FINAL REPORT

VOLUME IV OF VII
HYDROLOGIC DATA

MISSISSIPPI RIVER REINTRODUCTION INTO MAUREPAS SWAMP PROJECT PO-29

Louisiana Department of Natural Resources
U.S. Environmental Protection Agency

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URS Corporation
Evans-Graves Engineers, Inc.
3001, INC.

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Hydrologic data were collected in conjunction with researchers from Louisiana State University to support the Hydraulic Feasibility Study for the Mississippi River Reintroduction into Maurepas Swamp Project (PO-29). The work was divided into seven activities:

- Review of Existing Data
- Summary of Background Information
- Planning for Hydrologic Data Collection
- Installation and Operation of Continuous Hydrologic Data Instruments
- Additional Field Hydrologic Data Collection
- Data Compilation and QC
- Analysis of Hydrologic Data

This Volume describes methodologies (including quality control review) and presents results for rainfall, stage, and velocity hydrologic data collection. Tabulated data are given in Appendices A through H, which are included in the attached CD.

In addition to presenting the collected data, URS has analyzed the hydrologic characteristics and trends according to six key topics:

- Precipitation
- Stage Ranges
- Velocity, Flow, and Water Budget
- Water Surface Slopes
- Tidal Propagation and Channel Over-banking
- Low Frequency Signal Propagation and Channel-Swamp Exchange Resistance

Taken together, these characteristics comprise a Maurepas Swamp *Conceptual Hydrologic Model.* The information contained in this Volume, and particularly the *Conceptual Hydrologic Model*, are being used to develop a high resolution 2-D hydrodynamic model of the swamp, and to evaluate the swamp circulation, retention, and depth associated with a freshwater diversion.

Background information was collected and reviewed in support of the Hydraulic Feasibility Study for the Mississippi River Reintroduction into Maurepas Swamp Project (PO-29). The proposed project area is depicted in Figure 1. The project features a diversion on the order of 1,500 cfs from the Mississippi River at Garyville to a location just north of Interstate I-10 via a modified Hope Canal. The diversion is intended to freshen and nourish 50,000 acres of a currently isolated and declining coastal cypress-tupelo swamp forest along the southern shore of Lake Maurepas, north of US Highway 61 (Airline Highway).

The Hydraulic Feasibility Study is evaluating potential water circulation patterns in the central and north swamp areas associated with the diversion, as well as possible effects on gravity drainage from the south (Figure 1). (See *Volume III, Topographic and Bathymetric Survey* for a description of the areas.) A two-dimensional model is being used to assess swamp water elevations under various diversion scenarios, velocities in sensitive channels, and the detention time of the diversion water in the swamp. A one-dimensional model is facilitating the analysis of potential backwater impacts on Garyville and Reserve stormwater drainage.

The hydrologic information, which was reviewed as part of this task, included:

- *Development Plan for a Diversion into the Maurepas Swamp: Water Quality and Hydrologic Modeling Components,* Draft Report, John W. Day, G. Paul Kemp, Hassan S. Mashriqui, Robert R. Lane, and Dane Dartez, Louisiana State University, School of the Coast and Environment, Natural Systems Modeling Group, for U. S. Environmental Protection Agency, May 2004.
- *Modeling a Mississippi River Diversion into a Louisiana Wetland*, Stephan A. Capps, Louisiana State University, MS Thesis, May 2003.
- *Maurepas Area Continuous Staff Gage Data Collected Through October 2003*; Dane Dartez Research Associate, LSU.
- *Environmental Atlas of the Lake Pontchartrain Basin*, USGS Open File Report 02-206, Penland et. al., 2002 (see http://pubs.usgs.gov/of/2002/of02-206/index.html).
- *Diversion into the Maurepas Swamps, A Complex Project under the Coastal Planning, Protection, and Restoration Act,* Lee Wilson & Associates, with Gary Shaffer and Mark Hester (Southeastern Louisiana University), Paul

Kemp, Hassan Mashriqui, John Day, and Robert Lane (Louisiana State University), (Phase 0 Report), June 2001.

- *Surveys for Establishing 24 Proposed Staff Gages*, Pyburn and Odom, Inc., August 2000.
- *Flooding Along the Lower Amite River Basin: a Study of the Cause and Effect of Rain-Induced and Wind-Driven Floods*, Hsu, S. A. and Blanchard, Brian W., Louisiana State University, 2000.
- *Amite River and Tributaries, Feasibility Study*. US Army Corps of Engineers, September 1990.
- Stage Data, Near Real-Time Hourly Data, Lake Pontchartrain Basin, US Army Corps of Engineers, (see http://www.mvn.usace.army.mil/eng/edhd/Wcontrol/dcp.htm).
- Real-Time Data for Louisiana, US Geological Survey, Amite River Basin (see http://waterdata.usgs.gov/la/nwis/current/?type=flow).
- *Recent geomorphic history of the Pontchartrain Basin*, Roger T. Saucier, Louisiana State University Press, 1963.
- Interviews with Emile LeBlanc of LDW&F—who supervises the Wildlife Management Areas within the project area; Glen and Dale Martin—owners of Blind River Properties, which encompasses a large portion within the central and north areas; and Floyd Michel, Jr. and Jackie Robertson—who have extensive personal knowledge of the central and north areas as a result of living and guiding in the areas.

The available literature listed above—particularly the reports by Lee Wilson and Associates, Dartez, Capps, and Day et. al.—provides background information on the local patterns of rainfall and evapo-transpiration; project area hydrographic features; and surface water elevations, flows, and circulation.

Precipitation and Evapo-Transpiration

Average annual rainfall in the region is on the order of 62 inches. Typical local monthly rainfall totals are shown in Figure 2.

Figure 3 illustrates the local rainfall accumulations associated with various recurrence intervals and durations. Extremely high precipitation events can occur, as typified by estimates of four and ten inches for a once-in-25-year hourly and daily accumulations. In June 2001, Tropical Storm Allison brought over 20 inches of rainfall to portions of southeast Louisiana in a period of a few days.

Drought events also occur, including months in which no rainfall is recorded. South Louisiana has witnessed extended periods of drought since 1998. Long droughts have the potential to cause adverse salinity increases in the freshwater swamps adjacent to coastal estuarine lakes such as Lake Maurepas (*Diversion Into Maurepas Swamps*, June 2001).

Estimates of regional swamp evapo-transpiration are on the order of 30 to 57 inches (*Environmental Atlas of the Lake Pontchartrain Basin*). From May through October evapo-transpiration exceeds 5 inches per month, reaching 9 inches in July. Overall precipitation/evapo-transpiration deficits are most likely to occur in June and October.

Project Area Hydrographic Features

As shown on Figure 1, project area hydrologic features can be broken down into four subareas: Lake Maurepas, the area south of US Highway 61 (Airline Highway); the central swamp area between Airline Highway and Interstate 10 (I-10); and the north swamp area north of I-10. Project area channels are shown on Figures 4 and 5. The URS *Volume III, Topographic and Bathymetric Survey* presents more information on these and other features, including data on channel cross-sections.

A generalized project area cross section is shown in Figure 6. All references to elevation in this Volume are in NAVD-88, LDNR. For further information on the datum see *Volume II, Secondary Benchmark GPS Static Survey*, URS Corporation, April 2005.

Lake Maurepas

As illustrated in Figure 1, Lake Maurepas is the dominant water feature, receiving drainage from the surrounding region and introducing tidal flow. Lake Maurepas is an intermediate to brackish coastal estuarine embayment within the Lake Pontchartrain watershed covering approximately 90 square miles.

South Area

The project area south of Airline Highway lies on the elevated natural Mississippi River levee and has been largely developed. The area includes the residential and commercial districts within the towns of Gramercy, Lutcher, Garyville and Reserve, several large petro-chemical and refining facilities, and sugar cane farms. The area drainage is largely accomplished via a network of man-made gravity ditches and canals which carry runoff northward across Airline Highway.

The town of Gramercy and surrounding development that straddle higher ground east and west of Louisiana Highway 641 separates the drainage basins of Hope Canal to the east and Blind River to the west. The outer rim of the Blind River watershed is formed by the Mississippi River levee from Gramercy to Burnside and the “upland” areas of Gonzales and Sorrento. The drainage from Gonzales and Sorrento is carried via the New River, Conway Canal, Panama Canal, and New River Canal into the Blind River from the northwest.

The large Kaiser-LaRoche industrial complex lies just east of Louisiana Highway 641. East of this complex, Hope Canal drains the community of Garyville and areas to the east and west of Louisiana Highway 54. East of Garyville to Reserve, numerous small drainage canals carry stormwater north to Airline Highway. These canals have been modeled in the *River Introduction into Maurepas Swamp, 1-D (SWMM) Model Study*, (URS Corporation, 2006)

The total project area south of Airline Highway and east of the Blind River watershed, lying primarily in St. John the Baptist Parish, is about 7,100 acres. East of Reserve towards the City of LaPlace an additional 1,800 acres drains toward Airline Highway and into swamp east of Reserve Relief Canal.

Central Area

The central area encompasses 20,300 acres and consists largely of undeveloped swamp. One lobe of higher ground associated with an old Mississippi River crevasse extends a few thousand feet north of Airline Highway in the area of the St. John Airport. Cultivatable land within this lobe has been reduced over the last century by gradual subsidence.

Several channels carry drainage from the south, northward through the central area, and also exchange surface water with the surrounding swamp. The two largest channels comprise the west and east boundaries of the study area: the Blind River on the west and the Reserve Relief Canal on the east. The Blind River is a remnant minor distributary of the Mississippi River, while the Reserve Relief Canal is an entirely man-made canal.

Several north-south channels have been constructed in the interior of the central area to facilitate drainage from the south, including the entirely man-made Hope Canal, Bougere, San Francisco Plantation, Dolson, Lions, Guidry, and Godchaux Canals. Mississippi Bayou is the only significant natural channel within the interior of the Central project area and it has been widened and lengthened to facilitate drainage. Bourgere Canal transitions into Bougere Bayou.

Within the project area interior, surface water can only flow uninterrupted across I-10 via two channels: Hope Canal and Mississippi Bayou. There are culvert locations approximately every 3,000 feet which “equalize” water levels across I-10 and drainage ditches which parallel portions of the interstate. Four culverts are located at the crossing of Bougere Bayou. East-west communication of surface water between Blind River and Hope Canal is restricted by Louisiana Highway 641, which is also crossed by a series of culverts. East-west flow in the area east of Hope Canal is restricted by several oil-field roads and canal embankments.

One east-west canal was constructed to facilitate drainage from upper Mississippi Bayou and Godchaux Canal to Reserve Relief Canal (noted on the Figure 5 by its local name, the “Crossover Canal.”) The “T” at Godchaux Canal, however, is controlled by low dikes on the east and west banks of Godchaux canal which restrict flow across the Crossover Canal to high stages. This “T” was reportedly required to prevent short-circuiting of high oxygen demand runoff to Reserve Relief Canal and Lake Maurepas.

The Central Area also includes a major oil-field canal which connects to Blind River from the east, just south of I-10 (Tennessee-Gas Canal). Flow to this canal is constrained by

Louisiana Highway 641. There are also many small remnant channels associated with lumbering of the cypress forest.

In addition, a cleared pipeline right-of-way traverses the Central Area in an east-west direction. The open canopy generally allows for denser bottom vegetation in the right-of-way and a slightly elevated ground surface. However, the right-of-way is rutted by airboat traffic.

North Area

The swamp area north of I-10 between Blind River and Reserve Relief Canal covers 33,150 acres. Surface water from the project area interior is exchanged to the Lake primarily via Hope Canal and Mississippi Bayou.

Mississippi Bayou is the larger of the two interior channels. The lower reach, which extends from the confluence with Bayou Tent to Lake Maurepas, is commonly referred to as Dutch Bayou. Bourgere Bayou flows into Mississippi Bayou. Hope Canal drains into Bayou Tent.

Several minor natural, oil-field, and lumbering channels drain portions of the north swamp into Mississippi, Tent, and Dutch Bayous.

An electric transmission line right-of-way crosses the North Area in an east-west direction. As in the pipeline right-of-way, the open area has a slightly elevated ground surface but is rutted by airboat traffic.

The most significant channel in terms of flow input into the project area is the Amite River Diversion Canal (ARDC), which enters the Blind River from the west five miles upstream of the Lake (see Figure 5).

Surface Water Elevations, Flow, and Circulation

Previous investigations have yielded an extensive amount of information on the typical surface water stages, flows, and circulation patterns for the project area waterbodies.

Lake Maurepas

Lake Maurepas receives freshwater drainage via four watersheds: the Tickfaw River (727 square miles to the north); the Amite River (1,819 square miles to the northwest); the Blind

River (412 square miles to the west); and the minor south tributaries within the 90-plus square mile project area to the south of the Lake.

The Lake is estimated to receive an annual average freshwater input of about 2,900 cfs from the surrounding drainage basins, plus about 413 cfs in annual direct rainfall. The Tickfaw and Amite River basins introduce 345 and 2,146 cfs on an annual average basis. Blind River is estimated to contribute about 375 cfs of flow, or about 0.9 cfs per square mile of drainage area, (*Environmental Atlas of the Lake Pontchartrain Basin*). The project area south of the Lake is over 80 percent swamp and contributes an annual average input estimated to be over 100 cfs.

Direct exchange between the swamp and Lake Maurepas is limited to the channels over most of the normal range of Lake elevations by a natural berm along the Lake shoreline. The berm averages between 2.0 and 2.5 ft NAVD-88 LDNR over most of its length.

Lake Maurepas exchanges flow with Lake Pontchartrain via Pass Manchac to the east. General levels within Lake Maurepas are controlled by Lake Pontchartrain, which in turn is controlled by the Mississippi, Chandeleur, and Breton Sounds in the northern Gulf of Mexico.

Figure 7 depicts the stage-frequency for Lake Maurepas (taken from *Diversion into the Maurepas Swamps*, 2001) and converted to the NAVD-88 LDNR datum. The mean Lake elevation is about 1.1 ft, with Lake levels between 0.0 and 2.5 ft 90 percent of the time. Over 98 percent of the time the Lake is between -0.5 and 3.0 ft.

In early fall (typically October), a combination of high water temperatures (and consequent steric effects), southeast winds, and high tides combine to produce the highest typical annual water levels. The lowest Lake levels usually occur following the passage of strong cold fronts.

The Lake is subject to a diurnal tide, with a typical range of less than 0.5 ft and a maximum range of about one foot.

South Area

As previously noted, the portion of the project area south of Airline Highway drains northward, primarily by gravity. URS has prepared a comprehensive analysis of the drainage network for the Garyville-Reserve area (see, *Volume V, 1-D (SWMM) Model Study*).

Figure 8 illustrates the slope of gravity drainage for the developed areas and the relationship to a) the surrounding land elevation and b) the tailwater control from the Lake and adjacent swamp—such as an elevation of +3.0 ft (which occurs on average several days per year).

As depicted in Figure 9, drainage capacity can be substantially reduced during high tailwater conditions. The culvert draining into the Reserve Relief Canal is equipped with a gate that can be closed, and a pump station is utilized to facilitate drainage during high swamp water. St. John the Baptist Parish also maintains a second pump station near the St. John Airport in Reserve. However, return flow from the swamp via several gravity canals cannot be eliminated.

Central Area

The central swamp invert is generally above elevation +0.5 ft, a level that is one-half foot below the average Lake elevation, with slightly higher elevations to the south as the swamp approaches the margins of the oak and palmetto forest. However, most of the central swamp is permanently inundated, indicating that elevations are below the mean Lake level of 1.1 ft.

During most periods, the stages in the Blind River and Reserve Relief Canal north of Airline Highway closely follow the stages in Lake Maurpeas, given the size and efficiency of these two channel reaches. These two channels are thought to provide reasonable "boundaries" for the influence of a moderate diversion into the interior of the project area due to their capacity to intercept and divert flow to the Lake. At higher stages, these channels exchange flow with the surrounding swamp.

Channels which pass through the interior of the central area also exchange some flow with the large swamp storage areas. The major channels—including Blind River, Hope Canal, Mississippi Bayou, and Reserve Relief—are contained within raised banks that are a combination of natural overbank deposits and spoil banks (see *Volume III, Topographic and Bathymetric Survey*). Large exchanges occur when stages exceed bank elevations (above 1 ft). Godchaux Canal and the east bank of Reserve Relief Canal are contained within relatively high banks.

Historic central swamp circulation patterns are interrupted by the presence of Airline Highway, I-10, Louisiana Highway 641, several minor dirt roads, the canal embankments, and the pipeline right-of way. The result of these many hydrologic modifications has been to isolate the central swamp. The hydrologic isolation is consistent with reports that this swamp is very stagnant.

North Area

The north swamp floor elevation also generally lies between elevation 0.5 and 1.1 ft. Channel banks slightly exceed this range, while bank gap inverts fall slightly below. The boundary channels of the lower Blind River and Reserve Relief Canal are efficiently connected to the Lake, as is Dutch Bayou.

The ARDC carries a significant portion of the 2,146 cfs in annual average flow from the Amite River into the lower Blind River. Upstream flow into the ARDC is regulated by a rock weir at the canal entrance several miles west of the project area. The ARDC was reportedly designed to accommodate about 2/3 of the Amite River flow during flood stage and to restrict flow to about 1/3 at lower stages. However, settlement of the rock weir has reportedly allowed greater flow into the ARDC, causing possibly as much as 50 percent of the annual flow to divert into the ARDC.

Flood stage on the ARDC (and Lower Blind River) is at about 4 ft, based on a National Weather Service flood stage of 4 ft NGVD on the Amite River at French Settlement. A high water elevation of about 4 ft NAVD-88, LDNR for Tropical Storm Allison was measured at the confluence of the ARDC and Blind River. Flood stages exceeding 7 ft (NGVD) have been recorded at French Settlement.

Highly turbid flood waters from the Blind River and ARDC have been noted to move eastward across the swamp toward Hope Canal but reportedly can take a period of two or more weeks.

Bayou Tent, Mississippi Bayou, and Dutch Bayou and their tributaries are the main interior channels within the north swamp. These channels are contained within slight natural banks—at about 1.0 ft. The banks are gapped in numerous places by natural sloughs and remnant lumbering scar channels.

"Short-circuiting" between Hope Canal and Blind River can occur via the long oil-field canals identified as Bayou Secret, Number Twelve Canal, and Bourgeois Canal, Similarly, flow between Mississippi Bayou and Reserve Relief Canal can occur via the "South Oil-Field Canal."

In addition to the transmission line right-of-way, another key features which influences circulation in the area north of I-10 is the old railroad embankment, which forms the west bank of Hope Canal and then extends north and west to Blind River.

Circulation in the north swamp is more pronounced than in the central swamp due to conveyance of the interior channels. However, the lack of sufficient riverine input means that the circulation is dominated by the Lake. High salinity/stage conditions in Lake Maurepas therefore introduce damaging levels of salinity into the north swamp.

Summary of Project Area Channel Flows

Based on the information collected to date, Table 1 presents a Project Area Water Budget, including URS estimates of mean annual and typical inflows at major channels entering the project area by regional watershed. The annual average excess rainfall (precipitation minus evapo-transpiration) for the central and north swamps can exceed 100 cfs. A significant portion of this amount (possibly a third) is included in estimates of Blind River flow. Of the remainder, probably more than half is conveyed to Lake Maurepas via the Dutch Bayou central/north area system.

This indicates that the average annual flow in Dutch Bayou is likely to be on the order of 80 cfs, 40 cfs from the watershed south of Airline Highway and 40 cfs from project area net rainfall.

The Project Team undertook planning for the hydrologic data collection over a series of meetings during the fall of 2003, subsequent to project initiation. Participants in the planning included the following Project Team members:

- Ken Teague and Patty Taylor, USEPA;
- Chris Williams and Luke Lebas, LDNR;
- Mike Patorno, Bob Jacobsen, Harry Harlan, Chris Reed, and Justin Roper, URS Corporation;
- Drs. Paul Kemp and Hassan Mashriqui, Louisiana State University (LSU), and Dr. Gary Shaffer, Southeastern Louisiana University (leaders of other ongoing research efforts in the Maurepas Swamp).

For regional hydrologic data the team decided to rely on the existing network of US Geological Survey and US Army Corps of Engineers hydrographic and rainfall gages, thereby avoiding unnecessary and expensive duplication of effort. The regional gage information is given in Table 2. Data from these continuously recording instruments was available over the Internet. Digital files (EXCEL) for these gages are included in Appendix A.

A survey was performed by 3001, Inc. to tie the Corps gage at Pass Manchac to the project datum. The adjustment was found to be -0.50 ft, (i.e., 1.6 ft gage equals 1.1 ft NAVD-88, LDNR).

Precipitation data was available for three USGS locations (French Settlement, Maurepas, and Sorrento), the Southeastern Louisiana University research station at Turtle Cove (on Pass Manchac); the Marathon Refinery in Garyville (daily data only); and the Moisant and Lakefront Airports in New Orleans. A digital precipitation data file (EXCEL) is provided in Appendix B.

During the previous Phase 0 investigation, Lee Wilson and Associates—in conjunction with researchers from LSU and Pyburn and Odom—installed 23 staff gages. These gages were identified as S-1 through S-22 and SLU-A. At eleven of these locations continuous stage gages were installed and operated for some period of time. One location included an Acoustic Doppler Current Profiler (ADCP) velocity measuring instrument. Table 3 includes information on these Phase 0 gages, including their dates of operation prior to the start of the URS work.

After reviewing the existing data, as well as hydrographic information obtained in preparation for field surveys (see *Volume III, Topographic and Bathymetric Survey*), 13 key locations were identified by the Project Team for additional continuous stage data collection for the Hydraulic Feasibility Study. Two locations were also targeted for continuous ADCP velocity measuring instruments. [Note: due to extended delays in shipment from the manufacturer, the second ADCP instrument arrived too late for inclusion in the project.] Locations were selected in order to address the following objectives:

- Support evaluation of drainage flows in the populated Garyville- Reserve area, south of Airline Highway.
- Support evaluation of elevation, flow, and circulation patterns in the central and north area swamps, including:
  - Response to multi-day water elevation cycles (low frequency events) in Lake Maurepas—such as tropical storm surges and low lake conditions;
  - Response to intra-day (high frequency) tidal signals from Lake Maurepas;
  - Impact of flood elevations from Blind River/Amite River Diversion Canal;
  - Impact of rainfall runoff from Garyville and Reserve on the swamp;
- Facilitate calibration of URS 1-D model of the Garyville-Reserve area and a 2-Dmodel of the central and north swamp area. These models are intended to analyze the potential backwater impacts of diversion on the Garyville-Reserve drainage and retention time of diversion water in the swamp.
- Facilitate calibration by researchers at LSU of a 2-D RMA-2 model of the central and north swamp area. This purpose of this model is to assess long-term ecological benefits of a diversion.

Five of the 13 locations were at new sites—designated S-23 through S-27—while eight locations were selected from the previously used sites (S-3, S-4, S-5, S-7, S-9, S-10, S-11, and S-16). In addition to the 13 gages planned for the project, the gage at SLU-A was allowed to remain active for the initial weeks of the project period.

Two locations were in the interior area:

- S-23 in the north swamp along Bayou Bougere; and
- S-25 in the central swamp, just east of the Hope Canal Road, and north of the pipeline right-of-way.

Three locations were selected at major drainage canals near the boundary between the South and Central Areas:

- S-24 on Reserve Relief Canal (just north of Airline Highway at the boat launch);
- S-26 on Godchaux Canal (just north of Airline Highway); and
- S-27 on Hope Canal (south of Airline Highway, shown on Figure 4).

The location for the ADCP instrument was kept at S-9, on Dutch Bayou just downstream of the confluence of Bayou Tent and Mississippi Bayou.

The 13 locations used in this phase of work, along with those gages from the Phase 0 work located in the project area, are shown on Figures 4 and 5.

Information on the installation and operation of the stage and ADCP gages is included in Table 3. Instrument installation and operation were the responsibility of LSU researchers under separate contract to LDNR. URS provided field assistance to LSU in installing gages and periodically servicing the instruments. Instruments were routinely visited by the LSU staff in order to download data, replace batteries, and perform minor maintenance.

Data collection for this phase of work began in November 2003. The interior swamp gages were the last to be installed, with S-23 becoming operational in early April 2004. The stage and velocity instruments were operated through November 2004, and were in operation during the passage of three tropical events in September-October 2004. Table 3 identifies periods of gage malfunction or data loss.

Gage information was transferred by LSU researchers to an EXCEL file format. A field check of the water surface elevation at the gage TBM (or staff gage) was typically noted and the discrepancy with the instrument reading corrected. The most frequently cited causes for discrepancy were instrument “drift” and the need to “recalibrate” following removal and resetting of the instrument. Corrections for discrepancies were entered by LSU based on field observation, either internally or externally. Internal corrections were programmed into the data recorders, depending on the capabilities of the instrument. [Note: several different brands of units were employed during the project by LSU.] External corrections were made by LSU to the raw data on the EXCEL spreadsheet. Following correction, the updated EXCEL spreadsheets were periodically forwarded by LSU to URS. Appendix C includes copies of the LSU Stage Data digital files.

LSU periodically adjusted the intervals of data recording at each gage based on expected battery life and the schedule for maintenance visits. Thus, the records for a single gage, as well as data across gages at a particular time, do not reflect a consistent frequency. Data intervals typically spanned 5 to 60 minutes.

All gages were surveyed to the project datum, NAVD-88 LDNR by 3001, Inc. Gages near I-10 (S-11 and S-7) were surveyed directly to nearby Secondary Benchmarks. The remaining gages were surveyed using differential GPS or conventional methods to the project Secondary Benchmark Network. All gages have a nearby vertical control reference point (or Temporary Benchmark, TBM). A description of the TBMs is included in Table 3 along with the TBM elevation in the project datum. At the time of data collection, LSU recorded data at Gages S-3, 4, 5, 7, 9. 10, 11, and 16 relative to previously established TBM elevations. The stage data was post-corrected by URS to NAVD-88, LDNR. (Post-corrections for vertical datum are included in the Appendix C data files.)

The brief amount of data for SLU-A during the initial weeks of the field work are included for information purposes only. A vertical reference for this gage was not established and therefore the data must be considered "Uncontrolled."

The ADCP instrument at S-9 was also periodically serviced and data downloaded to an EXCEL spreadsheet and provided to URS. Appendix D provides the digital file of the LSU ADCP Velocity Data.

Additional stage and velocity data were obtained as part of two field program efforts. The first was a synoptic velocity measurement task that involved obtaining point velocity measurements at multiple locations several times over the course of a single day. A date was targeted following a rain event and the passage of a cold front to maximize gradients and flow rates within the project area channels. Several teams were mobilized to the project area on February 6, 2004. Velocity measurements were made using Marsh-McBirney hand-held flow meters at selected cross-sections. Measurements at each cross section were taken at several lateral points and depths. A summary of the maximum velocity measured at each cross-section location and time is provided on Table 4. [Note: water elevation data for these times is contained in Appendix C LSU Stage Data.]

The second effort involved the collection of additional point hydrographic data during the URS field survey of channel bathymetry and embankments. Between February 2 and March 10, 2004, URS personnel completed a comprehensive field reconnaissance of project area channels, including embankments and gaps. As part of this survey, point velocity measurements were taken using a hand-held Marsh-McBirney flow meter of the flows in a number of channels and at embankment gaps. Water stage measurements were also taken at a number of staff gage locations where continuous gages were not in operation. The results of these measurements are included in Appendix E.

Stage data obtained from outside sources were compiled and consolidated on a single EXCEL spreadsheet (see Appendix A.) The stage data for Pass Manchac includes a tab for "Controlled" data since a vertical adjustment to NAVD-88 LDNR was obtained for this gage.

Similarly, precipitation was consolidated into a single file (Appendix B). Marathon Refinery precipitation data was collected once per day at approximately 6 am (in conjunction with a shift change). The Marathon rainfall value thus represents 24-hour accumulation beginning at 6am on the preceding date.

URS completed additional field checks of stage gage reference elevations by using the water surface on low velocity days. Gage S-3 and S-10 were easily checked using the nearby secondary benchmarks. S-4 was checked using S-3 and S-10. The remaining gages were checked from these references. Appendix F includes information from field gage elevation checking. The values for gage vertical control TBMs in Table 3 reflect the URS field checks, as do the post-corrected stage data in Appendix C.

Following receipt of stage data from LSU, URS produced five sets of stage hydrographs for the period (roughly November 2003 through November 2004) by waterbody, including Lake Maurepas, Blind River, Hope Canal-Dutch Bayou, Mississippi-Dutch Bayou, and Reserve Relieve Canal. Using these stage hydrographs, URS performed visual checks of the data. Several minor discrepancies were identified and corrected. A list of the corrections is given in Appendix G and the final stage hydrographs are provided in Appendix H. The adjusted stage values are also included in the Appendix C files under the column "Adjusted Stage."

As a result of the combination of the high quality Secondary Benchmark Network, differential GPS surveying, field TBM checking, and hydrograph inspection, URS estimates that the final stage data is accurate to better than +/- 0.1 ft. Given that the observed range in stage over the period exceeded 4 feet, an estimate of the relative error is less than 2.5 percent of the range.

URS has analyzed the data for characteristics and trends according to six key topics:

- Precipitation
- Stage Ranges
- Velocity, Flow, and Water Budget
- Water Surface Slopes
- Tidal Propagation and Channel Overbanking
- Low Frequency Signal Propagation and Channel-Swamp Exchange Resistance

Taken together, these characteristics comprise a *Maurepas Swamp Conceptual Hydrologic Model.*

Precipitation

Figure 10 (a through d) summarizes the daily rainfall amounts reported according to the seven locations. Hourly data from six of the stations was aggregated to daily totals. The Marathon Refinery data is included "as is" (i.e., data for a given date is reported as of 6 am for the 24 preceding hours). None of the project period daily amounts (or the hourly accumulations from the data sources) corresponded to a notable extreme event.

The five highest 24 hour total rainfall events reported by the Marathon Refinery during hydrologic data collection—November 2003 through November 2004—were:

24-Hour Period Ending 6:00 AM on	24-hour Rainfall Total (inches)
11/27/03	6.3
04/26/04	5.2
10/09/04	3.1
05/13/04	3.1
05/15/04	2.9
02/24/04	2.7

The 5.2-inch event on April 25-26 corresponds to the highest recorded stage south of Airline Highway, at Gage S-27 (on Hope Canal), which was 3.88 ft NAVD-88, LDNR. The sharp responsiveness of S-27 to this modest event is illustrative of the impact that more significant rainfall events can have on the Garyville-Reserve gravity drainage system.

This rainfall was concurrent with a 0.4 ft rise in central swamp stage (S-25) over an 11 hour period. . This rise was followed by an additional increase of 0.2 ft over the next 40 hours as drainage from south of Airline Highway entered the central swamp. Elevations in the north swamp rose 0.27 ft over 25 hours. These responses illustrate the greater isolation of the central swamp, compared to the greater exchange (or "leakiness") of the north swamp.

Stage Ranges

Stage hydrographs by waterbody were prepared for three critical data periods using the final, adjusted data. The periods selected included:

- December 26, 2003 to January 25, 2004, which covers the period used by the LSU researchers to calibrate their RMA-2 model;
- April through June 2004, during which the project period low occurred on Lake Maurepas, followed by a modest flood on the ARDC and Blind River; the period also included the 3-day 5-inch Garyville rain event.
- September-October 2004, which saw the passage of three tropical storms: Hurricane Ivan (as it passed to the east of Louisiana toward a northwest Florida landfall); Tropical Storm Ivan (when the storm regenerated in the Gulf of Mexico and passed to the south of Louisiana); and Tropical Storm Matthew, which passed directly over the project area.

Fifteen figures—one for each waterbody (Lake Maurepas, Hope Canal, Mississippi Bayou, Blind River, and Reserve Relief Canal) for each of the three periods—are included as Figures 11 through 25.

The final adjusted data from the 13 gages were also used to prepare statistical summaries of stage data by waterbody. Table 5 presents summaries based on the entire period of data, while Table 6 presents summaries based only on time-frames in which all gage on waterbody were operating. Information is presented on the Time Weighted Average (TWA) stage and the maximum and minimum stage (and date/time). The TWA stage was developed to correct for the many variations in recording intervals employed by LSU.

Not surprisingly, the highest TWA stage values are at S-25 (located in the interior swamp between Airline Highway and I-10) and S-26 (on Godchaux Canal; Godchaux Canal is restricted from freely draining to Reserve Relief Canal and Mississippi Bayou). The two locations have maximum TWA values of 1.62 ft.

Consistent with the general drainage pattern, the lowest TWA values are typically near the Lake. TWA values for the project period of less than 0.9 ft were observed at S-4 and S-10. Gages S-3 and the Pass Manchac gage had slightly higher values due to gaps in data. When compared on common data periods, the TWAs for the four Lake gages are within 0.05 ft of each other, with S-10 on Blind River the highest, as would be expected. Thus, the project period averages for the Lake were very close to the corrected long-term mean value (1.1) previously noted. (Note: the overall TWA for S-23 is less 0.9 as it was out of service during the Blind River flood.)

Maximum stage values typically occurred during the passage of Tropical Storm Matthew on October 10-11, 2004. The maximum stages exceeded 4.5 ft NAVD-88, LDNR in Lake Maurepas, and were above 4 ft north of I-10, except at S-7 on Hope Canal (3.93 ft). As noted above, the maximum value at S-27 (Hope Canal south of Airline Highway) occurred with the 3-day 5.2-inch event. [Note: the values for the SLU gage are included for information purposes only; SLU-A stage data are "uncontrolled."]

Minimum stage values typically occurred during the April 14-15 low Lake event, with values at Pass Manchac, S-3, and S-4 below -1 ft. The stage at S-7 and S-9 also fell below -1 ft, and S-10, S-11, S-16, and S-24 all dropped to about -0.9 ft. Interestingly, the stage in upper Hope Canal, at S-5, remained about ½ foot above S-7.

Velocity, Flow, and Water Budget

Velocity hydrographs are presented together with the stage hydrograph for S-9 for each of the three periods in Figures 26, 27, and 28. The ADCP data at S-9 was also analyzed to determine TWA, maximum downstream, and maximum upstream velocities. The TWA average velocity, maximum downstream (toward Lake), and maximum upstream velocities were determined to be 0.18 downstream, 1.2, and 1.1 fps, respectively. Separate analysis without the tropical events produced the nearly the same results, with a slight reduction in maximum upsteam velocity (0.8 fps).

The surveyed cross-sectional area at S-9 is 458 square feet (based on earlier work by Pyburn & Odom, see URS *Volume III*, *Topographic and Bathymetric Survey*). The TWA discharge for S-9 is thus calculated to be 82 cfs. This figure closely agrees with the annual mean flow estimate provided in Table 1. Thus, Table 1 is considered to reflect a reasonable project area water budget.

Water Surface Slopes

The high quality stage gage vertical control allowed for analysis of project area water surface gradients. Data for several gages were interpolated to a set of common date/time increments in order to assess the stage differences and water surface slopes. Summaries of several average, maximum positive, and maximum negative gradients are shown in Table 7.

Gradients are extremely mild, consistent with the very flat project area topography and bathymetry:

- From Hope Canal at Airline Highway to the mouth of Dutch Bayou the water surface slope averages 5×10^{-6}, with maximum gradients in either direction of about 1 to 3×10^{-5}.
- By comparison, the average gradient from Mississippi Bayou at I-10 to the Lake is about 60% less, 2×10^{-6}.
- The gradient is steeper from the interior swamp south of I-10 to the Lake, 1×10^{-5}. This is consistent with the impounding of water in the swamp south of I-10.
- The Lake gradient (from the mouth of Dutch Bayou to Pass Manchac) is typically negligible, averaging 6×10^{-8}, and maximizing at 1×10^{-5} in either direction.
- Across the north swamp, from the junction of Mississippi and Dutch Bayous toward the ARDC at Blind River, the average gradient is about 2×10^{-6}, indicating a swamp flow towards the Blind River.

While the project did not include multiple interior central or north swamp stage gages, the above gradient findings indicate that the typical slope of the surface water within the swamp interior is likely to be very low—less than 1×10^{-6}. At very low gradients the flow is stagnant and critical thresholds for full turbulence may not be reached. It is important to note that as turbulence declines, the physical mechanisms controlling water velocities and solute mixing (e.g., nutrients and salinity) require special consideration.

Tidal Propagation and Channel Overbanking

Diurnal tidal signals are regularly generated in Lake Maurepas as shown in Figures 11, 16, and 21, and occasionally exceed an amplitude of 0.5 feet,. An inspection of Figures 11 through 25 shows that tidal signals are typically propagated up the project area channels only at low stages. However, as stages rise and channels flow into adjacent swamps, tidal signals are lost. Over-banking occurs in two phases: 1) as stages reach the inverts of bank gaps, limited flow is exchanged via the small openings; and 2) with further stage increase channels overflow their entire banks. After stages fall below bank level, the tidal signal is once again seen. Thus, the characteristics of high frequency signal propagation in the channel hydrographs reflect the elevation of banks and bank gaps, which control the stage-dependent exchange between the channels and swamp: .

- As shown in the LSU Calibration Period tidal signals are easily propagated up the larger, more efficient boundary channels, Blind River and Reserve Relief Canal. Due to the size of these channels, lags are very short (at most a few hours), with shorter lags and minor dampening at low channel flow and low interfering winds. When stages rise above 1.5 ft on the Blind River and about 1.2 ft on Reserve Relief Canal, tidal signals are lost. Similarly, tidal signals return when stages return to these elevations. (See the pre- and post- tropical storm periods on Figures 24 and 25).

- Tidal signals are also propagated up Dutch Bayou to S-9 with minor lags and dampening, with signal loss at about 1.5 ft

- Upstream to Hope Canal and Mississippi Bayou at I-10 (S-7 and S-11) signal propagation is clear only when the stage is well below 1 foot, with delays of several hours and dampening on the order of 50 percent. As stages approach 1 ft, exchange with the low swamp via bank gaps occurs and signals are lost.

- Tidal signals are further delayed and dampened through Upper Hope Canal (S-5). The total lag from the Lake exceeds five hours and magnitudes are dampened over 50 percent, with over-banking occurring at stages below 1 ft.

- Tides propagate into the north swamp (S-23) but are much more dampened than in the channels. Tides do not appear to propagate into the isolated central swamp (S-25).

- Comparison of the velocity and stage hydrographs at S-9 shows that the "high frequency" tidal velocity and stage signals are generally in phase.

- Tidal prism—the volume change in water covering an area between a low tide and the subsequent high tide—is not a useful calculation for the Maurepas project area due to : 1) lake-driven tidal signals affect only the footprint of the interior channels, less than 10 percent of the overall interior project area, and 2) the lag of many hours in the tidal propagation up the interior channels means that a simultaneous change in volume within the entire channel network does not occur.

- Table 8 provides a summary of the change in elevation—and rate of change in elevation—at various gage locations for several "In Channel Only" tidal swings. In general, the project area interior channels appear to be able to rise and fall at average rates of about 0.02 to 0.04 feet per hour over the course of a tide.

Low Frequency Signal Propagation and Channel-Swamp Exchange Resistance

The characteristic propagation of low frequency (multi-day) shifts in the Lake Maurepas elevation through the project area are also an important aspect of the project hydrologic conceptual model. Table 9 provides a summary of lag and dampening affects on the low frequency signals. These signals typically range from smaller "humps" (0.5 to 2 ft), such as those shown in the LSU Calibration Period hydrographs, to higher events, such as those shown on the High Blind River and Tropical Storm hydrographs. Some of the signals shown in these figures are not "pure" Lake forcing events. The LSU Calibration Period—which occurs within a generally low Lake period—includes three humps which are partly the product of modest local rainfall events (less than one inch). The High Blind River event reflects concurrent rises in the ARDC/Blind River, the Lake, and heavy rainfall in the project area (17 inches from May 1 to May 19). The first two tropical storm surges were not accompanied by significant rain, while the third (TS Matthew) coincided with a 5-day 6-inch rainfall.

The low frequency signatures of the system—including both the incoming (or filling or wetting) and outgoing (or draining or drying) phases of the events—are important indicators of several “resistance” factors which control the extent/rate of channel-swamp exchange:

- Bottom friction, or shear stress in the swamp and on the banks,
- Vegetation form drag in the swamp and on the banks,
- The width, bottom friction, and drag (i.e., conveyance) of gaps, and
- The “effective” exchangeable storage volume of interior swamp areas,

Key examples of channel-swamp resistance characteristics include the following:

- As with tidal propagation, low frequency propagation characteristics are stage dependent, indicating that resistance factors vary with water depth, which is consistent with the physical nature of shear stress, drag, and swamp storage. Note: In addition to depth dependence, low gradient conditions are likely to induce very low turbulence (possibly falling to a laminar state), which also needs to be considered.

- For small 1-to-2 foot Lake signals (e.g., Hurricane and TS Ivan), propagation is influenced by prior overall area stages. The Lake signals for Hurricane and TS Ivan were nearly identical (2.6 and 2.7 ft at S-3). However, the Hurricane Ivan signal took much longer to advance through the system due to the prior low stage (about 1.0 throughout the area), whereas the Tropical Storm Ivan surge followed within a week of the Hurricane Ivan surge when the area was already at elevation 1.5.

- Signals typically propagate up the more efficient Reserve Relief Canal and Blind River faster than the two main interior channels, Hope Canal and Mississippi Bayou, and with less dampening.

- A noticeable exception is the TS Matthew surge at S-16 (Blind River and I-10) which may have been impacted by rainfall.

- Propagation of the TS Ivan event up Mississippi Bayou and Hope Canal showed a lag of about 30 hours and dampening of about 20 percent. These results were slightly shorter and lower than for Hurricane Ivan (reflecting the prior setup of the area.)

- The same comparisons can be drawn for signal delay and reduction at Hope Canal at Airline Highway (S-5) and in the north and central swamps (S-23 and S-25).

- Signal lags and peak reductions were lower for TS Matthew—possibly due to the interference of rainfall. However, lower lags and dampening would also be consistent with reduced resistance for a higher surge.

- Propagation up Mississippi Bayou to I-10 is slightly faster than Hope Canal, consistent with the former being a slightly more efficient channel.

- During the drawdown after high events, the channels, particularly upper (north) reaches, remain slow to drain for some period of time, showing evidence of continued recharge from swamp storage areas. However, as general water elevations decline, recharge from the swamp falls off dramatically and channel levels fall more rapidly, indicating either:

    1. Resistance to flow in the swamps and gaps has significantly increased with falling depth/gradient, and/or

    2. The capacity for recharging the channels from the swamp is exhausted—i.e., the residual swamp storage volume becomes isolated.

    This effect is seen in all three periods, with the hydrographs showing a decline in recharge occurring below 1.5 ft.

- The rates of swamp elevation change (see Figure 29 for daily swamp elevation changes at S-23 and S-25) in response to low frequency events are sluggish, with rates generally below 0.4 ft/day range. Only with the high surge of TS Matthew did swamp water stage changes approach 1 ft/day. The sluggish response of the swamp has implications for a diversion shutdown in advance of an approaching tropical storm.

The various signatures of channel-swamp exchange are thus indicative of the system's response to hydrologic forcing. Understanding and modeling these observed events, including the nature of swamp resistance, are likely to facilitate prediction of the system's response to a diversion, including potential for increased backwater impacts on Garyville-Reserve drainage and the retention time and circulation of diversion water in the swamp.

It is worth noting that a 1,500 cfs diversion rate equates to 3,000 acre-feet of water per day. Should targeted retention times for the Maurepas diversion[1] be, for example, on the order of one-week, then the effective "diversion storage" requirement may be on the order of 20,000 to 30,000 acre-feet. Given that the project areas south and north of I-10 are roughly 20,000 and 30,000 acres, respectively, an adequately distributed and retained diversion is likely to increase swamp depths by several tenths of a foot. Depending on resistance and circulation patterns, increased depths of on the order of one foot are possible.

The information contained in this Volume, and particularly the *Conceptual Hydrologic Model*, are being used to develop a high resolution 2-D hydrodynamic model of the swamp, and to evaluate the circulation, retention, and depth aspects of a freshwater diversion.

[1] Effective nitrate removal requires retention of diversion water within the project area swamp. The evaluation of effective retention times for nitrate removal in the Maurepas Swamp is not a part of this study.

TABLES

Table 1

Project Area Water Budget

Watershed	Mean Annual Flow cfs	Typical Flow cfs
Blind River w/o ARDC	**375**[1]	**100**
ARDC	**1,000**	**400**
Reserve Relief Canal		
Inflow from south area		
Godchaux Canal	5	1
Reserve Relief Canal	15	3
Other	5	1
Estimated Swamp Net Precipitation (Prec – Evapo-Trans)	**25**	
Outflow to Lake	**50**	
Dutch Bayou		
Inflow from south area		
Hope Canal/Tent Bayou		
Hope at Airline Hwy	10	2
Other	5	1
Mississippi Bayou		
Bougere Canal	3	1
San Francisco Canal (West Marathon)	4	1
Dolson Canal (East Marathon)	4	1
Lions Canal	4	1
Guidry Canal	3	1
Pump Station	3	1
Other	4	1
Dutch Bayou Inflow Subtotal	**40**	**10**
Estimated Swamp Net Precipitation (Prec – Evapo-Trans)	**40**	
Outflow to Lake	**80**	

1 This figure includes net precipitation input from project area swamps.

Table 2
Regional Stage and Rainfall Gage Information

Location	Available Data	Frequency	Type of Data	Source
Amite River near French Settlement	01/16/04 - 11/19/04	30 minute readings	precipitation, real time stage data **NOT** TIED TO DNR DATUM	USGS
Amite River at Maurepas	01/16/04 - 11/19/04	30 minute readings	precipitation, wind speed and wind direction, real time stage data **NOT** TIED TO DNR DATUM	USGS
New River at Sorrento	01/16/04 - 11/19/04	30 minute readings	precipitation, stage data **NOT** TIED TO DNR DATUM	USGS
New Orleans Lakefront	11/01/03 - 11/30/04	hourly for November 03 only daily for all other data	precipitation, wind speed and wind direction **NOT** TIED TO DNR DATUM	LOSC
New Orleans Moisant	11/01/03 - 11/30/04	hourly for November 03 only daily for all other data	precipitation, wind speed and wind direction	LOSC
Turtle Cove	11/01/03 - 11/30/04	hourly	precipitation, wind speed and wind direction	LA Agriculture Center
Marathon Refinery	01/01/01 - 11/30/04	daily	precipitation	Marathon
Pass Manchac	11/01/03 - 11/19/04	hourly	real time stage data **TIED TO DNR DATUM**	USCOE
West End	11/01/03 - 11/19/04	hourly	real time stage data **NOT** TIED TO DNR DATUM	USCOE

Table 3
Gage Information Summary

Station ID	Type	Location of Gage	Staff Gage Installation Date	Recording Gage Installation Date	RG Controlled Data (tied to TBM)	Uncontrolled Data	Data Comment	TBM Elev (ft NAVD-P&O)	Vertical Control Correction	TBM Elev (ft NAVD-DNR)	TBM Description
Gages Installed by LSU Prior to URS Feasibiity Study											
S-1	Staff Gage Only	Reserve Relief at I-10	Jul-00					3.21			Nail set in tupelo tree on west side of canal across from gage
S-2	Staff Gage Only	North Side of Oilfield Canal East of Reserve Relief	Jul-00					3.62			Nail set in SW corner of well platform
S-3	Staff and Recording Gage	Reserve Relief Canal North	Jul-00	Jan-04	01/09/04 - 11/02/04 (YSI)			7.39	-0.6	6.79	Nail set in willow tree on west side of canal across from gage
S-4	Staff and Recording Gage	Dutch Bayou at Lake Maurepas	Jul-00	Nov-02	11/05/02 - 02/12/04 (RDS); 11/26/03 - 11/02/04 (YSI)		Out of service: 01/16/03 - 01/30/03; Gage capsized by TS Matthew; out of service 10/9/04 - 10/11/04	2.37	-0.68	1.69	Nail set in cypress stump on north side of bayou across from gage
S-5	Staff and Recording Gage	Hope Canal near Hwy 61 (at boat launch)	Jul-00	Dec-03	12/10/03 - 11/17/04 (Infinities)		Lost data 6/8/04 to 6/19/04	5.51	-0.52	4.99	Nail set in 6" gum tree on east side of canal across from gage
S-6	Staff and Recording Gage	Hope Canal at Pipeline ROW	Jul-00	Jan-03	01/20/03 - 03/26/03 (RDS)		Data logger stolen; No data after 03/26/03	1.52	-0.4	1.12	Nail set in third pile north of the south end of the bulkhead on the east side of the canal
S-7	Staff and Recording Gage	Hope Canal at I-10	Jul-00	Dec-03	12/19/03 - 11/17/04 (Infinities)		Lost data 6/8/04 to 6/18/04	2.67	-0.46	2.21	Nail set in 14" cypress tree 50 ft. south of gage
S-8	Staff and Recording Gage	Hope Canal at Tent Bayou	Jul-00	Nov-02	11/05/02 - 12/03/03 (RDS)		Out of service: 11/05/02 - 11/21/02; Out of service: 12/03/03 - 12/19/03;	3.18	-0.62	2.56	Nail set in cypress tree 50 ft. east of gage
S-9	Staff and Recording Gage, and ADCP	Dutch Bayou/Bayou Tent	Jul-00	Nov-02	11/04/02 - 02/12/04 (RDS); 12/19/03 - 11/17/04 (YSI)		ADCP platform installed on 8/13/03; Out-of-service 3/3/04 to 4/1/04	3.45	-0.82	2.63	Nail set in tupelo tree approx. 25 ft. northeast of gage; second nail set in tree just north of first at 4.79 ft NAVD-DNR
S-10	Staff and Recording Gage	Blind River/Diversion Canal	Jul-00	Nov-02	11/04/02 - 12/04/03 (RDS) 12/04/03 - 11/02/04 (Infinities)		Out of service: 11/21/02 - 12/17/02; Lost data: 03/25/03 - 03/27/03; Out of service: 10/07/03 - 12/04/03	4.15	-0.69	3.46	Pk nail in front of mailbox on Glen Martin's Boat Dock
S-11	Staff and Recording Gage	Mississippi Bayou at I-10	Jul-00	Dec-03	12/18/03 - 11/30/04 (Infinities)			2.41	-0.55	1.86	Nail in 6" cypress tree 40 ft. north of gage
S-12	Staff Gage Only	Mississippi Bayou at Pipeline ROW	Jul-00					2.90			Nail set in second pile south of the north end of the east side bulkhead
S-13	Staff Gage Only	Mississippi Bayou at Bayou Bec Croche	Jul-00					2.69	-0.53	2.16	Nail set in tupelo tree on north side of Mississippi Bayou across from the gage
S-14	Staff Gage Only	Blind River at Petite Amite	Jul-00					3.82			Nail set in cypress tree 25 ft. west of gage
S-15	Staff Gage Only	Blind River at Bourgeois Canal	Jul-00					2.97			Nail set in tree at the intersection of the east side of the Blind River and north side of Bourgeios Canal
S-16	Staff and Recording Gage	Blind River at I-10	Jul-00	Dec-03	12/04/03 - 11/02/04 (Infinities)		Out of service: 5/05/04 - 7/14/04	2.29	-0.53	1.76	Nail set in pile cluster across the river from the gage
S-17	Staff Gage Only	Blind River at US61	Jul-00					2.72	-0.54	2.18	Nail set in tree approximately 150 ft. west of the gage on the south side of the Blind River
S-18	Staff Gage Only	Petite Amite at New River Canal	Jul-00					2.78			Nail set in tupelo on north side of New River Canal at the intersection of New River Canal and Petite Amite River
S-19	Staff Gage Only	I-55 Canal north of boat ramp	Jul-00					4.07			Nail set in wooden bridge located at boat ramp
S-20	Staff Gage Only	Ruddock Canal West of I-55	Jul-00					1.63			Nail set in cypress tree on north side of Ruddock Canal across from gage
S-21	Staff Gage Only	Dead End Canal	Jul-00					3.43			Nail set in 18" cypress tree on west side of canal at end of Dead End Canal
S-22	Staff Gage Only	I-55 Canal south of North Pass	Jul-00					3.24			Nail set in power pole approx. 25 ft. south of gage
SLU A	Staff and Recording Gage	Swamp Gage set near SLU Location 8A	1/31/2003	1/31/2003		01/31/03 - 02/03/04 (RDS)	Lost data: 03/26/03	NA	-0.75	NA	No TBM was ever installed; vertical control correction is based on an average of the corrections
New Gages Installed by LSU During URS Feasibiity Study											
S-23	Recording Gage	North Swamp		Dec-03	4/01/04 - 11/30/04 (Infinities)	12/15/03 - 3/11/04	Data prior to 3/11/04 tied to S-13; water levels may have been below instrument on some days; Out of service 3/11/04 - 04/01/04 Out of service 5/4/04 to 6/22/04			4.30	Nail on tree to right of data logger; Set 3.00 ft above estimated water surface (1.30 ft) on May 3, 2004
S-24	Recording Gage	Reserve Relief Canal at US 61		Dec-03	12/11/03 - 11/02/04 (Infinities)		Data from 12/22/03 to 5/504 was originally tied to S-1; this data has been post-corrected to 3001 TBM at S-24 location.			2.48	First nail set at south boat ramp, in pier on north side of ramp, facing NW side of pier at 3.00 NAVD-DNR; this nail was subsequently damaged; a second nail set on NE side of pier, under deck at 2.48 NAVD-DNR
S-25	Recording Gage	Central Swamp		Mar-04	03/04/04 - 11/09/04 (Infinities)					4.22	Nail in tupelo/gum tree approximately 30 ft east of automatic gage
S-26	Recording Gage	Godchaux Canal		Feb-04	02/26/04 - 11/09/04 (Infinities)		Lost Data from 6/9/04 to 6/19/04			3.06	Nail on stand over Water
S-27	Recording Gage	Hwy 54		Dec-03	12/03/03 - 11/09/04 (Infinities)		Lost data from 6/9/04 to 6/19/04			2.88	Second nail set on stand, more directly over Water

Vertical control corrections are based on the evaluation of vertical control only; additional graphical adjustments based on evaluation of the hydrogrpahic data have also been developed and are presented elsewhere.
Initial data recorders were Remote Data Systems (RDS); these gages showed evidence of significant drift.
YSI Data Sonde instruments have been installed for multi-paramters, including stage; limited flexibility for utilizing software.
Infinities Data Logger has best software

Table 4
Synoptic Velocity Measurements
6-Feb-04

Stream	Location	Time	Vmax
Hope Canal	Gage S-5	11:00:00 AM	0.43
Hope Canal	Gage S-6	11:40:00 AM	0.42
Hope Canal	Gage S-8	12:23:00 PM	0.27
Hope Canal	Gage S-7	12:28:00 PM	0.21
Hope Canal	Gage S-5	1:43:00 PM	0.42
Hope Canal	Gage S-6	2:18:00 PM	0.29
Hope Canal	Gage S-7	2:50:00 PM	0.2
Hope Canal	Gage S-8	3:20:00 PM	0.14
Mississippi Bayou	Gage S-12	11:00:00 AM	0.12
Mississippi Bayou	3001 Cross Section N-19	12:06:00 PM	0.19
Mississippi Bayou	Gage S-13	12:47:00 PM	0.34
Mississippi Bayou	3001 Cross Section N-24	1:15:00 PM	0.39
Mississippi Bayou	Gage S-11	1:36:00 PM	0.43
Mississippi Bayou	Gage S-12	1:52:00 PM	0.37
Mississippi Bayou	Gage S-11	1:59:00 PM	0.43
Mississippi Bayou	3001 Cross Section N-24	2:22:00 PM	0.37
Mississippi Bayou	Gage S-12	2:30:00 PM	0.06
Mississippi Bayou	Gage S-13	2:43:00 PM	0.33
Mississippi Bayou	3001 Cross Section N-19	3:03:00 PM	0.46
Mississippi Bayou	Gage S-11	3:20:00 PM	0.03
Reserve Relief	at Lake	11:55:00 AM	0.63
Reserve Relief	Gage S-3	12:05:00 PM	0.67
Reserve Relief	3001 Cross Section N-27	12:55:00 PM	0.51
Reserve Relief	3001 Cross Section C-10	1:30:00 PM	0.59
Reserve Relief	Gage S-2	1:55:00 PM	0.31
Bayou Tent	3001 Cross Section N-16	1:23:00 PM	0.23
Dutch Bayou	Gage S-9	2:36:00 PM	0.33
Blind River	3001 Cross Section N-2	11:34:00 AM	1.72
Blind River	Gage S-10	12:00:00 PM	1.74
Blind River	3001 Cross Section N-5	1:00:00 PM	0.54
Blind River	Gage S-14	1:50:00 PM	0.62

Table 5
Stage Statistics by Waterbody for Total Project Period

Waterbody	Total Project Data Period	Gage Statistics					
		TWA	Max.	Date/Time	Min.	Date/Time	Major Data Gaps
Lake Maurepas							
S-3	11/1/03 - 10/31/04	0.96	4.53	10/10/04 19:30	-1.10	4/14/04 20:30	11/1/03 -1/9/04
S-4		0.89	4.54	10/11/04 1:30	-1.07	4/14/04 22:00	11/1-11/26/03 & 10/9-10/11/04
S-10		0.88	4.70	10/10/04 22:00	-0.98	4/14/04 4:30	11/1-11/4/03
Pass Manchac		0.93	4.74	10/10/04 14:00	-1.04	4/14/04 23:00	7/2-7/4/04 & 7/17-7/18/04
Blind River							
S-4	11/1/03 - 10/31/04	0.89	4.54	10/11/04 1:30	-1.07	4/14/04 22:00	11/1-11/26/03 & 10/9-11/04
S-10		0.88	4.70	10/10/04 22:00	-0.98	4/14/04 4:30	11/1-11/4/03
S-16		0.82	4.06	10/11/04 13:30	-0.96	4/14/04 19:00	11/1/03-12/4/03 & 5/5/04 - 7/14/04
Reserve Relief Canal							
S-26	12/11/03 - 11/9/04	1.62	4.12	10/11/04 9:00	1.08	9/7/04 12:00	12/1/03-2-26/04 & 6/9/04 - 6/19/04
S-3		0.96	4.53	10/10/04 20:00	-1.10	4/14/04 20:30	12/11/03-1/9/04 & 11/2-11/9/04
S-24		0.96	4.32	10/11/04 5:00	-0.94	4/14/04 11:30	11/2-11/9/04
Mississippi Bayou							
S-9	12/18/03 - 11/30/04	1.02	4.49	10/10/04 22:00	-1.07	4/14/04 22:00	12/18-12/19/03 & 3/3/04 - 4/1/04 & 11/17-11/30/04
S-11		1.13	4.07	10/11/04 7:30	-0.86	4/15/04 7:15	-
S-23		0.85	4.16	10/11/04 5:00	0.15	8/5/04 12:30	12/18/03-4/1/04 & 5/4/04 -6/22/04
S-25		1.62	3.92	10/11/04 19:00	1.09	4/24/04 19:00	12/18/03-3/4/04 & 11/9-11/30/04
Hope Canal							
S-4	11/26/03 - 11/17/04	0.90	4.54	10/11/04 1:30	-1.07	4/14/04 22:00	11/2-11/17/04 & 10/9/04 - 10/11/04
S-5		1.19	3.75	10/12/04 0:00	-0.59	4/15/04 15:20	11/26/03-12/10/03 & 6/8/04 - 6/19/04
S-7		1.16	3.93	10/11/04 14:00	-1.06	4/15/04 3:30	11/26/03-12/19/03 & 6/8/04 - 6/19/04
S-9		1.02	4.49	10/10/04 22:00	-1.07	4/14/04 22:00	11/26/03-12/19/03 & 3/3/04 - 4/1/04
S-27		1.25	3.88	4/25/04 21:50	-0.15	4/16/04 10:35	11/26/03-12/3/03 & 6/9/04 - 6/19/04
SLU A		0.65	1.40	11/27/03 20:00	0.50	12/24/03 2:00	11/26-11/31/03 & 2/3/04-11/17/04

Table 6
Stage Statistics by Waterbody for Common Data Periods

Waterbody	Common Data Period	Gage Statistics				
		TWA	Max.	Date/Time	Min.	Date/Time
Lake Maurepas						
S-3	1/9/04 - 10/9/04	0.91	3.15	10/9/04 4:30	-1.10	4/14/04 20:30
S-4		0.92	3.47	10/9/04 4:30	-1.07	4/14/04 22:00
S-10		0.96	3.36	10/9/04 5:00	-0.98	4/14/04 4:30
Pass Manchac		0.92	3.98	10/9/04 21:00	-1.04	4/14/04 23:00
Blind River						
S-4	12/4/03 - 5/5/04	0.70	2.12	2/24/04 23:00	-1.07	4/14/04 22:00
S-10		0.73	2.08	2/24/04 23:30	-0.98	4/14/04 4:30
S-16		0.77	2.71	10/9/04 5:00	-0.96	4/14/04 19:00
Reserve Relief Canal						
S-26	6/19/04 - 10/9/04	1.62	3.02	10/9/04 5:00	1.08	6/19/04 20:45
S-3		0.96	3.15	10/9/04 4:30	-0.44	9/8/04 7:00
S-24		1.04	2.72	10/9/04 4:30	-0.38	9/8/04 7:30
Mississippi Bayou						
S-9	6/22/04 - 11/9/04	1.09	4.49	10/10/04 22:00	-0.30	9/8/04 10:15
S-11		1.31	4.07	10/11/04 7:30	-0.16	9/8/04 18:30
S-23		1.11	4.16	10/11/04 5:00	0.15	8/5/04 12:30
S-25		1.67	3.92	10/11/04 19:00	1.11	9/17/04 15:00
Hope Canal						
S-4	12/19/03 - 2/3/04	0.58	2.00	2/2/04 12:15	-0.98	12/19/03 20:30
S-5		0.75	1.40	2/3/04 10:05	-0.51	12/20/03 2:05
S-7		0.71	1.39	2/3/04 7:45	-0.65	12/20/03 0:00
S-9		0.59	1.66	2/2/04 16:15	-0.96	12/19/03 20:45
S-27		0.78	1.42	2/3/04 8:05	-0.11	12/20/03 14:20
SLU A		0.63	1.34	2/2/04 14:00	0.50	12/24/03 2:00
Hope Canal w/o SLU						
S-4	6/19/04 - 10/9/04	0.96	3.47	10/9/04 4:30	-0.35	9/8/04 10:00
S-5		1.14	1.93	9/25/04 15:15	-0.47	7/29/04 10:05
S-7		1.10	2.12	9/25/04 3:30	-0.34	9/8/04 12:30
S-9		1.00	2.97	10/9/04 5:00	-0.30	9/8/04 10:30
S-27		1.20	3.22	8/9/04 12:30	-0.12	9/8/04 20:30

Table 7
Waterbody Surface Slope Statistics

Stage Locations	Gages	Distance (ft.)	Difference in Water Surface Elevation (ft)			Slope in Water Surface Elevation (ft/ft)		
			Average	Maximum +	Maximum -	Average	Maximum +	Maximum -
Hope Canal North of US61 to Lake	S5 to S4	60,900	0.32	1.79	-0.73	5.E-06	3.E-05	-1.E-05
Hope Canal Across US61	S27 to S5	4,000	0.05	1.98	-0.12	1.E-05	5.E-04	-3.E-05
Mississippi Bayou at I-10 to Lake	S11 to S4	52,300	0.13	1.39	-1.43	2.E-06	3.E-05	-3.E-05
Bayou Bougere South of I-10 to Lake	S25 to S4	50,600	0.62	2.31	-1.41	1.E-05	5.E-05	-3.E-05
Blind River at ARDC to Lake	S10 to S4	27,000	0.04	0.94	-0.49	1.E-06	3.E-05	-2.E-05
Dutch Bayou at Lake to Pass Manchac	S4 to Pass Manchac	69,000	0.00	0.88	-0.94	6.E-08	1.E-05	-1.E-05
Blind River at ARDC to Dutch & Miss Bayous	S10 to S9	22,000	-0.05	0.52	-1.10	-2.E-06	2.E-05	-5.E-05

Table 8
Tidal Prism

	S-3 Reserve Relief at Lake	S-4 Dutch Bayou at Lake	S-5 Hope Canal at Airline Highway	S-7 Hope Canal at I-10	S-9 Dutch Bayou at Mississippi Bayou	S-10 Blind River at ARDC	S-11 Mississippi Bayou at I10	S-16 Blind River at I-10	S-23 Bayou Bouger in North Swamp	S-24 Reserve Relief at Airline Highway	S-25 North Swamp
Prism in Channels Only											
Channel Width (Ft)	147	133	120	85	130	430	63	231	29	72	NA
Stage Start	0.422	0.436	0.341	0.370	0.441	0.327	0.205	0.543	0.188	0.298	1.158
Stage Start Date/Time	4/19/04 11:00	4/19/04 12:30	4/19/04 15:05	4/19/04 14:15	4/19/04 12:00	4/19/04 11:30	4/19/04 16:15	4/19/04 12:00	4/19/04 15:30	4/19/04 10:30	4/19/04 20:00
Stage Finish	0.779	0.787	0.614	0.640	0.768	0.728	0.426	0.988	0.419	0.715	1.161
Stage Finish Date/Time	4/20/04 2:30	4/20/04 2:00	4/20/04 7:20	4/20/04 6:30	4/20/04 3:15	4/20/04 3:00	4/20/04 8:15	4/20/04 4:30	4/20/04 6:30	4/20/04 3:00	4/20/04 9:00
Stage Range (Ft)	0.357	0.351	0.273	0.270	0.327	0.401	0.221	0.445	0.231	0.418	0.002
Elapsed Time (Day)	0.65	0.56	0.68	0.68	0.64	0.65	0.67	0.69	0.63	0.69	0.54
Vertical Feet per Hour	0.0230	0.0260	0.0168	0.0166	0.0214	0.0259	0.0138	0.0270	0.0154	0.0253	0.0002

Stage Start	0.461	0.452	0.396	0.420	0.486	0.363	0.210	0.618	0.217	0.349	1.203
Stage Start Date/Time	4/6/04 13:00	4/6/04 13:00	4/6/04 16:35	4/6/04 16:15	4/6/04 14:45	4/6/04 13:00	4/6/04 15:30	4/6/04 13:00	4/6/04 16:15	4/6/04 12:30	4/6/04 22:00
Stage Finish	1.005	1.132	0.832	0.830	0.948	1.006	0.668	1.242	0.604	0.920	1.244
Stage Finish Date/Time	4/7/04 3:30	4/7/04 1:30	4/7/04 10:20	4/7/04 10:00	4/7/04 3:45	4/7/04 2:00	4/7/04 9:45	4/7/04 7:00	4/7/04 9:30	4/7/04 1:30	4/7/04 3:00
Stage Range (Ft)	0.544	0.680	0.436	0.410	0.462	0.643	0.458	0.623	0.387	0.571	0.042
Elapsed Time (Day)	0.60	0.52	0.74	0.74	0.54	0.54	0.76	0.75	0.72	0.54	0.21
Vertical Feet per Hour	0.0375	0.0544	0.0246	0.0231	0.0355	0.0495	0.0251	0.0346	0.0224	0.0439	0.0083

Stage Start	0.310	0.327	0.447	0.439	0.418	0.331	0.847	0.383	0.344	0.380	1.472
Stage Start Date/Time	7/26/04 9:00	7/26/04 9:00	7/26/04 14:50	7/26/04 14:15	7/26/04 9:30	7/26/04 10:00	7/26/04 17:30	7/26/04 10:30	7/26/04 14:30	7/26/04 8:00	7/27/04 2:00
Stage Finish	0.923	0.952	0.688	0.673	0.874	1.027	0.863	0.923	0.544	1.009	1.456
Stage Finish Date/Time	7/26/04 21:00	7/26/04 19:30	7/27/04 5:20	7/27/04 5:15	7/26/04 22:45	7/26/04 20:30	7/27/04 14:30	7/27/04 1:00	7/27/04 6:30	7/26/04 22:00	7/27/04 14:00
Stage Range (Ft)	0.613	0.625	0.242	0.234	0.456	0.696	0.016	0.540	0.200	0.629	-0.016
Elapsed Time (Day)	0.50	0.44	0.60	0.63	0.55	0.44	0.88	0.60	0.67	0.58	0.50
Vertical Feet per Hour	0.0511	0.0595	0.0167	0.0156	0.0344	0.0663	0.0008	0.0372	0.0125	0.0449	-0.0013

Stage Start	0.549	0.546	0.558	0.534	0.573	0.553	0.972	0.556	0.479	0.527	1.442
Stage Start Date/Time	8/21/04 16:30	8/21/04 13:30	8/21/04 16:45	8/21/04 15:15	8/21/04 14:15	8/21/04 14:30	8/21/04 16:00	8/21/04 15:00	8/21/04 16:30	8/21/04 13:00	8/21/04 16:00
Stage Finish	0.789	0.836	1.004	0.979	0.913	0.784	1.062	0.909	0.845	0.941	1.497
Stage Finish Date/Time	8/21/04 19:00	8/21/04 17:30	8/22/04 8:15	8/22/04 6:15	8/21/04 19:45	8/21/04 18:30	8/22/04 14:45	8/21/04 18:00	8/22/04 11:30	8/21/04 17:00	8/22/04 4:00
Stage Range (Ft)	0.240	0.290	0.447	0.445	0.340	0.232	0.090	0.353	0.366	0.414	0.054
Elapsed Time (Day)	0.10	0.17	0.65	0.63	0.23	0.17	0.95	0.13	0.79	0.17	0.50
Vertical Feet per Hour	0.0960	0.0725	0.0288	0.0297	0.0618	0.0579	0.0040	0.1178	0.0193	0.1035	0.0045

Table 9
Analysis of Low Frequency Signal Propagation

Gage No.	Description	Hurricane Ivan				
		Date/Time	Stage	Lag S-3 (hrs)	Reduction v S-3 (ft)	Reduction v S-3 (%)
S-3	Reserve Relief at Lake	9/15/04 21:00	2.6			
S-24	Reserve Relief at Airline Hwy	9/16/04 21:00	2.3	24.0	0.2	9%
S-10	Blind River at ARDC	9/15/04 22:00	2.5	1.0	0.1	2%
S-16	Blind River at I-10	9/16/04 20:00	2.3	23.0	0.3	10%
S-4	Dutch Bayou at Lake	9/15/04 21:00	2.6	0.0	0.0	0%
S-9	Dutch Bayou D/S of Miss Bayou	9/16/04 15:45	2.3	18.7	0.3	12%
S-23	North Swamp	9/18/04 2:00	1.6	53.0	0.9	36%
S-11	Mississippi Bayou at I-10	9/17/04 8:15	1.8	35.2	0.8	31%
S-7	Hope Canal at I-10	9/18/04 2:30	1.7	53.5	0.9	34%
S-5	Hope Canal at Airline Hwy	9/19/04 4:00	1.6	79.0	1.0	40%
S-25	Central Swamp	9/20/04 1:00	1.6	100.0	1.0	38%

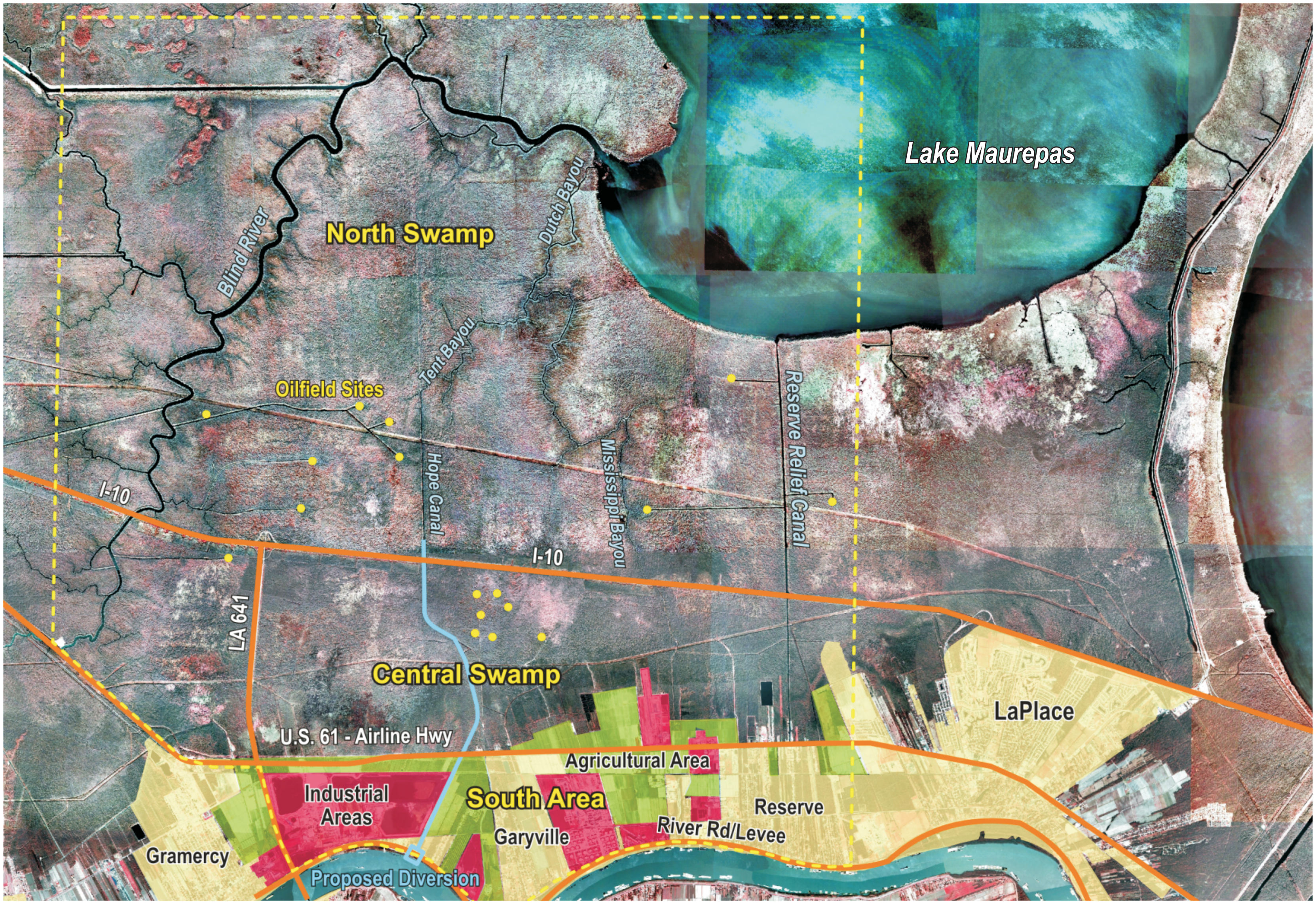
Gage No.	Description	Tropical Storm Ivan				
		Date/Time	Stage	Lag S-3 (hrs)	Reduction v S-3 (ft)	Reduction v S-3 (%)
S-3	Reserve Relief at Lake	9/23/04 21:30	2.7			
S-24	Reserve Relief at Airline Hwy	9/24/04 10:00	2.5	12.5	0.2	7%
S-10	Blind River at ARDC	9/23/04 23:00	2.8	1.5	-0.2	-6%
S-16	Blind River at I-10	9/24/04 4:30	2.5	7.0	0.1	5%
S-4	Dutch Bayou at Lake	9/23/04 21:30	2.8	0.0	-0.2	-6%
S-9	Dutch Bayou D/S of Miss Bayou	9/24/04 2:30	2.5	5.0	0.1	5%
S-23	North Swamp	9/25/04 3:30	2.1	30.0	0.5	21%
S-11	Mississippi Bayou at I-10	9/25/04 1:15	2.1	27.7	0.5	20%
S-7	Hope Canal at I-10	9/25/04 4:00	2.1	30.5	0.5	21%
S-5	Hope Canal at Airline Hwy	9/25/04 18:00	1.9	44.5	0.7	29%
S-25	Central Swamp	9/25/04 12:00	2.0	38.5	0.6	25%

Gage No.	Description	Tropical Storm Matthew (possibly impacted by rainfall)				
		Date/Time	Stage	Lag S-3 (hrs)	Reduction v S-3 (ft)	Reduction v S-3 (%)
S-3	Reserve Relief at Lake	10/10/04 20:00	4.5			
S-24	Reserve Relief at Airline Hwy	10/11/04 5:00	4.3	9.0	0.2	8%
S-10	Blind River at ARDC	10/10/04 22:00	4.7	2.0	-0.2	-6%
S-16	Blind River at I-10	10/11/04 13:30	4.1	17.5	0.5	18%
S-4	Dutch Bayou at Lake	OUT				
S-9	Dutch Bayou D/S of Miss Bayou	10/10/04 22:00	4.5	2.0	0.0	2%
S-23	North Swamp	10/11/04 5:00	4.2	9.0	0.4	15%
S-11	Mississippi Bayou at I-10	10/11/04 7:30	4.1	11.5	0.5	18%
S-7	Hope Canal at I-10	10/11/04 14:00	3.9	18.0	0.6	24%
S-5	Hope Canal at Airline Hwy	10/12/04 0:00	3.7	28.0	0.8	31%
S-25	Central Swamp	38271.79167	3.9	23.0	0.6	24%

FIGURES

FIGURE 1.

Project Area



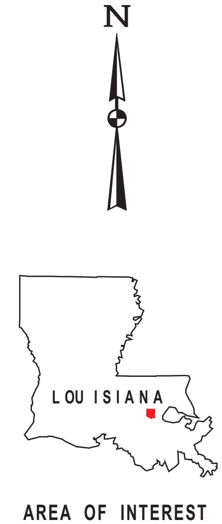
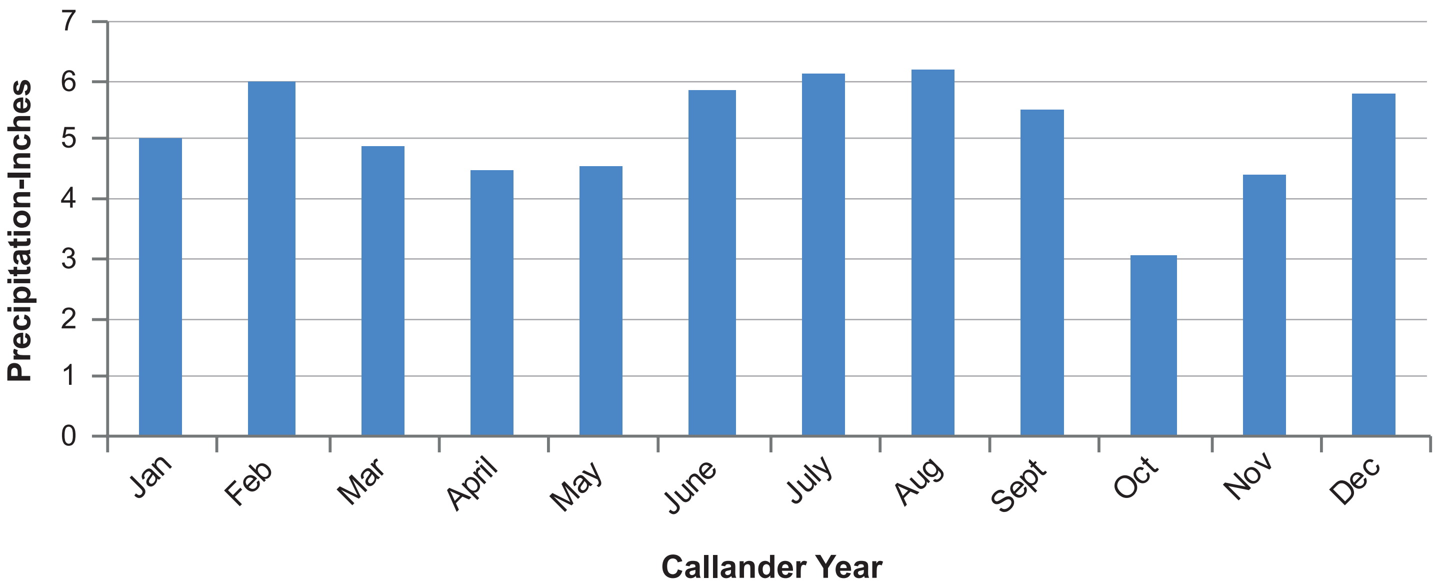


Figure 1

FIGURE 2.

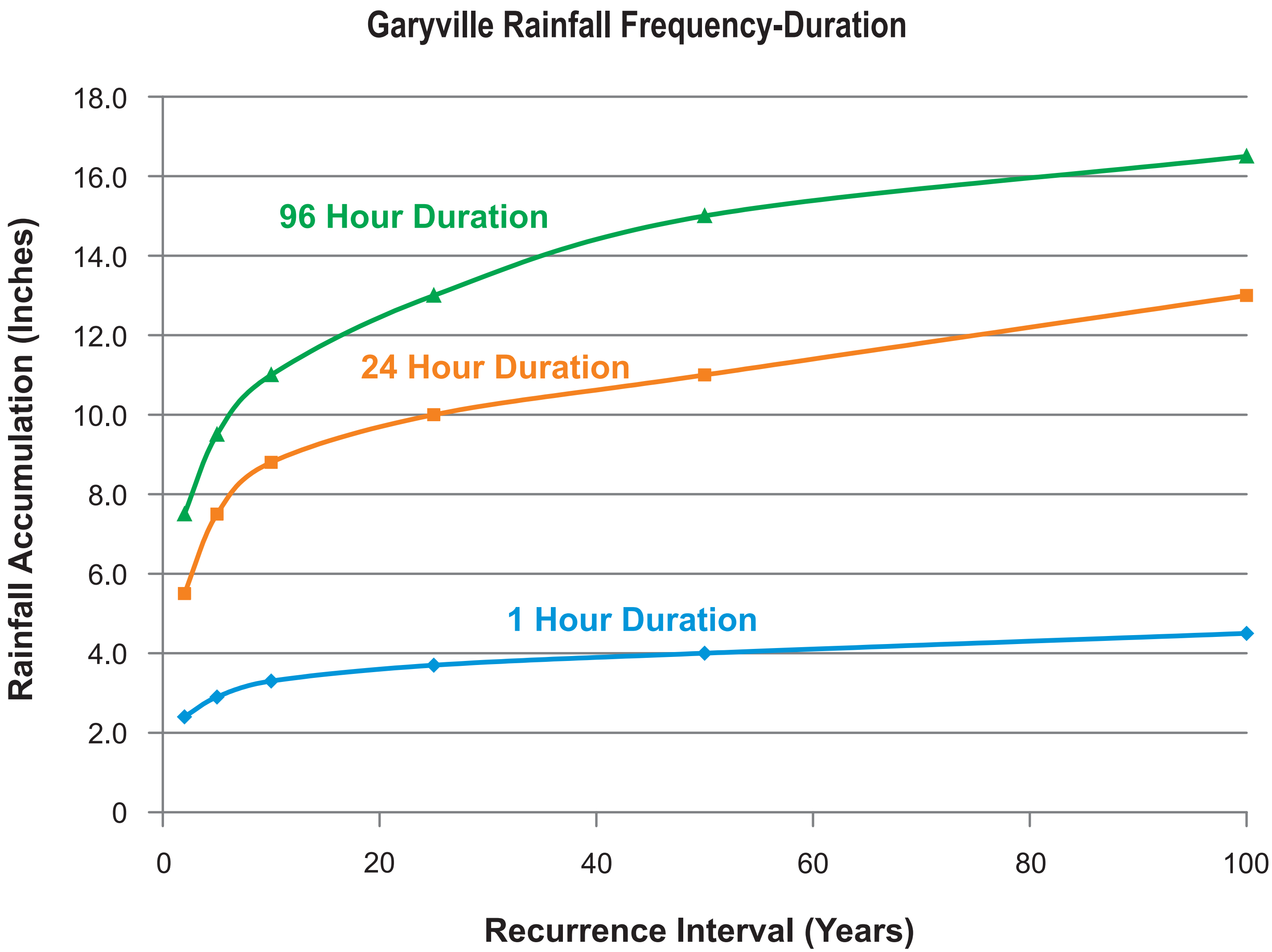
Typical Local Monthly Rainfall Totals (based on New Orleans)



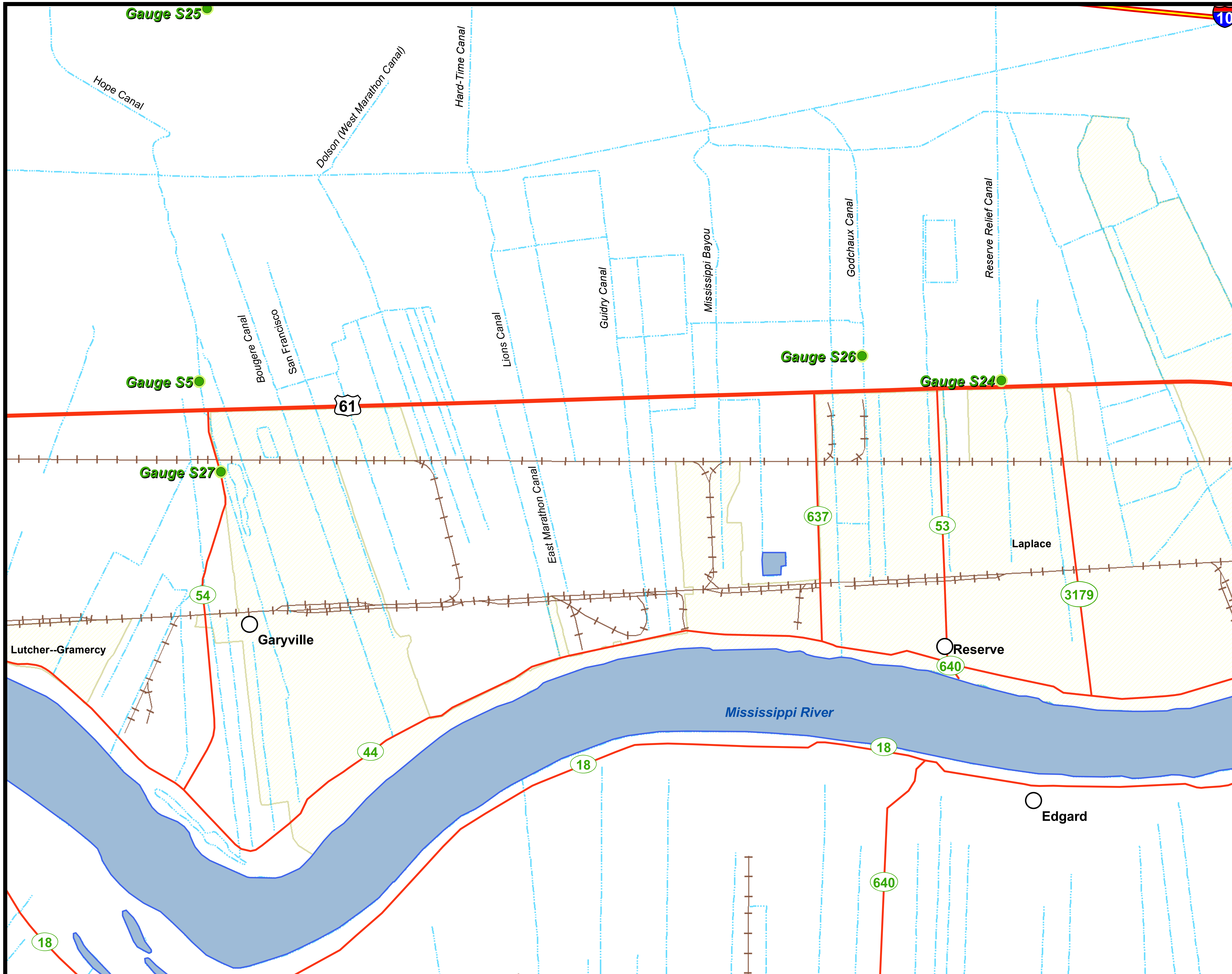
Reference: http://www.met.utah.edu

Figure 2

FIGURE 3.



Reference: technical Paper No. 40 - Rainfall Frequency Atlas of the Eastern United States (http://www.erh.noaa.gov)



N
W E
S

0 3,000 6,000
Feet

1 Inch equals 3,000 Feet

LEGEND
- Gauge Location
- Town or City
- Interstate Highway
- US Highway
- Louisiana Highway
- Railroad
- Hydrography
- Urban Area
- Parish

Figure 4
Hydrographic Features South of US Highway 61

Mississippi River Re-Introduction Into Maurepas Swamp (PO-29)
Louisiana Department of Natural Resources
US Environmental Protection Agency

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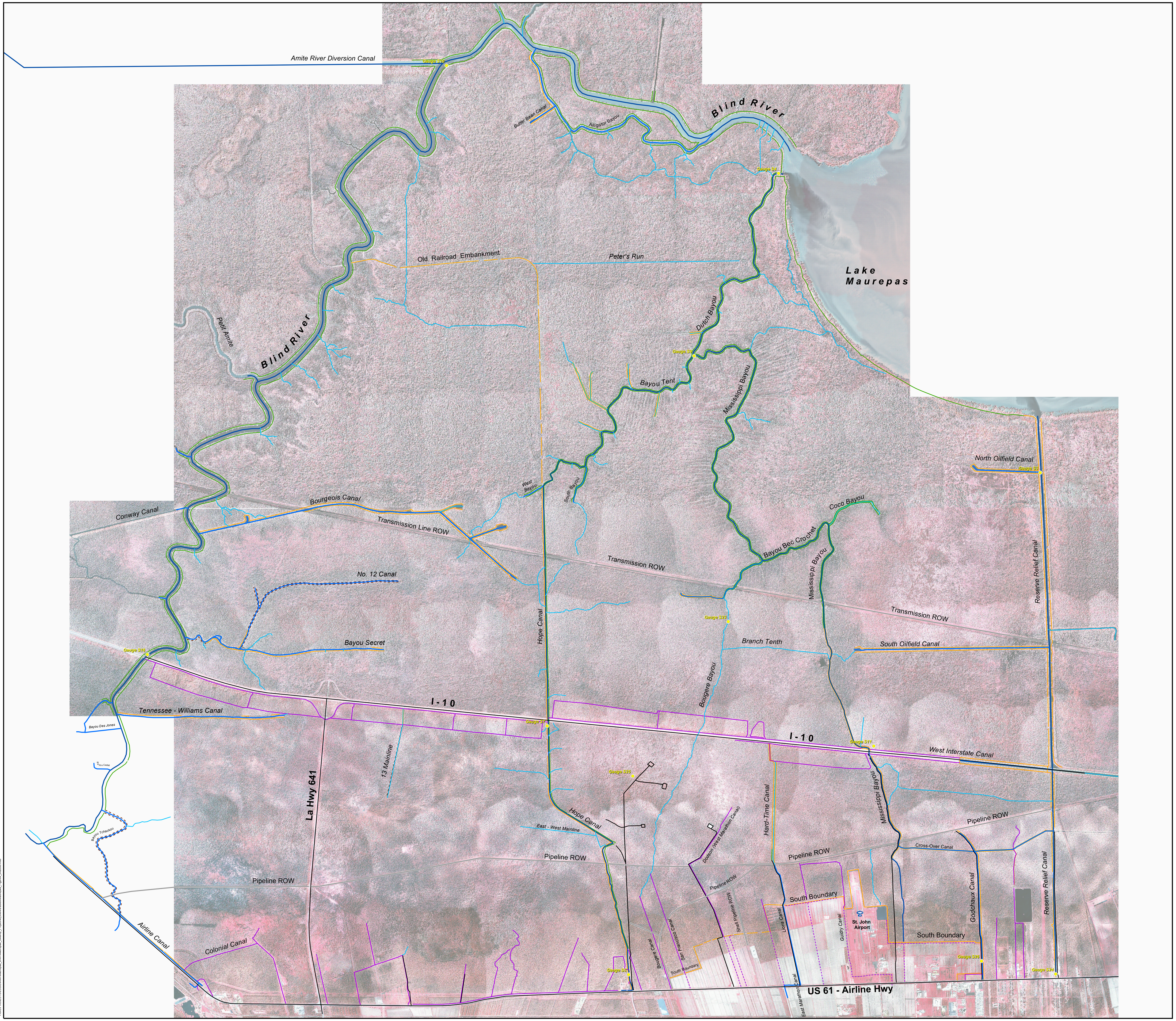


N
W E
S

0 1,500 3,000 4,500 6,000
Feet

1 Inch equals 1,500 Feet

LEGEND

- Gauge Location

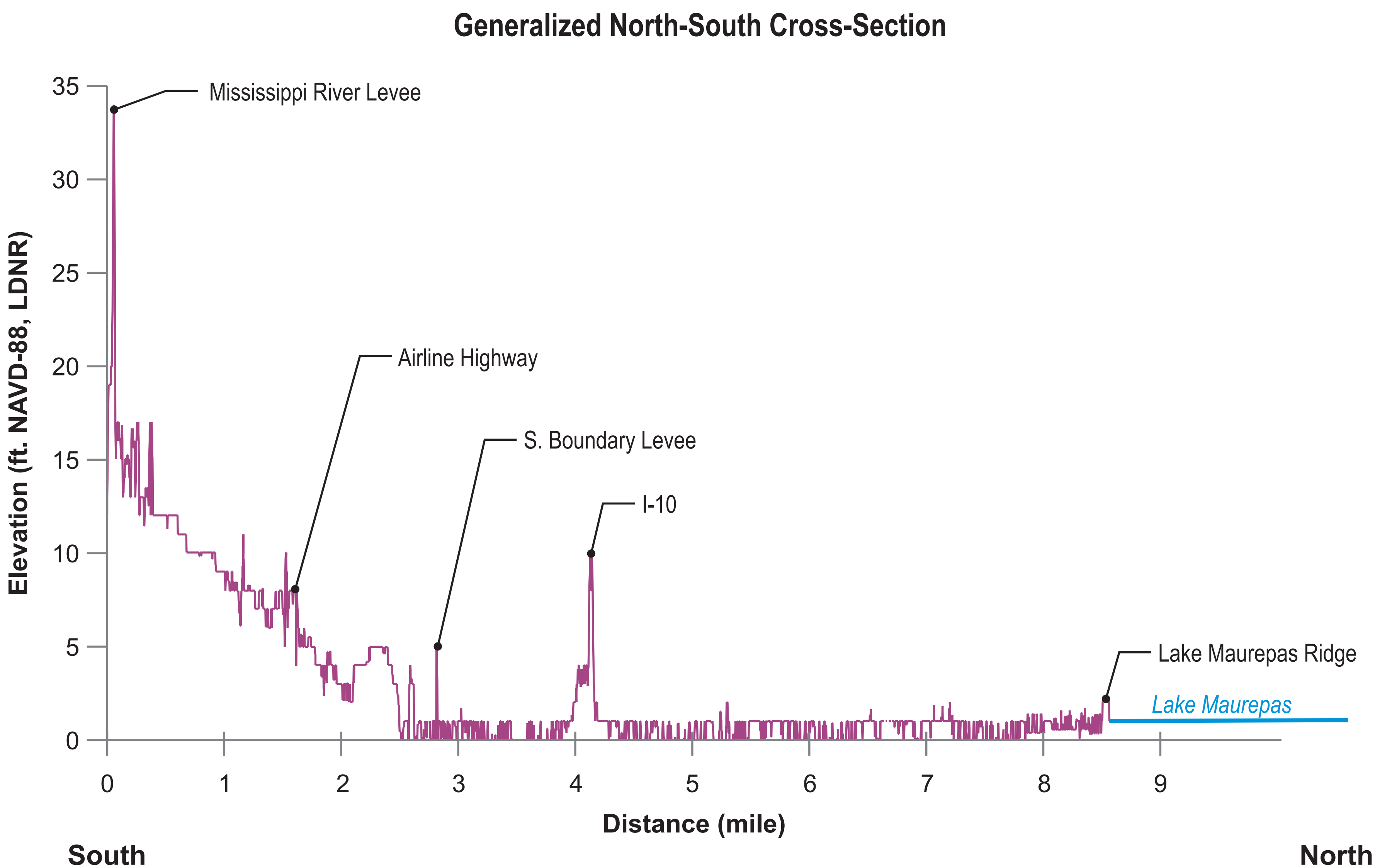
HYDROGRAPHY
- Primary
- Secondary
- Slough
- Ditch
- Interior Ditch

EMBANKMENT
- Natural Bank
- Artificial Bank
- Highly Broken Bank
- ROW
- ROAD

Figure 5
Hydrographic Features
North of US Highway 61

Mississippi River Re-Introduction
Into Maurepas Swamp (PO-29)
Louisiana Department of Natural Resources
US Environmental Protection Agency

FIGURE 6.



Generalized North-South Cross-Section
Mississippi River Levee
Airline Highway
S. Boundary Levee
I-10
Lake Maurepas Ridge
Lake Maurepas
Elevation (ft. NAVD-88, LDNR)
35
30
25
20
15
10
5
0
0
1
2
3
4
5
6
7
8
9
Distance (mile)
South
North

Lake Maurepas Stage-Frequency

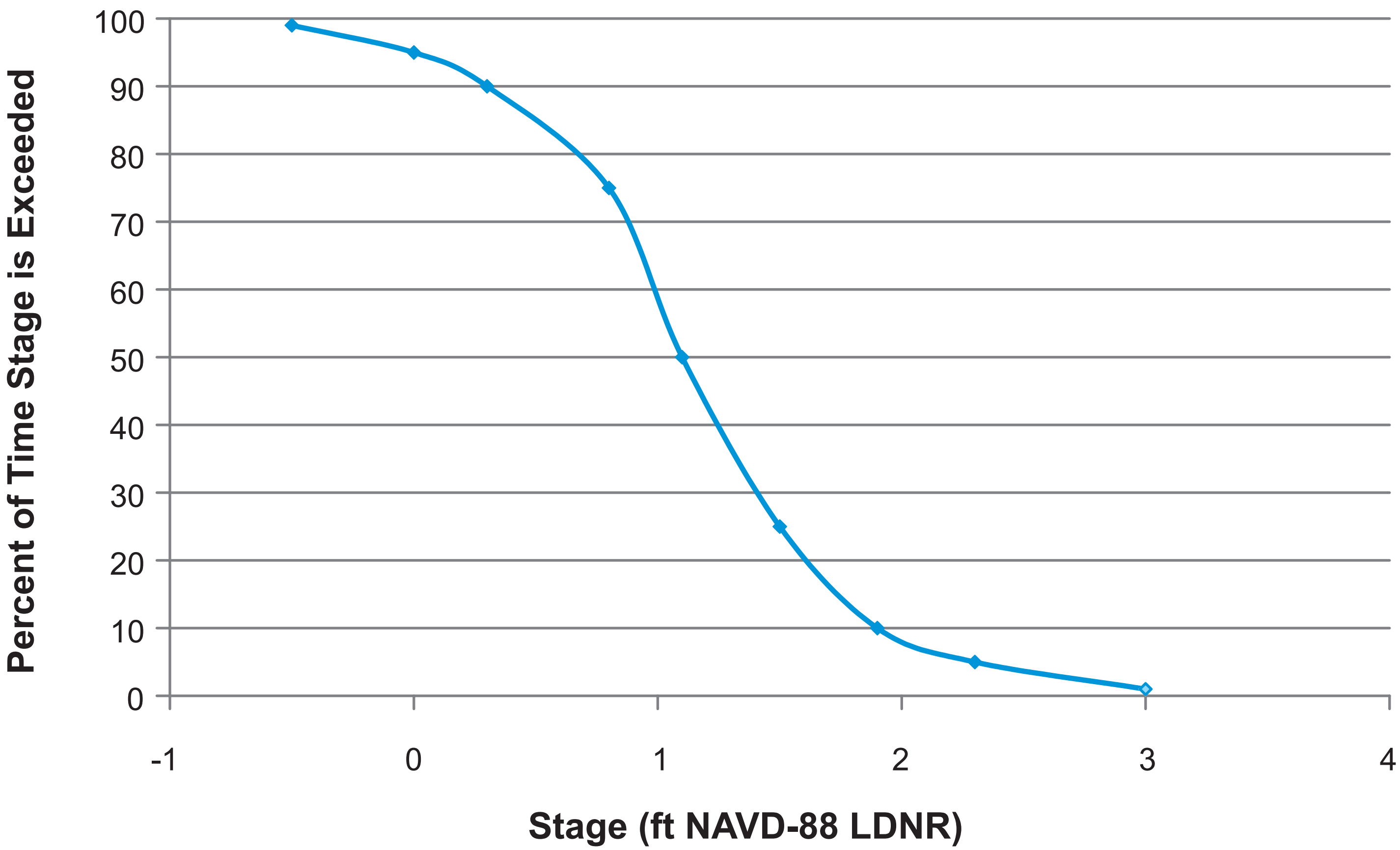
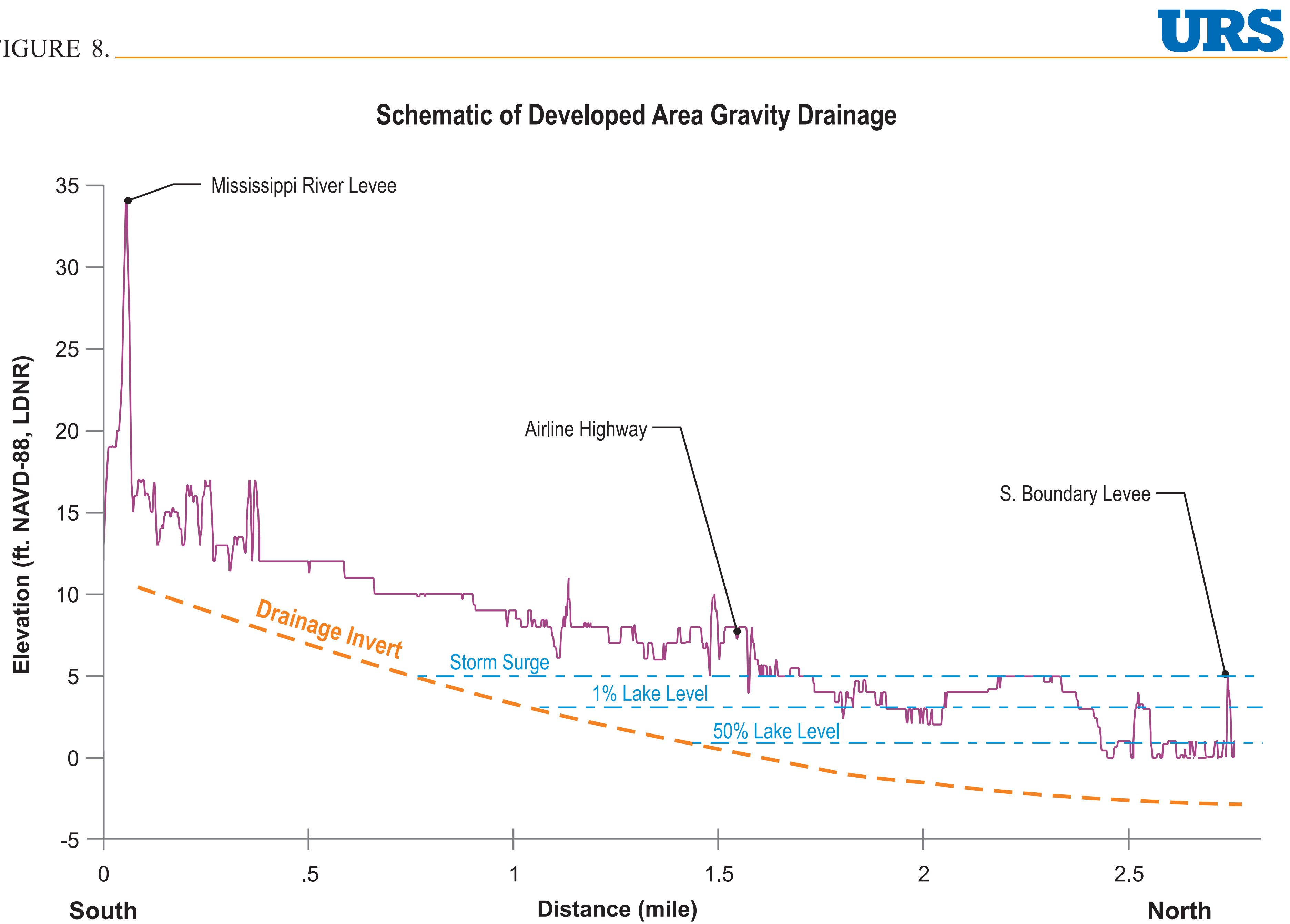
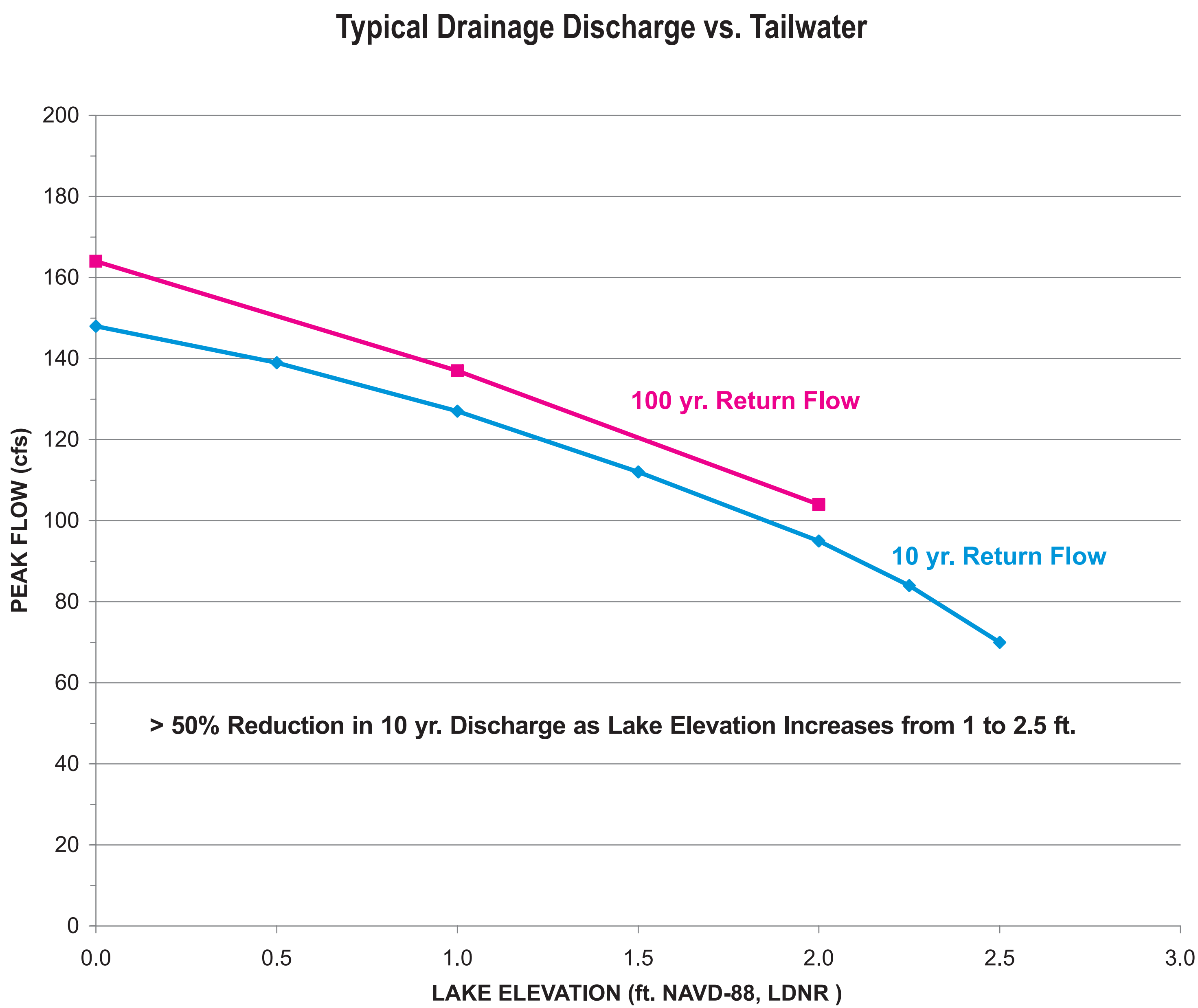


FIGURE 8.



URS
Schematic of Developed Area Gravity Drainage
Elevation (ft. NAVD-88, LDNR)
35
30
25
20
15
10
5
0
-5
Mississippi River Levee
Airline Highway
S. Boundary Levee
Drainage Invert
Storm Surge
1% Lake Level
50% Lake Level
0
.5
1
1.5
2
2.5
South
Distance (mile)
North

FIGURE 9.



Typical Drainage Discharge vs. Tailwater
200
180
160
140
120
100
80
60
40
20
0
PEAK FLOW (cfs)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
LAKE ELEVATION (ft. NAVD-88, LDNR)
100 yr. Return Flow
10 yr. Return Flow
> 50% Reduction in 10 yr. Discharge as Lake Elevation Increases from 1 to 2.5 ft.

Figure 10a Daily Precipitation

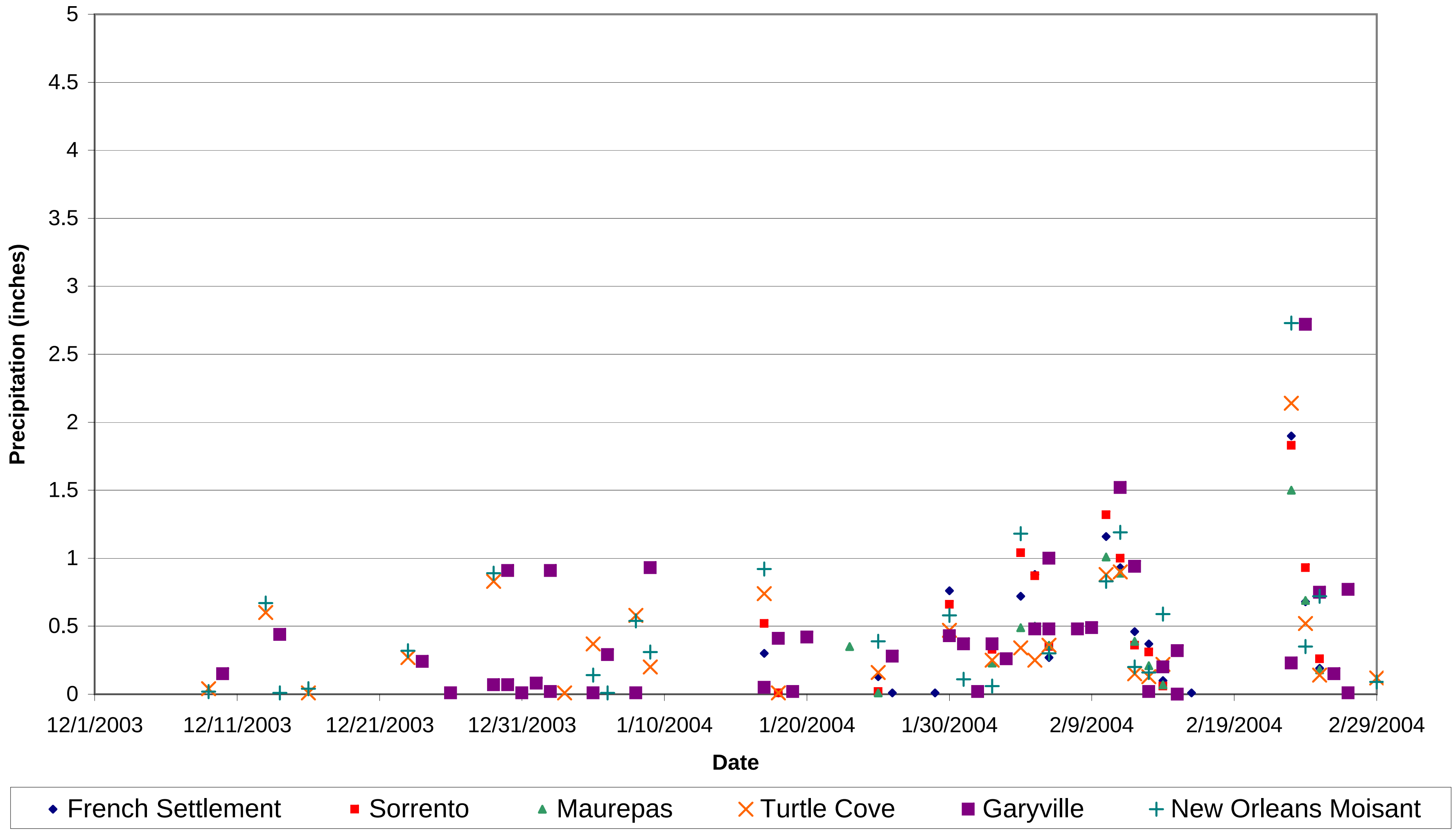


Figure 10b Daily Precipitation

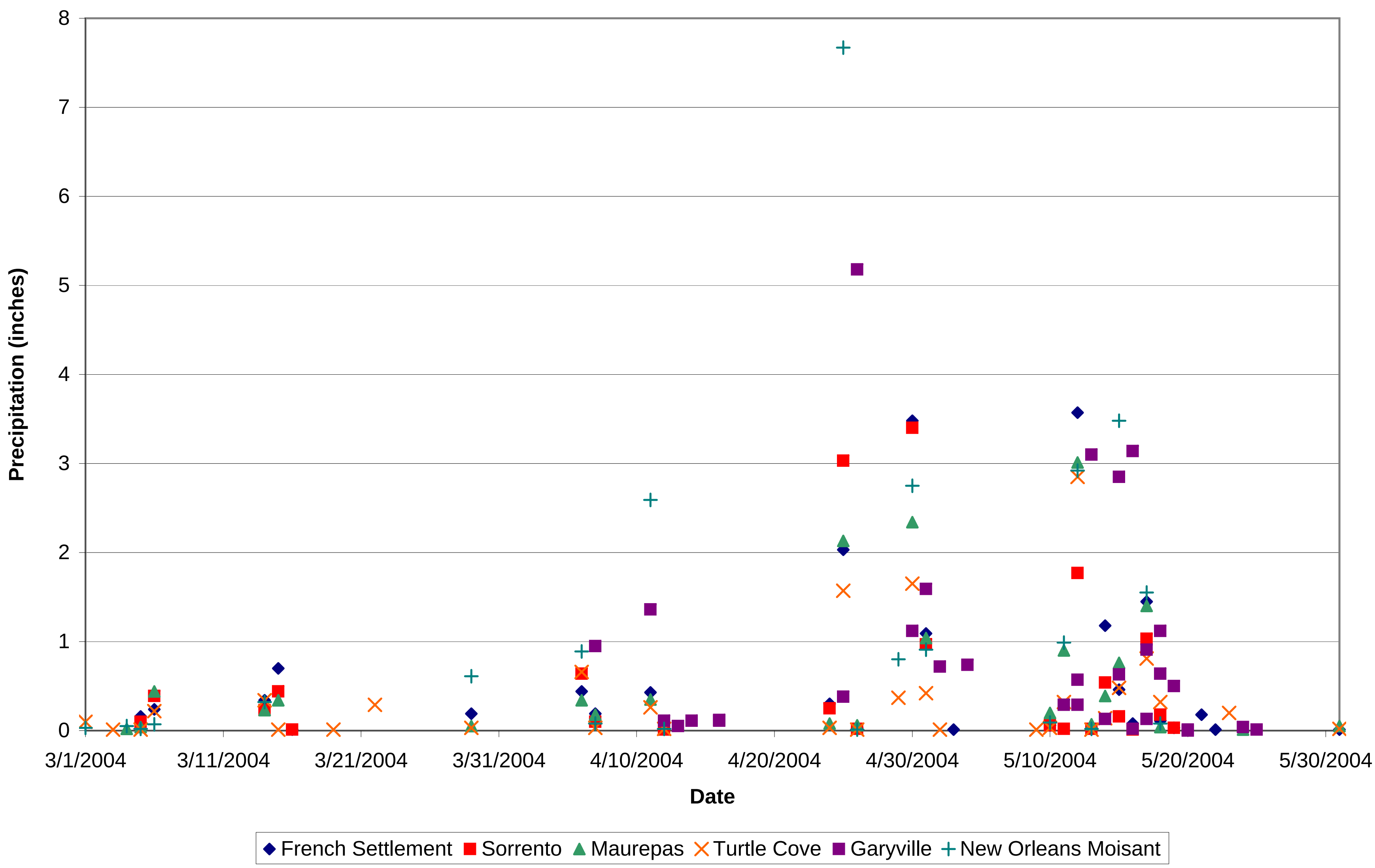


Figure 10c Daily Precipitation

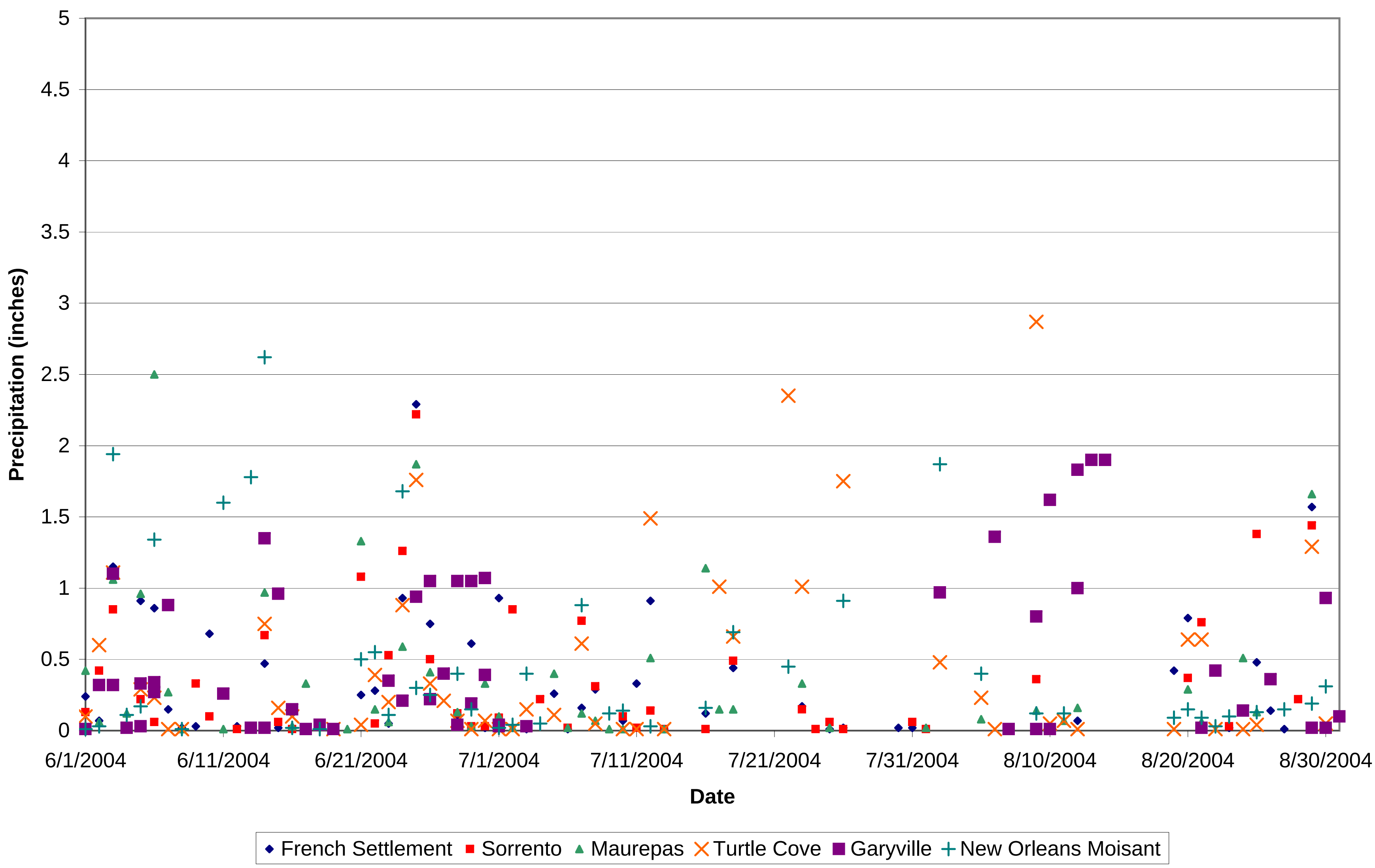


Figure 10d Daily Precipitation

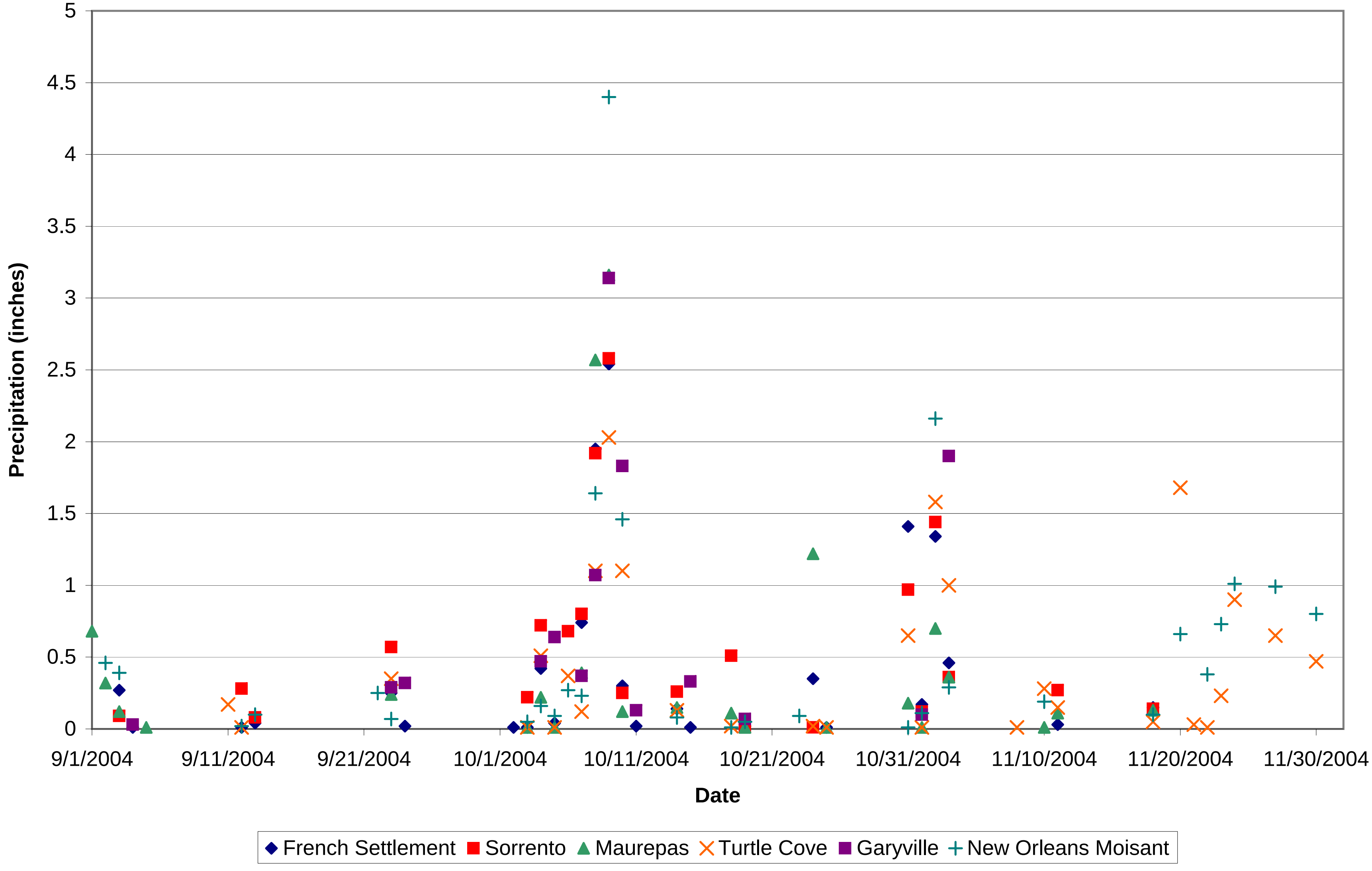
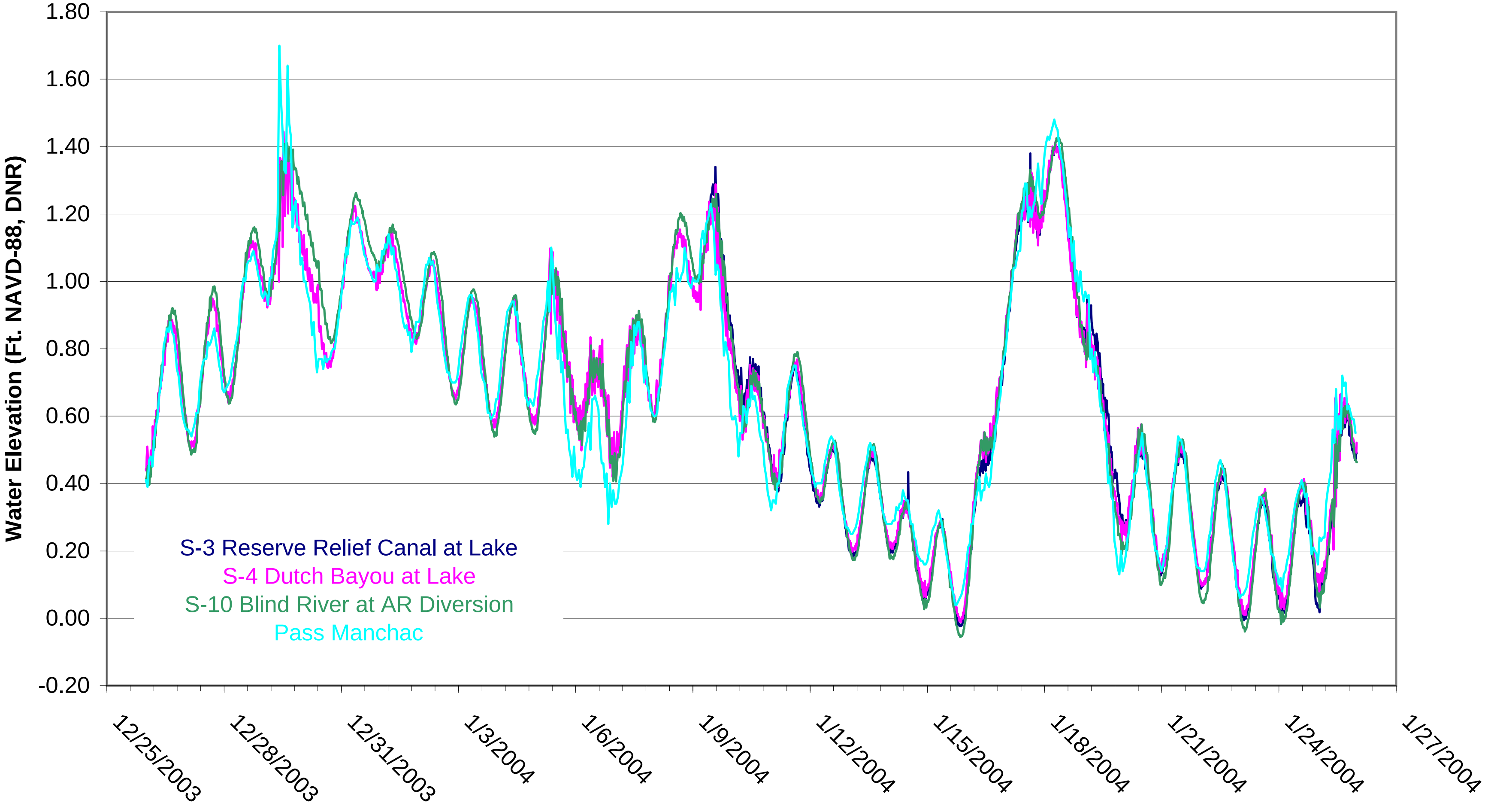


Figure 11
LSU Calibration Period
Stage Hydrographs for Lake Maurepas



Data Range is from December 26, 2003 to January 25, 2004

Figure 12
LSU Calibration Period
Stage Hydrographs for Hope Canal

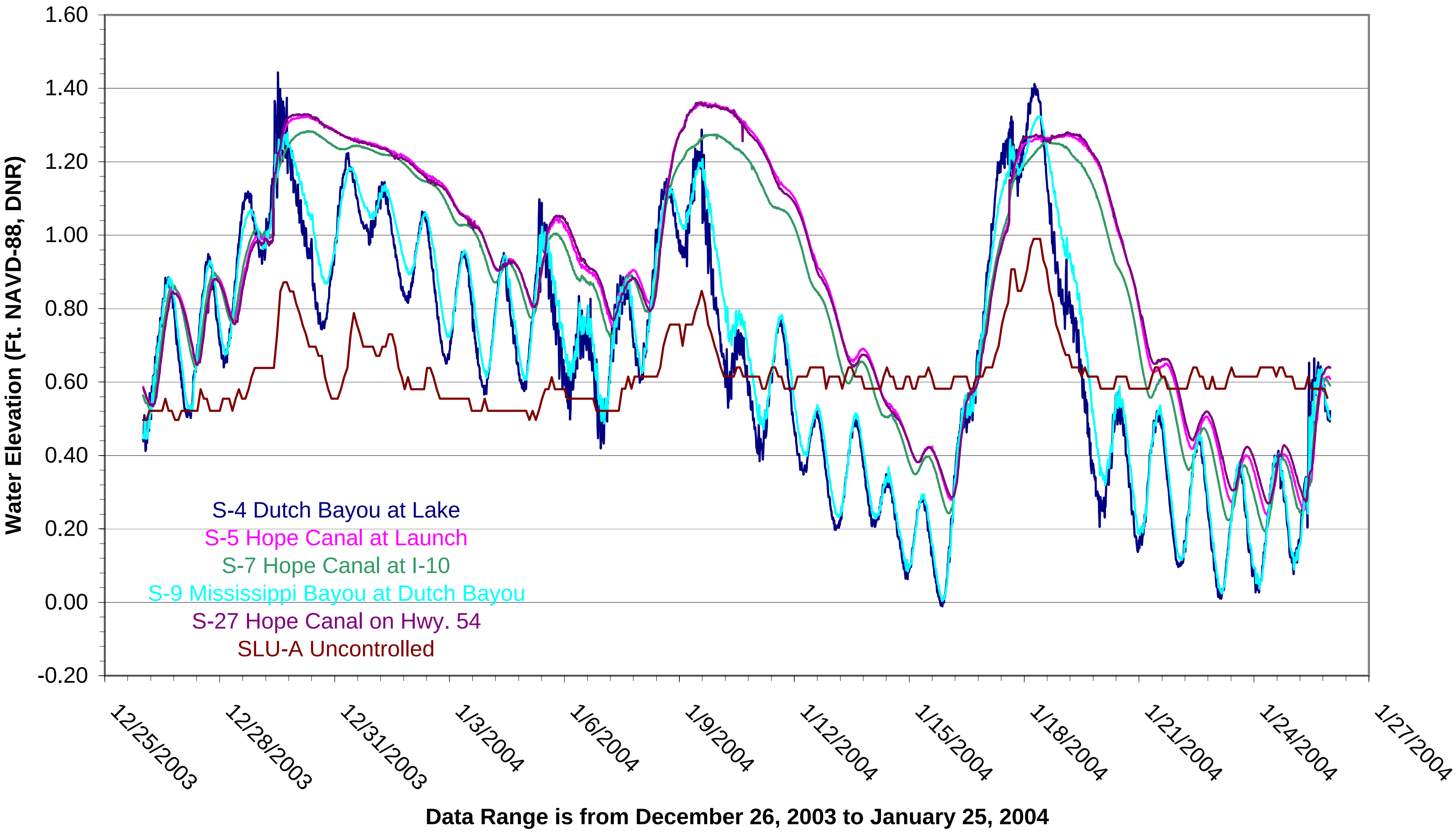
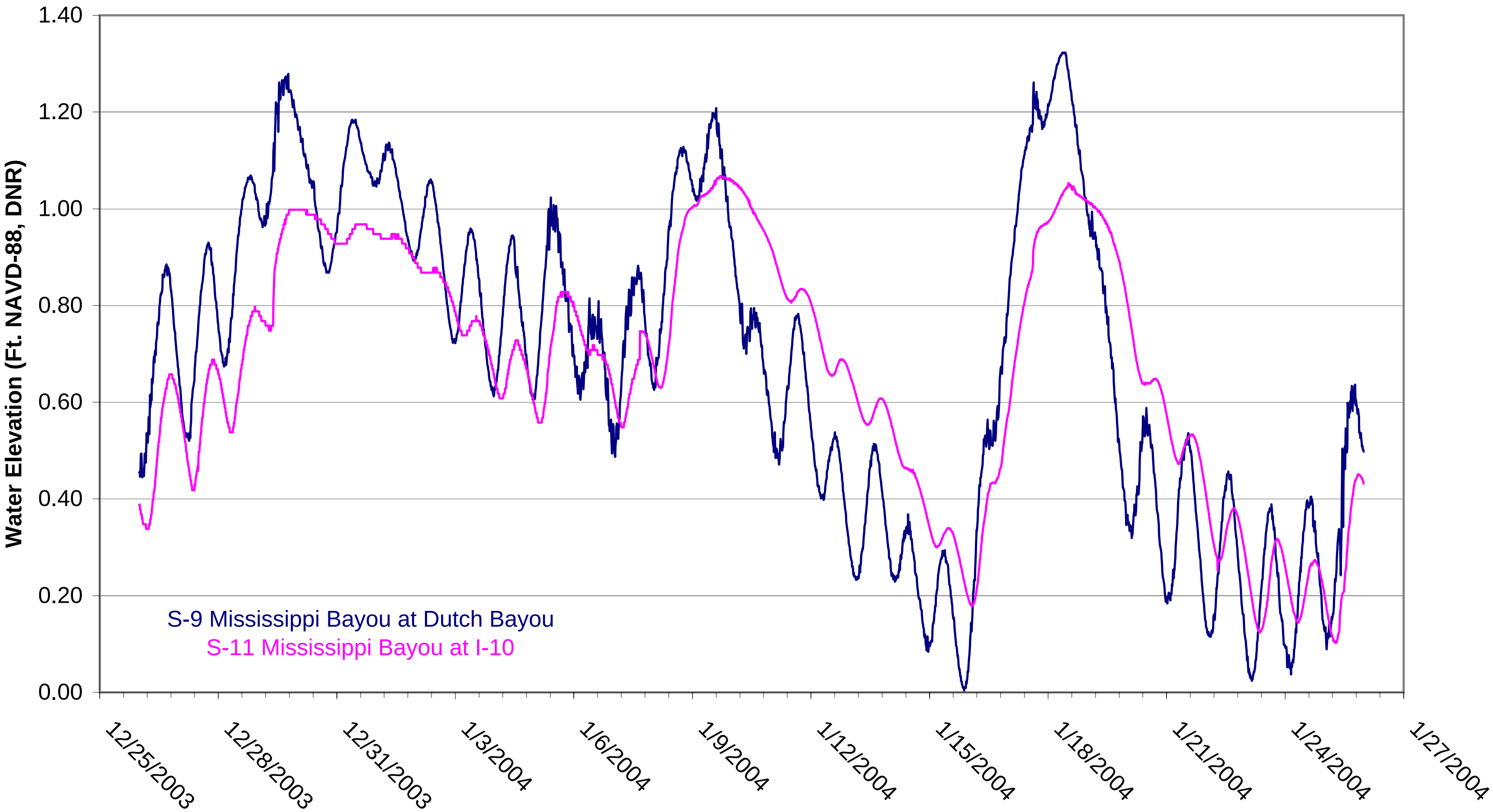


Figure 13
LSU Calibration Period
Stage Hydrographs for the Mississippi Bayou



Data Range is from December 26, 2003 to January 25, 2004

Figure 14
LSU Calibration Period
Stage Hydrographs for the Blind River

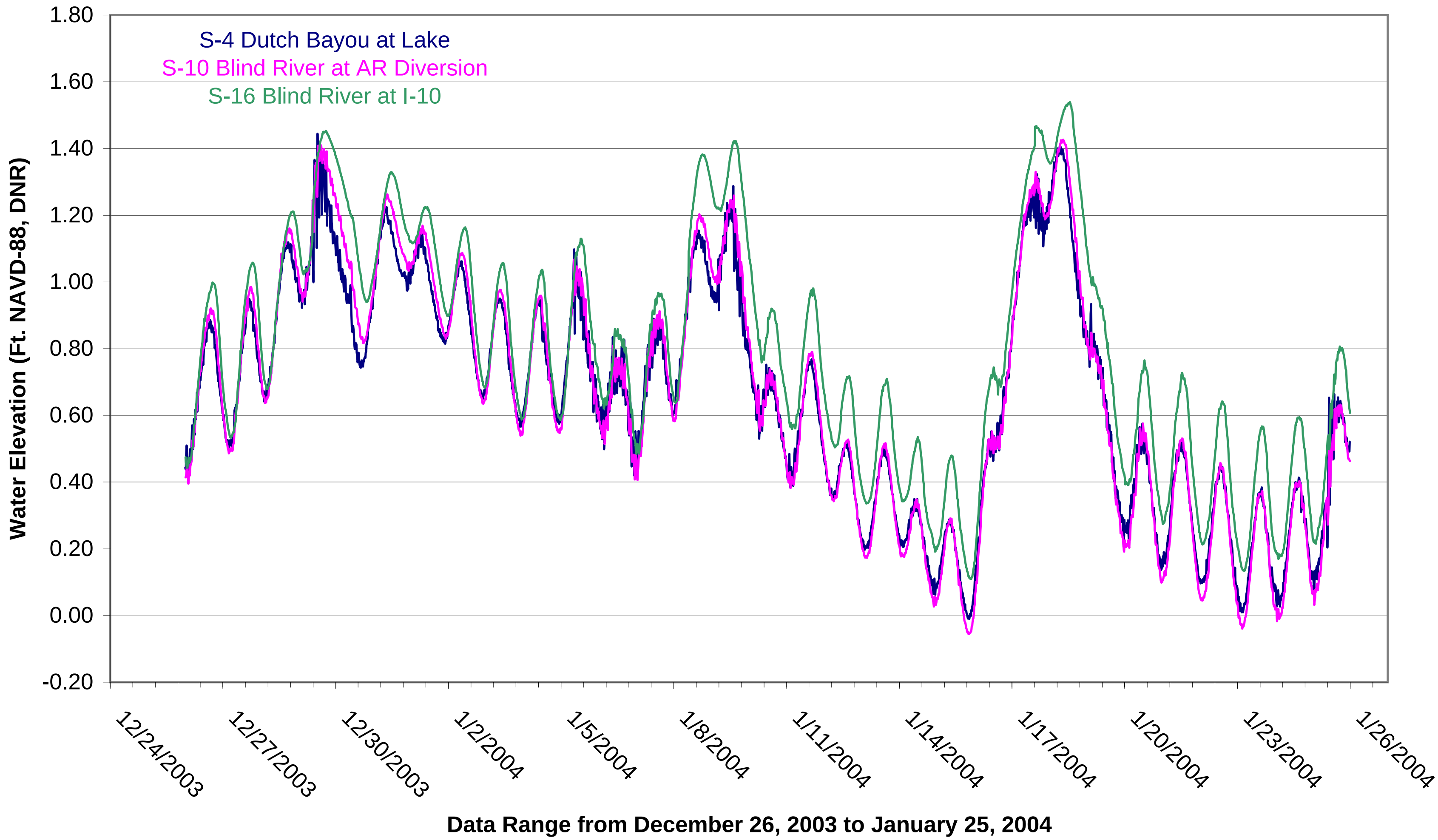


Figure 15
LSU Calibration Period
Stage Hydrographs for Reserve Relief Canal

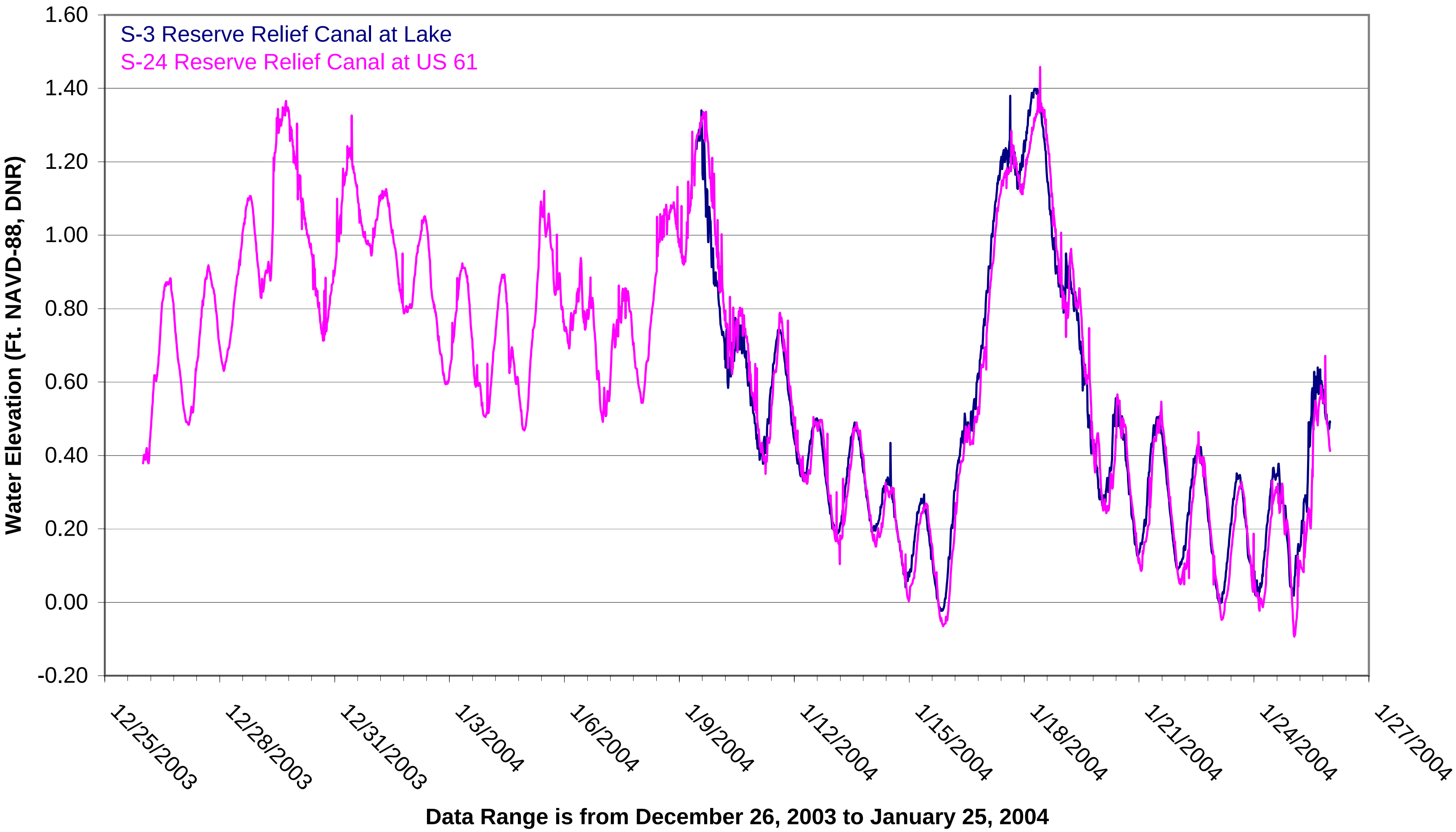


Figure 16
Low Lake and Blind River Flood Calibration Periods
Stage Hydrographs for Lake Maurepas

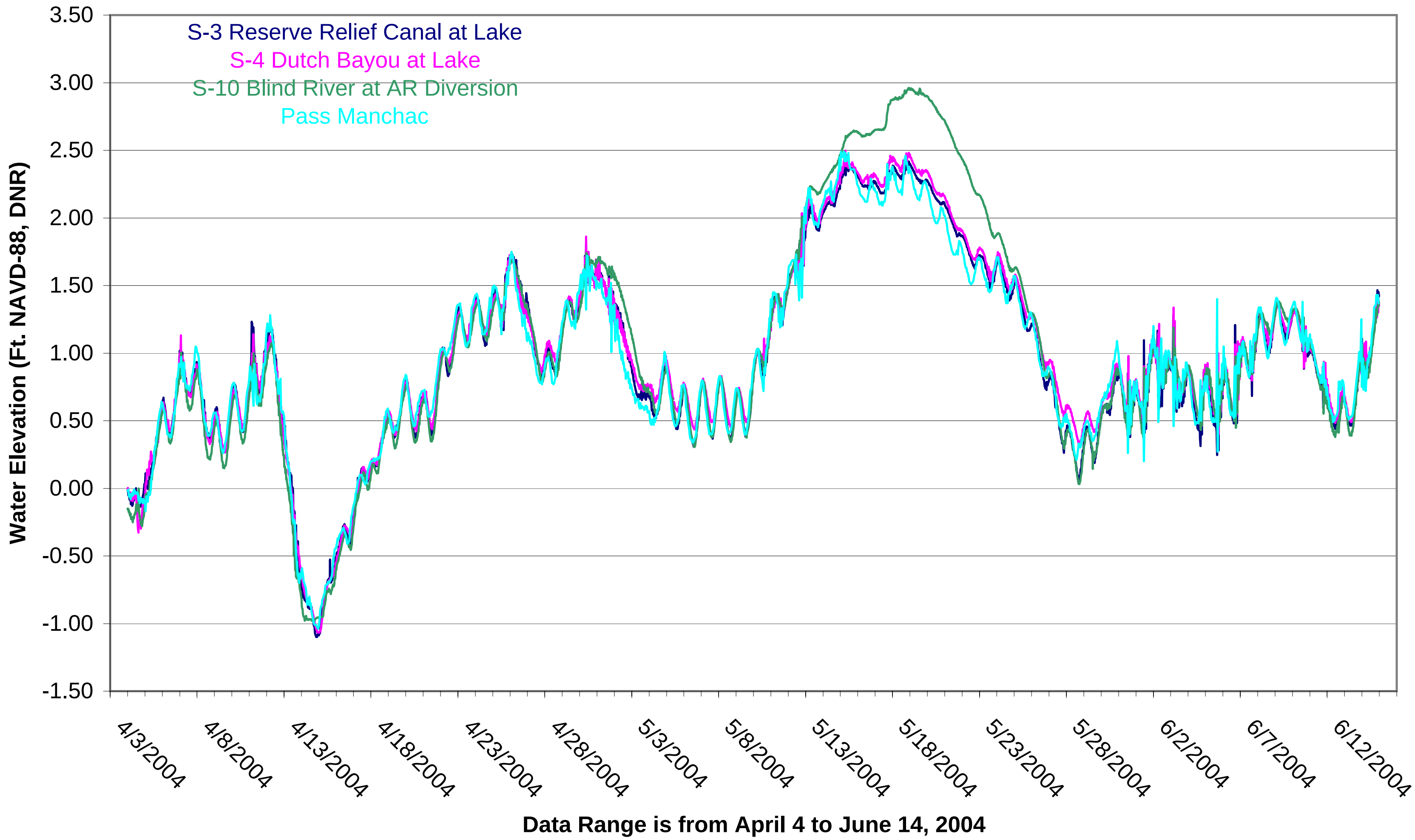


Figure 17
Low Lakes and Blind River Flood Calibration Periods
Stage Hydrographs for Hope Canal

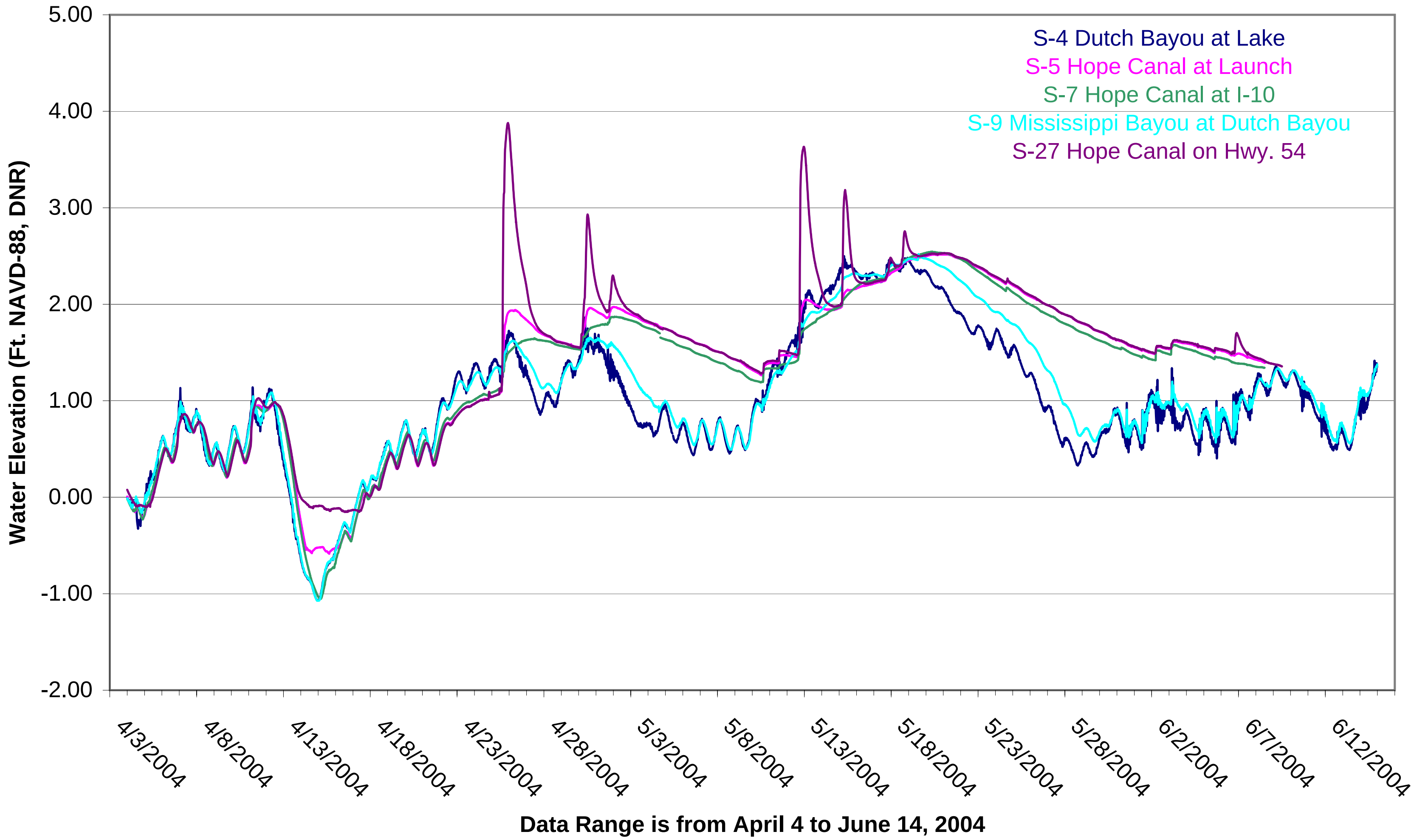


Figure 18
Low Lake and Blind River Calibration Periods
Stage Hydrographs for Mississippi Bayou

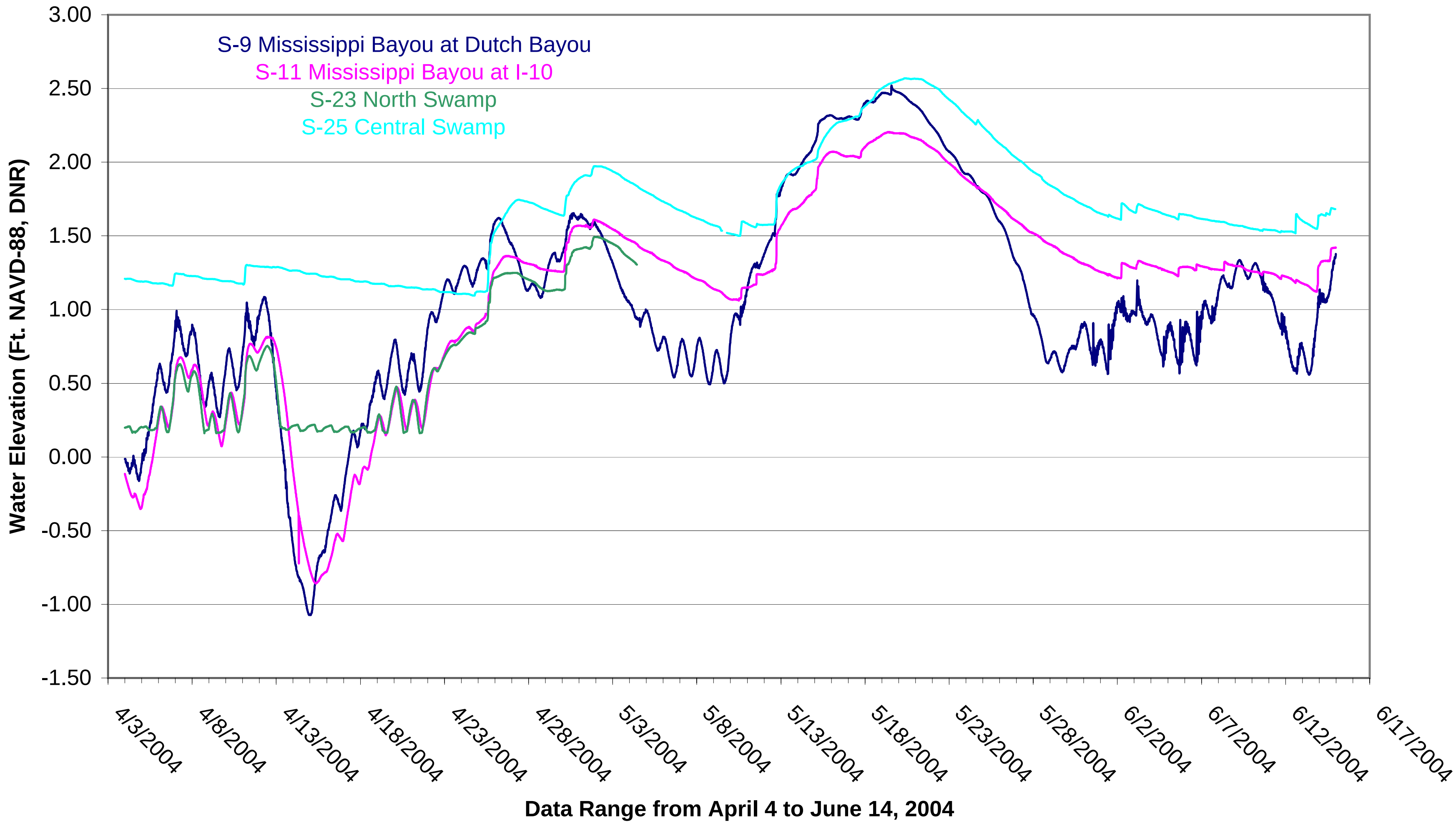


Figure 19
Low Lake and Blind River Flood Calibration Periods
Stage Hydrographs for Blind River

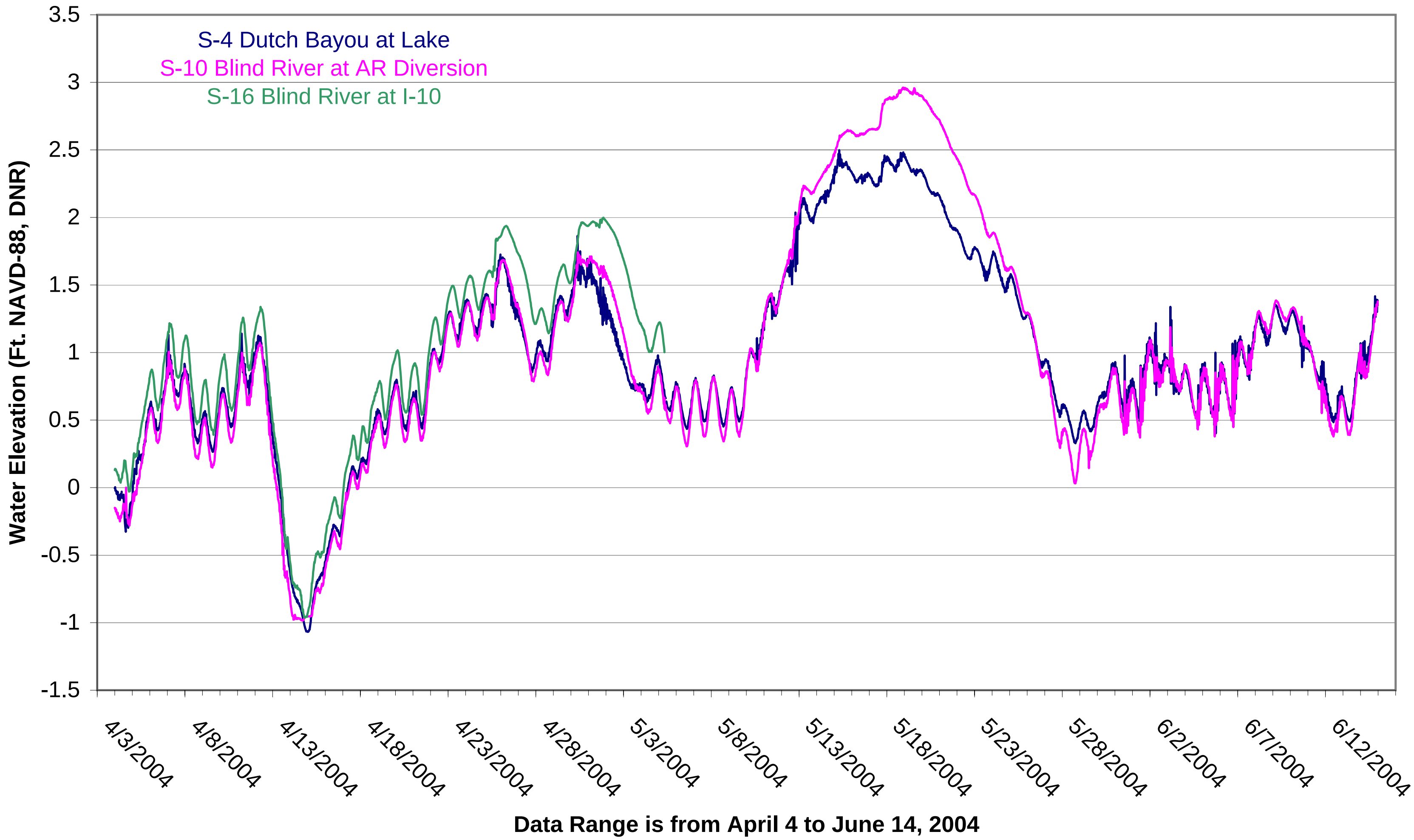


Figure 20
Low Lake and Blind River Flood Calibration Periods
Stage Hydrographs for Reserve Relief Canal

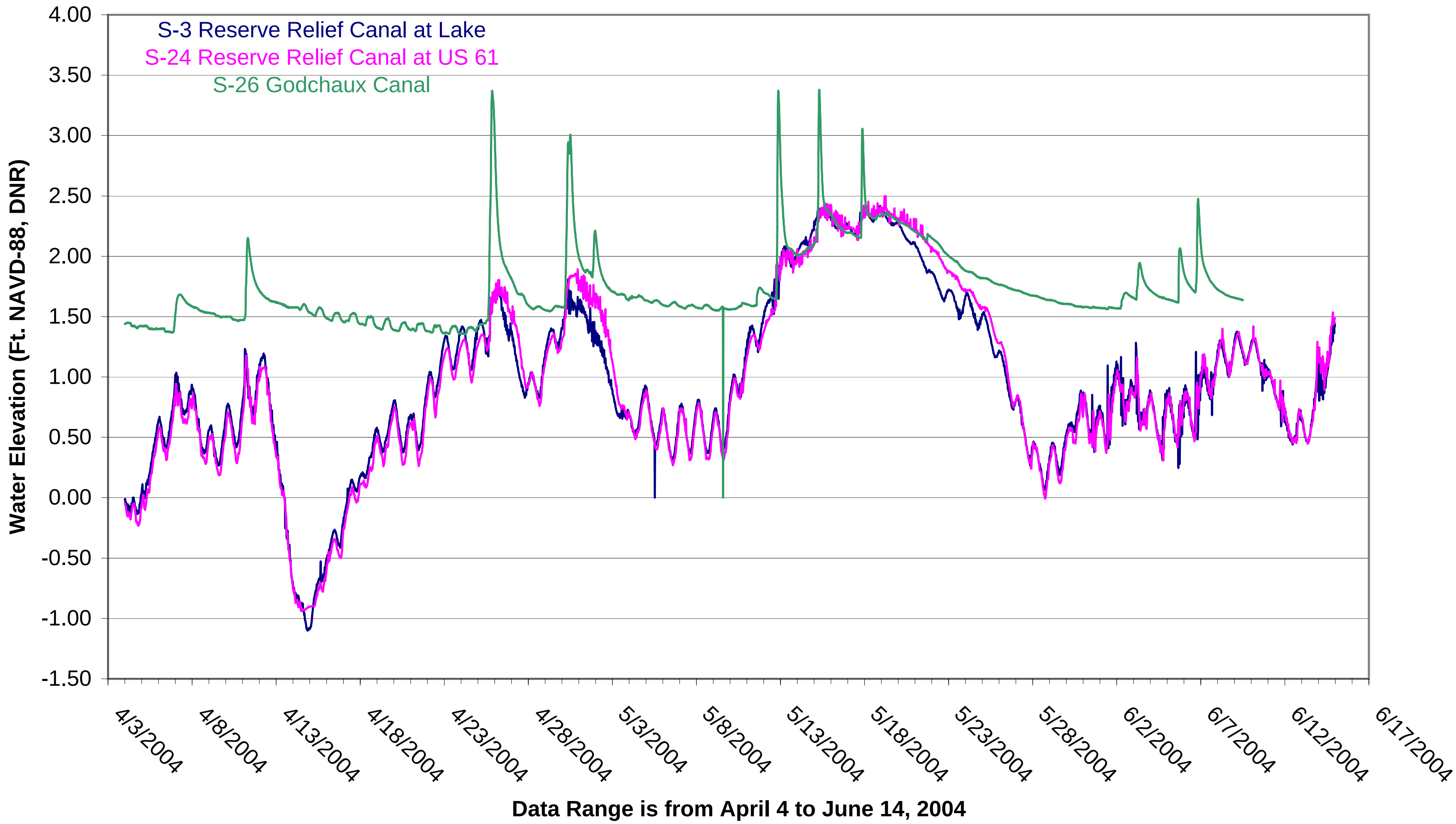


Figure 21
Tropical Storm Surge Calibration Period
Stage Hydrographs for Lake Maurepas

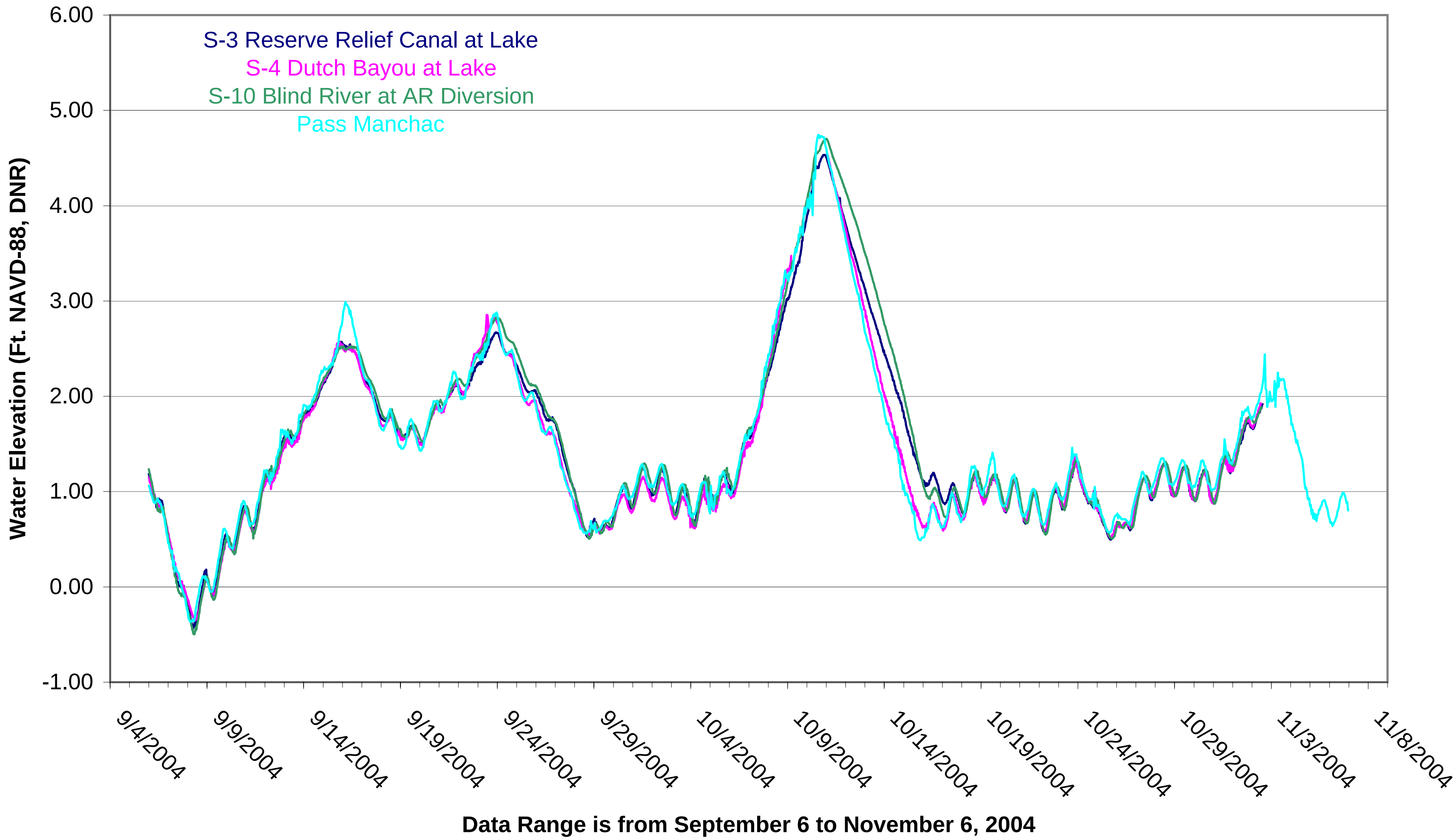
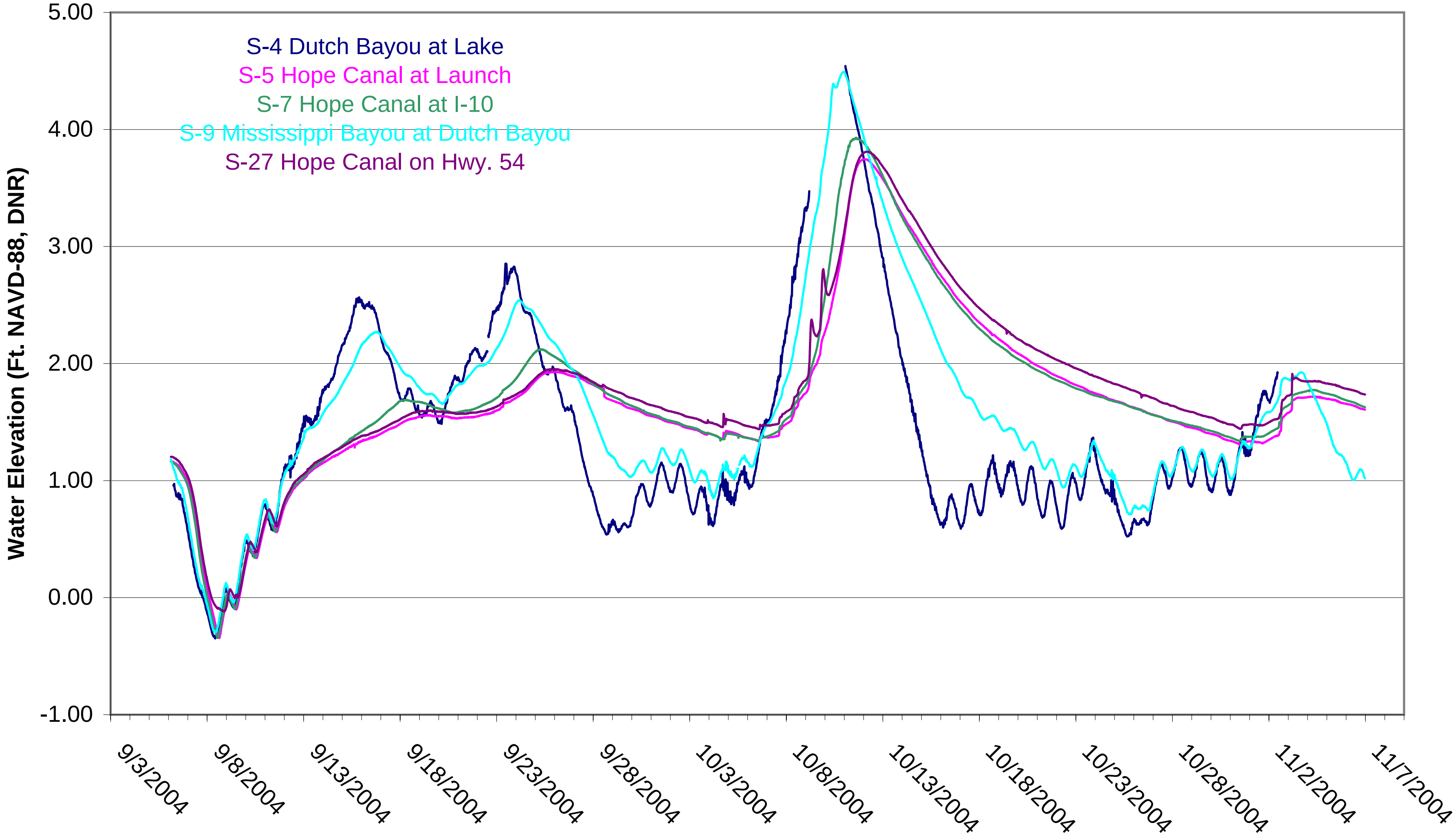


Figure 22
Tropical Storm Surge Calibration Period
Stage Hydrographs for Hope Canal



Data Range is from September 6 to November 6, 2004

Figure 23
Tropical Strom Surge Calibration Period
Stage Hydrographs for Mississippi Bayou

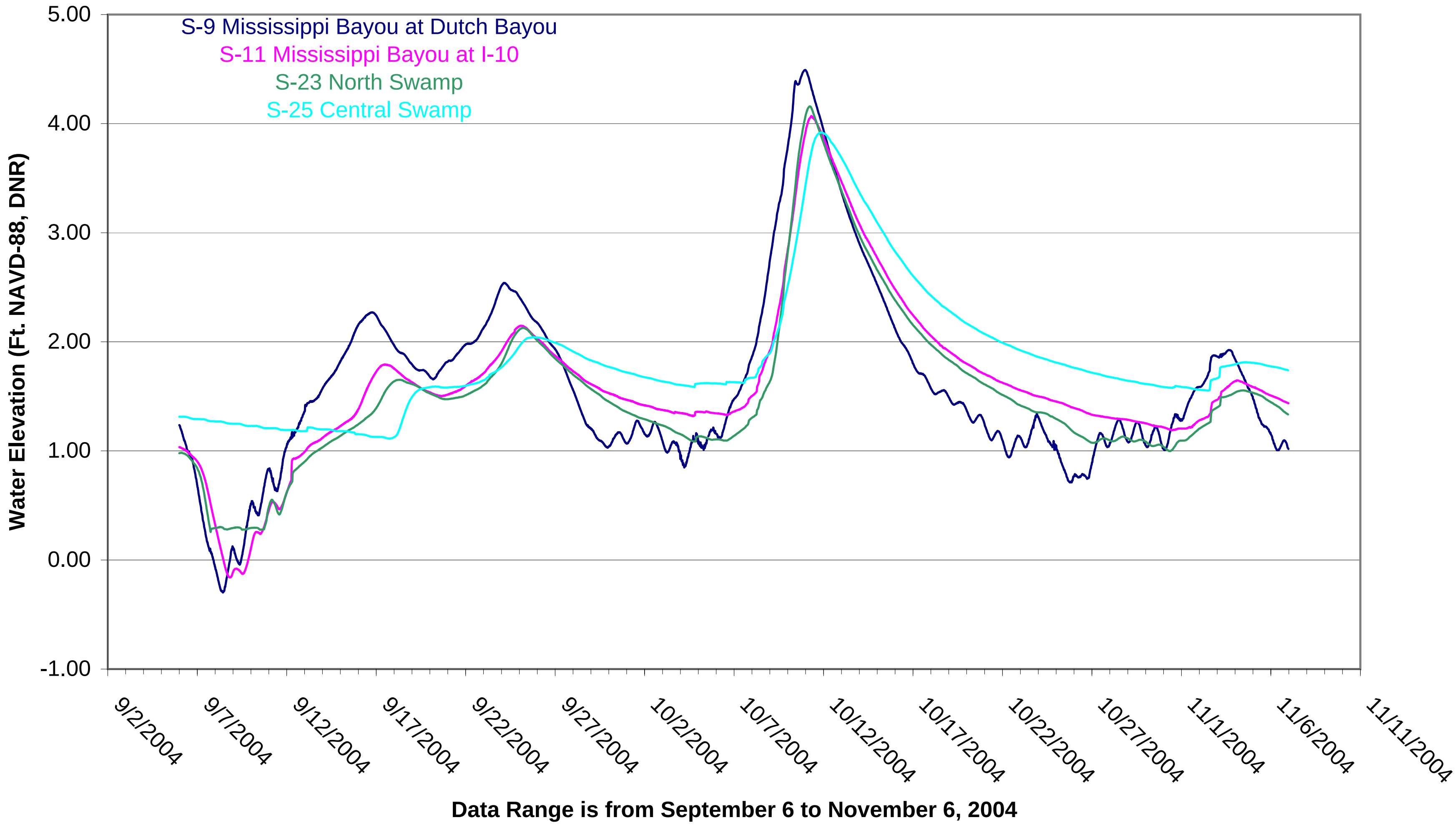
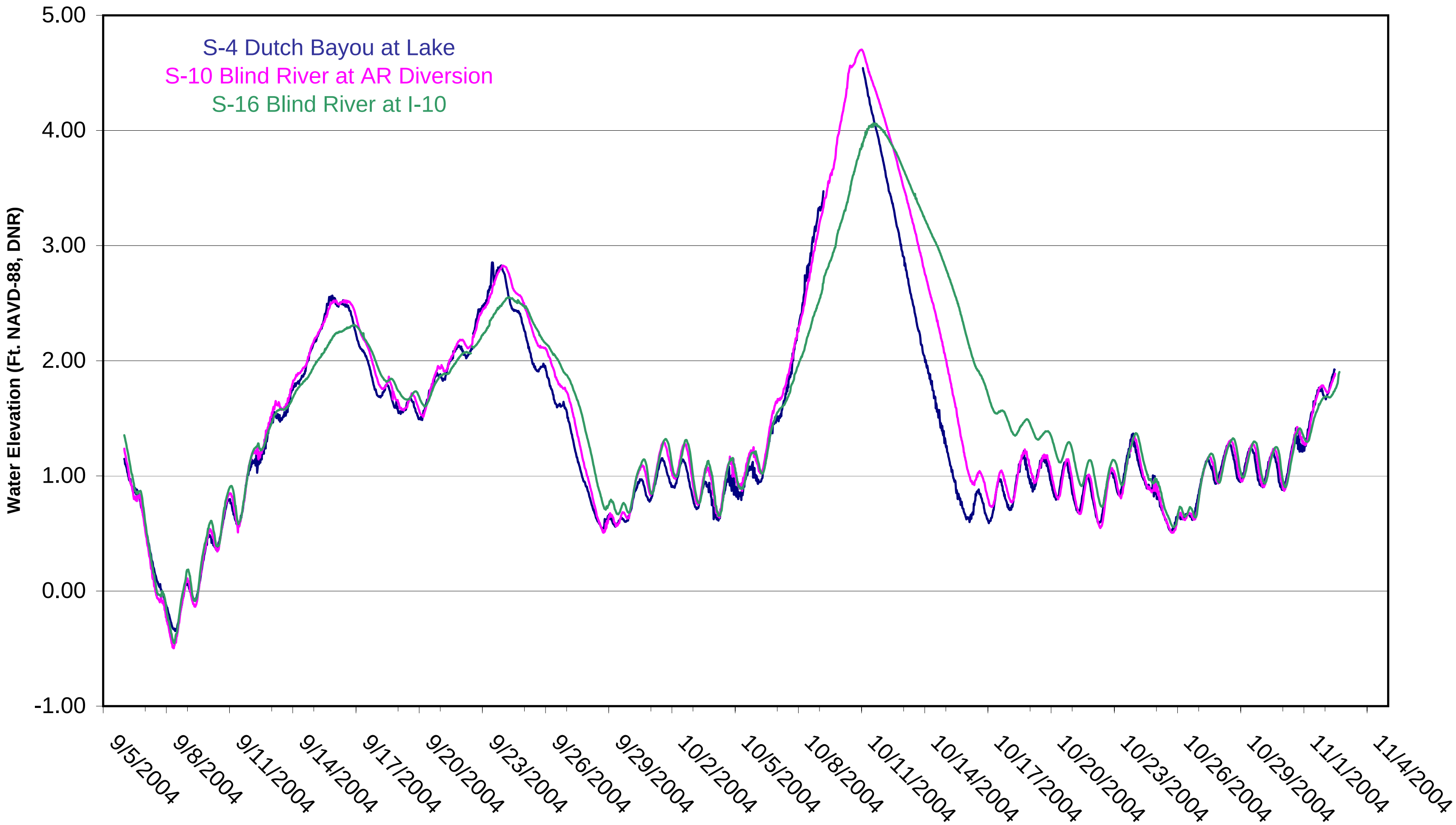


Figure 24
Tropical Storm Surge Calibration Period
Stage Hydrographs for Blind River



Data Range is from September 6 to November 6, 2004

Figure 25
Tropical Storm Surge Calibration Period
Stage Hydrographs for Reserve Relief

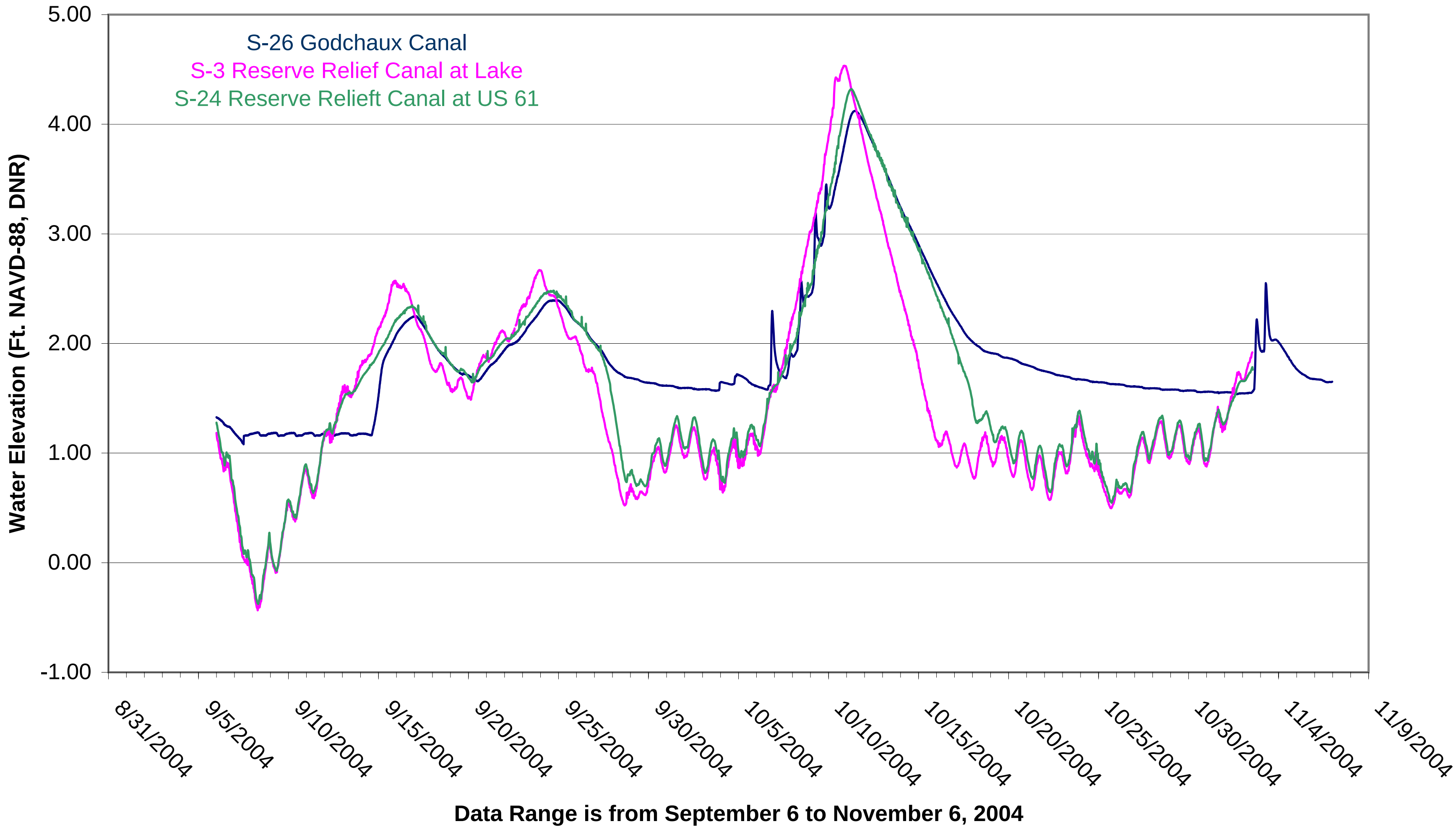
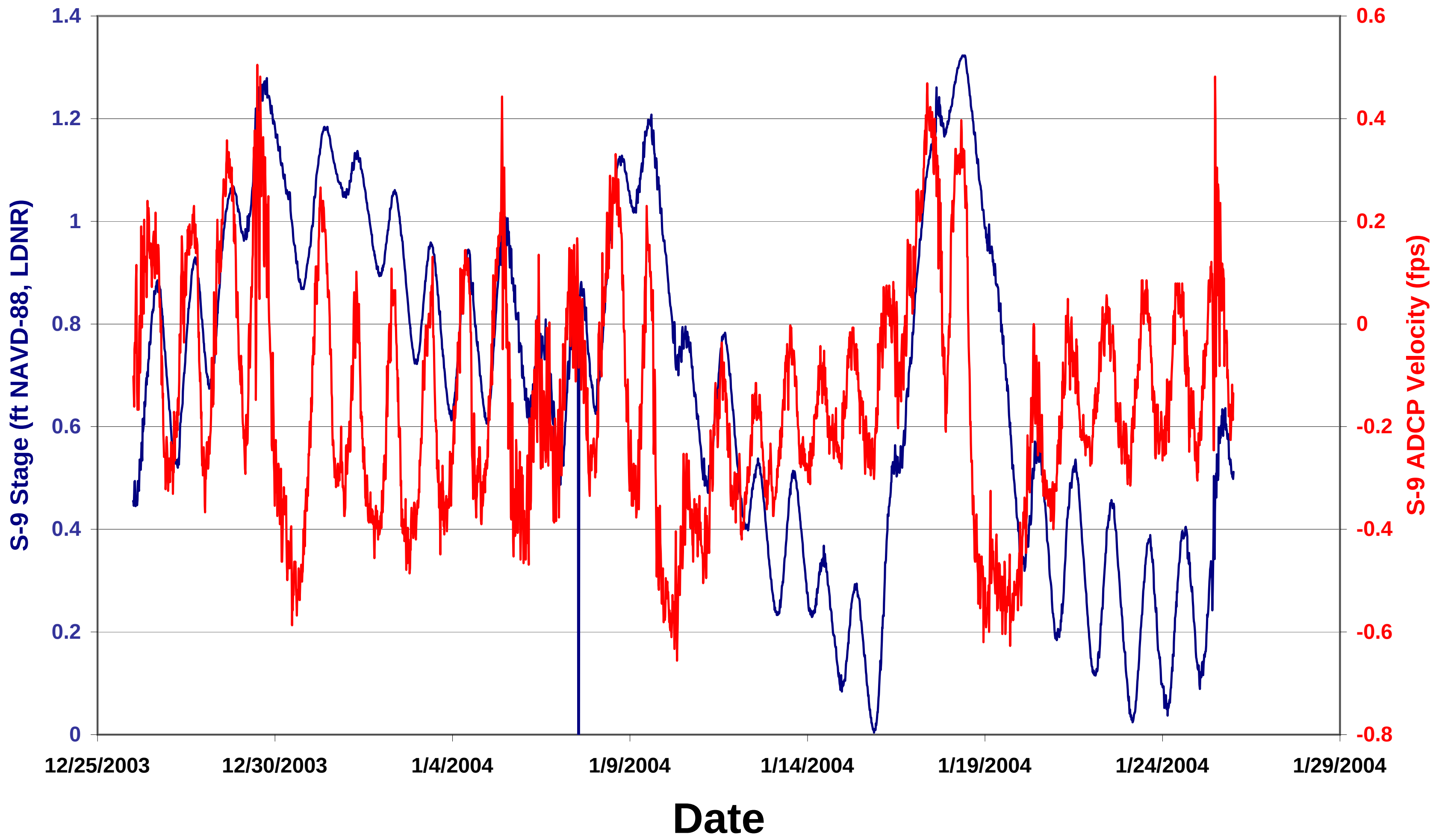


Figure 26

Velocity and Stage Hydrograph for LSU Calibration Period



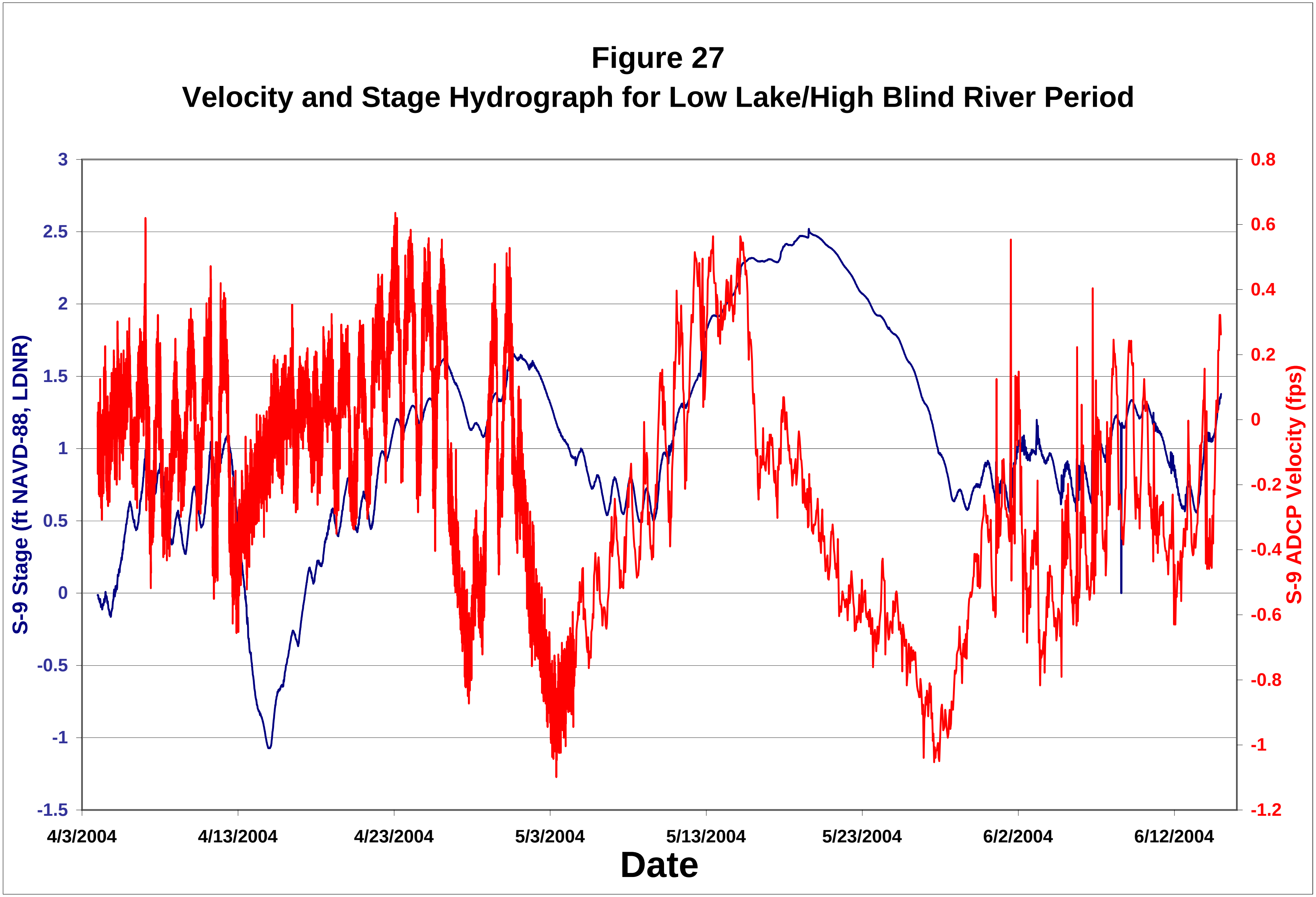


Figure 27
Velocity and Stage Hydrograph for Low Lake/High Blind River Period
S-9 Stage (ft NAVD-88, LDNR)
S-9 ADCP Velocity (fps)
3
2.5
2
1.5
1
0.5
0
-0.5
-1
-1.5
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
-1.2
4/3/2004
4/13/2004
4/23/2004
5/3/2004
5/13/2004
5/23/2004
6/2/2004
6/12/2004
Date

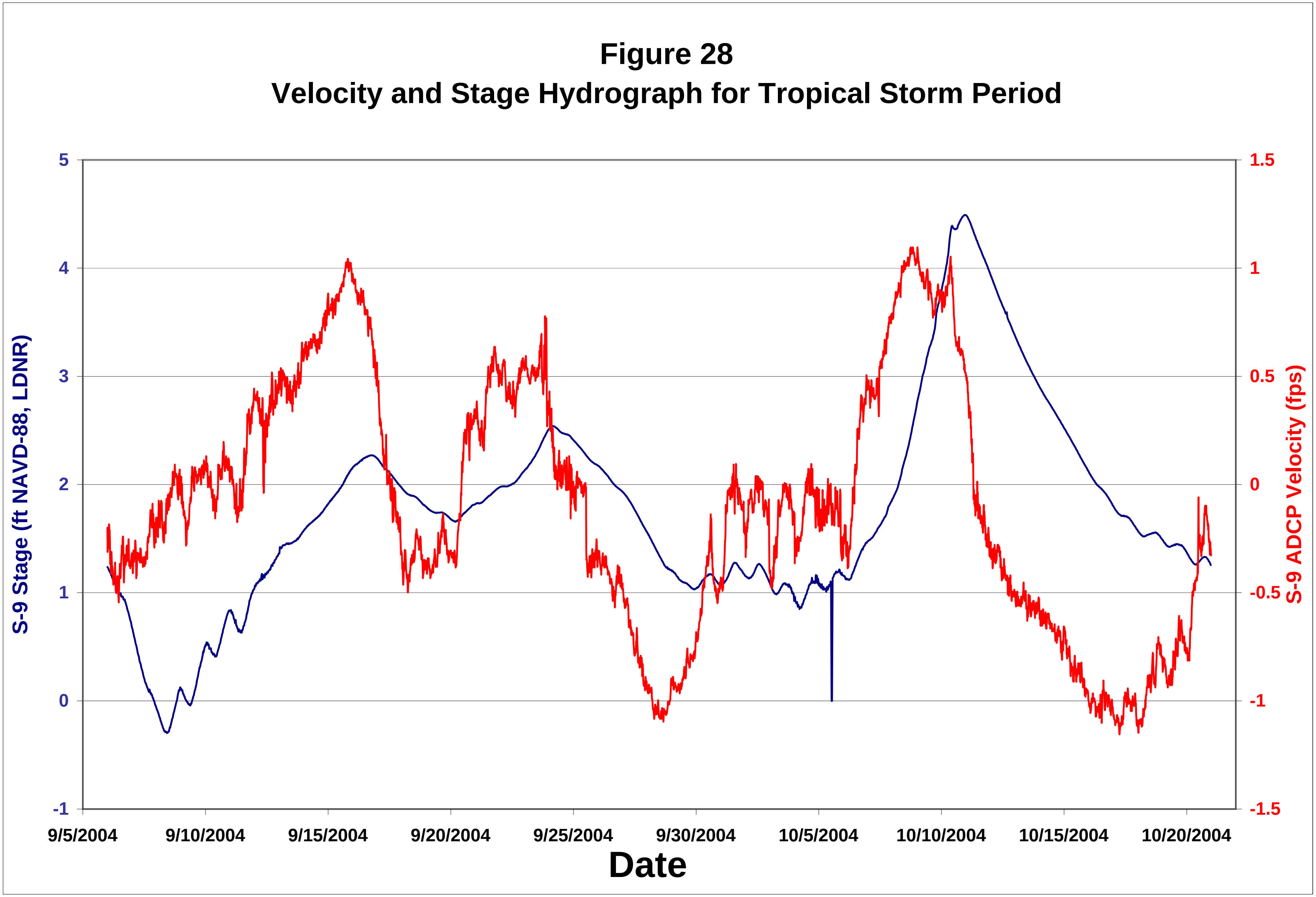


Figure 28
Velocity and Stage Hydrograph for Tropical Storm Period
S-9 Stage (ft NAVD-88, LDNR)
S-9 ADCP Velocity (fps)
5
4
3
2
1
0
-1
1.5
1
0.5
0
-0.5
-1
-1.5
9/5/2004
9/10/2004
9/15/2004
9/20/2004
9/25/2004
9/30/2004
10/5/2004
10/10/2004
10/15/2004
10/20/2004
Date

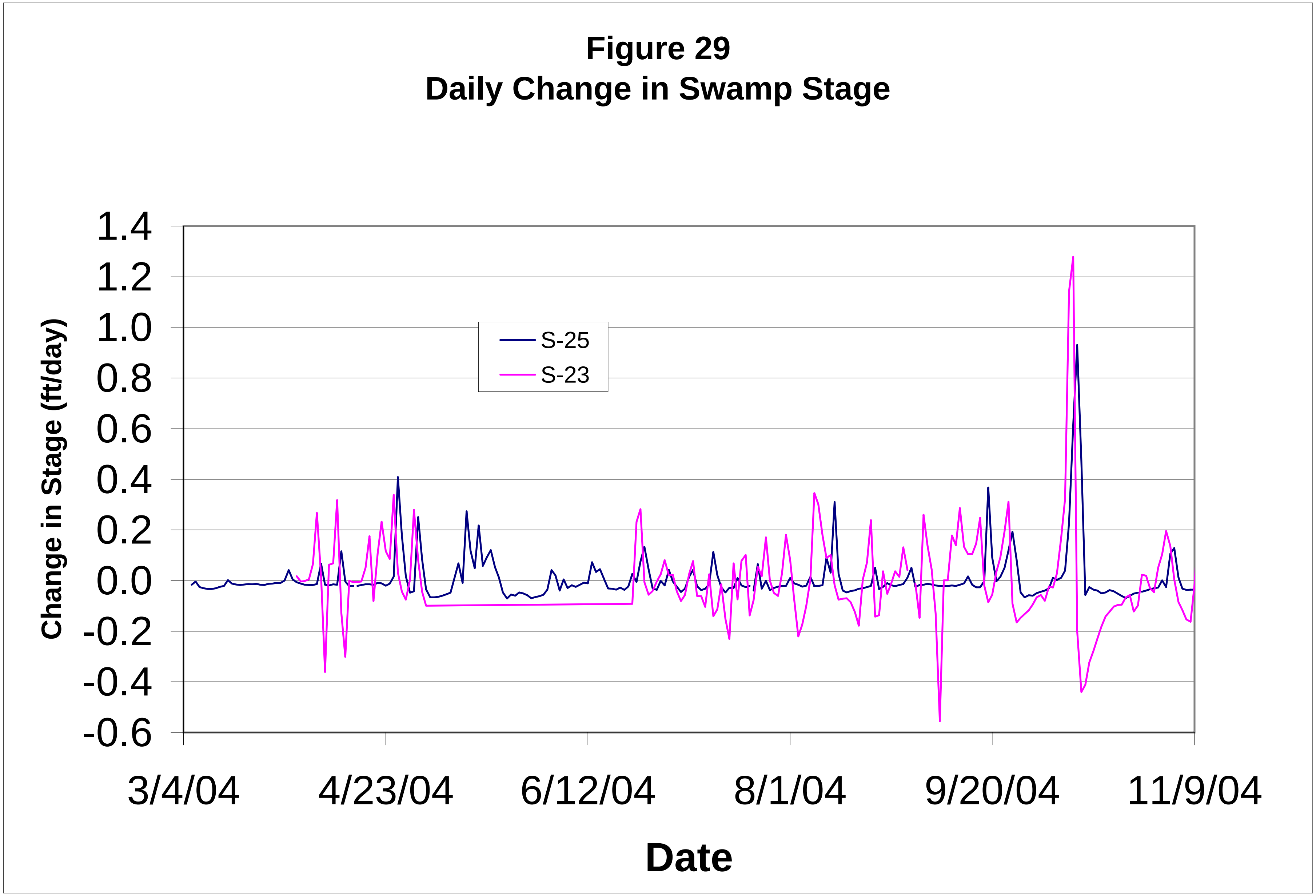


Figure 29
Daily Change in Swamp Stage
S-25
S-23
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
Change in Stage (ft/day)
3/4/04
4/23/04
6/12/04
8/1/04
9/20/04
11/9/04
Date