MISSISSIPPI RIVER - GULF OUTLET
NEW LOCK AND CONNECTING CHANNELS

SECTION 1 - HYDROLOGY AND HYDRAULICS

GENERAL

B.1.1. This section presents information on hydraulic and hydrologic studies, including hydrology, hydraulic design and water quality, that were completed for the recommended plan (1200 ft X 110 ft ship lock, sill at -36 ft NGVD and floor at -40 ft NGVD) and the NED plan (900 ft X 110 ft barge lock, sill and floor at -22 ft NGVD) as well as for the other alternative sizes of locks that were studied in detail in this phase. Numerous alternatives were studied for a replacement lock at the Inner Harbor Navigation Canal (IHNC) site and for a replacement lock near Violet, Louisiana. In 1990 the replacement lock near Violet, LA, was determined to be environmentally unacceptable and dropped from further analysis. Alternative analyses for proposed locations in the vicinity of the existing IHNC lock led to the decision to study four alternative sizes of locks, at the North of Claiborne Avenue location, in detail during the feasibility phase of this study. All of these four alternative sizes are miter gated and have a width of 110 ft. The barge lock alternatives that were studied have usable lengths of either 900 ft or 1,200 ft, with the lock floor and sill elevation at -22 ft NGVD. The 900-ft barge lock would be adequate to handle a design vessel configuration having a draft of 11 ft and consisting of three barges wide by four barges long (each barge 35-ft wide by 195-ft long) and an 80-ft long tugboat. The 1,200-ft barge lock would be adequate to handle a design vessel configuration having a draft of 11 ft and consisting of three barges wide by five barges long and an 80-ft long tugboat. The ship lock alternatives also have usable lengths of either 900 ft or 1,200 ft. The sill elevation for the ship lock is -36 ft NGVD, and the floor elevation is -40 ft NGVD. Either of the ship lock alternatives would be adequate to handle a design ship with a beam width of 100 ft, variable lengths, and a maximum draft of 31 ft. All elevations and stages are referenced to the National Geodetic Vertical Datum (NGVD) unless otherwise noted.

HYDROLOGY

Terrain

B.1.2. The project area, located in Orleans Parish in southeastern Louisiana, is of low relief characteristic of an alluvial flood plain. Situated near the eastern bank of the Mississippi River, land elevations in the project area slope gently from about 10 feet NGVD along the natural banks of the Mississippi River to 0.5-1.0 feet NGVD in unprotected marsh areas to several feet below sea level in portions of leveed areas. Lake Borgne lies to the east of the project area, while the City of New Orleans and Lake Pontchartrain lie to the north. The project area is protected against river flooding by the Mississippi River Levee system and against hurricane flooding by the Lake Pontchartrain and Vicinity Hurricane Protection project.

CLIMATOLOGY

General Climate

B.1.3. The climate of the area is subtropical marine, with long humid summers and short moderate winters. Southerly winds prevail throughout the warmer months, producing intense thunderstorms during the summer. In the colder months the area is subjected to frontal movements which produce squalls and sudden temperature drops. Climatological data for this area are contained in monthly and annual publications of the U.S. Department of Commerce, National Climatic Center, titled "Climatological Data for Louisiana," and "Local Climatological Data, New Orleans, LA."

Temperature

B.1.4. The maximum, minimum, and mean monthly and annual normal temperatures (1961-1990) for New Orleans at Audubon Park are shown in Table B-1. The location of this temperature gage is shown on plate B-1. Over this period, the extremes recorded were a high of 102 °F occurring in August 1980 and a low of 11°F in December 1989.

TABLE B-1
NEW ORLEANS AT AUDUBON PARK
TEMPERATURE NORMALS (°F)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
NORMAL MAX	61.3	64.5	71.8	78.7	84.5	89.4	90.8	90.5	87.1	80.0	70.5	64.8	77.9
NORMAL MIN	44.1	47.1	54.2	60.9	67.5	73.0	74.9	74.8	71.7	61.8	54.1	47.6	61.0
NORMAL 52.7	55.8	63.0	69.8	76.0	81.2	82.9	82.7	79.4	70.9	62.8	56.2	69.5	

Precipitation

B.1.5. Precipitation data for the stations New Orleans at Algiers, New Orleans pumping stations DPS 5 and DPS 14 represent the study area. The locations of these precipitation gages are shown on plate B-1. The average monthly and annual normals of the three stations are shown in Table B-2.

TABLE B-2
AVERAGE PRECIPITATION NORMALS
(inches) (1961-1990)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
AVG	4.89	5.45	4.75	4.59	4.90	4.92	6.09	5.90	5.30	2.98	4.09	5.20	59.07

Wind

B.1.6. Wind records are available from 1949 based at New Orleans Moisant Airport. The location of this wind gage is shown on plate B-1. The average wind velocity over the period of record is 8.2 miles per hour (mph). The predominant wind directions are north-northeast from September through February and south-southeast from March through June.

HURRICANE, STORMS AND FLOODS OF RECORD

B.1.7. Analyses of hurricanes and tropical storms along the Louisiana coast have been made for storms from 1893 to present. During that time, a total of 49 storms have either struck or affected the coastal area of Grand Isle to the Louisiana-Mississippi state line. The highest maximum observed winds at landfall came from Hurricane Camille (14-22 August 1969) and measured 160 mph near the center with gusts to 190 mph. Hurricane Florence (1988) was the last major storm to cross this area. Major floods have occurred on the Mississippi River in 1912, 1922, 1927, 1937, 1945, 1950, 1973, 1974, 1975, 1979, and 1983. The most severe flood in recent years occurred in 1973. Above normal rainfall began in the fall of 1972, proceeded through the winter, and climaxed in the early spring of 1973. Both the Morganza Floodway and the Bonnet Carre Spillway were operated. Flow passing New Orleans peaked at 1,257,000 cfs. Peak stage for the Mississippi River at the IHNC lock was 17.1 feet NGVD.

TIDES

B.1.8. Tides can influence river stages as far upstream as the head of ship navigation at Baton Rouge, Louisiana. Tides at the entrance channel to Southwest Pass are diurnal and have a mean range of 1.3 feet. Mean tide level is 0.6 feet mean low water. The spring range is 2.6 feet and the neap range is 0.1 foot.

B.1.9. The Mississippi River Gulf Outlet is a tidewater link between the IHNC and the Gulf of Mexico. Tides on this channel are essentially diurnal. The mean range varies between 1.0 foot at the IHNC and 1.5 feet at Gardner Island near the Gulf entrance in Breton Sound. The mean tide levels vary between 0.5 feet MLW at the IHNC to 0.8 feet MLW at Gardner Island. The maximum spring range at Gardner Island is 2.8 feet and is comprised of a -0.8 feet low and 2.0 feet high referenced to mean low water datum. The neap tides are semi-diurnal and have a range of 0.1 feet.

Currents

B.1.10. Currents in the Mississippi River are affected by headwater discharge and tidal action. During periods of high discharges, maximum velocities in the main channel may be as high as 12.0 feet per second (fps) with mean velocities of 9.0 fps for the same flow. At low flow in the river, velocities may be as low as 1 fps or less. During low water, the flow near the mouth is directed upstream along the bottom of the channel and directed downstream near the surface. A fully developed saline wedge can develop in the river and proceed upstream.

B.1.11. Currents on the Mississippi River-Gulf Outlet (MR-GO) are affected by tidal action and freshwater inflows. The mean annual velocity in the channel is about 0.6 fps, but may exceed 2 fps on ebb or flood tides. During periods of low inflows into the lake, July through November, surface ebb and bottom velocities average about 0.8 and 1.7 fps, respectively. Both may exceed 2 fps.

Visibility

B.1.12. River fog forms when warm, moisture-laden air moves over the relatively cold waters of the Mississippi River during the winter and spring. The potential for widespread river fog is greatest in the adjacent wetlands of the river. River fog is uncommon from May to November.

B.1.13. Table B-3 represents the average number of days per month river fog impacts the area. The number of river fog days is determined by accumulating the average number of days the water temperature at New Orleans is below daily average dew points. This phenomenon occurs primarily during the months of February, March, and April and substantially increases the number of fog days.

TABLE B-3
AVERAGE NUMBER OF DAYS OF FOG
(1970-1989)

River Fog	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Potential	3.8	5.6	9.6	5.4	-	-	-	-	-	-	-	2.9

Datums

B.1.14. Relative sea level rise (which results primarily from land subsidence, from other geologic activity, and possibly from global sea level rise) must be appropriately considered with respect to design, construction, and operation of a navigation project. Southeast Louisiana has been subsiding at a rate of about 2 cm per year since 1962. By comparison, the central Mississippi gulf coast has been subsiding at a rate of about 0.15 cm per year.

B.1.15. Table B-4 summarizes the relative sea level rise or subsidence rates at several gage locations in the Lake Pontchartrain Basin and includes data for Biloxi and Galveston for comparison.

TABLE B-4
COMPARISON OF LAKE PONTCHARTRAIN AND GULF COAST RELATIVE SEA LEVEL RISE OR SUBSIDENCE

Gage Location	Relative Sea Level Change MSL - NGVD cm per year
Little Woods	1.09
South Shore	1.00
Mandeville	0.48
Biloxi	0.15
Galveston	0.62

B.1.16. Table B-5 shows the relationship between MSL, NGVD, and MLG datums at the Corps gage at Shell Beach on the MR-GO.

TABLE B-5
MISSISSIPPI RIVER - GULF OUTLET AT SHELL BEACH

Datum	Height feet NGVD	Remarks
MSL (Mean Gage Record)	1.26	
Mean Low Water	0.61	Tide Range = 1.3
NGVD	0.00	1956 Leveling Epoch
MLG	-0.78	Current usage

Notes:

a. NGVD epoch is 1956
b. Approx MSL based on 0800 readings, True MSL is defined by averaging hourly ordinates over a 20 year (Metonic) cycle set by NOAA-NOS
c. MLW is equal to MSL minus half the tide range from NOAA-NOS Tide Table

B.1.17. Table B-6 shows the elevation of Mean Sea Level in feet for other locations along the MR-GO.

TABLE B-6
MEAN SEA LEVEL

Station	Feet NGVD
Lake Borgne at Rigolets	1.06
Gulf Intracoastal Waterway near Paris Road Bridge	1.51

Note: Approximate MSL based on 0800 readings, True MSL is defined by averaging hourly ordinates over a 18.6 year (Metonic) cycle as set by NOAA-NOS.

Stages

B.1.18. Table B-7 lists stage data in the immediate area of the project site. The locations of the gaging stations listed in Table B-7 are
shown on plate B-1.

TABLE B-7
STAGE DATA (FEET NGVD)

STATION	PERIOD OF RECORD	MEAN	MAXIMUM	DATE	MINIMUM	DATE
Miss. R. at Carrollton	1872-1991	6.66	21.27	04/25/22	-1.60	12/27/1872
Miss. R. at Harvey Lock	1924-1991	6.63	19.42	04/24/27	-0.68	12/18/53
Miss. R. at IHNC Lock	1945-1991	6.42	17.52	03/04/50	-0.48	01/04/54
Miss. R. at Chalmette	1923-1991	6.14	17.58	04/26/27	-0.52	01/26/40
Miss. R. at Algiers Lock	1956-1991	6.11	16.11	04/07/73	-0.15	01/19/81
IWW at Harvey Lock	1925-1991	1.33	4.74	10/29/85	-1.28	01/27/40
IWW at Algiers Lock	1956-1991	1.22	4.45	10/29/85	-1.64	09/09/65
IWW at New Orleans (IHNC Lock)	1922-1991	1.37	10.61	09/10/65	-2.00	04/12/88
IWW at Seabrook Bridge	1962-1991	1.39	6.47	08/18/69	-1.89	04/12/88
IWW at Florida Ave Bridge	1944-1991	1.46	9.82	08/18/69	-2.53	12/26/89
IWW near Paris Road Bridge	1944-1991	1.55	10.04	09/10/65	-2.56	04/12/88

Notes: a. Numbers in Table do not reflect changes in datum over time
b. Means are for the period 1963 to 1991
c. IWW near Seabrook Bridge also has intermittent records between 1942 and 1960
d. Maximum stages on IWW gages caused by hurricane
e. Maximum stage at IWW at New Orleans is a highwater mark

HYDRAULIC DESIGN - GENERAL PARAMETERS

Waterway Characteristics

B.1.19. The Inner Harbor Navigation Canal is a major navigation artery linking together the Mississippi River, Gulf Intracoastal Waterway (GIWW), Mississippi River-Gulf Outlet and Lake Pontchartrain. The canal is about 425 feet wide and 35 feet deep. Flow in the canal is minimal just north of the IHNC Lock and consists primarily of lockage flows and that necessary to empty and fill the tidal prism. Thus flow velocities within this area are minimal. The canal connects with the Mississippi River at Mile 92.6 AHP; the MR-GO/GIWW about 2.0 miles to the north and Lake Pontchartrain about 5.0 miles to the north.

B.1.20. The Mississippi River is approximately 0.5 miles wide and provides navigable depths of 45 feet or more. The river serves as the major flood control outlet for the entire Mississippi River Basin. Thus flows and velocities vary over a wide range. During low flow periods, discharge approaches 100,000 cfs with velocities less than 1.0 ft/sec. During floods, flows up to 1,250,000 cfs are experienced and velocities exceed 10 ft/sec. Because of the presence of strong river currents vessels usually approach the lock from the downstream direction.

The Mississippi River-Gulf Outlet is a 36 foot deep by 500 foot wide navigation channel connecting the Gulf of Mexico to the IHNC in New Orleans. The channel carries tidal flows from the Gulf of Mexico to Lake Pontchartrain via the IHNC at velocities of 3 ft/sec or less.

Design Stages

B.1.21. The project is impacted to the south by water levels on the Mississippi River and to the north by tidal influences and surges from the Gulf of Mexico. The replacement lock must serve to function as the line of protection from the Mississippi River floods. Thus, elevations must be consistent with providing protection to the Mississippi River and Tributaries (MR&T) Project design flowline standards. The MR&T project design flood flowline at the IHNC lock site (Mile 92.6 AHP) is 17.6 feet NGVD. The authorized freeboard at this location is 4.8 feet. Thus, the net embankment grade must be 22.4 feet NGVD.

B.1.22. To the north, hurricane surges are the predominant flooding threat. Therefore, project features must be consistent with providing the level of protection associated with the Lake Pontchartrain and Vicinity Project. Under this project, design stages are based on a Standard Project Hurricane producing a stage of 13.0 feet NGVD at the IHNC lock site. A freeboard of 1.0 feet is added to this design surge level to obtain net embankment grades.

B.1.23. The riverside and lakeside stage duration curves shown on plates B-2 and B-3 are based on the riverside and lakeside stages at the existing IHNC lock for the period of record 1945 to 1989.

Design Heads

B.1.24. Maximum differential head for hydraulic design purposes is based on the occurrence of a project design flood flowline (17.6 feet NGVD) on the Mississippi River concurrent with the observed historical minimum stage of -2.0 feet NGVD on the north side of the lock. Thus, the maximum normal design head is 19.6 feet. Similarly, the maximum reverse differential head is based on the minimum historical stage of -1.6 feet NGVD on the Mississippi River at Carrollton concurrent with the project design hurricane stage of 13.0 feet NGVD. Thus, the maximum design reverse head is 14.6 feet.

B.1.25. The maximum observed normal head of 16.9 feet (riverside 16.4 feet NGVD; lakeside -0.5 feet NGVD) occurred on 23 March 1945. The maximum observed reverse head of 2.6 feet (riverside 3.9 feet NGVD; lakeside 6.5 feet NGVD) occurred on 24 Sept 1956. See plate B-4.

B.1.26. The normal and reverse differential head duration curves are based on the riverside and lakeside stages at the existing IHNC lock for a period of record from 1945-89. Corresponding graphs are shown on plates B-5 and B-6. The following data in Table 8 were obtained from these graphs:

TABLE B-8
NORMAL AND REVERSE HEADS

Normal Heads		Reverse Heads	
Head (ft)	Duration (%)	Head (ft)	Duration (%)
16.0	0.1	1.5	0.01
14.0	2.2	1.0	0.12
11.0	12.4	0.5	0.45
7.0	32.6		
3.0	54.9		

Channel Depths

B.1.27. The IHNC canal is about 35 feet deep and has sufficient depth for design barge and ship traffic. No further deepening of the IHNC canal is required. Channel depth for accessing the replacement lock alternative will be consistent with sill depths in each design.

HYDRAULIC DESIGN OF THE LOCK COMPONENTS

B.1.28. Hydraulic designs were completed for each of the four alternative sizes of locks that were studied in detail in the feasibility phase. All of these alternative sizes are miter gated, 110 ft. in width, and would use the wall culvert side port filling and emptying system. The barge lock alternatives analyzed have usable chamber lengths of either 900 ft or 1,200 ft with the lock floor and sill elevation at -22 ft NGVD. The ship lock alternatives would also have usable chamber lengths of either 900 ft or 1,200 ft. The sill elevation for the ship lock would be -36 ft NGVD, and the lock floor elevation would be -40 ft NGVD. The references shown in paragraph B.1.172 were used during completion of the hydraulic analyses for all of these alternatives.

Miter Gated Lock for a Ship

Sill & Floor Depth; Determination of Required Length of Lock Chamber

B.1.29. Locks serving ship traffic utilize a criterion where sufficient clearance is provided between the ship keel and lock sill a majority of the time to provide for the safe entrance and exiting of vessels. Based on limited guidance and consultation with the Waterways Experiment Station (WES) in Vicksburg, Mississippi, a clearance of about 5 feet is required between the sill and the hull of the vessel. This will be available 95 percent of the time with an absolute minimum clearance of 3 feet occurring at a record low stage of -2.0 feet NGVD. In addition, sufficient clearance between vessel bottom and lock floor is necessary to provide an adequate cushion during filling or emptying operation to keep the hawser forces within allowable limits. The allowable hawser forces are between 10 and 25 tons depending on the ship size. For the design ship, the hawser forces were limited to within the range of 10 tons to 20 tons; however, a hawser force closer to 10 tons would be a preferable design condition. For the ship lock, the sill elevation was set at -36.0 feet NGVD and the floor elevation was set at -40.0 feet NGVD for the design vessel draft of 31 feet.

B.1.30. The required chamber lengths (centerline-of-pintle to centerline-of-pintle) were determined by adding to the usable lengths an amount equal to the length required for one miter gate to swing to the open position, plus a clearance of 12 feet. The chamber lengths would be 970 ft for the 900-ft lock and 1,270 ft for the 1,200-ft lock.

Filling and Emptying System

B.1.31. For the wall culvert side port system, the lock will be subjected to reverse heads and will therefore require the installation of a double set of miter gates. Rectangular culverts in each wall will extend over the full length of the lock. Multiport intakes will be connected to the upstream ends of the culverts and discharge outlet manifolds will be connected to the downstream ends. Ports in each wall of the lock chamber will connect the wall culverts to the lock chamber. The location of ports in each wall will be staggered in relation to the ports in the opposite wall for better diffusion of jets and reduction of surface turbulence. Reverse tainter valves upstream from the most upstream lock chamber port in each culvert will control the flow into the lock. Valves downstream from the most downstream lock chamber ports will control the flow out of the lock. For a ship lock 110 feet wide and a floor elevation of -40.0 feet NGVD, the chamber ports will have throats 2.54 feet wide and 3.75 feet high. The chamber ports will be spaced 28 feet (center to center) and will be located within 60 percent of the lock chamber length. The port inverts will be the same as the culvert invert (-42.0 ft NGVD). The total cross-sectional area of the ports in each wall will be 0.95 times the cross-sectional area of the wall culvert. For the 900-ft lock, twenty-one ports will be required in each wall and the end ports will be located 205 ft from the centerline of each gate pintle. The first seven ports from the river side will have triangular deflectors and the remaining ports will have square deflectors. For the 1,200-ft lock, twenty-eight ports will be required in each wall and the end ports will be located 257 ft from the centerline of each gate pintle. The first ten ports from the river side will have triangular deflectors and the remaining ports will have square deflectors. Recommendations presented in References 1, 7, and 8 in paragraph B.1.172 indicate that a system of deflectors in the lock floor are beneficial to the reduction of the surge effect in the lock chamber. Details of these features are shown on plates B-19 (ship), B-29 (barge), B-47N and B-47T.

Intake Manifold

B.1.32. The intake manifolds will be located in the sidewalls immediately upstream from the riverside miter gate monolith. They will also serve as outlet manifolds for reverse head situations. The intake manifolds will have 6 ports each with inverts at the same elevation as the lock floor. For the 900-ft lock, each port will have a wall face opening of 7 ft wide by 14.5 ft high. For the 1,200-ft lock, each port will have a wall face opening of 7.5 ft wide by 18.2 ft high. The maximum riverside pool elevation of 17.6 ft NGVD provides 43.1 ft of submergence for the 900-ft lock and 39.4 ft of submergence for the 1,200 ft lock. The minimum riverside pool elevation of -1.6 ft NGVD provides 23.9 ft of submergence for the 900-ft lock and 20.2 ft of submergence for the 1,200-ft lock. The submergence of the top of the wall openings was checked for all possible combinations of river side and lake side stages for both lock lengths to assure that it would always be at least equal to 110% of the velocity head computed for the peak flow, during filling, through the port having the smallest throat width. The transitions in the intake manifold were designed to provide a relatively uniform increase in velocities upstream and downstream of the port to the culvert section. Details are shown on plate B-47.

Outlet Manifold

B.1.33. The outlet manifolds will be located downstream from the lakeside miter gates. They will also serve as intake manifolds for reverse head situations. They will have five ports each with inverts at the same elevation as the lock floor. Their design was patterned after a sidewall outlet manifold shown in Reference 1 of paragraph B.1.172. WES was consulted to confirm that an outlet manifold design of this type would be adequate for the feasibility phase. Details are shown on plate B-47.

Filling and Emptying Times

B.1.34. The filling and emptying times were computed using the subroutine H5320 via the "CORPS" system as explained in Reference 3 of paragraph B.1.172. Examples of computed times for normal head conditions for the 900-ft and 1,200-ft locks using a hawser limit within the range of 10 tons to 20 tons are shown below. Filling and emptying times for various valve times are graphically displayed on plates B-7 through B-10. The minimum valve times that can be used for various lifts for a hawser limit within the range of 10 tons to 20 tons are shown graphically on plate B-11.

TABLE B-9
FILLING AND EMPTYING TIMES

Valve Time (min)	Lift (ft)	Filling Time (min)		Emptying Time (min)	
		900-ft	1,200-ft	900-ft	1,200-ft
4	3	4.12	4.14	4.18	4.21
6	7	6.28	6.31	6.41	6.43
7	11	7.67	7.70	7.84	7.88

Plate B-11 shows the relationship between valve times and lifts for keeping the hawser forces within allowable limits.

Miter Gated Lock for a Barge

Sill & Floor Depth; Determination of Required Length of Lock Chamber

B.1.35. Reference 5 in paragraph B.1.172 stipulates that the minimum lock sill depth for shallow depth barge locks should be approximately two times the design draft of the tows that use the waterway. This criterion may be relaxed if sill depths are normally greater, as will be the case at the IHNC lock. This provides for the most optimal entrance and exiting of vessels. In such situations, the requirement of two times the design draft should be available 95 percent of the time and an absolute minimum of 1.7 times the draft should be available 100 percent of the time. Providing twice the draft (22 feet of depth) over the sill 100 percent of the time would set the sill elevation at -24 feet NGVD. Using the relaxed criteria, elevation 0 ft NGVD is equalled or exceeded 95 percent of the time; therefore, a sill elevation of -22 feet NGVD would be required. Also, the absolute minimum lock sill depth for a sill elevation of -22 ft NGVD would be 1.82 times the design draft (as compared to the requirement of 1.7 times the design draft) at a stage of -2.0 ft NGVD (record low). Elevation -22 feet NGVD was selected as the sill elevation based on these criteria. Reference 5 also indicates that either a 2- or 3-foot gate sill or a floor recess in the area of the gate should be provided to provide space for gate seating, maintenance work, inspection, and to keep sediment and debris out of the chamber. A 2-foot floor recess is used in our designs. Reference 2 recommends that the floor submergence should be at least equal to the design vessel draft plus one-half of the spacing of the lock chamber ports. Since the lock chamber ports would be 28 feet apart, use of the criteria from Reference 2 would require that the floor elevation be no higher than -25 ft NGVD (design vessel draft of 11 feet, plus clear distance of 14 feet, below elevation 0 ft NGVD) in order to obtain the required submergence 95 percent of the time. The 14 feet of clear space between the bottom of the design vessel and the lock chamber floor is recommended as a safety consideration to prevent direct action of the port jets against the bottom of the vessel. A -25 ft NGVD floor elevation would also satisfy the criteria relative to sill height from Reference 5. Based upon these factors, the initial floor elevation considered was -25 ft NGVD. However, after further consideration and consultation with higher authority, it appeared possible that a higher floor elevation could be used, which would result in savings in construction costs. This led to the consideration of a floor elevation of -22 ft NGVD, with provision of a 3-ft recess for the miter gate swing. As explained in paragraph B.1.40 below, the trade-off for the floor elevation of -22 ft NGVD may be longer filling and emptying times; however, model studies would be required to either verify the feasibility of using this floor elevation or to determine what floor elevation should be used. It is noted that the Port Allen Lock, a miter-gated lock in the Mississippi River mainline levee system that was model-tested during design, has a floor at the same elevation as the sill. The absolute minimum lock sill depth provided at the Port Allen Lock during occurrence of the record low stage is equal to 1.67 times the design draft (vs 1.82 times the design draft for the proposed IHNC Lock); however, the clear space below the design vessel (9-ft draft) is only 7.5 ft at the 95% duration tailwater stage (port spacing is also 28 ft for Port Allen Lock). Port Allen Lock has operated satisfactorily since it was constructed, but the filling and emptying times have approached twice those computed for the proposed IHNC Lock due to the relatively small amount of submergence provided for many conditions.

B.1.36. The required chamber lengths were determined using the same methodology that was used for the ship lock and will be 970 ft for the 900-ft lock and 1,270 ft for the 1,200-ft lock.

Filling and Emptying System

B.1.37. The filling and emptying system is the same as for the ship lock except that the invert elevation of the culverts and lock chamber ports will be -24.0 feet NGVD. Details are shown on plates B-19 (ship), B-29 (barge) and B-47.

Intake Manifold

B.1.38. The intake manifolds will be the same as those for the ship lock except that the inverts of the ports will be at the same elevation as the lock floor for the barge lock (-22.0 ft NGVD). The maximum riverside pool elevation of 17.6 ft NGVD provides 25.1 ft of submergence for the 900-ft lock and 21.4 ft of submergence for the 1,200-ft lock. The minimum riverside pool elevation of -1.6 ft NGVD provides 5.9 ft of submergence for the 900-ft lock and 2.2 ft of submergence for the 1,200-ft lock. The submergence of the top of the wall openings was checked for all possible combinations of river side and lake side stages for both lock lengths to assure that it would always be at least equal to 110% of the velocity head computed for the peak flow, during filling, through the port having the smallest throat width. Details are shown on plate B-47.

Outlet Manifold

B.1.39. The outlet manifolds will be the same as those for the ship lock except that the inverts of the ports will be at the same elevation as the lock floor for the barge lock (-22.0 ft NGVD). Details are shown on plate B-47.

Filling and Emptying Times

B.1.40. The same subroutine H5320 used for the ship lock was used for the barge lock in computing filling and emptying times. A 5 ton hawser limit was used to determine the minimum valve time that could be used for a given lift (see plate B-11). The filling and emptying times shown below should be applicable for a lock having a floor submergence at least equal to that recommended by Reference 2 in paragraph B.1.172. As explained in paragraph B.1.35 above, a floor elevation no higher than -25 ft NGVD would be required to provide the recommended submergence below a design vessel having a draft of 11 feet. For a floor elevation of -22 ft NGVD, somewhat longer valve times than those shown below may have to be used. It is estimated that using a floor elevation of -22 ft NGVD may increase the valve times between a minimum of one minute and a maximum of two minutes for a given lift, thereby resulting in longer filling and emptying times than those shown below. Filling and emptying times for various valve times (applicable to both floor elevations) are graphically displayed on plates B-7 through B-10.

TABLE B-10
FILLING AND EMPTYING TIMES

Valve Time (min)	Lift (ft)	Filling Time (min)		Emptying Time (min)	
		900-ft	1,200-ft	900-ft	1,200-ft
2	3	2.96	2.98	3.05	3.07
2	7	4.00	4.02	4.20	4.21
3	11	5.43	5.45	5.67	5.69

Guide Walls

B.1.41. Guide walls are placed at each end of a lock to aid a towboat pilot in aligning the tow for entry into the lock chamber. The only satisfactory means of determining the proper locations and lengths of the guide walls is by studies on a general river model of the channel, lock approaches and the lock. Guide wall lengths are often the same as the usable lock chamber length. Some guidance relative to the lengths of the guide walls is provided in Reference 12. That reference indicates that the length of the guide wall on the land side of the lock should be at least half the usable length of the lock chamber and that the length of the guide wall on the river side of the lock should be at least two-thirds of the usable length of the lock chamber. If unusually hazardous situations are predicted during high river stages, then it may be necessary to increase the length of the guide wall. The guide wall lengths recommended in this phase for the land side of the lock are about two-thirds of the usable length of the lock chamber (645 ft) for the 900-ft lock and two-thirds of the usable length of the lock chamber (800 ft) for the 1200-ft lock. For the river side of the lock, it is recommended that the guide walls for both lock lengths extend to a point 100 ft riverward of the Claiborne Ave. bridge in order to facilitate navigation under the bridge and to minimize the lengths of time that the bridge is open during lockages. The elevation of the guide walls will be the same elevation as the top of the lock walls.

Scour Protection in the Bypass Channels

B.1.42. Standby tugboats will be used to assist vessels in navigating through the abrupt turns in the north bypass channel that will be constructed parallel to the proposed location of the new lock. Scour protection was designed to prevent erosion from propeller wash during operation of these tugboats. Riprap will be placed along the east side of the bypass channel at each of the turns (see plates B-16 (ship) and B-26 (barge). The riprap will have the following gradation:

Percent Lighter by Weight	Limits of Stone in lbs.
100	2200 - 900
50	930 - 440
15	460 - 130

Model Study Program

B.1.43. Model studies will be required in the next phase of this study in order to verify or refine design work completed on the recommended plan thus far and to evaluate all aspects of the recommended plan relative to navigability by ships and barges. Annex 1 consists of both a time and cost estimate for the proposed model studies and a detailed description of the studies envisioned at this time. The proposed model studies and associated field data required are summarized below. More specific descriptions of the various conditions for which the model studies would be performed are described in the numbered sub-paragraphs (see Annex 1).

a. Navigation Physical Model Study. Consists of tow and ship navigation tests to aid in design of river entrance to the lock canal.

(1) For tows only

(2) Tows and ships

b. Navigation Computer Simulation Study. Will concentrate on items of concern on the MRGO side of the existing lock. Vessel approaches to both sides of the new lock, navigation within the bypass channels and entrance/exit conditions at the turning basin north of the new lock will be evaluated.

(1) For tows only

(2) Tows and ships

c. Field Data Collection. Deployment of tide gages, as well as measurement of currents, on the MRGO side of the existing lock required for all conditions).

d. Lock Filling and Emptying Study. Will check all aspects of filling and emptying system to assure provision of satisfactory hydraulic characteristics.

(1) 110-ft X 900-ft non-standard (floor higher than the -25 ft NGVD elevation required by Reference 2) barge lock

(2) 110-ft X 1200-ft non-standard barge lock

Although time and cost estimates for filling and emptying studies for ship locks (900-ft and 1,200-ft lengths) are included in Annex 1, such studies will not be required for the recommended plan. The hydraulic design for the recommended plan is a conventional design based on recent model studies and guidance from WES. The traffic through this lock will be primarily tows, for which the submergence will be well in excess of that required for safe and efficient operation. Filling and emptying times for ships using this lock will not be critical to the economic analysis for this project. Since the recommended plan also provides adequate submergence for the design ship, the minimum filling and emptying times required for this lock for safe and efficient lockages of ships can be extrapolated reasonably well from existing studies and documents.

Table B-11 shows which model tests would be required for the recommended plan, the NED plan (non-standard barge lock) and the standard barge lock design.

TABLE B-11
MODEL TESTS REQUIRED FOR
VARIOUS LOCK DESIGNS

	Model Study/Condition from Above Summary								
Lock Design	a(1)	a(2)	b(1)	b(2)	c	d(1)	d(2)	d(3)	d(4)
Recommended Plan						X		X	X
NED Plan	X					X		X	X
Standard Barge Lock					X		X		X

B.1.44. The estimated time and cost for the proposed model studies for the recommended plan are 12 months and $535,000, respectively. Detailed time and cost breakdowns for the recommended plan, as well as for the other alternative sizes of locks that were studied in detail in the feasibility phase, are included in Annex 1.

WATER QUALITY

Introduction

B.1.45. An analysis of the existing water quality in the study area requires a review of applicable data from the Mississippi River, the Inner Harbor Navigation Canal (IHNC), and Lake Pontchartrain. Data from each of these features were reviewed and compared to Louisiana Department of Environmental Quality (LDEQ) and US Environmental Protection Agency (EPA) water quality criteria to develop an overview of water quality conditions in the study area. These data then can be used as a basis for assessing the potential impacts of considered projects. In addition to this historic data, water samples were collected from the Mississippi River, the IHNC and the proposed disposal area to the east of the IHNC as a part of the 1993 elutriate testing effort by New Orleans District (NOD).

B.1.46. The projected water quality impacts in the study area were formulated by utilizing data from the previous investigations, detailed water and sediment analysis, and on the results of computer modeling. Sediment samples were collected in 1993 from various locations in the IHNC. These samples were mixed with the water samples collected and analyzed as elutriates. Elutriate analysis aids in determining the effects of disturbing the bottom sediment during construction, dredging and disposal. The analysis results are representative of localized, short-term, worst case scenarios.

B.1.47. During the discussion of various water quality constituents, concentrations are compared to LDEQ and EPA criteria to determine if the criteria are exceeded. Applicable criteria are listed in the tables accompanying the text, and a comprehensive listing of the criteria are contained below in the Water Quality Criteria and Standards Section. This water quality portion of this Engineering Appendix is divided into three major sections: Water Quality Criteria and Standards, Existing Water Quality, and Projected Water Quality.

Water Quality Criteria and Standards

<u>INTRODUCTION</u>

B.1.48. Both the Louisiana Department of Environmental Quality (LDEQ) and the US Environmental Protection Agency have established ambient water quality criteria applicable to surface waters in the State of Louisiana. These criteria are discussed in the following paragraphs.

<u>APPLICABLE LOUISIANA STATE STANDARDS</u>

B.1.49. The LDEQ has established general written water quality criteria which 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 criteria were last revised in 1989.

<u>DESCRIPTIVE WATER QUALITY STANDARDS</u>

B.1.50. <u>Aesthetics</u>. The waters of the state shall be maintained in an aesthetically attractive condition and shall meet the generally accepted aesthetic qualifications.

All waters shall be free from such concentrations of substances attributable to wastewater or other discharges sufficient to:

a. settle to form objectionable deposits;

b. float as debris, scum, oil, or other matter to form nuisances or to negatively impact the aesthetics;

c. result in objectionable color, odor, taste, or turbidity;

d. injure, be toxic, or produce demonstrated adverse physiological or behavioral responses in humans, animals, fish, shellfish, wildlife, or plants; or

e. produce undesirable or nuisance aquatic life.

B.1.51. Color. Water color shall not be increased to the extent that it will interfere with present usage and projected future use of the state's waterbodies.

a. Waters shall be free from significant increases over natural background color levels;

b. The source of drinking water supply should not exceed 75 color units on the platinum-cobalt scale; and

c. No increases in true or apparent color shall reduce the level of light penetration below that required by desirable indigenous species of aquatic life.

B.1.52. Floating, suspended, and settleable solids. There shall be no substances present in concentrations sufficient to produce distinctly visible solids or scum, nor shall there be any formation of long-term bottom deposits of slimes or sludge banks attributable to waste discharges from municipal, industrial, or other sources including agricultural practices, mining, dredging and the exploration for and production of oil and natural gas. Certain short-term activities, such as maintenance dredging of navigable waterways may be exempted by the administrative authority.

B.1.53. Taste and odor. Taste- and odor- producing substances shall be limited to concentrations in the waters of the state that will not interfere with the production of potable water by conventional water treatment methods or impart unpalatable flavor to food fish, shellfish, and wildlife, or result in offensive odors arising from the waters, or otherwise interfere with the designated use of the waters.

B.1.54. Toxic substances. Toxic substances shall not be present in the waters of the state or the sediments underlying said waters in quantities that alone or in combination will be toxic to human, plant, or animal life or significantly increase health risks due to exposure to the substances or consumption of contaminated fish or other aquatic life.

B.1.55. Oil and grease. There shall be no free or floating oil or grease present in quantities large enough to interfere with the designated uses, nor shall emulsified oils be present in quantities large enough to interfere with the designated uses.

B.1.56. Foaming or frothing materials. None of a persistent nature are permitted.

B.1.57. Nutrients. The naturally occurring range of nitrogen-phosphorous ratio shall be maintained. To establish the appropriate range of ratios and compensate for natural seasonal fluctuations, the state will use site-specific studies to establish limits for nutrients. Nutrient concentrations that produce aquatic growth to the extent that it creates a public nuisance or interferes with designated water uses shall not be added to any surface waters. This shall not apply to designated intermittent streams.

B.1.58. Turbidity. Turbidity other than that of natural origin shall not cause substantial visual contrast with the natural appearance of the waters of the state or impair any designated water use. Turbidity shall not significantly exceed the natural condition of the water.

As a guideline, maximum turbidity levels, expressed as nephelometric turbidity units (NTU), are established and shall apply for the following named waterbodies and major aquatic habitat types of the state:

a. Red, Mermentau, Atchafalaya, Mississippi, and Vermilion Rivers and Bayou Teche -- 150 NTU;

b. estuarine lakes, bays, bayous, and canals -- 50 NTU;

c. Amite, Pearl, Ouachita, Sabine, Calcasieu, Tangipahoa, Tickfaw, and Tchefuncte Rivers -- 50 NTU;

d. freshwater lakes, reservoirs, and oxbows -- 25 NTU;

e. designated scenic streams and outstanding natural resource waters not specifically listed above -- 25 NTU; and

f. for other state waters not included above and in waterbody segments where natural background turbidity exceeds the values specified above, the turbidity in NTU caused by any discharges shall be restricted to the appropriate background value plus 10 percent. This shall not apply to designated intermittent streams.

Certain short-term activities, such as maintenance dredging of navigable waterways may be exempted by the administrative authority.

B.1.59. Flow. The natural flow of state waters shall not be altered to such an extent that the basic character and water quality of the ecosystem are adversely affected except in situations where alterations are necessary to protect human life or property. If alterations to the natural flow are deemed necessary, all reasonable steps shall be taken to minimize the adverse impacts of such alterations. Additionally, all reasonable steps shall be taken to mitigate the adverse impacts of unavoidable alterations.

B.1.60. Radioactive materials. Radioactive materials in the surface waters of the state designated for drinking water supply use shall not exceed levels established pursuant to the Federal Safe Drinking Water Act (P.L. 93-523 et Seq.).

B.1.61. Other materials. Limits on other substances not specified in these revised water quality standards shall be in accordance with recommendations set by the LDEQ and/or the Louisiana Department of Health and Human Resources Administration for municipal raw water sources.

NUMERICAL WATER QUALITY STANDARDS

B.1.62. Additionally, LDEQ has established numerical criteria which apply to specified waterbodies, and to their tributaries, distributaries, and interconnected streams and waterbodies if they are not specifically named therein, unless it can be shown through a use attainability analysis that unique chemical, physical, and/or biological conditions preclude the attainment of the criteria. In those cases, natural background levels of these conditions may be used to establish site-specific water quality criteria. Those waterbodies officially approved and designated by the state and EPA as intermittent streams, man-made watercourses, or naturally dystrophic waters may be excluded from some or all numerical criteria during specified seasonal periods. The numerical criteria apply specifically with respect to substances or conditions attributed to waste discharges or activities of man as opposed to purely natural phenomena. A list of surface waters in the study area for which numerical criteria are included in the published tables is shown in Table B-12. Table B-12 also includes designated use categories for the surface waters listed. Designated water uses for each stream are represented as follows:

A = Primary Contact Recreation
B = Secondary Contact Recreation
C = Propagation of Fish and Wildlife
D = Drinking Water Supply
E = Oyster Propagation
F = Agriculture
G = Outstanding Natural Resource Waters

The following is a description of the numerical water quality criteria presented in Table B-12.

B.1.63. pH. The pH represents minimum and maximum conditions throughout the segment with reasonable gradients applying toward segment boundaries.

In all cases, the pH shall fall within the range of 6.0 to 9.0 standard units (su) unless otherwise specified in the tables. No discharge of wastes shall cause the pH of the water body to vary by more than one pH unit within the specified pH range for that segment where the discharge occurs.

B.1.64. Chlorides, sulfates, and dissolved solids. Values for these parameters apply to the approximate midpoint of the stream segment with reasonable gradients applying toward segment boundaries. Values listed in the standards, in general, represent the arithmetic mean of existing data plus one standard deviation.

B.1.65. Dissolved oxygen. The following dissolved oxygen (DO) values represent minimum values for the type of water specified. These values shall apply at all times except in naturally dystrophic waters or where natural conditions cause the DO to be depressed. For short periods of time, diurnal variations below the standard specified might occur. However, no waste discharge or activity of man shall lower the DO concentration to the point where the diurnal variation falls below the specified minimum.

a. Freshwater. For a diversified population of warmwater biota including sport fish, the DO concentration shall be at or above 5 mg/L.

b. Estuarine water. DO concentrations in estuaries and tidal tributaries shall not be less than 4 mg/L at any time.

c. Coastal marine water. DO concentration in surface coastal waters shall not be less than 5 mg/L except when the upwellings and other natural phenomena might cause this value to be depressed.

B.1.66. Temperature. The temperature standards enumerated in Table B-12, in most cases, represent maximum values obtained from existing data. However, in a few cases, a limited number of unusually high temperatures in the range of 35 degrees to 36 degrees have been deleted as it is felt that these values were recorded during conditions of unseasonably high air temperatures and/or unusually low flows or water levels, and, therefore, do not represent normal maximum temperatures.

In order to protect a diversified warm water biota including game fish, the following temperature criteria shall apply (except when natural conditions cause the temperature to be raised above these limits).

The standard shall consist of two parts, a temperature differential and a maximum temperature. The temperature differential represents the maximum permissible rise above ambient conditions. There shall be no addition of artificial heat once the ambient temperature reaches the maximum temperature specified in the standards.

a. Freshwater (Temperature Differential).

(1) Maximum of 5^{o}F [2.8^{o} Centigrade (C)] rise above ambient for streams and rivers.

(2) Maximum of 3^{o}F (1.7^{o}C) rise above ambient for lakes and reservoirs.

b. Freshwater (Maximum Temperature). Ninety ^{o}F (32.2^{o}C) except where otherwise listed in Table B-1 or due to natural conditions such as unusually hot and/or dry weather.

c. Estuarine and Coastal (Temperature Differential).

(1) Maximum of 4^{o}F (2.2^{o}C) rise above ambient during the period October through May.

(2) Maximum of ^{o}F (1.1^{o}C) during the period June through September.

d. Estuarine and Coastal (Maximum Temperature). Ninety-five ^{o}F (35^{o}C) except when natural conditions elevate temperature above this level.

These temperature criteria shall not apply to privately-owned reservoirs, or reservoirs constructed solely for industrial cooling purposes.

B.1.67. Bacterial standards. The bacterial standard applicable to a particular stream segment depends upon the use classification of that individual stream segment. Limitations are placed on either fecal coliform content, most probable number (MPN) total coliform content, or a combination of both in order to achieve the stream sanitary quality required for the most restrictive stream water usage.

Table B-12, which contains applicable criteria for each water body, designates one of the following four standards as applicable according to present and anticipated usage of the waters.

Standard #1. PRIMARY CONTACT RECREATION - Based on a minimum of not less than five samples taken over not more than a 30-day period, the fecal coliform content shall not exceed a log mean of 200/100 Ml nor shall more than 10 percent of the total samples during any 30-day period or 25 percent of the total samples collected annually exceed 400/100 Ml.

Standard #2. SECONDARY CONTACT RECREATION - Based on a minimum of not less than 5 samples taken over not more than a 30-day period, the fecal coliform content shall not exceed a log mean of 1,000/100 Ml nor shall more than 10 percent of the total samples during any 30-day period or 25 percent of the total samples collected exceed 2,000/100 Ml.

Standard #3. DRINKING WATER SUPPLY - The monthly arithmetic mean of total coliform MPN shall not exceed 10,000/100 Ml, nor shall the monthly arithmetic mean of fecal coliforms exceed 2,000/100 Ml.

Standard #4. OYSTER PROPAGATION - The fecal coliform median MPN shall not exceed 14 fecal coliforms per 100 Ml, and not more than 10 percent of the samples shall exceed an MPN of 43/100 Ml for a 5-tube decimal dilution test in those portions of the area most probably exposed to fecal contamination during the most unfavorable hydrographic and pollution conditions.

TABLE B-12
1989 LDEQ NUMERICAL STANDARDS
APPLICABLE TO SURFACE WATERS IN THE STUDY AREA

Stream Description	A	B	C	D	E	CL	SO4 mg/L	DO mg/L	pH Range mg/L	su	Temper-	BAC	TDS	ature	mg/L
Mississippi River: Sano Bayou to Head of Passes	X	X	X	X		75	120	5.0	6.0-9.0	1			32	400	
Inner Harbor Navigation Canal - Mississippi River Lock to Lake Pontchartrain (Estuarine)		X	X	X			N/A[1]	N/A	4.0	6.5-9.0		1		35	N/A
Lake Pontchartrain - West of Highway 11 Bridge) (Estuarine)		X	X	X			N/A	N/A	4.0	6.5-9.0		1		32	N/A
Intracoastal Waterway - Inner Harbor Navigation Canal to Chef Menteur Pass (Estuarine)		X	X	X		X	N/A	N/A	4.0	6.5-9.0		4		35	N/A
Bayou Bienvenue - Headwaters to Hurricane Gate at Mississippi River Gulf Outlet (Estuarine)	X	X	X			N/A	N/A	4.0	6.5-9.0	1			35	N/A	

1 N/A - not applicable at present