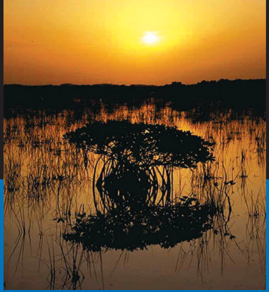

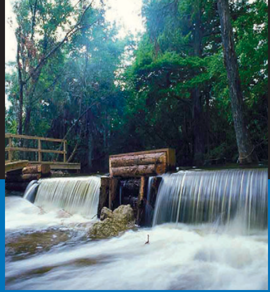

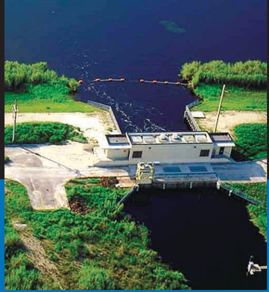

SFWMD

SOUTH FLORIDA WATER MANAGEMENT DISTRICT

FINAL

EVALUATION OF STORMWATER TREATMENT POTENTIAL OF THE WESTERN C-11 IMPOUNDMENT

WORK ORDER NO. C-15982-W006-05

TASK 2: ALTERNATIVES FORMULATION REPORT

DECEMBER 2003
PROJECT NO. 6308-03-0032

PREPARED BY

MACTEC

MACTEC ENGINEERING AND CONSULTING, INC
KENNESAW, GEORGIA AND WEST PALM BEACH, FLORIDA

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Prepared for:

SOUTH FLORIDA WATER MANAGEMENT DISTRICT
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KENNESAW, GEORGIA
WEST PALM BEACH, FLORIDA

MACTEC PROJECT NUMBER: 6308-03-0032

DECEMBER 2003

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LIST OF ACRONYMS

ATT	Advanced Treatment Technologies
C&SF	Central and South Florida
CERP	Comprehensive Everglades Restoration Plan
DMSTA	Dynamic Model for Stormwater Treatment Areas
ECP	Everglades Construction Project
EFA	Everglades Forever Act
EPA	Everglades Protection Area
ESP	Everglades Stormwater Program
MACTEC	MACTEC Engineering and Consulting, Inc.
ppb	parts per billion
SFWMD	South Florida Water Management District
STA	Stormwater Treatment Areas
WCA	Water Conservation Area
WRDA	Water Resources Development Act

EXECUTIVE SUMMARY

The South Florida Water Management District (SFWMD) has initiated a comprehensive Everglades Program to protect and restore the Florida Everglades. The Everglades Forever Act requires that urban and agricultural runoff discharged to the Everglades Protection Area (EPA) must achieve and maintain state water quality standards including the phosphorus criterion established in Rule 62-302.540, F.A.C. The SFWMD has contracted with MACTEC Engineering and Consulting, Inc. (MACTEC) to perform an alternatives evaluation for using the Western C-11 Impoundment as a treatment area for elevated levels of total phosphorus generated within the C-11 West Basin. These alternatives were selected to minimize the impact to flood protection and water supply which are the main purposes of the impoundment.

The Alternatives Formulation looked at the two internal configurations for the Western C-11 Impoundment. These two alternatives focused on increasing the hydraulic residence time in the impoundment to maximize the potential for phosphorus removal by settling of sediment. The two alternatives were also formulated to maximize the effective storage volume within the impoundment.

The two alternatives formulated for evaluation consist of constructing internal levees within the impoundment to route stormwater and prevent short-circuiting to the outfall. Alternative 1 consisted of a levee placed in a north-south orientation with an extension of this levee placed at the northern end directed eastward. One additional levee was also placed in the western portion of the impoundment to reduce the overall fetch length; thereby, reducing the potential for erosion from wave action. The influent and effluent structures for Alternative 1 are placed in the southeast and southwest corners of the impoundment, respectively. Also, the emergency spillway may be modified to serve as the primary outlet structure. Alternative 2 consists of a single levee directed to the northeast from below the midpoint of the western wall of the impoundment. At a distance of approximately two-thirds of the maximum width of the impoundment, the levee bends to the east. This configuration provides fetch reduction throughout the impoundment. For Alternative 2, the influent structure will remain in the southeast corner of the impoundment and the effluent structure will be moved to the north of the internal levee along the western wall.

Internal levees will be similar to the external levees that make the exterior sidewalls of the Western C-11 Impoundment. However, the internal levees will be designed with a 1:2 side slope. Top of levee elevations will be set at 16 feet above mean sea level (msl) or 10 feet above the bottom of the impoundment. The width of the top of the levee will be approximately 12 feet and the bottom width will be approximately 52 feet.

A feasibility study will be performed in the next phase of work to predict the performance of the selected alternative with respect to phosphorus removal. As part of the feasibility study, a low flow and a high flow scenario will be simulated using a phosphorus removal model that is appropriate for the project conditions.

1.0 INTRODUCTION

1.1 Background

During the settlement of southern Florida, the Everglades were changed when the region was drained for agriculture and development. Growth in the region continued through the 20th century, resulting in a loss of nearly half of the Everglades. The multi-purpose Central and south Florida (C&SF) project provides flood control, water supply for municipal, industrial, and agricultural purposes, prevention of saltwater intrusion, water supply for Everglades National Park, and protection of fish and wildlife resources. As an extension of the C&SF Project, the Comprehensive Everglades Restoration Plan (CERP) was authorized by the Water Resources Development Act (WRDA) of 2000 and approved as a framework and guide for modifications to the C&SF project needed to restore the south Florida ecosystem and to provide for the other water-related needs of the region (Brown and Caldwell, 2002). The CERP designates areas of concern and establishes projects to meet water quality and restoration goals.

In addition to CERP, Florida’s 1994 Everglades Forever Act (EFA) established long-term water quality goals designed to restore and protect the Everglades Protection Area (EPA). To meet the EFA goals, the Florida Department of Environmental Protection and the South Florida Water Management District (SFWMD) initiated a comprehensive and consistent set of strategies, known as the Everglades Program. A major component of the Everglades Program is the Everglades Stormwater Program (ESP). In accordance with the requirements of the EFA, the “Non-ECP (Everglades Construction Project) Permit” was issued to the SFWMD so the SFWMD could operate and maintain water control structures which discharge into, within, or from the EPA, and which are not part of the ECP. Upon issuance of the Non-ECP permit, the SFWMD initiated the implementation of the permit conditions through the creation of the ESP, which includes eight urban and tributary basins.

The long-term goal of the Everglades restoration effort is to implement the optimal combination of source controls, Stormwater Treatment Areas (STAs), Advanced Treatment Technologies (ATTs), and/or regulatory programs to ensure that all waters discharged into the EPA meet the numeric phosphorus criterion of 10 parts per billion (ppb) and other applicable state water quality standards (SFWMD FS, 2002). Although progress has been made towards reducing phosphorus levels discharged to the EPA, additional phosphorus control measures are needed to achieve compliance with the requirements of the EFA.

1.2 Project Background

To meet the phosphorus requirements designated in the EFA, the SFWMD and other stakeholders developed the Long-Term Plan for Achieving Water Quality Goals, which addresses both the ECP and ESP Basins. In order to evaluate the feasibility of additional water quality improvement measures to meet long-term water quality goals in the C-11 West Basin (an ESP Basin), the SFWMD requested that MACTEC Engineering and Consulting, Inc. (MACTEC) formulate two alternative modifications to the internal design of the Western C-11 Impoundment that would maximize the travel time of excess stormwater inflows into the impoundment and would thus maximize the potential for reduction of pollutants within the impoundment.

The C-11 West Basin is located in south central Broward County and covers an area of about 72 square miles. The excess water from the basin, which is comprised of stormwater runoff and ground water seepage from the EPA, is pumped from the C-11 Canal via the S-9 pump station into Water Conservation Area (WCA) 3A (Figure 1). WCA 3A is defined in the EFA as part of the EPA. The SFWMD has initiated projects and programs in the basin, some of which are discussed below, to protect the EPA and meet EFA requirements.

The C-11 West Basin Critical Project is an ongoing project sponsored by the SFWMD and is intended to isolate WCA 3A seepage from C-11 West Basin runoff. A divide structure (S-381) contains seepage west of this new structure while a set of smaller pumps (S-9A) returns seepage back to the WCA 3A. It is expected that total phosphorus levels going into WCA 3A will be reduced by the recycling of seepage water. In addition, the smaller S-9A pumps will not only minimize the amount of stormwater pumped from the C-11 West Basin by the S-9 pumps, but will also reduce the frequency of bottom scour and drawdown caused by the larger (S-9) pumps.

The Western C-11 Impoundment and Diversion Canal project, a planned CERP project, consists of a 1,600-acre stormwater impoundment and approximately 8-miles of canal to divert flood waters to other storage areas (i.e., C-9 Impoundment). Urban runoff from the C-11 West Basin will be captured in these two impoundments, thus diverting stormwater away from WCA 3A. However, the initial CERP projects will not result in the elimination of all stormwater discharges to WCA 3A. As per CERP design, inflows not directly accommodated by the Western C-11 and C-9 Impoundments will bypass untreated to the S-9 pump station and WCA-3A. The potential for routing through the impoundment all excess stormwater as a means to achieving additional water quality improvements needs to be investigated and evaluated. Once routed through the impoundment, the excess inflows would then be returned to the C-11 West Canal at a point downstream (west) of the S-381 structure.

MACTEC has developed two alternatives to the Western C-11 Impoundment internal design that would maximize the travel time of excess stormwater inflows into the impoundment and would thus maximize the potential for reduction of pollutants within the impoundment prior to being returned to the C-11 West Canal downstream (west) of the S-381 structure. Internal levees will be used to maximize travel time of the excess water through the impoundment and allow sediments to settle out. In addition to different levee configurations, a different location for the outlet structure was considered.

1.3 Project Objectives

The objective of this report is to present two alternative modifications to the internal design of the Western C-11 Impoundment that would maximize the hydraulic retention time of the impoundment and thus, would maximize the removal of pollutants within the impoundment prior to stormwater being returned to the C-11 West Canal downstream (west) of the S-381 structure. The design objective of the two alternatives is to meet the long-term water quality goals in the C-11 West Basin. Both alternatives are compatible with the goals and objectives of the Western C-11 Impoundment CERP project.

1.4 Report Organization

This report is organized as follows: Section 1.0 describes the background of the project and describes the project objective; Section 2.0 presents the two alternatives; Section 3.0 provides a summary and recommendations for the feasibility study; and Section 4.0 provides a list of references. Tables and figures follow immediately after Section 4.0.

2.0 DESIGN ALTERNATIVES FOR THE IMPOUNDMENT

2.1 General Description

The Western C-11 Impoundment has been designed to contain stormwater flow from the C-11 West stormwater management basin in Broward County, Florida. The C-11 West Basin is primarily urban with 41.6 percent classified as urban, 23.8 percent as agricultural primarily nurseries and the remaining classified as water, wetlands, transportation, forests and rangeland. Total phosphorus concentrations from samples collected within the C-11 West Canal and contributing areas have average of 22 µg/L. Because the EFA requires that all discharges to the EPA be in compliance with state water quality standards, including the phosphorus criterion the SFWMD is investigating the potential of using the proposed Western C-11 Impoundment to supplement total phosphorus removal of collected stormwater. As part of this investigation, the SFWMD has proposed two potential modifications to the design of the Western C-11 Impoundment.

The proposed design of the Western C-11 Impoundment encompasses approximately 1,600 acres and the maximum depth of the impoundment is planned to be 4 feet. A 215-acre portion of the impoundment at the northern end will consist of a wetlands protection area and will not be available for stormwater treatment. The influent structure will be located at the southeast corner of the impoundment (S-503) and stormwater collected by the C-11 West Canal will be pumped into the impoundment through this structure. Excess stormwater will be conveyed from the Western C-11 Impoundment through the outfall structure and transported to the C-9 stormwater impoundment south of the C-11 West Basin. As per CERP design, stormwater not directly accommodated by the Western C-11 nor C-9 Impoundments will bypass untreated to the S-9 pump station and WCA-3A.

SFWMD has proposed to modify the operation of the Western C-11 Impoundment by routing through the impoundment all excess stormwater as a means to achieving additional water quality improvements. Once routed through the impoundment, the excess stormwater would then be returned to the C-11 West Canal at a point downstream (west) of the S-381 structure. MACTEC has completed a review of two potential interior design alternatives for the Western C-11 Impoundment. These alternatives are designed to increase the travel time of stormwater within the impoundment. Increasing travel time will allow sediment to settle from the stormwater and also increase the opportunity for phosphorus removal. However, the primary purpose of the Western C-11 Impoundment is water storage and supply and the impoundment is expected to experience extended periods of dry weather. Therefore, phosphorus removal within the Western C-11 Impoundment is a secondary consideration in the overall design of the impoundment. A description and discussion for each alternative is presented below.

2.2 Optimization of Internal Levee Configuration

Two internal design configurations were considered in this evaluation. Since the primary purpose of the Western C-11 Impoundment is to provide storage and to act as a water supply source, the two design alternatives were selected to maximize the travel time within the impoundment while minimizing the reduction in overall storage volume.

Additionally, because of the size of the impoundment, considerable kinetic energy may be built up in the impoundment in the form of waves from wind action resulting in increased erosion and shortening of the design life of the structure. Therefore, levees are placed to reduce the length of the fetch in the impoundment and provide energy dissipating structures to help minimize erosion.

Internal levees will be constructed similar to the external levees that make the sidewalls of the Western C-11 Impoundment. However, the internal levees may have a 1:2 side slope. The elevations for the top of the internal levees will be at 16 feet msl. Internal levees will be approximately 10 feet in height above the bottom of the impoundment. The width of the top of the levee will be approximately 12 feet and the bottom width will be approximately 52 feet. A conceptual cross section for the internal levees is presented in Figure 2.

2.3 Alternative 1

Alternative 1 consists of a levee placed along the north-south axis of the impoundment. This levee will extend from the exterior southern levee northward approximately 6,880 feet. An additional levee will extend from the northern end of the first levee approximately 3,300 feet eastward forming an L-shaped internal levee. A conceptual layout of this first alternative is presented in Figure 3. Two to three fish refuge basins will be constructed within the impoundment to provide habitat for fish during dry periods.

In addition to the main levee, one additional secondary (fetch-reduction) levee will be placed near the north-south midway point on the west side to provide a point for dissipation of energy resulting from wave action (Figure 3). This levee will reduce the overall fetch length in the impoundment and allow waves to dissipate reducing the potential erosion. The fetch reduction levee will be placed approximately perpendicular to the axis of the longest fetch length (to the south-southeast) and will extend from the western wall of the impoundment approximately 2,000 feet to the east-northeast at a three to one angle. Placing the secondary levee in this configuration reduces the fetch length and provides additional travel distance for stormwater moving through the impoundment.

The total length of the internal levees placed in the configuration shown (Figure 3) is approximately 12,200 feet. If the levees are built as described above and the average depth is four feet, then the total storage volume of the impoundment will decrease by 0.81% or 16 million gallons. For Alternative 1, the minimum travel time of the impoundment when full and pumping at a maximum pumping rate of 2,500 cfs is approximately 15.5 hours. The estimated minimum travel length of a particle traversing the impoundment for Alternative 1 is approximately 17,000 feet or 3.2 miles. The average velocity would be 18.3 feet per minute. Table 1 provides a summary of the design of Alternative 1.

For Alternative 1, the influent and effluent structures will remain in the southeast and southwest corners of the impoundment, respectively. An approximate 1,600-foot long revetment will be added to the internal central levee along the eastern side to provide erosion protection from influent flow. Also, additional revetments will be added at interior and exterior corners and at the termination points of the internal levees.

Flow from the Western C-11 Impoundment will be returned to the C-11 West canal west (downstream) of the S-381 structure through the proposed discharge structure (S-504) located in the southwest corner of the impoundment. If S-504 and S-502C are used to direct water from the impoundment back to the C-11 West canal, the S-502C structure will have to be redesigned to increase its capacity from 300 cfs to 2,500 cfs.

As an alternative to using a separate structure for discharge back to the C-11 West canal, the emergency spillway may be modified to serve as a primary outfall structure. Potential considerations to the design of the emergency spillway would be to use a variable height gate such as an Obermeyer Gate. Raising or lowering the gate would allow varying discharge elevations with the maximum height set to the required height for the emergency discharge.

2.4 Alternative 2

Alternative 2 consists of a 5,700-foot long internal levee extending from the western wall of the impoundment approximately 3,000 feet north of the southern end to the northeast at an angle of 1.2 to 1 (approximately 3,800 feet from the western wall). At this point, the internal levee will bend and extend an additional 2,400 feet to the east. Figure 4 provides a conceptual design for Alternative 2. The outfall for Alternative 2 will move from the southwestern edge of the impoundment northward approximately 2,200 feet. Two fish refuge pools will be placed within the impoundment to protect fish during extended dry periods. These refuges will be placed along the southern end of the impoundment and near the location of the outfall structure.

Because of the angled placement of the internal levee from the western wall to the northeast, no additional levees will be required to reduce the overall fetch length in the impoundment. The total length of the levees placed in the configuration shown (Figure 4) is approximately 8,100 feet. If the internal levees are built similar to the exterior levees of the impoundment and the average depth is four feet, then the total storage volume of the impoundment will decrease by 0.64% or 12.6 million gallons. For Alternative 2, the minimum travel time of the impoundment when full and discharging at a maximum pumping rate of 2,500-cfs is approximately 18.5 hours. The estimated minimum travel length of a particle traversing the impoundment for Alternative 2 is approximately 15,500-feet or 2.9-miles. The average velocity would be 14 feet per minute. Table 1 provides a summary of the design of Alternative 2.

For Alternative 2, the influent structure will remain in the southeast corner of the impoundment. Because of the distance between the influent structure and the internal levee no additional revetments will be required to reduce erosion from influent flow. Additional revetments for the interior and exterior of the corner of the internal levee and for the terminal end will be required.

For this alternative, flow from the Western C-11 Impoundment will be returned to the C-11 West canal west (downstream) of the S-381 structure through the discharge structure located along the western wall of the impoundment approximately 3,200 feet north of the southern exterior levee. This discharge structure will be designed to have a capacity of 2,500 cfs and will discharge to the C-502A canal. Stormwater discharged to the C-502A canal will be returned to the C-11 West canal though the S-502C structure. To accommodate the required flows, the S-502C structure will have to be redesigned to increase its capacity from 300 cfs to 2,500 cfs.

2.5 Potential for Phosphorus Removal

As a secondary design consideration, the Western C-11 Impoundment may be used for removal of phosphorus from stormwater collected from the C-11 West Basin. Modifications to the internal design of the Western C-11 Impoundment are under consideration to provide phosphorus removal from stormwater. Removal of phosphorus may be accomplished as sediment settles from the stormwater within the impoundment. As part of the feasibility study, the removal of phosphorus within the impoundment will be simulated using a phosphorus removal model that is appropriate for the project conditions.

3.0 SUMMARY

The two alternatives to the internal design of the Western C-11 Impoundment are similar in function. However, Alternative 1 consists of 12,200 feet of internal levees and Alternative 2 consists of 8,100 feet of internal levees. Minimum estimated travel times for the two impoundments at a maximum discharge rate of 2,500 cfs are also similar with the estimated travel time being approximately 15.5 hours for Alternative 1 and 18.5 hours for Alternative 2. The estimated minimum travel length for each alternative is 3.2 miles and 2.9 miles for Alternative 1 and Alternative 2, respectively.

The feasibility study will look at the effectiveness of phosphorus removal for the two alternatives. Two scenarios will be simulated using a phosphorus removal model to predict the phosphorus removal in the impoundment. The two scenarios will look at a low flow and a high flow event. These scenarios will provide information of the potential long-term effectiveness of using the Western C-11 Impoundment for water quality treatment.

4.0 REFERENCES

Brown and Caldwell, et al. 2002. Final Report Basin Specific Feasibility Studies, Everglades Stormwater Program Basins. Brown and Caldwell, HSA Engineers and Scientists, DB Environmental, Inc., Wetland Solutions, Inc., and Milian, Swain and Associates, Inc. Contract C-E024. South Florida Water Management District. October 2002.

Burns and McDonnell. 2003. Final Report Everglades Protection Area Tributary Basins, Long-Term Plan for Achieving Water Quality Goals. October 27, 2003.

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SFWMD. 2001b. Central and Southern Florida Project Water Preserve Areas Feasibility Study, Draft Integrated Feasibility Report and Supplemental Environmental Impact Statement. South Florida Water Management District, October 2001.

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TABLE

Table 1

Alternatives Design Data for the C-11W Impoundment
Alternatives Evaluation Report
C-11W Stormwater Impoundment
South Florida Water Management District
MACTEC Project #: 6308-03-0032

	Alternative 1	Alternative 2
Total Area of Impoundment ($feet^2$)	75,500,000	75,500,000
Average Depth of Impoundment (feet)	4	4
Area of Wetlands Protection Area ($feet^2$)	9,400,000	9,400,000
Area for Stormwater Storage and Treatment ($feet^2$)	66,100,000	66,100,000
Total Volume of Storage in Impoundment ($feet^3$)	264,400,000	264,400,000
Total Proposed Internal Levee Length (feet)	12,200	8,100
Total Volume of Internal Levee based on 1:2 side slope ($feet^3$)	3,904,000	3,500,000
Total Volume of Internal Levee Below Maximum Water Level (4 feet) (feet3)	2,144,000	1,685,000
Percent Reduction in Storage Volume	0.81%	0.64%
Minimum Flow Path (feet)	17,000	15,500
Estimated Average Velocity (feet per minute)	18.3	12.6
Estimated Travel Time (at 2,500 cfs) (hours)	15.5	18.5

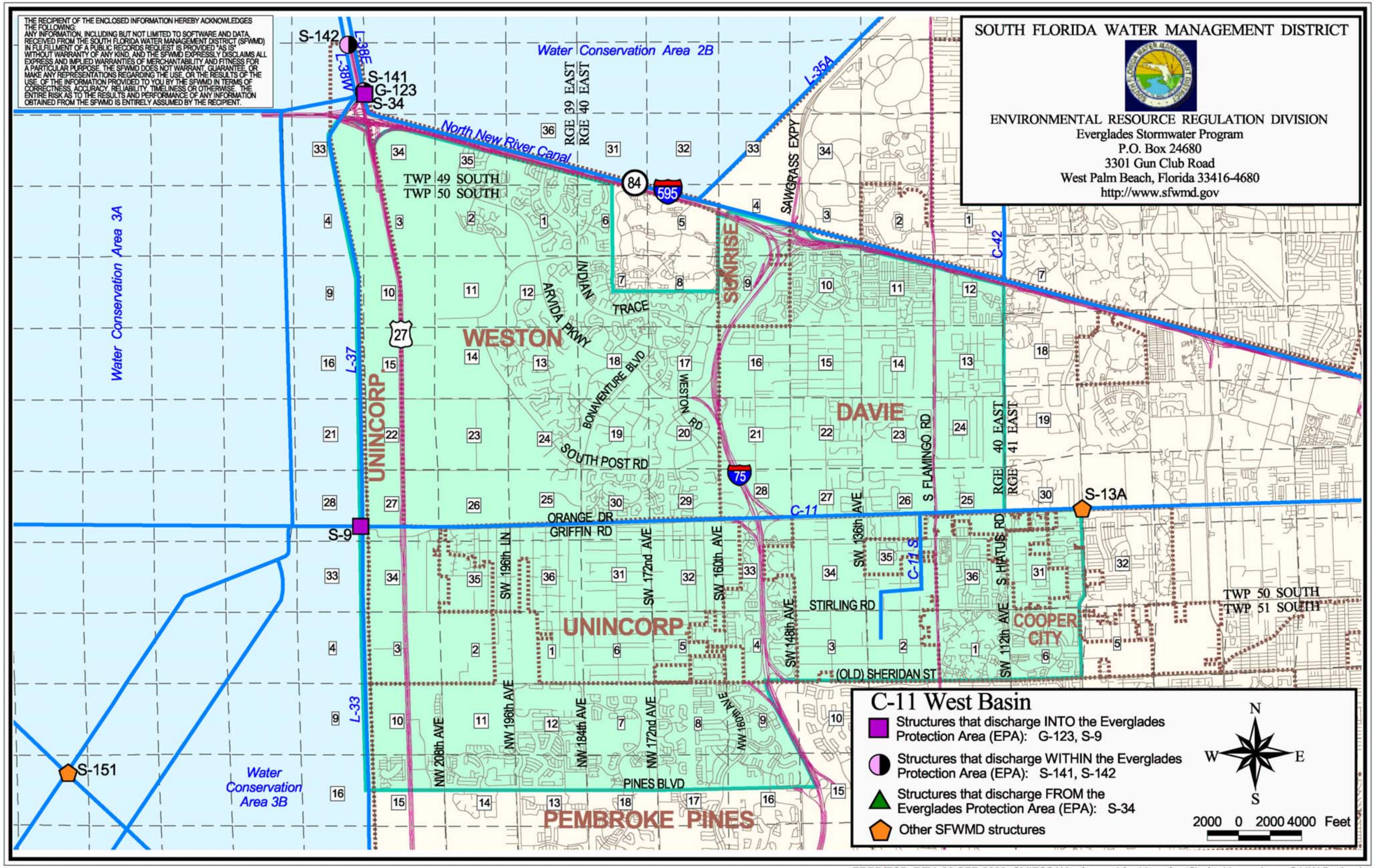
*Volumes and lengths are approxiamte

cfs - cubic feet per second

Prepared By: MET 12/01/2003

Checked By: TLN 12/01/2003

FIGURES



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sfwmd.gov

SOURCE: http://www.sfwmd.gov/org/reg/esp/pdfs/map_c11w_121800.pdf

FIGURE 1

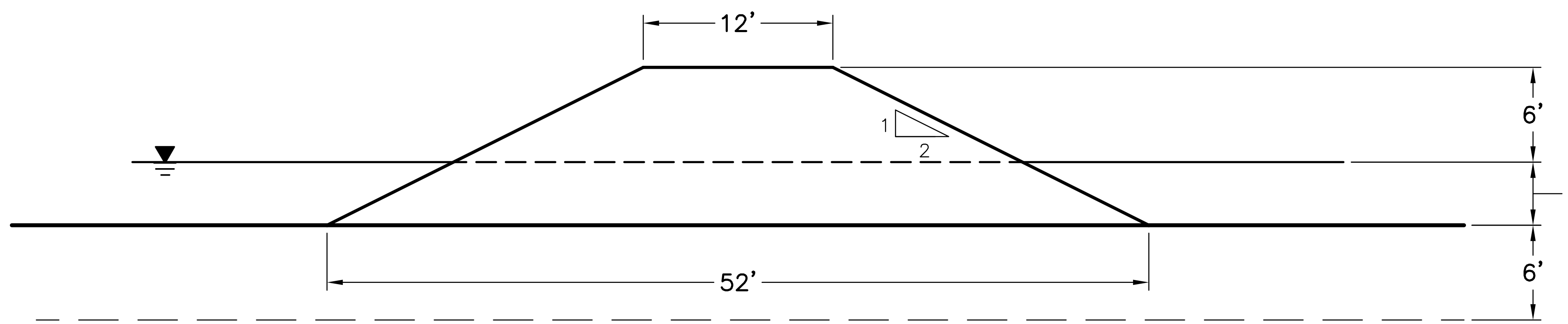
C-11 WEST STORMWATER MANAGEMENT BASIN

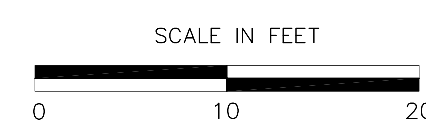
MACTEC PROJECT NUMBER: 6308-03-0032

MACTEC

SOUTH FLORIDA WATER MANAGEMENT DISTRICT
WEST PALM BEACH, FLORIDA

ALTERNATIVES EVALUATION REPORT
C-11 WEST IMPOUNDMENT





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ALTERNATIVES FORMULATION REPORT

CONCEPTUAL INTERNAL LEVEE
CROSS SECTION
WESTERN C-11 IMPOUNDMENT

JOB NO. 6306-03-0032

FIGURE 2

PREPARED BY/DATE

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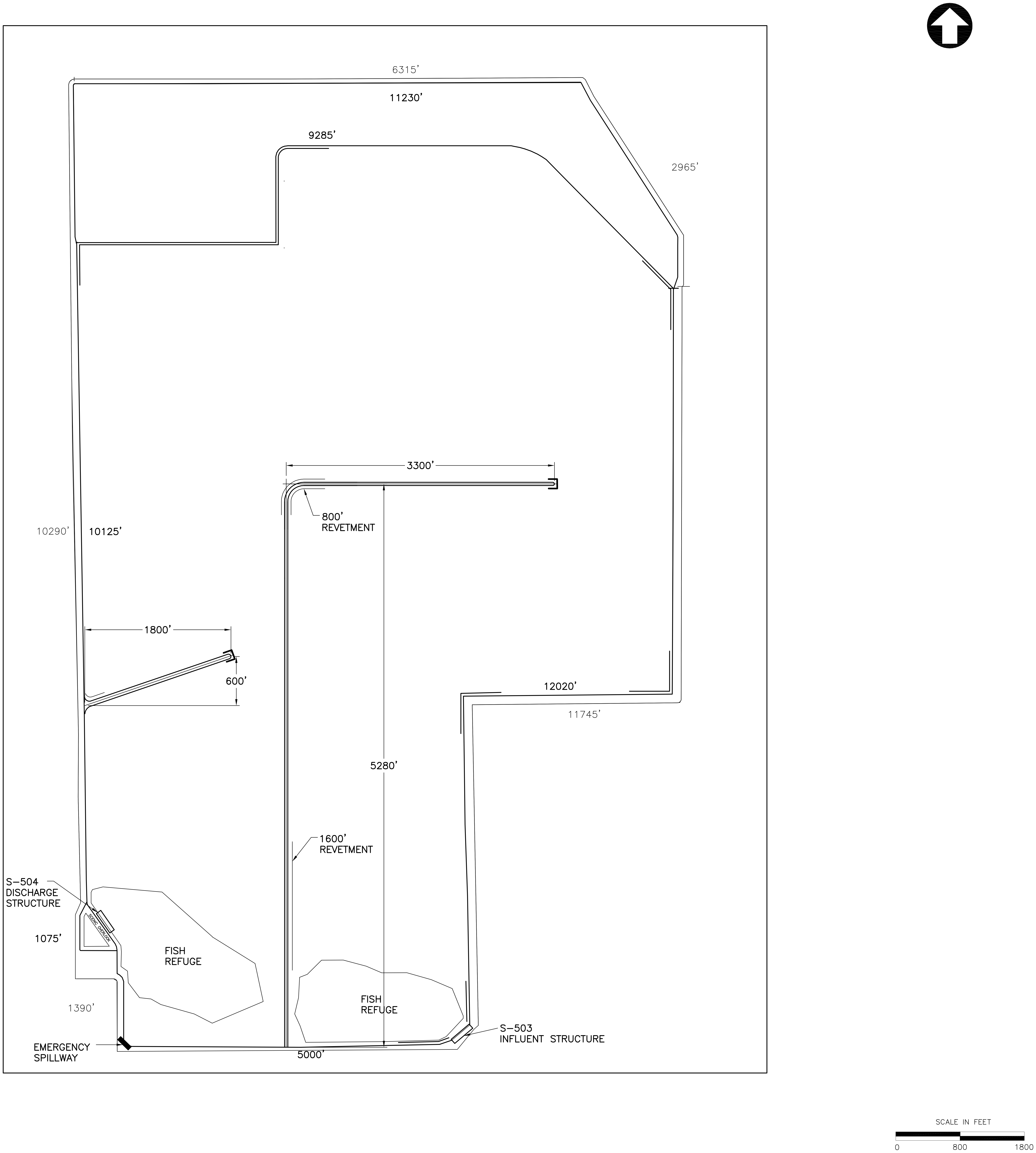

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DRAWN	T. GLADSTONE
CHECKED	M. TANNER
IN CHARGE	
DATE	10/23/03

SOUTH FLORIDA WATER MANAGEMENT DISTRICT

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ALTERNATIVES FORMULATION REPORT

ALTERNATIVE 1 CONCEPTUAL INTERNAL BERM CONFIGURATION WESTERN C-11 IMPOUNDMENT

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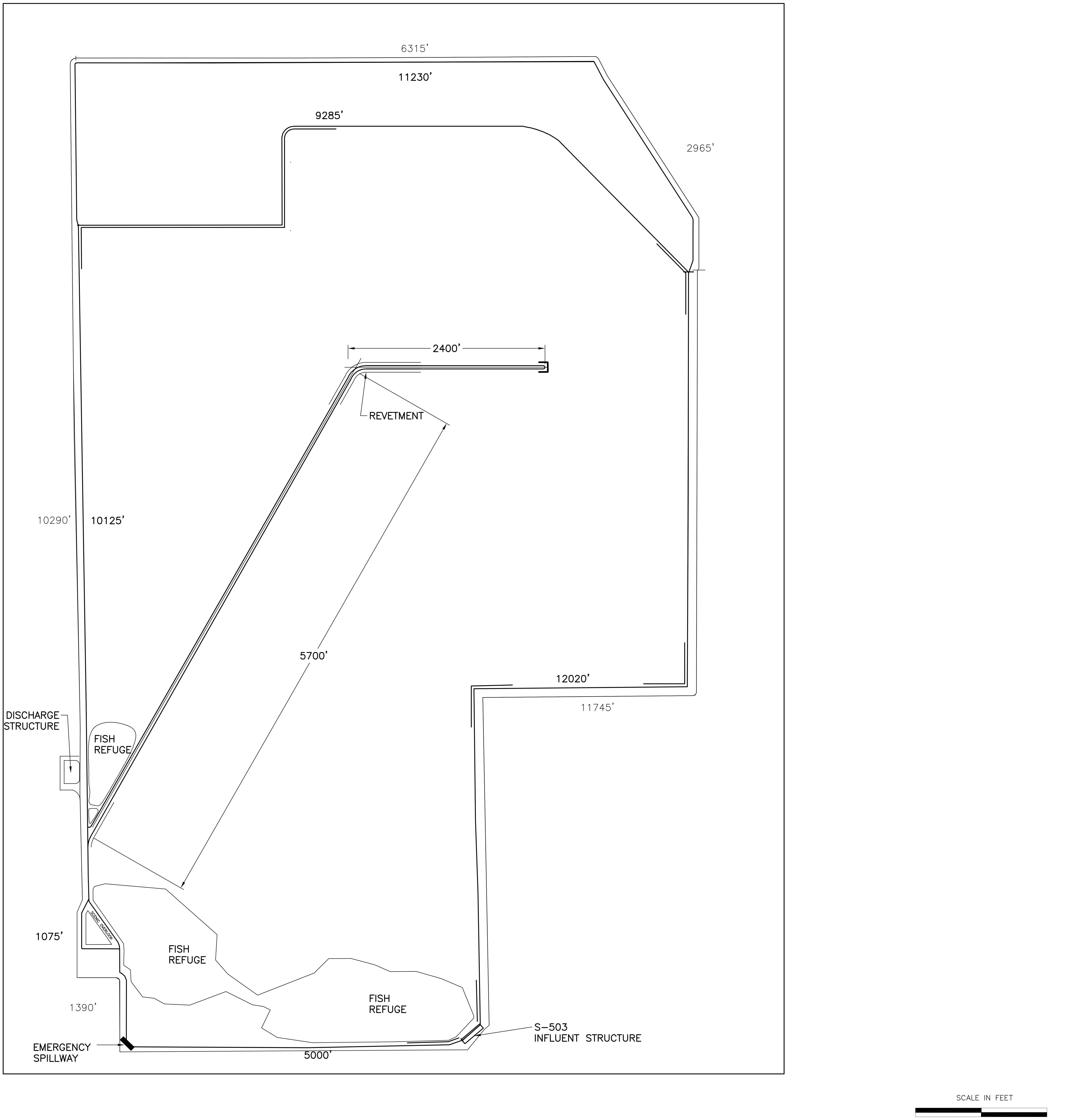

DESIGNED M. TANNER DRAWN T. GLADSTONE CHECKED M. TANNER IN CHARGE DATE 10/23/03	SOUTH FLORIDA WATER MANAGEMENT DISTRICT WEST PALM BEACH, FLORIDA MACTEC Engineering and Consulting, Inc. 3200 TOWN POINT DRIVE, SUITE 100 KENNESAW, GEORGIA 30144 (770) 421-3400	ALTERNATIVES FORMULATION REPORT ALTERNATIVE 2 CONCEPTUAL INTERNAL BERM CONFIGURATION WESTERN C-11 IMPOUNDMENT	SCALE AS SHOWN CONTRACT 6308-03-0032 DWG. NO. 4 REV PAGE NO

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