Pond Apple Slough

Preliminary Assessment and Rehydration Test

Technical Publication WS-10

Cynthia J. Gefvert and Steve L. Krupa, P.G.

December 2001

South Florida Water Management District
3301 Gun Club Road
West Palm Beach, FL 33306
(561) 686-8800
www.sfwmd.gov

EXECUTIVE SUMMARY

Pond Apple Slough is a 112-acre urban wetland in eastern Broward County. The unique characteristics of Pond Apple Slough can be attributed to the fact that it is part of the forested drainageway formed near the New River break in the coastal ridge, along the edge of the remnant Everglades. Most wetlands in eastern Broward County are man-made excavated systems, generally less than five acres in size. The health of Pond Apple Slough was impaired when its natural overland flow of fresh water was greatly diminished due to years of development and construction of Interstate 595 (I-595), the Broward County Resource Recovery Center, and the I-595/State Road 441 interchange. The South Florida Water Management District (District), along with Broward County and other interested parties, has been a participant in the Pond Apple Slough Working Group, an association created in 1991, dedicated to restoration of the slough.

The work of the PAS Working Group was funded by mitigation funds made available to Broward County in a 1991 agreement with the Homart Development Corporation. This work included a baseline study to determine the health and needs of the slough, removal of exotics from the area, and development of a long-term management plan to maintain a healthy, freshwater ecosystem. The PAS Working Group agreed that a permanent and stable supply of fresh water was needed for the slough. Based on this recommendation, the District, with concurrence from Broward County, agreed to use funds from a KMart™ mitigation agreement (Permit 06-00898-S-11) to fund the construction of a freshwater delivery system for Pond Apple Slough. The system, as designed, will divert water from the District's C-11 canal, through culverts, to Pond Apple Slough. The design of the system is now completed, and the contractor is in the process of obtaining necessary permits before beginning construction.

This report is intended to compile a summary of pertinent Pond Apple Slough information into one document. The report provides an overview of the Pond Apple Slough Ecosystem, a brief history of the restoration project, and a compilation of data collected by the District and Broward County staff. These data include water quality measurements from the slough, water levels (ground and surface) from sites in and near the slough, monitor well location and elevation information, and flow from structures located near the slough. Subsequent reports will be provided by the contractor.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ACKNOWLEDGEMENTS

The authors wish to acknowledge the many people and agencies connected with the Pond Apple Slough project. We thank Woody Wilkes of the Museum of Discovery and Science for his persistence in sticking with the project, and Don Burgess, Heather Carman, Gordon Dively, and Fran Henderson of the Broward County Department of Planning and Environmental Protection, and Don Charlton of the Broward County Office of Environmental Services. In particular, we thank Gordon Dively for his fieldwork and Don Burgess for his information regarding the history of the project and help in editing the manuscript.

Appreciation is extended to the many South Florida Water Management District (District) staff who participated in the project or helped with the compilation of data and production of this report. They include John Lukasiewicz, Nancy Demonstranti, Emily Hopkins, Eduardo Lopez, Angela Chong, Brenda Mills, Chris McVoy, Susan Coughanour, and Barb Conmy. Jim Karas, formerly with the District, currently with Broward County, provided information and editorial assistance. We thank the staff at the Fort Lauderdale Field Station for its time and effort with the rehydration test, and Kim Jacobs for her assistance in preparing this report for publication.

INTRODUCTION

Pond Apple Slough is a 112-acre remnant freshwater urban wetland in the eastern portion of Broward County, Florida (Lewis, 1996). As an urban wetland, Pond Apple Slough helps to absorb flood water, naturally filter water, and provide a refuge for wildlife in the midst of development. Over many years, development diverted the natural flow of water to the slough, causing its health to deteriorate. A decrease in natural overland flow allowed the intrusion of salt water, causing the deaths of cypress trees from salt stress, the invasion of mangroves into historic freshwater areas, and the toppling of pond apple trees due to marine isopods eating the pond apple roots. This deterioration prompted concerns by a number of public agencies and private organizations. Efforts to restore Pond Apple Slough appear to have begun in 1986, during the construction of the Interstate 595 (I-595) overpass.

The South Florida Water Management District (District) began working with Broward County in early 1991 to find a reliable source of fresh water for the slough and became an active participant in the Pond Apple Slough Working Group (BCWRMD, 1991). The working group was comprised of Broward County and District staff, as well as other individuals with an interest in the condition and restoration of Pond Apple Slough. In 1992, the working group contracted with Lewis Environmental to develop a long-term plan for restoration and management of the slough and, in 1995, the District approved the use of mitigation funds (Permit 06-00898-S-11) to help provide a permanent supply of fresh water to Pond Apple Slough. In 1997, the District established a cooperative agreement with Broward County to complete the project. The water delivery system has now been designed, and the contractor is in the process of applying for all necessary permits. The system is scheduled to be constructed in 2001.

Location and Geography

Pond Apple Slough is about six miles west of the Atlantic Ocean, west of the Atlantic Coastal Ridge, in eastern Broward County. The slough is a part of the Pond Apple Slough Ecosystem, which includes about 750 acres on both sides of the South New River Canal in southern Broward County (Lewis, 1996). The Pond Apple Slough ecosystem was originally a part of the flowway system connecting the Everglades to the New River and contained mixed forest vegetation with stands of sawgrass (Lewis, 1996). The elevation of Pond Apple Slough ranges from +5.0 feet National Geodetic Vertical Datum of 1929 (NGVD) at the northwestern corner, to 0.0 feet, where the slough meets the South New River Canal (Lewis, 1996; BCONRP, 1992). When the water level in the South New River is high, the eastern and central areas of the slough are inundated with water.

The slough is bordered by I-595 to the north, the South New River Canal (C-11 canal) to the south and east, and the 58-acre Griffey Tract to the west. Immediately west of the Griffey Tract is the Broward County Resource Recovery Facility, including a large ash residue landfill. The Florida Power and Light Fort Lauderdale Power Plant is on the southern side of the South New River Canal.

The District's G-54 structure is on the North New River, west of the Florida Turnpike, while the S-13 structure is on the South New River, west of the slough. West of the Resource Recovery Facility are several rock pits, artificial lakes, and the Central Broward Water Control District's N-1 canal. The N-1 canal connects to the District's C-11 canal, west of the S-13 structure. **Figure 1** shows a map of the area.

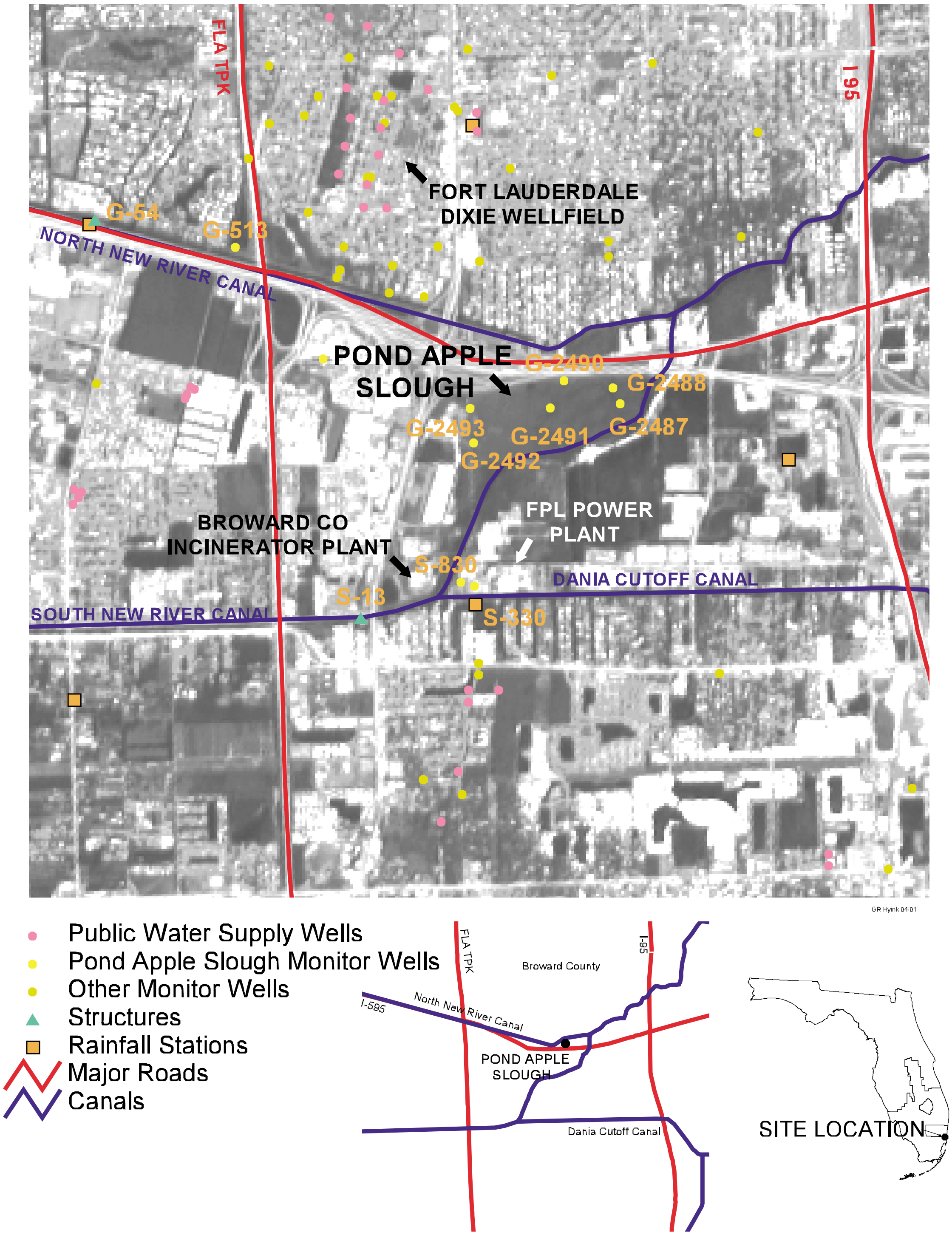

Figure 1. Map of Pond Apple Slough

Vegetation

The changes in vegetation were one of the key indicators that the health of Pond Apple Slough was in jeopardy. It had been observed by working group participants that freshwater cypress trees were dying off, mangroves were moving in, and exotic species (such as Australian pine and melaleuca) were intruding. As a step in the development of the Pond Apple Slough Management Plan, Lewis Environmental completed a vegetation inventory in 1996 (Lewis, 1996).

The results of the inventory indicate that, at the time, the Pond Apple Slough tree canopy was primarily pond apples with a leather fern understory (Lewis, 1996). Red and white mangroves had moved into the tidal portions of the slough, indicating saltwater intrusion into the historically fresh surface water. The changing environment caused the deaths of freshwater cypress trees due to salt stress, and the deaths of pond apple trees because of an isopod boring into roots of the trees. The upper elevations of the slough were inhabited by sawgrass, cattails, and some bald cypress and exotics, such as Brazilian pepper, Australian pine, and melaleuca (Lewis, 1996). **Figure 2** shows the results of the vegetation inventory.

Hydrogeology

In South Florida, the primary source of fresh water is the unconfined Surficial Aquifer System (SAS), which is comprised of all saturated sediments from ground surface to the Hawthorn Group. The Hawthorn Group is a thick sequence of relatively impermeable clayey sediments (Giddings, 1999; Scott, 1992; SFWMD, 1991). The highly transmissive Biscayne aquifer is part of the SAS, underlies central and eastern Broward County, and consists primarily of sediments considered to be Pleistocene in age (Parker et al., 1955; Leach, 1972). The thickness of the Biscayne Aquifer increases in Broward County from west to east. It is about 10 feet in the western part of the county, and thickens to about 200 feet in the Fort Lauderdale area (Leach, 1972; Hoffmeister, 1974).

According to the Florida Department of Transportation, a 1-foot layer of organic muck is on the surface of the slough (BCONRP, 1992). In eastern Broward County, this organic muck overlies the Pamlico sand (Finkl and Esteves, 1997; Parker et al., 1955; Hoffmeister, 1974). This low to medium permeability sand is carbonaceous quartz and is frequently very fossiliferous. In some areas, the Pamlico sand is clean and well sorted, while in other areas, it is poorly sorted with intermixed finer sand grains, silt, and organic materials. The sand is primarily gray-white to brown or black and is Pleistocene in age (Hoffmeister, 1974).

Underlying the Pamlico sand is the Miami limestone that forms the southern portion of the Atlantic Coastal Ridge. The Miami limestone has an oolitic facies overlying a bryozoan facies (Hoffmeister, 1974; Scott, 1992). The Miami limestone is also considered to be Pleistocene, is porous with large solution holes, and demonstrates high vertical permeability with lower horizontal permeability (Parker et al., 1955; Hoffmeister, 1974). In central Broward County, the oolitic facies grades into the Anastasia Formation. The

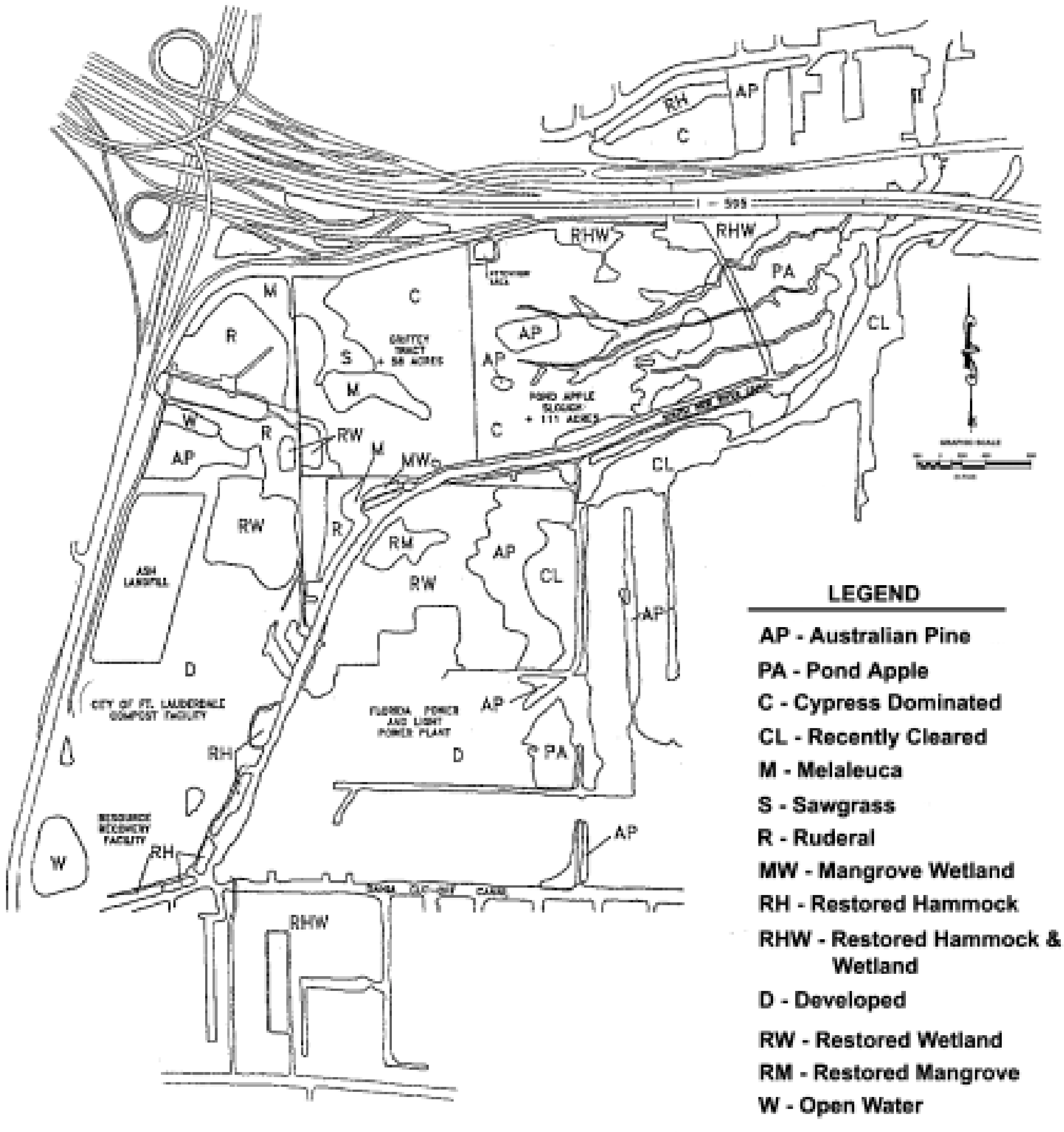

Figure 2. Vegetation in Pond Apple Slough Ecosystem (Lewis, 1996)

Anastasia Formation is Pleistocene in age (Parker et al., 1955) and may be as thick as 100 feet toward the coast, while thinning to the west. The Anastasia Formation is primarily sandy limestone, calcareous sandstone, fossiliferous calcareous quartz sand, shells, and coquina (Hoffmeister, 1974; Scott, 1992).

Underlying the Anastasia Formation is the upper Miocene Tamiami Formation. In Broward County, the Tamiami is comprised of a thin layer of nonoolitic limestone and a thick section of greenish clay marl, silty shelly limestone, and calcareous marl to limestone (Parker et al., 1955; Giddings, 1999). The impermeable Hawthorn Formation underlies the Tamiami and forms the base of the Biscayne aquifer (Parker et al., 1955;

Scott, 1992; Giddings, 1999). The Hawthorn Formation is comprised of greenish clays, marls, silts, and sand with some quartzite and phosphate pebbles and is lower/middle Miocene (Parker et al., 1955). The greenish clays of the Hawthorn and Tamiami formations require the identification of macrofossils to accurately differentiate between them.

POND APPLE SLOUGH HYDROLOGY

In the past, it was likely the Pond Apple Slough ecosystem watershed encompassed several thousand acres, while serving as an eastern Everglades drainage path during periods of high water. In rainy periods, water would move across the entire system as sheetflow from the west to the east (Lewis, 1996). Beginning in 1905, the normal overland flow of fresh water to Pond Apple Slough was diminished with the dredging of the North and South New River Canals. The dredging project began near the headwaters of the South Fork of the New River and worked westward (Anonymous, 1907). The spoil material from the dredging was used to construct a berm adjacent to the river (canal), forming a barrier between the New River and the wetlands.

Water was now allowed to flow steadily from Lake Okeechobee and the northern Everglades, through the open North New River Canal and into the Atlantic Ocean (Leach, 1972). This open canal system permitted the water to flow continually and surface water stages, including those in the slough, were reduced. After a drought period from 1943 through 1945, control structures were added to the major canals through the coastal ridge to allow management of the flow and water levels (Leach, 1972).

Saltwater intrusion from tidal flow in the canal was not a problem before completion of the water conservation areas (WCAs) west of the Pond Apple Slough ecosystem. The previously high levels of eastward flow through the North New River Canal had controlled the inland tidal flow. After completion of the WCAs, much of the water that had flowed eastward in the canal was now retained in the WCAs. With eastward flow in this canal now reduced by as much as 25 percent, the saline tidal water was able to travel further upstream and into the slough (Leach, 1972). Because parts of the slough are inundated with water when the South New River is high, brackish water was able to move into the slough surface water. The higher density of the salt water allowed the movement of this water into the shallow groundwater (BCONRP, 1992).

Construction of the Broward County Resource Recovery facility in the 1980s also had a negative impact on slough hydrology. As part of this project, over 97 acres of freshwater wetland west of the Griffey Tract were filled, drainage to the slough was diminished, and portions of the berm on the western side of the South New River Canal were removed (Lewis, 1996). Removal of the berm, though approved, facilitated the intrusion of salt water into the slough, damaging the cypress population. The construction of I-595 again reduced the area of the slough and the amount of available fresh water (Lewis, 1996). As a result of these activities, Pond Apple Slough was greatly reduced in size and supplied with a very limited supply of fresh water.

As a part of wetland mitigation for the I-595 construction projects, the Florida Department of Transportation purchased Pond Apple Slough and an additional 22.5 acres that run along the South New River Canal. The plan was to restore these two areas and the Griffey Tract, oversee removal of exotic plant species, and turn the land over to Broward County at the completion of the interstate. Pond Apple Slough was deeded to Broward County in September 1998, and is now managed by the Broward County Parks and Recreation Division (BCDNP, 2000).

Pond Apple Slough Restoration Project

Broward County began studying Pond Apple Slough restoration in 1988 when the Broward County Environmental Quality Control Board and the United States Geological Survey began a hydrologic study of the slough. The results of this study indicated that in drought conditions, the groundwater and surface water within the slough was considered low to moderately brackish and within the tolerance range of pond apples, but not cypress trees (BCEQCB, 1990). The study also showed the discharge of fresh water (from the G-54 structure) to tide had been decreasing over the years. In 1989, the average daily flow rate was 5 cubic feet per second (cfs), while the 10-year annual average was 154 cfs, and the 49-year annual average was 358 cfs.

Broward County Water Resources Management Division staff drafted a report in 1990 that reviewed the cause of the Pond Apple Slough problems and tried to identify a potential solution to the freshwater problem. As described in this report, water would be diverted from the C-11 structure though a series of existing culverts, under State Road 7, and into a new pond situated in the northwestern corner of Pond Apple Slough. Because the source of the fresh water is lower in elevation than Pond Apple Slough, a pump would be necessary to lift the water through all the culverts (BCWRMD, 1990). Construction costs would be contained by using existing culverts, as appropriate. The final plan design has changed somewhat from the original plan in the use of existing culverts and method of water delivery. Details regarding the revised design are provided in the District’s Surface Water Permit Application 001220-8.

In 1991, Broward County and the United States Army Corps of Engineers received $300,000 from Homart Development Company to settle a wetlands violation case. It was agreed to use this money to restore the Pond Apple Slough ecosystem. That same year, the Pond Apple Slough Working Group was formed to provide oversight for the planning efforts (BCEQCB, 1990). In 1992, Lewis Environmental Services was hired to review the proposed restoration plan, develop a long-term management plan for the slough, and oversee work, such as the removal of exotic plants. The proposed restoration plan had listed five key tasks that would need to be conducted to complete the restoration (Lewis, 1996):

1. Redirect retention pond discharge away from the existing direct stream discharge
2. Block the known breach (and any other confirmed breaches) in the South New River berm

3. Coordinate exotic plant control efforts in the area
4. Seek additional sources of fresh water for the slough
5. Investigate the need of constructing additional berms, as appropriate

By December 1996, a long-term management plan was developed, and the first three key tasks had been completed (Lewis, 1996). The working group decided to install five shallow 2-inch monitor wells to monitor current and future groundwater levels and water quality. The design of the proposed freshwater delivery system was in process, but slowed by lack of detailed topographic data. The topographic data were not available, and many working group members were against a survey because of the destructive trail blazing involved. Therefore, District staff proposed a temporary rehydration test to simulate the suggested plan and provide the following:

- Determine the general topography in the vicinity of the proposed recharge area by following the flow of the water
- Estimate the effects of the proposed discharge at the monitoring stations by establishing pumpage rates close to the proposed discharge rates
- Evaluate the temporary pumping effects by monitoring the groundwater and surface water levels with data loggers

The test was scheduled for late summer 1997. Before beginning the test, the five monitor wells were installed and constructed by Hydrologic Associates, Inc. under contract with Broward County and with direction from the Pond Apple Slough Working Group. The wells were situated in the center and in the four corners of the slough to obtain data representative of the entire area. Well construction details are provided in **Appendix A** of this report. Lithologic data are not available.

In the test, water was periodically pumped by District staff from the northwestern corner of the Griffey Tract into the slough, from September 4 to September 19, 1997. The pump was operated manually and was maintained by the District's Fort Lauderdale Field Station staff. The pump had a capacity of 1,460 gallons per minute (gpm). The rehydration pump schedule is provided in **Table 1**.

Table 1. Rehydration Pump Schedule

	9/4	9/5	9/8	9/8	9/9	9/9	9/10	9/10	9/11	9/11	9/12	9/15	9/15	9/16	9/17	9/19
Time Pump On	11:30	8:00	8:00	12:30	8:15	13:00	8:00	13:00	8:30	14:00	8:00	9:30	12:30	9:00	8:00	8:00
Time Pump Off	14:00	14:15	10:30	14:30	10:45	15:15	10:30	14:30	10:00	14:45	10:00	11:30	14:00	10:30	10:00	10:30

In-situ™ data loggers with 10 pounds per square inch (psi) pressure transducers were placed at the southwestern well (MW-3A-S) and the center well (MW-5A-S) on September 3, 1997, to monitor water levels during the test. The test began on September 4, 1997. Surface water and groundwater levels were measured and recorded every 15 minutes for the test duration. The data showed minimal water level changes between the times the pump was on and off. The differences ranged between 0.0 and 0.2 feet. These data, in graphical form, are provided in the appendices of this report. Possible reasons for this minimal effect is likely a combination of the following:

- Pump capacity was too small for the area and volume of water involved
- Individual pumping periods were not long enough
- Volume of groundwater recharge throughout the slough was greater than the volume of pumped water
- Upper layers of the aquifer have very high levels of hydraulic conductivity
- Tidal effect was so great that it dampened the overall effect of the pumping test

While the minimal effects of the additional surface water could be viewed as disappointing, it was not unexpected, due to the highly transmissive nature of the aquifer. The total volume of water pumped during the 16 days of the test was about 3.1 million gallons (9.5 acre-feet). The pump that will be used in the recharge plan has a greater capacity. The District anticipates that 1,000 to 1,350 acre-feet of water will be pumped into the slough annually (Hydrologic Associates, 2001a). The Pond Apple Slough Working Group believes the recharge plan will provide sufficient water on a stable basis to protect the health of the slough and stabilize the areas of cypress (Hydrologic Associates, 2001b).

To obtain baseline water quality data, District staff measured temperature, specific conductivity, dissolved oxygen, pH, and salinity at wells located in the Griffey Tract and at several of the new Pond Apple Slough monitor wells in 1996 and 1997. Dissolved oxygen levels in a number of wells including MWC-2C-A, MW-6A-S, and MW-7A-S exceed 3.2 milligrams per liter (mg/l), indicating surface water influence. Specific conductivity levels ranged from a low of about 700 microseconds per centimeter (µS/cm) to a high of nearly 10,000 µS/cm. Specific conductivity was measured more than once at three wells, but we do not have salinity measurements for each from the same days. Two of these wells show specific conductance differences in excess of 3,000 µS/cm, which could indicate groundwater influence that is dependent on the level of the surface water. Detailed results are provided in **Appendix A**, **Table A-3**.

Samples were collected and analyzed for major ions, nutrients, and metals from the five new monitor wells (**Table 2**). These samples were collected by Broward County staff in September 1997 and analyzed by the Broward County Laboratory. The results of the metals analysis were all below detection limits, except for wells MW-3A-S, MW-4A-2, and MW-7A-S, which had chromium levels slightly above the detection limit. The differences in major ion values indicate some wells have different sources of water. However, as sulfate was not measured, it is not possible to do a tri-linear diagram or ionic balance. Details of all water chemistry results are provided in **Appendix A**, **Table A-3**.

Table 2. Summary of Water Chemistry at Pond Apple Slough[a b]

Site ID	Type	Sample Depth (feet)	Spec. Cond.[c] (μS/cm)	Na (mg/l)	Ca (mg/l)	K (mg/l)	Mg (mg/l)	Cl (mg/l)	TKN (mg/l)	NO_2+NO_3 (mg/l)	Total P (mg/l)	Cr (μg/L)
Borrow pit	Surface		2,380	285.5	39.4	6.20	14.2	578	-	-	-	-
Borrow pit	Surface	4.7	2,400	358.5	91.6	17.6	33.4	588	-	-	-	-
MW-3A-S	Well	-	2,600	128.0	100	21.5	37.0	694	1.52	0.022	0.073	5.65
MW-4A-S	Well	-	3,360	450.0	187.0	10.3	21.2	851	3.99	< 0.0180	0.081	6.68
MW-5A-S	Well	-	2,400	119.0	143.0	11.9	25.2	578	1.65	0.019	0.044	< 5.27
MW-6A-S	Well	-	800	34.5	64.8	12.2	20.2	76.0	3.16	0.033	0.061	< 5.27
MW-7A-S	Well	-	9,910	1,660.0	164.0	97.9	141	2,940	1.68	0.02	0.102	5.34

a. Surface water samples were obtained on February 14, 1997, and groundwater samples were obtained on September 3, 1997.
b. Element and compound abbreviations are defined in **Table A-3**
c. Spec. Cond. = Specific Conductance

Broward County and the Pond Apple Slough Working Group (**Table 3**) are currently involved in finalizing the system design and obtaining permits to construct and operate the freshwater delivery system. The design plans include a pump capable of moving 2,500 to 3,000 gpm or 3.6 to 4.3 million gallons per day (MGD) (Hydrologic Associates, 2001). The contractor is currently in the process of obtaining the necessary permits. The schedule dated for construction completion and inspection is August 2001 with the system operational in August 2002.

Table 3. Pond Apple Slough Working Group

Member	Affiliation
Jim Breitenstein	City of Fort Lauderdale
Don Burgess	Broward County Department of Planning and Environmental Protection
Laura Burnett	Florida Department of Transportation
Heather Carman	Broward County Department of Planning and Environmental Protection
Kathy Cartier	Broward County Department of Planning and Environmental Protection
Don Charlton	Broward County Office of Environmental Services
Dan Cotter	Secret Woods Nature Center
Wendy Cyriaks	Florida Department of Transportation
Gordon Dively	Broward County Department of Planning and Environmental Protection
Becky Fierle	Broward County Water Resources Management Division
Jim Goldasich	J.J. Goldasich & Associates
Jim Hamilton	Broward County Parks and Recreation Division
Bob Harbin	Broward County Parks and Recreation Division
Tom Henderson	Broward County Office of Integrated Waste Management
Steve Higgins	Broward County Department of Planning and Environmental Protection
Jim Karas	South Florida Water Management District
Teri Klonsky, P.E.	SKS Engineering, Inc.
Steve Krupa	South Florida Water Management District
Angela Lucci	Broward County Department of Planning and Environmental Protection
Gil MacAdam	Broward County Parks and Recreation Division
Dave Markward	Broward County Office of Environmental Services

Table 3. Pond Apple Slough Working Group (Continued)

Member	Affiliation
Larry Marvet	Sierra Club
Frank Mazzotti	University of Florida's Institute of Food and Agricultural Sciences
Carlton Miller	Broward County Office of Integrated Waste Management
Cynthia Morani	South Florida Water Management District
Carol Morgenstern	Broward County Parks and Recreation Division
Eric Myers	Broward County Department of Planning and Environmental Protection
Howard Nelson, Esq.	Eckert, Seamans, P.A.
Mike Nichols	Craven Thompson
Gerald Peters	Broward County
Monica Ribaudo	Broward County Parks and Recreation Division
Al Sifferlen	City of North Lauderdale
Ram Tevari	Broward County
Linda White	Broward County Parks and Recreation Division
Woody Wilkes	Museum of Discovery and Science
Gangpen Zhang	Broward County Department of Planning and Environmental Protection

REFERENCES

Ali, A., and W. Abtew. 1999. *Regional Rainfall Frequency Analysis for Central and South Florida.* Technical Publication WRE 380, South Florida Water Management District, West Palm Beach, FL.

Anonymous. 1907. A Visit on August 30, 1907, to the Everglades Drainage Operations with Governor Broward and Investigating Committee. *Weekly Miami Metropolis,* Miami, FL.

BCDNP. 2000. Personal communication letter dated August 3, 2000, from Heather Carman, Broward County Department of Natural Resources, to Cynthia Gefvert, South Florida Water Management District, concerning removal of exotics on and around Pond Apple Slough.

BCEQCB. 1990. Memorandum dated October 15, 1990, from Francis Henderson, Broward County Environmental Quality Control Board, to Victor Howard, PCO, concerning the need for a management plan at Pond Apple Slough.

BCONRP. 1994. *Precipitation in Broward County.* Technical Report Series, TR:94-02, Environmental Monitoring Division, Planning and Evaluation Section, Broward County Office of Natural Resources Protection, Fort Lauderdale, FL.

BCONRP. 1992. *A Hydrologic Study of the Pond Apple Slough - unpublished report*. Biological Division, Wetland Resources Section, Broward County Office of Natural Resources Protection, Fort Lauderdale, FL.

BCWRMD. 1990. *Pond Apple Slough Fresh Water Recharge Study.* Broward County Water Resources Management Division, Fort Lauderdale, FL.

BCWRMD. 1991. Letter dated March 8, 1991, from Dave Markward, Broward County Water Resources Management Division to Debbie Goss, South Florida Water

Management District, concerning a suggestion for a reliable source of fresh water to Pond Apple Slough.

Finkl, C.W., Jr., and L.S. Esteves. 1997. A Preliminary Analysis of Neogene Depositional Environments in Broward County, Florida. *Florida Scientist* 60(2):94-103.

Giddings, J.B. 1999. Masters Thesis. Deposition and Chronostratigraphic Subdivision of the Quaternary Sediments, Broward County, Florida. Florida Atlantic University, Boca Ration, FL.

Hoffmeister, J.E. 1974. *Land from the Sea, the Geological Story of South Florida.* University of Miami Press, Coral Gables, FL.

Hydrologic Associates. 2001a. Personal communication on January 3, 2001, from Bradley Waller, Hydrologic Associates U.S.A., Inc., to Steve Krupa, South Florida Water Management District, concerning pump size planned for the rehydration project.

Hydrologic Associates. 2001b. Personal communication on April 11, 2001, from Bradley Waller, Hydrologic Associates U.S.A., Inc., to Cynthia Gefvert, South Florida Water Management District concerning the annual water volume to be pumped into Pond Apple Slough.

Leach, S.D, H. Klein, and E.R. Hampton. 1972. *Hydrologic Effects of Water Control and Management of Southeastern Florida.* Report of Investigations No. 60, Florida Bureau of Geology, Tallahassee, FL.

Lewis, R.R. 1996. *Pond Apple Slough Restoration Project Management Plan*. Prepared by Lewis Environmental for Broward County Department of Natural Resource Protection and the United States Army Corps of Engineers, Tampa, FL., 49 pages.

Parker, G.G., G.E. Ferguson, S.K. Love, et al. 1955. *Water Resources of Southeastern Florida, with Special Reference to the Geology and Ground Water of the Miami Area*. Water Supply Paper 1255, United States Geological Survey, United States Government Printing Office, Washington, D.C.

Scott, T.M. 1992. *A Geologic Overview of Florida*. Open File Report No. 50, Florida Geological Survey, Tallahassee, FL, 78 pages.

SFWMD. 1991. *Broward County Water Supply Plan Phase 1*. South Florida Water Management District, West Palm Beach, FL.

www.co.broward.fl.us/cgi-bin/AT-anc…/lpp/internet/server_root/pub/cni00600.htm. July 31, 2000, 13:23. (Physical/demographic details).

APPENDIX A

Pond Apple Slough Charts and Data

This appendix provides charts and data to support the Pond Apple Slough report. A site map of the Pond Apple Slough is shown in **Figure A-1**. The Pond Apple Slough monitor well construction table is provided in **Table A-1**, and water levels in the Pond Apple Slough ecosystem are shown in **Table A-2**. Water chemistry results are shown in a table (**Table A-3**) and in a series of five charts (**Figures A-2** through **A-6**). The MS-3A-S and MW-5A-S water level charts are shown in **Figures A-7** through **A-9**, and **Figures A-10** through **A-12**, respectively. The flow data at the G-54, G-54S, and S-13 structures are provided in **Tables A-4** through **A-7**.

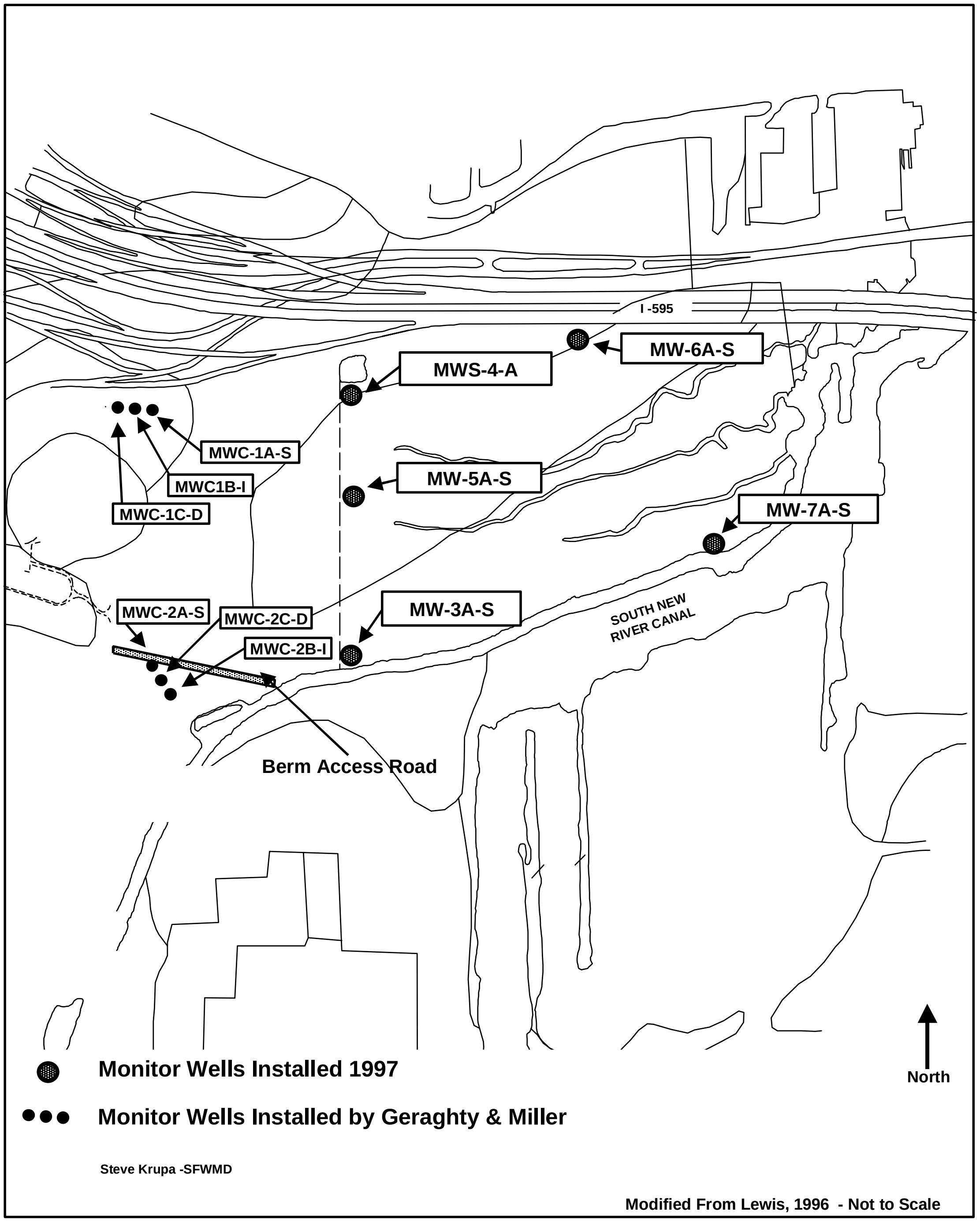

Figure A-1. Pond Apple Slough Site Map

Table A-1. Construction Table for Pond Apple Slough Ecosystem Monitor Well[a]

Well Name	Alternative Name	Source[b]	Well Location[c]	Well Installation Date	Elevation (feet NGVD) Top of Inner Casing	Top of Outer Casing	Ground Surface	Top of Screen	Bottom of Screen	Total Well Depth (feet)	Screen Length (feet)
Griffey Tract											
MWC-1A-S	6S	G&M	NW corner	October 1985	3.49	ND[d]	1.57	-1.45	-3.45	6.94	2
MWC-1B-I	5I	G&M	NW corner	October 1985	3.42	ND	1.63	-13.28	-23.28	26.70	10
MWC-1C-D	4D	G&M	NW corner	October 1985	3.29	ND	1.61	-38.31	-48.31	51.60	10
MWC-2A-S	9S	G&M	SW corner	October 1985	4.70	ND	2.05	-0.30	-2.30	7.00	2
MWC-2B-I	8I	G&M	SW corner	October 1985	4.34	ND	2.00	-13.46	-23.46	27.80	10
MWC-2C-D	7D	G&M	SW corner	October 1985	4.05	ND	1.96	-34.75	-44.75	48.80	10
Ecotone											
MW-3A-S		BC	SW corner	June 1997	4.94	5.25	ND	-4.16	-14.16	19.10	10
MW-4A-S		BC	NW corner	June 1997	4.39	4.92	ND	-2.20	-12.20	16.59	10
MW-5A-S		BC	Center	June 1997	4.66	4.83	ND	-1.72	-11.72	16.38	10
MW-6A-S		BC	NE corner	June 1997	5.92	6.40	ND	-1.21	-11.21	17.13	10
MW-7A-S		BC	SE corner	June 1997	5.28	5.58	ND	-2.41	-12.41	17.69	10

a. All wells are constructed of 2-inch PVC
b. G&M = Geragthy & Miller; BC = Broward County
c. NE = northeastern; NW = northwestern; SE = southeastern; SW = southwestern
d. ND = no data available

Table A-2. Water Levels in the Pond Apple Slough Ecosystem[a]

Well Name	Alternate Name	Position in Cluster	State Planar 1927 Datum (feet) Easting	Northing	Latitude	Longitude	Well Location[b]	Water Levels (1929 feet NGVD) 9/3/97	10/6/97	Depth to Water 9/3/97 (feet)
Griffey Tract										
MWC-1A-S	MWC-1C-S	East	ND[c]	ND	ND	ND	NW corner	2.25	ND	
MWC-1B-I	MWC-1C-B	Center	ND	ND	ND	ND	NW corner	2.00	ND	
MWC-1C-D	MWC-1C-A	West	ND	ND	ND	ND	NW corner	1.89	ND	
MWC-2A-S	MWC-2C-S	North	ND	ND	ND	ND	SW corner	1.78	ND	
MWC-2B-I	MWC-2B-I	Center	ND	ND	ND	ND	SW corner	2.08	ND	
MWC-2C-D	MWC-2A-D	South	ND	ND	ND	ND	SW corner	1.49	ND	
Ecotone										
G-2492	USGS well		ND	ND	ND	ND	Center	ND	ND	-1.86
MW-3A-S			920314.037	634810.57	26 04 40.3528	80 11 42.9415	SW corner	ND	1.26	ND
MW-3A-SW			ND	ND	26 04 40.3528	80 11 42.9415	Near MW-3A-S	ND	0.30	ND
MW-4A-S			920146.421	636453.123	26 04 56.6306	80 11 44.6686	NW corner	ND	ND	ND
MW-5A-S			920187.484	635573.991	26 04 47.9213	80 11 44.2777	Center	ND	1.61	ND
MW-5A-SW	staff gage		ND	ND	26 04 47.9213	80 11 44.2777	Near MW-5A-S	ND	2.62	ND
MW-6A-S			921872.597	636874.577	26 05 00.6988	80 11 25.7086	NE corner	ND	ND	ND
MW-7A-S			922990.576	635519.345	26 04 47.2079	80 11 13.5402	SE corner	ND	ND	ND

a. The staff gage on the South New River (near MW-3A-S) is set one-foot high. Measurements have been corrected.
b. NE = northeastern; NW = northwestern; SE = southeastern; SW = southwestern
c. ND = no data available

Table A-3. Water Chemistry at Pond Apple Slough

Site Name	Sample Name	Type	Sample Date[a]	Number of Samples	Sample Depth (feet)	Temperature (°C)	Specific Conductivity (microseconds/cm)	Dissolved Oxygen (percent)	Dissolved Oxygen (mg/l)	pH	Salinity (parts per trillion)	Oxidation Reduction Potential (millivolt)
MWC-1C-A	PAS1	Well	10/31/96	5	48.75	24.06	718	12.9	1.06	6.73	-	-
MWC-1C-B	PAS2	Well	10/31/96	5	22.80	23.83	722	11.5	0.97	6.75	-	-
MWC-1C-C	PAS3	Well	10/31/96	6	4.86	24.71	748	9.6	0.79	6.80	-	-
MWC-2C-SW	PAS4	Surface	10/31/96	1	0.23	24.89	764	31.2	2.58	7.27	-	-
MWC-2C-C	PAS5	Well	10/31/96	14	44.40	23.92	3,356	17.0	1.12	7.04	1.76	-
MWC-2C-B	PAS6	Well	10/31/96	13	23.67	23.93	3,107	26.4	2.20	6.91	1.62	-
MWC-2C-A	PAS7	Well	10/31/96	9	3.65	26.00	994	40.6	3.29	6.86	0.49	-
MW-3A-S (8/97)	SE well	Well	08/02/97	9	6.69	25.31	8,616	5.7	0.46	6.69	4.79	-26
MW-6A-S (10/96)	PAS8	Well	10/31/96	9	2.80	31.22	2,715	88.3	6.48	7.42	1.39	-
MW-6A-SW	PAS9	Surface	10/31/96	6	0.13	27.45	1,082	74.1	5.84	7.50	0.53	-
MW-7A-S (10/96)	PAS13	Well	10/31/96	5	0.24	27.45	1,262	60.6	4.77	7.20	0.63	-
G-2487	PAS17	Well	10/31/96	1	6.91	25.71	3,007	26.5	2.14	6.91	1.56	-332
Borrow pit	97N60634-SW	Surface	02/14/97	2	0.5?	-	2,380	-	-	-	1.2	-
Borrow pit	97N60635-SW	Surface	02/14/97	2	4.7	-	2,400	-	-	-	1.3	-
MW-3A-S (9/97)	-	Well	09/03/97	1	-	-	2,600	-	-	-	-	-
MW-4A-S	-	Well	09/03/97	1	-	-	3,360	-	-	-	-	-
MW-5A-S	-	Well	09/03/97	1	-	-	2,400	-	-	-	-	-
MW-6A-S (9/97)	-	Well	09/03/97	1	-	-	800	-	-	-	-	-
MW-7A-S (9/97)	-	Well	09/03/97	1	-	-	9,910	-	-	-	-	-

a. Samples from October 31, 1996, and August 2, 1997, were collected by SFWMD staff using a YSI water quality sensor (model 610DM handheld unit attached to a 600XL sonde). Samples from February 14, 1997, and September 30, 1997, were collected and analyzed by Broward County staff.

Table A-3. Water Chemistry at Pond Apple Slough (Continued)

Site Name	Sample Name	Sodium (Na)	Calcium (Ca)	Potassium (K)	Magnesium (Mg)	Chlorine (Cl)	Total Kjeldahl Nitrogen (TKN)	Nitrate + Nitrite ($NO_2 + NO_3$)	Total Phosphorus (Total P)	Lead (Pb)	Nickel (Ni)	Copper (Cu)	Zinc (Zn)	Cadmium (Cd)	Chromium (Cr)
		mg/l								µg/l					
MWC-1C-A	PAS1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MWC-1C-B	PAS2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MWC-1C-C	PAS3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MWC-2C-SW	PAS4	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MWC-2C-C	PAS5	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MWC-2C-B	PAS6	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MWC-2C-A	PAS7	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MW-3A-S (8/97)	SE well	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MW-6A-S (10/96)	PAS8	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MW-6A-SW	PAS9	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MW-7A-S (10/96)	PAS13	-	-	-	-	-	-	-	-	-	-	-	-	-	-
G-2487	PAS17	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Borrow pit	97N60634-SW	285.5	39.4	6.2	14.2	578	-	-	-	-	-	-	-	-	-
Borrow pit	97N60635-SW	358.5	91.6	17.6	33.4	588	-	-	-	-	-	-	-	-	-
MW-3A-S (9/97)	-	128.0	100.0	21.5	37.0	694	1.52	0.022	0.073	<22.0	<13.5	<10.4	<16.0	<2.47	5.65
MW-4A-S	-	450.0	187.0	10.3	21.2	851	3.99	<0.0180	0.081	<22.0	<13.5	<10.4	<16.0	<2.47	6.68
MW-5A-S	-	119.0	143.0	11.9	25.2	578	1.65	0.019	0.044	<22.0	<13.5	<10.4	<16.0	<2.47	<5.27
MW-6A-S (9/97)	-	34.5	64.8	12.2	20.2	76	3.16	0.033	0.061	<22.0	<13.5	<10.4	<16.0	<2.47	<5.27
MW-7A-S (9/97)	-	1,660.0	164.0	97.9	141.0	2,940	1.68	0.02	0.102	<22.0	<13.5	<10.4	<16.0	<2.47	5.34

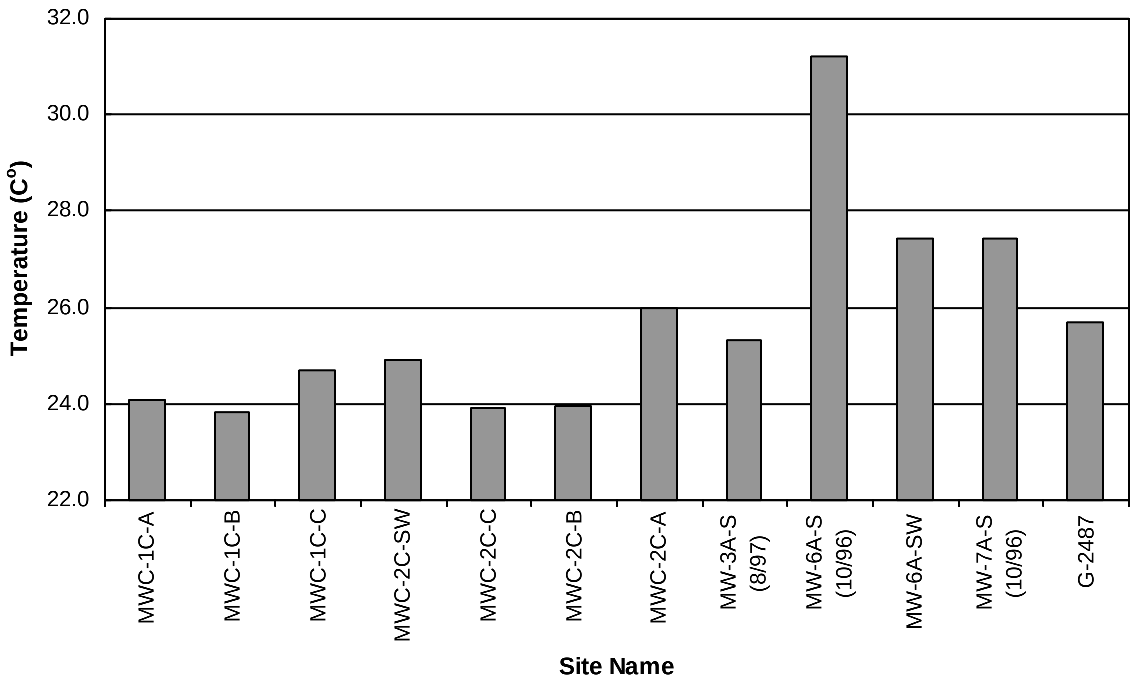

Figure A-2. Water Temperatures in Pond Apple Slough

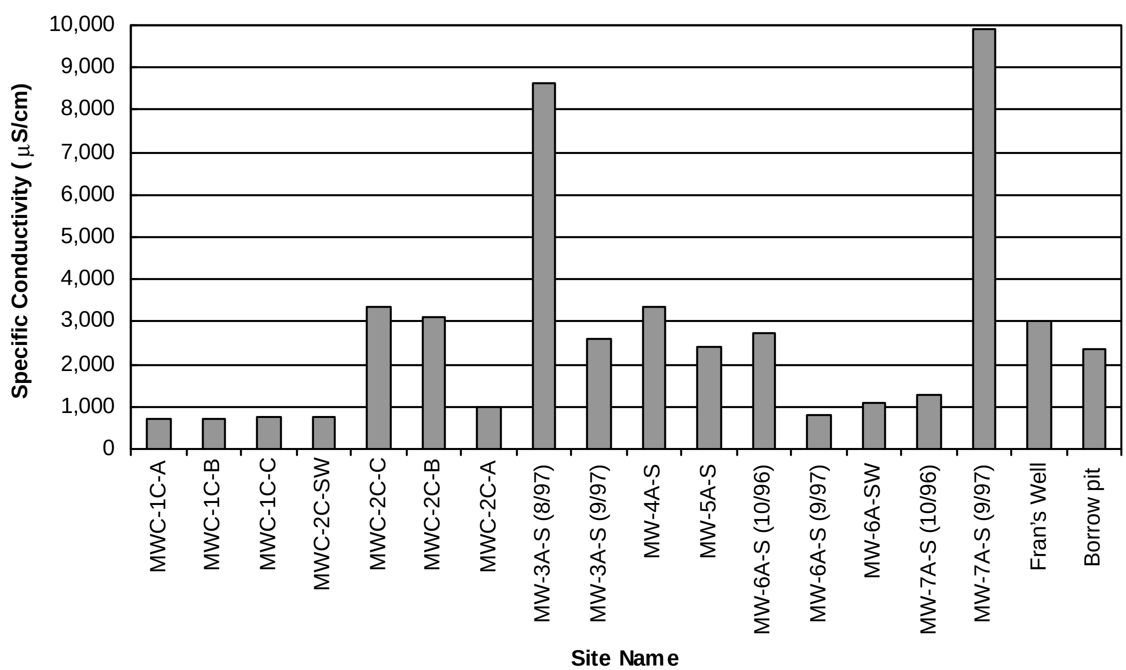

Figure A-3. Specific Conductivity in Pond Apple Slough

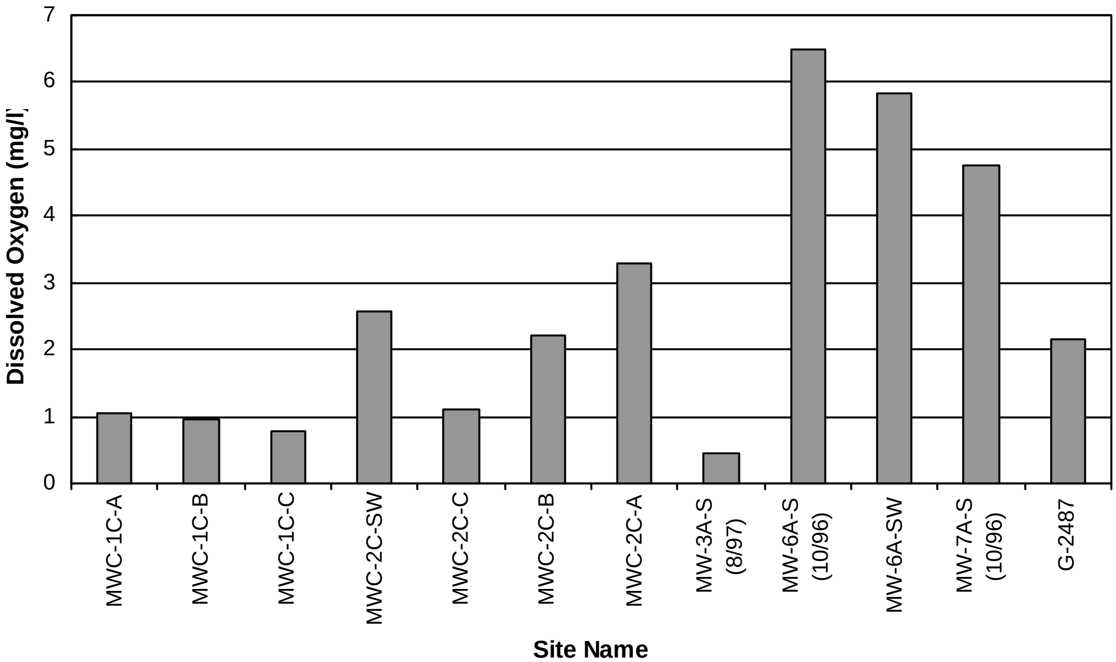

Figure A-4. Dissolved Oxygen in Pond Apple Slough

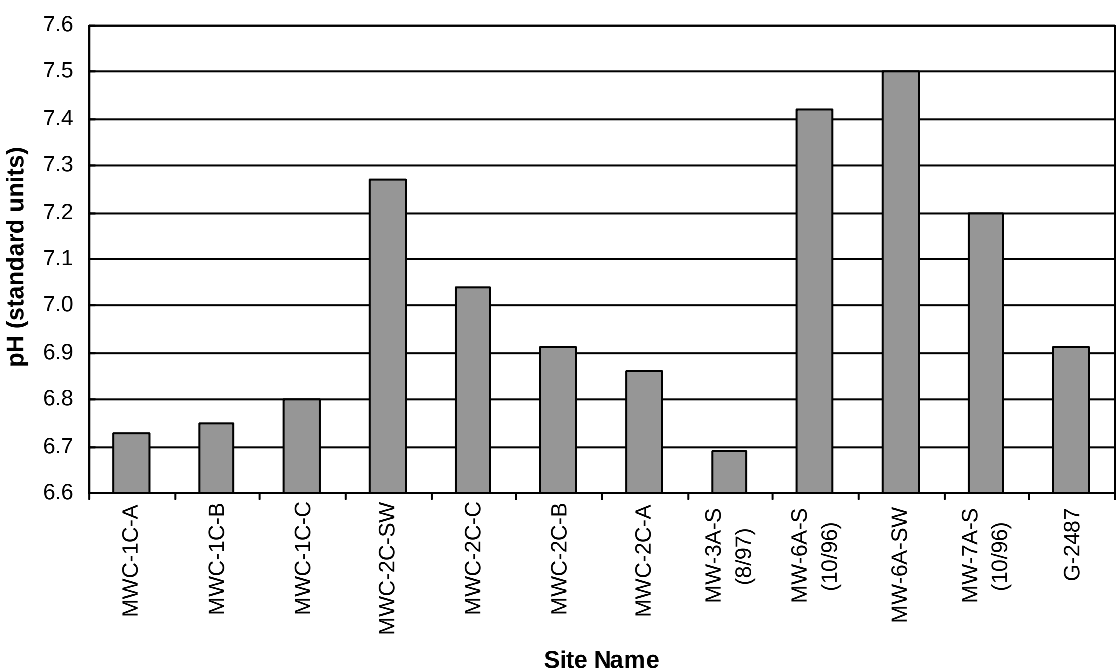

Figure A-5. pH in Pond Apple Slough

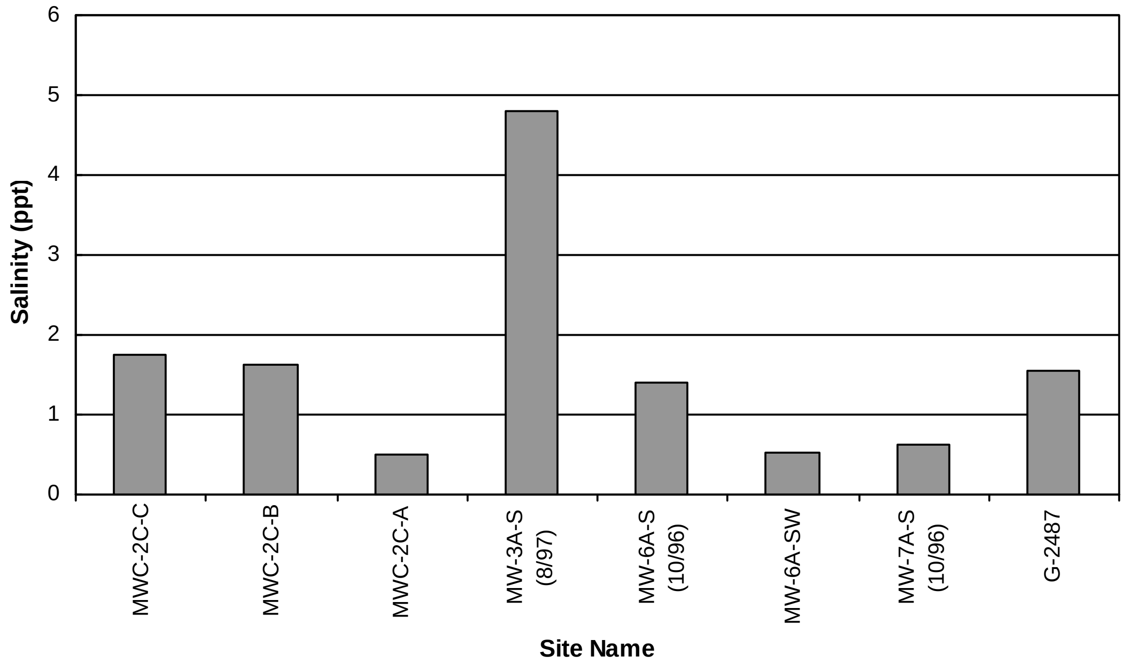

Figure A-6. Salinity in Pond Apple Slough

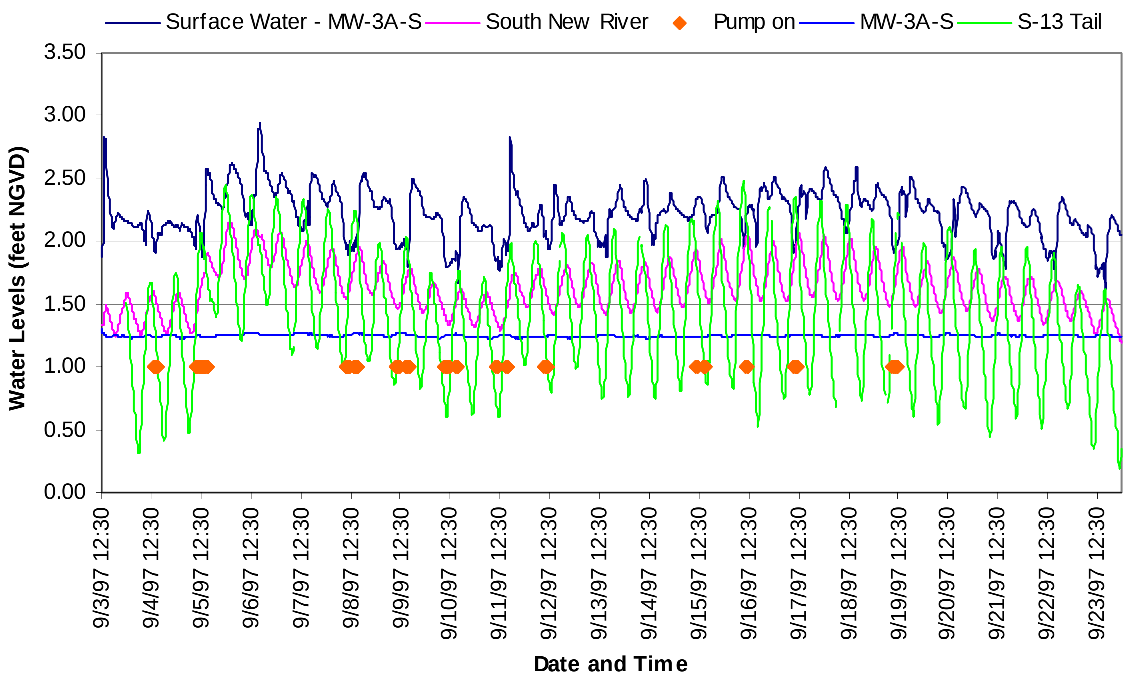

Figure A-7. Groundwater and Surface Water Levels with Pumping Times for MW-3A-S at Pond Apple Slough

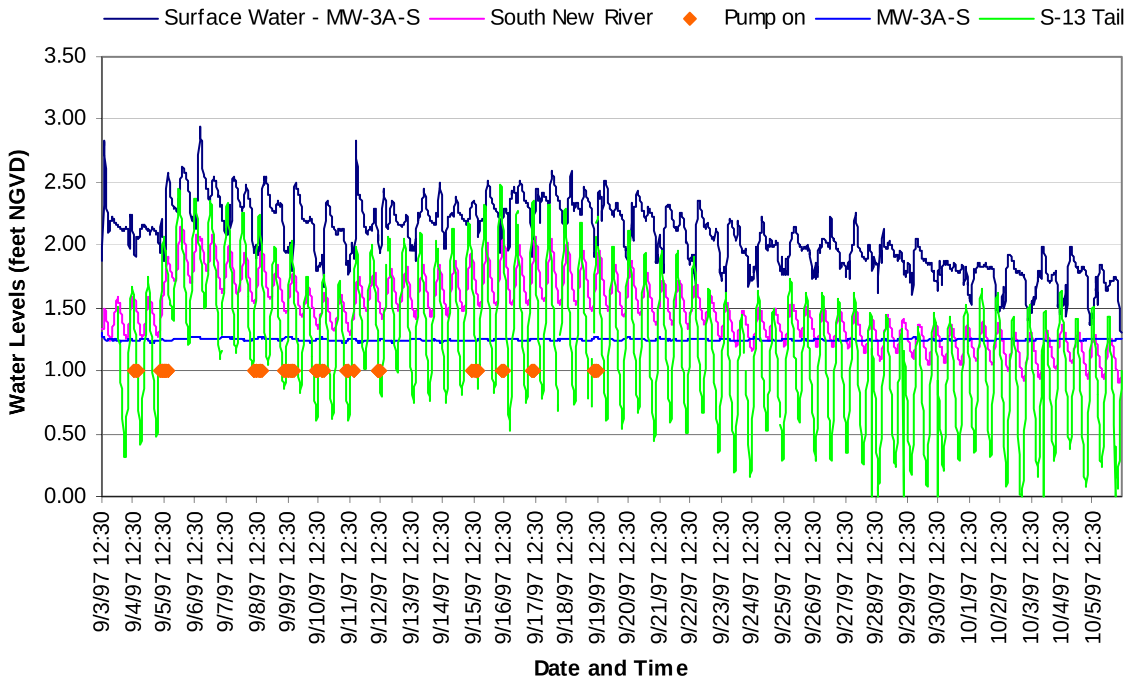

Figure A-8. Groundwater and Surface Water Levels with Rehydration Pump Times for MW-3A-S at Pond Apple Slough

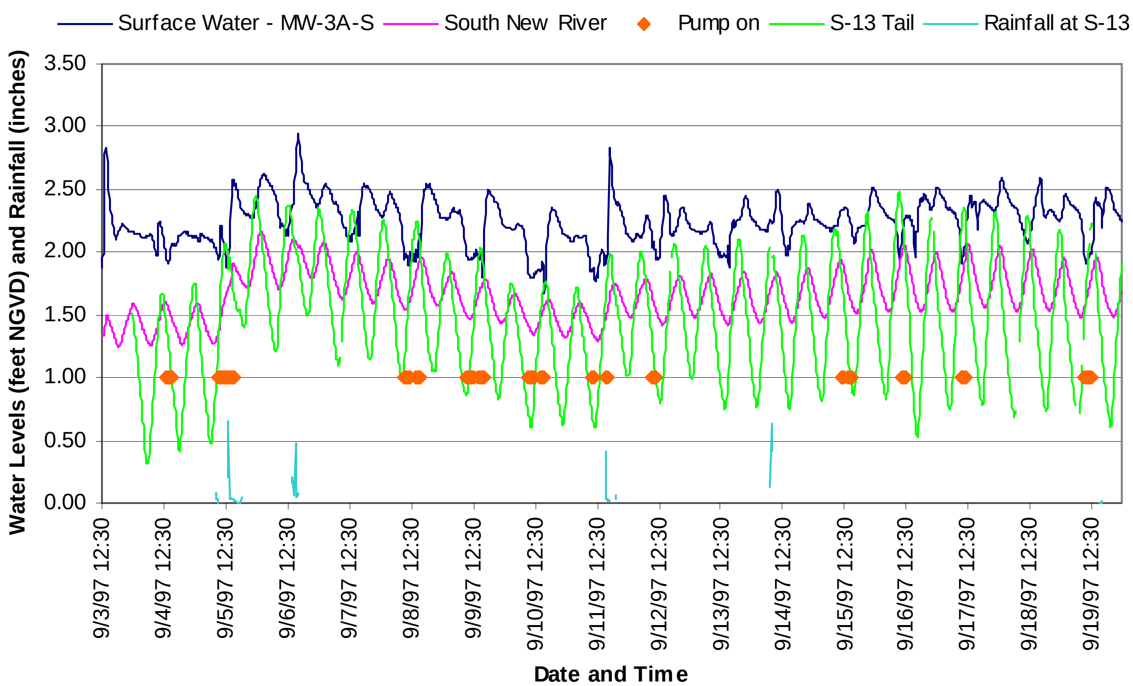

Figure A-9. Surface Water Levels, Rainfall, and Pumping Periods for MW-3A-S at Pond Apple Slough

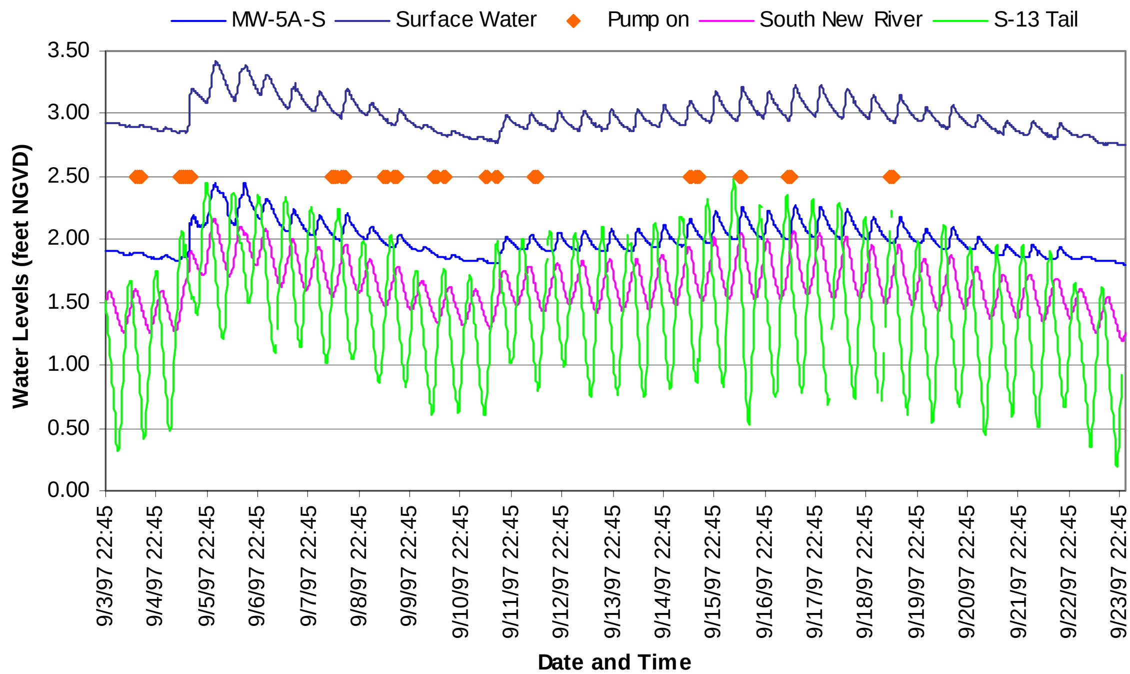

Figure A-10. Groundwater and Surface Water Levels with Pump Times for MW-5A-S at Pond Apple Slough

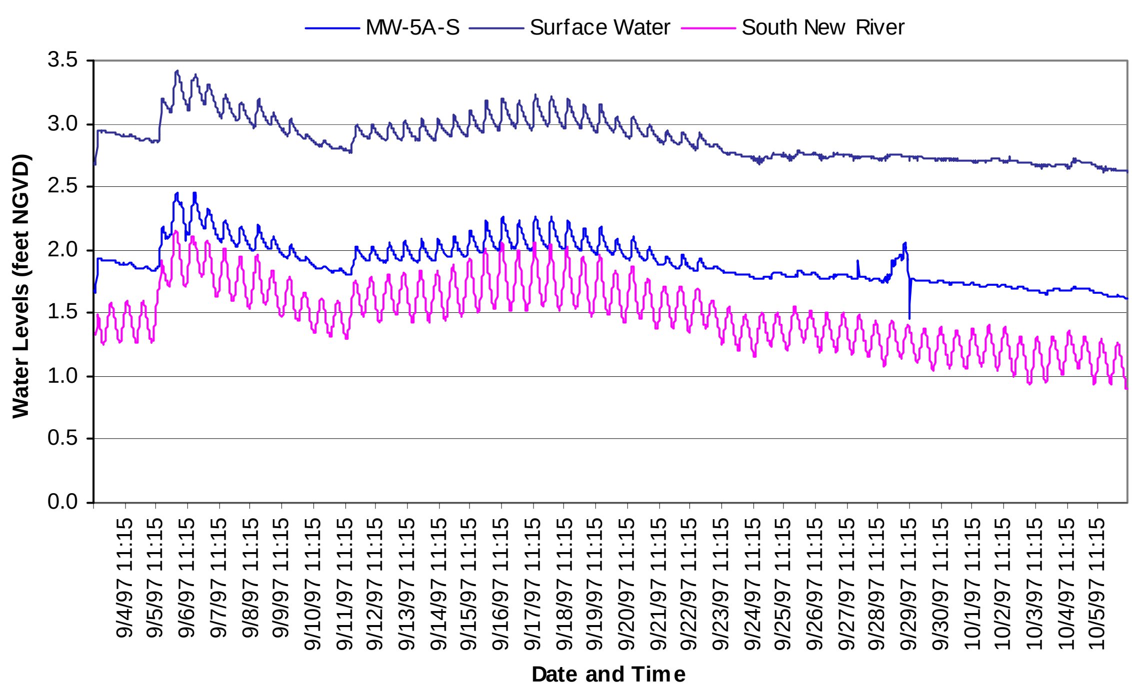

Figure A-11. Groundwater and Surface Water Levels for MW-5A-S at Pond Apple Slough

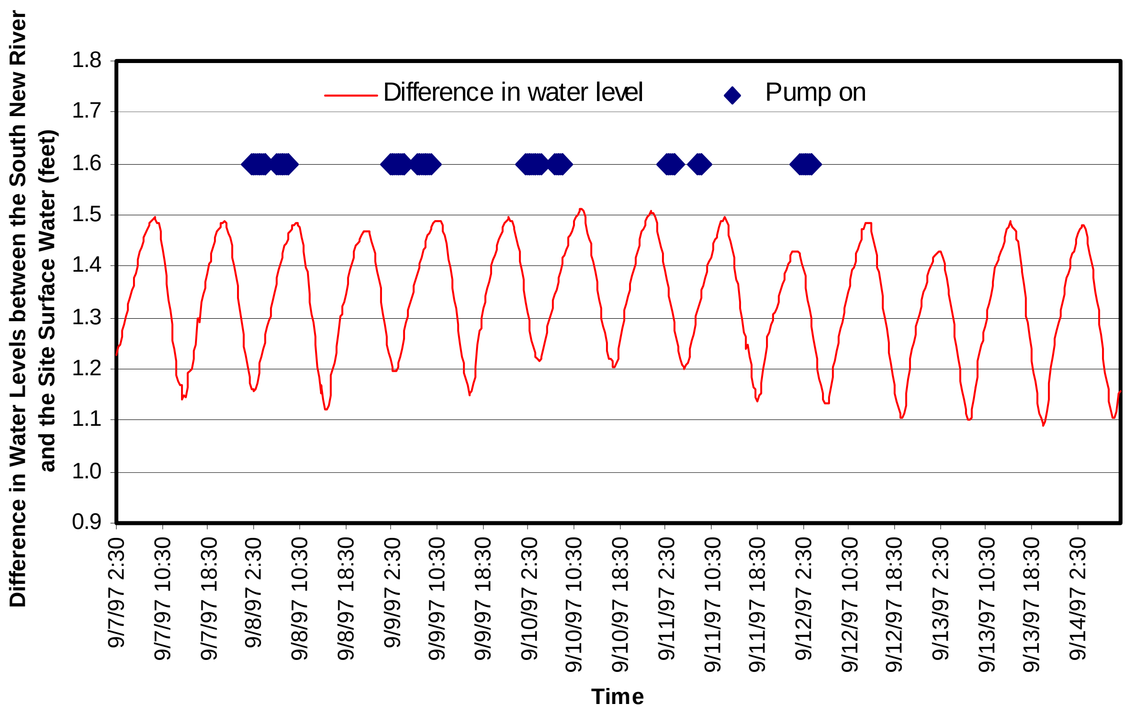

Figure A-12. Effect of Rehydration on Surface Water for MW-5A-S at Pond Apple Slough

Table A-4. Flow at Structure G-54

Year	Minimum (cfs/day)	Maximum (cfs/day)	Monthly Mean Calculated from Mean cfs per day (dbkey 456)											
			January	February	March	April	May	June	July	August	September	October	November	December
1940	80	1,440	272	466	351	305	147	645	491	819	1,073	846	691	541
1941	85	1,970	729	786	755	1117	511	513	1,535	1,322	1,089	1,164	671	375
1942	10	1,820	500	382	326	515	373	1,456	1,384	864	918	641	252	208
1943	24	608	108	123	54	42	91	88	297	364	510	435	149	180
1944	10	1,070	133	32	43	41	104	31	23	137	136	472	282	119
1945	3	1,390	70	36	12	5	4	4	31	38	427	826	1,159	338
1946	9	1,070	233	46	28	9	52	262	405	553	874	632	588	141
1947	2	3,280	41	12	481	252	52	808	2,048	2,248	2,125	2,151	2,714	2,199
1948	216	2,800	1,714	1,029	470	499	539	312	458	741	1,537	2,338	2,160	1,198
1949	75	2,110	408	238	193	197	238	572	656	756	1,144	1,391	932	649
1950	150	1,690	1,028	535	329	428	295	396	652	591	543	974	822	411
1951	160	1,460	250	277	160	262	295	189	623	845	841	1,319	1,068	517
1952	80	1,860	264	312	215	173	264	222	480	742	864	1,353	1,156	674
1953	90	1,700	570	691	132	168	122	260	641	918	1,145	1,496	1,377	1,031
1954	184	1,660	883	664	689	840	909	1,248	1,472	1,240	1,332	1,337	770	414
1955	75	923	292	199	185	183	169	442	732	624	461	478	125	116
1956	20	811	175	78	50	35	63	51	93	37	221	372	83	20

Table A-4. Flow at Structure G-54 (Continued)

Year	Minimum (cfs/day)	Maximum (cfs/day)	Monthly Mean Calculated from Mean cfs per day (dbkey 456)											
			January	February	March	April	May	June	July	August	September	October	November	December
1957	20	1,460	20	68	139	388	654	520	578	716	1,163	1,145	401	476
1958	176	1,600	1,164	1,073	993	984	931	975	959	977	864	346	243	489
1959	36	2,040	468	393	404	207	183	872	1,421	1,305	1,303	1,110	1,047	1,213
1960	135	1,540	743	353	310	318	436	615	530	484	733	1,055	1,054	911
1961	13	952	514	277	193	184	217	309	229	274	252	152	43	16
1962	11	495	17	16	14	33	26	157	339	250	338	254	102	52
1963	9	907	64	253	87	23	84	138	96	128	348	433	145	65
1964	8	1,380	241	104	37	29	194	271	145	130	289	581	373	203
1965	10	764	75	101	65	27	33	168	212	217	282	283	210	40
1966	0	1,200	112	126	102	67	15	508	672	873	693	667	329	152
1967	15	1,610	166	168	44	16	15	615	518	214	141	580	228	75
1968	15	1,240	29	21	15	15	415	906	1,025	560	395	512	277	57
1969	15	2,160	151	87	116	175	351	348	277	532	295	484	1,199	836
1970	15	2,110	318	223	1,209	1,262	347	1,357	955	289	170	275	197	15
1971	15	1,170	15	15	15	15	15	39	56	31	27	98	299	117
1972	15	1,480	47	125	66	57	145	346	221	215	211	79	163	49
1973	15	675	19	15	15	15	15	85	179	253	111	82	92	45
1974	14.4	828	38	14	17	14	14	182	144	190	126	251	69	87
1975	15	679	15	15	15	15	15	15	184	231	332	223	103	22
1976	15	1,240	15	70	31	15	139	210	76	304	192	42	70	28
1977	15	909	98	143	15	15	101	197	86	177	436	221	233	201
1978	15	960	208	111	53	15	15	137	199	197	196	250	235	89
1979	15	828	115	72	41	151	285	73	164	122	224	214	201	145
1980	30	778	105	124	127	229	163	146	240	214	322	193	189	124
1981	15	1720	87	175	61	33	44	69	67	288	178	57	72	15
1982	15	906	15	18	15	55	98	206	525	208	210	290	307	82
1983	15	1,040	187	650	728	628	60	302	133	428	286	277	174	132
1984	15	1,250	417	534	349	93	135	229	196	130	236	86	108	64
1985	15	1,010	19	15	15	33	24	21	228	97	307			
1986	49	1,230										160	122	715
1987	3	1,270	259	53	140	61	91	32	77	22	33	124	103	129
1988	3	712	34	25	16	15	72	246	168	275	76	12	10	3
1989	3	64	3	3	5	3	3	4	7	3	3	3	3	3
1990	3	140	3	3	3	3	3	16	24	3	8	17	3	3
1991	3	2,550	3	4	3	3	17	6	85	105	105	344	39	13
1992	3	25	10	6	4	3								

Table A-5. Flow at Structure G-54S

Year	Minimum (cfs/day)	Maximum (cfs/day)	Monthly Mean Calculated from Mean cfs per day (dbkey 456)											
			January	February	March	April	May	June	July	August	September	October	November	December
dbkey 15312														
1993	0	915.3	122	99	134	85	39	65	154	37	8	235	131	31
1994	12	1,013	102	32	23	51	12	114	63	176	313	474	1,013	878
1995	251	787	787	616	577	505	251	379	537	666	718	747	641	623
1996	0	612	612	70	34	112	124	360	548	562	357	313	34	0
1997	0	429	96	5	0	13	6	227	194	141	389	361	127	429
1998	127	823	492	501	644	471								
dbkey 15311														
1992	0	826						241	41	138	192	89	217	92
1993	0	742	194	91	124	74	26	61	132	22	1	202	117	23
1994	0	896	97	26	21	49	15						799	786

Table A-6. Flow at Structure S-13 (dbkey 6755)

Year	Flow (cfs)	January	February	March	April	May	June	July	August	September	October	November	December	Annual
1984	Minimum	320.0	ND[a]	101.0	ND	401.0	48.0	103.0	ND	ND	ND	ND	ND	48.0
	Mean	1,255.0	ND	1,143.4	ND	548.8	1,208.7	219.5	ND	ND	ND	ND	ND	902.4
	Maximum	1,812.0	ND	1,841.0	ND	599.0	1,563.0	641.0	ND	ND	ND	ND	ND	1,841.0
	Std. Dev.[b]	575.1	ND	714.3	ND	98.5	455.7	136.3	ND	ND	ND	ND	ND	619.8
1985	Minimum	ND	ND	ND	ND	ND	132.0	ND	ND	101.0	ND	ND	ND	101.0
	Mean	ND	ND	ND	ND	ND	132.0	ND	ND	308.5	ND	ND	ND	295.9
	Maximum	ND	ND	ND	ND	ND	132.0	ND	ND	581.0	ND	ND	ND	581.0
	Std. Dev.	ND	ND	ND	ND	ND	0.0	ND	ND	189.4	ND	ND	ND	187.9
1986	Minimum	ND	ND	ND	164.0	55.0	120.0	82.0	0.0	0.0	0.0	0.0	0.0	0.0
	Mean	ND	ND	ND	341.2	159.5	234.7	168.2	100.8	112.9	128.8	5.2	15.7	104.7
	Maximum	ND	ND	ND	595.0	269.0	365.0	336.0	419.0	211.0	587.0	156.0	185.0	595.0
	Std. Dev.	ND	ND	ND	201.2	69.4	100.8	63.2	109.2	90.0	156.7	28.5	44.2	129.7
1987	Minimum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Mean	5.4	9.9	48.3	0.0	20.0	0.0	12.8	0.0	13.8	70.8	83.4	47.8	25.6
	Maximum	168.0	163.0	399.0	0.0	203.0	0.0	192.0	0.0	142.0	501.0	268.0	446.0	501.0
	Std. Dev.	30.2	36.5	110.6	0.0	57.9	0.0	48.6	0.0	42.1	130.5	88.4	114.5	74.1
1988	Minimum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	56.0	0.0	0.0	0.0	0.0	0.0
	Mean	11.4	11.7	0.0	0.0	0.0	43.6	31.0	455.7	355.0	194.9	38.3	0.0	99.9
	Maximum	170.0	193.0	0.0	0.0	0.0	364.0	324.0	582.0	599.0	363.0	129.0	0.0	599.0
	Std. Dev.	40.7	44.3	0.0	0.0	0.0	114.1	79.0	129.5	209.5	133.1	56.7	0.0	177.5
1989	Minimum	0.0	0.0	0.0	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.0
	Mean	0.0	5.0	11.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	1.4
	Maximum	0.0	65.0	200.0	ND	ND	ND	ND	ND	ND	ND	ND	ND	200.0
	Std. Dev.	0.0	18.0	43.2	ND	ND	ND	ND	ND	ND	ND	ND	ND	14.6

a. ND = no data available
b. Std. Dev. = standard deviation

Table A-7. Flow at Structure S-13 (dbkey 15131)

Year	Flow (cfs)	January	February	March	April	May	June	July	August	September	October	November	December	Annual
1990	Minimum	ND[a]	ND	ND	0.0	0.0	0.3	60.4	36.2	0.0	22.7	0.0	0.0	0.0
	Mean	ND	ND	ND	10.1	72.2	162.3	172.1	64.4	181.4	95.3	24.2	13.7	84.5
	Maximum	ND	ND	ND	98.8	420.7	406.1	1,024.4	130.5	547.1	218.1	49.5	115.3	1,024.4
	Std. Dev.[b]	ND	ND	ND	30.4	121.4	102.7	186.0	23.2	180.4	46.0	13.3	24.0	112.7
1991	Minimum	0.0	0.0	0.0	0.0	0.0	0.0	26.0	0.0	0.9	-30.2	0.0	0.0	-30.2
	Mean	64.7	60.4	30.3	49.0	35.6	45.7	88.4	97.5	113.3	56.0	56.6	28.4	60.5
	Maximum	230.5	225.3	113.6	159.5	193.9	134.4	154.0	186.5	248.1	259.5	87.6	81.7	259.5
	Std. Dev.	72.7	69.8	40.7	49.4	55.2	48.6	35.0	52.5	45.0	72.8	19.1	16.3	56.6
1992	Minimum	20.7	4.9	0.0	1.0	0.0	-0.9	-0.5	0.0	55.8	0.0	0.0	0.0	-0.9
	Mean	53.5	38.6	22.3	36.6	1.0	130.5	96.3	68.3	114.6	38.5	73.3	41.2	59.5
	Maximum	154.1	126.1	83.4	105.5	17.7	345.5	209.8	169.2	185.0	104.1	174.0	134.1	345.5
	Std. Dev.	28.2	24.2	22.5	21.9	3.8	96.5	55.0	41.1	33.5	25.9	49.5	36.1	56.0
1993	Minimum	23.7	-0.3	0.0	0.0	0.0	0.0	27.8	35.3	70.3	3.4	52.2	136.2	-0.3
	Mean	90.3	47.6	99.6	38.0	16.5	87.3	143.7	94.7	110.3	115.7	152.0	166.0	97.2
	Maximum	202.5	101.1	213.8	103.3	138.1	216.0	292.5	178.8	182.6	203.5	210.4	213.8	292.5
	Std. Dev.	47.0	25.8	70.5	25.0	29.7	60.6	80.4	32.5	35.7	54.0	41.0	17.4	64.0
1994	Minimum	35.2	0.0	0.0	0.0	0.0	95.3	13.7	17.9	0.0	0.0	-146.0	-10.7	-146.0
	Mean	133.9	98.3	28.0	43.5	48.6	157.7	116.0	140.9	106.9	86.0	32.3	104.2	91.9
	Maximum	263.5	239.2	82.1	197.5	208.6	284.9	363.8	245.0	233.3	155.3	134.3	187.8	363.8
	Std. Dev.	76.6	61.0	22.9	67.0	41.3	58.1	86.5	56.4	69.8	45.2	52.5	50.1	72.2
1995	Minimum	45.3	15.3	55.1	0.0	0.0	0.0	0.0	-1.4	0.0	-0.4	40.3	86.1	-1.4
	Mean	155.0	112.2	143.3	147.9	88.1	160.3	199.6	97.5	102.4	58.1	111.0	130.9	125.6
	Maximum	220.4	205.8	198.3	217.8	215.3	349.0	279.7	230.1	233.7	177.0	189.2	186.1	349.0
	Std. Dev.	42.1	58.6	43.6	42.1	75.4	103.7	56.5	73.7	59.9	61.9	34.4	26.4	69.6
1996	Minimum	60.1	0.0	0.0	0.0	0.0	-2.1	9.0	0.0	0.0	0.0	0.0	0.0	-2.1
	Mean	123.2	115.1	20.8	90.9	123.8	161.6	76.5	66.3	91.1	73.6	38.8	0.0	81.5
	Maximum	175.6	172.2	103.9	160.1	363.4	364.4	138.5	244.6	199.8	184.4	153.2	0.0	364.4
	Std. Dev.	30.6	52.8	30.2	58.4	134.6	96.3	35.9	67.1	57.1	64.3	42.2	0.0	77.9
1997	Minimum	0.0	0.0	8.0	0.0	0.0	-351.9	36.0	90.0	0.0	51.6	31.6	138.5	-351.9
	Mean	13.0	72.0	76.1	96.5	58.7	-34.0	121.9	167.8	171.8	121.5	112.0	252.9	102.9
	Maximum	90.3	257.8	262.3	396.9	249.1	81.6	289.1	330.7	275.5	223.1	178.9	333.3	396.9
	Std. Dev.	29.3	66.7	58.7	92.5	53.5	108.3	63.5	63.2	70.6	45.3	41.1	59.5	97.3
1998	Minimum	205.6	0.0	266.7	0.0	ND	0.0	58.1	0.0	0.0	89.0	0.0	60.5	0.0
	Mean	290.6	299.7	348.5	199.3	ND	14.9	161.9	85.1	44.5	135.8	135.2	106.5	167.7
	Maximum	339.9	415.2	397.9	381.1	ND	68.6	320.5	155.2	172.7	225.0	270.7	234.6	415.2
	Std. Dev.	37.1	123.3	32.3	140.7	ND	23.2	76.2	40.4	59.8	38.0	72.0	45.7	123.7
1999	Minimum	28.5	0.4	0.0	0.0	0.0	0.0	22.0	0.0	0.0	0.0	49.9	261.7	0.0
	Mean	98.1	53.7	51.6	0.0	4.8	143.1	92.6	143.4	101.0	178.6	217.4	330.1	118.4
	Maximum	219.2	146.5	144.3	0.0	83.2	336.5	231.4	342.3	225.3	709.2	289.1	368.1	709.2
	Std. Dev.	49.8	36.4	43.2	0.0	17.0	90.1	57.7	88.0	68.1	176.3	58.5	25.7	115.8
2000	Minimum	134.6	158.4	0.0	45.3	0.0	48.4	62.5	0.0	32.6	0.0	0.0	40.1	0.0
	Mean	256.2	213.0	213.6	212.8	67.4	138.6	138.9	94.0	113.9	101.6	43.9	85.3	139.7
	Maximum	365.0	313.1	384.9	289.2	277.8	339.1	301.5	178.3	235.2	350.1	80.6	186.0	384.9
	Std. Dev.	68.5	36.0	86.2	65.8	75.5	70.2	57.0	42.7	43.5	93.8	22.6	41.7	89.8

a. ND = no data available
b. Std. Dev. = standard deviation