gage. The peak stage at Big Bayou Pigeon measured 18.10 feet (ft.), NGVD on May 25 and the EABPL Borrow Pit at Bayou Sorrel gage recorded a peak stage of 18.10 ft., NGVD on 23 May. Peak stages at Lower Grand Lake and IWW at Morley were 7.10 ft., NGVD on 19 April and 8.97 ft., NGVD on 18 April, respectively.

C2.1.5.2 1980 Flood. Heavy rains at the end of March and early April setup flooding which occurred over the study area during mid April. A maximum extreme was set at the Lower Grand Lake at Bayou Sorrel gage on 15 April with a reading of 7.90 ft., NGVD. LSU Ben Hur recorded a total of 6.11 inches of rain over the two day 12-13 April storm.

C2.1.5.3 Some of the major historical hurricanes that affected the study area include Hilda in 1964, Carmen in 1974, Babe in 1977, Juan in 1985, and Andrew in 1992.

C2.1.6 Visibility.

C2.1.6.1 Fog is formed when the air temperature is cooled to or below the saturation temperature of the air (dew point), producing condensation of water droplets at the surface. Two types of fog are possible in the study area, regional and river fog. River fog is formed when warm, moist gulf air blows gently over the relatively colder waters of the Mississippi and Atchafalaya Rivers during the winter and spring. The potential for widespread river fog is greatest in the basins, deltas, and adjacent wetlands of the two rivers. River fog is uncommon from May to November.

C2.1.6.2 Regional fog occurs primarily at night and early morning during the winter and spring months as relatively warm, moisture-laden gulf air contacts cooler land or water surfaces. Heavy fog days with ¼-mile visibility or less average 35 days a year at Baton Rouge Ryan Airport.

C2.2 Hydrology.

C2.2.1 Existing Conditions.

C2.2.1.1 Stage-duration and differential head-duration data was developed for the 1955-1996 time frame for the landside and floodside of the lock. The duration data was developed for the annual and monthly cases. Tables C4 and C5 provide the results of this analysis.

C2.2.1.2 Design cross-sections of the earthen chamber of the lock were obtained from Plate 23 of Bayou Sorrel Lock - Periodic Inspection Report No. 1, 1 Nov 72. A stage-storage relationship was developed from this data for the lock chamber (Table C7). This relationship was used to determine the impacts of diverting water in or out of the protected area through the existing lock.

C2.2.1.3 It should be noted that the existing lock is presently deficient with respect to level of protection and the project flood. The level of protection of the structure's height is approximately 8 feet below project flood (and freeboard). If the existing structure is maintained after the completion of the new lock, then this deficiency will have to be addressed.

TABLE C4

BAYOU SORREL LOCK
MONTHLY FLOODSIDE STAGES

PERCENT EQUALED OR EXCEDED	ANNUAL FLOODSIDE STAGE FT. NGVD	BAYOU SORREL LOCK MONTHLY FLOODSIDE STAGES (FT. NGVD)											
		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
0.01	18.10	10.70	10.60	11.00	16.10	18.10	17.60	11.00	9.00	7.90	7.00	8.60	9.70
1	11.50	10.20	10.30	10.50	14.50	17.60	13.90	9.66	8.75	6.56	6.68	6.81	9.14
2	10.70	9.78	9.96	10.10	13.70	16.90	12.20	9.32	8.39	5.85	6.36	6.56	8.61
5	9.48	8.83	8.81	9.56	11.40	11.00	11.20	8.14	7.09	4.82	5.65	5.98	8.13
10	8.46	7.96	8.36	9.13	10.70	10.20	9.80	7.31	5.21	4.09	4.56	5.32	7.41
15	7.79	7.46	7.92	8.78	9.61	9.79	8.98	6.81	4.71	3.49	4.10	4.76	6.95
20	7.26	7.17	7.54	8.45	9.08	9.32	8.32	6.30	4.35	3.25	3.78	4.26	6.42
30	6.37	6.47	6.94	7.87	8.30	8.23	7.23	5.27	3.77	2.96	3.29	3.57	5.64
40	5.50	5.87	6.43	7.34	7.86	7.54	6.57	4.81	3.33	2.74	2.90	3.10	4.67
50	4.59	5.00	5.72	6.77	7.37	6.98	6.06	4.40	2.95	2.55	2.60	2.76	4.03
60	3.75	4.55	5.16	6.25	6.90	6.42	5.50	3.86	2.64	2.37	2.33	2.48	3.32
70	3.03	3.91	4.49	5.81	6.48	5.89	4.66	3.33	2.33	2.20	2.09	2.22	2.88
80	2.46	3.00	3.94	5.10	5.90	5.02	3.93	2.71	2.01	2.00	1.83	1.93	2.34
85	2.19	2.47	3.23	4.44	5.60	4.57	3.63	2.38	1.84	1.87	1.68	1.76	2.04
90	1.91	1.92	2.29	3.52	5.23	4.09	3.20	1.98	1.65	1.71	1.52	1.56	1.76
95	1.57	1.34	1.64	2.87	4.16	3.41	1.76	1.60	1.48	1.50	1.36	1.34	1.39
100	0.00	0.00	1.00	1.90	1.60	1.70	0.60	0.80	1.00	0.40	0.00	0.30	0.50

TABLE C5

BAYOU SORREL LOCK
MONTHLY LANDSIDE STAGES

PERCENT EQUALED OR EXCEDED	ANNUAL LANDSIDE STAGE FT. NGVD	BAYOU SORREL LOCK MONTHLY LANDSIDE STAGES (FT. NGVD)											
		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
0.01	7.90	7.90	7.00	6.70	7.90	7.70	7.10	7.40	5.40	6.20	6.60	6.00	6.70
1	6.61	6.57	6.82	6.45	7.40	7.23	5.65	6.59	4.76	5.33	5.94	5.10	6.00
2	6.19	6.07	6.60	6.20	7.15	6.73	5.37	5.84	4.32	4.79	4.74	4.73	5.54
5	5.49	5.57	6.21	5.65	6.58	5.95	4.62	4.48	3.42	4.16	3.17	4.17	5.05
10	4.73	5.11	5.82	5.16	6.04	5.40	4.23	3.82	2.95	3.16	2.89	3.52	4.37
15	4.20	4.74	5.53	4.80	5.39	4.86	3.92	3.41	2.80	2.88	2.79	3.15	3.92
20	3.77	4.31	5.25	4.56	4.91	4.43	3.70	3.14	2.69	2.72	2.66	2.93	3.54
30	3.14	3.71	4.65	4.17	3.86	3.67	3.32	2.88	2.50	2.49	2.43	2.55	3.11
40	2.81	3.32	4.11	3.75	3.39	3.16	2.83	2.67	2.33	2.29	2.22	2.29	2.85
50	2.55	2.96	3.45	3.28	3.03	2.90	2.60	2.44	2.17	2.13	2.06	2.10	2.60
60	2.30	2.64	2.94	2.93	2.79	2.64	2.37	2.23	2.06	2.02	1.88	1.93	2.31
70	2.08	2.30	2.56	2.57	2.57	2.41	2.18	2.05	1.93	1.88	1.69	1.73	1.98
80	1.86	2.02	2.28	2.19	2.32	2.13	1.96	1.85	1.75	1.74	1.52	1.54	1.61
85	1.72	1.83	2.09	2.07	2.16	2.02	1.84	1.75	1.66	1.67	1.45	1.47	1.47
90	1.56	1.54	1.85	1.95	2.01	1.87	1.62	1.63	1.54	1.58	1.36	1.36	1.24
95	1.36	1.02	1.55	1.73	1.81	1.68	1.39	1.50	1.39	1.46	1.25	1.15	1.06
100	0.00	0.10	0.70	0.70	0.70	1.10	0.80	0.90	0.80	1.10	0.00	0.30	0.40

TABLE C6

BAYOU SORREL LOCK
MONTHLY DIFFERENTIAL STAGES

PERCENT EQUALED OR EXCEDED	ANNUAL DIFFERENTIAL STAGE FT. NGVD	BAYOU SORREL LOCK MONTHLY DIFFERENTIAL STAGES (FT. NGVD)											
		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
0.01	14.10	6.10	6.80	8.90	10.00	14.10	13.60	6.80	5.20	4.90	4.40	4.10	5.20
1	8.10	5.60	6.50	8.20	9.40	12.90	10.10	6.00	5.10	3.50	4.20	3.90	4.90
2	7.00	5.40	6.10	7.50	9.10	11.00	9.10	5.40	4.90	3.00	4.00	3.60	4.80
5	5.80	5.00	5.40	6.90	8.10	6.50	7.00	4.70	3.00	1.80	2.90	3.10	4.50
10	5.00	4.30	4.70	6.00	7.40	5.90	6.10	4.10	2.40	1.30	2.20	2.50	3.90
15	4.30	3.80	4.10	5.70	6.20	5.60	5.20	3.60	2.10	1.00	1.40	1.90	3.50
20	3.90	3.50	3.70	5.20	5.60	5.40	4.70	3.00	1.90	0.80	1.00	1.50	3.30
30	3.10	3.00	2.80	4.30	5.10	4.90	4.10	2.40	1.30	0.50	0.70	1.00	2.50
40	2.30	2.40	2.20	3.80	4.60	4.30	3.70	2.10	0.80	0.40	0.50	0.70	1.90
50	1.60	1.90	1.70	3.30	4.10	3.80	3.30	1.60	0.50	0.30	0.40	0.50	1.40
60	0.90	1.30	1.20	2.60	3.60	3.30	2.70	1.10	0.30	0.20	0.30	0.40	0.80
70	0.50	0.70	0.70	2.10	3.10	2.70	2.00	0.60	0.30	0.10	0.30	0.20	0.40
80	0.30	0.30	0.30	1.20	2.40	2.20	1.40	0.30	0.20	0.00	0.20	0.10	0.20
85	0.20	0.20	0.10	0.90	1.70	1.90	1.00	0.30	0.10	-0.11	0.10	0.10	0.00
90	0.10	-0.05	-0.11	0.50	0.50	1.40	0.50	0.20	0.00	-0.30	0.00	-0.07	-0.17
95	-0.25	-0.43	-0.58	0.20	0.20	0.50	0.20	-0.08	-0.25	-0.74	-0.25	-0.27	-0.53
100	-3.00	-2.30	-2.80	-3.00	-1.10	-0.70	-0.60	-2.50	-2.60	-2.10	-2.60	-1.90	-2.90

Note: Table C6 was prepared by computing the daily differential heads first and then determining the stage-duration percentages. As such, the values in Table C6 will not be the differences between the respective values in Tables C4 and C5.

TABLE C7

STAGE-STORAGE FOR EXISTING BAYOU SORREL LOCK

CHAMBER STAGE (FT. NGVD)	X-SECTION AREA (FT^2)	INCREMENTAL VOLUME (FT^3)	TOTAL VOLUME (FT^3)	TOTAL VOLUME (AC-FT)
-15	0		0	0
		509,550		
0	1,290		509,550	11.7
		248,850		
5	1,920		758,400	17.4
		288,350		
10	2,650		1,046,750	24
		81,370		
11	2,856		1,128,120	25.9
		120,870		
12	3,162		1,248,990	28.7
		75,050		
12.5	3,352		1,324,040	30.4
		41,277		
13	3,561		1,365,317	31.3
		15,879		
13.3	3,695		1,381,196	31.7
		4,178,073		
18.4	5,769		5,559,826	127.6

C2.2.1.4 The Water Control Plan for Bayou Sorrel Lock is contained within the document "Standing Instructions to the Project Manager for Water Control," dated April 1989. The operation of Bayou Sorrel Lock for freshwater diversion and flood control is governed by the stages on both sides of the lock. If the stage on the landside of the lock exceeds 3.0 ft NGVD and the floodway side stage is lower, the gates of the lock may be opened to relieve flooding on the landside; if the stage on the floodway side is higher, the gates are kept closed. If the stage on the landside of the lock is equal or less than 3.0 ft NGVD and the floodway side stage is lower, the gates of the lock are closed to retain low water flows on the landside; if the floodway side stage is higher, the gates are operated to divert water from the Atchafalaya Basin Floodway System into the landside. Diversions are limited so that velocities in the earthen lock chamber are less than 3 fps to avoid scour problems. However, the lockmaster indicated that velocities are not monitored.

Instead, gage openings are limited during diversions to 12 feet wide when differential heads exceed 5 to 6 feet. The gates are wide open for lower differential heads.

C2.2.1.5 From Table C4, it can be seen that floodside stages exceed 3.0 ft NGVD about 70 percent of the time. As such, the ability to divert freshwater into the landside area will be dependent on the landside stages. From Table C5, stages are below 3.0 ft NGVD about 70 percent of the time so the potential to provide freshwater diversions will occur frequently. However, for flood control purposes, Table C6 indicates that reverse head conditions exist only about 5 percent of the time. Depending on when these conditions exist and when the landside stage is above 3.0 ft NGVD, this may limit the effectiveness of using the new lock for flood control purposes. In addition, in accordance with a 1994 Memorandum of Agreement between the Corps, the Captain of the Port of New Orleans, the Louisiana Office of Preparedness, and the Iberville Parish Office of Emergency Preparedness, the lock will be closed to navigation when the landside gage exceeds 6.5 ft NGVD and remain so until the gage reaches 6.1 ft NGVD and falling.

C2.2.1.6 Quadrangle maps were used to compute areas within the landside area that could be impacted by the diversion of water in either direction through the lock. In general, diversion of water into the landside area would impact areas below the 5.0 foot NGVD contour. Those areas are broken down into areas north (upstream) of the lock (about 17.5 mi^2) and areas down the Lower Grand River east and south of the lock (about 4 mi^2). Areas that would be impacted by releasing flood flows through the lock to the floodside would be limited to those areas north of the lock below 10 feet NGVD (about 40 mi^2) which includes the areas below the 5 feet NGVD contour.

C2.2.1.7 Flows through a sector-gated structure were computed using the method found in the Sector-Gated Lock Filling And Emptying Program - Documentation Report, New Orleans District, Aug 1984. While actual flow through the Bayou Sorrel Lock sector gates may not be defined exactly by this method, the equation used should provide reasonable results. Flow through the structure is defined in terms of weir and orifice flows combined in the following manner:

$$Q = Qweir + Qorifice$$

with:

$$Q = 3.33 C1 b h^{1.5} + C2 b (H-h)(2gh)^{1/2}$$

where:

$$C1 = C2 = 0.95$$

thus:

$$Q = 3.16 b h^{1.5} + 7.62 b (H-h) h^{1/2}$$

where:

Q = Flow through Sector Gated Structure, cfs
b = Width of gate opening, ft
H = Stage - Sill Elev, ft
h = Differential head across structure, ft

For example, where:

b = 56 feet
Outside Stage = 3.0 ft NGVD
Inside Stage = 0.0 ft NGVD
Sill Elevation = -14.75 ft NGVD
H = 3.0 - (-14.75) = 17.75 feet
h = 3.0 - 0.0 = 3.0 feet

then:

Q = 11,820 cfs = 975 acre-ft/hr

C2.2.2 <u>Freshwater Diversion Capability</u>.

C2.2.2.1 During a field trip to the lock, the lockmaster was asked about diverting water into the landside area for environmental reasons. He indicated that when differential heads exist and lockage needs are met, they divert freshwater into the landside area. As mentioned above, diversions into the landside area are not conducted when the landside gage is at 3.0 ft NGVD or higher (in accordance with the Water Control Plan). However, virtually all of the water diverted throughout the year enters the Lower Grand River just above the lock and flows down toward Lake Verret. The lockmaster indicated that they are able to leave the lock open as much as 6 months of the year when differential heads are 2 feet or less. They use the lock gates for tows, however, when the differentials exceed 0.6 feet.

C2.2.2.2 Diversions to the landside of the lock will primarily divert down the Lower Grand River. The effects to stages upstream of the lock would therefore be limited to small stage increases within the channels but no increases within the overbank areas. Overbank areas that would experience higher stages (up to 3.0 ft NGVD) would be approximately 2,000 to 2,500 acres between the GIWW and Lower Grand River from the lock to Pigeon, LA. The distribution of water into these overbank areas would be further limited by the high natural stream banks and finite number of openings through those banks. Below Pigeon, the additional flows would be contained within the existing channels. Stages higher than 3.0 ft NGVD should be avoided both because of the Water Control Plan guidelines and because the town of Pigeon generally is located on or slightly above Elevation 5.0 ft NGVD (from quadrangle maps). Below the town of Pigeon, the additional flows would be expected to remain within the Lower Grand River channel due to its overbanks generally being at elevation 5.0 ft NGVD or higher.

C2.2.2.3 <u>Effects of Using Locked Flows with New Lock</u>. In order to raise stages by one foot in the overbank areas along the Lower Grand River, an additional volume of 2,000 to 2,500 acre-feet would be required. However, to accomplish this would require raising stages in the channels upstream of the lock (and the overbank areas) by at least one foot as well. Approximately 17.5 mi^2 of wetlands upstream of the lock have ground elevations below 5.0 feet NGVD. As such, a total volume of about 14,000 acre-feet would be required to raise stages one foot on the landside of the lock. From Table C6, annual differential head-duration data indicates that differentials of 1.6 feet, 3.1 feet, and 5.0 feet are exceeded 50%, 30%, and 10% of the time, respectively. While larger differentials can be experienced, these are probably the most likely ranges to occur when diversions to the landside would be desired. From Table C7, a lockage diversion where a 5-foot differential head existed would divert approximately 6 to 8 acre-feet per lockage (for the more common stages). For lesser differential heads, substantially less water would be diverted. As such, it would require approximately 2,000 lockages (or greater) to provide enough volume to raise the stages in the overbank areas one foot with the existing lock. This does not include the volume required to maintain the increased stages since much of this volume would flow down the Lower Grand River. In fact, without a continuous diversion into the landside area, it is unlikely that the increased stages could be maintained. Discussions with the lockmaster indicated that the lock averages about 600 lockages per month. As such, it would require an impractical amount of time to divert enough volume using only lockages from the lock. Use of a larger lock, such as being investigated in this study, could potentially cut the amount of lockages required by 50% or more, but this would still require an impracticably large number of lockages, not including the lockages required to maintain the increased stages.

C2.2.3 Flood Control Capability.

C2.2.3.1 Current Use of the Existing Lock for Flood Control Operations. The lockmaster indicated that the existing lock is occasionally used to lower stages on the landside. From the Water Control Plan, the lock is operated to lower landside stages when they exceed 3.0 feet NGVD at the lock and are higher than the floodside stages. As such, flood flows have occasionally been diverted out through the lock, but only when there has been a large event in the landside area and the floodside stages are lower. However, the amount of storage above elevation 3.0 feet NGVD (about 21.5 mi^2) on the landside and below elevation 8.0 feet NGVD (which is the stage of record) for the 40 mi^2 below the 10 foot contour is about 100,000 acre-feet. From Table C6, landside to floodside differential heads do not exceed 3.0 feet. In fact, these differentials heads occur less than 10 percent of the time (for that matter, the interior stage is often below 3.0 ft NGVD when these differential heads occur). With the lock gates wide open, this would translate to a maximum flow of about 11,000 cfs or about 22,000 acre-feet/day. Normally, this would be much less since the 3.0 feet differential head is a maximum of record. Also, the actual flow may be much less since the flows through the lock are required by the Water Control Plan to be regulated such that chamber velocities do not exceed 3 feet/second. A new, wider lock could under the same circumstances provide a larger flood stage reduction effect, depending on the needs of navigation. This route is often closed to navigation during extremely high landside stages because of increased damages to the channel and private property from shipping wavewash.

C2.2.3.2 Use of New Lock for Continuous Flood Control Diversions. The new lock may be operated for flood control purposes in a manner similar to the operation of the existing lock. The flow volume through the new lock is expected to be approximately 1.3 times that of the existing lock as the gates will be 75-feet wide versus the existing 56-feet wide gates. As the lock chamber is concrete, not earthen, velocities may no longer be a limiting factor. A new Water Control Plan will be developed during construction of the lock and will address diversions for freshwater and flood control purposes. The plan may be modified when features of the Lower Atchafalaya Reevaluation Study, the barrier levee and pumping station at Amelia, are constructed.

C2.2.3.3 Use of the existing lock for continuous evacuation of flood flows during an event could be done upon completion of the new lock. This option is similar to the option described in paragraph C2.2.2.2. As described in that option, the differential heads during a flood event would be 3.0 feet or less. Flows through the existing lock with the gates wide open would be a maximum of about 11,000 cfs, or about 22,000 acre-feet/day. The advantage of this option is that the old lock, while not able to divert at the rate of the new lock (about 2 times as much), would be operable while the new lock could be used for navigation.

C2.2.4 Sedimentation.

C2.2.4.1 Shoaling Rates. Shoaling rates in the GIWW Channel south of Bayou Sorrel Lock are reflected in the amounts of dredging required to maintain required depth for navigation. This deposition results from sediment transported in the distributaries from the Atchafalaya River. Shoaling is not influenced by the small quantities of water entering through the existing lock. Replacement of the lock will not influence the existing sediment patterns. Table C7 shows the historic dredging quantities for each year over the period 1977-1998.

TABLE C8 - HISTORIC DREDGING QUANTITIES

YEAR	DREDGED QUANTITIES IN CUBIC YARDS
1977	1,866,714
1978	926,510
1980	478,539
1982	381,870
1985	215,467
1986	655,000
1987	500,800
1988	263,634
1989	714,672
1990	750,000
1991	740,000
1992	518,000
1993	125,532
1994	400,884
1995	243,058
1996	124,882
1997	193,228
1998	163,779

C2.2.4.2 Sediment transport capacities for the reach of East Access Channel just upstream from Bayou Sorrel Lock and the reach of the Navigation Channel just downstream from the lock were computed using the computer program SAM published by the Waterways Experiment Station in Vicksburg, Mississippi. This program was developed to perform the hydraulic and sediment calculations required in the design of Alluvial Channels. The transport function developed by Mr. Fred B. Toffaleti in 1968 was used. The channel upstream of the lock has a higher transport capacity than the channel downstream of the lock. The difference in transport capacities is consistent with the dredging quantities listed above. Replacement of the lock will not affect these transport capacities and, hence, will have no effect on dredging quantities. The new approach channels, however, may experience some additional deposition for the first few years until the banks and bottom stabilize. Replacement of the lock will not induce any deposition in the GIWW channel north of the lock.

C2.3 Water Quality.

C2.3.1 General. This Water Quality Assessment considers the applicable standards and criteria used to assess existing water quality in the area. It also describes existing water quality and identifies the potential water quality impacts associated with the alternatives proposed in the Bayou Sorrel Lock Feasibility Study.

C2.3.2 Water Quality Standards And Criteria. Both the Louisiana Department of Environmental Quality (LDEQ) and the U. S. Environmental Protection Agency (EPA) have established ambient water quality standards and criteria applicable to surface waters in the State of Louisiana. These standards and criteria are discussed in the following paragraphs.

C2.3.2.1 Applicable Louisiana State Standards. The LDEQ has established general written water quality standards that are applicable to all waters of the State of Louisiana. The general written standards relate to the condition of the water as affected by waste discharges or human activity as opposed to purely natural phenomena, and are as follows. The standards were last revised in 1997.