

O&M costs account for more than half the resulting estimate of about $10.6 million dollars fully funded cost for Phase I of the project.

Table 5.5-6 presents an estimate of fully funded costs for Phase II of the Bayou Lafourche project, assuming the schedule for expenditures presented in Table 5.5-4, and an inflation factor of 2.6% per year which is first applied in the year 2000. Project operations are assumed to occur for 20 years. In the analysis, this causes Phase II of the project to continue after Phase I is over. In practice, this is simply an artifact of the analysis, which considers 20 years worth of operations for each phase; actual operations of Phase I would be expected to continue past 20 years, but funding for such operations are not part of the current assessment. The total fully funded cost of Phase II is on the order of $46 million dollars.

Fully funded costs for Phase I and Phase II combined are:

Phase I:	$10,573,480
Phase II:	$46,218,793
Total:	$56,792,273

Note that as discussed below, this value is subject to downward adjustment based on prospective cost-share arrangements.

Present worth and average annual costs. Present worth costs generally estimate the funds that must be invested today to build and operate a project in the future. They thus account for the fact that actual costs will increase over time, through inflation (the same assumption made for fully funded cost estimates), and the fact that money put aside for a project today can be invested and earn interest until it is needed. The present-worth method of estimating a project cost is a conventional engineering practice. It is necessary to assess the true cost of a project in terms that allow direct comparison to cost-estimates for alternative projects, and to provide a basis for estimating possible cost-share contributions by other parties.

The combined effect of adjusting current cost estimates for both inflation and investment return to estimate present worth costs is that while costs incurred in the future will be greater than today, so too will the funds available. Typically, and certainly at present, interest rates exceed inflation rates. Therefore, the effect of the present worth method, and of conventional real-world economics, is that expenditures that are deferred into the future will be relatively less costly than expenditures made today. Indeed, costs incurred far into the future have almost no value under present-worth economic terms. This result sometimes poses problems in demonstrating benefits when one invests to prevent the long-term loss of environmental resources, because in present-worth terms the future value of the resources may be virtually nil.

Although the present-worth method has drawbacks if applied to long-term resource decisions, for analyses carried out over a 20-year project lifetime it provides an effective method of measuring the fiscal impacts of alternative projects. Thus, in terms of providing cost estimates to benefit decisions about what is best for society, the method is in widespread use.

The interest and inflation rates applied to CWPPRA projects are calculated according to formulae specified in the Water Resources Development Act (WRDA). The WRDA formula for “interest rate” actually incorporates factors for both return on investment (“interest”) and inflation. Thus only the WRDA interest rate is applied in the CWPPRA present worth analysis. The current WRDA interest rate being applied to CWPPRA projects is 7.125%.

Present worth costs are not used in CWPPRA to define the amount of money that must be put aside to fund the project, since the ability to invest and earn interest is not considered for CWPPRA projects (fully funded project costs are used instead). Present worth cost is used only to estimate the average annual cost. The average annual cost is the amortized equivalent of the present worth cost of a project.

In present worth analyses, the time of project completion is set as "time zero". After this time, the project is operational and "earning" benefits based on the investment of capital. For annual expenditures that begin when the project is operational, the ability to earn interest makes future activities less costly in terms of 1998/99 (i.e., current) dollars than near-term expenditures. The deflation factor includes the interest rate raised to the negative power that represents the number of years in the future that the expenditure will be made.

Expenditures made before time zero, such as to construct, forgo the opportunity to earn money on the expended capital, which is also not yet earning benefits by the functioning of the project. To capture the cost of this lost opportunity, construction costs are increased by the WRDA interest rate raised to the power representing the number of years before project completion that the money is spent. In this perspective, the costs of the most immediate construction activities are higher than the costs of construction that will take place further in the future (i.e., closer to completion of the project).

Average annual cost is the present worth cost times an amortization factor. The amortization factor incorporates both the current interest rate and the intended duration of the project, defined as 20 years for CWPPRA projects. The amortization factor currently being applied to CWPPRA projects is 0.0953119.

Table 5.5-7 presents estimates of the present worth and average annual costs for Phase I of the Bayou Lafourche project. The schedule for expenditures is based on the schedule chart presented in Table 5.5-3. EPA believes that in terms of financial evaluations familiar to the average citizen, the present worth project cost of less than $8 million is a better indicator than the higher estimate of fully funded cost. The average annual cost for Phase I of the project is approximately $725,000/year.

Table 5.5-8 presents estimates of the present worth and average annual costs for Phase II of the Bayou Lafourche project. The schedule for expenditures is based on the schedule provided in Table 5.5-4. Again, for comparisons to other public works projects (not CWPPRA projects), the present worth project cost is a better indicator than the higher estimate of fully funded cost. The present worth cost is on the order of $40 million. The average annual cost for Phase II of the project is approximately $3.8 million/year.

Present worth costs for Phase I and Phase II combined are:

Phase I:	$ 7,601,739
Phase II:	$39,977,898
Total:	$47,579,637

This cost should be considered when comparing the project to other (non-CWPPRA) public works projects.

Average annual costs (amortized present worth costs) for Phase I and Phase II combined are:

Phase I:	$ 724,536
Phase II:	$3,810,369
Total:	$4,534,905

Table 5.5-1. Costs for environmental compliance and permitting

Activity	**Cost** (to nearest thousand)
NHPA compliance	
Cultural resources survey[1]	
Pumping facility (field research regarding Ft. Butler and any historic buildings; backhoe work)	$4,000
Bayou (archival research on boat wrecks and other cultural remains)	$11,000
Data analysis and report preparation	$19,000
Subtotal:	$34,000
NEPA compliance	
Environmental assessment	$75,000
Total NHPA + NEPA compliance	**$109,000**
Miscellaneous permitting/coordination	$41,000
Total environmental compliance and permitting	**$150,000**

[1] Source: Cost proposal submitted to Lee Wilson and Associates by Coastal Environments, Inc., May 4, 1998. Proposal is for what is known as a "Phase I" survey.

Table 5.5-2. Summary of Bayou Lafourche project costs, 1,000 cfs pumps and siphons

		Cost			
	Item	**Phase I**	**Phase 2**	**Total**	**Discussion**
1	New 660 cfs diversion station	$0	$9,877,000	$9,877,000	Submitted with Phase II construction costs
2	Upgrade 340 cfs pumps	$720,000	$0	$720,000	Submitted with Phase I construction costs
3	Highway & railway crossing	$0	$0	$0	Coordination with the owners of these crossings has identified no cost obligations
4	Sand trap	$236,125	$0	$236,125	Submitted with Phase I construction costs
5	Dredging	$534,375	$10,196,860	$10,731,235	Submitted with Phase 1 and II construction costs
6	Utility replacements	$200,000	$1,298,000	$1,498,000	Submitted with Phase I and II construction costs
7	Water management structures	$1,770,194	$0	$1,770,194	Submitted with Phase I construction costs
8	Bank protection	$0	$650,000	$650,000	Submitted with Phase II construction costs
9	Land rights	$0	$0	$0	Included in individual items
10	Monitoring system	$42,000	$0	$42,000	See Table 5.3-11. Not included in original budget.
	Construction costs	$3,502,694	$22,021,860	$25,524,554	Represents "FIRST COSTS" for project, excluding contingency and engineering.
11	Contingency	$700,539	$5,505,465	$6,206,004	Submitted with Phase I and II construction costs
12	Design, supervision	$560,431	$3,523,498	$4,083,929	Submitted with Phase I and II construction costs
13	Agencies	$105,081	$660,656	$765,737	Submitted with Phase I and II construction costs
14	Compliance	$0	$220,219	$220,219	Submitted with Phase II construction costs
15	**Total first costs**	$4,868,745	$31,931,697	$36,800,442	Does not reflect cost-share arrangements.
16	Labor & overhead	$0	$0	$0	Assumed part of existing FWD operations
17	Energy/repairs 660 cfs plant	$0	$290,000	$290,000	Submitted with Phase II O&M costs
18	Incremental O&M	$135,000	$0	$135,000	Submitted with Phase I O&M costs
19	Channel management/maint.	$42,000	$100,000	$142,000	Submitted with Phase I and II O&M costs
20	CWPPRA monitoring	$29,418	$0	$29,418	Submitted with Phase I O&M costs
21	Other O&M	$0	$0	$0	Assumed part of existing FWD operations
22	**Total annual costs**	$206,418	$390,000	$596,418	

PRELIMINARY: DRAFT

Table 5.5-3. Schedule for funding Phase I of the Bayou Lafourche diversion project, 340 cfs

Item	Total costs	1999	2000	2001	2002	2003	2004	2005
Upgrade 340 cfs pumps	$720,000	$720,000						
Sand trap	$236,125		$236,125					
Dredging	$534,375		$534,375					
Utility replacements	$200,000	$200,000						
Water management structures	$1,770,194	$354,039	$1,416,155					
Monitoring system	$42,000	$42,000						
Construction costs	$3,502,694	$1,316,039	$2,186,655					
Contingency	$700,539	$263,208	$437,331					
Design, supervision [1]	$560,431	$363,632	$196,799					
Agencies	$105,081	$39,481	$65,600					
Compliance[3]	$0	$0	$0					
Total first costs	$4,868,745	$1,982,360	$2,886,385					
Incremental O&M	$135,000			$135,000	$135,000	$135,000	$135,000	$135,000
Water management/monitoring	$42,000		$42,000	$42,000	$42,000	$42,000	$42,000	$42,000
CWPPRA monitoring	$29,418		$29,418	$29,418	$29,418	$29,418	$29,418	$29,418
Total annual costs[2]	$206,418		$71,418	$206,418	$206,418	$206,418	$206,418	$206,418

[1] For design and supervision, Year 1999 costs are 7% of total construction cost for design, and 9% of Year 1999 construction costs for supervision. Year 2000 costs are 9% of Year 2000 construction.

[2] O&M costs not adjusted for inflation.

[3] Compliance activities associated with Phase I construction are included within each construction component

Table 5.5-4. Schedule for funding Phase II of the Bayou Lafourche diversion project

Item	Total costs	1999	2000	2001	2002	2003	2004	2005
Diversion facilities	$9,877,000				$4,938,500	$4,938,500		
Sand trap[3]	$0							
Dredging	$10,196,860				$5,373,430	$4,823,430		
Utility replacements	$1,298,000				$1,298,000			
Water management structures[3]	$0							
Bank protection	$650,000				$650,000			
Monitoring system[3]	$0							
Construction costs	$22,021,860				$12,259,930	$9,761,930		
Contingency	$5,505,465				$3,064,982	$2,440,482		
Design, supervision [1]	$3,523,498		$770,765	$770,765	$1,103,394	$878,574		
Agencies[4]	$660,656		$165,164	$165,164	$165,164	$165,164		
Compliance	$220,219			$220,219				
Total first costs	$31,931,697		$935,929	$1,156,148	$16,593,470	$13,246,150		
Energy/repairs 660 cfs plant	$290,000						$290,000	$290,000
Incremental O&M	$0							
Channel maintenance	$100,000						$100,000	$100,000
CWPPRA monitoring [3]	$0							
Total annual costs[2]	$390,000		$0	$0	$0	$0	$390,000	$390,000

[1] For design and supervision, costs are 3.5% of "total construction costs" for years 2000 and 2001, and 9% of annual construction costs for the remaining years.
[2] O&M costs not adjusted for inflation.
[3] Included in Phase I.
[4] Assumed equal amounts over four year period

Table 5.5-5. Fully funded costs for the Bayou Lafourche Phase I, 340 cfs, project.

1998 DOLLARS		TOTAL	NEW DIVERSION	EXISTING DIVERSION	SAND TRAP	DREDGING	UTILITIES	WATER MGT.	BANK PROTECT	MON. SYSTEM	ENERGY	CHANNEL MGT.	CWPPRA MON.	CONTING.	ENGNRNG	AGENCY	COMPLI-ANCE
Base cost		$ 3,502,694	$0	$720,000	$236,125	$534,375	$200,000	$1,770,194	$0	$42,000	$135,000	$42,000	$29,418	$700,539	$560,431	$105,081	$0
1999				$720,000			$200,000	$354,039		$42,000				$263,208	$363,632	$39,481	
2000					$236,125	$534,375		$1,416,155				BEGINS	BEGINS	$437,331	$196,799	$65,600	
2001											BEGINS	CONTINUES	CONTINUES				
2002											CONTINUES	"	"				
2003											"	"	"				
2004											"	"	"				
2005											"	"	"				
YEAR		FACTOR		FULLY FUNDED CWPPRA DOLLARS													
1999	2	1		$720,000			$200,000	$354,039		$42,000				$263,208	$363,632	$39,481	
2000	1	1.026			$242,264	$548,269		$1,452,975				$43,092	$30,183	$448,702	$201,916	$67,305	
2001	-1	1.052676									$142,111	$44,212	$30,968				
2002	-2	1.080045576									$145,806	$45,362	$31,773				
2003	-3	1.108126761									$149,597	$46,541	$32,599				
2004	-4	1.136938057									$153,487	$47,751	$33,446				
2005	-5	1.166498446									$157,477	$48,993	$34,316				
2006	-6	1.196827406									$161,572	$50,267	$35,208				
2007	-7	1.227944918									$165,773	$51,574	$36,124				
2008	-8	1.259871486									$170,083	$52,915	$37,063				
2009	-9	1.292628145									$174,505	$54,290	$38,027				
2010	-10	1.326236477									$179,042	$55,702	$39,015				
2011	-11	1.360718625									$183,697	$57,150	$40,030				
2012	-12	1.396097309									$188,473	$58,636	$41,070				
2013	-13	1.432395839									$193,373	$60,161	$42,138				
2014	-14	1.469638131									$198,401	$61,725	$43,234				
2015	-15	1.507848723									$203,560	$63,330	$44,358				
2016	-16	1.547052789									$208,852	$64,976	$45,511				
2017	-17	1.587276162									$214,282	$66,666	$46,694				
2018	-18	1.628545342									$219,854	$68,399	$47,909				
2019	-19	1.670887521									$225,570	$70,177	$49,154				
2020	-20	1.714330597									$231,435	$72,002					
TOTAL			$0	$720,000	$242,264	$548,269	$200,000	$1,807,014	$0	$42,000	$3,666,949	$1,183,921	$778,820	$711,909	$565,548	$106,786	$0

Table 5.5-6. Fully funded costs for the Bayou Lafourche Phase II, 660 cfs, project.

1998 DOLLARS		TOTAL	NEW DIVERSION	EXISTING DIVERSION	SAND TRAP	DREDGING	UTILITIES	WATER MGT.	BANK PROTECT	MON. SYSTEM	ENERGY	CHANNEL MGT.	CWPPRA MON.	CONTING.	ENGNRNG	AGENCY	COMPLI-ANCE
Base cost		$22,021,860	$9,877,000			$10,196,860	$1,298,000		$650,000		$290,000	$100,000		$5,505,465	$3,523,498	$ 660,656	$220,219
1999																	
2000															$770,765	$165,164	
2001															$770,765	$165,164	$220,219
2002			$4,938,500			$5,373,430	$1,298,000		$650,000					$3,064,982	$1,103,394	$165,164	
2003			$4,938,500			$4,823,430								$2,440,482	$878,574	$165,164	
2004											BEGINS	BEGINS					
2005											CONTINUES	CONTINUES					
YEAR		FACTOR	FULLY FUNDED CWPPRA DOLLARS														
1999	5	1															
2000	4	1.026													$790,805	$169,458	
2001	3	1.052676													$811,366	$173,864	$231,819
2002	2	1.080045576	$5,333,805			$5,803,549	$1,401,899		$702,030					$3,310,321	$1,191,715	$178,385	
2003	1	1.108126761	$5,472,484			$5,344,972								$2,704,364	$973,571	$183,023	
2004	-1	1.136938057									$329,712	$113,694					
2005	-2	1.166498446									$338,285	$116,650					
2006	-3	1.196827406									$347,080	$119,683					
2007	-4	1.227944918									$356,104	$122,794					
2008	-5	1.259871486									$365,363	$125,987					
2009	-6	1.292628145									$374,862	$129,263					
2010	-7	1.326236477									$384,609	$132,624					
2011	-8	1.360718625									$394,608	$136,072					
2012	-9	1.396097309									$404,868	$139,610					
2013	-10	1.432395839									$415,395	$143,240					
2014	-11	1.469638131									$426,195	$146,964					
2015	-12	1.507848723									$437,276	$150,785					
2016	-13	1.547052789									$448,645	$154,705					
2017	-14	1.587276162									$460,310	$158,728					
2018	-15	1.628545342									$472,278	$162,855					
2019	-16	1.670887521									$484,557	$167,089					
2020	-17	1.714330597									$497,156	$171,433					
2021	-18	1.758903192									$510,082	$175,890					
2022	-19	1.804634675									$523,344	$180,463					
2023	-20	1.851555177									$536,951	$185,156					
TOTAL			$10,806,289	$0	$0	$11,148,521	$1,401,899	$0	$702,030	$0	$8,507,680	$2,933,683	$0	$6,014,685	$3,767,457	$704,730	$231,819

Table 5.5-7. Present worth and average annual costs for the Bayou Lafourche Phase I, 340 cfs, project.

	1998 DOLLARS		NEW DIVERSION	EXISTING DIVERSION	SAND TRAP	DREDGING	UTILITIES	WATER MGT.	BANK PROTECT	MON. SYSTEM	ENERGY	CHANNEL MGT.	CWPPRA MON.	CONTING.	ENGNRNG	AGENCY	COMPLI-ANCE
Base cost			$ -	$720,000	$236,125	$534,375	$200,000	$1,770,194	$0	$42,000	$135,000	$42,000	$29,418	$700,539	$560,431	$105,081	$0
1999				$720,000			$200,000	$354,039		$42,000				$263,208	$363,632	$39,481	
2000					$236,125	$534,375		$1,416,155				BEGINS	BEGINS	$437,331	$196,799	$65,600	
2001											BEGINS	CONTINUES	CONTINUES				
2002											CONTINUES	"	"				
2003											"	"	"				
2004											"	"	"				
2005											"	"	"				
YEAR		FACTOR		PRESENT WORTH DOLLARS													
1999	2	1.147576563		$826,255			$229,515	$406,287		$48,198				$302,051	$417,296	$45,308	
2000	1	1.07125			$252,949	$572,449		$1,517,056				$44,993	$31,514	$468,491	$210,821	$70,274	
2001	-1	0.933488915									$126,021	$39,207	$27,461				
2002	-2	0.871401554									$117,639	$36,599	$25,635				
2003	-3	0.813443691									$109,815	$34,165	$23,930				
2004	-4	0.759340668									$102,511	$31,892	$22,338				
2005	-5	0.708836097									$95,693	$29,771	$20,853				
2006	-6	0.661690639									$89,328	$27,791	$19,466				
2007	-7	0.617680876									$83,387	$25,943	$18,171				
2008	-8	0.576598251									$77,841	$24,217	$16,962				
2009	-9	0.538248075									$72,663	$22,606	$15,834				
2010	-10	0.502448612									$67,831	$21,103	$14,781				
2011	-11	0.469030209									$63,319	$19,699	$13,798				
2012	-12	0.437834501									$59,108	$18,389	$12,880				
2013	-13	0.408713653									$55,176	$17,166	$12,024				
2014	-14	0.381529665									$51,507	$16,024	$11,224				
2015	-15	0.356153713									$48,081	$14,958	$10,477				
2016	-16	0.332465543									$44,883	$13,964	$9,780				
2017	-17	0.310352899									$41,898	$13,035	$9,130				
2018	-18	0.289710991									$39,111	$12,168	$8,523				
2019	-19	0.270441998									$36,510	$11,359	$7,956				
2020	-20	0.252454608									$34,081	$10,603					
TOTAL			$0	$826,255	$252,949	$572,449	$229,515	$1,923,343	$0	$48,198	$1,416,402	$485,651	$332,737	$770,542	$628,117	$115,581	$0

Present worth costs from average annual costs

Total $ 7,601,739

	Present Worth	Amort. Factor	Ave. Annual
First costs*	$5,366,949	0.0953119	$511,534
Monitoring	$332,737	0.0953119	$31,714
O&M	$1,902,053	0.0953119	$181,288
Total	$7,601,739		$724,536

* First costs = construction plus contingency, engineering, and supervision

Table 5.5-8. Present worth costs for the Bayou Lafourche Phase II, 660 cfs, project.

1998 DOLLARS			NEW DIVERSION	EXISTING DIVERSION	SAND TRAP	DREDGING	UTILITIES	WATER MGT.	BANK PROTECT	MON. SYSTEM	ENERGY	CHANNEL MAINT.	CWPPRA MON.	CONTING.	ENGNRNG	AGENCY	COMPLI-ANCE
Base cost			$9,877,000	(Phase I)	(Phase I)	$10,196,860	$1,298,000	(Phase I)	$650,000	(Phase I)	$290,000	$100,000	(Phase I)	$5,505,465	$3,523,498	$660,656	$220,219
1999																	
2000															$770,765	$165,164	
2001															$770,765	$165,164	$220,219
2002			$4,938,500			$5,373,430	$1,298,000		$650,000					$3,064,982	$1,103,394	$165,164	
2003			$4,938,500			$4,823,430								$2,440,482	$878,574	$165,164	
2004											BEGINS	BEGINS					
2005																	
YEAR		FACTOR	PRESENT WORTH DOLLARS														
1999	5	1.410763369															
2000	4	1.316931967													$1,015,045	$217,510	
2001	3	1.229341393													$947,533	$203,043	$270,724
2002	2	1.147576563	$5,667,307			$6,166,422	$1,489,554		$745,925					$3,517,302	$1,266,229	$189,538	
2003	1	1.07125	$5,290,368			$5,167,099								$2,614,367	$941,172	$176,932	
2004	-1	0.933488915									$270,712	$93,349					
2005	-2	0.871401554									$252,706	$87,140					
2006	-3	0.813443691									$235,899	$81,344					
2007	-4	0.759340668									$220,209	$75,934					
2008	-5	0.708836097									$205,562	$70,884					
2009	-6	0.661690639									$191,890	$66,169					
2010	-7	0.617680876									$179,127	$61,768					
2011	-8	0.576598251									$167,213	$57,660					
2012	-9	0.538248075									$156,092	$53,825					
2013	-10	0.502448612									$145,710	$50,245					
2014	-11	0.469030209									$136,019	$46,903					
2015	-12	0.437834501									$126,972	$43,783					
2016	-13	0.408713653									$118,527	$40,871					
2017	-14	0.381529665									$110,644	$38,153					
2018	-15	0.356153713									$103,285	$35,615					
2019	-16	0.332465543									$96,415	$33,247					
2020	-17	0.310352899									$90,002	$31,035					
2021	-18	0.289710991									$84,016	$28,971					
2022	-19	0.270441998									$78,428	$27,044					
2023	-20	0.252454608									$73,212	$25,245					
TOTAL			$10,957,675	$0	$0	$11,333,522	$1,489,554	$0	$745,925	$0	$3,042,641	$1,049,187	$0	$6,131,669	$4,169,979	$787,023	$270,724

Total $39,977,898

Present worth costs from average annual costs

	Present Worth	Amort. Factor	Ave. Annual
First costs*	$35,886,071	0.0953119	$3,420,370
Monitoring	$0	0.0953119	$0
O&M	$4,091,827	0.0953119	$390,000
Total	$39,977,898		$3,810,369

* First costs = costruction plus contingency, engineering, and supervision

5.6 PROJECT EFFECTS

This report provides information on the effects of the diversion project in four different ways.

- General information is presented throughout the report and especially in Chapter 3. Section 5.6.1 below, itemizes the effects that have been identified.
- Impacts to bayou water flow have been quantified using the HEC-RAS and UNET models described in Chapter 4, and are discussed in Section 5.6.2.
- Section 5.6.3 provides a qualitative discussion of effects during emergency pump shut-down.
- Project benefits, as determined using the WVA procedure, are discussed in Section 5.7.

5.6.1 Effects other than associated directly with water flow

The following effects, impacts and changes can be anticipated as the result of the construction and operation of the project. Note that a detailed environmental impact document could expand upon this list, which reflects the general analysis contained in the current evaluation. Also, additional effects may be identified as a result of the public participation process.

- Extensive construction would occur at the head of the bayou in Donaldsonville. Effects (generally minor and localized) could include noise, dust, emissions from vehicles, disruption of traffic, acquisition of rights-of-way, and relocation of two small structures.
- A regional impact would result from the substantial investment of public funds for project construction, with its effect on payrolls, sales of materials, and related activities. Several dozen construction works and/or dredging contractor employees will be added to the working population of the area, and some may relocate to the area on a temporary basis.
- Cultural resources surveys would be performed (e.g. at Ft. Butler) and mitigation measures such as recordation may occur.

- Providing access to and from the bayou for dredging equipment will mostly occur near bridges. There will be localized effects to the batture, and probably some temporary disruption of traffic.

- Dredging operations will be associated with noise, engine emissions, and related effects of operating equipment. During project construction, such effects will be small, localized and (at any one place) very short term. During project operation, such effects will recur periodically in the area of the sand trap and channel above the sand trap. The dredge(s) also may restrict boat traffic and cause a temporary, localized increase in turbidity. Mobilization of bottom sediments during dredging may also cause a localized increase in organic matter and oxygen demand.

- The new channel will be deeper and have somewhat faster flow than the existing bayou. However, velocities will be far below that required to initiate bed or bank scour. Deeper water could raise issues of swimmer safety, if and to the extent this use occurs in the bayou.

- Disposal of dredged material will have effects related to the placement and movement of pipelines through culverts and along fields, construction of containment levees, operation of disposal equipment (noise, emissions, etc.) and drainage of water from the containment areas. There will be loss of land production until the material is dry enough to be cultivated. Very localized changes to drainage patterns will occur near the area of new fill.

- Utility replacements will have localized construction impacts and in some cases may result in a short interruption of the use of a pipeline or cable.

- There will be an increase in energy consumption associated with the increased rate of pumping. In other respects, operations and maintenance associated with Bayou Lafourche diversions will be similar to those now occurring.

- Removal of the weir at Thibodaux will reconnect the upper bayou to the lower bayou, which could increase recreational use and boat traffic. For short periods of time when the deployable controls are in operation, this new benefit would not be available.

- Water quality in the existing bayou reflects a mix of Mississippi River water, which is not known to cause any significant problems, and local runoff or seepage, which may cause some concerns (see Section 2.7). With an increase in river water diversion rates, the amount of better quality water available to dilute local runoff would generally increase, thus improving water quality.

- Overall, the water in the bayou should be slightly fresher (especially in the lower reaches) and more turbid with a higher rate of diversion.

- Salinity encroachment impacts to water users along the bayou would effectively be eliminated.
- Channel dredging should remove *Hydrilla* roots in most of the bayou. The higher flow velocities and greater turbidity may have some benefit in restricting the return of *Hydrilla* to the system, thus reducing long-term maintenance requirements for the FWD. These same effects would limit other types of aquatic growth as well.

5.6.2 Predicted hydrologic changes for normal operations

The HEC-RAS model described in Section 4.3 was used to predict the effects of improving the channel of Bayou Lafourche and then increasing diversion rates. All simulations represent steady-state conditions, for a dry weather condition. Thus there was no input to the flow in the bayou except the diversion at Donaldsonville; and no output except discharge at Lockport.

Phase I. The estimate of dredging quantities for Phase I assumed a dredging template that has 4H:1V (horizontal:vertical) side slopes. Numerous cross-sections illustrating this template were provided in EPA (1998b) (see also uppermost section in Figure 3.4-3). Collectively these sections cover the entire length of the impacted channel, which extends from the bottom of the sand trap to just above the Ascension-Assumption Parish line. Note that the cross-sections were prepared primarily as input to the HEC model, and their main purpose is to allow quantification of the relationship between dredging volume and water level. The sections are not intended as design drawings; formal design would look closely at placement of dredging relative to channel and bank features, and at optimization of dredging volume (which, as noted in Section 5.3.4, was determined to be 150,000 cubic yards).

Figure 5.6-1 shows water levels computed by the HEC model for “current conditions”: 185 cfs (a value actually observed when EPA personnel were in the field on July 8th of this year) and the cross-sections that were surveyed in 1986 and verified in 1997. Figure 5.6-1 also shows water levels computed by the model, assuming removal of the Thibodaux weir and the dredging effort described above; and further assuming a diversion of 340 cfs. The model results indicate that the improved section will convey 340 cfs with water levels that are generally lower than now occur.

Phase II. Figure 5.6-2 shows model results similar to those described above, except the diversion rate was 1,000 cfs, and the dredging program was 3.3 million cubic yards as described in Section 5.3.5. The projected water level would be several inches lower than the reference profile in all locations below the sand trap. Near Napoleonville, the model simulation indicates a water-level lowering of nearly one foot; in that reach, further optimization may be possible to reduce the dredging volume and project cost.

Note that the expectation is that the project would be operated at full capacity year-round, provided that water levels within Bayou Lafourche remain below the reference line. The management plan described in Section 3.5 would provide that if these levels are exceeded in dry periods, diversion rates would be reduced.

The one location where water levels would be higher than at present is not in the bayou proper, but in the outfall area above the railway crossing. In that area, the controlling effect on water levels is the capacity of the railway culverts to pass flow. The estimated water level elevation necessary to pass water through the culverts to the sand trap is about 9.5 feet NGVD. This is 1 foot above the existing level in the reach from the discharge point to the highway crossing, and 1.5 feet above the existing level in the 550-foot long reach between the highway and railway crossings.

In this area, the batture has steep, essentially undeveloped slopes. During the design phase of the project, it will be appropriate to evaluate this area for possible impacts to existing property.

Just above the railway crossing, LA 308 dips down to pass beneath the railway. Surveys indicate this road section is at elevation +10 ft NGVD, which is above the projected water level.

Water levels during storm runoff periods. Under present day conditions, storm runoff events cause short-term water level rises of as much as two feet. With the improved channel, and in the absence of specific operations to provide drainage benefits, a similar or smaller impact would be expected. Such improvements would be especially evident if diversion rates were decreased during periods of storm runoff, thus allocating channel capacity for the purpose of providing drainage. This concept is illustrated in Figure 5.6-3: the upper line is an actual water level profile over time in Thibodaux, for a storm in May, 1995; the lower line is a conceptualization of impacts with an improved channel. The benefits include a lower level to begin with, before the storm hits (see discussion of Figure 5.6-3, above); benefits from the fact that the improved channel would be deeper than the existing channel and would convey a greater amount of storm runoff, with equal or less of a rise in water levels, than occurs today; and additional benefits from reducing the diversion rate as the storm effects hit the bayou.

Ground water. The overall impact of the project, to lower water levels during storm events, may have small, temporary and localized effects on lowering the ground water table compared to present conditions. In other words, if ground water near the bayou now comes up during storms, it would come up less with the new project in place.

Flow velocity. Figure 5.6-4 plots flow velocities for a 1,000 cfs discharge into the improved channel. As is the case for HEC-RAS outputs, the fluctuations from one location to another are largely an artifact of the reconnaissance level of the modeling and the fact that optimization is not complete; in practice, the variability in velocities would be less than illustrated. Velocities are predicted to be less than 1 foot per second in the upper few miles of the channel, and less than 1.5 feet per second in the remainder of the channel.

5.6.3 Predicted water levels during emergency operations

It is standard operational practice for FWD to shut down its diversion when there is risk posed by a toxic spill in the Mississippi River above the intake. The effect of such a shut-down is to stop flows into the bayou; water levels in the channel drop as water drains out over the Thibodaux weir to the GIWW. At any given location, the rate of decline in water level increases in proportion to the difference in water levels between the location and the drainage point on the bayou (see UNET model results, Section 4.4). The rate also increases with increasing distance from the outlet point.

For the current situation, the weir at Thibodaux acts as an outlet point that is some 30+ miles below the head of the bayou. The weir provides stable water levels in the reach above Thibodaux, but allows for significant fluctuations in Donaldsonville. There, water levels can decline several inches in the first hour after a shut-down, and as much as 1.5 feet in the first 12 hours.

The optimized project would replace the permanent weir at Thibodaux with a deployable weir, which would continue to provide stable water levels upstream in emergencies. In addition, a second deployable weir would be installed at a location in the upper few miles of the bayou, below the most heavily developed batture areas in Donaldsonville. This structure should reduce dewatering rates by several-fold -- to less than an inch in the first hour, and less than one-half foot in the first 12 hours. The reduced rate of drawdown is expected to have a strongly positive impact on bank stability.

Figure 5.6-1. Phase I water surface elevations predicted by HEC-RAS modeling for 340 cfs with Phase I improvements compared to existing conditions at 185 cfs

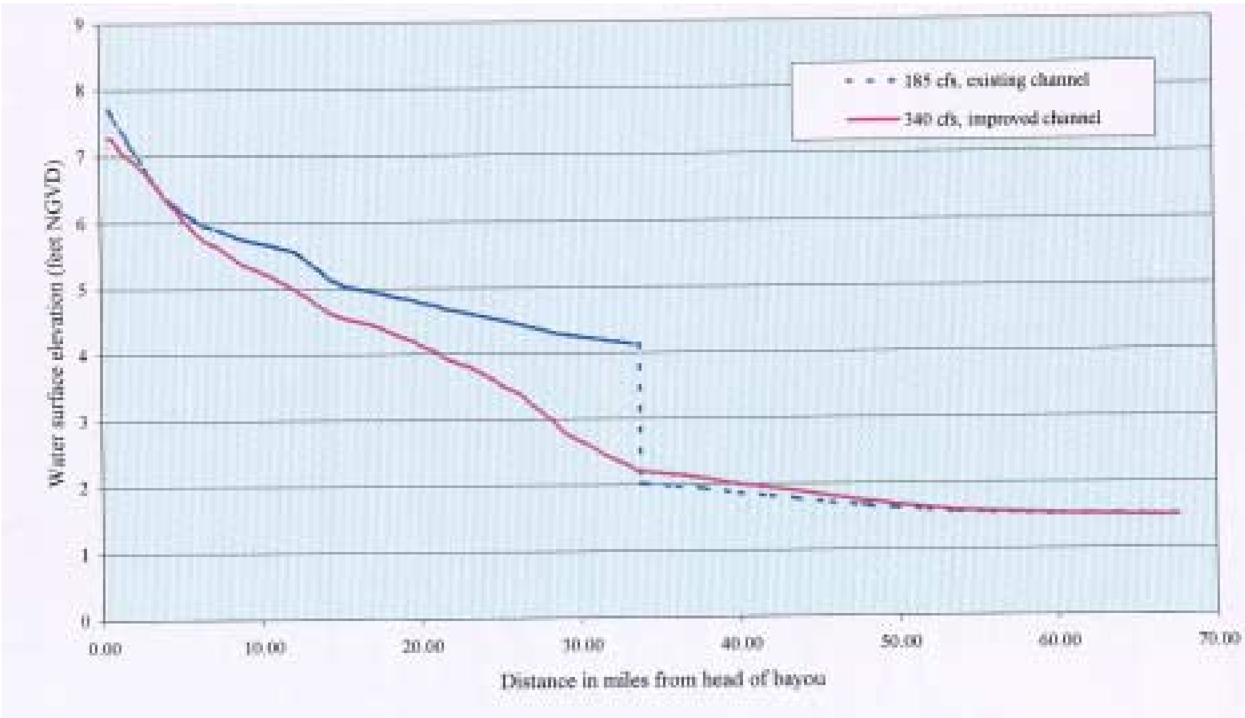


Figure 5.6-2. Effect of 1,000 cfs diversion on water level in Bayou Lafourche

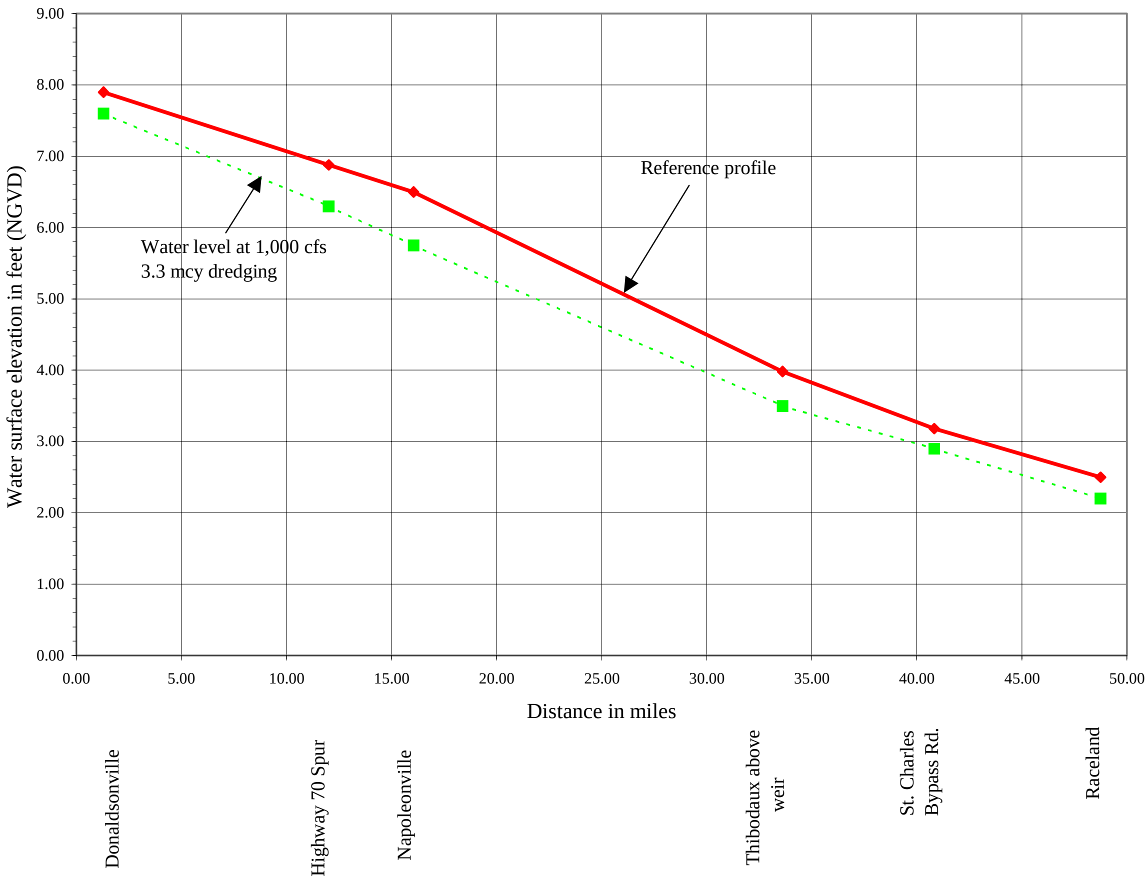
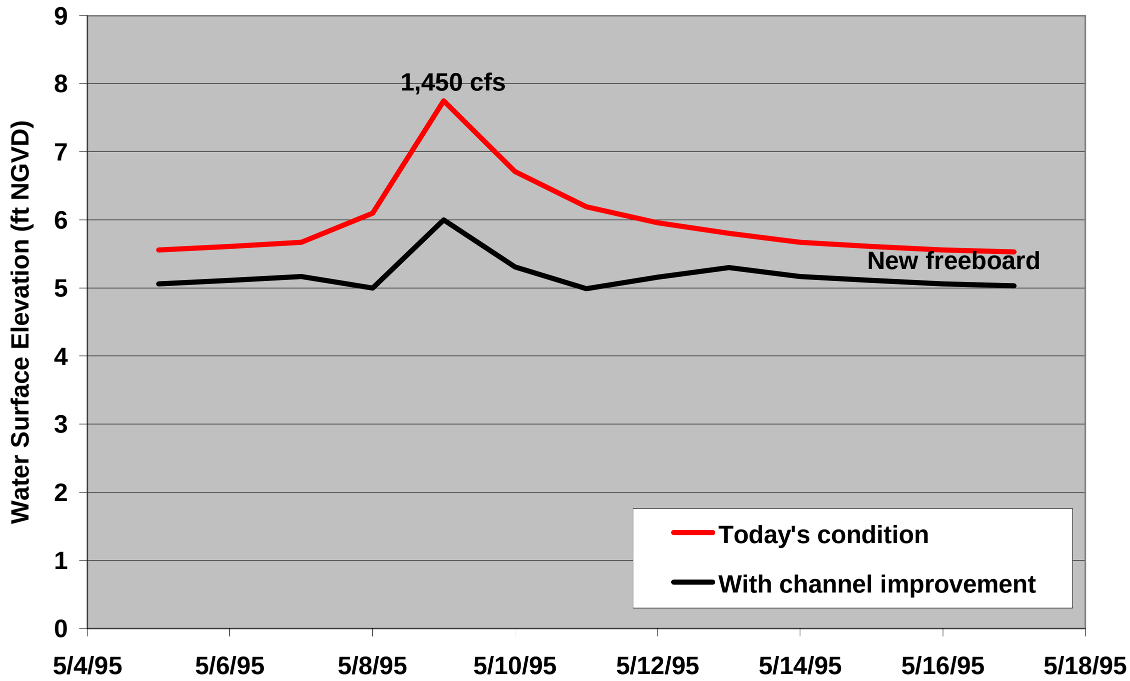
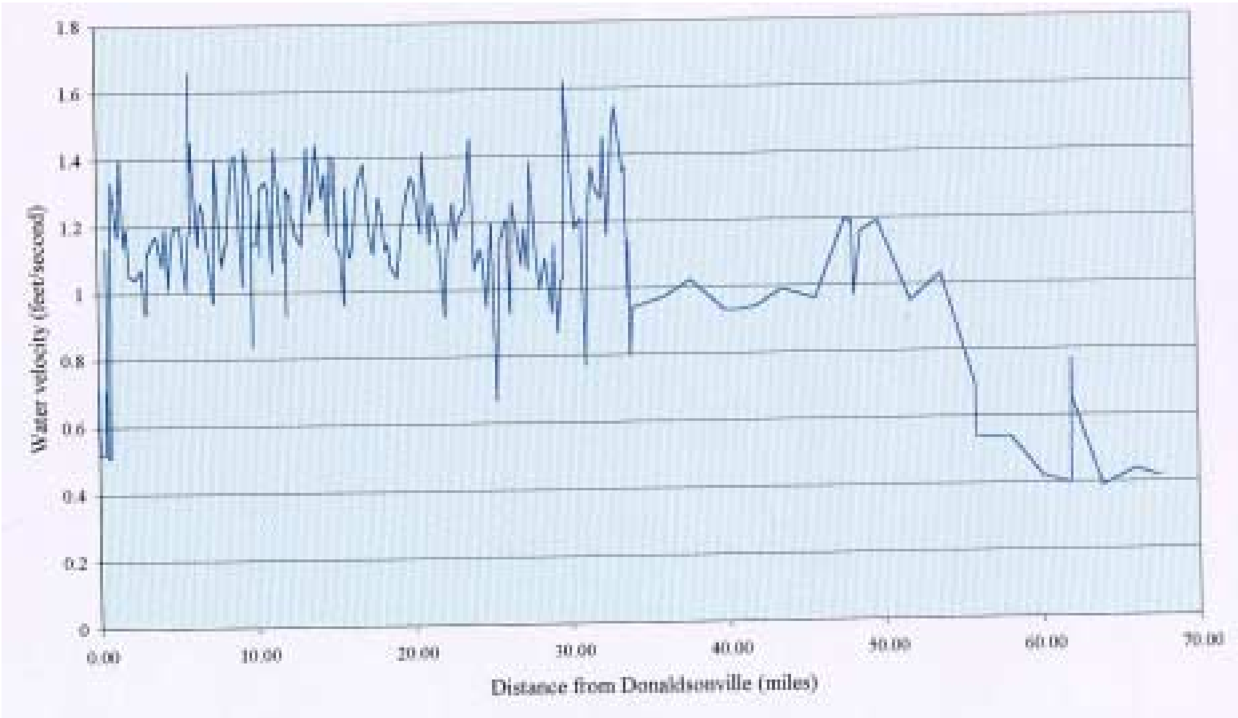


Figure 5.6-3. Water Level Management During Storms



PRELIMINARY: DRAFT

Figure 5.6-4. Water velocities predicted by HEC-RAS for 1,000 cfs in improved Bayou Lafourche channel



5.7 WETLANDS VALUATION ASSESSMENT

The WVA method described in Section 4.6 was applied to the optimized project by the CWPPRA Environmental Work Group in May-July, 1998. The following discussion summarizes the results of that effort, as follows: project boundaries (Section 5.7.1); assessment of variables V1-V6 for each variable (Sections 5.7.2 through 5.7.7); and application of the model to calculate habitat suitability units and average annual habitat units (Section 5.7.8).

5.7.1 Project boundaries

The UNET modeling (summarized in Section 4.4) provided an estimate of the relative impacts of a 1,000 cfs diversion down Bayou Lafourche, under various conditions of flow that reaches the GIWW from the upper Barataria Basin and the Atchafalaya River. The estimate reflects the direct model outputs tabulated in Section 4.6, adjusted downward to 815 cfs, which is the net increase in flow associated with the 1,000 cfs diversion. The adjustment, described in Section 4.6.4, reflects the fact that a small amount of Bayou Lafourche now reaches the marsh without the project; and, as at present, a portion of the diverted water will be withdrawn for water supply purposes before it reaches the wetlands. The distribution of adjusted flows is shown in Table 5.7-1.

Using this input, and also area-specific considerations, the Environmental Work Group identified target marshes which are outlined in Figure 5.7-1. The areas include:

- marshes along Company Canal west of Bayou Lafourche, in the vicinity of Lakes Fields and Long, and along the GIWW between Company Canal and Bayou Lafourche;
- marshes toward the southern end of the Houma Navigation Canal (HNC);
- marshes toward the southern end of Bayou Terrebonne (south of Montegut);

- marshes in the Grand Bayou area, fed by Bayou l'Eau Bleu;
- marshes in the vicinity of Delta Farms, including the southern shore of Lake Salvador, fed by the GIWW east of Bayou Lafourche;
- marshes in the vicinity of Bayous Perot and Rigolets, fed by the GIWW east of Delta Farms; and
- marshes adjacent to lower Bayou Lafourche and along the Tidewater Canal.

Because of diffuse distribution, no benefited area was identified in association with the additional water that would flow into the Penchant Subbasin from the GIWW due to influence of the Bayou Lafourche diversion. Similarly, no specific target marshes benefiting from diverted water flowing east in Company Canal were included. To the extent that these areas would benefit from the project, the project area is understated.

The broad distribution of benefited areas reflects the character of a deltaic distributary network (here modified by man-made canals) that, as the name implies, distributes water over an extended region. The GIWW serves as a special distribution channel that allows for water to move further east and to have effects further west than would otherwise occur. The total area within the seven benefited areas shown on Figure 5.7-1 is tabulated in Table 5.7-2. The total area is slightly more than 85,000 acres, of which a bit more than 40% is open water, and the rest is emergent wetlands.

5.7.2 Assessment of V1

Table 5.7-3 summarizes the estimates made for each subarea for V1, percent emergent marsh, of the WVA model. All benefits accruing to V1 were attributed to small reductions in the average existing loss rates for each subarea. No building of new marsh was predicted. The range in reductions in marsh loss rates estimated by the Environmental Work Group ranged from 0% for the area adjacent to Bayou Terrebonne to a 35% reduction for the marshes in the vicinity of Lake Fields and the GIWW.

Area 1, Lake Fields/GIWW. Benefits to emergent marsh in the Lake Fields to GIWW area were attributed to effects of diverted water flowing from Bayou Lafourche southwest down Company Canal. Based on UNET modeling (see Section 4.4), an average of 63% of the water diverted into the bayou is predicted to flow down Company Canal. Some proportion of this flow will enter the Lake Fields subarea, although no estimate of the percentage was available from the UNET modeling study.

The target marshes in the vicinity of Lake Fields and the GIWW are one of the first to receive diverted water. The Environmental Work Group thus expected these marshes to experience the greatest benefits from the diverted water. It was estimated that with the Bayou Lafourche diversion project, marsh loss rates for this area would be reduced by 35%.

Area 2, Grand Bayou. Marshes in the Grand Bayou area will receive additional fresh water, clay sediments, and nutrients from the Bayou Lafourche diversion via the connection of Bayou l'Eau Bleu to the GIWW. The UNET modeling showed that, averaged over all flow conditions, additional flow through Bayou l'Eau Bleu would be 67 cfs. This would represent a 21% increase over existing average flows.

The flow averages about 8% of the total diverted water available (815 cfs), and thus should deliver about 8% of the resources of nutrients and clay sediments (see Section 4.6). The area would receive about 1.98×10^9 g/yr of clay sediments, enough to sustain the needs of about 490 acres of brackish marsh if the efficiency of transferring this sediment to the marsh surface was 100%. The flow also would deliver about 8.72×10^7 g/yr of nitrogen, which if applied to salt marsh with 100% efficiency could double the standing crop biomass on about 385 acres per year.

This area was given the second greatest degree of benefits to emergent marsh by the Environmental Work Group, largely based on the rationale that the area is relatively contained hydrologically, and so the fresh water added to the area would not be diluted before it benefited the marsh. Also, causes of marsh loss in this area were identified by the Environmental Work Group as including saltwater intrusion, which the additional fresh water was expected to help. Benefits to emergent marsh of diverted water in the Grand Bayou area were estimated by the Environmental Work Group as reductions in marsh loss rates ranging from 15% to 30%. Over all three subareas in the Grand Bayou marshes, a total of 2,877 acres of marsh is projected to be lost over 20 years without the project (i.e., if no actions are taken to reduce existing loss rates). The Environmental Work Group estimated that about 548 acres would be saved over 20 years with the Bayou Lafourche diversion in place (see Table 5.7-3).

Area 3, Delta Farms. Benefits to emergent marsh estimated for the Delta Farms subareas were based on the assumption that about 10% of the approximately 331 cfs of water flowing east of Bayou Lafourche in the GIWW would flow into the Delta Farms area. This is an average increase over existing freshwater flow in this area of about 86%. The additional river water would deliver about 1.0×10^9 g/yr of clay sediments, enough to sustain about 248 acres per year of marsh if capture efficiency were 100%. It would also deliver about 4.4 x 107 g/yr of nitrogen, which would double standing crop on about 195 acres per year of marsh, again with 100% efficiency of use.

Based on existing loss rates, a total of about 466 acres of marsh are expected to be lost over 20 years if no remedial actions are taken (see Table 5.7-3). In comparison, the Environmental Work Group estimates that implementation of the Bayou Lafourche diversion would save about 51 acres over 20 years.

For areas 3-1 and 3-2, including Delta Farms proper and the area along the GIWW and the southern shore of Lake Salvador, the Environmental Work Group estimated that most (67% - 80%) of the existing loss was shoreline erosion and would not be helped by additional freshwater with its clay sediments and nutrients. Water from the Bayou Lafourche diversion was estimated to decrease the small fraction of “interior marsh loss” by 50% for these two subareas, for an overall reduction in loss of 10% to 15%. For the fresh marsh just south of the Delta Farms pond, the Environmental Work Group estimated a reduction in loss rate with the diversion project of 10%.

Area 4, Bayou Terrebonne. Flows in Bayou Terrebonne would be increased by an average of 238 cfs, which represents a 25% increase over average existing freshwater flows. This will deliver about 8.6×10^8 g/yr of clay sediments, which would sustain about 213 acres per year of marsh if use of the sediment were 100% efficient. It also will include introduction of about 3.8×10^7 g/yr of nitrogen, which could double the standing crop biomass on about 168 acres per year of marsh, assuming 100% efficiency.

The area of benefited marshes was identified based on local expertise that suggested that a substantial flow of water (enough to significantly lower salinities compared to the surrounding marsh and open water) enters from the bayou. The effect of the diversion is to increase inflows by about 25% over existing flows. Marsh loss over 20 years at the existing rate is expected to be about 533 acres if no remedial actions are taken. The Environmental Work Group was split on the effects of the project on this area. A small majority concluded that the area is so open to the Gulf of Mexico that it is essentially beyond help, even from an average increase of freshwater, nutrients and sediment of 25%.

Area 5, Houma Navigation Canal. Implementation of the Bayou Lafourche diversion will result in an average additional flow down the Houma Navigation Canal of about 200 cfs, representing an increase of almost 8%. During low flow periods (e.g., in the fall), an additional 219 cfs will flow down the HNC, representing an increase in freshwater of 20%. The additional flow will bring with it about 6.1×10^9 g/yr of clay sediments; enough to sustain about 1,505 acres per year at 100% efficiency of use. It will also bring about 2.7×10^8 g/yr of nitrogen, capable of doubling the biomass of about 1,184 acres per year of emergent marsh.

If no remedial actions are taken, this area is expected to lose a total of about 436 acres over 20 years. The Environmental Work Group estimated that the diversion would reduce loss rates by 15% in areas 5-1, 5-2, and 5-4, and by 5% in area 5-3 (see Table 5.7-3). This results in an estimate that about 67 acres would be preserved against loss if the Bayou Lafourche diversion is implemented. This decision, which EPA disagreed with, was based on the assumption that most of the resources (e.g., freshwater, nutrients) added to the HNC would remain in the HNC and pass out into the gulf.

Area 6, Tidewater Canal. The additional flow of fresh water in lower Bayou Lafourche will be about 99 cfs, an increase of almost 21% over existing average flows. This represents about 12% of the diverted water reaching the marshes, and so will deliver about 12% of the diverted resources. This will include about 3.0×10^9 g/yr of clay sediments, which would sustain about 739 acres per year of marsh at 100% efficiency. It will also include about 1.32×10^8 g/yr of nitrogen, enough to double the biomass on (and therefore probably sustain) about 582 acres per year of marsh. There are no data to show how much of these resources would enter the Tidewater Canal marshes; however based on existing conditions, average flow to these areas would be increased by 21%.

Based on estimated existing loss rates, this area is projected to lose about 1075 acres in 20 years with no restoration effort. The Environmental Work Group asserts that implementation of the Bayou Lafourche diversion would reduce the average loss rate in this area by only 7%. This would result in saving only 75 of these acres over 20 years if the diversion project is implemented.

Area 7, Bayous Perot-Rigolets. The additional flow of fresh water in the GIWW east of Bayou Lafourche will be about 331 cfs, an increase of 12% over existing average flows. Based on comparison of channel cross-sections, approximately 90% of this flow is expected to remain in the GIWW past Delta Farms, and will thus be transported to the Perot-Rigolets area. This flow (about 298 cfs) represents almost 41% of the diverted water reaching the marshes, and so will deliver about 41% of the diverted resources. This will include about 9.0 x 10^9 g/yr of clay sediments, which would sustain about 2,235 acres per year of marsh at 100% efficiency. It will also include about 3.99 x 10^8 g/yr of nitrogen, enough to double the biomass on (and therefore probably sustain) about 1,759 acres per year of marsh.

There are no data to show how much of these resources would enter the Perot-Rigolets areas. However, it is anticipated that a substantial proportion of the flow would be captured here due to the size of these bayous. The increase in freshwater, nutrients and sediments would be substantial.

Based on estimated existing loss rates, this area is projected to lose about 1,371 acres in 20 years if no action is taken. The Environmental Work Group asserts that implementation of the Bayou Lafourche diversion would reduce loss rates in this area by 10%, thereby saving about 137 acres of marsh that would otherwise be lost over 20 years.

Total acres saved by project. Summing over all subareas, the total acres that are estimated by the Environmental Work Group to be saved by the Bayou Lafourche diversion project is 988 acres. This represents about 14% of the 7,072 acres estimated to be lost in 20 years if no marsh restoration actions are taken.

Note that the value of V1 is recorded as the percent of coverage of emergent marsh, and not as acres of marsh. Because the preserved acres are spread over a large area (the result of diverting into what is essentially a distributary network that distributes the water and therefore the benefits broadly), the differences in percentage of marsh between the future with and without the diversion project are usually very small (only 1% or less for most subareas). In many cases, this is not translated into a difference in the suitability index with and without the project. Thus, many of the acres projected to be saved by the project are not actually accounted for in the WVA model that calculates average annual habitat units (AAHUs).

5.7.3 Assessment of V2

Table 5.7-4 summarizes the estimates made for each subarea by the Environmental Work Group for factor V2 of the WVA model, percent of open water dominated by submerged aquatic vegetation (SAV). Inputs for estimating the existing average abundances of SAVs included: field surveys conducted by various members of the Environmental Work Group in 1995 for evaluation of the original Bayou Lafourche project and for evaluation of the Terrebonne Parish Hurricane Protection Levee project; other field observations made by Work Group participants; inferences drawn from estimates of existing water depths and/or from examination of recent satellite images.

For more than half of the subareas evaluated, including areas 1-F, 2-1F, 3-1F, 3-2F, 3-3F, 5-1I, 5-3B, and 6-S, no change in abundance of SAVs was predicted for 20 years in the future without the project. This implies that a majority of the Environmental Work Group members believe these areas of marsh will be stable over the next 20 years, with little negative influence due to the following factors often associated with marshes experiencing subsidence and ongoing land loss:

- saltwater intrusion;
- marsh deterioration that often leads to greater exposure of associated open water areas;
- increased water flux or other hydrologic changes associated with progressive marsh loss.

For some of the indicated areas, the assumption of marsh stability is clearly wrong. For example, area 2-1F, near Grand Bayou, is expected to lose 737 acres of marsh over 20 years, or about 19% of existing marsh. Such deterioration of emergent marsh is typically assumed to be associated with deterioration of habitat quality for support of SAVs as well. However, such judgment was not applied by the majority of the Environmental Work Group in this case. The apparent reasoning was that over the next 20 years, as the Atchafalaya delta progrades, progressively more fresh water will flow down the GIWW to the same marshes targeted by the Bayou Lafourche diversion. Similar logic had not heretofore been utilized in WVA evaluations, and no consideration was given to interim benefits from the project.

For these 8 subareas, the Environmental Work Group estimated that with the Bayou Lafourche diversion, water area supporting SAVs would increase by 1% to 5%. Thus, the sometimes substantial loading of nutrients predicted to result from this project were credited with only minimal impacts on SAVs.

For all the other subareas, the percent of water area supporting SAVs was estimated by the Environmental Work Group to deteriorate slightly in the future with no restoration action. The range of change was from a 2% to a 5% decrease. In one of these areas, 2-1I, implementation of the Bayou Lafourche diversion was then predicted to increase the water area supporting SAVs by 5% over existing conditions. For most of the other areas expected to deteriorate slightly without the project, the Environmental Work Group predicted that the project would serve to hold the status quo in the future.

5.7.4 Assessment of V3

Table 5.7-5 summarizes the estimates made for each subarea by the Environmental Work Group for V3 of the WVA model, marsh edge and interspersion. Values estimated for this variable by the Environmental Work Group had virtually no impact on differentiating habitat quality in the future without any restoration compared to the future with the Bayou Lafourche diversion. Existing edge and interspersion was estimated from examination of recent satellite imagery. Future changes without any restoration projects were estimated based on the amount of marsh expected to be lost in that time. In only one case, area 2-1I, was the interspersion of the marsh predicted to reflect improvement in the future with the Bayou Lafourche diversion compared with no action. In all other cases, V3 was predicted by the Environmental Work Group to be the same in the future with and without the project. This primarily reflected the very small predicted differences in percent area of emergent marsh coverage predicted by the Environmental Work Group between the futures with and without the project.

5.7.5 Assessment of V4

Table 5.7-6 summarizes the estimates made for each subarea by the Environmental Work Group for V4 of the WVA model, percent of open water that is shallow (<1.5 ft). As for V3, this variable played almost no role in differentiating habitat quality between the future with the Bayou Lafourche diversion and the future with no restoration actions. Existing conditions were estimated from data collected on survey trips, individual observations, and examination of satellite imagery, as described above for other variables. For 12 of the 14 subareas, the percentage of shallow water was predicted by the Environmental Work Group either to remain stable over time both with and without the project, or to decline moderately but by the same proportion both with and without the project.

The Bayou Lafourche diversion will deliver clay sediments to marshes; however, all significant deposition and accumulation of heavier sediments (especially sands) will take place in the upper bayou, primarily in the sand trap. Thus no changes in bottom depths of waters associated with marshes was anticipated due to direct sedimentation.

EPA suggested that several of the target marsh subareas with higher marsh loss rates have the potential for greater rates of erosion as marsh loss progresses in the future, and would experience deepening of associated water bottoms in the future if no remedial actions are taken. EPA's expectation based on anticipated increases in marsh and aquatic vegetation productivity was that enhanced organic accretion would both decrease marsh loss rates and retard processes that lead to increasing water depths. Examples of such areas include all of the Grand Bayou marshes, area 3-2F including the Delta Farms pond, area 4-B at Bayou Terrebonne, and areas 5-1, 5-2, and 5-4 near the HNC.

The Environmental Work Group predicted only minor decreases in loss of shallow water area for areas 2-1F and 2-3B in the Grand Bayou region.

5.7.6 Assessment of V5

Table 5.7-7 summarizes estimates made for each subarea by the Environmental Work Group for V5 of the WVA model, salinity. Existing salinities for each subarea were estimated using data from existing long-term monitoring platforms for many areas; other sampling results (e.g., individual research studies) in some cases; and when direct sampling results were unavailable, professional judgement was used to estimate average salinities by comparison to adjacent areas.

Salinities either were predicted by the Environmental Work Group to remain stable over time without any restoration projects (e.g., the Delta Farms subareas, the fresh marsh subarea of Grand Bayou, and the intermediate and lower salinity brackish marsh areas of the HNC); or to increase slightly, reflecting gradual saltwater intrusion associated with progressive marsh loss. In many cases, the Environmental Work Group predicted that the Bayou Lafourche diversion project would retard this salinity increase, or slightly freshen the marsh areas. However, with only one exception (area 4-B at Bayou Terrebonne), all salinities for all time periods and project status fell within the optimal range for the designated marsh type. Thus, there were no differences in suitability indices to differentiate existing conditions, future without the project, and/or future with the project; and none of the small predicted salinity effects were captured in the WVA models.

It should be noted that the measure for V5 is either annual average salinity for brackish and saline marshes, or average high salinity during the growing season for fresh and intermediate marshes. Because long-term averages are used, this variable is not sensitive to the occurrence or the moderation of salinity spikes. For this reason, as well as the broad range of optimal salinities (all with a suitability index of 1.0) defined for each marsh type, variable V5 would not account for any benefits anticipated from operation of the Bayou Lafourche diversion through the late summer, fall, and early winter, when salinities are highest and generally unopposed by river flow.

5.7.7 Assessment of V6

Area 6-S at Tidewater Canal and lower Bayou Lafourche has some water control structures. Thus, access for aquatic organisms is not unrestricted for all portions of the subarea. There are several culverts that remain opened, several levee breaches, and several small bayous that provide access to the area. An access value of 0.675 was assigned to this area, reflecting a weighted average of 50% of the area with free access (value of 1.0); 25% of the area with access controlled by a fixed crest weir (value of 0.5); and 25% of the area with access controlled by a flap-gated weir (value of 0.2). The Bayou Lafourche diversion project will not alter or impede access in any area compared to existing conditions; therefore access was assigned the same value for the futures with and without the project.. A value reflecting unrestricted organism access was assigned to all other subareas for existing conditions, and for both future with and future without the diversion project. Thus variable V6 does not contribute to differentiating habitat quality between present and future conditions in the WVA model.

5.7.8 Application of model

Habitat suitability index without project. Habitat Suitability Indices (HSIs) calculated by the Environmental Work Group for the various project subareas are summarized in Table 5.7-8. HSIs for existing conditions ranged from 0.30 to 0.77, though most values fell between 0.57 and 0.7; the area-weighted average HSI was 0.61. The lowest HSI was calculated for area 3-2F, which includes the Delta Farms pond. The low marsh habitat suitability resulted primarily from the small amount of marsh and large area of open water that composes this subarea. The next lowest habitat suitability, for area 4-B at Bayou Terrebonne, also reflected the very low percentage of broken marsh interrupted by large areas of open water.

HSIs declined in almost all cases in the future with no restoration efforts (Table 5.7-8). The declines in HSI for the first year (TY1) was usually so small as to be lost within the error of rounding to two decimal places. By the end of 20 project years (TY20), HSIs typically were predicted to decline by 0.01 to 0.06 HSI units. Thus, for most of the project area, the Environmental Work Group predicted that on the average, the quality of the marsh habitat would only decrease by an average of 7.4% (i.e., an area-weighted average of 0.045 out of 0.61 HSI units) in the absence of restoration. This is in comparison to an expected loss of more than 14% of the existing marsh acres over 20 years with no restoration action.

The biggest decline in habitat quality with no restoration action was predicted to occur in the Bayou Terrebonne area (subarea 4-B). Here, a decrease in the future without the project from an HSI of 0.50 to an HSI of 0.36 reflects a relatively large decrease in marsh area (V1), as well as small decreases in several other variables (SAVs (V2), marsh interspersion (V3), shallow water (V4), and an increase in salinity (V5)).

Habitat suitability index with project. In two project subareas, 1-F near Lake Fields and the GIWW and 3-1F near Delta Farms, marsh habitat suitability increased slightly after 20 years with the Bayou Lafourche diversion project in operation compared to existing habitat suitability (Table 5.7-8). The increases were very small (0.01 habitat suitability units), and probably are a result of the small increases in V2 (SAVs), since V1 (marsh acreage) declined in 20 years with the project (though the declines were less than without the project).

The suitability of marsh habitat to support fish and wildlife remained stable for 20 years in the future with the Bayou Lafourche diversion project compared to present conditions in three areas. These included 2-1I near Grand Bayou, 3-3F near Delta Farms, and 5-3B near the HNC (Table 5.6-8). In all other cases, the HSI for each marsh area was predicted by the Environmental Work Group to decline in the future with the Bayou Lafourche diversion project, but to a slightly lesser extent than in the future without the project. The area-weighted average HSI for year 20 with the diversion in place is 0.58. This is a decline from 0.61 for existing conditions, and is compared to 0.56 for year 20 in the future with no restoration effort. Thus, the Environmental Work Group projects that if the Bayou Lafourche diversion project is implemented, it will only increase the average habitat suitability by about 3.6%, or about 0.02 HSI units, compared to conditions that will prevail with no restoration project. This is in contrast to the prediction that the Bayou Lafourche diversion project will save 988 ac, or about 2% of the existing marsh, over a 20 year period.

Project benefits in average annual habitat units. Table 5.7-9 summarizes the average annual habitat units (AAHUs) estimated for each subarea, and the total for the project.

Overall, the most benefits accrued from the Lake Fields/GIWW area and the Grand Bayou area, apparently because these areas are perceived as "seeing" the diverted water first and thus receiving the most benefit from its resources. A large proportion of the total benefits also came from the Perot-Rigolets area. Since this area only saw a saving of 1% of existing marsh with the diversion project compared to no action, the additional benefits apparently reflect a modest predicted increase in SAVs in the first year with the project. The fewest benefits were attributed to the marsh areas near Bayou Terrebonne and the HNC, apparently a result of the perception that these target marshes are far removed from the source of water. Net benefits attributed to the modified Bayou Lafourche diversion project are 705 AAHUs.

Potential effects of Grand Bayou Project. The Grand Bayou project (TE-10/XTE-49) is an authorized project listed on PPL5. Its main area of influence would be the Grand Bayou marshes; thus its project area overlaps with one of the target areas expected to be benefited by the Bayou Lafourche diversion.

There are several ways in which the Grand Bayou project and the Bayou Lafourche diversion would be synergistic. One feature of the Grand Bayou project is to enlarge the Bayou l'Eau Bleu connection between the GIWW and the Grand Bayou marshes. This will allow an approximately 20% increase in flow of fresh water from the GIWW into the marshes. With both projects implemented, the amount of water diverted as part of the Bayou Lafourche project that would flow to the Grand Bayou marshes would be increased by the Bayou l'Eau Bleu enlargement.

Another feature of the Grand Bayou project is to install a weir with a barge bay in Cutoff Canal, in the southwestern corner of the Grand Bayou project area. This structure is intended to manage the flow and increase retention of fresh water through the Grand Bayou marshes by reducing its rate of discharge out of the area through Cutoff Canal. In the WVA evaluation conducted for the Grand Bayou project, a roughly equivalent credit for marsh benefits was attributed to the function of this structure as was attributed to the introduction of additional fresh water via the enlargement of Bayou l'Eau Bleu. To the extent that this structure increases marsh benefits in this area by increasing the efficiency of use of the additional water, such increase in benefits would also occur for water introduced by the Bayou Lafourche diversion if both projects were in place.

The third major feature of the Grand Bayou project is to modify the structures and operation plans for structures controlling fresh water flow through the Point au Chien Wildlife Management Area, adjacent to the Grand Bayou marshes on the west. With this aspect of the Grand Bayou project in place, some of the additional water flowing through Bayou l'Eau Bleu would enter the Point au Chien area and benefit those marshes. In this case, water from the Bayou Lafourche diversion would also be introduced to the Point au Chien marshes, increasing those benefits. Thus, with the Grand Bayou project in place, the Point au Chien marshes would effectively become a part of the Bayou Lafourche project area.

Although the Grand Bayou project is authorized by CWPPRA, the federal sponsoring agency, the U.S. Fish and Wildlife Service (USFWS) reports substantial public concerns about alternate locations for the Cutoff Canal structure and how it may affect access for shrimping, as well as concerns regarding potential flooding perceived as a potential consequence of the planned alterations to the Point au Chien area. These concerns cast some doubt on the certainty of implementing this project as planned. If implemented, this project will increase the benefits of the Bayou Lafourche diversion in this area.

Synergistic interactions with listed projects are considered in current (e.g. PPL7 and 8) priority lists. If benefits of the Bayou Lafourche diversion are to be compared to projects being currently evaluated, then consideration must be given to the effects of TE-10. (A second difference in current WVA evaluations and those done for the original project is that there is now a revised model that splits marsh and open water effects, causing differences in the magnitude of benefits attributed to a project compared to the original, unsplit model. That difference is an artifact of methodology, whereas the TE-10 impact reflects an actual, on the ground effect of a listed project.)

Since it is known that implementation of the Grand Bayou project will increase the benefits of the Bayou Lafourche diversion in the Grand Bayou and Point au Chien region, the original WVA model was re-applied taking the effects of TE-10 into account. The Environmental Work Group did not run the WVA model incorporating TE-10, but provided input for this evaluation by estimating effects on V1 considering the Grand Bayou project and then the Bayou Lafourche diversion. Judgements on all remaining variables were made to be comparable to the judgments made by the Environmental Work Group during analysis of the Bayou Lafourche project without TE-10. The Environmental Work Group has not, however, officially reviewed the results of this WVA analysis considering TE-10.

The re-evaluation of the WVA for the Bayou Lafourche diversion project considering synergies with TE-10 only impacts the Grand Bayou area, where the effects of TE-10 occur. In addition to the three subareas included in the official Bayou Lafourche project area (2-1F, 2-1I, and 2-3B), the area to the west of Grand Bayou within the Point au Chien Wildlife Management area (designated 2-2B) would be added to the Bayou Lafourche project area, since as discussed above, the TE-10 project would allow flow from Grand Bayou into this area.

Tables 5.7-10 and 5.7-11 summarize estimates made for V1 (percent of emergent marsh) and V2 (percent of submerged aquatic vegetation), respectively, for the four subareas affected by both projects. These are the variables that captured most of the change between the analysis considering TE-10 and that done by the Environmental Work Group without consideration of TE-10.

Table 5.7-12 summarizes the benefits (as acres saved and AAHUs) estimated for the Bayou Lafourche diversion project if the effects of the Grand Bayou project are taken into account. Results of the Environmental Work Group analysis of the diversion project without considering synergies with TE-10 are also presented for comparison. The benefits for the modified Bayou Lafourche diversion would be increased to from 705 AAHUs without TE-10 to 784 AAHUs with TE-10. It should be remembered that this reflects a real, on-the-ground increase in benefits that would be expected from the Bayou Lafourche diversion project if the TE-10 project is implemented as planned.

Figure 5.7-1. Project boundaries

Reserved for Table 5.7-1 (incremental flows - in EXCEL)

Atchafalaya Flow	Barataria Flow	BLF Flow	Company Canal East	CIWW East Of BLF	BLF South	GIWW West Of Houma	Bayou L'Eau Bleu	Bayou Terrebonne	Houma Nav.Canal
2000	500	97	10.8	329.3	153.5	1631.2	108.7	51.6	1075.4
2000	500	912	32.1	611.5	276.5	1567.3	185.9	79.1	1294.2
Difference in flow			21.3	282.2	123.0	-63.9	77.2	27.5	218.9
Percent change			198%	86%	80%	-4%	71%	53%	20%
10000	500	97	21	680.3	306.4	3501.8	220.3	107.3	2264.4
10000	500	912	40	967.7	432.3	3439.3	302.5	140.0	2468.8
Difference in flow			18.9	287.4	125.9	-62.5	82.1	32.7	204.3
Percent change			90%	42%	41%	-2%	37%	30%	9%
20000	500	97	38.7	1215.7	540.7	6311.5	393.6	195.2	4025.7
20000	500	912	58.2	1505.7	667.3	6250.3	480.0	232.3	4218.8
Difference in flow			19.5	290.0	126.7	-61.2	86.3	37.1	193.1
Percent change			50%	24%	23%	-1%	22%	19%	5%
2000	5000	97	1.2	-77.2	317.8	1600.1	201.4	67.8	1187.2
2000	5000	912	29.7	324.9	380.9	1538.1	244.0	87.0	1383.4
Difference in flow			28.6	402.1	63.2	-62.0	42.6	19.1	196.2
Percent change			2434%	-521%	20%	-4%	21%	28%	17%
10000	5000	97	17.5	455.7	411.4	3488.1	275.6	115.6	2310.3
10000	5000	912	38.0	786.3	511.4	3425.5	344.7	145.8	2511.4
Difference in flow			20.5	330.7	100.0	-62.6	69.0	30.2	201.1
Percent change			117%	73%	24%	-2%	25%	26%	9%
20000	5000	97	36.6	1071.2	611.0	6303.4	430.4	200.6	4051.7
20000	5000	912	56.9	1376.6	726.9	6241.8	511.8	236.8	4244.9
Difference in flow			20.3	305.4	115.9	-61.6	81.5	36.2	193.1
Percent change			56%	29%	19%	-1%	19%	18%	5%
2000	10000	97	-15.6	-769.4	496.3	1502.9	311.5	94.6	1483.4
2000	10000	912	23.3	-483.1	585.4	1412.5	369.8	112.4	1716.7
Difference in flow			38.9	286.3	89.1	-90.4	58.2	17.8	233.2
Percent change			-249%	-37%	18%	-6%	19%	19%	16%
10000	10000	97	7.1	-142.9	642.7	3437.5	412.8	141.0	2474.8
10000	10000	912	33.7	300.7	695.2	3379.9	451.4	162.6	2648.3
Difference in flow			26.6	443.6	52.4	-57.6	38.7	21.7	173.5
Percent change			373%	-310%	8%	-2%	9%	15%	7%
20000	10000	97	31.9	710.7	772.6	6280.1	521.4	215.3	4126.2
20000	10000	912	54.8	1061.4	862.7	6219.0	389.0	248.7	4314.4
Difference in flow			22.9	350.6	90.1	-61.1	67.6	33.4	188.2
Percent change			72%	49%	12%	-1%	13%	16%	5%

1-negative numbers are flow blockages

Table 5.7-2. Subareas of the Bayou Lafourche WVA project area.

Area	Name	Marsh Type	Total Area	Marsh Area	Water Area
1-F	Lake Fields/ GIWW	Fresh	13,057 ac	8,722 ac (67%)	4,335 ac (33%)
2-1F	Grand Bayou	Fresh	4,793 ac	3,879 ac (81%)	914 ac (18%)
2-1I		Intermediate	4,272 ac	2,796 ac (65%)	1,476 ac (35%)
2-3B		Brackish	21,571 ac	9,143 ac (42%)	12,428 ac (58%)
3-1F	Delta Farms	Fresh	3,974 ac	2,700ac (68%)	1,274 ac (32%)
3-2F		Fresh	6,041 ac	413 ac (7%)	5,628 ac (93%)
3-3F		Fresh	2,549 ac	2,284 ac (90%)	265 ac (10%)
4-B	Bayou Terrebonne	Brackish	2,442 ac	904 ac (37%)	1,538 ac (70%)
5-1I	HNC	Intermediate	700 ac	440 ac (63%)	260 ac (37%)
5-2B		Brackish	1,587 ac	786 ac (50%)	801 ac (50%)
5-3B		Brackish	1,301 ac	773 ac (59%)	528 ac (41%)
5-4B		Brackish	5,237 ac	2,997 ac (57%)	2,240 ac (43%)
6-S	Tidewater Canal	Saline	6,180 ac	3,403 ac (55%)	2,777 ac (45%)
7-I	Perot-Rigolets	Intermediate	11,390 ac	9,721 ac (85%)	1,669 ac (15%)
	TOTAL		85,094 ac	48,961 ac (58%)	36,133 ac (42%)

Table 5.7-3. WVA Work Group estimates for V1 by subarea for the optimized Bayou Lafourche diversion project.

Area	Name	Marsh Loss Rate 1983-90 (USACE)	Marsh Area	FWOP[1]		FWP[2]				
				Marsh loss 1 year	Marsh loss 20 years	Reduction in loss rate	FWP loss rate	Marsh loss 1 year	Marsh loss 20 years	Acres save in 20 year
1-F	Lake Fields/ GIWW	0.18 %/yr	8,722 ac (67%)[3]	16 ac (67% remaining)	314 ac (64% remaining)	35%	0.117 %/yr	10 ac (67% remaining)	204 ac (65% remaining)	110 ac
2-1F	Grand Bayou	0.95 %/yr	3,879 ac (81%)	37 ac (80% remaining)	737 ac (66% remaining)	30%	0.665 %/yr	26 ac (80% remaining)	516 ac (70% remaining)	221 ac
2-1I		0.23 %/yr	2,796 ac (65%)	6 ac (65% remaining)	129 ac (62% remaining)	20%	0.184 %/yr	5 ac (65% remaining)	103 ac (63% remaining)	26 ac
2-3B		1.1 %/yr	9,143 ac (42%)	100 ac (42% remaining)	2,011 ac (33% remaining)	15%	0.935 %/yr	85 ac (42% remaining)	1,710 ac (34% remaining)	301 ac
3-1F	Delta Farms	0.12 %/yr; ~2/3 is shoreline loss (interior loss ~0.04 %/yr)	2,700 ac (68%)	3 ac (68% remaining)	65 ac (66% remaining)	50% of 0.04 %/yr (i.e., of interior loss)	0.10 %/yr	3 ac (68% remaining)	54 ac (67% remaining)	11 ac
3-2F		4.36 %/yr; ~80% is shoreline loss (interior loss ~0.872 %/yr)	413 ac (6.8%)	18 ac (6.5% remaining)	360 ac (0.9% remaining)	50% of 0.872 %/yr (i.e., of interior loss)	3.924 %/yr	16 ac (6.6% remaining)	324 ac (1.5% remaining)	36 ac
3-3F		0.09 %/yr	2,284 ac (89.6%)	2 ac (89.5% remaining)	41 ac (88.0% remaining)	10%	0.081 %/yr	2 ac (89.5% remaining)	37 ac (88.2% remaining)	4 ac
4-B	Bayou Terrebonne	2.90 %/yr	904 ac (37%)	27 ac (36% remaining)	533 ac (15% remaining)	0%	2.90 %/yr	27 ac (36% remaining)	533 ac (15% remaining)	0 ac
5-1I	HNC	0.51 %/yr	440 ac (63%)	2 ac (63% remaining)	45 ac (56% remaining)	15%	0.4335 %/yr	2 ac (63% remaining)	38 ac (57% remaining)	7 ac
5-2B		0.66 %/yr	786 ac (50%)	5 ac (49% remaining)	104 ac (43% remaining)	15%	0.561 %/yr	4 ac (49% remaining)	88 ac (44% remaining)	16 ac
5-3B		0.03 %/yr	773 ac (59%)	0.2 ac (59% remaining)	5 ac (59% remaining)	5%	0.0285 %/yr	0.2 ac (59% remaining)	4 ac (59% remaining)	1 ac
5-4B		0.47 %/yr	2,997 ac (57%)	14 ac (57% remaining)	282 ac (52% remaining)	15%	0.3995 %/yr	12 ac (57% remaining)	239 ac (53% remaining)	43 ac

Table 5.7-3 (continued). WVA Work Group estimates for V1 by subarea for the optimized Bayou Lafourche diversion project.

Area	Name	Marsh Loss Rate 1983-90 (USACE)	Marsh Area	FWOP[1]		FWP[2]				
				Marsh loss 1 year	Marsh loss 20 years	Reduction in loss rate	FWP loss rate	Marsh loss 1 year	Marsh loss 20 years	Acres save in 20 year
6-S	Tidewater Canal	1.58 %/yr	3,403 ac (55%)	54 ac (54% remaining)	1,075 ac (38% remaining)	7%	1.47 %/yr	50 ac (54% remaining)	1,000 ac (39% remaining)	75 ac
7-I	Perot-Rigolets	0.705 %/yr	9,721 ac (85.3%)	69 ac (84.7% remaining)	1,371 ac (73.3% remaining)	10%	0.6345 %/yr	62 ac (84.8% remaining)	1,234 ac (74.5% remaining)	137 ac
									Total acres saved in 20 years	988 ac

1 - FWOP = future without project.

2 - FWP = future with project

3 shows percent of total area for that subarea.

Table 5.7-4. WVA Work Group estimates for V2 by subarea for the optimized Bayou Lafourche diversion project.

Area	Name	Water area	Existing SAVs	FWOP		FWP	
				SAVs 1 year	SAVs 20 years	SAVs 1 year	SAVs 20 years
1-F	Lake Fields/GIWW	4,335 ac	25%	25%	25%	26%	30%
2-1F	Grand Bayou	914 ac	40%	40%	40%	41%	45%
2-1I		1,476 ac	30%	30%	25%	31%	35%
2-3B		12,428 ac	15%	15%	12%	15%	17%
3-1F	Delta Farms	1,274 ac	60%	60%	60%	61%	65%
3-2F		5,628 ac	25%	25%	25%	26%	30%
3-3F		265 ac	10%	10%	10%	11%	12%
4-B	Bayou Terrebonne	1,538 ac	5%	5%	1%	6%	2%
5-1I	HNC	260 ac	40%	40%	40%	41%	45%
5-2B		801 ac	15%	15%	12%	16%	15%
5-3B		528 ac	5%	5%	5%	6%	6%
5-4B		2,240 ac	20%	20%	16%	21%	20%
6-S	Tidewater Canal	2,777 ac	5%	5%	5%	6%	6%
7-I	Perot-Rigolets	1,667 ac	20%	20%	18%	22%	20%

Table 5.7-5. WVA Work Group estimates for V3 by subarea for the optimized Bayou Lafourche diversion project.

Area	Name	Existing	FWOP, 1 yr	FWOP, 20 yrs	FWOP, 1 yr	FWP, 20 yrs
1-F	Lake Fields/ GIWW	Class 1 = 25% Class 2 = 25% Class 3 = 10% Class 4 = 40%	Same as existing	Same as existing	Same as existing	Same as existing
2-1F	Grand Bayou	Class 1 = 50% Class 2 = 30% Class 3 = 20%	Same as existing	Class 1 = 40% Class 2 = 30% Class 3 = 30%	Same as existing	Class 1 = 45% Class 2 = 30% Class 3 = 25%
2-1I		Class 1 = 30% Class 2 = 40% Class 3 = 30%	Same as existing	Class 1 = 25% Class 2 = 40% Class 3 = 35%	Same as existing	Same as FWOP, 20 yr
2-3B		Class 2 = 20% Class 3 = 50% Class 4 = 30%	Same as existing	Class 2 = 15% Class 3 = 45% Class 4 = 40%	Same as existing	Same as FWOP, 20 yr
3-1F	Delta Farms	Class 1 = 70% Class 4 = 30%	Same as existing	Same as existing	Same as existing	Same as existing
3-2F		Class 4 = 100%	Same as existing	Same as existing	Same as existing	Same as existing
3-3F		Class 1 = 100%	Same as existing	Same as existing	Same as existing	Same as existing
4-B	Bayou Terrebonne	Class 3 = 35% Class 4 = 65%	Same as existing	Class 3 = 10% Class 4 = 90%	Same as existing	Same as FWOP, 20 yr
5-1I	HNC	Class 1 = 20% Class 2 = 30% Class 4 = 50%	Same as existing	Class 1 = 20% Class 2 = 25% Class 4 = 55%	Same as existing	Same as FWOP, 20 yr
5-2B		Class 2 = 30% Class 3 = 70%	Same as existing	Class 2 = 25% Class 3 = 75%	Same as existing	Same as FWOP, 20 yr
5-3B		Class 3 = 100%	Same as existing	Same as existing	Same as existing	Same as existing
5-4B		Class 2 = 50% Class 3 = 50%	Same as existing	Class 2 = 45% Class 3 = 55%	Same as existing	Same as FWOP, 20 yr
6-S	Tidewater Canal	Class 1 = 20% Class 2 = 40% Class 3 = 40%	Same as existing	Class 1 = 20% Class 2 = 20% Class 3 = 40% Class 4 = 30%	Same as existing	Same as FWOP, 20 yr
7-I	Perot-Rigolets	Class 1 = 5% Class 2 = 15% Class 3 = 30% Class 4 = 50%	Same as existing	Class 1 = 10% Class 2 = 20% Class 3 = 60% Class 4 = 10%	Same as existing	Same as FWOP, 20 yr

Table 5.7-6. WVA Work Group estimates for V4 for the optimized Bayou Lafourche diversion project.

		Percent area <1.5 ft		
Area	Name	Existing	FWOP, 20 yrs[1]	FWP, 20 yrs[1]
1-F	Lake Fields/GIWW	15%	15%	15%
2-1F	Grand Bayou	85%	80%	83%
2-1I		75%	70%	70%
2-3B		50%	45%	46%
3-1F	Delta Farms	5%	5%	5%
3-2F		20%	20%	20%
3-3F		15%	15%	15%
4-B	Bayou Terrebonne	25%	15%	15%
5-1I	HNC	50%	45%	45%
5-2B		25%	20%	20%
5-3B		35%	35%	35%
5-4B		60%	55%	55%
6-S	Tidewater Canal	40%	35%	35%
7-I	Perot-Rigolets	75%	70%	70%

1 - values for FWOP, 1 yr and FWP, 1 yr were always the same as existing.

Table 5.6-7. WVA Work Group estimates for V5 for the optimized Bayou Lafourche diversion project.

		Salinity (ppt)				
Area	Name	Existing	FWOP, 1 yr	FWOP, 20 yrs	FWP, 1 yr	FWP, 20 yrs
1-F	Lake Fields/GIWW	0.5 ppt	0.5 ppt	0.5 ppt	0 ppt	0 ppt
2-1F	Grand Bayou	1 ppt	1 ppt	1 ppt	1 ppt	1 ppt
2-1I		2 ppt	2 ppt	3 ppt	2 ppt	2 ppt
2-3B		7 ppt	7 ppt	8 ppt	7 ppt	7 ppt
3-1F	Delta Farms	0.5 ppt	0.5 ppt	0.5 ppt	0 ppt	0 ppt
3-2F		0.5 ppt	0.5 ppt	0.5 ppt	0 ppt	0 ppt
3-3F		0.5 ppt	0.5 ppt	0.5 ppt	0 ppt	0 ppt
4-B	Bayou Terrebonne	9 ppt	9 ppt	11 ppt	9 ppt	10 ppt
5-1I	HNC	4 ppt	4 ppt	4 ppt	3 ppt	3 ppt
5-2B		6 ppt	6 ppt	6 ppt	5 ppt	5 ppt
5-3B		7 ppt	7 ppt	8 ppt	7 ppt	7 ppt
5-4B		6 ppt	6 ppt	7 ppt	6 ppt	6 ppt
6-S	Tidewater Canal	11 ppt	11 ppt	11 ppt	11 ppt	10 ppt
7-I	Perot-Rigolets	3 ppt	3 ppt	3 ppt	2 ppt	2 ppt

Table 5.7-8. Habitat Suitability Indices (HSIs) by subarea for the future without and with the optimized Bayou Lafourche diversion project.

		Existing	FWOP[1]		FWP[2]	
Area	Name	TY0[3]	TY1	TY20	TY1	TY20
1-F	Lake Fields/ GIWW	0.60	0.60	0.59	0.60	0.61
2-1F	Grand Bayou	0.77	0.77	0.71	0.77	0.74
2-1I		0.67	0.67	0.63	0.67	0.67
2-3B		0.57	0.57	0.52	0.57	0.53
3-1F	Delta Farms	0.70	0.70	0.69	0.70	0.71
3-2F		0.30	0.29	0.25	0.30	0.26
3-3F		0.65	0.65	0.64	0.65	0.65
4-B	Bayou Terrebonne	0.50	0.50	0.36	0.50	0.37
5-1I	HNC	0.65	0.65	0.62	0.65	0.63
5-2B		0.59	0.59	0.55	0.59	0.56
5-3B		0.62	0.62	0.62[4]	0.62	0.62[4]
5-4B		0.67	0.67	0.63	0.67	0.64
6-S	Tidewater Canal	0.62	0.61	0.53	0.62	0.54
7-I	Perot-Rigolets	0.69	0.69	0.64	0.70	0.65
Area-weighted average[5]		0.61	0.60	0.56	0.61	0.58

1 - FWOP = future without project.
2 - FWP = future with project.
3 - TY = target year.
4 - rounding to two decimal places causes this HSI in TY20 to appear identical to the HSI for TY0. Slight differences in the third decimal places yielded small benefits in AAHUs for this subarea.
5 - average of the HSI for each area multiplied by the total acreage of that area, divided by total project acreage.

PRELIMINARY: DRAFT

Table 5.7-9. Average Annual Habitat Units (AAHUs) by subarea and cumulatively for the optimized Bayou Lafourche diversion project.

Area	Name	FWP[1]	FWOP[2]	Net
1-F	Lake Fields/ GIWW	7,886.36	7,745.42	140.93
2-1F	Grand Bayou	3,612.81	3,534.69	78.12
2-1I		2,853.82	2,780.78	73.04
2-3B		11,950.64	11,822.25	128.39
3-1F	Delta Farms	2,798.25	2,767.41	30.84
3-2F		1,670.03	1,634.99	35.04
3-3F		1,662.01	1,640.63	21.39
4-B	Bayou Terrebonne	1,071.78	1,055.66	16.13
5-1I	HNC	450.04	443.98	6.06
5-2B		913.84	905.74	8.10
5-3B		807.25	804.75	2.49
5-4B		3,443.68	3,413.25	30.43
6-S	Tidewater Canal	3,2549.93	3,569.77	19.84
7-I	Perot-Rigolets	7,597.22	7,711.88	114.66
			TOTAL	**705.46**

1 - FWP = future with project.
2 - FWOP = future without project.

Table 5.7-10. Estimates for V1 for the four subareas affected by both the optimized Bayou Lafourche diversion project and the TE-10 (Grand Bayou) project, considering synergies between the two projects.

Area	Name	Marsh Loss Rate 1983-90 (USACE)	Modified Loss Rate (Existing CWPPRA Projects)	Marsh Area	FWOP		FWP				
					Marsh loss 1 year	Marsh loss 20 years	Suggested reduction in loss rate	FWP loss rate	Marsh loss 1 year	Marsh loss 20 years	Acres saved in 20 years
2-1F[1]	Grand Bayou/Pt. au Chien	0.95 %/yr	0.57 %/yr (reduced by 40%)	3,879 ac	22 ac	442 ac	50%	0.285 %/yr	11 ac	221 ac	221 ac
2-1I[1]		0.23 %/yr	0.1495 %/yr (reduced by 35%)	2,797 ac	4 ac	84 ac	40%	0.0897 %/yr	3 ac	50 ac	34 ac
2-2B[2]		2.12 %/yr	1.484 %/yr (reduced by 30%	1,756 ac	26 ac	521 ac	7.14%	1.378 %/yr	24 ac	484 ac	37 ac
2-3B/S[1]		1.1 %/yr	0.935 %/yr (reduced by 15%)	9,143 ac	85 ac	1,710 ac	17.65%	0.77 %/yr	70 ac	1,408 ac	302 ac

1 - Corresponds to TE-10 area
2 - Corresponds to subareas B and C of the added Pt au Chien area for TE-10. In the WVA evaluation for this addition (done on 17 December 1997), the loss rate used was 1.72362%/yr, and this was reduced by 30% for FWP, to 1.206%/yr.

Table 5.7-11. Estimates for V2 for the four subareas affect by both the optimized Bayou Lafourche diversion project and the TE-10 (Grand Bayou) project, considering synergies between the two projects.

Area	Name	Water area	Existing SAVs	Influence of other projects on SAVs	FWOP		FWP	
					SAVs 1 year	SAVs 20 years	SAVs 1 year	SAVs 20 years
2-1F[1]	Grand Bayou/Pt. au Chien	914 ac	30%	40%	40%	40%	41%	45%
2-1I[1]		1,476 ac	30%	40%	30%	25%	31%	35%
2-2B[2]		2,524 ac	30%	40%	40%	40%	40%	45%
2-3B/S[1]		12,428 ac	15%[3]	20%[3]	15%	15%	15%	20%

1 - Corresponds to TE-10 area
2 - Corresponds to subareas B and C of the added Pt au Chien area for TE-10. In the WVA evaluation for this addition (done on 17 December 1997), the existing SAVs were estimated to be 30%. This was decreased to 25% in 20 years for FWOP and increased to 40% in 20 years for FWP.
3 - Estimates of SAVs from the original 1994 WVA evaluation of TE-10 were 50% existing and 55% in 20 years with the project. That decision was re-evaluated by the Environmental Work Group during the WVA analysis of the Bayou Lafourche project in June 1998.

Table 5.7-12. Benefits, as acres saved and AAHUs, estimated for the optimized Bayou Lafourche diversion project if synergistic effects with the Grand Bayou project are taken into account.

	EWG WVA results without TE-10		WVA results with TE-10	
Area	AAHUs	Acres saved	AAHUs	Acres saved
1-F	140.93	110	same	same
2-1F	78.12	221	87.94	221
2-1I	73.04	26	73.51	34
2-2B	n/a	n/a	18.21	37
2-3B	128.39	301	178.33	302
3-1F	30.84	11	same	same
3-2F	35.04	36	same	same
3-3F	21.39	4	same	same
4-1	16.13	0	same	same
5-1I	6.06	7	same	same
5-2B	8.10	16	same	same
5-3B	2.49	1	same	same
5-4B	30.43	43	same	same
6-S	19.84	75	same	same
7-I	114.66	137	same	same
Total	**705**	**988**	**784**	**1,034**

5.8 OVERALL COST-EFFECTIVENESS

The cost-effectiveness of CWPPRA projects is based on comparison among projects of the cost to fund a project, divided by the benefits obtained from the project (average annual dollars per AAHU). Important differences between how CWPPRA determines project costs, and the conventional cost-estimation method used throughout this report, were discussed in Section 5.5.5.

5.8.1 Significance of cost-sharing

It is not the intent of Table 5.5-2 to set forth costs that are to be born entirely by CWPPRA. The possibility exists for some portion of the costs to be born through funding partnerships with project beneficiaries. Evaluation of cost-effectiveness of the Bayou Lafourche project is very sensitive to consideration of cost-sharing. This is especially the case since many of the cost-shares being considered are for O & M costs, which become increasingly expensive over time when inflation is considered, and thus skew the apparent cost of the project.

For example, the project as configured has benefits to the Bayou Lafourche Freshwater District. Some component of these benefits are compensated for through the assumption that FWD will provide operational and administrative services to the level currently experienced by the District. The subject of additional FWD contributions remains to be explored. Similarly, there are potential benefits to Parish governments and local levee boards, with respect to providing drainage improvements. The subject of cost-sharing arrangements with such entities, if any, remains to be explored. Costs for items such as pipeline replacements also might be shared, at least in part, especially to the extent that the utilities are publicly owned water lines, or that mitigation credits could be obtained for private owners.

Because the CWPPRA method of costing out a project overstates operational costs, any financial contributions by others which reduce the projected O&M component of the project budget will have a disproportionate effect in reducing the estimate of CWPPRA costs.

A simple calculation has been made to illustrate the potential impact of cost-sharing. This estimate assumes that local sources pay for the pumping and channel management aspects of Phase I, and that the State would provide the local cost-share for project construction. Thus the FWD and parish cost-shares would be deducted from the CWPPRA fully funded costs.

Under these assumptions, which have been made only for the purpose of illustrating the effects of local cost-share, the fully funded costs for the Phase I portion of the project would change as follows.

Estimate in Section 5.5 of this report:	$ 10,573,480
Deduct energy costs:	$ 3,666,949
Deduct channel management:	$ 1,183,921
Adjusted Fully Funded Cost of Phase I:	$ 5,722,610

This calculation shows that cost-sharing has the potential to substantially improve the cost-effectiveness of the project. Similar calculations can be made for Phase II and the entire project, and for average annual costs. For example, consider the effects on average annual cost of the cost-share above, plus local sharing of the Phase II pumping costs. Then:

Estimate average annual cost (full project)	$ 4,534,905
Deduct annualized O&M costs, Phase I:	$ 181,288
Deduct annualized O&M costs, Phase II:	$ 390,000
Adjusted Average Annual Cost:	$ 3,963,617

5.8.2 Cost-effectiveness ratios for optimized project

The Wetland Value Assessment (WVA) conducted by the Environmental Work Group yielded an estimate of wetland benefits for the optimized Bayou Lafourche diversion project of 705 Average Annual Habitat Units (AAHUs) (see Section 5.7.8). This analysis excluded consideration of synergistic interactions with another CWPPRA project, TE-10, listed on PPL5 to address the Grand Bayou marsh area. An estimate of benefits for the Bayou Lafourche diversion project that includes effects of the TE-

10 project, and using principles set out by the Environmental Work Group, is 784 AAHUs (see Table 5.7-12).

Using the average annual cost for the complete project without cost-shares ($4,534,905), and using the lower of the WVA values above (705 AAHUs), the project cost-effectiveness ratio would be $6,433/AAHU. If the projected average annual cost with the upper-end of cost-shares and the WVA value that considers expected synergistic benefits with the TE-10 project are used, the ratio would be $5,056/AAHU. These values reasonably bracket the expected outcome of the final project evaluation.

Cost-effectiveness for Phase I. Phase I provides 19% of the total increased flow of the entire project. (The WVA for the entire project assumed 185 cfs of diverted water would either not get to the marsh; or would get to the marsh in a no-action future. A 1,000 cfs project would have a net 815 cfs to the marsh, and a 340 cfs project would have a net 155 cfs to the marsh. 155 cfs is 19% of 815 cfs.) If WVA benefits for Phase I were perfectly proportional to increased flow, the benefits would be 134 AAHUs (without TE-10) to 149 AAHUs (with TE-10).

Phase I has an average annual cost of $543,248, including cost-shares. A WVA for Phase I has not been performed. However, it would require only 84 AAHUs for Phase I to have a cost-effectiveness ratio of $6,433/AAHU, the upper range estimated for the entire project (e.g. no cost-shares, lower WVA value). 107 AAHUs for Phase I would produce a ratio of $5,056/AAHU, the lower range estimated for the full project (i.e. maximum cost-share, higher WVA value). Thus, even if the WVA were to determine benefits substantially less than 19% of the full project, Phase I would likely be similar to the full project in cost-effectiveness.

As discussed in Section 5.7, EPA believes the benefits of the project have been understated, in that zero benefits are assigned to 10% of the diverted flow, and benefits for the remaining 90% of the flow were not given in proportion to the percentage impact that the project has on freshwater flows, nutrient loadings and sediment availability.

All the above calculations assume 100% funding of the project by CWPPRA. There would be a 1% reduction in the CWPPRA cost per AAHU for each 1% of the present worth investment that is cost-shared.

5.8.3 Comparison of cost-effectiveness to original project

The original project provided 499 AAHUs for an annual cost of $2.36 million, for an average annual cost of $4,729 per average annual habitat unit. This estimate did not consider synergistic effects with TE-10, and so it would seem to be comparable to the $6,433/AAHU number presented above. However, this is not an apples-applies comparison, and therefore it does not indicate that the optimized project is less cost-effective than the original project.

As discussed in Section 6.3.1, the original project included almost no costs to avoid, compensate or otherwise mitigate for the fact that water levels would rise onto the batture by as much as five feet in some locations, and a much greater portion of the regional drainage would be routed to already over-burdened canals at the levee-wetlands interface. An order-of-magnitude estimate is that addressing this issue would triple the costs of the original project; if so, the true cost-effectiveness ratio for the original project would have been on the order of $14,000/AAHU. EPA believes the optimized project substantially improves upon the true cost-effectiveness of the original project.

For comparison to projects on current priority lists, it is necessary to determine the actual amount of cost-share investment that will be obtained for the project. If the project were being evaluated today, synergistic effects with TE-10 would be considered. The cost-effectiveness ratio for comparison to other current priority list projects would be about $5,056/AAHU. EPA considers that the optimized project is sufficiently cost-effective to justify a CWPPRA investment.

5.8.4 Summary of additional cost-effectiveness considerations

Evaluation of the benefits to society of the optimized Bayou Lafourche diversion project compared to its costs goes beyond a calculation of average annual dollars divided by average annual wetland habitat units. As discussed above, if the calculation of average annual dollars does not consider cost sharing by non-CWPPRA entities, then the real fiscal impact to the CWPPRA trust fund and to society is not fairly estimated. In addition, implementation of the optimized Bayou Lafourche diversion project would have positive impacts on other associated societal costs (e.g., water supply and drainage), and other benefits to these activities. A brief summary of these includes the following.

- Beyond direct wetland benefits, a bayou diversion would certainly control saline intrusion in the bayou, with benefits to water supply and industry, as well as to the wetlands.

- The proposed project, with year-round diversion of water as well as water-level control structures and a water management operation plan, would provide much more consistent and predictable water levels and greater associated bank stability than the existing condition.

- Because the plan for the optimized bayou diversion includes channel improvements, increased conveyance capacity, water management structures, and an operational plan that would be responsive to storm events and other drainage needs, the project would provide substantial drainage benefits to the surrounding area.

- Efforts to optimize the bayou water supply, control salinity, and provide comparable levels of drainage benefits would cost millions of dollars if pursued by water supply and/or drainage authorities independently of the proposed diversion project. Conversely, if water supply and/or drainage authorities contributed some cost-shares for management structures, bank protection, channel management, and/or other project operations, it would have a substantial positive impact on the cost-effectiveness to CWPPRA of the diversion project.

6. EVALUATION OF ALTERNATIVES

6.1 OVERVIEW OF CHAPTER 6

As noted in Chapter 5, this evaluation has considered many alternatives for a Bayou Lafourche diversion project. Project PBA-20 was intended to increase the river-marsh connection via a freshwater diversion. Therefore, except for the alternative of taking no action, EPA considered only alternatives that would involve freshwater diversion. Options that might benefit the marshes in other ways (barrier island restoration, hydrologic restoration and so forth) were not within the scope of this study. This narrowing of alternatives is not a decision to build a diversion, but a decision to limit the evaluation to diversion projects, as the Task Force intended.

The alternatives considered are discussed as follows.

- Section 6.2 considers an alternative that is a required component of environmental planning, namely the alternative of taking no action. In this case, the alternative would be to build no diversion into Bayou Lafourche.
- Section 6.3 considers specific alternatives which vary in capacity and type of diversion facility. This section also considers the potential for alternatives in phasing project features.
- During the scoping process and the current evaluation, there was an interest in determining whether a water source other than the Mississippi River could be used. One particular alternative received special attention in this regard. This alternative would be part of a flood control project for the Lower Atchafalaya River Basin, and would pump water from Lake Verret to Bayou Lafourche via Cancienne Canal. Section 6.4 discusses this option.

6.2 NO-ACTION ALTERNATIVE

The no-action alternative is intended to evaluate the consequences of not building a Bayou Lafourche diversion. These consequences need to be compared to the consequences of building the project in order to determine whether, on balance, the diversion project has merit. EPA's evaluation of the no-action alternative has considered three separate issues.

- Section 6.2.1 discusses the basic question of whether there is a need for a diversion down Bayou Lafourche in order to meet the objectives of coastal wetlands restoration. If there is no need for the project (e.g., if the same benefits could be obtained in other ways, as by using the Gulf Intercoastal Waterway as the conveyance channel), then no-action would be a viable alternative. If the benefits of the project are unique, this would be a reason to consider rejecting the no-action alternative.

- Section 6.2.2 reviews specific public comments that suggested potential fatal flaws to the project -- impacts or obstacles so great that the project could not or should not be built. The existence of an actual fatal flaw would require modification of the project to eliminate the flaw, or selection of the no-action alternative.

- Section 6.2.3 assesses the consequences of no-action, i.e. the effects on the future ability of Bayou Lafourche to function for water supply, drainage and other purposes. If this future is better than achieved by the project, then no-action could be the preferred alternative; and vice-versa.

Section 6.2.4 is a summary of EPA's evaluation that: with respect to issue 1, Project PBA-20 would have net benefits to coastal restoration compared to no-action; regarding issue 2, no fatal flaws have been identified; and for issue 3, no-action would not improve conditions in Bayou Lafourche.

EPA cannot identify any basis upon which to conclude that no-action would benefit the public interest. For purposes of public comment, EPA puts forth the provisional conclusion that no-action is not the preferred alternative. Note that rejecting the no-action alternative is not a commitment to build Project PBA-20, nor a decision to spend CWPPRA funds, nor a preference to a particular size and type of diversion. Rather, it is a determination that a diversion project with multi-purpose benefits has merit when compared to the option of allowing the future to occur without a diversion.

6.2.1 Evaluation of need for project

Public discussions about the project included two primary concerns regarding whether the project is needed. The first concern was that the project would not act to achieve meaningful wetlands benefits. The second was that equivalent benefits could be accomplished in other ways, as by using freshwater from other sources flowing through the Gulf Intercoastal Waterway (GIWW). To assess this subject, EPA has considered the merits and effectiveness of diversions in general, and of the proposed project in particular, and also has reviewed the potential to achieve comparable benefits without diverting water down Bayou Lafourche.

Effectiveness of the proposed project. Some public comments on the proposed Bayou Lafourche Project have suggested that diverting water into Bayou Lafourche will have little or no benefits to the marsh. The studies done by EPA have developed new information that is responsive to many of these public concerns. Based on the computer models discussed in Section 2, there is quantitative evidence that substantial benefits will occur.

- By adjusting the project so that it includes pumps, there will be a year-round supply of fresh water to the marshes. This action addresses concerns that the original siphon project would be of little value, because its benefits occur only during high water periods.

- Computer models developed by the Corps of Engineers, as part of the Bayou Lafourche study, demonstrate without question that flows down the Bayou do reach the marsh areas that are in need of freshwater, nutrients and sediment (see figures in Section 4.4). Indeed, the area of marsh benefited by Bayou Lafourche is larger than identified at the time the project was selected for the 5th Priority List. Areas benefited by water flowing down Bayou Lafourche include the central and western Barataria Basin, lower Bayou Lafourche, eastern Terrebonne Basin, Bayou Terrebonne, and the lower Houma Navigation Canal (see discussion in Section 5.7).

- Computer models developed by Louisiana State University, as part of the Bayou Lafourche study, demonstrate that some fine sediment diverted with river water into Bayou Lafourche will reach the wetlands areas. Note that coarse sediment - of the type that would actually build new wetlands - would be deposited near the head of the Bayou. Thus, it is not expected that a Bayou Lafourche project would build wetlands. The sediment benefits of the project are, like the benefits of freshwater, a contribution to the sustaining of existing wetlands.

The optimized project has been subject to formal evaluation of benefits, using standard procedures developed for CWPPRA projects. The results, presented in Section 5.7, confirm that the project will have significant wetlands benefits. The benefits for the optimized project are larger than for the original project.

Alternatives for achieving benefits without using Bayou Lafourche. During the scoping process, some members of the public suggested that either of the following may make more sense than a diversion down Bayou Lafourche (including a diversion from Lake Verret through Cancienne Canal): diversion of water from the sediment-rich Atchafalaya River through the GIWW; and/or using the GIWW to convey Mississippi River water which will soon be diverted into the Barataria Basin via the Davis Pond structure, east of Donaldsonville.

Based on the following factors, EPA does not believe that a Bayou Lafourche project can be simply replaced by other projects.

- A workshop on the river connection needed for the Terrebonne marshes was conducted in 1996, and was attended by scientists from agencies, universities and consulting firms. These experts agreed that, to restore the marshes of eastern Terrebonne Parish, there is a need to provide very large amounts of freshwater containing fine sediments (silts and clays) and nutrients. They also agreed that demand for freshwater far exceeds the supply: therefore, every project that might add to the supply must be considered. Specifically, the Terrebonne marshes were considered to need in excess of 50,000 cfs of river inputs. The workshop did not discuss the Barataria Basin, which has additional needs.

- The Davis Pond diversion, which is being built downstream of Donaldsonville in the Barataria Basin, will provide 10,560 cfs at peak diversion rate. However, the conceptual design for the project indicates that operations will occur in only 35 months out of each 120 months, or about 30% of the time. The weighted average discharge for this project is about 2,000 cfs. Natural flows and flood control projects associated with the Atchafalaya River may provide a few thousand cfs more, on average. Except for PBA-20, no other significant diversion opportunities have been identified. Clearly, all the projects together are not enough to fix the wetlands problems which exist in the

Terrebonne and Barataria basins. EPA considers that there is justification to consider all the alternatives, in order to provide as much restoration as practicable.

- According to computer models developed by the Corps of Engineers as part of the Bayou Lafourche study, diversions down Bayou Lafourche are additive to the effects of Atchafalaya water and/or the Davis Pond diversion; see Section 4.4. In particular, a Bayou Lafourche flow causes flows from the other sources to be simply displaced into other marsh areas. For example, if the GIWW is carrying high flows from the Atchafalaya River, and a Bayou Lafourche diversion is operating, the effect is for the GIWW water to have a higher benefit to the marshes along the Houma Navigation Canal. If the Bayou Lafourche diversion shuts down, some of the diversion benefits would shift eastward toward Larose.

Summary. A Bayou Lafourche diversion would benefit Louisiana's coastal wetlands. These benefits derive from the ability of the diversion to provide wetland areas with fresh water, fine sediments and nutrients. The benefits are not duplicative of other projects. On the contrary, because the prospective losses shown in Figure 1.2-4 are severe, and the options for providing fresh water to the lower Terrebonne and Barataria areas are limited, it is appropriate to consider every reasonable opportunity for providing the marshes with river inputs.

6.2.2 Evaluation of Potential Issues

Persons concerned about whether the Bayou Lafourche Project is cost-effective and environmentally acceptable identified a number of problems specific to the project (see Section 1.4). EPA considered whether these problems might be possible "fatal flaws", i.e. reasons why the project should not or could not be built. The three primary considerations of this type were: flooding and drainage impacts to batture and back-bayou properties; clogging of the bayou by vegetation; and withdrawal of diverted water before it reaches the marsh.

Flooding and drainage impacts to the batture and back-bayou properties. The project as originally proposed would have caused a large increase in the stage (water level) of Bayou Lafourche. This would have impacted batture properties and drainage canals that connect to the bayou.

Any impacts of the project will have to be determined with an environmental impact analysis. The determination would be complex, because of issues such as: ownership of batture lands; legality of past improvements that have 'filled' the bayou; availability of drainage alternatives; property values; possible compensation for damage; stream bank stability. The costs and delays associated with resolving the issues of batture and drainage impacts could represent a potentially difficult obstacle to successful, timely completion of the project.

The possibility of batture and back-bayou impacts was addressed by reconfiguring the diversion in the form of the optimized project. Not only does the optimized project eliminate the water level increase and routine fluctuations of the original project, it has the potential to create positive flood control and drainage benefits for batture and back-bayou properties by maintaining bayou water levels below the high levels experienced in recent years. These effects are generally discussed in Section 5.6.

Information obtained during the public participation project indicates that some bayou-side residents would support the project only if bank stabilization (bulkheading) is provided over a larger area. To the extent that bank stabilization issues may occur, they relate to whether or not the 3H:1V dredging template proposed to convey 1,000 cfs is assuredly stable in all reaches of the bayou. That issue can only be addressed through design-level studies that were beyond the scope of this evaluation. As noted elsewhere (e.g. Section 3.4.4), if stability problems do in fact arise as a result of design studies, alternative templates may be considered or, in the alternative, project size could be reduced to ensure stable conditions.

Extensive bulkheading is not part of the optimized project, for reasons of cost. To the extent that some members of the public would oppose the project unless bulkheading is provided, then public opposition to the project may exist. EPA cannot now determine if such opposition is a fatal flaw to ultimate completion of the project, since the no action alternative (discussed below) also would adversely impact bayou properties. However, opposition based on a perceived need for bulkheads could be a cause of potential project delays (e.g. through litigation), which may be a consideration in determining whether the project should be proposed for CWPPRA funding, or removed from the CWPPRA priority list and pursued in another manner.

Vegetative clogging. At the time of the 1996 public meetings, Bayou Lafourche was so clogged with vegetation that even small amounts of water diverted at Donaldsonville could not reach Lockport, much less the marshes. Obviously, had this situation remained unchanged, any increase in diversions would simply have exacerbated the high water levels that existed then, and marsh benefits would have been negligible.

The closing of Bayou Lafourche by vegetation or any other cause would indeed be a fatal flaw to the types of diversion projects considered here. As discussed in Section 2.6.2, a mowing program conducted by the Freshwater District has eliminated the problem at the present time. Ongoing vegetation removal is likely to be necessary at times, in order to keep the bayou open. Such maintenance will be needed so long as the bayou is used to convey water, whether small amounts for water supply as at present, or larger amounts for coastal restoration as proposed. Thus vegetative clogging is not considered a fatal flaw to the project. On the contrary, several aspects of the project may help control future aquatic growth: dredging should remove most remaining vegetation (e.g. near the channel margin); future flows will have a higher velocity and also may be slightly more turbid; the result should tend to inhibit vegetative growth by reducing light penetration.

Withdrawal of diverted water before it reaches the marshes. Another possible 'fatal flaw' identified at the public meetings was based on the fact that the population and industries in four parishes take their water supply from Bayou Lafourche. (Grand Isle, in Jefferson Parish, also uses bayou water.) The concern was that population and economic growth would increase water demands, and these demands would cause any increased diversions at Donaldsonville to be simply withdrawn by municipal and industrial users. Under this concept, increased pumping capacity at Donaldsonville would primarily or exclusively benefit public and private water supplies, not the marshes, and Project PBA-20 would have few if any restoration benefits.

This issue is discussed in Section 2.8.2. There appears to be no question that the capacity of the existing pumping station is more than adequate to meet both existing and projected future water demands. The average annual withdrawal of public and private water from Bayou Lafourche is expected to increase by only about 14 cfs over the next 20-plus years. This is a very small increase when compared to the proposed increase in diversion capacity from 340 to 1000 cfs. The small effect of water-supply withdrawals on flow to the wetlands has been considered in the project evaluation; see Section 4.4.5.

Summary. Based on the above discussions, no fatal flaws have been identified that would require rejecting Project PBA-20.

6.2.3 Impacts of the no-action alternative

A Bayou Lafourche diversion project can have both positive and adverse impacts. Judging the significance of these impacts requires consideration of what is likely to happen without a diversion project. Considerations with respect to no-action include the following.

- In the absence of the optimized project, it is assumed that the channel capacity will continue to decline (see general discussion in Section 2.2.1). This assumption effectively means that there will be no substantial effort made to improve channel conveyance for drainage and flood control purposes.
- It is reasonable to assume that the Freshwater District will continue to maintain the channel by actions such as mowing *Hydrilla*.
- As discussed in Section 2.8.2, FWD eventually will need to increase its pumping capacity for the purpose of salinity control. It is not known when this need may occur.
- There will be a general trend for water levels to increase in the region, and for drainage problems to also increase, due to the general pattern of coastal subsidence and sea level rise. The frequency of salinity problems in the lower bayou will increase.

Given these considerations, the question becomes how long Bayou Lafourche will remain open. At some point in time, and no later than the time when FWD needs to expand its diversion capacity, a decision must be made to either restore bayou capacity (by dredging) or to provide water supplies in a different way than now occurs.

A proposal to increase diversions for control of water-supply salinity would pose issues similar to those associated with Project PBA-20, except that all costs and benefits would be local. If the no-action scenario comes true, then presumably there would have been a decision that maintaining and increasing the capacity of Bayou Lafourche is not appropriate. Presumably, the reasons for adopting no-action would be reasons not to support any action by FWD to increase diversion rates. If so, then in order to avoid an increase in diversion rates, FWD could consider one of two alternatives for controlling salinity impacts to water supplies.

Gate alternative. Under one alternative, a retractable (swinging) gate would be constructed below the Mathews intake of the Lafourche Parish Water District #1. The diversion rate would be kept to no more than 140 cfs. This would be sufficient to supply all users, with some surplus. During most of the year, the gate would be open. Any surplus flow would pass to the wetlands. During the fall, the gate could be swung across the weir in order to block salt water intrusion from reaching the lowest water supply intake. Thus, during the critical time for wetlands maintenance, the freshwater contribution of Bayou Lafourche to the wetlands would be zero.

There would be several potentially adverse consequences to the gate alternative, including the following.

- During periods when the gate was closed, flow would effectively stop in the bayou. (Gate design might permit a very small amount of outflow.). Stagnant conditions could be conducive to adverse changes to the bayou, including rapid growth of submerged aquatic vegetation, algal blooms, and/or depletion of dissolved oxygen (with possible stress to fish populations). The quality of water diverted by water users could be affected.
- Gate closure would restrict recreational uses of the bayou, e.g. boat traffic.
- Assuming a gate were built below Mathews, intakes below the gate would not be protected from salt water. Thus Lockport and other users below Company Canal would need to obtain their water supplies directly from the Lafourche Parish water system, rather than from the bayou.
- Eventually, siltation would reduce bayou capacity to below that needed to carry 140 cfs. At that point the system would begin to fail to meet water supply needs. The choice then would be to implement the pipeline alternative below, or to dredge the bayou.

Pipeline alternative. As suggested above, if the bayou is never substantially dredged, then eventually a pipeline alternative will need to be implemented. This alternative would abandon the bayou to about Lafourche Crossing, and instead transport drinking water by pipelines placed within the former channel. The pipes would extend to the Terrebonne and Lafourche Parish intakes south of Thibodaux. Those locations would provide water at points that can feed existing pipelines that convey water to downstream areas.

One advantage of this pipeline alternative is that pumping rates and pumping capacity might be reduced to 100 cfs much of the time, because there would be less need for excess pumping to maintain heads for intakes. Also, the FWD would no longer need to expend funds on bayou maintenance, and would no longer have liabilities associated with bank failures or flooding. Any water quality and other operational concerns raised by the gate alternative would be avoided. The pipeline system would be as conventional as water systems get.

These advantages could substantially or entirely offset the costs of building pipelines. An impact with mixed effects is that existing industrial users would be forced to hook-up to municipal water systems and to pay directly for the water they use (as compared to present conditions, when industrial funding of water supply is indirect). Property owners along the bayou would no longer have a naturally flowing stream in their backyard.

Figure 6.2-1 illustrates the bayou cross-section under the abandonment scenario. The abandoned portion of the channel would filled in over water-supply pipes that would convey diverted river water directly to public and private intakes. A small drainage ditch would probably be provided within the filled bayou to carry limited amounts of storm runoff. By definition, water level problems along the batture would be at an end, at least with respect to the bayou. The backfill to cover the pipes would create usable land between Highways 1 and 308, and some development could result.

A vivid and relevant analogy to the view in Figure 6.2-1 is Bayou Terrebonne between Thibodaux and Houma. There, a once important stream is reduced to a drainage ditch bounded by land, development and highways. This analogy suggests that Figure 6.2-1 is a plausible future for Bayou Lafourche.

6.2.4 Provisional opinion on no-action alternative

Based on the above discussions, EPA reaches the following provisional conclusions. These conclusions will be revisited following public review and comment.

- A Bayou Lafourche diversion project is expected to have meaningful wetlands benefits. Locations of benefits have been determined through computer modeling and include some benefits from sediment (although not building of new land). These benefits have been confirmed through a detailed evaluation process that applies to all CWPPRA projects, and estimated to exceed 700 average annual habitat units (see Section 4.6).

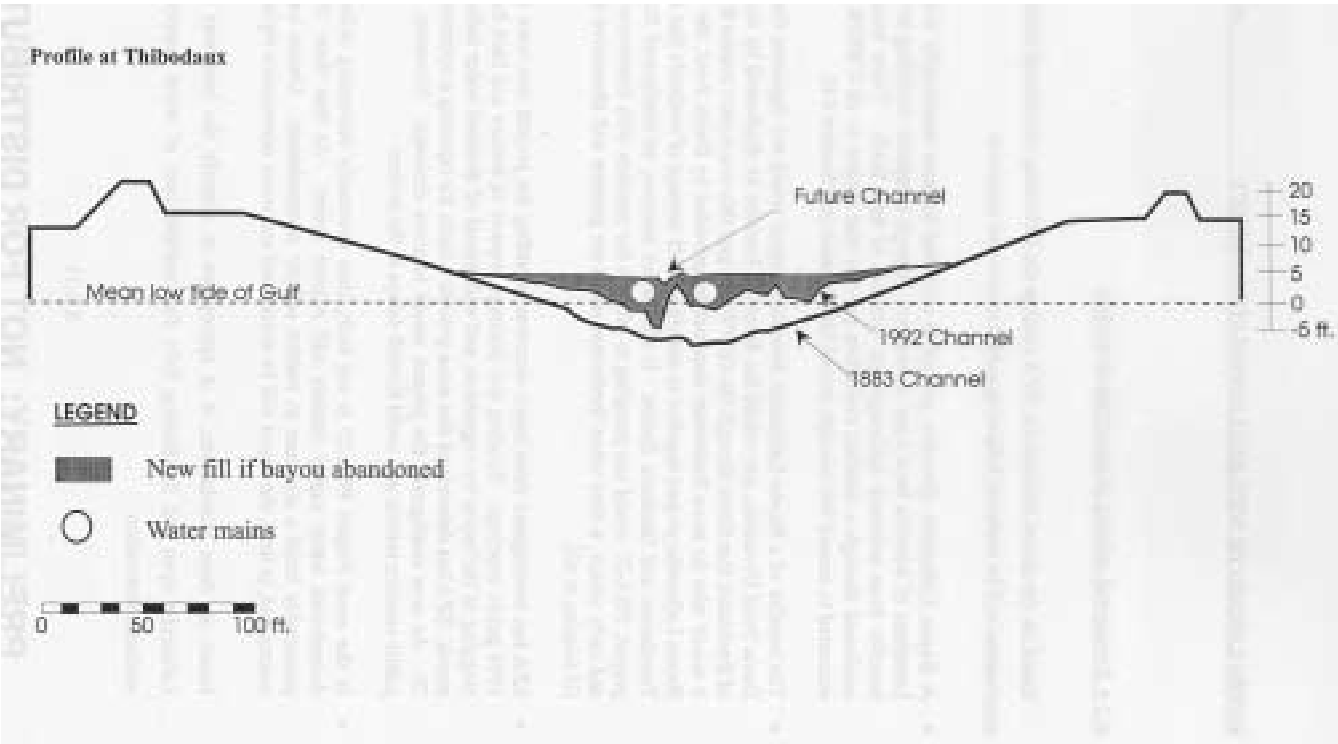
- The benefits of a Bayou Lafourche diversion project would not duplicate the benefits of the Davis Pond Diversion, nor would the diversion benefits be duplicated by improving the use of freshwater that flows through the GIWW. In part this conclusion results from the fact that it would take far more freshwater than will be provided by Davis Pond, the GIWW and the Bayou Lafourche project together to sustain the full acreage of wetlands that are at risk in the Terrebonne and Barataria Basins. It also arises because, as configured for the optimized project, PBA-20 would use pumping to provide the marshes with freshwater during late fall and early winter, a time when freshwater needs are greatest and alternative sources minimal (if existing at all).

- EPA has investigated three major concerns regarding the project that were suggested at the 1996 public meetings: flooding and drainage impacts to batture and back-bayou properties; clogging of the bayou by vegetation; and withdrawal of diverted water before it reaches the marsh. EPA has determined that none provide a basis for rejecting a optimized project PBA-20. As now configured, the project would improve drainage. However, some issues of public concern remain and could foretell delays in the project.

- In the event Project PBA-20 is not built, then eventually increasing salinity problems at downstream water supply intakes will require action. At that time, the FWD would presumably build a structure to restrict salinity encroachment. Unless bayou capacity is maintained, in time, the bayou will be abandoned and water conveyance replaced with pipes.

Based on these conclusions, it is appropriate to identify the best way to keep Bayou Lafourche open and functioning fully for multiple uses of water supply, drainage, and wetlands restoration.

Figure 6.2-1. No-action alternative.



6.3 REPRESENTATIVE ALTERNATIVES INVOLVING MISSISSIPPI RIVER WATER

The primary consideration with respect to developing alternatives has been to consider different project sizes; and also to consider using only siphons. Specific alternatives for which information has been obtained are as follows.

- A diversion of 2,000 cfs, using only siphons. This is the original project PBA-20 that was authorized on CWPPRA Priority List 5. It is discussed here in Section 6.3.1.
- A much larger diversion. At this time, the alternative of a larger diversion is conceptual. As discussed in Section 6.3.2, the option of building a new conveyance channel parallel to Bayou Lafourche is an important regional strategy in the Coast 2050 Plan.
- A diversion of 1,000 cfs, as for the optimized project, but using only siphons; see Section 6.3.3.
- A diversion of 1,000 cfs, as for the optimized project, but using an entirely new facility; the existing diversion works would be abandoned. This option is reviewed in Section 6.3.4.
- A diversion of 780 cfs, as by 440 cfs of new capacity in combination with the existing 340 cfs of capacity. Refer to Section 6.3.5.
- A diversion of 660 cfs, from construction of a new pumping station only; see Section 6.3.6.
- A diversion of 560 cfs, as by 220 cfs of new capacity in combination with the existing 340 cfs of capacity. See Section 6.3.7.
- Diverting 340 cfs continuously from the existing, renovated pump station, with channel improvements to convey the flow and provide drainage benefits. See Section 6.3.8.
- Building the optimized 1,000 cfs project in a single phase, with 340 cfs at the existing station and 660 cfs in a new station. This option is discussed in Section 6.3.9.

In addition, brief consideration has been given to relocating the diversion from the Mississippi River, so that it might avoid the more developed areas of Donaldsonville; see Section 6.3.10. A more extensive look at an entirely different location -- one that would eliminate almost all effects to the Donaldsonville area, is provided in Section 6.4; this option considers diversion of Lake Verret water, through Cancienne Canal.

6.3.1 2,000 cfs siphon

Project features. In many respects, the original 2,000 cfs siphon project that was selected for CWPPRA Priority List 5 is similar to the optimized project that is discussed in detail in Section 5 of this report. The following discussion highlights features of the original alternative that differ from the optimized project.

- Size: the original project is larger - 2,000 cfs vs. 1,000 cfs for the optimized project.
- Diversion method and period of operation: siphons only. In a typical year the project would operate about 6-7 months; and in low-river years, only two months. The optimized project would operate year-round.
- Dredging: much less dredging would occur (perhaps 1 million cubic yards, versus more than 3 million cubic yards in the optimized project).
- AAHUs: a total of 499 AAHUs were identified for the original project using the formal WVA process. This is less than the >700 AAHUs for the optimized project because the latter has fall-season benefits, and because computer models developed since the original WVA have indicated a wider area of influence for a Bayou Lafourche diversion.
- Water supply benefits: the original project provided minimal benefits to the FWD, whereas the optimized project provides pumping capacity that the FWD may eventually rely on for salinity control.
- Water level impacts: the original project involved a large flow with minimal dredging and therefore would have caused a substantial rise in bayou water levels. Figure 6.3-1 is a graph illustrating the projected water levels from the project. The existing (reference) profile from Figure 3.4-1 is provided for comparison. The figure illustrates the substantial increase in water levels that would result from the 2,000 cfs project, if there is minimal dredging to improve channel capacity.

- Property impacts: the higher water levels would inundate lower portions of properties along the bayou, with the largest impacts occurring upstream.
- Drainage impacts: the higher water levels would effectively eliminate all drainage to Bayou Lafourche through at-grade canals. As a practical matter, all such canals would need to be blocked at the Bayou Lafourche end (in order to avoid losing CWPPRA water), and opened at the wetlands end.
- Sediment transport: computer modeling indicates that sediment transport would be much more effective with a 2,000 cfs diversion than a 1,000 cfs diversion; see Figure 4.3-8. The additional sediment transport of the original project would be beneficial to the marshes and, perhaps, to control *Hydrilla*.
- Bank stability: the original project would cause a large water level lowering when the siphons are turned off each year, and a large increase when they are turned on. This could adversely impact stream bank stability.

Project costs, including mitigation. The original project costs were determined when the project was listed by the CWPPRA Task Force. The estimate of these first costs is summarized in Table 6.3-1. The estimate of fully funded project costs derived from these first costs, plus monitoring and operational costs, is summarized in Table 6.3-2. The equivalent annual cost for this fully funded cost is $2,360,000. This corresponds to an average annual cost of $4,729 for each average annual habitat unit.

Based on the current evaluation, the cost for the original project was underestimated. The primary reason is that the budget for the original project did not include any costs for mitigation for the projected water level increase that is shown in Figure 6.3-1.

There is no simple way to determine prospective mitigation costs. For example, a legal basis may exist upon which the government has a right to impact bayou-side properties through a project that has public benefits. However, if direct mitigation costs were avoided through exercise of such a property easement and servitude, EPA would expect there to be substantial costs and delays associated with associated legal proceedings. In the alternative, the government could provide compensation to affected property owners for policy reasons. Whether property were acquired by negotiation or condemnation, assuming past (confidential) litigation settlements are a guide, the associated costs could be substantial.

A surrogate estimate of mitigation costs was developed based on the assumption that in lieu of property compensation, the project would be designed in a manner similar to the optimized project, in that there would be enough dredging so as to keep water levels below the reference profile, even if 2,000 cfs were conveyed. It also was assumed that inflatable weirs would be used to maintain water at current levels during the time when the siphons did not operate, and bayou flows were limited to pumping at the existing FWD station.

HEC-RAS runs indicate that the quantity of dredging necessary to convey 2,000 cfs without an increase in water levels is on the order of 13 million cubic yards, or approximately 4 times that required to convey 1,000 cfs. The larger volume would probably increase costs by more than four-fold, because this amount of dredging (in a period of a few years) would require very large equipment; because it would require a very steep and deep cross-section that might require much more use of bulkheading to stabilize slopes, a greater number of utility replacements; and a much larger amount of material for which disposal areas would need to be found. Given that the dredging-related costs of the optimized project are on the order of $12 million (including relocations), an estimate of $50 million for the original project is not unreasonable as a minimum working estimate. This compares to a budget of $3.3 million shown in Table 6.3-1.

A second option for mitigation would be to add a pumping system to the 2,000 cfs project. This option would improve project benefits (by providing fall salinity control) and avoid one impact (routine seasonal shifts of water levels). However, this would increase costs and would not address the fundamental problem that 2,000 cfs cannot be conveyed down the bayou without flooding the batture and impeding regional drainage, unless there is a very large amount of dredging. No detailed consideration was given to this option.

6.3.2 Large conveyance channel

In general, the concept of diverting even more than 2,000 cfs down Bayou Lafourche was not evaluated because this would simply exacerbate any problems associated with high-water levels. Indeed, a diversion of only 8,000 cfs could be large enough to put water on top of the two highways. However, one special alternative was reviewed in the context of both EPA's project evaluation and the Coast 2050 planning process: construction of a very large channel parallel to Bayou Lafourche. It is expected that this alternative will be assessed as part of ongoing CWPPRA studies. The alternative is briefly summarized here, with an emphasis on determining whether construction of a 1,000 cfs optimized project (or alternative) would conflict with, or be supportive of, the large conveyance channel.

General description of the new conveyance channel. The concept underlying the alternative of a very large channel is to reproduce hydrologic conditions of the type observed in major delta-building environments. A modern analog is the Wax Lake Outlet, an artificial channel that functions as a distributary of the Atchafalaya River, and that has created a significant new delta. A similar channel built parallel to Bayou Lafourche could redirect flow and transported sediment from existing Mississippi and Atchafalaya River channels to supply controlled, land building subdeltas in the areas of the Terrebonne and Barataria Basins near lower Bayou Lafourche.

Conceptually, the conveyance channel would leave the Mississippi River along its west bank a short distance downstream from the Sunshine bridge, where there are no existing petrochemical plants. There would be a control structure and a lock at this location. The alignment of the conveyance channel would generally follow the backslope (toe) of the natural levee on the east side of Bayou Lafourche for approximately 30 miles to below Thibodaux, where the channel would bifurcate. One branch would continue to follow the backslope of the east levee for 35 miles to an area near Little Lake, where it would form a subdelta lobe. The other branch would cross the existing channel of Bayou Lafourche, and thence generally follow the backslope of the natural levee on the west side of Bayou Lafourche. It would swing away from the levee south of the GIWW until reaching the South Bully Camp marshes, where it would form the head of a second subdelta lobe.

A dam would be required across the channel of Bayou Lafourche at the crossing point of the conveyance channel. The bayou channel between Donaldsonville and the dam would be converted to a lake. A pumping station would be required at the dam to remove excess water from the lake and to accommodate drainage from the east bank natural levee of Bayou Lafourche, which would be trapped by levees built along the new conveyance channel. Transportation infrastructure crossings would be required along the new channel; these would include several high-rise and several low bridges. The channel bank could be used to site a new highway and/or railway corridor to service the Bayou Lafourche area, including the extremely active Port Fourchon area.

Flow quantities and impacts. The minimum discharge that would be needed to support a sustainable channel would be approximately 60,000 cfs at the Mississippi River during flood stage, with a flow velocity of 3 ft/sec. Following the pattern of natural distributary development, the discharge volume would start at about 20,000 cfs and grow as the channel developed larger capacities through natural scour.

In the upper part of the project, an existing area between Bayou Lafourche and the new channel (including most of Donaldsonville) would become isolated and would require forced drainage to handle storm runoff. Further downstream, it would be possible to consider small diversions from the channel to supply freshwater and some sediments to swamp and wetland areas. However, the main impacts would occur in the new subdeltas. Each new land mass would build to about 80 to 100 square miles over a 50-year period; salinity and turbidity effects would extend over a much larger area, perhaps 500-700 square miles each. Project costs and other features have not been evaluated.

The optimized project can be viewed as a near-term step for achieving wetland benefits, so that the large conveyance channel can be more effective if and when it is implemented.

6.3.3 1,000 cfs siphon

Project features. This alternative is similar to the optimized project described in Chapter 5, except that only 660 cfs of new siphons would be constructed.

- Size: same as optimized project, 1,000 cfs, but this level of flow would be obtained only 6-7 months of the year in most years, and two months of the year when the river is low.
- Diversion method: new facilities would be siphons only. FWD would operate its pump station at 340 cfs during the non-siphon season.
- Dredging: same as optimized project.
- AAHUs: assumed to be no more than half of the optimized project. This reflects a period of operations which is slightly more than half the year on average, but which never provides fresh water during fall salinity spikes.
- Water supply benefits: minimal, compared to the optimized project, because there is no additional salinity control during the low-water season.
- Water level impacts: during periods of 1,000 cfs flow, effects would be similar to the optimized project, with no increase in water levels above the reference profile (Figure 3.4-1). During periods when the siphons did not operate, the inflatable weirs would be in place, thus maintaining water levels relatively high even with flows that are in the range 150-250 cfs.
- Property impacts: same as optimized project.
- Drainage impacts: similar to optimized project, but with less flexibility to interactively adjust pumping rates and weir heights to accommodate storm runoff.
- Sediment transport: similar to optimized project during high water periods. However, compared to the optimized project, there would be much less sediment diverted in the late summer and fall, when total diversions would only be 340 cfs. In addition, during that period there could be greater deposition of sediment in the channel, because with a small flow in an enlarged channel, flow velocities would be less than at present. The low velocities might also contribute to adverse water quality effects.

- Bank stability: the on/off siphon cycles could require a more fail-safe mode of operation for the control structures, compared to the optimized project where there is substantial ability to adjust diversion rates.

Project costs. This alternative is similar to the optimized project described in Chapter 5, except that only siphons would be constructed. This results in three changes to the cost estimate for the optimized project.

- Diversion works: the estimated cost for a 2,000 cfs siphon was more than $5 million, prior to add-ons for contingencies and engineering (see Table 6.3-1). In comparison, for a 1,000 cfs siphon project, some cost elements would be cut in half (e.g. material costs for siphons), while others would be virtually the same (e.g. mobilization). A cost of $3.4 million has been assumed for the 1,000 cfs facilities.

- Pumping: the O&M costs associated with operation of a new pump station for the optimized project, would not occur for a siphons-only project. There would be incremental pumping costs for increasing diversions at the existing pump station, to 340 cfs at all times.

- Sand trap maintenance: diversion via the new siphons would only occur about half the year, reducing the amount of sediment accumulated. Maintenance costs are assumed to be half of those for the optimized project.

Table 6.3-3 summarizes the cost estimate for the 1,000 cfs siphon alternative. The costs are substantially more than half those for the optimized project described in Chapter 5. Since AAHU benefits are no more than half those of the optimized project, the alternative of a 1,000 cfs siphon project is clearly less cost-effective than the optimized project.

This analysis indicates that the reduction in cost for a siphons-only project is smaller than the reduction in benefits; thus inclusion of pumps in the project design is cost-effective. However, depending on local cost-shares, a siphons-only project probably could be built with little or no addition to the CWPPRA funds already committed to Project PB-20A.

6.3.4 New 1,000 cfs pump station

Project features. This alternative is similar to the optimized project described in Chapter 5, except that all 1,000 cfs of the diversion capacity would be provided through a new facility. The existing pumping station would be abandoned. The new facility would have five pipes and pumps, compared to three for the optimized project. The new facility, with its superior design and its reliance entirely on variable speed pumps, would be easier to operate and more efficient than the existing plant.

Project costs. This alternative is similar to the optimized project described in Chapter 5, except that the costs for the new diversion works would be greater because the facility would be larger, and the costs for the existing pump station would be deleted because this facility would be abandoned. (Put another way, this option trades the upgrade and O&M costs of the existing plant for construction and O&M costs of a larger, new plant.) The net result is four changes to the cost estimate that was previously presented for the optimized project.

- Diversion works: there would be a larger investment for the diversion works, which is detailed in Table 6.3-4.
- Existing plant: there would be no cost to upgrade the existing plant.
- Energy/repairs: O&M costs for the new 1,000 cfs facility were estimated by comparison to the 660 cfs facility that would be part of the optimized project. The assumption is that these costs would be 50% greater than for the 660 cfs facility, based pumping costs that would be slightly greater than 50%, but other costs slightly less than 50%.
- Incremental O&M: there would be no cost to operate the existing plant.

Table 6.3-5 provides an estimate of the construction and operations cost for the 1,000 cfs pumps-only facility. This alternative costs much more to construct (and slightly less to operate) than the optimized project, with identical wetlands benefits. The primary reason to construct this option would be to provide a more efficient facility. Note that this alternative is not well-suited for a phased approach to implementation. However, it would be possible to implement increased pumping rates incrementally, with the maximum diversion rate being set at the level the bayou can safely convey.

6.3.5 780 cfs siphon and pump combination

Project features. This alternative is the same as the optimized project except that the new diversion facility would have two pipes and pumps, compared to three for the optimized project, and thus would provide 440 cfs of new capacity, instead of 660 cfs. It is assumed this new facility would be built as a Phase II expansion of the 340 cfs upgrade that is part of the optimized project. Thus the total diversion capacity would be 780 cfs. (If appropriate, this station could be expanded in the future, to 660 cfs or larger.)

Wetlands benefits would reflect a net increase in flow to the marshes of 595 cfs (780 cfs, minus the 185 cfs adjustment discussed in Section 4.4.5). This is 73% of the 815 cfs which would be provided by the optimized project. As a rule of thumb, EPA has assumed that WVA benefits would not quite be proportional to flow. For incremental flows above 500 cfs, but less than 815 cfs, the effect is assumed to be a reduction in WVA benefits that is 1% greater than the reduction in flow. (The effect is assumed to be 2% for incremental flows in the 300-500 cfs range, and 3% for flows in the 100-300 cfs range.) Thus, in this case the WVA benefits are assumed to be 72% of the optimized project. For the situation in which Project TE-10 is built, this amounts to 72% of 784 AAHUs, or 564 AAHUs.

Project costs. Limiting the project to two pipes and pumps generally reduces costs for equipment, dredging and O&M. Specifically, the following four items are affected.

- Diversion works. The smaller diversion works would be less expensive to construct. Compared to the optimized project, some cost elements would be cut by one third (e.g. material costs for two pumps and siphons would be two-thirds of those for three pumps and siphons), while others would be perhaps only 10% less (e.g. mobilization). Overall, as a first approximation, the 440 cfs station is assumed to cost about 75% of the 660 cfs station.

- Dredging and utility replacements. Phase I would be similar to the optimized project, but Phase II channel improvements would be less. An increase in channel capacity from 340 cfs to 780 cfs is about 67% of an increase from 340 cfs to 1000 cfs. Cost savings may be greater because it may be possible to eliminate dredging in some sections (thus moves around bridges); and generally there would be less intrusion on existing utility crossings and less concern over bank stability. Overall, dredging and utility costs for Phase II were assumed to be 65% of those for the optimized project.

- Energy/repairs: energy costs for a new 440 cfs diversion works would be exactly two-thirds of those for 660 cfs. There may be some diseconomies of scale, so that repair costs are more than two-thirds of the optimized project. Overall costs for the 440 cfs component of this facility were assumed to be 70% of the 660 cfs facility.

- Sand trap: the total flow would be 78% of the optimized project. To allow from some diseconomies of scale, it is assumed that this would reduce construction and operation costs to 80% of the optimized project.

Table 6.3-6 provides an estimate of the construction and operations cost for the 780 cfs pumps and siphons facility. As a first approximation, this alternative would cost about 75% of the optimized project to build, and about 82% to operate, and would provide 72% of the wetlands benefits. Construction costs would be of the same order of magnitude as the allocation of CWPPRA funds already put aside for project PBA-20. However, unless O&M costs are substantially cost-shared, fully funded costs would be larger than the original project due to the larger O&M costs.

A 780 cfs option would appear to be a viable alternative to the optimized project, and may provide fewer perceived problems with respect to issues such as channel capacity and bank stabilization.

6.3.6 660 cfs siphon and pump combination

Project features. This alternative would provide 660 cfs of capacity, by building a new pump station as proposed for the 1,000 cfs project; the existing 340 cfs plant would be mothballed, or abandoned. Subsequent expansion of the new facility could be considered, if and when appropriate.

Wetlands benefits would reflect a net increase in flow to the marshes of 475 cfs (660 cfs, minus the 185 cfs adjustment discussed in Section 4.4.5). This is 58% of the 815 cfs which would be provided by the optimized project. As discussed in Section 6.3.5, EPA has discounted WVA benefits by 2% to reflect the fact that smaller projects may be disproportionally less effective in supplying freshwater and nutrients to wetlands. Thus, in this case the WVA benefits are assumed to be 56% of the optimized project. For the situation in which Project TE-10 is built, this amounts to 56% of 784 AAHUs, or 439 AAHUs.

Project costs. This alternative is similar to the optimized project described in Chapter 5, except that all costs for upgrading and operating the existing 340 cfs facility would be eliminated, and those costs that relate to channel capacity (sand trap construction and dredging, channel dredging, Phase II utility relocations) are assumed to be reduced in approximate proportion to the lower rate of diversion (e.g. to about 70% of the optimized project).

Table 6.3-7 provides an estimate of the construction cost for the 660 cfs facility. The construction cost of this alternative is more than 80% of the optimized alternative, and O&M costs are about 60%. Given that wetland benefits are about 58% of the optimum, the project is probably not cost-effective.

6.3.7 560 cfs siphon and pump combination

Project features. This alternative is the same as the optimized project except that the new diversion facility would have one pipe and pump, compared to three for the optimized project, and thus would provide 220 cfs of new capacity, instead of 660 cfs. It is assumed this new facility would be built as a Phase II expansion of the 340 cfs upgrade that is part of the optimized project. Thus the total diversion capacity would be 560 cfs. (If appropriate, this station could be expanded in the future, to 660 cfs or larger.)

Wetlands benefits would reflect a net increase in flow to the marshes of 375 cfs (560 cfs, minus the 185 cfs adjustment discussed in Section 4.4.5). This is 46% of the 815 cfs which would be provided by the optimized project. As discussed in Section 6.3.5, EPA has discounted WVA benefits by 2% to reflect the fact that smaller projects may be disproportionally less effective in supplying freshwater and nutrients to wetlands. In this case, WVA benefits are assumed to be 44% of the optimized project. For the situation in which Project TE-10 is built, this amounts to 44% of 784 AAHUs, or 345 AAHUs.

Project costs. Limiting the project to one pipe and pump generally reduces costs for equipment, dredging and O&M. Specifically, the following four items are affected.

- Diversion works: compared to the optimized project, some cost elements would be cut by two thirds (e.g. material costs for one pump and siphon would be one-third of those for three pumps and siphons), while others would be perhaps only 10% less (e.g. mobilization). An itemized review of costs resulted in a reduction of 25% for a 440 cfs diversion works compared to a 660 cfs diversion works; by extension, a reduction of 50% would be appropriate for a 220 cfs diversion works.

- Dredging and utility replacements. Phase I would be similar to the optimized project, but Phase II channel improvements would be less. An increase in channel capacity from 340 cfs to 560 cfs is about 33% of an increase from 340 cfs to 1000 cfs. Cost savings may be greater because it may be possible to eliminate dredging in some sections (thus moves around bridges); and generally there would be less intrusion on existing utility crossings and less concern over bank stability. Overall, dredging and utility costs for Phase II were assumed to be 35% of those for the optimized project.

- Energy/repairs: energy costs for 220 cfs should be one-third of those for 660 cfs. There may be some diseconomies of scale, so that repair costs are more than one-third of the optimized project. Overall costs for the 220 cfs component of this facility were assumed to be 40% of the 660 cfs facility.

- Sand trap: the total flow would be 56% of the optimized project. To allow from some diseconomies of scale, it is assumed that this would reduce construction and operation costs to 60% of the optimized project.

Table 6.3-8 provides an estimate of the construction cost for the 560 cfs pumps and siphons facility. As a first approximation, this alternative would cost about 50% of the optimized project to build and operate, and would provide 44% of the benefits. With cost-sharing, it is possible that fully funded costs could be within the allocation of CWPPRA funds already put aside for project PBA-20. A 560 cfs option would appear to be a viable alternative to the optimized project, and might eliminate most or all perceived problems with respect to issues such as channel capacity and bank stabilization.

6.3.8 340 cfs siphon and pump combination

Project features. This alternative would not build a new pump station, but would instead simply implement Phase I of the optimized project by replacing two existing fixed speed pumps with two variable speed pumps, dredging near Donaldsonville, and installation of water management and monitoring facilities.

Wetlands benefits would reflect a net increase in flow to the marshes of 155 cfs (340 cfs, minus the 185 cfs adjustment discussed in Section 4.4.5). This is 19% of the 815 cfs which would be provided by the optimized project. As discussed in Section 6.3.5, EPA has discounted WVA benefits by 3% to reflect the fact that smaller projects may be disproportionally less effective in supplying freshwater and nutrients to wetlands. In this case, WVA benefits are assumed to be 16% of the optimized project. For the situation in which Project TE-10 is built, this amounts to 16% of 784 AAHUs, or 125 AAHUs.

Project costs. The costs of Phase I are presented in Chapter 5; see especially Tables 5.5-2 and 5.5-3. If a 340 cfs diversion were proposed as a standalone project, then during the design phase of the project, it would be appropriate to determine if there would still be a need for a sand trap and/or an inflatable weir at Thibodaux. If not, costs could be substantially reduced when compared to Phase I of the optimized project. Proportionally, it is possible that there would be a greater cost-share for Phase I (because of its low overall cost, water management features) than for the optimized project as a whole. Consequently, even if the Environmental Work Group concludes that there are fewer wetlands benefits than estimated by EPA, it is likely that Phase I would be comparable in cost-effectiveness to the entire optimized project. However, long-term problems of salinity encroachment would not be addressed by this option.

6.3.9 Building the phased project as a single project

Most of the alternatives discussed above involve phased construction and operation of two separate pumping and siphon facilities -- the existing station and a new plant. The option exists to build the project in a single phase. This would result in very small cost savings, from two sources. First, it would not be necessary to replace the fixed speed pumps at the existing pump station, because the new pump station would provide adequate variable speed capacity. This benefit is not achieved by the optimized project, because the existing pump station must operate successfully before the new station is constructed. Second, dredging costs might be reduced because there would be only one mobilization of equipment.

These small cost savings --a few hundred thousand dollars in total -- are minimal when compared to the advantages of a phased project, which includes gaining public confidence.

6.3.10 Bypass of Donaldsonville

At least some of the controversy over PBA-20 relates to the fact that, for the original project, the largest potential adverse impacts would occur in the uppermost reaches of the Bayou. The optimized project has addressed this issue by eliminating the adverse impacts and by providing positive drainage management and bank stabilization measures to benefit the upper bayou. As an alternative to this approach, EPA also considered whether diversion water could be brought into the Bayou at an alternative location.

Alternative locations near Donaldsonville. The natural linkage point between the Mississippi River and Bayou Lafourche is at Donaldsonville. Undertaking a diversion at a substantially different location would either require considering a different water source (see Section 6.4) or would involve a project of much greater magnitude and cost than PBA-20. (See Section 6.3.2 for an example.)

Therefore, EPA considered that if the Mississippi River were to be used for Project PBA-20, the diversion would occur in the general vicinity of Donaldsonville. EPA's consultants investigated alternative routes for linking the Mississippi River to Bayou Lafourche. The obvious option would be to build a new diversion a few miles upstream of the existing facility, to take advantage of the fact that in its upper reach, the bayou remains very close to the Mississippi River for a distance of about two miles. This diversion route, which would be in the area known as Smoke Bend, was inspected by map, airplane, road and/or boat.

There is no obvious route that is free of development. Moreover, in all cases, it is expected that the cost of building a new channel would be at least as great as improving the existing channel. It would still be necessary to operate the existing diversion in order to supply water to Donaldsonville (which has their existing intake near the existing outfall).

The objective of minimizing impacts to the Donaldsonville area can be accomplished without changing the location of the diversion; in the optimized project, this was done by channel dredging and other improvements. EPA therefore screened out the alternative of relocating the Project in the Donaldsonville area. This decision does not preclude proposals that might be made in the future, to build new diversion channels at a substantially larger cost than PBA-20.

Locations involving use of flood drainage water. The farther one goes down Bayou from Donaldsonville, the less practical a link to the Mississippi River becomes. However, other sources of freshwater are potentially available, in the form of drainage from the low-lying areas on either side of the Bayou. Moreover, there is interest in pumping of this drainage water for the purpose of reducing flooding problems. The alternative of using drainage water rather than Mississippi River water is discussed in Section 6.4.

6.3.11 Summary of alternatives involving a Donaldsonville diversion

EPA has not developed estimates of fully funded costs, present worth costs, or average annual costs for alternatives presented in Chapter 6. In order to provide a perspective on cost-effectiveness, the following simple analysis has been performed.

- The estimates of AAHUs presented in Chapters 5 and 6 are used as a first approximation of the benefits of an alternative. The values for the optimized project include the synergistic effect of project TE-10, and those from alternatives are based on the ratio of a project's flow to the wetlands, compared to the flow from the optimized project, with some discounting for smaller projects. The AAHU values have not been verified by the Environmental Work Group.

- The estimates of project first (construction) costs has been used as one approximation of project cost. Cost-effectiveness is approximated as first costs per AAHU, with first costs expressed in units of one thousand dollars. The costs have not been verified by the Engineering Work Group and are not in "fully funded" terms as would be appropriate in comparing this project to other CWPPRA projects.

- The estimates of project annual (O&M) costs have been used as another approximation of project cost. Cost-effectiveness is approximated as annual costs per AAHU. The costs have not been verified by the Engineering Work Group and are not in "average annual" terms as would be appropriate in comparing this project to other CWPPRA projects.

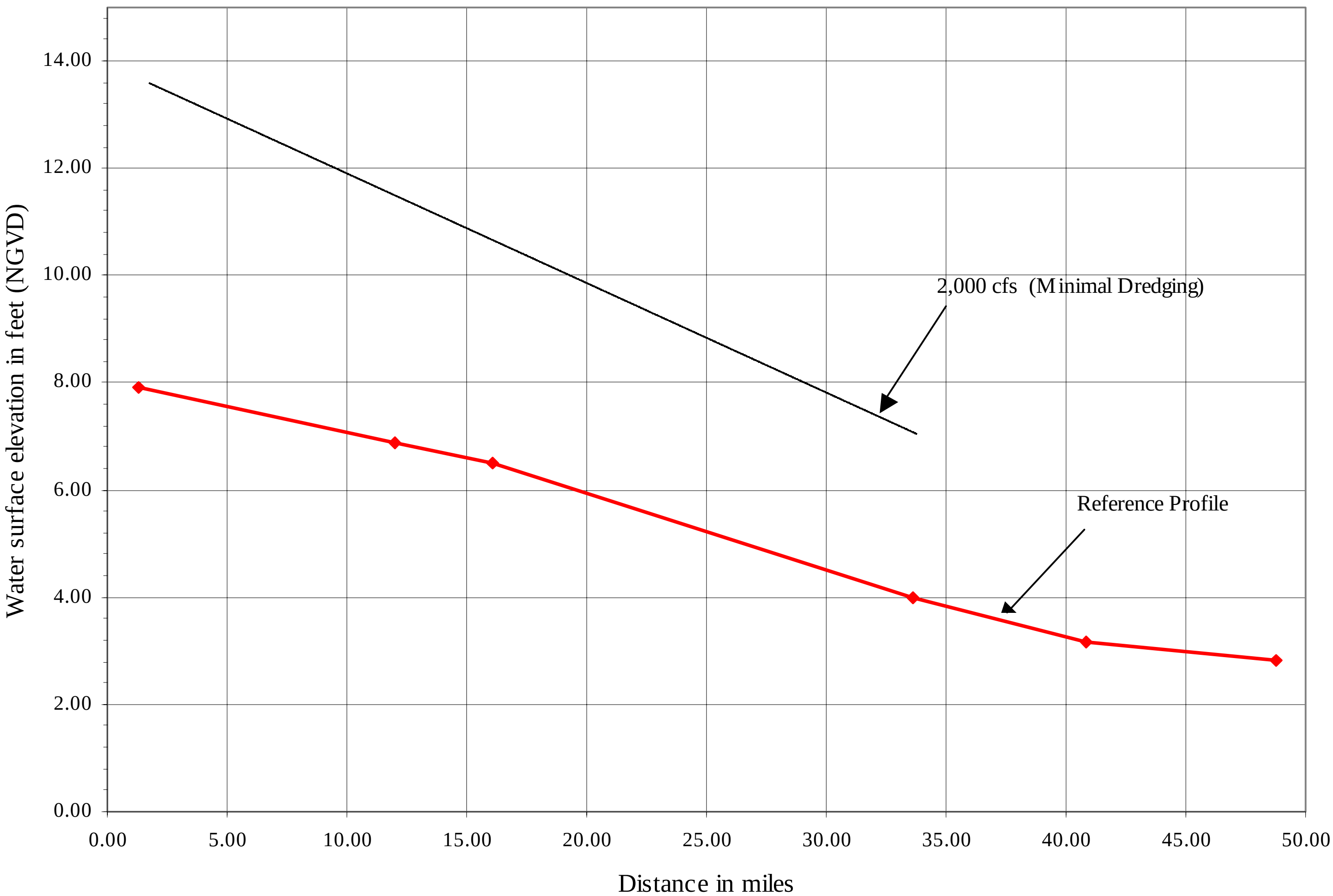
- No comparison is made to the original 2,000 cfs project, for two reasons. First, the costs of that project are not known, for reasons discussed in Section 6.3.1. Second, wetlands benefits also are not known, and would probably be increased if there were a reevaluation, because consideration would be given to a larger project area than was included in the original WVA review.

The resulting estimates of cost-effectiveness have been rounded off, to reflect their approximate nature, and are provided solely for the purpose of comparisons among Bayou Lafourche alternatives, and not for comparison to other CWPPRA projects. The values can be refined when the final cost estimates for the optimized project become available.

Alternative	**AAHUs**	**First cost $million**	**Cost/AAHU $thousands**	**O&M costs $million**	**O&M $Cost/AAHU**
Optimized project	784	37	47	0.6	750
1000 cfs siphon	392	26	66	0.3	765
1000 cfs new diversion	784	42	54	0.6	750
780 cfs diversion	564	27	48	0.5	900
660 cfs diversion	439	30	68	0.4	900
560 cfs diversion	345	19	55	0.3	900
340 cfs diversion	125	5	40	0.2	1600

Based on this simple comparison, no alternative is clearly superior to the optimized project, and most options appear to be less cost-effective. The perspective on any alternative could vary depending on cost-share arrangements.

Figure 6.3-1. Water level impact of 2,000 cfs diversion



PRELIMINARY: DRAFT

Table 6.3-1. Cost estimate for the original 2,000 cfs project

Source: CEEC, 1995.

2,000 cfs siphon project			**Cost**
I. Siphon pipes, supporting structures, and cross-overs (Mississippi River to Bayou Lafourche).			
1. Mobilization and demobilization			$340,000
2. Site preparation and clean-up			$250,000
3. Receiving structure on river			
a. Dolphin, fender system		$150,000	
b. Pipe supports		$125,000	
c. Couplings, supports		$125,000	
d. Excavation, backfilling		$125,000	
e. Rip-rap		$15,000	
f. Pipes (640 linear feet)		$175,000	
	Subtotal	$715,000	
4. Pipes (river to bayou: 9,520 linear feet)			$1,900,000
5. Highway crossings (two)			$540,000
6. Discharge pond (concrete box, bank stabilization)			$1,250,000
7. Electrical, navigation aids, vacuum system, painting			$250,000
	Subtotal		$5,245,000
Contingency (approx. 10% of construction cost)			$524,000
	Subtotal		$5,769,000
Engr., insp., & additional services (approx. 20%)			$1,111,000
		TOTAL	$6,880,000
II. Bayou Lafourche modifications and improvements			
1. LA 3089 bridge replacement			
a. Mobilization and demobilization		$150,000	
b. Temporary route		$250,000	
c. Excavation, fill		$100,000	
d. Two-lane bridge		$1,250,000	
e. Intersections		$250,000	
	Subtotal		$2,000,000
2. Railroad bridge			
a. Mobilization and demobilization		$125,000	
b. Excavation, removal		$150,000	
c. Bridge		$950,000	
d. Bank stabilization		$150,000	
	Subtotal		$1,375,000
3. Bank stabilization (first 2,500 ft)			$650,000
4. Dredging on Bayou Lafourche			$3,300,000
5. Flow restriction structures			
a. Mobilization and demobilization			$50,000
b. Two weir structures			$300,000
c. Structure at Lockport			$750,000
	Subtotal		$1,100,000
	Construction Cost Subtotal		$8,425,000
Contingency (approx. 10% of construction cost)			$842,000
	Subtotal		$9,267,000
Engr., insp. & additional services (approx. 20%)			$1,853,000
		TOTAL	$11,120,000

Table 6.3-2. Fully funded cost estimate for the original 2,000 cfs project

The method for calculating fully funded costs is discussed in Section 5.8.1.

2,000 cfs, fully funded	**Cost**
First construction costs	$14,126,731
Contingency (25% of construction costs)	$3,531,683
Engineering & design	$1,395,927
Easements & land rights	$217,789
Federal supervision & administration	$361,611
Supervision & inspection	$1,766,366
Total First Costs	$21,400,107
Operation & Maintenance	$2,231,237
Monitoring	$855,992
Fully Funded Project Costs	$24,487,336

Table 6.3-3. Costs for a 1,000 cfs siphon project

	1,000 cfs siphon project	**Cost**	**Source**
1	New 660 cfs diversion station	$2,961,667	Table 6.3-1, adjusted to smaller (one-third size) facility
2	Upgrade 340 cfs pumps	$0	Not included in this alternative
3	Highway & railway crossing	$0	Same as optimized project
4	Sand trap	$118,063	50% of optimized project
5	Dredging	$10,731,235	Same as optimized project
6	Utility replacements	$1,498,000	Same as optimized project
7	Water management structures	$1,770,194	Same as optimized project
8	Bank protection	$650,000	Same as optimized project
9	Land rights	$0	Same as optimized project
10	Monitoring system	$42,000	Same as optimized project
11	CONSTRUCTION SUBTOTAL	$17,771,158	
12	Contingency (25% of construction)	$4,442,790	See Section 5.4.1
13	Design, supervision (16% of construction)	$2,843,385	See Section 5.4.2
14	Agencies (3% of construction)	$533,135	See Section 5.4.3
15	Compliance (1% of construction)	$177,712	See Table 5.4-1 and Section 5.4.4
16	TOTAL	$25,768,179	Does not reflect cost-share arrangements
17	Labor & overhead	$0	Same as optimized project
18	Energy/repairs 660 cfs plant	$0	Not applicable
19	Incremental O&M, 340 cfs plant	$135,000	Same as optimized project
20	Channel management	$92,000	Tables 5.4-1 & 5.4-3, less pumping/maintenance for 660 cfs plant and less 50% of sand trap maintenance
21	CWPPRA monitoring	$29,418	Same as optimized project
22	Other O&M	$0	Same as optimized project
23	ANNUAL O&M SUBTOTAL	$256,418	

Table 6.3-4. Cost estimate for 1,000 cfs pump/siphon station

Source: P&O, 1997

1,000 cfs pump/siphon station	**Cost**
Site preparation (mobilization, utilities, demolition)	$1,325,000
Intake structure (structure, intake lines, dolphin, revetment repair, excavation)	$1,617,000
Intake lines (dike const., dewatering, pile supports, intake lines, backfill)	$2,136,000
Pump pit structure (cofferdam, dewatering, concrete, building, crane, catwalk)	$1,965,000
Mechanical & electrical (pumps, motors, formed suction intake, vacuum system)	$3,885,000
Discharge pipes (pile supports, excavation, bedding, pipe, backfill)	$2,449,000
Discharge structure (cofferdam, dewatering, excavation, stilling basin, riprap)	$615,000
TOTAL	$13,992,000

Table 6.3-5. Costs for a 1,000 cfs pump and siphon project, all new facilities

1,000 cfs pumps project		**Cost**	**Source**
1	New 1000 cfs diversion station	$13,992,000	Table 6.3-4
2	Upgrade 340 cfs pumps	$0	Not included in this alternative
3	Highway & railway crossing	$0	Same as optimized project
4	Sand trap	$236,125	Same as optimized project
5	Dredging	$10,731,235	Same as optimized project
6	Utility replacements	$1,498,000	Same as optimized project
7	Water management structures	$1,770,194	Same as optimized project
8	Bank protection	$650,000	Same as optimized project
9	Land rights	$0	Same as optimized project
10	Monitoring system	$42,000	Same as optimized project
11	CONSTRUCTION SUBTOTAL	$28,919,554	
12	Contingency (25% of construction)	$7,229,888	See Section 5.4.1
13	Design, supervision (16% of construction)	$4,627,129	See Section 5.4.2
14	Agencies (3% of construction)	$867,587	See Section 5.4.3
15	Compliance (1% of construction)	$289,196	See Table 5.4-1 and Section 5.4.4
16	TOTAL	$41,933,353	Does not reflect cost-share arrangements
17	Labor & overhead	$0	Same as optimized project
18	Energy/repairs 1000 cfs plant	$435,000	50% greater than optimized project.
19	Incremental O&M, 340 cfs plant	$0	Not applicable to entirely new plant
20	Channel management	$142,000	Same as optimized project
21	CWPPRA monitoring	$29,418	Same as optimized project
22	Other O&M	$0	Same as optimized project
23	ANNUAL O&M SUBTOTAL	$606,418	

Table 6.3-6 Costs of 780 cfs pump and siphon project

	Item	Cost Phase I	Phase 2	Total	Discussion
1	New 440 cfs diversion station	$0	$7,407,750	$7,407,750	75% of cost for optimized project, based on two pumps instead of three
2	Upgrade 340 cfs pumps	$720,000	$0	$720,000	Same as optimized project
3	Highway & railway crossing	$0	$0	$0	Same as optimized project
4	Sand trap	$188,900	$0	$188,900	80% of cost for optimized project, based on smaller diversion rate
5	Dredging	$534,375	$6,627,959	$7,162,334	Phase II = 65% of optimized project, based on smaller diversion rate
6	Utility replacements	$200,000	$843,700	$1,043,700	Phase II = 65% of optimized project, based on smaller diversion rate
7	Water management structures	$1,770,194	$0	$1,770,194	Same as optimized project
8	Bank protection	$0	$650,000	$650,000	Same as optimized project
9	Land rights	$0	$0	$0	Included in individual items
10	Monitoring system	$42,000	$0	$42,000	Same as optimized project
	Construction costs	$3,455,469	$15,529,409	$18,984,878	Represents "FIRST COSTS" for project, excluding contingency and engineering.
11	Contingency	$691,094	$3,882,352	$4,573,446	Proportions same as for optimized project
12	Design, supervision	$552,875	$2,484,705	$3,037,580	Proportions same as for optimized project
13	Agencies	$103,664	$465,882	$569,546	Proportions same as for optimized project
14	Compliance	$0	$155,294	$155,294	Proportions same as for optimized project
15	**Total first costs**	$4,803,102	$22,517,643	$27,320,745	Does not reflect cost-share arrangements.
16	Labor & overhead	$0	$0	$0	Assumed part of existing FWD operations
17	Energy/repairs 440 cfs plant	$0	$203,000	$203,000	70% of optimized project, based on reduced plant size, diversion rate
18	Incremental O&M	$135,000	$0	$135,000	Same as optimized project
19	Channel management/maint.	$42,000	$80,000	$122,000	Phase II = 80% of optimized project, based on reduced dredging reuirement
20	CWPPRA monitoring	$29,418	$0	$29,418	Same as optimized project
21	Other O&M	$0	$0	$0	Assumed part of existing FWD operations
22	**Total annual costs**	$206,418	$283,000	$489,418	

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Table 6.3-7. Costs for a 660 cfs pump and siphon project, all new facilities

660 cfs pump and siphon project		**Cost**	**Source**
1	New 660 cfs diversion station	$9,877,000	Same as optimized project, Phase II
2	Upgrade 340 cfs pumps	$0	Not included in this alternative
3	Highway & railway crossing	$0	Same as optimized project
4	Sand trap	$165,288	70% of optimized project
5	Dredging	$7,137,802	70% of optimized project
6	Utility replacements	$908,600	Phase I of optimized project + 70% of Phase II
7	Water management structures	$1,770,194	Same as optimized project
8	Bank protection	$650,000	Same as optimized project
9	Land rights	$0	Same as optimized project
10	Monitoring system	$42,000	Same as optimized project
11	CONSTRUCTION SUBTOTAL	$20,550,883	
12	Contingency (25% of construction)	$5,137,721	See Section 5.4.1
13	Design, supervision (16% of construction)	$3,288,141	See Section 5.4.2
14	Agencies (3% of construction)	$616,527	See Section 5.4.3
15	Compliance (1% of construction)	$205,509	See Table 5.4-1 and Section 5.4.4
16	TOTAL	$29,798,781	Does not reflect cost-share arrangements
17	Labor & overhead	$0	Same as optimized project
18	Energy/repairs 660 cfs plant	$290,000	Same as Phase II of optimized project
19	Incremental O&M, 340 cfs plant	$0	Not applicable to entirely new plant
20	Channel management	$112,000	Maintenance dredging = 70% of optimized project
21	CWPPRA monitoring	$29,418	Same as optimized project
22	Other O&M	$0	Same as optimized project
23	ANNUAL O&M SUBTOTAL	$431,418	

Table 6.3-8 Costs of 560 cfs pump and siphon project

		Cost			
	Item	**Phase I**	**Phase 2**	**Total**	**Discussion**
1	New 220 cfs diversion station	$0	$4,938,500	$4,938,500	50% of cost for optimized project, based one pump instead of three
2	Upgrade 340 cfs pumps	$720,000	$0	$720,000	Same as optimized project
3	Highway & railway crossing	$0	$0	$0	Same as optimized project
4	Sand trap	$141,675	$0	$141,675	60% of cost for optimized project, based on smaller diversion rate
5	Dredging	$534,375	$3,568,901	$4,103,276	Phase II = 35% of optimized project, based on smaller diversion rate
6	Utility replacements	$200,000	$454,300	$654,300	Phase II = 35% of optimized project, based on smaller diversion rate
7	Water management structures	$1,770,194	$0	$1,770,194	Same as optimized project
8	Bank protection	$0	$650,000	$650,000	Same as optimized project
9	Land rights	$0	$0	$0	Same as optimized project
10	Monitoring system	$0	$0	$0	Same as optimized project
	Construction costs	$3,366,244	$9,611,701	$12,977,945	Represents "FIRST COSTS" for project, excluding contingency and engineering.
11	Contingency	$673,249	$2,402,925	$3,076,174	See Section 5.4.1
12	Design, supervision	$538,599	$1,537,872	$2,076,471	See Section 5.4.2
13	Agencies	$100,987	$288,351	$389,338	See Section 5.4.3
14	Compliance	$0	$96,117	$96,117	See Table 5.4-1 and Section 5.4.4
15	**Total first costs**	$4,679,079	$13,936,966	$18,616,046	Does not reflect cost-share arrangements.
16	Labor & overhead	$0	$0	$0	Same as optimized project
17	Energy/repairs 220 cfs plant	$0	$36,000	$36,000	40% of optimized project, based on reduced plant size, diversion rate
18	Incremental O&M	$135,000	$0	$135,000	Same as optimized project
19	Channel management/maint.	$42,000	$60,000	$102,000	Phase II = 60% of optimized project, based on reduced dredging reuirement
20	CWPPRA monitoring	$29,418	$0	$29,418	Same as optimized project
21	Other O&M	$0	$0	$0	Same as optimized project
22	**Total annual costs**	$206,418	$96,000	$302,418	

6.4 CANCIENNE CANAL ALTERNATIVE

Increasing the amount of freshwater introduced from the Mississippi River results in progressively greater dredging costs for channel enlargement and maintenance, and increasingly insurmountable constraints related to development along the channel banks. These constraints are, however, most severe along the upper reaches of Bayou Lafourche. They could be partially overcome if freshwater were transferred at a downstream location into Bayou Lafourche from the adjacent watersheds. This alternative evaluates, primarily, the feasibility of using local runoff from the Verret Basin to the west of Bayou Lafourche by pumping water from Lake Verret into Bayou Lafourche via the Cancienne Canal (Figure 6.4-1). The emphasis on this alternative for evaluation derives in part from its relationship to proposed flood control measures for the Verret Basin as part of the U.S. Army Corps of Engineers, New Orleans District's (USACE/NOD) Morganza to the Gulf Project.

6.4.1 Alternative sources of freshwater and sediments

A significant increase in the freshwater discharge of Bayou Lafourche can be achieved through the introduction of additional freshwater from three sources, individually or combined. These sources are:

1. the Mississippi River at the head of Bayou Lafourche,

2. the Barataria Basin northward of approximately Highway 90, between the natural levees of Bayou Lafourche and the Mississippi River levee, and

3. the Verret Basin, the area confined between the natural levee of Bayou Lafourche and the East Guide Levee of the Atchafalaya Basin Floodway to the west.

The Mississippi River provides a source of fine grained materials that can be transported effectively through the Bayou Lafourche channel to the lower Barataria and Terrebonne estuaries. Clay concentrations in the Mississippi River are typically from 125 to 150 mg/l (USACE, 1990). The introduction of Mississippi River water into Bayou Lafourche is entirely supplemental, and would augment the freshwater and sediment presently supplied directly to the estuaries through local runoff and river diversions. Diversion from the Mississippi River through pumps would ensure a continuous freshwater supply during periods of precipitation deficits and high salinities in the estuary during the late summer and fall seasons.

Use of the upper Barataria Basin as a water source would involve withdrawal from the area northward of approximately Highway 90, between the natural levees of Bayou Lafourche and the Mississippi River levee. Freshwater in this area is derived entirely from local rainfall and runoff. During periods of heavy rainfall and sustained southerly winds with resultant high coastal water levels, runoff is ponded in the upper Barataria Basin and local flooding occurs. This condition is most prevalent during the spring season. Withdrawal of freshwater from the upper Barataria Basin thus would provide flood protection benefits during part of the year.

The absence of river-derived freshwater in the upper Barataria Basin, coupled with a land cover of primarily cypress-tupelo swamps, results generally in low concentrations of suspended sediments in the area's water bodies. Concentrations are higher during major rainfall events and associated runoff from adjacent, developed natural levee ridges. Withdrawal of water for introduction into Bayou Lafourche would diminish the freshwater volume stored in the upper estuary, and not add significantly to the sediment load of Bayou Lafourche. Furthermore, during periods of precipitation deficits and low river stages, freshwater withdrawal could induce an equivalent water transfer from the lower to the upper Barataria Basin. This could have local, adverse effects on freshwater wetland habitats, depending on future conditions related to the implementation of proposed and planned flood control and diversion measures. An additional consideration is the absence of a suitable water collection and delivery system in the upper Barataria Basin for the transfer of water into Bayou Lafourche.

Use of the Verret Basin as a supplementary source for water transfer into Bayou Lafourche is less constrained. Although connected to the Terrebonne estuarine system, the Verret Basin is an enclosed, freshwater basin and contains a large lake in close proximity to Bayou Lafourche. The use of this lake, Lake Verret, as a freshwater source could be achieved via the Cancienne Canal.

Cancienne Canal connects Lake Verret with Bayou Lafourche near the community of Labadieville (Figure 6.4-1). The Verret Basin is dependent for freshwater input primarily on local rainfall and runoff but with provision for supplemental input from the Atchafalaya River via the Bayou Sorrel Lock. Outflow from the basin is constrained during much of the year by elevated water levels at the outlet channel. The high water levels are the result of eastward diversion of Atchafalaya River flow into the Terrebonne estuary. This condition suggests that any reduction in outflow from the Verret Basin, as a result of water transfer to the lower estuary via Bayou Lafourche, will be fully restored by Atchafalaya River flows.

Use of the Verret Basin as an alternative or supplemental water source for Bayou Lafourche could also complement the flood protection measures presently being considered for the basin by the USACE/NOD as part of its Morganza to the Gulf Project. In that effort, the feasibility of reducing flooding in the Verret Basin is being determined. A reduction in water levels would be achieved by placing a structure in the basin outlet-channel to control Atchafalaya River backwater effects, and installing one or more pumps to remove excess runoff from the basin.

Suspended sediment concentrations in Lake Verret are generally low. Higher concentrations do occur, however, when flow is permitted into the Verret basin from the Atchafalaya Basin Floodway via the Bayou Sorrel Lock, when strong winds cause bottom disturbance by waves in this shallow water body, or after periods of intense rainfall and associated runoff. Data collected quarterly by the U.S. Geological Survey in 1985 and 1986 shows suspended sediment concentrations for Lower Grand River at Bayou Sorrel in the order of 50 to 100 mg/l. Louisiana Department of Environmental Quality (DEQ) data show an average concentration of 30 mg/l for suspended solids in Lake Verret as compared to 117 mg/l for upper Bayou Lafourche (Waldon, 1998). The generally low concentrations in Lake Verret are the result of extensive swamp and bottomland hardwood environments that separate the lake from agricultural development to the east and north, and of low surface water gradients that reduce runoff rates through, and retain sediments in, agricultural drainage channels. Higher concentrations of suspended load could potentially be attained through increased introduction of Atchafalaya River water through the Bayou Sorrel Lock within the constraints of flood control and aquatic habitat quality.

6.4.2 Source combination

Because the objective of increasing flow in Bayou Lafourche is to reduce coastal wetland loss, the Mississippi River must be considered the preferred water source because of the greater associated sediment benefits. While salinities and tidal hydraulics of the lower estuary would be affected equally by water introduction from either one of the alternative freshwater sources, the river source will provide a much greater quantity of readily transportable, fine grained sediments for reducing the rate of relative subsidence in the receiving area. At the same time, consideration must be given to potentially adverse effects resulting from the introduction of Mississippi River water into Bayou Lafourche.

The coarse grained sediments associated with diverted Mississippi River water and the resultant sedimentation in the upper Bayou Lafourche channel will require maintenance dredging and dredged material disposal. Both are constrained by access to the channel and development along the channel. The same constraints apply to initial requirements for channel enlargement through dredging in order to prevent an increase in water levels. Initial hydrologic modeling results (Section 4.3) suggest that cost and water level constraints will become severe for discharges substantially in excess of 1,000 cfs.

The requirements for channel modification, maintenance dredging, and spoil disposal for the upper reach of Bayou Lafourche could be reduced by diverting less than 1,000 cfs of Mississippi River water at the head of Bayou Lafourche, and adding water from either or both the Barataria and Verret Basins to bring the total flow to 1,000 cfs. Of these two basins, the Verret Basin is considered the preferred alternate or supplemental source for several reasons. These include the presence of Lake Verret as a reservoir, the connection with Bayou Lafourche provided by the Cancienne Canal, the likely abatement of reduced outflow from the basin by the Atchafalaya River, a congruence with proposed flood control measures, and the potential for increasing suspended sediment concentrations through inflow from the Atchafalaya Basin Floodway.

For the above reasons it was decided to evaluate at this time only the requirements, general costs, and primary impacts of combining Mississippi River flow and Verret Basin runoff as supplemental water sources. A combination of equal supplements was selected under which 500 cfs would be introduced from the Mississippi River at the head of Bayou Lafourche and augmented by 500 cfs from Lake Verret to a total of 1,000 cfs. Both discharges would be continuous. The Lake Verret water would be transferred via the Cancienne Canal (Figure 6.4-2) and pumped into Bayou Lafourche.

An alternative scenario, not requiring channel modification, would be maintaining the present 340 cfs capacity at the Mississippi River, supplemented by pumped discharge from the Verret Basin to 1,000 cfs or the extent practicable. A scenario under which Mississippi River water is replaced entirely by 1,000 cfs from Lake Verret was not evaluated because the introduction of sediments is considered a vital component of the proposed project.

6.4.3 Water level considerations

Lake Verret. Water levels in the Verret Basin are subject to seasonal variation. The primary causes of water level variation are backwater conditions governed by Atchafalaya River discharges and rainfall within the Verret Basin. Conditions are exemplified by Figure 6.4-3, which shows average water levels for the period of 1986 through 1990 and daily water levels for the years 1987 and 1989, respectively. Typically, high Atchafalaya River discharges and large precipitation surpluses combine during the spring to yield water levels of about 2 to 3 feet above National Geodetic Vertical Datum (NGVD). Although frontal passages and associated, strong, northerly winds may lower water levels occasionally to sea level during the winter, water levels are normally lowest, about 1 foot NGVD, during the late summer and fall, when low precipitation surpluses and low Mississippi and Atchafalaya River discharges coincide. This is also the period when the water salinities in the Barataria and Terrebonne estuaries are highest and the greatest need exists for freshwater introduction. Accordingly, transfer capacity from Lake Verret must be sufficient during low water conditions in the Verret Basin. For evaluation purposes, a minimum water level of 0.0 ft NGVD was used.

Bayou Lafourche. Bayou Lafourche presently receives water from the Mississippi River for water supply purposes at rates up to 340 cfs. Additionally, water levels are affected by sustained southerly winds and related high water levels in the adjacent estuaries, and to some extent local drainage. Water levels of Bayou Lafourche at the Cancienne Canal are typically about 4 ft NGVD. The proposed increase in discharge of Bayou Lafourche is not anticipated to change water levels significantly, either upward or downward. Accommodation of the larger discharge without altering water levels substantially is to be accomplished through channel enlargement by dredging. The stage difference between the Cancienne Canal and Bayou Lafourche is expected to be in the order of 3 to 4 feet, water levels being higher in Bayou Lafourche. Accordingly, water transfer from the Verret Basin cannot be accomplished through gravity flow but will require pumping from the Cancienne Canal.

6.4.4 Cancienne Canal improvements

Improvements for the Cancienne Canal were evaluated using the HEC-RAS, v.2.1, model under the assumption that flow from the Verret Basin toward Bayou Lafourche would be induced by a 500 cfs pumping plant at the junction of the Cancienne Canal and Bayou Lafourche. Present cross-section geometry was obtained at 16 locations along the 8-mile long canal (CEI, 1997b). Individual cross-section locations are identified in Figure 6.4-2. Locations are numbered 2 through 17 from Bayou Lafourche toward Lake Verret. An additional station (#1) was added at Bayou Lafourche for computational purposes.

Present channel conditions of the Cancienne Canal are illustrated in Figure 6.4-4. Bottom elevations along a major portion of the canal (stations 1 to 7) are in the vicinity of 0 ft NGVD and decrease to about –4 ft NGVD near Lake Verret. The shallow depths in the eastern half of the canal are the result of sediment deposition from agricultural runoff and the presence of a weir structure that prevents water exchange between Bayou Lafourche and the Cancienne Canal. Bank elevations range from 0 to 7 ft NGVD where the canal is surrounded by swamp and bottomland hardwood (stations 17 to 10) and reflect dredged material deposition associated with initial canal construction and possibly subsequent maintenance. Bank elevations increase gradually to 14 ft NGVD from station 10 toward Bayou Lafourche (station 1) as the canal crosses the natural levee ridge. The canal top-width is approximately 70 ft where it is bounded by agricultural fields and natural levee deposits, and increases to 120 feet within the overflow swamp area surrounding Lake Verret.

Computations using HEC-RAS suggest that conveyance requirements under stable channel conditions would be satisfied by a channel having a bottom width of 45 feet and an invert elevation of -8.0 ft NGVD. Based on present channel and bank conditions of the Cancienne Canal, computations specified a bank slope of 4:1 (horizontal/vertical). Assumptions included a Manning roughness coefficient of 0.035. Figure 6.4-4 shows the computed surface water profiles, together with present bank elevations, for the stated channel characteristics and draw-down levels at the pump of 2.5 and 0 ft

NGVD. Corresponding water levels in Lake Verret are 0 and 1 ft respectively. Computations showed average flow velocities to range from 0.70 ft/sec to 1.30 ft/sec, depending on Lake Verret water levels and draw-down at the pump, with surface-water slopes ranging from 0.000025 to 0.000062.

The present and required channel dimensions are shown together in Figure 6.4-5. Water levels would range between –2.5 and 0 ft NGVD at Station 1, and between 0 and +1 ft at Station 17. The top width of the required channel changes considerably from Lake Verret toward Bayou Lafourche, because of the increase in bank elevations in that direction from 0 to +14 ft NGVD. Accordingly, maintaining a bank slope of 4:1 would result in top width ranging from 100 ft near Lake Verret to 180 ft near Bayou Lafourche. These dimensions would result in a dredging and dredged material disposal requirement of 1.9 million cubic yards of material.

6.4.5 Direct impacts

The canal dimensions required in order to accommodate 500 cfs under stable conditions and gradually varied flow would necessitate substantial widening and deepening of the canal as mentioned. The canal banks are vegetated with bottomland hardwood species. Along the western one third of the canal (Stations 10-17), vegetation is contiguous with the cypress-tupelo swamp and bottomland hardwood vegetation that surround Lake Verret (Figures 6.4-6, 7 and 8). Within the cleared agricultural areas (Stations 1-11) bottomland hardwood vegetation of the canal banks forms a buffer zone, approximately 20-feet wide, between the canal and agricultural fields (Figure 6.4-9). Widening of the canal as required would eliminate the vegetated buffer zone and remove approximately 68 acres of bottomland hardwood because of the increase in the canal footprint. Canal widening east of Station 10 would remove from production approximately 65 acres of farm land.

Allowance for dredged material disposal along the canal would further increase the footprint of the project. Stacking dredged material to an elevation of 8 ft above the present bank surface with side slopes of 1:1 would impact approximately 40 additional acres of bottomland hardwood and cypress tupelo swamp, and 113 acres of farmland, bringing the total disturbance for those two land covers to 108 acres and 178 acres respectively.

A second direct impact concerns recreational buildings along the canal banks (Figure 6.4-10). A concentration of fishing and hunting camps exists in the vicinity of the State Highway 400 bridge crossing at Bayou Crab, with additional camps scattered between that location and Lake Verret. Removal of these structures would be required in all cases, unless canal widening would occur predominantly toward the south side. Most camps are located along the north side of the canal.

Further impacts derive from requirements for modification of existing infrastructure. In addition to the fixed bridge of Highway 400 (Figure 6.4-11), the Canal is crossed by the Southern Pacific Railroad (Figure 6.4-12) and by eight gas pipelines. Increasing the canal's conveyance capacity would require replacement of most or all of the pipelines and may require reconstruction of the highway and railroad bridges, depending on bridge foundations.

Where the Cancienne Canal intersects with Bayou Lafourche (Figure 6.4-13), impacts would include widening the top width to 180 feet and construction of a 500 cfs pumping plant. Channel dredging would be required below this point (and above it, if there is a concurrent diversion at Donaldsonville). If there is no diversion at Donaldsonville, a permanent weir would likely be required at this location, above the canal-bayou junction.

A non-structural aspect of concern relates to human health because of the potential adverse impact of canal water on water quality of Bayou Lafourche. A major portion of the natural levee ridge-lands are in agricultural use with sugarcane as the primary crop. These crops are regularly sprayed with herbicides containing atrazine. Atrazine levels in Lake Verret waters have been found to be significantly higher, and occurrence more persistent, than in Mississippi River water (personal communication, Dennis Demcheck, U.S. Geological Survey, 1998). While information is preliminary at this time, and further investigation is being undertaken by the Louisiana Department of Environmental Quality, introduction of water from Lake Verret via the Cancienne Canal could adversely affect the use of Bayou Lafourche as a water supply source. At least four potable water intakes occur along Bayou Lafourche downstream from the Cancienne Canal.

A related concern is the higher organic carbon content of waters from the Verret Basin as a result of the extensive swamp and bottomland hardwood environments. This could potentially raise the cost of meeting potable water standards because of trihalomethane formation when chlorine is used for water treatment.

6.4.6 General costs

While no detailed investigation was performed regarding implementation of a 500-cfs water transfer from the Verret Basin, costs were generally estimated as shown in Table 6.4-1. Cost estimates include a number of assumptions as follows: all known utility lines are assumed to require relocation; widening of the canal would occur toward the south side in order to impact the least number of camps, but even so some of the camps along the north bank (which total between 10 and 20, mainly in the area of the Bayou Crab ridge) may be impacted; no costs are included for bridge modifications.

The above cost estimates represent only part of the total capital outlay required for implementation of a 500-cfs Cancienne Canal alternative. Costs presented in Table 6.4-1 do not include improvements to Bayou Lafourche below the Cancienne Canal, including enlargement of the Bayou Lafourche channel through dredging and removal of the weir at Thibodaux.

Figure 6.4-1. Bayou Lafourche and adjacent freshwater basins

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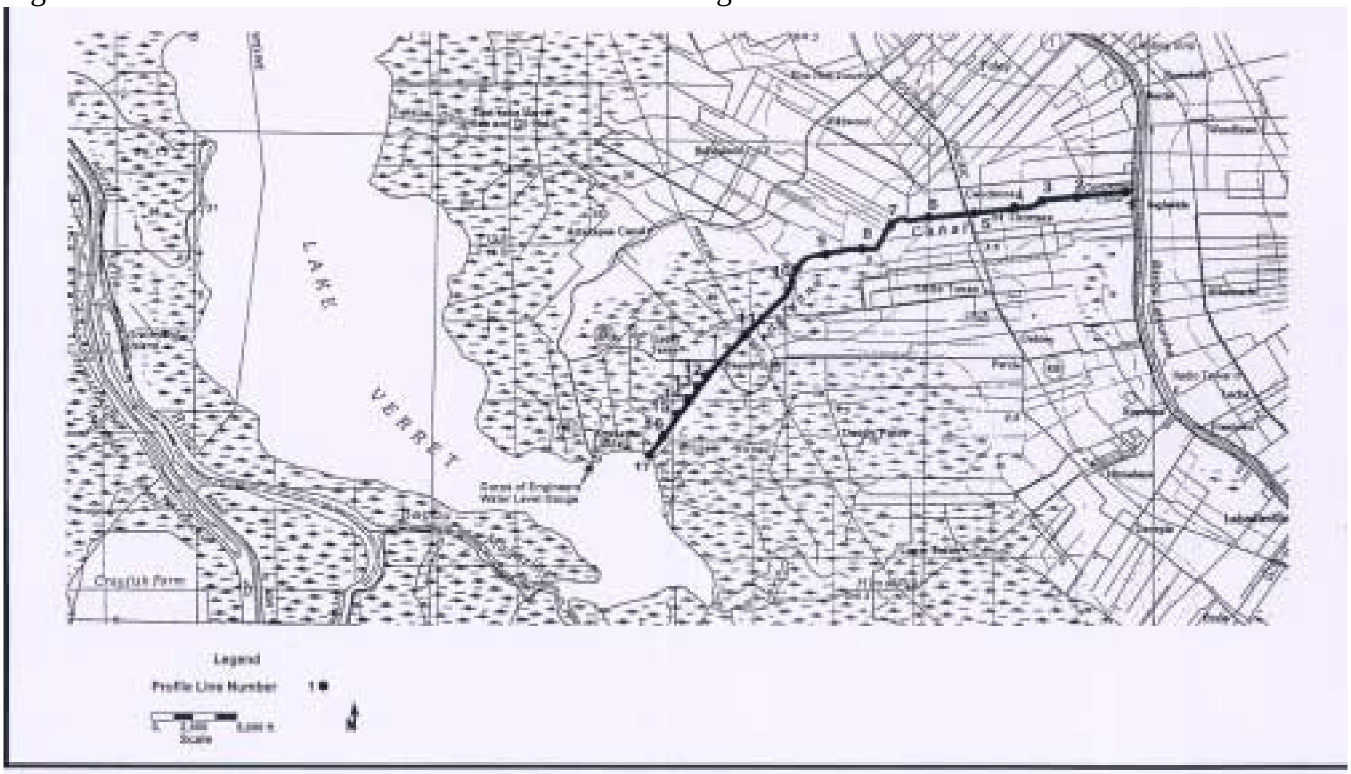
Figure 6.4-2. Location of measured cross-sections along the Cancienne Canal



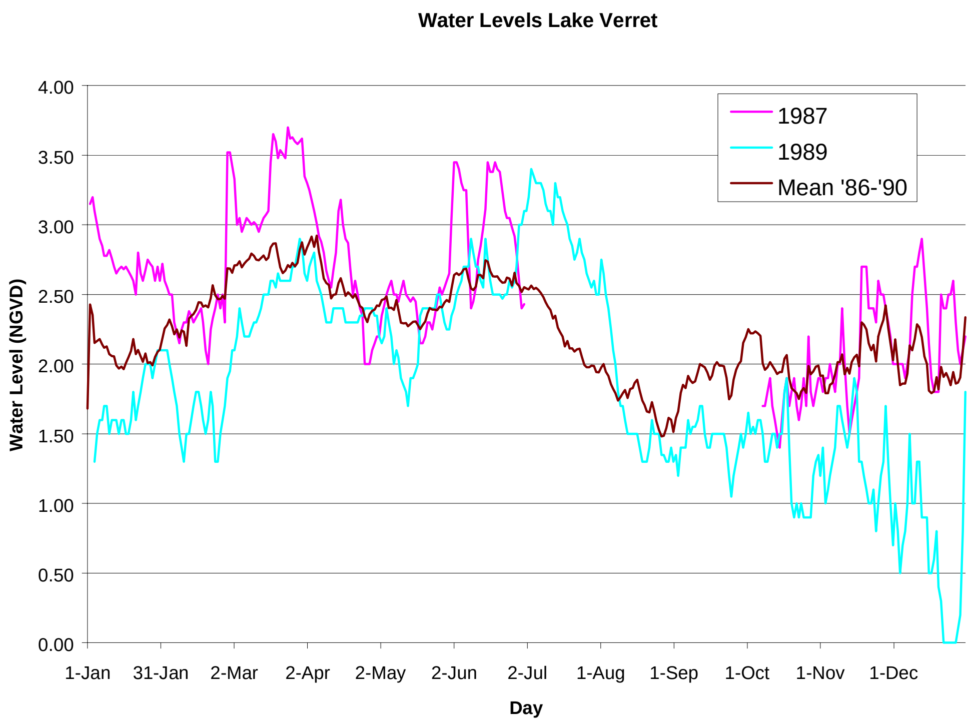
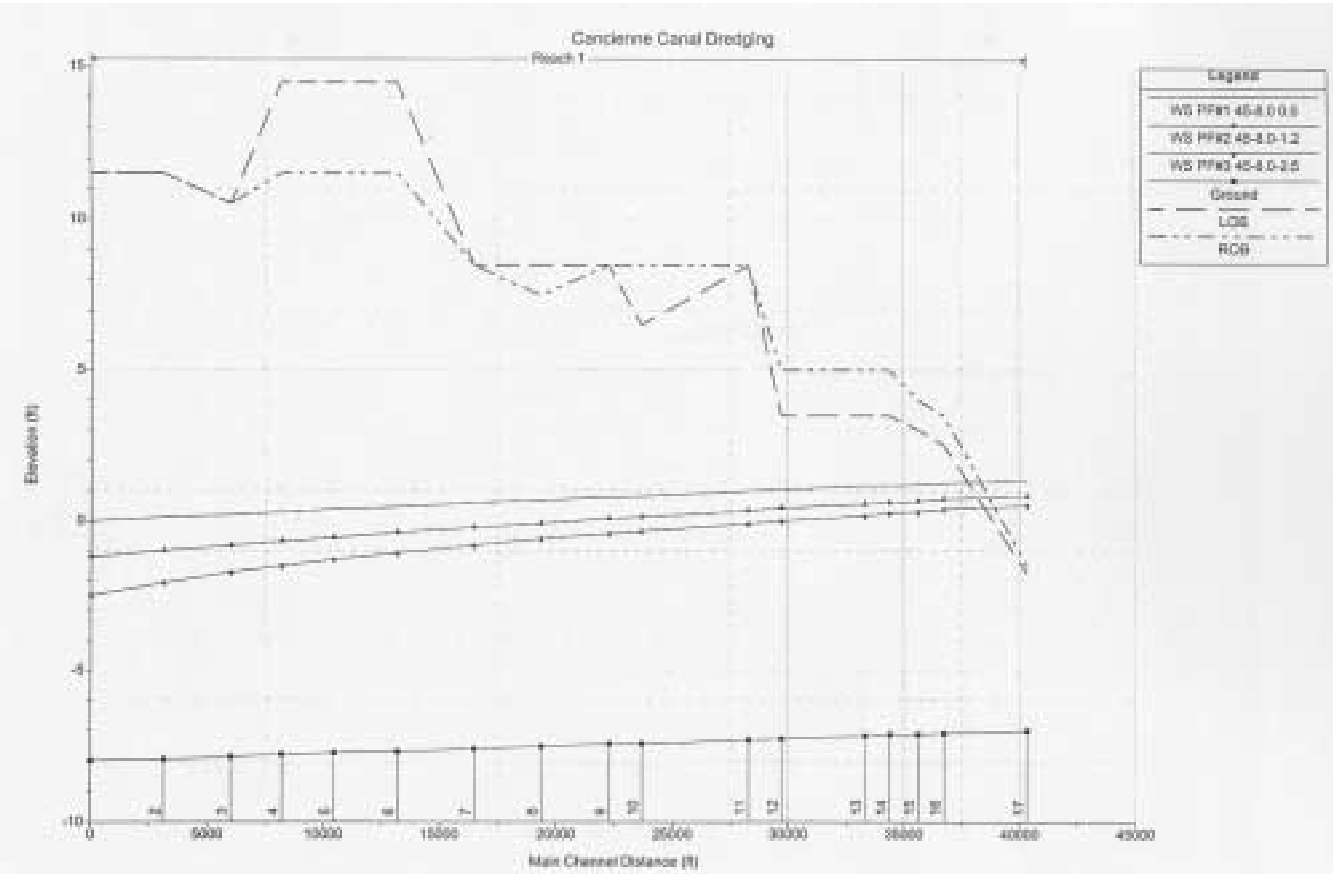


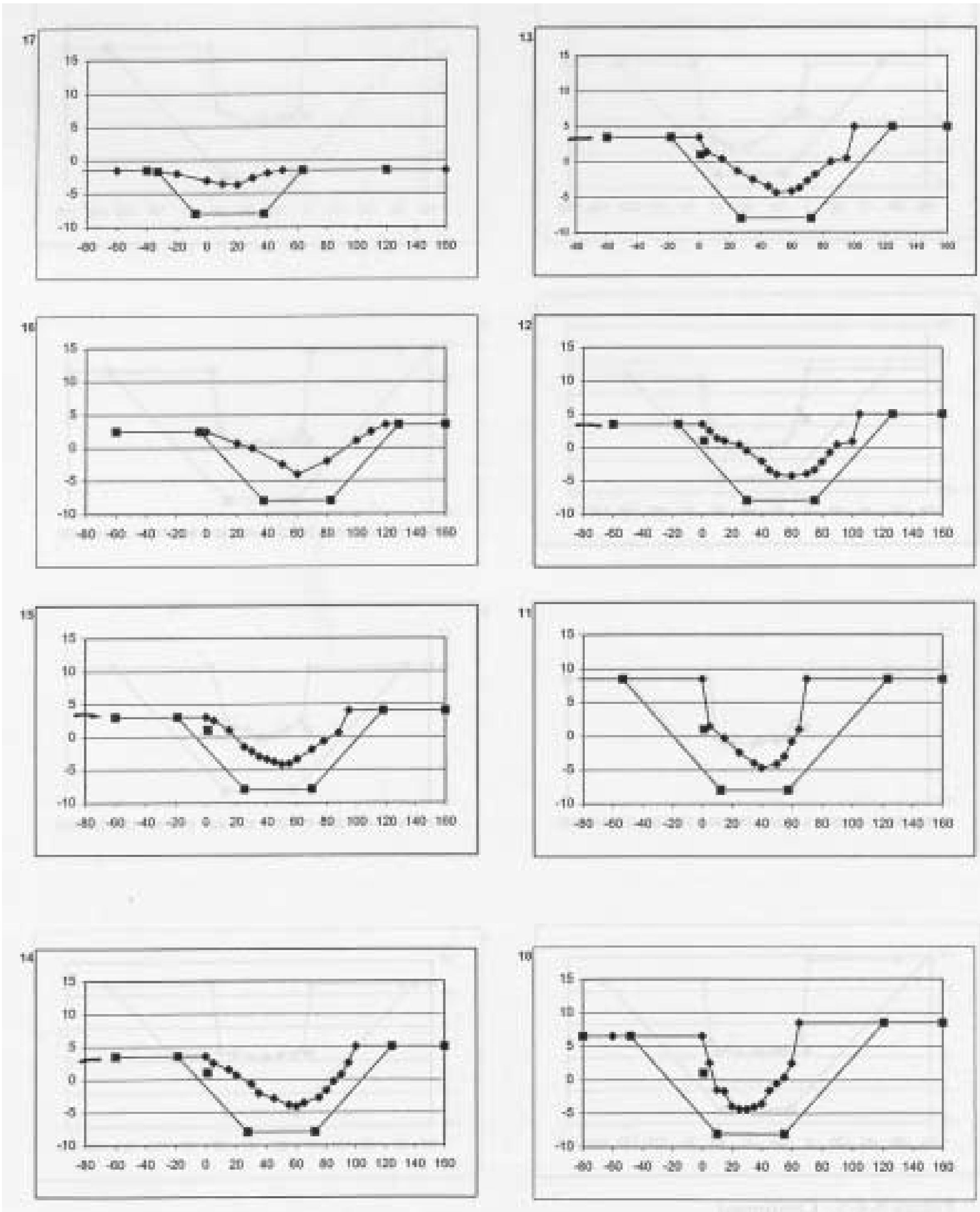
Figure 6.4-3. Seasonal water level variation of Lake Verret

Figure 6.4-4. Computed surface water profiles along Cancienne Canal for a channel having a bottom width of 45 ft and an invert elevation of –8.0 ft NGVD



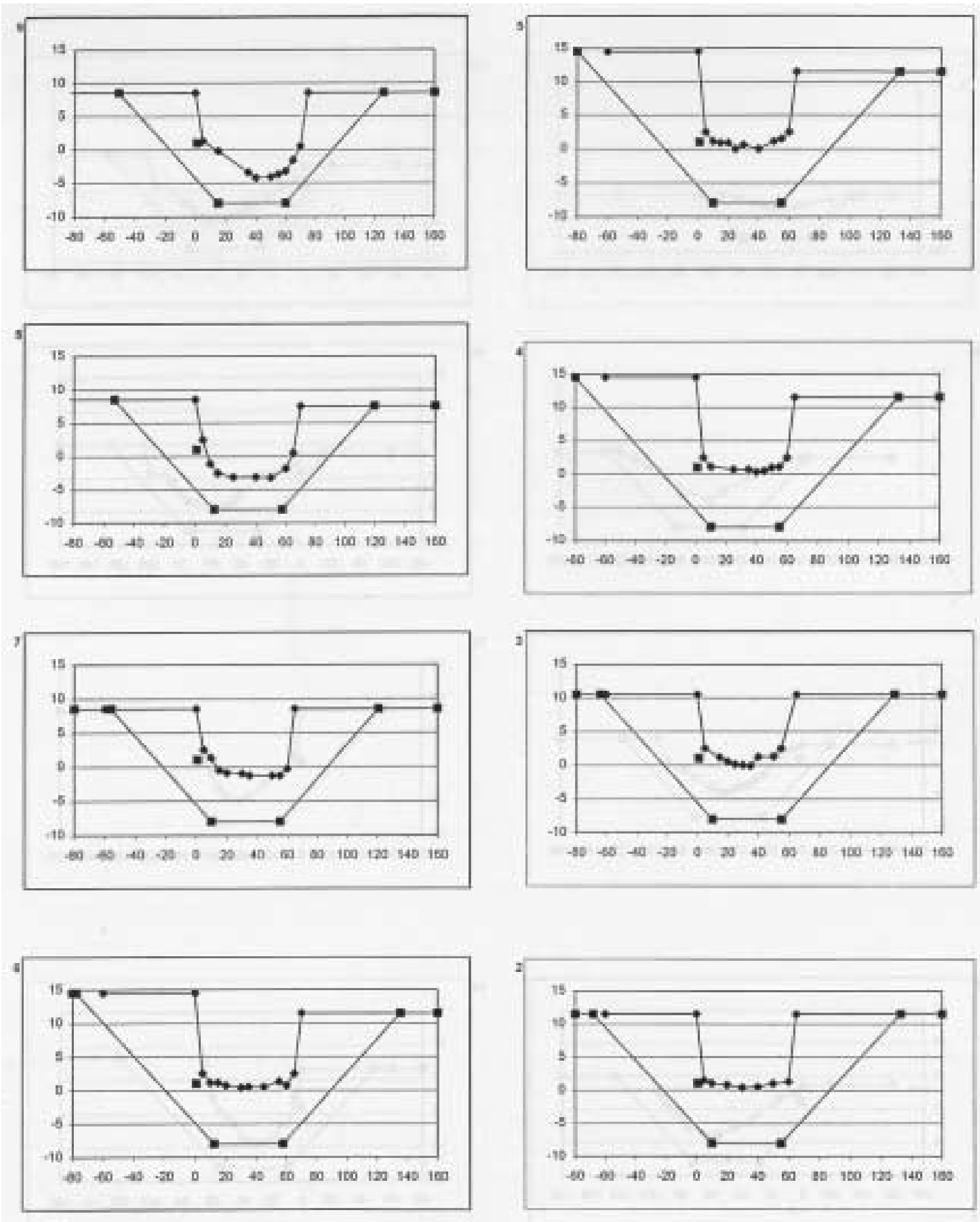
PRELIMINARY: DRAFT

Figure 6.4-5. Present and required cross sections for the Cancienne Canal



PRELIMINARY: DRAFT

Figure 6.4-5. Continued



PRELIMINARY: DRAFT

Figure 6.4-6. Cancienne Canal bank and adjacent cypress swamp at Lake Verret entrance

Figure 6.4-7. Cancienne Canal bank and adjacent cypress-tupelo swamp near Station 13

Figure 6.4-8. Cancienne Canal bank and adjacent bottomland hardwood forest near Station 8

Figure 6.4-9. Cancienne Canal bank and vegetated buffer zone within agricultural lands near Station 3

Figure 6.4-10. Fishing/hunting camps along Cancienne Canal near Station 10

Figure 6.4-11. State Highway 400 bridge across Cancienne Canal near Station 12

Figure 6.4-12. Southern Pacific Railroad bridge near Station 5

Figure 6.4-13. Confluence of Bayou Lafourche and Cancienne Canal

Table 6.4-1. Estimates of Initial Project Cost Elements, Cancienne Canal Alternative

Project Element	Type	Magnitude		Unit Cost	Total cost
Pumping Plant	design and construction	500	cfs		$ 3,000,000
	oper./maint.	20	yr	$ 35,000	$ 700,000
Dredging	clamshell	2,000,000	yd^3	$ 1.5	$ 3,000,000
Right of way	agricultural	178	ac	$ 2,000	$ 356,000
	forest	108	ac	$ 350	$ 37,800
Camps	remove	5	units	$ 20,000	$ 100,000
Gas pipeline	lowering	8	lines	$ 500,000	$ 4,000,000
Total					$11,193,800

7. RESPONSE TO PUBLIC ISSUES AND CONCERNS

7.1 INTRODUCTION

In 1996, EPA prepared and distributed a responsiveness summary that provided answers and comments to questions and concerns raised by citizens at four public scoping meetings held in April-May, 1996. In many cases, EPA's response to a public concern was to indicate that the issue would be considered in the project evaluation. Now that the evaluation has proceeded through the preliminary draft report stage, EPA is able to provide updated responses to the project scoping issues.

In this chapter, the updated responses are organized by topics, using the same categories as for the 1996 report:

7.2 Project scoping and coordination

7.3 Diversion facilities

7.4 Channel function

7.5 Conveyance of dry weather flows

7.6 Conveyance of wet weather flows

7.7 Legal and property issues

7.8 Effects on the marsh

7.9 Alternatives and optimization

7.10 Other

Within each section, the text that summarizes comments is identical to that presented in 1996. The 1996 response is then presented, in finer print, followed by EPA's current response to each comment based on the evaluations set forth in this report, is then presented. There are minor changes in wording in the 1996 responses, for consistency with findings in the current report. For example, in some 1996 responses, the evaluation itself was referred to as Phase I of the project; this language has been edited out, to avoid confusion. Throughout this report, Phase I refers to the proposed 340 cfs initial phase of the optimized project.

Two general responses need to be kept in mind when reading Chapter 7.

- The following statement, made in the 1996 Responsiveness Summary, remains valid. "It is recognized that the Bayou Lafourche evaluation addresses a complex situation. It is also recognized that not all questions related to this project, or to any major project, can be answered with unequivocal certainty." This report presents the best available information on important aspects of the project, and not every answer to every possible comment.
- The focus of EPA's evaluation shifted after the Responsiveness Summary was prepared. EPA determined that a design criteria for the project will be to not increase water levels along Bayou Lafourche, and to develop management features that will stabilize water levels and provide drainage capacity. Certain study elements that were identified in 1996 as forthcoming in the evaluation were no longer required. Examples of this change in focus are noted in many responses.

THE RESPONSES PROVIDED IN THIS DRAFT DOCUMENT ARE PRELIMINARY AND MAY BE REVISED IN RESPONSE TO PUBLIC COMMENTS RECEIVED AT MEETINGS HELD ALONG THE BAYOU IN SEPTEMBER, 1998.

7.2 PROJECT SCOPING AND COORDINATION

Comment. Several people asked what the time frame was for the evaluation, especially regarding availability of modeling results, and for subsequent project phases of final design and engineering, and construction.

1996 response. The time frame estimated for evaluation is one year from initiation; initiation is expected in the summer of 1996. Efforts associated with evaluating potential channel capacity, including modeling and associated data gathering efforts, are planned for earliest initiation, with the intent of generating substantial results by late fall of 1996 (e.g., October/November). The exact time frame for subsequent phases of the project can not be defined at this time; however, should results of the evaluation show the project (with any needed modifications) to be feasible and cost-effective, the intent is to proceed expediently to fulfill the CWPPRA directive of initiating implementation of approved restoration projects within five years. As more information on expected time frames for benchmark activities becomes available over the course of the Evaluation, it will be provided through the public outreach efforts organized under Task A.2 of the Scope of Work.

Response based on EPA's preliminary draft evaluation report. The evaluation was initiated in the summer of 1996 and some results were completed within one year. Because these results indicated the value of developing and refining the optimized project, EPA extended the study timeframe into 1998. It remains EPA's intent that if there is a decision that the optimized project is cost-effective, the agency will proceed expediently to fulfill the CWPPRA directive of initiating implementation of approved restoration projects within five years.

Comment. The question was raised whether the U.S. Army Corps of Engineers (USACE) will have to approve the project through the permitting process.

1996 response. In Task A.5, the Federal, State and local permits required to build and operate the Bayou Lafourche Restoration Project will be identified. COE will be involved in the permitting process, since "dredge and fill" activities in waters of the United States will certainly necessitate a Section 404 permit, issued by COE. A Clean Water Act Section 404 permit to dredge Bayou

Lafourche from Donaldsonville to Thibodaux was issued in 1994 to Bayou Lafourche Fresh Water District.

Response based on EPA's preliminary draft evaluation report. Section 3.6 summarizes the identified permitting requirements for this project.

Comment. The question was raised of how the flooding, backwater, and drainage problems that people have already identified can be brought to the attention of the agencies conducting the evaluation and making project decisions. It was recommended that a "hot line" be set up to receive calls and compile pertinent information.

1996 response. The agencies participated in the public meetings and therefore became well aware of the problems. Distribution of this responsiveness summary will further serve to make the information generally available. Task A.2 is intended to determine a method for receiving public input on existing problems and information pertinent to the evaluation.

Response based on EPA's preliminary draft evaluation report. During the evaluation, EPA's representatives investigated the flooding, backwater and drainage problems. Contacts were made with Parish officials, local engineers, the Natural Resources Conservation Service, and others with knowledge of the area. More than 400 specific points of drainage entry to the bayou were mapped, and elevations were surveyed on those drainage points that would be most impacted by a change in bayou water levels. An important aspect of the optimized project is to address these problems, by designing the diversion so that there is no increase in water levels, and there is increased drainage capacity in the bayou.

Comment. Several people expressed concern about accountability of the CWPPRA Task Force, who they were, who makes subsequent decisions about the project, and how all concerns about the project would be communicated to the agencies making project decisions.

1996 response. The CWPPRA Task Force is composed of five Federal members and the Governor of Louisiana. These are the Department of the Army, represented by the U.S. Army

Corps of Engineers; the Department of Interior, represented by the U.S. Fish and Wildlife Service; the Department of Commerce, represented by the National Marine Fisheries Service; the U.S. Environmental Protection Agency, represented by Region 6 (Dallas); and the State of Louisiana, represented by the Governor's Office on Coastal Activities. Task A.8 of the Scope of Work was established to ensure that agencies involved in CWPPRA will have a mechanism for receiving project information, including that coming from the public sector. In addition, all project concerns expressed in these public meetings will be published in a formal Responsiveness Summary (this report), which will be sent to all participating CWPPRA agencies as well as to the public (Task A.1). The CWPPRA Task Force will be involved in some future project decisions, particularly cost-effectiveness.

EPA, as the Federal sponsor of the Bayou Lafourche Wetlands Restoration Project, and DNR, as the State cost-share sponsor, hold the first line of decision-making responsibility on this project, and will rigorously review all information from the evaluation and other sources with regard to project feasibility, including cost-effectiveness and possible impacts. Criteria for cost effectiveness are not fixed, and require best professional judgment as well as comparison to other projects with similar objectives. One benchmark that will be used is the relative cost per average annual habitat unit (a measure of expected marsh benefits) that was estimated for the Bayou Lafourche project when it was evaluated as a candidate for funding. That level of estimated cost-effectiveness, about $4,800/AAHU, was sufficient for the project to be selected for funding. Note that EPA also has review and decision making responsibility under the National Environmental Policy Act (NEPA). The public will be informed of ongoing results and associated decisions through the public outreach program (A.2); final results and supporting documentation will be summarized in a report (Task H.7).

Response based on EPA's preliminary draft evaluation report. The previous response remains generally applicable. EPA coordinated with members of the CWPPRA Task Force during the evaluation, through distribution of the responsiveness summary, periodic meetings, and distribution of this draft report. This report and the public meetings to be held in 1998 represent EPA's primary method for informing the public of the results of the evaluation. EPA will share public comments on the report with the other agencies. EPA expects that Task Force agencies will attend at least some of the public meetings to be held in 1998.

Comment. Several people questioned how it would be assured that this project would be different from other Federal projects, such as the Carnaervon diversion, which were studied prior to project implementation but had many unanticipated problems after project implementation.

> **1996 response.** Agencies have learned from past problems and have responded with a comprehensive scoping process to help design project evaluations; such scoping was the objective of the recent meetings. It is expected that the combination of initial scope development and agency review, combined with substantial citizen participation will assure a well-conceived effort. Efforts under Task A.1 include the public meetings, as well as this summary report, which will allow the public to evaluate whether their input has been interpreted and applied adequately. The input from these meetings was used to modify the scope of work for the evaluation, both in terms of the specific tasks to be undertaken, and in the priority in which they would be done. Task A.2 is intended to develop a method by which continued public review and input can be received. With initial and ongoing review and input from participating agencies (Task A.8), local residents and other interested citizens (Task A.2), and from a variety of scientific, engineering, and other technical experts (in the course of conducting the evaluation), it is believed that most important questions will be anticipated. To augment this, Task A.3, was included in the scope of work to define the problems currently facing the bayou (e.g., progressive channel constriction, increasing water levels, etc.) that should be addressed in the evaluation. The effort will make use of the best expertise and information available to produce a credible, scientifically defensible job within the scope of work.

Response based on EPA's preliminary draft evaluation report. As stated in the original responsiveness summary, agencies have learned from past problems and have responded with a comprehensive scoping process to help design project evaluations; such scoping was the objective of the 1996 meetings. The evaluation was designed to identify and assess anticipated problems. Public review of this report should determine if the problems have been adequately addressed.

EPA understands that there could be unforeseen problems with the original project, due to the high water levels and the unknown impacts to regional drainage. Maintaining bayou levels at or below the same elevation as in recent years should minimize or prevent such problems. Moreover, the optimized project is very flexible and can be operated at various levels, as necessary to avoid problems that may now be unforeseen. It is planned to include a detailed geotechnical study in the development of the final project design, to address remaining design and implementation concerns.

Comment. Several people expressed interest in preserving Fort Butler and other associated historic or cultural sites in the Donaldsonville area that could potentially be impacted by project construction.

1996 response. Task A.6 of the evaluation involves coordination with the State Historic Preservation Office (SHPO) and the State Archaeologist to identify all potentially impacted historic and cultural sites, and plan how project construction could be undertaken to avoid these sites and/or mitigate any impacts. This information will be incorporated in planning final project design.

Response based on EPA's preliminary draft evaluation report. EPA has initiated coordination with the State Historic Preservation Office (SHPO) and the State Archaeologist to identify all potentially impacted historic and cultural sites, and plan how project construction could be undertaken to avoid these site and/or mitigate any impacts. Refer to Section 3.6 of this report.

Comment. It was commented that the project should offer alternatives that would restore the economic development of Donaldsonville and the upper Bayou, taken away by previous closure of the Bayou.

1996 response. By increasing flows in the Bayou, the project could indirectly increase economic activities, including tourism and recreation (e.g., boating and fishing), and could stimulate increased commercial navigation of the Bayou. Development of the siphon structures and facilities in Donaldsonville would be coordinated with the State Historic Preservation Officer and would be compatible with any planned historic restorations.

Response based on EPA's preliminary draft evaluation report. The previous response remains appropriate.

Comment. There was a comment expressing concern with the potential effects of the project on wildlife in the project area.

> **1996 response.** Task A.7 of the evaluation includes coordination with the U.S. Fish & Wildlife Service regarding potential effects of the project on fish and wildlife, as well as an inventory of existing information on fisheries and associated data, to assess how the project can best be accomplished with consideration of biological resources.

Response based on EPA's preliminary draft evaluation report. Inventory studies done at Nicholls State University indicate that past diversions down Bayou Lafourche have resulted in a healthy stream ecosystem; see, for example, Table 2.10-1. All information reviewed indicaters that the stream is healthier now than when it was a stagnant ditch. Evaluations of project impacts also indicate substantial benefits to restored wetlands (see Section 5.7).

This report will be distributed to the U.S. Fish & Wildlife Service, the Louisiana Department of Game and Fish, and the National Marine Fisheries Service to obtain their comments regarding potential effects of the project on fish and wildlife including endangered species.

Comment. Several people were concerned that the project would proceed to construction without first informing the public of the results of the evaluation.

> **1996 response.** The public will assuredly be informed of the results of the evaluation before further important project decisions are made. A public outreach program will be developed under Task A.2. It is intended to present interim results to the public when significant results on the channel evaluations and hydrologic studies become available.

Response based on EPA's preliminary draft evaluation report. This report informs the public of the results of EPA's evaluation. No final decisions regarding the project have been made.

Comment. Several people questioned whether the project would be done even if most of the public was against the project.

1996 response. Final decisions on whether or not to do the project will take all aspects of benefits into account, including direct environmental effects and effects on the public, as well as the associated costs. For most projects, some people or groups may be benefited and some may be negatively impacted. Usually, the net benefit to the public is considered. Local objections are also closely considered. It is hoped that the evaluation will provide satisfactory answers to the public and EPA's questions and concerns, to obtain a mutual evaluation and understanding about the project.

Response based on EPA's preliminary draft evaluation report. The prior response remains appropriate.

Comment. The comment was made that the public has been lied to in the past about this project, and that the public needs to get the facts so they can use these to base their expectations of the project.

1996 response. The evaluation is intended to be an unbiased investigation of the central questions people have with the Bayou Lafourche siphons project, and thereby make available those facts needed by everyone affected by the project.

Response based on EPA's preliminary draft evaluation report. The evaluation was conducted as an unbiased investigation of the central questions people have with the Bayou Lafourche siphons project. It is intended to provide those facts needed by everyone affected by the project.

Comment. Some people felt that in scheduling locations for the public meetings, emphasis was placed on northern and southern Bayou Lafourche, overlooking the residents of the central Bayou Lafourche area.

1996 response. Every effort was made to schedule several meetings in several different locations that might be accessible to most of the residents of the Bayou Lafourche area; the number of meetings was greater than for other CWPPRA projects. There was no intention to make access to or participation in the meetings more difficult for any group. All feasible efforts will be made in the future to assure that all project area residents will have convenient access to public meetings and presentations. However, budget constraints and practical limitations, such as availability of facilities, may limit some meetings to only one or two central locations. It is recognized that no location will be convenient for all interested parties, and the participation of all individuals, especially those who had to go out of their way or make special efforts, is greatly appreciated.

Response based on EPA's preliminary draft evaluation report. EPA's response with respect to the 1996 meetings is given above. With respect to meetings regarding the evaluation report, EPA expects to select meeting locations in consultation with officials of each of the three parishes through which Bayou Lafourche flows. Note that members of the public need not attend a meeting in order to have their comments heard. EPA gives equal weight to public comments that are submitted in writing, as to comments made at meetings.

7.3 DIVERSION FACILITIES

Comment. There was a question regarding how many siphons there would be, how they would be operated, and who would pay for pumping when the siphons could not be run.

1996 response. The initial conceptual design for the project was for eight siphon pipes, each 6 feet in diameter. However, the final decision on how many siphons should be installed to achieve the appropriate level of diversion, and how they should be operated, will be based on the results of the evaluation. For example, Tasks B.1 and B.2 will assess factors such as the relative efficiency of various combinations of siphon number and size, and relative water levels in the river and the bayou during each season, to establish the optimal siphon design and operations scheme. This will take into account results of the channel capacity and water level portions of the evaluation, which will be used to identify an acceptable volume of diversion. As is presently the case, the Bayou Lafourche Fresh Water District will continue to pay for pumping operations when the siphons are not operating.

Response based on EPA's preliminary draft evaluation report. Information now available indicates the original eight-siphon design would produce much more than 2,000 cfs during high river stages. The optimized project described in Chapter 5 of this report will provide three 72-inch pipes, with pumps, and will propose rehabilitation of the existing pumping station with its four smaller pipes and pumps. Costs of pumping that would normally be required for FWD operations are assumed to be paid by FWD. Costs for pumping that is beyond that required for water supply purposes will be part of the CWPPRA budget for this project; these costs may be cost-shared.

Comment. There was a question of whether the siphons would be over-designed, so that after installation the size of the diversion could be increased.

1996 response. Optimal siphon size and design will be evaluated in Task B.l. Based on these results, project design will be revised and presented to the public and the participating CWPPRA agencies. The project size that is presented is the size that will be constructed, if Phase I results show the project to be acceptable. The siphons will not be "over-designed" for any future considerations.

Response based on EPA's preliminary draft evaluation report. The range of diversion rates that the optimized project can achieve is shown on Table 3.2-1. During high river, the capacity will exist to divert greater than 1,000 cfs. However, it is not proposed that this capacity will be used. A water level management plan will be developed and implemented to allow reductions in the rate of siphoning or pumping in the event that stormwater runoff starts to increase bayou water levels (see Sections 7.4 and 7.6, below, for additional discussion of the water management plan).

Comment. There were a few questions regarding quality of the diverted Mississippi River water. Concerns included possible effects from contaminants from industries along the Mississippi, chemical and/or oil spills that could create short-term problems, and possible effects from nutrient enrichment that cause the "dead zone" at the mouth of the river.

> **1996 response.** Task B.4 of the evaluation is planned to evaluate the quality of the diverted water and sediment. River water conditions will be compared to quality standards for water and sediment. Any existing data on emergency conditions (e.g. spills), such as locations, frequency, and responsiveness of the warning network, will also be evaluated. This information will be used to evaluate the potential for water and sediment quality impacts to Bayou Lafourche; and to specify emergency operations to protect the Bayou from spills in the river.

Response based on EPA's preliminary draft evaluation report. Refer to Section 2.7 of this report for EPA's evaluation of the quality of the diverted water and sediment. Basically, EPA judges river water quality as suitable for the proposed uses, as shown by the long period over which this supply has met regulatory requirements and satisfied the drinking water needs of the bayou parishes. A warning network exists to allow shut-down of river diversions if there is an emergency in the river (e.g. barge spill). The nutrients that contribute to the dead zone problem are, when diverted to the marshes, environmentally beneficial.

Comment. It was questioned what would be done with the railroad bridge, whether the road crossing would be at grade or an underpass. The concern was that with a lot of train traffic, there is the potential for a grade crossing to hinder the relatively heavy road traffic, and possibly lead to unsafe conditions regarding passage of emergency vehicles.

> **1996 response.** The types of modifications that may need to be made to the railroad bridge and other crossings to provide sufficient capacity for the bayou to convey the siphoned water will be evaluated

in Task B.5. This will include consideration of grade versus overpass or underpass crossings, associated impacts on traffic volume and pattern, and emergency and safety issues. Information for this task will be obtained from local officials and agencies, including the fire department and other emergency response groups, and from interactions with the public, as well as from contacts with DOTD, the railroad, and engineering experts.

Response based on EPA's preliminary draft evaluation report. The railroad bridge does not require modification in order to pass the 1,000 cfs flow of the optimized project. This has been confirmed through coordination with Union Pacific Railway. The need for possible protection to the highway will be considered during the design-phase of the project; if needed, protection probably will involve a small berm. There would be no need to reroute any roads and thus no requirement to create a new road crossing.

Comment. Several people expressed concern about flooding of Highways 1 and 308, and that if flooding associated with the project leads to highway closures, this could compromise hurricane evacuation routes and trap people in emergency situations.

1996 response. Public safety and the maintenance of viable evacuation routes is critical, and will be incorporated in the evaluation of project effects. Specifically, possible impacts to the highways surrounding Bayou Lafourche will be evaluated in Task B.5, including review of whether any road improvements or grade changes would be required. Input for this will come from Tasks C.3, C.5, and C.11, in which information will be developed on channel capacity, existing water levels, and water levels that could be achieved with changes in channel capacity. Further input will come from Task D.1, in which project effects on expected water levels will be assessed.

Response based on EPA's preliminary draft evaluation report. The optimized project has been designed to eliminate this potential impact.

Comment. It was commented that any potential impact of the project on pump plant operations and maintenance costs of the Donaldsonville facility would have an impact on the cost of water furnished by the Consolidated Waterworks District No. 1 of Terrebonne Parish. It was requested that this issue be addressed.

1996 response. Current and prospective operations of the Bayou Lafourche Freshwater District will be evaluated in Task B.7.

Response based on EPA's preliminary draft evaluation report. Cost-sharing negotiations with the Bayou Lafourche Freshwater District have not yet been undertaken. The results of such negotiations will be made public before a cost-share agreement is finalized.

7.4 CHANNEL FUNCTION

Comment. Many comments were received that present water levels in the bayou are already too high, and are causing problems with drainage, flooding of property and facilities, and erosion. People presented observations that water levels have been rising in the past couple of years. Opinions on causes differed, and included the Bayou Lafourche Fresh Water District was pumping more water, vegetation was clogging the channel, and sedimentation was decreasing capacity of the Bayou channel. One commentor observed that the Bayou between Lafourche Crossing and the St. Charles Bridge was choked with grass, only leaving about a 10 foot open area and apparently restricting flow. Another commentor made a similar observation for the area 2.5 miles downstream of Labadieville, indicating that if the grass were removed, the channel could move a lot more water. An associated question was how present water levels could be high since there has been no rain. The concern was that with water level problems already existing, the siphon project could only make the situation worse.

> **1996 response.** This information is very important to the objectives of the evaluation, and was used to expand the tasks associated with the evaluation of channel capacity and flows in the Bayou. Special emphasis was placed in Tasks C.2, C.3, and C.4 on collecting and analyzing information on present channel capacity, geomorphology, and flows; and on how channel capacity, geomorphology, and flow have changed historically (including in the recent several years). Results of these tasks will provide insight into the cause and possible solutions to the existing problems, as well as form the foundation for evaluating how additional water will affect water levels in the Bayou. These results will be central to decisions on this project.

Response based on EPA's preliminary draft evaluation report. Reflecting this comment, EPA committed substantial resources to investigate the rise of water levels and the growth of vegetation. The results include documentation of actual changes in bayou conditions, and an evaluation of probable causes and solutions; see Section 2.6 of this report for details of the evaluation. By way of summary, EPA has determined that vegetation clogging was the cause of the water level rise. Subsequent mowing of the vegetation has allowed water levels to decline, for any given rate of flow.

Comment. There were several comments recommending that the Bayou be dredged to accommodate the increased flow and avoid raising the water height; and that the only way the project would work (to avoid flooding) was to dredge the Bayou to its maximum depth and maintain it there. A related suggestion was to remove the weir at Thibodaux, clean out the vegetation, and dredge the present deposits to increase capacity before considering the project.

> **1996 response.** Task C.11 of the evaluation will integrate information from other tasks in Section C on historic and current channel capacity, and evaluate what changes to the Bayou (e.g. dredging) would be needed to increase capacity and minimize water level effects.

Response based on EPA's preliminary draft evaluation report. EPA agrees that these comments go to the heart of concerns about the original project. The project has been modified in accordance with these recommendations.

Comment. There was a question about what the effect would be of removing the weir at Thibodaux. There was a related comment that removing the weir would reduce existing water levels and allow more water to be added to the Bayou.

> **1996 response.** The effect of removing the weir on water level and flow capacity will be addressed in detail in Task C.11 of the evaluation, along with other possible channel modifications such as dredging and bridge modifications.

Response based on EPA's preliminary draft evaluation report. As indicated in the comment, the effect of removing the weir will allow more water to be added to the bayou; see Section 3.5. Removal of the weir is included as part of the proposed optimized project.

Comment. There was a question about whether trees that die due to the higher water levels associated with the project will be removed so they do not restrict flow.

> **1996 response**. The potential for providing additional channel capacity with restoration efforts will be addressed in Task C.11 of the evaluation. Restoration efforts could include dredging of depth and/or width, clearing of vegetation, improving the bridges, removing the weir at Thibodaux, and/or

removing encroachments on the batture. The extent to which clearing of vegetation, including grasses and snags, is needed will be determined as part of this task.

Response based on EPA's preliminary draft evaluation report. Because the optimized project does not lead to encroachment of the bayou on its bank, impacts to trees are not expected. However, as at present it is the case that trees will occasionally fall into the bayou. With or without a CWPPRA project, the FWD will continue its existing channel maintenance program, which includes removal of such deadfalls.

Comment. There were several questions on sedimentation in the Bayou, including how much and where sediment would build up, and what would be done with it. One specific question was what the impact of increased sedimentation would be on the flood control gate in the Lefort Canal at Bayou Lafourche, and who would be responsible for maintaining and operating this structure. Some people commented that there is an expectation of high sedimentation from the diverted water, which will settle out mostly in the first few miles of the Bayou, and necessitate extensive and repeated dredging. A related question was what the dredging cycle would be (i.e., how many times the Bayou would be dredged during the project). The concern was that this dredging would be costly, and would have negative impacts on Bayou water quality.

1996 response. Information will be developed in Task C.8 (sediment load) and Task C.10 (numeric modeling of expected sediment deposition) on the locations and amount of sediment that is expected to be deposited in the Bayou as a result of the project. This information will then be used in Task C.11 to assess what dredging needs would be to control this expected level of sedimentation. The assessment of dredging will cover methods, disposal, costs, and impacts on water quality. If multiple (i.e., periodic) dredging efforts will be required, this will be identified in this task. An added separate task (B.5) will assess the possibility of designing a facility at the receiving area to remove sediments that would otherwise have to be dredged.

Response based on EPA's preliminary draft evaluation report. A sand trap has been included in project design. The results of the evaluation that relate to bayou sedimentation are provided in Sections 2.2 (general), 3.3 (sand trap), 4.3 (modeling), and 3.4 (dredging requirements for optimized project).

The expectation is that most sand will be deposited within the sand trap at the diversion outfall in Donaldsonville, and most clays will be transported to the marshes. Silt deposition is expected in the sand trap and channel. The sand trap will be maintained on a quarterly basis. No maintenance dredging is proposed within the bayou. No significant effects are expected with respect to the Lefort Canal.

Comment. There was a concern about utility relocations and associated costs due to dredging in the Bayou.

> **1996 response.** Any conflicts that would arise with utility crossing as a result of dredging will be evaluated in Task C.11. If relocations would be necessary, this will be identified, and associated costs estimated.

Response based on EPA's preliminary draft evaluation report. Section 3.4 summarizes what EPA learned about the occurrence of utility crossings along Bayou Lafourche during the evaluation; see especially Table 3.4-1. Section 5.3 estimates relocation costs for a 1,000 cfs project.

Comment. Some people asked what the dimensions of the Bayou Lafourche channel would be with the project.

> **1996 response**. The answer to this question is not known at the present time. This information will be one of the outcomes of the evaluation, specifically from a combination of the results of Task C.3, which will define current channel capacity; and Task C.11, which will evaluate changes that could be made to dimensions of the Bayou to increase capacity for accommodation of siphoned water.

Response based on EPA's preliminary draft evaluation report. Figure 3.4-2 shows a representative channel cross-section for the optimized project involving the diversion of 1,000 cfs, in comparison to existing conditions. In general, there will be no change to the width of the bayou; but the depth will be substantially increased.

Comment. It was commented that in order to restore wetlands to their 1904 condition, we should first restore Bayou Lafourche to its 1904 condition. In particular, note was made of the decreasing water depths of the Bayou.

1996 response. Historic channel capacity will be evaluated in Task C.2 of the evaluation, including channel morphology and associated flows, This information will be related to current needs for channel capacity associated with the proposed project in Task C.11.

Response based on EPA's preliminary draft evaluation report. 1904 conditions can be considered in two contexts: flood flows and low flows. A optimized project which has the capability of pumping 1,000 cfs into Bayou Lafourche in the fall is probably not substantially smaller than the natural bayou low flow in 1904. However, the siphoning of the same 1,000 cfs in spring would be much smaller than the 1904 spring flood flows in the bayou.

As discussed in Section 2.2.1, there has been extensive development in areas that were part of the channel in 1904. A project to restore the channel to 1904 conditions would represent a significant change from existing conditions, and would incur substantially greater costs and cause greater environmental impacts than the much smaller project being considered here. Separate from this evaluation, EPA has supported studies of a parallel conveyance channel that would be built at the levee-marsh interface east of Bayou Lafourche. Such a channel could potentially carry 100,000 cfs of Mississippi River flow and could lead to the building of large areas of deltaic land in parts of the Barataria and Terrebonne Basins.

Comment. There were several comments or questions that greater bank and levee erosion would likely result from higher flows associated with the project. The concern in several cases was the direct loss of property, the anticipated need to build structures to protect property, and the question of whether the landowners or the project would pay for these needed protections. Some people felt that with greater changes in water levels resulting from the project (i.e., with the siphons on and off over time), the incidence of bank erosion and slumping would be greater. It was specifically commented that if any project were considered for the Bayou it should include a constant water flow and level, and not just siphoning when the river is high. Many associated comments were made that measures for bank stabilization, such as bulkheading, would be necessary if the project was constructed, and questioned what help the project would provide in this regard.

1996 response. There are several tasks in the evaluation that will address the question of bank (and levee) stability. In Task C.9, sediment composition and other geotechnical characteristics of the existing banks will be measured to provide a basis for predicting erosiveness and slumping potential. In collecting these data, existing erosion problems will also be recorded. In Task D.3, the effects of project operations on potential erosion or bank stability will be assessed. This will include the effects of flow, the effects of fluctuating water levels, and the effects of dredging on stability. The possibility will be evaluated of adding a pump along with the siphons; the pump would allow a more gradual change in water levels as siphons are turned on or off, and could protect banks and levees from increased sloughing. In Task E.4, a similar analysis will be undertaken regarding the effects of storm flows on bank stability. Based on the results of these analyses, all areas that would need measures to protect and stabilize the banks will be identified, and types of stabilization will be recommended. Any mitigation measures determined to be needed for erosion that is a direct result of the project will be evaluated as a project expense.

Response based on EPA's preliminary draft evaluation report. The impacts of water levels over the bayou bank, and of siphons turning on and off have been eliminated through the development of the optimized project which includes: pumps as well as siphons that can maintain a consistent rate of diversion throughout the year; two deployable weirs which are designed to prevent rapid water-level changes in the event that pump/siphon operations must be curtailed in response to storm events or as an emergency response to a spill on the Mississippi River; and a series of water-level monitoring stations that will provide real-time input on bayou water conditions to facilitate implementation of a water-level management plan. The plan will be developed in consultation with stakeholders along the bayou and will determine the rate of operations of the pumps/siphons, and of weir deployment. Flow velocities are projected to be substantially lower than could cause significant bank erosion.

The issue of bank stability, including increased problems as a result of channel dredging, is discussed in Section 3.4.4. Project costs include an allowance for limited bank stabilization; see Section 5.3.9 for a general discussion of this issue.

Comment. There was concern that there was insufficient planning for traffic capacity and bridges, primarily in Donaldsonville.

1996 response. The evaluation of options for modifying the Bayou Lafourche channel (Task C.11) will include evaluation of possible changes to bridges and other infrastructure. As part of this, the possible impacts of such changes on transportation and traffic patterns will be evaluated. To the extent possible, information for this evaluation will come from existing data (e.g., recent existing studies on traffic volume and traffic patterns; existing population and development projections), with substantial input from locally knowledgeable people and coordination with Louisiana Department of Transportation and Development.

Response based on EPA's preliminary draft evaluation report. The Highway 3089 bridge in Donaldsonville is being replaced for safety reasons, independent of the diversion project. The optimized project does not require modifications of any other bridge. The project design is based on maintaining water levels at or below historic conditions and will not overflow any roadway. Therefore, there are no project impacts on traffic capacity. This evaluation will be provided to the Louisiana Department of Transportation and Development for their review and comment.

Comment. The comment was made that the high water event of 8 May 1995, while representing a flow of 2,040 cfs in the Bayou at Thibodaux, was not a good comparison for the proposed siphon project, because this level of flow only lasted a few hours.

1996 response. The May 1995 event can be used to estimate the water level that could be expected with a 2,000 cfs flow under present channel conditions (i.e., with no channel improvements). It can also be used to help identify the direction various drainage canals flow at that water level, other drainage problems, and the locations and extent of flooding. That is the extent of the intended uses for this comparison.

Response based on EPA's preliminary draft evaluation report. The previous response is unchanged.

Comment. It was commented that there is a discrepancy in information provided - that the May 1995 rain event raised water levels in the Bayou by 1.5 feet, but the project is expected to raise water levels by 5.7 feet at the same flow (2,000 cfs).

1996 response. The projected rise of 5.7 feet assumes no channel improvements and is for the uppermost end of the Bayou, where the channel is most narrow and the effect of the increased flow is greater. The projected rise for the wider channel at Thibodaux is 2 feet, for a discharge of 2,000 cfs; this also assumes no improvements to the present channel. During the May storm, a rise in water level of roughly 2 feet was observed at Thibodaux, where the USGS measured a maximum flow of just over 2,000 cfs. The model appears to be in reasonably good agreement with actual observations from the 1995 storm.

Response based on EPA's preliminary draft evaluation report. The discussion of the May, 1995 event was intended to show that a 2,000 cfs storm flow had increased water levels at Thibodaux by roughly 2 feet; and the models of a 2,000 cfs diversion showed the same effect. The optimized project that is included in this report is designed to eliminate the rise of 5.7 feet (at Donaldsonville) that had been predicted for the original project.

Comment. There was a comment that submerged grasses will affect channel capacity, but if project sponsors plan to control the grass by poisoning the grass, the result would be the loss of the bass fishery.

1996 response. A full evaluation of present channel capacity, including any recent changes that may have occurred in capacity and probable causes (including the potential contribution of submerged aquatic vegetation), will be made in Task C.3. Once relationships between factors and causes have been defined to the extent possible, the effectiveness of taking various possible actions to improve the channel for carrying fresh water will be evaluated (see Task C.11). Preserving the natural resources of the Bayou, including its bass fishery, will be a major consideration in evaluating the possible impacts of any channel modifications considered.

Response based on EPA's preliminary draft evaluation report. The effects of submerged grasses on channel capacity is discussed in Section 2.6; that section also notes the success of a control program that involved mowing of the grass, and not the use of herbicides. If herbicides are ever needed for grass control, the chemicals selected would be required to be non-toxic to fish.

7.5 CONVEYANCE OF DRY WEATHER FLOWS

Comment. There were questions on what the velocity of the Bayou current would be with the project, including specifically the velocity at some structures along the Bayou that allow boat passage, and whether public safety would be considered in these regards.

> **1996 response.** Based on some preliminary modeling, an estimate of current velocity with the siphons operating is 1.5 ft./sec., which is still relatively sluggish. For comparison, present current speed is estimated to be less than 1.0 ft./sec. In Task D.1, estimates of hydrologic conditions with the siphons operating will be made. This will include refined estimates of current velocity, which will be evaluated for its potential to impact public safety, as well as bank erosion and channel stability.

Response based on EPA's preliminary draft evaluation report. The velocity estimates cited in the 1996 response remain generally applicable to the alternatives now under consideration.

Comment. Many people asked how much water levels would be raised with a diversion of 2,000 cfs. They expressed concern that a 5.7 ft. rise in water level at Donaldsonville, which was presented as a preliminary modeling result, was too much and would cause flooding and other damage. The vicinity of Thibodaux was also mentioned as a specific area of concern with respect to flooding if water levels were raised.

> **1996 response.** The meaningful answer to how much water level rise is expected with a 2,000 cfs diversion will depend on the complement of channel modifications that may be recommended to increase channel capacity. This will be addressed primarily in Task D.1 (evaluation of project effects on water levels).

Response based on EPA's preliminary draft evaluation report. EPA did not revise the preliminary modeling with respect to a 2,000 cfs diversion, except to assess that it would require approximately 13 million cubic yards of dredging to eliminate the water-level impact of this greater flow (see Section 6.3.1). The optimized project described in this report involves a 1,000 cfs diversion with water levels that do not represent a rise over historic conditions.

Comment. Comments were made that based on the observations of people living up and down the bayou, it seems that water levels increase as much downstream as they do upstream when there is more water in the Bayou (e.g., on some storm events).

1996 response. Water level rise due to a storm event, with runoff entering at various points along the Bayou, is expected to give a different pattern of water level rise than that associated with a single point of water addition at the head of the Bayou at a predictable rate over a long period of time. The modeling that will be done as part of Task D.1, to predict project effects on Bayou water levels will account for all major processes that would affect water levels, including backwater effects, channel roughness, and channel constrictions.

Response based on EPA's preliminary draft evaluation report. The previous response is unchanged.

Comment. Many people expressed concerns about flooding associated with the project as well as existing flooding problems. Types of flooding problems that were of concern included croplands (especially sugar cane), houses, wharves, sewage overflow lines, backyard improvements and other property, gardens and trees and crawfish ponds. The economic importance of croplands especially to several of the affected parishes was noted. Several specific locations were mentioned in regard to existing flooding problems, including: the area southeast of Lake Fields (in the vicinity of Folse Bayou); the region of District 6, Highway 308 south of 155; the sugar fields behind Cancienne Canal; in the Bayou 3 to 4 miles north of Raceland; in the Bayou 1 mile south of the Labadieville bridge; the St. James Parish Canal; and downtown Donaldsonville (during rain). Many of the comments were to request that the locations and types of flooding mentioned be seriously considered in the evaluation and possible solutions be identified before major project decisions were made. A few commentors felt that flooding was already a problem of sufficient magnitude that the project should be rejected without further consideration.

1996 response. The magnitude of the existing flooding problems, including the locations of concern and the implications for present channel function have been incorporated into the scope of EPA's evaluation. Flooding issues will be addressed primarily in Tasks D.1 and D.4, in which project effects on surface water levels and on ground water will be evaluated. In a closely related topic, Tasks E.1 and E.5 focus on assessment of drainage characteristics of the Bayou, and their relationship to project operations and storm inputs. These results will also contribute to the ultimate understanding of any potential flooding problems and how they could be addressed. Consideration of specific actions mentioned in relationship to flooding, such as pumping water from Lake Boeuf to reduce flooding in District 6, may occur in a general manner in the evaluation effort.

Response based on EPA's preliminary draft evaluation report. EPA studied these problems sufficiently to determine that they could be impacted if the Bayou Lafourche diversion caused an increase in bayou water levels, as originally proposed. Rather than develop a comprehensive flood control plan for the region, which was outside the scope of the current study, EPA modified the project to eliminate the impacts. Indeed, the proposal to dredge the channel provides capacity that can be used to alleviate existing flood problems, if that operational approach is adopted; see Section 3.5.6. The alternative of using drainage from the Verret Subbasin as a source of water to Bayou Lafourche remains viable for the future; see Section 6.4.

Comment. There were concerns expressed that increased boat traffic associated with higher water levels would increase erosion of levees and private property.

1996 response. Bank and levee stability and the potential for erosion associated with higher water levels, changes in water levels, and dredging will be evaluated in Task D.3 of the evaluation. This will provide some insight into the vulnerability of land bordering the Bayou to erosion from all sources.

Response based on EPA's preliminary draft evaluation report. The optimized project will not increase water levels. Issues of bank stability are discussed in Section 3.4.4 of the current report.

Comment. There was a question of how ground water levels affected by greater flow in the Bayou would affect crawfish burrows.

1996 response. The potential for groundwater flooding of agricultural fields and associated changes in land use will be evaluated in Task D.4 of the evaluation.

Response based on EPA's preliminary draft evaluation report. The optimized project has been designed to maintain water levels at or below historic maxima. Therefore, there should be no significant change in ground water levels. Refer to Section 5.6.2.

Comment. There was a comment that if the project causes a rise in ground water levels, septic systems will be under water and will fail, resulting in the discharge of raw sewage into the Bayou.

> **1996 response.** This issue will be directly addressed in Task D.4 of the evaluation, including the estimated extent of ground water rise, and impacts to on-site systems (including septic), property values, and bank stability.

Response based on EPA's preliminary draft evaluation report. The optimized project has been designed to maintain water levels at or below historic maxima. Therefore, there should be no significant change in ground water levels. Refer to Section 5.6.2.

Comment. It was commented that the Consolidated Waterworks District No. 1, Terrebonne Parish, might experience increased operational costs (e.g., water treatment, canal maintenance) if there is increased silt in the water supply. The concerns were whether existing data would be reviewed to determine the potential significance of this issue, and who would bear any additional costs. There was an associated concern with whether increased flow and siltation would impact water quality in a manner that would cause exceedances of Maximum Contaminant Levels specified in the Safe Drinking Water Act, and whether this would incur the need for additional treatment, notification of customers, and payment of fines.

> **1996 response.** Potential effects of the project on water use, including impacts of suspended sediments on water supply diversions and treatment, will be evaluated in Task D.5 of the evaluation. Additional information on water quality will be evaluated in Task D.2. Costs associated with mitigating direct project effects will become project costs.

Response based on EPA's preliminary draft evaluation report. The amount of sediment in the water withdrawn from the bayou for water supply depends on the concentration of sediment in the water diverted from the river, and on how much of that sediment remains in suspension at the point where the water is diverted. The average concentration of sediment in the diverted Mississippi River water is expected to be comparable to that in the river water currently diverted. There may be a small increase in the amount of silt that remains in suspension along the bayou because of the increased flows associated with the project. The net effect on the waterworks is expected to be very small.

7.6 CONVEYANCE OF WET WEATHER FLOWS

Comment. It was commented that existing drainage mostly depends on Bayou Lafourche, including drainage for sugar cane fields, and that at present there is often too much water in the Bayou for drainage to be effective. Therefore, adding more water to the Bayou would make the drainage problem worse. One commentor added that dredging and widening the Bayou would help ease some of the concern. A specific area of concern was the area just north of Thibodaux that is drained by the Rienzi Canal, which feeds into Legendre Canal and eventually into Lake Boeuf. Water in this area typically drains northward, away from Bayou Lafourche, and the area experiences flooding during heavy rain storms. The concern was what the effects of high water levels associated with the project would be on the existing drainage system and flooding problems, and what the project would do to solve the problems. Another specific concern was with Forty-Arpent Canal and a weir at the intersection of Forty-Arpent and Lefort Canals, intended to allow Forty-Arpent Canal to drain to Bayou Lafourche. The concern was if increased water levels in Bayou Lafourche reversed the flow in Forty-Arpent Canal and caused flooding of cane fields and residential areas, who would pay for any needed structural modifications. Other concerns were presented about whether existing drainages would be maintained; whether they would be adequate to the job with the project in operation, or whether other measures would be taken to ensure proper drainage.

> **1996 response.** To address the issue of how drainage currently functions on the Bayou and how it would be affected by the project, the evaluation includes Task E.1, which is a characterization of existing drainage systems, including identification of points of inflow and outflow, drainage areas, types of drainage system, characteristics of drainage flow in storms, and water quality. Task E.5 is then focused on evaluating the effects of the project on these drainage systems. This task includes consideration of drainage alternatives that may be necessary. The results of these tasks will provide the viable options for maintaining adequate drainage along Bayou Lafourche. To the extent that drainage requirements may impose constraints on the amount or timing of diverted water, these will be incorporated in project plans and operations.

Response based on EPA's preliminary draft evaluation report. Addressing this issue was a priority in the evaluation. EPA confirmed that there would be adverse effects to existing drainage from an increase in Bayou Lafourche water levels and that, conversely, drainage could be improved if the project provided for an increase in capacity of the bayou channel. Consequently, the design of the optimized project provides for no increase in water stages beyond historic levels, and provides for a substantial increase in channel capacity. Thus, the project is considered as having no adverse impacts on existing drainage problems, and as potentially contributing to the solution of at least some of the problems.

Comment. The comment was made that the drainage system along the Bayou is complex and inter-related. Because of the interconnections, changing the drainage pattern in one place to accommodate increased water levels in the Bayou may cause additional flooding and drainage problems in an adjacent area.

1996 response. This information is acknowledged as being very important to the evaluation of drainage effects of the project. The effort to characterize the existing drainage system (Task E.1) will be conducted by engineers knowledgeable about the local area, and will focus on characterizing all interrelated drainage areas.

Response based on EPA's preliminary draft evaluation report. The design of the optimized project provides for no increase in water stages beyond historic levels, and provides for a substantial increase in channel capacity. Thus, the project is considered as having no adverse impacts on existing drainage problems, and as potentially contributing to the solution of at least some of the problems. See Section 5.6 of the current report.

Comment. Concern was expressed about how the project could be managed in storm conditions to avoid flooding. A specific concern was expressed about what would happen with Highway 308 under the Lafourche Crossing with increased water levels associated with the project and wet, rainy conditions.

1996 response. The question of project management in storm conditions will be directly addressed in Tasks E.2 and E.3. In Task E.2, possibilities for operational responses to storm events will be evaluated. In Task E.3, the impacts of the project plus stormwater inputs on water levels in the Bayou will be assessed. Together, this information will be used to identify potential flooding problems, and will ultimately be used to assess the extent of project impacts and needed mitigation (e.g., modification to drainage systems).

Response based on EPA's preliminary draft evaluation report. Discussion of the development and implementation of a Water Level Management Plan as part of the final design of the optimized project is presented in Section 3.5.6. The potential exists to operate the project so that pumping or siphoning rates are reduced at times when storm runoff is increasing, in order to provide channel capacity for conveyance of the runoff. The project design includes installation of water level and precipitation monitoring stations, which will facilitate implementation of a water level management plan by providing real-time data on water conditions within the bayou. Water level management also could be augmented by use of the deployable weirs, which could be used, if needed, to reduce the rapidity of water level changes when diversion rates are reduced. The net effect will be a decrease in bayou water levels for any given storm, compared to historic conditions.

7.7 LEGAL AND PROPERTY ISSUES

Comment. Several people asked who would be responsible for the project in terms of ownership; operations; and monitoring.

1996 response. While these issues are not defined at this time, the efforts in Task F.1 will include identification of the parties responsible for each aspect of the siphons project.

Response based on EPA's preliminary draft evaluation report. Project operations will be the responsibility of the Bayou Lafourche Freshwater District. Monitoring for day-to-day operations will be done in accordance with a management plan that is to be developed as described in Section 3.5.6. CWPPRA monitoring will be conducted by LDNR, as described in Section 3.5.7.

Comment. There were questions regarding who was legally responsible for the project, and what the process for litigation was.

1996 response. Legal responsibility for the project in the case of litigation will be defined in Task F.1 of the evaluation.

Response based on EPA's preliminary draft evaluation report. This question has not yet been addressed in final form.

Comment. The comment was made that there will be a law suit if the project is not good.

1996 response. While legal remedy is an option, it is the intention of the project sponsors that the evaluation provide an unbiased evaluation of project options, effects, and mitigation possibilities, conducted with close public interaction, so that clear consideration of problems and solutions can form the basis for decision making on the project.

Response based on EPA's preliminary draft evaluation report. No change to prior response.

Comment. There were numerous questions on who would be responsible for a large and ongoing dredging burden, especially after the end of the sponsored life of the project (i.e., after 20 years).

1996 response. The evaluation of any changes in obligation for such responsibilities at the end of the 20 year project life will be done in Task F.1. However, present CWPPRA funding carries no commitment of project funds beyond twenty years.

Response based on EPA's preliminary draft evaluation report. The dredging required during the project life will occur in the area of the sand trap and will be the responsibiltiy of the project operator; see Section 3.3.4. It is typical of CWPPRA projects that no specific plans are provided for activities after the project life. The expectation is that the project would continue, with dredging funded as needed. If dredging funds were not available, the project could continue to operate but the diversion rate might be reduced to the extent that sediment had reduced channel capacity.

Comment. A question was asked whether the existing levees, such as the +7-foot levees at Lockport, are adequate for protection from project water levels. Specific information was presented on the levees of Lafourche Drainage District No. 12, which had design heights of +6.0 ft. MSL more than thirty years ago, and have since experienced consolidation, in addition to silting in of associated outfall canals. The highest water level of record was +4.5 ft. experienced during Hurricane Juan, leaving 1.5 ft. of freeboard. If the project induces an additional 1.3 ft. water level rise in this area, there will be no freeboard left in a hurricane of similar magnitude, and overtopping of the levees will result in flooding of over 8,800 acres of residential, commercial, farm and crop lands.

1996 response. The submittal of specific information is valuable to the evaluation and very much appreciated, and will be incorporated in the data base developed for the evaluation. The adequacy of existing levees, and any needed mitigations including increasing levee heights, will be evaluated in Task F.3.

Response based on EPA's preliminary draft evaluation report. The optimized project is intended to maintain dry weather water stages at or below historic levels. Thus storm flows also will be similar to historic levels, except to the extent that the project is operated to reduce diversions during runoff periods, thus providing for less flooding problems in the future than in the past.

Comment. Several people asked how property values would be determined, and how the process of compensation would take place. A specific request was made that a house and property already prone to flooding be surveyed when the evaluation begins. There was also a question of how the project would affect property values.

1996 response. Real estate specialists will evaluate property. Property evaluation is covered under Tasks F.2 and F.3 of the evaluation. The Corps of Engineers indicated they typically use fair market value as a basis for negotiation. Negotiation with each affected property owner may be a part of the compensation process; the full process will be described in Task F.3. The question of how property value would be affected by the project depends to a great extent on what the final recommended project design is, what associated water levels are anticipated to be, and what mitigation measures (e.g., bulkheading, etc.) are recommended. Thus, this prediction must wait for the main outcome of the evaluation. However, in completing the identification of potential litigation measures in Task F.3, consideration of the recommended project design will be included, and the assessment of possible impacts to properties will include consideration of existing elevations and exposure, and will reflect on property value. A comparison of value of property without the project will be made.

Response based on EPA's preliminary draft evaluation report. The property evaluation work was not done because EPA determined to modify the project design to eliminate the prospective issue from any increase in water levels. The final dredging design may determine a need to obtain very small amounts of property to ensure an efficient channel. It may also be necessary to remove and replace boat docks impacted by dredging. Any such property considerations will be undertaken by negotiation with fair market value as the basis for establishing costs.

Comment. There was a question of who would pay for property damage associated with dredging. The type of damage anticipated by the commentor included shifting of levees, sinking of houses, and cracking of slabs,

1996 response. Potential damages (impacts) that may result from construction or operation of the Bayou Lafourche project will be identified through inputs from the modeling and engineering tasks in the evaluation, and will culminate in Task F.3, in which needed mitigation on measures will be assessed. The costs associated with needed mitigation for project-related impacts will become a project cost, and will be reflected in total cost of the project. If that total cost is acceptable and the project can proceed, then the project will bear the cost of any mitigation. If the total cost is unacceptable or the project does not go forward for any other reason, then the question no longer pertains.

Response based on EPA's preliminary draft evaluation report. The design of the channel cross-section was selected in order to avoid these impacts. Stability analyses indicate that the dredged channel will have stable slopes and will not impact properties along the bayou, except for structures (such as docks) that extend into the channel.

Comment. Several people indicated that they were in favor of the benefits from the project, but wanted fair treatment and compensation for any losses.

1996 response. Potential losses will be identified and values estimated in Tasks F.2 and F.3. The acceptability of mitigation and compensation to any affected landowners will be based on negotiations with the landowners. This should assure that all affected landowners are satisfied that offered compensation is fair, and that project costs reflect all compensation needs.

Response based on EPA's preliminary draft evaluation report. The project redesign has minimized the potential for losses and the need for compensation. As stated in 1996, any compensation needed would be determined through negotiations.

Comment. Several comments were made that the property owners were against any taking of their land; that nobody had the right to flood their land, that they would rather retain their land (i.e., free of flooding, erosion, or other impact) than get monetary compensation for the land or loss of its use; and/or that there was not enough money to compensate them for any loss of land.

1996 response. This preference will become a consideration in the evaluation of possible mitigations and compensations for any anticipated impacts (F.3). Also, the emphasis of the evaluation was modified to assure that any viable approaches for increasing channel capacity and conveying water with minimal impacts to private property are evaluated.

Response based on EPA's preliminary draft evaluation report. The project redesign has effectively eliminated the need for takings of land.

Comment. Several comments were made that structural protection such as bulkheading should be included as part of the project for all properties and improvements along Bayou Lafourche. There also was a question of how improvements to various docks, wharves, and bulkheads needed to accommodate increased water levels would be handled, since many of these are already under water.

1996 response. Any needed mitigation measures related to the project will be identified in Task F.3. Methods for implementing these mitigations will be discussed as appropriate in Task F.3.

Response based on EPA's preliminary draft evaluation report. Structural protection (e.g., bulkheading) is expensive (see Section 5.3.9), and could not be accomplished within a reasonable project budget. Instead, the mitigation plan is to lower and stabilize water levels through a program of extensive dredging which, along with other improvements (such as deployable weirs, and reduction of pumping during storm events) is intended to improve conditions for bayou-side properties. Some docks may need to be replaced as part of a dredging program.

Comment. There was a question regarding who had the authority to turn off the pumps if the dredging incurred by the project can not be afforded.

1996 response. The authority to operate the project will be identified in Task F.1 of the evaluation. The siphons (not pumps) of the proposed project would not be constructed unless any dredging incurred by the project was determined to be feasible during the evaluation.

Response based on EPA's preliminary draft evaluation report. The preliminary management plan, discussed in Section 3.5.6, provides that operations will be the responsibility of the Freshwater District, the same agency that will have that responsibility if the project is not built.

7.8 EFFECTS ON THE MARSH

Comment. There was a question regarding how many acres of marsh the project would rebuild.

1996 response. This project is considered a protection project. Due to its anticipated effects (which will be evaluated as part of EPA's study) on salinity in the target marshes, delivery of nutrients, and possibly even fine sediments, the project is expected to preserve marsh acreage that would otherwise be lost without the project. It is not anticipated that enough sediments will be delivered to the target marshes to build new acreage.

Response based on EPA's preliminary draft evaluation report. There is no change to the 1996 response.

Comment. There were several comments that the project would not be able to get sediments all the way down to the target marshes; that most sediments would drop out in the first few miles of the Bayou, and the marshes would gain little benefit. Specific comments were made that the project will not work without sediments; that the project will not work because all wetlands damages cannot be recovered; and that the project will not work without opening the Bayou entirely to the river.

1996 response. It is understood that most of the fine sands and larger silts will settle in the upper reaches of the Bayou. However, it is also expected that wash-load sediments, that is the fine clay particles, may remain in suspension, as they do in for instance, Atchafalaya River water as it moves east in the GIWW. The possibility that wash-load sediments may be transported to the marshes and contribute to marsh benefits when flows are increased will be evaluated as part of the modeling in Task G.3. At the present, marsh benefits have been evaluated based only on the positive impacts to salinity that the diverted water is expected to have on the transitional, deteriorating marshes; benefits from sediment and nutrients were not included. More detailed analyses of potential project effects on salinities in the target marshes will also be a part of Task G.3. The issue of whether the project will work as a limited diversion, without full re-connection to the river, will be addressed by the revised evaluation of benefits that will result from the evaluation. The more general question of "whether the project will work" depends on interpretation of whether the predicted benefits are sufficient compared to the costs of the project.

Response based on EPA's preliminary draft evaluation report. Modeling done as part of the evaluation has confirmed that clay-size particles will be transported to the marshes and will contribute to marsh benefits; see Sections 4.3.5 and 4.6.6. Salinity control benefits are substantially greater than for the original project, because it is now proposed to pump fresh water down the bayou during the fall, when salinity spikes are most common; see Section 4.6.5. The WVA evaluation of the revised project has shown that as a result of some sediment accretion, increased productivity of vegetation, and mitigation of salinity impacts, the optimized project will result in modest reductions of marsh loss rates within the relatively broad area that would be affected by the diversion. Based on this, the optimized project is expected to save about 988 acres of marsh that would otherwise be lost over 20 years with no restoration efforts. The net WVA benefit was estimated as 705 Average Annual Habitat Units (AAHUs); see Section 5.7.

Comment. The benefits of the project were questioned in terms of how the project could protect against subsidence and saltwater intrusion, especially if no sediment will get to the marsh.

> **1996 response.** Protection against saltwater intrusion in the target marshes will come from the increased freshwater head that will result from the additional freshwater input, and regional hydrologic characteristics that determine where the fresh water will go. The input of fresh water with its nutrients and fine particulates is expected to encourage more vigorous marsh plant growth, which by increased organic contribution to marsh soils helps a marsh maintain itself against subsidence. It is not anticipated, however, that this project by itself will entirely compensate for subsidence in the target marshes. The primary benefits evaluated so far have been those associated with moderating salinities.

Response based on EPA's preliminary draft evaluation report. As stated in 1996, the primary benefit of the project is in promoting healthy vegetation and increased organic productivity which helps maintain the marsh against subsidence. These benefits arise from salinity moderation, nutrient inputs and input of fine sediments. For a detailed discussion of project benefits, refer to Sections 4.6 and 5.7.

Comment. A concern was expressed that fresh water from this project could negatively affect salt marshes.

> **1996 response.** Water from the Bayou Lafourche project will not be added directly to a salt marsh system. It will be added in at the upper (fresh) end of an estuarine system that naturally grades from fresh through brackish conditions to salt conditions. The addition of more fresh water is expected to

shift the salinity gradient, on the average, further toward the Gulf. Given the proposed size of the diversion, this effect will mostly protect marshes that are near the transition zone from fresh to brackish water against becoming more brackish and deteriorating as a result. It will not likely have noticeable impacts on true salt marshes. However, the evaluations to be conducted in Task G.3 regarding modeling of salinity effects to predict project benefits, will provide the information needed to evaluate any potential negative effects of salinity changes.

Response based on EPA's preliminary draft evaluation report. The response made in 1996 remains correct. For a specific discussion of salinity effects of the project, refer to Section 4.6.5.

Comment. It was questioned how water from the project could get west in the GIWW (from Bayou Lafourche) to the marshes where it is needed, if flow in the GIWW is primarily east.

1996 response. The project concept assumes that water siphoned into Bayou Lafourche will flow from the Bayou to Company Canal, where it will flow southwest until Company Canal intersects with the GIWW. This intersection is substantially west of the intersection of Bayou Lafourche and the GIWW. Then water will flow east in the GIWW from Company Canal back toward the Bayou. Along the way, some of the water will flow into the target marshes, especially south of the GIWW. The evaluation will obtain field data and utilize models to help determine if this flow system is in fact likely to occur; and how the project would be designed if the flow system does not occur.

Response based on EPA's preliminary draft evaluation report. The hydrologic modeling done for the evaluation indicates that one effect of increased Bayou Lafourche flows is to partially block the eastward flow in the GIWW, causing some portion of the GIWW water to divert southwards into channels such as the Houma Navigation Canal. Because there is a highly interconnected hydrologic network in southeastern Terrebonne Basin, the effects of a Bayou Lafourche diversion can be quite widespread. See generally the discussions in Section 4.4.

Comment. There was a comment that if the project is going to grow fresh water plants, the first hurricane will kill them.

1996 response. The overall benefits of the project are calculated by estimating the wetlands that will be present in the future with the project and the wetlands that will be present in the future without the project, and taking the difference as an estimate of the amount of wetlands the project will preserve. In both cases, estimates used of wetland loss rates already incorporate the effects of hurricanes as well as other less episodic events (such as subsidence). While it is possible that the project could protect and encourage the growth of many acres of freshwater plants, some of which could be lost in a hurricane, on the average over the life of the project a net benefit to the marshes will occur as originally estimated.

Response based on EPA's preliminary draft evaluation report. The 1996 response remains valid. EPA further notes that if it were determined that wetlands loss must inevitably occur from hurricanes, then arguably there is little purpose to any restoration project other than ones that buffer hurricanes. In this context, the sustaining of additional marsh acreage from this Project PBA-20 will act as a buffer to interior marshes.

7.9 ALTERNATIVES AND OPTIMIZATION

Comment. Many people questioned whether alternatives to the siphons project had been considered, and encouraged or requested that alternatives be considered as part of the evaluation. The concern expressed was that there seemed to be many other ways to accomplish the overall project goal of benefiting the marshes without incurring the high impacts and costs to the people living along the Bayou. Some of the specific alternatives mentioned included: diverting water through Bayou Terrebonne; diverting water from the Mississippi River near Venice; diverting water from the Mississippi River near Myrtle Grove to the lower Lafourche area; diverting water from the Atchafalaya River; diverting through the GIWW; use of dedicated dredging and a sediment pipeline; running a pipeline in Bayou Lafourche; running a 10-20 ft. pipeline from the Mississippi River to the marshes; finding someplace closer to get water to the marshes; and removing the Old River structure.

1996 response. In the broadest sense alternatives for large-scale, sustainable marsh restoration have been considered in the forum of the CWPPRA restoration planning activities. The first and largest effort in planning was conducted from the summer of 1992 through the end of 1993, and culminated in the CWPPRA Restoration Plan for coastal Louisiana. While this plan is a "living document", with revisions and changes expected as knowledge of the problems and possible solutions increase, it does represent a significant evaluation of alternatives for restoration on a coast-wide scale. Through that planning effort, diversions (freshwater and sediment) were identified as potentially such an important component of a plan to achieve large-scale restoration and protection of marshes in a relatively self-sustaining manner, that a separate study of various options for diversions was initiated. That study, the Mississippi River Sediment, Nutrient, and Freshwater Redistribution study, represents another forum in which alternative diversions will be evaluated on a coast-wide scale. Therefore, many alternatives are being considered in other forums; consideration of alternatives in the Bayou Lafourche evaluation is more narrowly focused.

Some actions, such as any affecting the Old River structure, are controlled under a separate authority through the Corps of Engineers, and can not be considered as active alternatives to a specific project such as the Bayou Lafourche siphons. Alternative diversions in other locations may be viable projects in the Restoration Plan; but many, such as a diversion at Venice, while beneficial, would not reach the marshes of the Terrebonne basin. As a result, it was considered valuable to consider possibilities for diversions that could target marsh areas that are otherwise too distant from the Mississippi River to benefit from a diversion. However, alternatives to the Bayou Lafourche project which may be able to achieve similar objectives with respect to the target marshes will be considered in Task H.5 of the evaluation. Alternatives will be characterized, and a comparative assessment of their potential benefits and costs (including impacts) will be made.

Response based on EPA's preliminary draft evaluation report. The prior response remains generally applicable. The draft evaluation report discusses several alternatives, including: relying on the GIWW or other water sources, with no increase in Bayou Lafourche flow (Section 6.2); diverting drainage water through Cancienne Canal instead of or in addition to Mississippi River diversions at Donaldsonville (Section 6.4); and diversions at various rates (Section 6.3).

Comment. Several people asked whether alternative flows to the 2,000 cfs proposed, especially lower flows, will be considered. The opinion was expressed that 2,000 cfs was too much.

1996 response. Optimization of the project design, in Task H.1, is an important part of the evaluation. To accomplish this, siphon flows both lower and higher than 2,000 cfs (for example, a range such as 500, 1,000, 1,500, 2,000, 2,500, and 3,000 cfs for appropriate comparisons) will be evaluated throughout the modeling and other analyses in the evaluation. Results of these tasks will be integrated in the optimization analysis of Task H.1. From this analysis, the most efficient, cost-effective project design (including flow rate) will be selected.

Response based on EPA's preliminary draft evaluation report. The main focus of the current evaluation was to optimize project features so that a variety of considerations, including conveyance capacity of the bayou, wetland benefits, and potential effects of different diversions on bayou water levels, could be jointly addressed. As a result of this effort, an optimized project is recommended that provides for 1,000 cfs of flow on a year-round basis. Other alternatives, including 340, 660 and 780 cfs, also have been evaluated.

Comment. There were several comments related to the observation that all of the environmental benefits from this project occur very far down Bayou Lafourche in the marshes, while most of the impacts and costs in the project occur in the upper portion of the Bayou. The commentors posed that they were being asked to pay for and/or be harmed by a project for someone else's benefit. Several people also asked if the owners of the benefited marshes would be identified, especially because private land owners would be benefiting from investment of public money. In relation to this, several people questioned what the final ownership of benefited marshes would be, and whether the public would have access to the benefited marshes, since they would be restored using public money.

1996 response. It was noted to commentors that the CWPPRA mandate to restore coastal marshes is based on the recognition that as a whole, the marshes provide functions (e.g., support fisheries) that benefit the public on a national scale. Since the majority of the coastal marshland in Louisiana is privately owned, a large-scale restoration effort with great public benefit cannot be undertaken without indirectly benefiting some private landowners. Task H.6 in the scope of the evaluation will address such socio-economic questions associated with the project.

Response based on EPA's preliminary draft evaluation report. The historic closure of the bayou, which had adverse impacts to wetlands, allowed substantial benefits to bayou-side properties. The optimized project is intended to be protective of this development, while providing benefits to the wetlands. Because of the broad spatial extent of benefited marshes, EPA did not identify private landowners who might benefit from the project. The general statement made in 1996, that the entire public benefits from restoration, remains valid. EPA also notes that, in the absence of efforts to maintain flow through the channel, the bayou will gradually decline and cease to be a valued aesthetic and recreational resource.

Comment. Many people expressed concern that oil and gas companies caused some or all of the marsh loss, but are not being held responsible for paying for the marsh restoration. In association with ties was the concern that these marshes would be restored, and then oil and gas companies would again be allowed to explore and drill for oil, thereby damaging the marsh once more.

1996 response. The question of whether oil and gas companies are adequately held accountable for environmental damage they may cause is a broader question than appropriate to a single project. It is a policy and legal issue in the purview of the State of Louisiana and of various Federal agencies with responsibilities for wetlands protection. For damages caused in the past, retroactive actions to recover the costs of those damages are often not possible. In sponsoring the CWPPRA through passage by Congress, the State of Louisiana put forward the concept that whatever the combination of original causes of wetland loss, the outcome was a significant loss of a unique natural resource that would have repercussions not only to the state, but to the nation. This reasoning justified allocation of Federal money to help address the problem in coastal Louisiana. The Bayou Lafourche project is being considered as a possible means of contributing to a sustainable, coast-wide solution to an ongoing wetlands loss problem. It is designed to address some of the major factors associated with deteriorating wetlands, such as saltwater intrusion, but does not address every specific contributing cause, such as the digging of access canals that may have encouraged more rapid saltwater intrusion.

Response based on EPA's preliminary draft evaluation report. No change to prior response.

Comment. Some commentors were against spending public funds for private property.

1996 response. The Coastal Wetlands Planning, Protection, and Restoration Act (CWPPRA) applies public funds in the form of Federal monies with State matching funds to address a problem (coastal wetlands losses) that has been identified as one of national significance. The significance of the problem of wetlands loss in Louisiana is attributed to both its magnitude (representing about 80% of all the wetlands loss in the nation) and the importance and quantity of resources that are considered threatened by the wetlands loss, including commercial fisheries that supply the nation as well as recreational fisheries, wildlife, hunting, and other activities. Although the resources supported by the wetlands are considered a national asset, most of the wetlands themselves are privately owned in Louisiana. Thus it is considered almost impossible to address the problem of wetlands loss at the appropriate scale without acknowledging that privately owned wetlands must be protected and restored as well as publicly owned wetlands. Ownership of the benefited marshes will be identified in Task H.6 of the evaluation.

Response based on EPA's preliminary draft evaluation report. The 1996 response remains appropriate. Computer models identified such a large area over which marshes could be benefited that Task H.6 was not undertaken.

Comment. A few people expressed a belief and concern that the Bayou Lafourche project was being motivated by a special interest, perhaps even an owner of the benefited marshes.

1996 response. EPA and other individuals and agencies participating in the development of the Bayou Lafourche project have no knowledge of any special interest group or individual that has influenced approval of the project. However, owners of the benefited marshes will be identified as part of Task H.6, giving any concerned citizen the ability to evaluate whether there is a basis for their concern.

Response based on EPA's preliminary draft evaluation report. See response to prior comment.

Comment. Several comments were made that with the existing effects of high water and flooding along the bayou without the project, if the project were put into operation the need for mitigation would be high and cost a lot of money. The concern was that the estimated cost for the project seemed too low to cover the anticipated costs. One specific comment was that the estimated $800,000 for bank stabilization was inadequate, and that nobody knew how stable the banks were at present. Several people commented that the project couldn't be done for the estimated cost, and questioned how these costs were derived. A few commentors added that if the costs were underestimated, this would inflate the apparent cost-benefit ratio.

> **1996 response.** Task H.3 in the evaluation is a re-evaluation of project costs. This will be done based on the inputs from the previous tasks, so that a comprehensive inventory of the types of costs required (including dredging, bulkheading or other bank protection, mitigation, etc.) will be available. If the costs exceed the 25% contingency on the approved funding level, the CWPPRA Task Force will be informed and will evaluate all information on the project before malting a decision to proceed.

Response based on EPA's preliminary draft evaluation report. Most of the evaluation budget was spent either on re-design of the project, or on revising estimates of projects costs and benefits. This draft evaluation report contains detailed information on project costs and benefits and should provide the public with a basis for judging cost-effectiveness.

7.10 Other Comments

Comment. There were several concerns expressed about the accuracy of information that has been presented in the past, and of the accuracy of the data that will be used in the evaluation. There was a general concern that all data used be independently verified, and a specific concern that data on pumpage rates by the Fresh Water District be verified and evaluated.

1996 response. The accuracy and reliability of results of the evaluation depend on having accurate, unbiased data as input. Because information for the evaluation will come from many sources, including historic data bases, several different agencies, and new collection efforts, it will be important to subject all data used to a system of Quality Control (QC) checks to assure that all data are reasonable, accurate, complete, and comparable. The nature of the checks each data set will be subject to will vary for different types of data. In general, data received for use in the evaluation will be reviewed for appropriate ranges, completeness, internal consistency, outliers, and appropriate units. Some of the QC comes from initial analysis of the data, with checks to see if calculated values or trends and relationships are within reasons or are consistent with other available data. Any data that are questionable will be corroborated with the original source of the data if possible.

Response based on EPA's preliminary draft evaluation report. EPA's evaluation has been performed with the support of agencies such as the U.S. Geological Survey and the U.S. Army Corps of Engineers, experts at academic institutions such as LSU and Nicholls State University, and consultants selected in competitive bidding in which quality control credentials were a primary selection criteria. The information has been subject to review by Federal and State agencies and, through dissemination of the study results, will be subject to review by the public. With respect to the FWD data, these were compiled by the USGS using FWD records; the data are internally consistent and also consistent with the USGS independent data base of flow measurements at Thibodaux.

Comment. A comment was made that there are two sources of flooding for the Bayou Lafourche area, the Mississippi River and the gulf to the south. This project is needed to help maintain wetlands and forestall increased flooding from the south.

1996 response. Acknowledged.

Response based on EPA's preliminary draft evaluation report. No further response.

Comment. It was commented that achievement of a broad based approach to improving Bayou Lafourche as a fresh water supply and as a conduit for fresh water to counteract saltwater intrusion is essential to stability of the economy and population of the area. The commentor felt that problems of siltation can be resolved, that there are many ways the Bayou can be deepened to increase capacity, and that EPA's evaluation is designed to address these and other problems. He encouraged EPA to proceed with the project.

1996 response. Acknowledged.

Response based on EPA's preliminary draft evaluation report. No further response.

Comment. A comment was submitted supporting efforts to evaluate possibilities for bringing more water to the southern part of Lafourche Parish. This comment emphasized the importance of the Port of Fourchon to the Parish economy, and its contribution to the funding of the Fresh Water District.

1996 response. Acknowledged.

Response based on EPA's preliminary draft evaluation report. No further response.

Comment. A comment was submitted indicating support for the project, indicating that this represents an opportunity not only to combat saltwater intrusion and coastal land loss, but also to obtain other benefits, including dredging and maintenance of the Bayou, banks stabilization flood protection, monitoring and aquatic weed control. The critical nature of land loss in Lafourche was emphasized, indicating that if unchecked, the value of lost land, associated fish and wildlife, and costs of armoring unbuffered protection levees will be tremendous. The comment stated that the evaluation represents a significant opportunity to obtain information on Bayou Lafourche that the people along the Bayou would not otherwise be able to afford, and that will be helpful in many future decisions in addition to the specific decision on the project.

1996 response. Acknowledged. No further response.

Response based on EPA's preliminary draft evaluation report. No further response.

Comment. There was a comment strongly urging the Bayou Lafourche diversion project be built now and tightly monitored.

1996 response. Acknowledged.

Response based on EPA's preliminary draft evaluation report. No further response.

Comment. There was a comment detailing the extent of marsh loss, barrier island loss, and associated threat from the Gulf of Mexico from both wave action and saltwater intrusion in southern Lafourche, and urging the siphon project to be built now, indicating that there are about 40,000 people in south Lafourche who are the silent majority in favor of this project. It was also suggested that sheet piling along the lower Bayou would protect the highway and homes (there is only about 1 ft from high tide to Highway 1 there), and that material dredged from the Bayou could be used to fill in behind the sheet piling and would achieve deepening of the Bayou.

1996 response. Acknowledged.

Response based on EPA's preliminary draft evaluation report. No further response.

Comment. A comment was presented supporting the siphon project because the coastal problem won't just go away, because of a commitment to the advancement of the Donaldsonville area, and because the project would benefit the Fort Butler project, which is requisite to the revitalization of Donaldsonville. The commentor observed that many people currently opposed to the project would not be if they were assured no negative impact and compensation for change, and advocated representation by some with a local vested interest to present the benefits and advantages of the project and reduce the level of distrust.

1996 response. Acknowledged. No further response.

Response based on EPA's preliminary draft evaluation report. No further response.

Comment. A comment was submitted in favor of doing the project as soon as possible to combat saltwater intrusion and wetland loss. The commentor also urged controlling the numbers of nutria to benefit the wetlands.

1996 response. Acknowledged.

Response based on EPA's preliminary draft evaluation report. No further response.

Comment. A comment was submitted against the project because it leaves too many questions unanswered, and because taxpayer money could be spent in better ways. Another commentor indicated it would be a better use of taxpayer money to spend it on the homeless, sick, hungry, and elderly it was questioned what would happen if the project was done and it did not work.

1996 response. The first part of these comments are acknowledged. With regard to the second question, the intent of funding and conducting the evaluation is to assure that all questions and issues are addressed before the project is implement, to assure that if implemented, the project will function as expected.

Response based on EPA's preliminary draft evaluation report. EPA will consider its project recommendations after the next phase of public review and comment.

APPENDIX A. SUMMARY OF SUPPORTING STUDIES

This appendix provides summarizes (abstracts) of the studies that have been prepared as part of this report or are otherwise relevant. Note that there may be minor differences between the material contained in the supporting studies and in this summary report. The differences are not necessarily conflicts; they are differences in interpretation or use of data. For example, several of the supporting reports state that the existing capacity of the FWD pump station is 400 cfs. This is the correct value for the design capacity. However, the main report uses the value of 340 cfs, which is the operationally practical capacity.

PRELIMINARY: NOT FOR DISTRIBUTION

A.1 U.S. GEOLOGICAL SURVEY (USGS)

A.1.1 Swarzenski, Demcheck, and Tarver, 1998

Swarzenski, C. M., D. K. Demcheck, and A. Tarver, 1998. Selected hydrologic and water-quality data of Bayou Lafourche in south central Louisiana, 1988-1998. U.S. Geological Survey, Baton Rouge, Louisiana, 1998.

Under a cooperative agreement with EPA, the U.S. Geological Survey (USGS) collected new data and compiled previously collected data related to the hydrology and water quality characteristics of Bayou Lafourche, and hydrologically inter-related areas. This effort represents one of the significant accomplishments of the project evaluation. In addition, the USGS has provided EPA with the database in electronic format.

The USGS collected hydrologic and water-quality data on Bayou Lafourche from its source at Donaldsonville to Larose, where the bayou intersects with the Gulf Intracoastal Waterway. Mississippi River water is pumped and siphoned into the bayou at Donaldsonville at between 200 and 300 cfs to maintain flows.

Continuous stage and discharge data show an increase in water levels, and a decrease in discharge, at Thibodaux, about 35 miles downstream from Donaldsonville. These trends in bayou hydrology were markedly accelerated in 1995 and 1996. Measurements of instantaneous discharge in the bayou, made three times in 1996 at 8-10 locations, showed three somewhat distinct hydrologic reaches in Bayou Lafourche. From its source at Donaldsonville to Thibodaux, flows in the bayou dropped by about 50%. Between Thibodaux and Lockport (about 27 river miles), flows dropped further, to less than 10% of the original flow at Donaldsonville. Velocities were close to zero. Below Lockport, movement of water in Bayou Lafourche was determined by interactions with flows in the Gulf Intracoastal Waterway (GIWW) and Company Canal, indirectly connecting Bayou Lafourche to the GIWW about 10 miles east of Larose.

Water quality collected at six to eight stations along Bayou Lafourche in 1996 paralleled the three distinct hydrologic reaches. From Donaldsonville to Thibodaux, the water had elevated turbidity, and relatively higher concentrations of inorganic nutrients and suspended sediments. Between Thibodaux and Lockport, inorganic nutrients, especially nitrates, dropped close to detection limits, and turbidity and suspended sediments also were very low. Chlorophyll and total organic carbon were elevated along this stretch of Bayou Lafourche. Finally, suspended sediments and inorganic nutrients increased below Lockport, as water from the GIWW mixed with Bayou Lafourche. Here, fall calcium/magnesium ratios decreased to below 2 during the fall. Along with the elevated chlorides, this demonstrated marine influence. Marine waters entered Bayou Lafourche via Company Canal. Some of this water reached the study area during flow reversals in the north-south trending Houma Navigation Channel, which extends into Terrebonne Bay. The reach of Bayou Lafourche between Lockport and Larose is affected by marine waters almost on a yearly basis. The lack of freshwater inflow from north of Lockport, due to the stagnation of Bayou Lafourche between Thibodaux and Lockport, probably exacerbated the extent of saltwater intrusion between Lockport and Larose.

Water levels began going down in 1997 and 1998, concomitant to increases in discharge in the bayou. A resurvey of instantaneous discharge and suspended sediments on April 2 1998 demonstrated that flows had increased substantially in Bayou Lafourche compared with measurements in 1996. Suspended sediments, although still decreasing downstream from Donaldsonville, were higher in 1998 compared to 1996.

A.2 U.S. ARMY CORPS OF ENGINEERS (USACE)

A.2.1 USACE, 1994

USACE, 1994. Bayou Lafourche water management study. Prepared for the Bayou Lafourche Fresh Water District by the U.S. Army Corps of Engineers, New Orleans District, in cooperation with the U.S. Environmental Protection Agency, Region 6, Dallas, TX, December, 1994.

The Bayou Lafourche Fresh Water District (FWD) contracted with the Corps of Engineers to conduct a hydraulic and hydrologic study of Bayou Lafourche and associated wetlands to: 1) evaluate water supply needs; 2) quantify the existing hydraulic capacity of the bayou; 3) develop alternatives for diversions; 4) determine changes to the bayou induced by additional diversions; 5) evaluate current salinity trends; 6) and develop salinity reduction alternatives. The Corps' work included use of a HEC-6 model and TABS-MD model.

Water supply needs were assessed by evaluating current and projected rates of water supply withdrawals, diversion rates, and inflow to the channel above the weir. The existing diversion facilities can provide up to 340 cfs of freshwater which is adequate to supply current and future municipal and industrial water supply needs, but inadequate to prevent extreme events of saltwater intrusion.

Existing hydraulic conditions and diversion alternatives were evaluated using a HEC-6 model for the reach of Bayou Lafourche from the weir at Thibodaux, Louisiana, to its head at Donaldsonville, Louisiana. Historic diversion rates and channel cross-sections were provided by the FWD. Two bed samples were taken and identified mostly silt materials. The model was calibrated to match observed bayou stages.

The report indicates that the maximum flow that Bayou Lafourche can convey without overtopping the existing banks, which the report uses as a criterion of bank failure, is 1050 cfs. At this limit of flow, the average channel velocity never exceeded 2.5 feet per second (fps), which the report defined as the velocity at which the typically sand banks of Bayou Lafourche would start to erode. The natural bank elevation was determined using cross-sectional data provided by the BLFWD, and does not account for any structures that may be within the natural banks. At 1,050 cfs, flow velocities would be less than than the 2.5 feet per second that would be expected to cause erosion of the bayou's sand banks.

For 1,000 and 2,000 cfs, sediment discharges were estimated at:

	1000 cfs	2000 cfs
Clay	5 Tons/Day	16 Tons/Day
Silt	56 Tons/Day	112 Tons/Day
Sand	5 Tons/Day	1.6 Tons/Day

The model predicted that most sand would fall out of suspension in the upper part of the bayou, which would make the channel bed increase in elevation. Lesser sedimentation effects were associated with a diversion through Cancienne Canal. Sediment concentrations entering Bayou Lafourche are not high enough to achieve any significant marsh building, and velocities are not high enough to transport sediment if it were introduced.

Removal of the weir at Thibodaux would allow greater tidal influence in the bayou. However, there was not a marked impact on sedimentation. The report suggests dredging of the bayou to solve flooding problems.

To assess salinity issues, a hydrodynamic and salinity transport study was completed for Bayou Lafourche from Donaldsonville to the Gulf of Mexico, and the adjacent wetlands to the west of Bayou Lafourche, east of Louisiana Highways 55 and 56, and south of the GIWW. The study was completed in two independent phases. Phase 1 included Bayou Lafourche, the GIWW, Company Canal, and Grand Bayou. Phase 2 included the wetlands to the west of Bayou Lafourche. Both phases were completed by generating a numerical model for each study area. TABS-MD, a two dimensional, finite element, hydrodynamic and salinity transport model, was selected to complete this task.

As part of the studies, hydrologic (current or stage) and water-quality (salinity or conductivity) data were collected at 15 locations for several months in 1993-94. The stations were located along Bayou Lafourche and the GIWW, and in wetlands areas south of Larose. A salinity profile from July, 1994, was used to calibrate the TABS model.

The Phase 1 study consisted of analyzing plan conditions to reduce existing salinity concentrations along Bayou Lafourche during a high saline event. Plan conditions consisted of placing control structures in the study area as well as increasing flow into Bayou Lafourche north of the Thibodaux weir. The control structures reduce the existing channel cross sectional area, and alter circulation patterns that transport salinity. Two plan conditions yielded the required chloride concentrations in Bayou Lafourche north of the GIWW for the analyzed high saline event. The first plan specifies placing a control structure on Bayou Lafourche directly north of the GIWW and a structure on the Company Canal directly north of the GIWW. The inflow at Thibodaux would need to be increased to a net inflow of 400 cfs over the Thibodaux weir, or a gross inflow of 580 cfs. The second plan specifies for increasing the net inflow over the Thibodaux weir to 600 cfs, or a gross inflow of 780 cfs, without any additional structures.

The model results indicate that the minimum flow requirement for water supply and salinity management with the implementation of control structures is 580 cfs. Of this, 180 cfs would be for water supply demands and 400 cfs for maintaining desirable salinity during a worst case event similar to that of 1987. This alternative assumes channel constrictions at Bayou Lafourche above the GIWW and also on the Company Canal above the GIWW. Without constrictions, the minimum flow should be 780 cfs, of which 600 cfs would be for salinity control.

The Phase 2 study consisted of increasing the existing Grand Bayou flow rate (approximately 100-150 cfs) into the wetlands to determine the affected area during normal tidal and saline conditions. The effects from three flow rates, 200, 500 and 800 cfs, were analyzed. The results showed that a flow rate of 800 cfs would directly benefit an area up to three miles south of the GIWW by lowering salinities, with less noticeable impacts beyond that point. Such diversion of water to wetlands via Grand Bayou from the GIWW would lower salinity in that area without deleterious effects to the water supply of the nearby communities.

A.2.2 Shadie, C., 1997

Shadie, 1997. Bayou Lafourche siphon design. Prepared for the U.S. Environmental Protection Agency, Region 6, by the U.S. Army Corps of Engineers, New Orleans District, New Orleans, Louisiana, January, 1997.

This report presents preliminary hydraulic designs for siphons to divert Mississippi River water to Bayou Lafourche at Donaldsonville. Data on Mississippi River were combine with pipe hydraulics to indicate the number of 72-inch siphons needed to divert 1,000 cfs, 2,000 cfs and 3,000 cfs. A tailwater elevation (the water surface elevation at the outfall of the siphon) of 8.0 ft. NGVD was assumed in Bayou Lafourche, to conform to the assumption that the project would not increase stages in the bayou. The calculations were made for each month of the year, for river conditions that recur 30% of the time (high water), 50% of the time (median water) and 70% of the time (low water).

The Project Flood stage for the Mississippi River at Donaldsonville (Mile 175.4) is 34.3 ft NGVD. With an authorized freeboard of 3 feet, the levee crown and the invert of the proposed siphons will be a minimum of 37.3 feet NGVD. The inlet invert of the 72” diameter siphons will be at 0.0 ft NGVD to assure that the inlet is always submerged. From the inlet, the siphons will extend along the batture and up to the levee crown (about 600 feet), over the levee crown, and down the levee slope and extend to Bayou Lafourche (about 750 feet). Most or all of the siphon on the protected side of the levee will be buried to avoid highways and other obstructions. The outlet of the siphons will have an invert elevation of 04.0 ft NGVD and will empty into the discharge stilling basin. A stilling basin will be required at the siphon outlet. Enclosure 2 to the report provides a design sketch of the siphon alignment.

The number of siphon pipes for each design capacity and monthly 50% duration stage on the river was determined. Those results are summarized in Table 2 of this report which indicates that between 3 and 11 pipes are required for the design stages and discharges if substantial channel improvements to Bayou Lafourche are performed to prevent a tailwater stage increase at Donaldsonville. The analyses indicate that the siphons will not work for the months of August through November because a reverse head condition will exist. In addition, the practical limit to the siphon lift is about 26 feet (the theoretical limit is 34 feet). The siphon lift limit is the maximum negative pressure head (vacuum) at the crest of the pipe. Here it is equal to the centerline of the siphon (levee crown plus radius of pipe = 37.3 + 3 = 40.3 ft NGVD) minus the Mississippi River stage. As such, the maximum allowable siphon lift equals 40.3 ft minus 26.0 feet equals 14.3 feet. Table 2 of the report shows that this lift limit is exceeded for the months of July through November and, therefore, the siphons could not be operated during these times. Table 3 of the report provides a rating table for one 72” diameter steel pipe siphon at this site. Total discharge from multiple pipes is simply the number of pipes times the rating table. Table 4 of the report provides a comparison of the 50% duration stage design case and siphons with capacities and stages for the 30% and 70% duration stages on the river at the site. For all months except April and May, the 70% stage results in the siphon lift exceeding 26.0 feet, so that no flow will occur for that stage.

A.2.3 USACE, 1997a

USACE, 1997a. UNET modeling of flows in Bayou Lafourche in combination with Atchafalaya River and Barataria Estuary flows. Winer, Harley S., U.S. Army Corps of Engineers, New Orleans District, New Orleans, Louisiana, April, 1997.

Harley Winer of the New Orleans District of the U.S. Army Corps of Engineers (USACE) developed and evaluated a UNET model to assess probable hydrologic changes that would be associated with a diversion into Bayou Lafourche. Tables and figures summarizing modeling results (i.e., not a formal report) were submitted by USACE. This document summarizes the model inputs and assumptions used by USACE, the range of scenarios tested using the model, and the resulting model outputs on expected changes in flow in the various channels modeled under each scenario tested.

Model structure, inputs, and assumptions

The goal of the modeling work was to describe the distribution of flows and changes in flows under different existing hydrologic conditions and for a variety of diversion inputs. The UNET model was selected to accomplish this because it models multiple channels that are hydrologically linked, which makes a suitable analog for the Bayou Lafourche study area. The UNET model does not provide for modeling of overbank flow perpendicular to the channel, as would be expected to occur in the marshes. This was a concern only for the Penchant region of the model grid, where losses due to overbank flow affect how much water coming in from the Atchafalaya River is captured in Penchant and how much remains in the GIWW to flow past Houma. Details of flow within the Penchant region were not being evaluated in this modeling effort, and it was only important to assure that flows in the GIWW continuing east past Penchant were comparable to observed levels. Thus, channel size and friction were adjusted for some bayous in Penchant to adjust for overbank flow, so that calibration runs of the model fit USGS measurements of flows in the GIWW past Houma.

UNET also can use tidally driven boundary conditions (i.e., effects of tidal variations can be evaluated) and time-varying hydrographs (e.g., one could incorporate variations due to storm runoff in the model). However, for the purposes of this study, the UNET model was run in steady state, with boundary conditions set to mimic high and low flow conditions, and average gulf stage conditions, as described below.

The areas of interest were all parts of the region that are hydrologically connected to Bayou Lafourche, and therefore might be affected by a diversion. Since Bayou Lafourche forms the border between Barataria and Terrebonne hydrologic basins, and is hydrologically connected with both basins, the model was structured to include all the major channels between the Barataria Estuary and the Atchafalaya River that are interconnected to Bayou Lafourche, including those connected through the Gulf Intercoastal Waterway (GIWW).

Figure 1 shows all the channels included in the model, with channel segment numbers and arrows showing the assumed direction of predominant flow. This represents the model grid. Figure 2 shows this grid superimposed on a regional map so channel locations can be easily identified. Table 1 defines all the channel reaches in the grid by channel name and beginning and ending points, and also lists the other reaches to which that reach is connected in the model. Note that the model is not effective in handling four-way channel intersections in which two channels flow in and two flow out. At the intersection of Company Canal and the GIWW, a small artificial reach (# 6) was added to the model grid to avoid this problem.

Major freshwater inputs to the study area are the planned Davis Pond Diversion into the northeast corner of Barataria Basin, and the Atchafalaya River at the GIWW on the west side of Terrebonne Basin. These flows are accounted for in the model as steady state boundary inputs. To account for the full range of possible flow conditions to which a diversion into Bayou

Lafourche would add, the low, medium, and high flows for each of these major inputs were tested. This gave a total of nine combinations of Atchafalaya plus Barataria flows tested. Average low, medium, and high flows used were 2,000 cfs, 10,000 cfs, and 20,000 cfs respectively for the Atchafalaya River; and 500 cfs, 5,000 cfs, and 10,000 cfs respectively for Barataria. Other boundary conditions included the stage of the Gulf, which was set at 0 (zero) NGVD for all runs.

The tested range of diversion flows into the head of Bayou Lafourche included 1, 500, 1,000, 1,500, and 2,000 cfs. A value of 1 cfs rather than 0 (zero) cfs was used to represent essentially no flow into Bayou Lafourche, because a value of zero would not be handled well by the model equations. These five diversion flows were tested for each of the nine combinations of existing hydrologic conditions, giving a total of 45 model runs.

Model results

Table 2 shows the magnitude and direction of flow for major channel reaches within the Bayou Lafourche study area for each of the 45 model runs. Positive flow numbers indicate that the direction of flow is in the assumed predominant direction, as show on the grid map in Figure 1. Negative numbers indicate that flow was in the opposite direction of predominant flow (i.e., flow was reversed under the conditions of that model run).

To understand how much change a diversion into Bayou Lafourche of a particular magnitude would cause, the differences in flows in the major channels between flow with no diversion (represented by 1 cfs into Bayou Lafourche) and flow with the diversion level of interest must be examined. Estimated flow increases that are predicted in various major channel segments for 1,000 cfs and 2,000 cfs diversions are summarized in Tables 3 and 4, respectively.

A number of graphs illustrate model outputs. Figures 3-14 illustrate the effects which increasing Atchafalaya flows and increasing Bayou Lafourche discharges have at each level of Barataria flow on flows in various major channel segments throughout the study area. Figures 15-23 show how increasing flows in Bayou Lafourche affect channel flows for each combination of Atchafalaya plus Barataria inputs.

Model outputs also are illustrated using maps. Figures 24-27 show the distribution of diverted water for a 1,000 cfs diversion into Bayou Lafourche under various flow conditions. Note that these maps show the distribution of hydrologic effects, not the molecules of water. For example, it is often the case that the effect of Bayou Lafourche on the GIWW near Houma is to partially block the natural eastward flow. With high water in Bayou Lafourche, flow that would have gone east in the GIWW instead is diverted south into the Houma Navigation Canal. The molecules of Bayou Lafourche water flow down Company Canal and turn east, effectively replacing the blocked GIWW water. Hydrologically, it is the Houma Navigation canal that experiences this particular diversion impact.

Figures 28 and 29 show how diverted water changes flows in various channels for a 1,000 cfs diversion into Bayou Lafourche under the situation of low-flow at the boundaries, and high flow at the boundaries, respectively.

Distribution of BLF flows at low water

The changes in flow seen in various channel segments for a particular size of Bayou Lafourche diversion vary as the existing hydrologic inputs to the east (Barataria) and west (Atchafalaya) of the study area change. In a low-flow condition such as may occur during the fall (Figure 24), and with a 1,000 cfs diversion down Bayou Lafourche, almost two thirds of the diverted water is projected to flow west down Company Canal at Lockport. The flow effects split at the GIWW. The effects that go easterly in the GIWW interact with the effects that go through Bayou Lafourche from Lockport to Larose. This flow complexity helps illustrate the importance of using a model, as there is no other method to effectively characterize diversion impacts.

Overall, the net distribution of diverted water under low-flow conditions is 37% to the east (Barataria Basin), 35% to the west (much of which flows down the Houma Navigation Canal), and 28% to the south (to the marshes of southeastern Terrebonne Basin).

Effects of boundary conditions

The effect of higher Atchafalaya River flows is to increase the total flow in the model and to shift flows eastward. For example, for channels conveying water from Bayou Lafourche either east or south (e.g., Bayou Terrebonne, Grand Bayou, lower Bayou Lafourche, and the GIWW east of Bayou Lafourche), both increases in Atchafalaya flows and increases in Bayou Lafourche diversions progressively increase flow in that channel.

The effect of higher Barataria flows is similar to the Atchafalaya, but opposite in direction. Thus, increasing flows from the Barataria Basin tend to increase the amount of water from Bayou Lafourche and from the Terrebonne Basin that stays in the Terrebonne Basin.

When flow conditions in both basins are high (as could occur in the spring, once Davis Pond is operating), the overall impact is a net shift to the east when compared to low-water conditions. This effect is the result of assuming that high water produces twice as much flow at the Atchafalaya boundary as at the Barataria boundary (as reflected in the maximum boundary conditions defined for these model runs). For high water, a 1,000 cfs Bayou Lafourche diversion is distributed 46% to the east, 31% to the west, and 23% to the south (Fig. 27).

Effects of increasing BLF flows

Increasing flow into Bayou Lafourche progressively increases southerly or easterly flows in the channels confluent with the bayou, notably Company Canal and the GIWW; and also increases southerly flow in channels confluent with the GIWW, including Bayous Terrebonne and l'Eau Bleu, and lower Bayou Lafourche. Increasing flows in Bayou Lafourche progressively blocks flow (i.e., reduces the magnitude of easterly flow) in the GIWW west of Company Canal (east and west of Houma), and increases flow down the Houma Navigation Canal.

A 2,000 cfs diversion into Bayou Lafourche changes flows in the major channel segments more than a 1,000 cfs diversion does. The difference varies around a two-fold increase; the increase is greater than two-fold in some cases (e.g., Company Canal East and the Houma Navigation Canal under low flow conditions), but more often is slightly less than two-fold. Thus, the proportional distribution of benefits may vary slightly between a 1,000 cfs and a 2,000 cfs diversion, but net benefits would be approximately proportional to size of the diversion for this range of diversion sizes.

Effects on receiving channels

Obviously, at low water, flows in all the area channels are lower than at high water. The effect of a 1,000 cfs Bayou Lafourche diversion at such times can be substantial. As shown in Figure 28, the increase in low-water flow in many of the channels will approximately double if 1,000 cfs is diverted down Bayou Lafourche, when compared to a situation in which there is no Bayou Lafourche diversion. Channels where the increase is roughly two-fold include lower Bayou Lafourche, Bayou l'Eau Bleu and the GIWW east of Bayou Lafourche. The flow increase in Bayou Terrebonne would be almost as high, at 71%. The effects are marked even in the largest channels, such as the Houma Navigation Canal, which would carry 26% more fresh water with a 1,000 BLF diversion than without a diversion.

At high water, the relative change caused by flows in Bayou Lafourche are, of course, much less (see Figure 29). The primary reason for operating a Bayou Lafourche diversion at this time of the year would be to provide a small sediment input to the system (and also to reflect the fact that operations are inexpensive, since water can be siphoned). Note that even during high water, flows in the southern receiving channels (e.g., lower Bayou Lafourche, Bayou l'Eau Bleu, and Bayou Terrebonne) are increased by about one-third.

A.2.4 USACE, 1997b

USACE, 1997b. TABS modeling of flows and salinity in the Grand Bayou Area. Winer, Harley S., U.S. Army Corps of Engineers, New Orleans District, New Orleans, Louisiana, May, 1997.

This report summarizes a study conducted by USACE using the TABS-MD model, which is a two-dimensional hydrodynamic and salinity transport model, to assess the effects that increased fresh water would have on the distribution of salinities in the Grand Bayou marshes. This assessment is pertinent to both the proposed diversion into Bayou Lafourche at Donaldsonville, and the Grand Bayou project which involves enlargement of Bayou l'Eau Bleu to increase flow from the GIWW to the Grand Bayou marshes.

Model Structure

The study was based on expansion of an existing TABS grid, which was originally developed by USACE for a study contracted by the Bayou Lafourche Freshwater District, and which included only the marshes south of the GIWW (the Grand Bayou marshes); see USACE (1994). This two-dimensional marsh grid was expanded by adding some major channels within the marsh, including Sulfur Mine Canal, Bayou Blue below Bully Camp, and the connection between Bay Courant and Grand Bayou Blue. In addition, a one-dimensional grid was added that included the GIWW, Company Canal, and Bayou Lafourche from Thibodaux to the Gulf of Mexico.

Because there were problems with model verification, the one-dimensional channels were removed from the grid, and the model was run using only the enhanced two-dimensional marsh area plus channels. In this configuration, Bayou l'Eau Bleu was the northern boundary, and the gulf was the southern boundary. Outputs from the UNET model developed for evaluation of the Bayou Lafourche diversion (see Winer, 1997a) were used to define boundary flows in the GIWW east of Bayou Lafourche and west of Company Canal. A constant tidal range of 1.5 feet at the gulf boundary was used. Initial salinities were the same for all runs. Model output was the daily average salinity after a 30-day model run, which was recorded for seven locations throughout the Grand Bayou marsh area. A proposed structure with a boat bay in Cutoff Canal, in the southwest corner of the Grand Bayou marshes, was incorporated in the model. Total closure of this canal also was tested.

The model was verified by comparison to National Ocean Service (NOS) tidal range and phase charts. Synoptic velocity measurements also were compared to model results, especially for Cutoff Canal at the Pointe au Chien ridge, where strong tidal currents (several feet per second) are routinely observed. The model did not produce velocities that approached those observed in the field. This may indicate that tidal prism was not properly represented in the model, which could affect model results regarding salinity. This could explain why the TABS model did not show large salinity fluctuations that are sometimes observed in the Grand Bayou marshes.

Model Results

The TABS model showed that a 300 cfs increase in flow (from 200 cfs to 500 cfs) into the study area through Bayou l'Eau Bleu would result in a substantial decrease in average salinity, even at the southern perimeter of the study area. On the southeastern side, in Grand Bayou Blue near Catfish Lake, the modeled flow increase resulted in a decline in salinities of 2.3 ppt to 2.7 ppt (17% to 18%), depending on whether Cutoff Canal was opened or closed. On the southwestern side, in Cutoff Canal near the Pointe au Chien ridge, salinities decreased by 3.9 ppt (31%) with the Cutoff Canal opened, and by 0.6 ppt (4.5%) with the canal closed. Thus, introduction of more fresh water into the study area had a substantial effect on salinities.

The report focused on the question of whether the proposed structure in Cutoff Canal would affect salinities in the region. Salinities in the northern half of the study area decreased only slightly with the structure or with complete closure of the canal compared to the opened condition. Salinities showed a greater reduction with the structure in the southwestern portion of the study area. However, in the southeastern quadrant, salinities were predicted with the model to be higher with closure of Cutoff Canal than without closure. This was explained based on an empirical relationship, developed by USACE, between tidal prism and restriction of cross-sectional area of tidal passes. There is a threshold corresponding to about 30% of the natural tidal pass cross-section, before which there is little or no reduction in tidal prism, but rather a compensatory increase in tidal velocity in the remaining cross-section. Cutoff Canal represents about 50% of the cross-section available into this hydrologic unit of marsh. Therefore, closure would likely only result in increased tidal excursion through the remaining tidal passes, in this case notably Grand Bayou Blue on the eastern side of the study area. The model showed that closure of Cutoff Canal results in increased salinities in the southeastern portion of the study area, an apparent result of the induced increase in tidal excursion. In the southwestern portion of the study area (in Cutoff Canal near the Pointe au Chien ridge), the structure also increases salinities slightly over the open canal condition.

A.2.5 USACE, 1997c

USACE, 1997c. Daily 8AM stage at Houma on the GIWW. Winer, Harley S., U.S. Army Corps of Engineers, New Orleans District, New Orleans, Louisiana, January, 1997.

This report consists of two graphs of the daily 8AM stage at Houma on the GIWW, one graph from 1987 through 1993, and one graph from 1990 through 1996. An updated graph, through most of 1998, is provided in Section 2 of this report at Figure 2.3-2. The author notes that the graph captures the following events or information.

- An extreme weather event during late December 1989 which lowered the waters on the continental shelf, allowed the marshes to drain, and froze the marsh.
- An excessive rainfall in spring of 1991, coupled with southerly winds, which significantly raised coastal waters and caused prolonged flooding throughout coastal Louisiana.
- High water during Hurricane Andrew in August 1992.
- A slight increase in average stage over the seven years of the period of the graph, consistent with the author's analyses of many gage records in south Louisiana.
- No visual correlation between Simmesport (Atchafalaya) discharge and Houma stage.
- A similar Grand Island graph shows a similar winter low, summer high pattern.

A.3 U.S. FISH AND WILDLIFE SERVICE (USFWS)

A.3.1 Paille, R., 1997

Paille, Ronny, 1997. Lower Atchafalaya Basin re-evaluation study: planning aid report on freshwater inflows to the Terrebonne Basin. Prepared by the U.S. Fish and Wildlife Service, Ecological Services, Lafayette, LA, for the U.S. Army Corps of Engineers, New Orleans District, January, 1997.

This report characterizes the distribution and quantity of Atchafalaya River freshwater inflows that help maintain the health of wetlands in the northern Terrebonne Basin.

During moderate to high Atchafalaya River stages, water from the Lower Atchafalaya River flows northeastward into the Gulf Intracoastal Waterway (GIWW). A substantial portion of that flow escapes to the Gulf of Mexico via the Houma Navigation Channel (HNC) at Houma, while the remainder flows eastward toward Larose. During high river stages, fresh water may flow further eastward to Lake Salvador via Harvey Canal Number 2 and to Bayou Perot via the GIWW.

The report provides specific information as to the above. Key examples are as follows.

Flow direction - North Penchant Subbasin

- “As stages on the Lower Atchafalaya River increase, a point is reached where the Avoca Island Cutoff Channel and Bayou Chene begin functioning as a distributary channel, transporting river water and all Bayou Boeuf drainage eastward through the GIWW. … The Service’s data suggest that the point at which river water begins flowing eastward through the Avoca Island Cutoff Channel may occur when Atchafalaya discharge is somewhere around 300,000 to 320,00 cfs.”

- Measurements made by the U.S. Army Corps of Engineers in 1983-84 at a gage on the GIWW west of Houma recorded flow to the west 2 times and to the east 20 times.

- Measurements made by the USFWS May 5, 1995 indicated that “high stages on the Lower Atchafalaya River were apparently forcing all the drainage from the Verret Subbasin to the east.”

Discharges - Penchant Subbasin

- GIWW flow data for 1983/84 and 1995/96 were compared to Atchafalaya flow data, assuming a 3-day lag. "Because the R squared value associated with the 1995/96 discharges is higher than that for the 1983/84 discharges, this indicates that the GIWW is functioning increasingly like a distributary channel." That is, in 1995/96, the magnitude of flows in the GIWW correspond more closely to magnitude of flow in the Atchafalaya than they did in the earlier time period.

- "Using the predictive equations derived from the 3-day lagged regressions, … the different slopes of those lines indicate that GIWW discharges have increased over time." The increase is consistent with Corps modeling which projects increases solely due to the shoaling and growth of Atchafalaya Bay.

Flow direction - HNC

- "Approximately 70% of the GIWW flow entering Houma is discharged southward down the HNC."

Flow direction - GIWW east of Houma

- There are no routinely collected flow data. "Local residents, however, claim that GIWW flows at Larose are predominantly to the east."

Salinity data - GIWW east of Houma

- "Salinity data from 1981, 1984, and 1987 show that salinity spikes at Houma and Larose occur primarily during periods of low Atchafalaya River flow, especially when precipitation is below normal."

A.4 LOUISIANA DEPARTMENT OF ENVIRONMENTAL QUALITY

A.4.1 Asuquo and Baker, 1992

Asuquo, G. and J.T. Baker, 1992. Survey report for the Bayou Lafourche low flow time-of-travel study. Louisiana Department of Environmental Quality, Office of Water Resources, Water Pollution Control Division, Engineering Section, January 31, 1992. Revised Dec. 20, 1995.

A tracer dye time-of-travel survey was conducted from June 17 through 20, 1991, on Segment 020401 of Bayou Lafourche by the Louisiana Department of Environmental Quality (LDEQ). The survey was to provide information for the system to improve LDEQ's ability to predict arrival time of a contaminant spilled at any site between Donaldsonville and Clotilda.

The survey included discharge measurements at selected stations on the Bayou to determine flow characteristics. Three discharge measurement locations were established. Flows were measured from bridges using the Marsh McBirney 201D Flowmeter with cable suspension. Eight sampling stations were established on the Bayou, with dye released at various stations of interest. Automatic dye-sampling boats were used for point sampling of dye at specific locations downstream. The stream velocity varied from 0.35 ft/s to 0.52 ft/s with an average stream flow of 156.2 cfs.

The report includes some description of Bayou Lafourche. The stream has high banks, which were formed by floodwaters when the bayou functioned as a direct distributary of Mississippi River water. These natural levees range in elevation from 22 feet at the head to 1 foot at the mouth. The land adjacent to the bayou slopes away from the channel at approximately 1 foot per 11 miles nearest the channel and progressively decreases toward marsh areas. Several ditches along the reach provide drainage for local stormwater runoff; the drainage area of these ditches includes some agricultural areas. Water-thriving plants occur along the channel banks. Land uses are dominated by agriculture, especially sugar cane, and by urban areas and wetlands. A map of the study area showing river miles (RM), site locations, and city and parish boundaries was included with the report, along with tabular summaries of land uses and of water quality standards.

Land use in the Barataria River Basin is characterized primarily by agriculture with sugar cane being the dominant crop. Urban areas make up the second largest land use category within the basin. A detailed breakdown of land use in the Bayou Lafourche segment (0204) of the Barataria River Basin is presented in Table 1 of the report, based on the 1990 State of Louisiana Water Quality Management Plan.

A.4.2 Everett and Lee, 1995

Everett, D. and F. Lee, 1995. High flow time of travel survey report on Bayou Lafourche from Donaldsonville, La. to Valentine, La., Project No. 90. Prepared for Louisiana Department of Environmental Quality, Office of Water Resources, Water Pollution Control Division, Engineering Section, by Duane E. Everett and Fred N. Lee, Center for Louisiana Inland Water Studies, Civil Engineering Department, University of Southwestern Louisiana, March, 1995.

A high flow tracer dye time-of-travel survey was conducted from May 16 through 18, 1994 on Segment 020401 of Bayou Lafourche by the Louisiana Department of Environmental Quality. The acquired information will improve LDEQ's ability to predict arrival time of a contaminant spilled at any site between Donaldsonville and Valentine.

The survey included discharge measurements at selected stations on the Bayou to determine flow characteristics. Three discharge measurement locations were established. Flows were measured from a bridge at Thibodaux and by boat at Donaldsonville and Clotilda using the Price AA current meter. Seven sampling stations were established on the bayou, with dye released at various stations of interest. Automatic ISCO samplers were used for point sampling of dye at specific downstream locations. Streamflow measurements were made at the sampling stations. The stream peak velocity ranged from 0.38 ft/s to 0.83 ft/s with an average stream flow of 327 cfs.

The report describes the water supply history of the bayou. A dam across Bayou Lafourche (completed in 1904) was intended to be a temporary measure to prevent flooding in Donaldsonville. However, it became permanent when it was taken in as part of the Mississippi River levee system. The dam did prevent flooding, but caused a water supply problem for the population that depended on the bayou. Sugar refineries and mills along the bayou were also impacted because the bayou had supplied them with large quantities of water during the cane-grinding season (October through December). Bayou Lafourche became stagnant and polluted after the discontinuance of flow from the Mississippi River and also degraded further in the lower reaches of the bayou because of periodic saltwater intrusion from the Gulf of Mexico. Fresh water could be obtained only from the Mississippi River because no suitable ground water or other surface water was available.

The water-supply problem was resolved in February 1955 with the installation of the Walter Lemann, Sr., Pumping Plant at Donaldsonville constructed to pump and siphon water from the Mississippi River into Bayou Lafourche. The pumping plant had an initial capacity of 300 cfs (cubic feet per second) with three pumps activated. In March 1961 an additional 100 cfs was provided by installation of a fourth pump. Several dams and floodgates were built on the canals leading away from the bayou to control movement of water from the bayou to the adjacent land. The Early Warning Organic Compound Detection System EWOCDS) was established to warn Lower Mississippi River drinking water providers of chemical discharges which might adversely impact water quality, and would be an indicator of when pumps should be turned off at Donaldsonville if there is a chemical spill.

Information also was provided on pollution discharges. Two types of dischargers, non-point and point, are located within the Bayou Lafourche basin. Agricultural nonpoint source discharge is probably the predominant discharge source for Bayou Lafourche and its tributaries because of intensive agricultural land use in this area of the state. Urban runoff from small communities within the basin also may have some effect on water quality. Point source dischargers located within the basin include:

- Lafourche Parish Council/LA Dept. of Transportation & Development - permit # WG-010044; located at Cutoff, over Bayou Lafourche on PH. 571.

- LA Dept. of Transportation & Development - permits# LA0067440 and WG-010040; located at Golden Meadow on LAHWY 308.

- LA Dept. of Transportation & Development - permit# WG-010038; located at Galliano, LA on LAHWY 308 SPUR.

- LA Dept. of Transportation & Development - permits# LA0067458 and WP1163; located at Mathews on LAHWY 308.

- LA Dept. of Transportation & Development - permits# LA0067288 and WG-010063; located at Lockport, ACR Bayou Lafourche LA3220.

A.5 LOUISIANA STATE UNIVERSITY (LSU)

A.5.1 Mashriqui and Kemp, 1996

Mashriqui, H. S. and G. P. Kemp, 1996. Restoring the capacity of Bayou Lafourche to convey increased discharges from the Mississippi River. Natural Systems Management and Engineering Group, Center for Coastal, Energy and Environmental Resources, Louisiana State University, Baton Rouge, LA, September, 1996.

Much of this report has been supplemented or replaced by the 1997 and/or 1998 reports by Mashriqui and Kemp. This initial report focuses on evaluation of costs and benefits of a diversion up to 2,000 cfs, in part for wetlands restoration, and in part to provide water-supply benefits by controlling saline intrusion in late fall.

The report provides considerable background on the history of Bayou Lafourche, and its current condition. For example, data are provided showing that the discharge at Donaldsonville (e.g., the rate of FWD diversions) decreased from 285 cfs in 1961-69, before the Thibodaux weir was installed, to 222 cfs in 1970-85, after the weir was installed. (Data are not available for 1986-present.)

Among the most important considerations in project design are: meeting freshwater needs of the District and of the wetlands; considering impacts from batture flooding, bank instability, channel siltation, structures (e.g. bridges) and drainage. The report also comments on USACE (1994), abstracted in Section A.2.1, and notes some aspects of that report that require further consideration.

The evaluation used the HEC-RAS (HEC-2) and HEC-6 open-channel hydraulic models. The existing data set did not allow model calibration, especially for flow values associated with a much larger diversion rate, so assumptions regarding channel roughness made by the USACE were followed. An effort was made to reference all elevations to a single datum (LDOTD), but at least two different datums are currently in use along the Bayou, differing by an estimated 0.75 ft. This should be understood when interpreting stage information provided by the models. (Refer to subsequent report of surveying by Pyburn and Odom, 1997b.)

The study determined that siphons large enough to convey 2,000 cfs at mean high Mississippi River stage could be constructed in the District property available at Donaldsonville. These would consist of eight 72-inch diameter pipes more than 1,000 ft long. The discharge for each siphon would be approximately equal to $94.34 \times H^{0.5}$ where H is the head difference between the Mississippi River and Bayou Lafourche.

The cost of the siphons, concrete discharge pond and other necessary appurtenances is estimated at $6.9 million. Mississippi River stages are high enough on average at Donaldsonville that siphons could operate for 7 months each year, between December and June. Pumping would continue to be required for the remaining months. The 1994 USACE study recommended increasing pump capacity at the Lemann station from 340 cfs to at least 750 cfs. This will still be necessary to meet District freshwater needs during the high demand period in October and November, regardless of whether siphons are installed. The costs of increased pump capacity were not included in the estimate for the siphons.

Modification of the current outfall pool system in Donaldsonville is required for any increase in discharge above that currently pumped at the Lemann station. Conversion of the causeway/culvert systems at the La. 3089 and Missouri Pacific railroad crossing to pile supported bridges, and other changes to reduce hydraulic constriction and maintain the current vehicular traffic routing in Donaldsonville, are estimated at $3.4 million. Removal or enlargement of the existing culverts at these crossings is required for any increase in flow.

Bank elevation along Bayou Lafourche drops 10 ft between Donaldsonville and Thibodaux, while the elevation of the deepest part of the channel drops less than 4 ft. Currently, a relatively small portion of the original channel is used for conveyance in the free-flowing section downstream of the railroad crossing. Significant sedimentation has occurred in the first 10 miles. HEC-RAS modeling indicates that dredging of approximately 730,000 cubic yards of sand and silt will improve conveyance in this section and lower Donaldsonsville stages by more than 1 ft at 2,000 cfs. A total of $3.3 million has been budgeted for removal of this material, while $1.7 million has been estimated for bank stabilization and additional channel improvements.

Discharges of 1,000 to 2,000 cfs can be accommodated in the improved channel. If pump capacity were not increased but the proposed siphons were installed, stages at the head of the bayou in Donaldsonville would cycle between 6 and 12 ft. Water level would remain at least 3 ft below LA 1 and 308, except at the Missouri Pacific railroad crossing in Donaldsonville. Changing the drainage in La 308 where it passes under the railroad tracks would be required for any discharge greater than 1,000 cfs. One of the 18 bridges between Donaldsonville and Thibodaux is low enough that its lower chord would be partially submerged for a discharge of 2,000 cfs. This is a small footbridge that could readily be raised or removed. No other bridges would be affected by increasing discharge to 2,000 cfs. The amount of private investment within the channel batture area that would be affected by water level increases of up to 5 ft in the Donaldsonville area and 2 ft near Thibodaux has not yet been determined.

Velocities in the improved channel range from 1.5 to 2.0 fps for a 2,000 cfs discharge. The bayou will retain more introduced sediment than it will deliver past Thibodaux for any discharge less than 1,000 cfs. At 2,000 cfs, most sediment introduced at Donaldsonville will be delivered to Thibodaux. Bank slopes that are marginally stable today could begin to fail if significant oscillations in water levels occur. Slopes steeper than 18º occur within the first 2.5 miles in the Donaldsonville area and between miles 14 and 16. Relatively steep banks (18 to 27º) also occur in the last three miles upstream of the weir, but water levels will be more stable in this area, particularly if the weir is retained. The two upstream areas with steep banks represent a total of about 5 miles and should be subjected to more detailed investigation. It does not appear that flow velocities are responsible for any bank erosion.

Removing the Thibodaux weir would have little effect on maximum stages for discharges above 1,000 cfs. It has a greater influence on lower discharges, when stage is not generally a concern. The weir is not necessary if a constant discharge can be assured, but an ability to store water in the channel remains useful if pump capacity is not increased and discharges can be expected to drop to present levels at any time. The weir also has a beneficial effect on bank stability in that it does not allow water levels to drop as low as they otherwise would under low discharges.

HEC-6 modeling using input sediment concentrations and size fractions that are representative of Mississippi River values indicated a far greater potential to deliver sediments than was suggested by the earlier USACE effort. Mean sediment discharges for various siphon/pump operating regimes were in excess of 1,000 tons per day. It was estimated that such discharges could maintain 40,000 to 50,000 acres of brackish and salt marsh.

The HEC models used can provide much guidance regarding response to changing discharge for the non-tidal reach. Stage at the gage downstream of the weir at Thibodaux has also historically been correlated with discharge from the reservoir above the weir. While the correlation is highly significant, it generally explains only about 50 percent of the variability below the weir. There are indications in the record that factors unrelated to discharge have raised stages below the weir by 1.5 ft over the past two years. It is known that the influence of flow originating in the Atchafalaya River and moving eastward through the Intercoastal Waterway has been increasing in recent years. Many have noted that rooted aquatic vegetation has invaded this reach at such a density that flow appears restricted and sediment transport diminished. If this is the case, the discharge of sediments to the target marsh may be diminished if the “marsh” has moved into the Bayou itself. Other modeling tools and, most important, calibration data are needed to answer such questions. (Refer to subsequent Nichols State University studies of vegetation in the bayou; Section A.6.)

A.5.2 Mashriqui and Kemp, 1997

Mashriqui, H. S. and G. P. Kemp, 1997. Open-channel hydraulic modeling to support selection and preliminary design of coastal restoration projects (Bayou Lafourche). Draft Final Report. Natural Systems Management and Engineering Group. Center for Coastal, Energy, and Environmental Resources, Louisiana State University, Baton Rouge, Louisiana, June, 1997.

This report describes modeling methods and results that lead to the following conclusion: as much as 1000 cfs of Mississippi River water can be conveyed through Bayou Lafourche without substantially raising stages over those observed under normal conditions today, provided that the existing channel is enlarged by dredging. Hydraulic models used were HEC-RAS (the modern version of HEC-2) for open-channel flow, and HEC-6 for sediment transport.

Existing conditions in the study area were described. Stages at the siphon outfall are maintained at about +9.5 ft NGVD by a weir that is part of a box culvert passing under Highway 3089. There is 2 feet of drop from this point to the head of the actual bayou, below the railroad crossing. With respect to water supply, there is a marked peak in demand in the late fall, whereas river stage peaks in winter and spring. Gulf water levels peak in late spring and again in early fall. Thus the time of maximum concern regarding salinity intrusion is around November, when the river supply is low, the bayou demand is high, and the potential gulf influence large.

A long-profile of the channel bottom (thalweg) and banks was interpreted as showing four hydrologically distinct segments for the bayou above the GIWW: the steeper upper reach where sedimentation occurs; the remainder of the reach to Thibodaux; the remaining reach of single channel, to Lockport; and the segment from Lockport to Larose. Bayou flow velocity rarely exceeds 1 foot per second, even during high discharge events. Suspended sediment concentrations have been measured as high as 500 ppm at Thibodaux.

There is some development of the batture, especially in the uppermost reach. Thirty bridges cross the Bayou. (Refer to Section 2, Table 2.3-2, of this Phase I report). Most are concrete-pile supported fixed-span structures. There are eight navigable bridges south of Lafourche Crossing; these include draw, swing and pontoon bridge types. Location and types of bridges over Bayou Lafourche above Lockport.

The HEC-RAS (HEC-2) and HEC-6 open-channel hydraulic models were applied to this analysis. Model inputs included other studies done for the Phase I evaluation, especially the cross-sections surveyed by Pyburn and Odom (refer to Pyburn and Odom, 1997b). Relevant data were obtained from the FWD, USGS, LDOTD and USACE. A brief field reconnaissance was performed. The drainage study performed by CEEC was part of the LSU contract work, but is abstracted separately (refer to CEEC, 1997a).

Modification of the current outfall pool system in Donaldsonville is required for any increase in discharge above that currently pumped at the Lemann station. Conversion of the causeway/culvert systems at the La. 3089 and Missouri Pacific railroad crossings to pile supported bridges, or other changes to reduce hydraulic constriction will be needed. None of the remaining bridges appears to pose a problem with respect to passing greater discharges up to 2,000 cfs, at least from the standpoint of the hydraulic effects of the piles and deck position.

The effect of the weir at Thibodaux was examined. The model predicts that the weir would be submerged at 1,000 cfs but that it would still control stages upstream, and in fact raises stages for the entire reach between Donaldsonville and Thibodaux. It functions primarily to raise stages and maintain a pool of water upstream for storage when either discharge or tide are low. It reduces transmission of normal tidal fluctuations upstream, but only by raising stages well above the normal high tide north of Thibodaux.

In the absence of channel improvements, water levels in the existing channel would rise 3 and 6 ft at the Donaldsonville gage to accommodate 1,000 and 2,000 cfs inputs respectively. This would overflow the batture in some areas. Bank elevation along Bayou Lafourche drops 10 ft between Donaldsonville and Thibodaux, and another 7 ft to Larose. Exceedance of the lowest banks that have been identified within the larger channel would occur at a few locations if an effort was made to pass 1,000 cfs from Donaldsonville to Larose without modifying the channel except by changing the weir as suggested above. The need to accommodate large volumes of stormwater, as well as the amount of development within the channel suggests a need for normal stages to be lowered further still.

An "optimum" channel was derived that would result from the simulated dredging of 4.2 million cubic yards in the reach between Donaldsonville and Thibodaux within the portion of the channel area that is currently flooded. All dredging is projected in the 34 miles between Donaldsonville and Thibodaux, and none was proposed for the more tidally influenced lower reaches. Dredging requirements vary between 10 to 100 cubic yards per ft and average about 30 cyd/ft.

Enlarging the channel in this way has relatively minor effects on predicted average velocities. For a 1,000 cfs discharge, these range from 0.5 to 1.7 fps, values that are similar to what is observed during stormwater discharge events today. The model predicts that the 2.5 fps threshold for scour identified in the USACE would not be exceeded even for a 2,000 cfs discharge.

Stages are lowered for the optimum channel in the reach above Thibodaux relative to current normal conditions despite conveying more than three times the discharge. Stages for the channel below Thibodaux are raised, however, in the same comparison. As the field data collected during the December 27, 1996, event showed, such stages are observed today in this area following heavy rainfall. The optimum channel retains its capacity even if smaller discharges are to be conveyed. Accordingly, the new channel has the potential to offer significant new capacity for accommodating stormwater without raising stages if input from the River is proportionally reduced as stormwater enters the Bayou. Operating in this manner would relieve drainage concerns both above and below the weir.

The HEC-6 model was set up for the optimum channel configuration and run for a 50 year planning period to determine how much sediment would be introduced, retained and passed at Larose to downstream marshes for constant flows ranging between 340 and 2,000 cfs. The volume of material retained drops below that passed at a constant discharge of between 800 and 1000 cfs. Retained material that might eventually require dredging drops off quickly for discharges above this amount, such that virtually all sediment introduced, including sand and silt is passed beyond Larose at 2,000 cfs. As a result, annual dredging needs will tend to be close to a maximum for a constant discharge of around 1,000 cfs, which is estimated at 78,000 cubic yards. Sediment yield to the marshes at this discharge is estimated at 92,000 cubic yards per year. Nearly all the clay is passed, but velocities are not high enough at this discharge to transport much sand or silt.

The HEC models used can provide much guidance regarding response to changing discharge and the opportunities for enhancing conveyance through dredging. The reconnaissance work reported here with respect to stormwater drainage patterns and concerns has provided a critical first insight into the problems that stormwater inputs and related flooding are causing today along Bayou Lafourche. A restoration project designed to increase normal conveyance of river water to downstream wetlands might also provide some keys to addressing current flooding and water supply concerns.

A.5.3 Mashriqui and Kemp, 1998

Mashriqui, H. S. and G. P. Kemp, 1998. Bayou Lafourche freshwater diversion wetlands restoration project (PBA 20): HEC-RAS and HEC-6 hydrologic modeling. Draft Final Report. Natural Systems Modeling Group. Center for Coastal, Energy, and Environmental Resources, Louisiana State University, Baton Rouge, Louisiana.

Mashriqui and Kemp’s previous report (1997) demonstrated that the Bayou Lafourche channel could be enlarged to convey 1,000 cubic feet per second (cfs) without raising stages by dredging 4.2 million cubic yards (mcy) in the reach between Donaldsonville and Thibodaux. The 1998 report focuses on optimizing a dredging program that can achieve the same results as previously obtained in Mashriqui and Kemp (1997) while satisfying more stringent side-slope criteria (3:1).

The side-slope criterion limited the volume of dredging that could occur in some of the uppermost segments, while a new reference water level brought attention to certain areas in which dredging had either been over- or under-estimated in the earlier work. The sum of these effects was that dredging was increased downstream, and extended into the tidally influenced reach between Thibodaux and Raceland. A dredging volume of 3.2 mcy is now proposed for the improved channel.

Mashriqui and Kemp were asked to provide hydraulic performance data for this channel for comparison to current conditions. Information about the new channel was requested for discharges between 500 and 1,000 cfs, and for downstream tide elevations ranging from 0 to 3 ft NGVD. The discharge range for the existing channel was specified between 150 and 340 cfs, to provide a reference to current conditions. Runs were also made to explore the sensitivity of the results to the value of Manning's 'n' that was originally selected by the U. S. Army Corps of Engineers (USACE). All of the model output requested has been included in the appendices of Mashriqui and Kemp (1998).

The Bayou Lafourche model developed in 1994 by the USACE was a HEC-6 model that did not include engineered features like bridges. A HEC-RAS model was created from this, but did not initially include all of the existing bridge cross-sections. Mashriqui and Kemp modeled some of the bridges that had the most potential to cause backwater effects and found that these effects were negligible. In this phase, Mashriqui and Kemp (1997) explicitly included five bridges in HEC-RAS, and provided more detail on the hydraulic effects of these structures. Mashriqui and Kemp quantified the effects of the standard pile supported structures for 1,000 cfs at 0.01 ft per bridge, but this could be as much as 0.1 ft if bridge sections are not dredged to the same degree as adjacent upstream and downstream reaches.

The effect of tide levels at the downstream boundary (Larose) that range from 0 to +3 ft NGVD were modeled for the improved channel. The effect was primarily confined to the reach below Thibodaux for a 1,000 cfs discharge but influenced stages farther upstream for lower discharges. The effect of a 3 ft rise at Larose was limited to 0.3 ft at Donaldsonville for 1,000 cfs, but was twice this at 500 cfs.

A limited amount of stage-discharge data is available for use in deriving an appropriate 'n' value for the version of the Manning's equation used in HEC-RAS and HEC-6. Mashriqui and Kemp found no reason to deviate from the choice, 0.021, made by the USACE originally, but show that the magnitude of error resulting from choosing a high or low value increases upstream. Doubling of 'n' from 0.015 to 0.030, a range that brackets the selected value, would result in a 3 ft increase in predicted 1,000 cfs stage at Donaldsonville.

Any redesign of Bayou geometry can be expected to affect the volume and location where introduced sediments deposit. Results derived from HEC-6 runs are presented here for the latest channel refinements. The current longitudinal channel (thalweg) profile approaches an equilibrium profile that would be disrupted, or “reset” by the proposed dredging program. The places where deposition will tend to occur most rapidly will be the same as those from which most material will be removed during construction of the improved channel.

The tendency for in-filling will result in reduced conveyance if the channel is not maintained actively and relatively continuously. Predicted sediment input from the Mississippi River is estimated at 270 tons per day. Deposition begins upstream and expands downstream as the equilibrium profile is approached asymptotically. At the end of 5 years, 60 percent of all sediment introduced is retained in the first 5 miles, constituting 96 percent, 76 percent and 4 percent (by weight) of the sand, silt and clay introduced, respectively. The model predicts that 161 tons/day of sediment will transit this uppermost segment in the first year, but that this will increase by 16 percent to 187 tons/day at the end of year 5, if no maintenance dredging is undertaken.

The average annual deposition predicted from a 5 year run adds up to 46,657 cubic yards per year, of which 1 percent is sand, 90 percent is silt and 9 percent is clay. The engineers are investigating a number of options to keep coarser sediments from entering the pumped discharge, and to trap the sand and silts close to the discharge point where they can be economically removed.

A.6 NICHOLLS STATE UNIVERSITY (NSU)

Through a subcontract with LWA, Dr. David Schultz was asked to prepare three reports that provide information on the biological resources of Bayou Lafourche, with an emphasis on vegetative conditions. The first report summarized studies done prior to the listing of Project PBA-20. The second report documents conditions during the time when vegetation clogged the bayou. The third report documents conditions after cutting controlled the vegetation.

A.6.1 Schultz, 1996

Schultz, D.L, 1996. A survey of the fish fauna of Bayou Lafourche. Prepared for Lee Wilson and Associates by David L. Schultz, Assistant Professor, Nicholls State University, Thibodaux, Louisiana, August, 1996.

This survey documented species composition, distribution and abundance of fishes along Bayou Lafourche from August 1994 through July 1995, along with associated habitat characteristics, including prevalence of aquatic vegetation. The report graphs physical characteristics of water quality, fish species and relative abundance of vegetation at sample sites. The report concludes as follows.

> "Increased flow rates from increased input from the Mississippi will likely increase the distribution and biological importance of cyprinids and percids in Bayou Lafourche. If more water was introduced from the Mississippi River, it is likely that a wider variety of species, and greater numbers of the species that were found only rarely in this study, would be introduced into Bayou Lafourche. Top predators found in the upper bayou associated with high flow rates, such as *Micropterus punctulatus* [spotted bass], *Ictalurus furcatus* [blue catfish], and *Ictalurus punctatus* [channel catfish], would also likely benefit from higher flow rates. Species intolerant of high flow rates and little habitat structure, such as many centrarchids will likely decrease in abundance and importance in the bayou. Species now found only in the central bayou, such as *Lepomis symmetricus* [bantam sunfish] are likely to have their range displaced downstream and decreased. It is unclear how water flowing in Bayou Lafourche is distributed at the GIWW. If the majority of the bayou's water moves into the GIWW and not into the lower central bayou, then increased input will probably result in little change in the fish community of the bayou below the GIWW. If more freshwater is forced into the lower bayou, then many of the marine derived and estuarine species that are common there now will likely be displaced toward the Gulf."

A.6.2 Schultz and Schultz, 1997a

Schultz, D.L. and D.A. Schultz, 1997a. A description and analysis of the vegetation of the Bayou. Prepared for Lee Wilson and Associates by David L. Schultz, Assistant Professor, Nicholls State University, Thibodaux, Louisiana, and Deborah A. Schultz, Louisiana Universities Marine Consortium. February 1997.

This study surveyed the species composition, distribution, and relative abundance of the submerged aquatic vegetation of Bayou Lafourche in November 1996, and compared it to data obtained in 1994 and 1995. The study found that Bayou Lafourche supports a diverse flora consisting of emergent, floating, and submergent macrophytes and algae.

The report notes that “hydrilla is found in dense mats from Labadieville to below Raceland. In the area from Lafourche Crossing to Raceland hydrilla forms mats which obstruct water flow and boat traffic.” Comparison with previous data indicates that “there have been vegetation changes in Bayou Lafourche in the past two years, but the changes observed vary in different regions of the bayou. In the area between Thibodaux and Raceland the density of vegetation has increased greatly, while above Labadieville the density of vegetation has decreased.”

The report discusses various theories for the changes. One theory presented was that relatively low flow rates in the bayou were caused by hydrologic damming at the GIWW. Another theory was that low flow rates were due to the hydrilla. The report concludes that “Bayou Lafourche in a thickly vegetated state, like that documented in this study, could not accept significant increases in input.” The report notes that the Bayou Lafourche Freshwater District is cutting vegetation in the central bayou to allow greater flow, and that “if flow was reduced primarily due to vegetational obstruction, then we expect that cutting will allow normal flow rates, a return to low water clarity, and slow growth of vegetation.” Schultz and Schultz, 1997b is a follow-up to Schultz and Schultz, 1997a.

A.6.3 Schultz and Schultz, 1997b

Schultz, D.L. and D.A. Schultz, 1997b. A description and analysis of the vegetation of Bayou Lafourche: a follow-up survey. Prepared for Lee Wilson and Associates by David L. Schultz, Assistant Professor, Nicholls State University, Thibodaux, Louisiana, and Deborah A. Schultz, Louisiana Universities Marine Consortium. September, 1997.

This study documented the amount and type of vegetation in Bayou Lafourche during late 1997, after cutting of aquatic vegetation by the Bayou Lafourche Freshwater District (Shultz and Shultz, 1997b). *Hydrilla verticillata* (hydrilla), the most common species sampled in 1996, decreased from 66% to 31% of the total vegetation. Sites with 50% or more cover decreased from 6 of 20 to zero sites. Coverage remained the greatest in the central bayou, from Thibodaux to Raceland. The report concludes as follows.

> "The data obtained show that relative abundance of hydrilla in the bayou was reduced by 50% from 1996 to 1997. Moreover, the absolute amount of hydrilla has decreased to a greater extent. The thick mats of hydrilla that were present in the center channel and side channel areas in the central bayou in 1996 were not present in 1997. In addition, the bottom of the bayou in center and side channel areas, where hydrilla and other macrophytes were firmly rooted in 1996, had no obvious signs of their remains in 1997. It appears that vegetation cutting and a return of turbid flowing water have resulted in a dramatic reduction in the abundance of hydrilla and other plant species in Bayou Lafourche. The amount of vegetation in Bayou Lafourche in 1997 appears to be very similar to that seen in 1994 and 1995. In 1997, there was no vegetation obstructing flow or boat traffic in the center channel of the bayou and turbidity appeared sufficient to hamper growth of vegetation in all but the shoreline areas.
>
> One concern over the cutting of vegetation in the bayou was that the hydrilla and other species would drift downstream and become established in areas where it was not common previously. The data collected in this study suggests that this did not happen. At all sites sampled the abundance of hydrilla was decreased. The only site at which vegetation appeared to increase in abundance was the southernmost site. However, the increase at that site appears to be the result of increases in abundance of the species that were present at that site in 1996. Cutting appears to be an effective tool for control of hydrilla in Bayou Lafourche.
>
> Hydrilla is still the most common plant species in Bayou Lafourche but, currently, is not a significant problem for water flow. However, the potential for future growth of hydrilla in the bayou is uncertain. It appears the current conditions are similar to those seen in 1995. If all relevant factors are the same as in 1995, then we expect that hydrilla abundance will return to 1996 levels in 12 to 24 months. If this is the case, then cutting of hydrilla may be required on an annual or semiannual cycle. However, it is not clear if unusual conditions existed in the spring and early summer of 1996 that led to extreme growth of hydrilla and other plant species. Pumping rates by the Bayou Lafourche Freshwater District were reduced in early 1996 to respond to high water levels in the bayou. This short-term response may have led to long-term exacerbation of the problem by increasing sediment precipitation, increasing water clarity, and allowing hydrilla and other submergent forms to become established in deeper water than they would otherwise. Presently, hydrilla and other submergent vegetation are largely absent from the channel and side channel areas of the

bayou and there are no signs of roots or sprigs in those zones that might allow rapid regrowth. For hydrilla to become a problem again it must colonize those areas. We expect colonization will be a gradual process, unless water clarity increases substantially.

Water quality, in terms of clarity and conductivity, are similar to that seen in 1994 and 1995. The water in Bayou Lafourche is highly turbid in most regions. There does not appear to be enough light penetration in the bayou to support the growth of submerged rooted aquatic vegetation in any areas except shoreline areas with depths less than one meter. Conductivity was slightly higher in 1997 than that seen previously. This may be an artifact of high rainfall during the sampling period.

This study has provided no further information on the reduction in vegetation growth in the upper bayou. This remains a mystery. Understanding of the factor or factors that have led to the reductions in the amount of vegetation in the upper bayou may be valuable for management of the growth of vegetation in lower reaches. Clearly, more work is needed.

Current conditions in Bayou Lafourche appear sufficient to allow substantial increases in water input into the bayou. Record and near-record rainfalls in recent years have shown that the bayou can carry 4 to 8 times the current water input with minimal immediate impact to roadways and residences adjacent to the bayou. We expect that increased water input into the bayou would increase turbidity and thereby decrease the potential for vegetation to colonize the side channel areas of the bayou. Thus, greater water input into the bayou may be an effective tool for maintaining the bayou's hydrologic potential."

A.7 UNIVERSITY OF SOUTHWESTERN LOUISIANA

A.7.1 Waldon, 1998

Waldon, M. G., 1998. Water quality impact of proposed diversion of water from Lake Verret to Bayou Lafourche. Center for Louisiana Inland Water Studies, Department of Civil Engineering, University of Southwestern Louisiana, Lafayette, LA, March, 1998.

This study evaluates the potential water quality impacts of diverting water from Lake Verret into Bayou Lafourche via the Cancienne Canal. In doing so, it reviews water quality conditions from Donaldsonville to Lockport.

The report notes that seven public water freshwater intakes are located along the bayou, as indicated below. Eight other intakes (seven sugar companies and Nicolaus Paper) also draw from the bayou.

Rivermile	Freshwater intakes	In or near
0	Peoples Water Service	Donaldsonville
16.9	Assumption Parish Water District No. 1	Napoleonville
34.0	Thibodaux Municipal Water Plant	Thibodaux
37.4	Lafourche Parish Water District No. 1, North Plant	Lafourche
38.7	Consolidated Water Works District No. 1 (Houma)	Lafourche (Shriever)
54.7	Lafourche Parish Water District No. 1, South Plant	Clotilda
56.4	Lockport Filtration Plant	Lockport

(Editor's note: river miles may not match more precise data in reports prepared by Pyburn and Odum)

Time travel estimates are important in water quality assessments because transformation and loss processes are dynamic and frequently represented as first-order decay or reaction processes. Typical diversion flow is roughly 200 cfs. The report calculates Bayou Lafourche time-of-travel (prior to hydrilla cutting) to reach several locations. Travel time was 154 hours (6.4 days) from Donaldsonville to Lockport. This is an effective velocity of 0.5 feet per second. Travel times are faster in the reach above Cancienne Canal (0.6 feet per second) than below Thibodaux (0.45 feet per second).

The study uses water quality data collected by the Louisiana Department of Environmental Quality (LDEQ), which divides water basins into segments. Tables in the report list quality at the following five stations (four on the bayou, one on Lake Verret).

LDEQ water quality sampling stations	**LDEQ Site #**
Bayou Lafourche near:	
Donaldsonville	23
Raceland	112
Thibodaux	293
Lockport	294
Lake Verret at Attakapas Landing near Georgia	144

Parameters evaluated for each station are listed below. Data provided include number of observations, averages, medians and percentiles (10, 25, 75, & 90).

- pH
- total suspended solids
- nitrogen (nitrate plus nitrite, total khjeldal nitragen, total nitrogen)
- phosphorus (total Pand total N to total P mass ratio)
- total organic carbon
- color
- chloride
- fecal coliform

Nutrients and eutrophication. Nitrogen and phosphorus can cause excessive growth of microscopic algae and other plants. In Louisiana, numerical nutrient criteria have not been established by the LDEQ. In general, lakes are most sensitive to excess nutrients while rivers are least sensitive. Wetlands are often characterized as requiring nutrient enrichment to promote their exceptionally high levels of productivity.

Total nitrogen (nitrite + nitrate, and total Kjeldahl nitrogen) and total phosphorus both decrease downstream in Bayou Lafourche. Average total nitrogen concentration in Lake Verret (1.38 mg/l) is only slightly lower than the present average concentration at Lockport (1.48 mg/l). Thus, total nitrogen concentration in the bayou would not be greatly impacted by a Lake Verret diversion

Median phosphorus in Lake Verret is similar to that at Raceland and Lockport, indicating that diversion of Lake Verret water would have little impact on the phosphorus levels of Bayou Lafourche.

Water supply. Both total suspended solids and fecal coliform decrease by more than 70% between Donaldsonville and Lockport, though the data indicate a local source of coliform (possibly septic tanks) above Thibodaux. Fecal coliform levels in Lake Verret are low, indicating no adverse effect would occur from diversion of Lake Verret water.

Chloride concentrations at all sites are sufficiently low for drinking water use.

Color increases slightly downstream in Bayou Lafourche. Color is higher and more variable in Lake Verret.

Levels of color and total organic carbon in Lake Verret indicate the potential for trhialomethane (THM) formation. THMs are carcinogens formed during disinfection of drinking water with chlorine. In an effort to reduce levels of THMs in finished drinking water, chloramine disinfection has replaced chlorination in many Louisiana water treatment plants.

A.8 COASTAL ENVIRONMENTS INC. (CEI)

A.8.1 Gagliano, 1996

Gagliano, Sherwood M., June, 1996. Public meetings to aid in the evaluation, engineering and design of the Bayou Lafourche wetlands restoration project. Prepared for the U.S. Environmental Protection Agency by Coastal Environments, Inc., Baton Rouge, LA, June, 1996.

A series of four public meetings was hosted by the U.S. Environmental Protection Agency to initiate discussion and input from the general public concerning the Bayou Lafourche Wetlands Restoration Project. Meetings were held in April and May, 1996 in the following locations: Larose, LA (April 30, 1996), Napoleonville, LA (May 1, 1996), Donaldsonville, LA (May 2, 1996) and Thibodaux, LA (May 9, 1996). This document represents the information that was presented at the public meetings regarding the Bayou Lafourche Wetlands Restoration Project. The information includes the text of Dr. Gagliano's oral presentation, charts and photographs, and copies of meeting handouts.

A.8.2 Castille and Nakashima, 1997

Castille, G.J. and L.D. Nakashima, 1997. Historical changes in Bayou Lafourche. Prepared for Lee Wilson and Associates by Coastal Environments, Inc., Baton Rouge, LA.

This report documents changes in flow and channel morphology, due largely to the construction of artificial levees, pumps and weirs to accommodate changing land use. The report includes numerous cross-sections.

Changes in flow through time. Formerly a main course of the Mississippi River, by 1100 AD Bayou Lafourche had decreased in size to a minor distributary. During the nineteenth century, flow slowly decreased; the report provides the following historical discharges.

> "In 1851 and 1858, the Bayou Lafourche discharge ranged from 6,000 to 11,000 cfs, with the flow averaging around 10,000 cfs for both years. During the 1840s and 1850s, the maximum discharge was about 11,500 cfs and the mean annual discharge was about 2000 cfs. Prior to construction of the artificial levees, the channel below Lockport carried a maximum of 4,000

> cfs. By this estimate, at a high water of 11,500 cfs, about 7000-8000 cfs escaped via overbank flooding before it reached Lockport."

By 1887 a bar had developed at the head, shutting out most of the flow from the Mississippi River. In 1902, the Secretary of War granted permission for construction of a dam across the head of the bayou; the dam was completed by local residents in 1904. As a result of problems related to water stagnation and poor water supply for local industry, minimal flow (to 400 cfs) was reinstated with the construction of the present water pumping station in 1955. Today the channel is considerably smaller, both in width and depth, than it was even only 50 years ago.

Changes in the physical character of Bayou Lafourche. The Bayou has gone through four stages since 1700 AD: 1) natural distributary to circa 1800; 2) artificial levee confinement from 1800 to 1903; 3) immediate post-dam from 1904 to 1955; 4) modern stage from 1956 to present. See report Figures 3 through 6. The four stages are summarized below.

Natural distributary to circa 1800. Prior to the early 1800's, the bayou was relatively wide and deep. Following are some characterizations of the bayou in the early 1800's, as taken from the literature.

- about a 20 ft range between high & low water
- in 1812 the low water width was 90 ft
- in 1816 it was "not more than eighty yards wide" near the Mississippi River and "two hundred yards wide" closer to the Gulf
- the bed often went dry at the head during periods of low water
- the natural levee elevations along the channel ranged from about 22 feet above MSL at the head to 1 foot at the mouth.

Artificial levee confinement from 1800 to 1903. By 1859, artificial levees 5 to 7 feet high had been extended about 27 miles downstream from Lockport. Because these levees constricted the flow to a relatively narrow channel, the high water stages became elevated. Unless a crevasse occurred, confinement between the artificial levees also meant increased deposition within the channel, a problem noted as early as the 1850s.

The following are some measurements of the bayou's channel width during the 1850's and later.

- current did not exceed 3 feet per second
- channel width between natural banks averaged about 230 ft
- at extreme low-water the channel narrowed to as little as 90 ft wide at Donaldsonville
- water level range at the head was 24 ft; greatest depth at low water measured 3 ft

- low-water depths below Donaldsonville generally ranged from 7 to 10 ft
- near Thibodaux, high and low water widths were 228 ft and 120 ft in 1851
230 ft and 112 ft in 1858
205 ft and 97 ft in 1886

By the 1870s, sediment deposition within the channel had raised the surface of the water and required an increase in the height of the artificial levees. For example, levees in the vicinity of Lockport were 4 ft high in 1851 and by 1873 they were 12 ft high. There were reports that overbank deposition had raised the land just below Lockport about 2 1/2 ft in 50 years. In some places the channel had filled in so much that depths over some bars were as little as 2.5 ft at low water. Between 1888 and 1902, almost yearly snag removal and dredging operations resulted in a channel that was about 60 ft wide and 3 to 4 ft deep at low water.

<u>Immediate post-dam stage from 1904 to 1955</u>. The channel continued to fill in but at a slower rate than previously. The lack of a reliable water supply resulted in stagnation of the channel. The severance from the Mississippi River meant a much reduced high water level that was about 15 ft below the previous level. It also meant a somewhat lower low-water level and an increased tidal influence. The ruling depths at mean low Gulf (MLG) on June 30, 1916 were:

- Mouth to Lockport 4.5 ft
- Lockport to Thibodaux 3.5 ft
- Thibodaux to Donaldsonville 2.5 ft

By 1930, a channel 6 ft deep and 60 ft wide from Napoleonville to Pass Fourchon was to be maintained by the USACOE.

A 1972 study clearly demonstrated channel filling between 1903 and 1966. Within study portion of the channel (above Plattenville), the low-water depth had decreased by 2 to 4 ft and the width had decreased by 20 to 40 ft in 63 years. The more extreme changes occurred closest to the head of the channel at Donaldsonville.

<u>Modern stage from 1956 to present</u>. During this stage, virtually all artificial levees flanking the bayou were removed because they were no longer needed. In 1955 the existing pumping station was constructed to provide a minimal freshwater flow for the channel. Bayou Lafourche was now subjected to a much narrower high-water/low-water level range. Although the natural levee crest was about 22 ft above mean sea level (MSL) near the head, the high water level at that location was less than 8 ft. The high-water to low-water range was only about 2 ft along the upper part of the channel between Donaldsonville and Plattenville. This meant that a considerable land area was now permanently above high water.

Riparian owners began taking advantage of the batture lands that had once been subjected to annual high water flooding. Encroachment further out into the channel was made possible through the grading of the old artificial levees and through the construction of bulkheads behind which land was built up with earth and construction debris. This expansion onto batture land is most common in urban and suburban areas along Bayou Lafourche.

The modern stage is also characterized by continued channel filling and construction of control structures along lower Bayou Lafourche. In 1965-66 a concrete weir was constructed across the channel at Thibodaux, raising the low-water level immediately upstream from Thibodaux. Some low-water channel measurements are as follows.

- 1966, vicinity of Paincourtville 4.7 ft deep, 72 ft wide
- 1992, vicinity of Paincourtville 8 ft deep, 105 ft wide
- 1992, vicinity of Thibodaux 8 ft deep, 145 ft wide

The only known channel modification along the upper portion of the channel in recent years was maintenance dredging between Donaldsonville and Palo Alto bridge between 1990 and 1992 by the local drainage district. Channel dredging by the Greater Lafourche Port Commission has also occurred in the lower portion of the channel from the GIWW down to the mouth. After the construction of the weir at Thibodaux in 1966, the Corps of Engineers has maintained a minimum channel of 6 x 60 ft downstream from Thibodaux.

Cross-section information and data. The report lists available cross-sectional data, beginning in 1883. Figure 7 from the report displays the net change in bed morphology of the Bayou between the Mississippi River and Thibodaux over a 104-year period (see Figure 2.2-1 in the Phase I report). The cross-section at Thibodaux also shown on the figure reflects the modern stage model of channel confinement with decreases in channel depth and width of 15 ft and 255 ft, respectively, and complete abandonment of the levees. The longitudinal profile is marked by net deposition in two reaches of the channel: the first 6.5 miles, and between miles 9 and 25. The most conspicuous change in the sedimentation signature occurs in the upper 6.5 miles of the bayou where net accretion ranges from 3 to 8 ft and the bed datum rises above zero National Geodetic Vertical Datum (NGVD).

A.8.3 CEI, 1997a

CEI, 1997a. Bayou Lafourche project: required regulatory approvals and possible agency concerns. Final report. Prepared for Lee Wilson and Associates by Coastal Environments, Inc., Baton Rouge, Louisiana, March, 1997; revised March 27, 1998.

This report lists the agencies that would or could be involved in the permitting or review of any project to increase the flow in Bayou Lafourche. The report also gives some indication as to the purpose of the permits and the issues of most interest to the respective agencies. The report is summarized in Table 3.7-1 of the Phase I report.

A.8.4 CEI, 1997b

CEI, 1997b. Cancienne Canal cross-sections. Final report. Prepared for Lee Wilson and Associates by Coastal Environments, Inc., Baton Rouge, Louisiana, April, 1997.

This report documents a survey of the Cancienne Canal as the initial phase in assessing the viability of increasing flow into Bayou Lafourche from the Verret Basin. Figure 1 of the report locates 16 channel profiles taken by CEI on February 3, 1997. Cross-sections are appended to the CEI report.

Figure 2 displays the channel profiles at each end of the Cancienne Canal. Channel morphology changes in three ways toward Bayou Lafourche.

- Water depth decreases 4.5 feet, from 6.5 to 2.0 feet.
- Bank/levee height increases from +3.0 feet to +12 feet NGVD.
- Cross-sectional area is reduced 84 square feet along the channel bottom.

Figure 3 presents a thalweg plot showing three channel segments with two inflection points at 3.4 and 5.7 miles east of Lake Verret that yield a 4.5 ft difference in channel elevation. In plan view, the canal makes a sharp S-turn and is fed by a series of ditches draining the sugar cane fields which are elevated about 12 ft above the canal bottom. The sediments at each ditch/canal interface for mini deltas that provide an internal source of sediments for resuspension or transport under higher flow conditions. These differences in bottom topography pose the following implications for sourcing water from the Cancienne Canal:

- the channel bottoms of segments 1 and 3 slope toward Bayou Lafourche at a gentle 0.05 ft and 0.02 ft per 1,000 ft, respectively, but segment 2 slopes toward Lake Verret and 0.5 ft per 1,000 ft, about an order of magnitude steeper

- the sediment volume is approximately 190,000 cubic yards between mile 3.4 at -4.2 NGVD and last channel profile at mile 7.1 near Bayou Lafourche

- the total sediment volume between mile 3.4 at -4.2 NGVD and Bayou Lafourche would be approximately 220,000 cubic yards

- water would most likely be supplied via a pump system installed at the Cancienne Canal/Bayou Lafourche interface: based on surveyed slope, channel geometry characteristics, and an assumed flow velocity of 0.8 feet per second, the canal can only deliver 200 to 300 cubic feet per second (cfs) flow to a pump

- dredging the canal is another alternative, but there are questions regarding the logistics of operating in a small channel, dredge spoil quality, and sediment storage for the volumes cited above

- another non-dredging alternative involves the placement of suction pipe between Bayou Lafourche and deeper water in the canal, however, the draw would be nearly 5 miles

A.8.5 Ryan, 1997

Ryan, Joanne, 1997. Impacts to cultural resources of proposed pumping facility at head of Bayou Lafourche. Prepared for Lee Wilson and Associates by Coastal Environments, Inc., Baton Rouge, LA, October, 1997.

This report provides the results of preliminary research regarding installation of a pumping facility at the head of Bayou Lafourche. The authors electronically scanned archival maps to produce a series of overlays in order to estimate the location of Fort Butler and other structures which may have been in the project right-of-way. Material from the State Regional Archeologist was also considered.

In the early 1850s, ten structures stood along the west bank of Bayou Lafourche, including a possible ferry dock. Any traces of the buildings were probably destroyed during construction of a Confederate fortification early in the Civil War or of federal Fort Butler in 1863. Any remnant of the Confederate structure was probably destroyed or incorporated into Fort Butler.

A portion of an outlying earthen defense embankment and exterior moat probably was located in the proposed project right-of-way (see Figure 3.7-1 in the Phase I report). Although the embankment no longer exists, remnants of the moat could exist below ground. Presumably material would have been pushed into the moat when the fort was destroyed. Apparently the earthworks of the fort and also former levees along the bayou were used to in-fill surviving remnants of the moat and also to dam the bayou. The report states “That pre-Civil-War features survive within the ROW is considered highly unlikely, but can not be completely ruled out”.

No new structures were built in the bayou until after 1940. Existing structure will need to be examined to determine if they are eligible for the National Register of Historic Places.

A.8.6 van Beek, 1998

van Beek, 1998. Diversion of freshwater into Bayou Lafourche from Lake Verret via Cancienne Canal; requirements and impacts. Hans van Beek, Coastal Environments, Inc., Baton Rouge, Louisiana, April, 1998.

This report describes an alternative to increasing the flow in Bayou Lafourche through diversion at Donaldsonville. The alternative evaluates the feasibility of pumping water from Lake Verret into Bayou Lafourche via the Cancienne Canal. Compared to the Donaldsonville diversion, this alternative could avoid some possible constraints associated with dredging requirements and existing development along the Bayou Lafourche above the Cancienne Canal.

The water to be diverted from Lake Verret originates as local rainfall and as inflow from the Atchafalaya River via the Bayou Sorrel Lock. The COE is coordinating measures to control flooding in the Verret Basin, including installation of one or more pumps to remove excess water from the basin. A diversion to Bayou Lafourche could be part of the COE project.

Another alternative, transfer of water from the Barataria Basin north of Highway 90, was not studied by CEI; it could have greater environmental impacts than a Lake Verret diversion, and is constrained by the lack of a water collection and delivery system.

Suspended sediment concentrations in Lake Verret are generally low. Data collected quarterly by the U.S. Geological Survey in 1985 and 1986 show concentrations for Lower Grand River at Bayou Sorrel on the order of 50 to 100 mg/l. Higher concentrations can occur due to the introduction of Atchafalaya water and due to strong winds and intense rainfall.

The report suggests that the alternative could be used in combination with a diversion of Mississippi River water into the Bayou Lafourche at Donaldsonville. The report evaluates the pumping of 500 cfs from the Cancienne Canal into Bayou Lafourche; it is assumed that this would supplement 500 cfs diverted from the Mississippi River at Donaldsonville.

Water levels in the Verret Basin are subject to seasonal variation due to Atchafalaya River discharges and local rainfall. For evaluation purposes, a minimum water level of 0.0 feet NGVD was used for Lake Verret. Water levels in Bayou Lafourche at the Cancienne Canal are typically about 4 feet NGVD. Even with diversion of additional Mississippi River water into the bayou, this water level is not expected to change, but would be maintained by dredging. Due to the elevation difference, a 500 cfs pumping plant would be required at the confluence of the Cancienne Canal and Bayou Lafourche.

Cross-sections of the Cancienne Canal had been taken earlier (refer to the abstract of CEI, 1997b at Section A.8.4). Present canal conditions do not allow conveyance of 500 cfs. Current channel depths are from -4 to 0 feet NGVD, west to east, and top widths are from 120 to 70 feet, west to east. Computations using HEC-RAS modeling suggest that the channel would need a bottom width of 45 feet, an invert elevation of -8.0 feet NGVD, and top widths ranging from 100 feet to 180 feet, west to east. Figure 5 of the report shows the present and required channel dimensions.

The canal passes through cypress-tupelo swamp and bottomland hardwood forest in the west, and agricultural fields in the east that are buffered by bottomland hardwood vegetation. It is crossed by infrastructure elements and used for recreation. Impacts of the canal expansion and water diversion would include the following.

- loss of 68 acres of bottomland hardwoods
- loss of 65 acres of farmland
- disposal of 1.9 million cubic yards of dredged material on 40 additional acres of forest and swamp and 113 acres of farmland
- removal of numerous fishing and hunting camps/recreational buildings
- lowering of eight gas pipelines and possible modifications of the Highway 400 and Southern Pacific Railroad bridges
- potential water supply impacts (refer to Waldon, 1998, abstracted in Section A.7.1).

Project costs are estimated at over $11 million, plus any costs for bridge modifications. The estimate does not include channel improvements within Bayou Lafourche.

A.9 PYBURN AND ODOM

Under its ongoing subcontract with LWA, the Baton Rouge office of Pyburn and Odom, Inc., performed a number of engineering studies. These included surveying channel cross-sections and sampling of channel materials as input to computer modeling and hydrologic studies; engineering reports on the diversion and outfall works; and engineering reports related to channel improvements.

A.9.1 Pyburn and Odom, 1997a

Pyburn and Odom, 1997a. Bayou Lafourche sediment grab sample testing. Pyburn and Odom, Engineers, Baton Rouge, LA, May, 1997.

This report provides the results of particle size analyses for some 100 samples taken along Bayou Lafourche. Soil Testing Engineers of Baton Rouge performed the analyses. The results are included in a table and in grain size curves.

Table 1 from the report lists each sample and gives the percent passing standard sieve sizes. Particle size graphs are provided for selected sites. The graphs show the percent by weight of gravel, sand, silt and clay. Silts and clays are differentiated by hydrometer analysis.

A.9.2 Pyburn and Odom, 1997b

Pyburn and Odom, 1997b. Vertical and horizontal control network survey of Bayou Lafourche. Pyburn and Odom, Engineers, Baton Rouge, LA, May, 1997.

This document reported on field surveys by Pyburn and Odom (P&O) to establish an elevation reference network, establish accurate current contours and elevations of the Bayou, compare these results to previous surveys, measure gages and critical flows points, and determine whether any recent changes have occurred in the dimensions of the Bayou. Such information is necessary to ensure that past and present measurements are compatible, and to ensure that plans and estimates reflect current conditions.

Reference network. Initially, P&O established a vertical and horizontal measurement reference network along the Bayou from Donaldsonville to Larose. Key elevations used were those established by the National Geodetic Survey High Accuracy Reference Network, and the U.S. Coast & Geodetic Survey. The report includes the location and height at each reference point used by P&O.

Previous surveys. Using the P&O reference network, P&O was able to compare measurements between two previous surveys (Plaisance, 1986 and LDOTD, 1993) and P&O's own measurements for the same points. Differences were minor and consistent. The data comparisons are included in the report.

FWD gages. P&O also compared the elevations of its own measurements to those of the gages of the Bayou Lafourche Freshwater District (FWD). As the data in the report show, the elevations on the District gages were on average 0.51 feet lower than the measurements taken by P&O using its control network.

Critical drainage points. There are numerous points along the Bayou that need to be evaluated for the impact of increased flow in the Bayou. A report by Coastal Engineering and Environmental Consultants, Inc. (CEEC 1997a) identified many of these points, which mostly represent at-grade canals. For each point, P&O used its control network to establish an invert elevation (elevation at the bottom of each item). Elevations for each item are listed in the report.

Cross section results. Finally, P&O resurveyed cross-sections from previous surveys, to establish the extent of change. Criteria for selection of the cross-sections were based on information supplied by Dr. Kemp of Louisiana State University and Mr. Kirk Cheramie of the FWD. Review of the previous cross-sections compared to P&O cross-sections indicated little change from the time of the previous surveys (1986 and 1993). As a result, P&O recommended that "Based on the limited data sampling which we collected, we are of the opinion that insufficient change in the hydraulic conductivity of the bayou has occurred since the previous surveys to warrant further data collection at this time".

Field notes and engineering drawings for all fifty cross-sections are available from the files of Pyburn & Odom. For the Phase I report, the results are summarized in Table 2.3-1 and Figure 2.3-1.

A.9.3 Pyburn and Odom, 1997c

Pyburn and Odom, 1997c. Bayou Lafourche wetlands restoration project proposed diversion facility study. Pyburn and Odom, Baton Rouge, LA, September, 1997.

Introduction. This report estimates project costs for a 1000 cfs diversion facility with pumps. Costs are also provided for bayou crossings and a sediment trap.

Location of diversion facility. Figure 1 in the report is an aerial view showing the approximate location of Fort Butler, the existing diversion facilities, and the location of proposed diversion facilities. The Fort Butler site would be avoided. Two structures would be displaced by the preliminary alignment (including a water intake shed which contains two (2) 8" pumps that supply freshwater for Donaldsonville). A new pipe alignment would avoid the Fort Butler site (the existing alignment passes through it). For a detailed analysis, the alignment needs further investigation.

Configuration of the diversion facility. A screened intake structure will be required in the Mississippi River. Water will be routed to a pump pit below the diversion facility by 84" diameter gravity intake lines. Pumps will lift the water to the levee crown (variable speed motors will allow the flow to be reduced to about 60% of capacity), from where it will flow by gravity to the bayou. Pipes would be underground. A discharge basin will dissipate the velocity of the water entering the bayou. Details are provided in the report (e.g., pump sizes, motors, screens, pipe diameters), along with a scaled profile view of the proposed diversion facilities (refer to Figure 3.2-1 of the Phase I report).

Diversion flows. Diversion flow predictions of the proposed facility were based on a tailwater elevation of 9.0 feet NGVD in the bayou. As diversion through the proposed siphons is not possible during several months of the year due to low Mississippi River stages, the inclusion of pumps to maintain a year-round diversion was investigated. The existing 340 cfs diversion capacity is for fresh water supply; 660 cfs could be added to the existing diversion facility capacity, or a new facility could be built to handle the entire 1000 cfs diversion.

When river stages fall below elevation 14.3 NGVD, diversion will be made by pumping. The report provides maximum siphon flows by month for 50% duration stage for 660 cfs and for 1,000 cfs. The report also provides monthly siphon flows by 30% and 70% duration stages.

Estimated diversion facility costs. The report breaks down costs by construction and O&M (operation and maintenance) components. O&M assumes five months per year of pumping. Total costs are provided below; detailed breakdown of costs is provided in Tables 3 through 6 from the report. Refer to Section 5.2 of the Phase I report for additional discussion.

	Construction (incl. engineering, inspection and right-of-ways)	Total O&M over project life (20-year life)
660 cfs	$13,551,280	$10,217,089
1000 cfs	$19,642,480	$22,265,447

Bayou crossings. At 1,000 cfs, there would be no need to modify the Texas and Pacific railroad culverts. Two additional culverts could be added under LA Hwy 3089 to accommodate increased flows at that location, as shown on Figure 5 of the report. Total construction costs would be $475,200; Table 7 of the report provides details.

Sediment trap. Sand suspended in the diverted water is predicted to settle along the bayou, so that there is a need to investigate containing this material in a sediment trap to minimize maintenance dredging. Water elevation would increase upstream of the LA 3089 culverts. The pooling that would be caused would provide a favorable condition for location of a sediment trap. Minor dredging just upstream of the highway embankment would accomplish the sediment trap. Total construction and O&M costs (20-year life) are approximately $540,000 and $410,214, respectively. O&M would be $13,400 annually. Table 8 of the report provides details.

A.9.4 Pyburn and Odom, 1998

Pyburn and Odom, 1998. Bayou Lafourche wetlands restoration project: Pyburn and Odom, Inc. work task summary report and updates. Pyburn and Odom, Baton Rouge, LA, September, 1998.

This report is a consolidation of several memoranda prepared subsequent to the 1997 reports abstracted above, to address different aspects of conceptual project design and/or operation. The substantive information in the memoranda was incorporated into this evaluation report, especially Chapters 3 (design considerations) and 5 (optimized project). The report includes the following sections.

Diversion facility report. This section updates Pyburn and Odom (1997c) based on changes affecting capacity capabilities, and revisions to preliminary estimates of first cost.

- New 660 cfs diversion facility. This section discusses hydrology and hydraulics of the diversion and outfall area. Tables present siphon rates that were determined assuming a

9.5 foot tailwater elevation (which in turn reflects an elevation of 7.75 feet in the sand trap), and Mississippi River stages with probability of occurrence of 30%, 50% and 70%. The siphon rates are presented in Table 3.2-1 of the evaluation report. Updated first cost tables are provided, reflecting revised pump costs.

- Upgrade of existing diversion facility. Pyburn and Odom (1997c) examined two 1000 cfs capacity alternatives: 1000 cfs through a new diversion facility, or 660 cfs through a new plus 340 cfs through the existing diversion facility. Upgrades to the 40-year-old existing diversion facility under the 660 cfs alternative were considered. Costs were calculated for replacing the existing pumps with comparably-sized, variable speed ones.

- Bayou crossings. The Louisiana Hwy. 3089 crossing (one-half mile downstream of the bayou head) and Donaldsonville railway crossing (600 feet downstream of the highway) are on earthen embankments with culverts. Since Pyburn and Odom (1997c), LDOTD has committed to replacing the culverts with an opening sufficient to pass 1000 cfs. Thus this cost has been dropped from the current estimate. Additional culverts in the railway crossing are not proposed, but potential flooding and supporting soil saturation effects on Hwy. 308 where it crosses under the railway will need to be investigated, as will any effects on the capacity of existing drainage outlets upstream of the railway crossing, due to higher bayou stage. The report summarizes simplified calculations that indicate that 1,000 cfs will pass through the railway crossing culverts, and notes that the 9.5 foot stage upstream of the culverts is about 1.5 feet above the current level. Above the highway crossing, the stage will be about 1.0 feet above current level.

- Sediment trap. This section states that the LDOTD plan to replace the culverts at the 3089 crossing requires extensive modification to the preliminary sediment trap plan proposed in Pyburn and Odom (1997c), but that that redesign is the responsibility of others.

Utility crossing impact study. This section summarizes work done to identify utility crossings, and includes updated utility inventory tables. P&O conducted an inventory of utility crossings in the reach between the Donaldsonville railroad bridge and the Thibodaux weir, based on federal state and private sources including USACE NO District Permit Section, LDNR Office of Conservation Pipeline Operations and GIS Sections, Louisiana State Land Office, P&O files, and pipeline maps by Design Technics Company, Houston (DTC). In this reach P&O also conducted a cursory review, consisting of driving La. Hwys. 1 and 380, and noting utility warning signs and mileages. In the reach between the Thibodaux weir and the GIWW, P&O assumed that only limited dredging would be required, and its inventory there was based only on the DTC maps. It is likely that there are additional existing pipelines and cables crossing BLF that are not recorded by the agencies researched.

The section also presents the basis for reconnaissance level engineering judgments about the number of pipelines that would require replacement, the method of replacement, and the cost of replacement. Of the 61 crossings were identified in the upper reach, 26 lacked sufficient profile information to render a judgement regarding placement. By screening those with profile information based on the assumptions that replacement would be required if cover were reduced to less than shown on the permit drawing, or less than three feet, 10 crossings ranging in size from 1.5" to 8" would require replacement. Order of magnitude costs for replacements were developed, assuming standard cut and cover construction in the existing right-of-way without extensions for or complications due to bank roads or development, and without including design and other peripheral costs. Alternatives to replacement (lowering in place, directional drilling, and riprap cover) are briefly discussed. That information has been discussed in Sections 3.4.7 and 5.2.5 of this evaluation report.

Thibodaux weir removal. Removal of the weir is proposed to increase the conveyance capacity of the bayou, and water supply intakes along the bayou should not be adversely impacted. The weir provides a low water barrier at roughly elevation 3.3 NGVD, and is a sheet pile wall (pile length thirty feet at mid-channel) with reinforced concrete cap and walkway, and rock upstream and down. Demolition access is restricted by bridges up and downstream, and development on banks. A rock ramp will have to be constructed from the bank into the channel. After the concrete is removed (a difficult task), a large crane can then be brought into the channel to pull the piles. Rock will then need to be removed to the final channel bottom elevation (-4.0 NGVD assumed). Rock can be placed along banks in reach of the crane, and excess debris hauled for disposal. Order of magnitude costs (not including engineering, permitting and construction right-of-way) should not exceed $100,000.

Inflatable weir foundation. To avoid bank stability problems associated with rapid draw down of bayou water levels when the diversion facility must be shut down, inflatable weirs are proposed at Thibodaux and at Donaldsonville. Soils are soft and flow must be maintained in the bayou during construction. The sheet pile and concrete foundation, with anchor bolts embedded in a concrete cap, would need to be constructed in the dry. P&O proposes actually constructing two separate inflatable weirs, one for each half of the bayou cross section. For each half of the channel, the foundation contractor would build a cofferdam from a permanent 30-foot-deep sheet pile along the midline of the channel. The contractor will need a rock ramp into and working platform in the channel; the rock can be used on the downstream channel bottom after construction. A discussion of foundation alternatives is provided. Preliminary construction costs are $473,000 at Donaldsonville, $365,000 at Thibodaux. Less costly alternatives which would not require bayou dewatering could conceivably be some type of stop log control structure, or an earthen embankment with gated steel culverts.

Bank stability. The intent of the BLF project is to divert roughly five times as much water down the bayou, while not permitting bayou water levels to go up substantially, or allowing encroachment upon properties adjacent to the bayou. P&O provides engineering recommendations for stable dredge templates to meet these conditions. This section evaluates bank stability through an engineering analysis, and provides a general discussion of stability analysis methodology.

The BLF conceptual design was based on the assumption that the banks of a dredged channel would be stable if they did not exceed a slope of 3H:1V. This section discusses preliminary results of evaluations to determine the dredge-section side-slopes that would be potentially unstable. The stability analyses performed to date have been preliminary in nature and are qualitative, taking into consideration immediate post-construction conditions utilizing undrained strength parameters. Long-term stability conditions utilizing drained strength parameters with rapid drawdown considerations were not performed at this time.

Analyses focussed on the restricted upper reaches of the bayou. The initial analysis was based on the nearest upstream and downstream proposed 3H:1V dredging templates for three sites with existing LDOTD soil boring data (typically taken in association with construction of a bridge across the bayou). The nine boring logs used (Palo Alto: 2 borings, Hwy. 70: 3 borings & Spur 70: 4 borings) are included in the submittal. Other boring logs were obtained but not used or reproduced. Results, shown below, invalidated previous assumptions regarding stable dredge templates. Generally slopes with factors of safety greater than 1.3 are considered stable.

Soil Boring Data Location	Critical Slope Height	Factor of Safety For 3H:1V Slope	Slope Reqd. for Stable Bank
Palo Alto Crossing	29	1.18	3.5H:1V
Hwy. 70 Crossing	27	1.11	3H:1V
Spur 70 Crossing	26	1.04	4H:1V

To improve stability conditions, two additional templates were considered. Analysis of a benched template as described in the report, using the Spur 70 location boring data and the surcharge loading of a residential structure, indicated instability. Analysis of a broken slope dredge template for a more average existing section, again using a residential surcharge loading and the Spur 70 boring data, indicated factors of safety of 1.3 for the surcharged case and 1.43 for the non-surcharged condition. Stability determinations for locations with existing channel features less favorable than the average condition analyzed here will have to await the more detailed analysis of the next project phase. Details are provided in the STE geotechnical report included as Appendix E to Pyburn and Odom (1998).

The analysis indicates that stabilization of the bank slopes at some locations might be required if 1,000 cfs is to be conveyed. P&O provides a generalized preliminary per-linear-foot estimate of the cost associated with bank stabilization.

A.10 COASTAL ENGINEERING AND ENVIRONMENTAL CONSULTANTS (CEEC)

A.10.1 CEEC, 1995

CEEC, 1995. Bayou Lafourche siphons - a freshwater diversion from the Mississippi River to Bayou Lafourche; project report. Submitted to the Louisiana State University, Center for Coastal Energy and Environmental Resources, by Coastal Engineering and Environmental Consultants, Inc., September 1995.

This study expanded the project concept of diverting water from the Mississippi River into Bayou Lafourche to the level necessary for submittal of the project to the CWPPRA Task Force for consideration as a candidate for Priority Project List funding. The effort included identification of site-specific issues at a reconnaissance level, development of preliminary siphon design, estimation of project costs, and development of a Project Information Sheet to support submittal of the project for CWPPRA review.

Concept development. Key considerations regarding conceptual design of a diversion into Bayou Lafourche were identified as follows.

- High water elevations in the river and bayou.
- Bank elevations at key points along the length of the bayou.
- Expected increases in water levels in the bayou.
- Regional drainage patterns and existing infrastructure.
- Trends in wetlands losses.
- Expected distribution of fresh water and sediment.
- Expected wetlands benefits.
- Economics.

Consideration of these factors led CEEC to conclude that the most beneficial plan would be for water to be introduced into Bayou Lafourche at Donaldsonville. The water would then be diverted west down Company Canal at Lockport, and east and west into the GIWW at Larose. Areas of benefit identified included the Lake Fields region via Company Canal, and the wetlands south of Larose via numerous distributaries from the GIWW and southern Bayou Lafourche.

Field investigation. This included several reconnaissance-level field surveys to identify:

- locations where bayou cross-sections are potentially constricted;
- the locations of culverts along the bayou;
- locations where bank elevations are low;
- locations of railroad crossings;
- locations of incoming ditches and stormwater outfalls; and
- locations of major channel intersections.

This information was used to define what work would be necessary to improve the channel and to construct secondary structures to accommodate higher flow.

Reconnaissance survey at Donaldsonville. This included a general topographic survey for location of the existing pump station, levee, discharge pond, roadways, and other structures and buildings (summarized in Figure 2 of the report). In addition, the elevations of the ground profile along the centerline of the siphon pipes and length of the pipes were determined (summarized in Figure 3 of the report).

Development of drainage maps of the region. Surface runoff from the banks was estimated from contour maps. Drainage areas were identified by plotting drainage levees. Existing forced drainage systems and pump stations also were located. This information was used to characterize the general drainage pattern along the bayou, which was summarized on a 1:100,000 scale map and further detailed on a set of 11 (1:24,000 scale) maps. An atlas comprising finalized versions of the 11 (1:24,000 scale) drainage maps is included in a subsequent report (see CEEC, 1997a).

Water levels. Gage data from 1986-1994 were used to calculate monthly average water elevations (summarized in Tables 1 and 2 of the report). An average elevation for Bayou Lafourche of +6.5 ft was used to calculate average head differences between the bayou and the Mississippi River.

Preliminary conceptual design of the siphon system. A system was designed to accommodate a 2,000 cfs discharge through the siphons. CEEC determined this could be accomplished using eight (8) 72-inch pipes. CEEC also determined that head differences between the river and the bayou would be sufficient for siphoning from January through June, when average head differences ranged from 7.5 ft to 14 ft. During the rest of the year, head may not be adequate for siphoning, and CEEC recommended inclusion of "adequate" pumping capacity. CEEC also recommended that since pipes with bigger diameters would allow siphoning for a longer period of time each year, alternatives using larger pipes should be analyzed to determine optimal pipe diameter. Siphon pipe alignment was assumed to follow the existing layout. CEEC suggested that the following new construction or modifications would be necessary to increase the capacity of Bayou Lafourche, to prevent scouring and overbank or backwater flooding, and to maintain the desired distribution of fresh water and sediment.

- Improvement of discharge pond at Donaldsonville.
- Bank stabilization.
- Dredging.
- Modification of bridges and railroad crossings.
- Bank improvement.
- Widening of channel cross-sections at constricting points.
- Structures to prevent backwater flooding.
- Flow restriction structures.

Cost estimate of the overall project. CEEC presented a preliminary opinion of probable project cost in two parts:

I. Siphon pipes, supporting structures, and cross-overs	$ 6.88 million
II. Bayou Lafourche modifications and improvements	11.12 million
	TOTAL$18.0 million

Itemization of these costs are provided in Table 4.3-1 of the Phase I report; estimates did not consider operation and maintenance, or monitoring costs.

Other. The report notes that CEEC made a formal presentation of results of this study to LSU and DNR, and participated in several meetings to discuss this project with LSU, DNR, and the Bayou Lafourche Freshwater District. CEEC submitted this report to LSU as assistance in development of a Project Fact Sheet (the document required for formal submittal of a project to the CWPPRA Task Force for consideration for Priority List funding).

A.10.2 CEEC, 1996

CEEC, 1996. Bayou Lafourche wetlands restoration project: a freshwater diversion from the Mississippi River into Bayou Lafourche. Project Briefing Booklet. Prepared for the U.S. Environmental Protection Agency, Region 6, Dallas, Texas, by Coastal Engineering and Environmental Consultants, Inc., Houma, Louisiana, April, 1996.

This booklet provides the following:

- a brief history of the bayou;
- project features and costs (for the original 2,000 cfs siphon diversion);
- a summary of benefits.

The original 2,000 cfs diversion was estimated at $24,487,300; basic costs are broken out in the report.

The report notes that the current lack of freshwater flow in the bayou has allowed saltwater to encroach inland, causing extremely high rates of wetland loss in the Terrebonne/Barataria Basin. Continued wetland deterioration and saltwater intrusion will eventually threaten local freshwater supplies.

The report locates the benefited marshes in relation to the bayou (9,500 acres of fresh marsh, 7,800 acres of intermediate salinity marsh, and 12,000 acres of shallow open water), and notes that fish and wildlife productivity would be enhanced significantly. In addition to retarding saltwater intrusion, the project would make available additional municipal and industrial freshwater to meet increased demands in the future.

A.10.3 CEEC, 1997a

CEEC, 1997a. Bayou Lafourche drainage plan - existing drainage into Bayou Lafourche from Donaldsonville, LA. to the Company Canal in Lockport, LA. Prepared for the Louisiana State University, the Environmental Protection Agency, and the Louisiana Department of Natural Resources by Coastal Engineering and Environmental Consultants, Inc., Houma, Louisiana, January, 1997.

This survey identified existing culverts and drainage structures into Bayou Lafourche from Donaldsonville to Lockport, and described general drainage patterns along the bayou, to identify critical areas where drainage might be affected by changes associated with the proposed diversion project. Invert elevations were estimated for a few locations where these were needed to estimate vulnerability to future drainage problems.

Survey results, including a complete list of drainages and descriptive information for critical areas, were presented by parish for the three parishes (Ascension, Assumption, and Lafourche) through which the bayou flows. Drainage structures and general drainage patterns were also depicted on a set of 7.5-minute topographic quadrangles, included as an attachment to the report. A total of 444 drainage structures were identified within the study area. Of these, 46 were listed as potentially affected by increased flow through Bayou Lafourche. (In effect, these are the open “at grade” canals.) Table A.10.3-1, attached, provides information on the 46 at grade channels;

the table has been amended to reflect a subsequent field survey of the channels by Pyburn and Odom (1997b).

In Ascension Parish, most of the drainage along Highway 1 is away from Bayou Lafourche to the Smoke Bend/Lake Verret watershed, except for a strip about 300 ft wide along Highway 1 that drains into the bayou. Similarly, most drainage along Highway 308 is away from the bayou to the Baker watershed, except for a few small areas. CEEC identified 22 specific drainage structures into Bayou Lafourche, and characterized 6 of these locations as potential concerns. The critical locations included the railroad crossing at LA. Highway 308 in Donaldsonville, as well as several drainage canals and culverts.

In Assumption Parish, most of the reach on the west (Highway 1) side drains to the Lake Verret watershed. Most of the parish east of the bayou drains east into the Baker watershed. On both the east and west sides, there are strips about 300 ft wide along the highways that drain into the bayou. CEEC identified 171 drain locations, with 10 listed as potential problems. Most of these involved concerns of flooding, loss of drainage capacity in high rainfall, and in one case, deterioration of exposed highway foundation. For example, the Marais area has been flooded when bayou water levels increase, and the Labadieville site could lose capacity to drain both residential and agricultural lands if water levels in the bayou increase. Both might require forced drainage if flows are increased in Bayou Lafourche.

In Lafourche Parish, CEEC located 250 drainage structures along Bayou Lafourche. Drainage in Lafourche Parish includes both gravity flow and forced drainage. CEEC identified the area between the railroad tracks and Highway 1 from the parish line to Thibodaux as draining into Bayou Lafourche. In this same reach the area west of the railroad tracks drains into a forced drainage system. The main concern in Thibodaux was storm drainage capacity with a rise in Bayou Lafourche. A couple of other short reaches south of Thibodaux also drain into Bayou Lafourche, with the remainder of the west side draining to the Bayou Folse watershed and Lake Fields. Most of the drainage on the east side is to the southeast towards Lakes Boeuf, Des Allemands, and Salvador, with a few forced drainage systems identified. CEEC identified several canals and drainage areas on both sides of the bayou in this reach that could be a concern if flows are increased in Bayou Lafourche.

Table A.10.3-1 At-grade channels, Bayou Lafourche

Critical drainages identified by CEEC (1997a) survey and field checked by Pyburn and Odom (1997b).

			Elevations in feet (NGVD)		
			Object		Water surface
Item #	River mile	Description and location	Invert	Top	12/27/1996[1]
#8	3.8	Two 48" box culverts of Smoke Bend, nth side of Sagona's Gift Shop	5.87	9.87	7.6
#9	3.8	7' round culvert at 3074 La. Hwy 1	5.65	12.65	7.6
#13	4.9	6' culvert at 1515 La. Hwy 1	2.97	8.97	7.6
#20	2.5	RR xing, La. Hwy 308 Donaldsonville, 6' deep x 5' wide box culvert	5.37	11.37	7.6
#21A	2.7	2' CMP north of New bridge	7.46	9.46	7.6
#21B	2.7	1.5' CMP south of New bridge	9.60	11.10	7.6
#23	5.7	Napoleon Bayou 1.5' CMP south of New Bridge	3.35	4.85	7.6
A - 34	12.3	36" culvert at La. Hwy 1 and Westfield Road	10.27	13.27	7.6
A - 59	18.2	36" culvert at La. Hwys 1 and 401 behind Assumption Area Chamber	2.63	5.63	6.9
A - 80	24.8	72"x60" box culvert at 3227 La. hwy 1 (Marais Area)	-0.52	5.48	6.6
A - 85	26.7	6' x 6' box culvert at La. Hwy 1 and Locust Street	2.34	8.34	6.4
A - 90	27.7	6' x 6' box culvert at La. Hwy 1 and Pear Street	2.53	8.53	6.4
A - 138		Baker Canal at La. Hwy 308			6.4
A - 153	24.8	Under La. Hwy 308 bridge 1000' nth of La. Hwy 1011, Bayou bottom	2.04		6.6
A - 157	26.3	4' box culvert at 2828 La. Hwy 308	1.11	5.11	6.4
A - 167	28.2	2' box culvert at 2405 La. Hwy 308	1.92	3.92	6.4
A - 168	28.4	3' culvert at 2373 La. Hwy 308	1.72	4.72	6.4
L - 1	29.5	3' culvert below water at La. Hwy 1 200' south of Parish line	-0.32	2.68	6.4
L - 7	32.0	24" culvert 7' below La. Hwy 1 on south line of Donald Peltier	6.48	8.48	6.3
L - 8	32.0	36" box culvert 8' below La. Hwy 1 150' north of Dixie Rd	6.60	9.60	6.3
L - 13	34.1	36" box culvert 9' blw La. Hwy 1 on Waverly-Leighton Plantation Line 300' south of Winder Rd	3.77	6.77	6.2
L - 28	29.5	36" culvert below 1954 La. Hwy 308	6.35	9.35	6.4
L - 34	30.9	36" culvert at La. Hwy 308 250' north of Dixie Road	2.24	5.24	6.3
L - 47	33.0	5' steel drainage canal between 1922 and 1924 La. Hwy 308 at Thompsonville Construction Co.	-0.03	4.97	6.2
L - 51	34.1	48" box culvert at La. Hwy 3185 bridge at La. Hwy 308	5.42	9.42	6.2
L - 52	34.1	48" culvert at 960 La. Hwy 308	2.03	6.03	6.2
L - 53	35.6	4' concrete box culvert at West Thibodaux Water booster station on La. Hwy 308	4.53	8.53	6.1
L - 55	35.0	2 culverts 14' under La. Hwy 1 50' north of City of Thibodaux sign across from FWD office			6.1
L - 59	35.6	6' box culvert under Canal Blvd (Thibodaux)	0.63	6.63	6.1
L - 64	37.7	3' large box culvert submerged 200' nth of La. Hwys 648 & 1	-0.17	2.83	4.5

Table 2.5-1, continued

Item #	River mile	Description and location	Elevations in feet (NGVD)		
			Object		Water surface
			Invert	Top	12/27/1996[1]
L - 68	38.0	Dugas Canal at 1072 La. Hwy 1, 6' concrete culvert	-4.68	1.32	4.3
L - 77	39.7	Sluice gates and weir ties at Lefort Canal 400' north of Lefort By-Pass Road, 6' CMP	-3.63	2.37	4.1
L - 117	45.5	Theriot Canal ties Bayou Lafourche to Bayou Cutoff Sluice Gate, 12.5' deep x 8' wide	-4.66	7.84	3.4
L - 186	36.0	2- 4' box culvert at 310 La. Hwy 308	-1.35	2.65	5.9
L - 195	38.0	Laurel Valley Canal at La. Hwy 308 next to Old Fountain Missionary Baptist Church	0.01		4.3
L - 201	39.7	Lafourche Crossing La. Hwy 308			4.1
L - 207	39.9	36" culvert at La. Hwy 308, 800' north of St. Charles Bridge	0.05	3.05	4.1
L - 219	45.5	Large lateral canal at La. Hwy 308 south side of Third Zion Church, Raceland			3.4
L - 229	49.7	60" culvert under La. Hwy 308 200' sth of Brocato Ln, Raceland	-0.36	4.64	2.9
L - 231	49.7	36" culvert at La. Hwy 308 at Gazzo Canal	-0.48	2.52	2.9
L - 237	50.7	Large open canal below La. Hwy 308 bridge south side of Central Crude Raceland Terminal	-5.50		2.7
L - 238		36" culvert at La. Hwy 308 1000' south of L - 237	-0.21	2.79	
L - 240	51.7	48" culvert at La. Hwy 308 1000' north of La. Hwy 90 Raceland	-0.23	3.77	2.6
L - 243	53.7	48" culvert at La. Hwy 308 and Amerada Hess Road	-0.24	3.76	2.3
L - 245		3' culvert at La. Hwy 308 1/2 mile north of 4839 Church and Cemetary Mathews	1.39	4.39	
L - 249	55.7	48" culvert at La. Hwy 308 South Side Water Plant in Lockport (filled 1/2 way w/concrete)	-0.11	3.89	
L - 250	57.8	Company Canal Bottom	-2.29		

1 Interpolated water surface elevation (CEEC) on 12/27/96.

A.10.4 CEEC, 1997b

CEEC, 1997b. An alternative analysis to increase the conveying capacity of Bayou Lafourche. Prepared for the Louisiana State University, the Environmental Protection Agency, and the Louisiana Department of Natural Resources by Coastal Engineering and Environmental Consultants, Inc., Houma, Louisiana, April, 1997.

This study reviewed two scenarios at a preliminary level: 1) dredging the upper 33.6 miles of Bayou Lafourche to increase conveyance capacity; and 2) diverting drainage water from one or more sites along the eastern bank of the bayou.

Dredging options. Dredging options were reviewed to determine what general approaches might be feasible to accommodate an increase in flow to 2,000 cfs in Bayou Lafourche without a significant increase in water level, and to identify the most crucial aspects of such a dredging approach. To evaluate potential dredging logistics, it was estimated that about 10 million cubic yards (mcy) of material would have to be dredged from the upper 33.6 miles of the bayou from Donaldsonville to Thibodaux, to increase the depth of flow by about 6 feet. Dredging quantity was estimated by dividing the bayou above Thibodaux into 18 segments, based on major obstacles to dredging (mostly bridge crossings). The amounts of material that would be removed from each segment were estimated using depth of dredging, segment length, and channel width. Both the depth of dredging and the volume of material to be removed to improve channel capacity were revised in CEEC (1997c). This analysis, as well as that in CEEC (1997c), assumes that dredging can be used only to increase channel depth to increase capacity, since there is extensive development along much of the upper reach of the bayou that would make increasing channel width difficult.

Based on limitations of water depth, the presence of numerous low-elevation bridges, and the associated need to pull and re-deploy the dredge between each segment, the study indicates that only smaller dredges could be used for dredging Bayou Lafourche. Information on several micro-dredges was presented. There are logistic limitations associated with using micro-dredges, primarily regarding dredging rate (capacity) and the distance over which dredged material can be pumped without booster pumps. Of the several micro-dredges examined, the highest dredging capacity was 300 cy/hr. This limited capacity compared to the large volume of dredging required (10 mcy) would result in a relatively long period of time needed to complete the dredging. This logistical limitation is presented as an important consideration in identifying a feasible dredging approach for Bayou Lafourche. In addition, booster pumps would likely be required to reach potential disposal locations. Dredging cost for this option was estimated at $6/cy to $8/cy.

Another dredging option presented is use of a slightly larger dredge, the C.F. Bean Corporation Flexi-Float, mounted on a modular barge and with an 800 cy/hr capacity. Logistical benefits would include a substantially reduced duration of dredging, and capability of greater disposal distance without booster pumps. Using the same operating frequencies, dredging of 10 mcy at 800 cy/hr would take about 2.5 yr. Potential drawbacks would include increased complexity of moving the barge and dredge between dredging segments because the equipment would be larger and heavier; and greater draft of the barge, which may require pre-dredging in the vicinity of Donaldsonville. Dredging cost for this option was estimated at $3/cy to $4/cy.

To keep costs associated with additional booster pumps at a minimum, the study considered possible disposal sites within 2,000 feet on each side of the bayou, as well as disposal on the batture between the high banks.

In locations where bank erosion is a problem, disposal on the batture may be an option. However, the potential for creating unstable banks must be considered. For disposal in low areas adjacent to the bayou, it was assumed that disposal pipes could be run under the roads (Highways 1 and 308) through existing culverts. Landowner willingness to accept dredged material on the lands adjacent to the bayou was preliminarily investigated by holding a meeting to which all landowners were invited. The concept of receiving dredge material appeared to be well received by most landowners, especially for placement at the back side of their properties closest to the marsh. However, specific commitments have not been obtained.

Drainage from the east. This study developed a preliminary review of the possibility of modifying the drainage of the Baker watershed, along the east bank of Bayou Lafourche, from its current pattern through Bayou Des Allemands into Lake Salvador to Bayou Lafourche. The rationale is that this drainage water is an alternative source of fresh water that could be introduced into Bayou Lafourche at several locations along the bayou instead of all at the top where the greatest conveyance problems are encountered. Madewood Canal, Theriot Canal, and Laurel Valley Channel, as well as other minor canals, were identified as potential locations for freshwater input.

General feasibility of this concept was evaluated by meeting with government representatives of the three parishes that border the eastern bank of the bayou - St. James, Assumption, and Lafourche. There are no existing parish plans for improving drainage in these parishes, although all expressed interest in further studies that could include drainage into Bayou Lafourche as a viable option. Particular interest was expressed in a pump station at the junction of Madewood Canal and Bayou Lafourche, and possibly also at Theriot Canal. Some dredging of the canals may be necessary to improve hydraulic efficiency.

The main concern expressed by the public through the parish meetings was for potential changes in water quality associated with introducing black water, with its high levels of organics, into Bayou Lafourche. The high organic levels may pose a particular problem for the water supply treatment plants along the bayou.

A.10.5 CEEC, 1997c

CEEC, 1997c. Bayou Lafourche Freshwater Diversion - preliminary dredging plan. Prepared for the Louisiana State University, the Environmental Protection Agency, and the Louisiana Department of Natural Resources by Coastal Engineering and Environmental Consultants, Inc., Houma, Louisiana, September, 1997.

This report formulates a preliminary plan for dredging in Bayou Lafourche to modify the channel profile from Donaldsonville to Thibodaux to convey 1,000 cfs of water without significantly increasing water levels over existing conditions.

Characteristics of the preliminary dredging plan include the following.

- Dredging would take place along the upper 33.66 miles of Bayou Lafourche.
- 4.2 mcy of material would be dredged (this represents an average of 23.6 cy per linear foot).
- Maximum pumping distance would be 3 miles.
- Dredging would be done with a bucket dredge with a slurry processing unit.
- Dredge capacity would be 200 cy/hr (allowing dredging of about 200 ft/dy).
- Pumping capacity would be about 2 miles, with booster pumps needed for greater distances.
- Disposal pipes would be plastic, with Y-ended discharge.
- Density of slurry and other dredging operations would be computer controlled.
- Bridge cross-overs would be accomplished by rolling the dredge over the bank.
- Containment areas would be about 500 ft wide with 24 inch earthen levees.
- Return water would be diverted to adjacent wetlands.
- Dredging operations would be 24 hours/day, 365 days/year.

The volume of dredging needed to accomplish this was estimated by LSU based on decreasing the average elevation of the channel bottom to -4.0 ft, and comparing the resulting profile to existing profiles to calculate needed material removal. As in CEEC (1997b), calculations were done for each of 18 segments between Donaldsonville and Thibodaux, divided by bridges or other major obstructions to dredging.

Although the previous study (CEEC, 1997b) suggested small hydraulic dredges were the best option for dredging Bayou Lafourche, two additional concerns were presented in this study.

Hydraulic dredging usually produces a slurry with relatively low percent solids, leaving a relatively high volume of return water that would be difficult to manage in the Bayou Lafourche area and would be undesirable in the agricultural fields targeted for potential disposal. Also, substantial quantities of debris that could damage the cutter head of a hydraulic dredge are expected to occur in Bayou Lafourche. One alternative is use of a combination of a bucket dredge to remove gross debris, plus a small hydraulic dredge capable of producing a slurry with relatively high solids content. Another alternative identified was use of a bucket dredge with a slurry processing unit, similar to the Liebherr 984. Formulation of the preliminary dredging plan and the associated cost estimate was based on use of this bucket dredge.

In a previous study, CEEC (1997a) identified 444 culverts that potentially could be used for passage of disposal pipes under the highways that parallel the bayou. One objective of the CEEC (1997c) study was to identify the culverts that would be used for disposal logistics. However, it was recognized that specific disposal areas must be identified and the dredging schematic finalized before appropriate culverts can be selected. The formulated dredging plan assumed identification of appropriate culverts approximately one mile apart along the length of bayou to be dredged.

As in the previous study (CEEC, 1997b), it was assumed that dredged material disposal sites would be available on the low-elevation land beyond Highways 1 and 308 along each side of Bayou Lafourche. Based on several additional meetings with landowners, CEEC reported wide support for the project and agreement to provide the rights-of-way necessary for disposal of dredged material. However, CEEC reported that "some of the land owners were hesitant to identify specific areas of their property because they thought that showing a tentative boundary at this time may be interpreted as a commitment at a later date". The study estimate was that an area 33.66 miles long by 430 feet wide would suffice for disposal of 4.2 mcy, assuming an average placement thickness of 18 inches. Placement on the eastern side of Bayou Lafourche was considered preferable along most of the bayou because the interface between the agricultural fields and the marshes, where disposal would likely take place, is closer.

Disposal along the batture within the high banks along Bayou Lafourche, as proposed in the April 1997 report (CEEC, 1997b), was no longer considered a viable option in formulation of this dredging plan. CEEC indicated concern that additional overburden could increase bank instability; however, supporting evidence or specific areas of concern were not presented.

Other assumptions used to estimate dredging costs included the following.

- Duration of dredging was estimated to be 3.5 years.
- Manpower needed for 24-hour operation was estimated to be 8 people during the day and 5 people at night, including a project manager, two operators, a crew chief, two watch engineers, four fill hands, a roligon operator, and a surveyor.

- Daily rental of the dredge would include the dredge, two boats, a derrick barge, and a lifting device.
- The dredge would be fueled by diesel.
- The dredge would be lifted 25 times to cross bridges and other obstructions.

Construction costs were estimated to be $12.6 million, including personnel, fuel, consumables, equipment rental, remobilization of dredging equipment across bridges, and containment. This amount also includes overhead (15%), profit (10%), and contingency (15%). Added to this were 8% for engineering fees, and 10% for additional services (e.g., surveying, rights-of-way, permitting, etc.), for a total cost of $14.9 million. This corresponds to an average unit cost of $3.55/cy.

A.10.6 CEEC, 1998a

CEEC, 1998a. Cost estimates, water control gate structure, Bayou Lafourche project. Coastal Engineering and Environmental Consultants, Inc., Houma, Louisiana, July, 1988. Supplemented September 8, 1998.

This report provided a conceptual drawing and cost estimate for light-weight lift-type gated weirs across the Bayou Lafourche at Donaldsonville and Thibodaux. The supplemental report assessed a larger gate that would not create a backwater effect.

A.10.7 CEEC, 1998b

CEEC, 1998b. Preliminary spoil disposal sites, Bayou Lafourche project. Coastal Engineering and Environmental Consultants, Inc., Houma, Louisiana, September 30, 1998.

This report presents a map showing 14 tracts of land that are possible disposal sites for material dredged from Bayou Lafourche, based on contact with and favorable responses from land owners and/or operators. Land owner/operator agreement was indicated as contingent on compensation for any damages that might occur. If site usage is coordinated with crop rotation, costs were predicted to be minimal. Many of the tracts are very large, and collectively they extend from Belle Terre (bracketing the Ascension/Assumption Parish line) to the area bracketing the Assumption/Lafourche Parish line, downstream of Labadieville.

A.11 LEE WILSON AND ASSOCIATES (LWA)

A.11.1 LWA, 1997

LWA, 1997. Bayou Lafourche Freshwater Diversion - water supply uses of diverted water. Prepared by Lee Wilson and Associates, Inc., April, 1997.

Water diverted by the Bayou Lafourche Freshwater District meets virtually all of the municipal and industrial needs of Assumption and Lafourche Parishes; the needs of Ascension Parish south of the Mississippi River; much of the needs of Terrebonne Parish; and the needs of Grand Island in Jefferson Parish. Water service is provided to approximately 250,000 persons.

The cited report provides tables that list the entities that withdraw water from Bayou Lafourche for municipal and industrial purposes; and details of their actual withdrawals for 1994. Data from 1984 and 1989 are provided for comparison. The 1994 withdrawals averaged 61 cfs (40 MGD), with a peak of 112 cfs in late fall when industrial uses (sugar cane refining) were at a maximum.

Projected population growth in the four parishes that use most of the bayou water is projected to be 21% over the next 20 years. This will increase water demand, as will any expanded industrial activity; however demand will be reduced as water conservation becomes increasingly effective. Overall, it is reasonable to forecast that future water demands (over a 20-year period) will increase by no more than 25% compared to present levels. The resulting withdrawals - an average of 75 cfs with a peak of 140 cfs, would be substantially less than the existing diversion capacity of the Freshwater District.

Based on this analysis, any diversions added by Project PBA-20 would not be taken by municipal or industrial users along the bayou, but would reach downstream channels and marshes and thereby provide wetlands benefits.

Table 1 from the report is provided here. It summarizes average daily water use for public and private users in 1994.

TABLE 1: USE OF FRESHWATER FROM BAYOU LAFOURCHE, 1994

Source: U.S. Geological Survey

	AVERAGE USE, MILLION GALLONS/DAY
PUBLIC USERS	
Lafourche Parish WD #1	7.94
Assumption Parish WD #1	3.14
Peoples Water Service (Ascension Parish)	1.64
Thibodaux Municipal Water Plant	3.29
Lockport Filtration Plant	0.22
Terrebonne Parish Water District	8.50
TOTAL PUBLIC	24.73
INDUSTRIAL USERS	
Lafourche Sugars	0.08
Raceland Sugars	2.77
Supreme Sugars	5.16
Glenwood Sugar Coop.	2.14
Savoi Sugar Industries	2.64
Nicolaus Paper Inc.	2.13
TOTAL PRIVATE	14.92
TOTAL	39.65

A.12 U.S. ENVIRONMENTAL PROTECTION AGENCY (EPA)

A.12.1 EPA, 1996

EPA, 1996. Bayou Lafourche Wetlands Restoration Project public scoping meetings responsiveness summary. U.S. Environmental Protection Agency, Region 6, Dallas, TX, August, 1996.

EPA response to written comments and comments received at public meetings held in Larose, Donaldsonville, Napoleonville, and Thibodaux in April and May 1998, concerning a 2000 cfs Bayou Lafourche proposal. Summary of topics:

- Scoping and coordination: one year schedule, Section 404 permit required, CWPPRA Task Force composition, prevention of problems like those that have arisen in other projects, Fort Butler preservation, Donaldsonville area economic development, effects on wildlife, pre-implementation and thorough public consultation.

- Siphon facilities: number of siphons and pumping costs, potential for diversion increase, Mississippi River water quality, railroad bridge, Hwy. 1 and 308 flooding and hurricane evacuation, water supply cost effects.

- Channel function: current water levels already too high, dredge and water management recommendations (incl. Thibodaux Weir), sediment distribution and Lefort Canal gate, utility relocations, final channel dimensions, restoration of bayou to 1904 conditions, bank and levee erosion and need for constant flow, traffic capacity and bridges, criticism of May 8 1995 high water level as benchmark, submerged grass treatment.

- Dry weather conveyance: current velocity and public safety, water level rise expectations and flooding, effects on crawfish burrows and septic systems, increased Terrebonne water treatment costs.

- Wet weather conveyance: drainage via Bayou Lafourche is currently not effective and more water would worsen the situation.

- Legal evaluations: project ownership and operations and monitoring, legal responsibility and litigation process, dredging burden especially at end of project life, levee height adequacy, property value determination, dredging property damage compensation, dock and wharf improvement responsibility, pumping authority.

- Benefited marshes: acres to be rebuilt, how and what sediment will get to marsh, negative effects on salt marsh, flow system at the GIWW, hurricane effects on marshes.

- Project evaluation: alternatives to siphon project, concern that 2000 cfs is too much, distribution of costs and benefits to different communities, holding oil and gas companies responsible, opposition to spending public funds for private property, estimated cost seemed low.

- Other comments: concerns about data accuracy, support of project principles.

A.12.2 EPA, 1998a

EPA, 1998a. Design and cost information, Bayou Lafourche diversion project. Submitted to CWPPRA Engineering Work Group. Prepared for U.S. Environmental Protection Agency by Lee Wilson and Associates, Inc., May, 1998.

This report consisted of preliminary descriptions and cost estimates for diversion works; rehabilitation and expansion of existing facilities; construction of new facilities; channel modification and maintenance through dredging; construction and maintenance of sediment trap; and water control structures. Cost estimates and back-up support included construction costs, operation and maintenance costs; and costs associated with engineering and design, supervision, permitting, and monitoring.

Some of the attachments reflected completed work, and presented or supported planning-level estimates of project costs. Other attachments gave the most current information with respect to tasks that were ongoing. The report was provided to the CWPPRA Engineering Work Group in order to determine which cost estimates were considered reasonable, what modifications should be made, and what further information would be required in accordance with standard CWPPRA procedures.

The report was made up of 20 “attachments”, which were described as follows.

Attachment 1 is a brief project overview (project information sheet).

Attachment 2 is a summary of the project costs, i.e. it captures in one place the information contained in other attachments.

Attachment 3 describes the proposed new diversion works and presents the estimated planning level construction costs for this facility.

Attachment 4 describes the rehabilitation and expansion needs at the existing diversion works and estimates costs for overhaul of pumps at the facility.

Attachment 5 explains the basis for concluding that no costs are required to build bridges in Donaldsonville to replace an existing highway crossing and an existing railway crossing; and the basis for determining that existing bridges do not present a constraint to conveyance of 1,000 cfs.

Attachment 6 presents the concept and provisional costs for a sediment trap that would be constructed in the Donaldsonville area, to concentrate the area of sand deposition.

Attachment 7 describes the criteria used in design of a channel improvement program, particularly dredging. The criteria include a reference profile of water stages that reflect historic conditions; the design objective was to maintain future water levels (with 1,000 cfs diversion) at or below this condition. The criteria also included a standard cross-section or dredging template.

Attachment 8 summarizes the methods and results of HEC-RAS modeling that was used to design an optimized dredging program. Dredging of approximately 3.3 million cubic yards will be required if 1,000 cfs is to be conveyed without causing water levels to rise above historic conditions.

Attachment 9 describes two alternatives for dredging (cutter head or bucket) and the proposed operations and disposal plan. Dredging costs are provided for both alternatives.

Attachment 10 summarizes work done to identify utility crossings, and the cost for replacing those crossings that would potentially be impacted by dredging.

Attachment 11 describes and provides a cost estimate for the proposed removal of the weir at Thibodaux. A new design concept involving inflatable weirs to stabilize bayou water levels in emergency conditions is being evaluated.

Attachment 12 discusses bank protection costs for the project.

Attachment 13 provides the basis for an estimate of permitting costs.

Attachment 14 briefly discusses a proposed system for monitoring impacts and controlling project diversions.

Attachment 15 tabulates existing costs for labor and overhead associated with routine operations and maintenance of the existing diversion. This budget is considered to not require an increase for a new facility.

Attachment 16 presents an operations schedule for the 1,000 cfs diversion and estimates utility and repair costs for the operations. These include 100% of the costs of the new facility, and the incremental costs for the existing facility.

Attachment 17 estimates the cost of maintenance dredging for the project, which is expected to be limited to the sediment trap area.

Attachment 18 itemizes "CWPPRA add-on" costs: monitoring, contingencies, design and supervision, and agency supervision.

Attachment 19 provides costs for the alternative of providing diversion water through Cancienne Canal, rather than at Donaldsonville.

Attachment 20 provides costs for alternatives that are smaller than the 1,000 cfs project: 340 cfs, 660 cfs and 780 cfs.

A.12.3 EPA, 1998b

EPA, 1998b. Cost evaluation, Phase I construction, Bayou Lafourche diversion project. Submitted to CWPPRA Engineering Work Group. Prepared for U.S. Environmental Protection Agency by Lee Wilson and Associates, Inc., August, 1998.

Subsequent to EPA (1998a), the project was divided into two phases. EPA (1988b) in conjunction with EPA (1998a) provides descriptions and cost estimates for construction of Phase I.

This report describes Phase I: diversion works; rehabilitation of existing facilities; channel modification through dredging; construction of a sediment trap; and water control structures. Cost estimates and back-up support include construction costs and costs associated with engineering and design, supervision, permitting, and monitoring.

The contents are as follows.

1. Overview of Phase I. The intent is to operate Phase I at 340 cfs for at least one year prior to initiating construction of Phase II, which is the full 1,000 cfs project. This section includes a map of the Donaldsonville area locating most of the following:

- Upgrade of the existing pump station
- Dredging of a sand trap
- Limited dredging within the channel in the Donaldsonville area
- Relocation of one utility line
- Removal of the weir at Thibodaux
- Installation of two deployable weirs
- Installation of water monitoring stations

The only Phase I facilities not shown on the figure are: a) one deployable weir that will be at the site of the existing weir in Thibodaux; and b) new monitoring stations at or near locations of existing FWD staff gages at the water plants in Labadieville and Mathews, and at an existing temporary USGS installation in Larose.

2. Costs for upgrade of pump station. Describes the plan to replace the two existing pumps with variable speed units, rather than simply overhaul the existing pumps. Includes a cost table.

3. Costs to construct sand trap. Discusses bank stability, dredging method, disposal of material, and basis for cost estimates. Includes a location map (just below the UP Railway crossing), cross-section, soil boring logs (2), basis for each construction cost item, and cost table. The main structure is 1,000 feet long, has a bottom section at -7' NGVD that is up to 100 feet wide, and 3H:1V side slopes. A bucket dredge would dispose of material to a slurry pump for discharge to the Mississippi River.

4. Costs to dredge channel. The channel would be dredged from the reach of Bayou Lafourche that extends from just below the sand trap, at cross-section 150+00, to cross-section 300+00, just below the Palo Alto bridge. Discusses encroachment on the batture (there will be none), bank stability (4H:1V side slopes), disposal of material, and basis for cost estimates. Includes cross-sections of dredged channel (10); dredging volume print out; HEC model print outs (2, of three pages each); graphs of water level impacts (2); cost table. The HEC-2 model indicates approximately 150,000 cubic yards of material will be dredged and that the improved section will convey 340 cfs with water levels that are generally lower than now occur.

5. Costs to relocate one utility line. Section includes a table of utility crossings (improved through use of a questionnaire) and a cost table. One line (water service line owned by

People's Water Service of Donaldsonville) was found to be affected and must be replaced, by offset into a much deeper alignment at the sand trap.

6. Costs to remove weir at Thibodaux. Updates the EPA, 1998a estimate by accounting for right-of-way costs, permitting and ancillary costs. Includes a cost table.

7. Costs to install two deployable weirs, Donaldsonville and Thibodaux. Discusses installation and operation of rubber dams, one near the existing Thibodaux water plant and one in the Donaldsonville area. Includes diagram and photo of weir, memo on conceptual design of foundation, quote from dam vendor, and cost table.

8. Costs to install monitoring stations. Discusses data collection platforms (DCPs) along the bayou. Locations and descriptions of five existing facilities (Donaldsonville, Labedieville, Thibodaux, Mathews, Larose), with required upgrades, are summarized in table format. The DCPs would provide digital read-outs which could be retrieved remotely on a real-time basis at a central control system located at the pumping plant. The expectation is that a specific management plan will be developed in conjunction with stakeholders along the bayou. Includes cost table.

9. Contingencies, engineering, agency oversight, permitting. Lists the following multipliers.

- Contingency: 20% of the construction cost estimate.
- Design: 7% of construction cost.
- Supervision of construction: 9% of construction cost.
- Agency oversight: 3% of construction cost.
- Permitting: accounted for within individual line items.

10. Summary of Phase I construction costs. Summarizes all cost estimates identified above, and provides an anticipated schedule for expenditure of the funds. The schedule reflects the following assumptions:

First year =	project design relocation of utility line install monitoring stations initiate weir construction (assumed to be 20% of total) install new pumps
Second year =	complete weir construction; remove existing weir dredging

The report notes that it is EPA's intent that the design of Phase II be included within the funding package for which Phase I approval is sought. However, for Phase I alone, a first cost of less than **$5 million** (unadjusted for timing) appears to be reasonable.

It further notes that EPA is investigating potential cost-share arrangements for the Bayou Lafourche diversion project.

A.12.4 EPA, 1998c

EPA, 1998c. Cost evaluation, Phase II construction, Bayou Lafourche diversion project. Submitted to CWPPRA Engineering Work Group. Prepared for U.S. Environmental Protection Agency by Lee Wilson and Associates, Inc., September, 1998.

Subsequent to EPA (1998a), the project was divided into two phases. EPA (1988b) in conjunction with EPA (1998a) provided descriptions and cost estimates for construction of Phase I. EPA (1988c) in conjunction with EPA (1988a) provides descriptions and cost estimates for construction of Phase II.

This report describes Phase II: a new 660 cfs pump station; additional channel modification through dredging; bank stabilization; and utility line protection and relocations. Cost estimates and back-up support include construction costs and costs associated with engineering and design, supervision, permitting, and monitoring.

The contents are as follows.

1. Overview of Phase II. Design of Phase II will be undertaken while Phase I is under construction, and will be completed during the first year of Phase I operation. Subject to refinements that arise from this design and operational experience, Phase II would provide the following.

- A new 660 cfs pump-siphon station
- Extensive dredging
- Limited bank stabilization
- Relocation of utility lines

All of these improvements are for the purpose of increasing and maintaining channel capacity to convey 1,000 cfs without an increase over historic water levels.

2. Construction of new 660 cfs pump station. Provides additional supporting material to supplement description of the new pump station as originally described in EPA (1998a). Includes a revised cost table and a two-page extract of key cost estimates. Cost revisions include funding for a model study of the design, as requested by the Engineering Work Group (EngWG), and updating of pump costs.

3. Dredging methods and costs. Updates the extensive information provided in the EPA (1998a) submittal by discussing estimates of dredge volume and dredging costs. Discusses water quality (no impacts found) and use of culverts for disposal pipes (no impacts found if removable during storms). Provides the following.

- A map showing mileage values down Bayou Lafourche, along with ten representative cross-sections which illustrate the templates.

- A graph showing the channel bottom profile, before and after dredging.

- Output from a HEC-2 model indicating dredging volume and impact on flow. Volume equals 3 MCY (3.3 MCY, minus 250,000 CY from Phase I and minus optimization - i.e., review of individual cross-sections to eliminate excess dredging).

- A figure showing no encroachment of projected water levels above the reference water level. The model printout indicates typical flow velocities in the range of <1 to a maximum of 1.65 feet per second. Areas of low velocity represent candidates for potential decreased dredging.

- An estimated cost for dredging, with the basis for each cost item.

4. Bank stability analysis. Evaluates the assumption that, in most cases, the banks of a dredged channel would be stable if they did not exceed a slope of 3H:1V. Includes:

- nine boring logs (from LDOTD) which were used in the geotechnical stability analyses (Palo Alto: 2 borings, Hwy. 70: 3 borings & Spur 70: 4 borings);

- for the initial stability analysis, six dredging templates, two for each boring data location.

The geotechnical engineer determined the most critical slope (slope with the greatest overall height) for each of the three boring data sets. Results are as follows.

Soil boring data location	**Critical slope height**	**Factor of safety for 3H:1V slope**	**Slope reqd. for stable bank**
Palo Alto Crossing	29	1.18	3.5H:1V
Hwy. 70 Crossing	27	1.11	3H:1V
Spur 70 Crossing	26	1.04	4H:1V

The analysis indicates stability problems should be expected for a 3H:1V dredging template if it turns out that the areas of high, steep natural banks coincide with the presence of weak soil material at depth. Several factors bear on interpretation of this result.

- The result is in contrast to the observation of apparent actual stability for the existing slopes. The result may indicate that the highest, steepest existing slopes are only marginally stable; or it may suggest that the geotechnical analysis performed here is quite conservative. The latter interpretation is consistent with the limited boring data, which indicate that the highest and steepest slopes are not in the same location as the weakest soils. The possibility of weak material at depth appears to be greater down-bayou, where the existing banks are lower and less steep.

- The scope of the current study did not permit detailed soil sampling and stability analyses for the dredging program, as that would be part of project design. Thus the extent to which an actual stability problem exists, if any, was not determined.

As discussed in Part 3 of this submittal, except at the upper and lower ends, and near the existing weir, dredging at 3H:1V produces a substantial lowering of water levels compared to the reference line. Therefore, in at least some reaches, it should be practical to reduce the template to 3.5H or 4H:1, and/or to use a template with a broken slope, without reducing conveyance capacity below 1,000 cfs. However, widespread use of the broken and 4H:1V templates would (in comparison to the analysis given in EPA, 1998c) result in a smaller project, with less costs and benefits.

5. Bank stabilization costs. Presents costs (per 1,000 linear feet of stabilization) for two alternatives for channel stabilization, using the Palo Alto Bridge area as a prototype. Neither of the sections has been analyzed by the geotechnical engineer.

- Alternate No. 1 (report includes sketch) consists of stabilization of the left descending bank (La. 308 side) utilizing anchored sheet piling: $600,000.

- Alternative No. 2 (report includes sketch) consists of stabilization of both banks utilizing anchored sheet piling: $1,125,000.

The original PBA-20 budget included $650,000 for bank stabilization, which has been retained for the modified project. It clearly provides for limited bank stabilization and will be used only in one or two particularly critical sections of the improved channel, which would likely be within the same reach that is dredged in Phase I.

6. Costs for utility line protection and relocations. Provides verification of the number of lines to be replaced based on results from a questionnaire distributed to utility line owners. Includes a table of utility lines and 16 maps. The table is summarized as follows.

Reach	Length in miles	Locations	Pipelines and cables	Profile info available
Below Donaldsonville through Thibodaux	34	73	86	62
Below Thibodaux through Lockport	21	5	5	Not assessed
Totals	55	78	91	

Also includes a table that assesses the information for the channel reach above Thibodaux based on a qualitative characterization of dredging activity (i.e., no dredging, light dredging, moderate dredging, heavy dredging); the indicates EPA's preliminary assessment of each pipeline above Thibodaux. Below Thibodaux, dredging is in the "light" category, and pipelines in that reach are subject to federal requirements such that line relocation costs can be presumed to be born by the owner of the line.

The inventory of replacement costs for utility crossings is:

Gas line at mile 23.08:	small line, $150,000
Water line at mile 6.22:	protection, $25,000
Gas line at mile 5.86:	small line, $150,000
Gas line, mile 4.36:	small line, $150,000
Two gas lines at mile 3.16, 32" combined diameter:	large line equivalent, $225,000
Water line at mile 3.09:	protection, $25,000
Gas line at mile 2.27:	medium line, $170,000
Hydrocarbon line at mile 2.16:	medium line, $170,000
Two hydrocarbon lines at mile 2.10, 12" combined diam.:	medium line equivalent, $150,000

Water line at mile 0.66:	included in Phase I

This can be summarized as: replacement of three small lines, three medium lines, and one large line; and two protections.

7. Costs related to bridges. Confirms, through coordination with LDOTD and Union Pacific, that the existing and proposed structures will carry 1,000 cfs, and thus involve no costs for modification of the structures. Note that the subject of bridge protection related to the dredging program is a separate line item.

Regarding the impacts of channel dredging on bridges, as a rule of thumb LDOTD has indicated that bridge stability is not expected to be impacted if the bridge pilings reach at least 20 feet below the channel bottom. EPA's preliminary evaluation indicates that bridges typically have pilings to 30 feet or more. During project design, it will be necessary to evaluate detailed bridge records for confirmation.

EPA's coordination with LDOTD has included that velocities would be too low to cause a scour problem, although the issue should be revisited during project design.

8. Land costs. Discusses the costs of the following.

- Bank erosion (no costs expected due to slumping, scour or wakes).
- Dredging encroachment on the batture (no costs expected because all dredge templates are designed to be within the existing wetted perimeter of the channel).
- Flow encroachment on the batture (no costs expected because future flow lines are to be at or below historic flow lines).
- Disposal easements through culverts (per LDOTD, no problems provided lines can be removed during storm conditions).
- Disposal areas (easement costs increased to $300,000 for 1250 total acres, the total acreage required to dispose of 3 million cubic yards of material to a depth of 1.5 feet, plus an allowance for other easements).

Note that the heaviest dredging is at the upper end of the bayou, where disposal to the Mississippi River is practical in the event that land costs have been under-estimated.

9. Contingencies, engineering, agency oversight, permitting. Lists the following multipliers.

- Contingency: 25% of the construction cost estimate.
- Design: 7% of construction cost.
- Supervision of construction: 9% of construction cost.
- Agency oversight: 3% of construction cost.
- Permitting: 1% of construction cost.

Note that EPA has checked with LDEQ and does not anticipate the need for any permits related to decant water quality. No fill in marsh is required. Section 10 permits are not required above the Thibodaux weir. The primary cost item for permitting is NEPA compliance.

10. Summary of Phase II construction costs. Summarizes all cost estimates identified above and provides an anticipated schedule for expenditure of the funds. The schedule reflects the following assumptions:

Design:	Contemporary with Phase I construction and initial operation
Construction year 1:	Initiate diversion facilities; do utility replacements; bank protection; the investigations/easements portion of dredging.
Second year:	Initiate dredging; complete diversion facilities
Third year:	Complete dredging

A first cost of **$32 million** (unadjusted for timing) appears to be reasonable.

A.12.5 EPA, 1998d

EPA, 1998d. Cost evaluation total and annual costs, Bayou Lafourche diversion project. Submitted to CWPPRA Engineering Work Group. Prepared for U.S. Environmental Protection Agency Region 6 by Lee Wilson and Associates, Inc., September, 1998.

In conjunction with material submitted to the CWPPRA Engineering Work Group in May (EPA (1998a)), and with prior submittals regarding the construction costs of Phases I and II (EPA (1998b) and EPA (1998c), respectively), this report represents the complete package for **annual and total costs** of the modified Bayou Lafourche diversion project. Specifically, this submittal provides information on annual costs; and uses this information in conjunction with the prior estimates of construction costs, to provide working estimates of fully funded costs, present worth costs, and average annual costs. All estimates are provided separately for Phase I and Phase II of the project; combined totals also are provided. Finally, LWA comments on these cost estimates if certain non-CWPPRA cost-share funds are assumed available.

The contents are as follows.

1. Operations and maintenance costs: Phase I. O&M costs for Phase I (year-round diversion at 340 cfs) fall into five categories:

- Pumping: During times of low river, more pumping will be required than currently done. This submittal makes no changes to the EPA (1998a) submittal's determination of the incremental cost.
- Water management: Includes expenses for maintenance of deployable weirs, and actual operation (weir inflation), but not costs associated with fine-tuned management for storm runoff conveyance. Cost is equivalent to one-half of a technical level employee, although work would be done by current parish employees.
- Water monitoring: Provides updated replacement pages and Table 5.2-9 from EPA (1998b), for installing/upgrading the same five stations, but reflecting minor design changes since that submittal. Provides projected O&M costs for each station which are not currently funded.
- Other O&M: None over and above existing O&M costs.
- CWPPRA monitoring. Project-specific monitoring has not been designed, so the estimate here is based on standardized per-acre costs, and the standard 20 years of monitoring for CWPPRA projects.

These costs are summarized in Table 5.2-x (Table 5.4-1 of this BLF Wetlands Restoration Report). The submittal also provides a replacement copy of Table 3.2-1 from EPA (1998a), with typos corrected.

2. Total and average annual costs: Phase I. Provides a funding schedule table summarizing Phase I costs by year, reflecting three changes from EPA (1998b): the minor change in monitoring platforms cost, a start date in year 1999 instead of 2000, and inclusion of O&M costs. Discusses the CWPPRA fully funded cost calculation, which accounts for inflation but not for interest earned on funding not yet spent, and provides a fully funded cost table for 20 years of Phase I operations. Also provides and discusses a present worth and average annual cost table. The present worth calculation accounts for earning interest on expenditures that begin when the project is operational, and therefore makes future activities less costly in current dollars. Present worth is better that fully funded cost for comparison with non-CWPPRA public works projects. Since CWPPRA funding is based on fully funded cost instead of present worth, present worth is used here only as a basic for calculating amortized average annual cost. O&M costs are more than half of total Phase I cost.

3. Operations and maintenance costs: Phase II. Addresses O&M costs for the new 660 cfs pump/siphon station, and for increased channel capacity. Costs associated with the new pump/siphon facility are energy costs plus facility maintenance. This submittal presents no changes to the estimate provided in EPA (1998a), but does provide Pyburn and Odom's back-up for the calculation.

Channel maintenance costs are for maintenance dredging of the sand trap. Provides HEC-6 dredge material volume modeling output. Notes that HEC-6 makes different assumptions from earlier HEC-2 modeling, and that EPA is relying on the earlier HEC-2 water levels, rather than the HEC-6 modeled water levels. Key HEC-6 model results: 40 percent of input sediment is retained in top five miles; less than 10,000 cubic yards of sand trap maintenance dredging is required per quarter; and there is a possibility of channel siltation below the sand trap, although actual historic conditions as reflected by comparison of 1997 and 1986 surveys found no significant infill. Provides Phase II O&M cost table 5.3-2, based on the modeled HEC-6 annual maintenance dredging requirement, and on a lower maintenance dredging unit cost than for initial dredging. The evaluation does not consider possible commercial value of dredged sands. Existing routine maintenance costs would not change, and are not included.

4. Total and average annual costs: Phase II. Provides a Phase II funding schedule table (with one change from the version in the EPA (1998c) submittal). Also provides a fully funded cost table, and a present worth and average annual costs table.

5. Cost summary and consideration of cost-shares. Table 5.4-2 summarizes project costs from EPA (1998b), EPA (1998c), and this submittal. Cost schedules show no funding schedule overlap, except that Phase II design would begin while Phase I is still under construction and be completed during the first year of Phase I operation. In simple terms, costs to build are on the order of $5 million (Phase I) + $32 million (Phase II), and the combined operational cost is almost $0.6 million per year. Summaries of other cost calculations:

Fully funded cost:	$11 million +	$46 million	= $57 million
Present worth:	$ 8 million +	$40 million	= $48 million
Average annual cost:	$ 0.7 million +	$ 3.8 million	= $ 4.5 million

Potential cost-share partners include the BLF Freshwater District, and several parishes (the submittal gives an example illustrating the effects of local cost-share).

Cost effectiveness: The Environmental Workgroup's WVA estimated the wetland benefits for the entire BLF project to be 705 Average Annual Habitat Units (AAHUs); EPA estimates that the benefit would be 784 AAHUs, by including synergistic interaction with CWPPRA project TE-10 (Grand Bayou marsh area). An estimate of Phase I cost-effectiveness is provided as follows: based on net flow increase to marsh, if WVA benefits for Phase I were perfectly proportional to increased flow, then the Phase I benefit would be 134 AAHUs (149 with TE-10).

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