West Terminus - Cross-Florida Greenway Assessment

Work Order 2 Final Report

Lower Withlacoochee River Restoration Alternatives Feasibility Study

Prepared for:

SOUTHWEST FLORIDA WATER MANAGEMENT DISTRICT
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August 12, 2004

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EXECUTIVE SUMMARY

ES-1 GENERAL PROJECT INFORMATION

A Basin Initiative was requested by the Withlacoochee River Basin Board in fiscal year 2003 to evaluate restoration alternatives for the portion of the Withlacoochee River downstream of Inglis Dam. The purpose of this study is to carry out this Basin Initiative and evaluate a number of restoration alternatives, which are intended to mitigate some of the environmental impacts created by the construction of the Cross-Florida Barge Canal system.

The West Terminus Cross-Florida Greenway comprises a number of facilities, within the Cross Florida Barge Canal system, (illustrated on **Figure 1**). Currently, the Cross-Florida Barge Canal facilities are owned by the Florida Department of Environmental Protection (FDEP). With the exception of the Main Dam and Bypass Channel Spillway, these facilities are operated by FDEP's Office of Greenways and Trails. The dam and spillway are operated by the Southwest Florida Water Management District (District).

The portion of the Withlacoochee River downstream of Inglis Dam has undergone significant alteration since the turn of the twentieth century. The lower segment of the river receives flows only from the Bypass Channel System via a spillway at its western terminus. The maximum flow rate from this bypass system is considerably less than maximum normal flow rates and flood flow rates for the river system. The changes described above altered the historic flow regime of the Withlacoochee River downstream of Inglis Dam, creating environmental impacts.

ES-2 RESTORATION ALTERNATIVES DESCRIPTION

Listed below are the four (4) alternatives that were provided in the District's scope-of-work for this study. Each of the alternatives was evaluated with respect to their impact on flooding, natural systems, water quality, and navigation. Additionally, each alternative was assessed with respect to permitability and implementation costs. Please see **Figure 3** through **Figure 12** for plans and details of these facilities. *It is important to note that the proposed alternatives do not impact water levels in Lake Rousseau. These alternatives simply facilitate redistribution of flows presently carried by the Barge Canal to the lower segment of the river.*

Alternative 1 consists of: (1) removing the Rock Dam; (2) constructing an operable control structure in the Barge Canal; and (3) replacing the US-19 bridge over the Withlacoochee River. Alternative 2 consists of: (1) removing the Rock Dam and replacing it with an operable control structure (at the same location); (2) constructing an operable control structure in the Barge Canal; and (3) constructing a lock in the Barge Canal. Alternative 3 consists of reconstructing the existing Bypass Channel and Spillway with increased discharge capacity. Alternative 4 represents existing conditions with no improvement planned (baseline condition).

ES-3 HYDRAULIC MODEL DEVELOPMENT

HEC-RAS models were developed from previous studies of the Western Terminus area. Separate computer models were developed for each of the four (4) alternatives evaluated as part of this study. Model simulations for long term, 100-year flood and dam failure conditions were conducted using these models. Results of the long-term simulations were used in the natural systems, flooding and water quality assessments. Results of the 100-year flood and dam failure simulations were used in the flooding assessment.

ES-4 RESTORATION ALTERNATIVES ASSESSMENT

Natural Systems Assessment

A natural systems assessment was conducted to determine the impact that each of the proposed alternatives would have on wetlands and other systems in the West Terminus Cross-Florida Greenway area.

Implementation of any of the three alternatives will increase freshwater down the river. Within the study area, most of the vegetation along the river consists of freshwater species, including the bald cypress (*Taxodium distichum*), red maple (*Acer rubrum*), and loblolly bay (*Gordonia lasianthus*). The increase in freshwater should not affect the community's composition along the river. However, downstream of the study area, the increase in freshwater may decrease salinities within the river.

Finally, depending on construction methodologies, implementation of the alternatives may impact the wetlands within and adjacent to the construction area.

Flooding Assessment

A flood assessment was conducted to determine the impact that each of the proposed alternatives would have on structure flooding within the floodplain of only the upper and lower segments of the Withlacoochee River. The structures that were considered part of this analysis included primarily residential dwellings, with some commercial and publicly owned buildings.

Navigation Assessment

A navigation analysis was conducted to assess the navigational impact of the proposed alternatives in the West Terminus Cross-Florida Greenway area. The navigation analysis compared travel times to the Gulf of Mexico (Gulf) from selected locations within the study area.

Results of the navigation analysis indicate that Alternative 1 would require an additional 2.23 hour travel time relative to existing conditions. The travel time for Alternative 2 will increase by 0.5 hours over existing conditions, and the travel time for Alternative 3 is identical to existing conditions.

Water Quality Assessment

A water quality assessment was conducted to determine the impact on salinity levels of each of the proposed alternatives within the West Terminus Cross-Florida Greenway area. The water quality analysis was limited to a general estimate of the location of the saline-water front within the Withlacoochee River study segment. The saline-water front, determined from the long-term simulation model results, was taken to be the upstream-most cross-section where negative flows occur.

Water quality is predicted to improve in the Withlacoochee River Lower Segment for all of the proposed alternatives, due to the decrease in the duration of negative flows. Water quality is predicted to improve in the Withlacoochee River Upper Segment, for Alternatives 1 and 2, due to the decrease in the duration of negative flows. However, water quality will decrease under Alternative 3 due to increased duration of negative flows.

IMPLEMENTATION COST

A conceptual level estimate of probable construction costs was developed for each of the proposed alternatives. The conceptual level plans, cross-sections, and details referenced above in the restoration alternatives description were used as a basis for the estimate.

Table ES-1 presents a summary of probable implementation costs for each of the proposed alternatives. This table provides the total cost including real estate, permitting and contingencies.

Table ES-1
Implementation Cost Summary

Alternative	Estimated Construction Cost
1	$41,843,063
2	$26,311,222
3	$12,320,751
4	$0

PERMITTING REQUIREMENTS

All three proposed alternatives will likely require permits from the U.S. Army Corps of Engineers (ACOE) and the Florida Department of Environmental Protection (FDEP).

The Cross-Florida Barge Canal is a federally designated navigable waterway. As such, Alternative 1, which would impede navigation within the Canal, will require a permit pursuant to Sections 9 and 10 of the Rivers and Harbors Act of 1899. De-authorization of the waterway would require approval by the U.S. Congress. Because of the potential effects this alternative may have on the human environment, an EIS will most likely be required.

Alternative 2 will alter navigation in the Cross-Florida Barge Canal just below the Withlacoochee River with the construction of a control structure and lock. This action will not result in the loss of navigation above the proposed structure, will likely result in fewer environmental impacts, and will likely require the development of an Environmental Assessment (EA). Alternative 3 will not result in the loss of navigation on the Florida Barge Canal and as a result, the development of the environmental document for this proposed action would be less complex than either Alternatives 1 or 2.

Based on the ERP regulations, an individual ERP would be required for any of the three proposed alternatives associated with this project.

COMPARISON MATRIX

A comparison matrix was developed as a tool to aid in the evaluation of the proposed alternatives. **Table ES-2** shows the grading matrix. The grading matrix was prepared based on the assessment results as well as implementation costs and permitting requirements.

The comparison matrix provides a numeric value for each alternative by the category shown. Within a particular category the alternatives are graded from 1 to 4 (best to worst) based on the performance criteria for that particular category. The notes at the bottom of **Table ES-2** describe each category's performance criteria.

Table ES-2
Comparison Matrix

Grade Category	Relative Grade Values			
	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Natural Systems [(a)]	1	1	1	2
Flooding [(b)]	2	1	1	1
Navigation [(c)]	3	2	1	1
Water Quality [(d)]	1	1	2	3
Permitability [(e)]	4	3	2	1
Cost [(f)]	4	3	2	1
Values Summation	15	11	9	9

(a) Considers the creation of wetland habitat and improvement to estuary systems.
(b) Considers the number of buildings flooded.
(c) Considers travel time to the Gulf.
(d) Considers the location and duration of salt water in the river.
(e) Considers the feasibility and ease of obtaining permits.
(f) Considers construction, design, permitting and land acquisition dollar costs.

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1 GENERAL PROJECT INFORMATION

1.1 Background

The West Terminus Cross-Florida Greenway comprises of a number of facilities within the Cross Florida Barge Canal system. **Figure 1** illustrates the Cross-Florida Barge Canal system and its components. The system was partially constructed in the 1960s and abandoned in the early 1970s. Authorized by the U.S. Congress during the 1940's, the project was intended to facilitate the movement of ocean going vessels traveling between the Atlantic Ocean and the Gulf of Mexico, the Caribbean Sea, and the Panama Canal. The Barge Canal facilities were designed by the U.S. Army Corps of Engineers (ACOE). Significant elements of the overall project completed by the ACOE within the West Terminus area include the following: (1) the portion of the canal from the Gulf of Mexico to the Inglis Lock; (2) the Inglis Lock; (3) the Inglis Dam; (4) the Bypass Channel and Spillway; and (5) the Rock Dam/Flood Control Levee.

Construction of the Barge Canal system was halted during the Nixon administration in 1971 because of concerns related to cost and the project's effect on the environment. Although construction activities ended three decades ago, it was not until 1990 that the official construction de-authorization was approved by Congress and signed by President Bush (after an extensive study by the ACOE). Subsequent to its de-authorization, the Inglis Lock and associated facilities became part of the Cross-Florida Greenway State Recreation and Conservation Area that was established by the Florida State Legislature through the enactment of a law (F.S. 90-328). Currently, the Cross-Florida Barge Canal facilities constructed near Inglis are owned by the Florida Department of Environmental Protection (FDEP). With the exception of the Main Dam and Bypass Channel Spillway, these facilities are operated by FDEP's Office of Greenways and Trails. The dam and spillway are operated and maintained by the Southwest Florida Water Management District (District) under contract with the FDEP.

1.2 Purpose

The portion of the Withlacoochee River downstream of Inglis Dam has undergone significant alteration since the turn of the twentieth century. The construction of the Cross-Florida Barge Canal in the 1960s created additional impacts to the segment of the river downstream of the canal. Construction of the barge canal included a dam on the Withlaccochee River known locally as the "Rock Dam." This dam effectively severs all flows released from the Inglis Dam main gates including large flood flows. The lower segment of the river, downstream of the Rock Dam, receives flows only from the Bypass Channel System via a spillway at its western terminus. The maximum flow rate from this bypass system is estimated to be 1,540 cfs, considerably less than maximum normal flow rates and flood flow rates for the river system. The changes described above have altered the historic flow regime of the Withlacoochee River downstream of Inglis Dam, creating environmental impacts. It should be noted, pursuant to the findings of a previously completed dam safety planning study, the Rock Dam was recently reconstructed as a flood control levee. The flood control levee (FCL) is designed to offer full protection to structures on the lower segment of the Withlacoochee River in case of failure of the Inglis Dam.

The Withlacoochee River Basin Board requested a Basin Initiative in fiscal year 2003 to evaluate restoration alternatives for the portion of the Withlacoochee River downstream of Inglis Dam. The purpose of this study is to carry out this Basin Initiative and evaluate a number of restoration alternatives, intended to mitigate some of the environmental impacts created by the construction of the Cross-Florida Barge Canal system. *It is important to note that the proposed alternatives do not impact water levels in Lake Rousseau. These alternatives simply facilitate redistribution of flows presently carried by the Barge Canal to the lower segment of the river.* Listed below is a summary of alternatives that were evaluated as part of this study. Each of the alternatives was evaluated with respect to their impact on flooding, natural systems, water quality, and navigation. An estimate of the cost to construct the proposed facilities was developed for each alternative. Evaluation results and implementation costs were used to create a comparison matrix to help determine the feasibility of each alternative.

Alternative 1: Remove the Rock Dam/FCL which presently severs the connection of the lower and upper river segments, construct an operable control structure in the Barge Canal, and replace the US-19 bridge over the Withlacoochee River to facilitate navigation. **Figure 3** is a conceptual plan of Alternative 1.

Alternative 2: Replace the Rock Dam/FCL with an operable control structure (at the same location), construct an operable control structure in the Barge Canal, and construct a lock in the Barge Canal for navigation. **Figure 7** is a conceptual plan of Alternative 2.

Alternative 3: Reconstruct the existing Bypass Channel and Spillway with increased discharge capacity to facilitate increased flows to the lower segment of the river. **Figure 10** is a conceptual plan of Alternative 3.

Alternative 4: Represents existing conditions with no improvement planned (baseline condition). **Figure 12** is a conceptual plan of Alternative 4.

The restoration alternatives study was broken down into two work orders. Work Order 1 (WO-1) was previously completed and a report was submitted to the Southwest Florida Water Management District on December 31, 2003. The report contained herein is intended to document the tasks conducted as part of Work Order 2 (WO-2). The tasks are listed below and were taken from the District's Scope of Work. The following sections of this report address each of the tasks listed below (in order).

2.3.1 Perform Additional Field Surveys
2.3.2 Update Watershed Model
2.3.3 Restoration Alternatives Model Evaluation
2.3.4 Land Acquisition Requirements and Probable Acquisition Costs
2.3.5 Probable Implementation Cost
2.3.6 Permit Requirements for Restoration Alternatives
2.3.7 Restoration Alternatives Analysis Matrix
2.3.8 Report of Findings – Work Order 2

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2 DATA COLLECTION AND SUPPLEMENTAL LAND SURVEY

Data originally collected under WO-1 as part of Task 1.1.2.1 were presented in Section 2 of the WO-1 Report. The results of that data collection task were used to identify additional information and land survey requirements. Additional data collected as part of the WO-2 studies are presented in **Table 2-1** below.

The additional land survey requirements were formalized into a survey scope of work under WO-2 as part of Task 2.3.1. A survey subcontractor was retained to carry out this work, which included re-surveying the bank-to-bank portions of 15 existing cross-sections on the Withlacoochee River and Barge canal, obtaining three new cross-sections on the Withlacoochee River and Bypass Channel and conducting a detailed survey of the US-19 bridge over the Withlacoochee River. **Figure 2** illustrates the location and extent of the survey conducted under WO-2.

Table 2-1
Inventory Of Data Collected – Work Order 2

TITLE	SOURCE	DATE
Environmental Data Inventory		
Quarter 1 (1984) Report, Technical Summary and data Appendix	Mote Marine Laboratory	1984
Property Appraiser Office		
Property Value & Structure Information - Parcel 3038-000-00	Levy County Soil Survey	May-04
Property Value & Structure Information - Parcel 3043-000-00	Levy County Soil Survey	May-04
Property Value & Structure Information - Parcel 3039-000-00	Levy County Soil Survey	May-04
Property Value & Structure Information - Parcel 3037-001-00	Levy County Soil Survey	May-04
Property Value & Structure Information - Parcel 3037-002-00	Levy County Soil Survey	May-04
Property Value & Structure Information - Parcel 3041-000-00	Levy County Soil Survey	May-04
Property Value & Structure Information - Parcel 3037-000-00	Levy County Soil Survey	May-04
Property Value & Structure Information - Parcel 03086-000-00	Levy County Soil Survey	May-04
Property Value & Structure Information - Parcel 03135-001-00	Levy County Soil Survey	May-04
Property Value & Structure Information - Parcel 03135-000-00	Levy County Soil Survey	May-04
Property Value & Structure Information - Parcel 03972-000-00	Levy County Soil Survey	May-04
Property Value & Structure Information - Parcel 16-17-02 33000	Citrus County Soil Survey	May-04
Property Value & Structure Information - Parcel 16-17-02 33000	Citrus County Soil Survey	May-04
Property Value & Structure Information - Parcel 16-17-03 22210	Citrus County Soil Survey	May-04
Property Value & Structure Information - Parcel 16-17-03 22220	Citrus County Soil Survey	May-04
Property Value & Structure Information - Parcel 16-17-03 22230	Citrus County Soil Survey	May-04
Property Value & Structure Information - Parcel 16-17-03 22240	Citrus County Soil Survey	May-04
Property Value & Structure Information - Parcel 16-17-12 14110	Citrus County Soil Survey	May-04
Property Value & Structure Information - Parcel 16-17-12 14110	Citrus County Soil Survey	May-04
Property Value & Structure Information - Parcel 16-17-03 22000	Citrus County Soil Survey	May-04

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3 RESTORATION ALTERNATIVES DESCRIPTIONS AND DETAILS

The purpose of this study was to carry out an initiative by the Withlacoochee River Basin Board to evaluate a number of restoration alternatives for the Cross-Florida Barge Canal system. This section provides a detailed description of the proposed alternatives and presents the conceptual plans and details developed in Task 2.3.5 of this study. This information was used in the development of hydraulic models whose results form the basis of the assessments conducted as part of this study.

The development of Alternatives 1 through 3 was influenced by the allowable discharge rate in the lower segment of the Withlacoochee River. For the purpose of this study, the allowable discharge rate was assumed to be 2,500 cfs. This discharge rate is approximately equivalent to the estimated maximum flow rate for the 'average year' discharge hydrograph in this segment of the Withlacoochee River. The reader is referred to Section 6.3 of the WO-1 Report for a detailed discussion regarding the selection of the 'average year' hydrograph.

Prior to the development of the proposed alternatives, a study was conducted to assess flood impacts in the lower segment of the river due to flows from the 'average year' discharge hydrograph. The 'average year' discharge hydrograph was routed through the system with the corresponding tide-stage hydrograph serving as the downstream boundary condition. Results of this preliminary study indicated that there was no structural flooding attributable to river flows. Thus, a peak discharge rate of 2,500 cfs was assumed to be the design maximum rate for all future simulations conducted as part of the design and assessment of proposed alternatives. It should be noted that higher flows might be feasible for use in the development of restoration alternatives. However, allowable flow rates, which are based on structure flooding are greatly influenced by tide conditions and additional detailed studies are required to optimize the maximum flow rate.

3.1 Alternative 1

Alternative 1 consists of removing the Rock Dam/FCL, constructing an operable control structure in the Barge Canal, and replacing the US-19 Bridge over the Withlacoochee River. **Figure 3** is a conceptual plan illustrating the location of existing and proposed elements of this alternative. This plan also illustrates the direction and course of normal and flood flows in the system.

The location and extent of the proposed Rock Dam/FCL removal is illustrated on the **Figure 4** Plan view. **Figure 5** illustrates the proposed river cross-section that will be constructed in place of the Rock Dam/FCL. This cross-section was developed from a surveyed cross-section of the river at the location shown on the **Figure 4** Plan view. The proposed removal of the Rock Dam/FCL will allow flows released from Inglis Dam's main gates to pass directly from the Withlacoochee River Upper Segment to the lower segment of the river. Presently, normal flow releases are made primarily to the lower segment of the river via the Bypass Channel Structure, with periodic normal flow releases to the upper segment of the river via the main gates. All main gate releases are then conveyed to the Gulf via the Barge Canal. Removal of the Rock Dam/FCL will allow larger peak flow rates and an increased volume of flow to the lower segment of the river, as well as increased flows to the upper segment of the river as all discharge will go through the main gates.

The proposed operable control structure will be constructed across the Barge Canal at the approximate location illustrated on the **Figure 4** Plan view. The proposed control structure will consist of earthen embankments, an ogee crest weir and five (5) vertical lift roller gates as illustrated by the **Figure 4** Section views. Under conditions of normal flow, the gates will remain closed, allowing all water to pass to the lower segment of the river. Presently, flood flows are released from the main gates and are conveyed to the Gulf via the Barge Canal. With Alternative 1 in place, a portion of the flood flows will be shunted down the Barge Canal through the gates of the control structure and the remainder of the flows will be conveyed to the lower segment of the river.

Presently, access by water craft to the Withlacoochee River Upper Segment and Lake Rousseau via Inglis Lock is provided by the Cross-Florida Barge Canal. Implementation of Alternative 1 will prevent navigational access to these areas via the Barge Canal due to construction of the Canal Control structure. Instead, navigational access to these areas will be provided via the Withlacoochee River Lower Segment. To accommodate existing vessel size (height) the existing bridges over the Withlacoochee River at US-19 will require replacement. **Figure 6** illustrates the proposed replacement bridge. This design was adopted from proposed FDOT plans for an additional single span bridge over the Barge Canal at US-19, which is part of the Suncoast Parkway expansion. The FDOT Alternative 2 bridge configuration, shown on **Figure 6**, represents a 40-foot high 2-lane vertical clearance facility, which was selected by FDOT based on a Boat User Survey conducted in 2002. The same bridge configuration is proposed for use in Alternative 1 in this study. The primary difference is that two (2) 2-lane bridge spans will be required for the US-19 crossing at the Withlacoochee River.

3.2 Alternative 2

Alternative 2 consists of removing the Rock Dam/FCL and constructing an operable control structure (River Control Structure) in its place, constructing an operable control structure in the Barge Canal (Canal Control Structure), as well as constructing a navigation lock in the Barge Canal. **Figure 7** is a conceptual plan illustrating the location of existing and proposed elements of this alternative. This plan also illustrates the direction and course of normal and flood flows in the system.

The function of Alternative 2 is similar to Alternative 1 with respect to normal flows, but differs from Alternative 1 with respect to flood flows and navigation. The proposed operable River Control Structure will allow normal flows to be conveyed to the lower segment of the river similar to Alternative 1. However, during flood flows this structure can be operated to allow a safe flow rate to be conveyed to the lower segment of the river while the remainder of the flows are shunted down the Barge Canal. This is similar in function to the system under existing conditions. Alternative 2 also provides navigational access to the Withlacoochee River Upper Segment and Lake Rousseau via Inglis Lock, similar to existing conditions by means of a new lock in the Barge Canal.

The proposed operable control structure and lock will be constructed across the Barge Canal at the location illustrated on the **Figure 8** Plan view. The proposed Canal Control Structure will consist of earthen embankments, an ogee crest weir and five (5) vertical lift roller gates as illustrated by the **Figure 8** Section views. The proposed lock will consist of a concrete chamber and upstream and downstream miter gates with through-the-gate filling and emptying as illustrated by the **Figure 8** Section view. The proposed River Control Structure will be constructed in place of the Rock Dam/FCL at the location illustrated on the **Figure 8** Plan view. The proposed River Control Structure will consist of earthen embankments, an ogee crest weir and three (3) vertical lift roller gates as illustrated by the **Figure 9** Section views.

3.3 Alternative 3

Alternative 3 consists of reconstructing the existing Bypass Channel and Bypass Channel Spillway (operable control structure) to provide additional conveyance capacity. **Figure 10** is a conceptual plan illustrating the location of existing and proposed elements of this alternative. This plan also illustrates the direction and course of normal and flood flows in the system.

The function of Alternative 3 is similar to existing conditions (Alternative 4) with respect to normal flow direction, flood flows and navigation. The primary difference in function between Alternative 3 and existing conditions is in normal flow rate and volume. Presently, normal flows up to a maximum discharge rate of 1,540 cfs are discharged to the lower segment of the river via the Bypass Channel System. All required releases above this flow rate are made through Inglis Dam's main gates including major flood releases. The main dam's gates were designed to accommodate flows up to 18,000 cfs, nearly double the 100-year flood flow rate.

Under Alternative 3 proposed conditions, the Bypass Channel System's capacity will be increased to approximately 2,500 cfs (62 percent increase), to accommodate the estimated maximum flow rate for the average year. For this study, the average year was selected to be 1996 based on a statistical analysis of annual runoff volume for the Withlacoochee River system. Section 6.3 of the WO-1 Report provides details of the analyses conducted to determine the average year hydrograph. As a result of increasing the capacity of the Bypass Channel System, normal flow releases from the main gates (rate, volume and frequency) will be decreased, as will flows in the receiving system including the upper segment of the river and Barge Canal. Navigational access and flood flow operations under Alternative 3 conditions will be similar to existing conditions, although flood flows from the main gates will be decreased slightly due to the increased capacity of the Bypass Channel system.

The proposed Bypass Channel System improvements will be constructed as illustrated on the **Figure 11** Plan view. The proposed replacement control structure has been conceptually designed to fit within the confines of the existing structure. The structure will consist of earthen embankments, an ogee crest weir and two (2) vertical lift roller gates as illustrated by the **Figure 11** Section view. The proposed channel improvements consist of widening the channel by approximately 30 over the entire length of the channel (approximately 8,500 linear feet) and providing channel stabilization as illustrated by the **Figure 11** Section view.

3.4 Alternative 4

Alternative 4 represents the existing or baseline condition and is illustrated on **Figure 12.** Section 4 of the WO-1 Report provides a detailed description with photo-documentation of the Cross-Florida Barge Canal system and its components as well as design data for these facilities. Alternative 4 does not propose improvements to the system. **Figure 12** illustrates the direction and course of normal and flood flows in the system. The following is a description of present day system operations.

Presently, normal flows up to a maximum discharge rate of 1,540 cfs are discharged to the lower segment of the river via the Bypass Channel System. All required releases above this flow rate are made through Inglis Dam's main gates including major flood releases. The Dam's main gates were designed to accommodate flows up to 18,000 cfs, which is nearly double the 100-year flood flow rate. Periodic normal flow releases to the upper segment of the river are made through the main gates for water quality purposes. As illustrated on **Figure 12**, flood releases are made through the main gates and are conveyed along the upper segment of the river to the Barge Canal and ultimately to the Gulf.

Presently, access by water craft to the Withlacoochee River Upper Segment and Lake Rousseau via Inglis Lock is provided by the Cross-Florida Barge Canal. Lake Rousseau was designed to provide water to operate the lock system. Inglis Lock has fallen into disrepair and is rarely operated. However, studies and designs for a replacement lock within the present lock chamber have been completed by the State of Florida, and the project awaits construction funding.

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4 HYDRAULIC MODEL DEVELOPMENT AND OUTPUT

This section of the report describes: (1) the basis (previous models) for the hydraulic (open-channel) models developed and used in this assessment; (2) updates made to the previous models, which more accurately define the physical characteristics of the Cross-Florida Barge Canal System; (3) specific model revisions and additions made to facilitate modeling the various alternatives; (4) details of model configuration and operating parameters for each simulation by alternative; and (5) model results (output) for each of the simulations by simulation type.

Previous modeling of the Cross-Florida Barge Canal system was conducted using the Army Corps of Engineers' UNET model. The ACOE's HEC-RAS (Version 3.1.1, May 2003) computer model was selected for use in this study. The HEC-RAS unsteady-flow module was built upon the UNET model code, which runs through the RAS interface. The RAS interface simplifies model input and provides superior graphical and tabular output.

4.1 Model Basis, Updates, and Revisions

4.1.1 Model Basis

The open-channel model (UNET) developed as part of previous dam safety planning studies for Lake Rousseau was used as a basis for the HEC-RAS models developed in the present study. The UNET model consists of two reaches representing the Withlacoochee River Lower Segment and the Barge Canal/ Withlacoochee River Upper Segment. The reaches are integrated at the Rock Dam/FCL, as the model was intended to simulate flows and water levels in the system due to a failure of Inglis dam and a consequential failure of the Rock Dam. Geometric elements of the UNET model (cross-sections and model framework) were converted for use in the present study.

The UNET model was developed to simulate high flow rates (dam failure) in the Cross-Florida Barge Canal system. The model studies conducted as part of the West Terminus Assessment require low flow as well as high flow simulations. A number of updates (refinements) were made to the geometric elements of the imported UNET model to facilitate its use in the West Terminus Assessment. These updates are described in Section 4.1.2.

4.1.2 Generic Updates

This section describes the revisions made to the geometric elements of the UNET model to facilitate their use in the present assessment. The UNET geometry files were imported to HEC-RAS, which was used to create the update geometry files. The generic model updates were applicable to the models developed for each alternative.

<u>Cross-Section Revisions</u>

The West Terminus Assessment included long-term low flow simulations of the system, where the majority of the flow was carried within the main channel. The bank-to-bank portion of the cross-sections imported from the previous model was updated to more accurately reflect existing conditions within the channel. Land surveying of the bank-to-bank portion of 15 existing cross-sections on the Withlacoochee River and Barge Canal as well as three (3) new cross-sections on the Withlacoochee River and Bypass Channel was conducted in February 2004 to obtain this information. **Figure 2** illustrates the location and extent of the cross-section survey.

The surveyed cross-sections were used to update the remaining cross-sections where necessary. **Appendix A** contains the cross-sections used in the West Terminus Assessment model studies for the Withlacoochee River, Barge Canal and a typical cross-section for the Bypass Channel. **Figure 13** illustrates the location and identifies the cross-sections used in these model studies.

River Restoration Section, Cross-Section 12

Alternative 1 requires the use of a cross-section to represent the connection of the upper and lower segments of the Withlacoochee River. This section was incorporated into the model framework, and is illustrated in **Appendix A.**

US-19 Bridge

The US-19 Bridge over the Withlacoochee River was not explicitly represented in the UNET model. As part of the present study, detailed survey data of the bridge was collected and this information was used to specify the physical nature of the bridge within the HEC-RAS models. **Appendix A** contains details of the US-19 Bridge as represented in the models including plan and profile views to illustrate spatial relationships and a cross-section view to illustrate channel and bridge elements. It should be noted that the US-19 Bridge proposed as part of this study is a clear span facility with no obstruction to low flow within the channel. However, due to uncertainty as to the ultimate design of this facility, the bridge in its present configuration was modeled for all alternatives.

Barge Canal Lateral Outflow Areas

The previous UNET model included lateral outflow areas from the Withlacoochee River Upper Segment and from the Barge Canal. The river upper segment outflow areas functioned only for very high flows and were not required for this study. The Barge Canal outflow areas were incorporated into the HEC-RAS models. **Appendix A** contains details of these facilities as represented in the models, including a plan view to illustrate spatial relationships and a cross-section view to illustrate geometry.

Channel Roughness Revisions

The UNET model from the previous studies focused on channel roughness in the overbank areas, due to the high flow nature of these analyses. The West Terminus Assessment model studies include low flow simulations, which require accurate channel roughness within the bank-to-bank portion of the channel. Field reconnaissance was conducted to obtain the information necessary to refine the bank-to-bank channel roughness. Photo-documentation at various location within the Cross-Florida Barge Canal system is presented in the WO-1 Report. **Appendix A** contains a summary of the channel roughness (Manning's Roughness Coefficient 'n') used in current modeling studies.

4.1.3 Alternative Specific Revisions

This section provides documentation of revisions (additions) made to the HEC-RAS models specific to a particular alternative.

Barge Canal Control Structure

Alternatives 1 and 2 require the use a control structure to divert higher than normal flows out of the Withlacoochee River and into the Barge Canal where it can be safely conveyed to the Gulf. **Figure 4** provides details of the location and design of this facility. **Appendix A** contains details of this facility as represented in the models, including a plan view to illustrate spatial relationships and a cross-section view to illustrate geometry. This facility as conceptualized for this study is located within the Barge Canal just downstream of the confluence of the Withlacoochee River Upper Segment. The control structure is represented as a lateral outflow structure (gated-weir), situated on the left bank of the river between Cross-Sections 12 and 27.

The proposed Barge Canal Control Structure consists of a weir and five-20-ft wide vertical lift roller gates. The primary purpose of this structure is to convey flows in excess of normal flow into the Barge Canal, which acts to minimize flooding on the lower segment of the river. A detailed study was conducted to determine the size (capacity) of this facility. This study was conducted using the Alternative 1 model based on a 100-year flood simulation. The study consisted of conducting a number of model runs and varying the number of gates (2 through 10) in the control structure. Model results were reviewed with respect to the number of structures (dwellings) flooded and the feasibility of siting the structure at the selected location. Results of the study showed that six (6) structures flooded if two gates were used, two (2) structures flooded if four to six gates were used and one (1) structure flooded if ten gates were used. As a compromise between cost and minimizing the number of structures flooded, the five (5) gate option was selected for use in the study. It should be noted that hydraulic limitations of the Barge Canal control the flow through the Control Structure. As an example of this, increasing the number of gates in the structure from 5 to 10 decreases the flow to the lower segment of the river from 3,152 cfs to 2,997 cfs for the 100-year flood event.

River Control Structure

Alternative 2 requires the use a control structure within the Withlacoochee River channel (at the present location of the Rock Dam) to divert higher than normal flows out of the Withlacoochee River and into the Barge Canal where it can be safely conveyed to the Gulf. The River Control Structure works in conjunction with the Barge Canal Control Structure. **Figure 8** provides a plan view of the location and alignment of this facility and **Figure 9** provides a section and details of the design of this facility. **Appendix A** contains details of this facility as represented in the models, including a plan view to illustrate spatial relationships and cross-section and profile views to illustrate geometry. This facility as conceptualized for this study is located within the Withlacoochee River channel at Cross-Section 12 and is represented as an inline (gated-weir) structure.

The proposed River Control Structure consists of a weir and three-40-ft wide vertical lift roller gates. The primary purpose of this structure is to regulate flows into the lower segment of the river. Flows in the upper segment of the river, in excess of normal flows can be shunted into the Barge Canal by restricting flows across the River Control Structure and increasing flows across the Barge Canal Control Structure. This operation acts to minimize flooding on the lower segment of the river. A detailed study was conducted to determine the size (capacity) of this facility. This study was conducted using the Alternative 2 model based on the average year flows used for the long-term simulation. The study consisted of conducting model runs and varying the number and size of gates in the control structure so that water levels in the upper segment of the river would not increase over estimated water levels expected if the control structure were not present (baseline condition). The baseline condition was taken as Alternative 1. Model results were reviewed with respect to the number of structures (dwellings) flooded and the feasibility of siting the structure at the selected location. It should be noted that the River Control Structure is designed to convey the peak normal year flow (approximately 2,500 cfs) without increasing headwater levels. However, this structure is capable of conveying much higher flows if necessary. The conveyance capacity of this facility will be limited by the hydraulic capacity of the receiving channel (lower segment of the river) if headwater level restrictions are not imposed.

Bypass Channel Control Structure

Alternative 3 requires the replacement of the control structure at the western terminus of the Bypass Channel. This structure controls discharge from Lake Rousseau while maintaining the lake's normal water level. **Figure 11** provides a plan view of the location and alignment of this facility and a section view with details of the design of this facility. **Appendix A** contains details of this facility as represented in the models, including a plan view to illustrate spatial relationships and cross-section and profile views to illustrate geometry. This facility as conceptualized for this study is located at the downstream end of the Bypass Channel and discharges through a man-made lateral channel to the Withlacoochee River just upstream of Cross-Section 11. This facility is represented as an inline (gated-weir) structure.

The proposed Bypass Channel Control Structure consists of a weir and two-14-ft wide vertical lift roller gates. The replacement structure was designed to fit in the same width as the existing structure. Capacity was increased by lowering the weir elevation and effectively increasing head on the facility. The primary purpose of this structure is to regulate flows into the lower segment of the river directly from Lake Rousseau. A detailed study was conducted to determine the size (capacity) of this facility. This study was conducted using a model developed specifically for the Bypass Channel facility, included an inline gated-weir and 8,500 linear feet of supply canal. The study, run in steady-flow mode, consisted of conducting model runs and varying the flow until the upstream water surface profile matched the normal pool level (27.5 ft-NGVD) in Lake Rousseau.

It should be noted that the Bypass Channel Control Structure required capacity is approximately 2,500 cfs, which is equivalent to the peak discharge of the normal year hydrograph. However, this structure has been designed to convey approximately 3,500 cfs at the given headwater level. The maximum discharge capacity for this structure can be increased by lowering the weir crest elevation. Studies should be conducted in the design phase to optimize the maximum discharge for this facility.

4.2 Model Concepts

Separate computer models were developed for each of the four (4) alternatives evaluated as part of this study. All of the models include the generic updates documented in Section 4.1.2. Models specific to a particular alternative also include the applicable revision(s) documented in Section 4.1.3. Model simulations for long term, 100-year flood and dam failure conditions were conducted using the models specific to a particular alternative. This section of the report provides details of model configuration and operating parameters for each alternative and simulation type.

4.2.1 Alternative 1

Alternative 1 is described in detail in Section 3.1 of this report and shown schematically on **Figure 3**. The HEC-RAS model for this alternative consists of two (2) river reaches, connected through a lateral outflow structure at the confluence of the Barge Canal and the Withlacoochee River Upper Segment. **Appendix A** contains a plan view of the model framework for Alternative 1. This plan view illustrates cross-sections and their spatial relationship for the entire system. Reach 1 (U Withlacoochee) represents the upper and lower segments of the river from the west end of Yankeetown (RS-0) upstream to Inglis Dam (RS-8.06). Reach 2 (Barge Canal) represents the Barge Canal from the Gulf (RS-0) upstream to the confluence of the Withlacoochee River (RS-5.95). **Figure 13** identifies and illustrates the cross-sections used in the study area and provides a table, which cross references the cross-section ID with the river station. **Appendix A** contains a river profile for the two reaches described above.

Alternative 1, as proposed, includes removing the Rock Dam/FCL to reconnect the upper and lower segment of the river, constructing a control structure in the Barge Canal to divert flood flows to the canal and releasing all flows from Lake Rousseau through Inglis Dam main gates. The river reconnection was modeled through the placement of Cross-Section 12 between Cross-Sections 11 and 27. The Barge Canal Control Structure was modeled using a lateral outflow structure located in the Withlacoochee River and discharging to the Barge Canal. **Appendix A** contains a large-scale plan view of the model framework illustrating the river reconnection section (RS-6.47) and the lateral outflow structure (RS-6.59). **Appendix A** also contains a summary print out of the HEC-RAS model input for Alternative 1 for each of the simulations described below.

For the long-term simulation, an inflow hydrograph representing the average flow year (1996) was input to the system at Cross-Section 26 (RS-8.06). Additionally, a downstream stage hydrograph simulating tidal fluctuations for the same year, was applied to the Barge Canal at Cross-Section 32 and to the Withlacoochee River at Cross-Section 1. Section 6.3 of the WO-1 Report provides detailed documentation regarding the selection of the long-term simulation hydrographs. **Appendix A-Boundary Conditions** contains plots the long-term inflow (Lake Rousseau Long-Term Discharge (Daily)), Alternatives 1 and 2 (Main Gates) and tidal (Long-Term Tide Stage Hydrograph) hydrographs.

For the long-term simulation, the Barge Canal Control Structure was operated with the gates closed during the entire one-year simulation length. This allows the entire flow series to be conveyed down the lower river segment. Please note that lockage flows are insignificant with respect to annual flow volumes and were ignored in this study.

For the 100-year flood simulation, an inflow hydrograph representing discharge from Lake Rousseau (March 1960) was input to the system at Cross-Section 26 (RS-8.06). Additionally a downstream stage hydrograph simulating tidal fluctuations for the same time period, was applied to the Barge Canal at Cross-Section 32 and to the Withlacoochee River at Cross-Section 1. Section 6.4 of the WO-1 Report provides detailed documentation regarding the selection of the 100-year flood simulation hydrographs. **Appendix A-Boundary Conditions** contains plots of the 100-year flood inflow (Lake Rousseau 100-year Discharge (Daily)), Alternatives 1 and 2 (Main Gates) and tidal (100-year Tide Stage Hydrograph) hydrographs.

For the 100-year flood simulation, the Barge Canal Control Structure was operated with the gates fully open during the entire simulation length. This is reasonable given the nature of flood flows on the river and allows the maximum volume of runoff to be conveyed to the Barge Canal, thereby minimizing flows to the lower river segment.

For the Dam Failure simulation, an inflow hydrograph representing a Sunnyday failure of Inglis Dam was input into the system at Cross-Section 26 (RS-8.06). Additionally a downstream stage hydrograph was applied to the Barge Canal at Cross-Section 32 and to the Withlacoochee River at Cross-Section 1. The Sunnyday dam failure hydrograph developed as part of a previous dam safety planning study was adopted without modification for use in this study. The Sunnyday dam failure condition was the basis for the Emergency Action Plan developed for Lake Rousseau. The downstream stage hydrograph was set at a constant elevation (3.4 ft-NGVD) for the entire simulation length. This elevation represents the average tide stage for 1996. **Appendix A-Boundary Conditions** contains a plot of the Sunnyday dam failure inflow hydrograph (Inglis Dam Sunnyday Failure).

For the Dam Failure simulation, the Barge Canal Control Structure was operated with the gates closed for the first hour of the simulation. After which, the gates were opened at a constant rate such that they were fully open within 45 minutes. This operating condition is reasonable given the normal level of vigilance provided by the dam's owner and assumes that the control structure can be operated remotely.

4.2.2 Alternative 2

Alternative 2 is described in detail in Section 3.2 of this report and shown schematically on **Figure 7**. The HEC-RAS model for this alternative consists of two (2) river reaches, connected through a lateral outflow structure at the confluence of the Barge Canal and the Withlacoochee River Upper Segment. Additionally, an inline structure is located between the upper and lower segments of the Withlacoochee River. **Appendix A** contains a plan view of the model framework for Alternative 2. This plan view illustrates cross-sections and their spatial relationship for the entire system. Reach 1 (U Withlacoochee) represents the upper and lower segments of the river from the west end of Yankeetown (RS-0) upstream to Inglis Dam (RS-

8.06). Reach 2 (Barge Canal) represents the Barge Canal from the Gulf (RS-0) upstream to the confluence of the Withlacoochee River (RS-5.95). **Figure 13** identifies and illustrates the cross-sections used in the study area and provides a table, which cross references the cross-section ID with the river station. **Appendix A** contains a river profile for the two reaches described above.

Alternative 2, as proposed, removes the Rock Dam/FCL to reconnect the upper and lower segments of the river and replaces it with a control structure to regulate flows, constructs a control structure in the Barge Canal to divert flood flows to the canal and releases all flows from Lake Rousseau through Inglis Dam main gates. The river reconnection was modeled through the placement of Cross-Section 12 between Cross-Sections 11 and 27 and placing an inline control structure (River Control Structure) at Cross-Section 12. The Barge Canal Control Structure was modeled using a lateral outflow structure located in the Withlacoochee River and discharging to the Barge Canal. **Appendix A** contains a large-scale plan view of the model framework illustrating the inline structure (RS-6.45) and the lateral outflow structure (RS-6.59). **Appendix A** also contains a summary print out of the HEC-RAS model input for Alternative 2 for each of the simulations described below.

For the long-term simulation, an inflow hydrograph representing the average flow year (1996) was input to the system at Cross-Section 26 (RS-8.06). Additionally, a downstream stage hydrograph simulating tidal fluctuations for the same year, was applied to the Barge Canal at Cross-Section 32 and to the Withlacoochee River at Cross-Section 1. Section 6.3 of the WO-1 Report provides detailed documentation regarding the selection of the long-term simulation hydrographs. **Appendix A-Boundary Conditions** contains plots of the long-term inflow (Lake Rousseau Long-Term Discharge (Daily)), Alternatives 1 and 2 (Main Gates) and tidal (Long-Term Tide Stage Hydrograph) hydrographs.

For the long-term simulation, the Barge Canal Control Structure was operated with the gates closed and the River Control Structure was operated with the gates open during the entire one-year simulation length. This allows the entire flow series to be conveyed down the lower river segment. Please note that lockage flows are insignificant with respect to annual flow volumes and were ignored in this study.

For the 100-year flood simulation, an inflow hydrograph representing discharge from Lake Rousseau (March 1960) was input to the system at Cross-Section 26 (RS-8.06). Additionally a downstream stage hydrograph simulating tidal fluctuations for the same time period, was applied to the Barge Canal at Cross-Section 32 and to the Withlacoochee River at Cross-Section 1. Section 6.4 of the WO-1 Report provides detailed documentation regarding the selection of the 100-year flood simulation hydrographs. **Appendix A-Boundary Conditions** contains plots of the 100-year flood inflow (Lake Rousseau 100-year Discharge (Daily)), Alternatives 1 and 2 (Main Gates) and tidal (100-year Tide Stage Hydrograph) hydrographs.

For the 100-year flood simulation, the Barge Canal Control Structure was operated with the gates fully open during the entire simulation length. This is reasonable given the nature of flood flows on the river. The River Control Structure is operated so as to maintain a maximum discharge down the lower segment of the river at or below the maximum flow for the normal year hydrograph. This maximum flow is approximately 2,500 cfs.

For the Dam Failure simulation, an inflow hydrograph representing a Sunnyday failure of Inglis Dam was input into the system at Cross-Section 26 (RS-8.06). Additionally, a downstream stage hydrograph was applied to the Barge Canal at Cross-Section 32 and to the Withlacoochee River at Cross-Section 1. The Sunnyday dam failure hydrograph developed as part of a previous dam safety planning study was adopted without modification for use in this study. The Sunnyday dam failure condition was the basis for the Emergency Action Plan developed for Lake Rousseau. The downstream stage hydrograph was set at a constant elevation (3.4 ft-NGVD) for the entire simulation length. This elevation represents the average tide stage for 1996. **Appendix A-Boundary Conditions** contains a plot of the Sunnyday dam failure inflow hydrograph (Inglis Dam Sunnyday Failure).

For the Dam Failure simulation, the Barge Canal Control Structure was operated with the gates closed for the first hour of the simulation. After which, the gates were opened at a constant rate such that they were fully open within 45 minutes. The River Control Structure was operated with the gates fully open for the first hour of the simulation. After which, the gates were closed at a constant rate until the maximum discharge down the lower segment of the river was at or below the maximum flow for the normal year hydrograph. This maximum flow is approximately 2,500 cfs, and it is assumed that the discharge was achieved within 45 minutes after the commencement of gate closing. This operating condition is reasonable given the normal level of vigilance provided by the dam's owner and assumes that the control structures can be operated remotely.

4.2.3 Alternative 3

Alternative 3 is described in detail in Section 3.3 of this report and shown schematically on **Figure 10**. The HEC-RAS model for this alternative consists of two (2) unconnected river reaches. **Appendix A** contains a plan view of the model framework for Alternative 3. The plan view illustrates cross-sections and their spatial relationship for the entire system. Reach 1 (L Withlacoochee) represents the lower segments of the river from the west end of Yankeetown (RS-0) upstream to the Rock Dam/FCL (RS-6.47). Reach 2 (U Withla & B.C.) represents the Barge Canal and the upper segment of the river from the Gulf (RS-0) upstream to Inglis Dam (RS-7.53). **Figure 13** identifies and illustrates the cross-sections used in the study area and provides a table, which cross references the cross-section ID with the river station. **Appendix A** contains a river profile for the two reaches described above. **Appendix A** also contains a summary print out of the HEC-RAS model input for Alternative 3 for each of the simulations described below.

Alternative 3, as proposed, includes reconstructing the Bypass Channel and Bypass Channel Spillway (operable control structure) to provide additional conveyance capacity. The Bypass Channel and control structure were represented in the Alternative 3 models as an inflow hydrograph, which was input to the system at Cross-Section 12. Information regarding the design of this facility is presented in Section 4.1.3 and details are contained in **Appendix A.**

For the long-term simulation, inflow hydrographs representing the average flow year (1996) were input to the system at Inglis Dam (XS-26/ RS-7.53) and at the Rock Dam/FCL (XS-12/ RS-6.47). The inflow hydrograph at the Rock Dam/FCL simulates inflow to the lower segment of the river from the Bypass Channel System. Additionally, a downstream stage hydrograph simulating tidal fluctuations for the same year, was applied to the Barge Canal at Cross-Section 32 and to the Withlacoochee River at Cross-Section 1. Section 6.3 of the WO-1 Report provides detailed documentation regarding the selection of the long-term simulation hydrographs. **Appendix A-Boundary Conditions** contains plots of the long-term inflow (Lake Rousseau Long-Term Discharge (Daily)), Alternative 3 (Main Gates and Bypass) and tidal (Long-Term Tide Stage Hydrograph) hydrographs.

For the long-term simulation, the Lake Rousseau controls were operated so that the majority of discharge was through the Bypass Channel System. A 100 cfs baseflow and periodic water quality releases of 400 cfs were made through the main gates.

For the 100-year flood simulation, an inflow hydrograph representing discharge from Lake Rousseau through the main gates was input to the system at Cross-Section 26 (RS-7.53). A second inflow hydrograph representing discharge from Lake Rousseau from the Bypass Channel System was input to the river and at the Rock Dam/FCL (XS-12/ RS-6.47). Additionally, a downstream stage hydrograph simulating tidal fluctuations for the same time period, was applied to the Barge Canal at Cross-Section 32 and to the Withlacoochee River at Cross-Section 1. Section 6.4 of the WO-1 Report provides detailed documentation regarding the selection of the 100-year flood simulation hydrographs. **Appendix A-Boundary Conditions** contains plots of the 100-year flood inflow (Lake Rousseau 100-year Discharge (Daily)), Alternative 3 (Main Gates and Bypass) and tidal (100-year Tide Stage Hydrograph) hydrographs.

For the 100-year flood simulation, the Lake Rousseau controls were operated so that majority of discharge was through the main gates. The Bypass Channel System was operated to provide a near structure capacity discharge of 2,400 cfs to the lower segment of the river.

For the Dam Failure simulation, an inflow hydrograph representing a Sunnyday failure of Inglis Dam was input to the system at Cross-Section 26 (RS-7.53).). A second inflow hydrograph representing discharge from Lake Rousseau from the Bypass Channel System was input to the river and at the Rock Dam/FCL (XS-12/ RS-6.47). The Bypass Channel discharge rate was assumed to be 2,400 cfs. Additionally a downstream stage hydrograph was applied to the Barge Canal at Cross-Section 32 and to the Withlacoochee River at Cross-Section 1. The Sunnyday dam failure hydrograph developed as part of a previous dam safety planning study was adopted without modification for use in this study. The Sunnyday dam failure condition was the basis for the Emergency Action Plan developed for Lake Rousseau. The downstream stage hydrograph was set at a constant elevation (3.4 ft-NGVD) for the entire simulation length. This elevation represents the average tide stage for 1996. **Appendix A-Boundary Conditions** contains a plot of the Sunnyday dam failure inflow hydrograph (Inglis Dam Sunnyday Failure).

4.2.4 Alternative 4

Alternative 4, the baseline condition is described in detail in Section 3.3 of this report and shown schematically on **Figure 11**. The HEC-RAS model for this alternative consists of two (2) unconnected river reaches. **Appendix A** contains a plan view of the model framework for Alternative 4. The plan view illustrates cross-sections and their spatial relationship for the entire system. Reach 1 (L Withlacoochee) represents the lower segments of the river from the west end of Yankeetown (RS-0) upstream to the Rock Dam/FCL (RS-6.47). Reach 2 (U Withla & B.C.) represents the Barge Canal and the upper segment of the river from the Gulf (RS-0) upstream to Inglis Dam (RS-7.53). **Figure 13** identifies and illustrates the cross-sections used in the study area and provides a table, which cross references the cross-section ID with the river station. **Appendix A** contains a river profile for the two reaches described above. **Appendix A** also contains a summary print out of the HEC-RAS model input for Alternative 4 for each of the simulations described below.

For the long-term simulation, inflow hydrographs representing the average flow year (1996) are input to the system at Inglis Dam (XS-26/ RS-7.53) and at the Rock Dam/FCL (XS-12/ RS-6.47). The inflow hydrograph at the Rock Dam/FCL simulates inflow to the lower segment of the river from the Bypass Channel System. Additionally, a downstream stage hydrograph simulating tidal fluctuations for the same year, was applied to the Barge Canal at Cross-Section 32 and to the Withlacoochee River at Cross-Section 1. Section 6.3 of the WO-1 Report provides detailed documentation regarding the selection of the long-term simulation hydrographs. **Appendix A-Boundary Conditions** contains plots of the long-term inflow (Lake Rousseau Long-Term Discharge (Daily)), Alternative 4 (Main Gates and Bypass) and tidal (Long-Term Tide Stage Hydrograph) hydrographs.

The long-term simulation, with respect to discharges from Lake Rousseau, reflects actual operation of the discharge facilities. Under normal flow conditions the majority of discharge is through the Bypass Channel System up to a maximum discharge rate of 1,540 cfs. All releases from Lake Rousseau in excess of this rate are made through the main gates.

For the 100-year flood simulation, an inflow hydrograph representing discharge from Lake Rousseau through the main gates was input to the system at Cross-Section 26 (RS-7.53). A second inflow hydrograph representing discharge from Lake Rousseau from the Bypass Channel System was input to the river and at the Rock Dam/FCL (XS-12/ RS-6.47). Additionally, a downstream stage hydrograph simulating tidal fluctuations for the same time period, was applied to the Barge Canal at Cross-Section 32 and to the Withlacoochee River at Cross-Section 1. Section 6.4 of the WO-1 Report provides detailed documentation regarding the selection of the 100-year flood simulation hydrographs. **Appendix A-Boundary Conditions** contains plots of the 100-year flood inflow (Lake Rousseau 100-year Discharge (Daily)), Alternative 4 (Main Gates and Bypass) and tidal (100-year Tide Stage Hydrograph) hydrographs.

The 100-year flood simulation with respect to discharges from Lake Rousseau reflects actual operation of the discharge facilities. Under flood flow conditions, discharges through the Bypass Channel System are made up to a maximum discharge rate of 1,540 cfs. All releases from Lake Rousseau in excess of this rate are made through the main gates.

For the Dam Failure simulation, an inflow hydrograph representing a Sunnyday failure of Inglis Dam was input to the system at Cross-Section 26 (RS-7.53). A second inflow hydrograph representing discharge from Lake Rousseau from the Bypass Channel System was input into the river and at the Rock Dam/FCL (XS-12/ RS-6.47). The Bypass Channel discharge rate was assumed to be 1,540 cfs. Additionally, a downstream stage hydrograph was applied to the Barge

Canal at Cross-Section 32 and to the Withlacoochee River at Cross-Section 1. The Sunnyday dam failure hydrograph developed as part of a previous dam safety planning study was adopted without modification for use in this study. The Sunnyday dam failure condition was the basis for the Emergency Action Plan developed for Lake Rousseau. The downstream stage hydrograph was set at a constant elevation (3.4 ft-NGVD) for the entire simulation length. This elevation represents the average tide stage for 1996. **Appendix A-Boundary Conditions** contains a plot of the Sunnyday dam failure inflow hydrograph (Inglis Dam Sunnyday Failure).

4.3 Model Output

This section of the report describes model results (output) for each of the simulation types conducted as part of this study.

4.3.1 Long-Term Simulations

Results of the long-term simulations were used in the natural systems, flood and water quality assessments conducted as part of this study. Long-term simulation model output included tabular summaries and stage hydrographs at each cross-section. The tabular summary included total discharge, water surface elevation and other hydraulic parameters at each cross-section for the maximum water surface profile. The stage hydrographs provided a history of stage for the one-year simulation period. **Appendix B** contains the long-term simulation model output described above for each of the 4 alternatives addressed as part of this study.

Additionally, included with the long-term simulation results in **Appendix B** is model output for the Bypass Channel simulation. This output includes a table of total discharge, water surface elevation and other hydraulic parameters at each cross-section and a typical cross-section with water surface elevation as well as a profile of the system.

4.3.2 100-Year Flood Simulations

Results of the 100-year flood simulations were used in the flood assessment conducted as part of this study. The 100-year flood simulation model output included tabular summaries and stage/flow hydrographs at selected locations throughout the system. The tabular summary included total discharge, water surface elevation and other hydraulic parameters at each cross-section for the maximum water surface profile. Stage/flow hydrographs were provided at Cross-Sections 26, 11, 3 and 29 as well as at the lateral discharge structure (RS-6.59) and the inline structure (RS-6.45) where applicable. The hydrographs provided a history of stage and flow for the simulation period. **Appendix B** contains the 100-year flood simulation model output described above for each of the 4 alternatives addressed as part of this study.

4.3.3 Dam Failure Simulations

Results of the Dam Failure simulations were used in the flood assessment conducted as part of this study. Dam Failure simulation model output included tabular summaries and stage/flow hydrographs at selected locations throughout the system. The tabular summary included total discharge, water surface elevation and other hydraulic parameters at each cross-section for the maximum water surface profile. Stage/flow hydrographs were provided at Cross-Sections 26, 11, 3 and 29 as well as at the lateral discharge structure (RS-6.59) and the inline structure (RS-6.45) where applicable. The hydrographs provided a history of stage and flow for the simulation period. **Appendix B** contains the Dam Failure simulation model output described above for each of the 4 alternatives addressed as part of this study.

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5 RESTORATION ALTERNATIVES EVALUATION

This section of the report describes each of the assessments that were conducted as part of this study.

5.1 Natural Systems Assessment

A natural systems assessment was conducted to determine the impact that each of the proposed alternatives would have on wetlands and other systems in the West Terminus Cross-Florida Greenway area. The results of this assessment were used to grade each of the alternatives. The grading is discussed in detail in Section 7 of this report.

All three proposed alternatives will have an affect on the natural systems along the Withlacoochee River. While the effect will vary from alternative to alternative, each will result in a change in the river's long-term water elevations and the length of time the river will remain at a given elevation. These changes not only vary by alternative, but also by location along the river. The effects on the river are discussed below by alternative and by river segment. For purposes of this study, the river was broken into the upper segment of the river, between Inglis Dam and the Barge Canal (Cross-Sections 27 through 26) and the lower segment of the river, from the Rock Dam/FCL to west of Yankeetown (Cross-Sections 1 through 12). **Figure 13** shows the location of the cross sections along the Withlacoochee River.

Assessment of the effects of the proposed alternatives to the natural systems of the Withlacoochee River was based on review of the long-term simulation composite stage-duration curves, stage hydrographs, topography of the study area, and topographic surveys of the cross-sections modeled in the analysis. **Appendix C–Natural Systems Assessment** contains composite stage-duration curves for each cross-section within the study area. Additionally, selected stage-duration curves were reproduced and included as figures for convenience. **Appendix B** contains stage hydrographs as well as graphic representations of each cross-section within the study area. The effect on the natural resources was evaluated for the three proposed alternatives versus the existing condition (Alternative 4) for the cross-sections located along the upper and lower segment of the Withlacoochee River, as identified above.

5.1.1 Withlacoochee River Upper Segment

<u>*Alternatives 1 and 2*</u>

Alternatives 1 and 2 similarly affects to the river and its natural systems. In the upper segment of the river, Alternative 1 and Alternative 2 result in the river staging (on average) approximately 1 to 3 feet above the existing condition. The increase in stage varies depending on tidal condition, but is always higher than the existing condition. For both alternatives, the resulting increase in river staging is greatest at Inglis Dam (Cross-Section 26) and decreases at each subsequent downstream cross-section to the river's junction with the Barge Canal (Cross-Section 27). **Table 5-1** shows the maximum, minimum and median stage elevation for Alternatives 1 and 2 compared to the existing conditions (Alternative 4). The maximum and minimum stages were determined from the stage hydrographs (presented in **Appendix B**). The median stage was determined from the long-term simulation composite stage-duration curves presented on **Figure 14** through **Figure 16**.

In addition to the stage changes, the tidal fluctuation ranges also changed. Under the existing condition, on a daily basis tidal fluctuation is typically between 2 and 3 feet. With Alternatives 1 and 2, the tidal fluctuation decreases to between 1 and 2 feet.

Table 5-1
Withlacoochee River Upper Segment Normal Water Elevations – Alts 1 and 2 vs. Alt 4

Alternative	Elevation ft-NGVD (Deviation from Existing Condition)					
	Cross-Section 26			Cross-Section 27		
	Maximum	Minimum	Median	Maximum	Minimum	Median
4 (Existing Condition)	6.5	<1.5	3.8	5.9	<1.5	3.6
1	8.1 (+1.6)	3.9 (+2.4)	6.2 (+2.4)	7.1 (+1.2)	2.9 (+1.4)	5.4 (+1.8)
2	8.3 (+1.8)	4.1 (+2.6)	6.3 (+2.5)	7.3 (+1.4)	3.1 (+1.6)	5.5 (+1.9)

The cross-sections of the upper river segment indicate that the banks of the river are relatively high and steep. In this river segment, bank elevations are approximately 10 ft-NGVD. The resulting increase in water surface elevations for Alternatives 1 and 2 generally will remain within the banks of the river. Any wetland vegetation established on the riverbanks should migrate up the banks and reestablish within the new wetland zone at the tidal interface with the river. **Appendix A** contains illustrations of cross-sections representative of this reach (27 through 26).

However, for Cross-Section 22 the left bank has a top elevation of approximately 5 ft-NGVD. Under the existing condition, the top of bank is overtopped for approximately 500 hours (6%) of the year. Alternatives 1 and 2 stage above the top of bank approximately 6,000 hours (68%) of the year, flooding approximately 150 feet inland, or a 4 acre area beyond the existing condition. This approximate 4 acre area will likely maintain a wetland hydrology and the existing upland vegetation will die off with hydrophytic vegetation being established.

Alternative 3

Alternative 3 will result in slightly lower river stages (0.6 feet) below the existing condition. The decrease in stage varies depending on tidal condition. The resulting change in river stage is greatest near Inglis Dam (Cross-Section 26) and diminishes at each subsequent cross-section downstream to zero change at the river's junction with the Barge Canal (Cross-Section 27). **Table 5-2** shows the maximum, minimum, and median river stages for Alternative 3 versus existing conditions.

Table 5-2
Withlacoochee River Upper Segment Normal Water Elevations – Alt 3 vs. Alt 4

Alternative	Elevation ft-NGVD (Deviation from Existing Condition)					
	Cross-Section 26			Cross-Section 27		
	Maximum	Minimum	Median	Maximum	Minimum	Median
4 Existing Condition	6.5	<1.5	3.8	5.9	<1.5	3.6
3	5.9 (-0.6)	<1.5 (0.0)	3.5 (-0.3)	5.9 (0.0)	<1.5 (0.0)	3.6 (0.0)

Due to the high banks in this portion of the river, the slight lowering of river stage as a result of Alternative 3 should have a negligible effect on the natural systems. Any wetland vegetation established on the riverbanks should migrate down the banks and reestablish within the new wetland zone at the tidal interface with the river.

5.1.2 Withlacoochee River Lower Segment

In the lower segment of the river, Alternative 1 and Alternative 2 result in the river staging (on average) approximately 1 foot above the existing condition at the Rock Dam/FCL. Alternative 3 also stages above the existing condition at this location, but the increase in stage is less, just under 1 foot. For all three alternatives, the elevated river stage decreases at each subsequent cross-section downstream to zero change in stage west of Yankeetown. Downstream of US 19 (i.e. Cross-Section 6), the maximum and minimum stages do not differ from the existing condition, but on average, the river stages within this range are slightly higher, as evidenced by the increase in the median stage. **Table 5-3** shows the maximum, minimum, and median stage elevation for the three alternatives compared to the existing conditions. The maximum and minimum stages were determined from the stage hydrographs, presented in **Appendix B**. The median stage was determined from the long-term simulation composite stage-duration curves presented on **Figure 17** through **Figure 23**.

In addition to the stage changes, the tidal fluctuation ranges also change. Compared to the existing condition near the Rock Dam/FCL, on a daily basis the tidal fluctuation range may be reduced by 0.5 to 1 foot under Alternatives 1 and 2. This deviation also decreases at each subsequent cross-section downstream with zero change west of Yankeetown. The decrease in tidal fluctuation range is not as noticeable in Alternative 3.

Table 5-3
Withlacoochee River Lower Segment Normal Water Elevations – Alts 1, 2 and 3 vs. Alt 4

Alternative	Elevation ft-NGVD (Deviation from Existing Condition)											
	Cross-Section 12			Cross-Section 9			Cross-Section 6			Cross-Section 2		
	Max.	Min.	Med.	Max.	Min.	Med.	Max.	Min.	Med.	Max.	Min.	Med.
4 Existing Condition	6.3	2.1	4.6	6.1	1.5	4.1	6.0	<1.5	3.9	5.9	<1.5	3.6
1	7.1 (+0.8)	2.9 (+0.8)	5.5 (+0.9)	6.3 (+0.2)	2.1 (+0.6)	4.6 (+0.5)	6.0 (0.0)	1.5 (0.0)	4.2 (+0.3)	5.9 (0.0)	<1.5 (0.0)	3.6 (0.0)
2	7.3 (+1.0)	3.0 (+0.9)	5.4 (+0.8)	6.3 (+0.2)	2.1 (+0.6)	4.6 (+0.5)	6.0 (0.0)	1.5 (0.0)	4.2 (+0.3)	5.9 (0.0)	<1.5 (0.0)	3.6 (0.0)
3	7.1 (+0.8)	2.1 (0.0)	5.2 (+0.6)	6.3 (+0.2)	1.7 (+0.2)	4.4 (+0.3)	6.0 (0.0)	1.5 (0.0)	4.1 (+0.2)	5.9 (0.0)	<1.5 (0.0)	3.6 (0.0)

The cross-sections in the lower river segment indicate that the banks of the river are relatively high. The resulting increase in water surface elevations for the three alternatives generally will remain within the banks of the river. Any wetland vegetation established on the riverbanks should migrate up the banks and reestablish within the new wetland zone at the tidal interface with the river. **Appendix A** contains illustrations of cross-sections representative of this reach (1 through 12).

At four locations along the lower segment of the river, water stages above the riverbank. For three of these locations including Cross-Section 4, Cross-Section 2, and Cross-Section 1, the river stages above the riverbank, but the peak elevation and duration of the staging is the same for the three alternatives as under the existing condition. The proposed alternatives will not result in any change in the river's water elevation or the length of time the river will remain at a given elevation at these locations.

However, the top of bank elevation of Cross-Section 10 is approximately 5 ft-NGVD. Under the existing condition, the river overbanks for approximately 2,000 hours of the year (23%). Alternatives 1 and 2 stage above the top of bank approximately 4,200 hours of the year (48%), flooding approximately 50 feet inland, or 1.2 acres, beyond the existing condition. Alternative 3 stages above the top of bank approximately 3,600 hours of the year (41%), flooding approximately 30 feet inland, or 1 acre, beyond the existing condition. This approximate 1 acre additional area will likely maintain a wetland hydrology and the existing upland vegetation will die off with hydrophytic vegetation establishing.

5.1.3 Conclusions

Depending on the location within the study area, river stage and duration increase or decrease to some extent. The change is greatest at Inglis Dam and diminishes downstream to zero change west of Yankeetown. Due to the high and steep slopes of most of the riverbank, the effect on the natural systems will be minimal. Any wetland vegetation established on the riverbanks should migrate up or down the bank accordingly and reestablish within the new wetland zone at the tidal interface with the river.

At two locations (Cross-Sections 10 and 22), the proposed alternatives increase stages and duration of overbank flow compared to existing conditions. This will inundate approximately 5 acres of additional land that would likely maintain a wetland hydrology, causing the existing upland vegetation to die off, and hydrophytic vegetation to establish if any of the proposed alternatives are implemented.

Implementation of any of the three alternatives will result in an increase in freshwater down the river. Within the study area, most of the vegetation along the river consists of freshwater species, including bald cypress (*Taxodium distichum*), red maple (*Acer rubrum*), and loblolly bay (*Gordonia lasianthus*). The increase in freshwater should have not affect the community's make up along the river. However, downstream of the study area, the increase in freshwater may decrease salinity within the river. In addition, depending on construction methodologies, implementation of the alternatives may impact wetlands within and adjacent to the construction area.

5.2 Flood Assessment

A flood assessment was conducted to determine the impact that each of the proposed alternatives would have on flooding within the West Terminus Cross-Florida Greenway area. The assessment area illustrated on **Figure 13** begins at Cross-Section 1 located west of Yankeetown and terminates upstream at Cross-Section 26 located at Inglis Dam. The results of this assessment were used to grade each of the alternatives. The grading is discussed in detail in Section 7 of this report.

5.2.1 Affected Structure Analysis

The flood assessment considered impacts to structures located within the floodplain of only the upper and lower segments of the Withlacoochee River. The structures considered as part of this analysis included primarily residential dwellings with some commercial and publicly owned buildings. For the purpose of this analysis, an impact is defined as floodwater above the finished floor elevation of a particular structure. This assessment did not address the severity of structure flooding in terms of inundation depth and duration. Additionally, this assessment did not assess flood damage to structures in dollar costs.

The affected structure analysis was conducted using a database of structures, which was developed as part of previous dam safety planning studies for Lake Rousseau. The structure database includes 456 structures and their associated finished floor elevations. The finished floor elevations were acquired through land surveys and were taken to be the elevation of the lowest entry point (doorway) into the building. The database also includes a reference to the nearest model cross-section for each of the structures. **Figure 13** illustrates and identifies the cross-sections used in this study. The cross-section reference allows the structure's finished floor elevations to be compared to flood stages within the river.

Flood impacts were analyzed for all four alternatives and for each of the event simulation types, which included normal flow, 100-year flood flow and dam failure flow conditions. Results of the hydraulic modeling, described Section 4.3 and documented in **Appendix B** of this report, were used in the affected structure analysis. The model output, consisting of maximum water elevation (flood stage) at each cross-section, was imported to spreadsheets containing the structure database. Individual spreadsheets were prepared for each alternative and simulation type. The spreadsheets were used to determine the depth of inundation, if applicable and to tally the number of affected structures. **Appendix C–Flooding Assessment** contains the spreadsheets used in this analysis.

It is important to note that the flooding results considered in this assessment reflect flooding caused by releases from Lake Rousseau (fluvial flooding). Tidal stages for the normal condition and 100-year flood simulations were responsible for a number of structures being flooded. The maximum, normal condition tide level was estimated to be elevation 5.88 ft-NGVD. This elevation caused flooding at ten (10) structures. The maximum, 100-year flood tide level was estimated to be elevation 5.58 ft-NGVD. This elevation caused flooding at three (3) structures. The results computed by the affected structure spreadsheets were adjusted to reflect fluvial flooding only. These results discussed in the following section.

5.2.2 Results and Conclusions

Table 5-4 below summarizes of the results of the affected structure analysis conducted as part of this assessment. The table presents the number of structures flooded for each alternative and by simulation type.

Table 5-4
Flood Assessment Summary

Event Simulation	Number of Structures Flooded [(a)]			
	Alternative 1	Alternative 2	Alternative 3	Alternative 4 [(e)]
Normal Condition Flows [(b)] (Average Flow Year 1996)	0	0	0	0
100-year Flood Flows (Record Flood 1960)	2 [(c)]	0 [(d)]	0 [(d)]	0 [(d)]
Dam Failure Flows (Sunnyday Event)	227	14	14	14

(a) Tidal flooding is ignored for this assessment.
(b) High tide levels cause flooding at 10 structures for all alternatives.
(c) High tide levels cause flooding at 3 structures for this alternative.
(d) High tide levels cause flooding at 1 structure for this alternative.
(e) Baseline Condition, as exists under present system configuration.

As indicated in **Table 5-4**, zero structures are predicted to flood under normal condition flows for existing conditions or for proposed alternative conditions. For Alternative 1, two structures are predicted to flood for the 100-year flood condition. These structures are located on the lower segment of the river, and are protected from flooding under Alternative 2 by the action of the proposed River Control Structure. Similarly, for Alternatives 3 and 4 these structures will be free from flooding because flood flows are shunted down the Barge Canal by the action of the Rock Dam/FCL. Under Dam Failure flow conditions, 227 structures are predicted to flood for

Alternative 1. These structures are located on the lower segment of the river (213) as well as the upper segment of the river (14). The structures located on the lower segment of the river are protected from flooding under Alternative 2 by the action of the proposed River Control Structure and under Alternatives 3 and 4 by the Rock Dam/FCL.

5.3 Navigation Assessment

A navigation analysis was conducted to assess the impact that each of the proposed alternatives would have on navigation in the West Terminus Cross-Florida Greenway area. The analyses conducted as part of this assessment were compared to the baseline condition (Alternative 4), which represents the system as it presently exists. Refer to **Figure 1** for an illustration of the existing system. The results of this assessment were used to grade each of the alternatives. The grading is discussed in detail in Section 7 of this report.

The navigation analysis does not address trafficability of the system with respect to vessel size and frequency of use. Instead, the proposed system improvements were designed in accordance with existing facilities or proposed replacement facilities, which in part were based on the Boat User Survey conducted for the Florida Department of Transportation and issued as Draft on November, 2002. This navigation analysis assumes that the proposed facilities are both feasible to implement and adequate to accommodate the size and frequency of travel of all vessels using the system under similar conditions of the existing and proposed replacement facilities. The navigation analysis conducted as part of this assessment compares travel times to the Gulf of Mexico (Gulf) from selected locations within the West Terminus Cross-Florida Greenway area for each of the alternatives. The locations selected for comparison include Lake Rousseau, at the upstream (east) end of Inglis Lock, and Withlacoochee River Upper Segment at Inglis Dam. Travel times from these locations to the Gulf were computed for each alternative.

5.3.1 Speed Zones and Travel Velocities

Speed zones and travel velocities used in this assessment were developed from information provided by the U.S. Coast Guard Station at Yankeetown. These speed zones, travel velocities, as well as river distances and estimated travel times are illustrated on **Figure 24**. The mixed speed zone from the Gulf to the first home (west of Yankeetown is approximately three (3) miles long and consists of several 20 miles per hour (mph) zones and 'Slow Speed Manatee Zones'. Based on travel time through this segment of the river, the average speed is estimated to be 6.7 mph. The 'Slow Speed Manatee Zone' is posted at 5 mph and the Barge Canal speed is posted at 25.mph. The 'Idle Speed Zone' does not have a posted speed and thus velocity varies with the type of vessel. For this analysis, a speed of 3 mph is assumed. Also for this analysis, lockage times were assumed to be one-half hour. This assumption was based on a field observation of one lock cycle for Inglis Lock conducted in 1999.

The travel time for the river segments illustrated on **Figure 24** were computed by dividing the estimated river segment lengths by the velocity for the respective zone(s) within that segment. **Table 5-5** provides a summary of travel time for each alternative at each of the selected study reference locations. For example, the travel time from Lake Rousseau to the Gulf is 0.81 hours for Alternative 4 (baseline condition). This time is composed of a lockage time of 0.5 hours plus travel time through the Barge Canal of 0.31 hours (0.26+0.05). The travel time from Lake Rousseau to the Gulf is 3.04 hours for Alternative 1. This travel time is composed of a lockage time of 0.5 hours plus travel time through the Barge Canal of 0.05 hours plus travel time down the Withlacoochee River Lower Segment of 2.49 hours (1.74+0.3+0.45).

5.3.2 *Results and Conclusions*

Results of the navigation analysis are summarized in **Table 5-5**. As indicated in the table, Alternative 1 would have longest travel time, and requires an additional 2.23 hour travel time relative to existing conditions. The travel time for Alternative 2 would increase by 0.5 hours over existing conditions. Alternatives 3 travel times would be identical to existing conditions.

Table 5-5
Navigation Assessment Summary

Study Location	Travel Time (hours) (1)			
	Alternative 1	Alternative 2	Alternative 3	Alternative 4(2)
Lake Rousseau (At Inglis Lock)	3.04	1.31	0.81	0.81
Withlacoochee River Upper Segment (At Inglis Dam)	2.78	1.05	0.55	0.55
	Travel Time Greater-Than Baseline Condition (hours)			
Lake Rousseau (At Inglis Lock)	2.23	0.50	0.00	NA
Withlacoochee River Upper Segment (At Inglis Dam)	2.23	0.50	0.00	NA

(1) Travel time is from the Gulf of Mexico to the particular study location.
(2) Baseline Condition, as exists under present system configuration.

Please note that as conceptualized in this study, Alternative 2 requires a navigation lock to be constructed within the Barge Canal. The travel times presented in Table 5-5 reflect this condition. As an alternative, the River Control Structure could be modified to include a navigation lock. In this case, the travel times are expected to increase slightly over the Alternative 1 travel times, reflecting the added lockage time.

5.4 Water Quality Assessment

Previous studies conducted by the Water Management District and others indicate that elevated salinity concentration is a critical water quality concern in the Withlacoochee River downstream of Lake Rousseau. Elevated salinity is attributed to a die-back of Bald Cypress and sea grasses communities in areas of the river downstream of the study reach. Construction and operation of the Cross-Florida Barge Canal System has resulted in increased salinity levels due to the diversion of river flows into the Barge Canal system. The canal itself, which is relatively wide, facilitates the introduction of seawater nearly 10 miles upstream of the river mouth.

A water quality assessment was conducted to determine the impact that each of the proposed alternatives would have on salinity levels within the West Terminus Cross-Florida Greenway area. The analyses conducted as part of this assessment were compared to the baseline condition (Alternative 4), which represents the system as it presently exists. The assessment area illustrated on **Figure 13** begins at Cross-Section 1 located west of Yankeetown and terminates upstream at Cross-Section 26 located at Inglis Dam. The results of this assessment were used to grade each of the alternatives. The grading is discussed in detail in Section 7 of this report.

5.4.1 Methodology

The water quality analysis conducted as part of this study was limited to an estimate of the location of the saline-water front within the Withlacoochee River study segment. For this simplified study, it is assumed that this point represents the maximum saline intrusion upstream from the coast for a particular alternative. The saline-water front was assumed to be represented by the upstream-most cross-section with negative flows. Negative flows are those that flow up the river from the Gulf.

The long-term models were used in this analysis to simulate normal flows conditions within the river based on the 'Average Year' discharge hydrograph (1996) and corresponding tidal fluctuations. The model simulations were conducted using daily river flow data and 15-minute increment tide-stage data. Model output, consisting of a flow hydrograph at each cross-section, was used to determine the location of the upstream-most negative velocity vector. The hydograph data was also used to develop flow-duration curve at selected locations within the system. The flow-duration curves formed the basis of the water quality assessment. **Appendix C–Water Quality Assessment** contains model printouts of flow hydrographs at selected locations within the Withlacoochee River for the proposed alternatives and existing conditions. Composite flow-duration curves illustrating all four alternatives are also provided at these selected locations.

5.4.2 Results and Conclusions

The results of the water quality analysis are summarized in **Table 5-6**. The top portion of the table documents the estimated number of hours that negative flows persist at a particular cross-section. The lower portion of the table represents the change in duration at a particular cross-section for the proposed alternatives relative to existing conditions (Alternative 4). As such negative numbers represent improved conditions.

Table 5-6
Water Quality Assessment Summary

River Location	Number of Hours Per Year With Reverse Tidal Flows[1]			
	Alternative 1	Alternative 2	Alternative 3	Alternative 4[2]
Cross-Section 1 (River Mile 0, West Yankeetown)	2,667	2,667	2,747	2,933
Cross-Section 2 (River Mile 0.72, Central Yankeetown)	1,123	1,119	1,119	1,516
Cross-Section 22 (River Mile 6.68/6.15)	0	0	2,098	953
	Improvement Over Baseline Condition (hrs/yr)			
Cross-Section 1	-266	-266	-186	NA
Cross-Section 2	-393	-397	-397	NA
Cross-Section 22	-953	-953	1,145	NA

(1) Based upon normal condition flow simulation (average flow year 1996).
(2) Baseline Condition, as exists under present system configuration.

For the Withlacoochee River Lower Segment, it was found that the saline-water front did not change location for any of the alternatives. Negative flows occurred at Cross-Section 2 under existing and proposed conditions. Cross-Section 3, which is approximately one-mile upstream of Cross-Section 2 experienced no negative flows. However, as indicated in **Table 5-6**, there is a significant decrease in negative flow duration at Cross-Section 2 for the proposed alternatives with respect to existing conditions. Under proposed conditions, negative flows will occur greater than two weeks less than existing conditions. This effect decreases to one week at Cross-Section 1.

For the Withlacoochee River Upper Segment, it was found that the saline-water front did change location with respect to the particular alternative. More specifically, the entire reach (Cross-Section 22 through Cross-Section 26) experienced only positive flows for Alternatives 1 and 2. This is consistent with the results describe above for the lower segment, which found that negative flows ceased at Cross-Section 3. For Alternatives 3 and 4 negative flows were found to exist between Cross-Section 22 and Cross-Section 24 inclusive. Negative flows persist in the upper segment for these alternatives due to the influence of the Barge Canal. The Barge Canal, which is relatively wide and deep, helps to extend the saline-water front much farther upstream than the river channel allows. Cross-Section 22 closely represents conditions within the upper segment of the river and was selected for used in the analysis.

As indicated in **Table 5-6**, there are no negative flows at Cross-Section 22 for Alternatives 1 or 2. This condition reflects a 5.5 week decrease in the duration of negative flows for these alternatives with respect to existing conditions. However, there are negative flows at this location for Alternatives 3 and 4. The table also shows a significant increase in the duration of negative flows between Alternative 3 and existing conditions. The duration of negative flows is nearly 7 weeks longer under Alternative 3 than existing conditions. This condition is due to the increase in the discharge volume from the Bypass Channel System for Alternative 3, which causes a necessary decrease in discharge volume from the main gates into the upper river segment.

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6 IMPLEMENTATION COST AND PERMITTING REQUIREMENTS

This section of the report provides details of the estimated cost to plan, design, permit and construct the facilities necessary to implement each of the proposed alternatives. Overall costs are discussed in Section 6.1 and include real estate and permitting dollar costs. Section 6.2 provides specific details of real estate requirements. Section 6.3 provides a summary of the probable permit requirements for each alternative as well as an indication of the feasibility of acquiring these permits. The implementation costs and permitability information was used to grade each of the alternatives. The grading is discussed in detail in Section 7 of this report.

6.1 Construction Costs

This section documents the conceptual level estimate of probable construction costs that were developed for each of the proposed alternatives. The conceptual level plans, cross-sections, and details that were developed as part of this study and presented in detail in Section 3 of this report, were used as a basis for the estimate. The cost estimates included the following general items:

- Mobilization,
- Associated General Costs,
- Construction,
- Utility Relocation,
- Planning, Engineering, Permitting and Design,
- Construction Management,
- Real Estate, and
- Contingency factor applies consistent with the level of details of the estimate.

In general, construction costs were developed from the conceptual plans and details, which were used to estimate quantity takeoffs as necessary to support the estimate. Unit rates for labor and materials were applied based upon information in standard references, information in prior cost studies for similar facilities, and cost estimates from the manufacturer in the case of the vertical gate assemblies. All of the estimates were adjusted to reflect local conditions to the extent possible.

In the case of the US-19 replacement bridge, the estimated construction cost was based on information supplied by FDOT regarding the design and cost of the proposed US-19 bridge over the Barge Canal. As described above, the FDOT bridge design was adopted for use in this study. Costs were adjusted to reflect the need for two spans and real estate requirements. Utility relocations were assumed to be included in the base FDOT estimate. Real estate requirements and costs are discussed in detail in the following section.

Contingency factors were applied to base cost estimates in accordance with the level of detail of the estimate. In general, a 20 percent factor was applied. However, for Alternative 1 a 15 percent factor was applied to reflect the higher level of detail for the U.S.19 bridge estimate and its significance in cost relative to Alternative 1. The escalation factors for Planning, Engineering and Design as well as Construction Management were 15 and 12 percent, respectively. These factors were adopted from standard ACOE planning guidelines for studies at similar levels of detail. The Planning, Engineering and Design cost also covers permitting requirements.

Table 6-1 summarizes of probable implementation costs for each of the proposed alternatives. This table provides the total cost including real estate, permitting and contingencies. **Appendix D** contains a detailed estimate in table format for each alternative.

Table 6-1
Implementation Cost Summary

Alternative	Estimated Construction Cost
1	$41,843,063
2	$26,311,222
3	$12,320,751
4	$0

6.2 Land Acquisition Requirements and Costs

This section documents the land acquisition requirements and costs for each of the proposed alternatives. The conceptual level plans, cross-sections, and details that were developed as part of this study, and presented in detail in Section 3 of this report, were used as a basis for the land acquisition requirements. The land acquisition costs documented herein were included in the overall implementation costs documented in the previous section. The following items were considered in this study:

- Land area requirements,
- Property boundary information from applicable county (Maps),
- Parcel information (Owner, ID Number, Acreage, Improvements),
- Market value of land and improvements (Lands and Damages), and
- Public Law 91-646 relocation costs and Administrative costs.

Land requirements for the proposed facilities were determined from the conceptual plans and details for each alternative. The Citrus and Levy County Property Appraiser's database was then accessed to determine property ownership and value information for the proposed facilities.

Results of the database assessment found that all but one of the proposed facilities were to be sited on land owned by the State of Florida as part of the Cross-Florida Greenway area. Only the proposed US-19 replacement bridge would required the purchase of privately owned property. For this study, it was assumed that there would be no costs associated with the use of State owned land.

Table 6-2 presents details of land acquisition requirements and costs for Alternative 1. Land requirements for this alternative consist of area for frontage roads and rights-of–way adjacent to the bridge. For this assessment, it was assumed that only parcels on the east side of the highway would be required. Additionally, if the land required impacted the use of the parcel for its present purpose, the entire parcel was assumed to be purchased outright. **Figure 28** illustrates the location of the required parcels. The parcels are identified by the Property Number in the table.

The cost to acquire the land and any improvements (Land and Damages) is illustrated at the bottom of the table. These costs were obtained from the Tax Assessor's database as the greater of either Market Value or Last Sale. Escalation factors for acquisition (administrative) and Public Law 91-646 relocation costs were adopted from standard ACOE planning guidelines. The escalation factors are 25 percent and 10 percent, respectively.

Table 6-2
Land Acquisition Requirements and Cost

Property No.	County	Parcel ID	Owner/Address	Acreage (ac)			Market Value (Total Property)	Purchase Price
				Total	Required (ROW)	Purchased		
1	Levy	3038-000-00	Clyde C. Quinby 3800 Airport Pulling Rd. Naples, FL 33942	1.50	0.34	1.50	$100,500	$100,500
2	Levy	3043-000-00	Daniel L. Allen P.O. Box 4 Inglis, FL 34449	1.00	0.26	1.00	$74,705	$74,705
3	Levy	3039-000-00	Donald J. Crawford P.O. Box 992 Crystal River, FL 34429	0.46	0.11	0.46	$33,500	$33,500
4	Levy	3037-001-00	Donald J. Crawford.O. Box 992 Crystal River, FL 34429	0.42	0.11	0.42	$61,589	$61,589
5	Levy	3037-002-00	Jeffrey M. Killion Palm Point Dr. Inglis, FL 34449	0.17	0.06	0.17	$190,000	$190,000
6	Levy	3041-000-00	Jeffrey M. Killion 23 Palm Point Dr. Inglis, FL 34449	0.27	0.09	0.27	$83,656	$83,656
7	Levy	3037-000-00	Joseph Sabel Aldah B. Hitson A. L. Price & Hitson Yankeetown, FL 34498	2.66	0.41	0.41	$146,447	$22,573
8	Citrus	16-17-02 33000	Mabel Peters Caruth 5803 Greenville Ave. Dallas, TX 75206-2916	32.00	1.27	1.27	$440,406	$17,479
						Total Lands and Damages:		$584,001
						Acquisition (administrative) Costs:		$146,000
						Public Law 91-646 Costs:		$58,400
						Total Real Estate Costs		**$788,402**

6.3 Permitting Requirements and Feasibility

All three proposed alternatives will likely require permits from the U.S. Army Corps of Engineers (ACOE) and the Florida Department of Environmental Protection (FDEP). Depending on the resulting effect of the alternative chosen and the extent of any wetland impacts resulting from construction activities associated with implementation of the alternative selected, the permitting effort and requirements will vary.

The complexity of the permitting process will depend greatly on the degree of the impact to jurisdictional wetland areas and the affect the alternative may have on navigation within the waterway. The ACOE regulates the placement of any dredged or fill material within waters of the United States pursuant to Section 404 of the Clean Water Act. As part of their review under Section 404, the ACOE requires the development of an alternatives analysis in compliance with guidelines found within Section 404(b)(1) of the Clean Water Act, including verification that all impacts have first been avoided to the greatest extent possible, that unavoidable impacts have been minimized to the greatest extent possible, and lastly that unavoidable impacts have been mitigated in the form of wetlands creation, restoration, and/or enhancement.

Because the Cross-Florida Barge Canal is a federally designated navigable waterway, implementation of any alternative which would impede navigation within the Canal would require a permit pursuant to Sections 9 and 10 of the Rivers and Harbors Act of 1899. In addition, prior to the approval of any action, which would result in the removal of navigation within a federally designated waterway, de-authorization of the waterway would be required. This de-authorization of the waterway would require approval by the U.S. Congress.

Prior to the recommendation of any modification to a navigational waterway, the ACOE would be required to undertake the development of an environmental document in compliance with guidelines developed by the Council on Environmental Quality (CEQ), pursuant to the National Environmental Policy Act (NEPA) of 1969, as amended. Under this act, effects resulting from the modification or closure of the canal would be assessed to determine the overall impact the project may have on the human and/or natural environment. Depending on the complexity of the proposed action and its environmental effects, the NEPA document may either be a Categorical Exclusion (CatEx), Environmental Assessment (EA) or Environmental Impact Statement (EIS), with the CatEx being the least complex document and the EIS being the most complex document.

The construction of the control structure associated with Alternative 1 will result in the removal of the navigation in the Cross-Florida Barge Canal just below the Withlacoochee River. This alternative will re-route navigation to the Withlacoochee River with removal of the existing Rock Dam/FCL on this river. Because of the potential effects this alternative may have on the human environment, an EIS will most likely be required. Completion of this document could take as long as two to three years and cost over $1,000,000. Upon completion of the EIS, the project could be deemed not permitable due to the environmental impacts.

Alternative 2 will result in an alteration in navigation in the Cross-Florida Barge Canal just below the Withlacoochee River with the construction of a control structure and lock. This action will not result in the loss of navigation above the proposed structure, will likely result in fewer environmental impacts, and will likely require the development of an Environmental Assessment (EA). The proposed lock can be designed to maintain current navigational requirements, as such a Finding of No Significant Impact (FONSI) will likely result. While an EA will be less costly and time consuming than an EIA, it could still take up to 18 months and cost over $500,000.00 to complete.

Alternative 3 will not result in the loss of navigation on the Florida Barge Canal, and as a result, the development of the environmental document for this proposed action would be less complex than either Alternatives 1 or 2.

FDEP requires an Environmental Resource Permit (ERP) when construction of any project results in the creation of a new, or modification of an existing surface water management system or results in impacts to waters of the State or isolated wetlands. As with ACOE permits, the complexity associated with the ERP permitting process will depend on the size of the project, the extent of wetland impacts, and the effects of the projects on drainage and water quality. Based on the ERP regulations, an individual ERP would be required for any of the three proposed alternatives associated with this project.

♦ ♦ ♦

7 COMPARISON MATRIX

A grading matrix was developed as a tool to aid in the evaluation of the proposed alternatives. The grading matrix was prepared based on the results of the assessments presented in Section 5 of this report, as well as implementation costs and permitting requirements presented in Section 6 of this report.

The comparison matrix provides a numeric value for each alternative by the category shown. Within a particular category the alternatives were graded from 1 to 4 (best to worst) based on the performance criteria for that particular category. The performance criteria are described for each category in the notes at the bottom of **Table 7-1**. As an example of the grading scheme, using the cost category, Alternative 1 is awarded a 4 based on having the highest cost and Alternative 4 is awarded a 1 based on having the lowest cost. In the case where alternatives performed equally, they receive the same value. An example of this is the Natural Systems category where Alternatives 1 through 3 performed equally well and each received a value of 1 and Alternative 4 received a value of 2. For this study no attempt was made to have the grade within a category reflect the absolute level of performance of one alternative versus another. Additionally, no weight was given to reflect the relative importance of one category over another.

Table 7-1 is the comparison matrix developed to grade Alternatives 1 through 4. For convenience, the grades are totaled for each alternative.

Table 7-1
Comparison Matrix

Grade Category	Relative Grade Values			
	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Natural Systems [a]	1	1	1	2
Flooding [b]	2	1	1	1
Navigation [c]	3	2	1	1
Water Quality [d]	1	1	2	3
Permitability [e]	4	3	2	1
Cost [f]	4	3	2	1
Values Summation	15	11	9	9

(a) Considers creation of wetland habitat and improvement to estuary systems.
(b) Considers the number of buildings flooded.
(c) Considers travel time to the Gulf.
(d) Considers the location and duration of salt water in the river.
(e) Considers the feasibility and ease of obtaining permits.
(f) Considers construction, design, permitting and land acquisition dollar costs.

As discussed in Section 5.1 of this report, all of the proposed alternatives provide an improvement to the natural systems in the study area. Although Alternative 3 provides less area of wetland creation than Alternatives 1 or 2, its potential for improvements to the estuary area near the mouth of the river is the same as Alternatives 1 and 2. As such all of the proposed alternatives are graded as performing equally followed by Alternative 4 (existing condition), which is graded lower. The maximization of wetland and estuary system improvements can be addressed in future design studies.

The flood assessment is discussed in detail in Section 5.2 of this report. As illustrated in **Table 5-4**, the number of structures flooded under Alternative 1 is greater, for both the 100-year flood and dam failure conditions, than Alternatives 2 through 4. As such, Alternatives 2 through 4 are graded as performing equally and Alternative 1 is graded lower.

The navigation assessment is discussed in detail in Section 5.3 of this report. As illustrated in **Table 5-5**, the travel time under Alternative 1 is the greatest followed by Alternative 2 and then Alternatives 3 and 4, which are equivalent. As such, Alternatives 3 and 4 are graded highest followed by Alternative 2 and Alternative 1 respectively, which are graded sequentially lower.

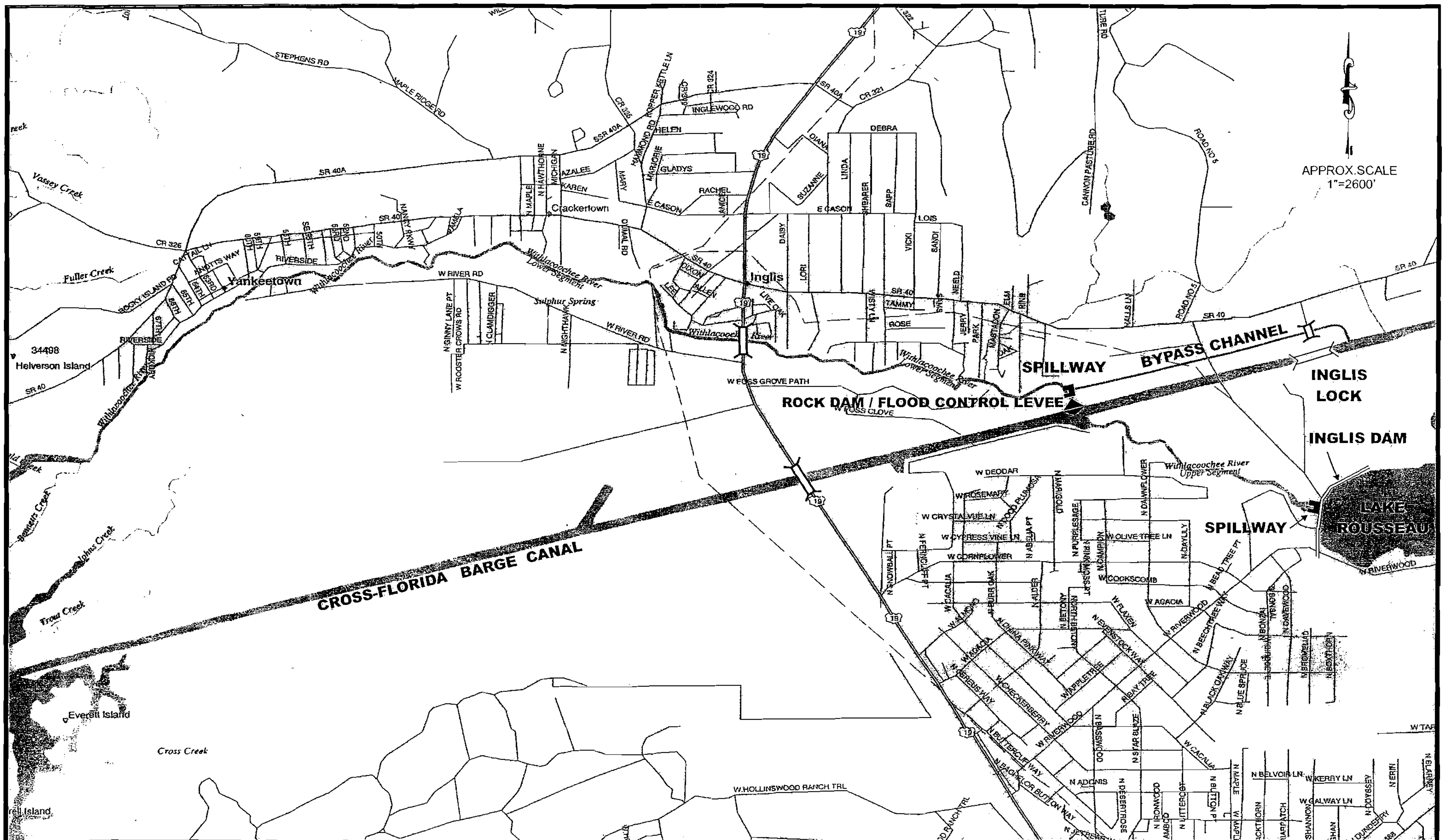
The water quality assessment is discussed in detail in Section 5.4 of this report. As illustrated in **Table 5-6**, the improvement to water quality is approximately equivalent for all of the proposed alternatives in the lower segment of the Withlacoochee River. In addition, the improvement to water quality in the upper segment of the Withlacoochee River is the same for Alternatives 1 and 2. However, Alternative 3 results in lower water quality in this segment relative to the existing conditions. As such, Alternatives 1 and 2 are graded highest followed by Alternative 3 and Alternative 4 respectively, which are graded sequentially lower.

A discussion of permitting requirements is provided in Section 6-3 of this report. The level of complexity in the required permits is addressed in that section. This grading is based on permit complexity and hence time and capital requirements. Alternative 1 has the most stringent permit requirements and is thus graded the lowest. Alternative 2 and Alternative 3 have progressively less stringent permitting requirements and are graded sequentially higher. Alternatives 4 requires no permitting and receives the highest grading.

The construction cost assessment is discussed in detail in Section 6.1 of this report. As illustrated in **Table 6-1**, Alternative 1 has the highest cost followed by Alternative 2 and Alternatives 3 respectively. Alternative 4 is a no cost alternative as it reflects existing conditions. As such, Alternative 4 is graded highest based on having the lowest cost followed by Alternatives 3, 2 and 1, whose progressively higher costs yield lower grades.

♦ ♦ ♦

FIGURES



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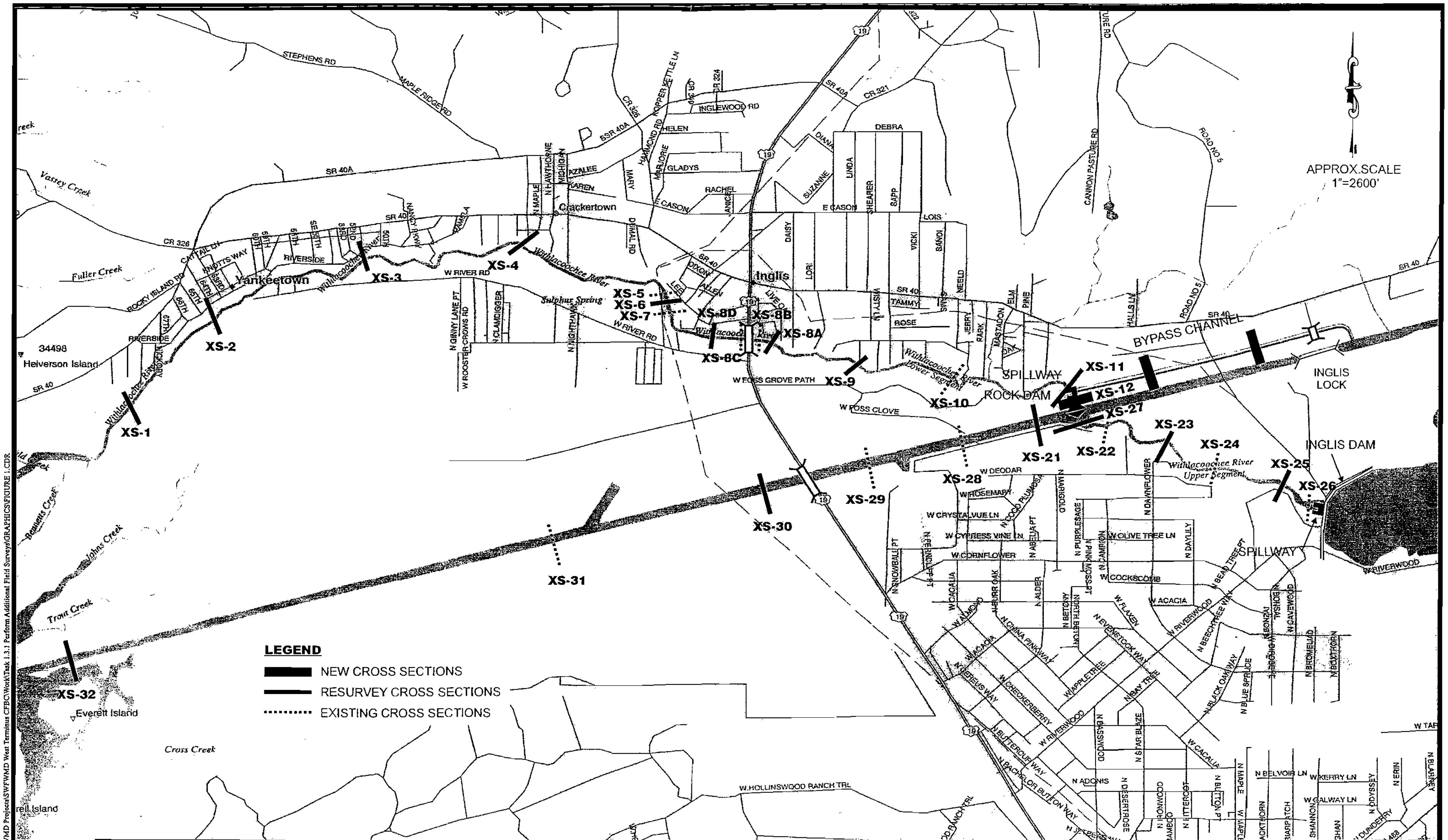
WEST TERMINUS CROSS-FLORIDA GREENWAY ASSESSMENT
Southwest Florida Water Management District

FIGURE 1
CROSS-FLORIDA BARGE CANAL
SYSTEM COMPONENTS



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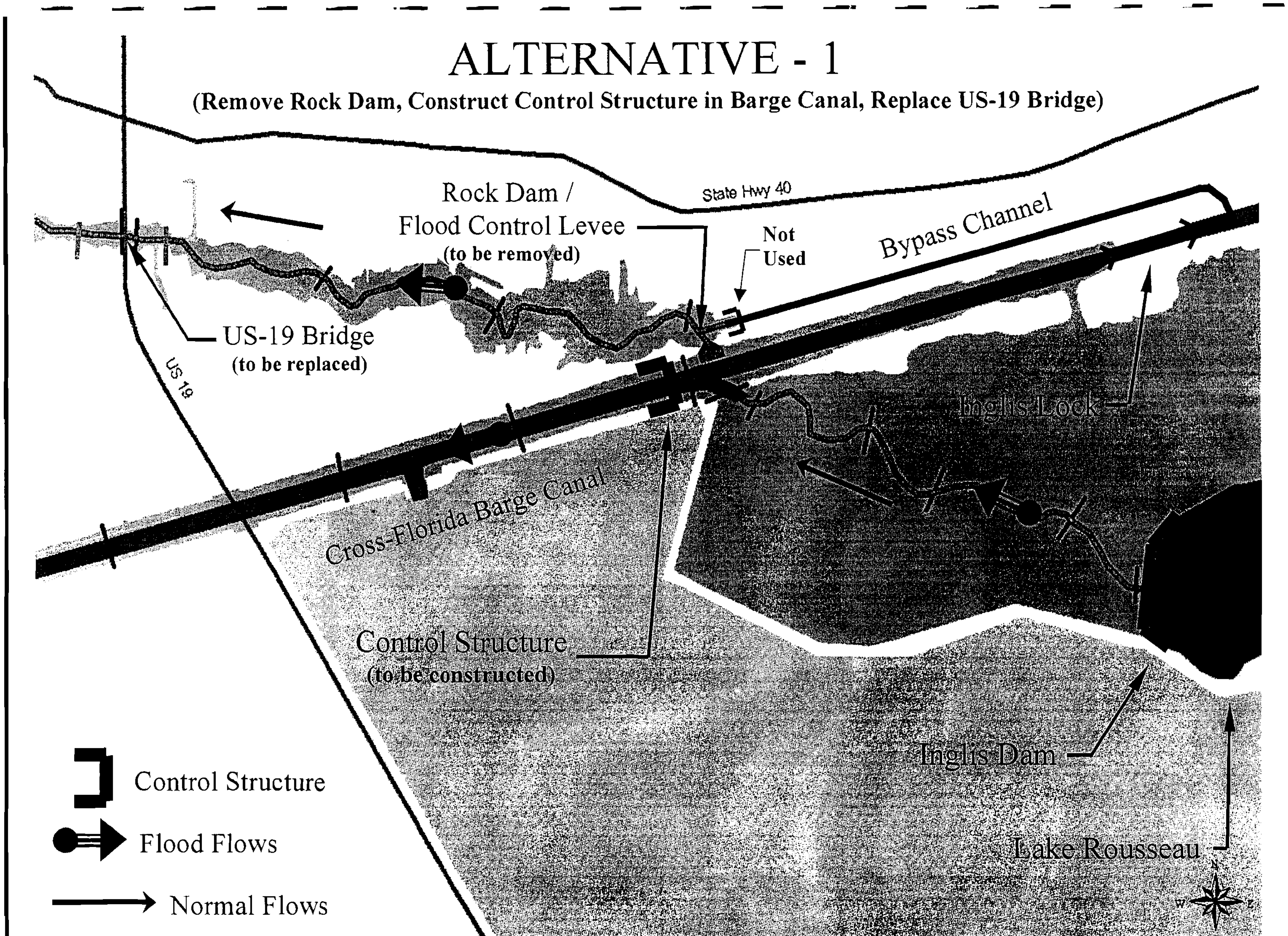
Southwest Florida Water Management District

FIGURE 2
ADDITIONAL LAND SURVEY LOCATIONS

G:\WATER\Projects\SWFWMD Projects\SWFWMD West Terminus CFBC\Work\Task 1.3.1 Perform Additional Field Surveys\GRAPHICS\FIGURE 1.CDR



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Southwest Florida Water Management District

FIGURE 3
ALTERNATIVE 1
CONCEPTUAL PLAN

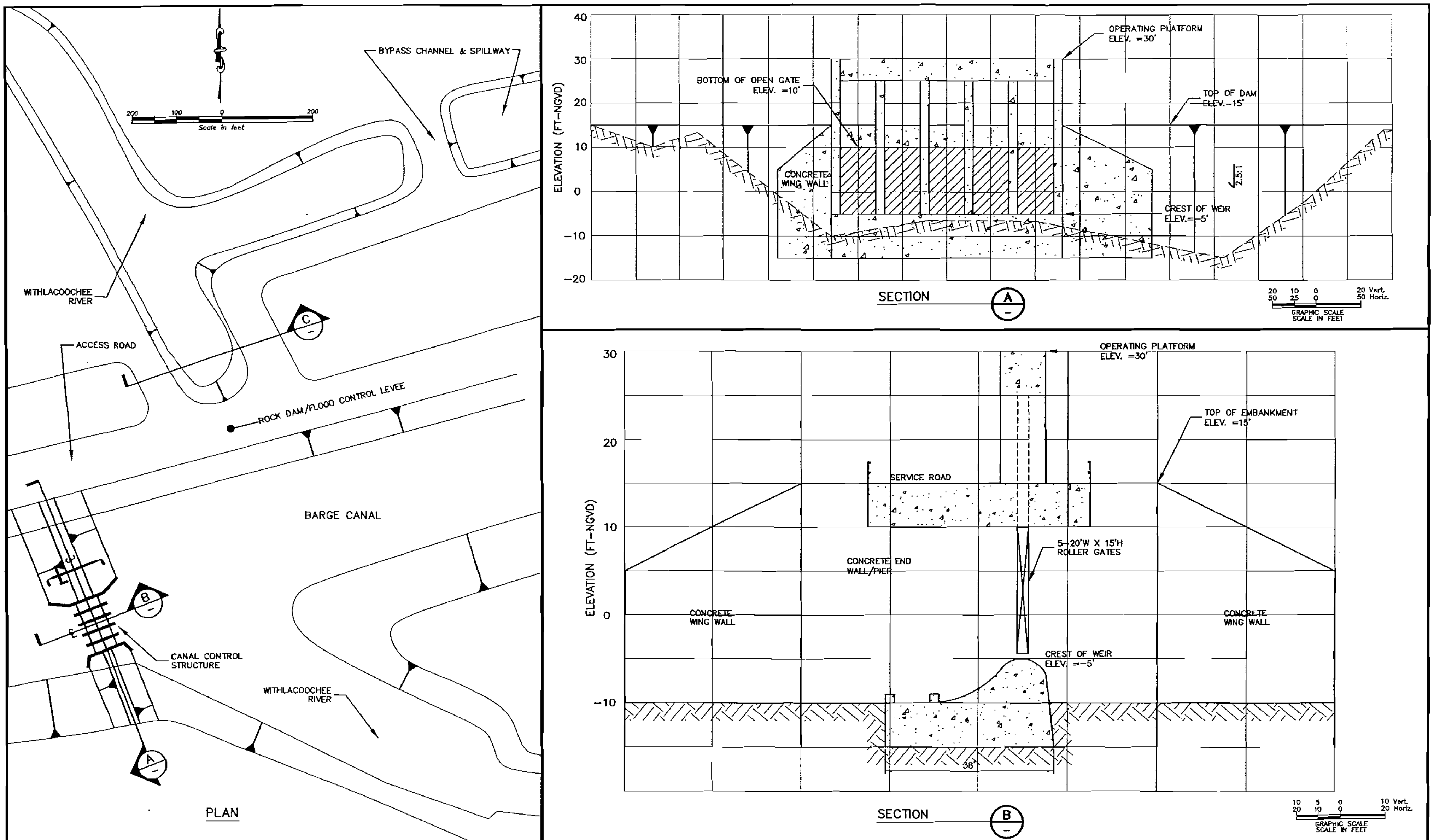

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FIGURE 4
ALTERNATIVE 1
CANAL CONTROL STRUCTURE
PLAN AND SECTIONS

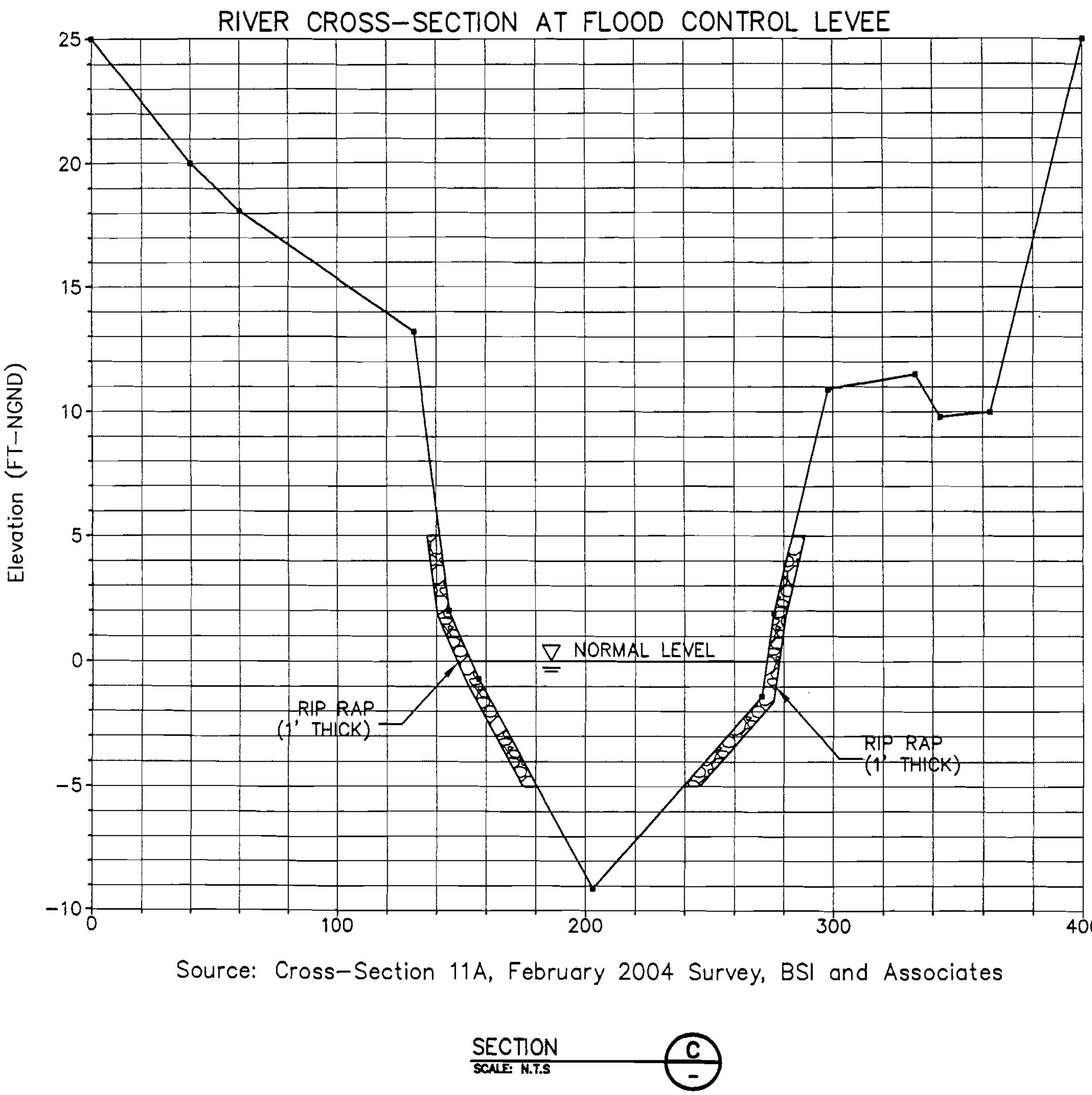

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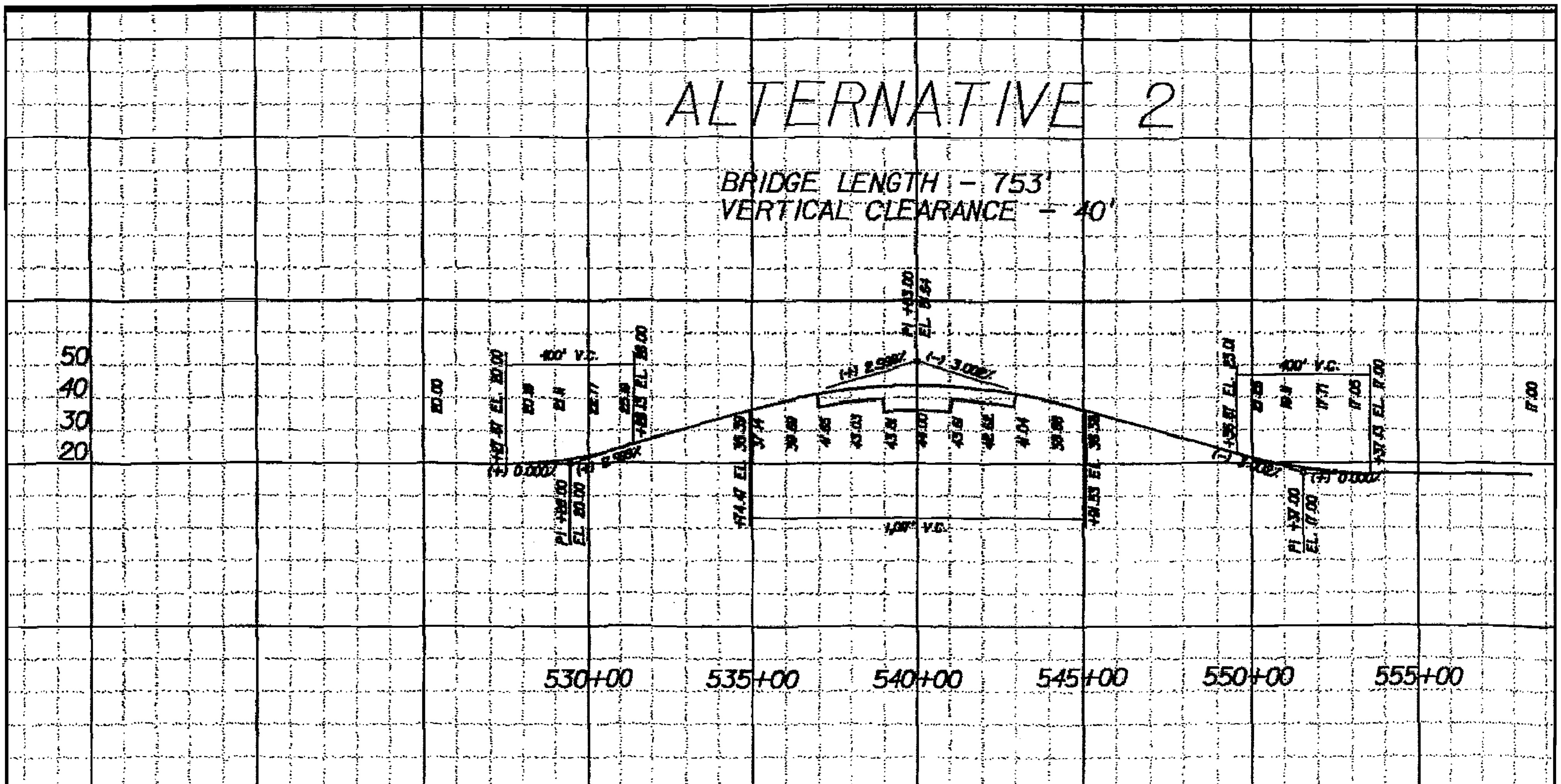
FIGURE 5
ALTERNATIVE 1
PROPOSED RIVER CROSS-SECTION



STATE OF FLORIDA DEPARTMENT OF TRANSPORTATION			US 19 BRIDGE Over FLORIDA BARGE CANAL PD&E STUDY	SHEET NO.
ROAD NO.	COUNTY	FINANCIAL PROJECT ID		
US 19	CITRUS	257167-1-21-01		8

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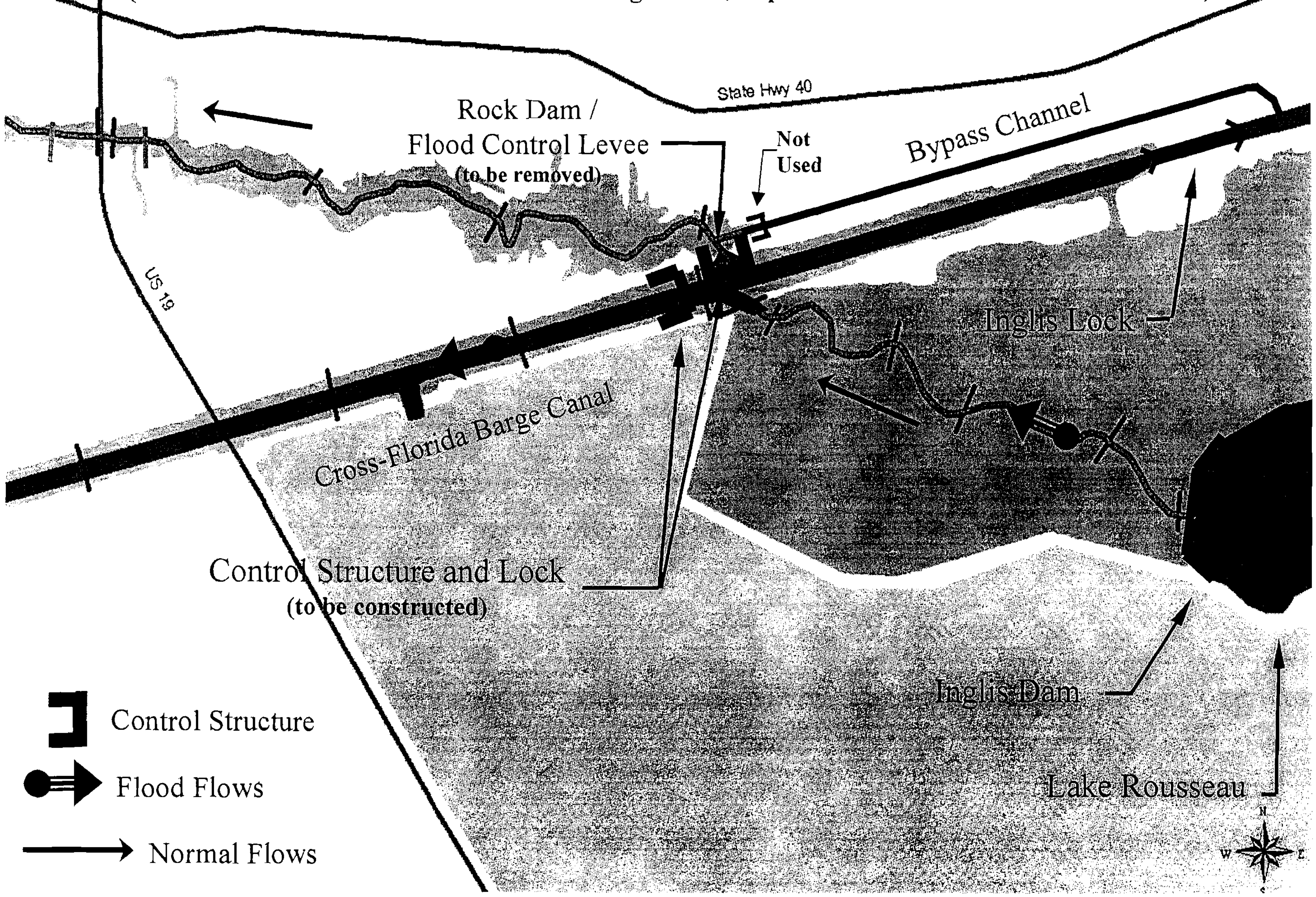
WEST TERMINUS CROSS - FLORIDA GREENWAY ASSESSMENT
Southwest Florida Water Management District

FIGURE 6
ALTERNATIVE 1
US-19 REPLACEMENT BRIDGE

ALTERNATIVE - 2

(Construct Control Structure and Lock in Barge Canal, Replace Rock Dam with Control Structure)



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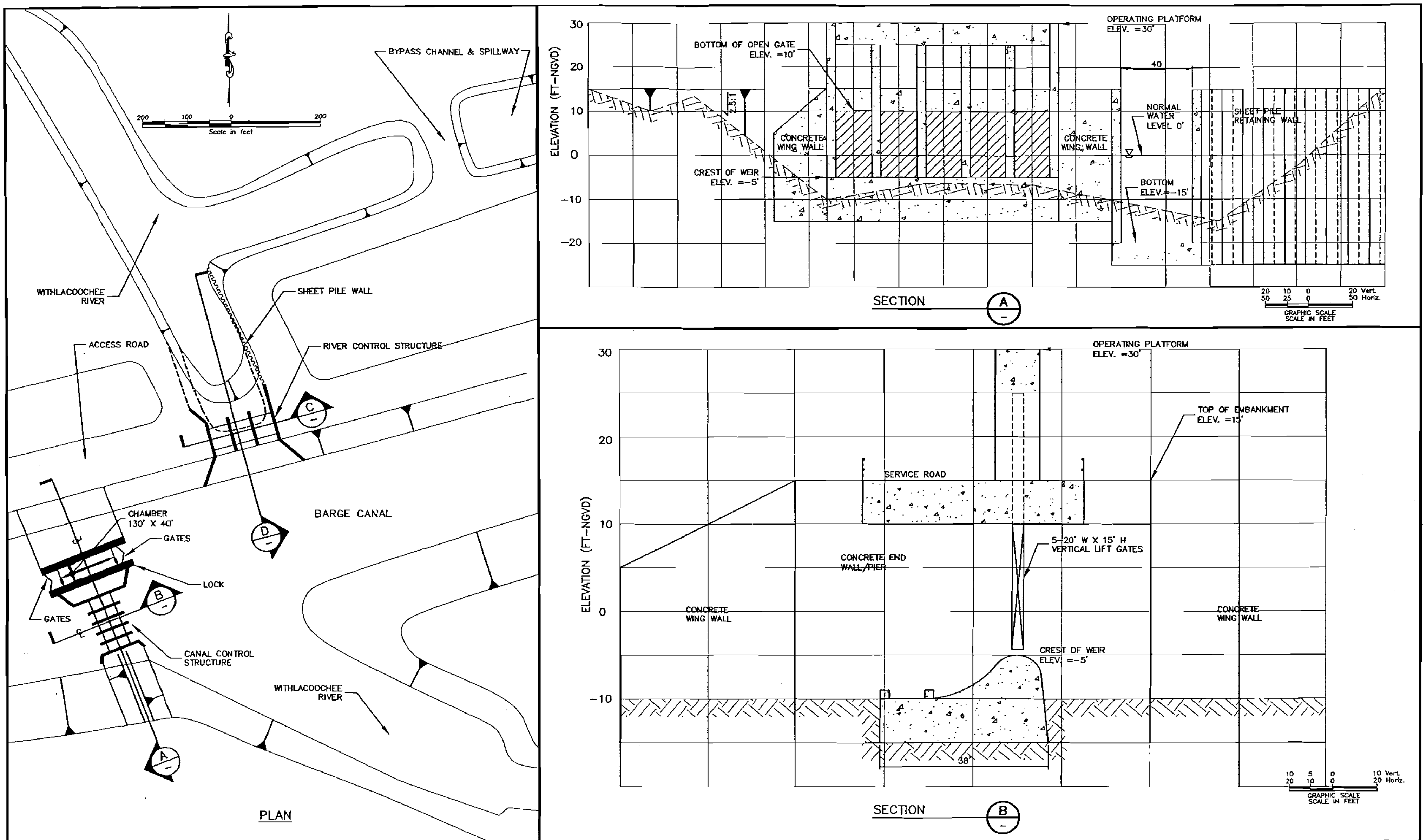
Southwest Florida Water Management District

FIGURE 7
ALTERNATIVE 2
CONCEPTUAL PLAN



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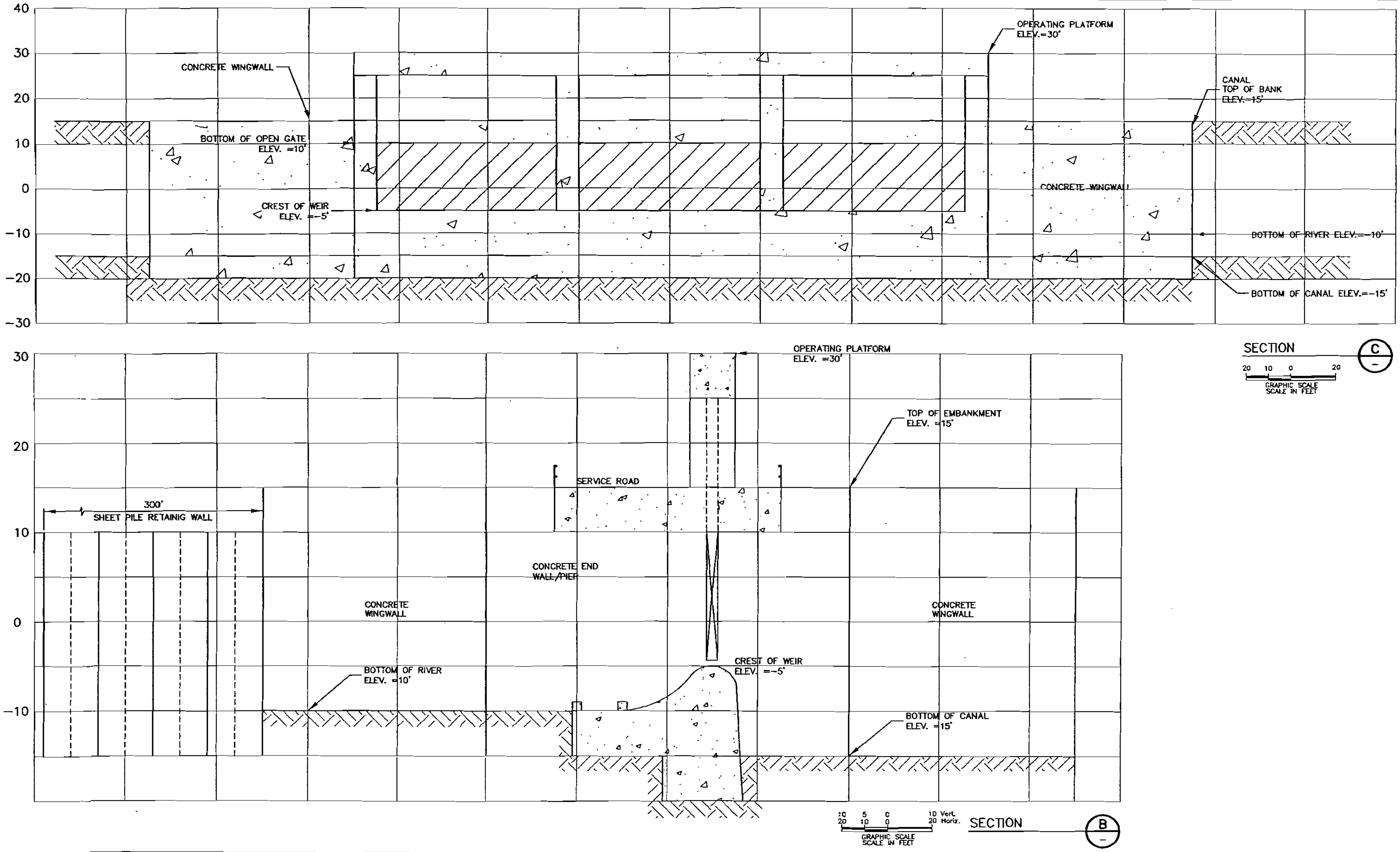
Southwest Florida Water Management District

FIGURE 8
ALTERNATIVE 2
CANAL AND RIVER
CONTROL STRUCTURES AND LOCK
PLAN AND SECTIONS



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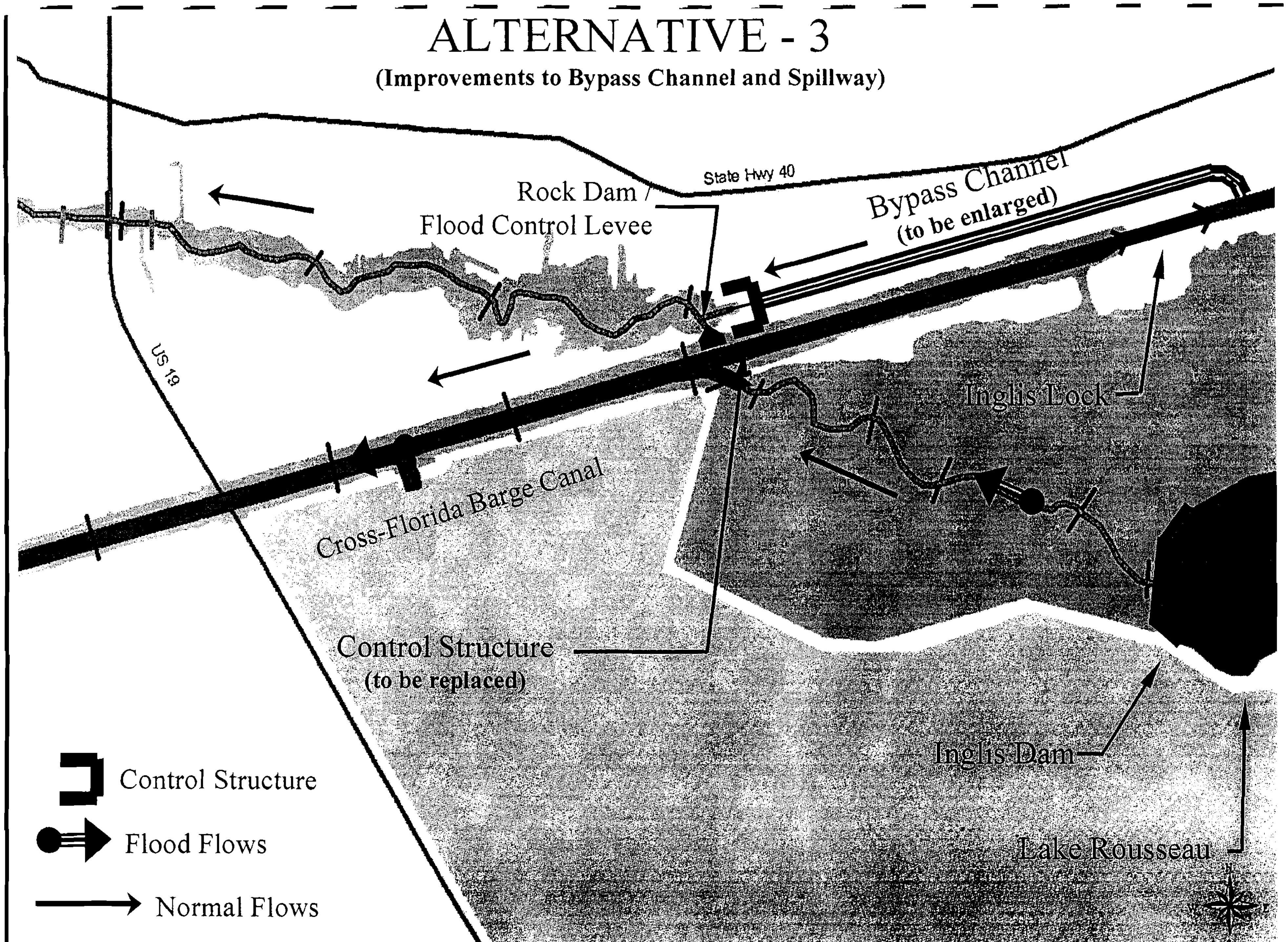
WEST TERMINUS CFGA STUDY
Southwest Florida Water Management District

FIGURE 9
ALTERNATIVE 2
RIVER CONTROL STRUCTURE
SECTIONS



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Southwest Florida Water Management District

FIGURE 10
ALTERNATIVE 3
CONCEPTUAL PLAN

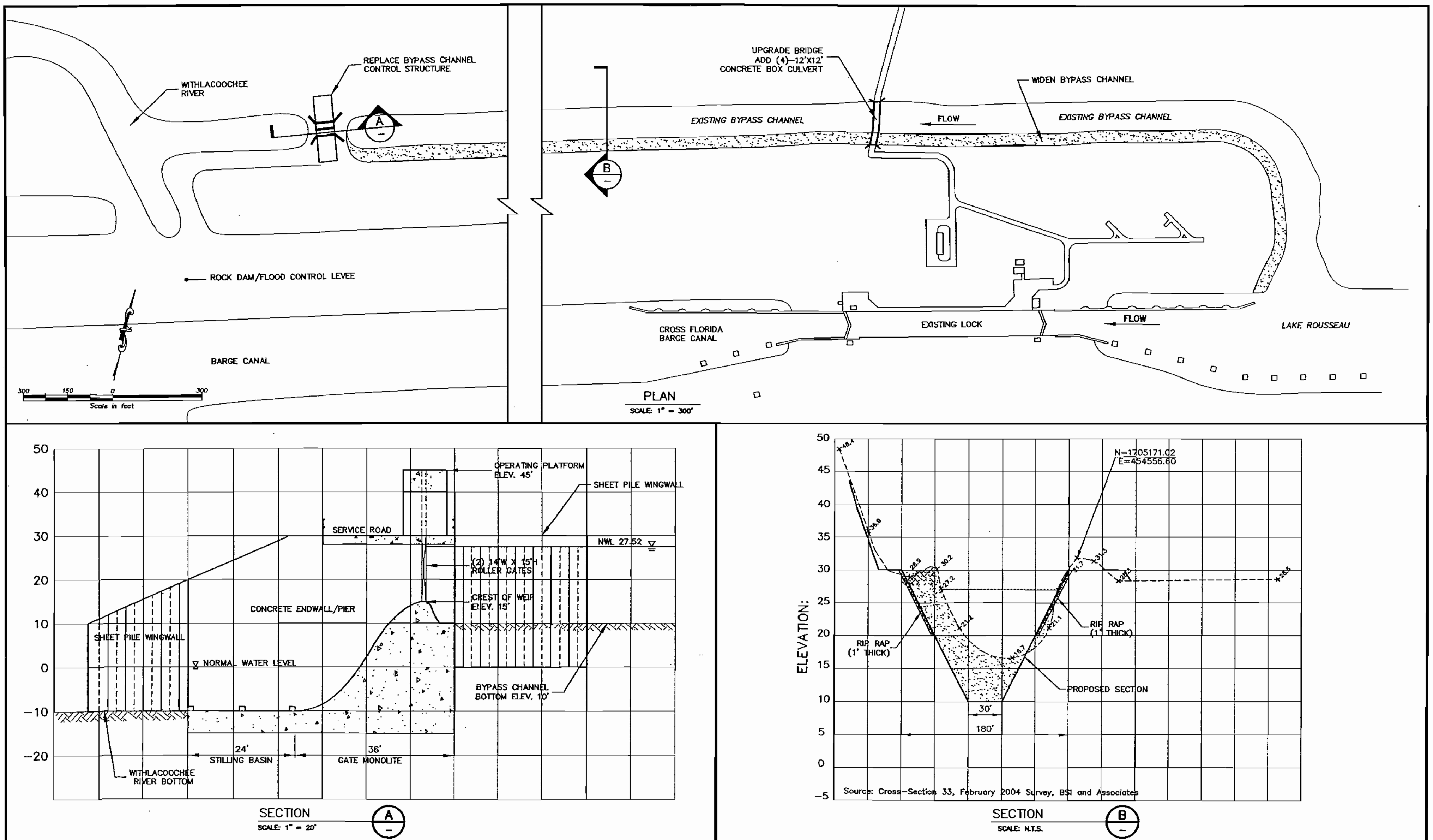

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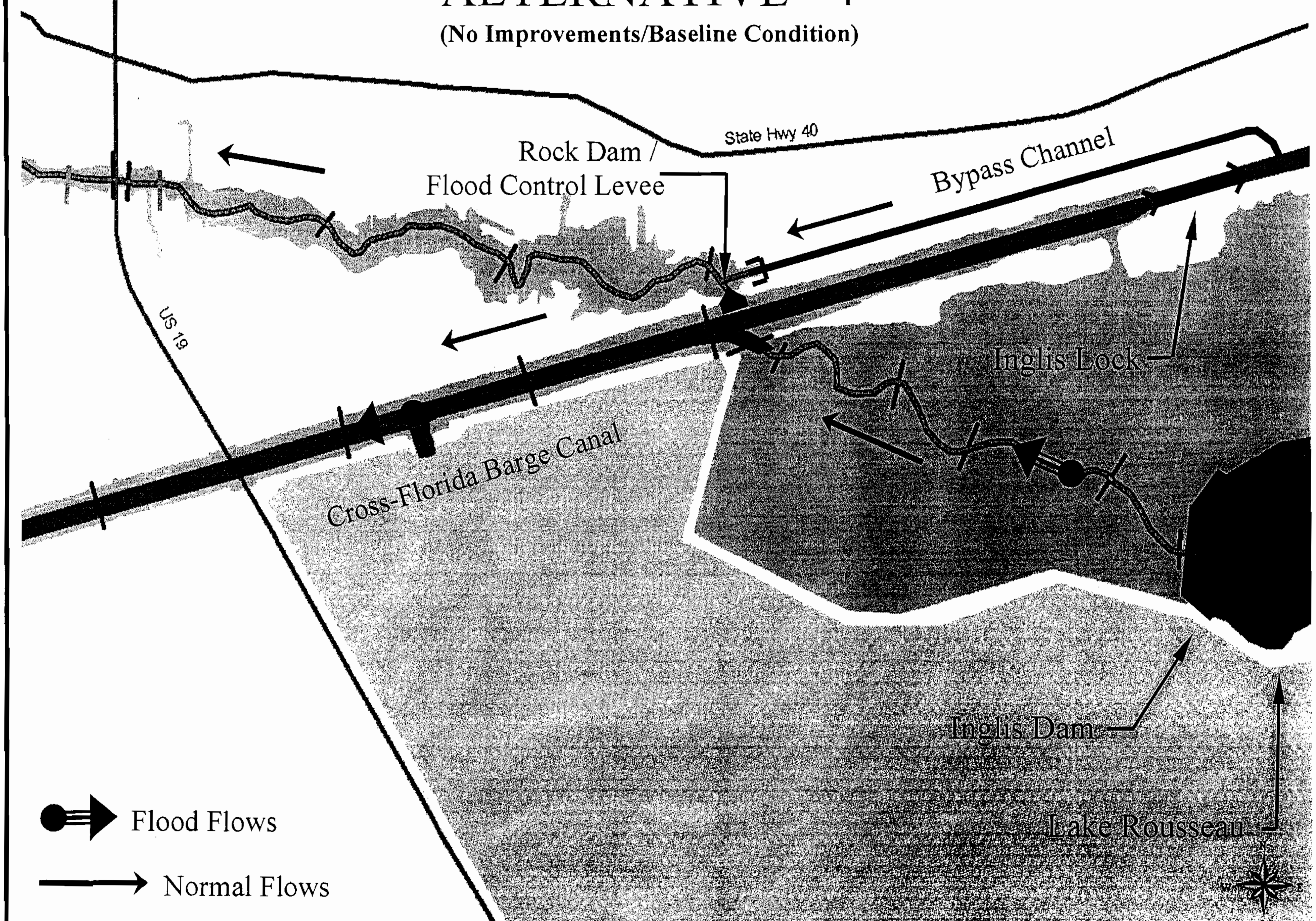
FIGURE 11
ALTERNATIVE 3
BYPASS CHANNEL AND CONTROL STRUCTURE
PLAN AND SECTION

ALTERNATIVE - 4

(No Improvements/Baseline Condition)



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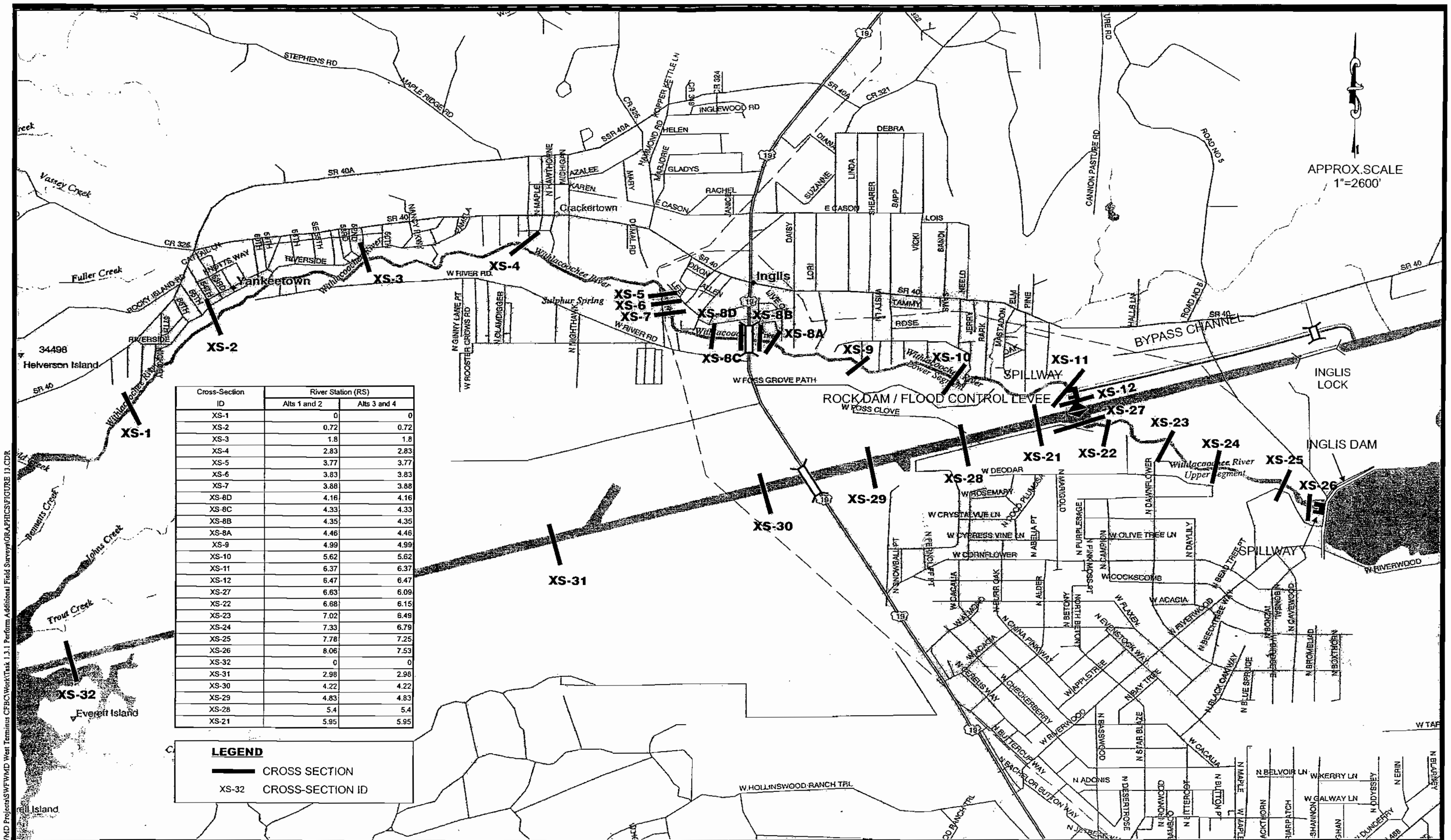
Southwest Florida Water Management District

FIGURE 12
ALTERNATIVE 4
CONCEPTUAL PLAN



Cross-Section ID	River Station (RS)	
	Alts 1 and 2	Alts 3 and 4
XS-1	0	0
XS-2	0.72	0.72
XS-3	1.8	1.8
XS-4	2.83	2.83
XS-5	3.77	3.77
XS-6	3.83	3.83
XS-7	3.88	3.88
XS-8D	4.16	4.16
XS-8C	4.33	4.33
XS-8B	4.35	4.35
XS-8A	4.46	4.46
XS-9	4.99	4.99
XS-10	5.62	5.62
XS-11	6.37	6.37
XS-12	6.47	6.47
XS-27	6.63	6.09
XS-22	6.68	6.15
XS-23	7.02	6.49
XS-24	7.33	6.79
XS-25	7.78	7.25
XS-26	8.06	7.53
XS-32	0	0
XS-31	2.98	2.98
XS-30	4.22	4.22
XS-29	4.83	4.83
XS-28	5.4	5.4
XS-21	5.95	5.95

LEGEND

CROSS SECTION

XS-32 CROSS-SECTION ID

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WEST TERMINUS CROSS-FLORIDA GREENWAY ASSESSMENT
Southwest Florida Water Management District

FIGURE 13
CROSS-SECTION LOCATIONS

G:\WATER\Projects\SWFWMD Projects\SWFWMD West Terminus CFBC\Work\Task 1.3.1 Perform Additional Field Surveys\GRAPHICS\FIGURE 13.CDR

LONG-TERM SIMULATION RS-8.06/7.53 (Cross-Section 26)

Composite Stage-Duration Curve

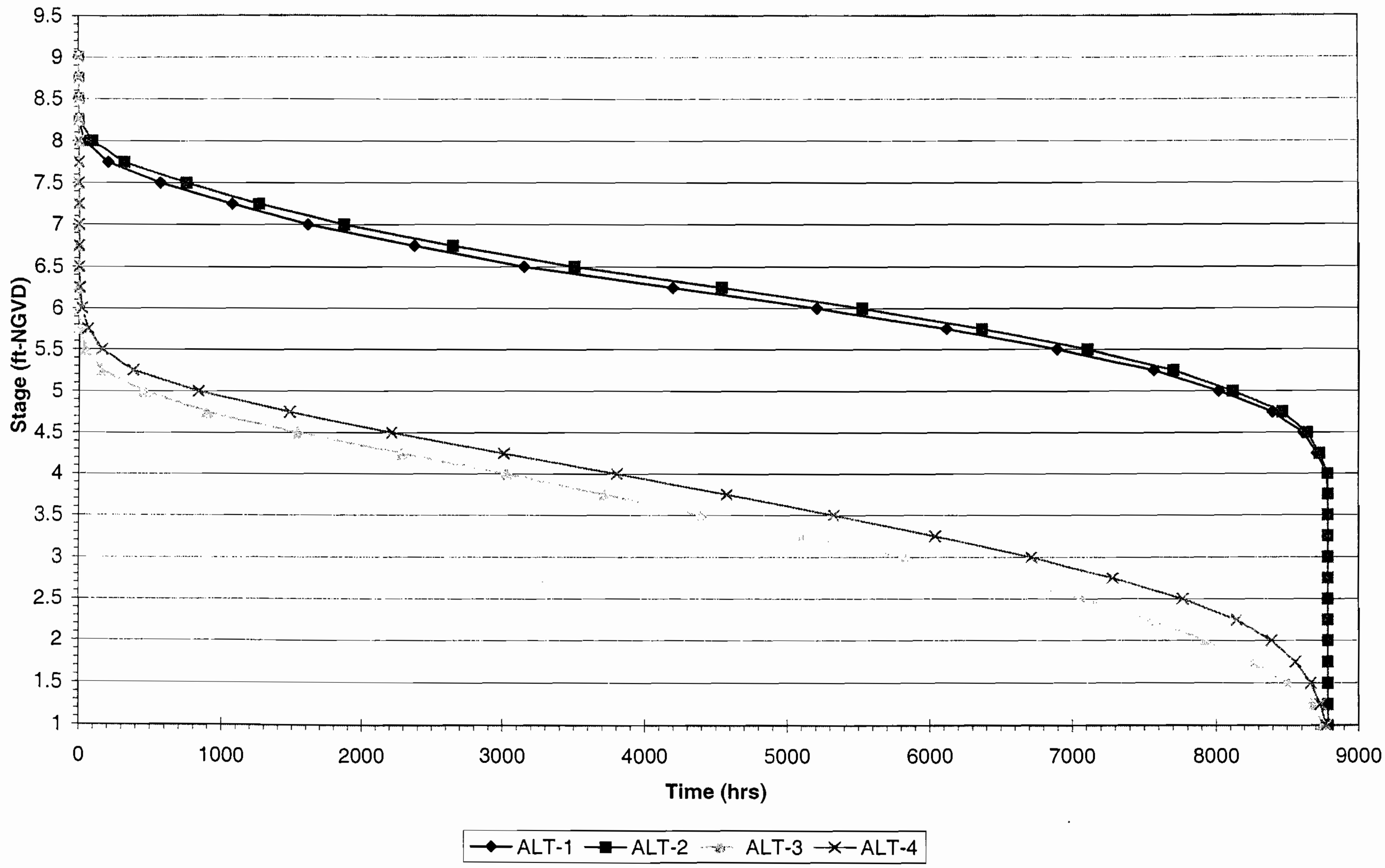


Figure 14

LONG-TERM SIMULATION RS-6.63/6.09 (Cross-Section 27)

Composite Stage-Duration Curve

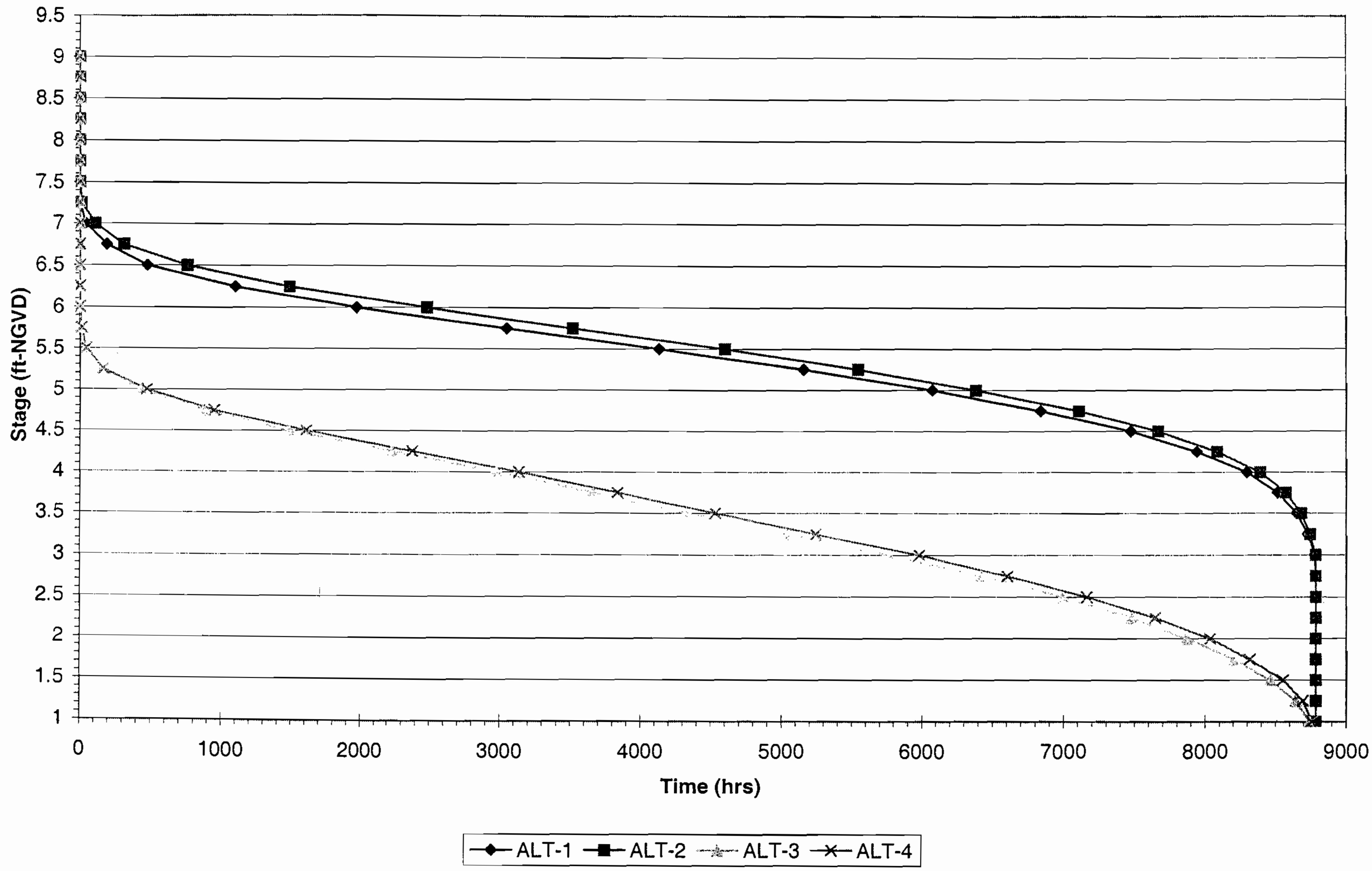


Figure 15

LONG-TERM SIMULATION RS-6.68/6.15 (Cross-Section 22)

Composite Stage-Duration Curve

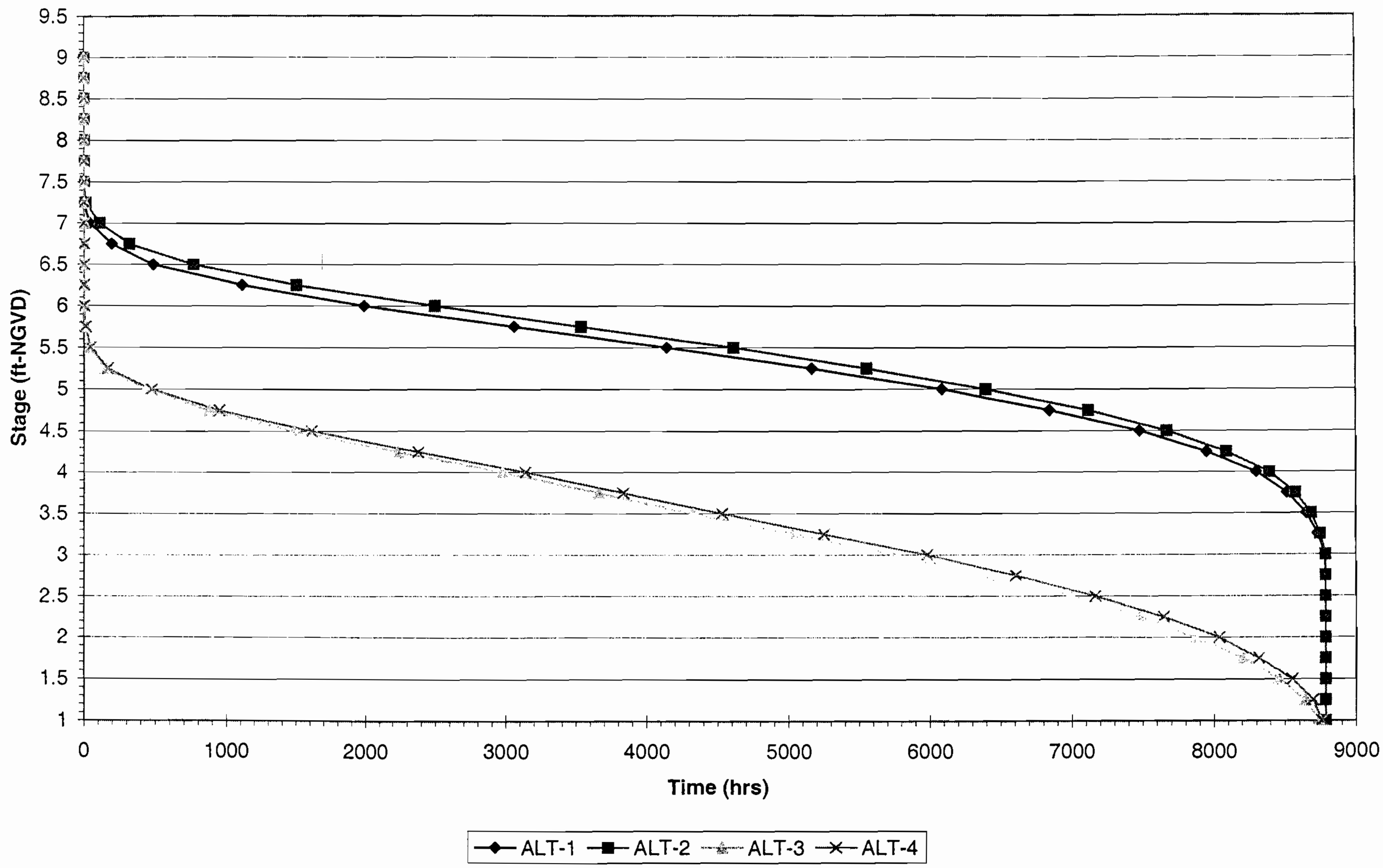


Figure 16

LONG-TERM SIMULATION RS-6.47 (Cross-Section 12)

Composite Stage-Duration Curve

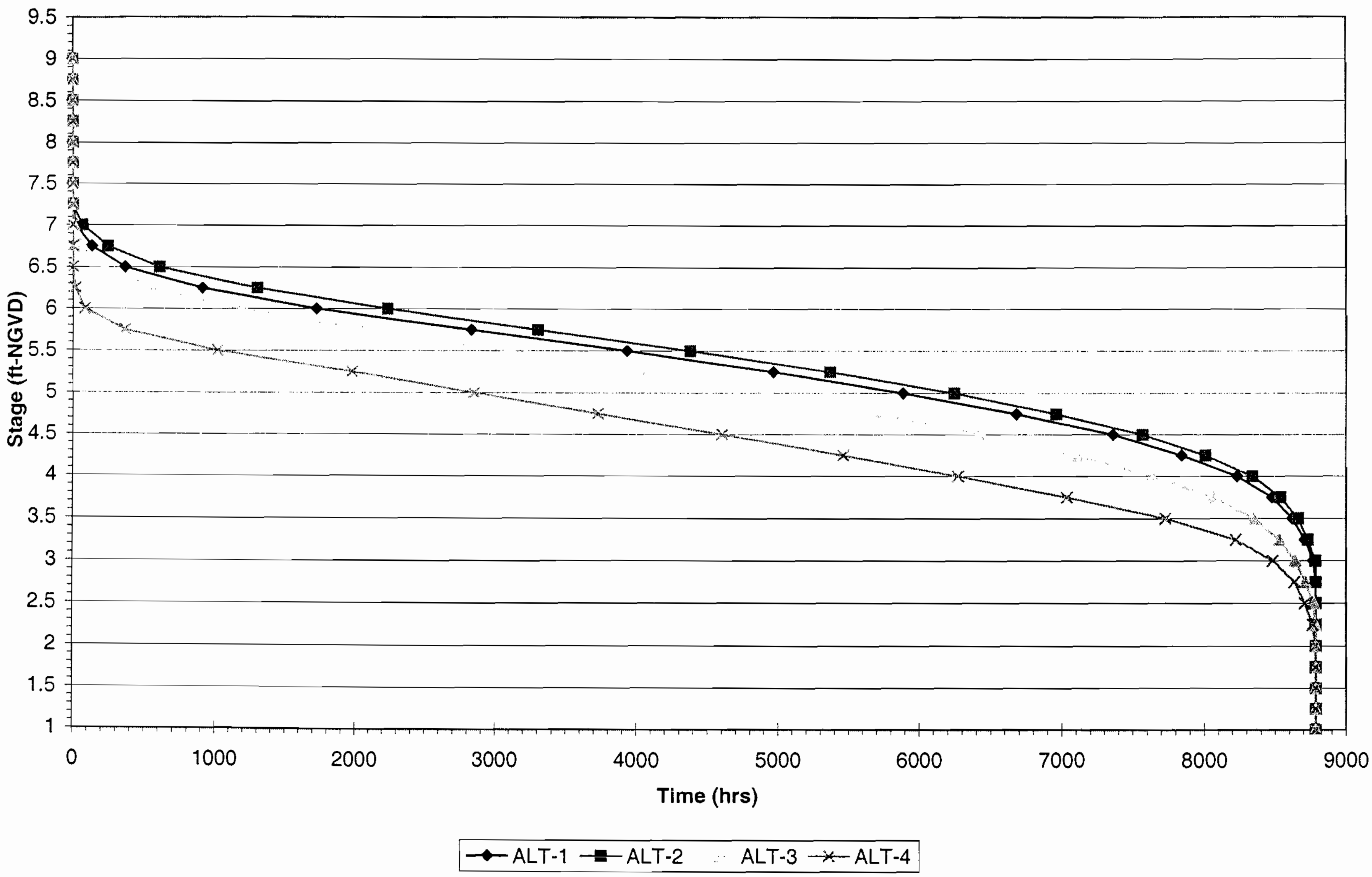


Figure 17

LONG-TERM SIMULATION RS-4.99 (Cross-Section 9)
Composite Stage-Duration Curve

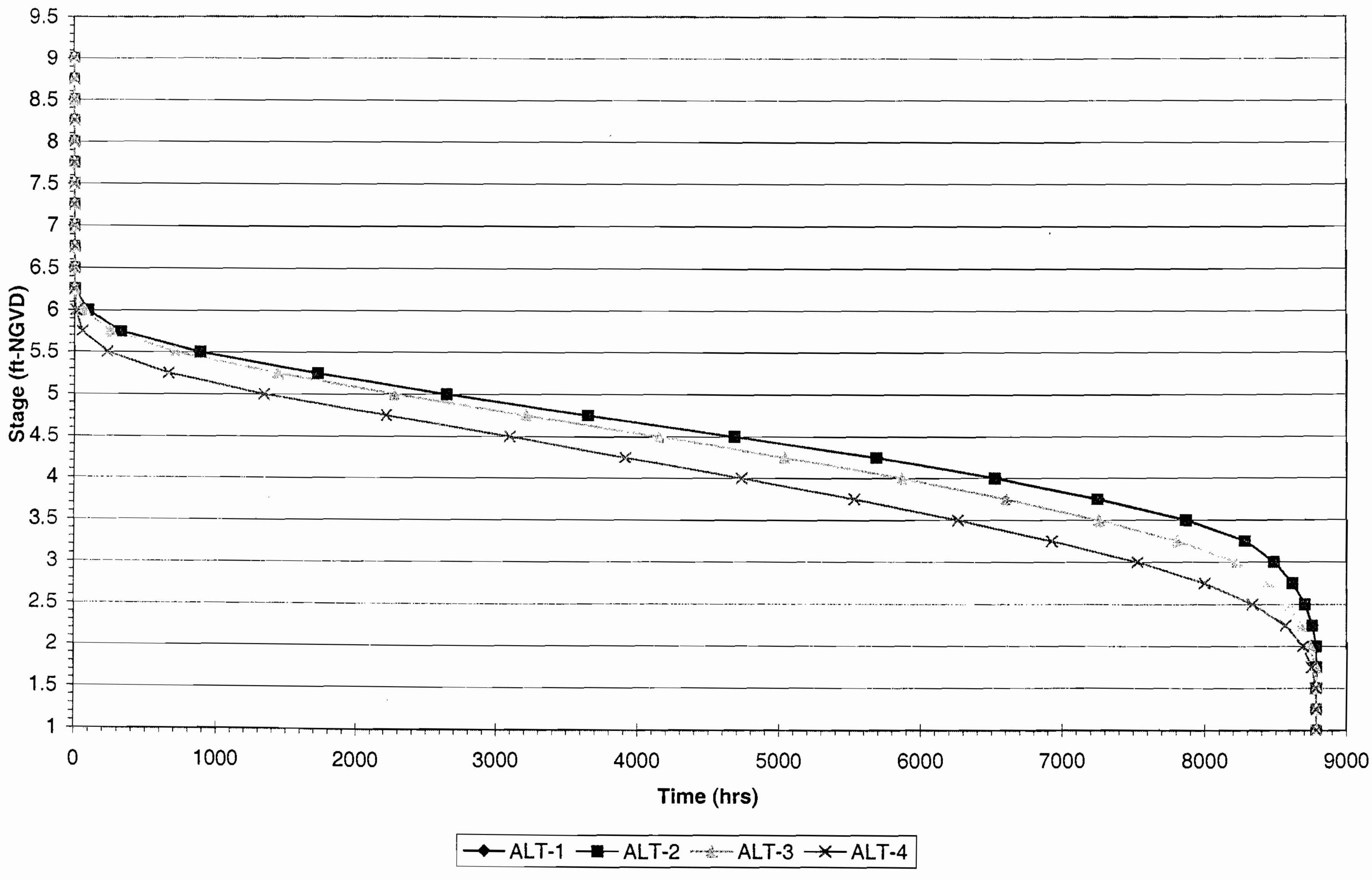


Figure 18

LONG-TERM SIMULATION RS-3.83 (Cross-Section 6)

Composite Stage-Duration Curve

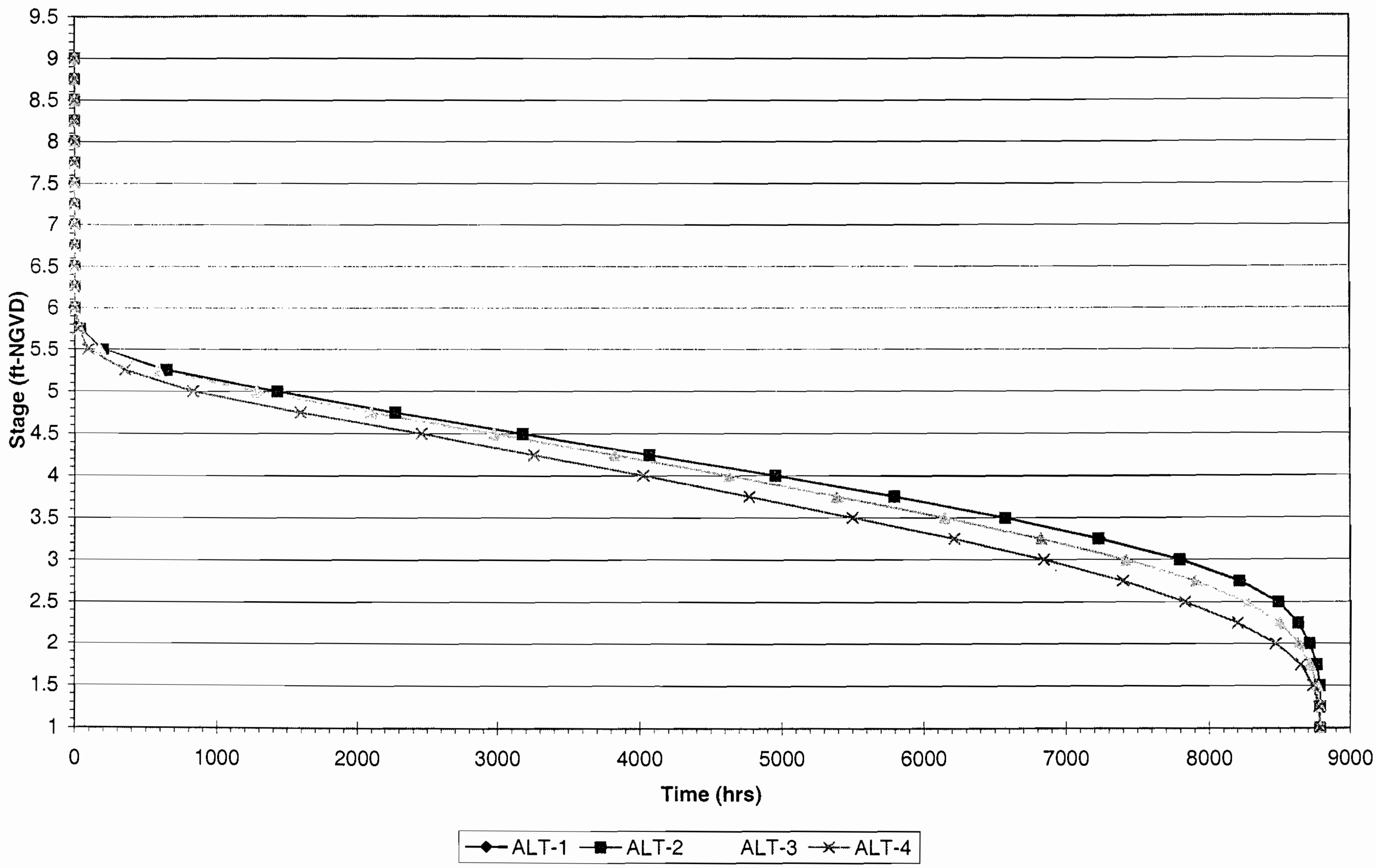


Figure 19

LONG-TERM SIMULATION RS-0.72 (Cross-Section 2)
Composite Stage-Duration Curve

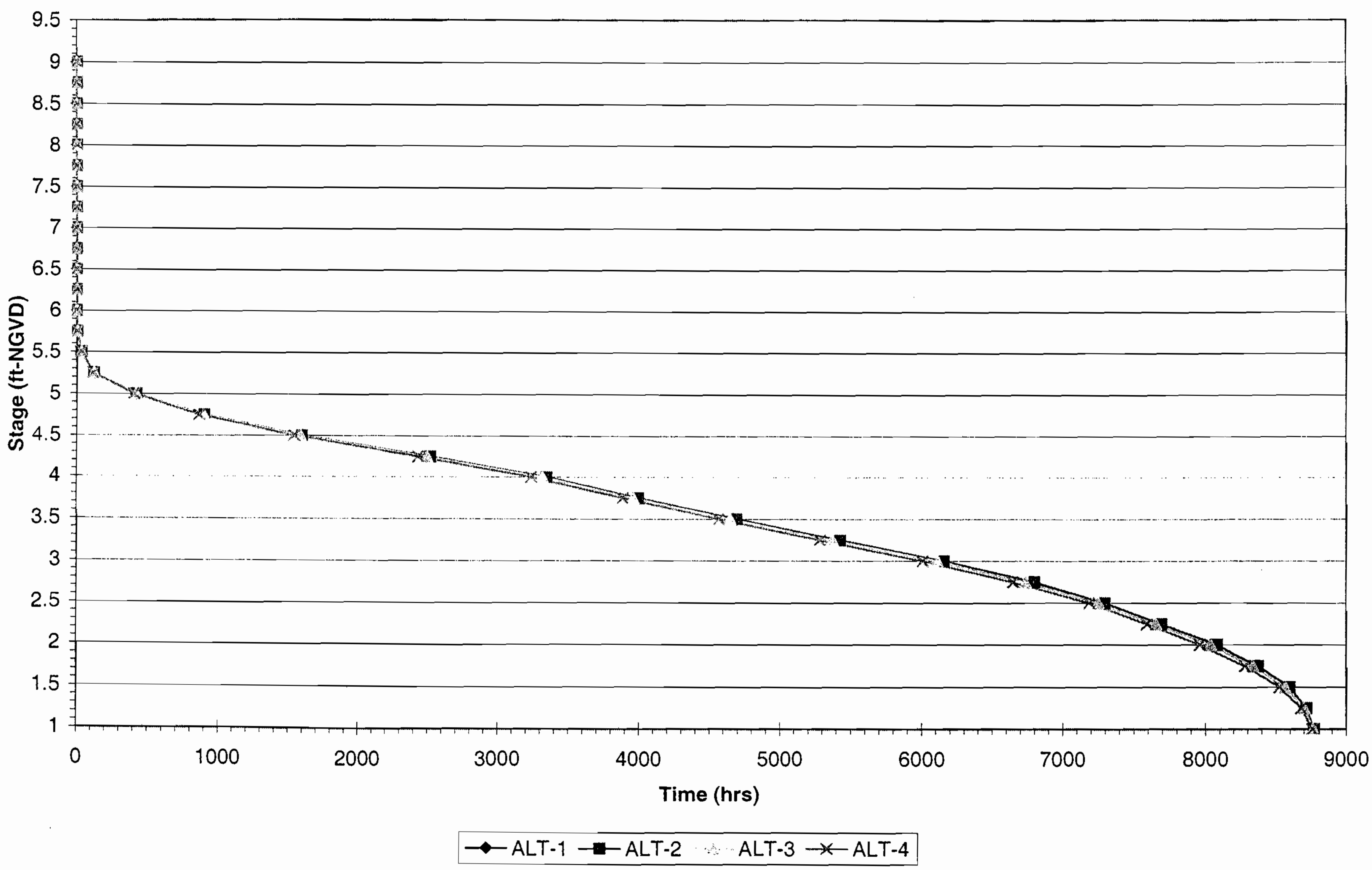


Figure 20

LONG-TERM SIMULATION RS-5.62 (Cross-Section 10)

Composite Stage-Duration Curve

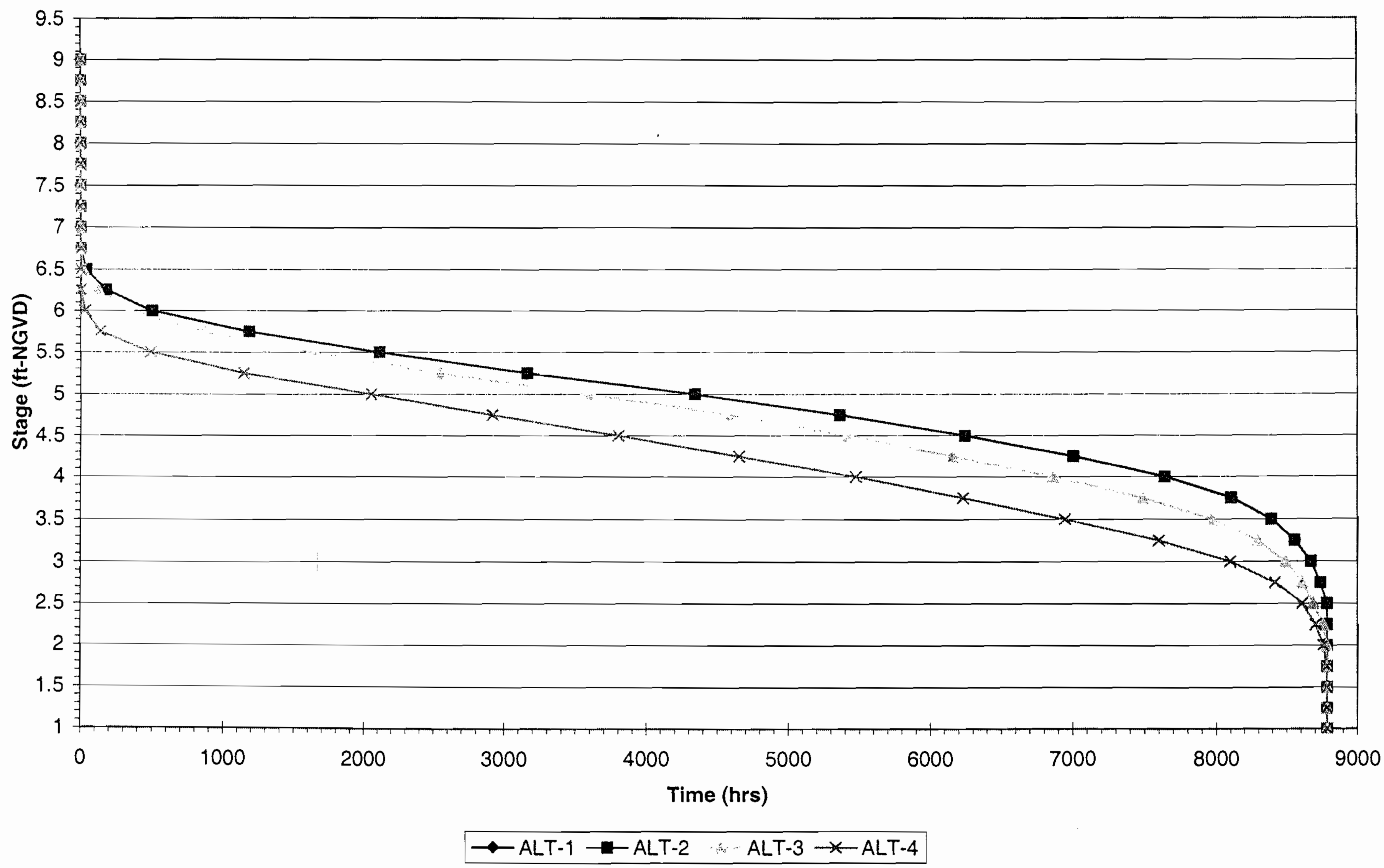


Figure 21

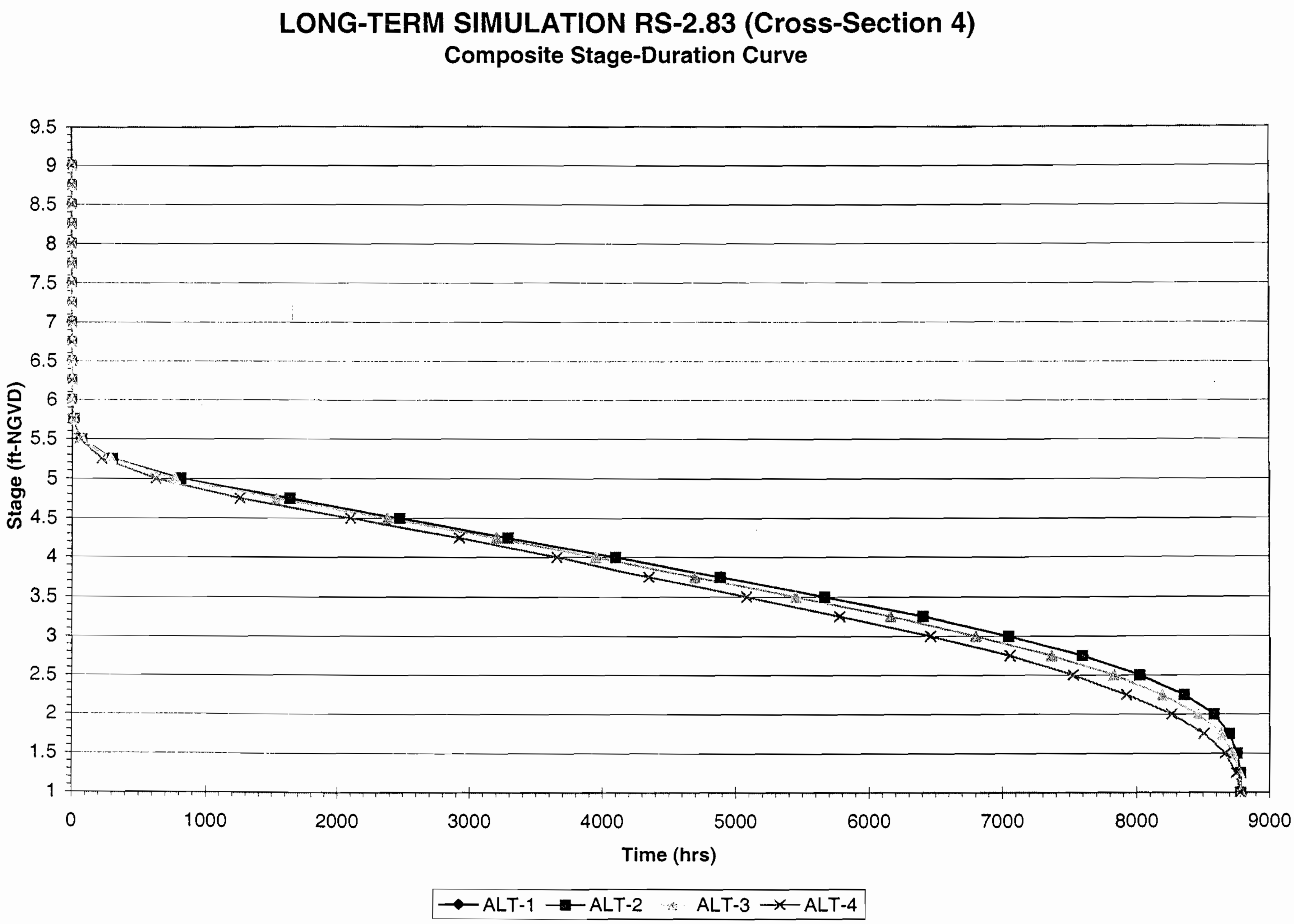

LONG-TERM SIMULATION RS-2.83 (Cross-Section 4)
Composite Stage-Duration Curve
Stage (ft-NGVD)
9.5
9
8.5
8
7.5
7
6.5
6
5.5
5
4.5
4
3.5
3
2.5
2
1.5
1
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
Time (hrs)
ALT-1
ALT-2
ALT-3
ALT-4

Figure 22

LONG-TERM SIMULATION RS-0 (Cross-Section 1)
Composite Stage-Duration Curve

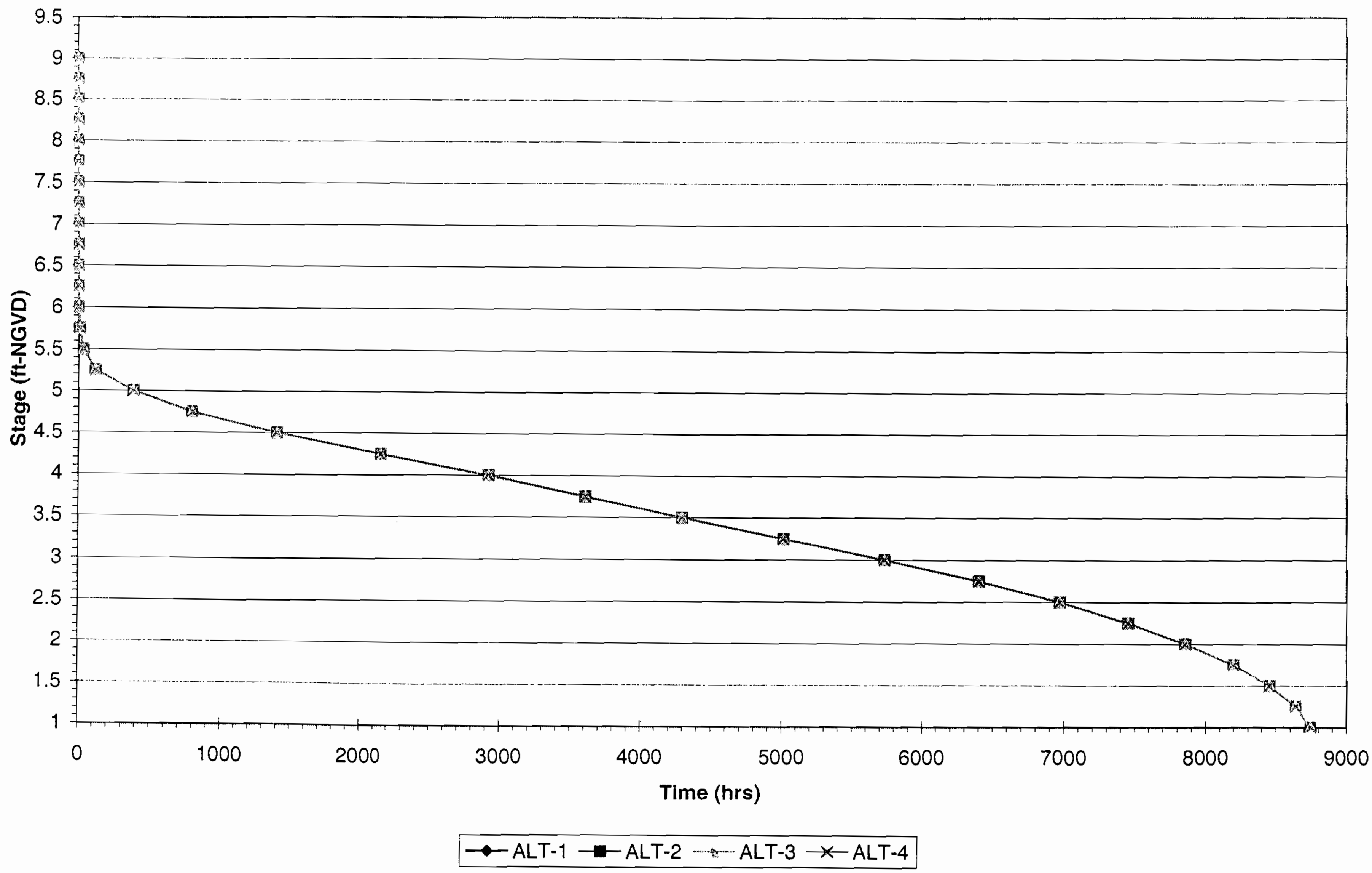
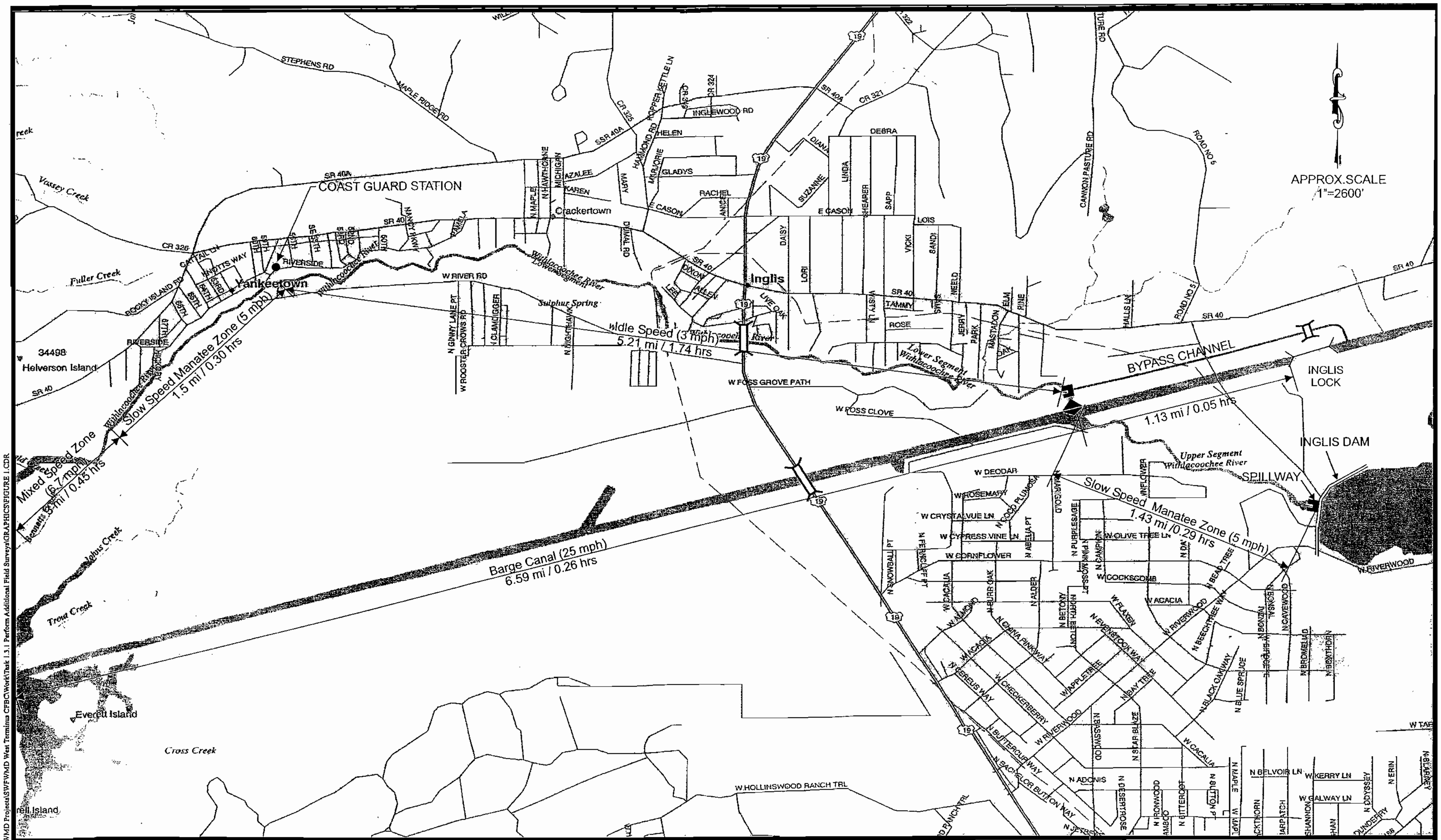


Figure 23



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WEST TERMINUS CROSS-FLORIDA GREENWAY ASSESSMENT
Southwest Florida Water Management District

FIGURE 24
NAVIGATION ASSESSMENT
TRAVEL ZONES

LONG-TERM SIMULATION RS-0 (Cross-Section 1)
Composite Flow-Duration Curve

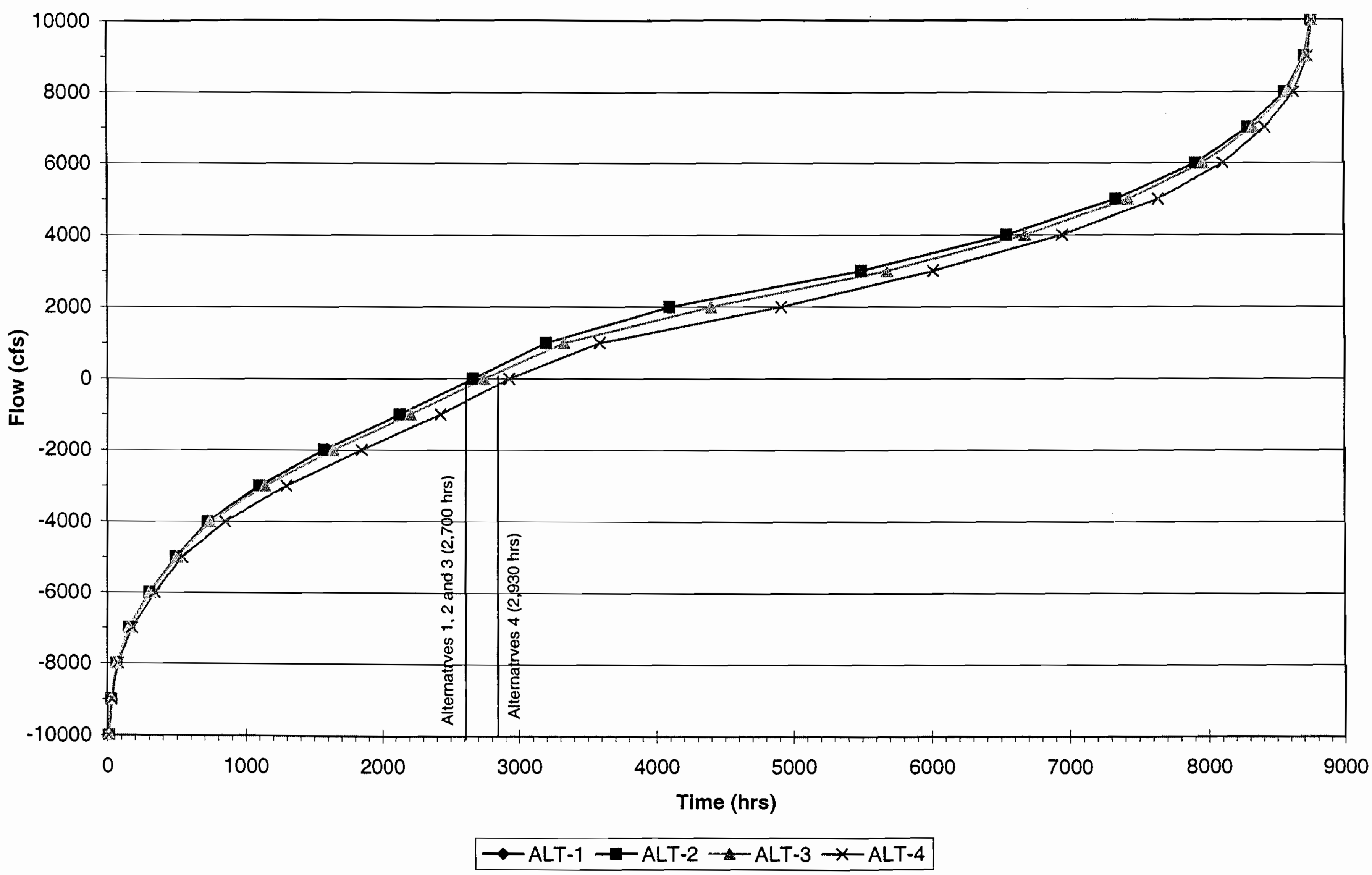


Figure 25

LONG-TERM SIMULATION RS-0.72 (Cross-Section 2)
Composite Flow-Duration Curve

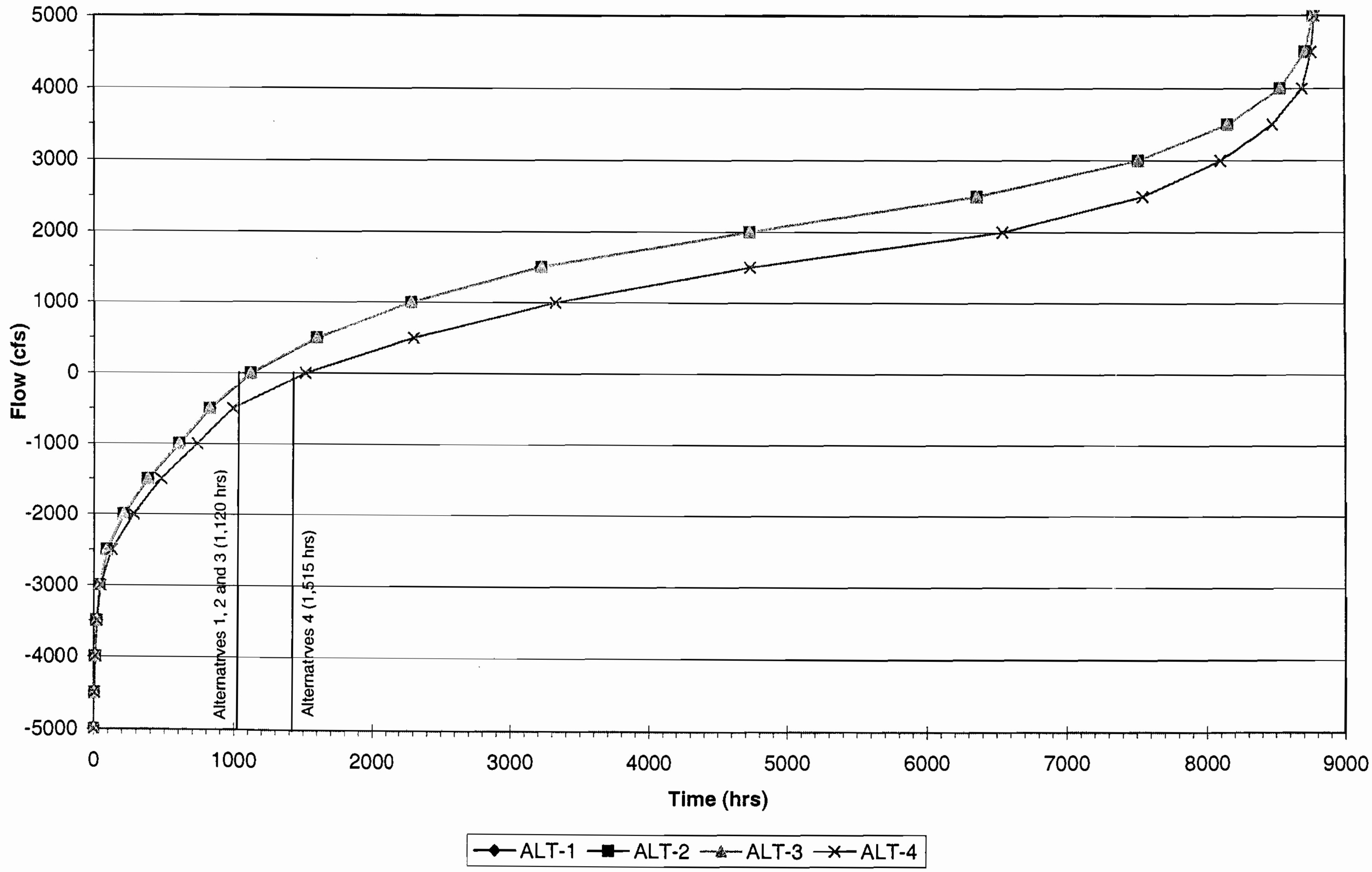


Figure 26

LONG-TERM SIMULATION RS-6.68/6.15 (Cross-Section 22)

Composite Flow-Duration Curve

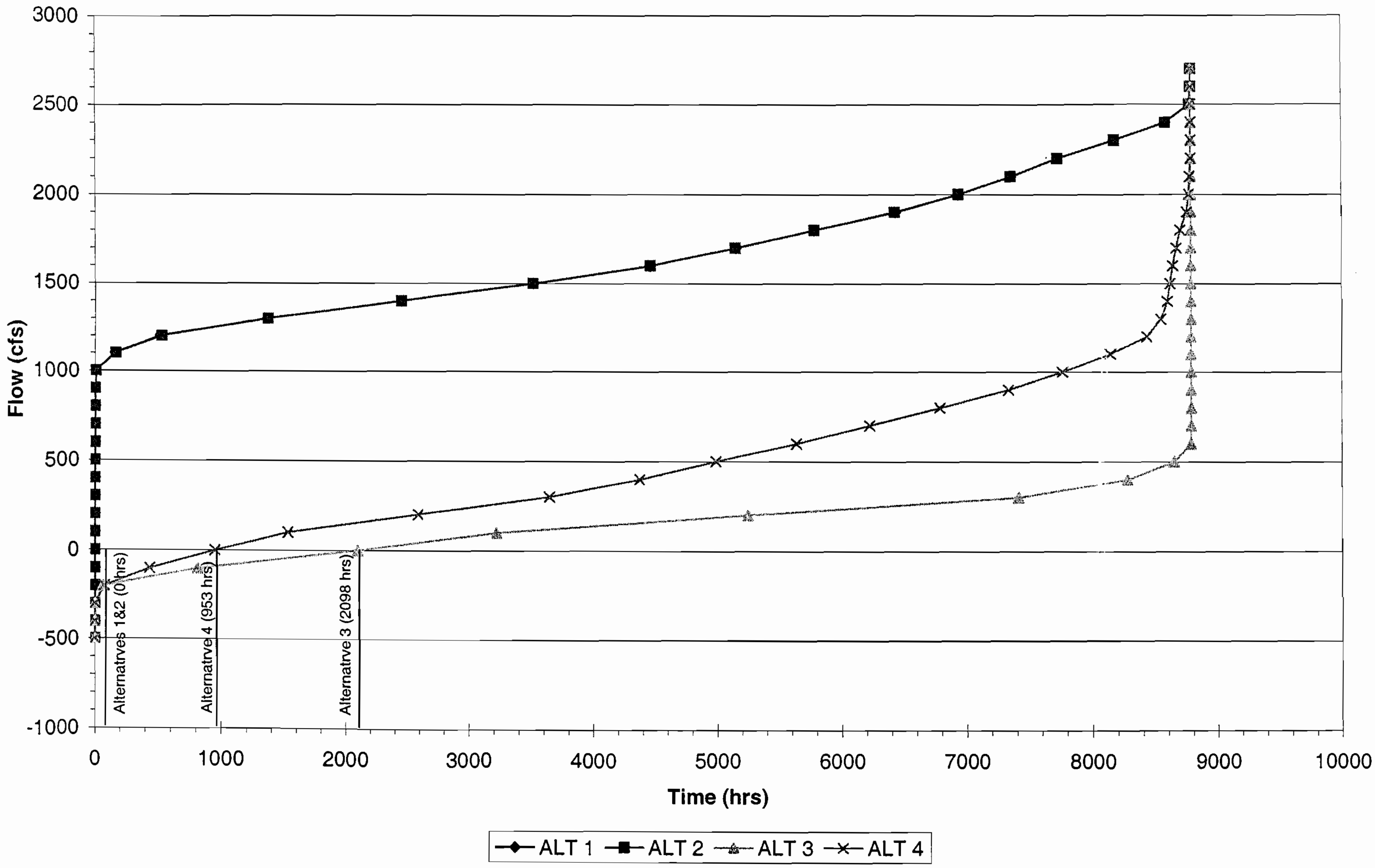
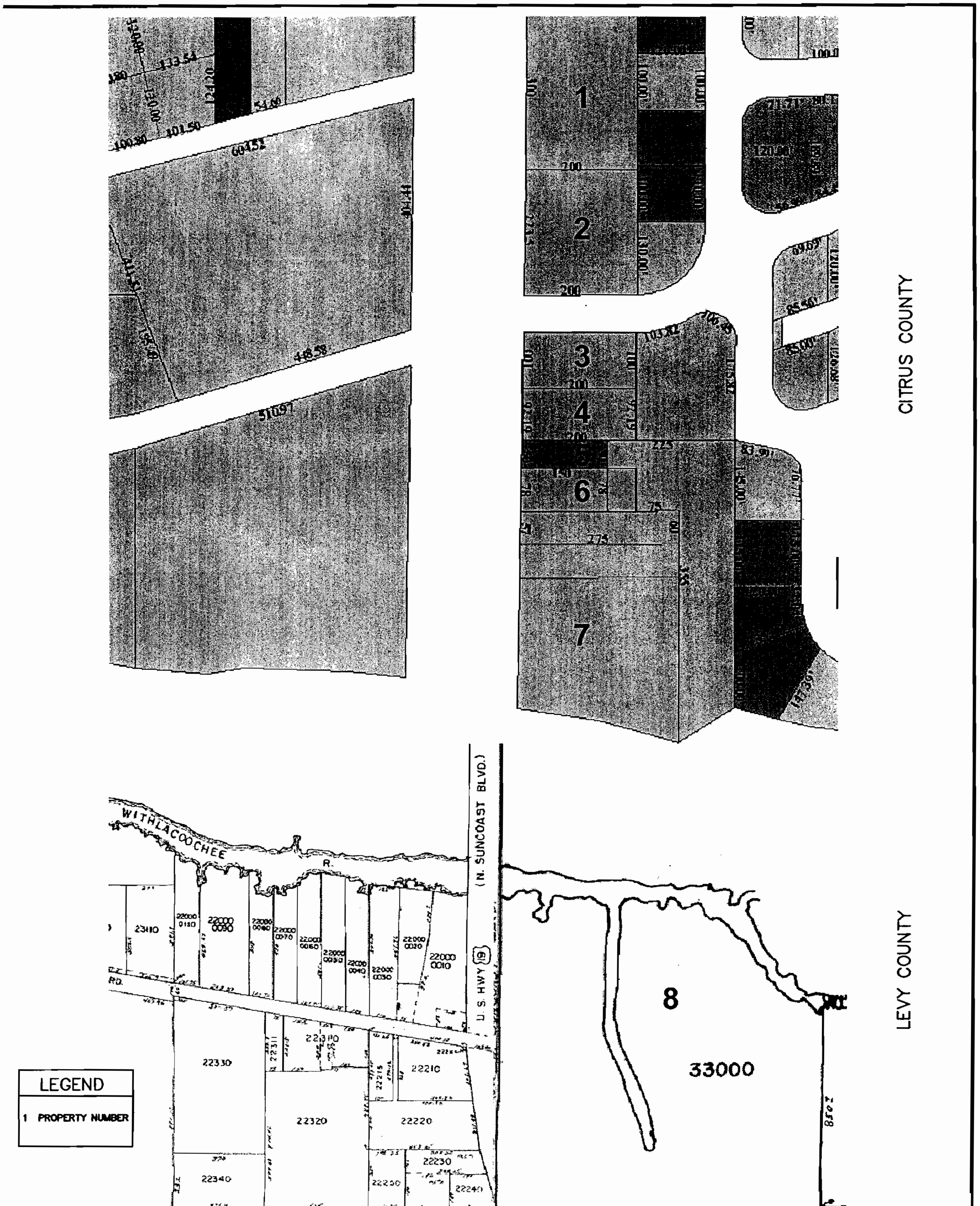


Figure 27



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Southwest Florida Water Management District

FIGURE 28
ALTERNATIVE 1
LAND ACQUISITION REQUIREMENTS