THE BROOKS
DEEP AND SHALLOW
WET DETENTION PONDS
WATER QUALITY MONITORING REPORT

BONITA SPRINGS, FLORIDA

JUNE 2005

PREPARED FOR:

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AND

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Acknowledgments

This study could not have been accomplished without the growing research partnership between the Bonita Bay Group, the Florida Department of Environmental Protection, Lee County Community Development staff, and Johnson Engineering Water Resources-Environmental Group. Johnson Engineering would like to thank the Bonita Bay Group for their assistance and cooperation in the site selection of The Brooks development and allowing water quality monitoring of shallow and deep wet detention systems.

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1.0 INTRODUCTION

The purpose of this report is to provide a summary of water quality monitoring of aerated and non-aerated deep and shallow wet detention (ponds) within The Brooks residential development in Bonita Springs, Florida. Monitoring involved using submerged water quality sondes to record dissolved oxygen levels and other water quality data in both aerated and non-aerated wet detention ponds. The plan for this project was developed by Eric Livingston of the Florida Department of Environmental Protection (FDEP) Bureau of Watershed Management to better understand the effects of detention pond depth and aeration on water quality.

1.1 Project Background

1.1.1 Wet Detention Systems

Wet detention systems are ponds that include a permanent pool of water that are designed to collect and detain stormwater runoff. These systems are a popular stormwater management technique in southwest Florida, where groundwater tables are usually high. Rainfall and stormwater runoff collected by the ponds is allowed to slowly release through an outlet structure set at a controlled elevation. Several pollutant removal processes occur within these ponds including sedimentation, precipitation and absorption. In addition, littoral zones are often planted along the perimeter of the ponds to provide further pollutant removal through biological uptake, much like a natural lake system. A schematic diagram of a typical wet detention system is shown in Figure 1.

1.1.2 Wet Detention Pond History

Since the beginning of Florida's stormwater treatment program in the early 1980s, a fundamental principle has been to limit the depth of wet detention systems so that anaerobic conditions do not occur in either the water column or the pond sediments (Eric Livingston, *personal communication*). Such anaerobic conditions could lead to the release of pollutants sequestered in the pond's sediments and adversely affect other chemical, physical, and biological processes that occur within the ponds to reduce stormwater pollutants. A Lee County, Florida ordinance requires ponds greater than twelve (12) feet deep to have aerators to prevent low dissolved oxygen conditions or stratification of the water column.

1.1.3 Present Considerations

Recent observations of water quality associated with deep ponds, especially those using aerators, indicate that the concerns expressed above may not be true in wet detention systems in southwest Florida (Robert Knight, *personal communication*). Additionally, more stringent stormwater treatment requirements imposed by the United States Environmental Protection Agency (EPA) and United States Army Corp of Engineers (ACOE) imply that deeper ponds may be beneficial.

1.2 Project Objectives

The primary objective of this study was to evaluate wet detention ponds of various depths to understand whether or not aeration of the ponds is beneficial or desired. The secondary objective of this study was to determine whether or not stratification of the water column occurs in ponds.

1.3 Project Overview

Four (4) ponds were selected from a shallow and deep wet detention system at The Brooks residential development for this study. Each pond contains multiple aerators.

The study consisted of placing water quality data sondes in each of the ponds. The sondes continuously monitored temperature, conductivity, pH, dissolved oxygen, oxidation-reduction potential and turbidity. The study was made up of two (2) phases lasting approximately three (3) weeks each. Background data was collected for approximately one (1) month prior to the first phase. During the background period, the aerators in the ponds were left on as normal. In each phase, aerators in two (2) of the ponds were operated as normal while aerators were turned off in the other two (2) ponds. Ponds selected to be aerated during phase two were different than those being aerated in phase one.

In addition to the data collected by the water quality sondes, three (3) sets of water quality data were collected from each lake using a portable water quality meter outfitted with a 25 foot cable. The readings taken by the portable meter were used to verify the accuracy of the sonde data and also to provide a vertical profile of the water column.

Three (3) sets of water quality samples were also collected from each of the ponds during the study, at the same depths as the sondes. The samples were laboratory analyzed for a variety of parameters. Analysis results were compared to the water quality sonde and meter data.

2.0 SCOPE OF WORK

2.1 Site Selection

The Bonita Bay Group (BBG), in cooperation with Johnson Engineering, Inc. (JEI), selected four (4) wet detention ponds (Lakes 17, 19A, 20 and 41) from within The Brooks residential development in Lee County, Florida. Figure 2 shows the location of the development. Pond locations within the development are shown on Figure 3. Wilson Miller, Inc. and JEI surveyed the bathymetry of the ponds. For the purpose of this study, Lake 19A is considered to be a shallow (<12 feet) wet detention pond. Lakes 17, 20 and 41 are considered to be deep (>12 feet) wet detention ponds. The ponds are interconnected with underground pipe to maintain similar water levels. Lakes 17, 19A and 41 are directly connected to each other. Lake 20 is connected through a series of other ponds. All of the ponds are indirectly connected to a single outfall structure set at a control elevation of 13.6 feet referenced to the National Geodetic Vertical Datum (NGVD). The ponds have a similar surrounding land use consisting of residential, golf course and roadways. Ponds used for blending of groundwater from deeper aquifers for irrigation were not used as part of this study.

2.2 Aeration Control

Each of the four (4) ponds in this study is equipped with multiple piston compression type aerators manufactured by Vertex Water Features and maintained by Lake Masters Aquatic Weed Control, Inc. The aerators are spaced evenly throughout the ponds and are positioned approximately ten (10) feet below the surface of the water. Each unit produces up to twenty (20) pounds per square inch (psi) of aeration in a cone shaped area that extends outward and upward from the device. These aeration systems are capable of aerating each pond volume over a period of 24 - 48 hours. The Bonita Bay Group obtained permission from the Lee County Community Development (LCCD) staff to temporarily turn off some of the aerators during the study. JEI coordinated with Lake Masters Aquatic Weed Control, Inc. to turn on and shut off the aerators as needed. Please refer to Table 1 for the aeration schedule.

2.3 Monitoring Equipment Installation

2.3.1 Stage Recorders

Pressure transducers and dataloggers manufactured by Infinities USA, Inc. were installed in Lake 17, Lake19A, Lake 20 and Lake 41. The dataloggers were programmed to automatically record and store the lake level elevations every fifteen (15) minutes.

2.3.2 Rain Gauge

One (1) tipping bucket style rain gauge data logger manufactured by Infinities USA, Inc. was installed near the lakes being studied. The gauge records rainfall to the nearest 0.01 inch. The datalogger was programmed to automatically record and store precipitation data every fifteen (15) minutes.

2.3.3 Water Quality Sondes

YSI, Inc. 6600 model extended deployment system (YSI 6600 EDS) water quality data sondes were deployed in all four (4) ponds on September 30, 2004. Each of the probe sensors on the water quality sondes was calibrated according to the manufacturer specifications prior to deployment. The YSI 6600 EDS units were anchored two (2) feet above the bottom of the pond and suspended from the surface using a float, as shown in Figure 4. The sonde deployed in each pond was placed equidistant from the banks of the pond and between aerators. Sonde locations are shown on Figures 5, 6 and 7. The sondes were programmed to record temperature, specific conductivity, pH, dissolved oxygen, oxidation-reduction potential and turbidity every fifteen (15) minutes. A list of detection levels for each monitored parameter is included as Table 2.

2.4 Water Quality Monitoring

2.4.1 Background Monitoring

Background water quality parameters were monitored and recorded by each of the YSI 6600 EDS sondes for approximately one (1) month after their

initial deployment. Water level and rainfall data continued to be collected during this time period also.

2.4.2 Phase One (November 1st-15th, 2004)

Aerators in shallow Lake 19A and deep Lake 20 were turned off on October 26, 2004 (one week prior to beginning Phase One) to allow for a one (1) week stabilization period. Aerators in deep Lakes 17 and 41 continued to operate. Figure 8 shows the aerator status for each pond during Phase One.

The YSI 6600 EDS sondes from all four (4) ponds were retrieved November 1-2, 2004. Data from the sondes was uploaded to an YSI 650 Data Reader and a Panasonic Tuffbook laptop computer using cables and the EcoWatch software package provided by YSI. The sondes were cleaned and properly calibrated using solutions provided by YSI. The dissolved oxygen probe membranes were replaced at this time as well. The YSI 6600 EDS sondes were then re-deployed to the same locations.

Two weeks later, November 15-16, 2004, the YSI 6600 EDS sondes from all four (4) ponds were retrieved, uploaded, cleaned, calibrated and re-deployed as before. This marked the end of the first monitoring phase.

2.4.3 Phase Two (November 22nd - December 6th, 2004)

On November 16, 2004, aerators in deep Lake 17 were turned off. Aerators in deep Lake 20 were turned back on at this time also. This allowed the ponds one (1) week to stabilize before beginning Phase Two. Figure 9 shows the aerator status for each pond during Phase Two.

The YSI 6600 EDS sondes from all four (4) ponds were retrieved December 6-7, 2004; three weeks after Phase Two began. Data was uploaded from the sondes to an YSI 650 Data Reader and a Panasonic Tuffbook laptop computer using cables and the EcoWatch software package provided by YSI. The sondes were cleaned and properly calibrated using solutions provided by YSI. The YSI 6600 EDS sondes were then re-deployed to the same locations. This marked the end of the second monitoring phase.

2.5 Water Quality Sample Collection

Three (3) sets of water quality samples were collected from Lake 17, Lake 19A, Lake 20 and Lake 41 using a Van Dorn type sampler to capture water samples at the

same depths as the YSI 6600 EDS sondes. The Van Dorn type sampler consists of an open cylinder attached to a rope. After being lowered to the appropriate depth, the cylinder closes at a desired depth by dropping a messenger from above. The water quality samples were collected in accordance with the FDEP Standard Operating Procedures for Field Activities (DEP-SOP 001/01) dated January 1, 2002 on the following dates:

November 1, 2004 (beginning of Phase One)
November 15, 2004 (end of Phase One)
December 6, 2004 (end of Phase Two)

The samples collected using the Van Dorn sampler were placed directly into laboratory-supplied containers and immediately placed in a laboratory supplied cooler and covered with ice. The sampler wore powder-free latex gloves during each sampling event. All samples were delivered to the laboratory following chain of custody procedures. Laboratory analyses were performed by Benchmark EnviroAnalytical, Inc. (FDEP Number E84167) in Palmetto, Florida. The water quality samples were laboratory analyzed for the following parameters: pH, turbidity, ammonia nitrogen, total kjeldahl nitrogen, total nitrogen, nitrate + nitrite, orthophosphorus, total phosphorus, chlorophyll-a and specific conductance. The purpose of these samples was to verify proper operation of the YSI 6600 EDS sondes for selected parameters, and to provide additional data for parameters that were not monitored by the YSI 6600 EDS sondes.

2.6 Water Clarity Measurements

Secchi disk depths and total pond depths were taken on the same dates as the water quality samples were collected: November 1, 2005, November 15, 2005 and December 6, 2005. These measurements were taken alongside the YSI 6600 EDS sondes deployed in each pond. Turbidity samples were collected on those dates also, from the same depths as the YSI 6600 EDS sondes, using the Van Dorn type sampler device described above. The turbidity samples were analyzed using a properly calibrated LaMotte 2020 turbidimeter. Pond measurements including the secchi disk readings and turbidity values for each sample collected are presented in Table 3.

2.7 Water Column Profiles

In addition to collecting water quality data from near the bottom of each pond, measurements were also taken at one (1) foot depth increments throughout the water column to assess potential stratification. These measurements were taken alongside the YSI 6600 EDS sondes deployed in each pond. Three (3) sets of water column data were

collected from Lake 17, Lake 19A, Lake 20 and Lake 41 using a properly calibrated YSI 556 multi-parameter water quality meter with a 25 foot cable. The data sets were collected on the same dates as the water quality samples were collected: November 1, 2005, November 15, 2005 and December 6, 2005.

2.7.1 Monitoring Procedure

To prevent disturbance of the water column, the YSI 556 meter readings were recorded before collecting samples or taking any other measurements. The YSI 556 meter was turned on for at least fifteen (15) minutes and the YSI 556 probe was carefully lowered a few inches below the water surface to allow the readings to stabilize. After the initial readings had stabilized, the probe was lowered to a depth of one (1) foot below the surface and readings began being recorded at ten (10) second intervals for the following parameters: temperature, specific conductivity, pH, dissolved oxygen and oxidation-reduction potential. Readings were logged at each interval for a period of two (2) minutes before the probe was lowered to the next one (1) foot depth interval. Measurements continued to be taken in this manner, down to a depth of one (1) foot above the bottom of the pond.

2.7.2 Sonde Verification

As part of the water column monitoring performed with the YSI 556 multi-parameter meter, water quality parameters were monitored at the same depth as the YSI 6600 EDS sondes. The multi-parameter meter values were compared to the sonde measured values for quality control. Turbidity sample readings from the LaMotte 2020 turbidimeter were compared to the sonde values as well. Also, specific conductance, pH and turbidity values for the laboratory-analyzed samples were compared to the sonde and multi-parameter readings. The water quality data comparisons for each parameter are shown in Table 4.

3.0 DATA RESULTS

3.1 Water Level Data

Water level data collected by the Infinities USA, Inc. stage recorders is included on the enclosed compact disc as Excel spreadsheet: Lake Levels.xls. A chart displaying

water surface elevations throughout the study period for Lake 17, Lake 19A, Lake 20 and Lake 41 is presented in Appendix A.

Water levels for each of the ponds remained consistent, relative to each other, except for Lake 20, which fluctuated due to apparent daily irrigation water withdrawals. During the study period, the pond surface water elevations were below the outfall structure control elevation. Therefore, no flow existed through the detention system. Overall, water levels declined gradually throughout the study due to evaporation and infiltration into the surficial aquifer.

3.2 Rain Gauge Data

Rainfall data collected by the Infinities USA, Inc. rain gauge is included on the enclosed compact disc as Excel spreadsheet: Rainfall.xls. A chart displaying daily rainfall at The Brooks throughout the study period is presented in Appendix A.

The study took place during the dry season, with rainfall for October–December averaging about four (4) inches. Normal rainfall for this period is about six (6) inches.

3.3 Water Quality Sonde Data

Data recorded by the YSI 6600 EDS water quality sondes is included on the enclosed compact disc as Excel spreadsheet: Sonde Data.xls. Charts displaying the water quality data monitored by the sondes are presented in Appendix B.

Dissolved oxygen levels in ponds with aerators not operating ranged from approximately 2 to 8 milligrams per liter (mg/L). Levels measured in ponds with aerators operating generally ranged between 6 and 9 mg/L. During the phase two (aerator on) monitoring period for Lake 20, dissolved oxygen levels remained very stable at approximately 8 mg/L except for very defined daily variation of less than 1 mg/L.

3.4 Multi-Parameter Meter Depth Profile Data

Data recorded by the YSI 556 multi-parameter water quality meter is included on the enclosed compact disc as Excel spreadsheet: Multiparameter Meter Data.xls. Depth profile charts with plots of the multi-parameter meter data monitored are included in Appendix C. Separate charts are presented for Lake 17, Lake 19A, Lake 20 and Lake 41 for each of the three (3) dates monitored. Appendix C also includes dissolved oxygen depth profile charts comparing readings from all four (4) ponds on each date monitored.

Dissolved oxygen levels in ponds with aerators operating varied less than 1 mg/L in the water column. In ponds with aerators not operating, dissolved oxygen levels decreased with increasing depth.

3.5 Laboratory Data

Laboratory data for water quality parameters analyzed is included on the enclosed compact disc as Excel spreadsheet: Lab Results.xls. Laboratory reports and chains of custody records for water quality samples collected are provided in Appendix D and on the enclosed compact disc as portable document files (pdf). Ranges for concentrations of ammonia nitrogen, total kjeldahl nitrogen, total nitrogen, nitrate+nitrite, chlorophyll-a, ortho phosphorus and total phosphorus were similar in both ponds with aerators operating and those with aerators not operating. Concentration ranges were also similar between deep ponds and the shallow pond.

4.0 CONCLUSIONS

Water quality monitoring of four (4) ponds within a deep and shallow wet detention system at The Brooks residential development was successfully performed. The monitoring involved using submerged water quality sondes to record dissolved oxygen levels as well as temperature, specific conductivity, pH, oxidation-reduction potential and turbidity in both aerated and non-aerated ponds. The study consisted of two (2) phases in which aerators in two of the ponds operated as normal while aerators were not operating in the other two (2) ponds.

Dissolved oxygen levels measured in ponds with aerators operating were more stable and averaged from 2 to 3 mg/L higher than levels of dissolved oxygen measured in ponds with aerators not operating. Other parameters measured by the water quality data sondes were also generally more stable in the ponds with aerators operating versus ponds with aerators not operating. Specifically, dissolved oxygen levels were affected most significantly by the presence or lack of aeration. Readings taken by the portable multi-parameter water quality meter indicated stratification of dissolved oxygen and other parameters in ponds that were not aerated. Lake 20, the shallowest pond monitored with aerators operating, provided the most stable dissolved oxygen readings. However, the depths of the ponds did not appear to significantly influence the measured parameters.

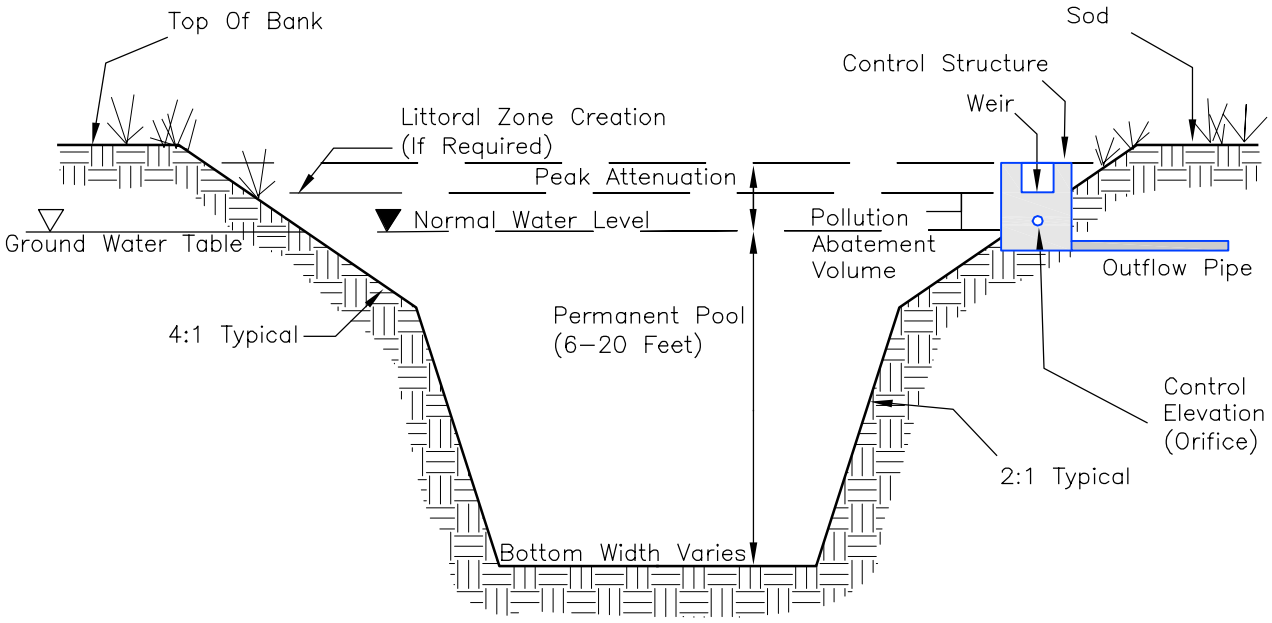
Water quality parameters monitored by the YSI 6600 EDS water quality sondes compared well to measurements of the same parameters taken with the YSI 556 multi-parameter water quality meter. Laboratory results from water quality samples collected were also similar to the same parameters measured with the water quality monitoring equipment. The correlation of water quality data is shown in Table 4. The YSI 6600 EDS sondes functioned well during the test periods. The data comparison shows that there was generally good agreement between the lab data, the YSI 6600 EDS sondes and the YSI 556 multiparameter probe.

Use of the YSI 6600 EDS sondes for measurement of dissolved oxygen proved somewhat problematic. This parameter is especially sensitive to a variety of membrane

and environmental conditions that may reduce the accuracy of the data, especially over long periods of deployment.

Overall, the YSI 6600 EDS sondes appear to provide a very effective method of monitoring water quality data. When combined with laboratory analysis for quality control, the YSI 6600 EDS sondes proved valuable in assessing continuous in-situ water quality.

FIGURES



TYPICAL SECTION
WET DETENTION

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Typical Section
Wet Detention

DATE	PROJECT NO.	FILE NO.	SCALE	SHEET
03/18/05	20044445		No Scale	FIG 1

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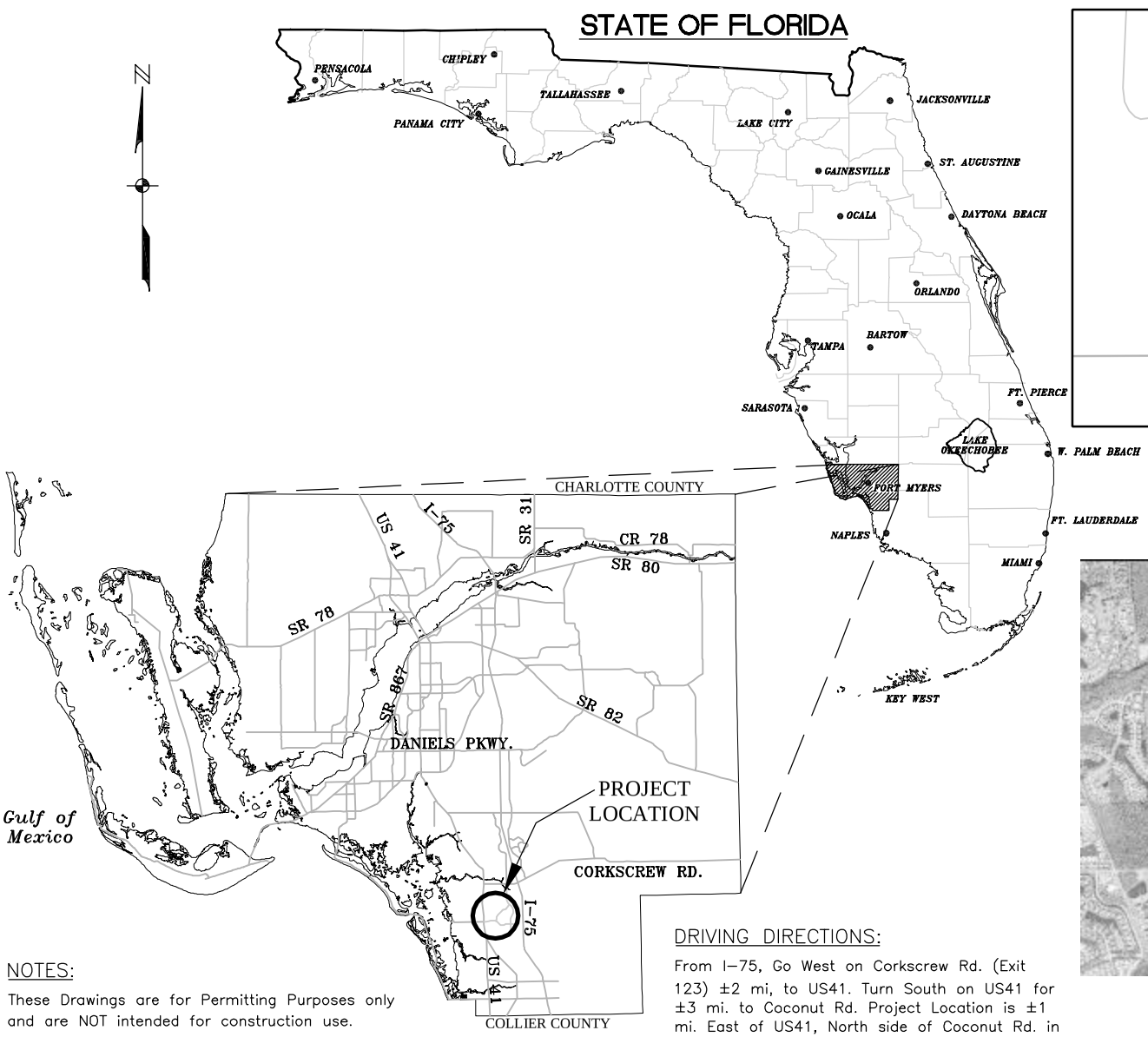
STATE OF FLORIDA



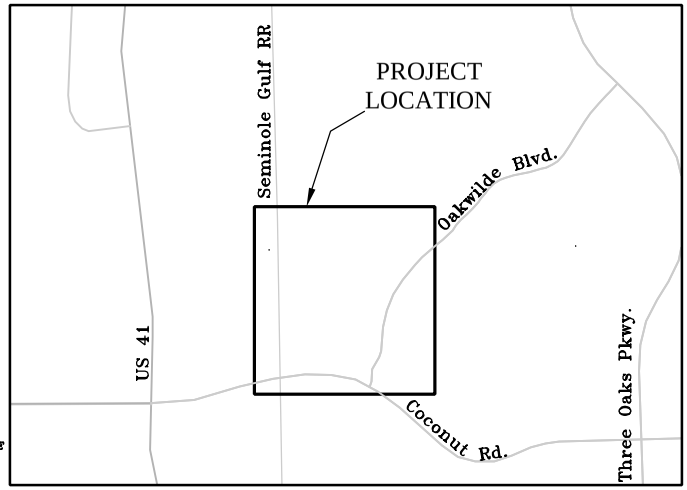
LEE COUNTY
N.T.S.

NOTES:

These Drawings are for Permitting Purposes only and are NOT intended for construction use.

DRIVING DIRECTIONS:

From I-75, Go West on Corkscrew Rd. (Exit 123) ±2 mi, to US41. Turn South on US41 for ±3 mi. to Coconut Rd. Project Location is ±1 mi. East of US41, North side of Coconut Rd. in The Brooks.



STREET MAP
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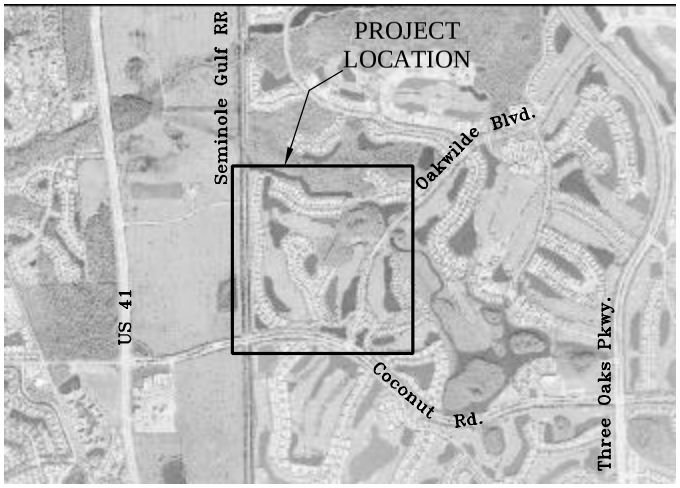

VICINITY AERIAL
N.T.S.

SEC 10 – TSP 47S – RGE 25E
LATITUDE 26°24'09", LONGITUDE 81°48'00"

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Deep Lake Monitoring
The Brooks, Lee County

DATE	PROJECT NO.	FILE NO.	SCALE	SHEET
1/18/05	20044445		N.T.S.	FIG 2

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Note: Imagery from Digi-Air and Dated: Nov. 2002

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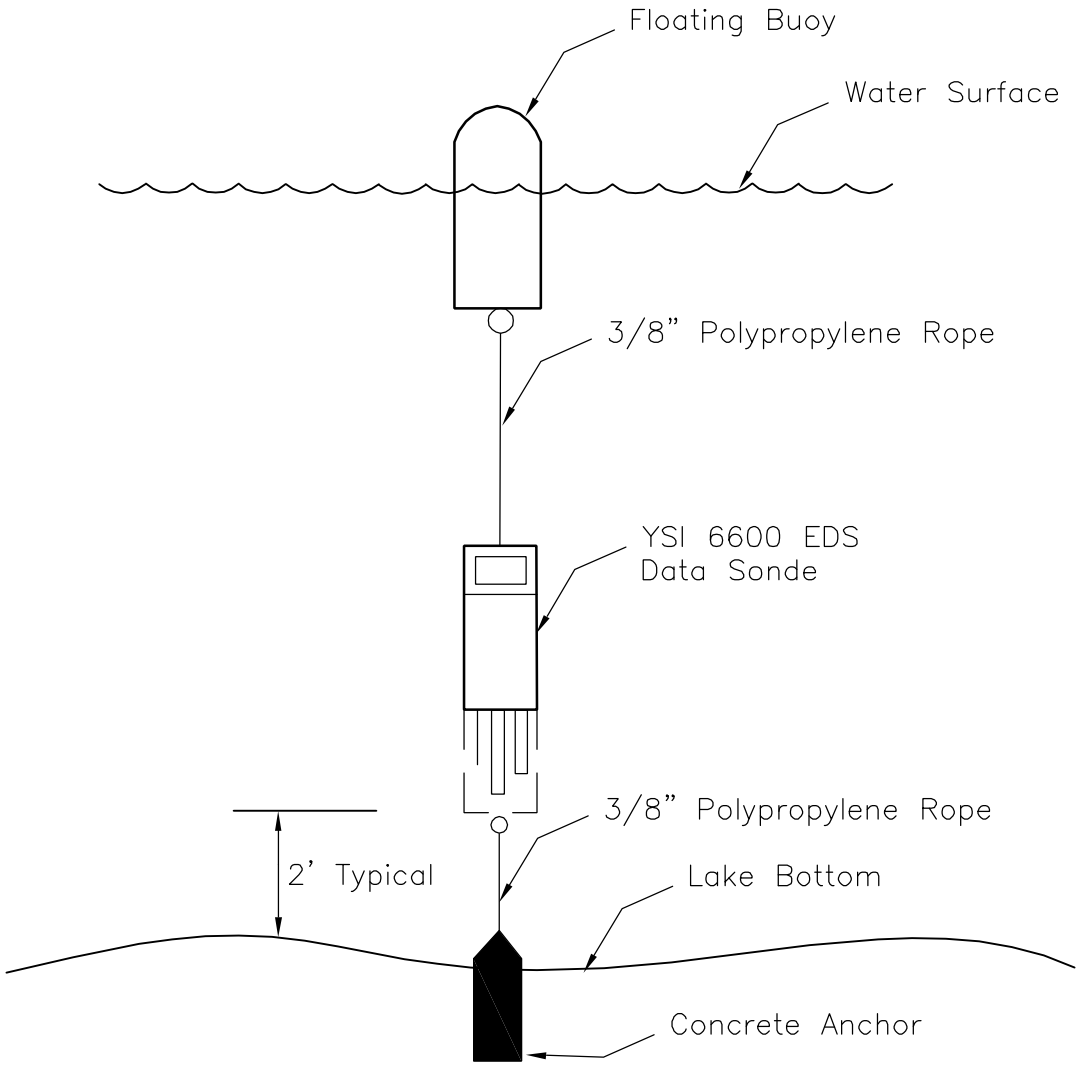
Deep Lake Monitoring Plan - General Layout
The Brooks, Lee County

DATE	PROJECT NO.	FILE NO.	SCALE	SHEET
01/18/05	20044445		As Shown	FIG 3



YSI 6600 EDS
DEPLOYMENT SCHEMATIC

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YSI 6600 EDS
Deployment Schematic

DATE	PROJECT NO.	FILE NO.	SCALE	SHEET
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Note: Imagery from Digi-Air and Dated: Nov. 2002

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Deep Lake Monitoring Plan - Lake 17
The Brooks, Lee County

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01/18/05	20044445		As Shown	FIG 5

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Deep Lake Monitoring Plan - Lakes 19A & 20
The Brooks, Lee County

DATE	PROJECT NO.	FILE NO.	SCALE	SHEET
01/18/05	20044445		As Shown	FIG 6

TABLES

APPENDIX A

RAINFALL AND LAKE LEVEL DATA

APPENDIX B

WATER QUALITY SONDE DATA

APPENDIX C

MULTI-PARAMETER METER

DEPTH PROFILE DATA

APPENDIX D

LABORATORY DATA