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CONSULTING GEOTECHNICAL ENGINEER

FLORIDA REGISTRATION NO. 48303

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Date: July 31, 2003	*Devo's Project No.* 02-121.96
To: Lake County Water Authority 107 North Lake Avenue Tavares, Fl 32778-3119 phone: 352-343-3777 fax: 352-343-4259 attention: LANCE LUMBARD	*cc:* Professional Engineering Consultants, Inc. 200 East Robinson Street, Suite 1560 Orlando, FL 32801 phone: 407-422-8062 fax: 407-849-9401 attention: DAVID HAMSTRA, P.E.
LCWA Lake County Water Authority	PEC

Ref:

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GROUND WATER/SURFACE WATER INTERACTION MODELING
CLERMONT CHAIN OF LAKES, LAKE COUNTY, FLORIDA

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TECHNICAL MEMO #1
STUDY PURPOSE & CONTRACTED SCOPE

THE CLERMONT CHAIN OF LAKES



Prepared for

LCWA

Lake County Water Authority

PEC

Professional Engineering Consultants, Inc.

Prepared by

DEVO Engineering

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Date: April 24, 2002	*Devo's Project No.* Not yet assigned
To: Professional Engineering Consultants, Inc. 200 East Robinson Street, Suite 1560 Orlando, FL 32801 phone: 407-422-8062 fax: 407-849-9401 attention: **DAVID HAMSTRA, P.E.** PEC	*cc:* Lake County Water Authority 107 North Lake Avenue Tavares, FL, 32778-3119 phone: 352-343-3777 fax: 352-343-4259 attention: **MICHAEL J. PERRY** LCWA Lake County Water Authority
Ref: **TECHNICAL MEMO #1: STUDY PURPOSE & CONTRACTED SCOPE PROPOSAL FOR... GROUND WATER/SURFACE WATER INTERACTION MODELING FOR PORTION OF SOUTH LAKE COUNTY (FL) WHICH ENCOMPASSES THE CLERMONT CHAIN OF LAKES**	

Dear Mr. Hamstra:

Attached is our proposal for the above-captioned services.

We trust that this work effort will provide the analysis sought by LCWA and the findings and results will provide them with a better understanding of the hydrogeology of the study area and the numerical information needed for effective planning of the county's freshwater resources in the Clermont Chain of Lakes subregion.

Please feel free to contact us if there are any questions and we look forward to working with LCWA and PEC on this project.

Sincerely,

D

Devo Seereeram, Ph.D., P.E.
Principal Engineer

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LAKE COUNTY WATER AUTHORITY

The Lake County Water Authority (LCWA), formerly known as the Oklawaha Basin Recreation and Water Conservation and Control Authority, was created in 1953. Member districts are shown in Exhibit 1.

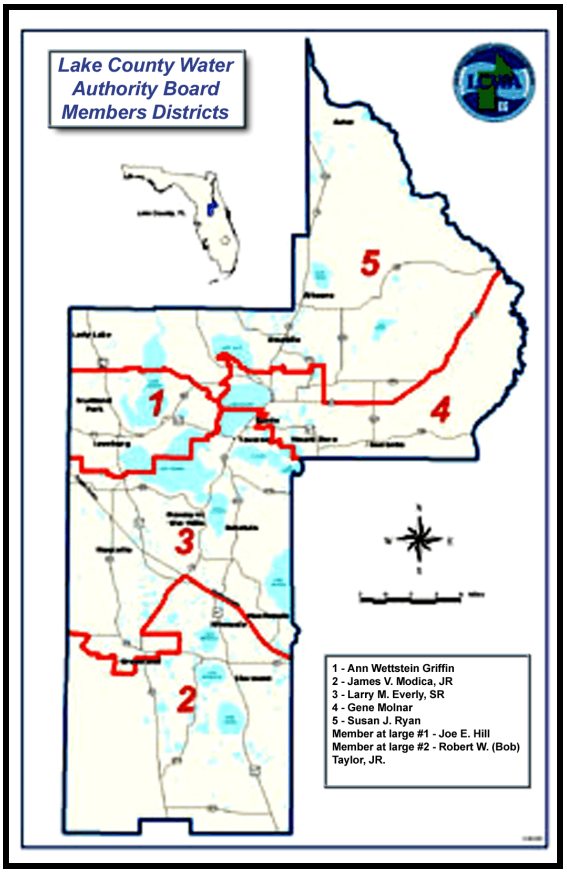


Exhibit 1. Member Districts in LCWA

The Legislature directed that the Authority be created for the following purposes:

① **Controlling and conserving the freshwater resources of Lake County;**

② **Fostering and improving the tourist business in the county by improvements for the streams, lakes, and canals in the county;**

③ **Providing recreational facilities for the tourists and citizens and taxpayers of the county by a more efficient use of the streams, lakes, and canals in the county;**

④ **Preserving, protecting, and improving the fish and wildlife of the county; and**

⑤ **Protecting the freshwater resources of Lake County through assisting local governments in treatment of stormwater runoff.**

Exhibit 2 shows the basins, sub-basins, and watersheds within Lake County.

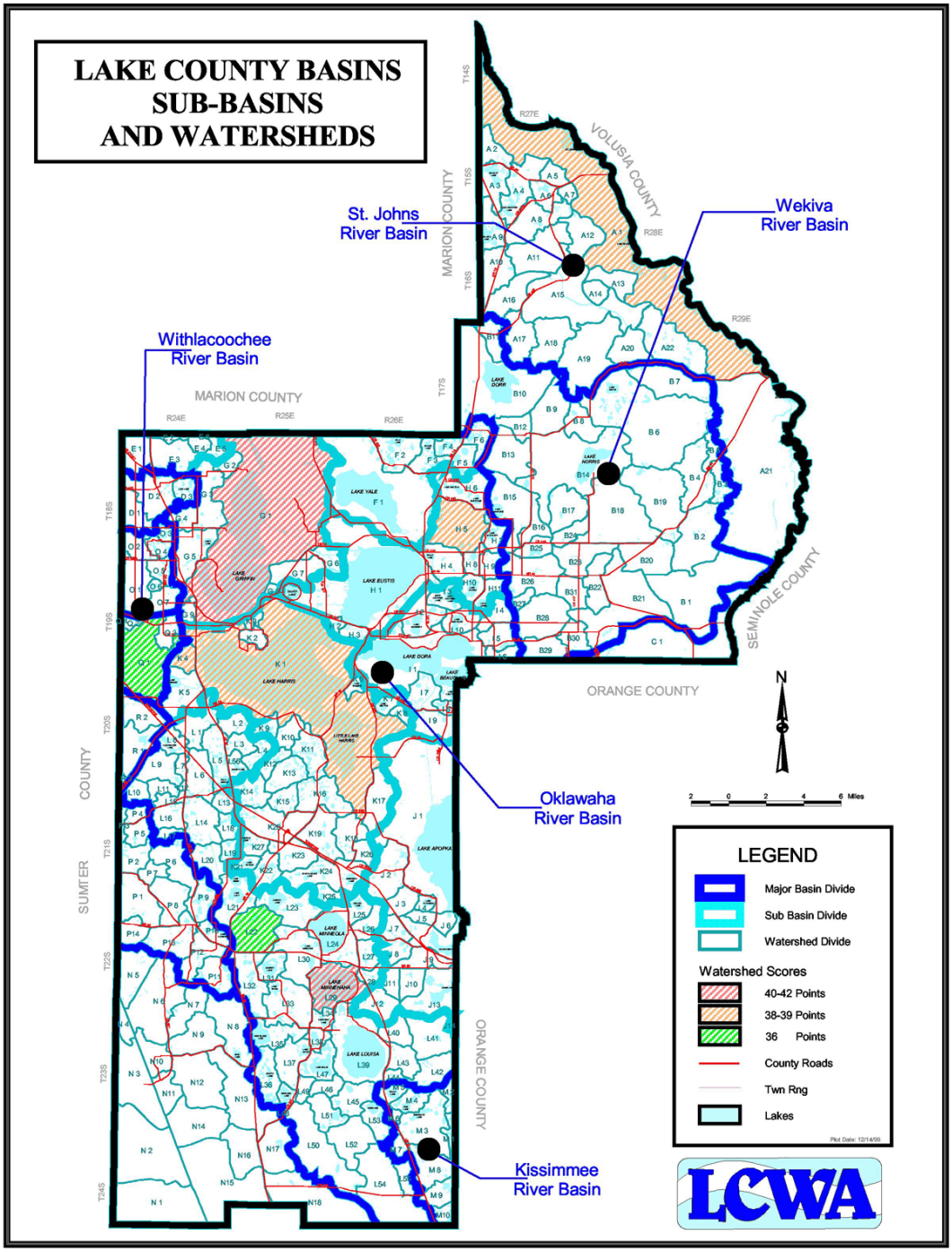


Exhibit 2. Basins, Sub-basins, & Watersheds in Lake County

Exhibit 3 shows the properties and water structures controlled by LCWA.

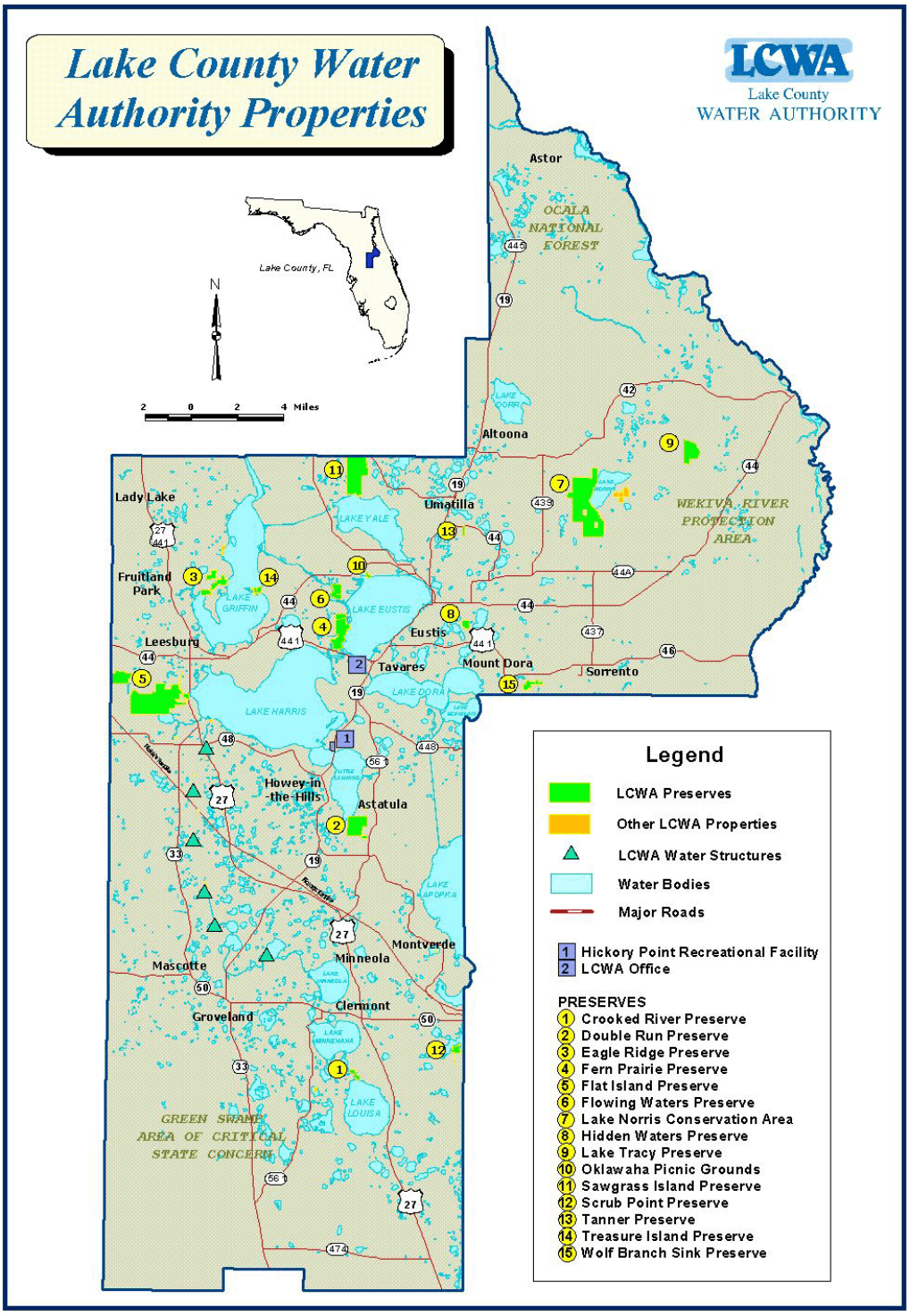


Exhibit 3. LCWA Structures & Properties

PROBLEM STATEMENT

In the southern part of Lake County, especially in the Clermont Chain of Lakes (see Exhibit 5), lake water levels have experienced a wide range of fluctuation over the past eight (8) years (April 1994 ➟ April 2002), with extreme highs and lows recorded during this time period.

In particular, LCWA is concerned about the dramatic drop in lake levels in this basin in recent years. Exhibit 4, for example, shows the measured water table at a monitored site in the southeast corner of Lake County. As noted, the range of fluctuation of the water table at this site was approximately 9 ft over this period, with high levels occurring following the un-seasonal El-Nino rains in early 1998 and the lowest levels in May-June 2001.

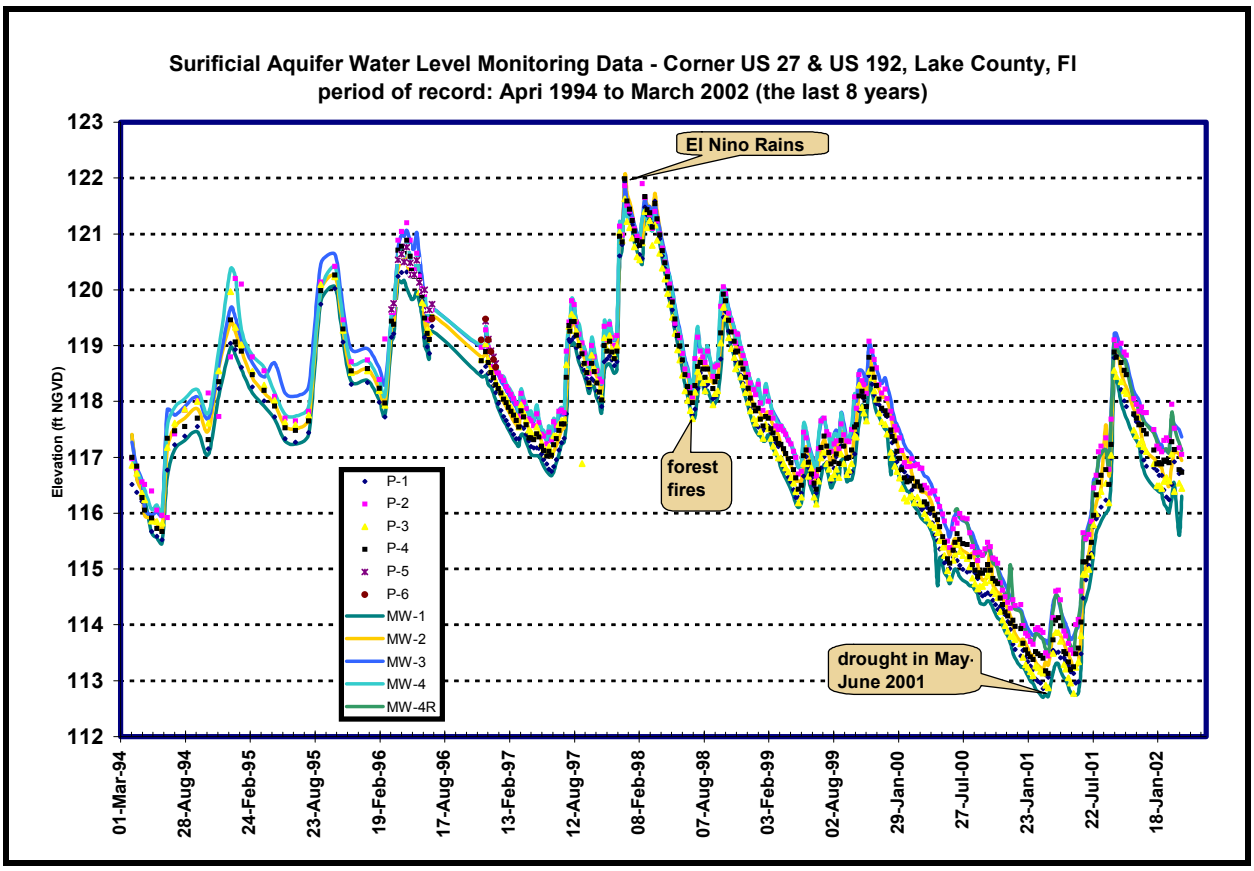


Exhibit 4. Measured Water Levels at Southlake WWTF Perc Pond Site

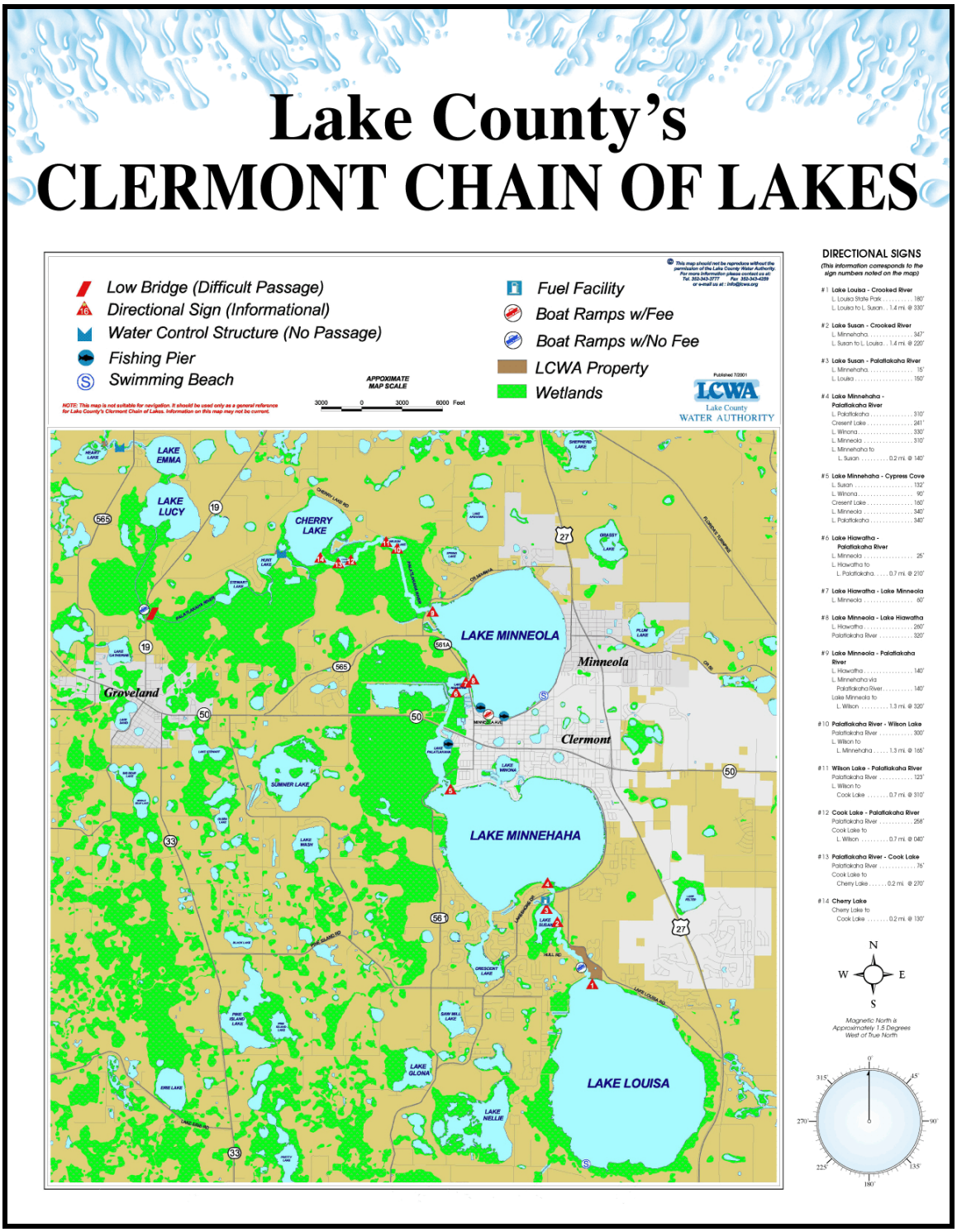


Exhibit 5. Clermont Chain of Lakes Study Area

In addition to aesthetic, recreational, and ecological impacts, these lowered water levels have led to settlement of the underlying peat layers and major roadway settlement distress in parts of Lake County. For example, County Road 561 on both sides of the bridge over Lake Minnehaha has undergone major settlement in the past year due to compression of the underlying peat (see Photo 1).



Photo 1. Settlement on County Road 561 (April 2, 2002) due to drought

As a result of these observations, Lake County Water Authority (LCWA) would like to develop a subregional ground water/surface water model to quantify and distinguish the lake level influence of the following:

❶ natural weather patterns, and

❷ artificial ground water withdrawals.

LCWA would like to quantify these impacts for various scenarios including normal and drought conditions, with and without ground water withdrawals.

The area of interest (Exhibit 5) is characterized by a unique hydrogeologic regime wherein some of the lakes and water bodies (wetlands, etc) are well connected to the underlying Floridan aquifer and others are less well connected (somewhat perched). The model will have to incorporate this hydrogeologic framework.

APPROACH

The tool to be used for this assessment is a ground water/surface water interaction model for this portion of South Lake County (Florida) which hydrologically encompasses the Clermont Chain of Lakes. A major part of this study however is data collection and assimilation prior to model development.

The ground water/surface water interaction modeling will be performed using the USGS MODFLOW computer model. Groundwater Vistas [Version 3] software will be used as a pre-processor and post-processor for the USGS MODFLOW model. A multi-layered model will be set up to incorporate the surficial aquifer (which contains the lakes) and the underlying Floridan aquifer (from which most of the ground water is withdrawn). The model area will extend outside of the study area to capture the subregional effects of recharge in the Green Swamp.

TASKS

The following tasks need to be performed as part of this study:

1. Review published geologic and hydrogeologic reports which pertain to the study area.

2. Define the model area based on hydrogeologic considerations.

3. Collect available hydrologic data from SJRWMD, USGS, LCWA, and SFWMD for representative points within the model domain. This data includes but is not limited to the following:

   - Rainfall records,
   - Lake levels,
   - Surficial aquifer ground water levels,
   - Floridan aquifer ground water levels
   - Gaged discharge rates from the lakes and other surface water bodies (where available)
   - Permitted ground water withdrawals from Floridan aquifer wells within model domain
   - Estimated ground water withdrawals from small diameter individual residential and commercial wells
   - Estimated surface pumping from lakes and ponds for irrigation and other uses
   - Artificial recharge within the model domain (i.e., septic tanks, sprayfields, and perc ponds).
   - Surface water and subsurface water drainage basin divides
   - Topographic data showing the elevation and relief of the land
   - Results of aquifer characterization tests (pump tests) within the model domain

❹ Overlay contours of ground surface topography, Floridan aquifer potentiometric levels, and lake levels (i.e., surficial aquifer) to see if there are readily identifiable trends which may distinguish perched lakes from lakes which are well connected to the underlying Floridan aquifer. This raw data comparison is precursory to detailed modeling and provides guidance on development and expectations of the hydrogeologic model. Emphasis will be placed on the major water bodies. Some field verification may be performed as part of this task.

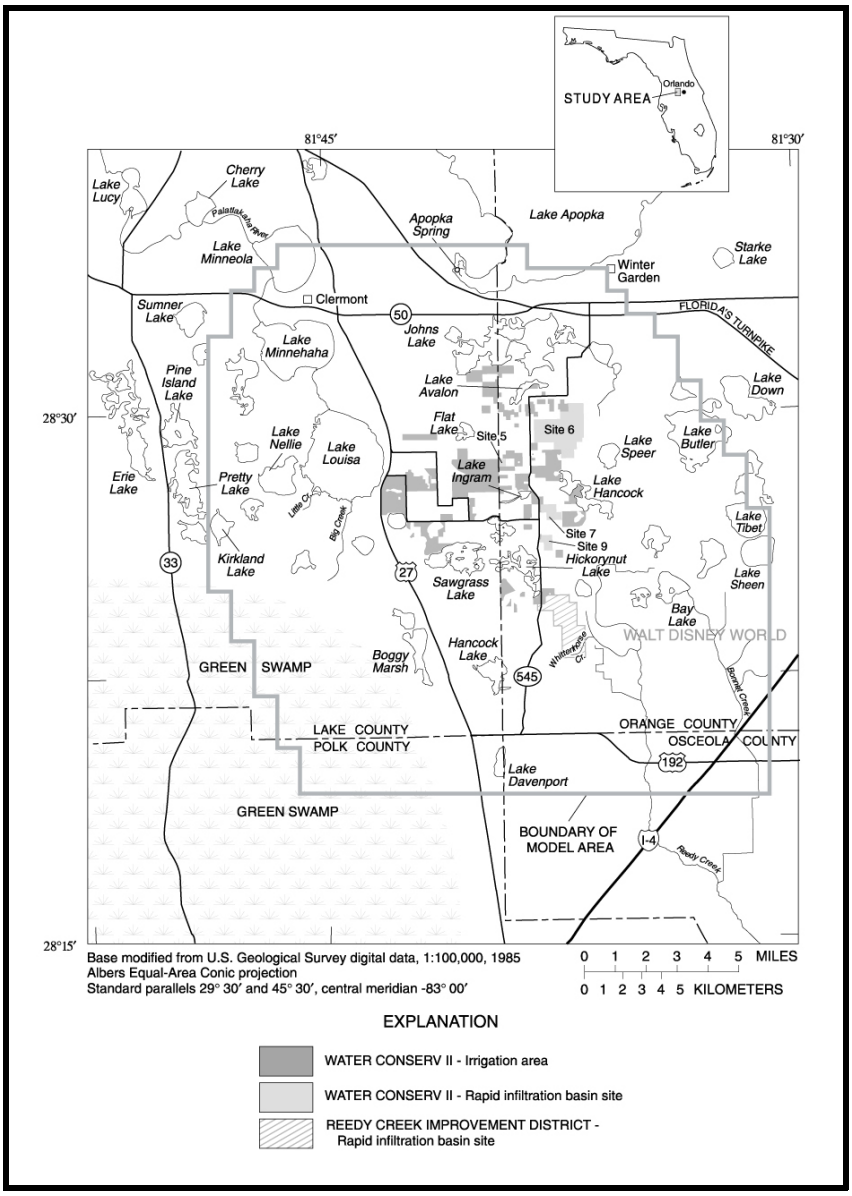


Exhibit 6. Artificial recharge east of study area

❺ Calibration of the time-variant ground water/surface water interaction model to existing conditions for say the last 8 calendar years (1994-2002). A calibrated model will provide a reasonable representation of the hydrologic regime and it will be a mathematical tool which can be used to predict alternative scenarios such as water level patterns without pumpage, etc. for various antecedent rainfall conditions (such as drought).

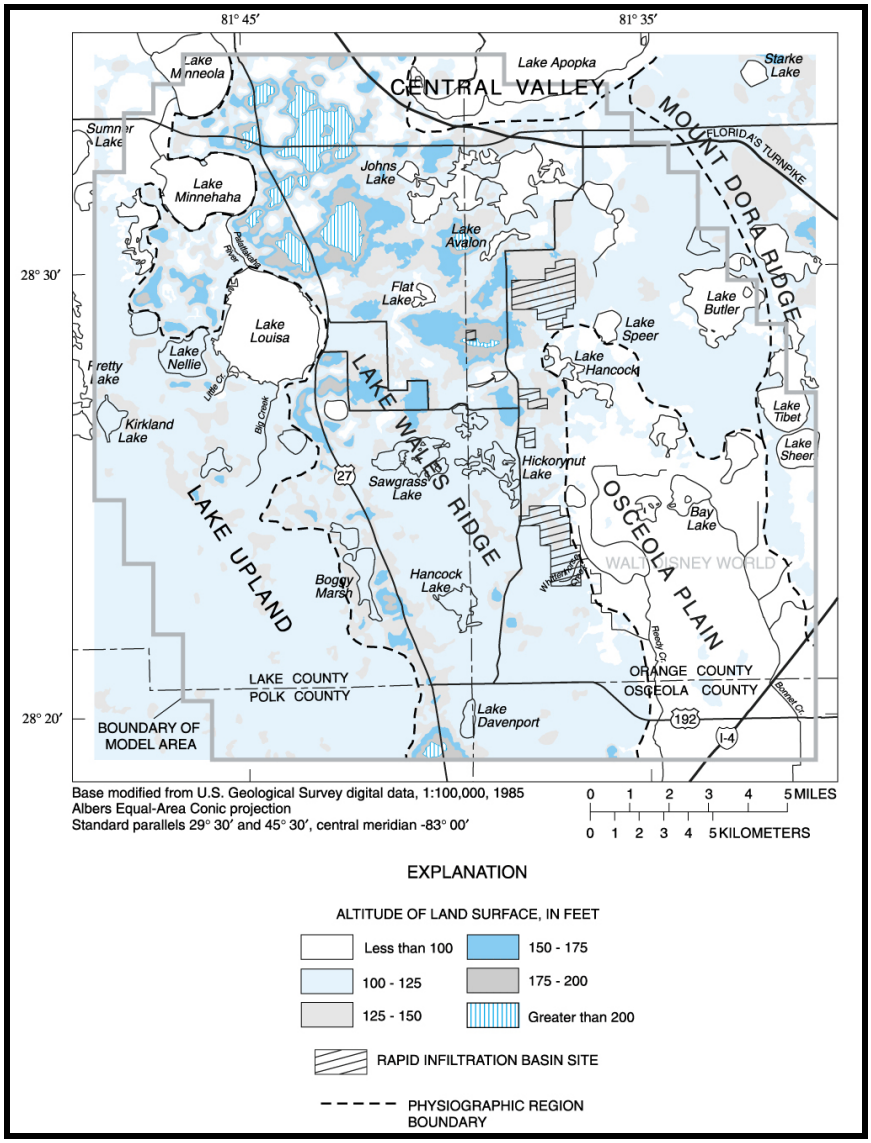


Exhibit 7. Topography & physiography in study area

❻ Use the calibrated ground water/surface water model to predict various scenarios including the water level fluctuation for

① normal conditions with pumpage of the Floridan
② normal conditions without pumpage of the Floridan
③ drought conditions with pumpage of the Floridan
④ drought conditions without pumpage of the Floridan

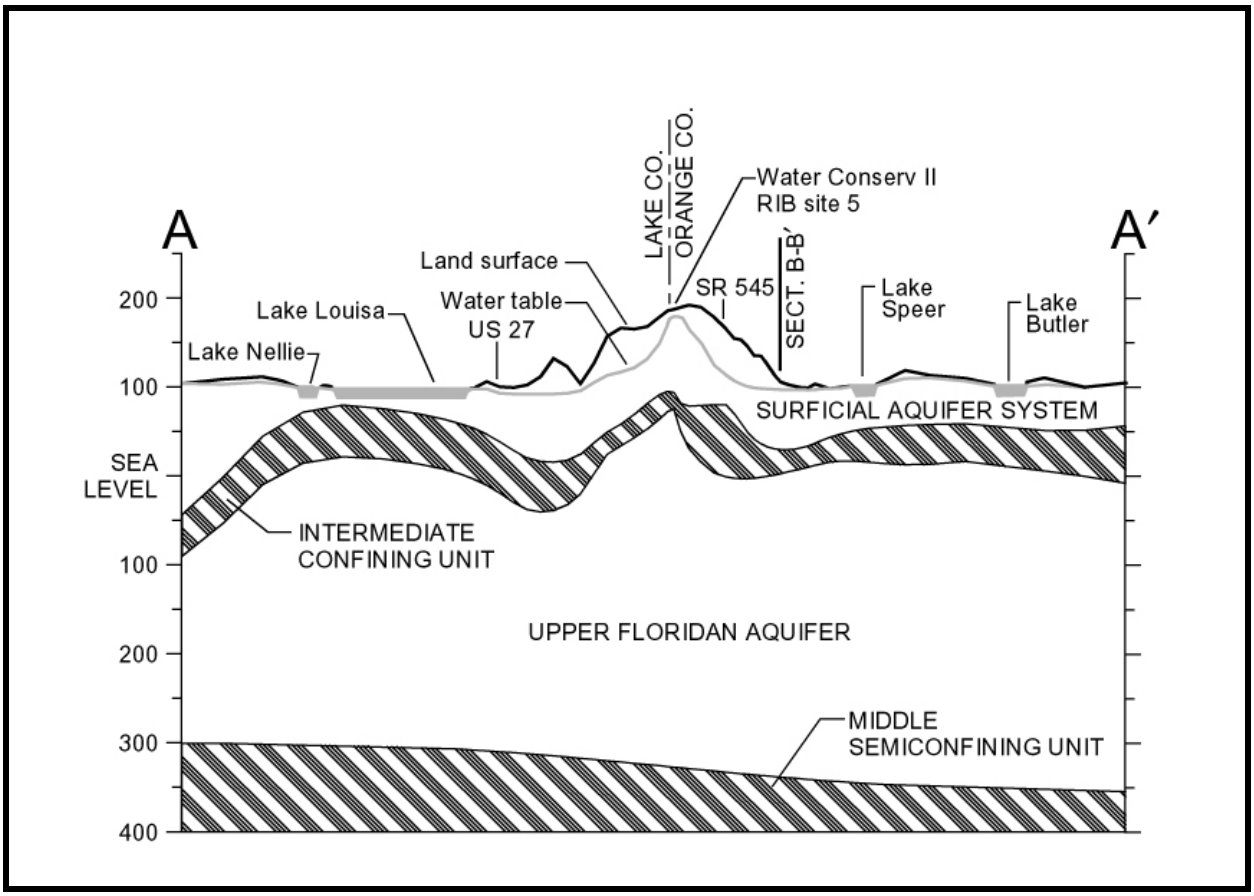


Exhibit 8. Geologic section in study area

❼ Preparation of the modeling report with exhibits and impact analysis.

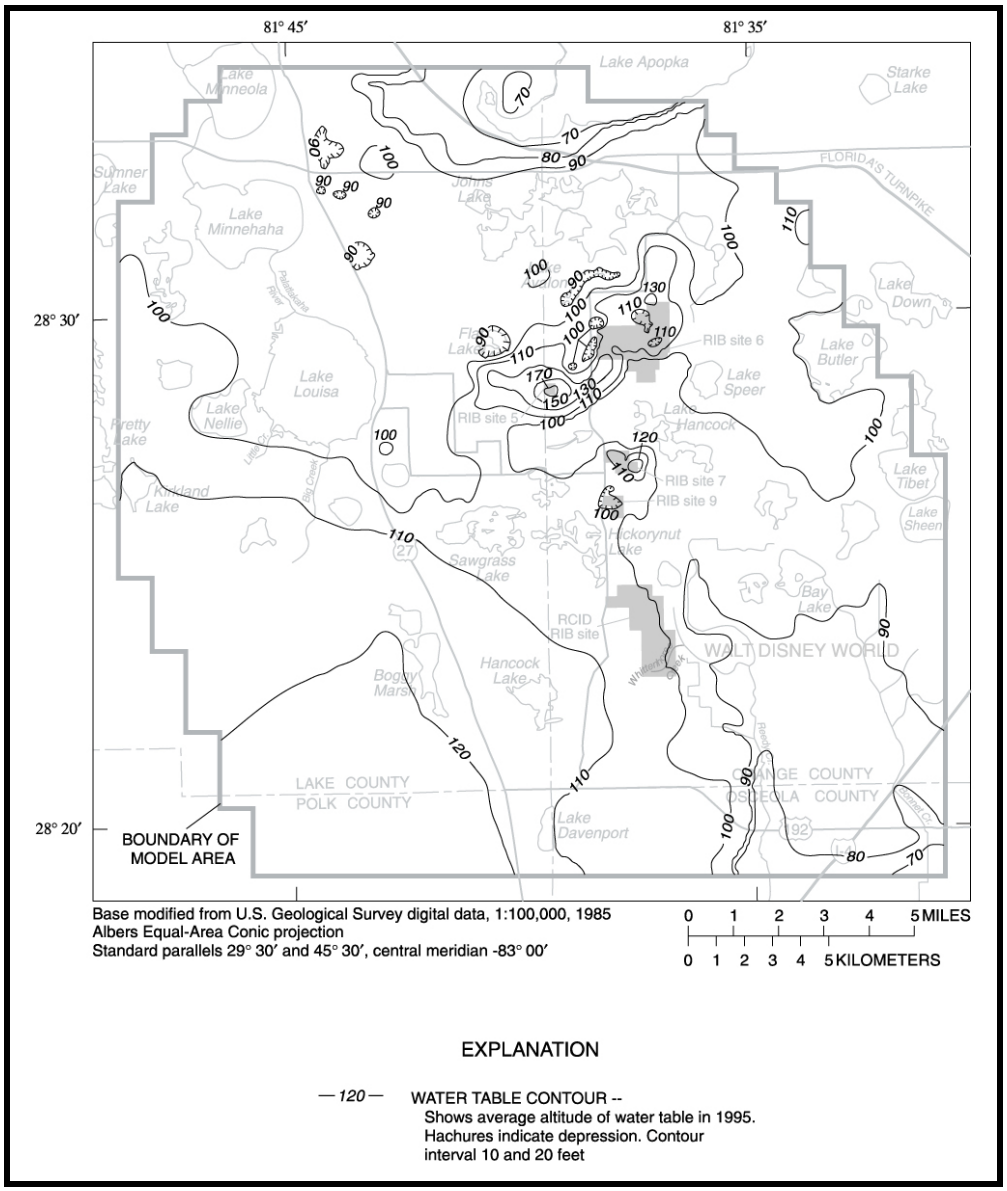


Exhibit 9. Water table contours in study area in 1995

❽ Monthly status meeting with LCWA staff and board members.

❾ Public presentations (two maximum)

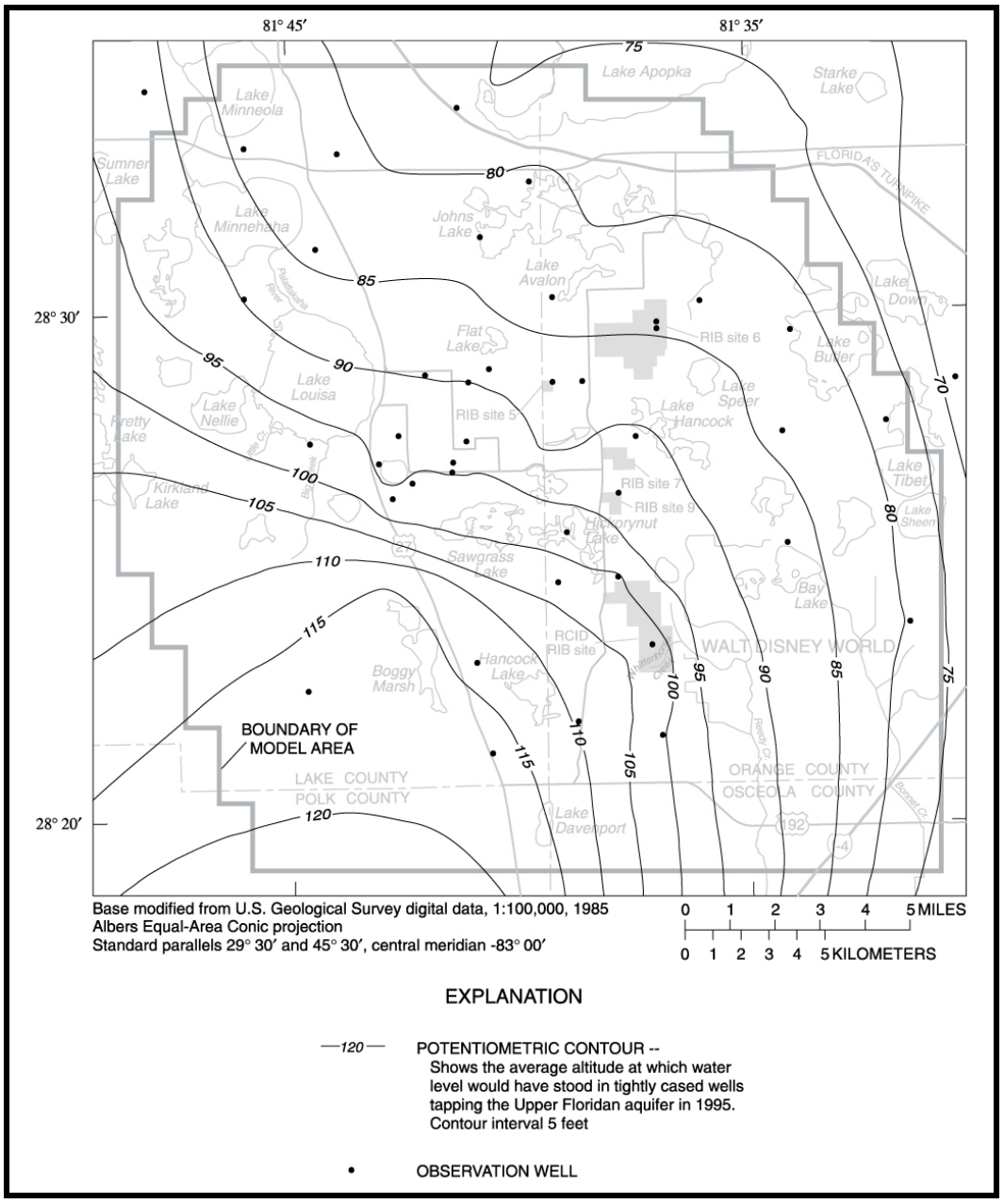


Exhibit 10. Floridan Potentiometric Surface Contours in 1995

Note that we do not plan any site-specific geotechnical or hydrogeologic investigations as part of this study. However, we may survey water levels in several existing deep wells adjacent to lakes to compare the potentiometric surface and the corresponding lake level.

We anticipate that there is enough available data to provide the model inputs and we will not be required to perform any site-specific aquifer performance tests. All data will be entered into our GIS system.

ITEMS REQUIRED FROM LCWA

The following information is required from LCWA:

- ❒ Access to hydrologic records (preferably in electronic format) & GIS files
- ❒ Letters of introduction (where needed) to enter property or request data from other agencies.

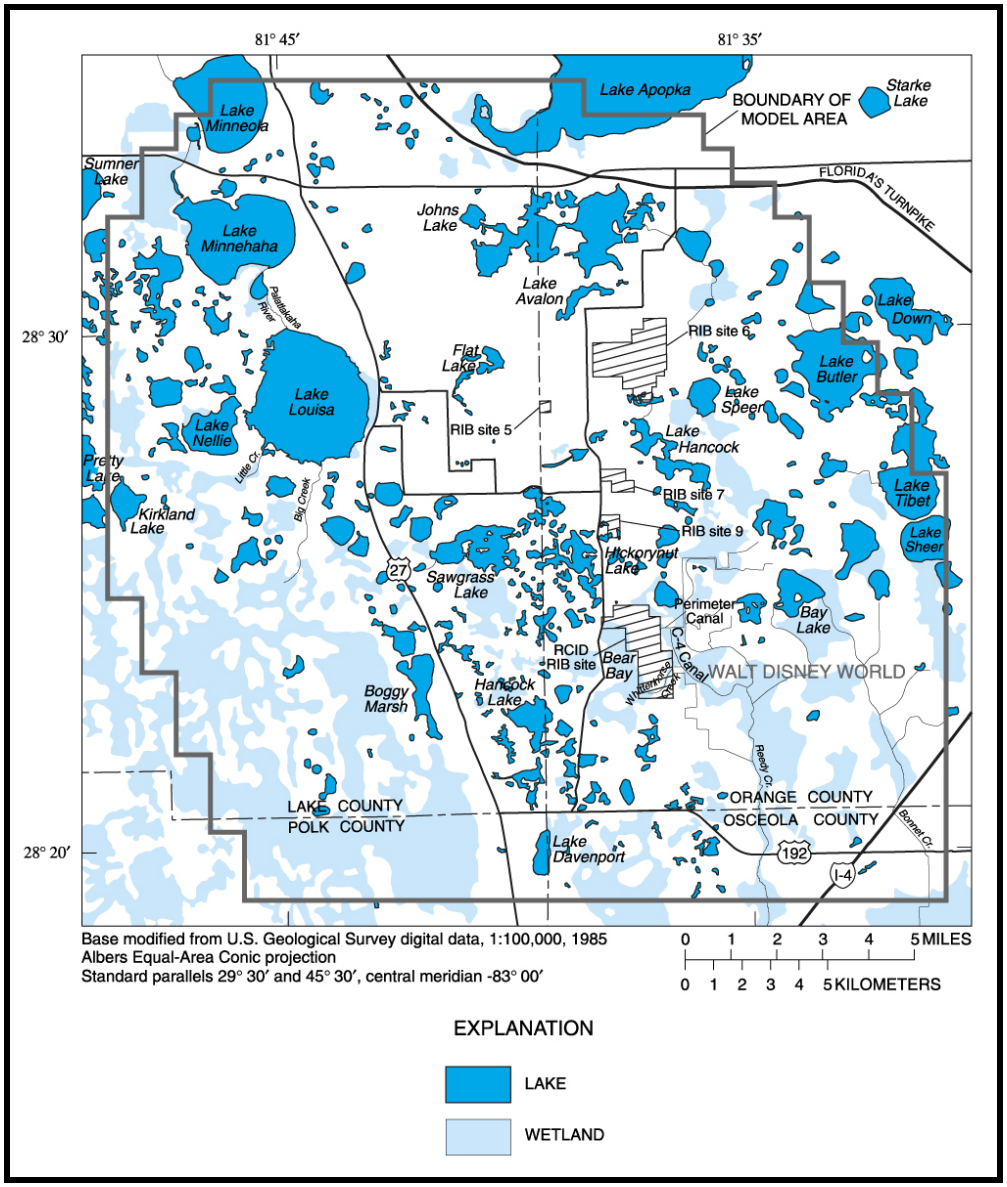


Exhibit 11. Lakes & Wetlands

Key Personnel Assigned to Project

This project will be performed under the direction of Devo Seereeram, Ph.D., P.E., who will be the lead modeler. Dr. Seereeram has extensive experience with ground water/surface water modeling and also has first-hand experience with the unique hydrogeology of the study area.

David Kincaid, P.G. will be the senior hydrogeologist involved with the project.

Other staff member will provide data collection and modeling/report preparation assistance.

Table I. Professional & Technical Staff (2002)
Geotechnical/Hydrogeologic Engineering Services

Individual	Title	Rate
Devo Seereeram, Ph.D., P.E. Note: These Rates Do Not Apply for Expert Witness Services	Principal Engineer/Modeler Senior Geotechnical Engineer	$90/hr
David Kincaid, B.Sc., P.G.	Senior Project Manager Senior Hydrogeologist	$85/hr
Robin Persad, B.Sc.	Project Manager/Project Engineer	$80/hr
Robert Casper, M.E., E.I.	Project Engineer - Geotechnical	$75/hr
Natushka Shoemaker, B.Sc., E.I.	Project Engineer - Stormwater	$75/hr
Toney Allen	Engineering Technician	$55/hr
Ahmed Zahloul, B.Sc.	Senior Design/Graphics Technician	$55/hr
Anila Rasul, B.A.	Technical Assistant	$50/hr
Vikash Gayah	CADD Graphics & Lab Technician	$40/hr
Vickie Smith	Clerical	$32/hr

SCHEDULE

We estimate that we can complete this study within twelve (12) months of your authorization to proceed.

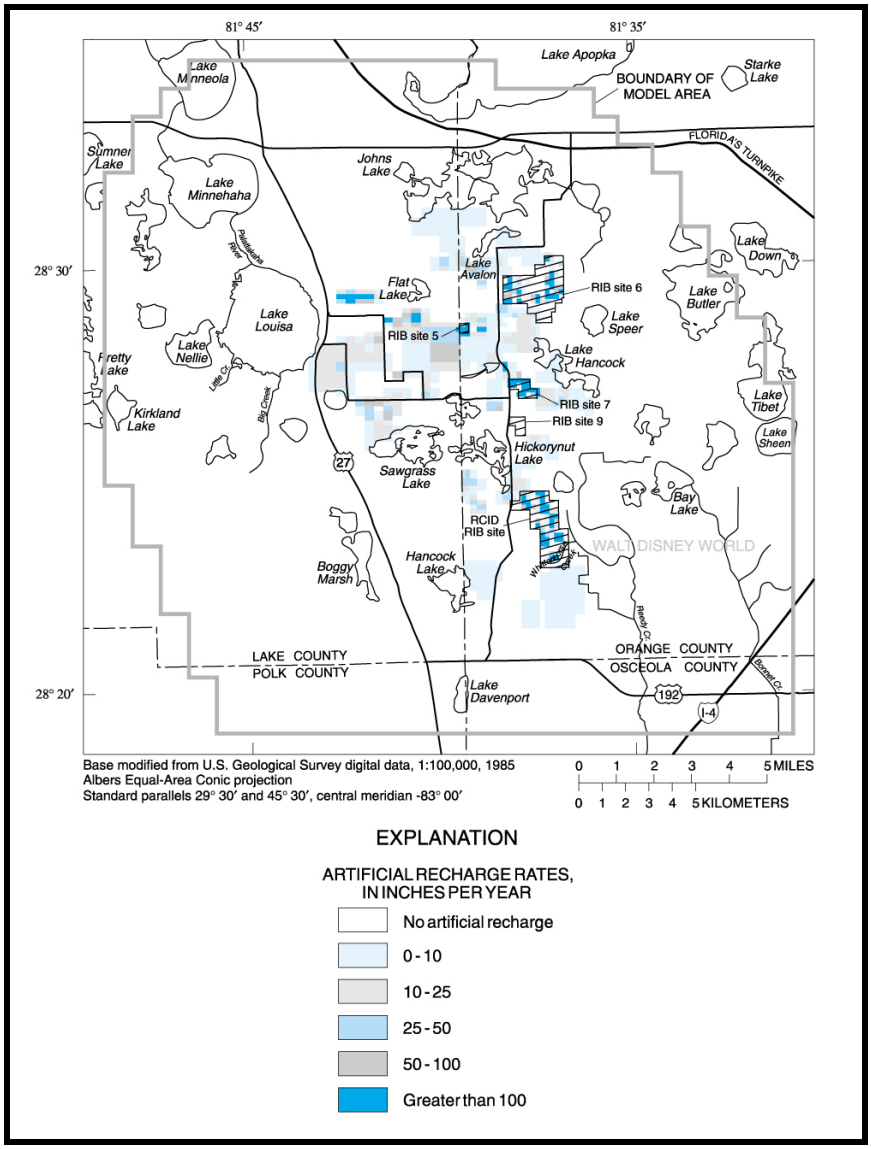


Exhibit 12. Artificial recharge in study area

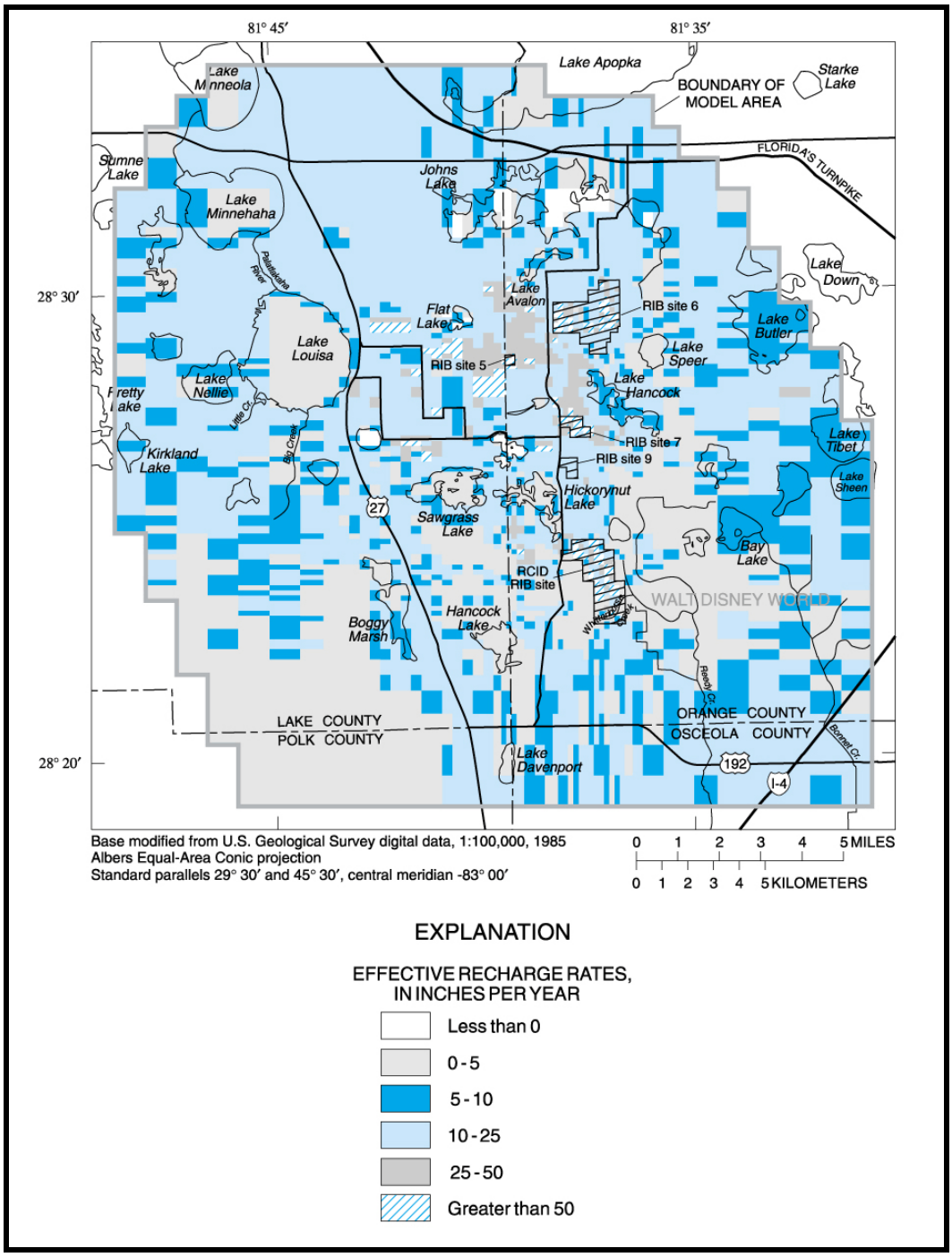
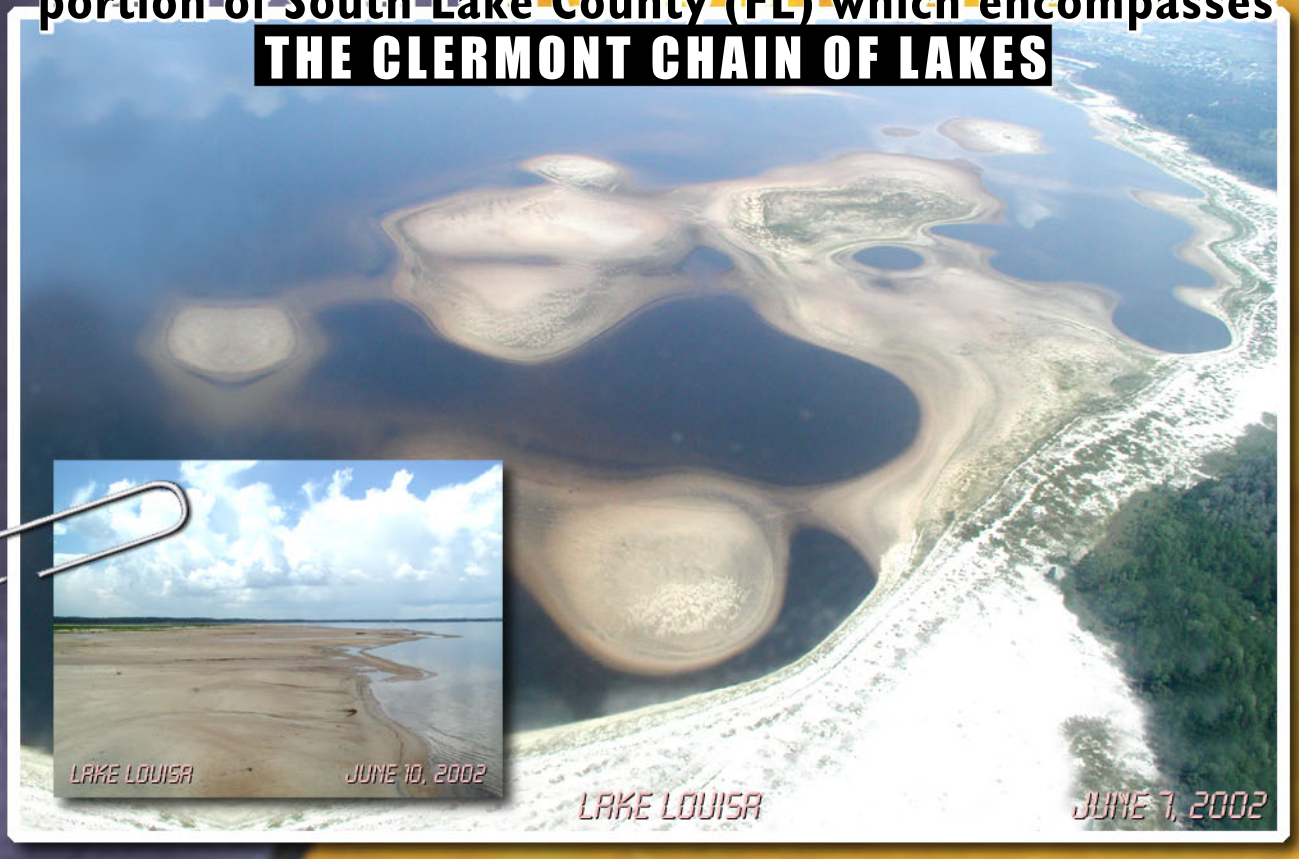


Exhibit 13. Effective recharge rates in study area

TECHNICAL MEMO #2: INITIAL DATA COLLECTION & PRELIMINARY ANALYSIS

Ground water / Surface water interaction modeling for portion of South Lake County (FL) which encompasses

THE CLERMONT CHAIN OF LAKES



Prepared for

ICWA
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JUNE 2002

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Date: July 1, 2002	*Devo's Project No.* 02-121.96
To: Lake County Water Authority 107 North Lake Avenue Tavares, Fl 32778-3119 phone: 352-343-3777 fax: 352-343-4259 attention: LANCE LUMBARD	*cc:* Professional Engineering Consultants, Inc. 200 East Robinson Street, Suite 1560 Orlando, FL 32801 phone: 407-422-8062 fax: 407-849-9401 attention: DAVID HAMSTRA, P.E.
LCWA Lake County Water Authority	PEC

Ref:

TECHNICAL MEMO #2: INITIAL DATA COLLECTION & PRELIMINARY ANALYSIS
STATUS REPORT FOR MAY & JUNE, 2002
GROUND WATER/SURFACE WATER INTERACTION MODELING FOR PORTION OF SOUTH LAKE COUNTY (FL) WHICH ENCOMPASSES THE CLERMONT CHAIN OF LAKES

Dear Mr. Lumbard:

The following status report briefly outlines our completed and ongoing efforts for the period of May-June 2002. This report also has a section on problems we are experiencing with data collection, a critical task where we can use your help. Some interesting hydrologic data is presented in this status report showing a strong link between cumulative rainfall over the last century and lake levels. Please contact us if you have any questions regarding this interim status report.

Sincerely,

Robert D. Casper, E.I.
Project Engineer

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Figure 2-6. Contributing Basin Areas For Big Creek and Little Creek

KICK-OFF MEETING

The kick-off meeting for the project was held on June 7, 2002, directly following a scheduled fly-over of the project area. Those in attendance included Ron Hart and Lance Lumbard of the Lake County Water Authority (LCWA), and Devo Seerreeram, Dave Kincaid and Robert Casper of Devo Engineering.

AIR & LAND SITE RECONNAISSANCE

Figure 2-1 (attached) shows the approximate limits of the study area as defined by hydrogeologic considerations. The rational for selection of this area was described in a previous memo. Figure 2-2 shows a magnified view of the lakes within the area of interest (i.e., the Clermont Chain of Lakes).

On June 7, 2002, we conducted a fly-over of the project site in a chartered single engine small aircraft. Present on the flight were Ron Hart and Lance Lumbard of the LCWA, and Devo Seereeram, Dave Kincaid, and Robert Casper from Devo Engineering.

The flight path originated from Leesburg Regional Airport, and proceeded south over Lake Harris, and on to the Clermont Chain of Lakes. A considerable time was spent circling the major lakes in this chain including Cherry Lake, Lake Minneola, Lake Minnehaha, and Lake Louisa. From there, we flew southward to the headwater of the surface water system which feed the Clermont Chain (see Figure 2-6). This took us to Lake Lowery where we turned around and headed back through the Green Swamp to the Leesburg Airport. The flying time was a little over 1 hour.

To date, we also visited the study area (by land) on two occasions to observe the conditions and obtain a photographic record of the prevailing surface water conditions. On June 10, 2002, we visited the major lakes in the Clermont chain (Lakes Minneola, Minnehaha, and Louisa) stopping at a number of accessible shoreline locations and channel crossings. On June 22, 2002 we visited the Cherry Lake outfall structure. Additional site visits are anticipated in the near future.

Representative Photos

The cover page for this report includes two photos from Lake Louisa, one aerial shot from the plane and one from land. Both photos dramatically illustrate the severe low lake levels which are fairly typical throughout the Clermont chain.

Additional representative photos from these visits are described in this section of the report. Photo 1 was taken on the north shore of Lake Minneola, in the vicinity of C.R. 561A and Kamlin Court. This photograph shows the severe drop in lake levels and a dramatically receding shoreline.



Photo 1. North Shore of Lake Minneola (6/10/02)

Also taken at the north end of Lake Minneola near the intersection of C.R. 561A and Kamlin Court, Photo 2 offers a different perspective of the same scene, this time taken from the present shoreline, looking back to the roadside.



Photo 2. North Shore of Lake Minneola (6/10/02)

Evidence of surface water pumping from the lakes (for landscape irrigation) was common at locations where residential communities are adjacent to the lakes. Photo 3 shows a 2-3 inch diameter PVC intake pipe (typical of what was encountered) extending a significant distance from the shoreline. This photograph was also taken on the north side of Lake Minneola.



Photo 3. North Shore of Lake Minneola. Surface pump intake line (6/10/02)

At the C.R. 565A bridge over the channel connecting Lakes Minneola and Hiawatha, the receding water levels have left the channel discontinuous and unnavigable. Photo 4 was taken from the Lake Minneola side of the bridge, looking back towards Lake Hiawatha. Note the staining on the sheet piling, indicating the anticipated normal water level.



Photo 4. CR 565A bridge over channel between Lakes Minneola &Hiawatha (6/10/02)

Photo 5 shows the bridge on Bronson Road which crosses the channel connecting Lake Minnehaha and Crescent Lake. The picture is taken from the Lake Minnehaha side of the bridge, looking back towards Lake Crescent. Staining on the culvert walls is clearly visible, indicating the probable normal water level for the canal.



Photo 5. Bronson Rd Bridge over channel between Lakes Minnehaha & Crescent (6/10/02)

Water levels at the outfall structure which separates Cherry Lake and Little Lake Cherry are currently (as of June 22, 2002) below the sill elevation of the structure. Photo 6 was taken on the upstream side of the structure (note: evidence of moisture at the base of the structure is due to direct rainfall on the day of the site visit).



Photo 6. Cherry Lake Outfall Structure - Upstream View (6/22/02)

Photo 7 was taken on the downstream (Little Lake Cherry) side of the Cherry Lake outfall structure.



Photo 7. Downstream Side of Cherry Lake Outfall Structure (6/22/02)

REVIEW OF HYDROGEOLOGIC PUBLICATIONS & REPORTS

Definition of study area

Potentiometric surface maps of the Floridan aquifer (USGS) were used to select the model area to take advantage of natural groundwater divides within the upper Floridan aquifer. Regionally, flow in the upper Floridan aquifer is driven by a local area of high potentiometric pressure centered in the vicinity of the Green Swamp. Flow in the upper Floridan aquifer will radiate away from this potentiometric high, perpendicular to the potentiometric contours. This establishes a natural no-flow boundary condition on the western and southern edges of the proposed model area, across which no horizontal flow will occur in the aquifer. On the northeast side of the proposed model area, the boundary was chosen to coincide with the naturally occurring contour at a potentiometric pressure of +70 ft, establishing a constant head boundary condition for the model. These boundaries are depicted on the attached Figure 2-1.

Large scale ground water flow in the surficial aquifer is presumed to be primarily vertical, i.e., leakage into the Floridan aquifer, so the boundary conditions in the Floridan aquifer will take precedence in determining the model boundaries.

Inter-connectivity of lakes

The inter-connectivity of the lakes in the Clermont chain was established based on review of USGS 7.5 minute quadrangle maps and site reconnaissance. The interconnectivity of the lakes is depicted on the attached Figure 2-2.

Review of published and unpublished geologic reports

Below is a list of some the publications were reviewed in order to develop a generalized understanding of the project domain and its predominate geological and hydrological features:

- Hydrogeology and Simulation of the Effects of Reclaimed-Water Application in West Orange and Southeast Lake Counties, Florida. U.S. Geological Survey, Water Resources Investigations Report 97-4199. Prepared in cooperation with the Reedy Creek Improvement District, Orange County, and the City of Orlando. 1998. By Andrew M. O'Reilly. *(Attached Figures 2-3 and 2-4 depict hydrogeologic cross sections from this report which are pertinent to the current study area.*)

- Palatlakaha River Restoration, Phase I Report - Appendix, Draft Technical Memorandum. Lake County Water Authority. Tavares, Florida. prepared by Stanley Consultants.

- U.S. Geological Survey, Water Rosources Data, Florida, Water Year 2000, Volume 1A - Northeast Florida Surface Water, and Volume 1B -Northeast Florida Ground Water.

DATA COLLECTION

Our data collection effort is ongoing. A partial list of pertinent data obtained thus far includes the following (gage and measuring stations are shown in Figure 2-2):

- Rainfall data from LCWA for the period of 1994 through 1998 at the following stations: Emerald Marsh, Tavares, M-1, Villa City, 474, Brown Shin, Thornhill Ranch

- Rainfall data from the Clermont 7 S weather station (NOAA) for the period of January 1, 1901 through November 30, 2001. The location of this rain gage is shown in Figure 2-2.

- Lake levels from Lake Minnehaha gaging station (USGS), located near the CR 561 bridge over the channel connecting Lake Minnehaha to Lake Hiawatha, with lake levels for the period of June 1, 1945 through March 2, 2002. The location of this gage is shown in Figure 2-2.

- Stream flow measurements from the Big Creek gaging station near Lake Louisa (USGS station 02236500), for the period of August 1, 1958 through September 30, 2000.

- Stream flow measurements from Little Creek gaging station near Lake Louisa (USGS station 022363700), for the period of July 1, 1979 through September 30, 2000.

- Water stage levels at USGS gaging stations at Big Creek (station 02236500) , Little Creek (station 02236700) and Cherry Lake Outfall, upstream (station 02236900), for a period of record of July 1, 1979 through January 7, 2002.

- Ground water levels at Southlake Utilities (source: Devo Engineering) near the intersection of US 192 and US 27 in the Green Swamp (see location in Figure 2-6).

- Potentiometric surface data for the upper Floridan from USGS contour maps.

- Location of permitted ground water withdrawals for Saint Johns Water Management District, South West Florida Water Management District, and South Florida Water Management District, from online GIS libraries (see attached Figure 2-5).

PRELIMINARY ANALYSIS OF COLLECTED DATA

Rainfall Data

The rainfall data from the Clermont 7 S weather station was of particular interest because of its completeness over a long period of record. It is also centrally located within the project area. These data were used to calculate the 4-year cumulative rainfall trends over the last century. As previously discussed in our transmittal of June 19, 2002, the 4-year cumulative rainfall is a useful tool in revealing long turn wet or dry periods. It is a useful parameter in assessing ground water impacts in areas of high recharge and basins with limited discharge capacity.

Exhibit 1 is a plot of the 4-year cumulative rainfall for the last century. This plot shows that the year 2001 was a record low four-year-cumulative rainfall for the 100 year period of record.

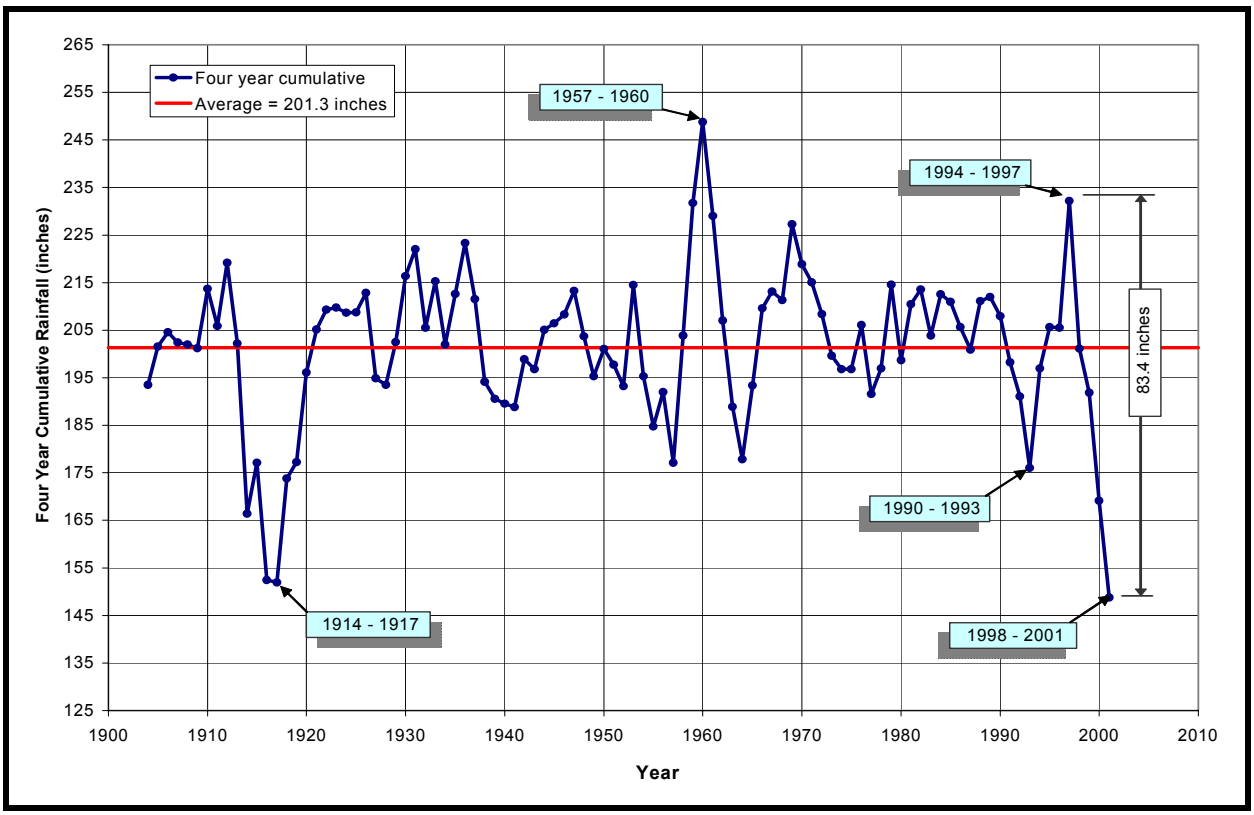

Exhibit 1. Four-Year-Cumulative Rainfall for Clermont 7 S Weather Station

A superposition of the water levels at the Lake Minnehaha gaging station and the 4-year cumulative rainfall is shown in Exhibit 2. The trends shows a generally good correlation as seen in this exhibit.

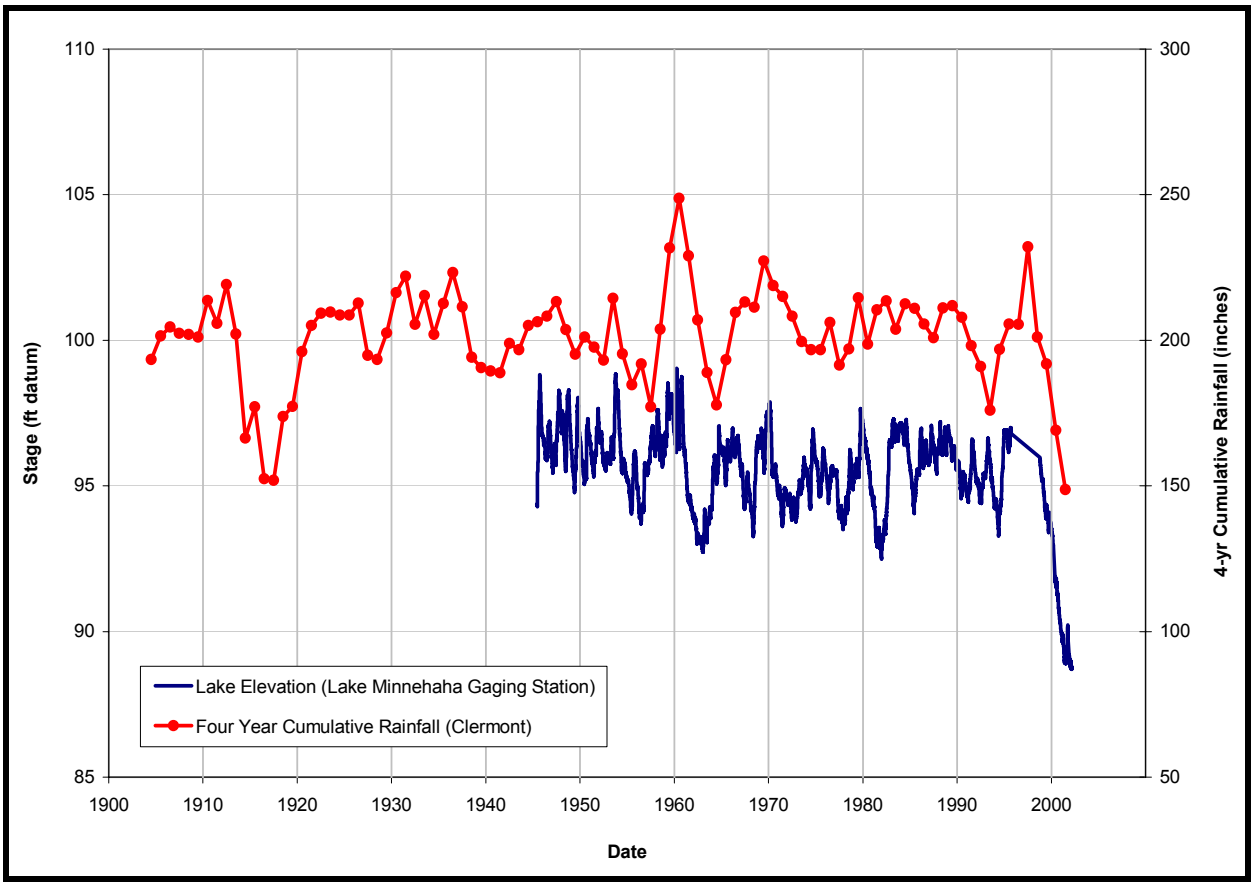

Exhibit 2. Lake Minnehaha gaging station & 4 yr Cumulative Rainfall-Time

Stream Flow at Big Creek and Little Creek

The daily mean stream flow data at Big Creek and Little Creek gaging stations near Lake Louisa (see Figure 2-2) were used to calculate the yearly cumulative stream discharge volume at each location. Data for Big Creek is a available for a longer period of record, but where the data overlap they indicate that the stream discharges for Big Creek and Little Creek are of similar magnitude, with discharge at Big Creek tending to be slightly greater than at Little Creek, as seen below in Exhibit 3.

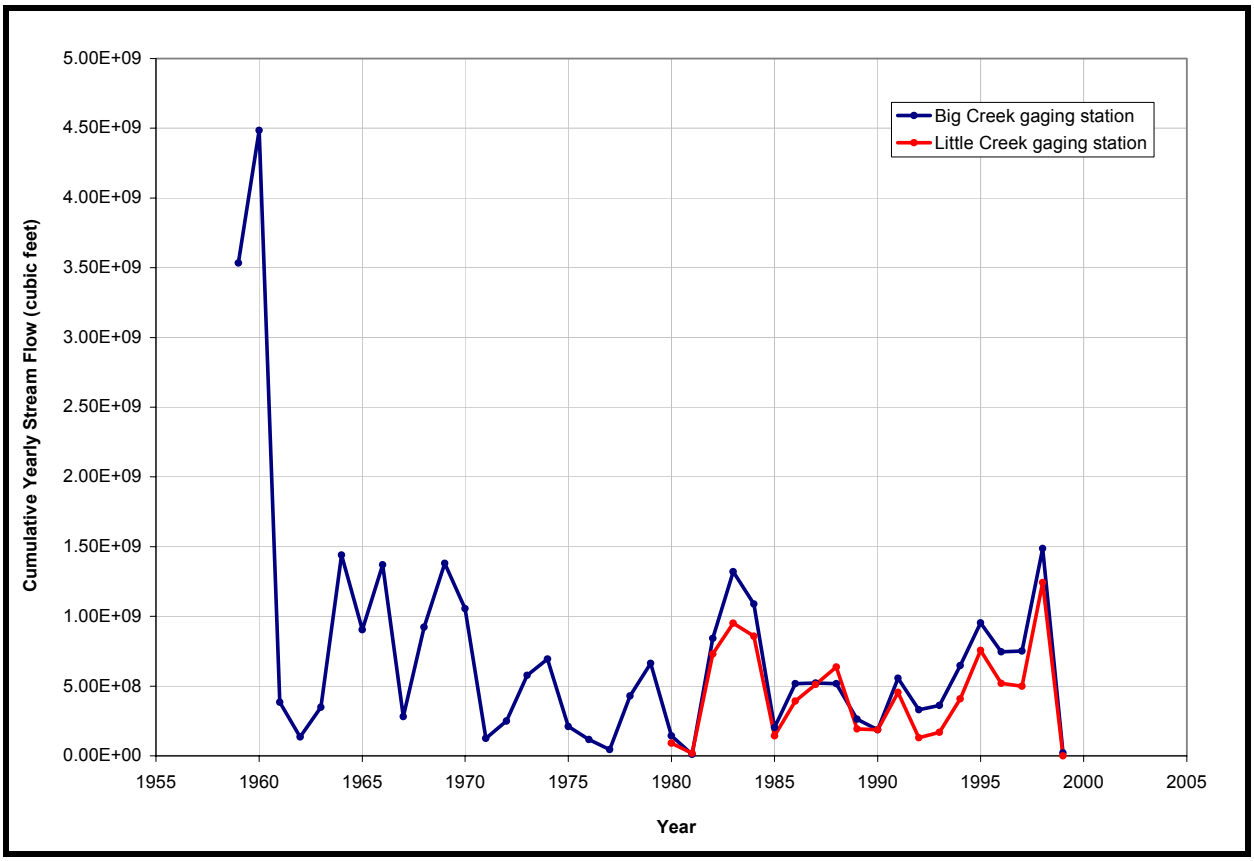

Exhibit 3. Cumulative Yearly Stream Discharge Volume at Big Creek and Little Creek

The available stream gage data for Big Creek gaging station includes data as recent as September 30, 2000. The data for year 2000 are not included in the previous plot of yearly cumulative discharge. They do, however, indicate that the period of very low discharge starting in the year 1999 is ongoing, as seen in Exhibit 4 [note: as more recent data becomes available, we expect this trend will continue to the present date.] For comparison, the daily discharge rates for year 1960 (Hurricane Donna) are included as an example of extreme high discharge, and year 1984 is included as an example of normal to high discharge.

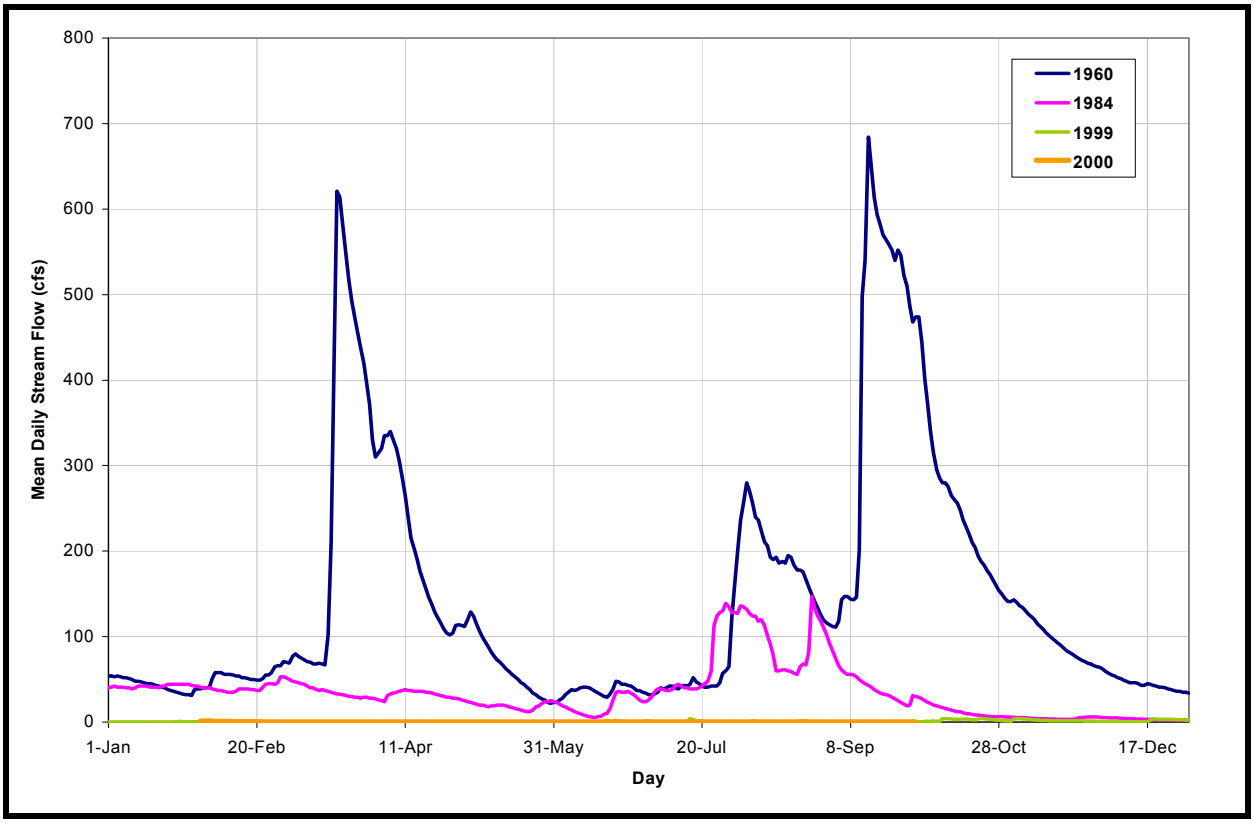

Exhibit 4. Mean Daily Discharge Rates for Selected Years at Big Creek

The correlation between cumulative yearly discharge volumes at Big Creek and Little Creek, and the lake levels at the Lake Minnehaha gaging station can be seen in Exhibit 5.

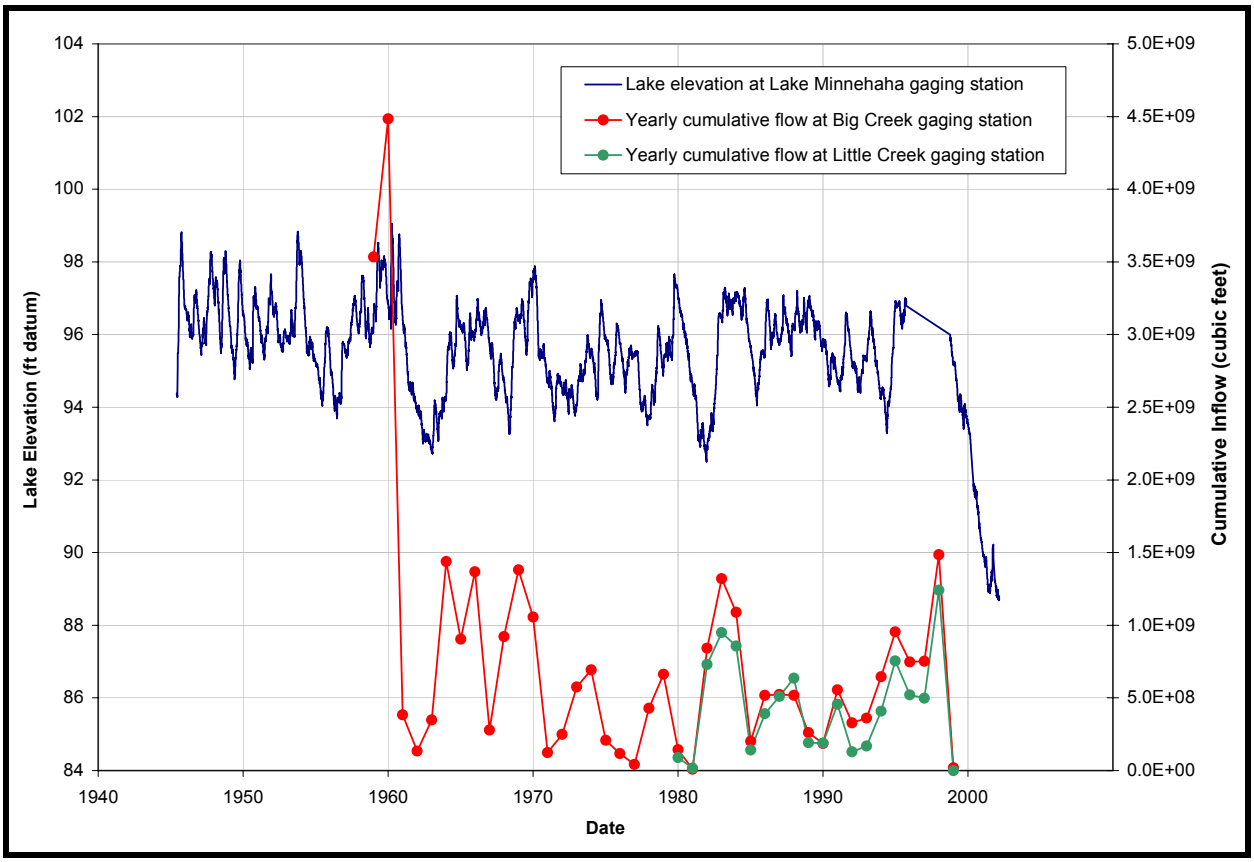

Exhibit 5. Yearly Discharge at Big & Little Creeks and Lake Minnehaha Water Levels

Southlake Utilities Monitor Wells

The shaded area in Figure 2-6 is the contributing surface water basin which feeds Little Creek and Big Creek. The location of the Southlake Utilities monitoring wells is shown on this figure within the watershed near the intersection of US 192 and US 27. This area not only provides surface water feed to the Clermont Chain but it also is a high recharge area where the surficial aquifer water levels are virtually coincident with the potentiometric surface of the upper Floridan aquifer. Exhibit 6 shows the measured water table levels in these wells for the period April 1994 to the present. These are the water levels in the main body of the swamp which flows out into Big Creek and Little Creek.

This data is important in that it shows a dramatic decline in water level in the swamp which could mean that the swamp water levels are below the discharge elevations which result in surface water flows into the Clermont chain.

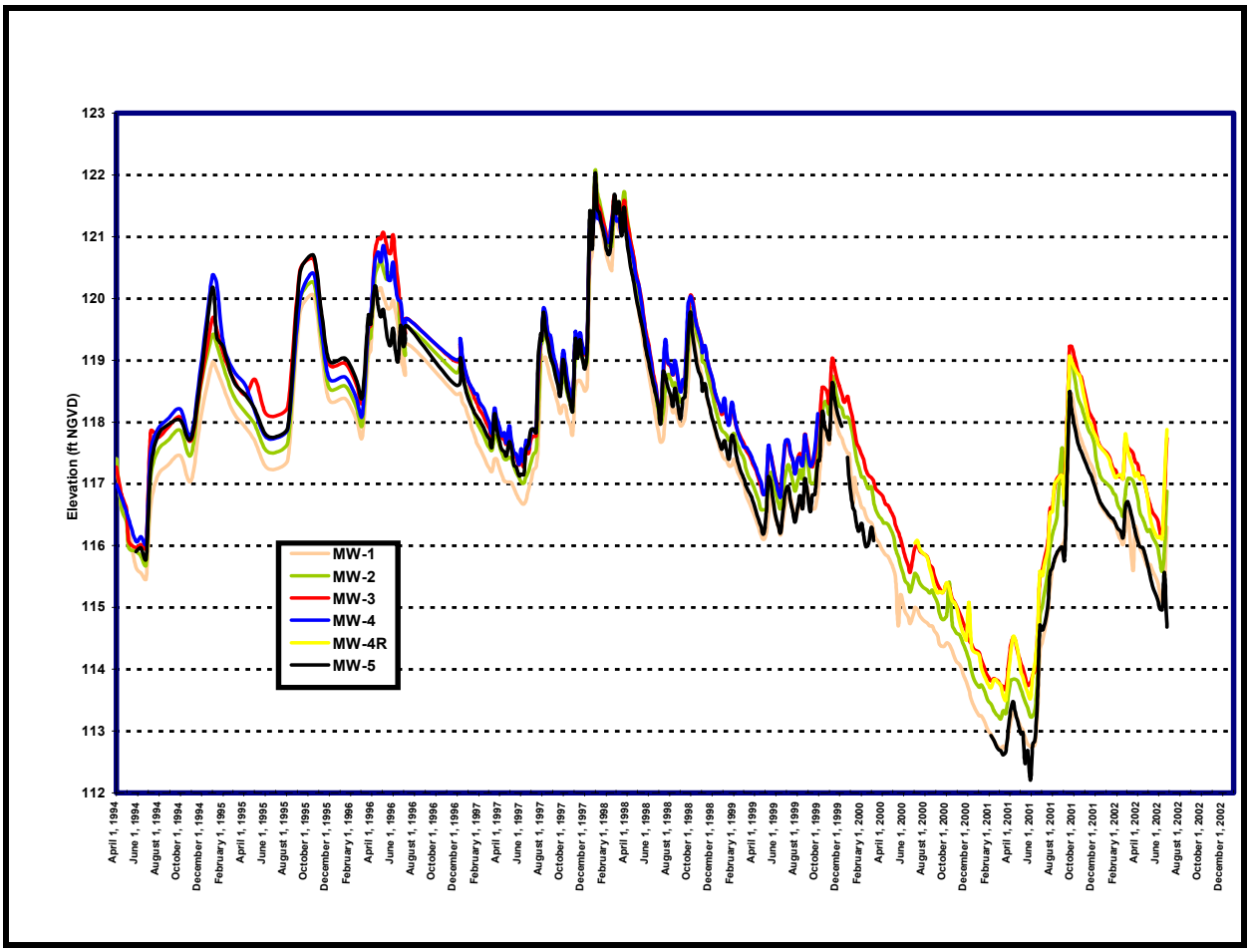

Exhibit 6. Southlake Utilities Monitor Wells near US 192 and US 27

DEVELOPMENT OF MODELING STRATEGY

The modeling strategy which we anticipate will consist of two phases. The first phase will consist of developing a regional model of Floridan aquifer in order to better understand its response to contributing factors such as direct rainfall, evapotranspiration, direct aquifer pumping, etc. This phase of the study will be performed using the MODFLOW (USGS) computer program aided by the Groundwater Vistas pre/post-processing software.

The anticipated second phase of the modeling effort will include the use of the PONDS software in order to model the surficial lake system as a series of interconnected lakes, in a continuous simulation analysis reacting to external variables such as direct rainfall, evapotranspiration, runoff, direct lake pumping, leakage, etc. Data from the first phase MODFLOW study will be used to characterize the leakage characteristics between surficial aquifer system and the upper Floridan aquifer.

In this way we hope to isolate potential contributing factors such as pumping in order to provide a model which will be of future benefit to regional planning.

PRELIMINARY THOUGHTS

The period of drought that we are currently experiencing is the most severe for the last hundred years for which rainfall data are available. A similar event may have occurred in 1916-1917 (based on the plot of four-year cumulative rainfall), but we have not yet found any lake level data from this period to indicate whether the lake levels were similarly affected. In addition, the region would not have been residentially developed at the time, and the falling lake levels, if present, may not have been a source of alarm.

The lack of rainfall is also effecting the aquifer recharge area centered in the Green Swamp near Polk City. This area of high aquifer pressures drives the regional flow within the upper Floridan aquifer, and is sensitive to lack of rainfall, as there are no other contributing sources of recharge in the area. It also serves as an important contributing source of overland flow entering the chain of lakes at Lake Louisa (through Little Creek and Big Creek). Normally, water pressures in the upper Floridan aquifer are at or near the ground surface within the Green Swamp. Monitor well data (Southlake Utilities site) suggests that the surficial ground water aquifer and the upper Floridan aquifer are well connected in this area, so the drop in Floridan aquifer pressures has resulted in the loss of flow from the Green Swamp to Lake Louisa. (The attached Figure 2-6 depicts the basin areas contributing to flow in Big Creek and Little Creek, as well as the location of the Southlake Utilities monitor wells.)

PROBLEMS WE HAVE ENCOUNTERED & ASSISTANCE REQUESTED

As anticipated, the data collection phase of the study is proving to be time-consuming and difficult. We are continuing to request data from USGS, SJRWMD, SWFWMD and SFWMD, and are making use of their online data libraries.

In addition, the data that we have collected thus far, from online sources for example, do not generally include up-to-date readings for the most recent years. We are attempting to augment this data in order to develop a more complete picture of recent site conditions.

Thus far, we have not uncovered a significant amount of data for lake levels in the Clermont chain, other than the data reported for the Minnehaha gaging station.

We would appreciate your efforts in helping us to obtain any and all hydrologic data which may be available within the study area and which may be in your files.

WHAT'S NEXT

We are scheduled to present the results of our data collection effort at a September 18, 2002, board meeting.

Before the end of the summer, we also plan to have the Phase 1 ground water model complete which models the potentiometric surface altitude of the Florida aquifer.

FIGURES

NORTH

GRAPHIC SCALE
1 INCH = 3,000 FEET

1,500 0 750 1,500 3,000 6,000

LEGEND:

- Proposed no-flow boundary.
- Proposed constant head boundary.
- Potentiometric surface of the upper Floridan aquifer - May 2001.

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Website: http://home.cfl.rr.com/devo1

Figure Name:

PROPOSED STUDY AREA

Project Name: Clermont Chain Of Lakes Study

Checked & Approved By:	Drawn By:	Date:	Scale:	Project #	
DS	AZ	06-12-02	NOTED	02-121.96	FIGURE 2-1

NORTH

GRAPHIC SCALE
1 INCH = 4,000 FEET
2,000 0 1,000 2,000 4,000 8,000

LEGEND:

- Gauging Stations
- Floridians Wells
- NOAA Weather Station - Clermont 7S

CHERRY LAKE
96
CLEAR LAKE
APSHAWA LAKE
GRASSY LAKE
83
COOK LAKE
WILSON LAKE
SPRING LAKE
87
GAUGING STATIONS
CHERRY LAKE OUTFALL STRUCTURE
PALATLAKAHA RIVER
LAKE MINNEOLA
96
LITTLE GRASSY LAKE
86
FORMER SAND MINE
LAKE DOUGLAS
SPARKLING WATER LAKE
EAST LAKE
88
92
SHADY NOOK LAKE
CENTER LAKE
CRYSTAL LAKE
JACKS LAKE
82
83
LAKE PALATLAKAHA
SUNSET LAKE
LAKE WINONA
99
LAKE SUNNYSIDE
SUMNER LAKE
96
GAUGING STATION
WILMA LAKE
84
86
LAKE MINNEHAHA
96
LOST LAKE
83
LAKE WASH
98
LAKE FELTER
85
LAKE SUSAN
Lake Louisa Rd.
CRESCENT LAKE
96
RALPH LAKE
103
PINE ISLAND LAKE
108
SAW MILL LAKE
100
FLORENCE LAKE
99
LITTLE LAKE NELLIE
LAKE GLONA
102
LAKE LOUISA
98
LAKE NELLIE
102
LAKE GARY
PRETTY LAKE
108
Lake Nellie Rd.
GAUGING STATION
LITTLE CREEK
BIG CREEK
BEAR LAKE
105
TROUT LAKE
96
GAUGING STATION
BRANTLY LAKE
107

Cherry Lake Rd.
Colonial Dr.
Lakeshore Dr.
Floridas Turnpike
Lake Minneola Dr.
Montevista Rd.
Pine Island Rd.
Florida's Boys Ranch Rd.
Crescent Bay Blvd.

50
27
561
561A
565A
565B

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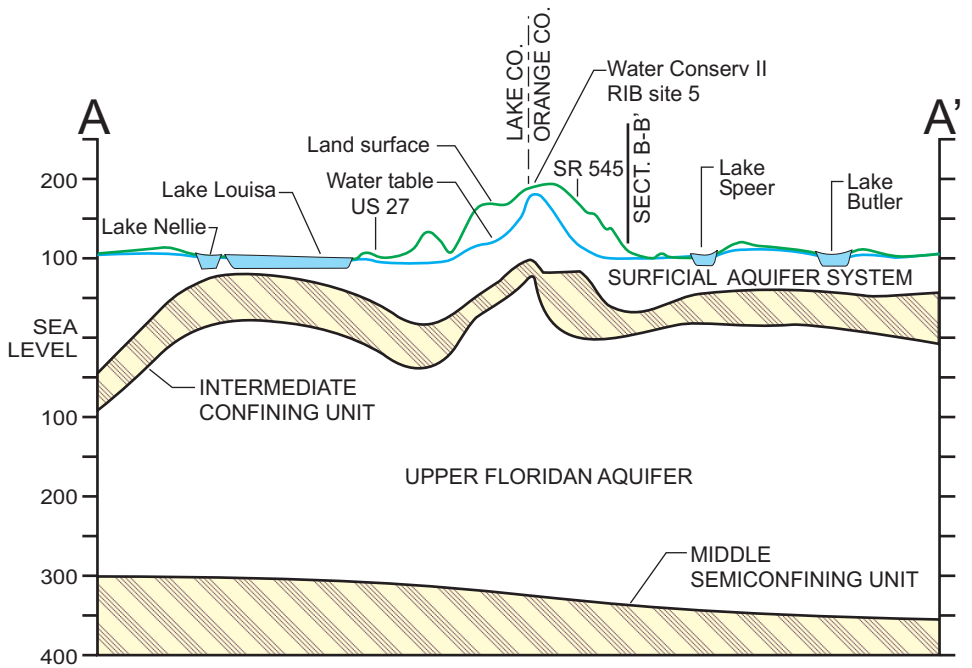
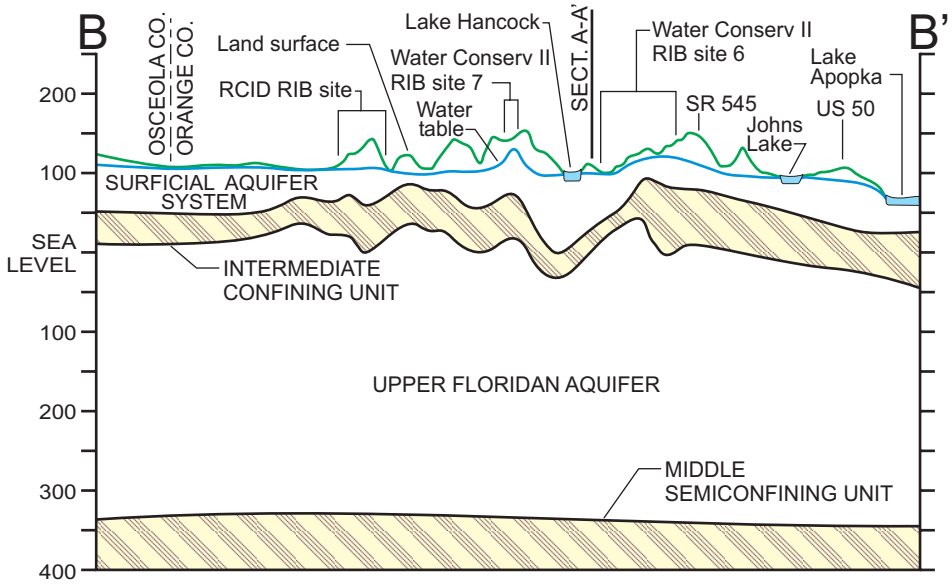
Figure Name: Interconnectivity Of Clermont Chain Of Lakes

Project Name: **Clermont Chain Of Lakes Study**

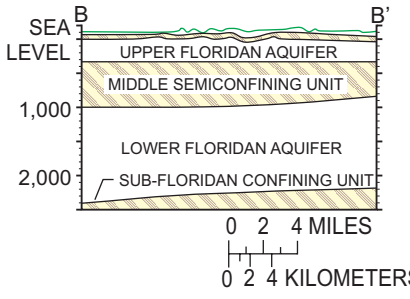
Checked & Approved By:	Drawn By:	Date:	Scale:	Project #	
DS	DC	06-24-02	NOTED	02-121.96	FIGURE 2-2





0 2 4 MILES
0 2 4 KILOMETERS

WATER TABLE REPRESENTS
AVERAGE 1995 CONDITIONS



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Website: http://home.cfl.rr.com/devo1

Figure Name:
Hydrogeologic
Cross-section

Project Name:
Clermont Chain Of Lakes Study

Checked & Approved By:	Drawn By:	Date:	Scale:	Project #	
DS	DC	06-28-02	NOTED	02-121.96	FIGURE 2-3

NORTH

GRAPHIC SCALE
1 INCH = 125,000 FEET

62,500 0 31,250 62,500 125,000 250,000

A

A'

B

B'

LAKE APOPKA

LAKE COUNTY

ORANGE COUNTY

POLK COUNTY

OSCEOLA CO

WALT DISNEY WORLD

Howey In The Hills

Howey

Astatula

Lake Harris

Potter

McDonald

Plymouth

Pumping station

South Apopka

Ferndale

Montverde

Kerlin

Minneola

Mohawk

Citrus tower

Oakland

Clermont

Killarney

South Clermont

Lake Minnehaha

Lake Louisa

Winter Garden

Ocoee

Longcoy

Maguire

Gotha

Harlem Heights

Fullers

Lookout tower

Lake Ingram

Trout Lake

Cypress Lake

Lake Buena Vista

Vineland

Lake Buena Vista

REEDY CREEK

DEVO Engineering CONSULTING GEOTECHNICAL ENGINEERS 5500 Alhambra Drive . Orlando, Florida 32808 Phone: (407) 290-2371 . Fax: (407) 298-9011 E-Mail addresss: dseereeram1@cfl.rr.com Website: http://home.cfl.rr.com/devo1				Figure Name: Location Of The Hydrogeologic Cross-sections Project Name: Clermont Chain Of Lakes Study		
Checked & Approved By: DS	Drawn By: DC	Date: 06-29-02	Scale: NOTED	Project # 02-121.96	FIGURE 2-4	

Graphic Scale

6000 0 6000 12000 18000 Feet

N

Legend:

- SFWMD Water Use Permits
- SWFWMD Water Use Permits
- SJRWMD Consumptive Use Permits, Wells
- SJRWMD Cuonsumptive Use Permits, Pumps
- SJRWMD Free flowing wells
- Study Area
- Water Management District Boundaries

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Figure Name: Location of Permitted Wells

Project Name: Clermont Chain Of lakes Study

Checked & Approved By:	Drawn By:	Date:	Scale:	Project #:	
DS	AZ	06-28-02	Noted	02-121.96	Figure 2-5

Graphic Scale

5000 0 5000 10000 Feet

N

Legend:

- Location of Southlake Utilities Monitor Wells
- Contributing Basin for Little Creek
- Contributing Basin for Big Creek

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Checked & Approved By:	Drawn By:	Date:
DS	DC	07-01-02

Figure Name:

Contributing Basin Areas for Big and Little Creeks

Project Name:

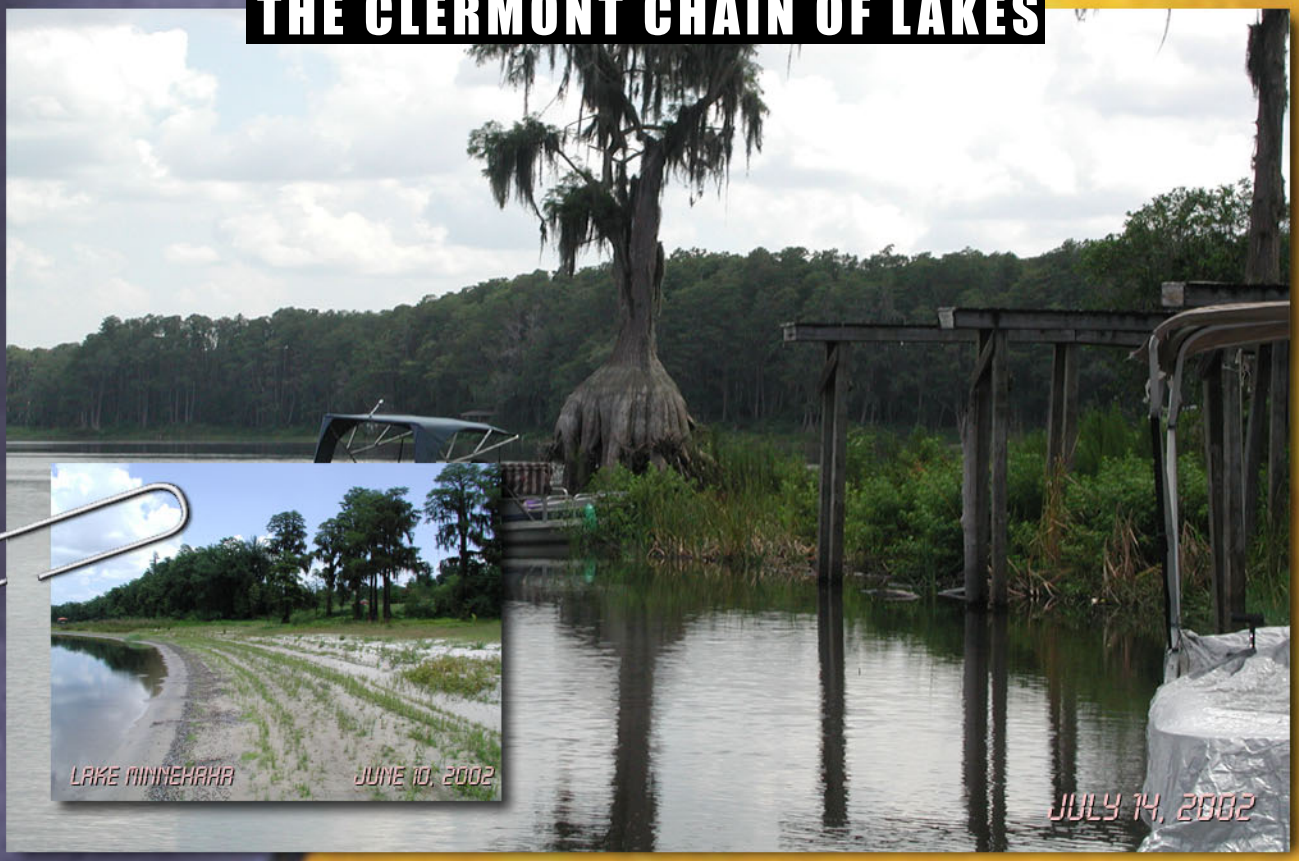
Clermont Chain Of Lakes Study

Scale:	Project #:	
Noted	02-121.96	Figure 2-6

TECHNICAL MEMO #3: HYDROLOGIC DATA REVIEW & ASSIMILATION

Ground water / Surface water interaction modeling for portion of South Lake County (FL) which encompasses

THE CLERMONT CHAIN OF LAKES



Prepared for

Lake County Water Authority

Professional Engineering Consultants, Inc.

Prepared by

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JULY 2002

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Date: August 5, 2002	*Devo's Project No.* 02-121.96
To: Lake County Water Authority 107 North Lake Avenue Tavares, Fl 32778-3119 phone: 352-343-3777 fax: 352-343-4259 attention: LANCE LUMBARD	*cc:* Professional Engineering Consultants, Inc. 200 East Robinson Street, Suite 1560 Orlando, FL 32801 phone: 407-422-8062 fax: 407-849-9401 attention: DAVID HAMSTRA, P.E.
LCWA Lake County Water Authority	PEC

Ref:

TECHNICAL MEMO #3 – HYDROLOGIC DATA REVIEW & ASSIMILATION STATUS REPORT FOR JULY 2002 GROUND WATER/SURFACE WATER INTERACTION MODELING FOR PORTION OF SOUTH LAKE COUNTY (FL) WHICH ENCOMPASSES THE CLERMONT CHAIN OF LAKES

Dear Mr. Lumbard:

The following status report briefly outlines our work effort for the month of July 2002. Our preliminary evaluation of the data continues to suggest that the Clermont Chain of Lakes behaves more like a surface water impoundment which is influenced to a large extent by surface water inflows from the Green Swamp (via Big Creek & Little Creek). The Cherry Lake outfall structure acts as a dam for this "surface water" reservoir. This evaluation is preliminary and our research and analysis is ongoing.

Sincerely,

Robert Casper

Robert D. Casper, E.I.

Project Engineer

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SITE RECONNAISSANCE (JULY 14, 2002)

On July 14, 2002, we visited parts of the study area near Lake Louisa, following a period of frequent rainfall in late June and early July. Points of interest during this field trip include:

- Public facilities and bathing area at Lake Louisa State Park
- Big Creek gaging station
- Little Creek gaging station
- Crooked River Preserve on the Palatlakaha River, northeast side of Lake Louisa
- Lake Susan, at Lake Susan Lodge
- Trout Lake, southeast of Lake Louisa

At Lake Louisa State Park, Robert Casper had a brief discussion with two local residents who expressed concern about the effects of surface water pumping from lakes on the current general conditions throughout the Clermont Chain of Lakes. Although we do not yet have any data to quantify these effects in order to comment on the actual contribution of surface water pumping, it appears from this conversation that there may be a general sensitivity to this issue within the community.

Representative photos from our July field visits are described on the following pages.

Photo 1 was taken at the bridge over Big Creek near the Big Creek gaging station which is on the entrance road to Lake Louisa State Park (accessible from US 27 just south of Lake Louisa). On the day of our visit, there was a noticeable flow in Big Creek toward Lake Louisa, following a period of regular rainfall in late June and early July.



Photo 1. Bridge over Big Creek near Big Creek Gaging Station. 7/17/2002

At the Little Creek gaging station (see Photo 2 below) and at the Crooked River Preserve (Palatlakaha River, northeast of Lake Louisa) there was no obvious sign of stream flow.



Photo 2. Little Creek at Little Creek gaging station. 7/14/2002

Photo 3 was taken at Trout Lake, southeast of Lake Louisa. The low water levels have caused a land bridge to form dividing Trout Lake into two (2) separate water bodies.



Photo 3. Trout Lake. 7/14/2002

RAINFALL DATA REVISITED

In our May-June progress report, we presented a plot of the four-year-cumulative rainfall data for the Clermont weather station based on rainfall data collected between the years 1901 to 2001. That plot indicated that the year 2001 represented the record low four-year-cumulative rainfall for the Clermont weather station. In addition to the record low of 2001, there was a similar period of very low four-year-cumulative rainfall for the years 1915 and 1916.

Since then, we have acquired rainfall data for three other stations in the central Florida area for comparison to the Clermont rainfall data set. These data represent measurements taken at the Orlando weather station in Orange County, the Bartow weather station in Polk County, and the Bushnell weather station in Sumter County. These data are plotted in Exhibit 1 below.

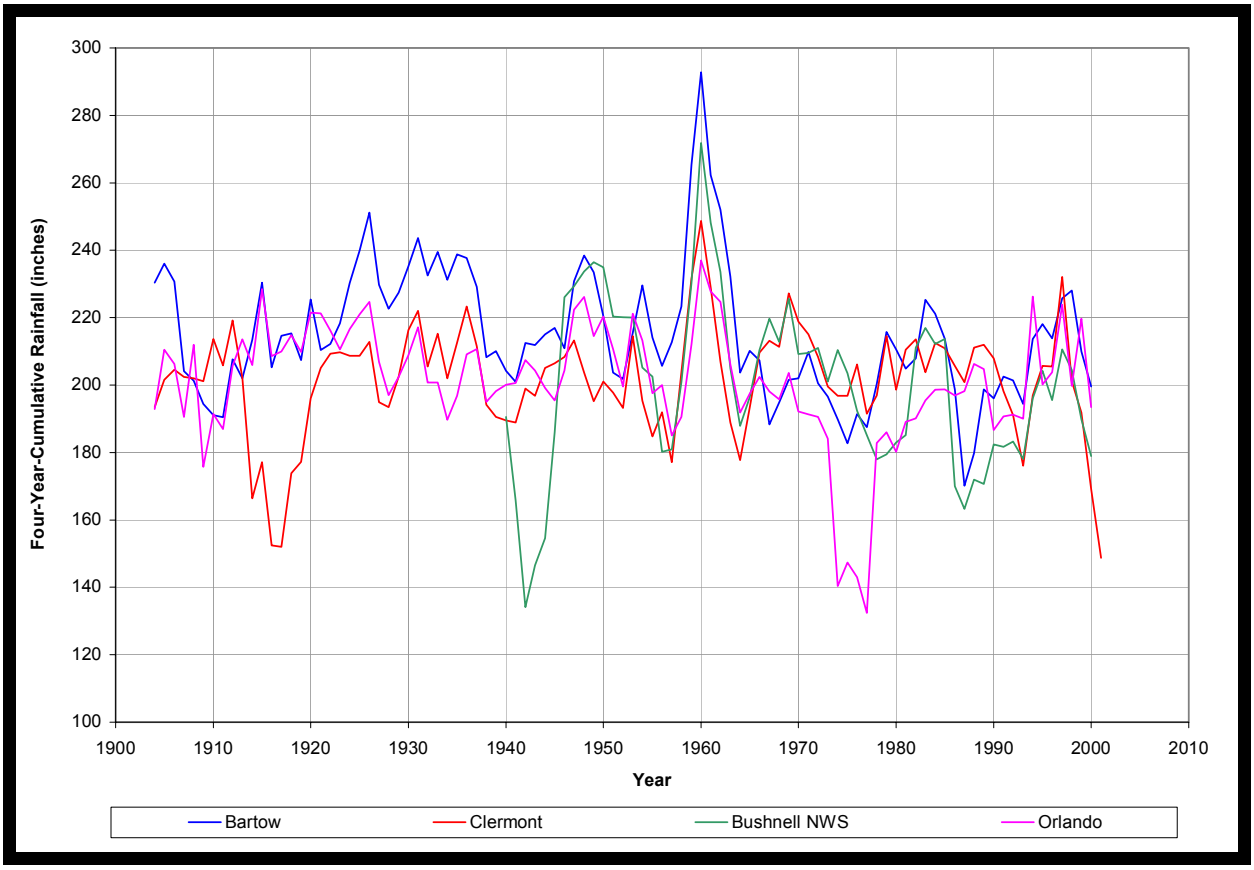


Exhibit 1. Comparison of rainfall data for various weather stations in Central Florida.

The data show a generally good correlation between the different weather stations, with the exception of occasional periods of distinctly lower rainfall at individual stations. While it is possible that these deviations may represent localized drought conditions, it is also likely that they represent inaccuracies in the data collection at these locations, or missing data. In particular, it calls into question the extreme low four-year-cumulative rainfall event previously noted at the Clermont weather station in years 1915 and 1616, and further emphasizes the uniqueness and severity of the record low event of 2001.

Stream Discharge Data Revisited

The plot of cumulative yearly stream discharge for Big Creek and Little Creek presented in our May-June progress report has been augmented with:

① the inclusion of some more recent data for year 2001, and

② the inclusion of discharge volumes for the Palatlakaha River at the Cherry Lake outfall structure.

The additional data confirms that the current period of very low discharge into Lake Louisa is ongoing, as of year 2001, as was assumed but not documented in our May-June progress report.

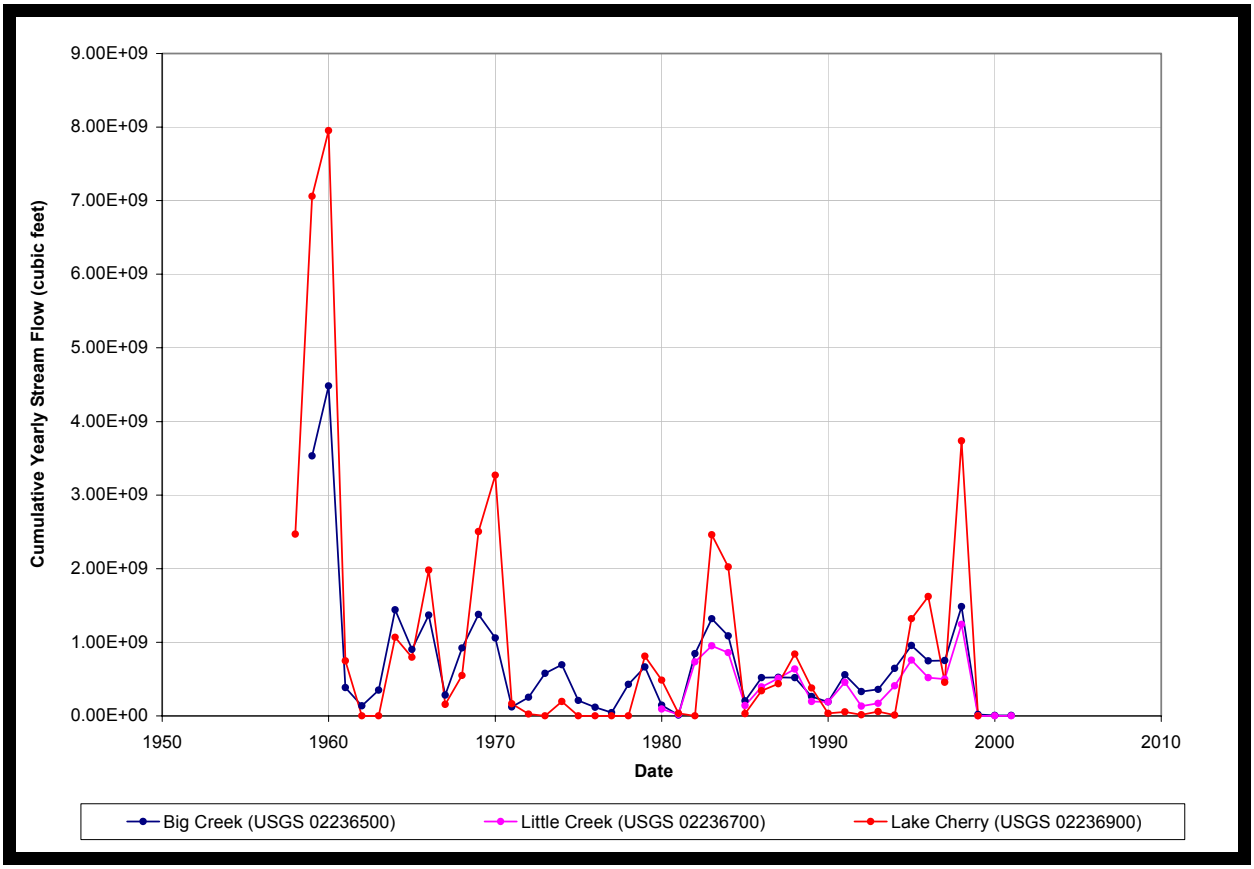


Exhibit 2. Cumulative yearly stream flow at Big Creek, Little Creek, and Cherry Lake Outfall

LAKE LEVELS IN CLERMONT CHAIN - REVISITED

In our May-June progress report, we presented lake levels measured at the Lake Minnehaha gaging station. Since then, we have obtained lake level data for Lake Louisa and Cherry Lake. These additional data are shown together with the Lake Minnehaha lake levels in Exhibit 3 below.

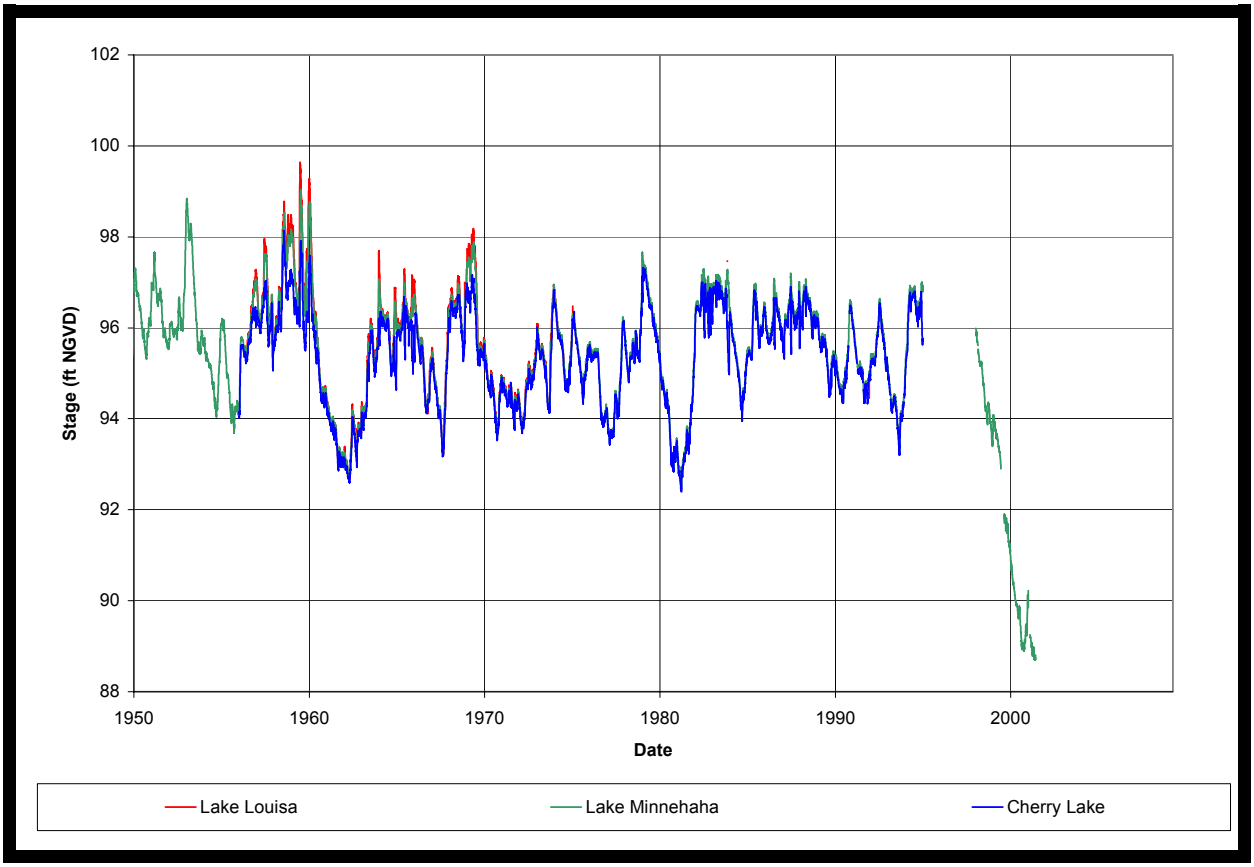


Exhibit 3. Lake levels at Lakes Louisa, Minnehaha, and Cherry

As evidenced in Exhibit 3, the high correlation of lake levels throughout the chain demonstrates the lack of a significant head difference between lakes under normal conditions. This is further demonstrated in Exhibit 4 which shows the lake levels for the select years of 1979 to 1981.

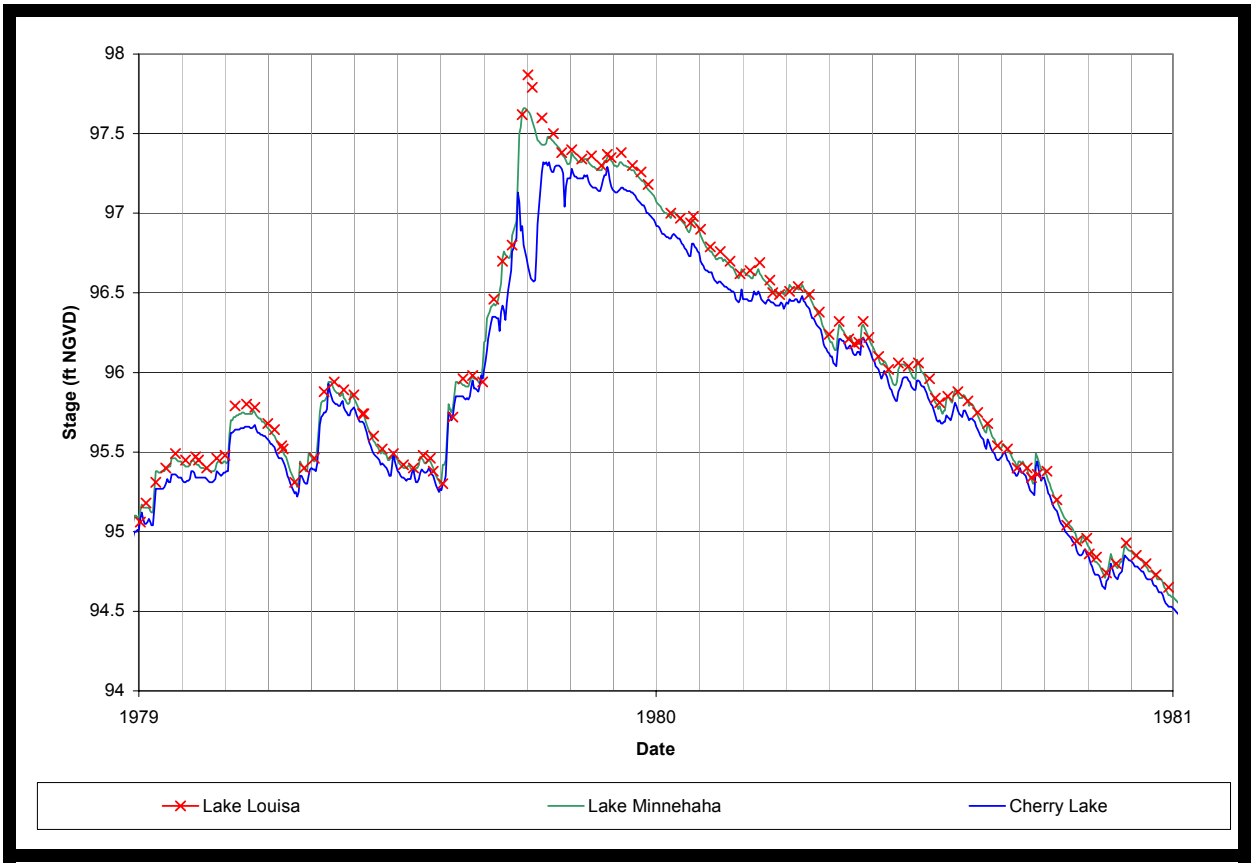


Exhibit 4. Lake levels for Lakes Louisa, Minnehaha and Cherry (1979 ➟1981)

As seen in Exhibit 4, the hydraulic gradient between Lake Louisa and Cherry Lake is normally on the order of 0.25 feet or less. Note that the sudden dip in the water level at Cherry Lake in October 1979, near the peak stage, represents a change in the operating elevation of the Cherry Lake outfall structure.

In contrast, during periods of extreme high rainfall, accompanied by high discharge rates from Big Creek and Little Creek into Lake Louisa, a more significant hydraulic gradient may develop between Lake Louisa and Cherry Lake. Exhibit 5 shows the Lake levels between 1959 and 1961, which corresponds to a period of generally high rainfall, including Hurricane Donna in 1960. As seen in Exhibit 5, during such periods a head difference of between approximately 1.5 to 1.75 feet was observed between Lakes Louisa and Cherry Lake.

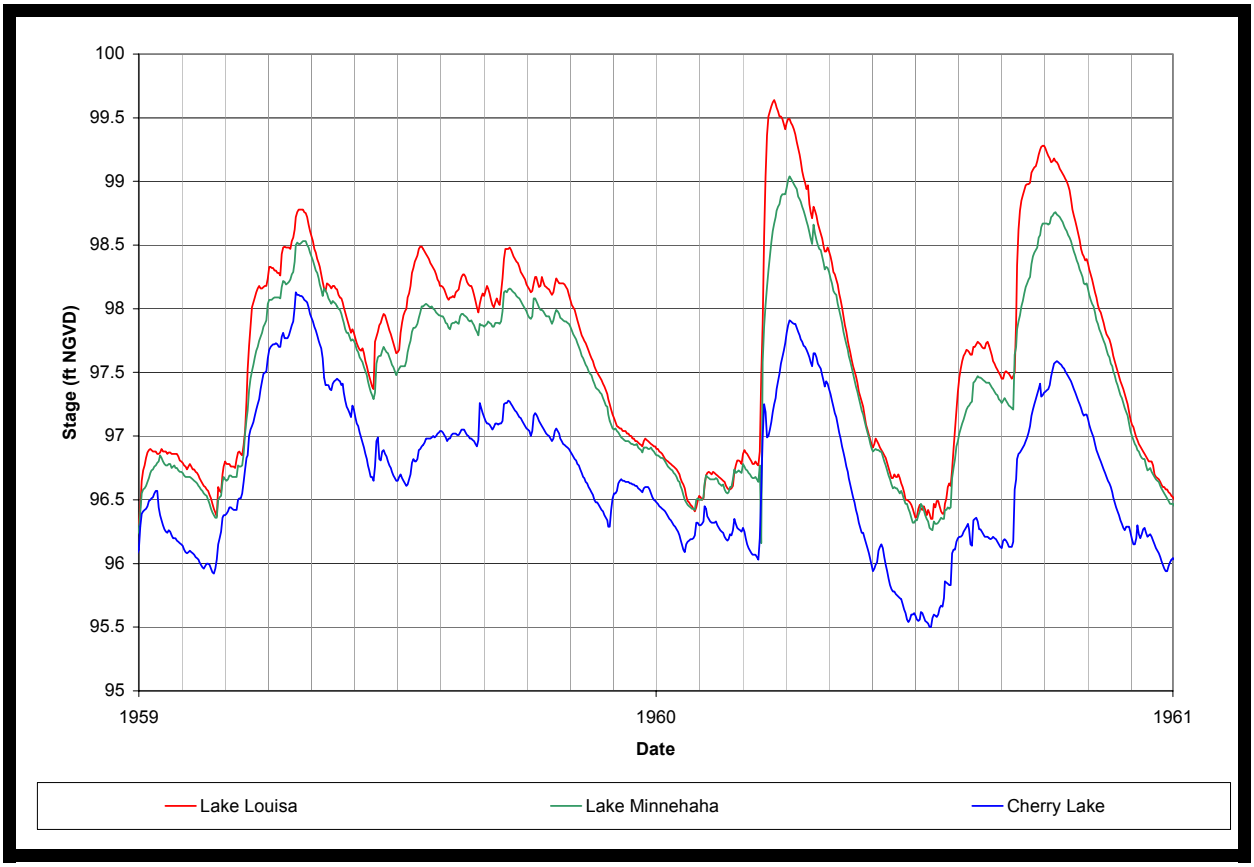


Exhibit 5. Lake levels for Lakes Louisa, Minnehaha and Cherry (1959 ➟ 1961)

Additionally, lake levels for Trout Lake were obtained and plotted versus the lake levels for Lake Minnehaha and Lake Louisa, as seen in Exhibit 6. Trout Lake is a small land-locked lake located just southeast of Lake Louisa. Normally, Trout Lake responds to a somewhat different set of hydraulic factors than does Lake Louisa, most significant of which is the lack of direct stream flow into Trout Lake. Therefore, the lake levels in Trout Lake are not normally coincident with Lake Louisa or Lake Minnehaha, and Trout Lake appears to routinely experience a much greater variation in lake level. It is, however, of interest that the lake levels for Lake Minnehaha during the period of 1999 to 2001, during which there were no significant stream flows to Lake Louisa from Big Creek and Little Creek, are closely mirrored at Trout Lake, suggesting that the lake levels are now responding more directly to prevailing ground water conditions than would normally be the case. (No lake levels were available for Lake Louisa during this period, but lake levels at Lake Louisa are assumed to be similar to Lake Minnehaha.)

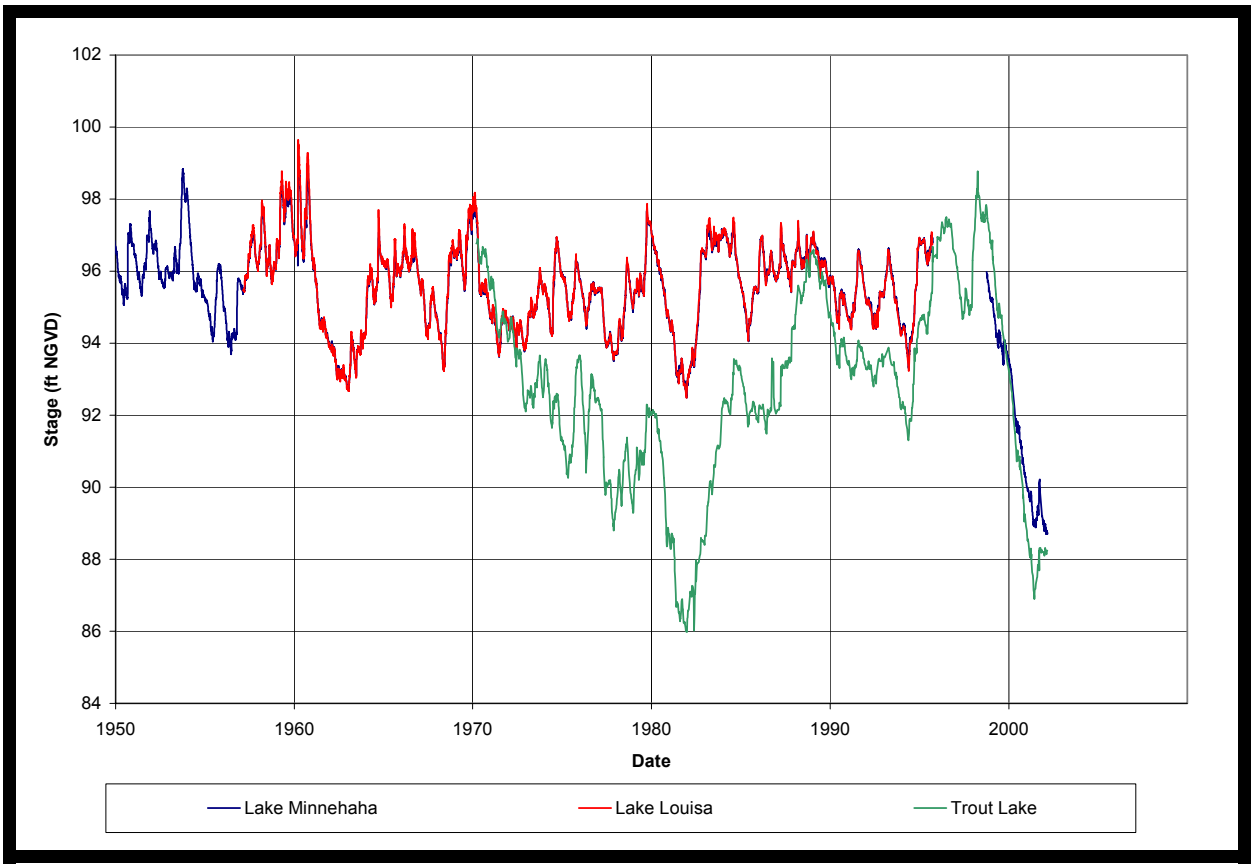


Exhibit 6. Lake levels for Lakes Louisa, Minnehaha, and Trout Lake

CHERRY LAKE AS A LEAKY IMPOUNDMENT

Cherry Lake is the most downgradient lake of the Clermont Chain of Lakes (refer to Figure 2 of the May-June progress report). The normal water level for this lake is +96 ft NGVD based on the Clermont West 7.5 minute series quadrangle map. This lake is controlled by the Cherry Lake dam which is regulated generally between +95 and +97 ft; this structure was constructed in 1956.

Examination of the quadrangle map for the area around Cherry Lake indicates that the normal water level of some of the water bodies adjacent to Cherry Lake (and not part of the chain) are generally +87 ft, or about 8-9 ft lower than the normal water level of Cherry Lake. This means that Cherry Lake likely loses water to seepage from the lake during periods of drought.

We have also reviewed some of the history of Cherry Lake and other lakes in the chain as published in "Clermont - Gem of the Hills 1884-1984" by Johnson and Young (1984).

STAGE-DISCHARGE RELATIONSHIPS FOR BIG CREEK, LITTLE CREEK, AND CHERRY LAKE OUTFALL

Stage versus discharge relationships were developed, to facilitate surface water modeling, at Big Creek and Little Creek gaging stations, and Cherry Lake outfall structure. The stage versus discharge relationships were developed by combining time-series data for daily mean discharge rates and stage at each locations. Exhibit 7 shows the developed relationship for Big Creek gaging station. The data appear well correlated with little scatter.

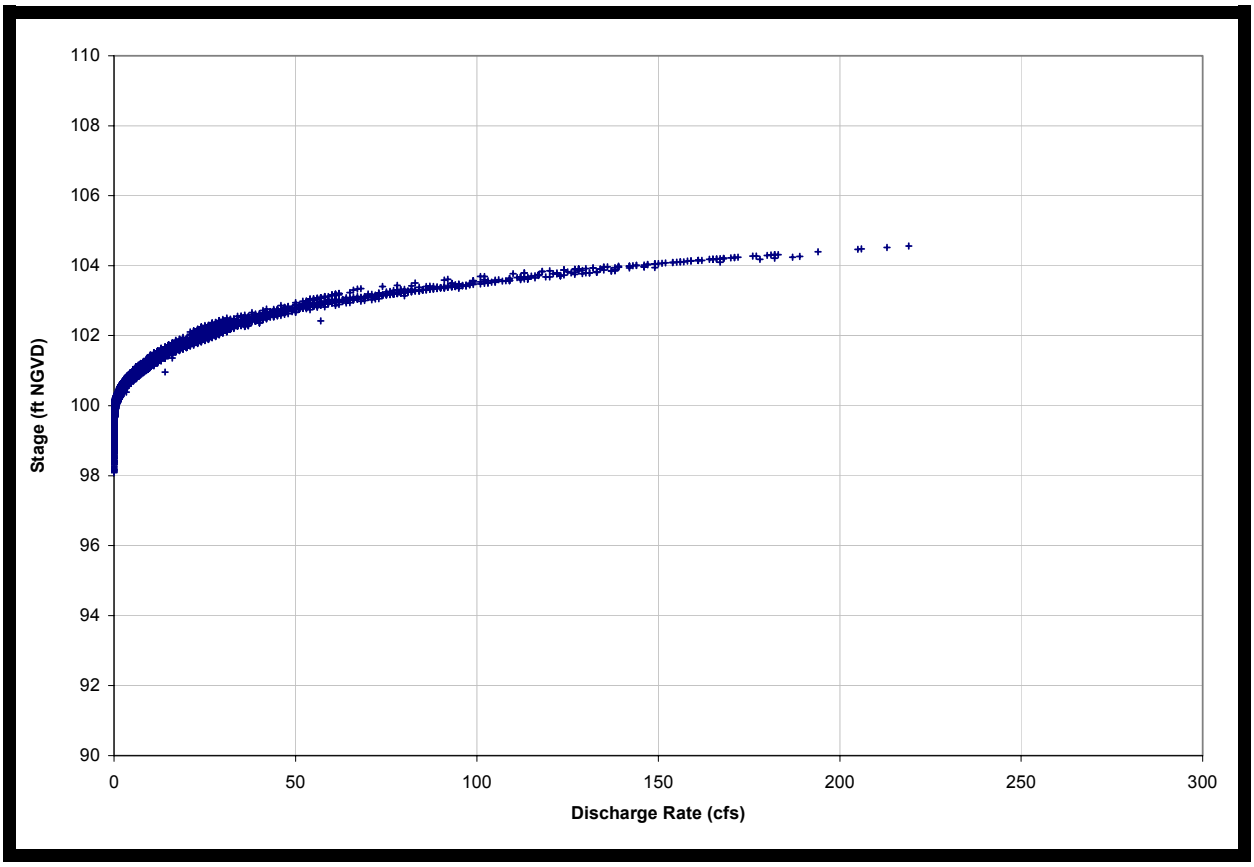


Exhibit 7. Stage vs Discharge for Big Creek Gaging Station (USGS 2236500)

Exhibit 8 shows the stage versus discharge relationship for Little Creek gaging station for years 1979 to 2000. These data appear less well calibrated than those for Big Creek.

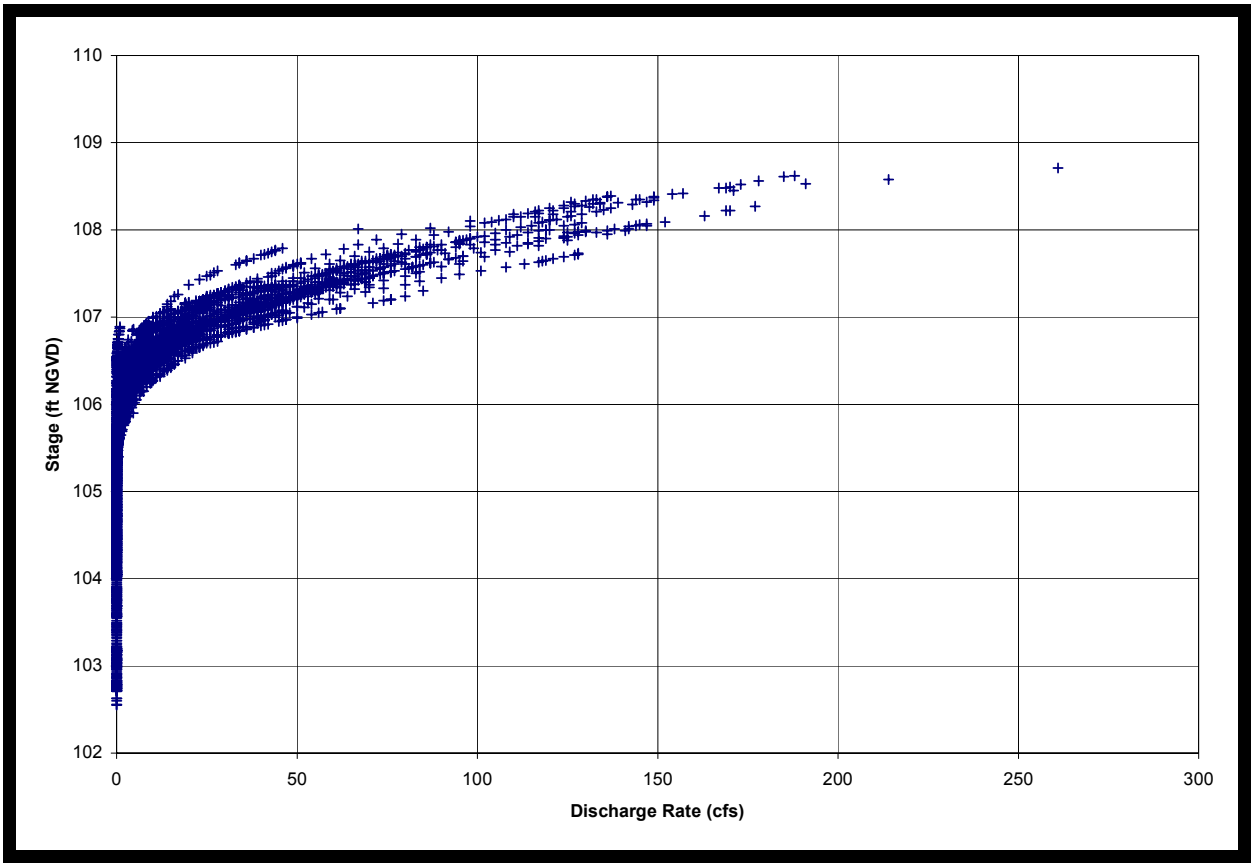


Exhibit 8. Little Creek Stage vs Discharge, 1979 - 2000

Note that Big Creek starts to flow when the water elevation is about +100 ft NGVD while Little Creek flows when it is about +105.5 ft NGVD. Little Creek therefore has a higher level outfall elevation.

In order to minimize the scatter in the Little Creek stage versus discharge relationship, Exhibit 9 shows only the data between years 1994 and 2000, which corresponds to the anticipated modeling duration, and produces a slightly better defined stage versus discharge relationship.

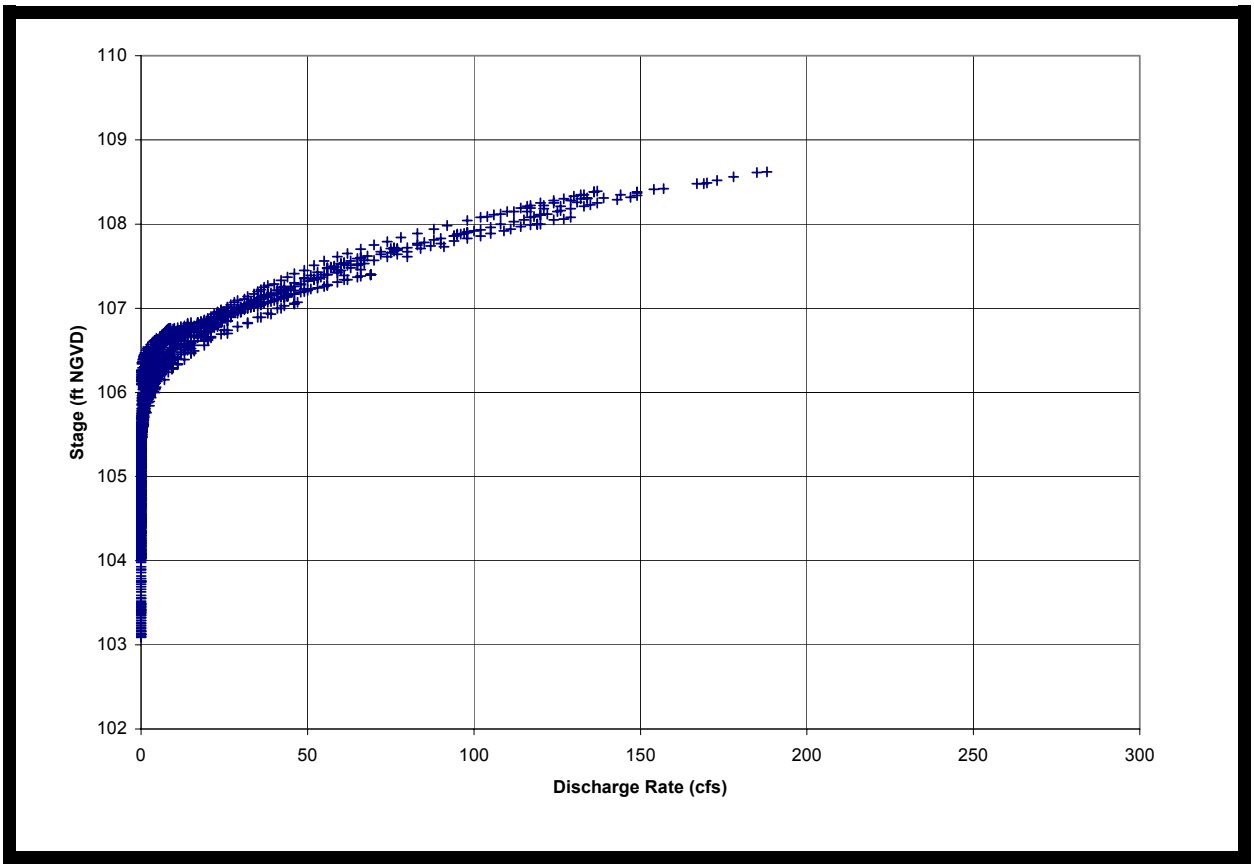


Exhibit 9. Little Creek Stage vs. Discharge, 1994 - 2000

Exhibit 10 shows the stage-discharge relationship for the Cherry Lake outfall structure for years 1957 to 2000. As expected, no clear relationship exists because the Cherry Lake outfall elevation is not fixed, and is routinely adjusted in order to help regulate the lake levels in the Clermont Chain.

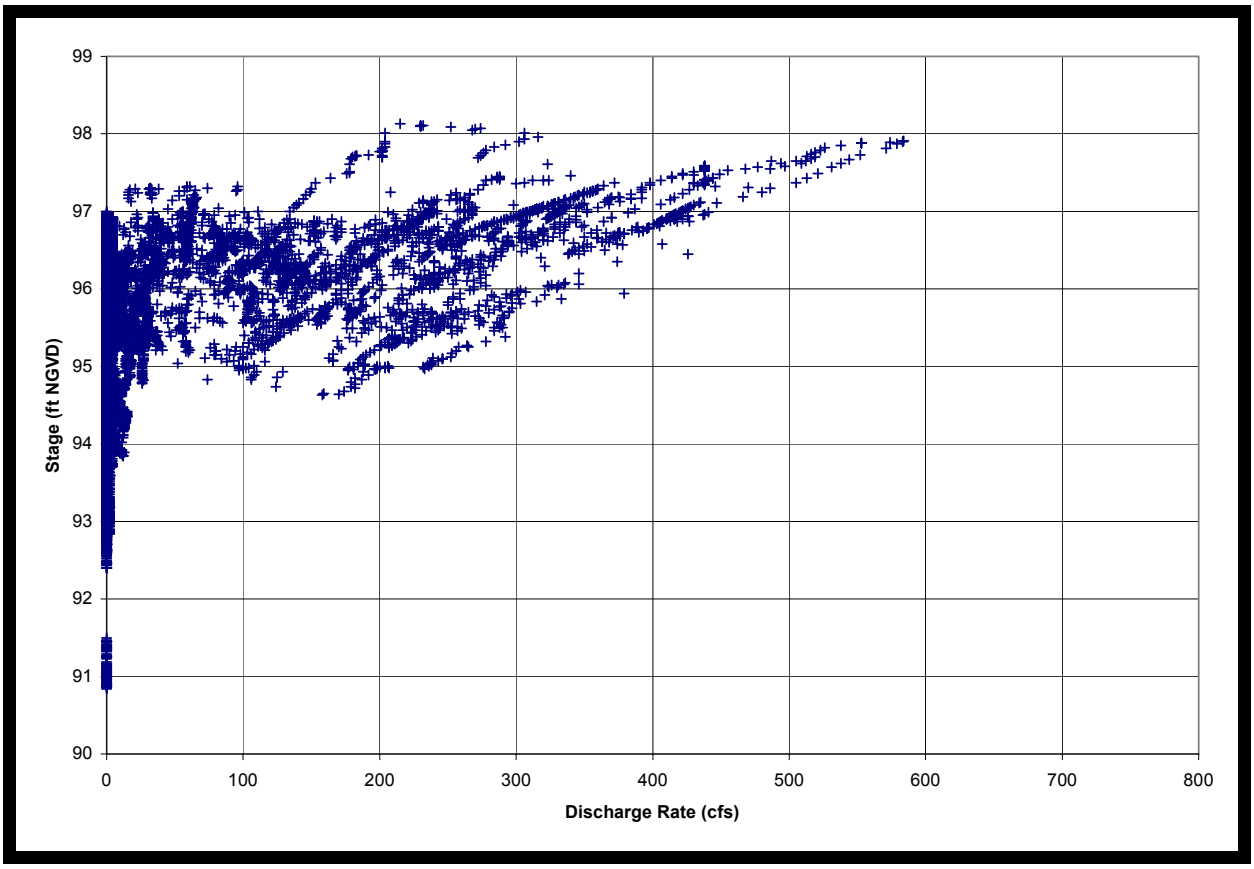


Exhibit 10. Cherry Lake Outfall Structure, Stage vs. Discharge, 1956 - 2000

A detailed history of lake levels and discharge rates for Cherry Lake is presented in Appendix A, for years 1956 through 2001. From this detailed history, it appears that the outfall weir elevation has historically ranged between roughly +95 and +97 ft NGVD, depending on prevailing conditions.

Rising Water Levels in Green Swamp - Summer 2002

We have continued to monitor ground water levels at the Southlake Utilities wastewater plant near the intersection of US 192 and US 27. As mentioned in our May-June progress report, this area reflects the water level trend in the body of the Green Swamp which feeds through Big Creek and Little Creek into Lake Louisa. Exhibit 11 shows the measured water table which was updated on August 5, 2002 and it shows a rebound in the water table following the rains in June and July of 2002. This is consistent with the flows observed at Big Creek.

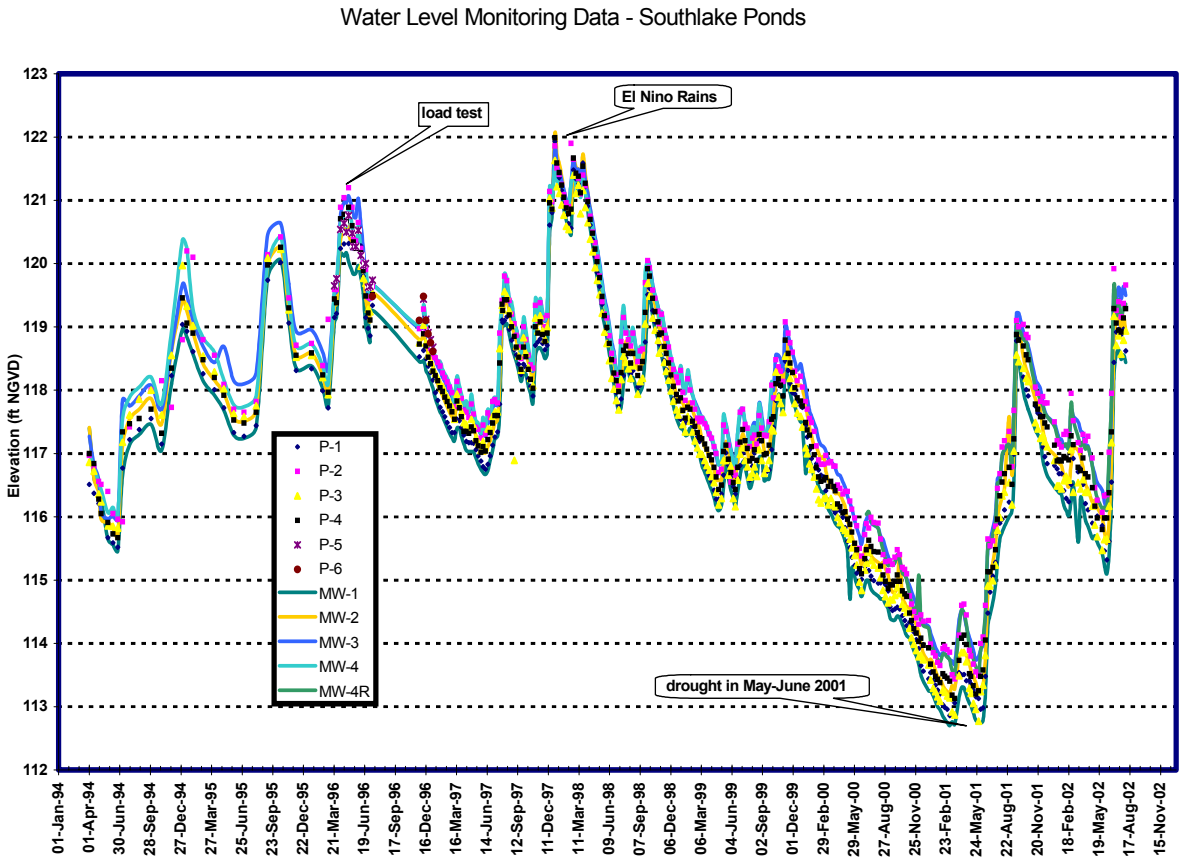


Exhibit 11. Measured Water Table At Southlake WWTF (updated on 8/5/02)

THOUGHTS ON THE ROLE OF THE GREEN SWAMP

In previous reports and memos we have referred to the Green Swamp as an important recharge area for the Floridan Aquifer, and similar characterizations. The actual role of the Green Swamp in regards to aquifer recharge has been debated and deserves further consideration.

In the published report *Hydrogeology and Simulation of the Effects of Reclaimed-Water Applications in West Orange and Southeast Lake Counties, Florida*, (1998), Andrew O'Reilly presents the results of a groundwater modeling study conducted to assess the effects of application of reclaimed water at the Water Conserv II and Reedy Creek rapid-infiltration basins. The model boundaries of this report overlap our proposed study area considerably, and offer some insight, by extrapolation, as to the role of the Green Swamp.

In order to calibrate his model, O'Reilly presents results for calibrated transmissivity in the Upper Floridan aquifer (Exhibit 12), calibrated leakance of the intermediate confining layer (Exhibit 13), and simulated rate of leakage through the intermediate confining layer (Exhibit 14).

(Note: the original figure numbers from the O'Reilly report have been re-numbered to preserve internal consistency within this document.)

As seen in Exhibit 12, the calibrated aquifer transmissivities increase significantly from the southwest corner of the study area to the northeast corner of the study area, with the an increase on the order of 50 times greater in the northeast. Although the O'Reilly study area does not include a large area of the Green Swamp, it is reasonable to assume that transmissivites there will be more similar to those seen in the southwest corner than in the northwest corner, i.e., we would expect to see fairly low aquifer transmissivities in the area of the Green Swamp.

In Exhibit 13, the calibrated leakance of the intermediate confining unit, separating the surficial ground water aquifer and the Upper Floridan aquifer, is seen to decrease from the southwest corner of the study area to the northeast corner of the study area, in a manner somewhat opposite to the calibrated transmissivity in the Upper Floridan aquifer of Exhibit 12. It is reasonable to assume that the calibrated leakance in the area of the Green Swamp will be relatively high, such as in the southwest corner of the O'Reilly study area.

The overall effect of the somewhat opposing factors in Exhibit 12 and Exhibit 13 can best be seen in Exhibit 14, which shows the simulated leakage rate between the surficial and Upper Floridan aquifers, expressed in inches per year. In this figure, the volumetric leakage between

the surficial aquifer to the Upper Floridan aquifer generally increases from the southwest to the northeast.

Therefore, if the O'Reilly calibration is correct, and if the data can be reasonably extrapolated into the area of the Green Swamp, then it appears that the volumetric contribution of recharge to the Upper Floridan aquifer in the Green Swamp is probably not significantly large compared to areas to the northeast, i.e., the Green Swamp does not contribute an unusually high degree of recharge volume to the Upper Floridan aquifer.

However, the Green Swamp does define an area of regional high aquifer pressures, and this is probably due to the combination of a relatively high vertical leakage rate between the surficial aquifer and Upper Floridan aquifer which promotes vertical flow, and the relatively low transmissivity within the Upper Floridan aquifer which acts to retard the horizontal flow away from the Green Swamp within the Upper Floridan Aquifer, creating a high pressure zone. This is also a topographic high in the landscape.

Of importance to our ongoing study, the relatively low overall volumetric leakage rate (Exhibit 14) within the Green Swamp, and the relative lack of vertical relief to the land surface, results in the accumulation of surface water in the Green Swamp, a portion of which ultimately feeds into the Clermont Chain of Lakes through Big Creek.

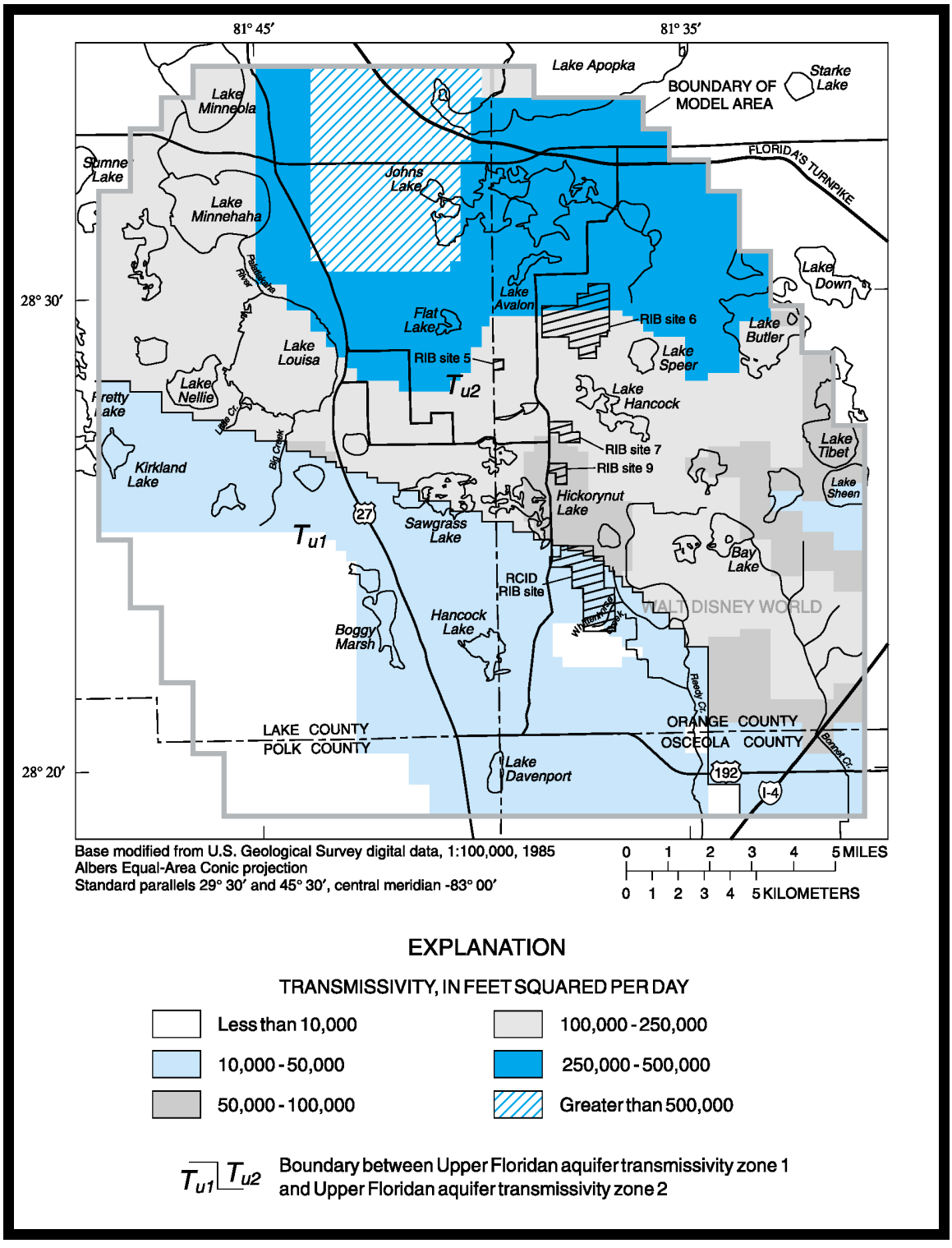


Exhibit 12. Calibrated transmissivity of the Upper Floridan Aquifer. O'Reilly, 1998.

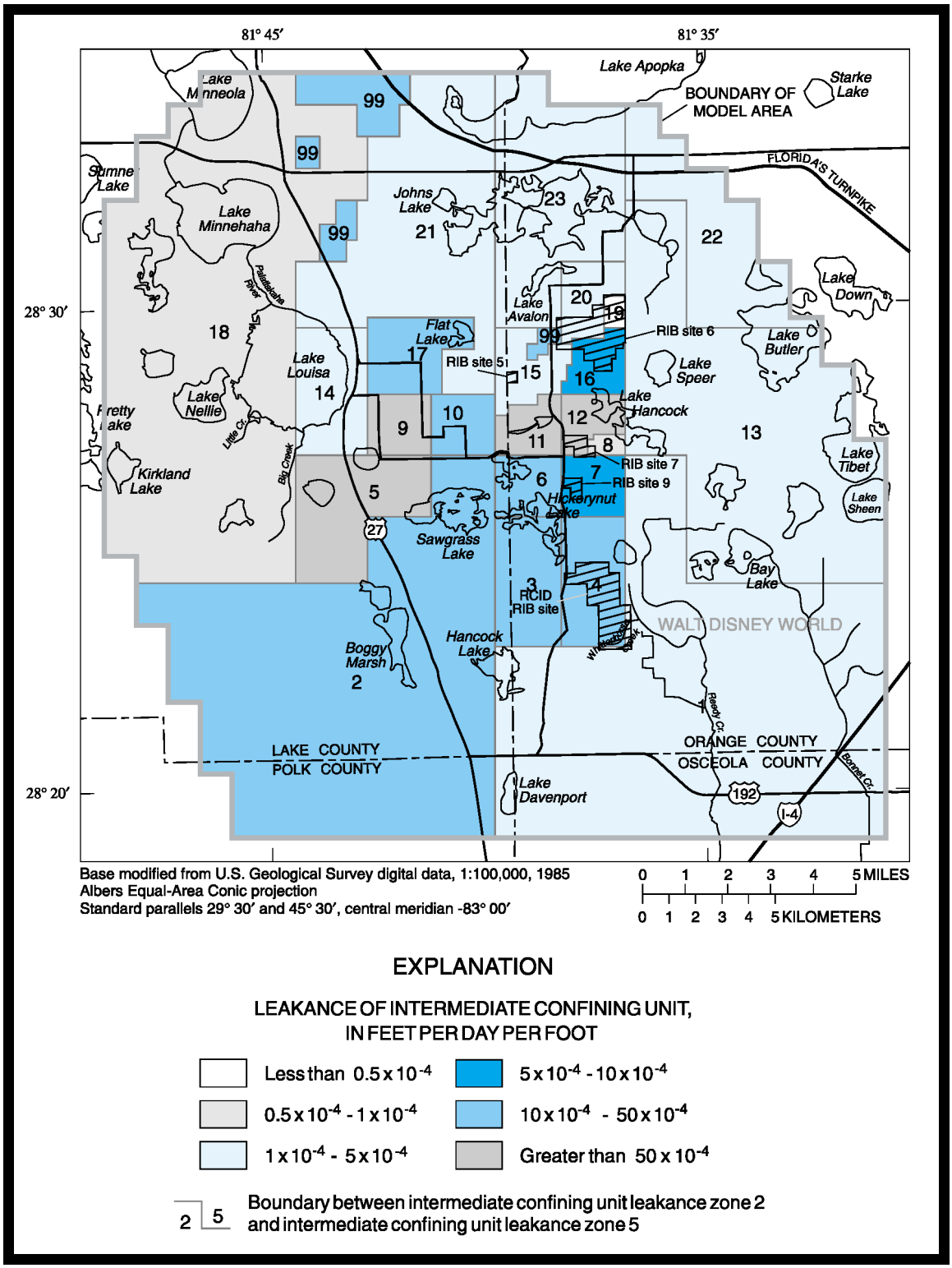


Exhibit 13. Calibrated leakance of intermediate confining unit. O'Reilly, 1998.

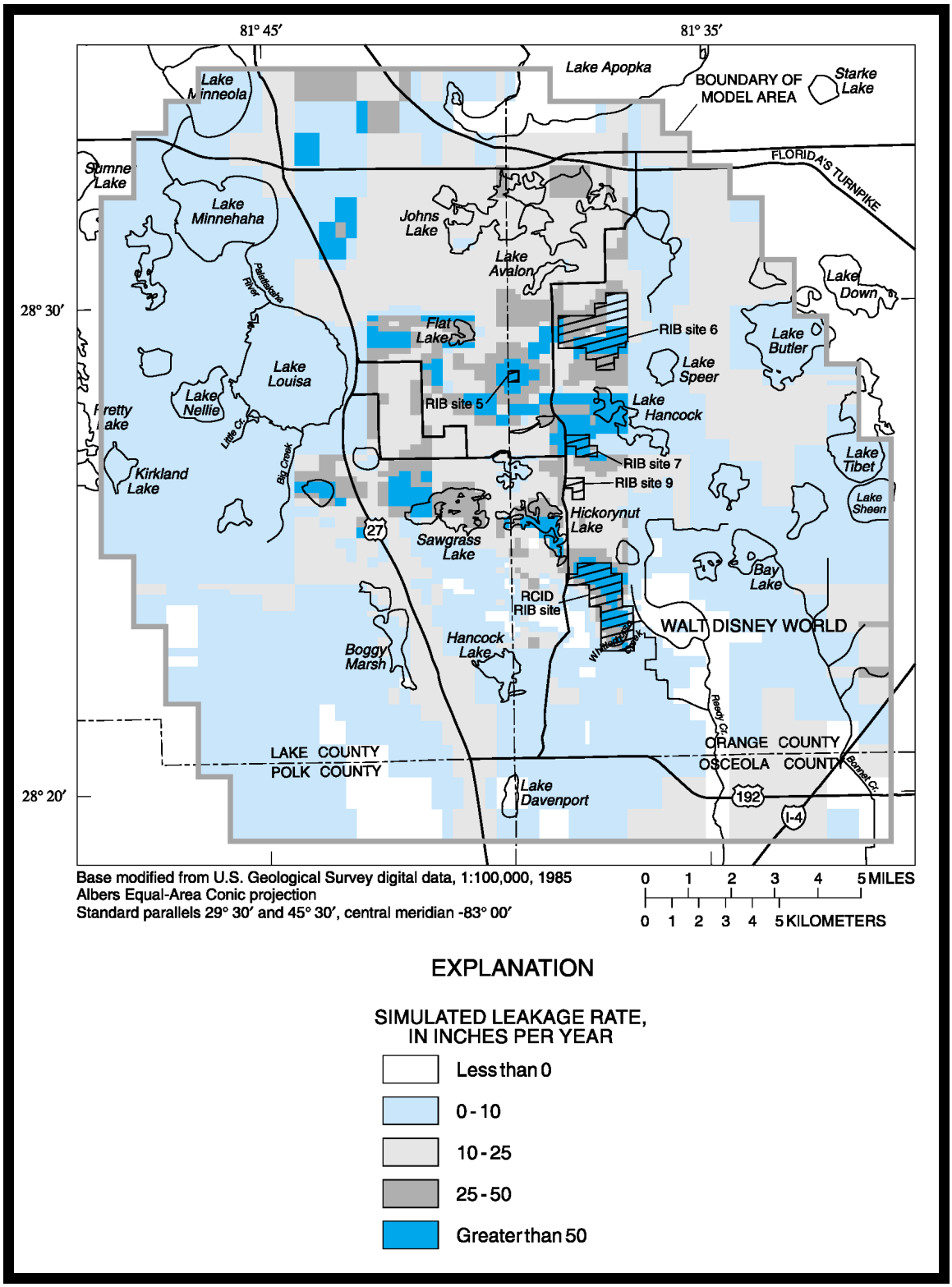


Exhibit 14. Simulated rate of leakage through the intermediate confining unit. O'Reilly, 1998.

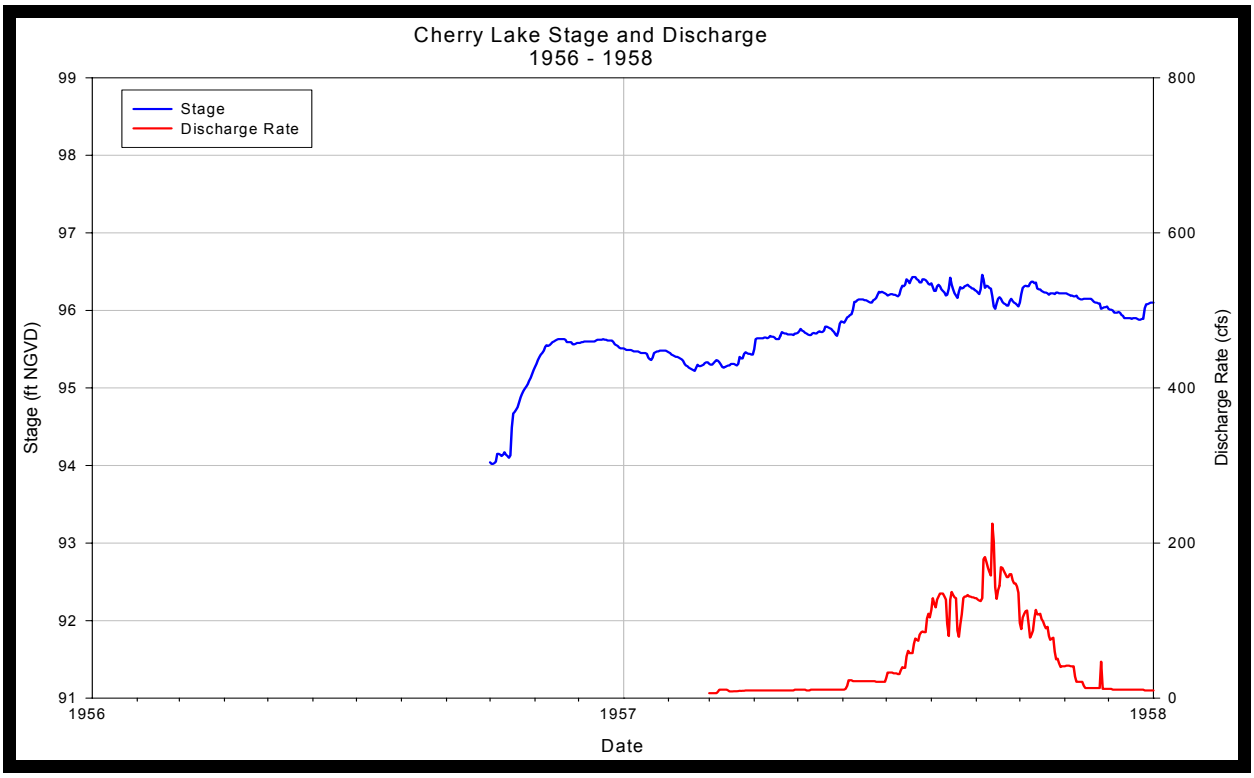
WHAT'S NEXT

Based on our findings and observations to date, we are proceeding to perform some preliminary continuous surface water/ground water modeling on the chain of lakes using the PONDS software program.

The purpose of this modeling is to see how well the observed lake levels (including the record low levels) can be explained by surface water flows only (i.e., the aquifer water level will be held constant during the simulation). We will then proceed with the ground water model to refine the predictions by varying the aquifer head during the simulation.

Appendix A:

A history of the Cherry Lake outfall structure, Lake Levels vs Discharge Rate


Cherry Lake Stage and Discharge
1956 - 1958
Stage
Discharge Rate
Stage (ft NGVD)
Discharge Rate (cfs)
Date
99
98
97
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91
800
600
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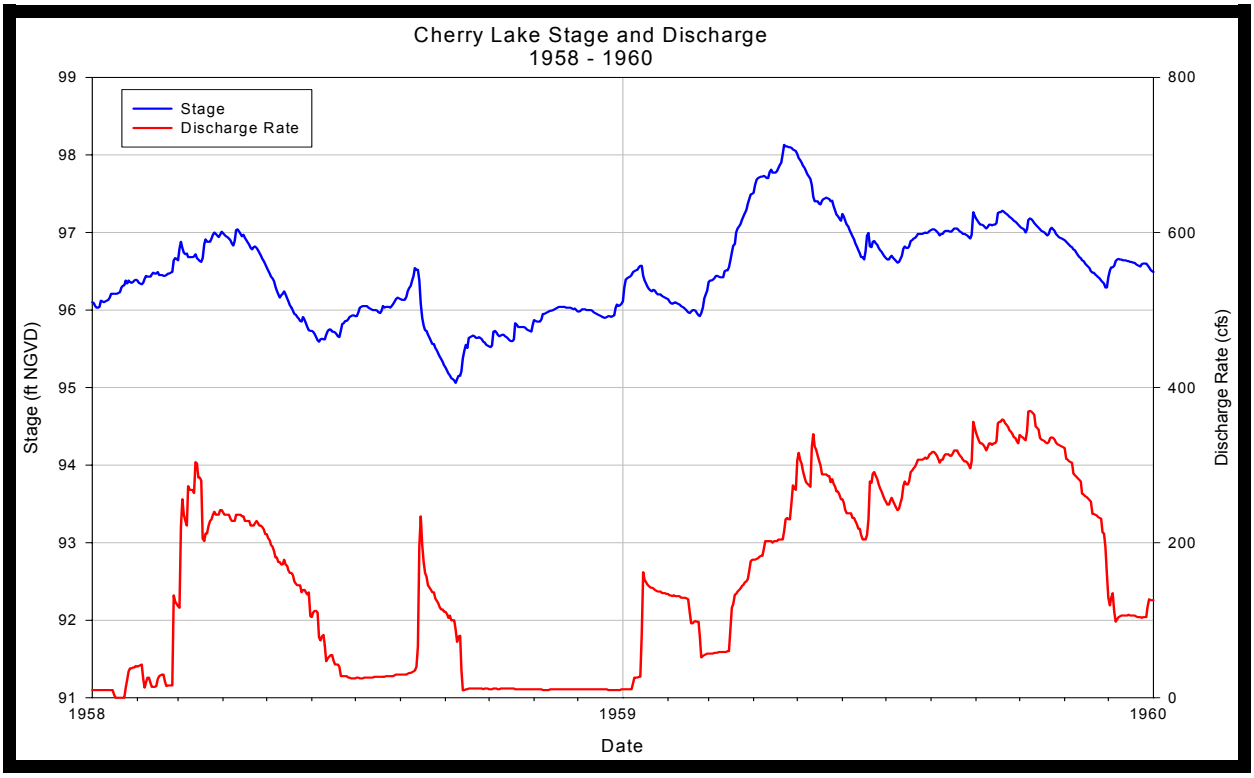
1956
1957
1958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1958 - 1960
Stage
Discharge Rate
Stage (ft NGVD)
Discharge Rate (cfs)
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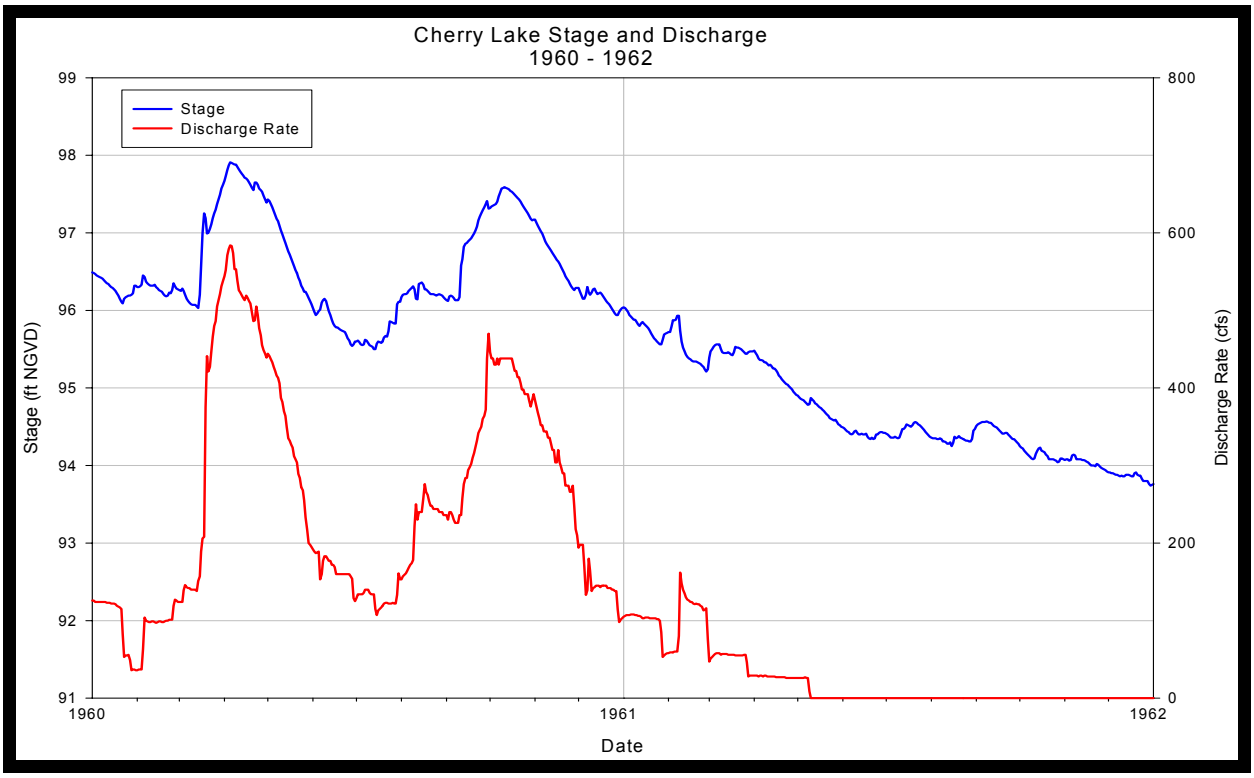
1959
1960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1960 - 1962
Stage
Discharge Rate
Stage (ft NGVD)
Discharge Rate (cfs)
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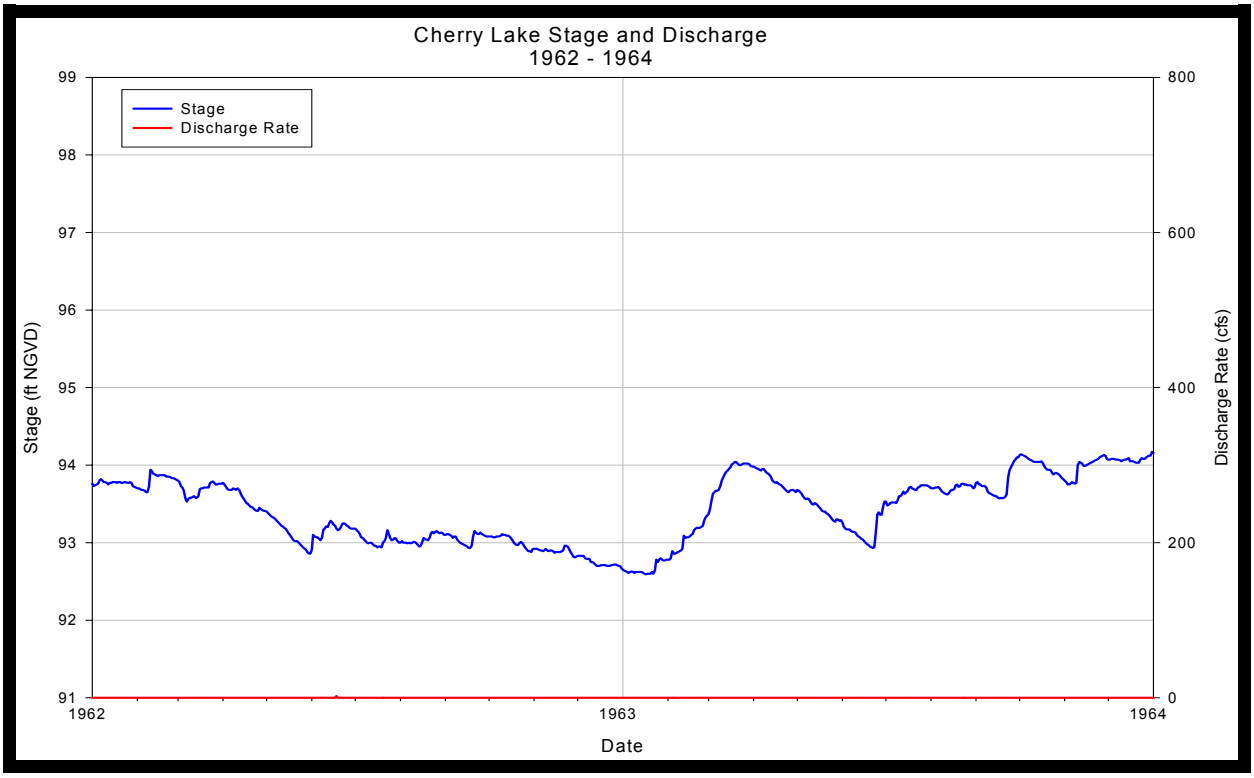
1960
1961
1962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Discharge Rate
Stage (ft NGVD)
Discharge Rate (cfs)
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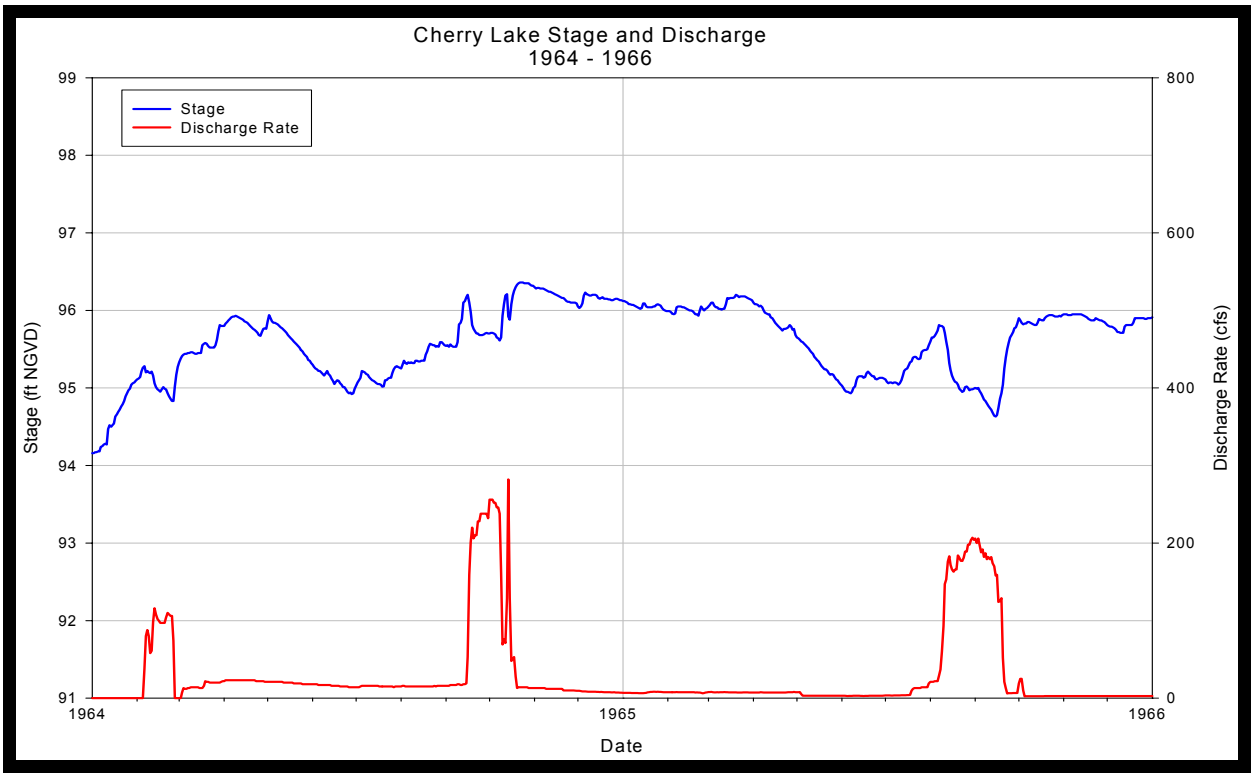
1964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1964 - 1966
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Discharge Rate
Stage (ft NGVD)
Discharge Rate (cfs)
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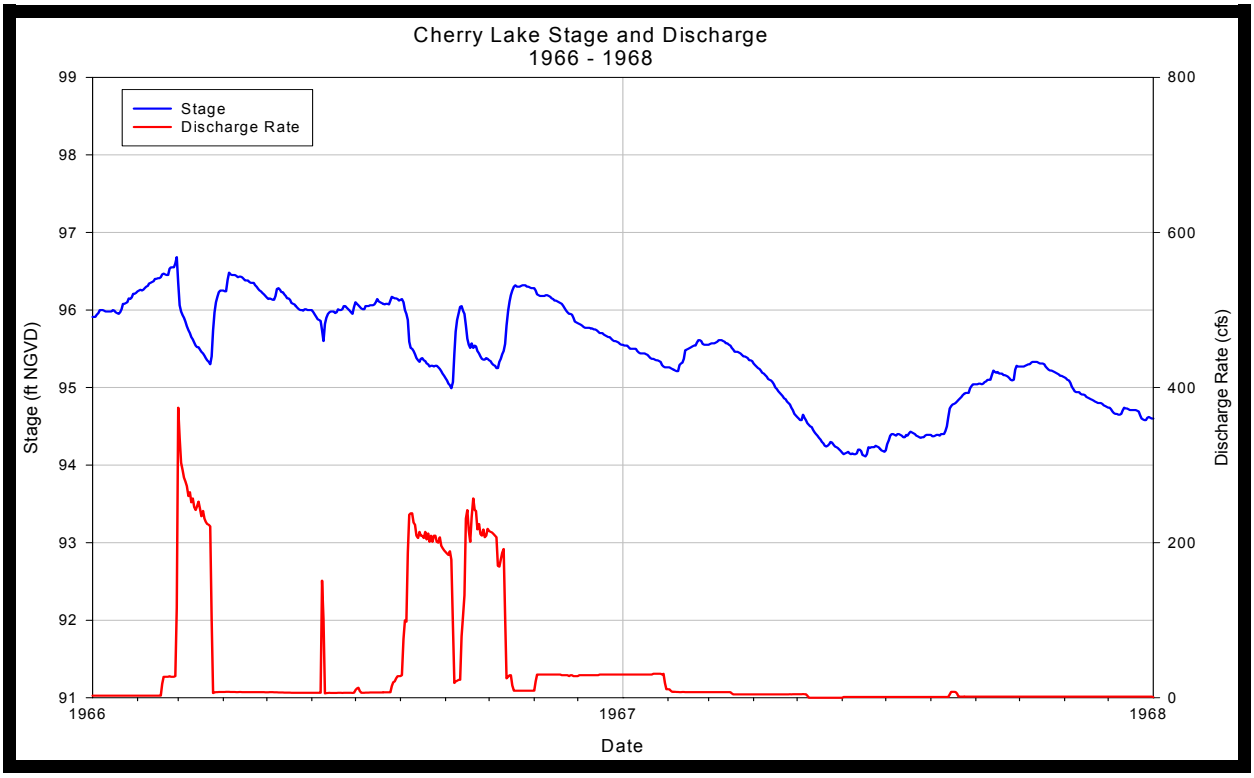
Cherry Lake Stage and Discharge
1966 - 1968
Stage
Discharge Rate
Stage (ft NGVD)
Discharge Rate (cfs)
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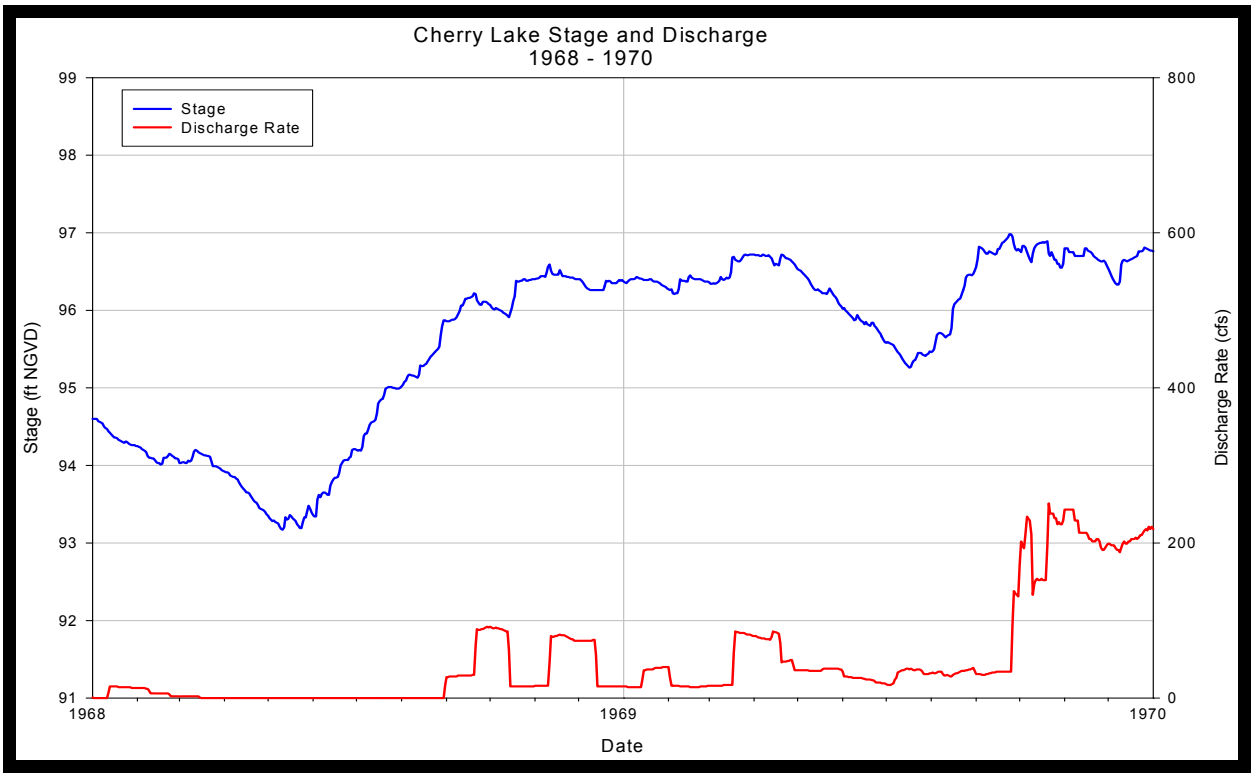
1968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1968 - 1970
Stage
Discharge Rate
Stage (ft NGVD)
Discharge Rate (cfs)
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1968
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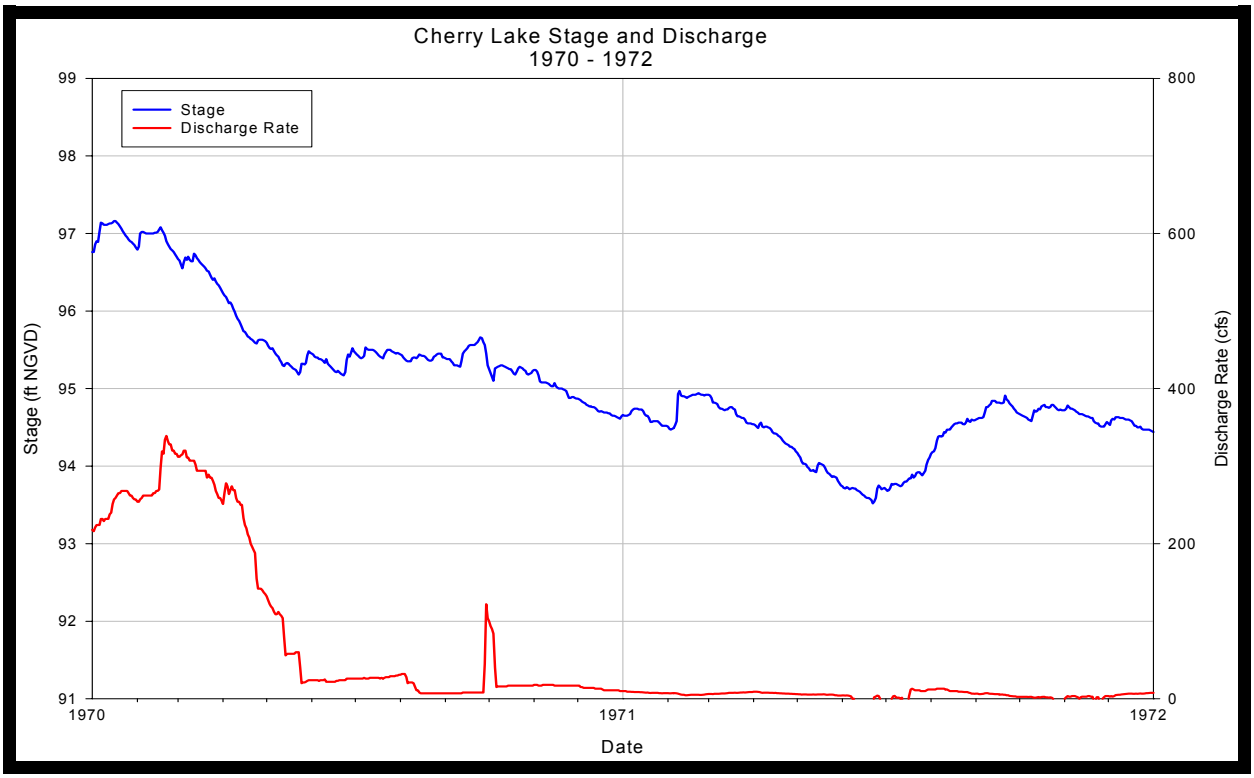
1970


Cherry Lake Stage and Discharge
1970 - 1972
Stage
Discharge Rate
Stage (ft NGVD)
Discharge Rate (cfs)
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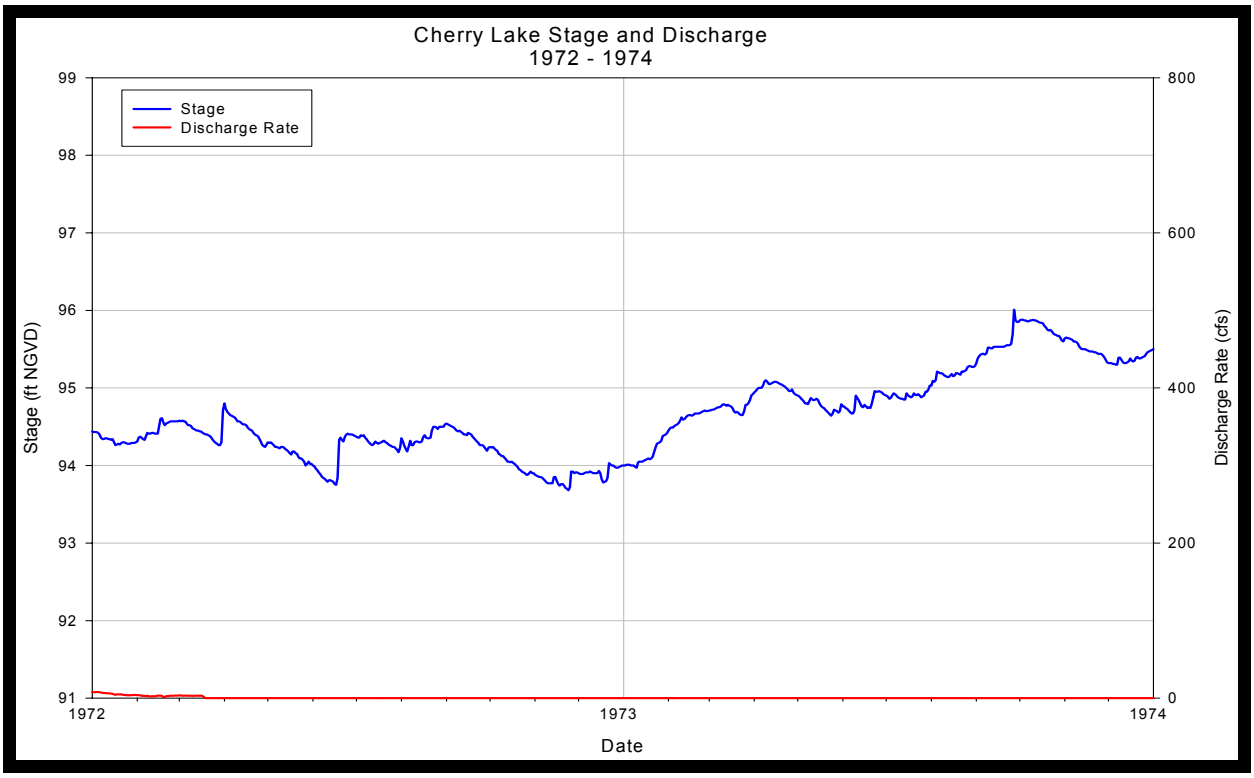
1972


Cherry Lake Stage and Discharge
1972 - 1974
Stage
Discharge Rate
Stage (ft NGVD)
Discharge Rate (cfs)
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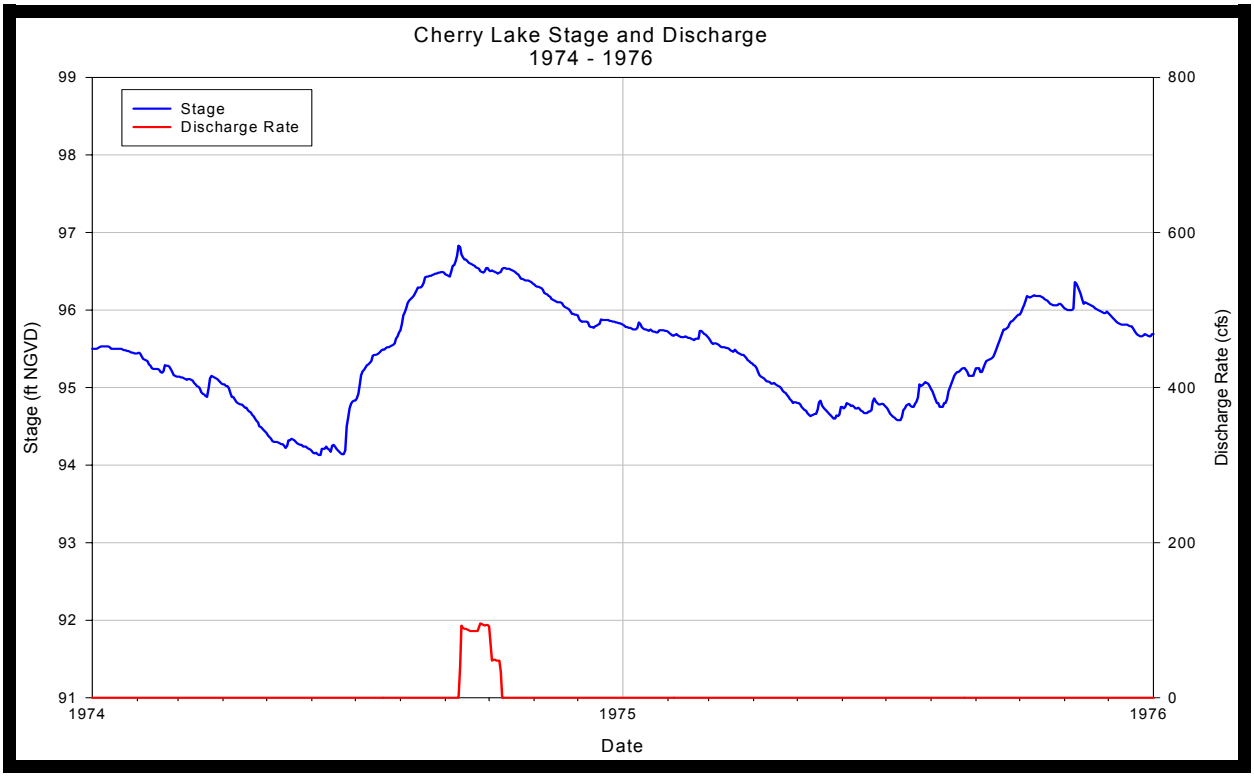
1972
1973
1974


Cherry Lake Stage and Discharge
1974 - 1976
Stage
Discharge Rate
Stage (ft NGVD)
Discharge Rate (cfs)
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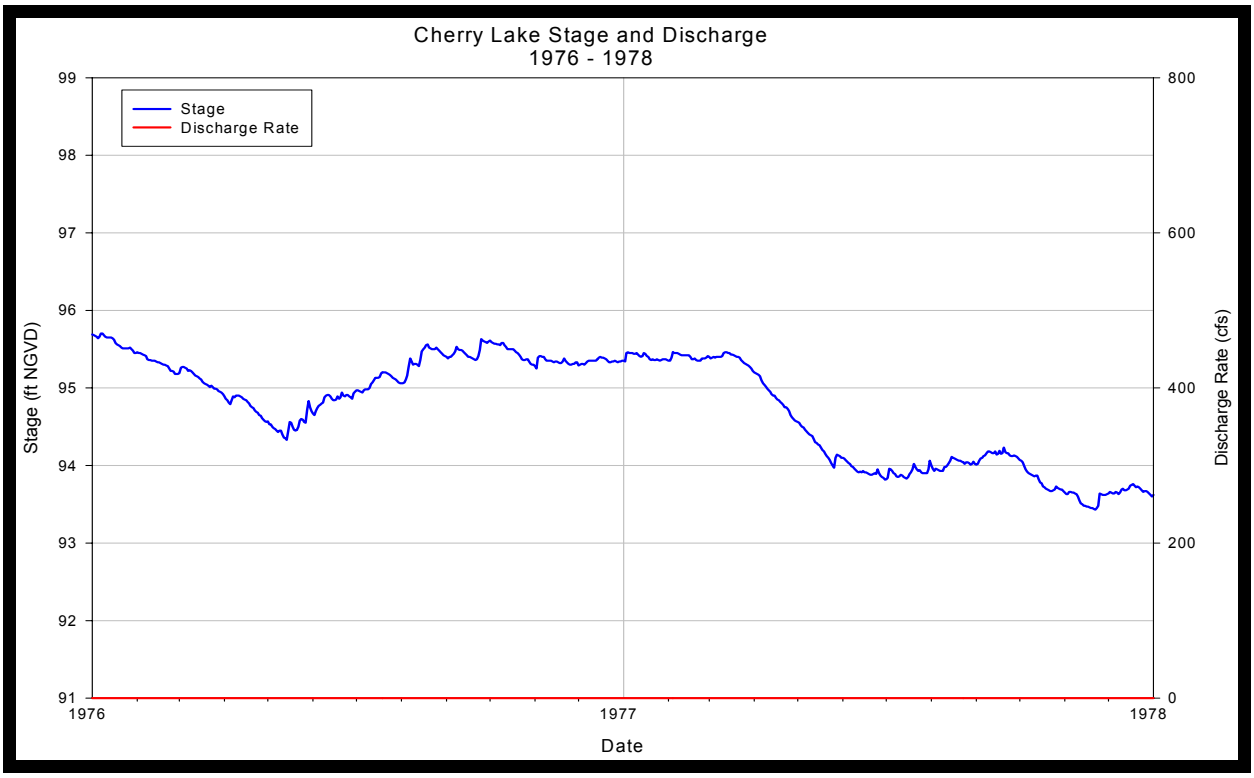
1976


Cherry Lake Stage and Discharge
1976 - 1978
Stage
Discharge Rate
Stage (ft NGVD)
Discharge Rate (cfs)
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1976
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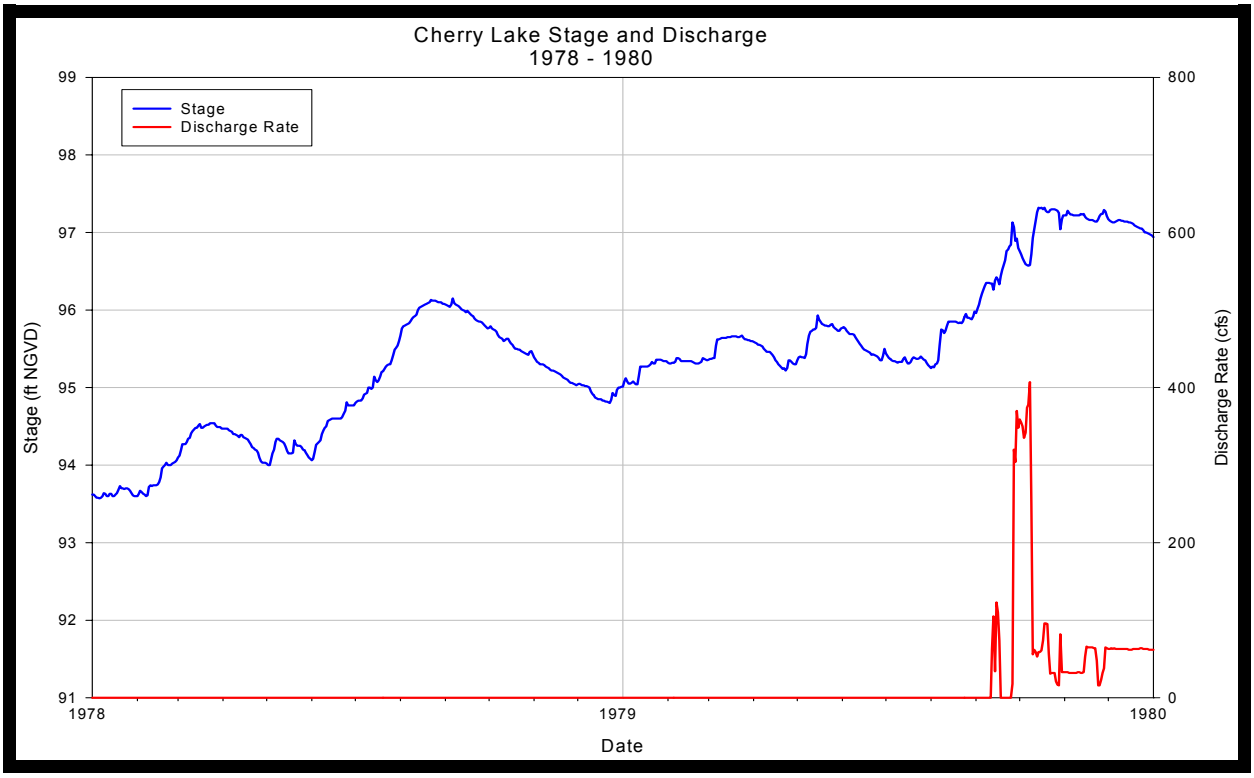
1978


Cherry Lake Stage and Discharge
1978 - 1980
Stage
Discharge Rate
Stage (ft NGVD)
Discharge Rate (cfs)
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1978
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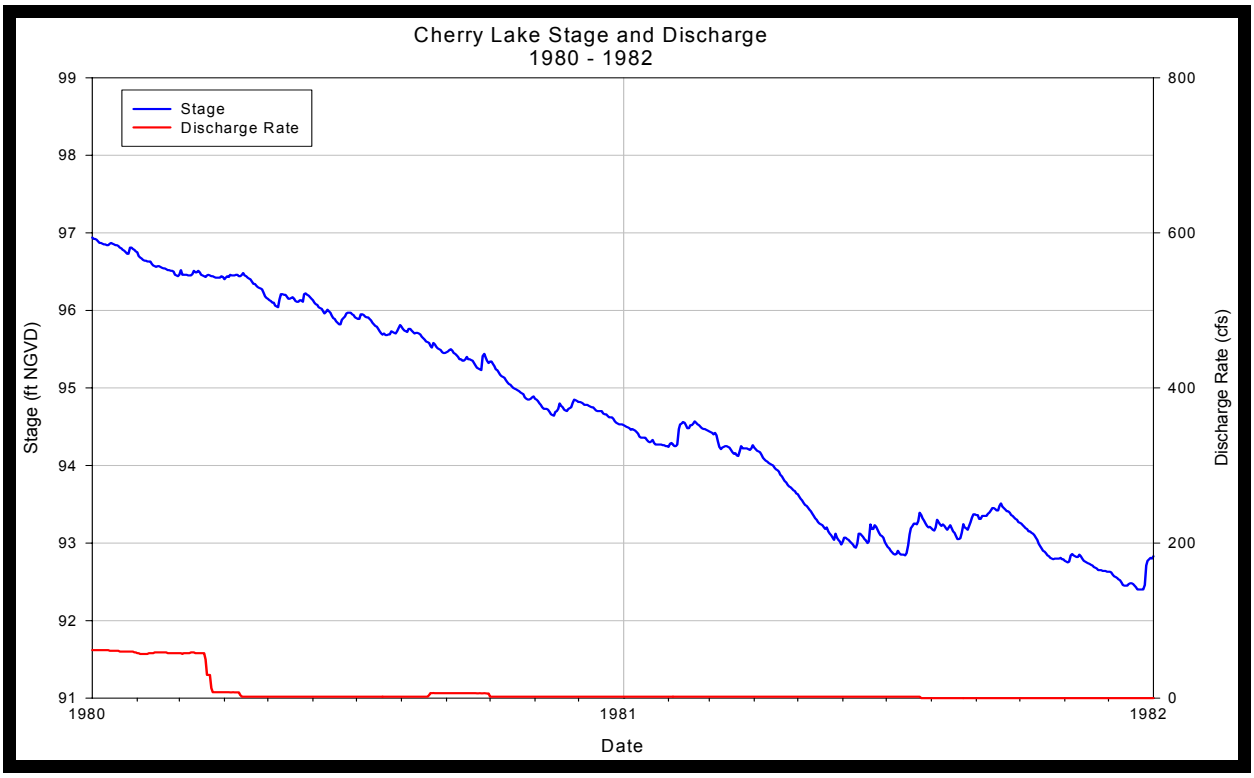
1980


Cherry Lake Stage and Discharge
1980 - 1982
Stage
Discharge Rate
Stage (ft NGVD)
Discharge Rate (cfs)
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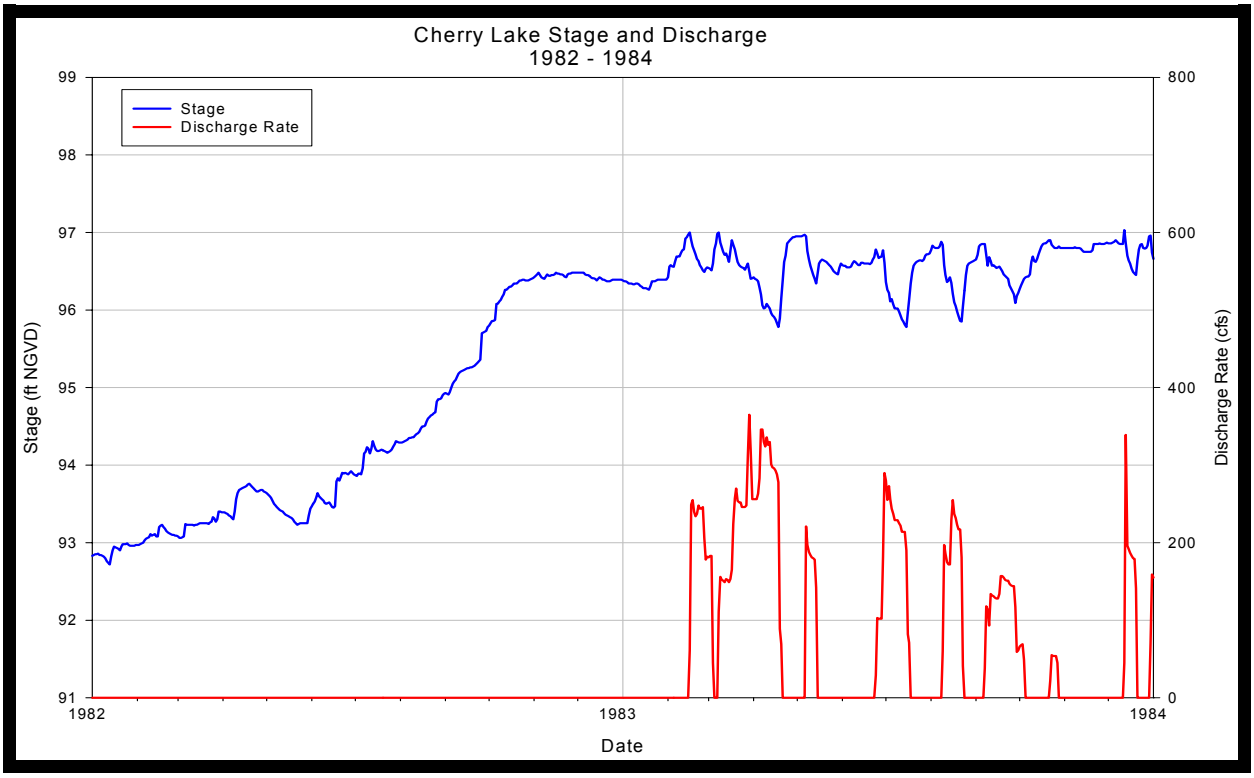
1980
1981
1982


Cherry Lake Stage and Discharge
1982 - 1984
Stage
Discharge Rate
Stage (ft NGVD)
Discharge Rate (cfs)
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400
200
0
1982
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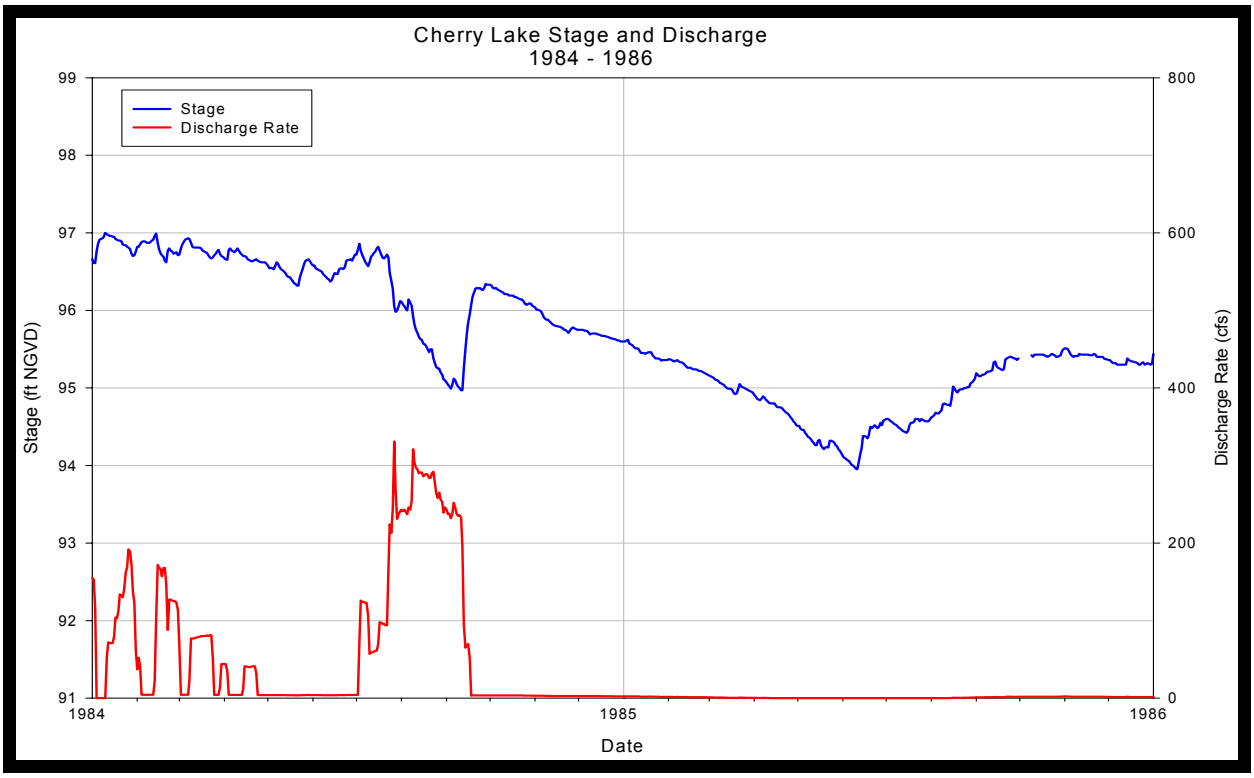
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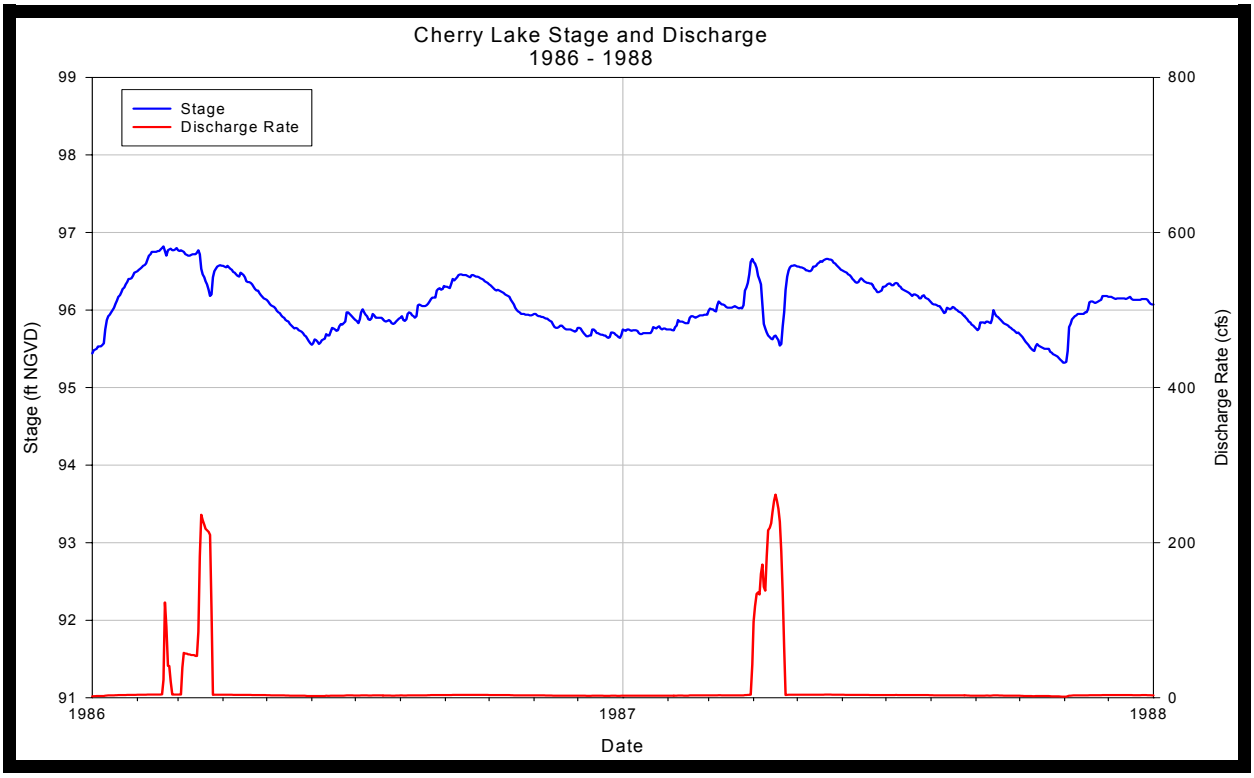
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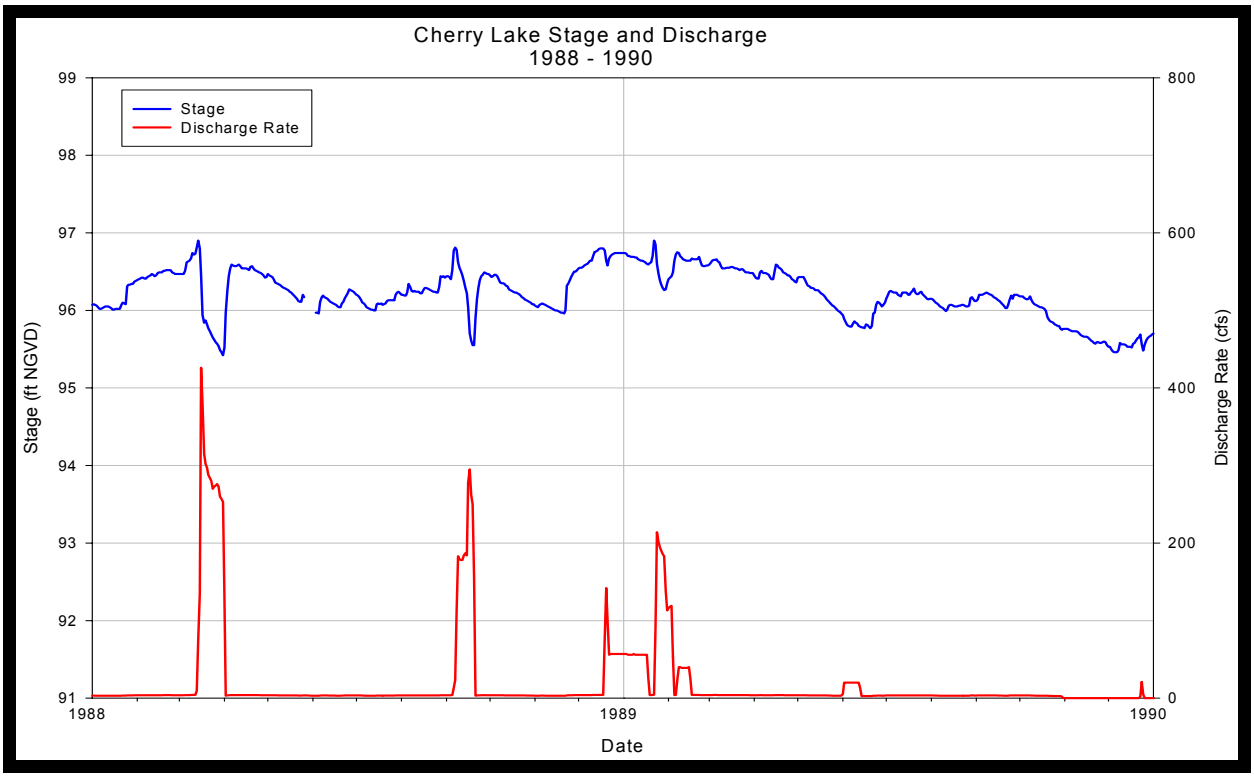
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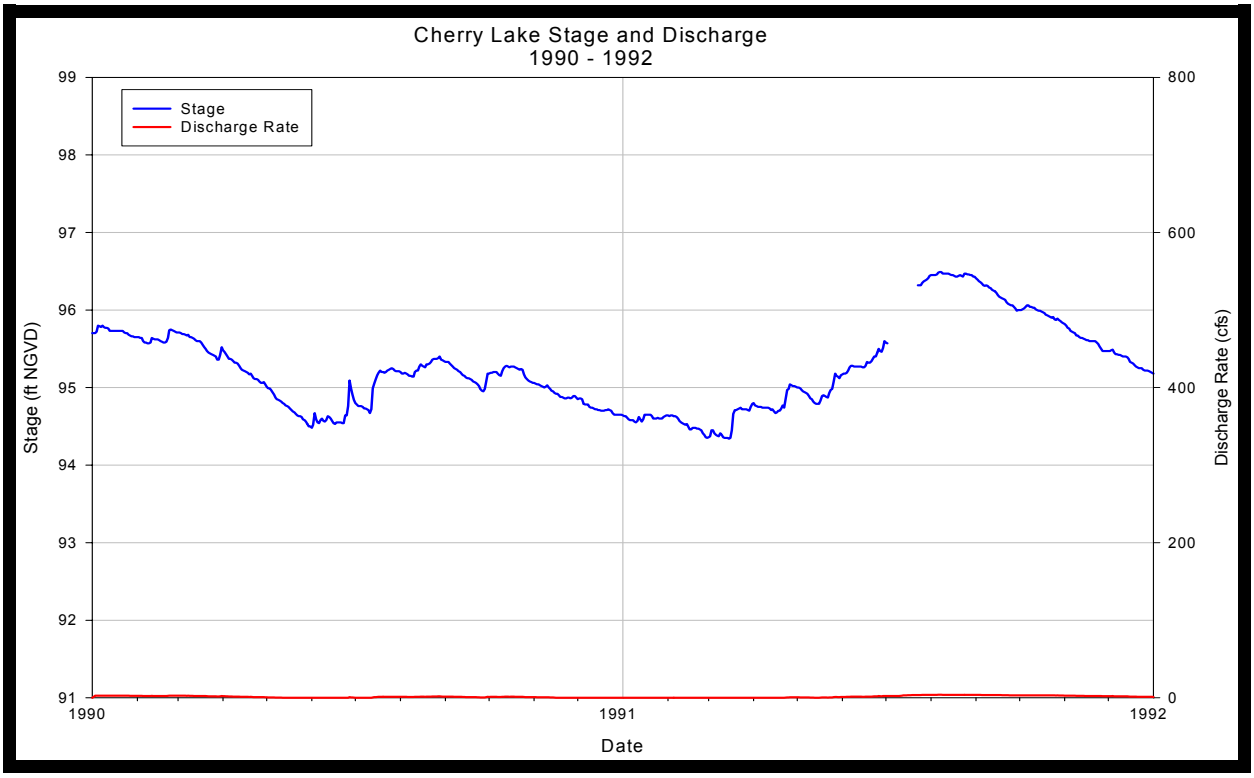
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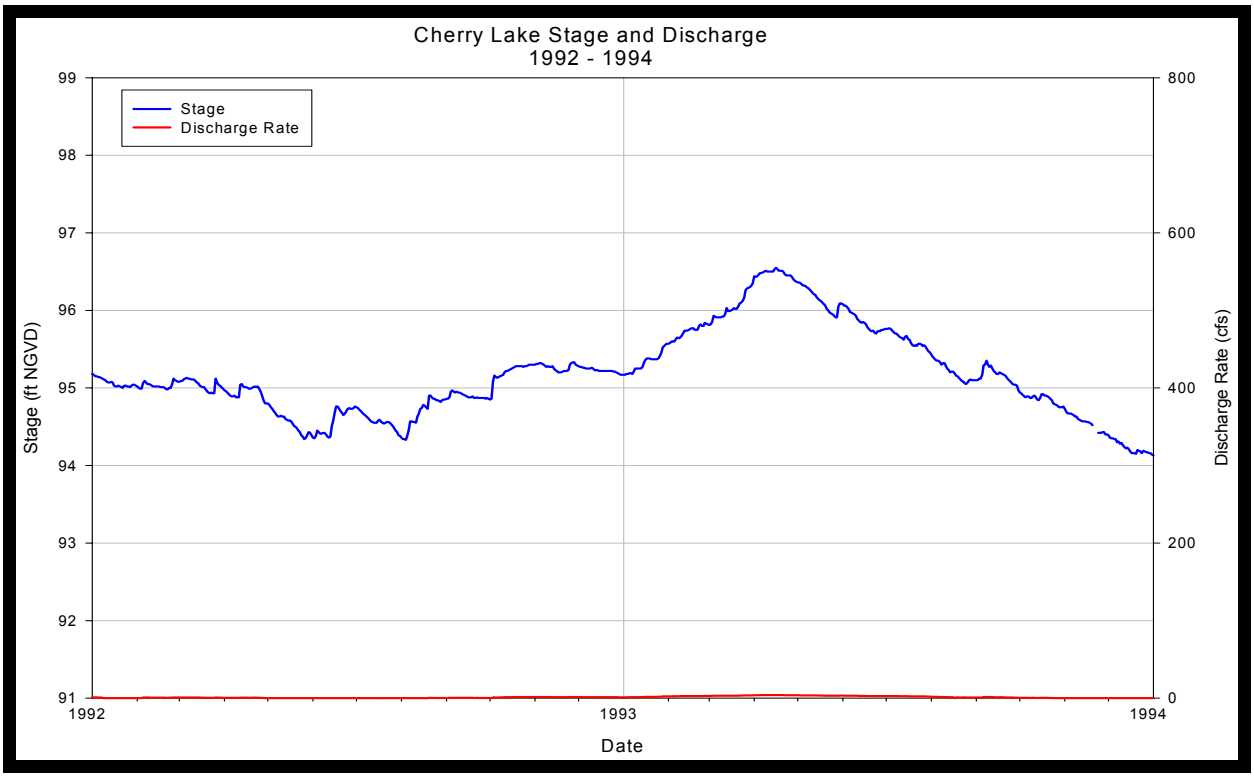
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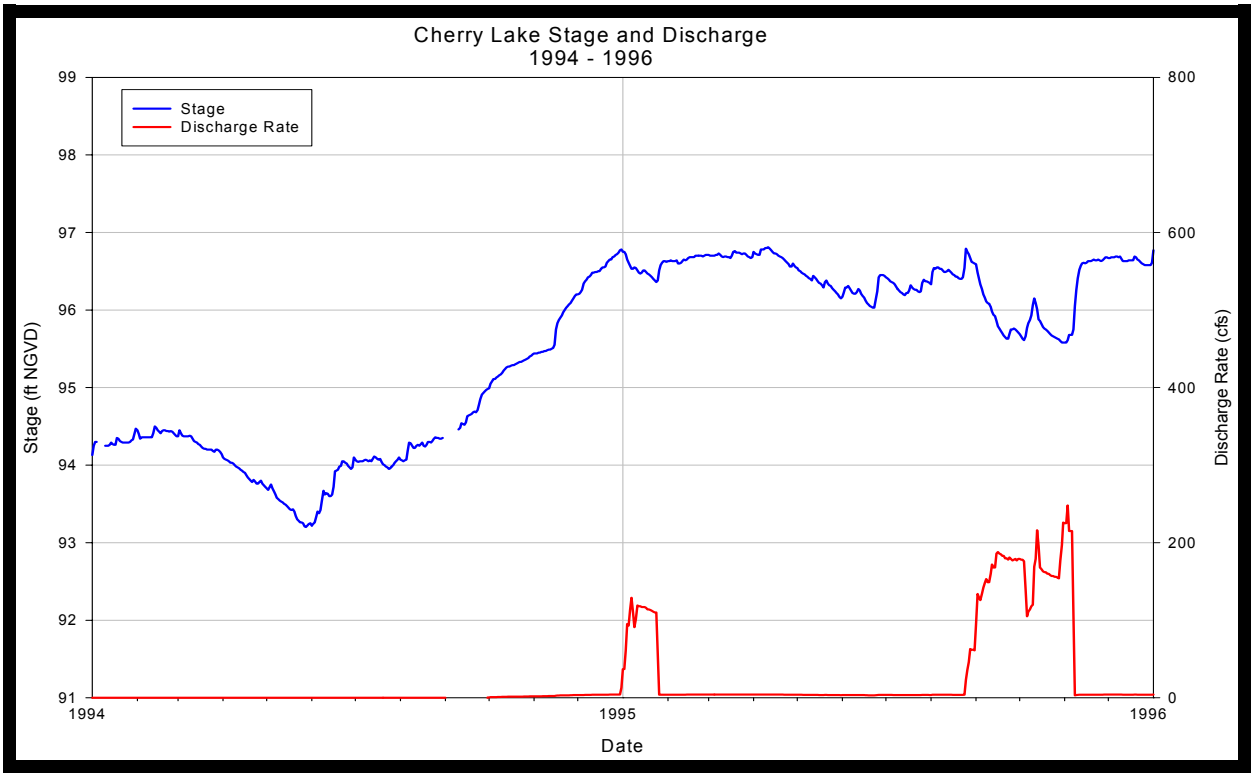
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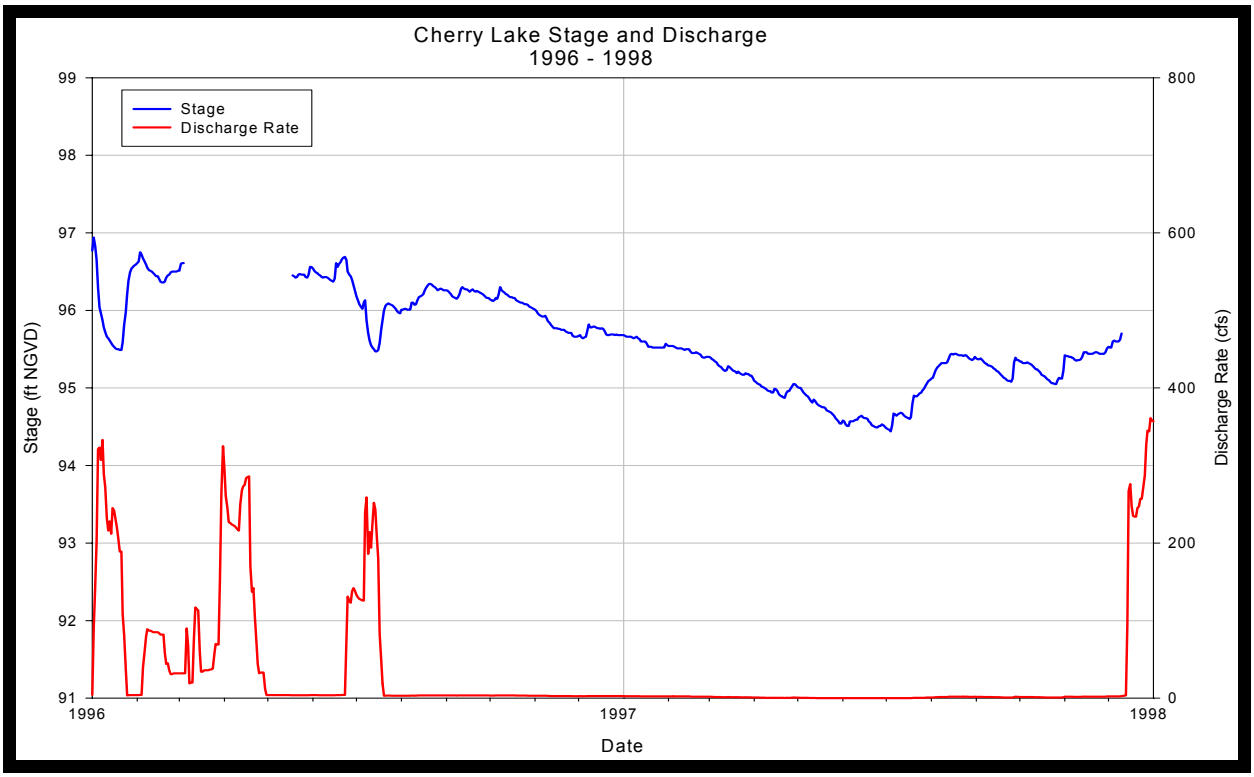
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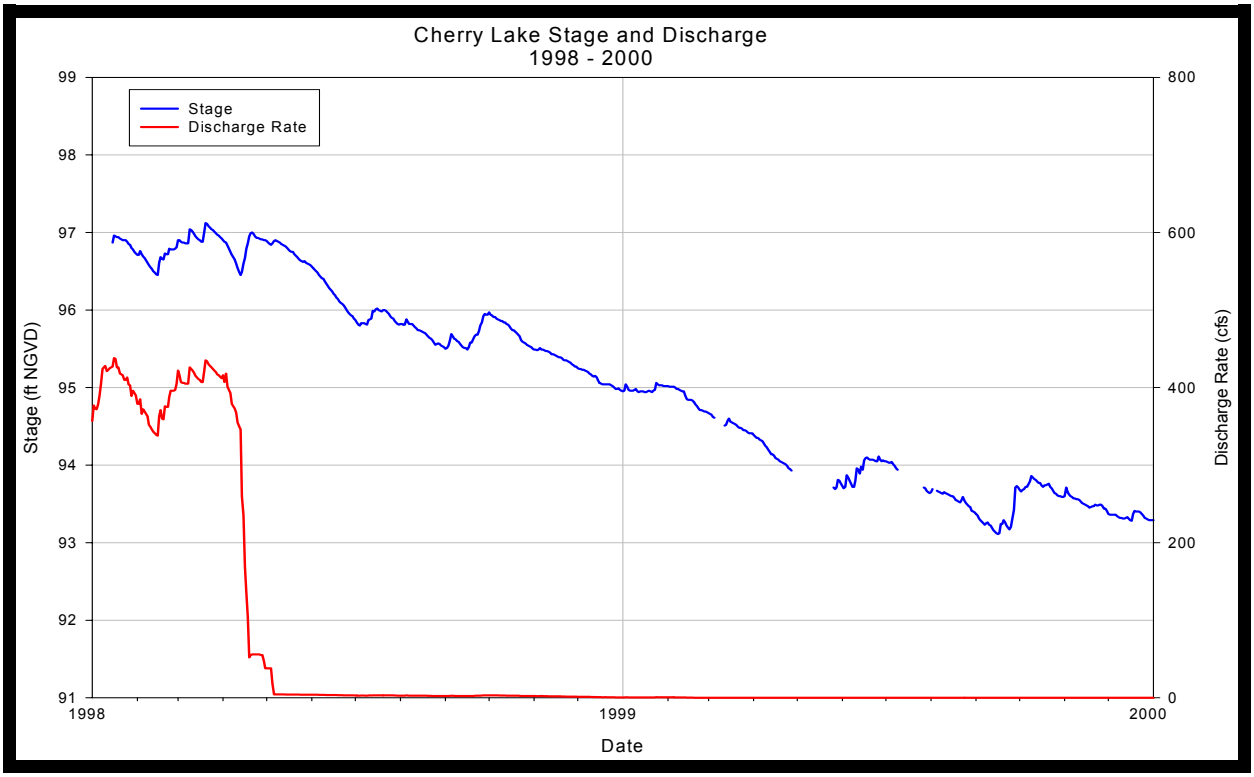
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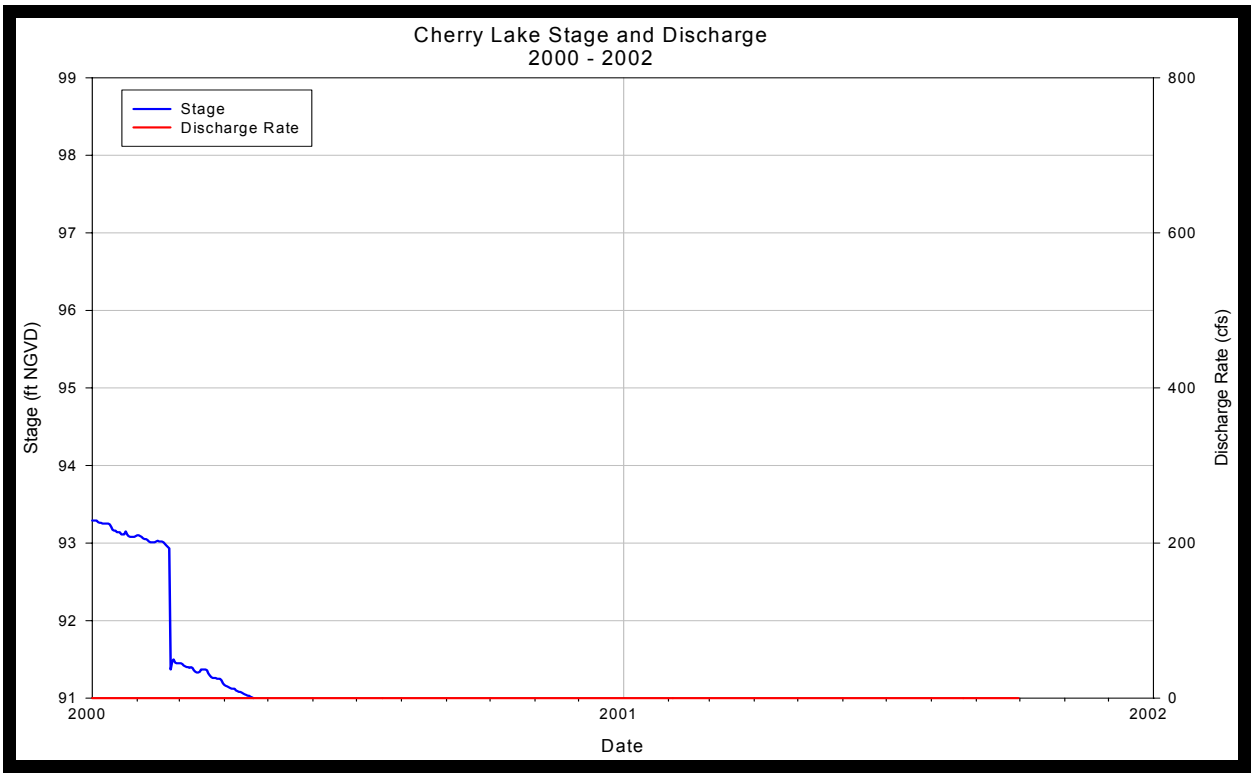
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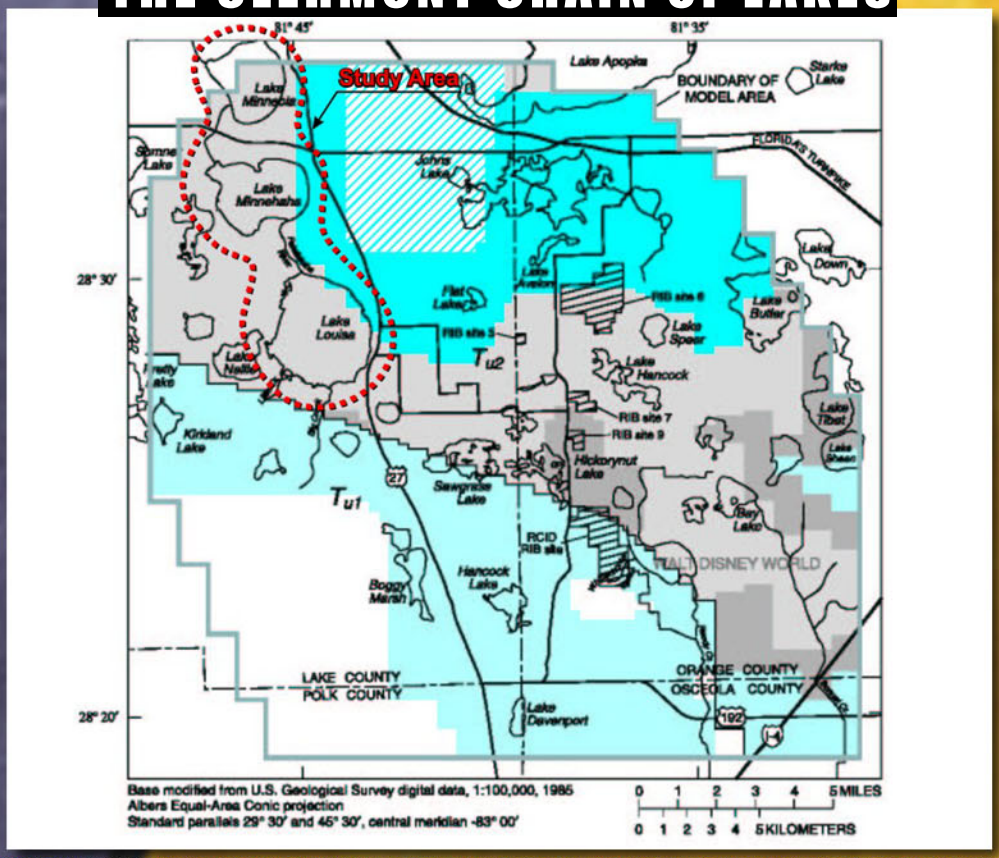
TECHNICAL MEMO #4: HYDROLOGIC OVERVIEW OF STUDY AREA

Ground water / Surface water interaction modeling for portion of South Lake County (FL) which encompasses

THE CLERMONT CHAIN OF LAKES



Prepared for

ICWA

Lake County Water Authority

PEC

Professional Engineering Consultants, Inc.

Prepared by

DEVO Engineering

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Date: May 22, 2003	*Devo's Project No.* 02-121.96
To: Lake County Water Authority 107 North Lake Avenue Tavares, Fl 32778-3119 phone: 352-343-3777 fax: 352-343-4259 attention: **LANCE LUMBARD**	*cc:* Professional Engineering Consultants, Inc. 200 East Robinson Street, Suite 1560 Orlando, FL 32801 phone: 407-422-8062 fax: 407-849-9401 attention: **DAVID HAMSTRA, P.E.**
LCWA Lake County Water Authority	PEC
Ref: **TECHNICAL MEMO #4** **HYDROGEOLOGIC OVERVIEW OF STUDY AREA – CLERMONT CHAIN OF LAKES STUDY**	

Dear Mr. Lumbard:

The attached technical memo summarizes the geology and hydrogeology of the Clermont Chain of Lakes study area. The area of interest is characterized by a unique hydrogeologic regime wherein some of the lakes and water bodies (wetlands, etc) are well connected to the underlying Floridan aquifer and others are less well connected (somewhat perched). Our models incorporate this hydrogeologic framework.

Sincerely,
Robert Casper
Robert D. Casper, E.I.
Project Engineer

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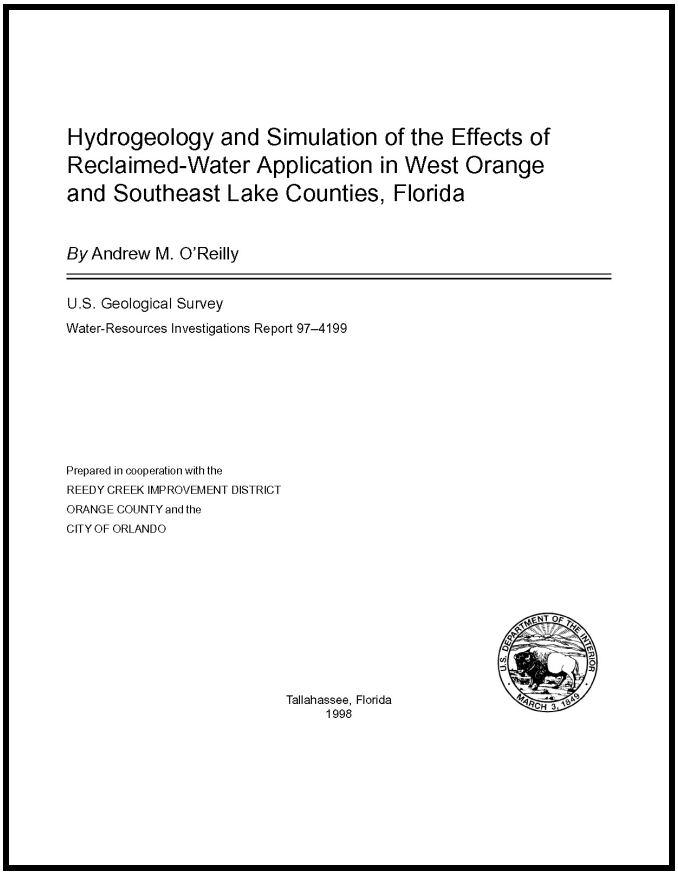
HYDROGEOLOGIC OVERVIEW

The U.S. Geological Survey conducted a recent hydrogeologic overview and subregional ground water model which encompasses portions of Orange, Lake, Osceola, and Polk Counties (O'Reilly, 1997, see Exhibit 1 for reference).



Hydrogeology and Simulation of the Effects of Reclaimed-Water Application in West Orange and Southeast Lake Counties, Florida

By Andrew M. O'Reilly

U.S. Geological Survey

Water-Resources Investigations Report 97–4199

Prepared in cooperation with the
REEDY CREEK IMPROVEMENT DISTRICT
ORANGE COUNTY and the
CITY OF ORLANDO

Tallahassee, Florida
1998

Exhibit 1. USGS report reference

PHYSIOGRAPHY

The Chain of Lakes study area lies within physiographic region known as the Lake Upland (Exhibit 2). It is on the western flank of the Lake Wales Ridge.

CLIMATE

Long-term average annual rainfall in central Florida is 51 inches based on 80 years of record (1913–92) for Orlando and Sanford (Murray and Halford, 1996). However, annual rainfall varies from year to year; for example at one rain gage site, annual rainfall was 80 percent higher in 1994 (70 in) than in 1993 (39 in).

Rainfall in central Florida follows seasonal trends. Between 69 and 77% of the total annual rainfall typically occurs during the 5-month period from June through October. This seasonal variation is corroborated by long-term monthly rainfall data and leads to significant seasonal trends in surface-water and ground-water levels and stream discharge.

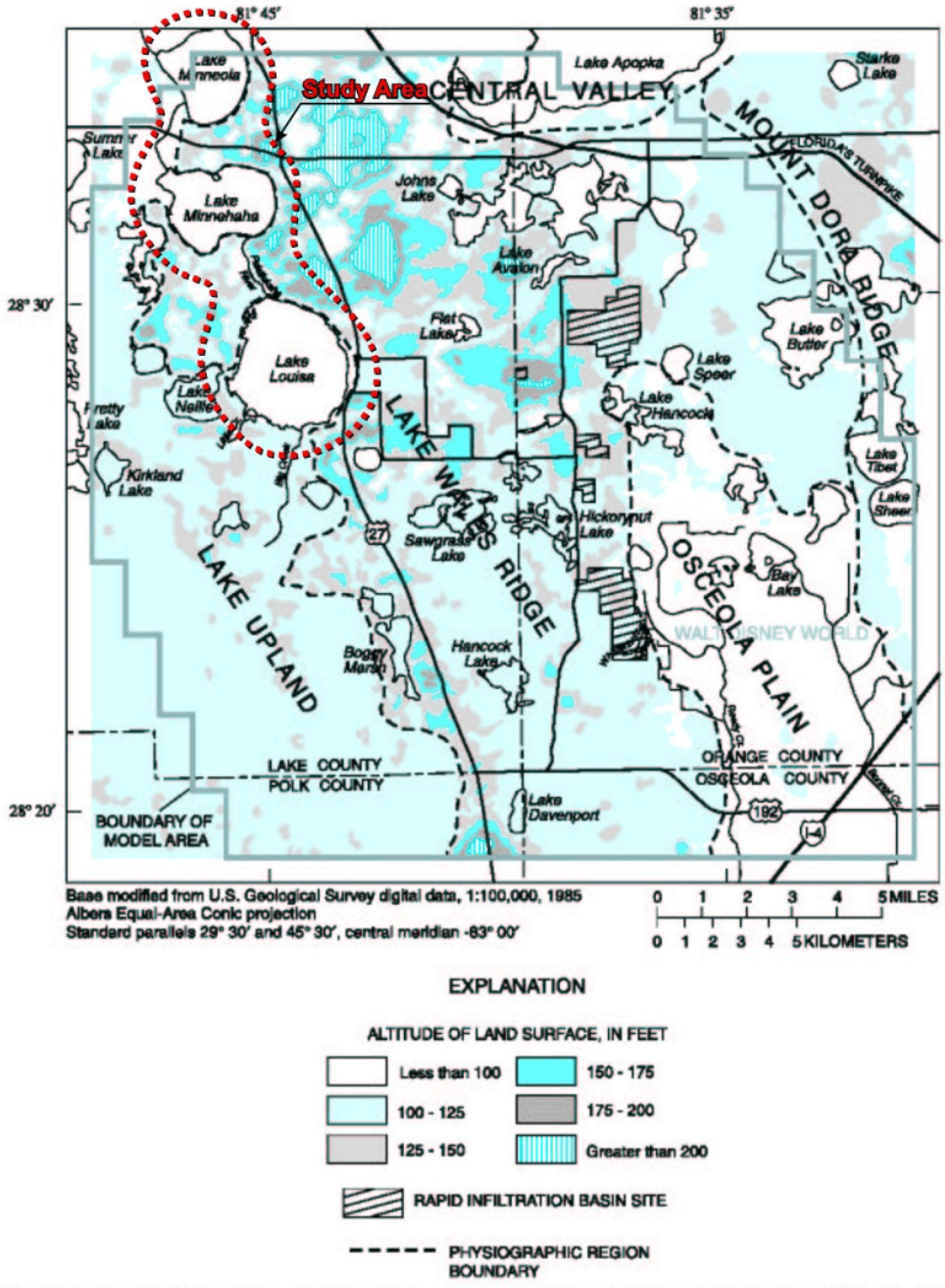


Figure 5. Generalized topography and physiographic regions in the study area (physiographic regions modified from White (1970) and Knochenmus and Hughes (1976)).

Hydrologic Setting 13

Exhibit 2. Physiographic Regions

Hydrogeologic Units

The ground-water flow system beneath the study area is a multi-aquifer system that consists of a thick sequence of carbonate rocks overlain by unconsolidated deposits of sand, silt, and clay. The hydrogeologic units are the surficial aquifer system, the intermediate confining unit, and the Floridan aquifer system (Exhibit 3). Beneath the Floridan aquifer system is marine dolomite that contains considerable gypsum and anhydrite of low permeability and defines the bottom of the freshwater flow system in the study area.

The surficial aquifer system is the uppermost water-bearing unit in the study area. The system is unconfined and consists mainly of undifferentiated deposits of marine sand, silt, clay, and crushed shell of late Pliocene to Recent age (Exhibit 3). The upper boundary of the system is defined by the water table, which in most areas is a subdued reflection of land-surface topography. The base of the surficial aquifer system is defined by the first persistent bed containing a significant increase in silt and clay of Miocene or Pliocene age. Thickness of the system averages about 50 ft but ranges from less than 25 ft in low-lying areas around Reedy Creek to greater than 200 ft at and near collapse features located along karstic ridge areas.

The fine- to medium-grained sand that characterizes much of the surficial aquifer system contains relatively small amounts of fine-grained sediments and is quite permeable. Grain-size analyses of core samples collected during drilling operations indicate that the upper half of the surficial sediments generally are poorly graded and contain less than 10 percent (by weight) silt- and clay-sized particles. Finer-grained cores generally contained 10 to 30 percent (by weight) silt- and clay-sized particles. Most of the finer-grained sediments are near the base of the system, although isolated beds of clayey to silty sand are present in upper parts as well. However, these shallower beds tend to be thin, discontinuous, and only locally affect the ground-water flow system.

The intermediate confining unit separates the surficial and Floridan aquifer systems throughout the study area, except where breached by sinkholes, and retards the vertical exchange of water between these systems. The unit consists of bedded clay, silt, sand, crushed shell, and phosphatic limestone of Miocene age (Hawthorn Group) and, locally, low permeability beds of early Pliocene age (Exhibit 3). Strata of these various lithologies are not present in all areas and where present they usually occur in varying proportions; therefore, the overall lithology of the intermediate confining unit is quite variable. Beds of basal Hawthorn limestone that are in direct contact with the limestone of the Upper Floridan aquifer generally are not considered to be part of the Floridan aquifer system because the beds occur locally and the hydraulic conductivity of the Hawthorn limestone is at least an order of magnitude less than that of the Floridan limestone (Murray and Halford, 1996).

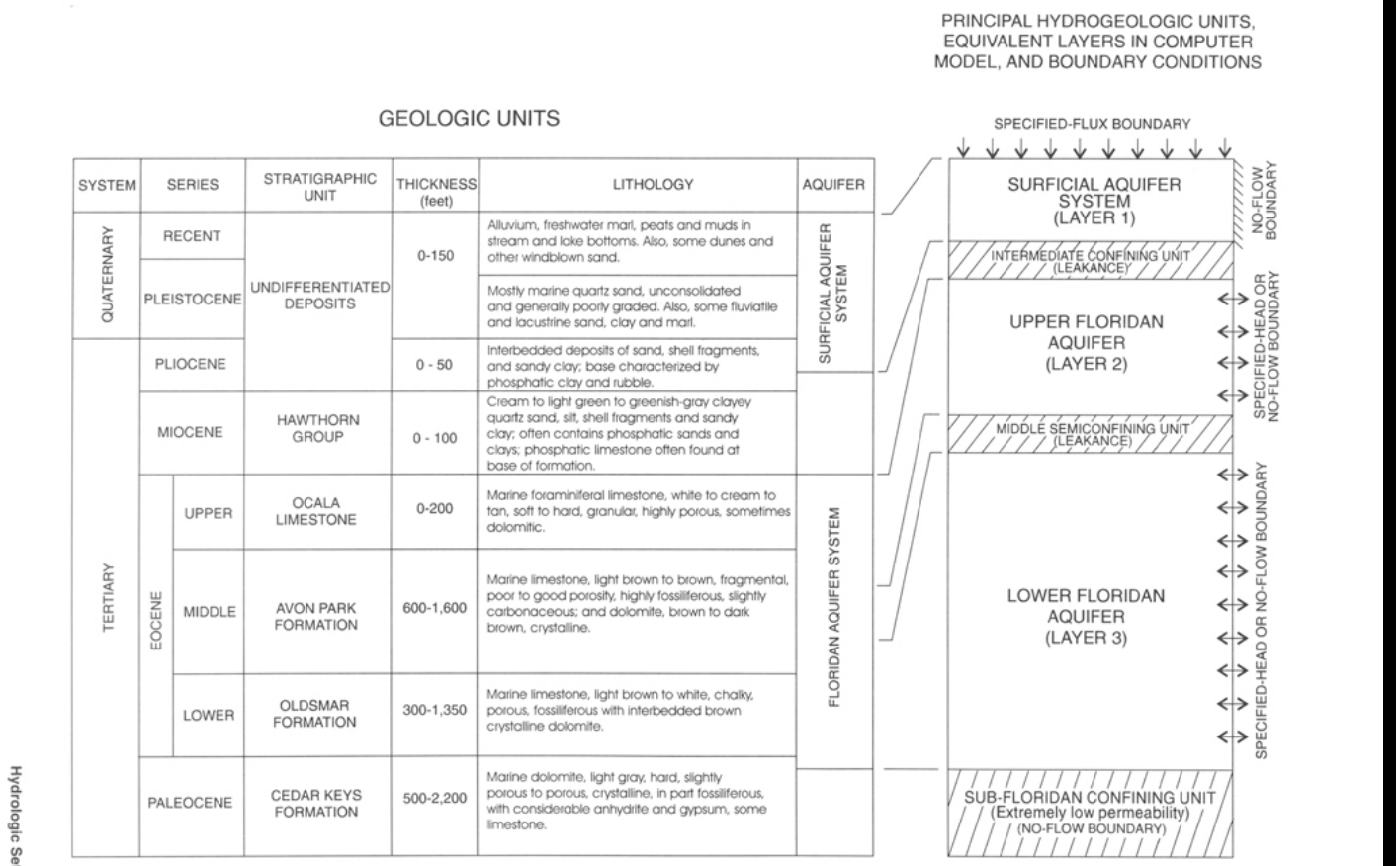


Figure 7. Geologic units, hydrogeologic units, and equivalent layers and boundary conditions used in ground-water flow model (modified from Murray and Halford, 1996, fig. 4).

Hydrologic Setting 15

Exhibit 3. Hydrogeologic Units

The altitude of the top and thickness of the intermediate confining unit are highly variable, owing to the effects of past erosional processes and sinkhole formation. Where present, the top of the unit generally ranges from less than 50 ft below to greater than 75 ft above sea level across the study area (Exhibit 4). Intermediate confining unit thickness ranges from less than 25 ft in the southwestern part of the study area and localized areas in the center of the study area, to greater than 150 ft in the northeastern part (Exhibit 5).

The contours for the top and thickness of the unit (Exhibits 4 and 5) are highly generalized and are based on lithologic and geophysical data collected at the indicated sites. Actual tops and thicknesses can vary considerably from those shown in Exhibits 4 and 5 because of the presence of local erosional and collapse features in the underlying limestone. The Clermont Chain of Lakes study area is annotated on both Exhibits 4 and 5 which indicates that the altitude of the top of the intermediate confining unit is between +50 and +75 ft NGVD and its thickness is approximately 50-75 ft.

The Floridan aquifer system is composed of a sequence of highly permeable Tertiary carbonate rocks of Eocene age that average about 2,300 ft in thickness across the study area. The top of the system is defined by the porous Ocala limestone of upper Eocene age and the base of the system is defined by the first occurrence of relatively impermeable, persistent beds of anhydrite associated with the Cedar Keys Formation of Paleocene age (see Exhibit 3). The system has been subdivided into two major permeable zones, the Upper and Lower Floridan aquifers, separated by the less permeable middle semiconfining unit (Miller, 1986). The Upper Floridan aquifer consists of the Ocala limestone, where present, and the dolomitic limestone of about the upper one-third of the Avon Park Formation and ranges in thickness from about 200 to 400 ft across the study area. The Ocala limestone is absent in some areas as a result of past erosional processes (Lichtler and others, 1968). Because of past erosional and dissolution processes, the top of the Upper Floridan aquifer is highly irregular but generally ranges from an altitude of about +50 ft in northern Polk County to about -50 ft just southeast of Lake Apopka.

The middle semiconfining unit underlies the Upper Floridan aquifer and consists of the less permeable, micritic limestone and dense dolomitic limestone found in about the middle one-third of the Avon Park Formation. The lithologic character of the Avon Park limestone varies considerably with depth and spatially across the study area. The top of the middle semiconfining unit slopes from west to east, from an altitude of about -300 to -350 ft. The thickness of the unit beneath the study area averages about 600 ft (Miller, 1986). The Lower Floridan aquifer underlies the middle semiconfining unit and includes about the bottom one-third of the Avon Park Formation and all of the Oldsmar Formation. The Lower Floridan aquifer dips from north to south across the study area and averages 1,300 ft in thickness (Miller, 1986).

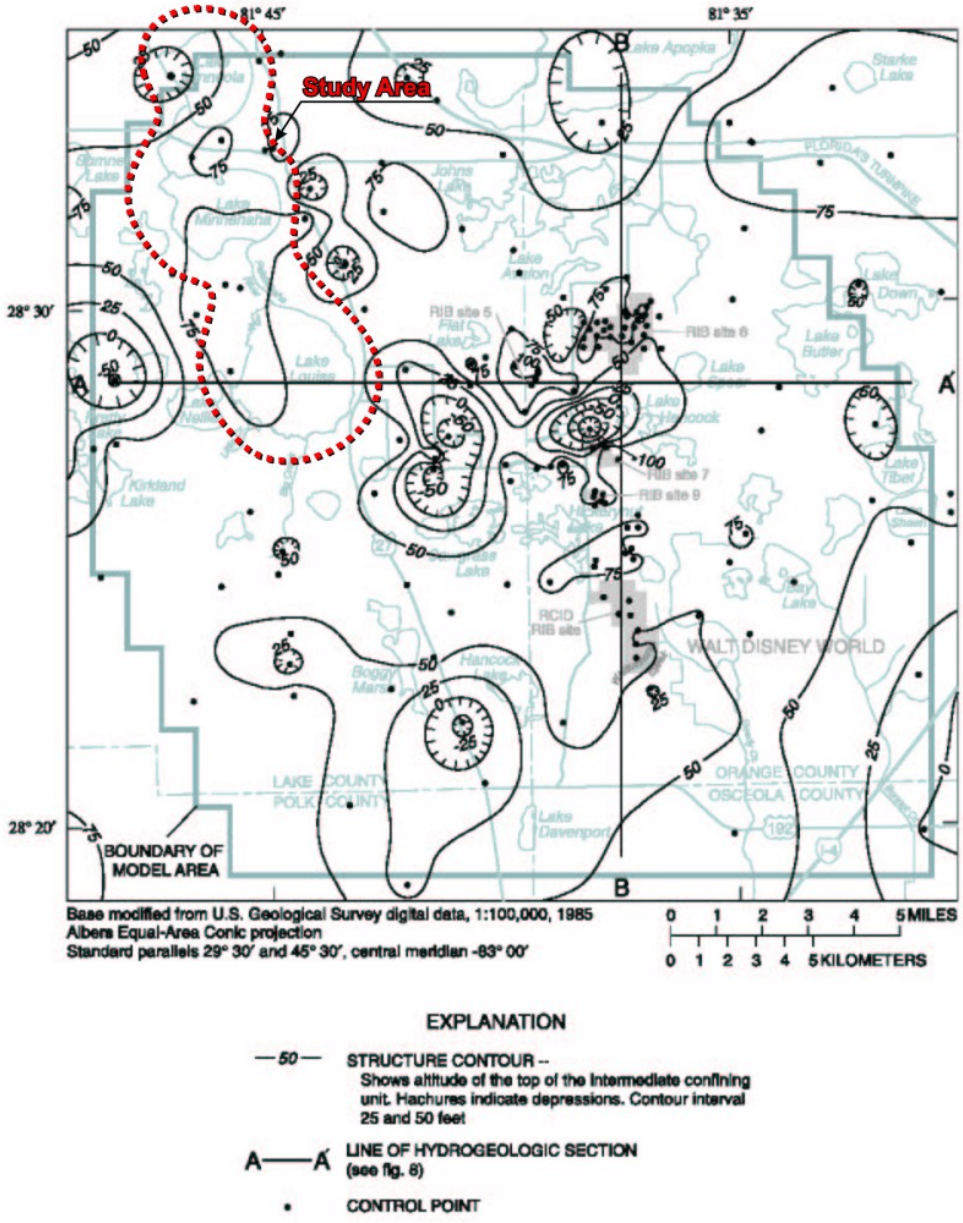


Figure 9. Altitude of the top of the intermediate confining unit and locations of hydrogeologic sections.

Exhibit 4. Top elevation of intermediate confining unit

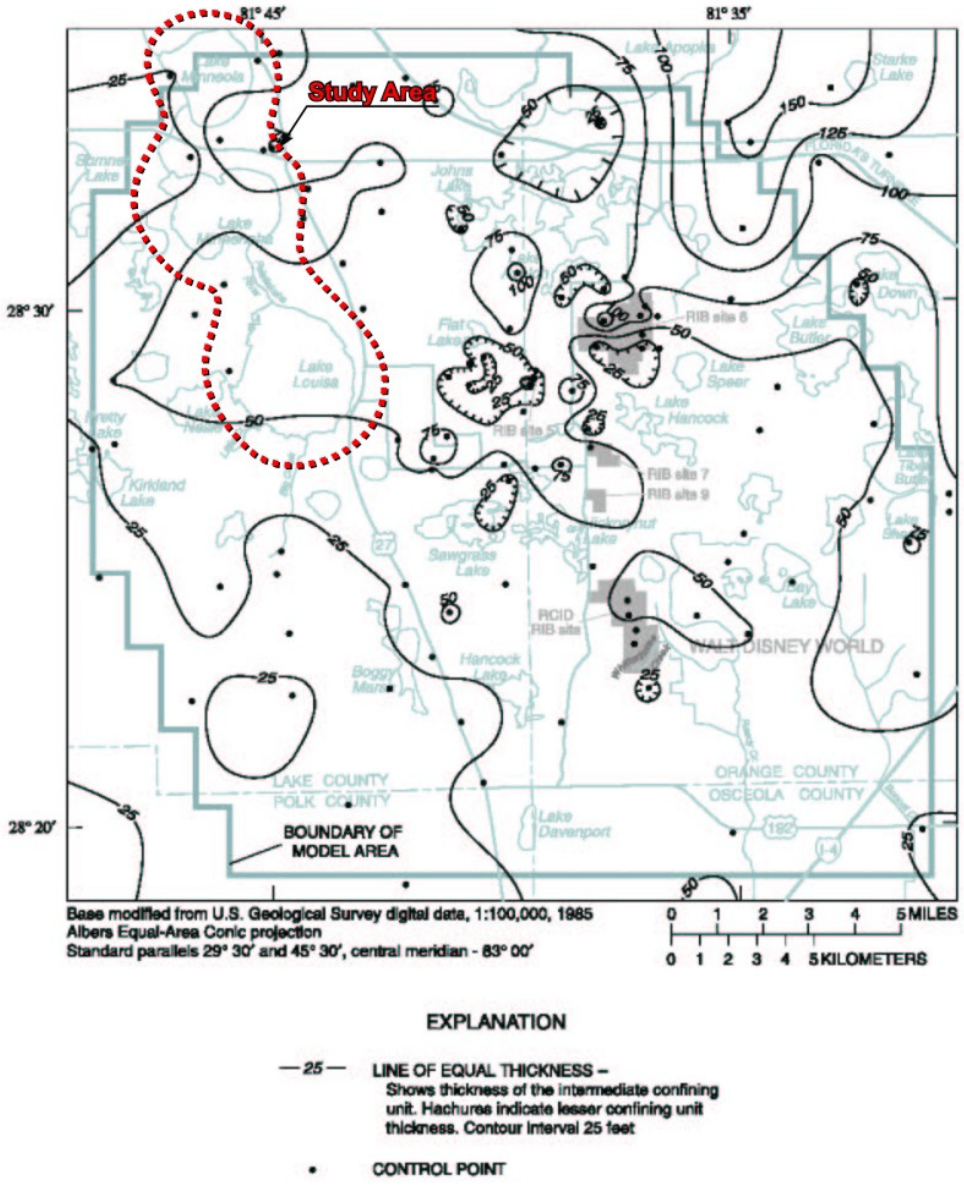


Figure 10. Thickness of the intermediate confining unit.

Exhibit 5. Thickness of intermediate confining unit

Ground Water Flow - System Characteristics

The surficial aquifer system is recharged by rainfall, irrigation, septic-tank effluent, reclaimed water and, in areas where the water table is below the potentiometric surface of the underlying Upper Floridan aquifer, by diffuse upward leakage from the Floridan aquifer system. Water is discharged from the surficial aquifer system through ET in areas with relatively shallow water tables, by lateral seepage to lakes and streams, and by downward leakage to the Floridan aquifer system in areas where the potentiometric surface of the Upper Floridan aquifer is below the water table. Little water is pumped from the surficial aquifer system because well yields are typically low (compared to the Floridan aquifer system) and the water often contains high concentrations of dissolved iron and can be highly colored (Tibbals, 1990).

The Upper Floridan aquifer is recharged by downward leakage from the surficial aquifer system and upward leakage from the Lower Floridan aquifer in areas where the potentiometric surface of the Upper Floridan aquifer is below that of the Lower Floridan aquifer. Excluding recharge from reclaimed water, recharge rates from the surficial aquifer system to the Upper Floridan aquifer have been estimated to range from 3 to 20 in/yr across most of the study area (Murray and Halford, 1996). The aquifer is discharged by pumping wells, Apopka Spring, diffuse upward leakage to the surficial aquifer system (primarily beneath Reedy Creek and Lake Apopka), and by downward leakage to the Lower Floridan aquifer in any areas where the potentiometric surface of the Upper Floridan aquifer is above that of the Lower Floridan aquifer. Nearly all of the water withdrawn by wells in the study area is from the Upper Floridan aquifer.

The potentiometric surface of an aquifer is defined as the level to which water will rise in a tightly cased well which penetrates the aquifer. Exhibit 6 ashows a potentiometric surface map of the upper Floridan aquifer for 1995. As noted, the potentiometric surface of the upper Floridan aquifer in the study area is approximately +80 ft to +95 ft NGVD and the direction of groundwater flow in this aquifer is from south to north-northeast. Exhibit 6b shows specific measurements in the study area for September 2000. Note that these levels are well below the lake levels.

Flow in the Upper Floridan aquifer primarily is regional because the high transmissivity of the Upper Floridan aquifer precludes the formation of significant mounds or depressions in the potentiometric surface that would induce local flow systems. Accordingly, mounds in the potentiometric surface from reclaimed-water application are not apparent.

Seasonal changes in the Upper Floridan aquifer potentiometric surface that were measured during 1995 were typically 3 to 5 ft.
No data exist within the study area on the potentiometric surface of the Lower Floridan aquifer, although what little data exist elsewhere indicate that the potentiometric surface generally is similar to that of the Upper Floridan aquifer.

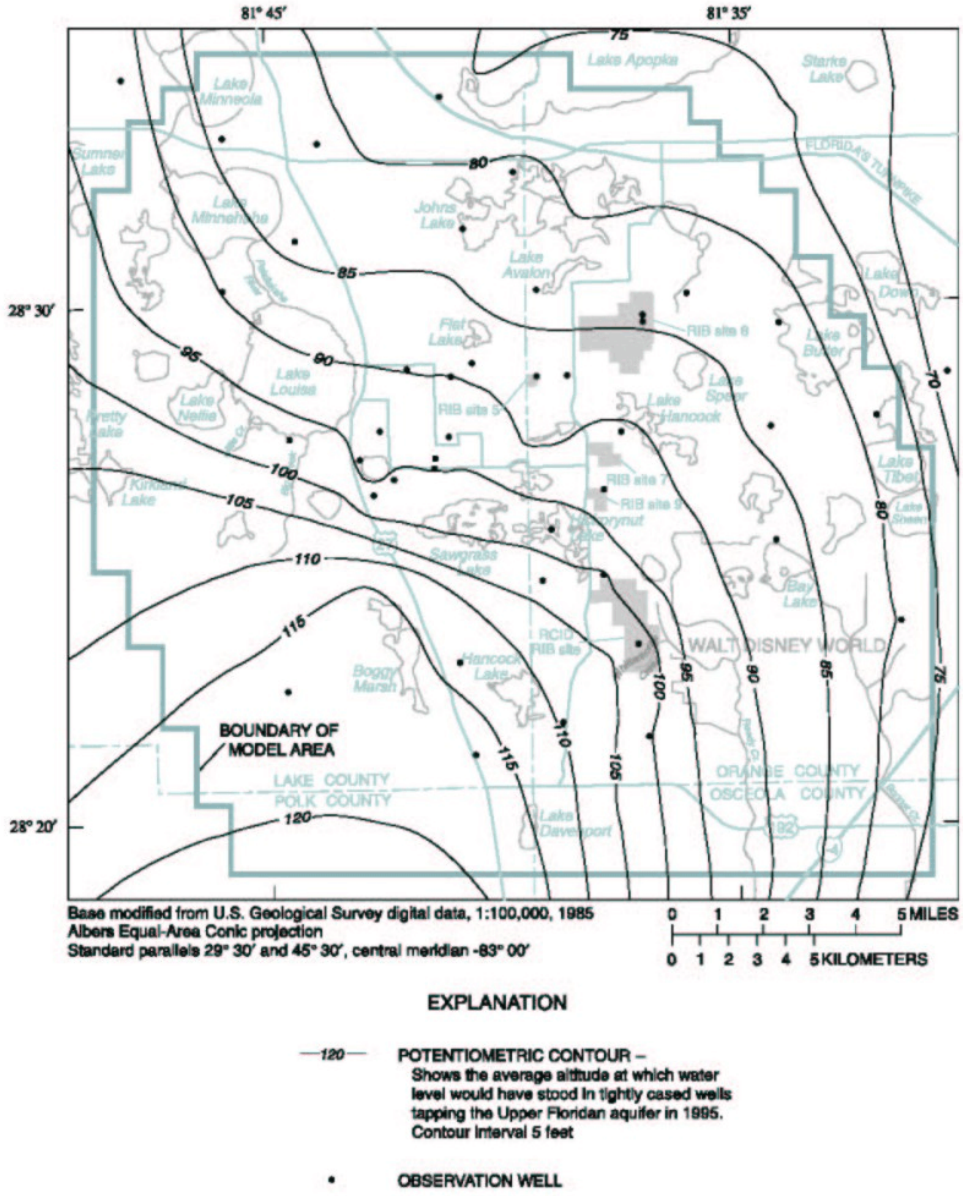


Figure 13. Potentiometric surface of the Upper Floridan aquifer, average 1995 conditions.

Exhibit 6a. Potentiometric surface of Upper Floridan aquifer

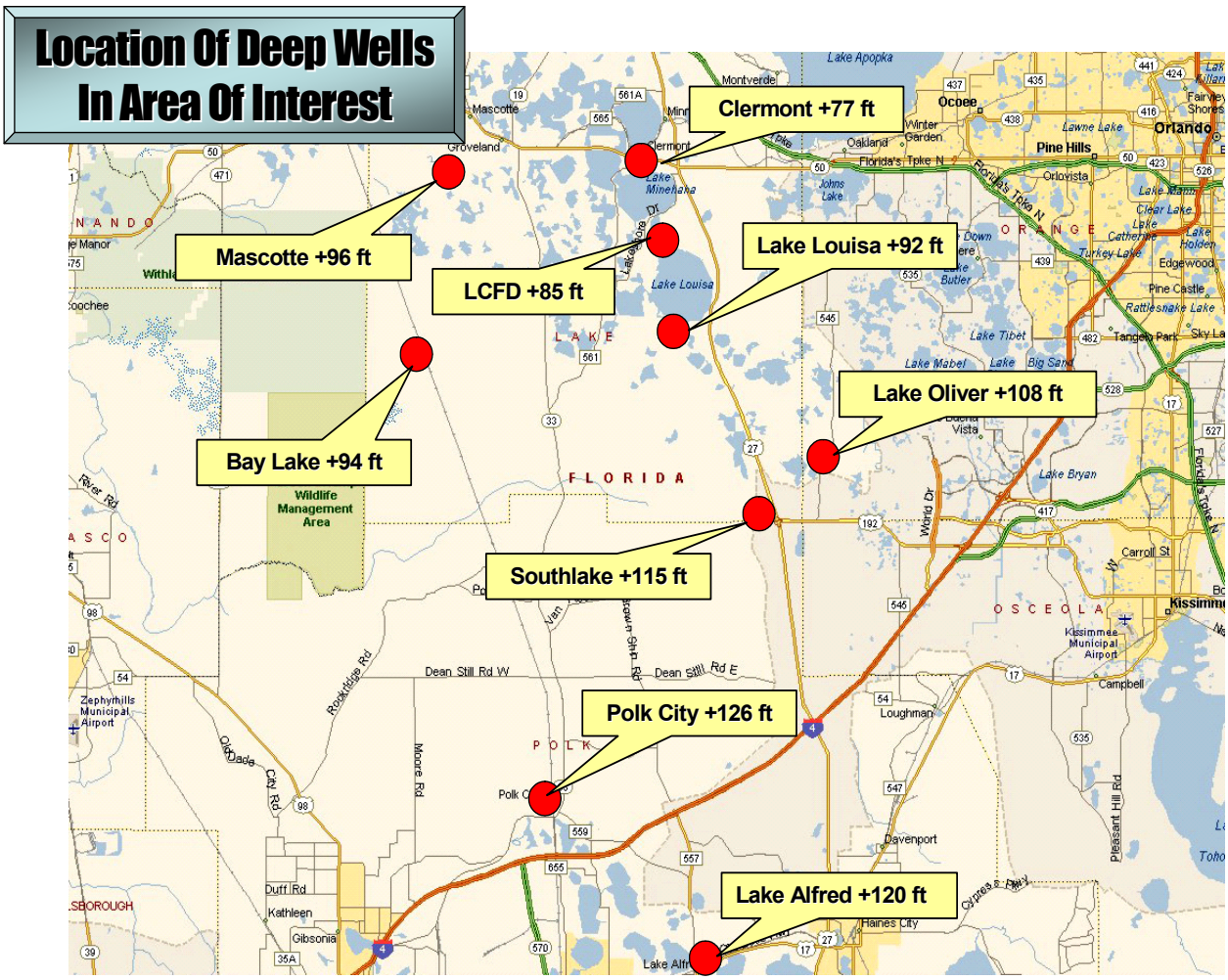


Exhibit 6b. Specific potentiometric surface measurements in Clermont Chain

Hydraulic conductivity of the surficial aquifer system has been estimated by previous investigators. Slug tests performed at the RCID RIB site yielded horizontal hydraulic conductivity values between 25 and 160 ft/day (CH2M Hill, 1989); additional tests conducted just north of the RCID RIB site yielded values of 35 to 67 ft/day (CH2M Hill, 1993). Sumner and Bradner (1996) reported that a horizontal hydraulic conductivity of 150 ft/day was required to calibrate a numerical flow model designed to analyze a loading test conducted at one of the RCID RIBs. Camp Dresser and McKee, Inc. (1984) reported hydraulic conductivity values generally between 20 and 80 ft/day based on laboratory analyses of numerous cores collected at each of the Water Conserv II RIB sites. This range of values was consistent with those used to calibrate a ground-water flow model of the Water Conserv II area (Camp Dresser and McKee, Inc., 1984). Exhibit 9 shows that the calibrated transmissivity of the surficial aquifer is approximately 30 ft/day within the study area.

The leakance of the intermediate confining unit is highly variable across the study area and depends on the vertical hydraulic conductivities and thicknesses of the individual strata of the unit

from one location to the next. The leakance of any vertically homogeneous geologic unit is equal to its vertical hydraulic conductivity divided by its thickness. Field-derived estimates of leakance are sparse; however, two Upper Floridan aquifer tests conducted in the Water Conserv II project area yielded leakance values of $2x10^{-4}$ to $9x10^{-4}$ (ft/day)/ft (Camp Dresser and McKee, Inc., 1984). Leakance values calibrated in a more regional flow model ranged from $4x10^{-5}$ to $8x10^{-4}$ (ft/day)/ft (Murray and Halford, 1996). Results from this calibrated model indicate that the highest leakance values are in the southwestern part of the study area where the confining unit is thinnest. Lowest leakance values are in the northeastern part, just southeast of Lake Apopka, where the unit is thickest. Exhibit 11 indicates that the calibrated leakance in the vicinity of the study area is, for the most part, in the range $0.5x10^{-4}$ to $1x10^{-4}$ (ft/day)/ft.

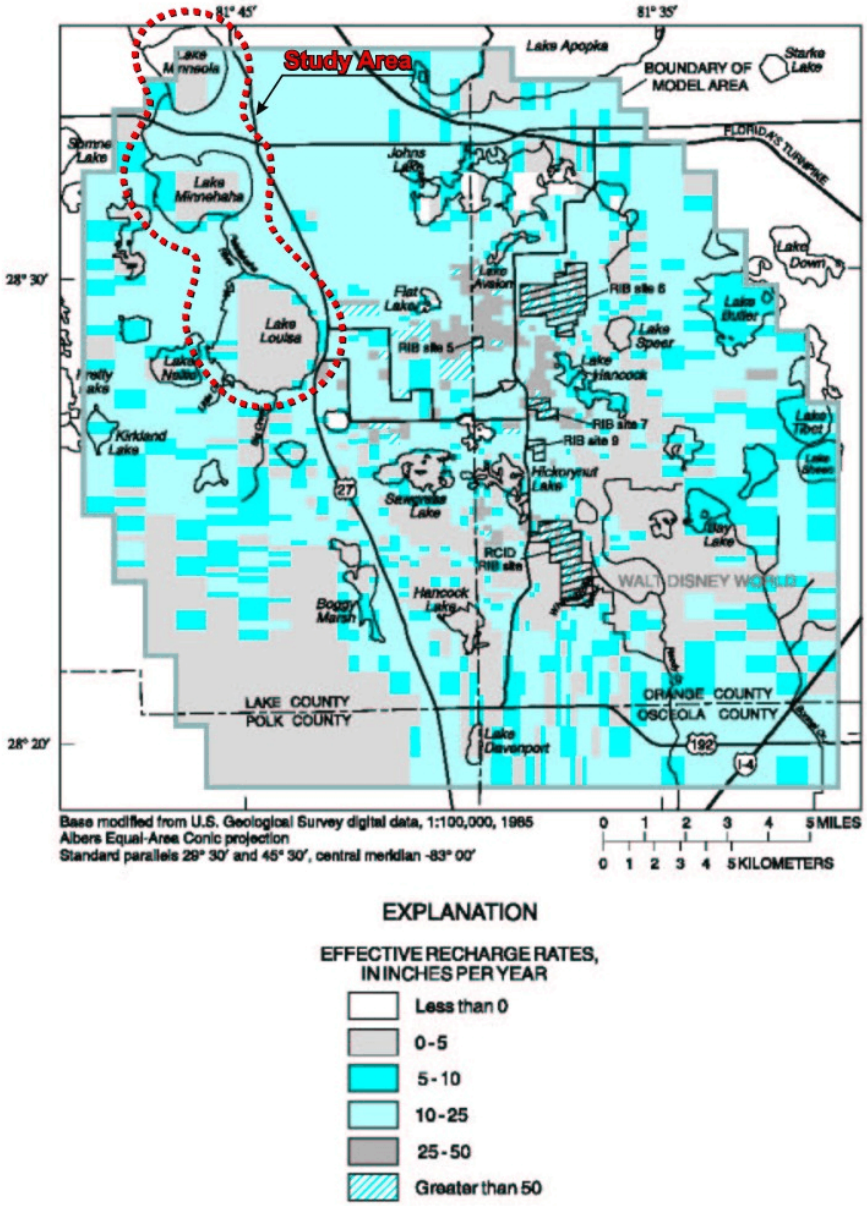


Figure 26. Effective recharge rates specified in the model, average 1995 conditions.

Exhibit 7. Effective recharge rates

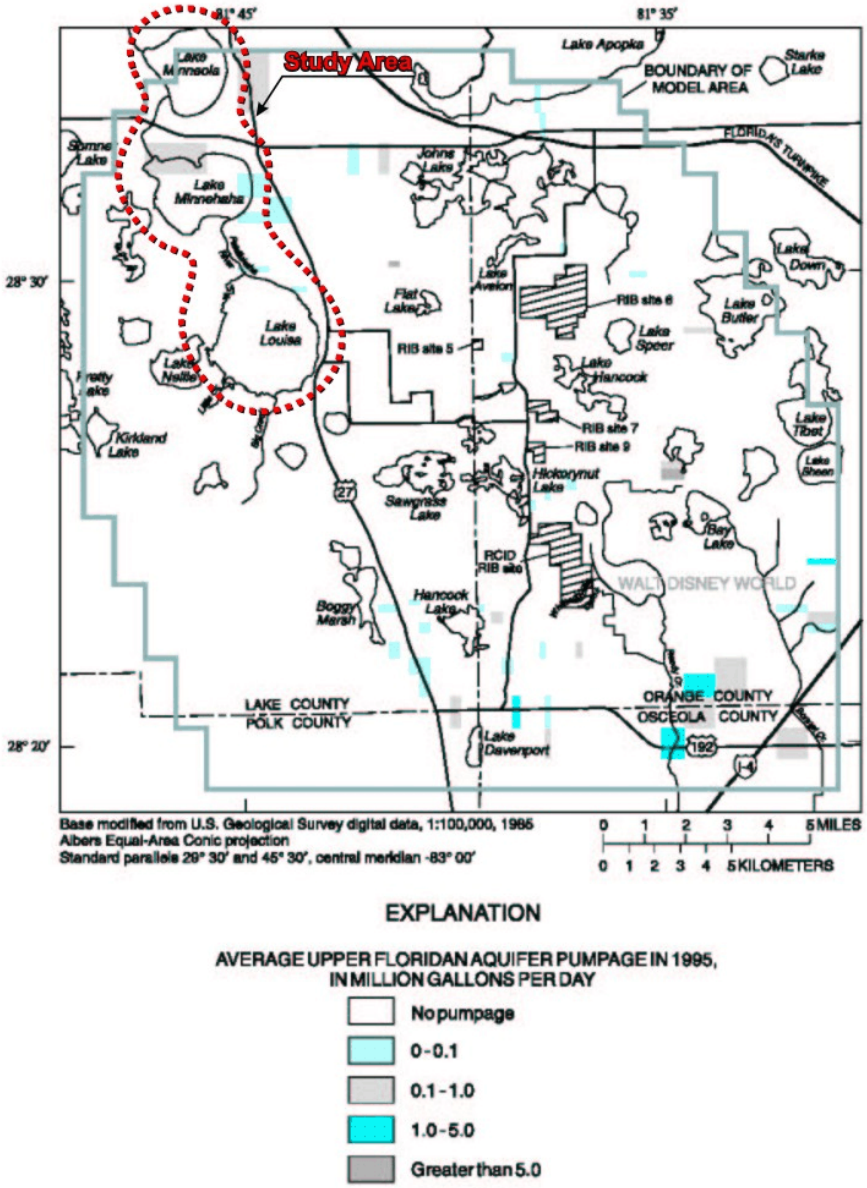


Figure 27. Ground-water withdrawal rates for the Upper Floridan aquifer specified in the model, average 1995 conditions.

Exhibit 8. Ground-water withdrawal rates

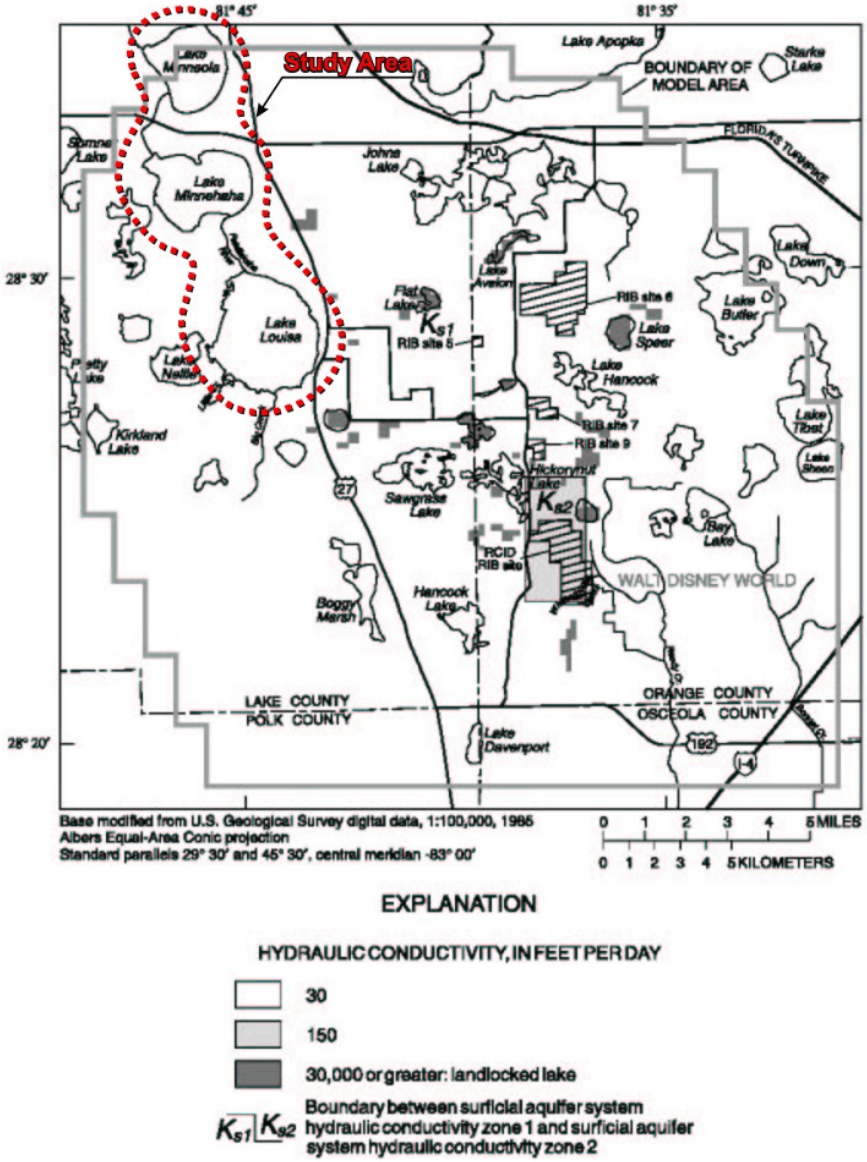


Figure 28. Calibrated hydraulic conductivity of the surficial aquifer system and delineation of zones used for parameter estimation.

Exhibit 9. Calibrated hydraulic conductivity

Results of aquifer tests indicate that the transmissivity of the Upper Floridan aquifer generally is lowest in the Green Swamp and increases toward the northeast with values of between 3,400 and 130,000 ft^2/day (Pride and others, 1966; Grubb and Rutledge, 1979; Camp Dresser and McKee, Inc., 1984). Preferential flow zones occur in the Upper Floridan aquifer as a result of variations in lithology and solution-enlarged cavities in the limestone. Likewise, zones of reduced transmissivity exist where sinkhole collapses have caused the filling of cavities with a mixture of overlying sand and clay. Exhibit 10 shows that the calibrated transmissivity of the Upper Floridan aquifer in the study area is, for the most part, in the range 100,000 to 250,000 ft^2/day.

No data exist within the study area concerning the leakance of the middle semiconfining unit and transmissivity of the Lower Floridan aquifer. Based on regional ground-water flow models, Tibbals (1990) and Murray and Halford (1996) reported a value of $5x10^{-5}$ (ft/day)/ft for leakance of the middle semiconfining unit and 30,000 to 130,000 ft^2/day for transmissivity of the Lower Floridan aquifer in the study area.

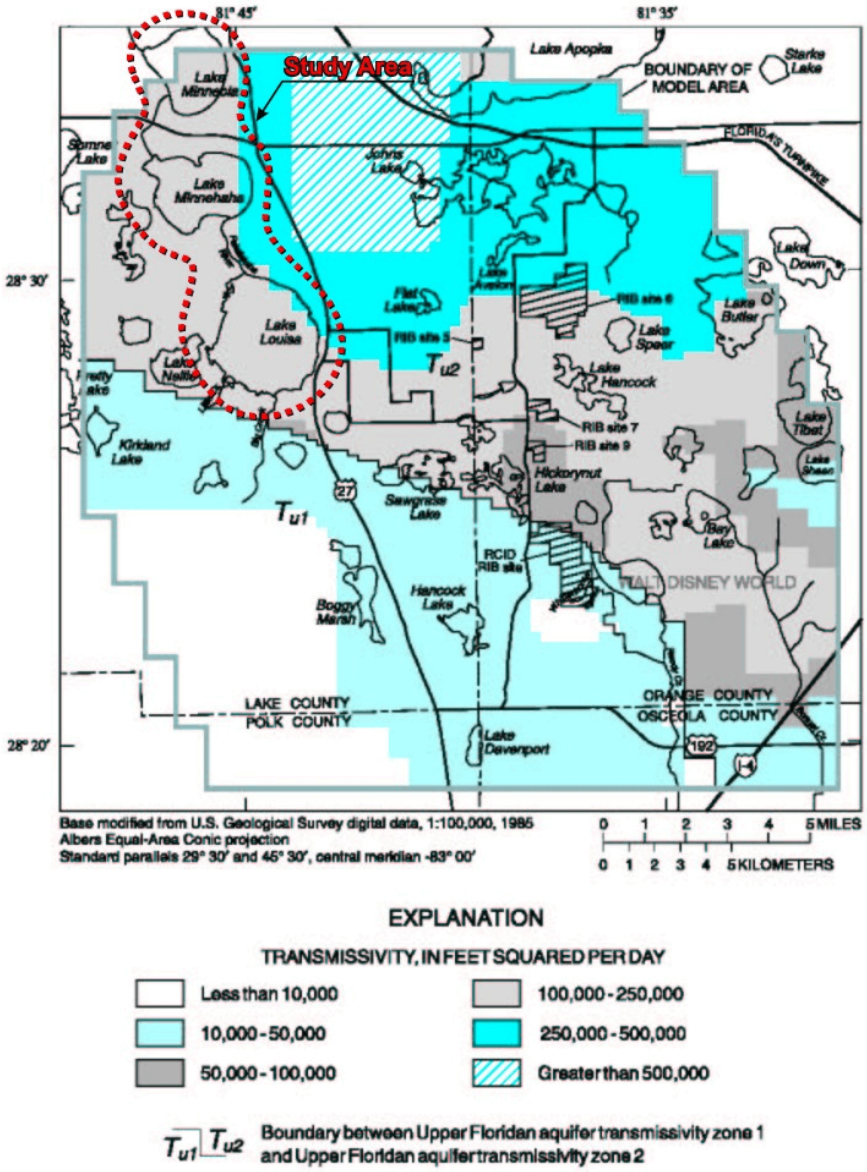


Figure 29. Calibrated transmissivity of the Upper Floridan aquifer and delineation of zones used for parameter estimation.

Exhibit 10. Calibrated transmissivity of the Upper Floridan Aquifer

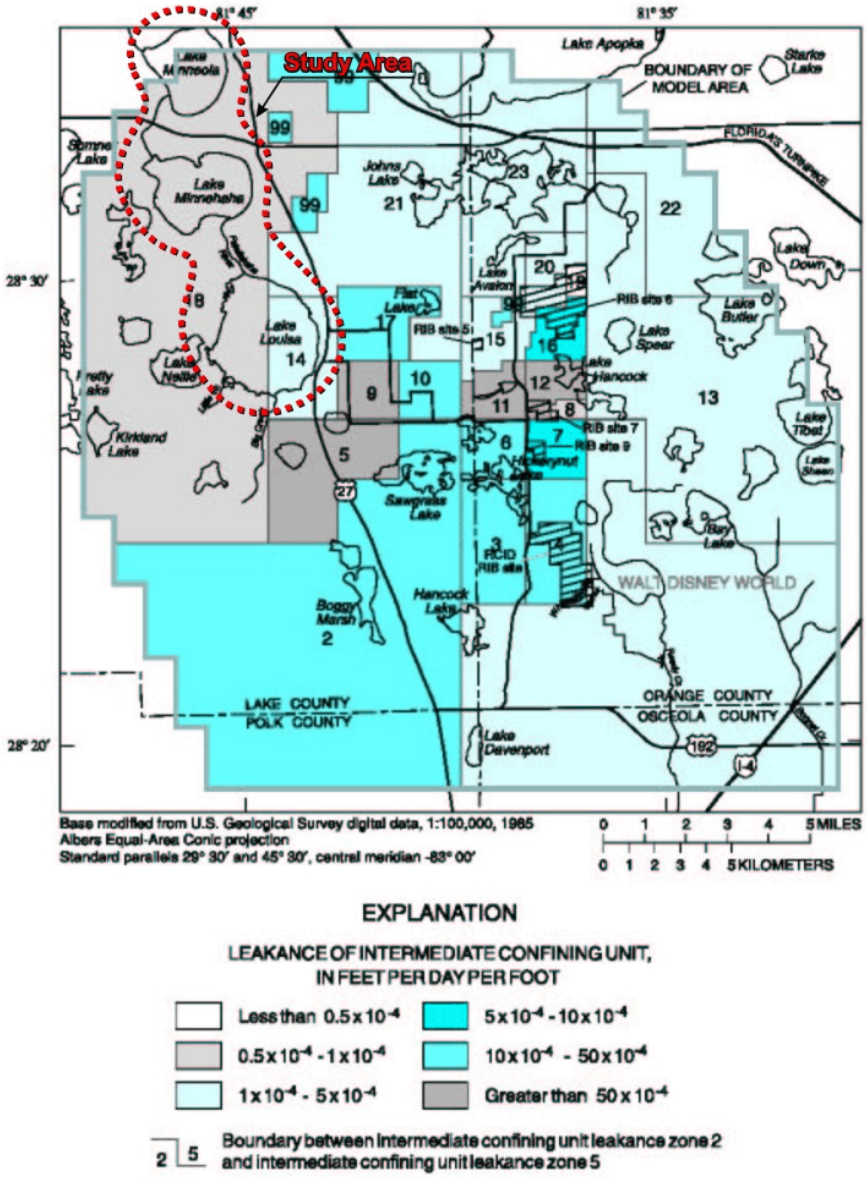


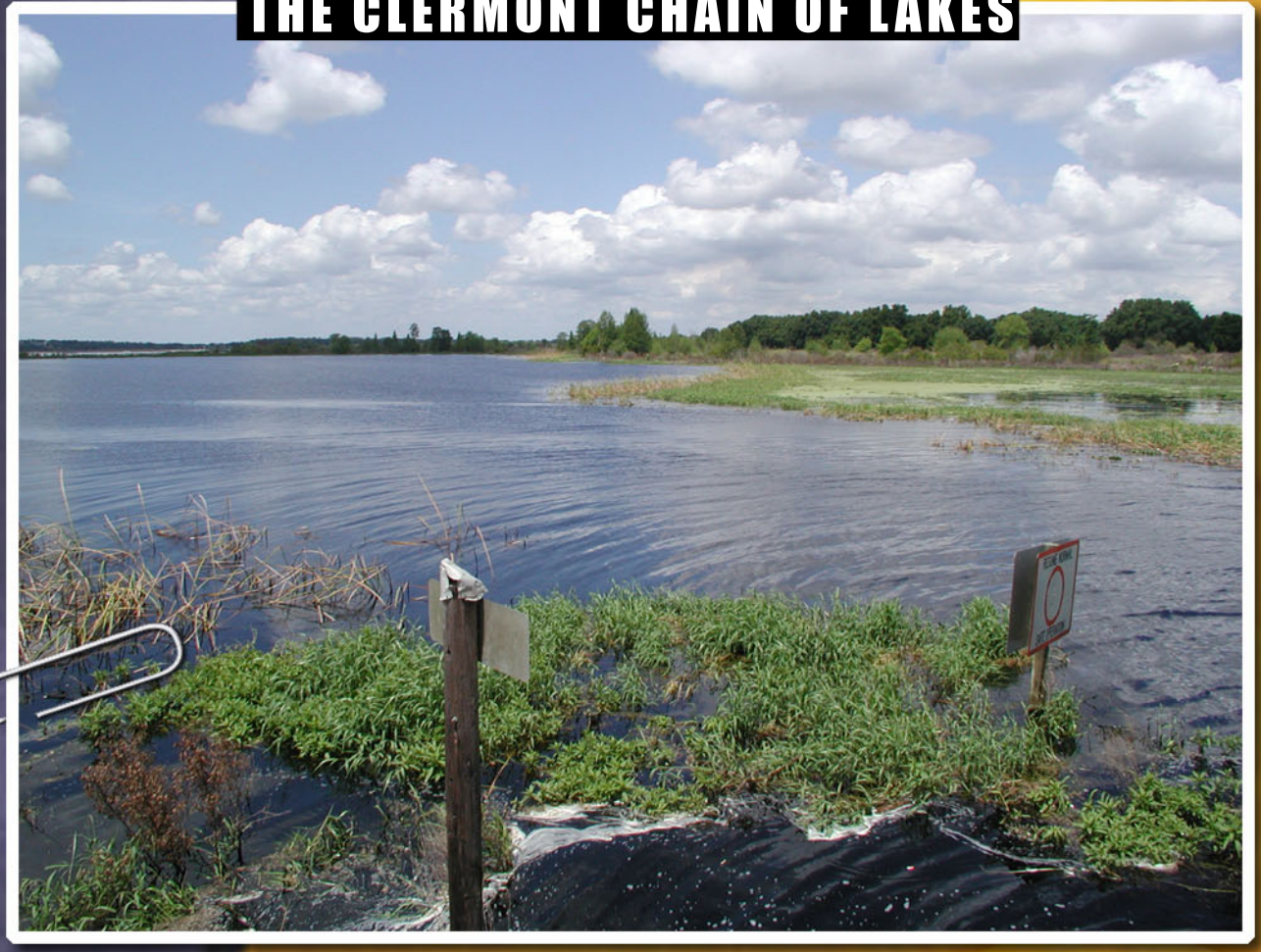
Figure 30. Calibrated leakance of the intermediate confining unit and delineation of zones used for parameter estimation.

Exhibit 11. Calibrated leakance

TECHNICAL MEMO #5: CONTINUOUS SIMULATION MODEL RESULTS

Ground water / Surface water interaction modeling for portion of South Lake County (FL) which encompasses

THE CLERMONT CHAIN OF LAKES



Prepared for

Lake County Water Authority

Professional Engineering Consultants, Inc.

Prepared by

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Date: September 1, 2002	*Devo's Project No.* 02-121.96
To: Lake County Water Authority 107 North Lake Avenue Tavares, Fl 32778-3119 phone: 352-343-3777 fax: 352-343-4259 attention: LANCE LUMBARD	*cc:* Professional Engineering Consultants, Inc. 200 East Robinson Street, Suite 1560 Orlando, FL 32801 phone: 407-422-8062 fax: 407-849-9401 attention: DAVID HAMSTRA, P.E.
LCWA Lake County Water Authority	PEC
Ref: **TECHNICAL MEMO #5 – CONTINUOUS SIMULATION MODEL RESULTS STATUS REPORT FOR AUGUST 2002 GROUND WATER/SURFACE WATER INTERACTION MODELING FOR PORTION OF SOUTH LAKE COUNTY (FL) WHICH ENCOMPASSES THE CLERMONT CHAIN OF LAKES**	

Dear Mr. Lumbard:

The attached status report contains preliminary modeling results which shed light on the primary factor which affects the water levels in the Clermont Chain of Lakes and the reason for the sharp decline in water levels (prior to the 2002 wet season).

A continuous simulation model was developed for the Clermont Chain of lakes and the model was run at daily time steps for the period beginning on January 1, 1994, and extending through November 30, 2001. This corresponds to the interval over which we currently have good rainfall data from the Clermont 7 S weather station.

A remarkable correlation was obtained between measured and predicted water levels in the chain (see Exhibit 13 on the next page).

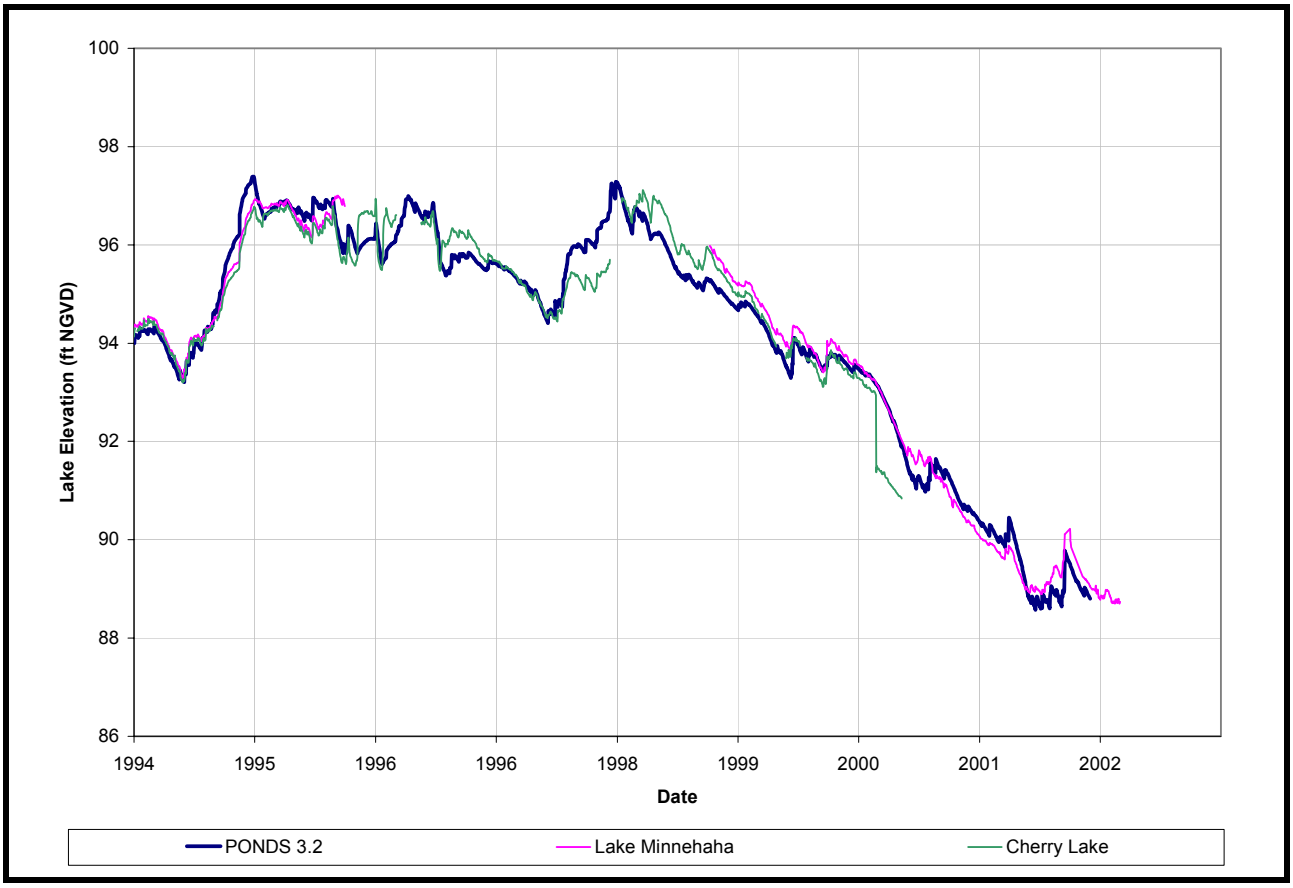

Exhibit 13. Measured and modeled lake elevations for calibration trial 4-2

The modeling results indicate that the lake levels in the Clermont Chain are controlled primarily by the surface water inflows from Little Creek and Big Creek, and not the fluctuation of the ground water levels in the underlying aquifer. The discharge rates from Little Creek and Big Creek are directly correlated to rainfall, as seen in additional Exhibits A1 and A2 below.

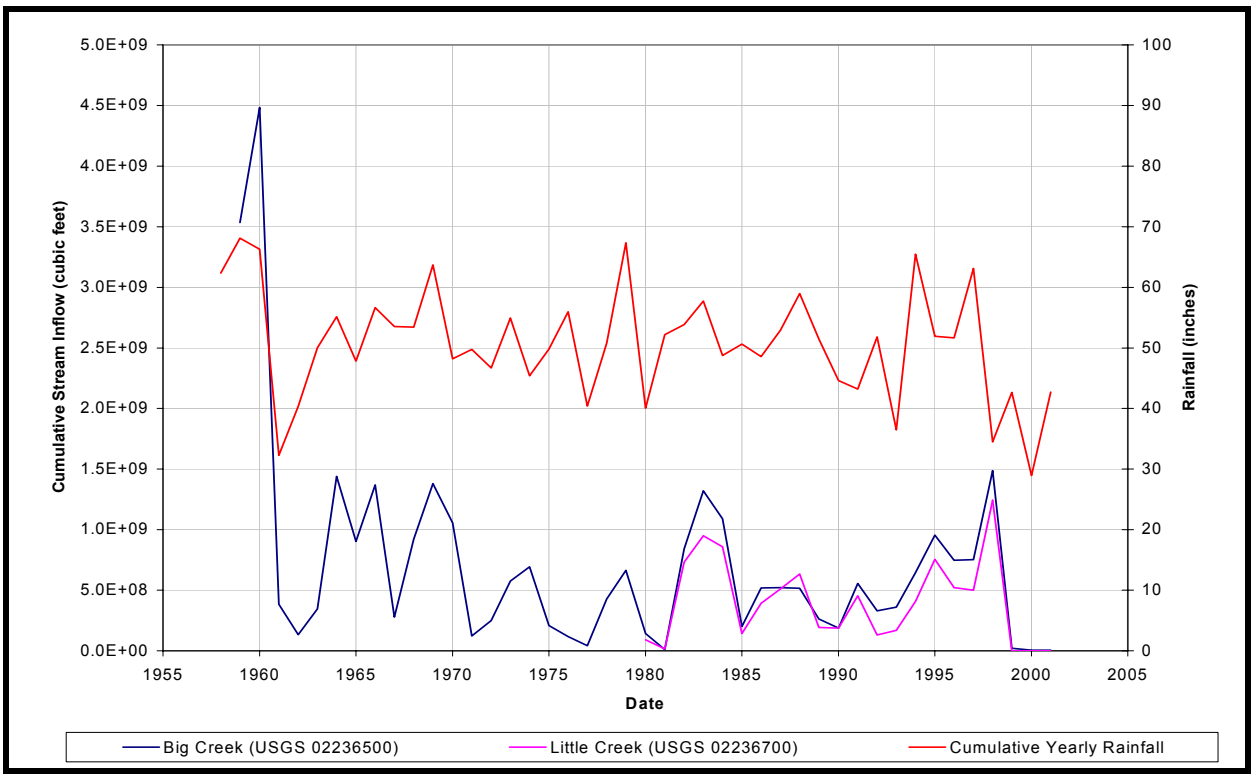

Exhibit A1. Yearly stream inflow at Big and Little Creeks and yearly rainfall

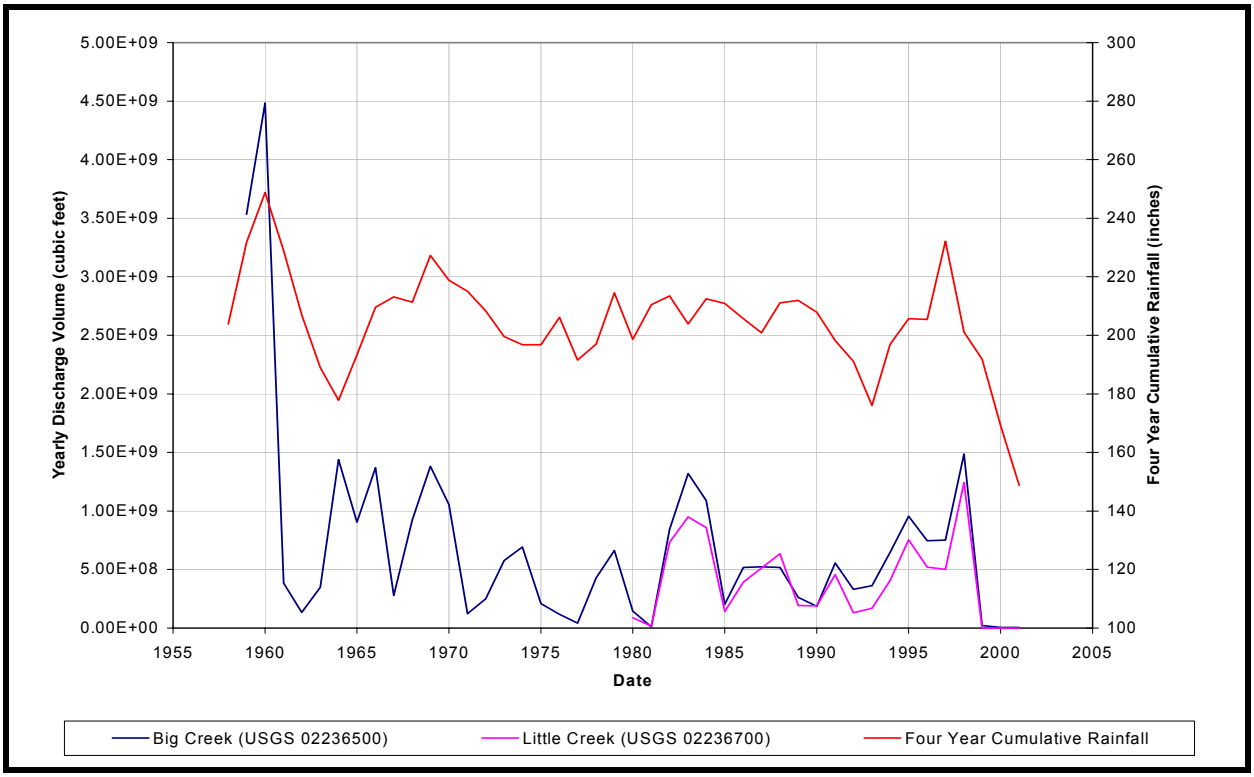

Exhibit A2. Yearly stream inflow at Big and Little Creeks and 4-yr-cumulative rainfall

Detailed information on the modeling effort are presented within the body of the report.

The status report also contains additional hydrogeologic data which suggests that the lakes are not well connected to the Floridan aquifer.

Our efforts are continuing with further analyses as we direct our attention to the underlying Floridan aquifer. We are also in the process of compiling our data for presentation to the LCWA board on Sept 18. Please feel free to call us if any questions in the interim.

Sincerely,
Robert Casper
Robert D. Casper, E.I.
Project Engineer

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1.0 INTRODUCTION

This report documents the results of a series of continuous simulation modeling calibrations of the surface water behavior in the Clermont chain of lakes, including lakes Louisa, Minnehaha, Minneloa, and Cherry. The modeling was performed using the Refined Method Module of the PONDS 3.2 computer program, for a series of progressively refined calibrations, as presented herein.

2.0 SIMULATIONS

For modeling purposes, the Clermont chain of lakes was modeled as a single lake, whose area was equivalent to the surface area of the combined lakes in the chain, at an elevation of +96 ft NGVD, and whose length was approximately equal to the total length of the chain from Lake Louisa in the south to Cherry Lake in the north. This idealized representation is depicted on the attached Figure 5-1.

It was deemed appropriate to model the entire chain (Lake Louisa to Cherry Lake) as a single unit based on previously reported observations of generally uniform lake levels throughout the chain, except during times of extreme rainfall and inflow. This assumption also allowed us to disregard the behavior of the channels connecting the lakes, which would otherwise need to be modeled as individual discharge structures in a de-coupled model.

A modeling period was chosen beginning on January 1, 1994, and extending through November 30, 2001, which corresponds to the interval for which we currently have good rainfall data from the Clermont 7 S weather station.

A successive series of calibrations was performed; these were progressively refined to arrive at our final (preliminary) calibration.

3.0 INPUT PARAMETERS

The following section provides a general overview of the input data parameters utilized for the continuous simulations performed with the PONDS 3.2 software. However, each successive calibration trial introduces a degree of refinement over its predecessor, and changes in the core data for these calibrations will be noted, as and when they apply.

3.1 Rainfall Data

Recorded daily rainfall data were obtained for the Clermont 7 S weather station, for the period of January 1, 1994 through November 30, 2001. The Clermont 7 S rainfall data have been discussed in previous progress reports an memos.

These data include the effects of Tropical Storm Gordon on November 15 & 16, 1994, and the record rainfall totals in December 1997 and February 1998 caused by El- Nino driven storms.

3.2 Surface Water Runoff Parameters

Surface water runoff parameters were determined based on data from the report titled *Palatlakaha River Restoration Phase I Report - Appendix, Draft Technical Memorandum, April, 2002*, prepared for the Lake County Water Authority by Stanley Consultants, Inc., hereafter referred to as the "Stanley Report." These runoff parameters are summarized in Table 1. The basin group boundaries, as well as the individual sub-basins for each basin group, are shown in the attached Figure 5-2.

The data in Table 1 represent the calibrated values used by Stanley Consultants, Inc., in their Screening Model Design and Calibration. Reductions in contributing basin areas were made to account for factors such as physical features and topography, internal depressional storage, and losses due to infiltration and recharge in remote basins. No further effort was made on our part to analyze runoff basin characteristics, with the following exception.

For the purpose of our simulation, basin group L60_100 (see Figure 5-2), which includes contributing basins which feed Big and Little Creeks, was not included in the contributing runoff basin areas. **The stream flows from Big and Little Creeks were input directly into the model as upgradient flow, using measured data for their respective gaging stations near Lake Louisa, and are not included in the basin parameter data.** The remaining basins, as outlined in Table 1, were grouped together and are hereafter referred to as the "contiguous basins."

Initial calibrations did not include the effects of storm water runoff from the contiguous basins, based on the assumption that the direct inflow from Big and Little Creeks would be a more significant contributing factor. The effects of storm water runoff from the contiguous basins was added in subsequent calibrations, and will be noted where applicable in the discussion of the calibration results.

In calibrations where runoff from the contiguous basins was considered, no credit was given for directly connected impervious areas (DCIA), which was considered to be negligible. For the pervious (non-DCIA) areas, a weighted average curve number, CN = 40.3, was utilized.

Table 1. Runoff Parameters for Contiguous Basins

Basin ID	Destination	Area (acres)	% DCIA	CN Perv	CN DCIA	DCIA (ac)	non-DCIA (ac)
L61_100	UPPER_WS	1,000	0	35	99	0	1,000
L62_100	UPPER_WS	6,591	49	50	98	3,229	3,361
L63_100	UPPER_WS	2,000	50	45	98	1,000	1,000
L30_100	LK_MINOL	1,500	0	35	98	0	1,500
L70_100	LK_MINOL	1,500	0	35	98	0	1,500
L24_100	LK_MINOL	4,030	20	35	98	1,894	2,135
L23_100	CHERRY_L	1,000	20	35	98	200	800
Total		17,621		40.3	98	6,324	11,297

Notes: Source: Palatlakaha River Restoration Phase I Report, Draft Technical Memorandum, April 2002, Stanley Consultants, Inc.

The above data do not include contributing basins for Big Creek and Little Creek, which were considered separately using direct input of stream flow measurements.

3.3 Evapotranspiration & Lake Evaporation

Monthly evapotranspiration and lake evaporation rates are presented in Table 2 with the sources of data referenced therein. For simplicity, the evaporation and evapotranspiration rates are assumed to be uniform over a period of 1 month.

Table 2. Monthly Rainfall Data

Month	No. of days in month	Monthly rates (inch)			Daily rates (inch)	
		Normal Rainfall	Lake Evaporation	Evapo-transpiration	Lake Evaporation	Evapo-transpiration
January	31	2.30	2.2	1.969	0.07097	0.06350
February	28	3.02	2.5	1.850	0.08929	0.06609
March	31	3.21	3.9	2.677	0.12581	0.08636
April	30	1.80	5.5	3.307	0.18333	0.11024
May	31	3.55	6.7	3.071	0.21613	0.09906
June	30	7.32	5.8	4.882	0.19333	0.16273
July	31	7.25	6.2	4.764	0.20000	0.15367
August	31	6.78	5.5	4.449	0.17742	0.14351
September	30	6.01	4.4	4.094	0.14667	0.13648
October	31	2.42	3.6	4.055	0.11613	0.13081
November	30	2.30	2.4	2.323	0.08000	0.07743
December	31	2.15	2.2	1.969	0.07097	0.06350
TOTALS	365	48.11	50.9	39.409		

notes:
① Normal Rainfall - average for MCO weather station at Orlando Intl Airport (1961-1990)
② Lake evaporation rates from Lichtler et al. 1968
③ Assumed evapotranspiration rates are for citrus from Jones et al., 1984

3.4 Water Table Aquifer Parameters

Aquifer parameters used in the simulations (including initial water elevations) were estimated based on experience in this area and review of the historical lake levels. These parameters are listed in Table 3.

Table 3. Aquifer Parameters	
Parameter	Value
Initial water table elevation	94 ft
Base of aquifer	66 ft
Horizontal hydraulic conductivity	5
Fillable porosity of surficial aquifer	25

3.5 Artificial Recharge to Water Table Aquifer & Surface Water Pumping

No attempt was made during this preliminary calibration phase to include the effects of artificial recharge to the water table (septic leachfields, irrigation, etc.) Or direct surface water pumping withdrawals from the lakes. These effects may be introduced in future calibrations, once they are sufficiently quantified. However, we do not expect these contributions to have a dramatic impact on the results presented herein.

3.6 Idealized Lake Geometry

For the purpose of our continuous simulation model, the Clermont chain of lakes, from Lake Louisa in the south to Lake Cherry in the north, was idealized as a single rectangular body, as depicted in the attached Figure 5-1. The control elevation for the idealized lake was established at elevation +96 ft NGVD, based on lake elevations reported on USGS 7.5 degree quadrangle maps and recorded lake level data. The equivalent length of the idealized lake was chosen to be approximately equal to the distance from the south end of Lake Louisa to the north end of Cherry Lake, and the equivalent lake width was calculated to preserve the total area of the chain of lakes at elevation +96 ft NGVD.

As discussed in our July progress report, the head difference between Lake Louisa and Cherry Lake is generally less than 0.5 feet, except during extreme rainfall events.

3.7 Stage-Area Data

Preliminary calibration trials utilized a simple stage-area relationship derived from the available contour data, but which does not include the storage volume in the soil voids beneath the pond. The final calibration trial used a more refined stage-area representation, which includes the storage volume in soil voids beneath the pond.

3.7.1 Simple Stage-Area Relationship

The stage-area profile for the idealized lake was constructed based on USGS 7.5 degree quadrangle maps, GIS lake boundary data from Lake County Water Authority, and stream profile data from the Stanley Consultants, Inc., report. The following steps were applied:

- A control elevation of +96 ft NGVD was selected based on USGS quadrangle maps, as previously noted.
- Lake areas were then determined from the GIS lake boundary data from LCWA, for each lake, and assigned to the control elevation (+96 ft NGVD), establishing the normal surface area for the chain of lakes.
- The stage area profile below +96 ft NGVD was estimated based on lake bottom contours presented in the Stanley report stream profiles, where available, and assumed where data were not available.
- Above the control elevation (+96 ft NGVD) an attempt was made to include increased storage associated with surrounding marsh areas, as determined

from USGS 7.5 degree quadrangle maps. This increased storage area is depicted on attached Figure 5-1.

The simple stage-area relationship is shown in Exhibit 1 below. A construction table, with the estimated areas for each lake or marsh, is included in the following Table 4.

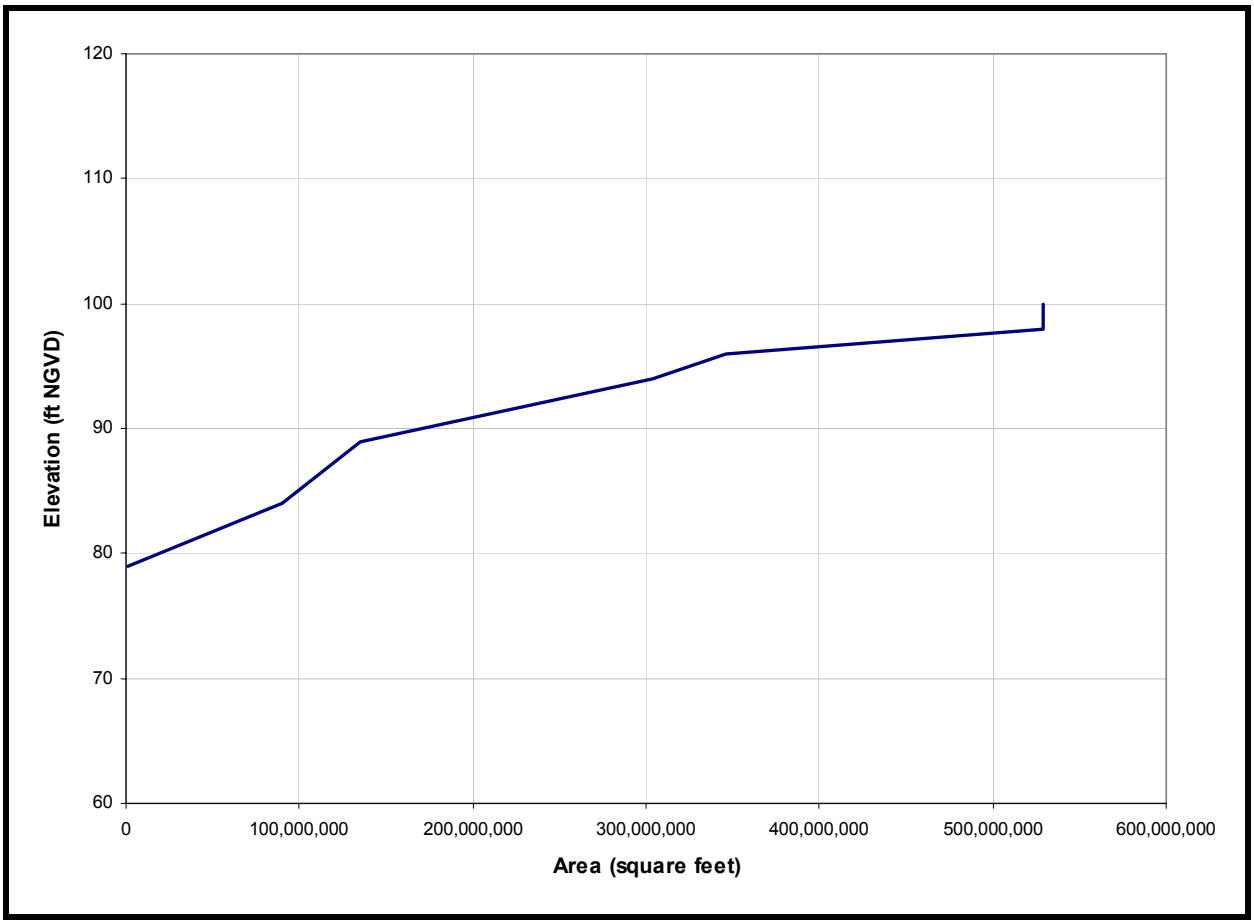

Exhibit 1. Simple Stage-Area Relationship

Table 4. Stage-Area estimates for Clermont Chain of Lakes

	Area (square feet)						
Lake	100 ft NGVD	98 ft NGVD	96 ft NGVD	94 ft NGVD	89 ft NGVD	84 ft NGVD	79 ft NGVD
Lake Louisa			137,618,869	123,856,982	20,642,830	1,376,188	
Lake Susan							
Lake Minnehaha			100,030,372	95,028,853	75,022,779	15,004,556	1,000,304
Lake Palatlakaha			4,464,514	3,571,611	1,116,128		
Lake Mineola (including Lake Hiawatha)			84,106,603	63,079,953	25,231,981	16,821,321	
Wilson Lake			1,384,771	1,038,578			
Cook Lake			917,580	688,185			
Cherry Lake			17,443,000	16,570,850	10,465,800	2,616,450	
Surrounding swampy areas							
Lake Louisa including swamp	169,344,930	169,344,930					
Lake Susan plus swamp	8,375,970	8,375,970					
Lake Minnehaha plus swamp	106,611,206	106,611,206					
Lake Palatlakah plus swamp	6,731,630	6,731,630					
"Sand Mine" Swamp, excluding Lakes Palatlakaha and Hiawatha	90,922,380	90,922,380					
Lake Mineola (includes Lake Hiawatha)	84,106,603	84,106,603					
"Cherry Swamp", includes Wilson Lake and Cook Lake	45,448,617	45,448,617					
Cherry Lake	17,443,000	17,443,000					
Total	528,984,336	528,984,336	345,965,709	303,835,012	132,479,519	35,818,515	1,000,304

3.7.2 Refined Stage-Area Relationship

The refined stage-area relationship includes the storage volume in the soil voids beneath the pond, in addition to the storage volume of the lake itself. This representation of the stage-area relationship of the lake is advantageous in lakes which are subject to significant vertical leakage, as it better represents the storage capacity within the soil, and more accurately models lakes which may be subject to periodic drying. Exhibit 2 shows the derivation of the refined stage-area relationship. The resulting stage-area profile is shown in Exhibit 3 below.

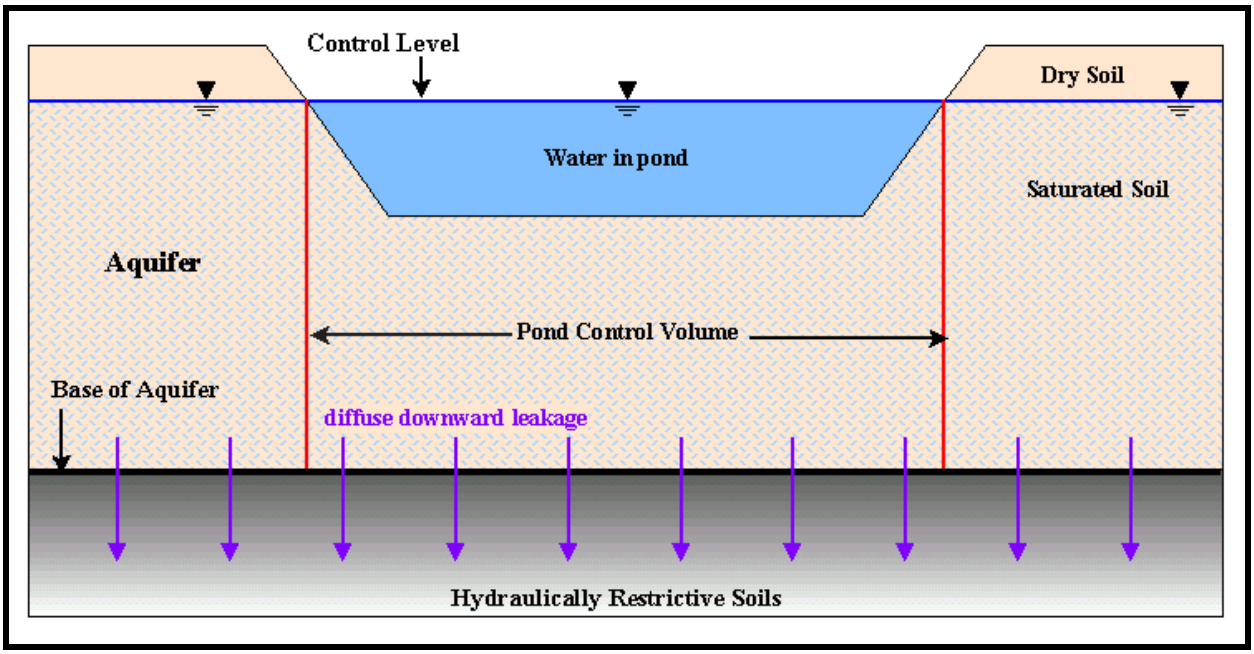

Exhibit 2. Schematic for refined stage-area representation

Definitions

A_{open} = Area of water surface in pond, varies with stage
A_c = Area of water surface in pond at control level
n = soil porosity or soil storage
S_b = Stage at physical bottom of pond
S_c = stage at pond control level

Stage	Area for model
$> S_c$	A_{open}
S_b	$A_c = A_{open}$
between S_b and S_c	$[A_c - A_{open}] \times n + A_{open}$
$< S_b$	$A_c \times n$

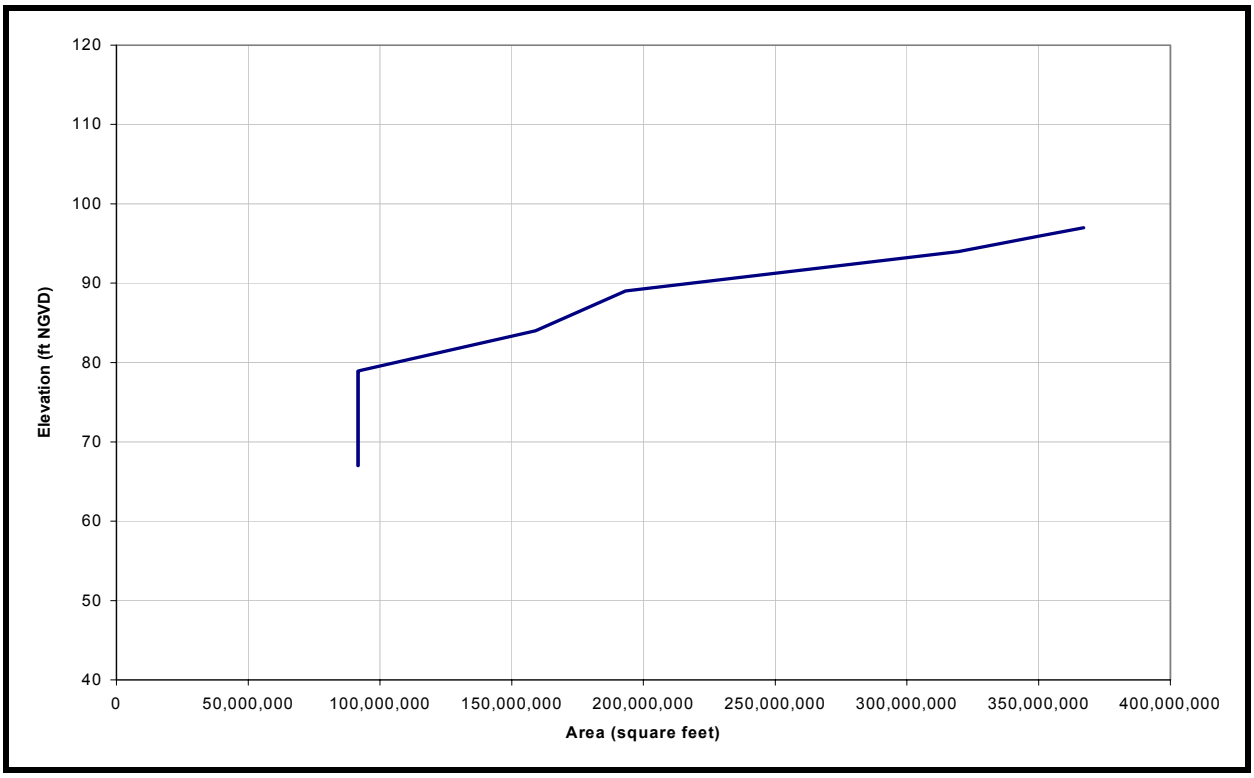

Exhibit 3. Refined stage-area relationship (with soil storage in side slopes)

3.8 Cherry Lake Discharge Structure

The Cherry Lake discharge structure consists of a variable elevation weir. The weir parameters used in the continuous simulation modeling were obtained from the Stanley Report, as follows

Table 5. Cherry Lake Discharge Structure Parameters	
Discharge structure type	Rectangular sharp crested weir
Weir elevation (h_o)	+96 ft NGVD
Weir length (L)	40 ft
Weir coefficient (C)	3.33
Weir Exponent (n)	1.5

The governing equation for discharge from a rectangular sharp crested weir is as follows:

$$q = C\ L\ (h-h_0)^n$$

where

q = discharge rate (cfs)
h = elevation of the water surface (ft)
C, L, h_0, n as defined in Table 5

Our initial calibration was performed using a constant weir elevation of +96 ft NGVD. Subsequent calibrations were performed using the lake elevation and discharge rates from the Cherry Lake gaging station to back-calculate the weir elevation. This was done for periods where there were significant discharge rates recorded. These periods of significant discharge, within the specified modeling period can be seen in Exhibit 4, as follows.

❶ December 1994 through January 1995
❷ August 1995 through November 1995
❸ December 1995 through April 1996
❹ June 1996 through July 1996
❺ December 1997 through May 1998

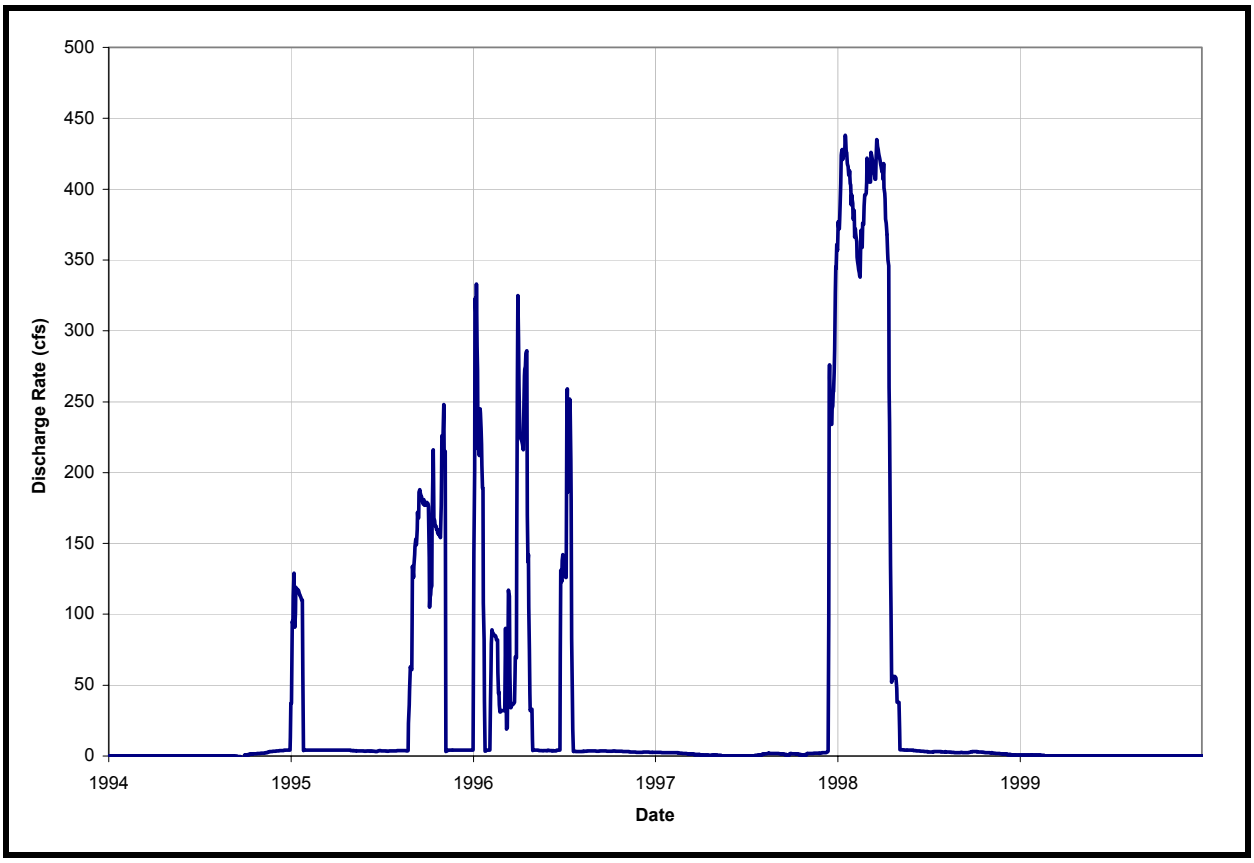

Exhibit 4. Recorded discharge rate at Cherry Lake gaging station, 1994 - 1999

For the period of 1999 to the end of the modeling interval of November 30, 2001, the discharge rates are essentially zero.

Rearranging the discharge equation, the weir elevation was calculated as follows

$$h_0 = h - [\, q / (C\ L)\,]^{1/n}$$

The following series of plots (Exhibits 5 through 9) show the weir elevation, as back-calculated from the stage and discharge data from the Cherry Lake gaging station, as well as the assumed weir elevation used in our continuous simulation calibrations. This presently represents our best estimate for the weir elevation over time, as we do not have any historical records for changes in the weir level.

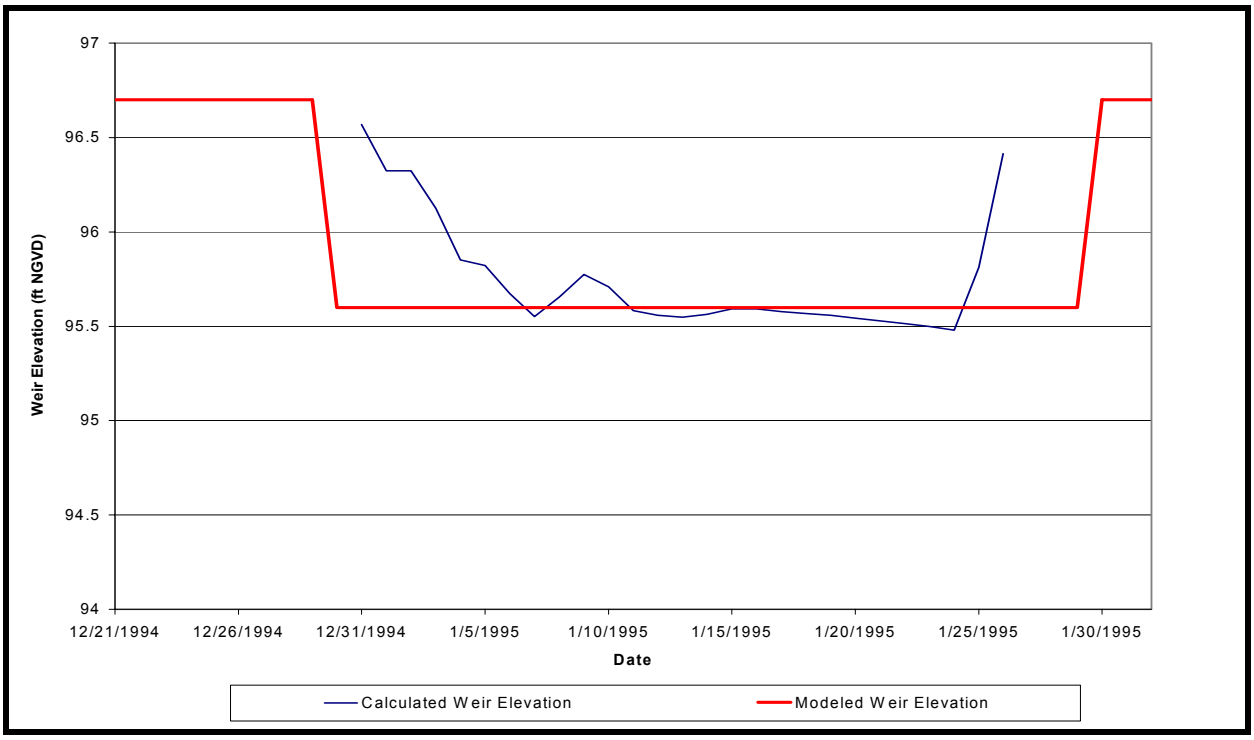

Exhibit 5. Back-calculated and modeled weir elevation, Dec 1994 - Jan 1995

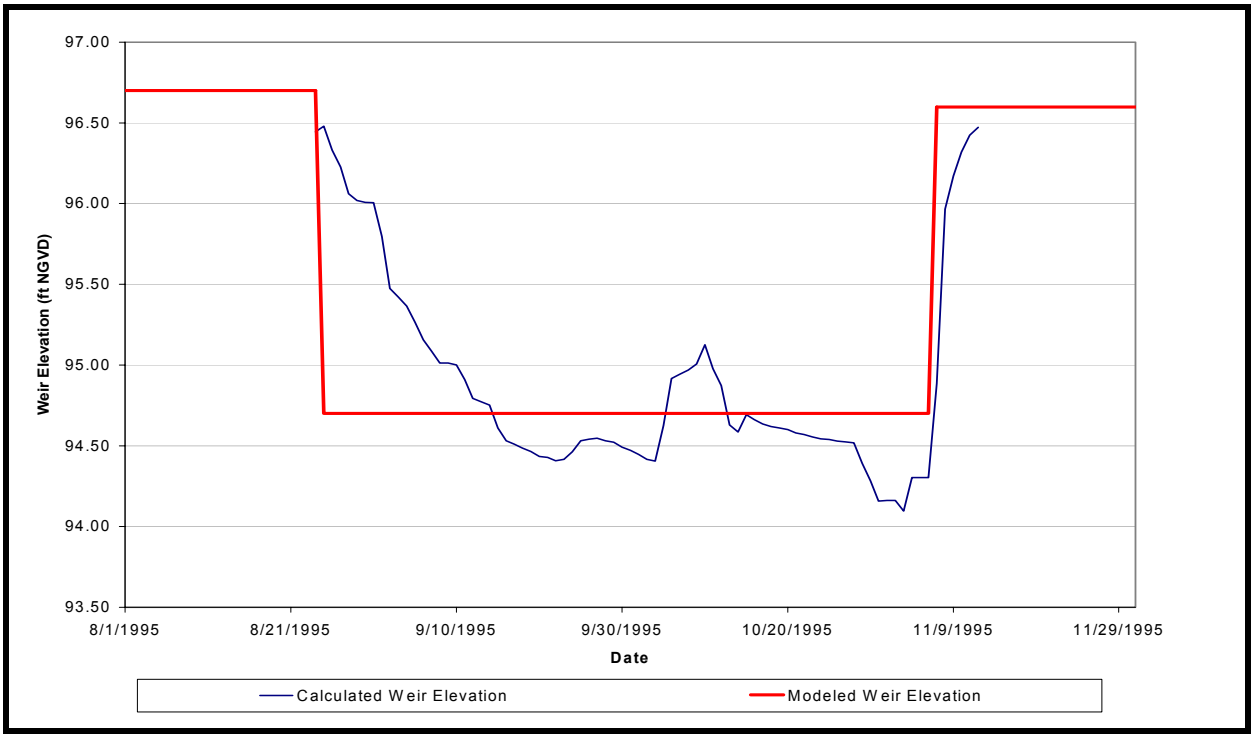

Exhibit 6. Back-calculated and modeled weir elevations, Aug 1995 - Nov 1995

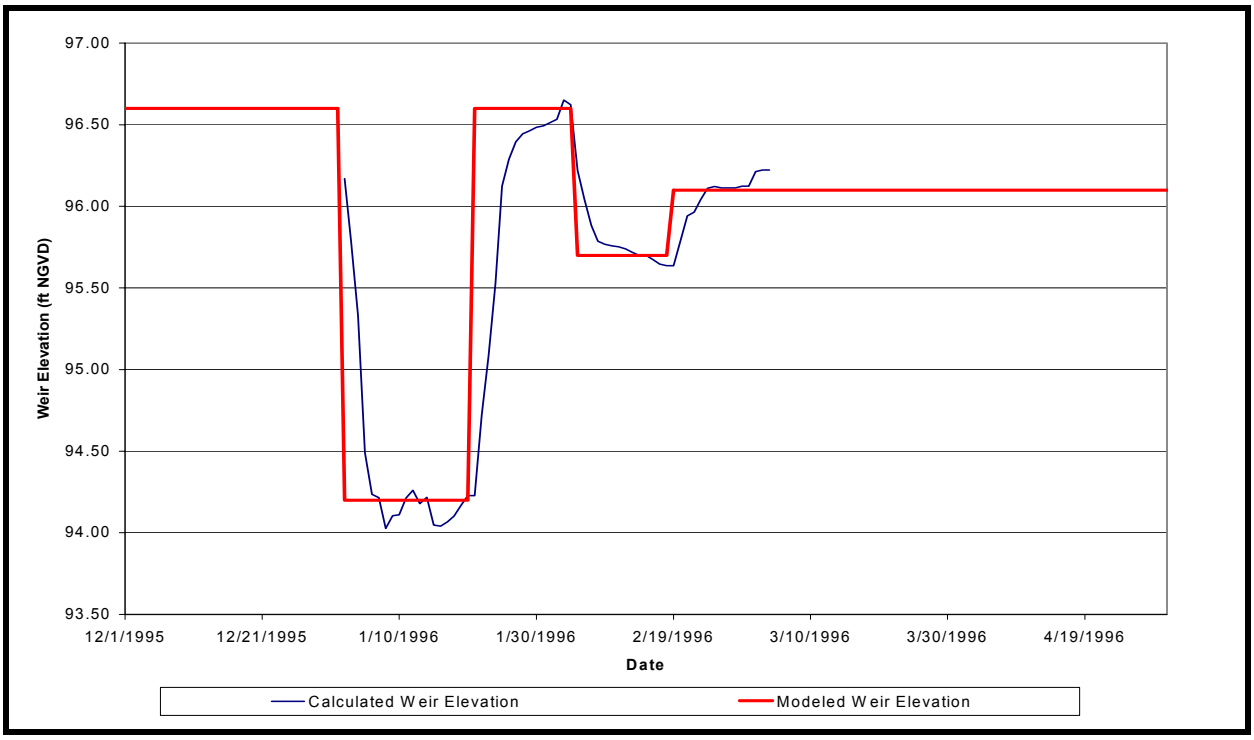

Exhibit 7. Back-calculated and modeled weir elevations, Dec 1995 - April 1996

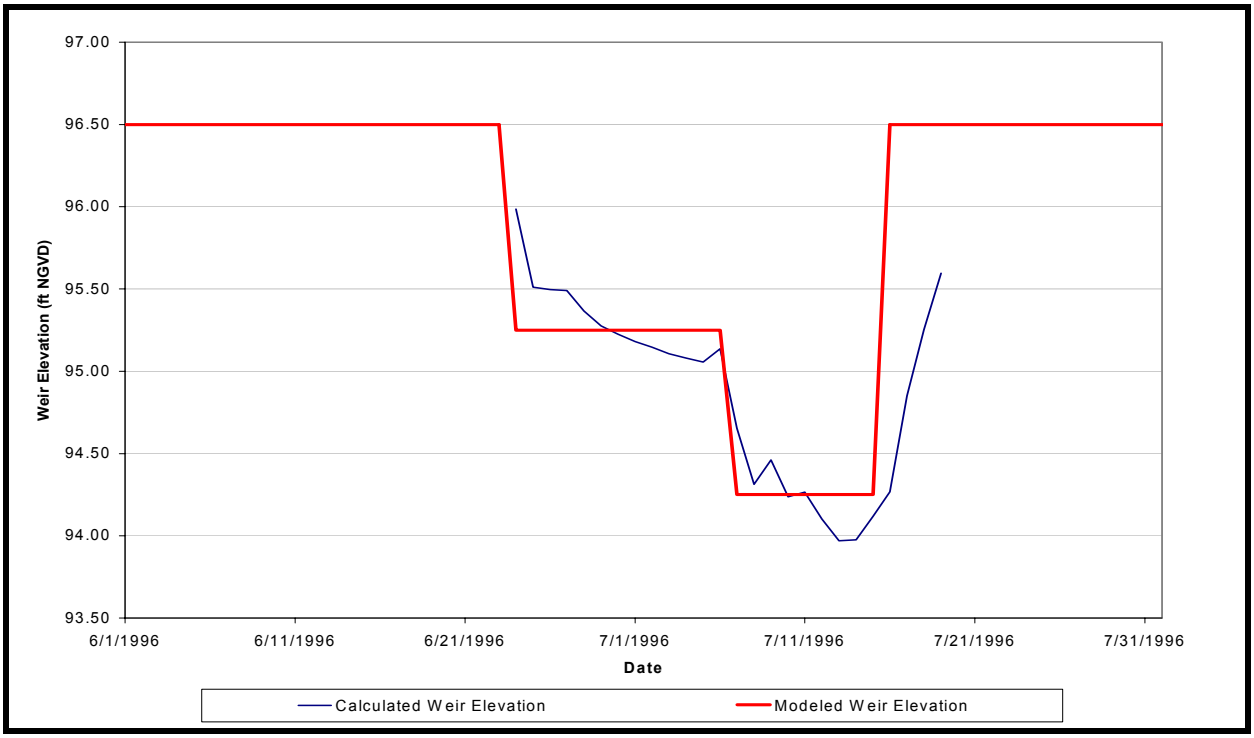

Exhibit 8. Back-calculated and modeled weir elevations, Jun 1996 - July 1996

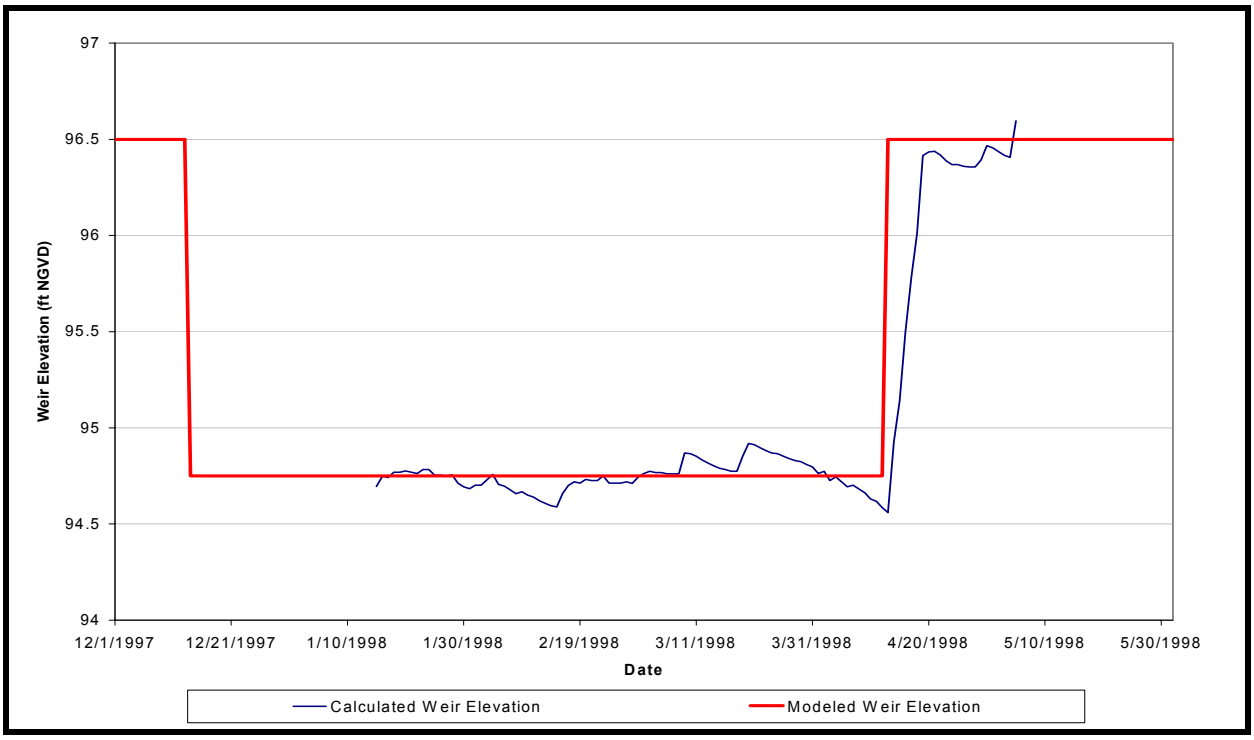

Exhibit 9. Back-calculated and modeled weir elevation, Dec 1997 - May 1998

Note: In the above Exhibit 9, discharge data from Cherry Lake gaging station indicate a period of significant discharge beginning at approximately December 14, 1997 and lasting until May 6, 1998. No lake level elevations were available at the beginning of this period, so the back-calculated weir elevation is incomplete for the beginning of this discharge period. We have assumed a constant weir elevation for the duration of this discharge period.

Where the discharge data from the Cherry Lake gaging station indicate little or no discharge, we have modeled the weir elevation at an arbitrarily high elevation, typically +96.5 ft NGVD.

3.9 Vertical Leakage to Floridan Aquifer

The vertical leakage from the surficial aquifer to the Upper Floridan aquifer was considered to be unknown, and was used as a primary calibration target, by varying the leakage rate to obtain a good fit between modeled and measured lake levels.

4.0 CALIBRATION TRIALS

4.1 Initial Calibration, Trial 1-1

An initial calibration trial was performed based, using data previously discussed, with the following assumptions:

① A constant weir elevation was assumed for the entire duration of the simulation. The weir elevation was set to +96 ft NGVD

② No stormwater runoff was assumed to reach the lake from the contiguous basin areas, with the exception of stream inflows from Big Creek and Little Creek, which were input directly as upgradient flow. (For this initial trial, it was assumed that the contributing factor of runoff from contiguous basins would be less significant than direct inflow from Big and Little Creeks. Runoff from the contiguous basins was considered in subsequent calibrations.)

③ A simple stage-area relationship was utilized, as discussed in the preceding section 3.7.1.

The model was then calibrated by assuming a constant leakage rate between the surficial aquifer and the underlying Floridan aquifer. This leakage rate was varied until a reasonable agreement was obtained between the modeled and measured lake elevations. **The model was calibrated to a leakage rate of 5 inch/year.** The results of this calibration are plotted in Exhibit 10, below.

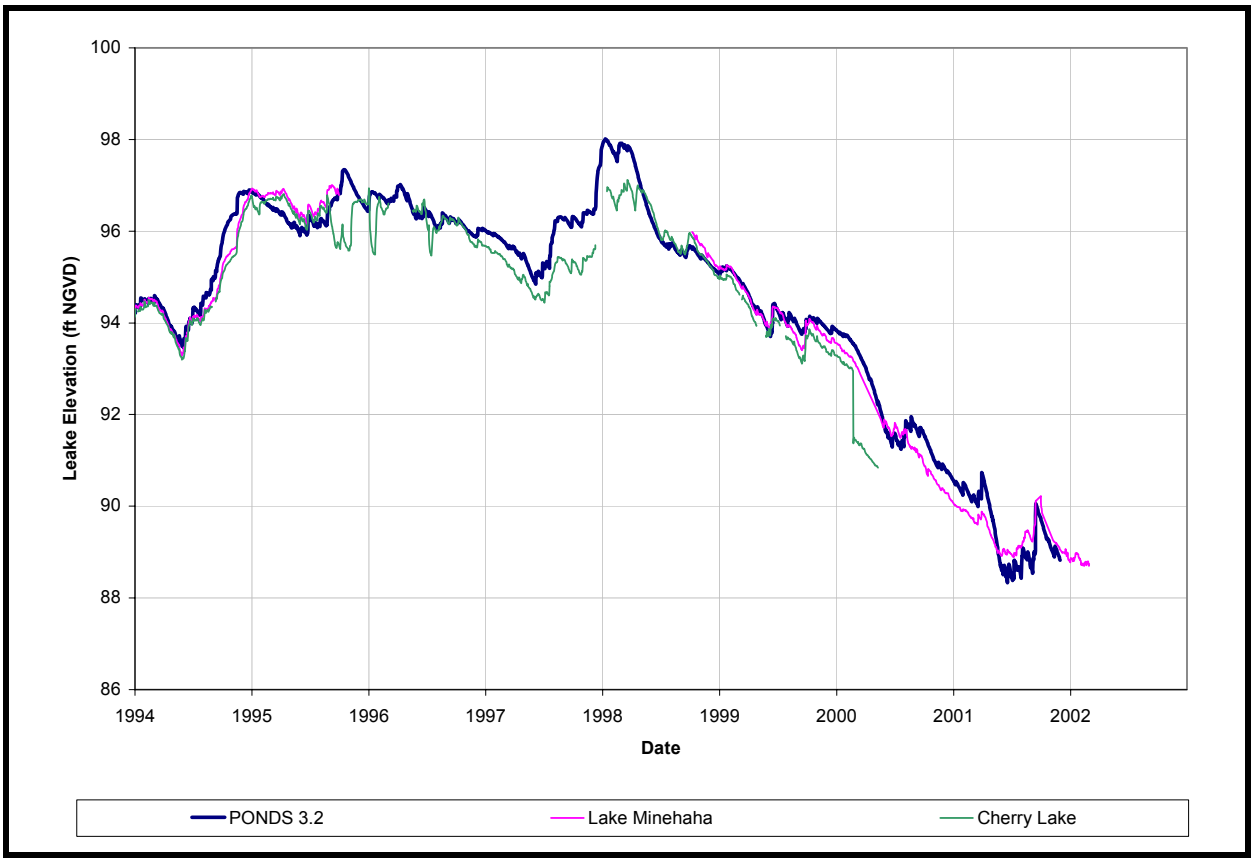

Exhibit 10. Modeled and measured lake elevations for calibration Trial 1-1

This calibration was considered to be very good, in general, given the simplifying assumptions of constant weir elevation and no runoff from contiguous basins. In particular, the modeled results show good agreement in the latter part of the model interval, mid-1998 and onwards, where drought conditions apply and there is no discharge from the Cherry Lake discharge structure. There is a pronounced peak in the modeled results at the beginning of 1998, where the influences of El Nino driven storm events are present, and a lowering of the discharge elevation Cherry Lake is likely to have occurred (see Exhibit 9).

4.2 Calibration Trial 1-7

This calibration trial is a further refinement of the assumptions utilized in Iteration 1-1 above, notably the following

❶ A variable weir elevation was introduced, based on back-calculations performed on recorded lake elevations and discharge rates at the Cherry Lake discharge structure, as previously described. The discharge structure was modeled as a Time Variant Weir in PONDS 3.2

❷ As in Iteration 1-1, it was assumed that no stormwater runoff reaches the pond from the contiguous basins, other than the direct stream inflow from Big and Little Creeks.

❸ A simplified stage-area relationship was utilized.

The model was then calibrated by assuming a constant leakage rate between the surficial aquifer and the underlying Floridan aquifer. This leakage rate was varied until a reasonable agreement was obtained between the modeled and measured lake elevations. **The model was calibrated to a leakage rate of 5 inch/year.** The results of this calibration are plotted in Exhibit 11, below.

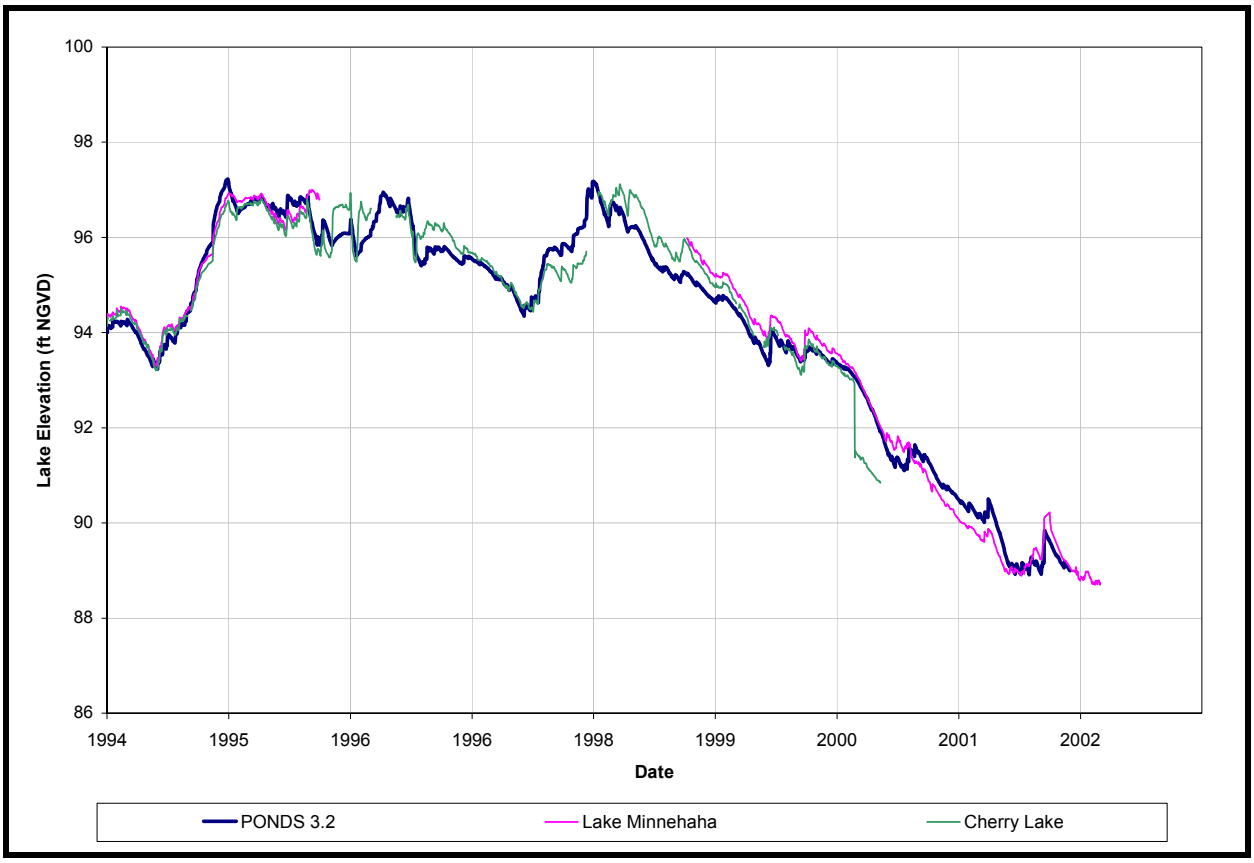

Exhibit 11. Modeled and measured lake elevations for calibration Trial 1-7

This calibration was also deemed to be very good, and shows an improvement in the modeled lake elevation for early 1998.

4.3 Calibration Trial 2-24

This calibration introduces the effect of stormwater runoff from the contiguous basins, based on the calibrated parameters from the Stanley Report. The following assumptions apply

❶ Runoff from directly connected impervious areas (DCIA) is assumed to be negligible. The directly connected impervious area was assumed to be zero.
❷ Runoff from pervious (non-DCIA) basin areas was modeled using the calibrated areas from the Stanley report, as previously discussed and presented in Table 1, with a weighted curve number (CN) of 40.3.
❸ The Cherry Lake discharge elevation was assumed to vary as in calibration Trial 1-7.
❹ A simple stage-area relationship was utilized.

The model was calibrated to a leakage rate of 5 inch/year between the surficial and deep aquifers. The results of this calibration are plotted in Exhibit 12, below.

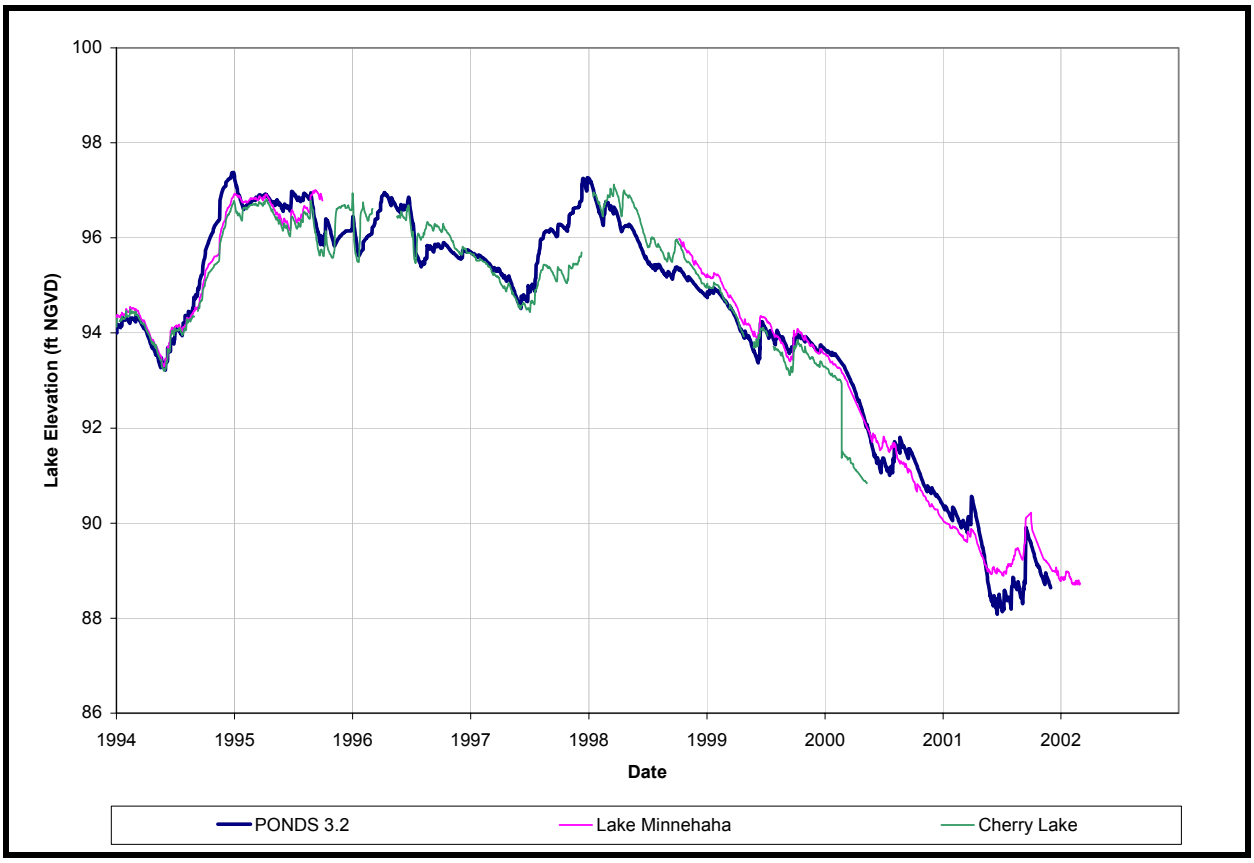

Exhibit 12. Modeled and measured lake elevations for calibration Trial 2-24

Again, the calibration appears very good. The following periods deserve further consideration.

Beginning in mid-1994, and continuing to the end of 1994, there is a period of rising lake levels. This period includes the effects of Tropical Storm Gordon on November 15-16, 1994. As seen in the above Exhibit 12, there is a slightly greater deviation between the modeled lake elevation and the measured lake elevations during this period. This may indicate that any one, or a combination of, the following factors are influencing the modeled results:

① The storm water runoff parameters for the contiguous basin areas introduced in this calibration may be over-predicting the actual runoff which reaches the lakes.

② There may be more storage capacity in the system of lakes, at an elevation of approximately +95 ft NGVD and above, than is accounted for in our estimates of the stage-area relationship. An increased storage capacity would tend to buffer the increased runoff.

③ The discharge elevations, which were estimated by back-calculating the recorded lake elevations and discharge rates, may not be entirely accurate, due to insufficient data

From early in 1998 through the end of the year in 1998, the modeled lake elevation is dropping at a faster rate than is observed in the measured lake levels. This may be an indication that there is more storage volume in the system than is accounted for in our model, including the possibility that surrounding marsh and wetland areas may be releasing water back into the system. (Note: This can also be seen in calibration Trial 1-7.)

In the mid portion of 2001, the modeled lake elevation shows a greater fluctuation than in previous calibrations, with a greater deviation from measured lake levels for this period. This may indicate that there is greater storage capacity in the system, at depth, than is accounted for in our model, which would have a buffering effect on the fluctuation of lake levels.

4.4 Calibration Trial 4-2

Calibration Trial 4-2 uses a refined stage-area relationship, which takes into consideration the storage volume in the soil voids beneath the pond. Otherwise, data used in Iteration 4-2 are as per Iteration 2-24.

- ❑ Runoff from directly connected impervious areas (DCIA) is assumed to be negligible. The directly connected impervious area was assumed to be zero.

- ❑ Runoff from pervious (non-DCIA) basin areas was modeled using the calibrated areas from the Stanley report, as previously discussed and presented in Table 1, with a weighted curve number of 40.3.

- ❑ The Cherry Lake discharge elevation was assumed to vary as in calibration Trial 1-7.

- ❑ The stage-area relationship for the lake was modified to include storage in the soil voids beneath the lake, as discussed in section 3.7.2.

The model was calibrated to a vertical leakage rate of 6.5 inches/year between the surficial and deep aquifers. The results of this calibration are plotted in Exhibit 13, below.

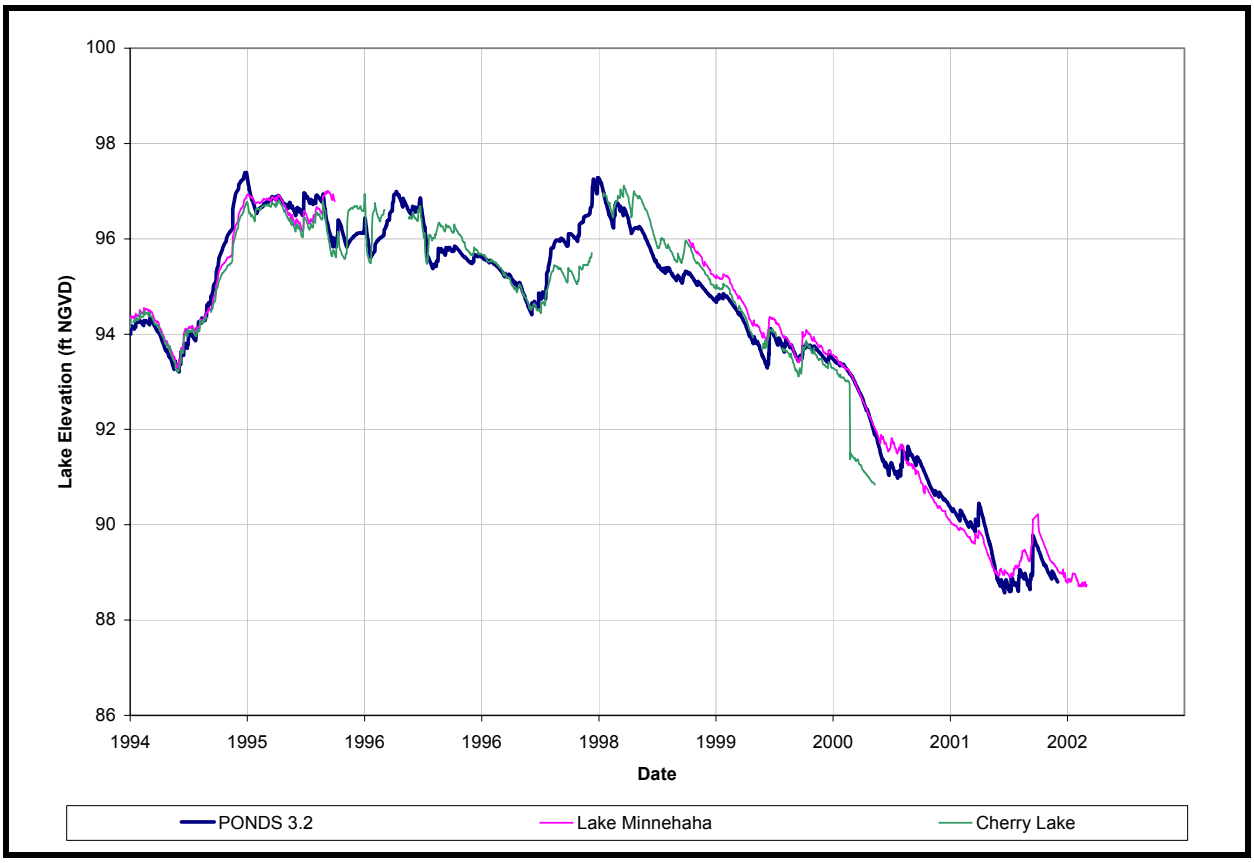

Exhibit 13. Measured and modeled lake elevations for calibration trial 4-2

The results of this calibration are also deemed to be very good. In particular, the refined stage-area relationship improves the modeled lake elevations for the period of mid-2001, where lake elevations are at their lowest.

Calibration trial 4-2 represents our final calibration, for the purpose of this report.

The modeled discharge rate from calibration trial 4-2 is shown in Exhibit 14, along with the recorded discharge rates for Cherry Lake gaging station, below. They indicate a generally good correlation.

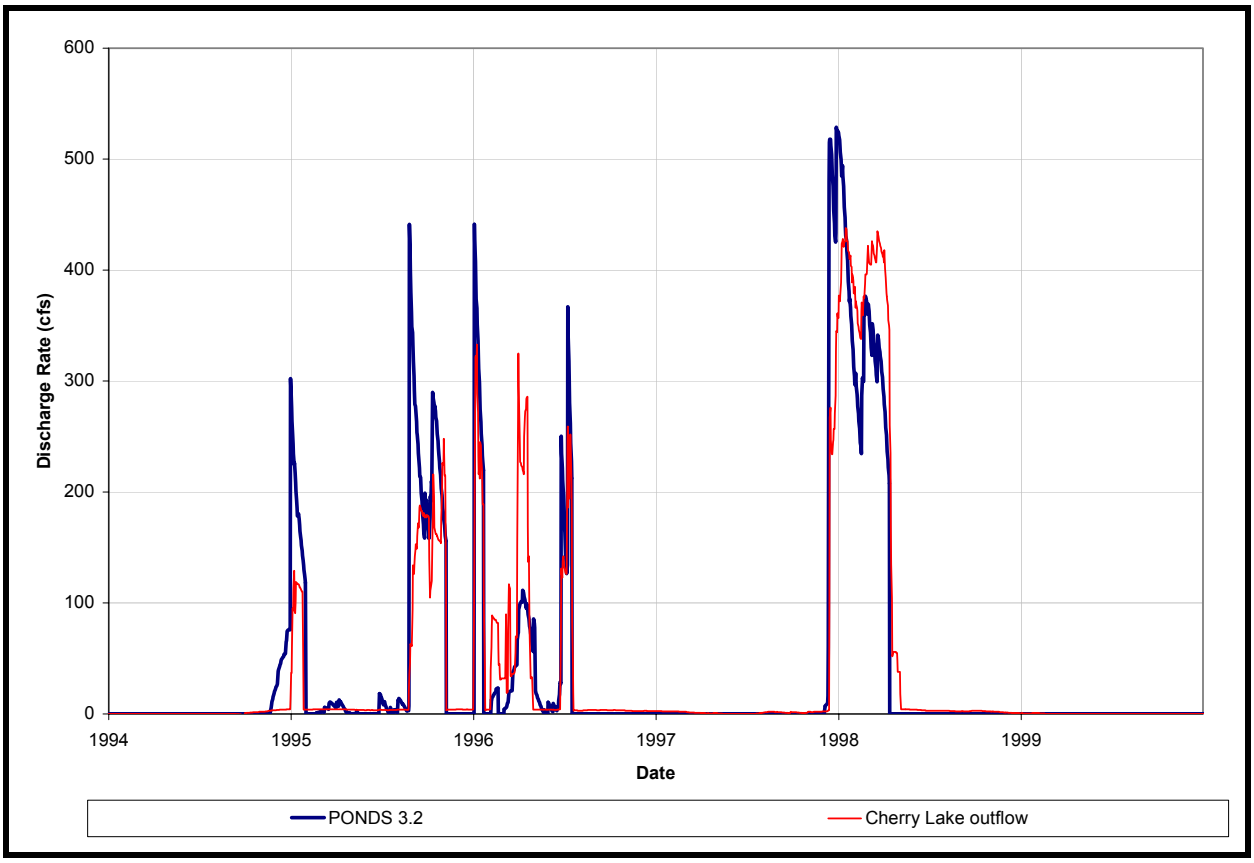

Exhibit 14. Modeled and measured discharge at Cherry Lake

5.0 SENSITIVITY ANALYSIS

5.1 General

An analysis was performed to assess the sensitivity of the continuous stimulation modeling results to variation in the horizontal conductivity of the soil, K_h, and the curve number for pervious (non-DCIA) runoff calculation, CN.

5.2 Sensitivity to horizontal soil conductivity, K_h

The horizontal soil conductivity, K_h, was varied between 5 ft/day and 20 ft/day, using the data parameters obtained in the final calibration trial 4-2. The results from the sensitivity analysis are shown in Exhibit 15, and indicated that the model is relatively insensitive to variations in K_h

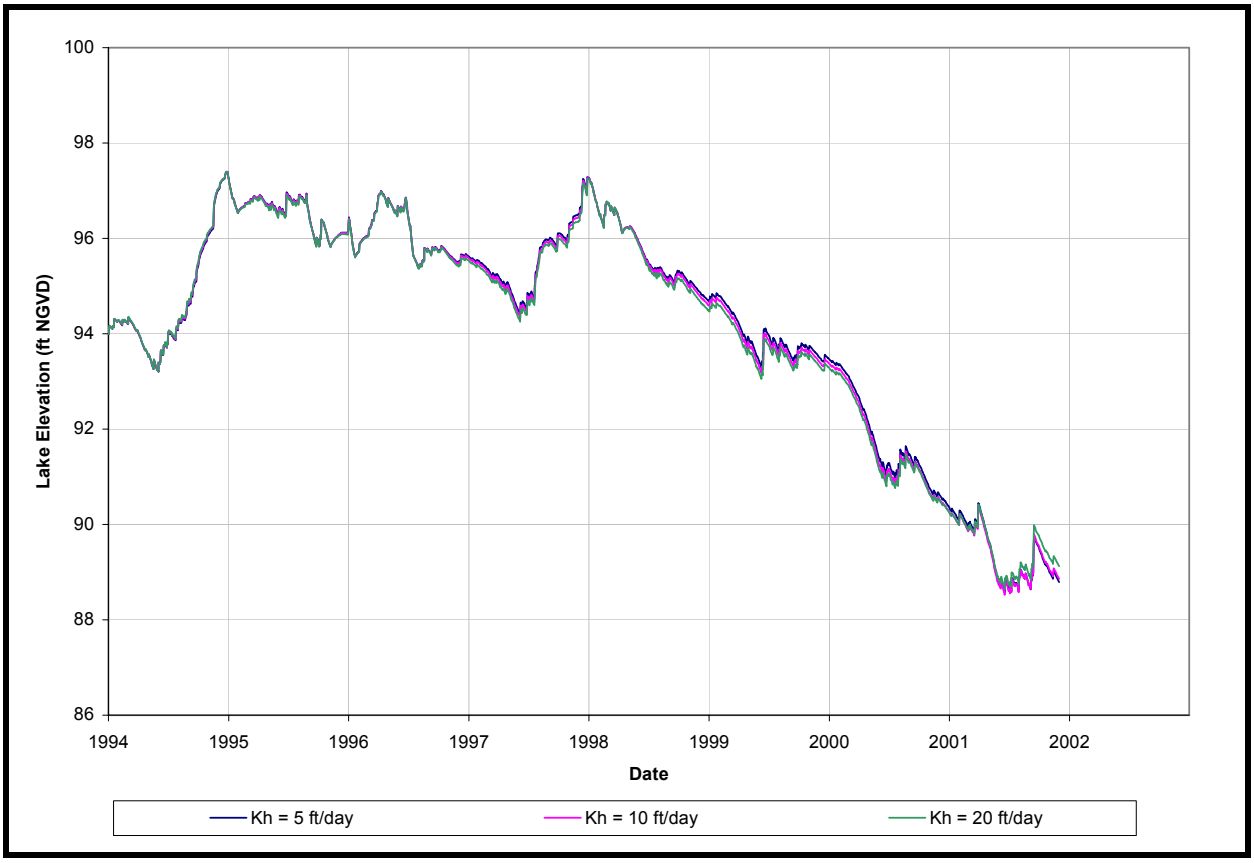

Exhibit 15. Sensitivity of modeled lake elevation to variation in K_h

5.3 Sensitivity to non-DCIA curve number, CN

The curve number, CN, used for calculation of storm water runoff from pervious areas in the contiguous basin areas was varied between 40 and 50, using the data parameters obtained in the final calibration trial 4-2. The results from the sensitivity analysis, shown in Exhibit 16, indicated that the model is relatively insensitive to variations in CN.

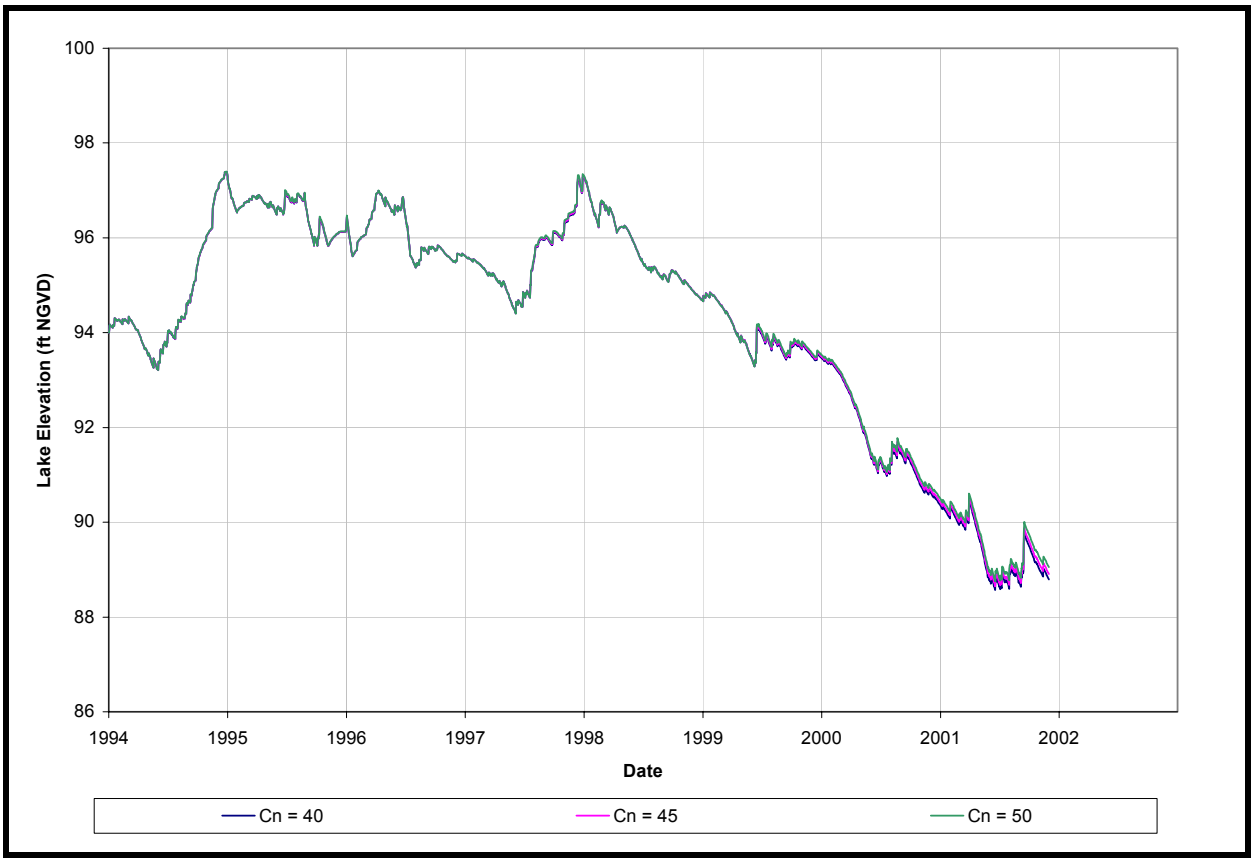

Exhibit 16. Sensitivity of modeled results to variation in CN

6.0 ANCILLARY FINDINGS

6.1 Recorded stream inflows and outflows

Exhibit 17 shows a comparison of the combined inflow rate for Big and Little Creeks, and the outflow rate at the Cherry Lake gaging station. It is of interest in that it suggests that, at times of peak outflow from Cherry Lake, the combined stream inflow at Big and Little Creeks account for the majority of discharge seen at Cherry Lake, and that the contribution of storm water runoff from the contiguous basins is less significant.

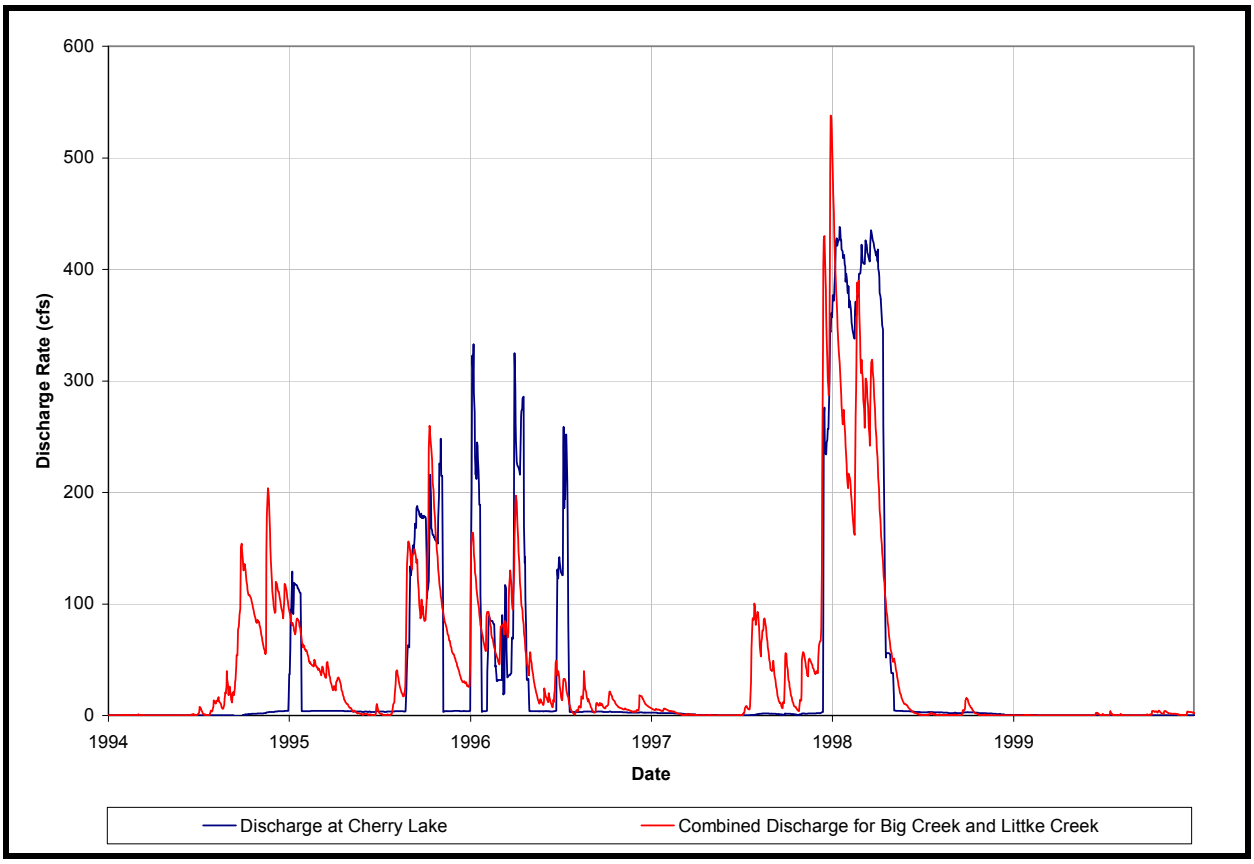

Exhibit 17. Cherry Lake discharge and combined inflow from Big and Little Creeks

6.2 Well locations for USGS monitored well sites

The attached Figure 5-3 indicates the locations of well data that we have recently received from a database search performed for us by Tim Curran at the USGS branch office in Altamonte Springs, FL. A preliminary evaluation of these data indicates that the majority of the well data received do not provide data of significant interest to our study for one or more of the following reasons:

- infrequent readings
- short period of record
- no data for our given modeling interval, 1994-2001

However, several of the well locations did contain daily readings within our specified model period. These locations, where good quality data are available, are also indicated in attached Figure 5-3.

6.3 Lake levels in the Clermont Chain and nearby deep aquifer pressures

Exhibit 18, below, compares the recorded lake levels at Lake Minnehaha and Cherry Lake to Floridan aquifer levels in three (3) deep wells in the immediate vicinity of the Clermont Chain of Lakes. The locations of these wells are noted on attached Figure 5-4.

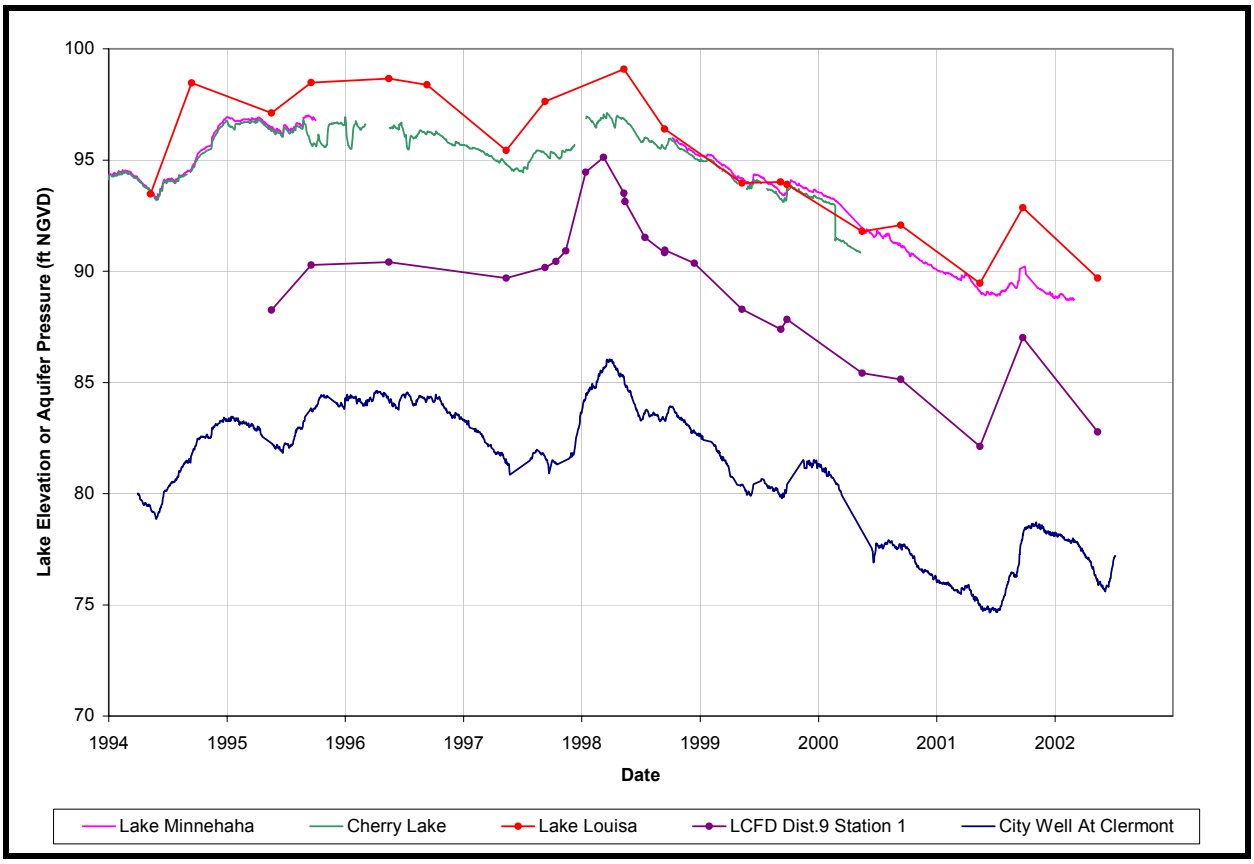

Exhibit 18. Lake levels and aquifer pressures at nearby deep wells

This plot indicates that there is a large gradient in the upper Floridan aquifer pressure beneath the Clermont chain of lakes, sloping downward from south to north.

The plot also indicates, in our opinion, that the surficial aquifer is not well connected to the upper Floridan aquifer in this vicinity. For example, comparing lake levels at Lake Minnehaha to Floridan aquifer pressures for the City Well at Clermont and LCFD Dist 9 Station 1 well, and noting that the lakes become disconnected below an elevation of approximately +94 ft NGVD (based on Stanley stream profiles), indicates that there is a head difference of approximately 5 to 12 feet, generally, between the lake level of Lake Minnehaha and aquifer pressures in the Upper Floridan aquifer.

6.4 Comparison of Upper Floridan aquifer pressures

Exhibit 19 compares the measured aquifer pressures in the Upper Floridan aquifer for a series of deep wells within and/or nearby the proposed model boundary. These data were obtained from a database search performed by USGS, and/or from online data sources. The location of these wells is indicated on the attached Figure 5-4.

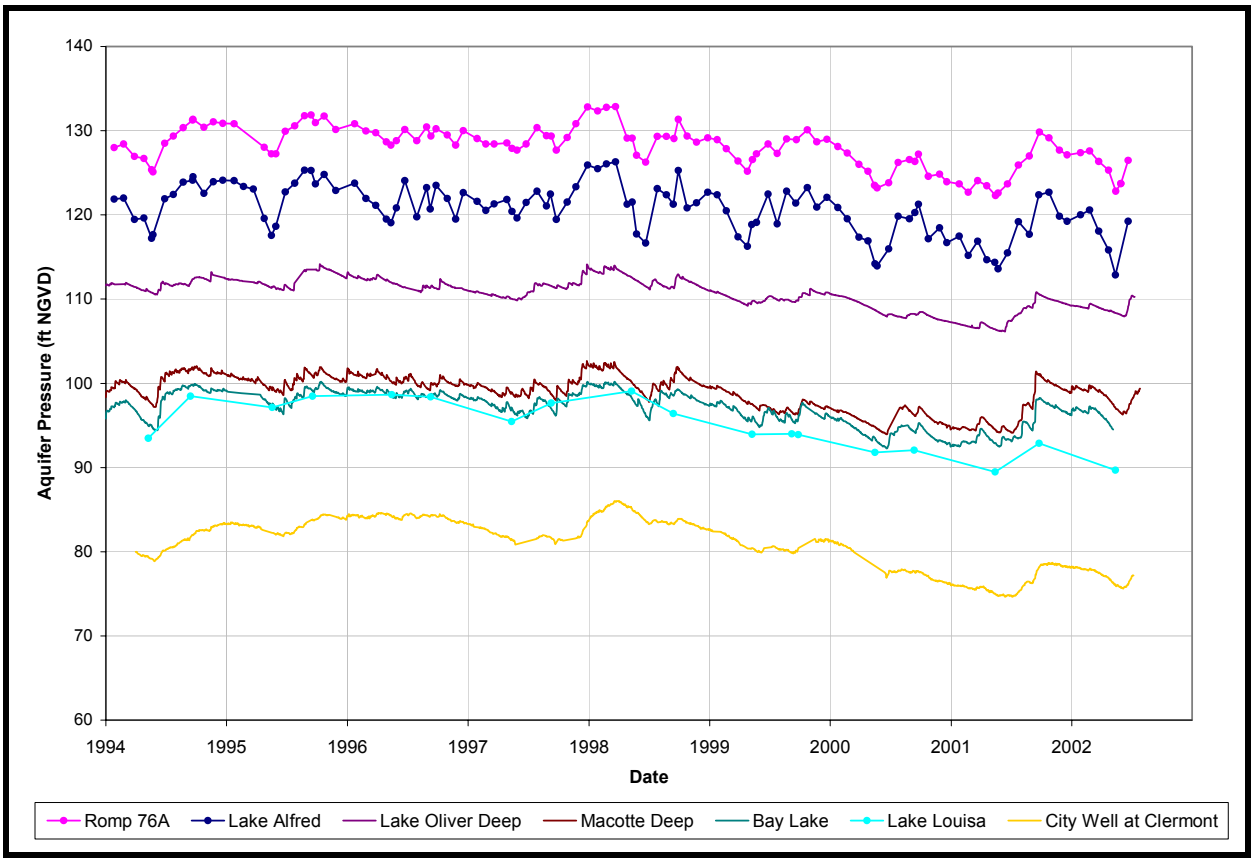

Exhibit 19. Deep well comparison

The Romp 76A well near Polk City, and the Lake Alfred well, are both located near the center, and south of the locus of high pressure located in the Green Swamp. They show a tendency to fluctuate more than the other wells to the north (Lake Oliver, Mascotte, Bay Lake, Lake Louisa, and Clermont), which display a more damped response to fluctuations in the aquifer pressure.

7.0 PRELIMINARY CONCLUSIONS

Based upon our preliminary continuous simulation modeling results, subject to change upon further analysis, it appears that the severe drawdown in lake levels for the Clermont Chain of Lakes, can best be explained due to surface water phenomenon, most notably the severe lack of rainfall in recent years and the subsequent lack of stream inflow from Big Creek and Little Creek, along with a relatively constant leakage rate between the surficial ground water aquifer and the Upper Floridan aquifer.

Our continuos simulation calibrations, using the PONDS 3.2 software, indicate that the leakage between the surficial groundwater aquifer and the upper Floridan aquifer is on the order 5 to 6.5 inches/year in the vicinity of the Clermont chain. This range of leakage values is consistent with leakage rates calibrated by O'Reiley in the published report *Hydrogeolgy and Simulation of the Effects of Reclaimed-Water Application in West Orange and Southeast Lake Couties, Florida*, 1998, as indicated in Exhibit 20. The O'Reilly results were discussed previously in our July progress report.

Based on recent verbal communications with the pilot from our initial fly-over of the project site on June 7, 2002, it appears that Lake Louisa has begun to rebound significantly following above average rainfall in recent months, while other lakes in the chain have not. This tends to support the view that the inflows from Big Creek and Little Creek exert a primary effect on lake levels in the chain, as opposed to stormwater runoff from contiguous basins. (Note: Stream flow was observed in Big Creek at our last site visit on July 14, 2002). If true, we would expect to see a cascading recovery effect as lakes in the south end of the chain begin to fill up, one after another, and discharge north through the Palatlakaha river, starting with Lake Louisa.

This cascading effect may have implications for future modeling efforts, in that the assumption that the Clermont chain is behaving as a single body will no longer apply during the recovery phase.

We are planning to re-visit the site in the upcoming days to confirm the observations reported to us.

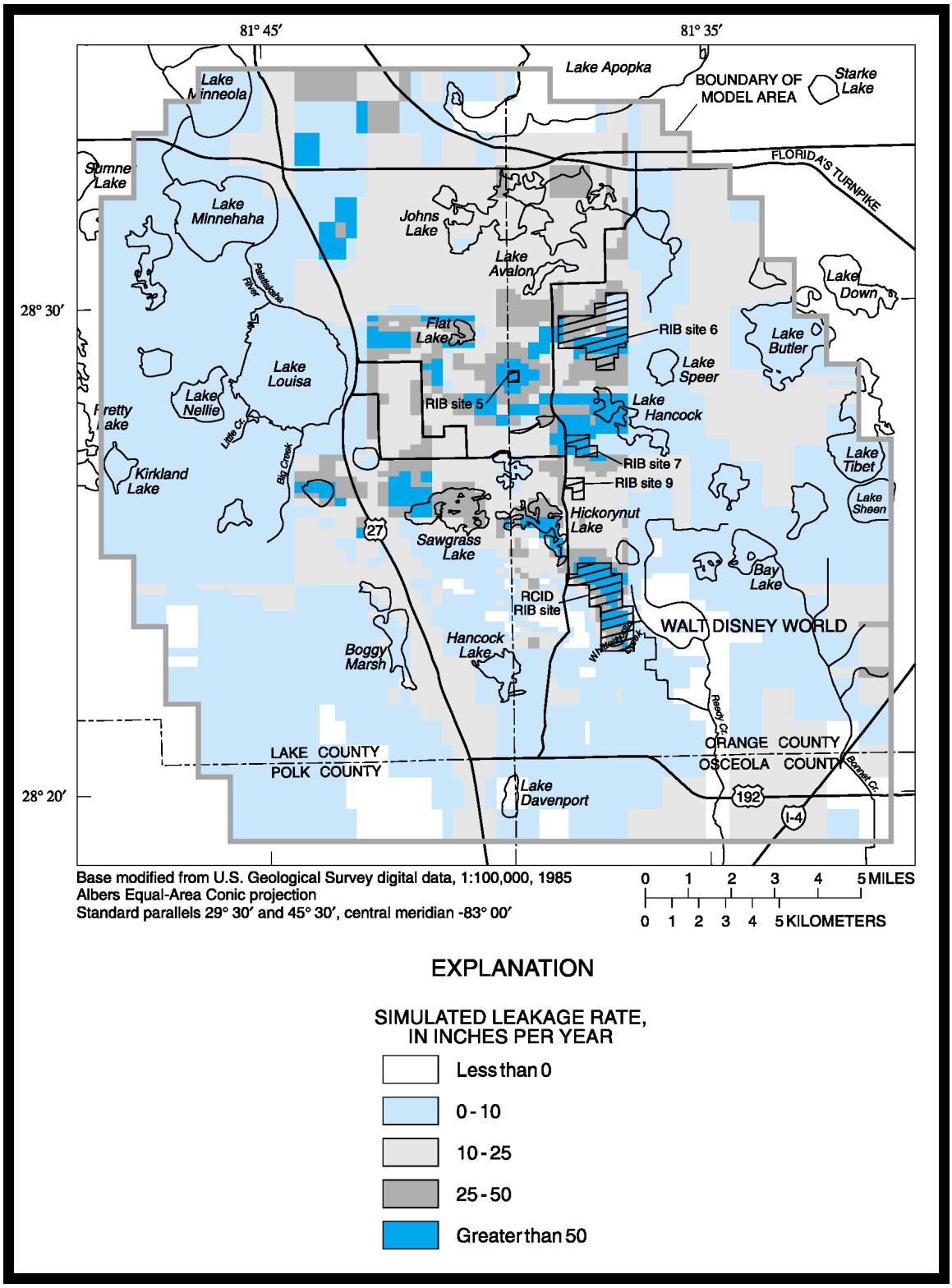

Exhibit 20. Simulated rate of leakage through the intermediate confining unit. O'Reilly, 1998.

FIGURES

Graphic Scale
2000 0 2000 4000 Feet
N

Cherry Lake
"Cherry Marsh"
Lakes Minneola & Hiawatha
"Sand Mine Marsh"
Lake Palatlakaha
Lake Minnehaha
Lake Susan
Lake Louisa

Lake Arthur
Lake Spencer
Deacon Lake
Shepherd Lake
Grassy Lake
Spring Lake
Wilson Island
Lake Minneola
LINE
COAST
SEABOARD
Minneola
Clermont
Reavills Corner
Groveland
Sumner Lake
Cypress Cove
Lake Wash
Groveland Municipal Airport
Black Lake
Pine Island Lake
Crescent Lake
South Clermont
Saw Mill
Orange Mountain
Lake Louisa
Eva Lookout
Lake Gary
Lake Nellie
Pretty Lake
Kirkland Lake
Bear Lake
Trout Lake
Brantly Lake
Dixie Lake
Pike Lake
Hammond
Lake Glona
Live Oak Lake
Cypress Lake
Big Creek
Little Creek
Bowles Island
FLORIDAS TURNPIKE
T 21 S
T 22 S
T 23 S
561

Legend:

- Equivalent lake area at elevation +96 ft NGVD, as modeled in PONDS 3.2
- Outline of assumed storage area above elevation +96 ft NGVD

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E-mail address: dseereeram1@cfl.rr.com
Website: http://home.cfl.rr.com/devo1

Figure Name: Equivalent lake area at elevation +96 ft NGVD and Storage area for elevation greater than +96 ft NGVD

Project Name: Clermont Chain of Lakes Study

Checked & Approved By:	Drawn By:	Date:	Scale:	Project #:	
DS	AZ	08-30-02	Noted	02-121.96	Figure 5-1

Graphic Scale
3000 0 3000 6000 9000 Feet
N

L23_100
L24_100
L70_100
L30_100
L63_100
L62_100
L61_100
L60_100

CHERRY LAKE
LAKE MINNEOLA
LAKE MINNEHAHA
LAKE LOUISA

L23
L25
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Ferndale
Montverde
Reavills Corner
Roan
Killarney
Castle Hill
Groveland
Groveland Municipal Airport
Avalon Lookout
Radio Tower

Moon Lake
Lake Arthur
Lake Emma
Lake Lucy
Lake Merrie
Lake Minneola Shores
Shepherd Lake
Smith I
Lake Louisa
Lake Avalon
Lake Ingram
Trout Lake
Pike Lake
Island Lakes
Lake Needham
Sawgrass Lake
Sawgrass Bays
Hancock Bays
Hancock Lake
Lake Star
Lake Mac
Doe Lake
Lake Oliver
Rexford Lake
Crooked Lake
Hickorynut Lake
Sumner Lake
Big Bear Lake
Slag Lake
Erie Lake
Lake Catherine
Mill Stream Swamp
Alligator Lake Swamp
Gourd Neck
Johns Lake

SEABOARD
FLORIDA TURNPIKE
TOLL
ORANGE CO
GREEN

T 21 S
T 22 S
T 23 S
T 24 S

Legend:

Basin Group ID's

- L60_100
- L61_100
- L62_100
- L63_100
- L24_100
- L30_100
- L23_100
- L70_100

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Website: http://home.cfl.rr.com/devo1

Figure Name: Runoff Basins for Clermont Chain of Lakes

Project Name: Clermont Chain of Lakes Study

Checked & Approved By:	Drawn By:	Date:	Scale:	Project #:	
DS	AZ	08-30-02	Noted	02-121.96	Figure 5-2

Graphic Scale

8000 0 8000 16000 Feet

N

USGS 284842081533001

USGS 283314081455501

USGS 283204081544901
USGS 283204081544902

USGS 282717081553101

USGS 282738081341401

USGS 282528081340901

USGS 282210081352601

USGS 282202081384602

Legend:

- Wells with daily readings for period of interest (1994 to present)
- All wells
- Proposed model boundary

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Website: http://home.cfl.rr.com/devo1

Checked & Approved By:	Drawn By:	Date:
DS	AZ	08-30-02

Figure Name: Location of Monitored Wells From USGS Database Survey

Project Name: Clermont Chain Of Lakes Study

Scale:	Project #:	
Noted	02-121.96	Figure 5-3

Graphic Scale

8000 0 8000 16000 Feet

N

Clermont (USGS 283314081455501)

Mascotte (USGS 283204081544901)

LCFD Dist.9 Station 1 (USGS 283019081455701)

Bay Lake (282717081553101)

Lake Louisa State Park (USGS 282729081443301)

Lake Oliver (USGS 282202081384601)

Polk City, Romp 76A (USGS 281057081495002)

Lake Alfred (USGS 280531081431601)

Legend:

- Well Location
- Proposed Model Boundary
- Potentiometric Surface of the Upper Floridan Aquifer (Sept 2000)

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Website: http://home.cfl.rr.com/devo1

Figure Name: Location of Deep Wells in Area of Interest

Project Name: Clermont Chain of Lakes

Checked & Approved By:	Drawn By:	Date:	Scale:	Project #:	
DS	AZ	08-30-96	Noted	02-121.96	Figure 5-4

TECHNICAL MEMO #6: MODELING RESULTS, SUMMARY OF FINDINGS, AND PRELIMINARY CONCLUSIONS

Ground water / Surface water interaction modeling for portion of South Lake County (FL) which encompasses

THE CLERMONT CHAIN OF LAKES



Prepared for

LCWA

Lake County Water Authority

PEC

Professional Engineering Consultants, Inc.

Prepared by

DEVO Engineering

CONSULTING GEOTECHNICAL ENGINEERS

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September 2002

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Date: October 4, 2002	*Devo's Project No.* 02-121.96
To: Lake County Water Authority 107 North Lake Avenue Tavares, Fl 32778-3119 phone: 352-343-3777 fax: 352-343-4259 attention: LANCE LUMBARD	*cc:* Professional Engineering Consultants, Inc. 200 East Robinson Street, Suite 1560 Orlando, FL 32801 phone: 407-422-8062 fax: 407-849-9401 attention: DAVID HAMSTRA, P.E.
LCWA Lake County Water Authority	PEC

Ref:

TECHNICAL MEMO #6 – MODELING RESULTS, SUMMARY OF FINDINGS, AND PRELIMINARY CONDITIONS
STATUS REPORT FOR SEPTEMBER 2002
GROUND WATER/SURFACE WATER INTERACTION MODELING FOR PORTION OF SOUTH LAKE COUNTY (FL) WHICH ENCOMPASSES THE CLERMONT CHAIN OF LAKES

Dear Mr. Lumbard:

The attached status report summarizes our activities for the above referenced project for the month of September, 2002.

Sincerely,
Robert Casper
Robert D. Casper, E.I.
Project Engineer

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AERIAL AND LAND RECONAISSANCE 5
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- Aerial Reconnaissance, September 15, 2002 6
- Aerial Reconnaissance, September 22, 2002 6
- Summary of Lake Conditions as of September 22, 2002 6

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LIST OF APPENDICES

Appendix A. Hardcopy of Slide Show presented at LCWA Board Meeting on Sept 18

INTRODUCTION

This report summarizes our activities in regards to our ongoing ground water/surface water modeling effort for the Clermont Chain of Lakes for the month of September, 2002. The bulk of our effort for the month of September falls into the following categories

- ✎ Aerial and land reconnaissance.
- ✎ Preparation of materials for and presentation of preliminary modeling results to the Board of Directors of the Lake County Water Authority, and members of the public, at the September 18 board meeting.

WATER LEVEL UPDATE IN GREEN SWAMP

The Southlake WWTF monitor well cluster serves as an indication of the water level in the Green Swamp which feeds Big Creek and Little Creek.

Chart 1 below shows that the ground water level in the Green Swamp continues to rise as the rainfall in the Clermont area continues at above-normal levels. Water levels at this location has risen almost 10 ft above the June 2001 levels. Current water levels are almost as high as the record high levels observed during the El Nino rains.

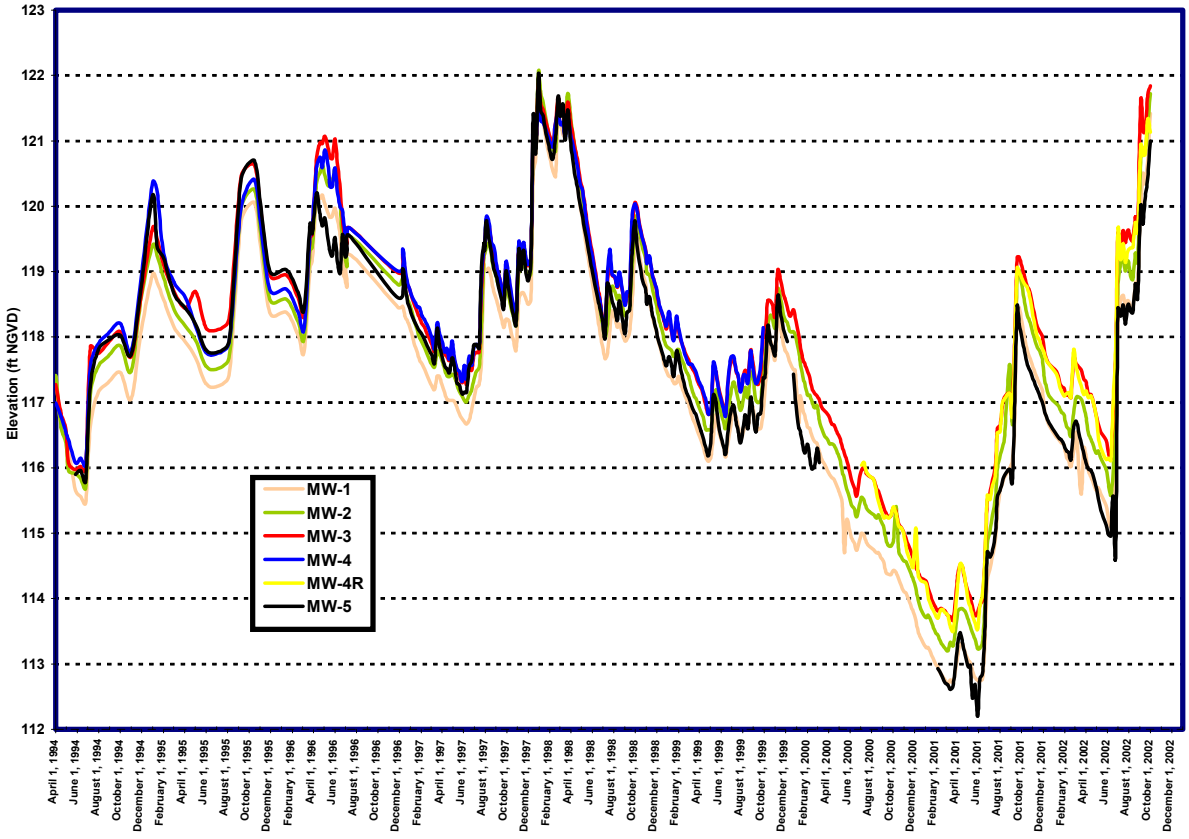


Chart 1. Water levels at Southlake WWTF from April 1, 1994 to Sept 30, 2002

AERIAL AND LAND RECONAISSANCE

Land Reconnaissance, September 10, 2002

Land reconnaissance was conducted on September 10, 2002, with stops at representative locations at each of the major lakes in the Clermont Chain. The following observations were noted:

- ☞ Big Creek continues to flow, as it was on our previous July 14, 2002, visit, with water levels at the Big Creek gaging station rising significantly since then.

- ☞ At the Little Creek gaging station, significant stream flow was observed, in contrast to our previous visit of July 14, 2002, when there was no obvious sign of stream flow.

- ☞ At Lake Louisa, water levels had recovered significantly, and appeared to be near normal. Robert Casper spoke to a six-year resident living on the north shore of Lake Louisa, who also expressed his belief that levels water levels were about normal there, as well as his surprise at how fast the water levels had risen. He also expressed concern over an apparent fish kill, as evident from approximately a dozen to two dozen dead fish in the immediate vicinity of his boat dock, which appeared to be of a single species. The water in the lake appeared darkly stained.

- ☞ Water levels were up significantly in Lake Susan, with significant flow in the Palatlakaha River, from Lake Susan to Lake Minnehaha.

- ☞ Water levels in Lake Minnehaha were up slightly, but were still considerably below normal. In general, boat docks around Lake Minnehaha still appeared to be high and dry. The Monte Vista Canal, between Lake Minnehaha and Crescent Lake, while showing some signs of standing water, remained non-navigable.

- ☞ At the CR 561 bridge between Lake Palatlakaha and Lake Minnehaha, water in the Palatlakaha River was observed to be flowing backwards, i.e., flowing from Lake Palatlakaha to Lake Minnehaha.

- ☞ At the CR 565A bridge, between Lake Hiawatha and Lake Minneola, there was a trickle of flow from Lake Hiawatha to Lake Minneola, although the channel was still non-navigable.

- ☞ The Palatlakaha River flowing out of Lake Minneola was slightly wet, but with no obvious signs of flow to Lakes Wilson, Cook, and Cherry.

- ☞ At the Cherry Lake discharge structure, the downstream water elevation (Little Lake Cherry) was higher than the upstream level (Cherry Lake). A foot to a foot-and-a-half of water was observed on the downstream side of the discharge structure, at the foot of the structure, while the water levels on the upstream side of the discharge structure were still below the foot of the structure.

Aerial Reconnaissance, September 15, 2002

On September 15, 2002, aerial reconnaissance was performed using a chartered helicopter. In attendance were Devo Seereeram and Robert Casper from Devo Engineering. The flight path commenced south of the Clermont Chain of Lakes, near the intersection of US 27 and US 192, at the location of the Southlake Utilities site, for which Devo Engineering have been collecting regular monitor well readings since April 1994. The flight path then proceeded west, over the Green Swamp, where wet conditions and standing water prevailed throughout Green Swamp, then north following the Big Creek drainage basin to Lake Louisa, and sequentially through the Clermont Chain to Cherry Lake.

Aerial Reconnaissance, September 22, 2002

On September 22, 2002, we revisited the Clermont Chain of Lakes by helicopter, following an aerial reconnaissance of another unrelated project, with a fly-over of Lakes Minneola, Minnehaha, and Louisa, as well as Big Creek just south of Lake Louisa.

Summary of Lake Conditions as of September 22, 2002

While Lake Louisa and Lake Susan have rebounded significantly, due to the resumption of inflow from Big Creek and Little Creek, water levels in the other lakes of the Clermont Chain have risen only slightly (likely reflecting the contributions of direct rainfall and direct runoff from contiguous basins only). As of September 22, 2002, there was significant flow from the Palatlakaha River into Lake Minnehaha, which while it has not yet rebounded significantly, may be expected to recover next if current weather conditions prevail, and Big Creek and Little Creek continue to flow. It is expected that the lakes will continue to fill sequentially, in a cascading manner from south to north, such that no significant improvement is likely in the northern end of the chain, Lake Cherry for example, for some months to come.

The following is a representative series of photographs from land and aerial reconnaissance of September 10, 15, and 22, 2002.



Exhibit 1. High water levels at foot bridge near Big Creek gaging station, 9/10/2002



Exhibit 2. North shore of Lake Louisa, 9/10/2002



Exhibit 3. Aerial view over Green Swamp. 9/15/2002



Exhibit 4. Aerial view of Little Creek near gaging station on Lk Nellie Road, 9/15/2002



Exhibit 5. Flow into Lake Minnehaha from Lake Susan, 9/15/2002



Exhibit 6. North shore of Lake Minneola, 9/15/2002



Exhibit 6. Shore of Lake Minnehaha, 9/22/2002

SEPTEMBER 18 PRESENTATION TO THE LCWA GOVERNING BOARD

On September 18, 2002, Devo Seereeram, Ph.D., P.E., representing Devo Engineering, presented the preliminary results of our modeling effort to the Lake County Water Authority Board of Directors, during their regularly scheduled public meeting. The content of this presentation is reproduced in Appendix A. Dr. Seereeram reiterated our opinion, subject to change, that the severe drop in lake levels are due to an unprecedented four year drought (which appears to have ended with the above average rainfalls experienced in 2002) which had severely diminished (and stopped) stream inflows from Big Creek and Little Creek which would otherwise would have been crucial in maintaining lake levels throughout the chain. Also presented were the preliminary results of modeling using the PONDS 3.2 Refined Method software, which produced a very good correlation to measured lake levels for the modeling period of January 1, 1994 to November 30, 2001. The following table, presented during the presentation, summarizes the water budget components for the specified model period, based on the model results presented in our August, 2002, progress report.

	Yearly Inflows			
	Rainfall (million gallons)	Stream Inflow (million gallons)	Runoff (million gallons)	Infiltration ** (million gallons)
1994	14,121	7,886	3	351
1995	11,197	12,793	297	616
1996	11,137	9,486	33	742
1997	13,608	9,365	186	344
1998	7,434	20,404	62	701
1999	9,200	161	295	90
2000	6,237	36	97	-178
2001*	9,213	0	35	-11
Total	82,147	60,132	1,009	2,656

Table 1-A. Summary of yearly inflows from PONDS 3.2 model.

	Yearly Outflows		
	Evaporation (million gallons)	Leakage (million gallons)	Discharge (million gallons)
1994	-10,977	-1,402	-1,487
1995	-10,977	-1,402	-15,416
1996	-10,977	-1,402	-10,147
1997	-10,977	-1,402	-6,835
1998	-10,977	-1,402	-22,709
1999	-10,977	-1,402	0
2000	-10,977	-1,402	0
2001*	-10,503	-1,283	0
Total	-87,342	-11,095	-56,595

Table 1-B. Summary of yearly outflows from PONDS 3.2 model

Notes:

* Year 2001 represents the period from January 1 through November 30, 2001.

** Positive infiltration represents flow into the lakes from the surrounding ground water table, while negative inflitration represents flow from the lakes into the surrounding ground water table.

As seen in the above Tables 1-A and 1-B, the magnitude of the yearly rainfall and the yearly evaporation are of similar magnitude, and tend to offset one another to a large degree, which is generally the case for water bodies in the Central Florida area.

The stream inflows, from Big Creek and Little Creek, represent a significant portion of the inflow to the system for years 1994 through 1998, after which they drop sharply, falling to zero by year 2001.

Direct runoff from the contiguous drainage basins, not including the contributing basins of Big Creek and Little Creek, represent a relatively small portion of total inflows, as does direct horizontal infiltration between the lakes and the surrounding surficial aquifer.

The vertical leakage between the surficial aquifer and the upper Floridan Aquifer, as calibrated to a constant leakage rate of 6.5 inches per year in our August progress report, represents a relatively intermediate loss to the system, but expresses itself more prominently when both rainfall and stream inflows fall significantly below normal for extended periods.

Yearly evaporation rates and vertical leakage rates are assumed to be constant throughout the model period, and the combination of direct rainfall and, in particular, stream inflow from Big Creek and Little Creek, are the principle fluctuating variables.

WHAT'S NEXT

The focus of our modeling effort will shift to the behavior of the Green Swamp and factors which affect the discharge rate/volume for Big Creek and Little Creek, including whether the Green Swamp behaves as a perched lake, and whether the increase in deep Floridan pumpage is expected to impact these discharge rates.

APPENDIX A
SLIDE SHOW



Discussion Topics

1- Description of Study Area

2- Statement of Problems

3- Objectives of Study

4- Hydrologic Data Collection

5- Hydrogeology of Study Area

6- Hydrologic Data & Analysis

7- Continuous Simulation Model

8- Modeling Results

9- Implications of Model Results

10- More Photos

Item #1

Description of Study Area

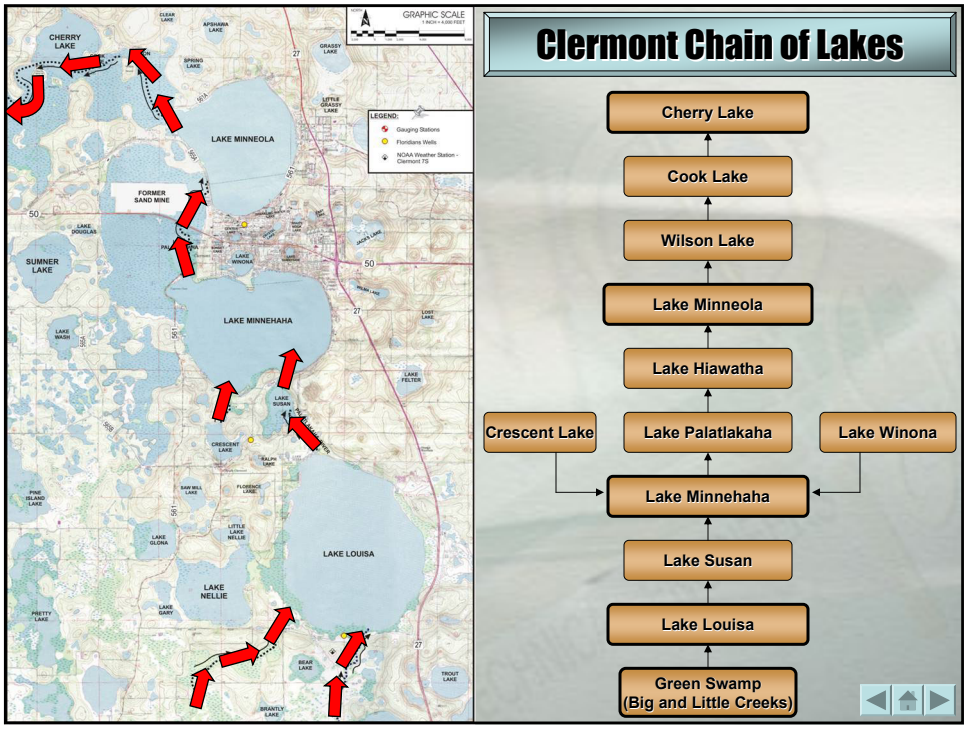


Little Creek, at gaging station, 9/10/2002

The Clermont Chain of Lakes

For the purpose of this study,
the Clermont Chain of Lakes consists of
the navigable lakes along the Palatlakaha River,
starting with Lake Louisa in the south,
and ending at Cherry Lake in the North.

This includes:
Lake Louisa, Lake Susan, Lake Minnehaha,
Crescent Lake, Lake Winona, Lake Palatlakaha,
Lake Hiawatha, Lake Minneola, Wilson Lake,
Cook Lake, and Cherry Lake



Notable Events

- 1885, first steamboat navigates from Lake Harris to Lake Minneola during period of high water. Later, as water levels fell, a channel was dug between Wilson Lake and Lake Minneola, and between Lake Hiawatha and Lake Palatlakaha.
- 1889, first excavation of Monte Vista Canal, connecting Crescent Lake and Lake Minnehaha. Re-dug in 1908, following drought in 1907
- 1926, Yacht and Water Sports Club is organized and commissions an investigation on the possibility of opening a canal between Lake Nellie and Lake Louisa. It was not considered feasible, as the difference in water levels would necessitate the construction of a series of locks.
- 1938, Clermont-Minneola Waterways Club is Organized. Reorganized in 1951, becoming the South Lake Waterways Club, leading an effort resulting in the "Engineering Report on Inland Waterways of Florida." This leads to...
- 1951, legislature creates Oklawaha Basin Recreation and Water Conservation and Control Authority, now known as the Lake County Water Authority
- 1956 Cherry Lake dam is completed. The possibility of constructing a lock to allow boat traffic beyond Cherry Lake was considered not to be feasible
- 1956-1958, Monte Vista canal re-dredged and a new wooden bridge was built, replacing a dirt road and culvert which had obstructed boat traffic for the previous 35 years.
- 1972, wooden bridge over Monte Vista canal is replaced with large metal culvert, large enough boat travel.

Source: Clermont Gem of the Hills.

Item #2

Problem Statement



Lake Minneola, north shore, 6/10/2002

Problem Statement

Record low lake levels affecting...



CR 561

Roadway Failure



CR 565A Bridge

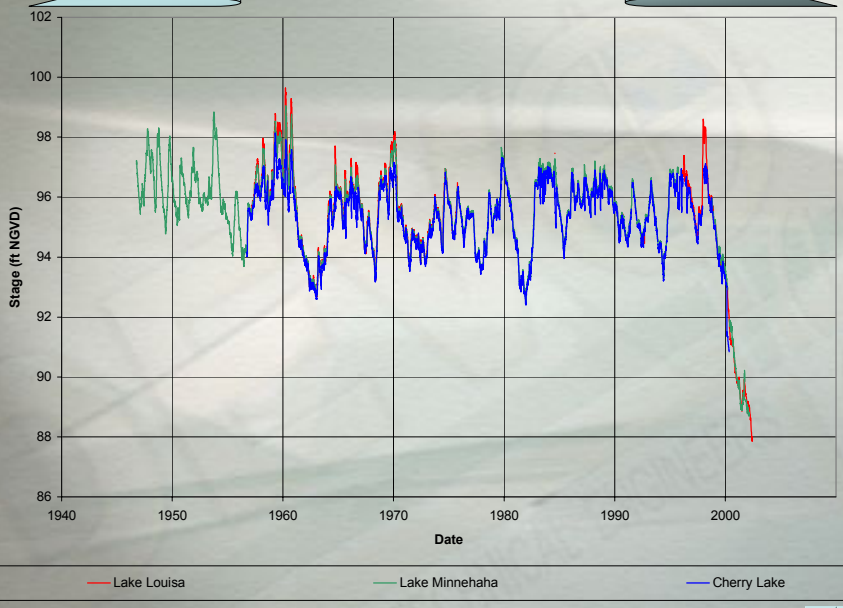
Navigability and Recreation



Lake Minneola

Aesthetics and Property Value

Historical Lake Levels (1946 – 2002)



Data for the period of 10/1/1946 through 3/2/2002

Summary of Extreme Stages in the Clermont Chain

YEAR	Condition	Lake Stage (ft)
1960	Flood	99.04
1963	Drought	92.72
1979	Flood	97.66
1981	Drought	92.47
1998	Flood	98.11
2002	Drought	87.57

Source: Stanley Consultants, Inc.

100 year flood elevation: +99.0 ft

Mean high water level: +96.97 ft

Mean low water level: +94.63 ft

Item #3

Objectives



Lake Minneola, north shore, 6/10/2002

Objectives

Develop a subregional ground water / surface water model to quantify and distinguish the lake level influence of the following:

- natural weather patterns
- artificial ground water withdrawals

Item #4

Hydrologic Data Collection Effort



Cherry Lake Discharge Structure, 6/7/2002

Aerial Reconnaissance

June 7 & Sept 15, 2002



Lake Minnehaha, 6/7/2002



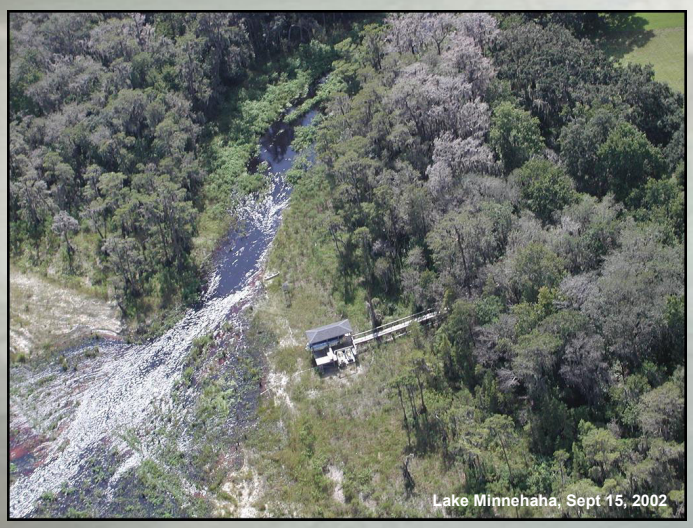
Cherry Lake Discharge Structure, 6/7/2002

Lake Louisa
June 7 & Sept 15, 2002





Flow From Lake Susan Into Lake Minnehaha
Sept 15, 2002



West Shore Of Lake Minnehaha
Sept 15, 2002



Crescent Lake
Sept 15, 2002



North Shore Of Lake Minneola
Sept 15, 2002



Lake Minneola, Sept 15, 2002

Ground Reconnaissance
June 10, June 22, July 14, & September 10, 2002 Site Visits



Lake Minneola, 6/10/2002



Monte Vista Canal, between Lake Minnehaha and Crescent Lake, 6/10/2002



Cherry Lake, 6/22/2002



Lake Louisa State Park, 6/22/2002

Mining of Data Resources

- **Published Resources**
  - *USGS Water Resources Data, Volume 1A: Surface water, and Volume 1B: Ground Water, Water Year 2001* (et. al.)
  - USGS Potentiometric Surface Maps of the Upper Floridan Aquifer
  - USGS 7.5 Degree Quadrangle Maps
  - *Hydrogeology and Simulation of the Effects of Reclaimed Water Application in West Orange and Southeast Lake Counties, Florida*, Andrew O'Reilly, 1998
  - *Palatlakaha River Restoration Phase 1 Report – Appendix, Draft Technical Memorandum*, Stanley Consultants, Inc., April 2002
  - *Clermont, Gem of the Hills*, Miriam Johnson and Rosemary Young, 1984
- **Online Resources**
  - Online data resources LCWA, SJRWMD, SFWMD, SWFWMD, USGS
- **Transmitted data sources**
  - Data from LCWA, SJRWMD, USGS
  - Southlake Utilities monitor well data

Item #5
Hydrogeologic Setting



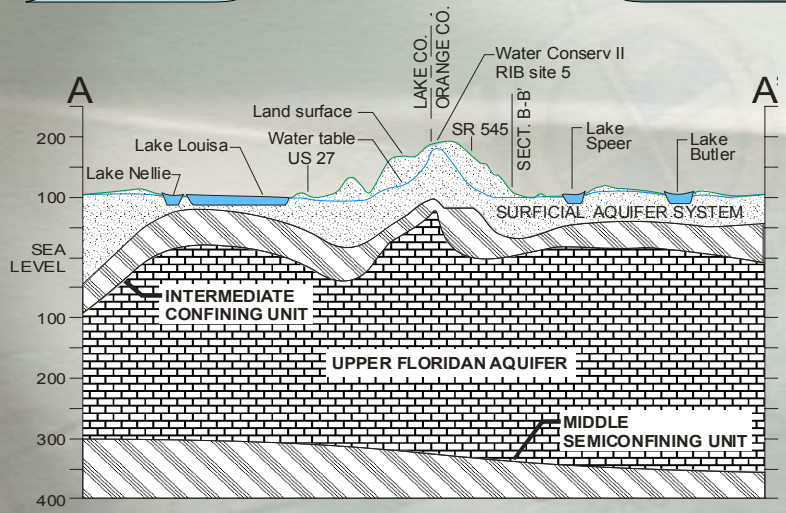
Cherry Lake, 6/7/2002

Geological Cross Section



Location of geological cross section presented in O'Reilly report

Cross Section A-A'

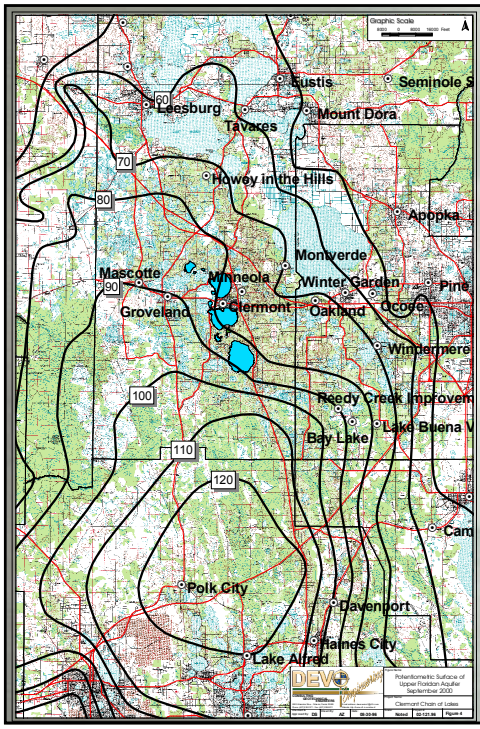


Source: O'Reilly

Note: thickness of intermediate confining unit in vicinity of Lake Louisa

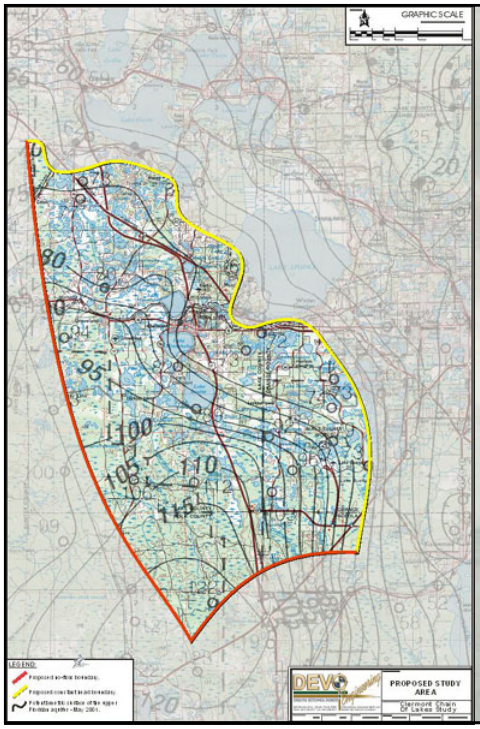
0 2 4 MILES
0 2 4 KILOMETERS

WATER TABLE REPRESENTS AVERAGE 1995 CONDITIONS



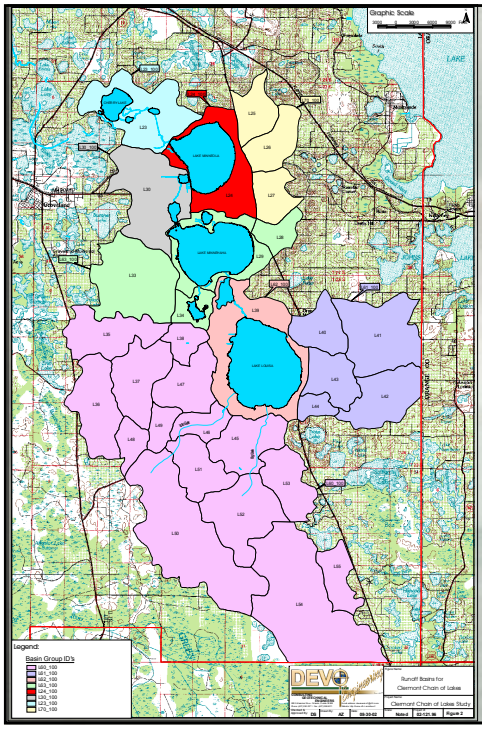
Potentiometric Surface of the Upper Floridan Aquifer

September 2000



Floridan Aquifer Watershed for Area of Interest

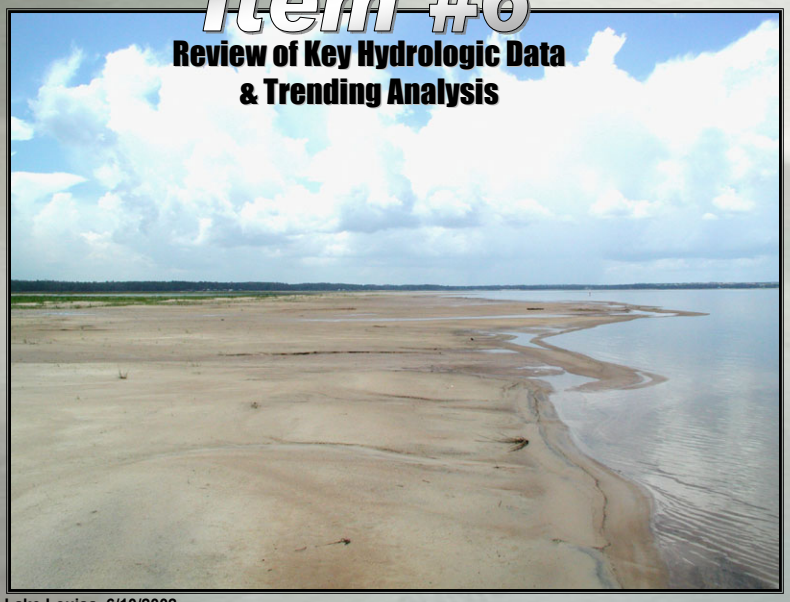
- Model boundary was selected to take advantage in naturally features in the Upper Floridan aquifer
- A boundary perpendicular to potentiometric lines represents a no-flow boundary. No flow crosses this boundary
- A boundary parallel to a pontentiometric line represents a constant head boundary.



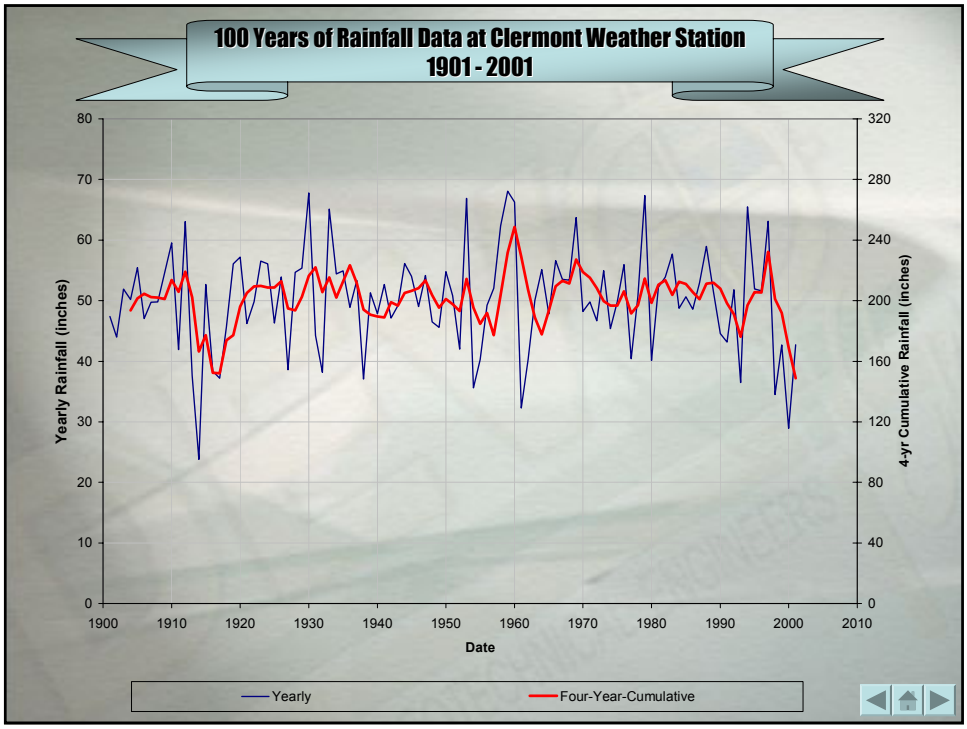
Surface Water Watersheds Contributing to Clermont Chain of Lakes

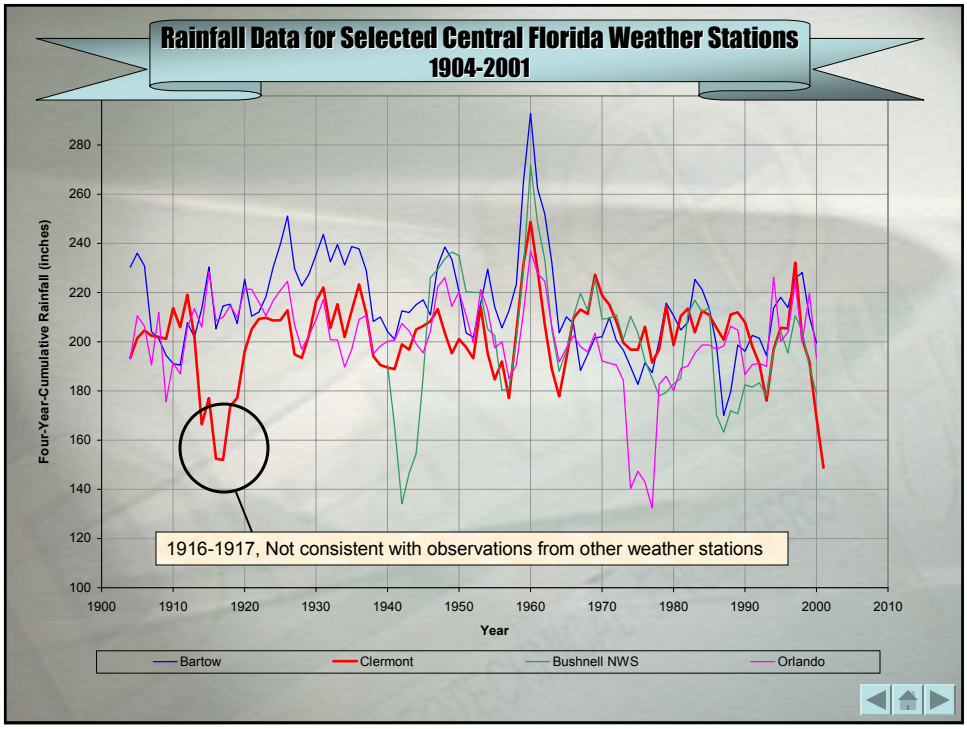
Item #6

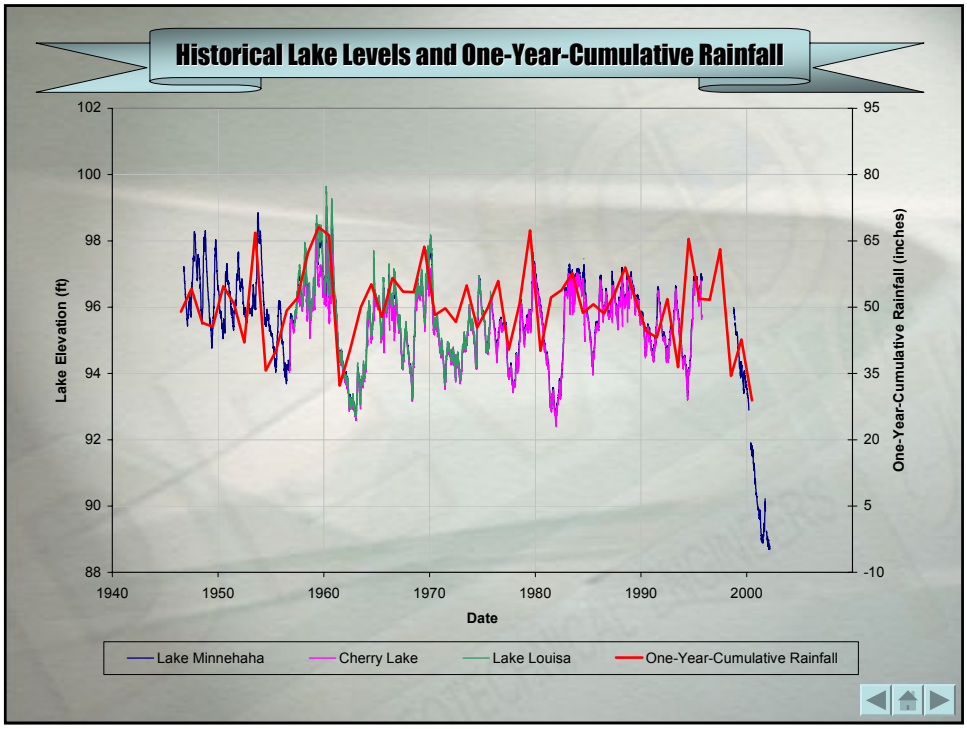
Review of Key Hydrologic Data & Trending Analysis

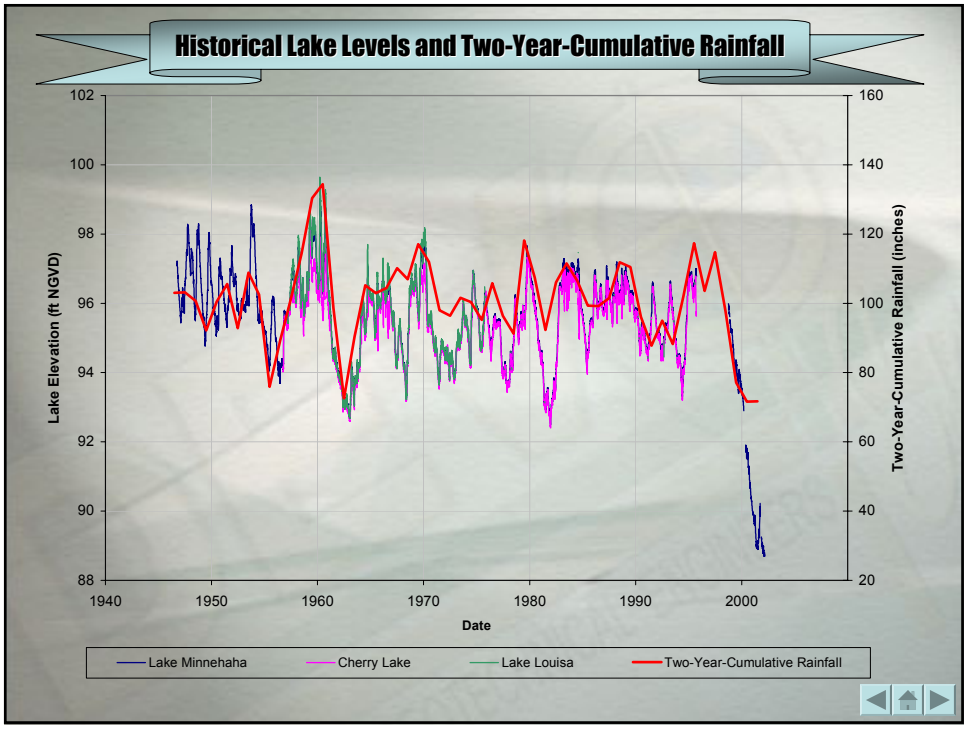


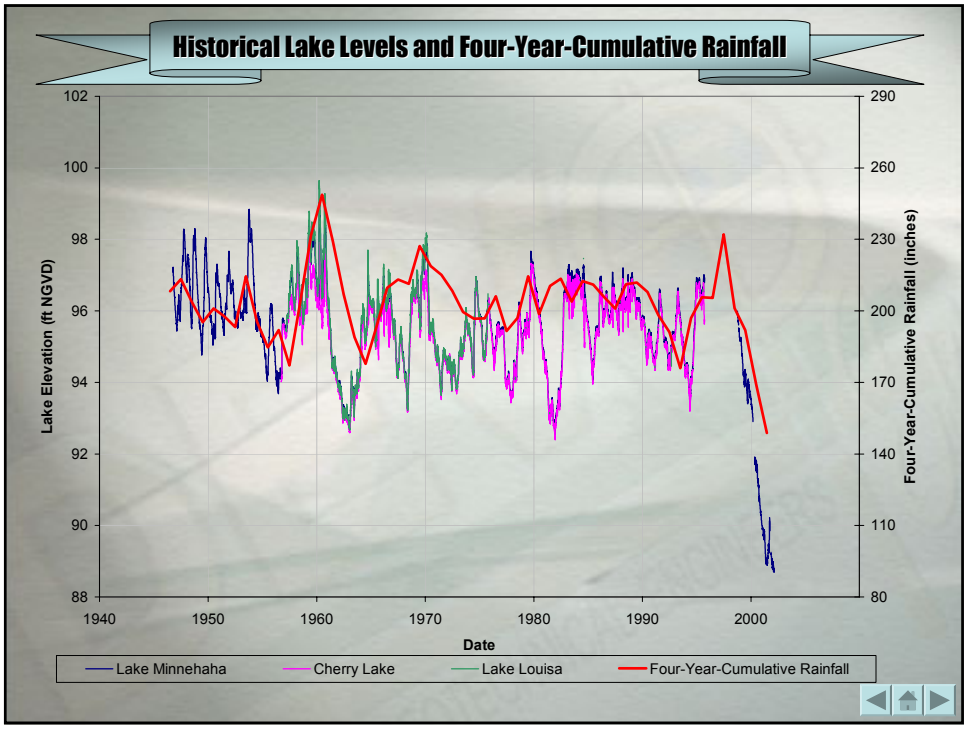
Lake Louisa, 6/10/2002

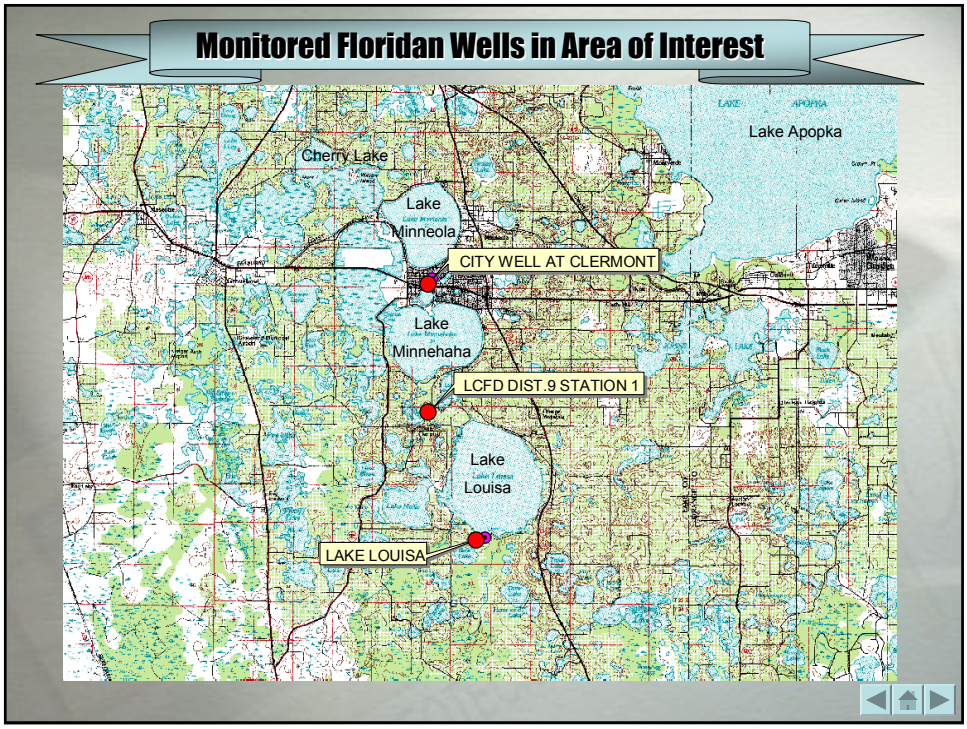

100 Years of Rainfall Data at Clermont Weather Station
1901 - 2001
Yearly Rainfall (inches)
4-yr Cumulative Rainfall (inches)
Date
Yearly
Four-Year-Cumulative


Rainfall Data for Selected Central Florida Weather Stations
1904-2001
Four-Year-Cumulative Rainfall (inches)
1916-1917, Not consistent with observations from other weather stations
Year
Bartow
Clermont
Bushnell NWS
Orlando

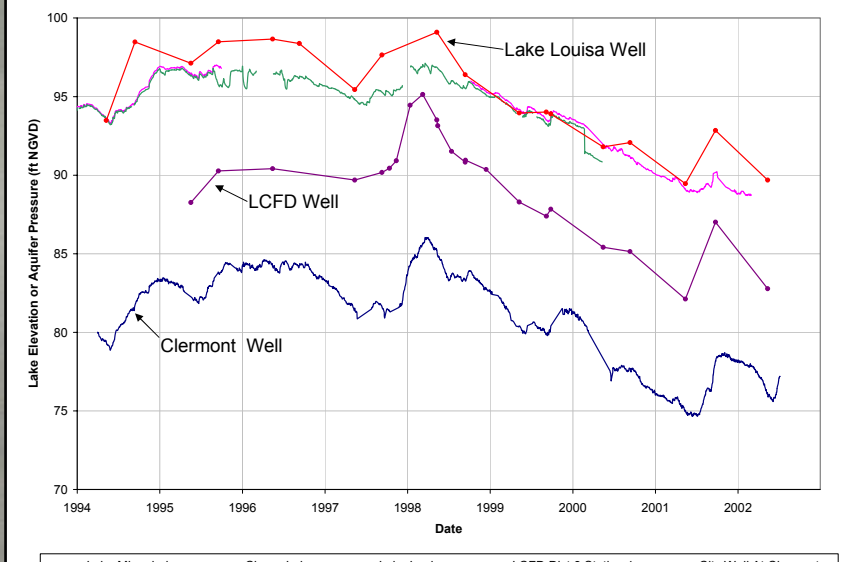

Historical Lake Levels and One-Year-Cumulative Rainfall
Lake Elevation (ft)
One-Year-Cumulative Rainfall (inches)
Date
Lake Minnehaha
Cherry Lake
Lake Louisa
One-Year-Cumulative Rainfall


Historical Lake Levels and Two-Year-Cumulative Rainfall
Lake Elevation (ft NGVD)
Two-Year-Cumulative Rainfall (inches)
Date
Lake Minnehaha
Cherry Lake
Lake Louisa
Two-Year-Cumulative Rainfall

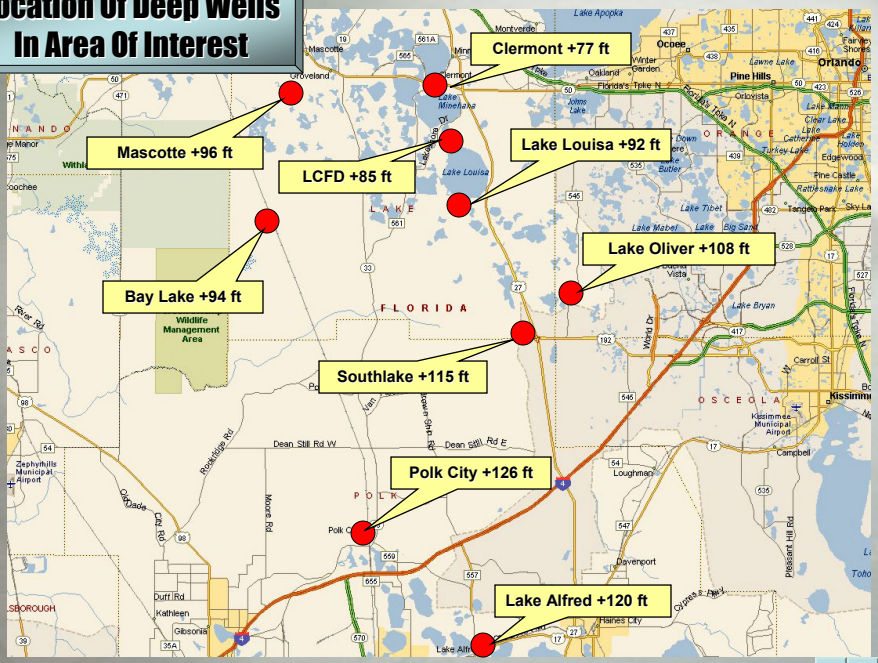

Historical Lake Levels and Four-Year-Cumulative Rainfall
Lake Elevation (ft NGVD)
Four-Year-Cumulative Rainfall (inches)
102
100
98
96
94
92
90
88
290
260
230
200
170
140
110
80
1940
1950
1960
1970
1980
1990
2000
Date
Lake Minnehaha
Cherry Lake
Lake Louisa
Four-Year-Cumulative Rainfall


Monitored Floridan Wells in Area of Interest
Lake Apopka
Cherry Lake
Lake Minneola
CITY WELL AT CLERMONT
Lake Minnehaha
LCFD DIST.9 STATION 1
Lake Louisa
LAKE LOUISA

Lake Levels compared to Floridan Aquifer Levels

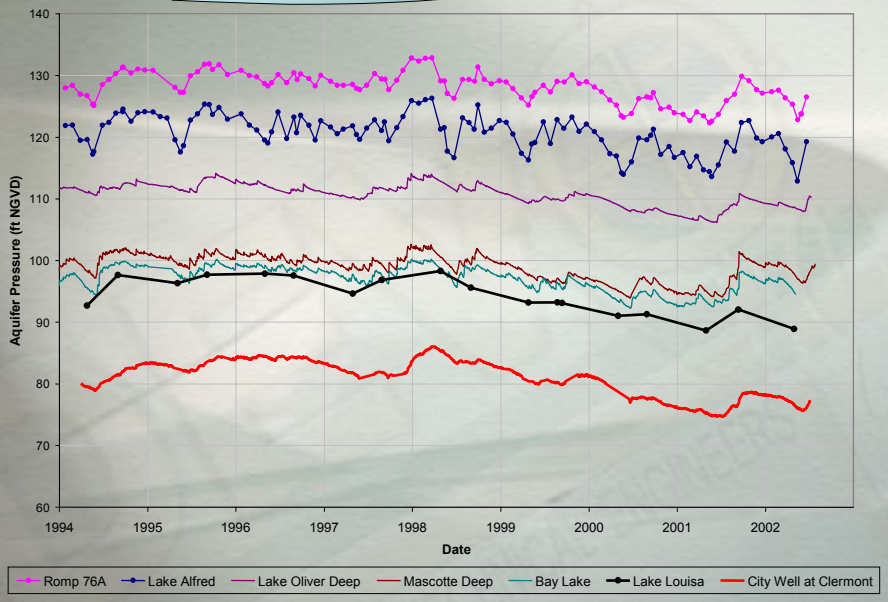


Location Of Deep Wells In Area Of Interest

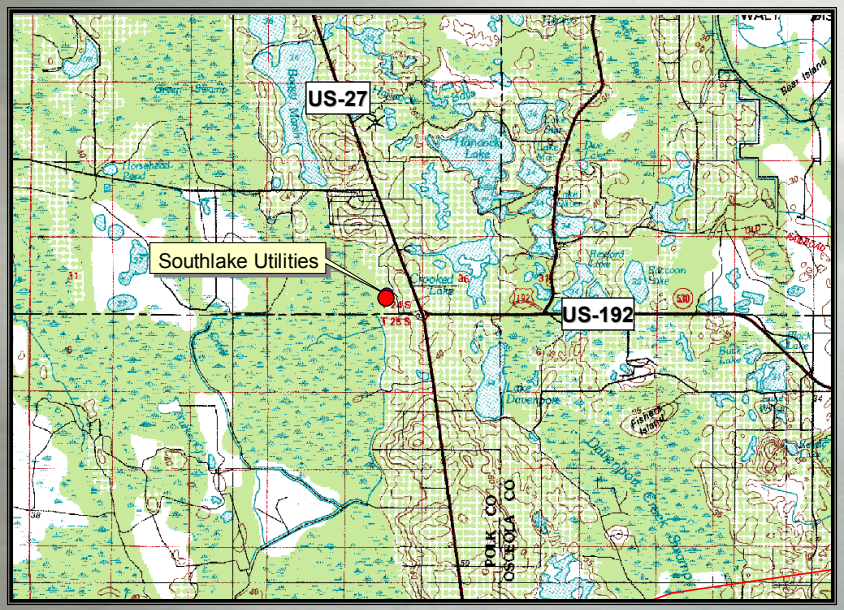


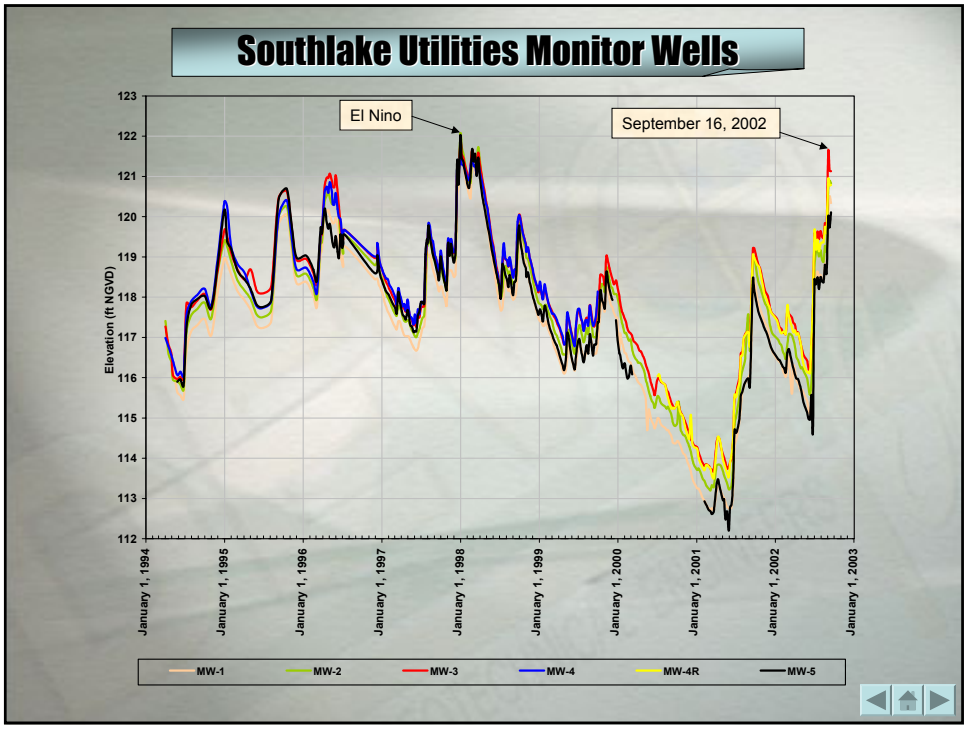
Note: Aquifer Pressure, Sept. 2000

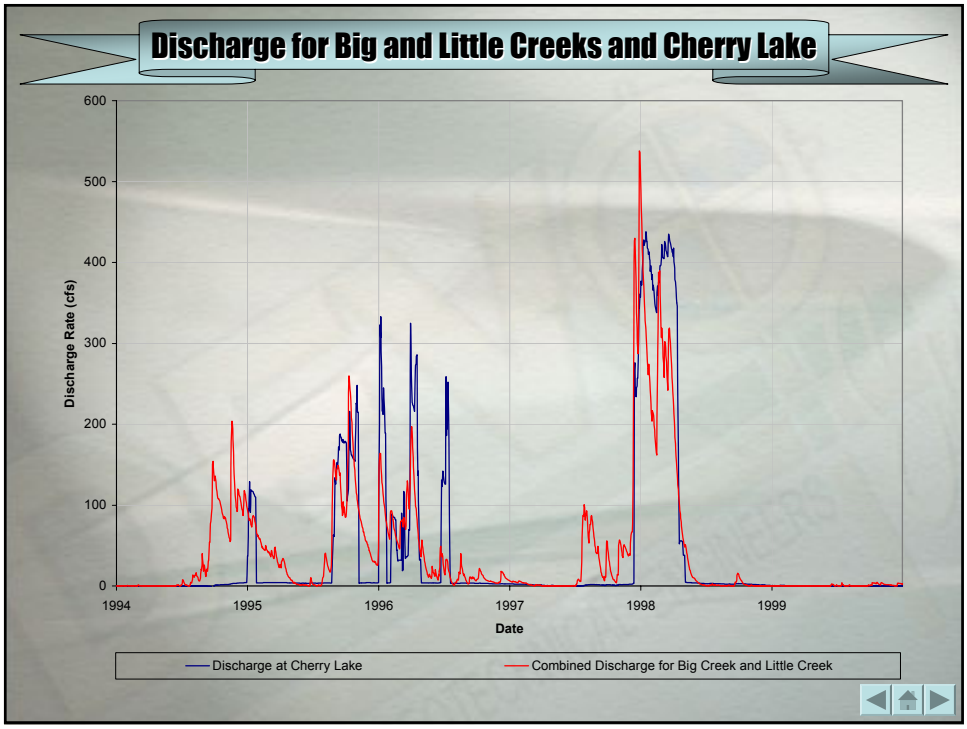
Potentiometric Surface Trends



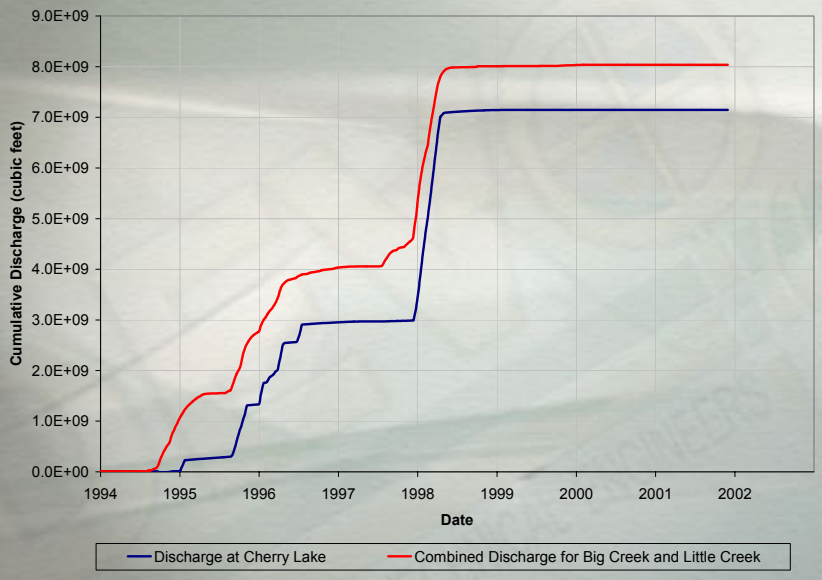
Location of Southlake Utilities Monitor Wells




Southlake Utilities Monitor Wells
El Nino
September 16, 2002
Elevation (ft NGVD)
123
122
121
120
119
118
117
116
115
114
113
112
January 1, 1994
January 1, 1995
January 1, 1996
January 1, 1997
January 1, 1998
January 1, 1999
January 1, 2000
January 1, 2001
January 1, 2002
January 1, 2003
MW-1
MW-2
MW-3
MW-4
MW-4R
MW-5


Discharge for Big and Little Creeks and Cherry Lake
Discharge Rate (cfs)
600
500
400
300
200
100
0
1994
1995
1996
1997
1998
1999
Date
Discharge at Cherry Lake
Combined Discharge for Big Creek and Little Creek

Cumulative Discharge for Big and Little Creeks and Cherry Lake



Item #7
What is a Continuous Simulation Model

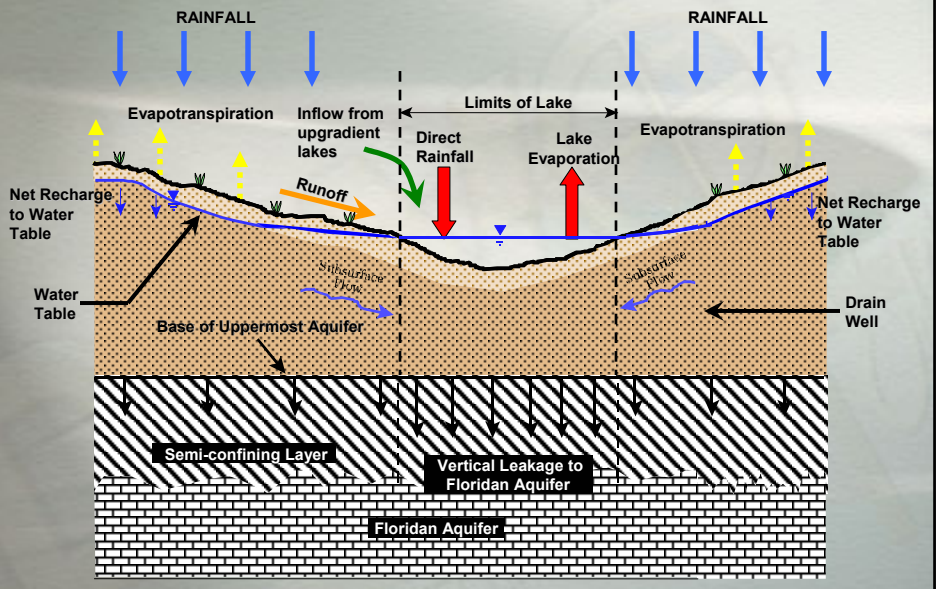


Lake Minneola, CR 565A Bridge, 6/10/2002

What is long-term, continuous simulation modeling?

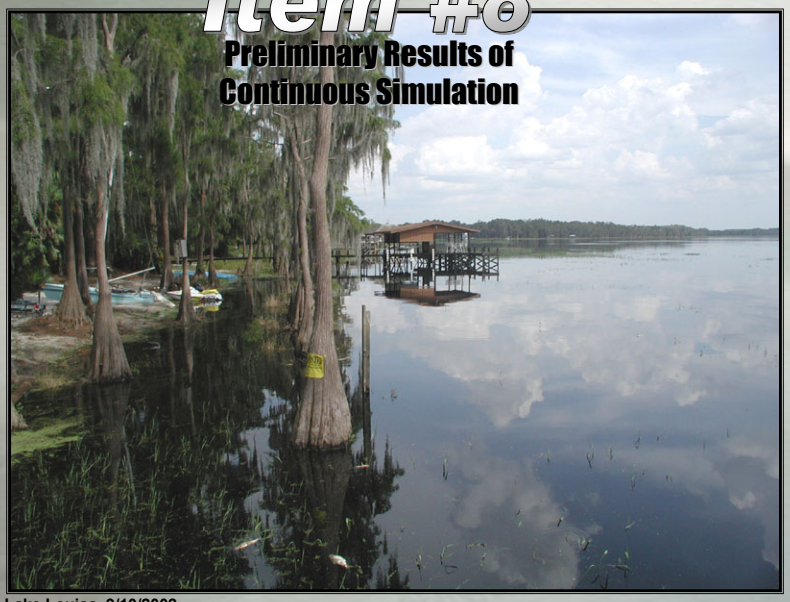
- A model which analyzes the day to day hydrology of the system over a long period of time (say 3 to 100 years), taking into account all components of the system's water budget.
- Such a model can predict, on a daily basis, stages, inflows, and discharge rates and volumes (both ground water & surface water).

Conceptual Model for Closed Basin Modeling in Central Florida



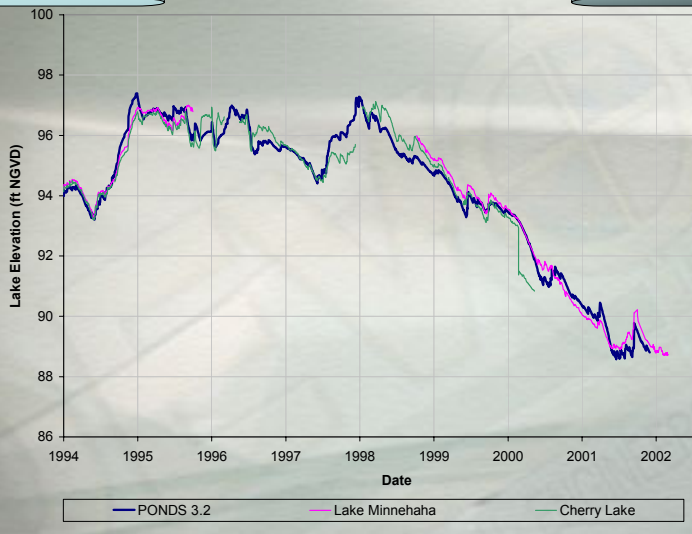
Item #8

Preliminary Results of Continuous Simulation



Lake Louisa, 9/10/2002

Measured and Predicted Lake Levels



Model Period: January 1, 1994 through November 30, 2001.

The beginning if the modeling period was chosen such that the long term behavior of the model could be assessed. The end of the modeling period corresponds to the most recent data obtained for Clermont 7 S weather station.

Summary of Water Budget Components

	Inflows			
	Rainfall (million gallons)	Stream Inflow (million gallons)	Runoff (million gallons)	Infiltration ** (million gallons)
1994	14,121	7,886	2	351
1995	11,197	12,792	296	616
1996	11,136	9,486	33	742
1997	13,608	9,365	185	343
1998	7,433	20,404	62	700
1999	9,200	161	295	90
2000	6,236	35	97	-177
2001*	9,212	0	35	-11
Total	82,146	60,131	1,008	2,655

	Outflows		
	Evaporation (million gallons)	Leakage (million gallons)	Discharge (million gallons)
1994	-10,977	-1,401	-1,487
1995	-10,977	-1,401	-15,415
1996	-10,977	-1,401	-10,147
1997	-10,977	-1,401	-6,835
1998	-10,977	-1,401	-22,709
1999	-10,977	-1,401	0
2000	-10,977	-1,401	0
2001*	-10,502	-1,282	0
Total	-87,342	-11,095	-56,595

* Year 2001, data for January 1 through November 30, 2001

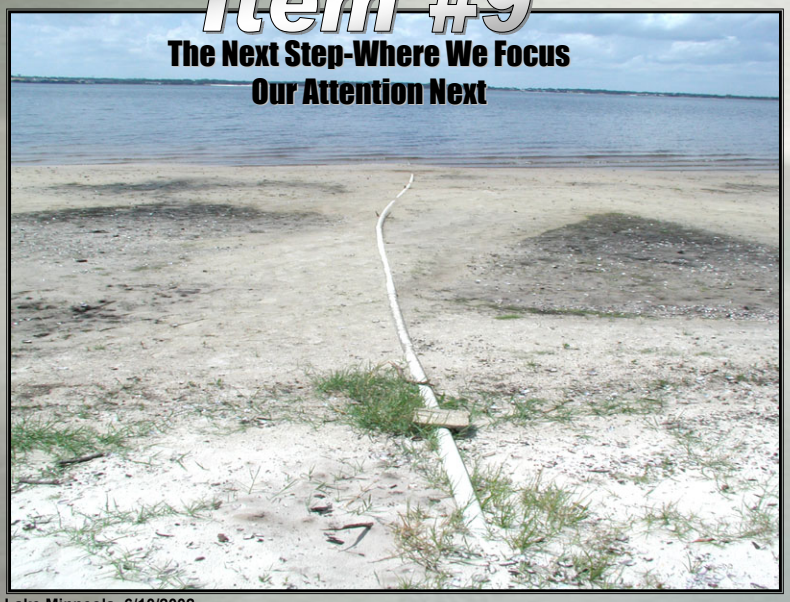
** Positive infiltration represents flow into lakes. Negative infiltration represents flow out of lakes.

Implications of Model Results

- Leakage rate between surficial aquifer and Upper Floridan aquifer is on the order of 5 to 6.5 inches/year
- Lakes in the Clermont Chain do not appear to be well connected to the upper Floridan aquifer
- Big Creek and Little Creek are the main sources of surface water inflow
- The recent drop in lake levels appear to be caused by the recent severe deficit in rainfall, and subsequent lack of stream inflow from Big Creek and Little Creek

Item #9

The Next Step-Where We Focus Our Attention Next



Lake Minneola, 6/10/2002

What's Next

- Big Creek and Little Creek. What factors affect the discharge rate/volume from these creeks. Is the increase in deep Floridan pumpage expected to impact these discharge rates.
- How does the Green Swamp behave. Is it a perched lake?

Item #10

Before and After Assorted Photos



Trout Lake





Big Creek Gaging Station





Big Creek has spread out, so the difference in perspective reflects inability to get close to bridge due to rising water.

Big Creek Gaging Station





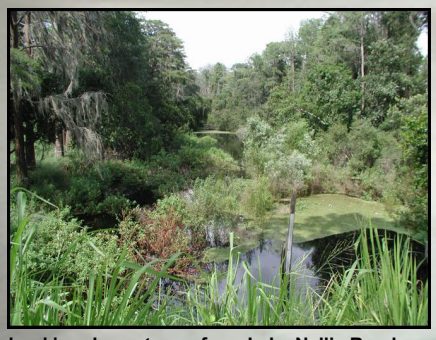
Gage up from about 3.15 to 4.55

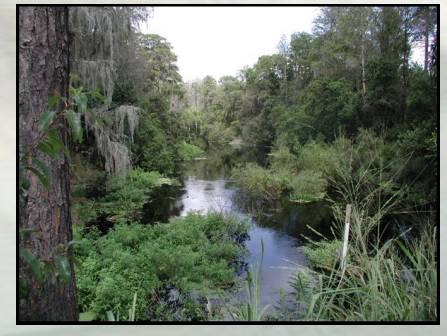
Big Creek Gaging Station



Foot bridge over Big Creek. (No “before” picture available)

Little Creek Gaging Station





Looking downstream from Lake Nellie Road

Little Creek Gaging Station





Looking upstream from Lake Nellie Road

Little Creek Gaging Station





Gage up from 7.8 to 8.75

Lake Louisa State Park



7/14/2002


9/10/2002

Approximate location of shoreline on 9/10/2002

Orange pole, denoting safe bathing area (presumably)

Lake Louisa State Park


6/10/2002

Lake Louisa State Park





Lake Louisa State Park





Note: Can't identify a common feature. These pictures are looking in the same direction but may not have been taken at exactly the same spot

North Shore of Lake Louisa





Note: Both pictures taken on same date. Not "before-and-after"

North Shore of Lake Louisa





Fish kill

Note: Both pictures taken on same date. Not "before-and-after"

Crooked River Preserve
on Lake Louisa Rd





Looking upstream on the Palatlakaha River between Lake Louisa and Lake Susan

← Common Feature: tree line

Crooked River Preserve





Looking downstream on the Palatlakaha River between Lake Louisa and Lake Susan

← Common feature: cypress tree

Lake Susan Lodge





Lake Susan Lodge





Monte Vista Canal between Lake Minnehaha and Crescent Lake





Looking toward Crescent Lake from Bronson Road



Monte Vista Canal between Lake Minnehaha and Crescent Lake





Looking towards Crescent Lake, back to Lake Minnehaha



Lake Minnehaha near Monte Vista Canal





Boat dock near mouth of Monte Vista Canal on Lake Minnehaha

North Shore of Lake Minnehaha





Note: both pictures taken on same date. Not "before-and-after"

CR 561 Bridge over channel between Lake Minnehaha and Lake Palatlakaha





Note: on 9/10/2002 water was flowing from Lake Palatlakaha to Lake Minnehaha

CR 561 Bridge over channel between Lake Minnehaha and Lake Palatlakaha





CR 561A Bridge over channel between Lake Minneola and Wilson Lake





Looking towards Lake Minnehaha



CR 561A Bridge over channel between Lake Minneola and Wilson Lake





Looking towards Wilson Lake



North Shore of Lake Minneola





North Shore of Lake Minneola





Cherry Lake Discharge Structure Downstream Face





Note: Downstream lake level was higher than upstream lake level on September 10, 2002. A foot to a foot-and-a-half of water was being retained above the base of the structure on the downstream side.

Cherry Lake Discharge Structure Upstream Face

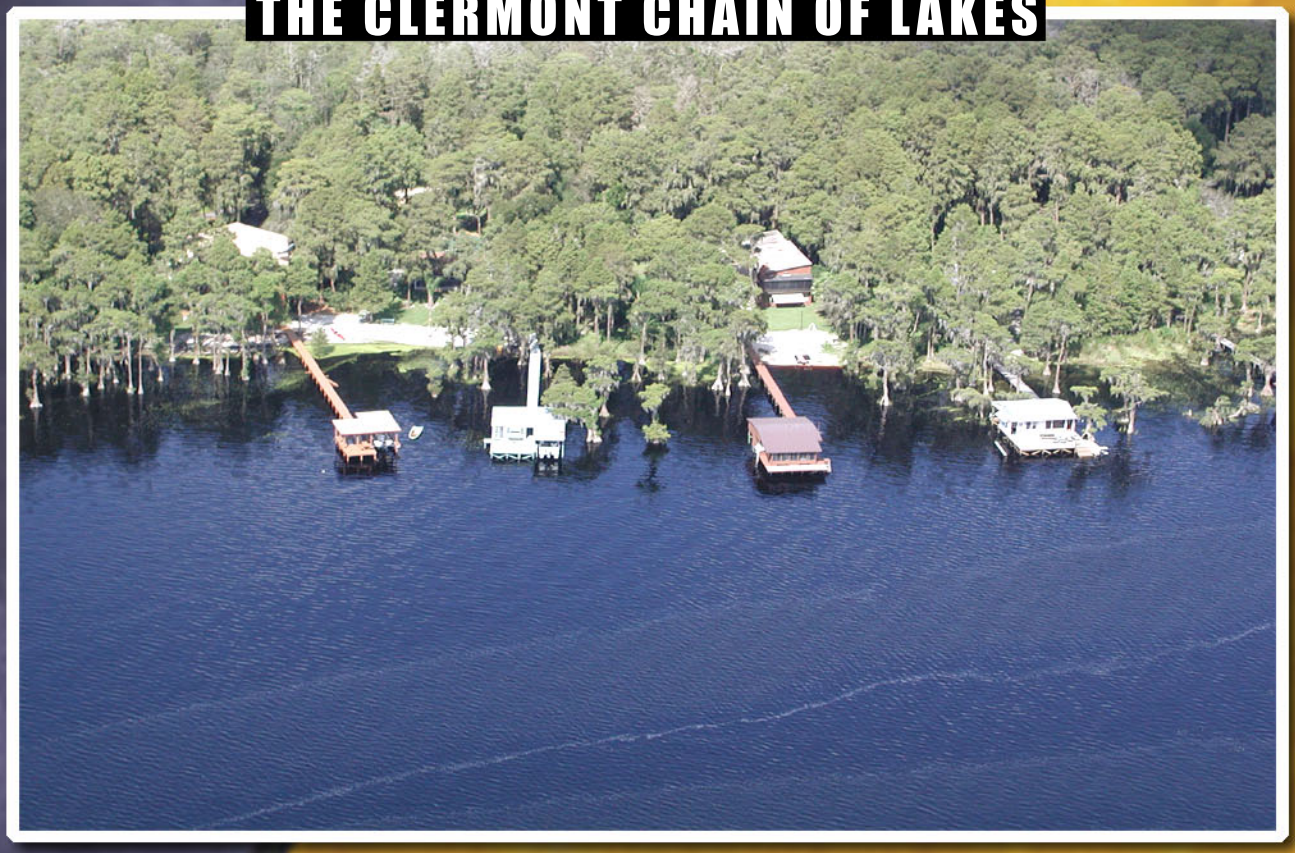




TECHNICAL MEMO #7: MODELING LITTLE CREEK DISCHARGE

Ground water / Surface water interaction modeling for portion of South Lake County (FL) which encompasses

THE CLERMONT CHAIN OF LAKES



Prepared for

LCWA

Lake County Water Authority

PEC

Professional Engineering Consultants, Inc.

Prepared by

DEVO Engineering

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December 2002

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Date: December 12, 2002	*Devo's Project No.* 02-121.96
To: Lake County Water Authority 107 North Lake Avenue Tavares, Fl 32778-3119 phone: 352-343-3777 fax: 352-343-4259 attention: LANCE LUMBARD	*cc:* Professional Engineering Consultants, Inc. 200 East Robinson Street, Suite 1560 Orlando, FL 32801 phone: 407-422-8062 fax: 407-849-9401 attention: DAVID HAMSTRA, P.E.
LCWA Lake County Water Authority	PEC

Ref:

TECHNICAL MEMO #7 – MODELING LITTLE CREEK DISCHARGE
STATUS REPORT FOR OCTOBER & NOVEMBER 2002
GROUND WATER/SURFACE WATER INTERACTION MODELING FOR PORTION OF SOUTH LAKE COUNTY (FL) WHICH ENCOMPASSES THE CLERMONT CHAIN OF LAKES

Dear Mr. Lumbard:

The attached status report summarizes our activities for the above referenced project for the months of October, November and first week of December, 2002.

Sincerely,
Robert Casper
Robert D. Casper, E.I.
Project Engineer

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EVALUATION OF PONDS 3.2 REFINED METHOD TO MODEL LITTLE CREEK STAGE AND DISCHARGE . . 5

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Exhibit 3. Measured and predicted stage at Little Creek gaging station 7
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INTRODUCTION

This report summarizes our activities in regards to our ongoing ground water/surface water modeling effort for the Clermont Chain of Lakes for the months of October, November and first week of December 2002.

- Update of Lake Minnehaha lake levels
- Presentation of preliminary modeling results for the Clermont Chain of Lakes at the FWEA–FDEP–FSA 2nd Biennial Stormwater Management Conference
- Evaluation of the PONDS 3.2 Refined Method for modeling the Little Creek basin

Update of Lake Minnehaha Lake Levels

Recent lake level data obtained from Lance Lumbard of LCWA for Lake Minnehaha has been appended to our historical lake level data for Lake Minnehaha, as seen in Exhibit 1 (below). The data indicate that Lake Minnehaha is recovering rapidly from recent historical low water levels, with water levels rapidly climbing back into the normal range (+94 to +97 ft).

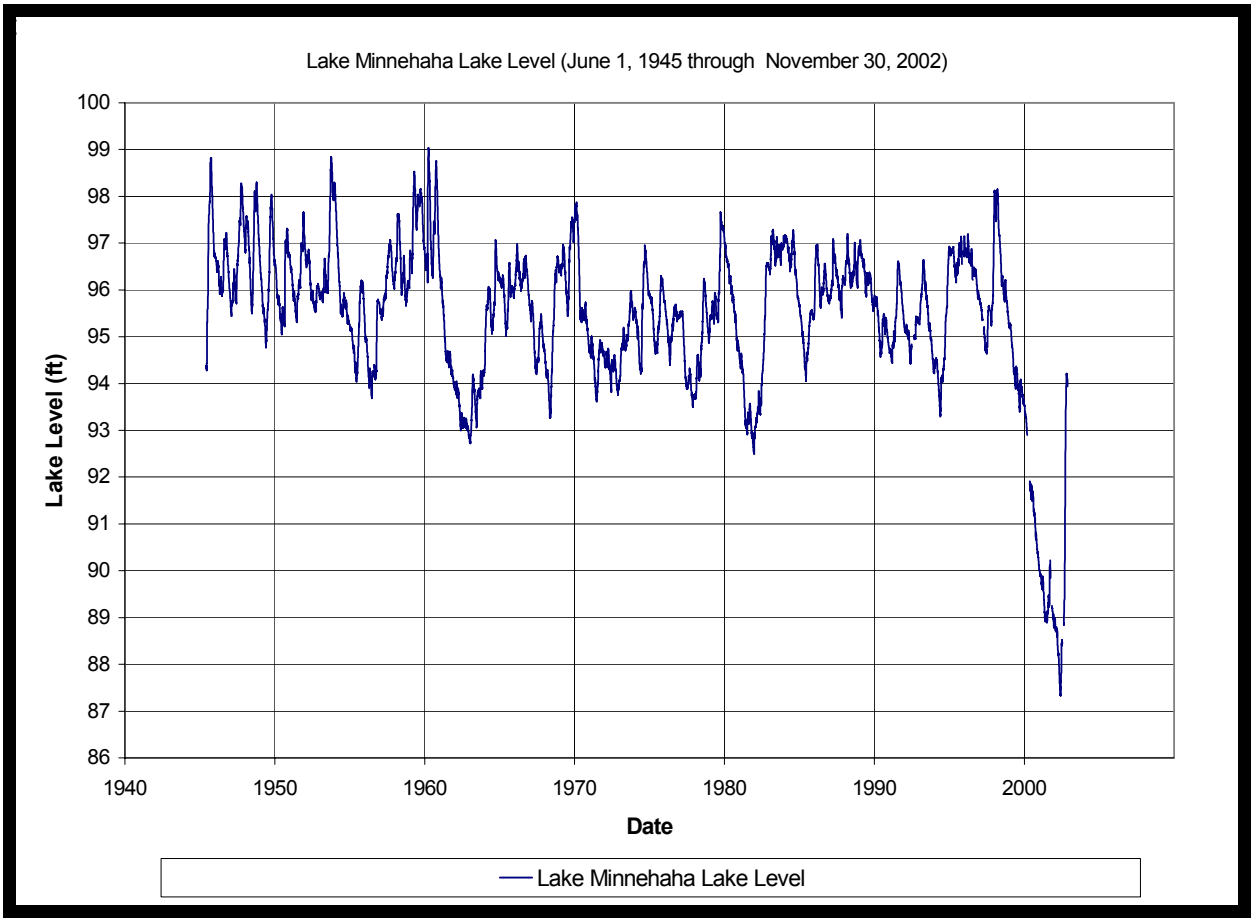

Exhibit 1. Lake levels for Lake Minnehaha, 6/1/1945 through 11/30/2002

PRESENTATION OF MODEL RESULTS AT FWEA-FDEP-FSA STORMWATER CONFERENCE

On December 5, 2002, we had the opportunity to present the preliminary results of modeling of the Clermont Chain of Lakes at the FWEA-FDEP-FSA 2nd Biennieal Stormwater Management Conference held in Orlando, Florida. The presentation was similar in nature to the presentation given to the Lake County Water Authority Board of Directors on September 18, 2002, with additional technical information of interest to stormwater modeling professionals.

EVALUATION OF PONDS 3.2 REFINED METHOD TO MODEL LITTLE CREEK STAGE AND DISCHARGE

We are currently evaluating the suitability of the PONDS 3.2 Refined Method for modeling the measured stage and discharge at Little Creek gaging station. The Little Creek basin was chosen for initial evaluation because of the more compact geometry when compared to the Big Creek basin.

The primary modeling assumption is that Little Creek acts as a perched lake, and can consequently be modeled in PONDS 3.2 Refined Method as a lake with an outfall structure and runoff from the contiguous basin area. The modeled discharge characteristics at the Little Creek gaging station are shown in Exhibit 2 (below).

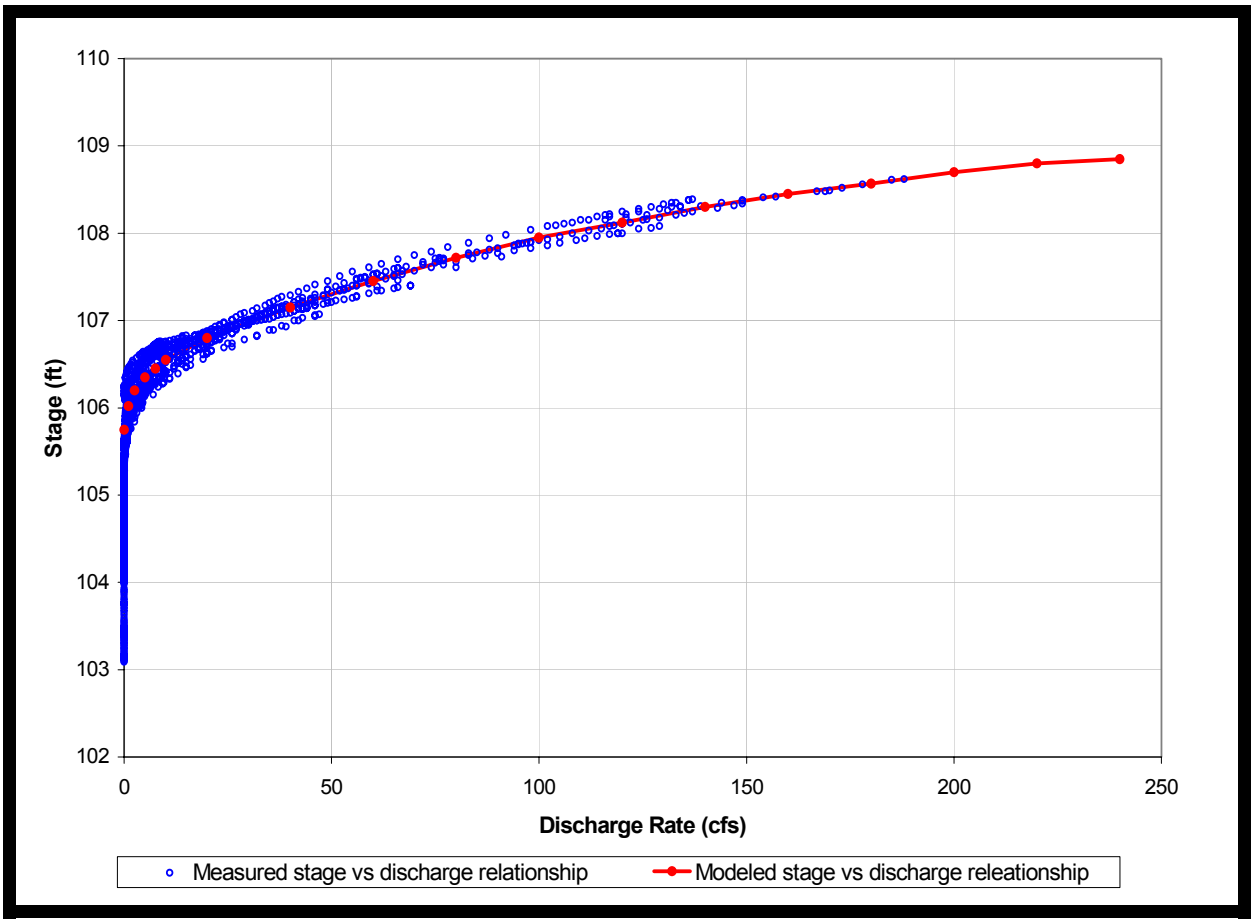

Exhibit 2. Stage vs. discharge relationship at Little Creek gaging station

Initial model predictions for the stage at Little Creek are shown in Exhibit 3 (below). The correlation is somewhat promising, although the modeled response appears compressed compared to the measured stage data. As a consequence, the discharge rates are underpredicted, as seen in Exhibit 4.

It is not yet clear whether the PONDS 3.2 Refined Method will provide a suitable model for the Little Creek basin. Further analysis will be needed in order to refine and validate model assumptions and improve performance.

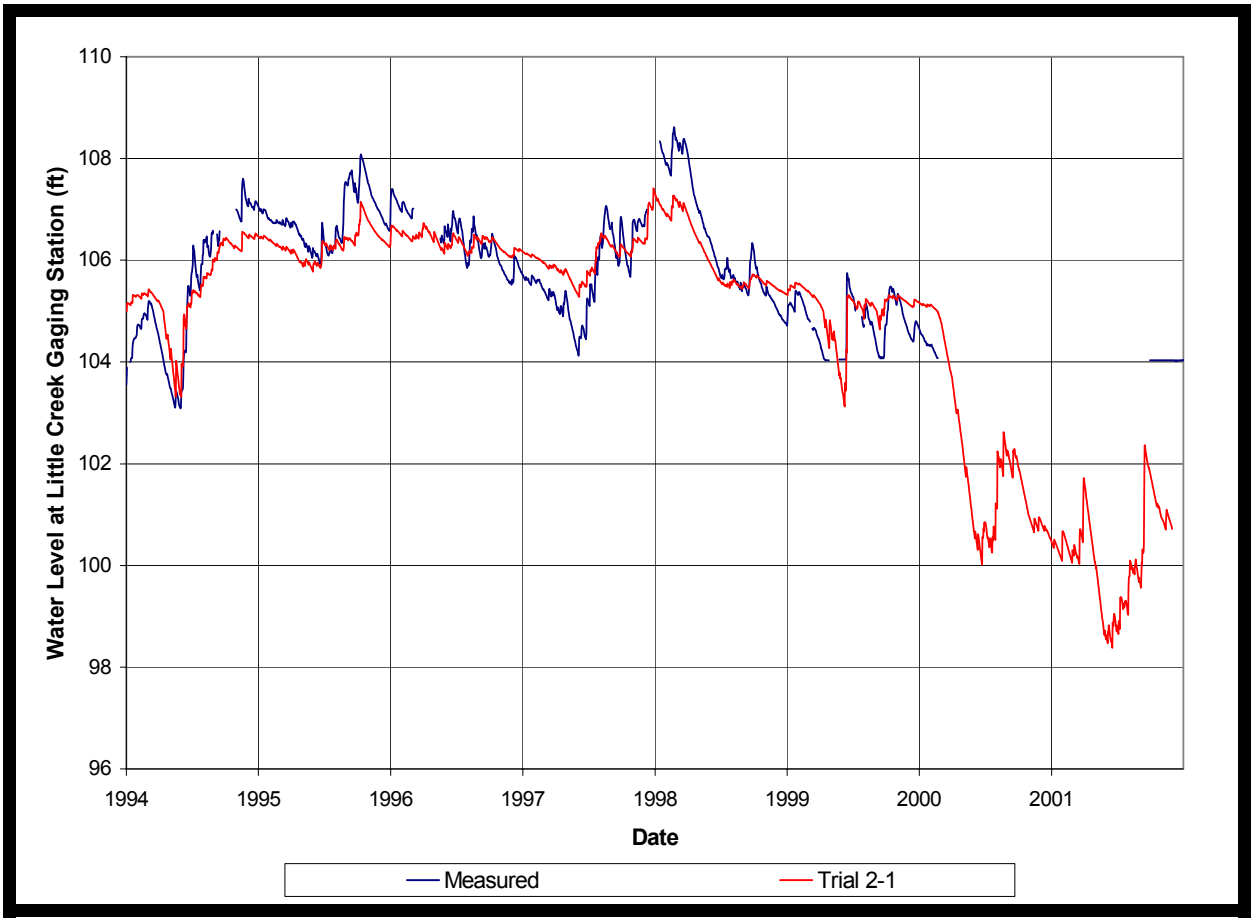

Exhibit 3. Measured and predicted stage at Little Creek gaging station

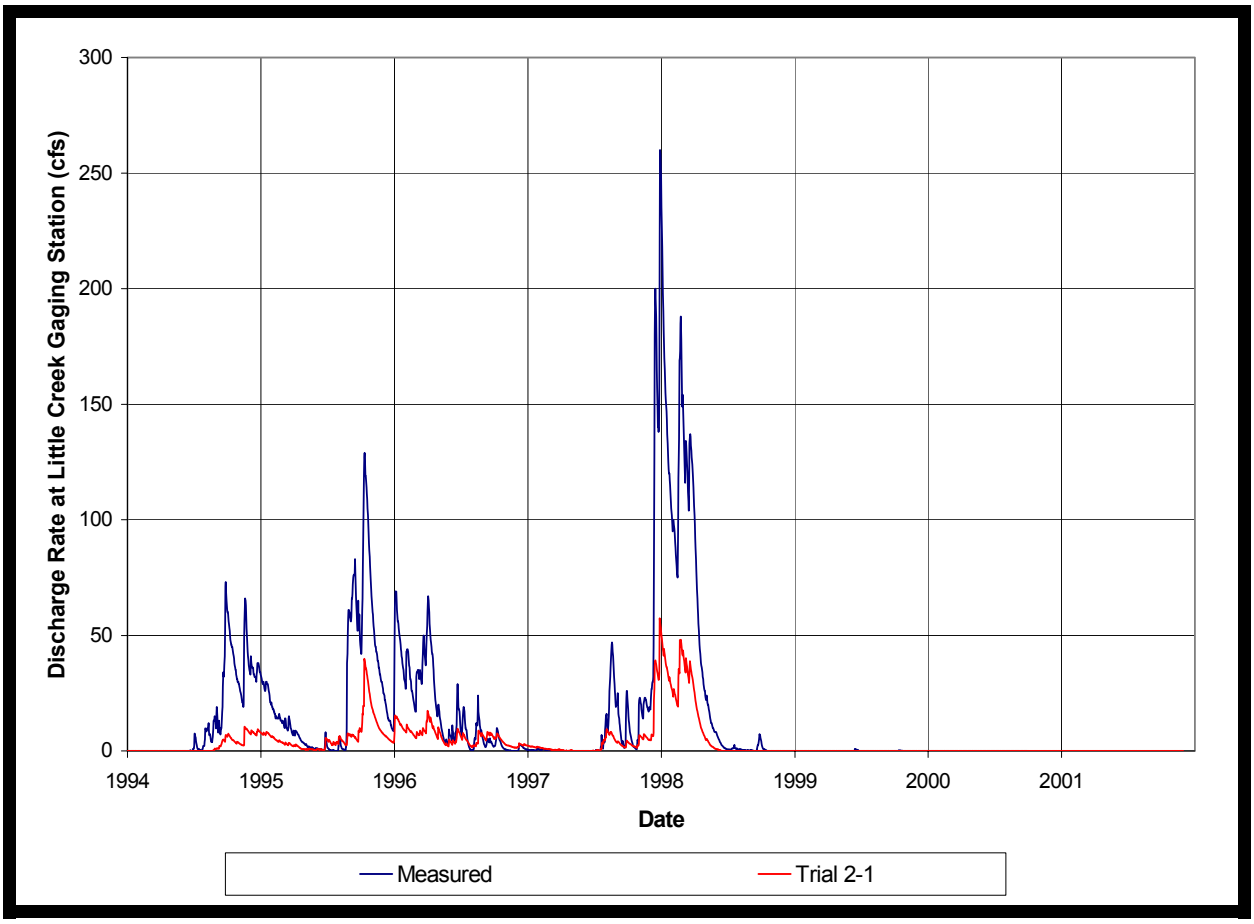

Exhibit 4. Measured and predicted discharge for Little Creek gaging station

TECHNICAL MEMO #8: PRELIMINARY - FLORIDAN AQUIFER DRAWDOWN MODEL FOR BIG CREEK AND LITTLE CREEK

Ground water / Surface water interaction modeling for portion of South Lake County (FL) which encompasses

THE CLERMONT CHAIN OF LAKES



Prepared for

LCWA

Lake County Water Authority

PEC

Professional Engineering Consultants, Inc.

Prepared by

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Date: February 5, 2003	*Devo's Project No.* 02-121.96
To: Lake County Water Authority 107 North Lake Avenue Tavares, Fl 32778-3119 phone: 352-343-3777 fax: 352-343-4259 attention: LANCE LUMBARD	*cc:* Professional Engineering Consultants, Inc. 200 East Robinson Street, Suite 1560 Orlando, FL 32801 phone: 407-422-8062 fax: 407-849-9401 attention: DAVID HAMSTRA, P.E.
LCWA Lake County Water Authority	PEC

Ref:

TECHNICAL MEMO #8 – PRELIMINARY - FLORIDAN AQUIFER DRAWDOWN MODEL FOR BIG CREEK AND LITTLE CREEK
STATUS REPORT FOR JANUARY 2003
GROUND WATER/SURFACE WATER INTERACTION MODELING FOR PORTION OF SOUTH LAKE COUNTY (FL) WHICH ENCOMPASSES THE CLERMONT CHAIN OF LAKES

Dear Mr. Lumbard:

The attached status report summarizes our work for the above-referenced project for the month of January 2003, including recent site reconnaissance and ongoing modeling efforts.

Water levels have reached near normal levels throughout the Clermont Chain of Lakes, including Cherry Lake. Low-level discharge is now occurring through orifices built into the Cherry Lake discharge structures, although water levels at Cherry Lake are still about 12 to 18 inches below the current discharge structure gate elevation.

Sincerely,
Robert Casper
Robert D. Casper, E.I.
Project Engineer

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1.0 INTRODUCTION

This report summarizes our activities in regards to our ongoing ground water/surface water modeling effort for the Clermont Chain of Lakes for the month of January 2003.

- ❒ Site visit and reconaissance, January 26, 2003
- ❒ Update of ground water levels at Southlake Utilities WWTF
- ❒ Groundwater modeling calibration

2.0 SITE VISIT AND RECONNAISSANCE

Land reconnaissance was conducted on January 26, 2003, with stops at representative locations at each of the major lakes in the Clermont Chain. The following observations were made:

- ❖ Water levels at the Big Creek gaging station, are up slightly from levels observed on our last visit of September 10, 2002, with a current staff gage reading of approximately 4.60 feet compared to a reading of 4.55 feet in September, indicating that discharges from Big Creek continue to be significant.

- ❖ Water levels in Lake Louisa have risen slightly above levels observed on our September, 2002 visit, although less dramatically than was observed for the time period of July to September, 2002. As noted in previous communications, Lake Louisa had recovered significantly during the period between June/July and September, 2002.

- ❖ Lake Minnehaha and Lake Minneola have recovered significantly since September, 2002, at which time no significant rise in lake levels were observed. Lakes Minnehaha and Minneloa now appear to be at or near normal levels. [Note: At Lake Minnehaha, staff gage readings of approximately +96.5 ft have been observed. Lake County is currently in the process of rebuilding a portion of C.R. 561 (south of the C.R. 561 bridge over the Palatlakaha River) which had undergone severe pavement distress caused by the extreme low ground water and lake levels of the recent drought which ended in 2002. The recent rebound in the level of Lake Minnehaha is now beginning to adversely effect the reconstruction of this portion of C.R. 561.]

- At the Cherry Lake discharge structure, a water level of +96 ft was observed on an upstream staff gage, i.e. Cherry Lake. This level is approximately one to one-and-a-half feet below the current overflow discharge elevation of the structure. However, water was observed to be discharging through the two rectangular orifice openings in the main gates. These orifice openings appear to be on the order of six by eight inches, and allow for minimal discharge before the upstream water levels reach the top of the gate structure. On the downstream side of the discharge structure, a water level of approximately +93.8 ft was noted.

Appendix A contains a series of photographs of various reference points along the Clermont Chain of Lakes, showing the changed conditions between our initial visits of June/July 2002, and our recent visit in January 2003.

3.0 WATER LEVEL UPDATE IN GREEN SWAMP

The Southlake WWTF monitor well network serves as an indication of the water level in the Green Swamp which feeds Big Creek and Little Creek. Exhibit 1below shows that water levels reached a record high (for the period of record for which data is recorded for these wells) in late December 2002 to early January 2003, and have since started to drop again. At their peak, the ground water level in the Green Swamp rose 10 ft above the June 2001 levels.

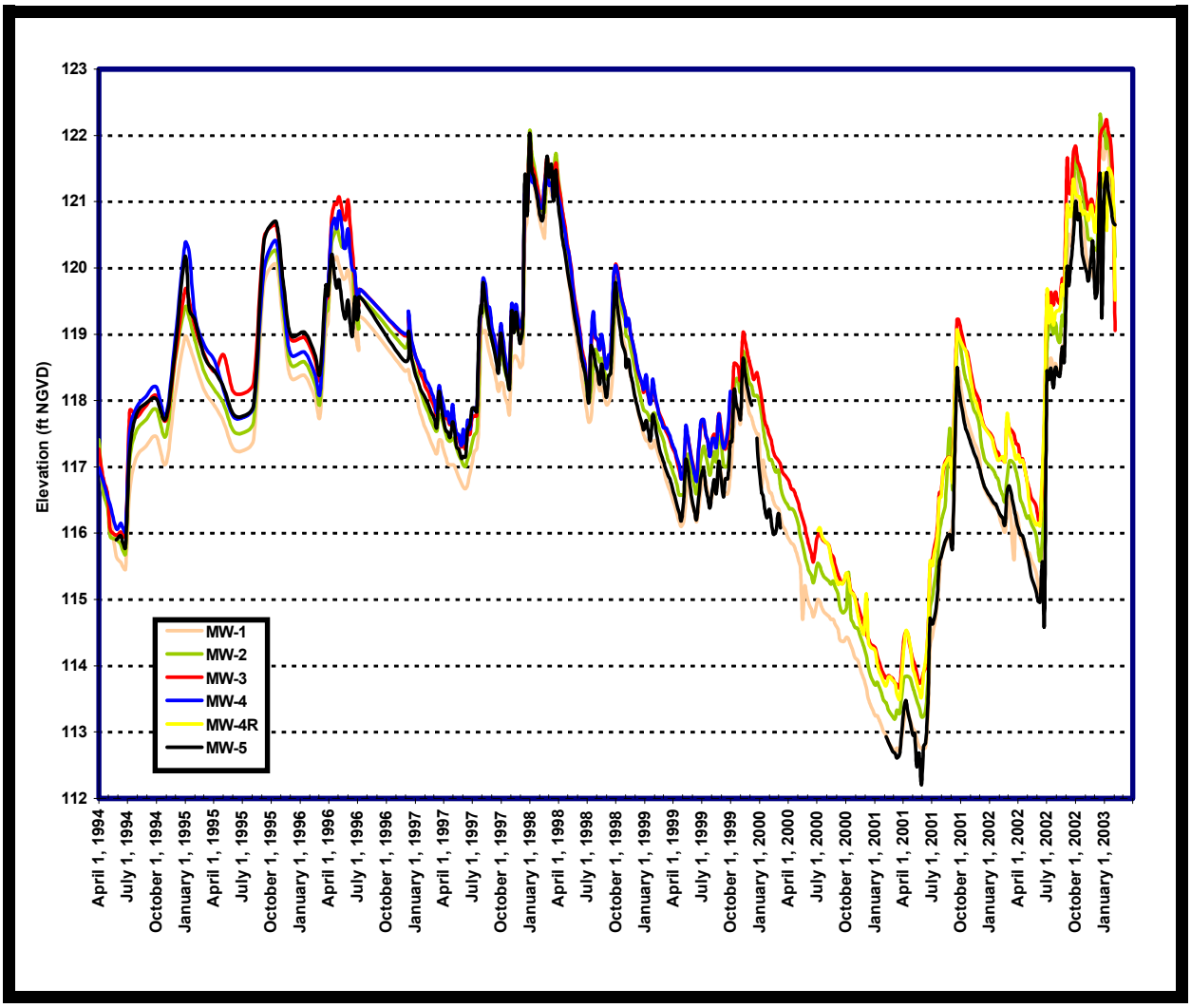


Exhibit 1. Southlake Utilities monitor well levels

Note that water levels are starting to recede in the Green Swamp now with little or no rainfall during the month of January 2003.

4.0 GROUNDWATER MODELING

We are currently in the process of constructing and calibrating a regional groundwater model which encompasses the Clermont Chain of Lakes and its primary inflow sources from the Big Creek and Little Creek drainage basins. Our modeling effort to date is outlined below.

4.1 Modeling Strategy

The model is being developed using the USGS groundwater modeling software MODFLOW, aided by the Groundwater Vistas pre/post processing software. The model consists of a two layer system, representing the surficial ground water aquifer (Layer 1) and the Upper Floridan Aquifer (Layer 2).

We are currently calibrating the model to steady state conditions in order to obtain a reasonable agreement with publisned potentiometric water pressure contours in the Upper Floridan Aquifer, based on published USGS contour maps, with the goal of expanding the model to include the effects of regional ground water pumping withdrawals, and their effect on potentiometric pressures in the Floridan Aquifer and surface water system.

As noted in previous communications, the Clermont Chain of Lakes relies on inflows from Big Creek and Little Creek in order to maintain normal water levels throughout the chain of lakes. Therefore, it is important to develop a more thorough understanding of the potential impacts to these systems from possible future aquifer pumping associated with increased development.

The report *Hydrogeology and Simulation of the Effects of Reclaimed-Water Application in West Orange and Southeast Lake Counties, Florida*, by Andrew O'Reilly, 1998, served as a starting point in assigning modeling parameters. The majority of the O'Reilly study area is included within our current model boundaries, and represents roughly one third of the total model area being considered.

4.2 Model Area and Model Grid

The model area has been expanded beyond the original conception presented in our previous communications. The model area has been expanded to the southeast to include the entire Big Creek drainage basin, and to the northwest in order to establish suitable boundary conditions. This expanded model area is depicted in Exhibit 2, below. Exhibit 2 also depicts the potentiometric water pressure contours in the upper Floridan Aquifer (September, 2000) which were used to establish the boundary conditions and which serve as a base for calibration.

A model grid of 253 rows and 206 columns is being utilized, with a uniform cell size of 1000 ft by 1000 ft.

4.3 Boundary Conditions

Presently, all boundary conditions along the perimeter of the model area in the surficial layer are set to No-Flow boundaries, signifying that no water will enter of leave the model area in Layer 1along the perimeter of the model area. Major lakes in the Clermont Chain, and to the south, have been assigned Constant Head boundary conditions, representing the normal water levels in these lakes. These boundary conditions are illustrated in Exhibit 3. Boundary conditions in the surficial layer may be modified slightly in the future as the model is refined.

In the Upper Floridan layer of the model, boundary conditions on the southwest and south perimeter of the model, where the model area intersects perpendicular to the potentiometric water pressure contours, are set to No-Flow boundaries. (The direction of flow is always perpendicular to the pressure contours, so no flow will enter the model area along this portion of the perimeter. Boundary conditions along the north and east perimeter of the model are set to Constant Head boundaries. This portion of the perimeter of the model area follows the potentiometric pressure contour at +70 ft, and is held constant. Boundary conditions for the Upper Floridan Aquifer are illustrated in Exhibit 4.

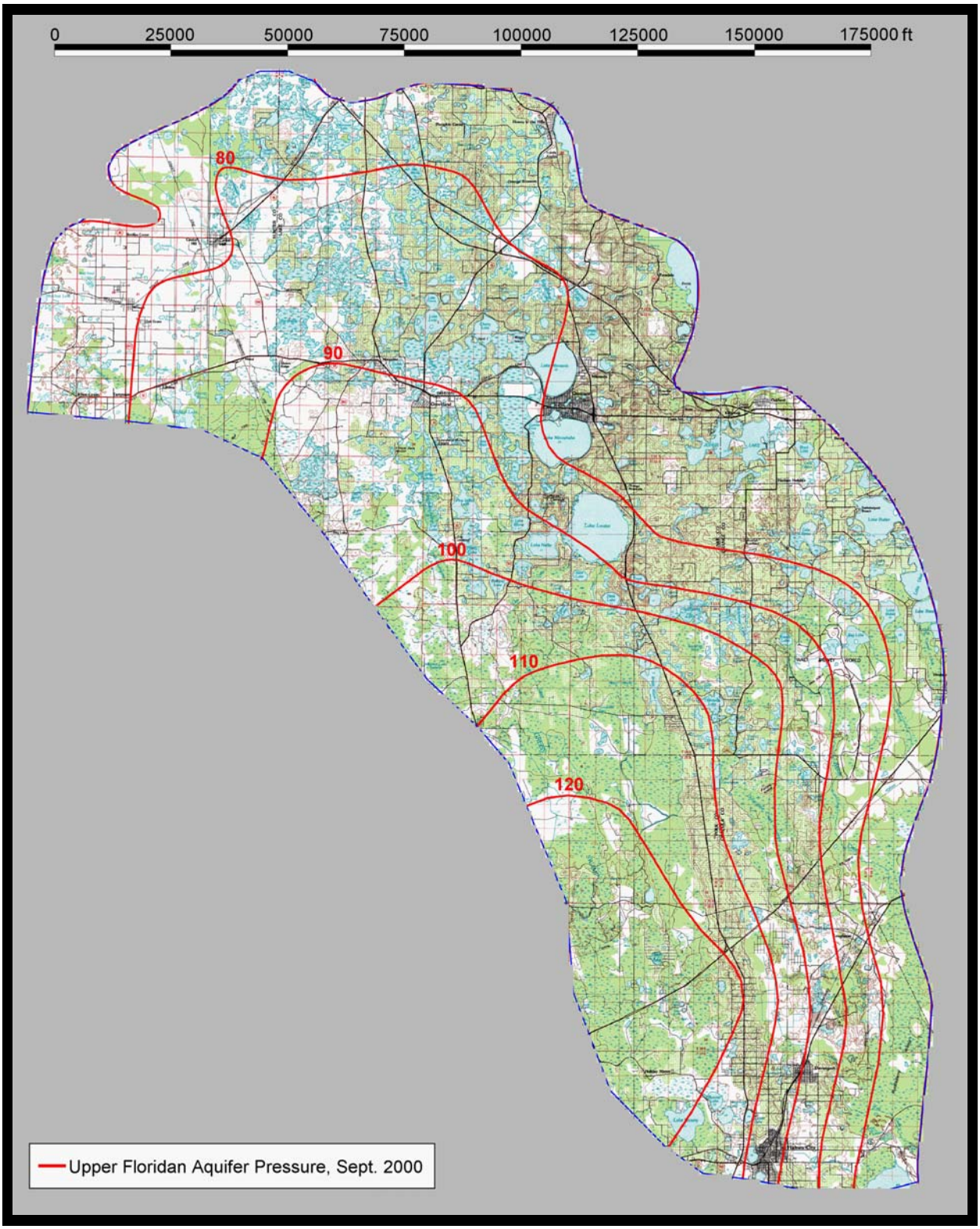


Exhibit 2. Expanded model area

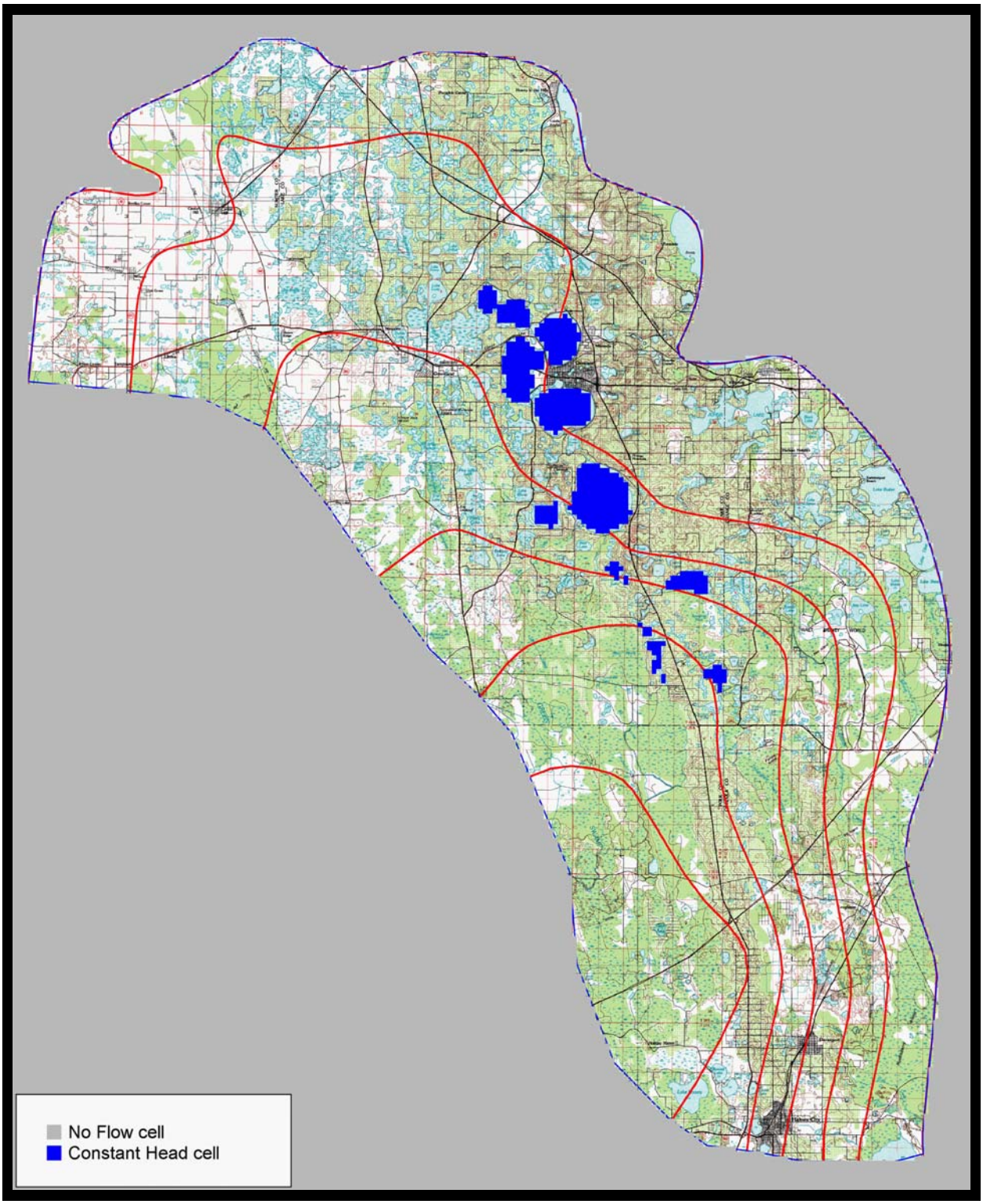


Exhibit 3. Layer 1 (surficial aquifer) boundary conditions

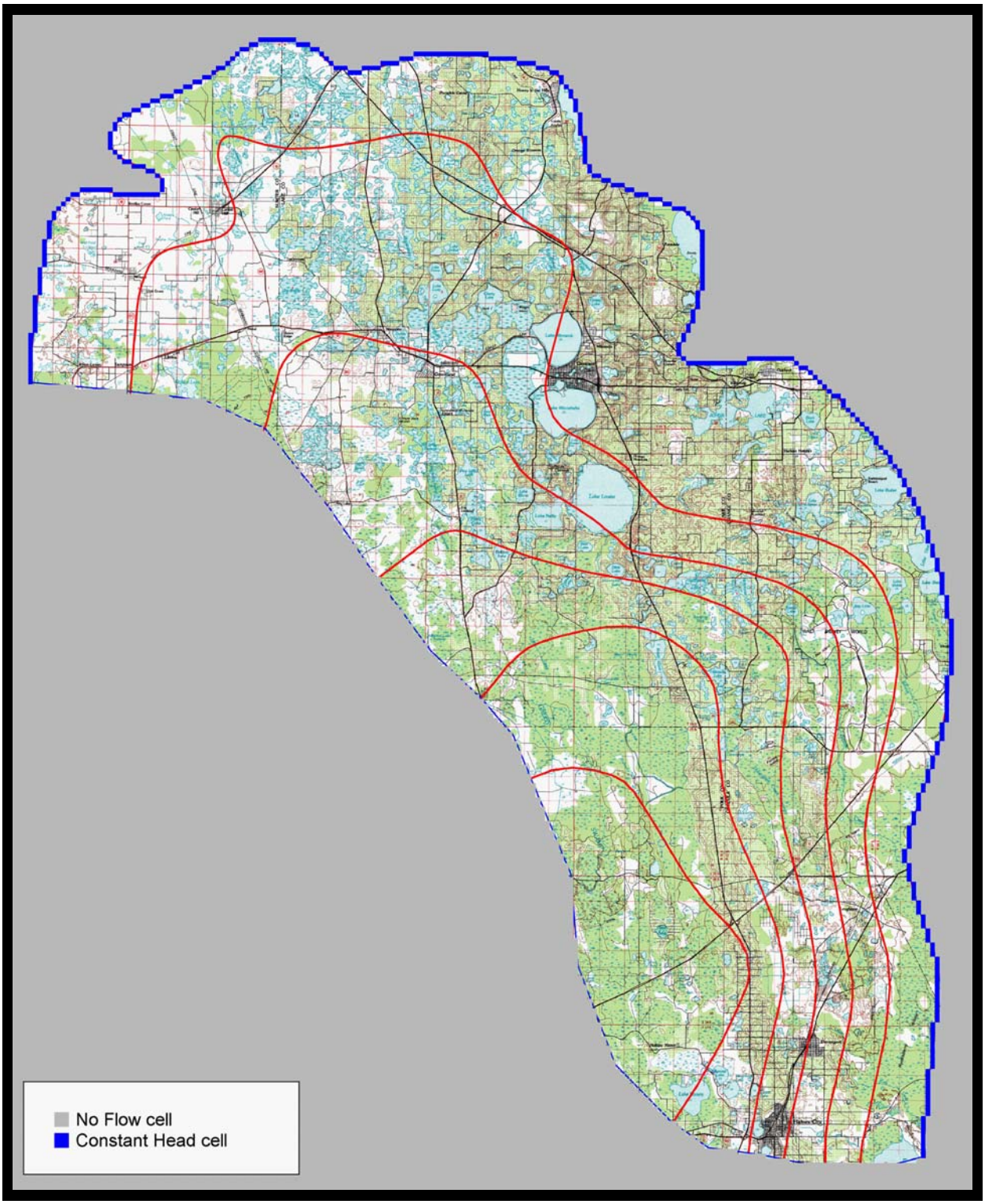


Exhibit 4. Layer 2 (Upper Floridan Aquifer) boundary conditions

4.4 Hydraulic Conductivity and Aquifer Transmissivity

The hydraulic conductivity in the surficial layer (Layer 1) of the model has presently been assigned a uniform value of 30 ft/day.

In the Upper Floridan Aquifer layer (Layer 2), a zoning procedure has been utilized to define a number of regions of varying transmissivity. Within each zone, the transmissivity is assumed to be constant, but varies from zone to zone. These transmissivity zones are illustrated in Exhibit 5, and the modeled values of the transmissivity in each zone are indicated in Table 1, below.

Table 1. Modeled Transmissivity of Upper Floridan Aquifer

Zone	Transmissivity (ft/day/ft)
1	7,500
2	30,000
3	175,000

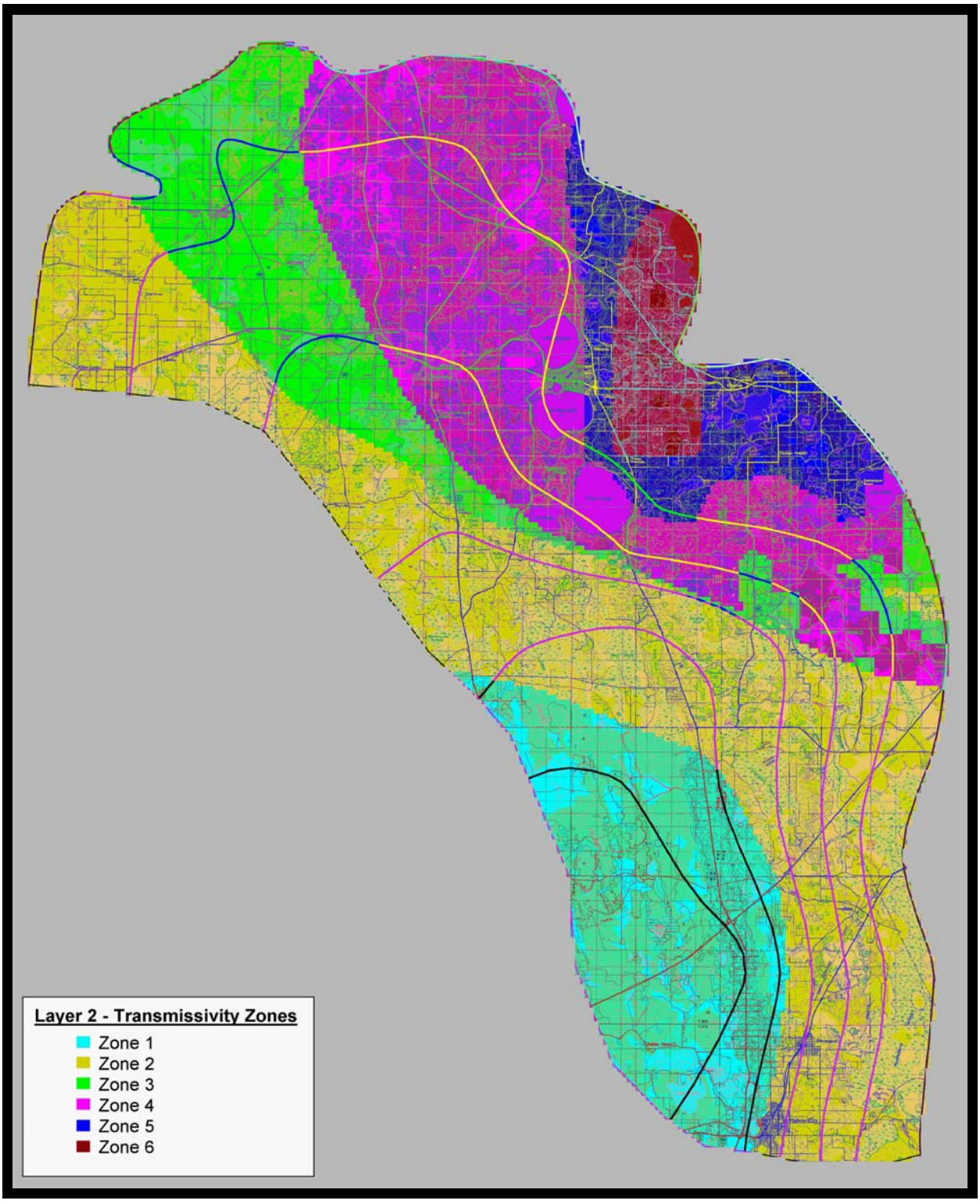


Exhibit 5. Layer 2 (Upper Floridan Aquifer) transmissivity zones

4.5 Porosity

The porosity in the surficial aquifer was assigned a uniform value of 0.25.

The porosity of the Upper Floridan Layer was assigned a uniform value of 0.2, with storage coefficients (S and S_y) of 0.001

4.6 Vertical Leakance

The vertical leakance between the surficial aquifer and the Upper Floridan Aquifer was assigned using a zoning procedure, as illustrated in Exhibit 6. Leakance values for each zone are indicated in Table 2 below.

Table 2. Vertical Leakance between Surficial Aquifer and Upper Floridan Aquifer

Zone	Transmissivity (ft/day/ft)
1	2.5×10^{-5}
2	7.5×10^{-5}
3	3.0×10^{-4}
4	7.5×10^{-4}
5	3.0×10^{-3}

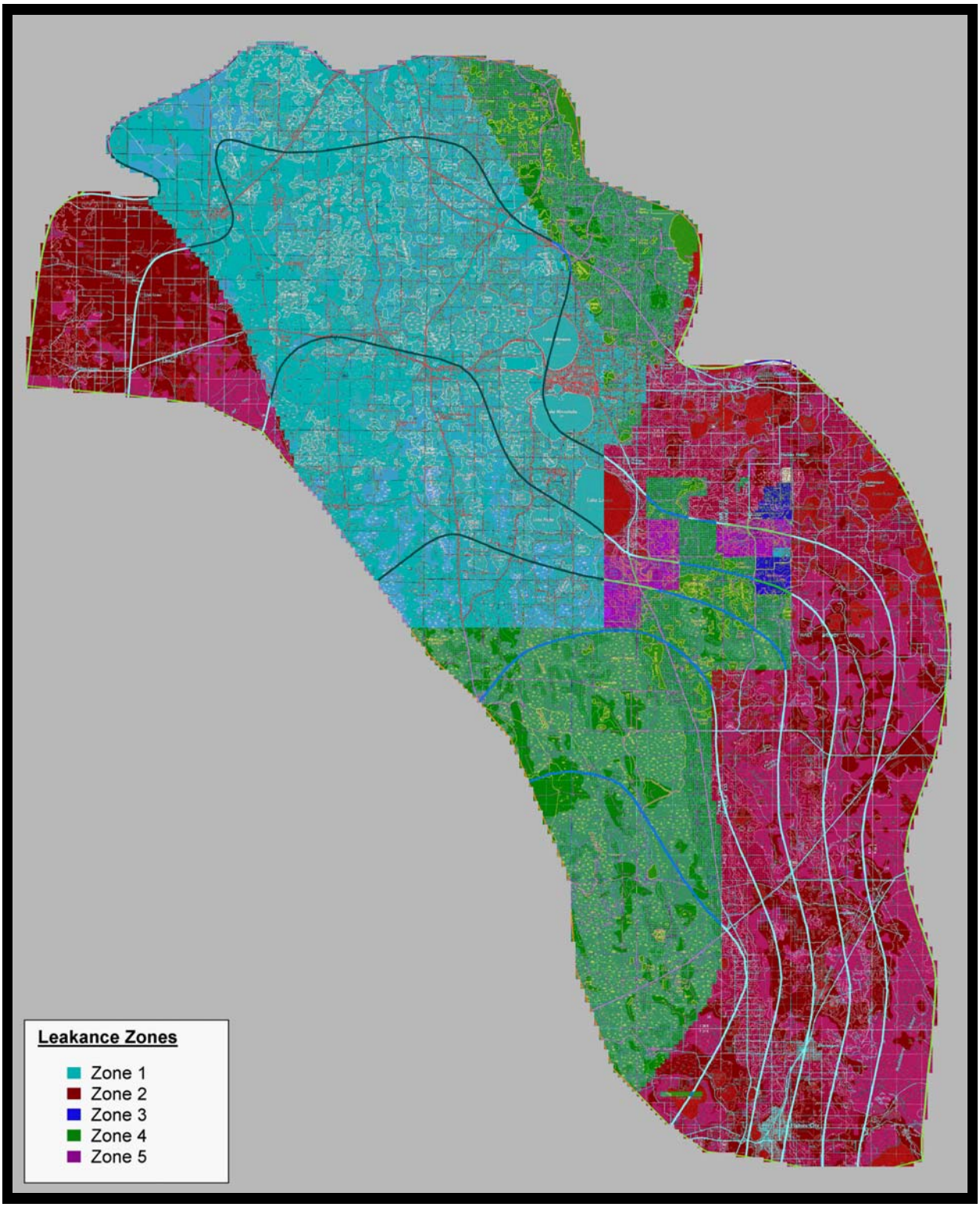


Exhibit 6. Leakance zones

4.7 Net Recharge

The net recharge to the system represents the combined effects of rainfall and evapotranspiration, and is applied to the surficial layer of the model. Recharge values were assigned using the zoning depicted in Exhibit 7. Values for each recharge zone are indicated in Table 3 below.

Table 3. Net Recharge (applied to surficial aquifer)

Zone	Net Recharge (in/yr)
1	1.2
2	5.0
3	17.5

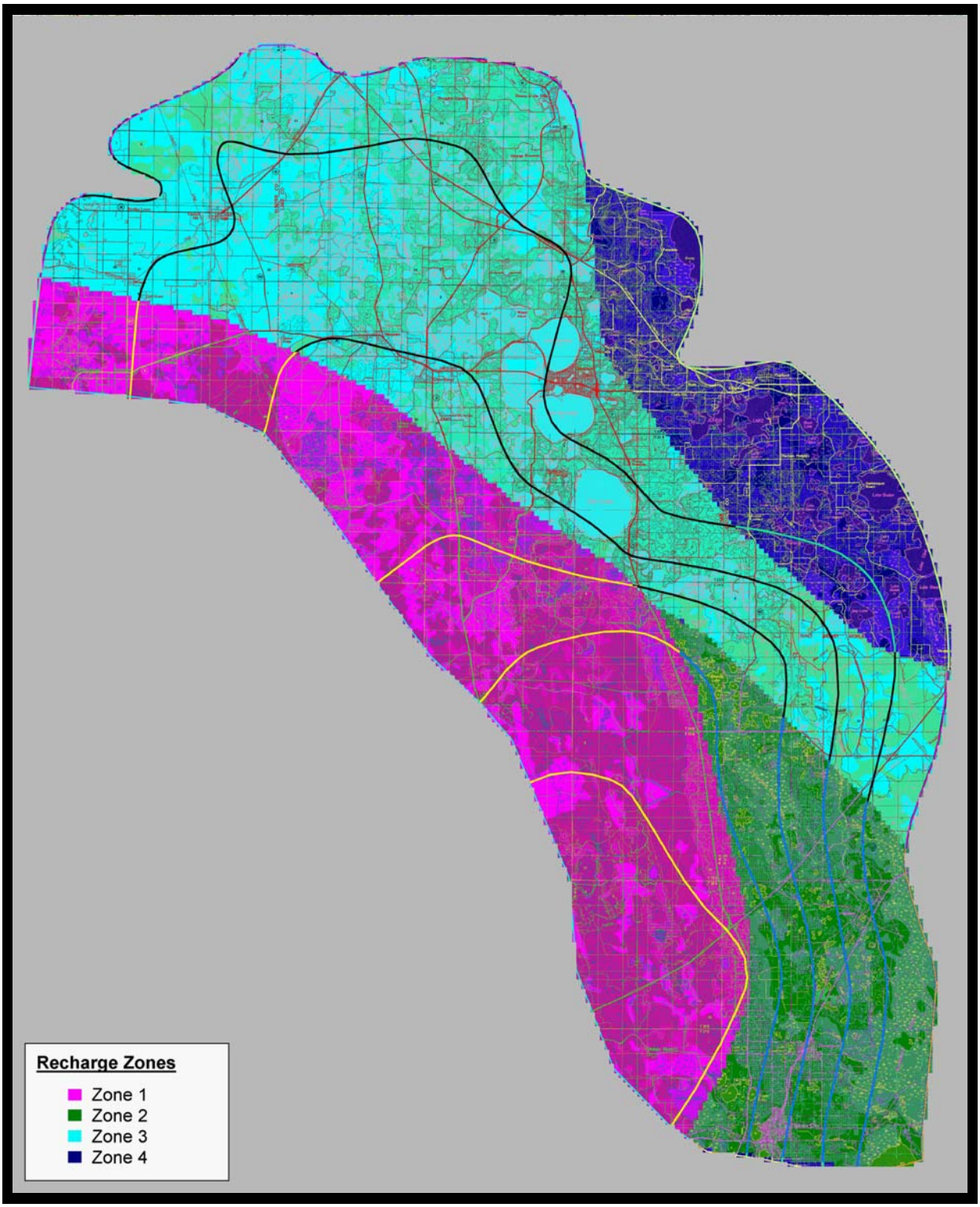


Exhibit 7. Recharge zones

4.8 Initial Heads

Initial heads in the surficial aquifer were set uniformly to +120 ft.

In the Upper Floridan Aquifer, the initial heads were assigned based on pupished contour maps of the potentiometric water pressures in the Uppper Floridan Aquifer (USGS, September 2000) using the zoning depicted in Exhibit 8. Initial head values for each zone are indicated in Table 4 below.

Table 4. Starting Heads in Upper Floridan Aquifer

Zone	Aquifer Pressure (ft)
1	75
2	85
3	95
4	105
5	115

Note: In the steady state analysis used in the preliminary calibration, the actual surface water and aquifer pressure levels will reach a natural equilibrium which reflects the boundary conditions, recharge, leakage, etc. The initial heads provide a starting point at which iteration of the model begins, but do not ultimately dictate the final water levels for the steady state analysis.

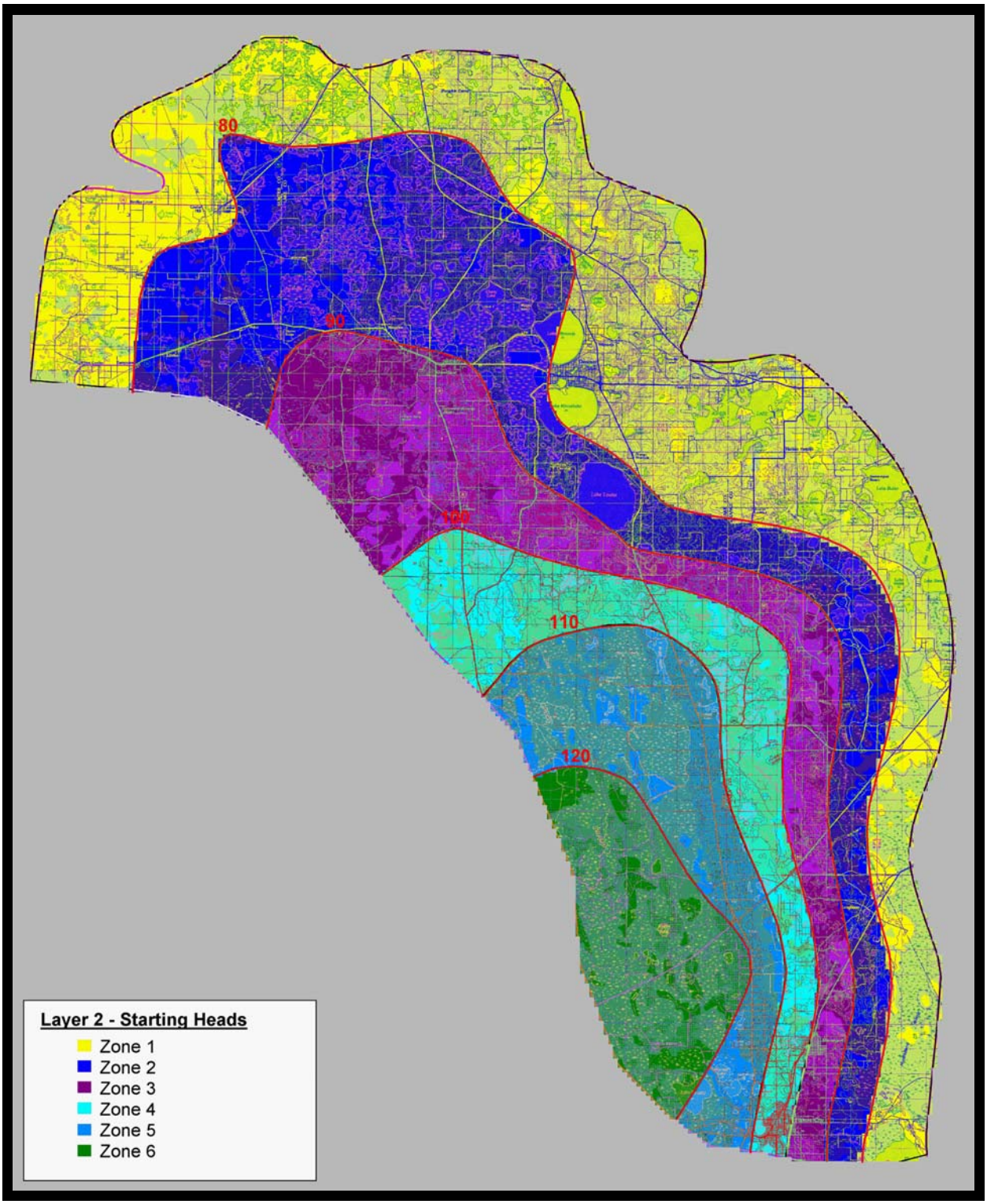


Exhibit 8. Layer 2 (Upper Floridan Aquifer) starting heads

4.9 Preliminary Model Results

Preliminary calibration results have yielded the potentiometric pressure contours in the Upper Floridan Aquifer as illustrated in Exhibit 9, which also shows the potentiometric pressure contours of the calibration target, USGS potentiometric countour map.

The modeled potentiometric contours, while similar in character to the calibration target will require further refinement.

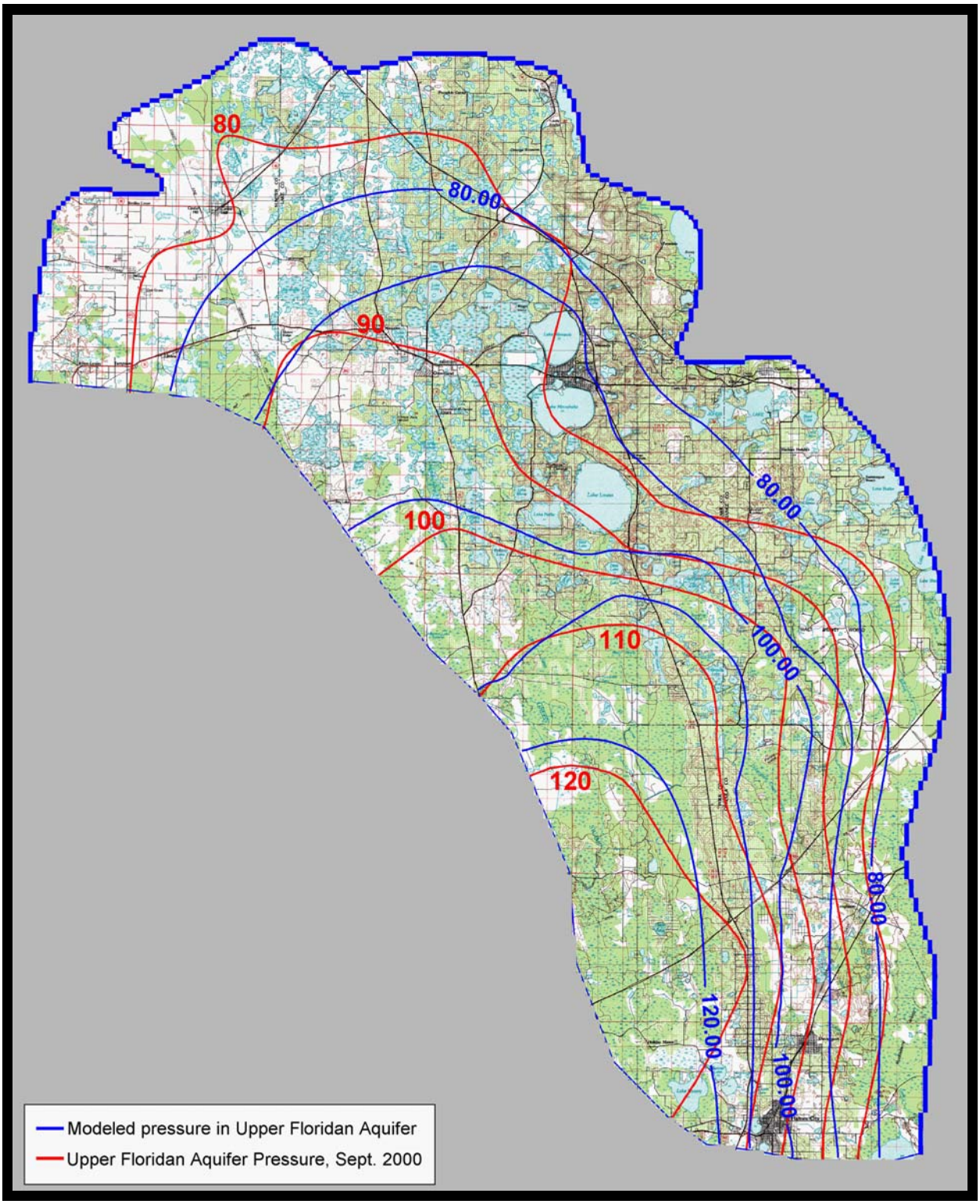


Exhibit 9. Modeled aquifer pressures in Upper Floridan Aquifer)

5.0 WHAT'S NEXT

The model calibration of the Upper Floridan Aquifer pressures needs to be further refined, while simultaneously introducing calibration targets for the surficial aquifer, and current rate pumping withdrawals from the Floridan Aquifer.

Once the model calibration is completed, it will be possible to assess the effects of future pumping withdrawal scenarios, and the impact it may have on future surface water discharges from the Big Creek and Little Creek drainage basins.

APPENDIX
PHOTOGRAPHS

Staff Gage at Big Creek Gaging Station



July 14, 2002



January 26, 2003

Lake Louisa State Park, Beach



July 14, 2002



January 26, 2003

Lake Louisa State Park, Beach, Looking East



July 14, 2002



January 26, 2003

Crooked River Preserve, Palatlakaha River, Looking North



July 14, 2002



January 26, 2003

Crooked River Preserve, Palatlakaha River, Looking South



June 14, 2002



January 26, 2003

Lake Susan Lodge



July 14, 2002



January 26, 2003

Lake Susan Lodge



July 14, 2002



January 26, 2003

Lakeshore Drive Bridge, Looking Towards Lake Susan



June 10, 2002



January 26, 2003

Lakeshore Drive Bridge, Looking Towards Lake Minnehaha



June 10, 2002



January 26, 2003

MONTE VISTA CANAL, LOOKING TOWARDS CRESCENT LAKE



June 10, 2002



January 26, 2003

Monte Vista Canal, Looking Towards Crescent Lake



June 10, 2002



January 26, 2003

Monte Vista Canal, Looking Towards Lake Minnehaha



June 10, 2002



January 26, 2003

Monte Vista Canal, Boathouse on Lake Minnehaha



June 10, 2002



January 26, 2003

Monte Vista Canal, Bronson Rd Crossing



June 10, 2002



January 26, 2003

CR 565 A Bridge, View From Lake Minnehaha



June 10, 2002



January 26, 2003

CR 565 A Bridge, Sheetpile Wall, Lake Minnehaha



June 10, 2002



January 26, 2003

CR 565 A Bridge, Lake Minnehaha



June 10, 2002



January 26, 2003

CR 561A Bridge, Looking Towards Lake Minneola



June 10, 2002



January 26, 2003

CR 561A Bridge, Looking Towards Lake Wilson



June 10, 2002



January 26, 2003

North Shore of Lake Minneola



June 10, 2002



January 26, 2003

North Shore of Lake Minneola



September 10, 2002



January 26, 2003

Cherry Lake Discharge Structure, Upstream Face



June 22, 2002



January 26, 2003

Cherry Lake Discharge Structure, Downstream Face



June 22, 2002



January 26, 2003

Cherry Lake Discharge Structure, Looking Towards Cherry Lake



June 22, 2002



January 26, 2003

Cherry Lake Discharge Structure, Looking Towards Little Cherry Lake



June 22, 2002



January 26, 2003

Cherry Lake Discharge Structure, Upstream Staff Gage



June 22, 2002



January 26, 2003

Cherry Lake Discharge Structure, Downstream Staff Gage



September 10, 2002

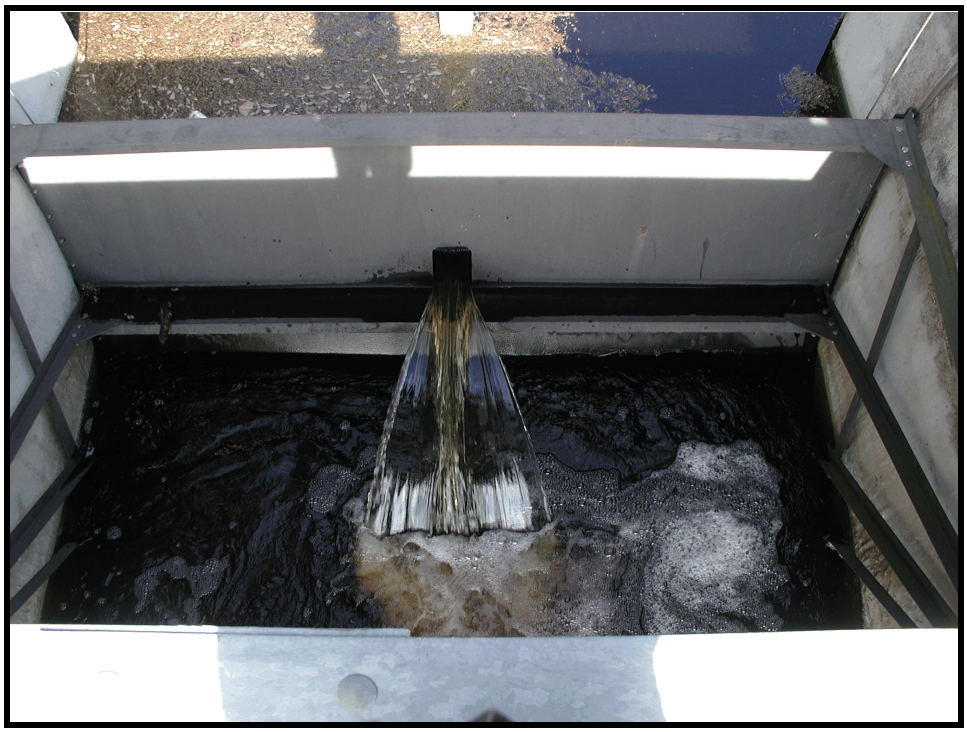


January 26, 2003

Cherry Lake Discharge Structure



June 22, 2002

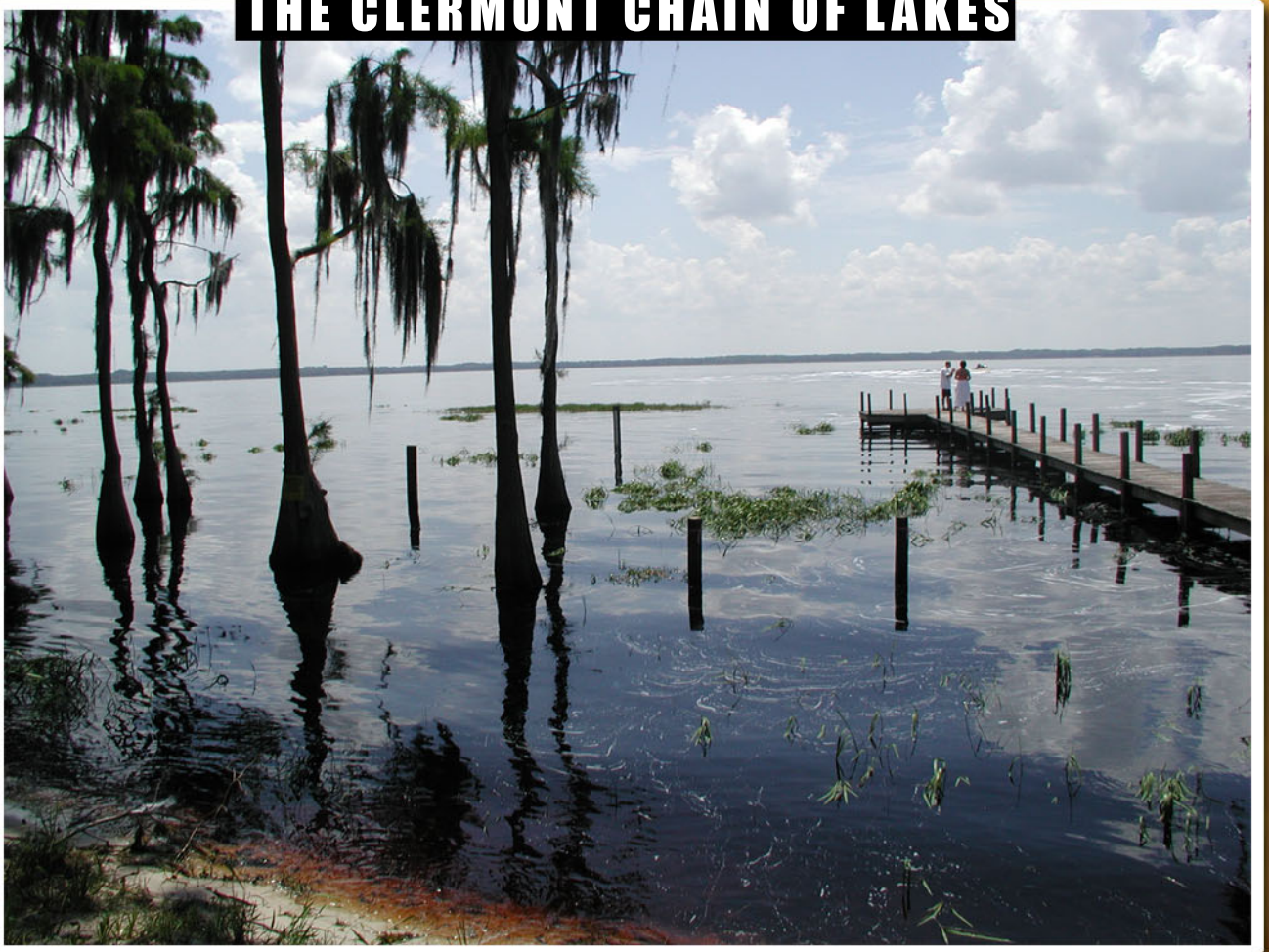


January 26, 2003

TECHNICAL MEMO #9

INVENTORY OF WATER USE PERMITS WITHIN MODEL DOMAIN

THE CLERMONT CHAIN OF LAKES



Prepared for

LCWA

Lake County Water Authority

PEC

Professional Engineering Consultants, Inc.

Prepared by

DEVO Engineering

CONSULTING GEOTECHNICAL ENGINEERS

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e-mail: devo@devoeng.com | www.devoeng.com

Date: May 20, 2003	*Devo's Project No.* 02-121.96
To: Lake County Water Authority 107 North Lake Avenue Tavares, Fl 32778-3119 phone: 352-343-3777 fax: 352-343-4259 attention: LANCE LUMBARD	*cc:* Professional Engineering Consultants, Inc. 200 East Robinson Street, Suite 1560 Orlando, FL 32801 phone: 407-422-8062 fax: 407-849-9401 attention: DAVID HAMSTRA, P.E.
LCWA Lake County Water Authority	PEC
Ref: **TECHNICAL MEMO #09** **INVENTORY OF WATER USE PERMITS WITHIN MODEL DOMAIN...** **CLERMONT CHAIN OF LAKES STUDY**	

Dear Mr. Lumbard:

The attached memo summarizes the collection and data reduction for permitted wells within the model domain which are pumping from the Floridan aquifer. These wells are used in calibrating the final ground water model for the Floridan aquifer.

Sincerely,

Robert Casper

Robert D. Casper, E.I.
Project Engineer

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Appendices

Appendix A.1 Permitted Floridan Aquifer in SJRWMD

Appendix A.2 Permitted Floridan Aquifer in SFWMD

Appendix A.3 Permitted Floridan Aquifer in SWFWMD

Attached Figures

Figure 9-1 Floridan Aquifer Wells Used in Model

1.0 PURPOSE

An inventory of permitted wells was performed in order to identify the number of wells within the model domain pumping from the Floridan aquifer, and to estimate the average daily pumping rates of these wells. The model domain intersects three water management districts (SJRWMD, SFWMD and SWFWMD), and water use permit data was collected from each of these districts.

2.0 DATA SOURCES

Permitted well data was obtained using a combination of online resources and archival records search, depending on the format of data available from each of the water management districts.

2.1 SAINT JOHNS REGION WATER MANAGEMENT DISTRICT

Consumptive Use Permit Data from Saint Johns Region Water Management District was obtained using the online SJRWMD Regulatory Permit Search Tool. This database provides information for water use permits, and for wells and surface pumps, which were cross referenced in order to make estimates of daily pumping rates for individual wells.

2.2 SOUTH FLORIDA WATER MANAGEMENT DISTRICT

Permitted well data for the South Florida Water management district was obtained by combining online GIS data (which provided well locations, permit numbers, depths, diameters, etc.) and an archival records search conducted at the SFWMD office in Orlando, Florida to determine permitted water use allocations.

2.3 SOUTHWEST FLORIDA WATER MANAGEMENT DISTRICT

Permitted well data for the Southwest Florida Water management district was obtained using online GIS data, which provided sufficient information to determine the location of permitted wells, and to estimated their average daily pumping capacity.

3.0 DATA REDUCTION

Permitted well data for each of the water management districts was converted into GIS format, if necessary, and a subset of the wells which fall within the model boundary was selected. This subset was then examined to determine which wells are pumping from the Floridan aquifer. The attached Figure 9-1 shows the location of wells within the model area which are pumping from the Floridan aqiuifer.

Typically, water use permits provide a total yearly permitted withdrawal rate, which may be distributed among multiple well governed by the permit. It was therefore necessary to estimate pumping capacities for individual wells, as some fraction of the total allocated pumping capacity. This was done using a weighted average of the total pumping capacity based on the cross-sectional area of the individual wells.

In addition, the water use permit data obtained sometimes provided a total allocated pumping rate for both ground water and surface water pumping. In these cases, we attempted to estimate the portion of the total allocated pumpage which would represent aquifer pumpage, and divided this portion among individual wells using an area weighted procedure.

Occasionaly, the yearly allocated pumping rates were not reported. In these cases, we estimated pumpage based on a statistical average for other wells with the same cross-sectional area.

Appendices A.1 through A.3 list the wells within the model domain which are pumping from the Floridan aquifer, their estimated pumping rates, depths, diameters, and locations (in UTM-17 map projection coordinates).

APPENDIX A.I
PERMITTED FLORIDAN WELLS IN SJRWMD

Permit Number	Model Rate (ft^3/day)	Well Diameter (inches)	DPETH	X Coordinate (meters)	Y Coordinate (meters)	Station ID	County
79	4,218	8	365	418,119	3,149,092	8935	Lake
81	4,218	8	291	411,616	3,155,940	8936	Lake
83	4,218	8	490	424,718	3,151,910	8937	Lake
94	14,000	12	650	415,317	3,179,027	10353	Lake
94	14,000	12	265	415,314	3,171,086	22437	Lake
94	14,000	12	400	415,312	3,170,809	22440	Lake
98	3,421	6	0	426,880	3,171,439	18993	Lake
99	4,021	10	200	411,322	3,160,251	18992	Lake
100	50,257	10	260	420,313	3,159,787	18990	Lake
271	3,989	12	750	417,900	3,164,482	19037	Lake
271	3,989	12	550	418,230	3,165,033	19038	Lake
271	2,770	10	580	414,736	3,162,627	23156	Lake
271	4,682	13	550	417,435	3,167,809	23157	Lake
273	12,841	10	350	415,135	3,161,485	19035	Lake
277	5,384	10	180	413,718	3,164,512	19036	Lake
310	8,387	8	0	433,157	3,110,221	19243	Polk
312	7,186	10	600	430,827	3,113,158	13338	Polk
316	2,208	6	150	434,326	3,109,384	19244	Polk
1665	8,348	8	400	414,626	3,166,105	18805	Lake
1665	8,348	8	395	413,558	3,164,975	18806	Lake
1665	1,174	3	110	413,504	3,164,975	18807	Lake
1666	327	4	0	423,325	3,155,089	9440	Lake
1666	735	6	0	423,325	3,155,058	18813	Lake
1670	1,666	12	110	418,171	3,160,417	18829	Lake
1670	1,666	12	0	418,142	3,160,140	18830	Lake
2387	1,859	4	150	425,247	3,140,889	8862	Lake
2387	1,859	4	150	425,246	3,140,827	21323	Lake
2389	7,860	12	459	431,487	3,137,650	18964	Lake
2391	9	8	0	427,359	3,139,183	8868	Lake
2391	2	4	121	427,605	3,139,305	8869	Lake
2391	9	8	400	427,288	3,140,938	8870	Lake
2391	2	4	301	427,396	3,140,845	8871	Lake
2392	27,102	12	200	433,282	3,137,363	8872	Lake
2392	18,821	10	240	433,472	3,137,270	8873	Lake
2392	6,776	6	400	433,580	3,136,992	8874	Lake
2392	27,102	12	448	433,527	3,137,269	8875	Lake
2392	48,182	16	600	433,581	3,137,300	24965	Lake
2392	48,182	16	600	433,581	3,137,300	34048	Lake
2394	44,173	10	0	420,135	3,149,632	8877	Lake
2396	18,862	12	480	423,867	3,150,654	8887	Lake
2397	13,690	12	610	432,079	3,141,155	8888	Lake
2407	6,043	10	0	409,097	3,167,532	8939	Lake
2419	18,873	6	520	423,657	3,176,723	8979	Lake
2419	37,745	12	905	423,631	3,176,846	8980	Lake
2419	50,327	16	700	423,576	3,176,846	8981	Lake
2433	19,825	12	500	424,361	3,147,080	9023	Lake
2433	8,811	8	387	424,226	3,147,174	9024	Lake
2433	13,768	10	350	424,361	3,147,080	33231	Lake
2451	14,000	12	940	429,675	3,162,343	19956	Lake
2451	30,400	16	980	429,627	3,163,451	19957	Lake
2451	14,000	12	900	430,363	3,163,878	19958	Lake
2460	26,297	12	728	424,705	3,175,208	9111	Lake
2462	8,549	8	450	415,284	3,163,238	9115	Lake
2462	13,358	10	450	415,012	3,163,240	20078	Lake
2465	8,215	10	330	423,256	3,173,555	19753	Lake
2467	1,859	4	160	421,589	3,139,312	9130	Lake

Permit Number	Model Rate (ft^3/day)	Well Diameter (inches)	DPETH	X Coordinate (meters)	Y Coordinate (meters)	Station ID	County
2467	6,400	8	250	422,034	3,140,633	9131	Lake
2467	14,000	12	350	421,429	3,139,775	9132	Lake
2467	1,859	4	160	421,456	3,139,682	9133	Lake
2478	14,000	12	918	423,998	3,158,285	9167	Lake
2478	14,000	12	840	424,624	3,158,312	9168	Lake
2478	9,600	10	840	425,410	3,158,061	9169	Lake
2478	30,400	16	885	431,718	3,158,576	10364	Lake
2478	46,500	18	750	431,720	3,159,007	10365	Lake
2478	30,400	16	1200	430,963	3,155,011	10366	Lake
2478	112,000	24	810	430,086	3,158,309	33695	Lake
2487	3,412	12	492	427,166	3,143,154	8880	Lake
2487	2,369	10	370	431,053	3,142,608	8881	Lake
2487	3,412	12	428	426,842	3,143,679	8882	Lake
2487	2,369	10	472	429,015	3,142,958	8883	Lake
2487	2,369	10	315	429,640	3,142,862	8884	Lake
2487	2,369	10	0	430,902	3,144,670	8885	Lake
2487	6,065	16	440	430,353	3,143,812	8886	Lake
2487	2,369	10	595	426,922	3,143,279	9198	Lake
2487	2,369	10	315	427,191	3,142,908	33243	Lake
2487	6,065	16	440	426,922	3,143,279	33244	Lake
2487	3,412	12	428	426,922	3,143,279	33245	Lake
2487	2,369	10	472	426,922	3,143,279	33335	Lake
2487	2,369	10	370	426,922	3,143,279	33336	Lake
2497	12,086	12	500	430,680	3,139,348	9242	Lake
2504	16,030	16	402	434,979	3,148,925	9272	Lake
2504	16,030	16	1400	435,224	3,148,924	9273	Lake
2504	16,030	16	452	435,581	3,149,568	9274	Lake
2504	16,030	16	660	431,134	3,147,162	9275	Lake
2504	16,030	16	655	431,651	3,147,190	9276	Lake
2504	16,030	16	1000	433,151	3,147,766	9277	Lake
2504	16,030	16	622	433,391	3,147,026	9278	Lake
2504	16,030	16	270	432,346	3,149,771	9279	Lake
2504	16,030	16	590	433,212	3,148,996	9280	Lake
2504	16,030	16	342	432,315	3,149,032	9281	Lake
2504	16,030	16	690	430,790	3,148,733	9282	Lake
2504	16,030	16	822	432,063	3,147,803	9283	Lake
2504	16,030	16	800	437,094	3,152,730	9284	Lake
2504	16,030	16	600	435,579	3,154,153	9285	Lake
2504	16,030	16	600	435,581	3,154,461	9286	Lake
2504	16,030	16	0	435,603	3,153,569	9287	Lake
2517	2,212	6	310	424,098	3,148,498	19987	Lake
2531	5,165	8	300	433,699	3,138,930	9363	Lake
2531	8,071	10	376	433,726	3,138,868	18972	Lake
2537	14,829	10	283	412,095	3,172,587	9391	Lake
2538	6,845	6	500	418,711	3,175,525	9392	Lake
2539	15,968	6	410	420,175	3,175,392	9393	Lake
2550	26,130	10	337	421,460	3,168,735	9414	Lake
2550	26,130	10	330	421,487	3,168,766	9415	Lake
2555	17,012	8	450	430,097	3,141,998	9439	Lake
2556	13,053	12	456	434,913	3,146,679	9443	Lake
2556	13,053	12	0	432,877	3,147,459	9444	Lake
2556	13,053	12	0	432,333	3,147,432	9445	Lake
2556	13,053	12	0	431,086	3,148,178	9446	Lake
2556	13,053	12	0	431,082	3,147,501	9447	Lake
2556	17,766	14	0	432,953	3,146,536	9448	Lake
2563	476	4	160	422,077	3,175,748	19874	Lake

Permit Number	Model Rate (ft^3/day)	Well Diameter (inches)	DPETH	X Coordinate (meters)	Y Coordinate (meters)	Station ID	County
2563	1,072	6	248	422,050	3,175,779	19875	Lake
2563	1,906	8	330	422,131	3,175,778	19876	Lake
2565	5,660	6	447	432,392	3,157,649	9473	Lake
2565	5,660	6	245	432,392	3,157,680	9474	Lake
2567	11,892	12	600	419,233	3,172,659	9476	Lake
2567	11,892	12	415	419,639	3,172,441	9477	Lake
2568	1,413	10	210	408,069	3,174,988	9479	Lake
2568	2,035	12	154	408,068	3,174,773	9480	Lake
2571	20,403	24	580	423,993	3,174,166	9486	Lake
2571	1,275	6	0	424,104	3,174,534	9487	Lake
2580	1,253	6	440	433,234	3,157,706	9507	Lake
2580	1,253	6	200	433,399	3,158,043	9508	Lake
2580	557	4	300	433,427	3,158,197	9509	Lake
2581	23,144	8	402	409,848	3,162,787	9510	Lake
2581	23,144	8	400	407,615	3,162,158	9511	Lake
2581	36,163	10	400	408,214	3,162,307	9512	Lake
2581	23,144	8	400	407,862	3,162,433	9513	Lake
2581	52,074	12	400	409,092	3,163,408	9514	Lake
2585	6,400	8	0	424,492	3,171,547	9528	Lake
2587	989	6	0	420,228	3,179,238	9531	Lake
2588	5,010	8	0	420,169	3,178,469	9532	Lake
2592	6,845	6	0	412,081	3,170,741	9540	Lake
2594	1,921	10	309	418,955	3,163,828	9547	Lake
2594	1,921	10	0	418,573	3,163,646	9548	Lake
2594	2,766	12	615	417,317	3,162,670	9549	Lake
2594	2,766	12	546	417,018	3,162,672	9550	Lake
2594	2,766	12	725	417,753	3,162,913	9551	Lake
2594	307	4	150	416,857	3,162,889	9552	Lake
2594	4,917	16	0	419,446	3,164,071	9553	Lake
2594	1,921	10	150	419,283	3,164,103	9554	Lake
2595	9,127	6	0	412,838	3,163,072	9555	Lake
2596	6,512	10	400	424,116	3,176,350	9556	Lake
2596	9,377	12	400	424,143	3,176,381	9557	Lake
2596	9,377	12	0	424,125	3,177,735	9558	Lake
2602	4,533	12	290	410,444	3,162,628	9578	Lake
2602	4,533	12	205	410,443	3,162,536	9579	Lake
2602	4,533	12	269	410,307	3,162,414	9580	Lake
2602	4,533	12	329	410,306	3,162,321	9581	Lake
2602	126	2	80	410,089	3,162,385	9582	Lake
2612	2,249	8	340	415,999	3,175,852	9599	Lake
2623	13,540	12	500	421,789	3,165,255	18974	Lake
2631	53,176	16	900	433,368	3,147,734	9705	Lake
2635	4,791	6	365	435,548	3,158,339	9717	Lake
2645	5,464	12	500	425,880	3,167,875	9765	Lake
2648	2,282	6	549	433,535	3,162,874	9779	Lake
2653	31,948	10	350	425,936	3,172,461	9798	Lake
2654	4,563	10	0	419,426	3,169,149	9800	Lake
2655	9,795	12	400	416,376	3,167,878	9801	Lake
2655	4,353	8	364	416,866	3,168,028	9802	Lake
2658	9,600	10	950	432,525	3,138,321	18985	Lake
2662	2,477	6	300	424,016	3,177,643	9815	Lake
2662	6,880	10	300	424,177	3,177,396	9816	Lake
2662	4,403	8	300	423,393	3,177,801	9817	Lake
2662	6,880	10	300	423,691	3,177,738	9818	Lake
2662	6,880	10	350	422,577	3,177,499	23908	Lake
2663	4,219	8	640	430,239	3,161,293	9819	Lake

Permit Number	Model Rate (ft^3/day)	Well Diameter (inches)	DPETH	X Coordinate (meters)	Y Coordinate (meters)	Station ID	County
2664	13,723	0	500	424,098	3,177,858	33995	Lake
2667	7,816	10	330	417,863	3,174,577	18879	Lake
2669	4,578	6	500	411,238	3,159,852	9838	Lake
2670	13,698	12	525	411,617	3,159,664	9839	Lake
2671	8,241	12	607	433,428	3,163,060	19923	Lake
2673	9,533	8	100	414,310	3,174,941	9844	Lake
2675	7,032	6	100	411,097	3,159,176	9846	Lake
2682	1,971	6	0	411,243	3,160,560	9870	Lake
2682	3,504	8	350	411,380	3,160,651	9871	Lake
2683	11,262	12	296	434,236	3,156,961	9874	Lake
2684	8,745	10	265	426,369	3,172,304	9876	Lake
2690	2,282	8	0	424,855	3,168,959	9887	Lake
2695	8,328	12	110	418,821	3,175,740	9908	Lake
2696	9,127	8	0	414,028	3,162,355	9913	Lake
2700	9,600	10	340	427,093	3,153,372	9930	Lake
2700	6,400	8	297	426,930	3,153,465	9931	Lake
2700	6,400	8	316	415,433	3,157,513	20031	Lake
2704	1,426	6	230	421,285	3,179,047	9947	Lake
2704	3,961	10	300	420,606	3,178,928	9948	Lake
2704	1,426	6	222	420,633	3,178,928	9949	Lake
2704	1,426	6	220	420,551	3,178,836	9950	Lake
2704	634	4	150	420,740	3,178,742	9951	Lake
2704	1,426	6	220	420,604	3,178,620	9952	Lake
2708	2,055	6	460	418,072	3,150,200	9957	Lake
2709	2,282	6	500	424,679	3,171,114	9958	Lake
2710	2,282	6	510	429,076	3,157,669	9959	Lake
2722	3,536	12	500	418,643	3,177,495	18859	Lake
2722	3,536	12	500	418,616	3,177,526	18860	Lake
2723	5,591	12	0	419,612	3,176,350	10003	Lake
2723	5,591	12	520	419,530	3,176,258	10004	Lake
2725	952	6	0	433,970	3,157,978	10008	Lake
2725	3,809	12	0	433,916	3,158,040	10009	Lake
2728	3,834	6	400	425,341	3,172,741	70	Lake
2728	3,834	6	0	425,423	3,172,833	10014	Lake
2731	1,344	6	480	416,566	3,171,631	10021	Lake
2732	3,868	8	0	418,813	3,159,028	10022	Lake
2734	1,141	8	400	427,011	3,170,669	10028	Lake
2734	1,141	8	400	426,493	3,170,364	10295	Lake
2737	1,599	6	0	419,131	3,153,824	10042	Lake
2737	1,599	6	0	419,129	3,153,640	10043	Lake
2737	6,395	12	97	422,525	3,153,278	10044	Lake
2763	3,834	6	0	432,798	3,157,493	10102	Lake
2763	3,834	6	0	432,496	3,156,879	10103	Lake
2763	1,859	4	0	432,498	3,157,187	10104	Lake
2763	14,000	12	163	432,797	3,157,339	10105	Lake
2764	14,000	12	0	426,206	3,163,564	10107	Lake
2768	4,336	8	0	421,784	3,176,643	10126	Lake
2770	2,282	6	360	424,789	3,171,391	10135	Lake
2773	1,978	6	370	414,967	3,160,748	10142	Lake
2773	220	2	110	415,021	3,160,686	10143	Lake
2774	1,451	8	380	411,533	3,173,700	10144	Lake
2774	363	4	80	411,071	3,173,580	10145	Lake
2774	3,264	12	420	411,017	3,173,642	10146	Lake
2774	91	2	175	411,071	3,173,580	34052	Lake
2775	2,472	6	280	415,500	3,178,102	10152	Lake
2775	6,867	10	260	415,230	3,178,197	10153	Lake

Permit Number	Model Rate (ft^3/day)	Well Diameter (inches)	DPETH	X Coordinate (meters)	Y Coordinate (meters)	Station ID	County
2778	10,354	10	180	419,661	3179519.382	10168	Lake
2791	14,000	12	500	423,401	3174969.859	10209	Lake
2791	14,000	12	600	423,703	3175491.061	10210	Lake
2791	14,000	12	0	423,322	3175370.464	10211	Lake
2791	14,000	12	0	423,593	3175245.592	10212	Lake
2791	14,000	12	600	424,056	3175458.067	10213	Lake
2793	4,566	8	389	431,106	3156209.957	10218	Lake
2793	10,274	12	600	430,942	3,156,149	10219	Lake
2794	7,006	4	0	419,875	3,143,386	10222	Lake
2796	13,319	10	825	416,181	3,159,569	10235	Lake
2796	13,319	10	750	415,767	3,158,588	10236	Lake
2796	13,319	10	600	417,464	3,160,422	10237	Lake
2796	13,319	10	600	417,382	3,160,300	10238	Lake
2796	2,131	4	0	417,518	3,160,329	10239	Lake
2817	7,442	8	240	424,787	3,166,867	18941	Lake
2817	1,861	4	200	424,761	3,166,959	18942	Lake
2828	2,330	4	350	434,710	3,154,374	10343	Lake
2828	5,243	6	172	434,713	3,154,897	10344	Lake
2828	14,564	10	0	434,303	3,154,376	10345	Lake
2828	5,243	6	247	434,711	3,154,435	10346	Lake
2829	4,106	8	435	426,760	3,169,655	10347	Lake
2832	4,219	6	473	436,387	3,152,795	23241	Lake
2837	3,115	10	390	433,162	3,140,164	18936	Lake
2837	1,994	8	412	433,162	3,140,195	18937	Lake
2840	3,543	6	310	418,369	3,169,372	10378	Lake
2840	3,543	6	310	418,178	3,169,250	32899	Lake
2842	4,563	8	460	421,765	3,161,531	10381	Lake
2843	81,087	6	320	422,749	3,178,975	10383	Lake
2847	6,405	10	0	429,235	3,152,405	18880	Lake
2847	4,099	8	970	428,881	3,152,345	18881	Lake
2849	1,859	4	100	422,539	3,159,464	10398	Lake
2849	14,000	12	0	422,539	3,159,557	10399	Lake
2850	12,837	12	530	412,610	3,165,259	10401	Lake
2850	8,915	10	460	412,793	3,164,395	10402	Lake
2855	498	4	260	417,478	3,150,789	18945	Lake
2856	4,622	10	360	417,320	3,166,979	18975	Lake
2866	3,238	6	0	435,056	3,152,956	19013	Lake
2879	45,266	18	738	432,179	3,139,647	10501	Lake
2879	45,266	18	750	432,153	3,139,862	10502	Lake
2886	7,568	8	460	426,812	3,160,575	10512	Lake
2886	11,825	10	450	427,281	3,161,742	10513	Lake
2886	30,273	16	702	429,199	3,160,007	10514	Lake
2886	30,273	16	373	427,308	3,161,742	10516	Lake
2886	17,029	12	702	429,226	3,160,037	23386	Lake
2886	17,029	12	702	427,279	3,161,496	23387	Lake
2893	1,505	6	0	429,696	3,152,279	10527	Lake
2897	525	4	225	426,771	3,145,311	10537	Lake
2897	4,724	12	390	426,798	3,145,280	10538	Lake
2898	1,547	4	150	424,835	3,165,820	10539	Lake
2898	9,666	10	500	425,164	3,166,403	10540	Lake
2898	3,480	6	0	425,055	3,166,342	10541	Lake
2898	9,666	10	400	424,920	3,166,404	10542	Lake
2903	2,271	9	300	411,486	3,156,680	10552	Lake
2911	2,282	6	200	421,739	3,173,996	10567	Lake
2912	4,106	8	0	421,950	3,173,010	10568	Lake
2913	7,834	12	300	424,627	3,163,082	10569	Lake

Permit Number	Model Rate (ft^3/day)	Well Diameter (inches)	DPETH	X Coordinate (meters)	Y Coordinate (meters)	Station ID	County
2913	13,928	16	300	423,563	3,162,443	10570	Lake
2913	7,834	12	0	424,655	3,163,236	10571	Lake
2913	7,834	12	0	424,655	3,163,205	18907	Lake
2914	1,859	4	0	420,783	3,148,920	10572	Lake
2914	1,859	4	0	420,728	3,148,797	10573	Lake
2918	7,039	4	0	420,729	3,149,043	10576	Lake
2925	6,856	4	0	418,684	3,179,557	10590	Lake
2926	7,990	10	450	420,566	3,165,079	10592	Lake
2926	320	2	210	420,540	3,165,263	10593	Lake
2926	1,278	4	200	420,648	3,165,078	10594	Lake
2927	4,454	6	0	432,739	3,161,309	10595	Lake
2930	18,257	12	310	412,681	3,163,935	10598	Lake
2937	9,156	6	70	420,024	3,161,205	10610	Lake
2938	8,790	8	325	417,184	3,155,407	10611	Lake
2939	21,100	12	250	410,739	3,165,704	10614	Lake
2941	37,431	10	400	418,772	3,149,149	10616	Lake
2944	332	4	0	417,176	3,165,779	10619	Lake
2944	2,075	10	450	417,313	3,165,932	10620	Lake
2944	332	4	0	417,313	3,165,932	33119	Lake
2946	37	4	0	409,770	3,166,819	10623	Lake
2949	5,171	10	350	418,231	3,176,759	10626	Lake
2949	5,171	10	380	418,228	3,176,421	10627	Lake
2958	45,174	10	435	414,810	3,172,690	10650	Lake
2958	45,174	10	0	415,020	3,171,827	10651	Lake
2958	65,050	12	0	414,613	3,171,738	10652	Lake
2958	65,050	12	0	415,000	3,172,781	10653	Lake
2958	7,228	4	0	415,055	3,172,873	10654	Lake
2960	4,358	10	400	426,276	3,170,366	10656	Lake
2965	234	12	0	423,394	3,144,778	10666	Lake
2967	12,168	8	275	419,297	3,174,013	10669	Lake
2971	1,063	4	165	420,891	3,144,703	10677	Lake
2971	1,063	4	165	420,833	3,144,241	10678	Lake
2971	1,063	4	0	420,996	3,144,209	10679	Lake
2971	9,567	12	0	420,834	3,144,303	10680	Lake
2976	11,412	10	150	420,540	3,157,262	10693	Lake
2979	8,900	8	400	413,544	3,155,618	10697	Lake
2986	4,563	8	0	417,949	3,179,100	10710	Lake
2989	7,874	6	475	435,271	3,157,387	10713	Lake
2991	30,400	16	980	430,498	3,154,459	10715	Lake
2991	6,400	8	800	430,000	3,153,108	24656	Lake
2991	6,400	8	800	430,498	3,154,459	33708	Lake
2991	1,859	4	420	430,028	3,153,139	33709	Lake
3182	11,481	10	525	442,782	3,154,055	11825	Orange
3182	1,033	3	40	442,890	3,153,869	11826	Orange
3207	14,000	12	0	436,345	3,155,072	11933	Orange
3228	6,358	6	186	442,684	3,156,240	12006	Orange
3281	1,611	6	426	437,722	3,158,512	12177	Orange
3285	2,271	10	237	438,237	3,158,201	12183	Orange
3286	226	6	250	439,520	3,159,333	12184	Orange
3314	8,387	10	500	439,079	3,152,935	12281	Orange
3322	120	6	160	439,166	3,153,827	12329	Orange
3322	214	8	500	439,193	3,153,888	12330	Orange
3325	4,932	16	600	441,549	3,152,122	12340	Orange
3325	4,932	16	600	442,092	3,151,965	12341	Orange
3347	12,668	10	494	438,595	3,159,061	12410	Orange
3347	32,430	16	0	438,406	3,159,247	12411	Orange

Permit Number	Model Rate (ft^3/day)	Well Diameter (inches)	DPETH	X Coordinate (meters)	Y Coordinate (meters)	Station ID	County
3347	8,107	8	500	438,622	3,159,061	12412	Orange
3386	83	8	360	441,634	3,152,860	19207	Orange
3386	5	2	0	441,310	3,153,169	19208	Orange
3387	403	6	225	436,278	3,152,796	12608	Orange
3387	403	6	225	436,414	3,152,795	12609	Orange
3390	1,546	6	200	437,310	3,157,560	12614	Orange
3395	1,685	6	250	436,534	3,154,764	12623	Orange
3440	3,208	12	535	435,663	3,109,561	19234	Polk
3456	6,417	10	450	433,107	3,115,853	13341	Polk
3480	864	8	575	435,284	3,109,963	19238	Polk
3480	337	5	0	435,311	3,109,901	19239	Polk
3498	3,276	6	285	438,487	3,112,070	19230	Polk
3498	5,825	8	300	431,454	3,112,970	19231	Polk
3501	2,395	6	320	435,525	3,109,223	19237	Polk
3502	3,611	10	601	438,574	3,113,023	13434	Polk
3506	1,872	10	0	431,374	3,113,401	13441	Polk
3507	2,666	6	450	437,729	3,113,243	13443	Polk
3508	6,137	6	325	434,739	3,134,985	13444	Polk
3508	2,728	4	100	434,440	3,135,049	13445	Polk
3508	2,728	4	100	434,221	3,134,927	13446	Polk
3508	2,728	4	100	434,847	3,134,769	13448	Polk
3509	4,960	8	536	436,058	3,116,945	13451	Polk
3509	310	2	189	436,248	3,116,790	13452	Polk
3510	13,414	12	400	433,906	3,132,066	13453	Polk
3510	13,414	12	400	433,715	3,132,098	13454	Polk
3511	2,740	6	500	431,908	3,111,336	13455	Polk
3512	1,677	8	50	431,893	3,122,938	13456	Polk
3516	11,501	10	543	436,428	3,119,835	13464	Polk
3516	29,442	16	543	436,970	3,119,186	13465	Polk
3517	34,900	12	532	436,308	3,117,836	13466	Polk
3518	46,440	12	0	438,127	3,116,318	13467	Polk
3519		12	0	437,554	3,116,229	21527	Polk
4485	645	4	250	418,632	3,160,383	18817	Lake
4485	645	4	300	418,632	3,160,291	18818	Lake
4485	1,450	6	305	418,631	3,160,168	18819	Lake
4486	18,257	12	0	419,993	3,176,532	18823	Lake
4487	436	6	0	435,380	3,157,447	18828	Lake
4492	6,845	8	0	415,301	3,158,129	18840	Lake
4493	3,342	8	365	433,663	3,137,330	18841	Lake
4494	4,336	10	0	417,695	3,154,542	18842	Lake
4496	7,716	10	250	419,404	3,177,767	18846	Lake
4496	1,235	4	0	419,460	3,177,920	18847	Lake
4496	1,235	4	0	419,319	3,177,183	18848	Lake
4496	1,235	4	0	419,131	3,177,430	18849	Lake
4497	513	6	0	417,530	3,165,900	18850	Lake
4497	228	4	110	417,422	3,165,931	18851	Lake
4499	3,406	12	404	419,363	3,175,705	18853	Lake
4501	25,017	10	0	421,031	3,157,535	18856	Lake
4501	16,011	8	0	420,375	3,156,955	18857	Lake
4501	16,011	8	0	426,030	3,157,256	18858	Lake
4505	3,539	10	0	417,693	3,154,327	18864	Lake
4505	566	4	0	418,126	3,154,077	18865	Lake
4508	10,273	10	0	425,781	3,173,693	18868	Lake
4510	2,874	4	0	420,604	3,150,583	18871	Lake
4510	6,466	6	0	420,739	3,150,489	18872	Lake
4524	3,516	12	300	415,360	3,158,806	18896	Lake

Permit Number	Model Rate (ft^3/day)	Well Diameter (inches)	DPETH	X Coordinate (meters)	Y Coordinate (meters)	Station ID	County
4526	1,242	12	500	417,943	3,178,208	18900	Lake
4529	9,525	12	700	413,488	3,173,839	18909	Lake
4529	1,058	4	230	413,462	3,173,962	18910	Lake
4529	1,058	4	245	413,483	3,173,162	18911	Lake
4529	1,058	4	250	413,998	3,173,096	18912	Lake
4529	265	2	50	413,299	3,173,963	18913	Lake
4531	10,270	8	250	421,776	3,151,006	18917	Lake
4537	2,659	8	500	420,559	3,147,906	18930	Lake
4542	12,551	12	660	418,441	3,175,711	18935	Lake
4551	4,615	10	0	418,102	3,173,836	18946	Lake
4556	9,600	10	0	430,902	3,144,670	8885	Lake
4568	4,747	6	400	425,403	3,148,366	18976	Lake
4610	3,083	6	200	439,827	3,155,608	19135	Orange
4610	1,370	4	0	440,017	3,155,576	19136	Orange
4610	8,563	10	0	439,936	3,155,731	19137	Orange
4613	23,636	12	210	442,680	3,155,378	19140	Orange
4613	10,505	8	0	443,441	3,155,406	19141	Orange
4613	2,626	4	0	442,544	3,155,410	19142	Orange
4613	2,626	4	84	442,216	3,154,981	19143	Orange
4613	2,626	4	0	442,488	3,155,010	19144	Orange
4613	2,626	4	0	442,706	3,155,194	19145	Orange
4623	1,859	4	0	440,091	3,159,361	19157	Orange
4643	3,528	8	280	438,585	3,115,208	19224	Polk
4643	1,984	6	0	438,477	3,115,393	19225	Polk
4646	5,897	10	600	436,878	3,117,402	19229	Polk
5709	57,377	18	691	416,237	3,159,754	8855	Lake
5709	17,709	10	0	416,129	3,159,816	8856	Lake
5709	11,334	8	0	416,183	3,159,816	8857	Lake
5716	22,372	12	600	431,457	3,141,805	8867	Lake
5736	208,618	12	350	432,775	3,153,492	8900	Lake
5736	144,873	10	350	432,748	3,153,461	8901	Lake
5736	370,876	16	933	432,531	3,153,586	8902	Lake
5736	144,873	10	0	431,473	3,153,869	8903	Lake
5773	6,625	6	0	423,814	3,150,869	18934	Lake
5774	9,127	8	400	425,619	3,165,261	8965	Lake
5965	4,052	10	1300	431,636	3,149,252	9160	Lake
5965	4,052	10	1300	431,582	3,149,252	9161	Lake
5965	2,593	8	377	430,954	3,148,856	9245	Lake
6124	5,248	8	0	423,234	3,153,581	18933	Lake
6254	6,410	12	685	430,204	3,146,213	9666	Lake
6254	6,410	12	650	430,833	3,146,733	9667	Lake
6254	4,451	10	395	431,242	3,146,884	9668	Lake
6254	4,451	10	390	432,572	3,146,446	9669	Lake
6254	6,410	12	0	432,707	3,146,199	9670	Lake
6254	6,410	12	550	431,644	3,150,637	9671	Lake
6254	6,410	12	425	432,211	3,149,864	9672	Lake
6254	6,410	12	546	432,831	3,149,029	9673	Lake
6254	6,410	12	669	432,855	3,148,352	9674	Lake
6254	6,410	12	650	434,791	3,149,234	9675	Lake
6254	6,410	12	825	434,815	3,148,772	9676	Lake
6311	2,944	8	490	423,147	3,152,812	9762	Lake
6311	736	4	135	423,202	3,152,874	9763	Lake
6340	4,644	10	400	430,177	3,141,689	9792	Lake
6340	4,644	10	412	430,177	3,141,689	9793	Lake
6398	15,578	8	295	422,646	3,167,527	9861	Lake
6398	15,578	8	300	422,813	3,168,049	9862	Lake

Permit Number	Model Rate (ft^3/day)	Well Diameter (inches)	DPETH	X Coordinate (meters)	Y Coordinate (meters)	Station ID	County
6398	3,894	4	150	422,837	3,167,587	9863	Lake
6477	2,084	6	400	435,055	3,157,757	9964	Lake
6575	1,859	4	240	426,834	3,164,114	10095	Lake
7654	15,976	8	300	440,894	3,156,988	19113	Orange
7747	9,771	12	460	431,478	3,121,832	13281	Polk
7754	8,982	10	467	434,663	3,126,123	13288	Polk
7754	8,982	10	820	435,073	3,126,274	13289	Polk
7762	12,225	10	618	433,268	3115390.371	13294	Polk
7777	39,884	8	360	434,742	3135446.901	13320	Polk
7803	3,721	10	550	432,395	3110656.108	13337	Polk
7806	4,278	8	545	437,183	3113214.994	23381	Polk
7811	10,255	12	410	437,064	3116508.362	13347	Polk
7816	9,255	12	600	435,410	3123102.767	21886	Polk
7818	3,351	6	488	432,042	3110873.592	13355	Polk
7822	732	8	504	434,816	3,109,319	13361	Polk
7829	5,054	8	500	434,001	3,109,909	19232	Polk
7841	57,867	12	0	431,712	3,124,693	13381	Polk
7841	57,867	12	0	431,223	3,125,004	13382	Polk
7846	1,196	6	110	438,633	3,114,008	13390	Polk
7848	8,285	6	260	432,128	3,111,673	13396	Polk
7848	8,285	6	250	432,292	3,111,641	13397	Polk
7851	4,035	8	460	436,659	3,117,157	13405	Polk
7854	4,662	6	0	436,894	3,115,309	13407	Polk
7855	2,282	8	524	436,406	3,115,742	13409	Polk
7856	14,000	12	0	430,994	3,123,128	13410	Polk
7856	14,000	12	555	430,967	3,123,128	13411	Polk
7858	2,395	6	330	432,792	3,122,933	13413	Polk
7862	8,085	12	600	435,804	3,110,360	13416	Polk
7862	8,085	12	535	435,834	3,110,883	13417	Polk
7862	8,085	12	575	435,721	3,110,176	13418	Polk
7862	898	4	160	435,835	3,111,099	19842	Polk
7872	3,835	6	350	432,081	3,122,475	13450	Polk
10360	6,230	8	450	434,463	3,109,629	13367	Polk
10367	4,820	6	638	437,274	3,114,969	13375	Polk
10377	4,565	8	80	420,138	3,146,031	8890	Lake
10377	4,565	8	133	419,759	3,146,341	8891	Lake
10377	4,565	8	143	420,137	3,145,908	31882	Lake
10377	1,141	4	0	419,865	3,145,910	31923	Lake
10418	7,669	8	900	438,502	3,115,024	13364	Polk
10846	20,366	12	500	422,408	3,151,956	8859	Lake
10846	20,366	12	600	422,217	3,151,895	8860	Lake
10846	2,263	4	0	422,276	3,152,634	8861	Lake
10900	1,780	8	0	430,857	3,122,882	13275	Polk
10901	9,486	12	521	431,503	3,121,463	13276	Polk
10902	3,716	8	0	432,384	3,123,120	13277	Polk
10903	2,395	12	450	438,638	3,114,869	13278	Polk
10904	3,593	12	625	436,158	3,115,251	13279	Polk
10906	12,335	12	393	431,901	3,124,323	13282	Polk
10906	12,335	12	361	432,089	3,123,921	13283	Polk
10908	7,828	10	0	434,156	3,132,927	13285	Polk
10908	20,040	16	0	433,584	3,132,868	13286	Polk
10908	20,040	16	0	433,179	3,133,609	13287	Polk
11146	1,859	4	300	415,450	3,163,637	20158	Lake
11581	1,941	12	365	419,972	3,177,394	18991	Lake
50081	27,047	12	400	421,963	3,174,918	9518	Lake
50093	5,357	6	0	434,966	3,111,750	324	Polk

Permit Number	Model Rate (ft^3/day)	Well Diameter (inches)	DPETH	X Coordinate (meters)	Y Coordinate (meters)	Station ID	County
50093	9,523	8	0	436,796	3,112,109	325	Polk
50101	4,791	10	400	434,369	3,127,171	337	Polk
50102	9,972	10	0	431,801	3,116,476	338	Polk
50102	14,360	12	0	431,417	3,116,139	339	Polk
50102	9,972	10	0	431,629	3,115,000	340	Polk
50102	9,972	10	500	430,674	3,114,944	341	Polk
50107	6,710	10	300	431,046	3,113,157	13372	Polk
50113	21,960	4	0	421,507	3,143,221	826	Lake
50113	87,841	8	0	421,969	3,143,280	8992	Lake
50127	864	6	280	437,495	3,115,337	367	Polk
50135	31,253	8	400	423,697	3,162,134	425	Lake
50135	31,253	8	400	423,588	3,162,012	426	Lake
50135	7,813	4	165	423,806	3,162,103	427	Lake
50135	17,580	6	350	423,672	3,162,473	428	Lake
50145	3,194	6	150	413,601	3,156,018	435	Lake
50148	1,538	10	500	431,179	3,112,540	437	Polk
50148	246	4	230	431,424	3,112,539	438	Polk
50151	2,157	8	90	434,109	3,109,662	463	Polk
50159	42,485	12	460	408,760	3,166,119	464	Lake
50186	19,191	8	300	418,963	3,157,118	583	Lake
50195	4,922	8	345	417,732	3,171,438	679	Lake
50207	8,741	24	923	432,323	3,155,126	640	Lake
50207	243	4	0	432,322	3,155,064	641	Lake
50214	5,991	12	680	435,333	3,153,909	690	Lake
50214	4,161	10	540	439,953	3,158,931	1032	Lake
50214	4,161	10	540	441,382	3,156,739	11932	Lake
50216	6,849	8	0	429,233	3,156,560	688	Lake
50218	2,106	6	200	426,210	3,164,334	687	Lake
50239	10,201	10	493	408,043	3,168,217	809	Lake
50239	14,689	12	450	408,095	3,167,878	810	Lake
50251	4,556	10	500	430,552	3,140,702	824	Lake
50252	2,190	8	376	437,755	3,154,419	825	Orange
50292	1,201	6	358	436,461	3,120,881	960	Polk
50307	3,428	6	212	422,408	3,168,421	1016	Lake
50313	8,680	10	900	437,770	3,115,797	19724	Polk
50314	16,272	10	229	434,431	3,133,418	19723	Polk
50318	20,810	10	250	420,551	3,146,859	19738	Lake
50318	20,810	10	250	420,711	3,146,366	19739	Lake
50318	3,330	4	110	420,849	3,146,549	19740	Lake
50318	3,330	4	150	420,849	3,146,549	19741	Lake
50430	3,194	10	0	424,357	3,163,269	19885	Lake
50718	1,498	6	580	437,985	3,109,918	20121	Polk
50736	13,026	12	300	421,723	3,171,534	10189	Lake
50736	13,026	12	300	421,340	3,171,044	18831	Lake
50736	13,026	12	314	420,772	3,171,479	18832	Lake
50736	13,026	12	310	420,932	3,170,924	18833	Lake
50736	13,026	12	317	420,820	3,170,524	18834	Lake
50736	13,026	12	314	420,338	3,171,451	18835	Lake
51073	17,722	6	398	419,865	3,153,881	21539	Orange
51119	2,623	10	329	423,406	3,150,780	21849	Lake
51119	420	4	80	417,481	3,155,067	21851	Lake
51273	7,186	12	0	438,737	3,113,022	22025	Polk
56606	10,284	12	428	435,315	3,130,735	22428	Polk
63669	87	2	75	412,309	3,168,616	23832	Lake
63669	787	6	250	412,146	3,168,617	23833	Lake
64455	45,526	14	534	428,807	3,153,577	9236	Lake

Permit Number	Model Rate (ft^3/day)	Well Diameter (inches)	DPETH	X Coordinate (meters)	Y Coordinate (meters)	Station ID	County
64455	33,448	12	580	428,888	3,153,576	9237	Lake
64455	23,228	10	578	428,753	3,153,731	9238	Lake
65432	1,758	10	350	415,970	3,160,402	27693	Lake
65762	4,263	6	231	429,167	3,159,238	27792	Lake
66695	15,655	10	250	430,854	3,155,042	31870	Lake
66769	14,000	12	0	421,592	3,164,179	31883	Lake
66769	1,859	4	0	421,807	3,163,747	31884	Lake
66769	6,400	8	0	421,107	3,164,767	31885	Lake
69472	14,000	12	0	435,452	3,135,966	33274	Lake
81093	9,600	10	380	430,269	3,157,169	34192	Lake
81093	1,859	4	323	429,834	3,157,141	34193	Lake

APPENDIX A.2
PERMITTED FLORIDAN WELLS IN

Permit Number	Model Rate (ft^2/day)	Well Depth (feet)	Well Diameter (inches)	X Coordinate (meters)	Y Coordinate (meters)	LU_CODE	County
48-00007-W	4,966	440	6	437,781	3,148,042	AGR	Orange
48-00009-W	27,057	393	12	448,122	3,139,477	PWS	Orange
48-00009-W	27,057	500	12	444,792	3,136,626	PWS	Orange
48-00009-W	87,553	350	24	448,636	3,141,305	PWS	Orange
48-00009-W	87,553	485	24	449,475	3,139,329	PWS	Orange
48-00009-W	87,553	907	24	443,863	3,144,416	PWS	Orange
48-00009-W	87,553	900	24	443,139	3,145,030	PWS	Orange
48-00009-W	87,553	340	24	443,186	3,145,093	PWS	Orange
48-00009-W	3,404	200	4	444,256	3,144,605	PWS	Orange
48-00009-W	87,553	400	24	443,863	3,140,891	PWS	Orange
48-00009-W	27,057	403	12	442,368	3,139,364	PWS	Orange
48-00009-W	3,404	270	4	442,195	3,138,310	PWS	Orange
48-00009-W	27,057	900	12	448,628	3,141,375	PWS	Orange
48-00009-W	27,057	398	12	442,147	3,138,199	PWS	Orange
48-00009-W	87,553	890	24	443,926	3,137,428	PWS	Orange
48-00009-W	87,553	700	24	445,379	3,133,831	PWS	Orange
48-00009-W	45,125	500	18	444,792	3,136,618	PWS	Orange
48-00009-W	87,553	700	24	447,001	3,132,542	PWS	Orange
48-00009-W	87,553	620	24	445,891	3,142,401	PWS	Orange
48-00009-W	82,500	420	20	444,792	3,136,704	PWS	Orange
48-00009-W	87,553	600	24	444,329	3,135,660	PWS	Orange
48-00009-W	87,553	600	24	447,064	3,134,980	PWS	Orange
48-00009-W	15,002	700	10	439,899	3,139,436	PWS	Orange
48-00015-W	10,314	492	10	437,836	3,150,126	AGR	Orange
48-00016-W	13,196	525	12	436,852	3,149,679	AGR	Orange
48-00019-W	13,826	370	10	440,230	3,149,129	AGR	Orange
48-00021-W	18,917	500	10	440,853	3,148,467	AGR	Orange
48-00022-W	15,712	500	12	436,022	3,150,430	AGR	Orange
48-00023-W	23,583	426	16	439,643	3,137,919	AGR	Orange
48-00024-W	20,949	500	12	436,806	3,146,602	AGR	Orange
48-00027-W	6,928	300	6	436,416	3,138,972	AGR	Orange
48-00031-W	53,725	1169	12	438,415	3,149,738	AGR	Orange
48-00032-W	27,315	385	12	439,317	3,148,263	AGR	Orange
48-00035-W	5,237	408	8	438,563	3,147,915	AGR	Orange
48-00037-W	27,057	378	12	437,322	3,145,301	AGR	Orange
48-00037-W	27,057	435	12	437,775	3,145,188	AGR	Orange
48-00040-W	79,476	400	6	447,498	3,150,878	GOL	Orange
48-00042-W	5,029	390	8	445,150	3,148,485	AGR	Orange
48-00043-W	13,617	448	10	443,534	3,147,878	AGR	Orange
48-00044-W	37,706	1005	12	443,919	3,151,786	AGR	Orange
48-00044-W	16,758	475	8	443,593	3,152,402	AGR	Orange
48-00047-W	9,427	360	10	445,487	3,145,564	AGR	Orange
48-00050-W	27,057	450	12	443,346	3,150,950	AGR	Orange
48-00057-W	15,002	406	10	441,851	3,151,154	AGR	Orange
48-00057-W	27,057	409	12	442,085	3,150,501	AGR	Orange
48-00061-W	45,361	650	12	439,168	3,142,518	AGR	Orange
48-00061-W	31,501	406	10	439,178	3,141,946	AGR	Orange
48-00061-W	45,361	405	12	439,380	3,141,406	AGR	Orange
48-00061-W	45,361	390	12	439,772	3,140,135	AGR	Orange
48-00066-W	27,057	397	12	447,465	3,147,814	AGR	Orange
48-00066-W	27,057	400	12	447,054	3,148,339	AGR	Orange
48-00066-W	27,057	380	12	446,245	3,146,478	AGR	Orange
48-00069-W	27,057	435	12	445,386	3,147,190	AGR	Orange
48-00071-W	13,862	400	10	446,433	3,148,584	AGR	Orange

Permit Number	Model Rate (ft^2/day)	Well Depth (feet)	Well Diameter (inches)	X Coordinate (meters)	Y Coordinate (meters)	LU_CODE	County
48-00095-W	5,029	400	8	441,449	3,148,520	AGR	Orange
48-00098-W	14,588	409	12	440,383	3,146,010	AGR	Orange
48-00100-W	14,785	500	12	436,904	3,148,062	AGR	Orange
48-00106-W	6,911	365	8	444,744	3,148,191	AGR	Orange
48-00121-W	12,751	350	12	448,388	3,143,438	GOL	Orange
48-00121-W	17,355	525	14	448,482	3,141,679	GOL	Orange
48-00121-W	12,751	650	12	449,731	3,139,943	GOL	Orange
48-00121-W	8,855	385	10	450,171	3,139,708	GOL	Orange
48-00121-W	8,855	391	10	448,192	3,142,299	GOL	Orange
48-00132-W	7,395	450	12	440,728	3,146,889	AGR	Orange
48-00135-W	3,404	218	4	438,695	3,136,738	GOL	Orange
48-00135-W	6,928	380	6	438,702	3,136,771	GOL	Orange
48-00135-W	27,057	500	12	440,291	3,138,224	GOL	Orange
48-00135-W	15,002	400	10	438,716	3,136,797	GOL	Orange
48-00194-W	7,208	400	6	437,512	3,150,929	AGR	Orange
48-00196-W	18,485	450	10	437,458	3,149,681	AGR	Orange
48-00226-W	8,927	305	8	441,086	3,146,595	AGR	Orange
48-00227-W	8,380	0	12	445,428	3,148,561	AGR	Orange
48-00261-W	14,517	421	16	438,966	3,148,294	AGR	Orange
48-00261-W	14,517	742	16	438,903	3,147,568	AGR	Orange
48-00261-W	14,517	462	16	437,339	3,149,700	AGR	Orange
48-00261-W	14,517	342	16	438,948	3,148,181	AGR	Orange
48-00261-W	14,517	717	16	439,327	3,147,525	AGR	Orange
48-00261-W	14,517	369	16	438,943	3,146,918	AGR	Orange
48-00261-W	14,517	400	16	437,702	3,148,169	AGR	Orange
48-00261-W	14,517	702	16	437,559	3,147,047	AGR	Orange
48-00261-W	14,517	408	16	437,719	3,144,337	AGR	Orange
48-00261-W	14,517	402	16	437,522	3,142,694	AGR	Orange
48-00261-W	14,517	862	16	436,873	3,143,397	AGR	Orange
48-00288-W	25,000	560	13	444,451	3,153,279	GOL	Orange
48-00365-W	2,589	310	6	444,724	3,151,800	AGR	Orange
48-00366-W	4,992	400	10	443,129	3,150,647	AGR	Orange
48-00367-W	4,808	360	10	445,618	3,145,539	AGR	Orange
48-00367-W	3,077	400	8	445,568	3,145,778	AGR	Orange
48-00368-W	4,190	500	10	439,592	3,138,720	AGR	Orange
48-00381-W	13,309	600	12	436,939	3,149,426	AGR	Orange
48-00386-W	4,472	420	8	435,670	3,144,466	AGR	Orange
48-00394-W	12,940	500	12	447,704	3,142,576	AGR	Orange
48-00396-W	7,395	380	8	442,745	3,148,564	AGR	Orange
48-00403-W	15,172	735	16	445,392	3,149,076	GOL	Orange
48-00403-W	8,534	446	12	446,320	3,149,686	GOL	Orange
48-00403-W	8,534	450	12	446,703	3,148,924	GOL	Orange
48-00403-W	8,534	450	12	446,703	3,148,886	GOL	Orange
48-00496-W	9,229	443	8	437,004	3,138,331	AGR	Orange
48-00503-W	3,404	205	4	443,021	3,143,416	NUR	Orange
48-00517-W	21,440	700	12	438,330	3,137,730	AGR	Orange
48-00519-W	36,965	600	12	439,014	3,147,244	AGR	Orange
48-00526-W	8,021	250	4	450,127	3,139,564	IND	Orange
48-00547-W	5,214	4	1	444,388	3,153,457	PWS	Orange
48-00567-W	5,911	450	8	437,024	3,148,787	AGR	Orange
48-00586-W	21	200	4	442,247	3,137,903	PWS	Orange
48-00617-W	41,228	1150	12	435,834	3,148,576	AGR	Orange
48-00617-W	18,324	482	8	436,318	3,147,948	AGR	Orange
48-00716-W	6,226	500	10	443,062	3,150,844	AGR	Orange

Permit Number	Model Rate (ft^2/day)	Well Depth (feet)	Well Diameter (inches)	X Coordinate (meters)	Y Coordinate (meters)	LU_CODE	County
48-00742-W	4,077	200	4	443,952	3,134,314	IND	Orange
48-00742-W	4,077	200	4	443,479	3,135,640	IND	Orange
48-00798-W	13,185	430	10	440,558	3,147,530	AGR	Orange
48-00808-W	6,592	600	4	439,711	3,136,125	LAN	Orange
48-00832-W	7,559	400	12	444,628	3,153,925	LAN	Orange
48-00833-W	9,358	300	6	440,880	3,135,789	IND	Orange
48-00888-W	6,527	500	10	437,807	3,146,462	LAN	Orange
48-00888-W	6,527	500	10	437,807	3,146,401	LAN	Orange
48-00899-W	10,636	250	4	444,934	3,148,656	GOL	Orange
48-00983-W	27,057	397	12	447,044	3,148,355	LAN	Orange
48-00983-W	3,404	250	4	446,023	3,146,642	LAN	Orange
48-00983-W	3,404	250	4	446,041	3,147,254	LAN	Orange
48-01072-W	1,069	412	6	436,636	3,137,848	PWS	Orange
48-01072-W	1,069	400	6	436,484	3,137,637	PWS	Orange
48-01104-W	4,010	350	10	437,094	3,140,402	IND	Orange
48-01114-W	70,583	300	4	447,746	3,141,748	LAN	Orange
48-01114-W	70,583	300	4	447,752	3,141,748	LAN	Orange
48-01120-W	133,681	200	4	446,405	3,149,696	LAN	Orange
48-01120-W	133,681	200	4	445,869	3,149,326	LAN	Orange
48-01120-W	133,681	270	4	446,713	3,150,084	LAN	Orange
48-01150-W	642	105	4	444,470	3,150,159	PWS	Orange
48-01197-W	3,487	200	4	446,955	3,149,388	LAN	Orange
48-01197-W	3,487	200	4	445,142	3,149,068	LAN	Orange
48-01202-W	1,469	300	4	447,803	3,141,961	LAN	Orange
48-01202-W	1,469	300	4	447,810	3,141,961	LAN	Orange
48-01216-W	3,404	250	4	437,617	3,140,642	LAN	Orange
48-01216-W	3,404	250	4	437,617	3,140,642	LAN	Orange
48-01222-W	3,919	300	4	444,333	3,148,829	LAN	Orange
48-01222-W	3,919	300	4	444,888	3,148,797	LAN	Orange
48-01245-W	57,989	600	24	442,463	3,150,676	PWS	Orange
48-01245-W	57,989	600	24	442,330	3,150,871	PWS	Orange
48-01245-W	57,989	600	24	442,096	3,150,724	PWS	Orange
48-01294-W	10,815	450	6	442,901	3,150,318	LAN	Orange
48-01300-W	164	150	4	444,592	3,152,785	LAN	Orange
48-01300-W	164	150	4	444,505	3,152,668	LAN	Orange
48-01300-W	164	150	4	444,180	3,152,147	LAN	Orange
49-00021-W	30,372	333	20	447,266	3,134,728	PWS	Osceola
49-00021-W	19,438	500	16	447,316	3,134,716	PWS	Osceola
49-00029-W	13,476	446	12	436,463	3,128,485	AGR	Osceola
49-00029-W	13,476	426	12	436,079	3,127,714	AGR	Osceola
49-00048-W	33,691	450	12	436,315	3,127,270	AGR	Osceola
49-00048-W	33,691	450	12	436,734	3,127,279	AGR	Osceola
49-00048-W	33,691	587	12	435,864	3,127,321	AGR	Osceola
49-00052-W	11,072	441	12	438,598	3,133,568	AGR	Osceola
49-00058-W	8,142	425	10	441,272	3,132,965	AGR	Osceola
49-00059-W	12,408	433	12	437,415	3,126,485	AGR	Osceola
49-00060-W	21,898	680	12	437,066	3,129,272	AGR	Osceola
49-00062-W	4,715	400	12	435,607	3,129,340	AGR	Osceola
49-00062-W	4,715	700	12	435,618	3,129,506	AGR	Osceola
49-00062-W	4,715	700	12	435,621	3,129,711	AGR	Osceola
49-00062-W	4,715	700	12	435,621	3,129,882	AGR	Osceola
49-00063-W	13,478	385	8	435,844	3,130,646	AGR	Osceola
49-00079-W	8,380	400	10	436,085	3,128,642	AGR	Osceola
49-00091-W	19,371	350	8	437,271	3,128,110	AGR	Osceola

Permit Number	Model Rate (ft^2/day)	Well Depth (feet)	Well Diameter (inches)	X Coordinate (meters)	Y Coordinate (meters)	LU_CODE	County
49-00100-W	7,413	0	10	436,001	3,131,779	AGR	Osceola
49-00103-W	78,942	385	16	448,172	3,134,629	PWS	Osceola
49-00103-W	44,405	375	12	442,767	3,135,393	PWS	Osceola
49-00103-W	44,405	367	12	442,807	3,135,395	PWS	Osceola
49-00103-W	30,837	480	10	441,997	3,130,861	PWS	Osceola
49-00103-W	30,837	820	10	442,007	3,130,652	PWS	Osceola
49-00103-W	177,618	886	24	441,208	3,130,992	PWS	Osceola
49-00103-W	177,618	500	24	448,474	3,134,853	PWS	Osceola
49-00103-W	78,942	500	16	442,126	3,135,363	PWS	Osceola
49-00103-W	78,942	500	16	442,793	3,135,764	PWS	Osceola
49-00103-W	123,346	600	20	447,338	3,128,310	PWS	Osceola
49-00103-W	123,346	600	20	447,220	3,128,652	PWS	Osceola
49-00341-W	10,478	745	12	441,352	3,133,791	AGR	Osceola
49-00353-W	611	300	2	442,796	3,131,670	PWS	Osceola
49-00353-W	49,528	600	18	442,777	3,131,586	PWS	Osceola
49-00372-W	11,648	375	10	437,380	3,134,141	PWS	Osceola
49-00372-W	11,648	375	10	437,280	3,134,148	PWS	Osceola
49-00372-W	16,773	375	12	437,316	3,134,096	PWS	Osceola
49-00372-W	16,773	375	12	437,344	3,134,059	PWS	Osceola
49-00372-W	16,773	375	12	437,387	3,134,022	PWS	Osceola
49-00597-W	2,139	303	8	442,123	3,132,570	NUR	Osceola
49-00644-W	10,396	360	12	438,481	3,134,591	PWS	Osceola
49-00644-W	4,620	360	8	438,481	3,134,583	PWS	Osceola
49-00710-W	13,185	215	6	440,490	3,129,745	AGR	Osceola
49-00740-W	13,185	25	4	447,085	3,132,937	NUR	Osceola
49-00742-W	1,524	425	4	446,107	3,125,369	PWS	Osceola
49-00766-W	6,928	450	6	436,140	3,129,366	AGR	Osceola
49-00786-W	8,926	360	8	440,205	3,126,214	AGR	Osceola
49-00832-W	3,404	300	4	437,352	3,135,486	LAN	Osceola
49-00836-W	27,058	450	12	436,167	3,126,608	AGR	Osceola
49-00836-W	27,058	450	12	436,793	3,126,588	AGR	Osceola
49-00836-W	27,058	890	12	435,721	3,126,601	AGR	Osceola
49-00838-W	2,289	200	10	440,677	3,132,515	GOL	Osceola
49-00923-W	13,185	300	6	441,471	3,133,431	LAN	Osceola
49-00931-W	2,417	200	8	440,624	3,132,468	LAN	Osceola
49-00931-W	2,417	200	8	440,534	3,132,427	LAN	Osceola
49-00998-W	14,650	400	16	438,087	3,127,774	GOL	Osceola
49-01013-W	79,005	150	4	449,182	3,133,678	LAN	Osceola
49-01021-W	1,317	100	4	439,673	3,126,284	LAN	Osceola
49-01021-W	1,317	100	4	439,150	3,126,306	LAN	Osceola
49-01021-W	1,317	100	4	438,845	3,126,845	LAN	Osceola
49-01021-W	1,317	100	4	439,398	3,126,607	LAN	Osceola
49-01021-W	5,267	100	8	437,669	3,127,701	LAN	Osceola
49-01034-W	12,367	400	4	436,176	3,130,108	LAN	Osceola
49-01044-W	2,637	200	4	436,984	3,134,837	LAN	Osceola
49-01044-W	2,637	200	4	436,844	3,135,014	LAN	Osceola
49-01044-W	2,637	200	4	436,751	3,135,095	LAN	Osceola
49-01044-W	2,637	200	4	436,645	3,135,180	LAN	Osceola
49-01044-W	2,637	200	4	437,014	3,135,748	LAN	Osceola
49-01059-W	5,838	200	6	440,325	3,132,366	LAN	Osceola
49-01100-W	465	100	4	438,993	3,126,105	LAN	Osceola
49-01107-W	36,315	600	16	442,508	3,127,116	GOL	Osceola
49-01128-W	2,065	340	4	442,297	3,131,871	LAN	Osceola
49-01128-W	2,065	340	4	442,297	3,131,799	LAN	Osceola

Permit Number	Model Rate (ft^2/day)	Well Depth (feet)	Well Diameter (inches)	X Coordinate (meters)	Y Coordinate (meters)	LU_CODE	County
49-01149-W	5,000	300	5	439,665	3,127,060	LAN	Osceola
49-01149-W	5,000	300	5	439,786	3,126,886	LAN	Osceola
49-01208-W	3,404	380	4	441,383	3,135,417	LAN	Osceola
49-01208-W	3,404	410	4	441,867	3,135,601	LAN	Osceola
49-01208-W	3,404	390	4	441,952	3,135,428	LAN	Osceola
49-01208-W	3,404	380	4	442,026	3,135,544	LAN	Osceola
49-01208-W	3,404	380	4	441,853	3,135,677	LAN	Osceola
49-01231-W	27,056	500	12	443,093	3,128,765	LAN	Osceola
53-00126-W	111,889	750	12	445,566	3120356.272	PWS	Polk
53-00126-W	111,889	1200	12	445,566	3120226.166	PWS	Polk
53-00165-W	80,819	600	16	446,153	3118620.72	AGR	Polk
53-00165-W	80,819	600	16	445,428	3120878.827	AGR	Polk
53-00165-W	80,819	600	16	445,670	3122455.022	AGR	Polk
53-00188-W	3,404	250	4	445,601	3110208.961	LAN	Polk
53-00188-W	3,404	250	4	445,601	3110208.961	LAN	Polk

APPENDIX A.3
PERMITTED FLORIDAN WELLS IN SWFWMD

Permit Number	Model Rate (ft^3/day)	Well Depth (ft^3)	Well Diameter (inches)	X Coordiante (meters)	Y Coordinate (meters)	Well Use Code
000213	134	155	3	401,695	3,170,164	
000213	401	237	6	401,223	3,170,393	
000511	3,289	483	8	435,670	3,108,358	Irrigation
000516	1,564	360	6	435,477	3,108,731	Irrigation
001347	16,042	940	12	416,208	3,145,420	Irrigation
001347	16,042	950	12	415,998	3,146,718	Irrigation
001347	16,042	950	12	416,259	3,144,802	Irrigation
001347	16,042	1030	12	415,902	3,146,363	Irrigation
001350	6,965	460	16	436,506	3,125,498	Irrigation
001351	16,443	670	12	436,875	3,124,267	Irrigation
001356	8,154	506	10	429,478	3,121,052	Irrigation
001356	22,592	555	12	430,090	3,120,674	Irrigation
001523	6,283	539	12	429,665	3,113,770	Irrigation
001727	642	127	6	397,273	3,161,282	
001727	642	127	6	397,492	3,161,198	
001808	9,037	759	12	436,168	3,123,903	Irrigation
001811	6,323	140	6	396,198	3,171,851	Irrigation
001811	6,323	200	6	396,289	3,171,850	Irrigation
001853	134	144	6	395,853	3,171,539	Livestock
002039	10,801	330	10	427,803	3,126,216	Irrigation
002040	3,289	300	6	427,384	3,127,549	Irrigation
002041	3,730	350	6	428,254	3,127,431	Irrigation
002107	160	280	6	396,141	3,159,057	Livestock
002122	3,863	175	6	395,477	3,164,289	Irrigation
002122	3,863	175	6	395,378	3,164,159	Irrigation
002122	3,863	215	6	395,323	3,164,427	Irrigation
002123	1,190	185	6	396,346	3,164,346	Irrigation
002135	4,572	447	6	430,482	3,126,253	Irrigation
002135	4,986	558	8	429,728	3,126,729	Irrigation
002135	13,488	378	12	430,547	3,126,066	Irrigation
002135	13,903	428	12	430,664	3,123,813	Irrigation
002135	19,103	384	12	430,489	3,125,205	Irrigation
002145	14,330	105	8	412,125	3,150,835	Irrigation
002220	22,592	865	10	435,537	3,121,656	Irrigation
002222	5,962	800	8	395,342	3,167,371	Irrigation
002342	3,692	500	6	395,033	3,165,586	
002404	10,374	680	12	442,899	3,108,392	Irrigation
002425	3,476	450	10	429,795	3,116,185	Irrigation
002425	4,946	380	10	430,331	3,115,958	Public Supply
002425	6,951	510	12	430,400	3,118,066	Irrigation
002426	8,301	620	10	439,627	3,111,412	Irrigation
002465	4,117	690	10	440,033	3,107,757	Irrigation
002615	10,333	354	10	425,274	3,129,012	Irrigation
002615	10,333	280	10	425,299	3,128,890	Irrigation
002615	16,296	168	10	425,489	3,128,168	Irrigation
002650	8,957	1000	10	428,828	3,115,356	Irrigation
002873	10,948	376	10	429,745	3,129,356	Irrigation
002873	16,563	387	10	429,004	3,130,086	Irrigation
002873	27,150	438	12	430,038	3,127,969	Irrigation
002939	4,010	135	6	410,252	3,150,767	
003001	12,432	500	12	426,088	3,128,228	Irrigation
003127	2,674	170	4	394,682	3,170,725	Irrigation
003127	2,674	200	6	395,467	3,170,268	Irrigation
003127	2,674	165	4	394,744	3,171,037	Irrigation
003127	2,674	165	4	394,769	3,171,032	Irrigation
003226	13,274	417	12	426,025	3,126,312	Irrigation

Permit Number	Model Rate (ft^3/day)	Well Depth (ft^3)	Well Diameter (inches)	X Coordiante (meters)	Y Coordinate (meters)	Well Use Code
003242	134	430	10	413,894	3,154,170	Livestock
003304	53	312	8	415,589	3,149,512	Livestock
003316	1,965	142	6	395,771	3,172,180	Irrigation
003351	8,689	580	10	404,082	3,176,929	Irrigation
003351	8,689	600	8	404,796	3,177,203	Irrigation
003457	481	390	10	415,247	3,152,223	Livestock
003457	11,443	395	6	416,181	3,152,558	Irrigation
003457	11,443	410	12	415,465	3,153,101	Irrigation
003457	11,443	420	12	416,142	3,153,258	Irrigation
003460	2,994	225	6	411,452	3,149,458	Irrigation
003507	6,537	400	8	395,871	3,170,047	Irrigation
003527	4,077	400	6	429,617	3,121,783	Irrigation
003527	6,310	490	10	428,713	3,121,811	Irrigation
003569	15,373	320	6	395,870	3,173,916	Irrigation
003569	15,373	672	8	396,495	3,174,096	Irrigation
003576	535	166	6	439,457	3,112,674	Irrigation
003576	2,674	995	10	439,328	3,112,825	Irrigation
003576	5,347	600	10	439,263	3,112,357	Irrigation
003576	8,823	613	12	439,271	3,112,462	Irrigation
003594	12,967	630	12	442,886	3,110,768	Irrigation
003769	3,342	420	8	442,672	3,112,439	Irrigation
003770	2,059	130	6	443,187	3,115,435	Irrigation
003771	2,059	301	6	439,087	3,112,502	Irrigation
003772	3,088	410	6	441,870	3,113,652	Irrigation
003773	1,965	337	6	441,522	3,113,269	Irrigation
003776	8,850	400	8	439,239	3,123,747	Irrigation
003777	2,059	426	6	437,435	3,120,307	Irrigation
003778	3,436	525	8	437,878	3,116,647	Irrigation
003980	4,117	657	10	440,239	3,107,617	Irrigation
003982	1,644	300	8	442,232	3,107,876	Irrigation
003982	5,147	110	6	442,342	3,107,933	Irrigation
003984	3,502	250	8	442,595	3,108,933	Irrigation
003984	11,724	546	10	442,613	3,107,896	Irrigation
003985	4,117	480	6	442,504	3,109,798	Irrigation
003986	3,529	463	6	442,955	3,110,102	Irrigation
003987	7,753	456	8	442,671	3,110,745	Irrigation
003988	2,473	491	8	441,516	3,113,107	Irrigation
003989	2,714	470	6	442,769	3,113,291	Irrigation
003990	3,502	500	8	442,737	3,108,482	Irrigation
003991	4,157	556	8	443,709	3,110,090	Irrigation
003992	2,540	560	6	443,538	3,110,180	Irrigation
004013	1,444	555	8	442,318	3,110,062	Irrigation
004017	2,486	300	6	440,503	3,110,119	Irrigation
004040	628	528	6	436,327	3,124,436	Irrigation
004042	4,117	500	10	442,575	3,111,440	Irrigation
004045	5,187	642	10	443,172	3,112,352	Irrigation
004045	6,229	525	10	443,233	3,112,358	Irrigation
004047	4,117	550	8	440,901	3,113,674	Irrigation
004120	2,072	350	6	442,119	3,115,150	Irrigation
004121	9,759	380	10	441,775	3,112,148	Irrigation
004169	5,802	480	10	422,966	3,133,602	Irrigation
004170	4,117	560	8	437,829	3,117,536	Irrigation
004171	4,946	400	8	440,164	3,108,941	Irrigation
004174	922	420	6	441,992	3,124,680	Irrigation
004175	5,013	550	8	442,088	3,124,593	Public Supply
004176	11,216	340	10	440,633	3,125,761	Irrigation

Permit Number	Model Rate (ft^3/day)	Well Depth (ft^3)	Well Diameter (inches)	X Coordiante (meters)	Y Coordinate (meters)	Well Use Code
004178	3,342	355	6	443,810	3,123,941	Irrigation
004225	1,557	179	6	442,319	3,111,391	Irrigation
004240	40	1000	12	435,962	3,125,863	Irrigation
004256	7,887	225	12	436,113	3,125,327	Irrigation
004262	6,163	455	8	442,647	3,109,776	Irrigation
004263	4,144	396	8	442,598	3,111,032	Irrigation
004265	4,866	250	8	442,288	3,109,460	Irrigation
004280	10,694	520	10	440,274	3,108,494	
004312	134	576	8	441,112	3,115,620	Industrial
004312	49,461	526	16	441,069	3,115,536	Industrial
004312	49,461	600	12	441,005	3,115,470	Industrial
004353	3,930	800	8	428,413	3,114,631	Irrigation
004356	7,820	625	12	443,427	3,111,371	Irrigation
004357	2,674	950	12	443,857	3,112,586	Irrigation
004358	10,280	350	12	443,653	3,112,009	Irrigation
004359	7,192	350	12	439,112	3,112,718	Irrigation
004389	4,117	529	8	441,524	3,110,754	Irrigation
004392	14,531	825	10	436,712	3,125,016	Irrigation
004392	18,688	430	12	437,403	3,124,956	Irrigation
004644	6,149	150	8	397,492	3,167,866	Irrigation
004644	6,149	150	8	397,479	3,167,472	Irrigation
004687	11,630	170	6	396,324	3,164,639	
004755	8,555	103	6	395,903	3,168,335	Irrigation
004755	2,139	50	4	395,901	3,168,450	Irrigation
004760	5,080	549	8	441,957	3,107,536	Irrigation
004792	7,219	300	8	424,688	3,137,730	Irrigation
004792	14,437	301	8	424,518	3,138,645	Irrigation
004792	14,571	360	8	423,950	3,138,542	Irrigation
004839	3,837	300	6	410,996	3,150,102	Irrigation
004857	27	400	4	441,835	3,118,096	Industrial
004857	40	180	4	441,931	3,118,236	
004857	40	180	4	441,931	3,118,236	
004857	53	400	4	441,835	3,118,096	
004857	67	400	6	441,902	3,118,145	
004857	80	400	2	442,794	3,118,400	
004857	80	400	2	442,794	3,118,400	
004857	80	400	2	442,437	3,118,233	
004857	80	400	2	442,437	3,118,233	
004857	94	300	2	441,588	3,118,057	
004857	94	300	2	441,588	3,118,057	
004857	134	400	4	442,061	3,118,206	
004857	134	400	4	442,061	3,118,206	
004857	6,417	440	8	441,173	3,121,018	Irrigation
004857	6,417	440	8	441,173	3,121,018	Irrigation
004857	6,457	1535	10	444,174	3,118,500	Irrigation
004857	6,457	1535	10	444,174	3,118,500	Irrigation
004857	6,858	440	12	440,599	3,121,909	Irrigation
004857	6,858	440	12	440,599	3,121,909	Irrigation
004857	7,566	566	12	444,625	3,118,424	Irrigation
004857	7,566	566	12	444,625	3,118,424	Irrigation
004857	10,614	430	12	444,313	3,118,600	Irrigation
004857	10,614	430	12	444,313	3,118,600	Irrigation
004857	11,069	553	12	444,358	3,118,964	Irrigation
004857	11,069	553	12	444,358	3,118,964	Irrigation
004857	14,330	548	12	440,602	3,120,504	Irrigation
004857	14,330	548	12	440,602	3,120,504	Irrigation

Permit Number	Model Rate (ft^3/day)	Well Depth (ft^3)	Well Diameter (inches)	X Coordiante (meters)	Y Coordinate (meters)	Well Use Code
004857	253,991	453	16	442,617	3,118,333	
004857	253,991	453	16	442,617	3,118,333	
004877	7,219	100	8	440,948	3,110,320	Irrigation
004885	2,072	500	6	442,355	3,113,269	Irrigation
004885	2,072	440	6	442,050	3,113,269	Irrigation
004925	2,072	507	8	441,711	3,113,835	Irrigation
004926	7,433	525	8	443,554	3,108,166	Irrigation
004964	13,368	125	6	399,071	3,161,890	
005005	2,460	235	6	411,031	3,150,585	
005005	3,262	200	8	410,819	3,151,005	
005006	4,010	200	8	411,002	3,149,849	
005026	19,116	450	8	410,882	3,151,278	Irrigation
005027	5,347	242	6	413,873	3,150,427	Irrigation
005027	12,031	261	8	415,754	3,151,416	Irrigation
005027	12,031	261	8	414,165	3,151,677	Irrigation
005028	8,555	260	8	411,823	3,154,620	Irrigation
005209	5,962	265	8	414,580	3,146,384	Irrigation
005209	5,962	232	10	415,557	3,144,524	Irrigation
005275	160	185	4	392,074	3,161,357	Livestock
005275	7,272	185	8	392,332	3,161,816	Irrigation
005471	60,156	253	8	439,928	3,124,797	
005471	60,156	456	10	439,893	3,124,791	
005735	6,229	800	10	440,103	3,108,437	Irrigation
005736	6,363	110	12	440,520	3,119,436	Irrigation
005750	102,024	450	8	440,523	3,115,423	Public Supply
005750	133,907	485	12	440,523	3,115,373	Public Supply
005903	976	566	8	438,682	3,108,084	Irrigation
005994	3,743	385	8	440,368	3,115,265	Irrigation
006055	3,462	403	8	443,056	3,108,286	Irrigation
006066	789	300	8	439,449	3,115,110	Irrigation
006161	3,890	610	10	439,787	3,107,687	Irrigation
006202	2,124	150	12	396,191	3,169,354	Public Supply
006213	7,433	573	10	394,968	3,167,065	Irrigation
006213	7,433	660	12	394,972	3,166,999	Irrigation
006232	4,157	165	10	442,707	3,111,373	Irrigation
006254	5,187	438	8	441,091	3,120,197	Irrigation
006272	13,903	260	6	396,696	3,169,285	Irrigation
006345	2,072	350	6	442,437	3,115,256	Irrigation
006361	60,156	600	12	406,288	3,165,173	Irrigation
006493	1,163	396	8	443,261	3,108,990	Irrigation
006509	3,583	493	12	436,505	3,122,374	
006509	23,247	497	12	436,110	3,123,418	
006509	37,551	755	12	437,585	3,120,023	
006509	114,456	255	24	434,773	3,124,357	
006520	4,278	545	12	441,322	3,107,592	Irrigation
006530	1,003	260	6	443,694	3,121,020	Public Supply
006552	4,719	200	10	403,024	3,171,517	Irrigation
006683	134	100	4	405,741	3,166,320	Irrigation
006683	11,136	200	8	405,912	3,165,978	Irrigation
006732	25,947	480	10	442,293	3,112,681	Irrigation
006758	3,636	300	8	439,695	3,114,776	Irrigation
006782	1,724	450	6	442,885	3,112,484	Irrigation
006897	2,072	360	6	440,290	3,108,663	Irrigation
006914	2,446	71	6	395,542	3,165,141	Public Supply
006931	2,567	340	6	437,533	3,119,187	Irrigation
006941	67	124	6	395,120	3,171,501	Livestock

Permit Number	Model Rate (ft^3/day)	Well Depth (ft^3)	Well Diameter (inches)	X Coordiante (meters)	Y Coordinate (meters)	Well Use Code
006993	4,812	600	8	442,274	3113106.131	Irrigation
006998	4,946	200	6	400,117	3164963.353	Irrigation
007014	4,478	460	8	404,446	3169791.075	Irrigation
007063	2,941	156	8	441,229	3108267.554	Irrigation
007107	8,957	428	8	430,458	3115178.091	Irrigation
007108	1,604	261	6	435,624	3122527.077	Irrigation
007180	80	300	6	399,354	3171269.377	Livestock
007180	401	300	6	399,112	3,171,259	Livestock
007180	10,106	300	6	398,477	3,171,339	Irrigation
007185	15,641	200	10	396,591	3,166,762	Public Supply
007185	15,641	200	10	396,827	3,164,190	Public Supply
007185	15,641	470	6	397,990	3,165,452	Public Supply
007297	3,409	300	6	398,303	3,165,656	Irrigation
007297	3,409	300	6	398,424	3,165,464	Irrigation
007333	12,553	300	6	444,253	3,124,958	Public Supply
007333	12,553	300	6	444,293	3,124,958	Public Supply
007355	4,411	465	8	411,571	3,148,087	Irrigation
007380	7,352	144	12	406,230	3,169,354	Irrigation
007380	21,522	540	16	406,487	3,167,969	Irrigation
007432	4,438	300	6	443,978	3,123,555	Irrigation
007455	4,746	301	6	411,323	3,151,409	Irrigation
007455	7,820	260	6	411,884	3,149,877	Irrigation
007456	3,743	301	12	410,024	3,154,214	Irrigation
007456	4,478	250	6	410,163	3,154,392	Irrigation
007584	7,058	360	6	442,454	3,111,671	Irrigation
007652	4,946	381	8	440,752	3,112,021	Irrigation
007678	1,938	482	8	443,965	3,108,656	Irrigation
007925	2,232	440	8	391,027	3,163,873	Irrigation
007927	7,713	485	12	441,195	3,123,626	Irrigation
008023	11,269	310	8	395,891	3,172,705	Irrigation
008031	267	100	6	401,068	3,164,545	Irrigation
008193	4,585	157	10	402,420	3,169,523	Public Supply
008193	7,085	100	6	402,834	3,169,514	Public Supply
008211	1,738	300	8	396,623	3,173,178	Livestock
008211	75,034	300	8	396,620	3,173,005	Irrigation
008285	6,430	230	4	442,383	3,125,821	
008285	6,430	470	8	442,407	3,125,820	
008399	8,689	470	4	443,893	3,120,280	Public Supply
008399	8,689	310	8	443,870	3,120,297	Public Supply
008404	12,459	547	10	440,064	3,114,494	Irrigation
008464	29,008	280	10	437,431	3,121,582	Aquifer Water Level
008515	4,157	520	8	441,378	3,113,333	Irrigation
008522	133,679	570	12	438,807	3,109,523	Public Supply
008522	133,679	810	12	438,481	3,109,553	Public Supply
008522	133,679	600	16	438,403	3,109,926	Public Supply
008522	133,679	600	16	438,547	3,109,814	Public Supply
008522	133,679	950	16	439,581	3,107,884	Public Supply
008522	133,679	700	18	439,618	3,107,683	Public Supply
008546	3,837	600	12	435,780	3,125,411	Irrigation
008547	382	350	8	437,073	3,122,470	
008547	11,470	343	10	436,969	3,123,590	
008580	3,877	300	6	396,040	3,171,125	Irrigation
008607	4,184	460	10	430,438	3,112,657	Irrigation
008656	2,072	250	6	442,363	3,108,024	Irrigation
008667	3,583	200	6	398,420	3,163,189	Irrigation
008667	3,583	200	6	398,667	3,163,132	Irrigation

Permit Number	Model Rate (ft^3/day)	Well Depth (ft^3)	Well Diameter (inches)	X Coordiante (meters)	Y Coordinate (meters)	Well Use Code
008731	8,301	420	8	441,480	3,125,874	Irrigation
008753	7,392	522	8	434,254	3,109,151	
008753	7,392	520	8	434,227	3,109,145	
008826	1,872	507	8	441,512	3,113,839	Irrigation
008835	6,564	102	8	392,003	3,164,705	Irrigation
008835	6,564	105	6	391,624	3,164,666	Irrigation
008835	6,564	190	8	393,852	3,165,555	Irrigation
008835	6,564	390	8	393,693	3,164,661	Irrigation
008835	6,564	80	6	393,975	3,165,204	Irrigation
008871	5,267	603	10	443,529	3,107,492	Irrigation
008960	856	120	6	401,976	3,169,990	Irrigation
008967	13,141	500	8	433,476	3,109,229	
009037	7,967	715	12	425,200	3,138,144	Irrigation
009210	1,457	267	6	441,233	3,108,881	Irrigation
009266	3,890	350	8	441,569	3,108,600	Irrigation
009299	2,072	230	8	442,889	3,113,535	Irrigation
009300	7,820	301	8	411,757	3,149,076	Irrigation
009341	1,016	200	8	443,478	3,123,012	
009407	12,526	641	12	442,225	3,108,785	Irrigation
009410	42,777	510	8	401,786	3,165,924	Livestock
009430	120	255	4	443,743	3,115,410	Livestock
009430	3,716	170	8	443,859	3,115,528	Irrigation
009448	1,337	205	4	441,156	3,108,295	Irrigation
009448	6,270	415	6	441,135	3,108,319	Irrigation
009448	8,221	404	10	440,438	3,108,087	Irrigation
009475	8,101	512	8	444,218	3,110,638	Aquifer Water Level
009498	1,150	210	6	440,693	3,113,538	Irrigation
009540	1,658	207	8	441,940	3,114,526	Irrigation
009669	6,951	600	12	440,475	3,108,481	Irrigation
009680	642	100	6	424,019	3,133,060	Livestock
009680	642	100	8	425,804	3,131,672	Livestock
009680	642	100	8	423,907	3,131,538	Livestock
009680	1,283	400	6	426,909	3,133,849	Irrigation
009680	1,337	100	6	426,093	3,133,329	Irrigation
009680	1,470	308	6	427,331	3,132,513	Irrigation
009680	1,537	100	6	426,233	3,134,423	Irrigation
009680	3,061	100	6	431,689	3,131,976	Irrigation
009680	3,128	100	6	428,315	3,132,612	Irrigation
009680	3,128	100	6	428,820	3,130,933	Irrigation
009680	5,187	120	6	428,268	3,131,758	Irrigation
009680	7,807	400	12	426,913	3,133,881	Irrigation
009680	9,211	550	10	427,312	3,132,578	Irrigation
009680	9,371	540	12	426,095	3,134,569	Irrigation
009712	5,748	740	8	436,682	3,121,437	Irrigation
009712	8,689	820	10	436,534	3,121,943	Irrigation
009752	1,497	150	6	429,145	3,122,805	Irrigation
009759	6,965	150	6	404,768	3,164,403	Irrigation
009852	4,157	350	10	438,391	3,116,741	Irrigation
009876	3,075	492	6	442,185	3,111,690	Irrigation
009893	3,476	500	6	442,992	3,109,765	Irrigation
009899	4,331	200	6	400,076	3,164,483	Irrigation
009975	2,072	275	6	442,307	3,115,108	Irrigation
009985	1,404	250	4	438,577	3,118,654	Irrigation
009985	1,404	250	4	438,602	3,118,530	Irrigation
009985	15,373	250	4	439,389	3,118,401	Aquifer Water Level
010141	11,764	291	6	441,812	3,125,774	Industrial

Permit Number	Model Rate (ft^3/day)	Well Depth (ft^3)	Well Diameter (inches)	X Coordiante (meters)	Y Coordinate (meters)	Well Use Code
010141	11,764	500	8	441,864	3,125,776	Industrial
010261	3,877	560	6	443,530	3,109,781	Irrigation
010514	8,475	460	10	444,990	3,115,782	Irrigation
010526	1,497	500	6	441,736	3,113,200	Irrigation
010528	7,513	500	12	442,208	3,110,926	Irrigation
010529	2,299	475	6	442,901	3,113,130	Irrigation
010534	6,229	300	8	442,923	3,112,677	Irrigation
010769	48,125	205	12	404,834	3,179,815	Irrigation
010769	48,125	693	6	404,978	3,178,661	Irrigation
010801	67	100	2	442,177	3,110,313	Livestock
010801	2,754	500	8	442,387	3,110,560	Irrigation
010857	3,395	710	10	429,454	3,113,092	Irrigation
011094	1,872	400	10	397,303	3,169,600	Irrigation
011094	2,941	500	10	397,036	3,170,187	Irrigation
011094	2,941	330	10	397,212	3,170,170	Irrigation
011094	2,941	330	10	397,035	3,169,942	Irrigation
011094	4,371	320	4	397,050	3,169,996	Irrigation
011094	4,371	90	4	397,034	3,169,940	Irrigation
011238	2,072	332	6	442,456	3,111,003	Irrigation
011292	2,072	360	6	439,524	3,110,225	Irrigation
011358	12,098	601	12	407,657	3,154,629	Irrigation
011512	27	428	6	442,437	3,121,300	Industrial
011539	10,079	545	8	443,781	3,108,347	Irrigation
011548	4,157	600	10	442,182	3,107,789	Irrigation
011575	307	387	4	401,426	3,169,513	
011575	1,858	680	10	401,428	3,169,543	
011622	67	120	4	399,032	3,170,388	Public Supply
011622	4,545	250	8	399,146	3,170,549	Irrigation
011622	16,576	400	10	399,183	3,170,383	Irrigation
011622	16,576	400	10	398,758	3,170,528	Irrigation
011658	37,510	250	10	392,322	3,161,702	Irrigation
011776	134	200	8	396,611	3,158,956	Industrial
011776	134	200	4	396,719	3,158,925	Industrial
011849	12,700	140	4	398,040	3,169,519	Irrigation
011849	12,700	545	10	398,268	3,169,518	Irrigation
011853	48,686	150	12	398,892	3,162,975	Irrigation
011879	22,057	300	10	396,745	3,174,316	Irrigation
011909	10,374	600	12	437,460	3,116,631	Irrigation
011910	46,788	500	12	440,376	3,119,826	Irrigation
011935	6,296	500	13	425,951	3,127,427	Irrigation
012039	7,072	150	6	396,589	3,171,345	Irrigation
012105	1,551	225	6	437,855	3,118,068	Irrigation
012138	6,550	150	6	397,555	3,169,733	Irrigation

FIGURE

Graphic Scale

10000 0 10000 20000 30000 40000 Feet

N

Legend:

- Floridan Wells in SJRWMD
- Floridan Wells in SFWMD
- Floridan Wells in SWFWMD
- Water Management District Boundaries
- Model Boundary

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Figure Name: Floridan Aquifer Wells Used in Model

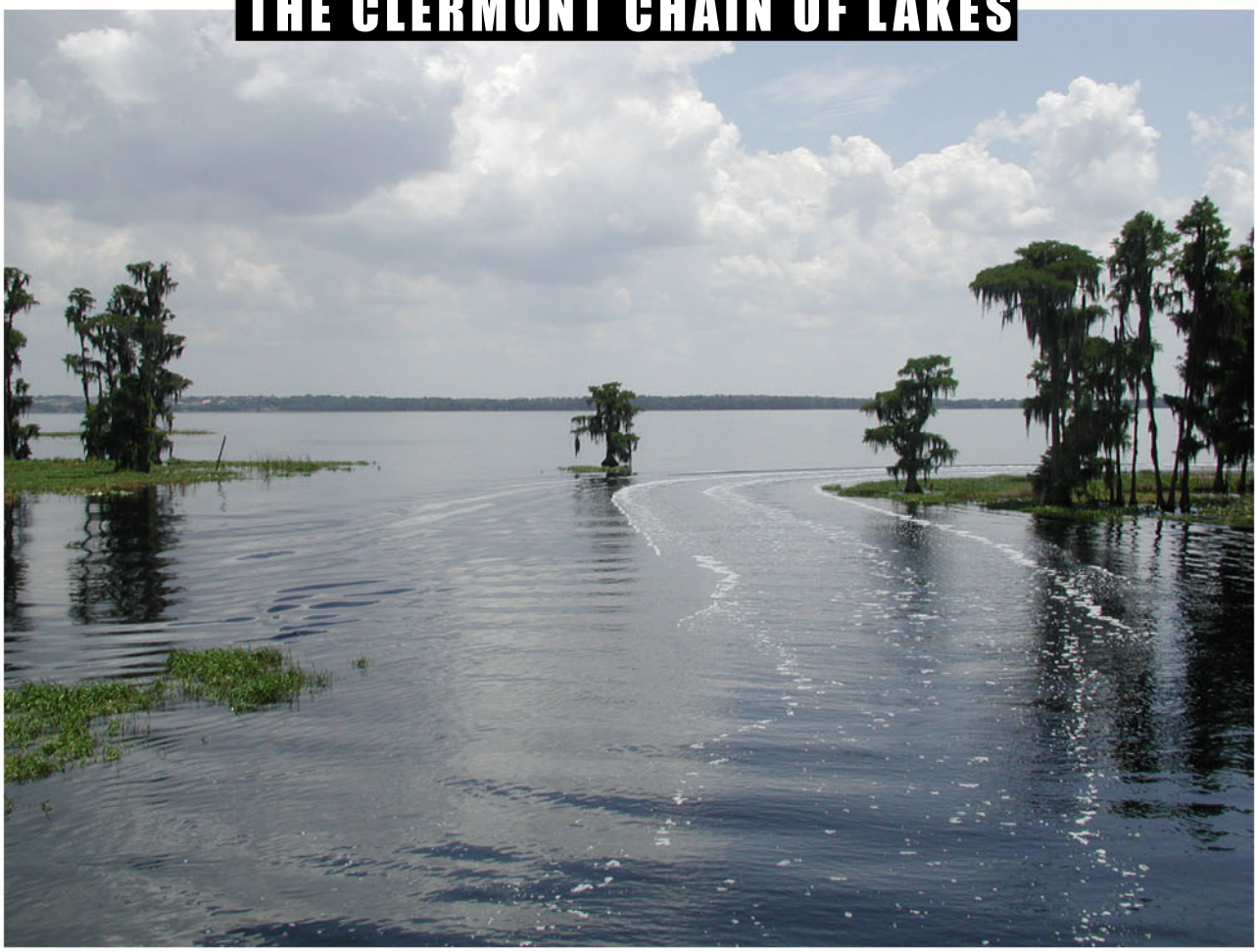
Project Name: Clermont Chain of Lakes

Checked & Approved By:	Drawn By:	Date:	Scale:	Project #:	
DS	AZ	05-21-2003	Noted	02-121.96	Figure 9-1

TECHNICAL MEMO #10: FINAL FLORIDAN AQUIFER DRAWDOWN MODEL FOR...

BIG CREEK AND LITTLE CREEK GROUND WATER/SURFACE WATER INTERACTION MODELING FOR PORTION OF SOUTH LAKE COUNTY (FL) WHICH ENCOMPASSES THE CLERMONT CHAIN OF LAKES

THE CLERMONT CHAIN OF LAKES



Prepared for

LCWA

Lake County Water Authority

PEC

Professional Engineering Consultants, Inc.

Prepared by

DEVO Engineering

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Date: May 20, 2003	*Devo's Project No.* 02-121.96
To: Lake County Water Authority 107 North Lake Avenue Tavares, Fl 32778-3119 phone: 352-343-3777 fax: 352-343-4259 attention: LANCE LUMBARD	*cc:* Professional Engineering Consultants, Inc. 200 East Robinson Street, Suite 1560 Orlando, FL 32801 phone: 407-422-8062 fax: 407-849-9401 attention: DAVID HAMSTRA, P.E.

Ref:

TECHNICAL MEMO #10 – FINAL - FLORIDAN AQUIFER DRAWDOWN MODEL FOR BIG CREEK AND LITTLE CREEK BASINS
GROUND WATER/SURFACE WATER INTERACTION MODELING FOR PORTION OF SOUTH LAKE COUNTY (FL) WHICH ENCOMPASSES THE CLERMONT CHAIN OF LAKES

Dear Mr. Lumbard:

The attached technical memo discusses the final form of our ground water model of the Floridan aquifer for the area which encompasses the Big Creek and Little Creek basins. The calibrated model was used to assess the potential for drawdown of the Floridan aquifer levels in the Green Swamp during prolonged periods of deficit to aquifer recharge, such as might occur during protracted periods of below average rainfall. The results of the model indicate that the aquifer levels in the Green Swamp are highly sensitive to relatively small reductions in long-term recharge. Our previous analyses have indicated that a multi-year drop in aquifer pressures of even a few feet will have a serious impact on the stream flows from Big Creek and Little Creek, which are major inflow components to the Clermont Chain of Lakes water budget.

Note that this model has been reduced to a 1-layered system from the 2-layered system described in Tech Memo #8. This simplification was possible because the critical portions of the Big Creek watershed are within a zone where the surficial and Floridan aquifers are well connected. Therefore, the model predicted drawdown in the Floridan aquifer would be the same (for all practical purposes) as the surficial aquifer drawdown.

In this zone of high leakance, there is little or no low permeability geologic media separating the suficial and Floridan aquifers.

We trust that this model is explained in adequate detail herein. However if there are any questions, please do not hesitated to contact us.

Sincerely,
Robert Casper
Robert D. Casper, E.I.
Project Engineer

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Figure 10-2 Calibrated Recharge Zones

1.0 GROUNDWATER MODELING

1.1 General

A single layer ground water model of the upper Floridan aquifer was constructed using the USGS ground water modeling software MODFLOW and the Groundwater Vista pre/post processing software to in order to assess the potential for drawdown of the Floridan aquifer under conditions of reduced recharge such as might occur due to long term deficits in rainfall.

We have shifted to a one layer model, as opposed to a two layer model, because of the high leakage rates in the Green Swamp where the surficial ground water aquifer is well connected to the Floridan aquifer, and the shallow ground water aquifer levels generally reflect the potentiometric surface of the Floridan aquifer.

The Clermont Chain of Lakes relies on stream inflows from Big Creek and Little Creek in order to maintain normal water levels throughout the chain of lakes. These stream flows are dependent on the hydrologic conditions which develop the Green Swamp.

The report *Hydrogeology and Simulation of the Effects of Reclaimed-Water Application in West Orange and Southeast Lake Counties, Florida*, by Andrew O'Reilly, 1998, served as a starting point in assigning modeling parameters. The majority of the O'Reilly study area is included within our current model boundaries, and represents roughly one third of the total model area being considered.

1.2 Model Area and Model Grid

As indicated in our January 2003 progress report, the model area has been expanded to the southeast to include the entire Big Creek drainage basin, and to the northwest in order to establish suitable boundary conditions. This expanded model area is depicted in Exhibit 1, below. Exhibit 1 also depicts the potentiometric water pressure contours in the upper Floridan aquifer (September, 2000) which were used to establish the boundary conditions and which serve as a base for calibration.

A model grid of 253 rows and 206 columns was utilized, with a uniform cell size of 1000 ft by 1000 ft.

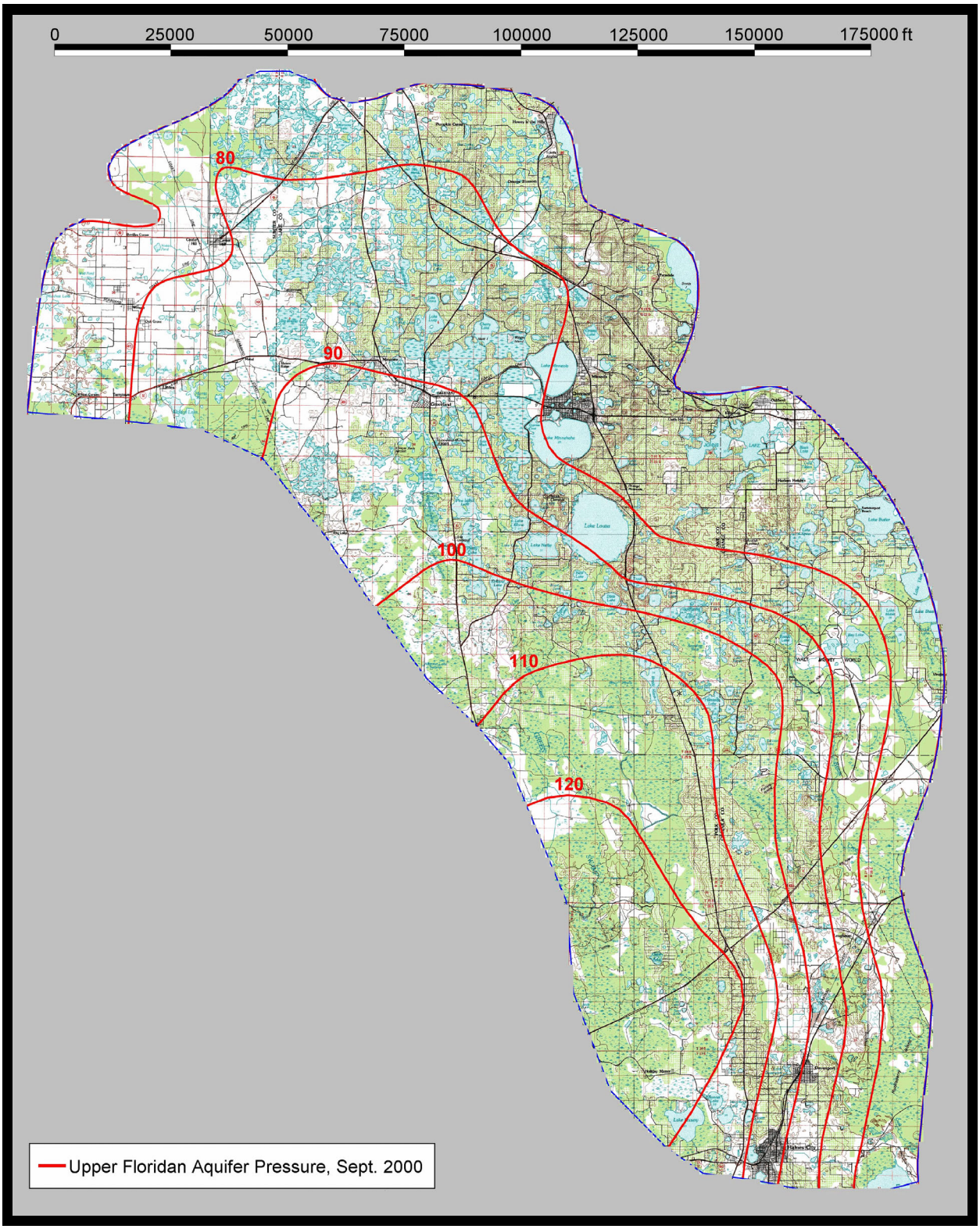

Exhibit 1. Model area and potentiometric pressure in Upper Floridan Aquifer.

1.3 Boundary Conditions

Boundary condtions in the model are set to No-Flow boundaries along the southwest and south perimeter of the model, where the model area intersects perpendicular to the potentiometric water pressure contours. Boundary conditions along the north and east perimeter of the model are set to Constant Head boundaries. This portion of the perimeter of the model area follows the potentiometric pressure contour at +70 ft, and the water pressure is held at constant along this boundray. These boundary conditions are illustrated in Exhibit 2.

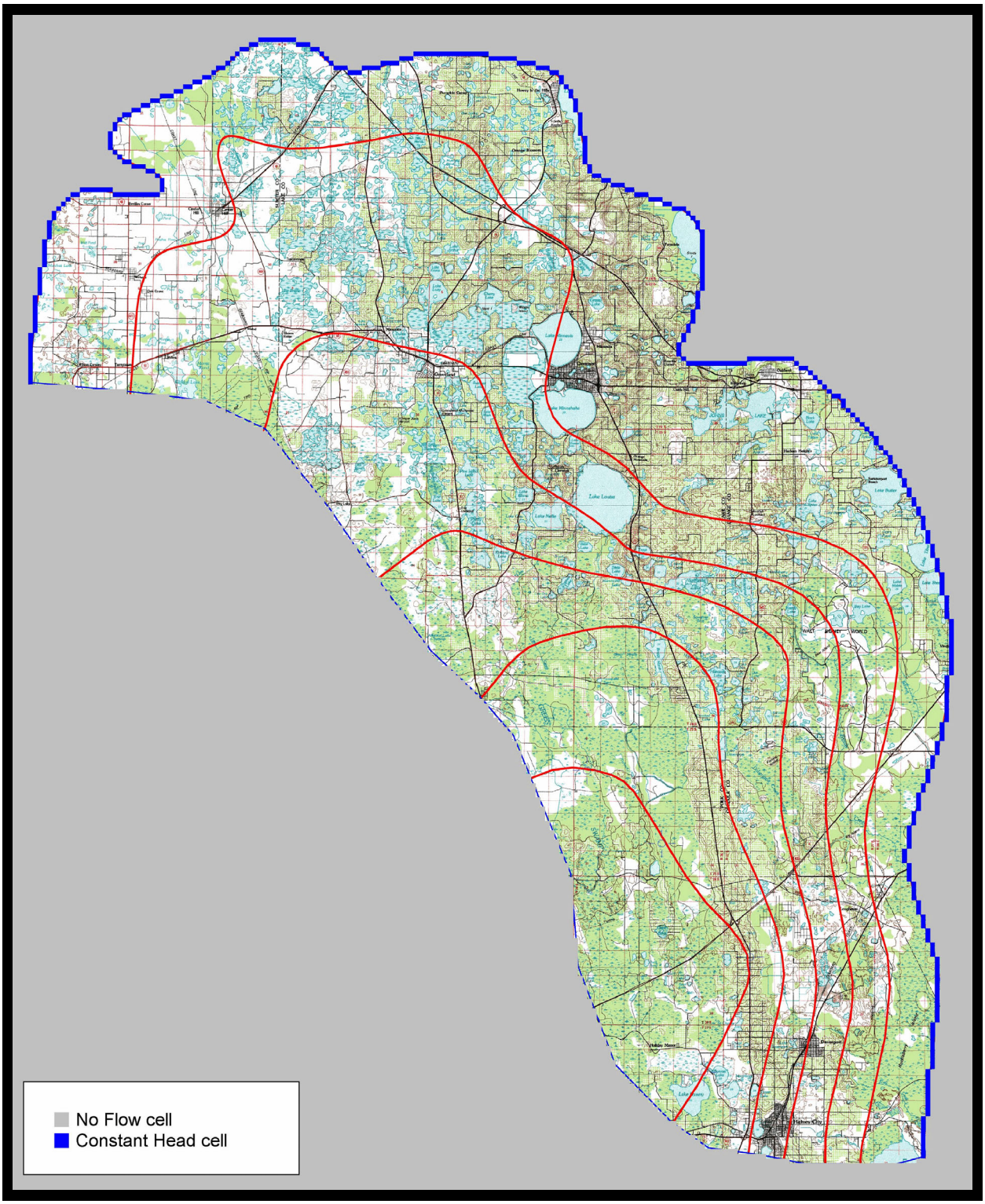

Exhibit 2. Boundary conditions for upper Floridan aquifer.

1.4 Aquifer Transmissivity

A zoning procedure was utilized to define a number of regions of varying transmissivity in the Upper Floridan Aquifer. Within each zone, the transmissivity is assumed to be constant, but varies from zone to zone. These calibrated transmissivity zones are illustrated in the attached Figure 10-1. Calibrated transmissivity values for each zone are listed in Table 1, below.

Table 1. Aquifer Transmissivity

Model Zone	Calibrated Transmissivity (ft^2/day)
1	150,000
2	75,000
3	60,000
4	157,500
5	22,500
6	75,000
7	360,000
8	105,000
9	60,000
10	120,000
11	120,000
12	90,000
13	82,500
14	105,000
15	67,500
16	60,000
17	180,000

1.5 Recharge to Floridan Aquifer

The net recharge to the aquifer represents the combined effects of rainfall, evaporation, evapotranspiration and leakage between the surficial ground water aquifer and the Floridan aquifer, and is applied directly to the modeled aquifer. Recharge values were assigned using the zoning depicted in Figure 10-2. Values for each recharge zone are indicated in Table 2 below.

Table 2. Recharge to Floridan Aquifer

Model Zone	Recharge (in/yr)
1	7.7
2	9.2
3	4.8
4	13.1
5	6.5
6	8.8
7	10.0
8	3.1
9	7.3
10	16.6
11	3.1

1.6 Porosity & Storage Coefficient

The porosity of the Upper Floridan Aquifer was assigned a uniform value of 0.2, with a storage coefficients of 0.001.

1.7 Initial Heads

Initial aquifer heads throughout the model were assigned a value of +120 feet, and the model was run for steady state conditions to establish the long term aquifer pressures. In the steady state analysis, the aquifer pressure levels will reach a natural equilibrium which reflects the boundary conditions, recharge, and transmissivity in the aquifer.

1.8 Floridan Aquifer Well Pumpage

Pumpage from the Floridan Aquifer was modeled using the WELL boundary condition for individual cells for which permitted wells were identified (see *Tech Memo #9: Inventory of Water Use Permits Within Model Domain*). The location of WELL boundary cells within the model domain is shown in Exhibit 3.

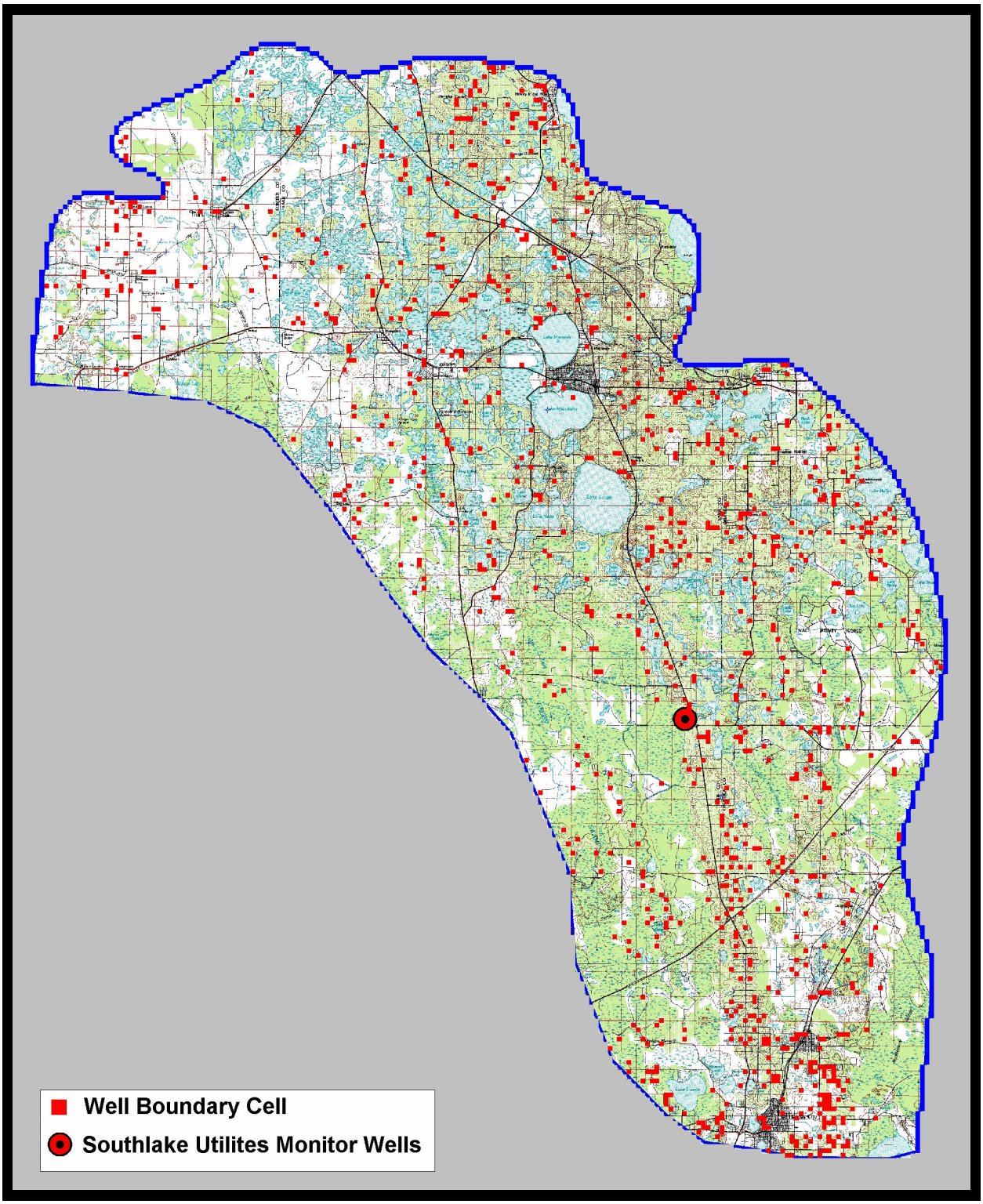

Exhibit 3. Location of well boundary cells within model domain.

1.9 Model Calibration

The model was calibrated by iteratively adjusting the initial estimates of transmissivity and recharge, until a good fit was observed between the modeled aquifer pressures and the published (September 2000) aquifer pressures under steady state conditions.

The calibrated model was then used to assess the potential for drawdown in the aquifer due to long term deficits in aquifer recharge.

2.0 MODEL RESULTS

2.1 Pumping Rate and Recharge Statistics

Table 3 (below) shows statistics for well pumpage and calibrated recharge within the model domain. As seen in Table 3, the total pumpage from all wells in the model domain represents an average loss of approximately 3.03 inches per year over the entire model domain, and the total recharge within the model domain represents a net gain of 9.18 inches per year.

	Area Stats		Pumping Stats				Calibrated Model Recharge			
Zone Number	Hit Count	Zone Area (ft^2)	Zone Pump Rate (ft^3/day)	Zone Pump Rate (ft^2/day)	Zone Pump Rate (in/yr)	Area Times Pump Rate	Calibrated Zone Recharge (ft/day)	Calibrated Zone Recharge (in/yr)	Area Times Recharge (ft^2*in/yr)	Pumping Divided by Recharge (%)
1	1036	1.04E+09	-579464	-0.00056	-2.45	-2.54E+09	0.00175	7.67	7.94E+09	31.96160751
2	1561	1.56E+09	-391587	-0.00025	-1.10	-1.72E+09	0.00210	9.20	1.44E+10	11.9455611
3	2227	2.23E+09	-605382	-0.00027	-1.19	-2.65E+09	0.00110	4.82	1.07E+10	24.71248517
4	2185	2.19E+09	-2954460	-0.00135	-5.92	-1.29E+10	0.00300	13.14	2.87E+10	45.07185591
5	1479	1.48E+09	-542383	-0.00037	-1.61	-2.38E+09	0.00148	6.50	9.61E+09	24.71175615
6	2518	2.52E+09	-3946204	-0.00157	-6.86	-1.73E+10	0.00200	8.76	2.21E+10	78.35988932
7	2344	2.34E+09	-1982221	-0.00085	-3.70	-8.68E+09	0.00228	10.00	2.34E+10	37.04150824
8	1873	1.87E+09	-578489	-0.00031	-1.35	-2.53E+09	0.00070	3.07	5.74E+09	44.12241476
9	2902	2.90E+09	-1148482	-0.00040	-1.73	-5.03E+09	0.00167	7.31	2.12E+10	23.69792122
10	4324	4.32E+09	-3386509	-0.00078	-3.43	-1.48E+10	0.00380	16.64	7.20E+10	20.61023239
11	1568	1.57E+09	-491855	-0.00031	-1.37	-2.15E+09	0.00070	3.07	4.81E+09	44.81190334
			Weighted Average (in/yr)			-3.03	Weighted Average (in/yr)		9.18	

Table 3. Pumping and recharge statistics for Floridan aquifer model.

Unpublished ground water usage data from the USGS was obtained online and compared to the aquifer pumping rates used in the calibrated model to assess whether the estimated pumping rates are reasonable. As seen in Table 4, the average pumping rate for the counties in which the model domain intersects represents about 3.06 inches per year of pumpage, which correlates well with the 3.03 inches of pumpage used in the model.

Ground water withdrawls					
Data Source: USGS, unpublished, online					
URL: http://fl.water.usgs.gov/Water_Use_web/Data%20Tables%202000.htm					
	County				
Water Source	Lake	Orange	Osceola	Polk	Sumter
Total agricultural (irrigation and non-irrigation) water withdrawals in Florida by County, 2000 (mgd)	73.4	27.51	80.47	174.31	14.08
Total public-supplied water withdrawals in Florida by County, 2000 (mgd)	39.92	211.76	30	75.43	4.44
Total recreational irrigation water withdrawals in Florida by County, 2000 (mgd)	4.54	13.66	1.57	9.65	3.35
Total domestic self-supplied water withdrawals in Florida by County, 2000 (mgd)	4.29	8.82	4.61	12.47	4.57
Total commercial-industrial-mining water withdrawals in Florida by County, 2000 (mgd)	10.44	24.21	0.84	71.2	0.36
Total power generation water withdrawals in Florida by County, 2000 (mgd)	0	0.76	0.03	4.27	0
Total water withdrawals in Florida by County, 2000 (mgd)	132.59	286.72	117.52	347.33	26.8
Total water withdrawals in Florida by County, 2000 (gal/d)	132,590,000	286,720,000	117,520,000	347,330,000	26,800,000
Total water withdrawals in Florida by County, 2000 (ft^3/d)	17,724,705	38,328,888	15,710,139	46,431,267	3,582,639
Area (acres)	739,706	641,832	963,331	1,285,516	371,193
Area (ft^2)	3.22216E+10	2.79582E+10	4.19627E+10	5.59971E+10	1.61691E+10
Ground water withdrawals, expressed as recharge (ft/day)	0.000550088	0.001370936	0.000374384	0.000829173	0.000221573
Ground water withdrawals, expressed as recharge (in/yr)	2.41	6.00	1.64	3.63	0.97
Area x recharge (ft^2 x in/yr) for weighted average recharge calc	7.76342E+10	1.67881E+11	6.88104E+10	2.03369E+11	1.56920E+10
Weighted average ground water withdrawals (in/yr)	**3.06**				

Table 4. Unpublished USGS water usage data.

2.2 Steady State Calibration

The final calibration using the transmissivities listed in Table 1, and recharge values listed in Table 2, resulted in the potentiometric aquifer pressure contours shown in Exhibit 4.

For the purpose of model verification, a five-year transient analysis was performed using the calibrated aquifer pressures as the initial head conditions, and using the calibrated values of transmissivity and recharge, in order to check that the calibrated model was well behaved, and that there was no significant drift from steady state conditions. Exhibit 5 shows the results of the five-year transient simulation, and indicates that the calibrated model parameters are well posed.

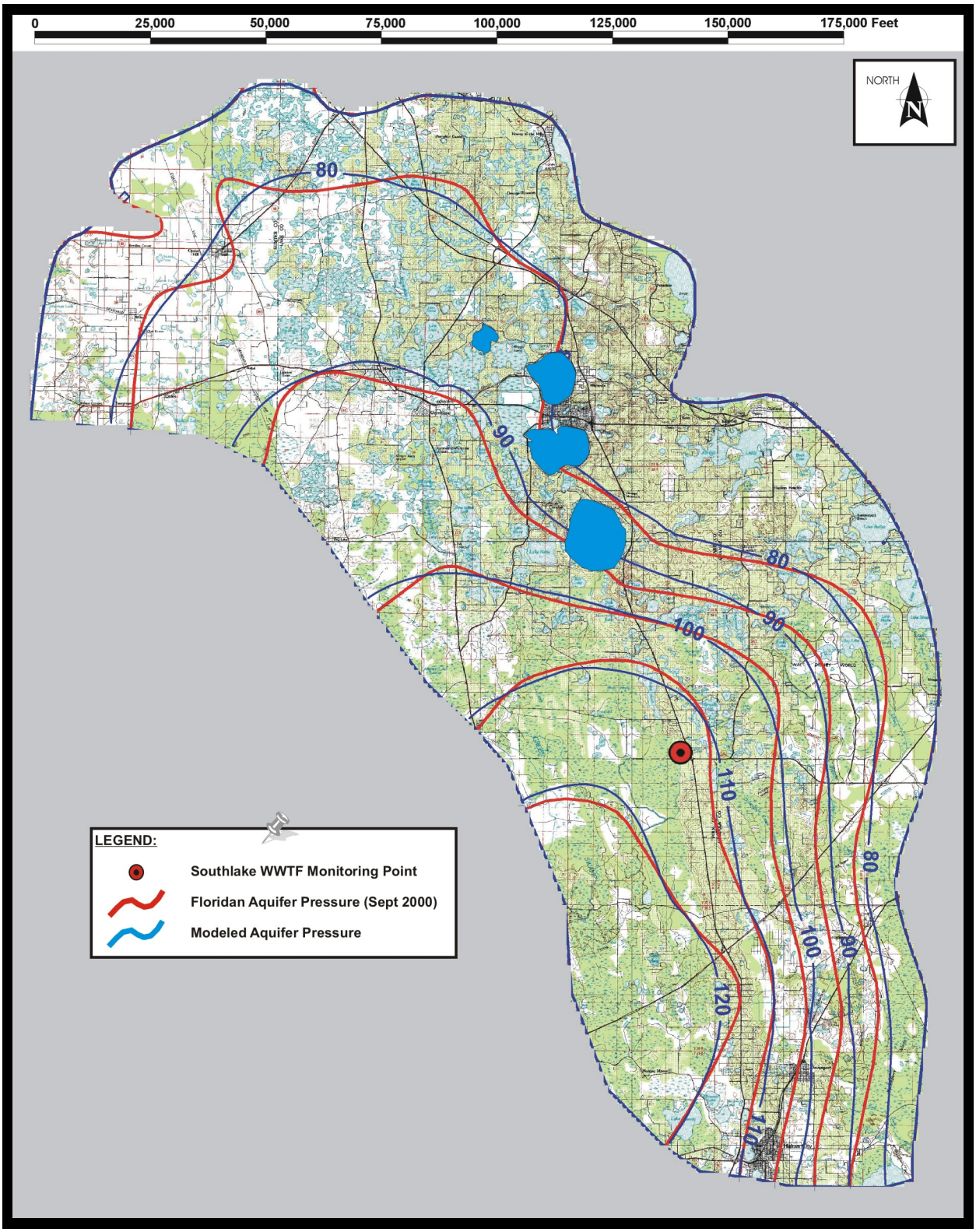

Exhibit 4. Calibrated steady state Floridan aquifer potentiometric head contours.

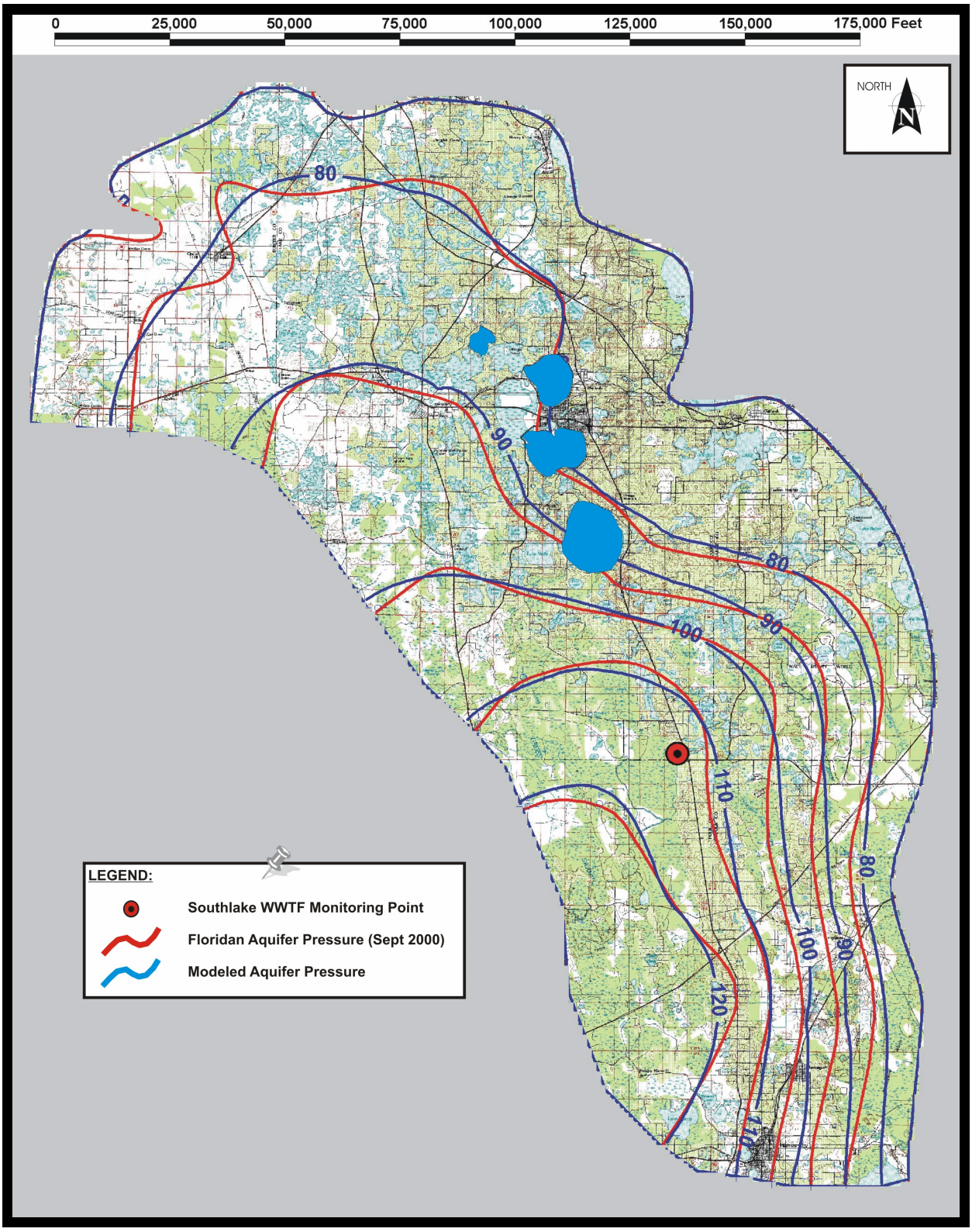

Exhibit 5. Five-year transient response using calibrated recharge values

2.3 Transient Model Response to Long-Term Recharge Deficits

Based on the continuous simulation model, we know that the Clermont Chain of Lakes is highly dependent on stream inflows from Big Creek and Little Creek to maintain normal lake levels. These stream flows are in turn strongly correlated to the potentiometric Floridan aquifer pressures which develop in the Green Swamp. A series of model simulations was performed to assess the potential for drawdown of the aquifer pressures under chronic uniform recharge deficits of 5%, 10%, 15% and 20% of normal calibrated recharge. These recharge deficits were applied across the entire model domain to reflect a regional drought.

The Southlake Utilities monitor well cluster, located near the intersection of US 27 and US 192, provides a good source of aquifer pressure data in the Green Swamp for the period of record of April 1994 to present (May 2003). These data were used in conjunction with measured stream flows from Big Creek in order to curve-fit aquifer pressure vs. stream flow as shown in Exhibit 6 (below).

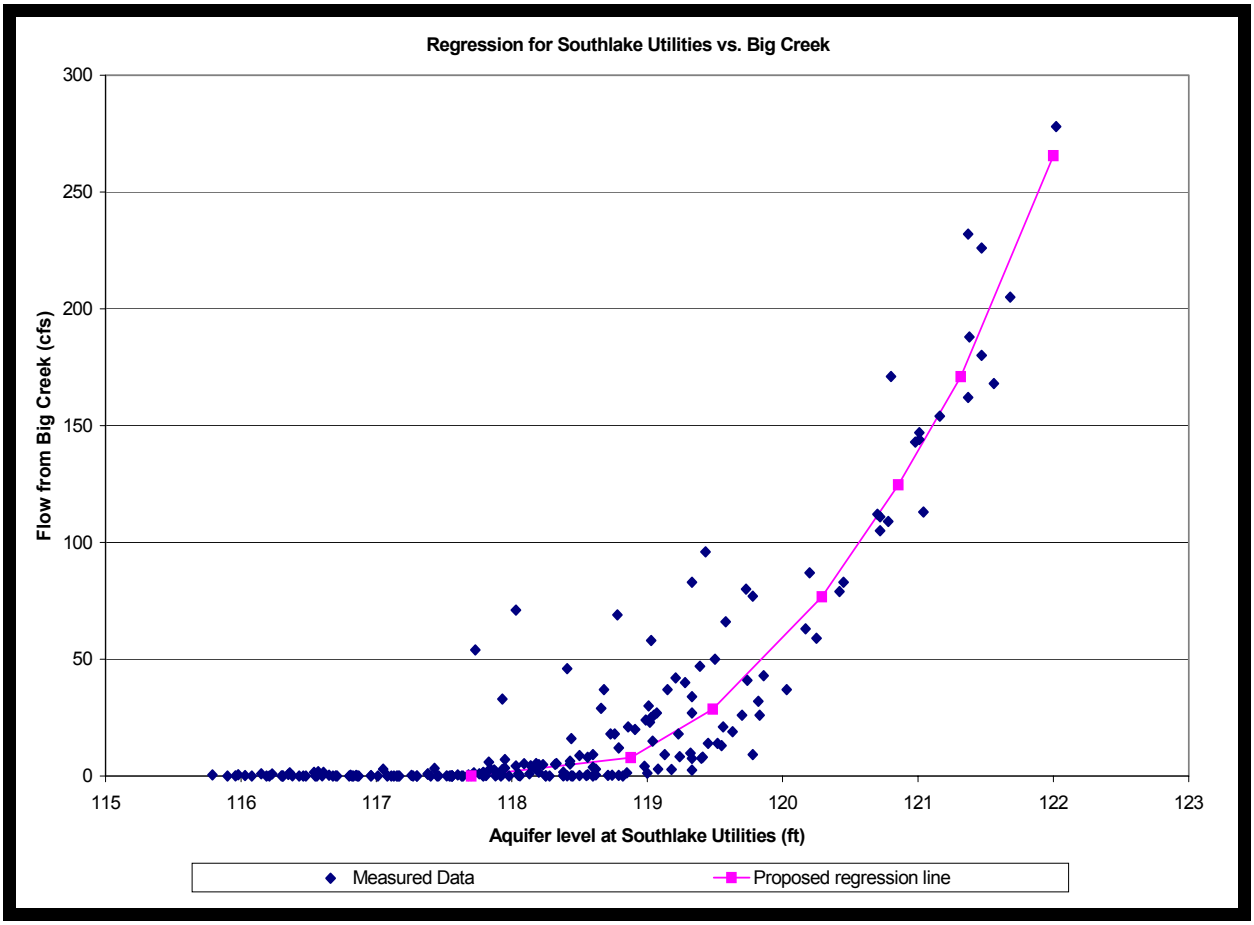

Exhibit 6. Regression of Big Creek stream flow and Southlake Utilites aquifer pressure

These data provide a useful indicator of the relationship between aquifer pressures in the Green Swamp (at the Southlake location) and stream discharge from Big Creek. The correlation implies that stream flow from Big Creek will cease if the water table/potentiometric head in the Green Swamp (near the Southlake Utilities monitor wells) drops below approximately +117.7 feet.

Exhibit 7 (below) shows another view of these data, plotted by date, which demonstrates the strong correlation between water table altitude and stream flow.

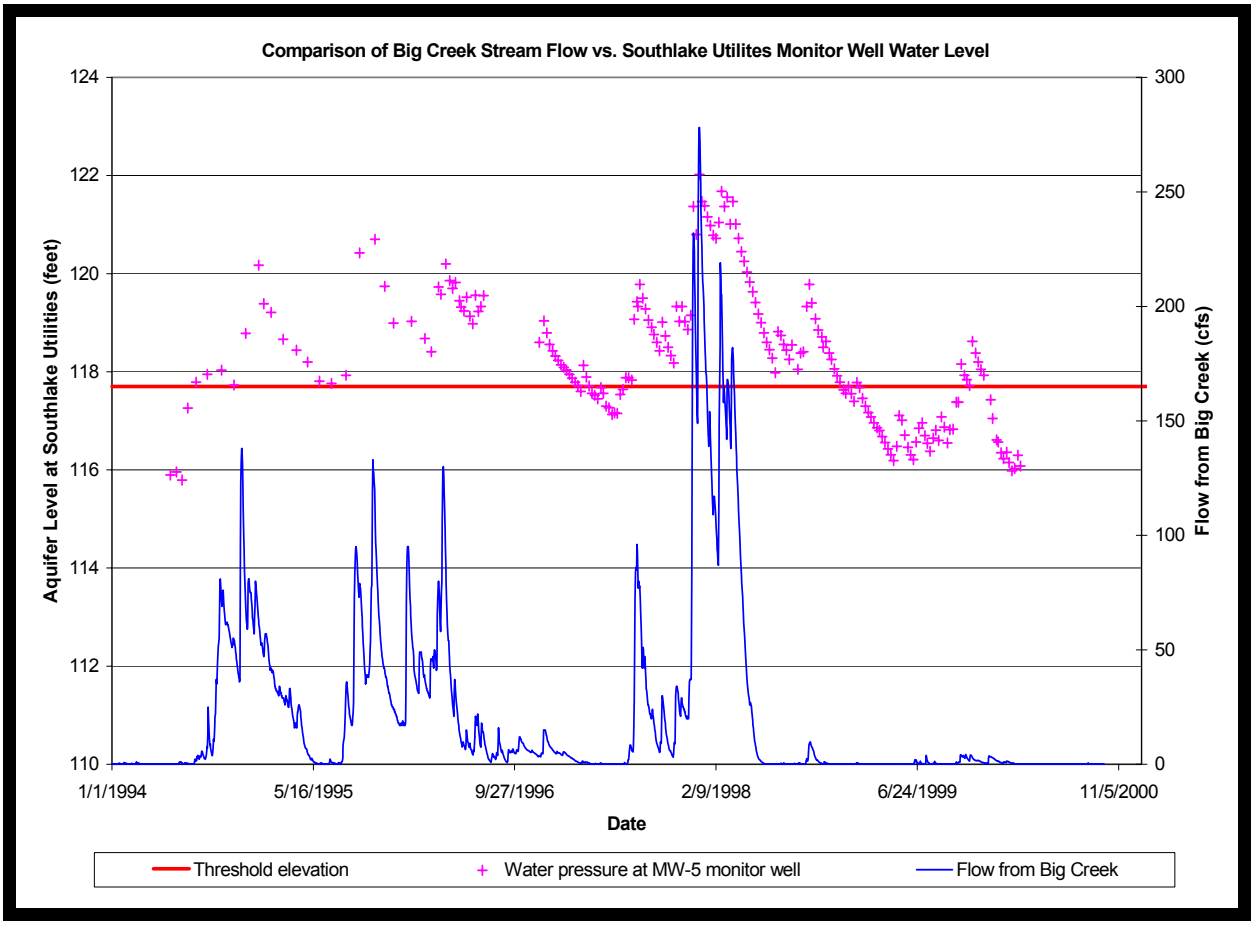

Exhibit 7. Comparison of Big Creek stream discharge and Southlake water table elevation in swamp

Results of model simulations for five-year recharge deficits of 5%, 10%, 15% and 20% are shown in Exhibits 8 through 11. The predicted five-year drawdown in the Floridan aquifer pressure at Southlake Utilites is summarized in Table 5 (below).

Table 5. Drawdown at Southlake Utilites for 5-year Rainfall Deficits

Deficit (%)	Drawdown (feet)
5	2.7
10	5.7
15	8.5
20	11.5

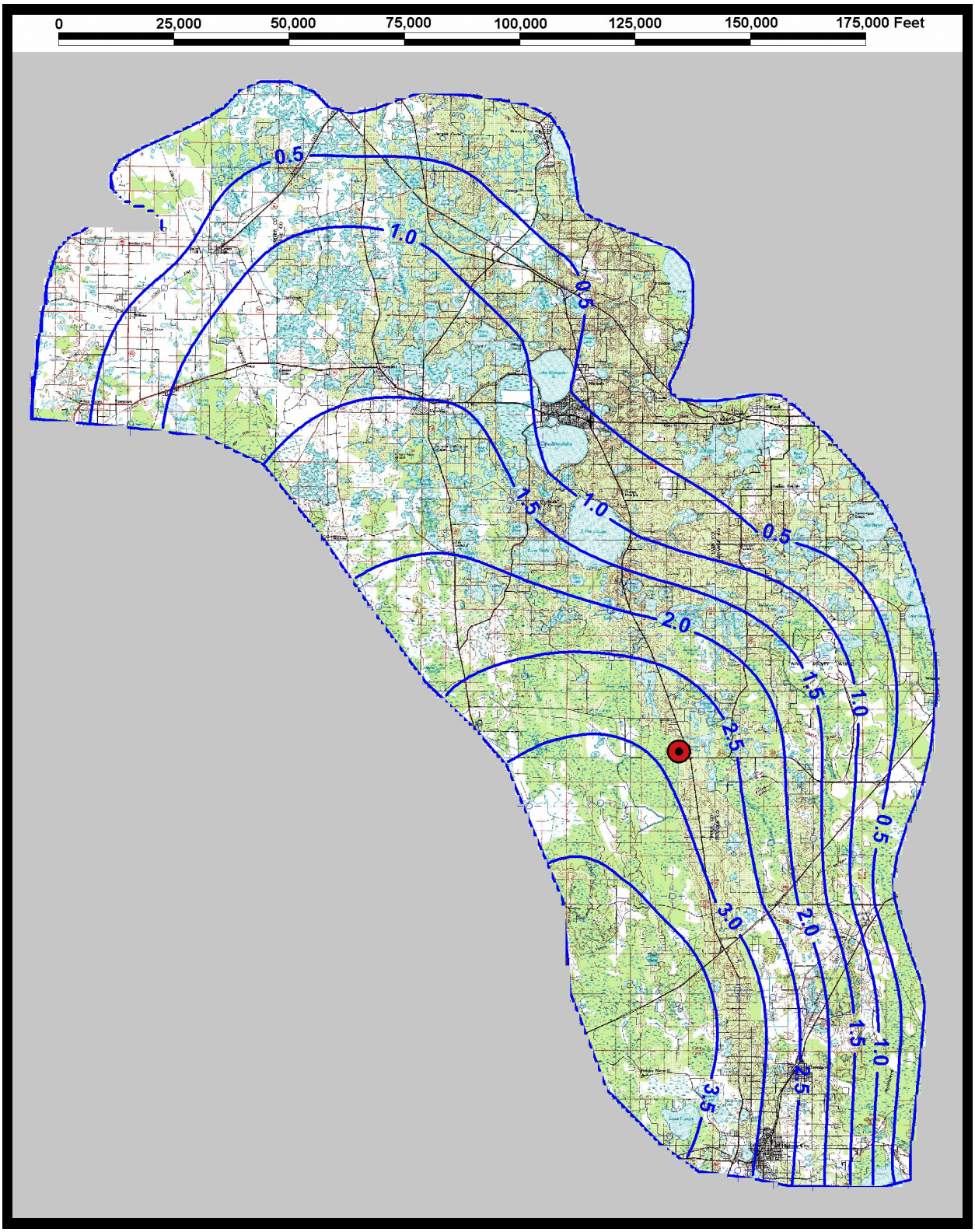

Exhibit 8. Aquifer drawdown for 5-year / 5% recharge deficit

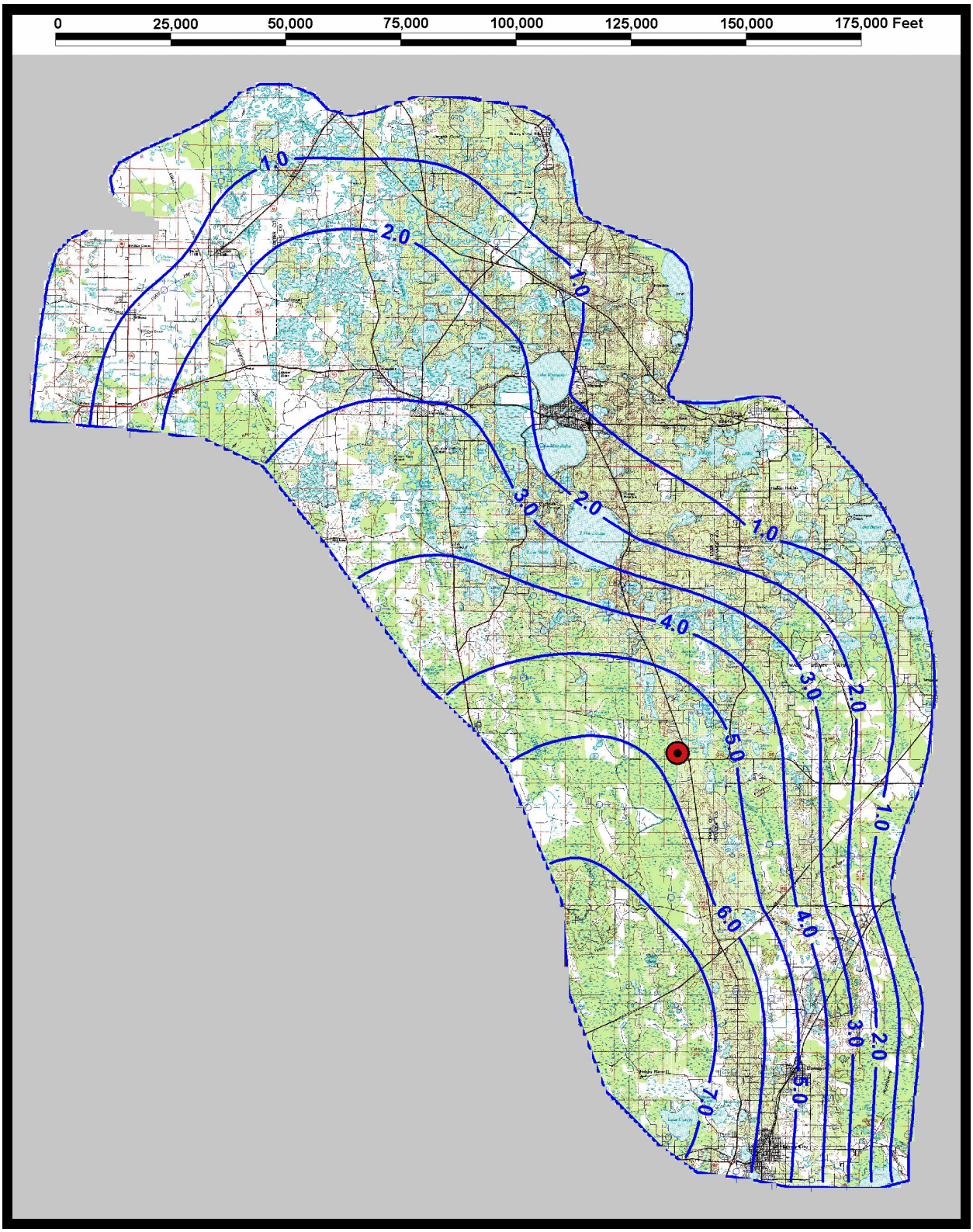

Exhibit 9. Drawdown for 5-year / 10% recharge deficit

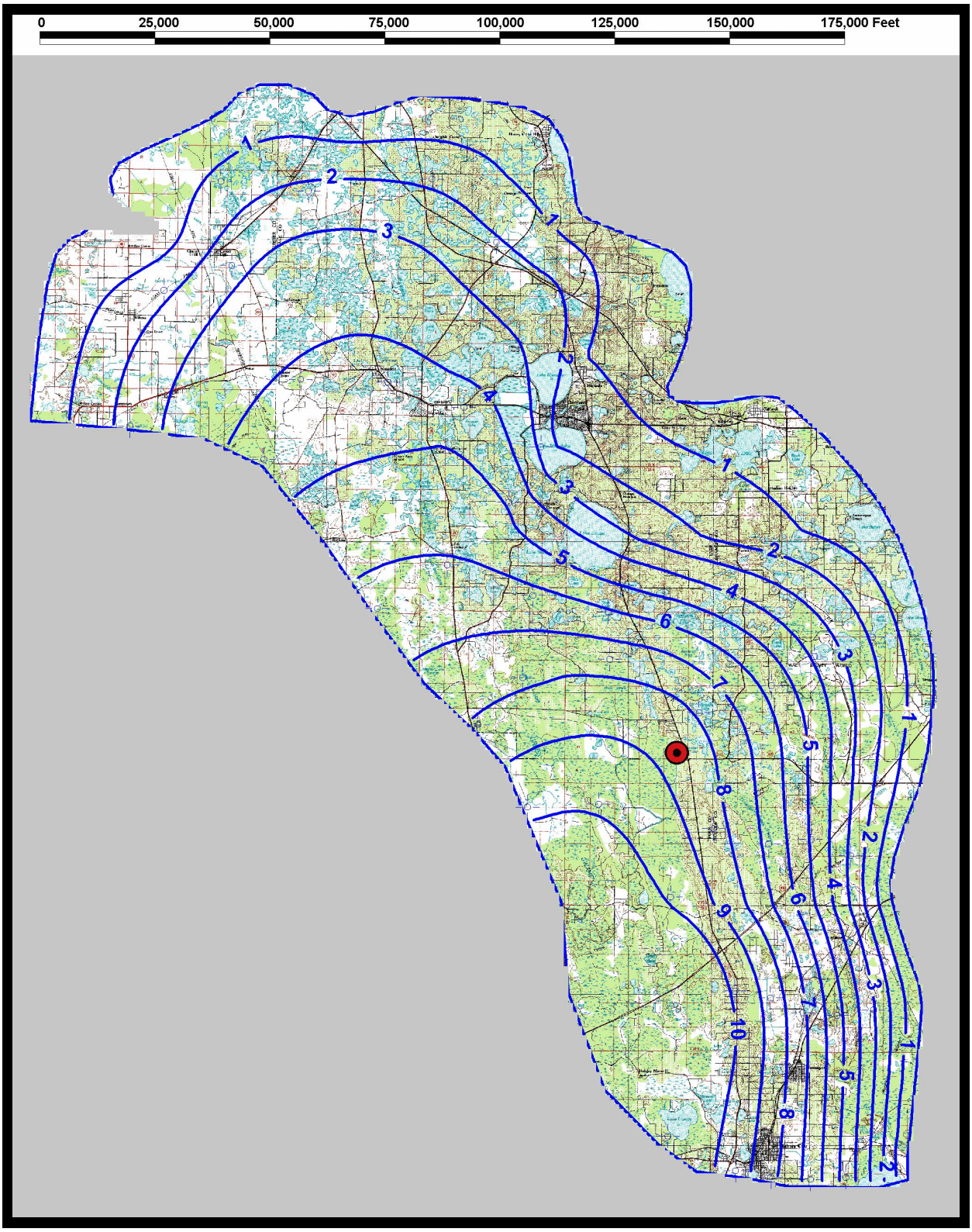

Exhibit 10. Drawdown for 5-year / 15% recharge deficit

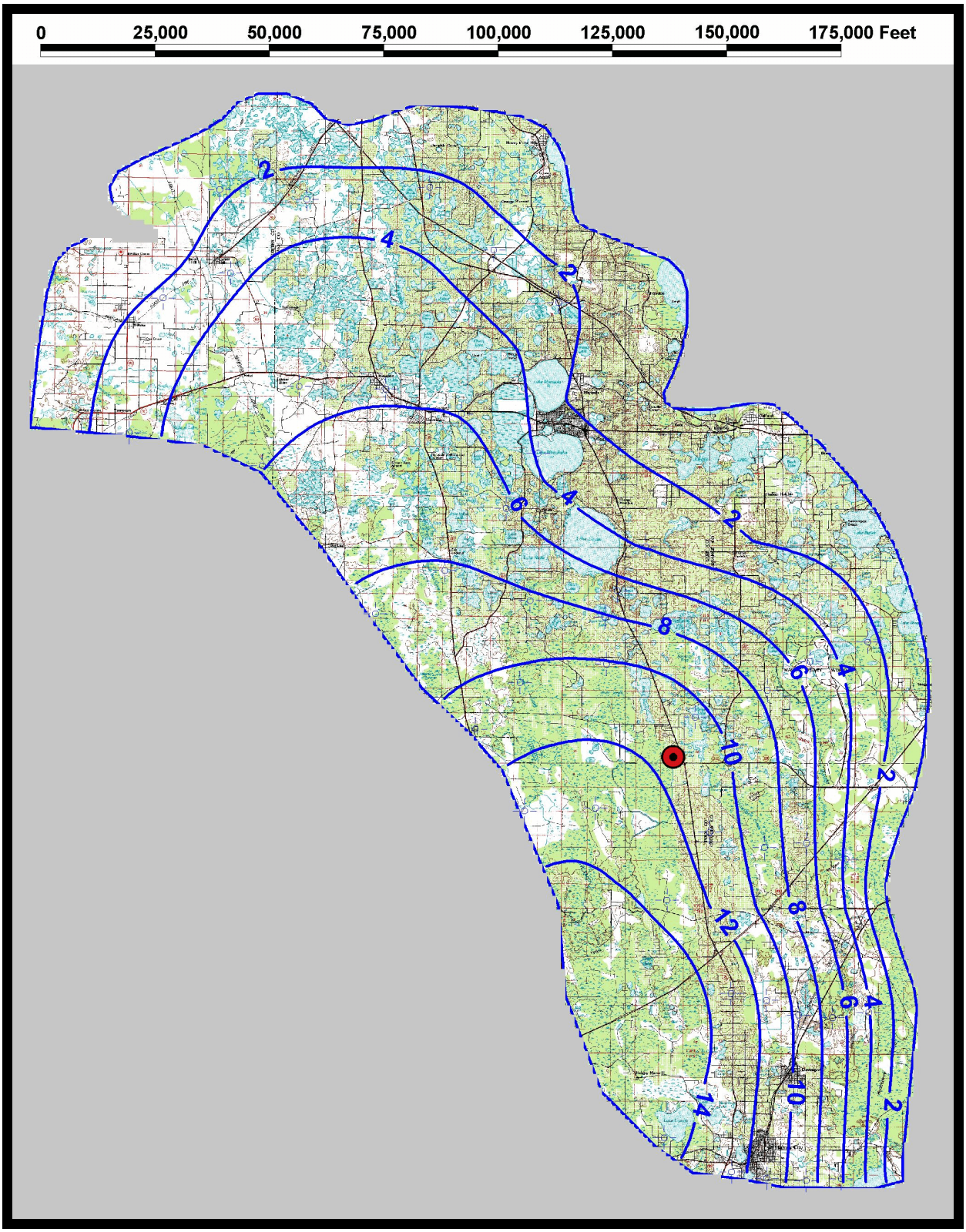

Exhibit 11. Drawdown for 5-year / 20% recharge deficit

3.0 Conclusions

The stream discharge from Big Creek and Little Creek which replenish the Clermont Chain of Lakes are strongly correlated to potentiometric water pressures in the Green Swamp. The modeling indicates that even small deficits in recharge (caused by say chronic shortages in rainfall) can have significant impacts on stream flow and that a prolonged drop in aquifer pressures of about 3 feet could result in negligible stream flows to the Clermont Chain of Lakes.

FIGURES

NORTH

0 25,000 50,000 75,000 100,000 125,000 150,000 175,000 Feet

Zone 9
60,000 ft²/day

Zone 1
150,000 ft²/day

Zone 3
60,000 ft²/day

Zone 10
120,000 ft²/day

Zone 12
90,000 ft²/day

Zone 5
22,500 ft²/day

Zone 7
360,000 ft²/day

Zone 8
105,000 ft²/day

Zone 13
82,500 ft²/day

Zone 6
75,000 ft²/day

Zone 14
105,000 ft²/day

Zone 11
120,000 ft²/day

Zone 4
157,500 ft²/day

Zone 16
60,000 ft²/day

Zone 2
75,000 ft²/day

Zone 15
67,500 ft²/day

LEGEND:

- Location of Southlake Utilities Monitor Wells
- Surface Water Drainage Basin Divides
- Transmissivity Zone Boundaries

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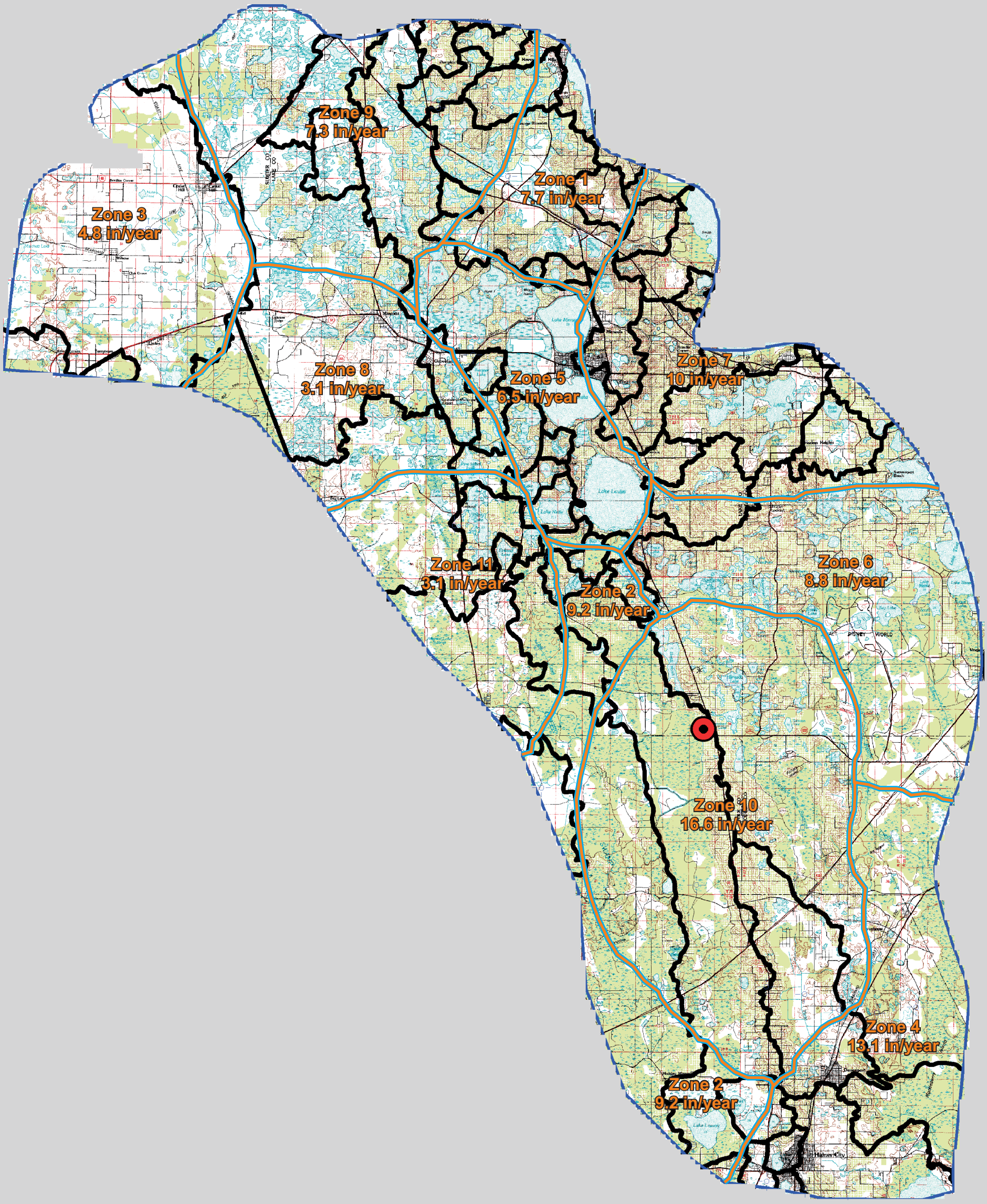
Figure Name:
Calibrated Transmissivity Zones

Project Name:
Clermont Chain of Lakes

Checked & Approved By:	Drawn By:	Date:	Scale:	Project #	
DS	AZ	05-16-03	NOTED	02-121.96	FIGURE 10-1

NORTH

0 25,000 50,000 75,000 100,000 125,000 150,000 175,000 Feet



LEGEND:

- Location of Southlake Utilities Monitor Wells
- Surface Water Drainage Basin Divides
- Recharge Zone Boundaries

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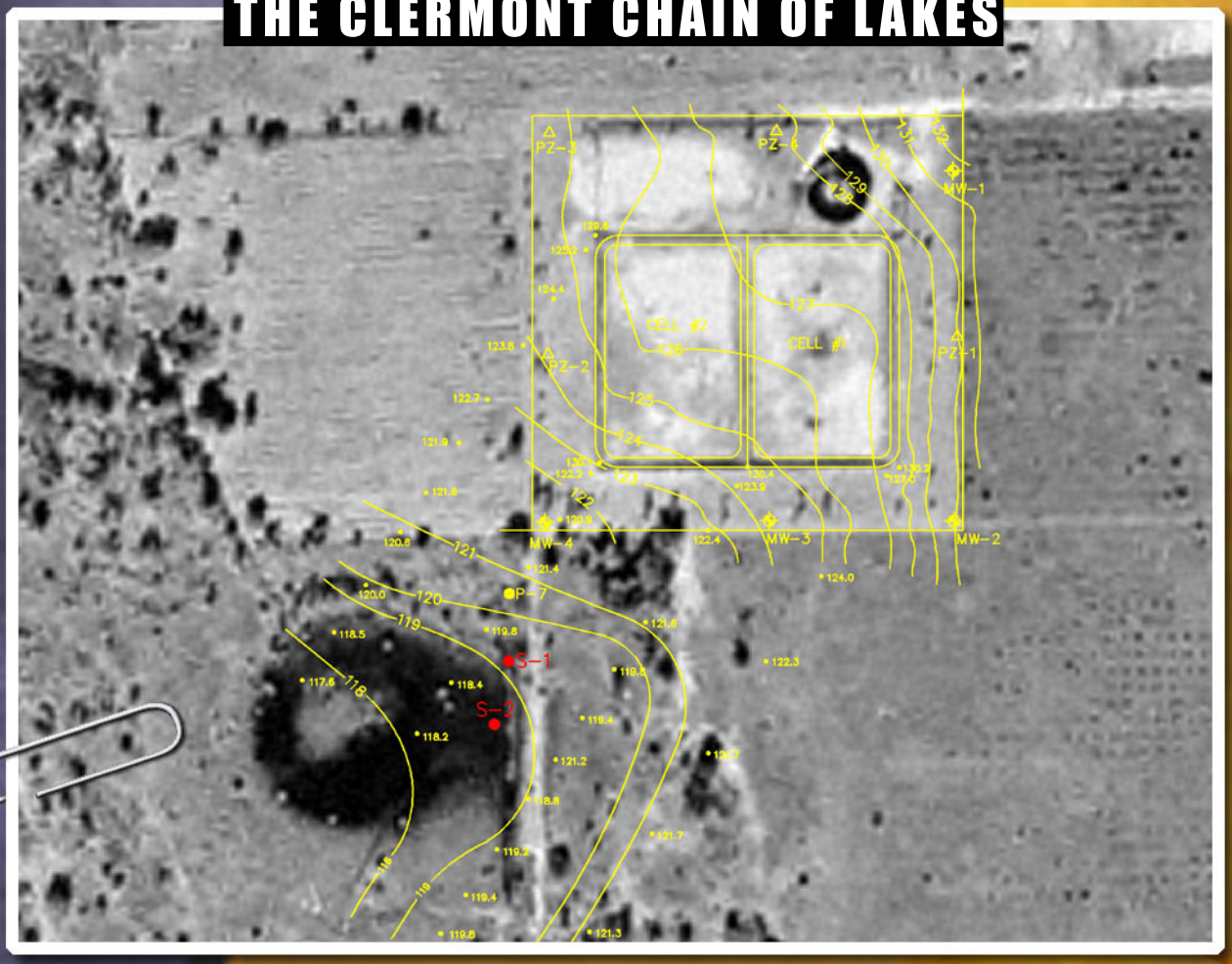
Figure Name: **Calibrated Recharge Zones**

Project Name: **Clermont Chain of Lakes**

Checked & Approved By:	Drawn By:	Date:	Scale:	Project #	
DS	AZ	05-16-03	NOTED	02-121.96	FIGURE 10-2

TECHNICAL MEMO #11: REVIEW OF HISTORICAL AERIALS & SHIFT IN GREEN SWAMP WETLAND LINE FOR BIG CREEK BASIN NEAR US 192 & US 27

THE CLERMONT CHAIN OF LAKES



Prepared for

Lake County Water Authority

Professional Engineering Consultants, Inc.

Prepared by

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Date: June 24, 2003	*Devo's Project No.* 02-121.96
To: Lake County Water Authority 107 North Lake Avenue Tavares, Fl 32778-3119 phone: 352-343-3777 fax: 352-343-4259 attention: **LANCE LUMBARD**	*cc:* Professional Engineering Consultants, Inc. 200 East Robinson Street, Suite 1560 Orlando, FL 32801 phone: 407-422-8062 fax: 407-849-9401 attention: **DAVID HAMSTRA, P.E.**
LCWA Lake County Water Authority	PEC

Ref:

TECHNICAL MEMO #11 (REVISED)
REVIEW OF HISTORICAL AERIALS & SHIFT IN GREEN SWAMP WETLAND LINE FOR...
BIG CREEK BASIN NEAR US 192 & US 27 – CLERMONT CHAIN OF LAKES STUDY

Dear Mr. Lumbard:

The attached technical memo summarizes our review of historical aerials dating back to 1941, the purpose being to detect any potential shift in Green Swamp wetland line in the Big Creek Basin. We have also reviewed published maps of the potentiometric surface of the Upper Floridan aquifer in the Green Swamp for November 1959 and May 1962, and compared these to more recently published potentiometric surface maps (September 1994 and May 1999). The purpose of this review is to see if there is an observable decline in the swamp water level as a result of development since 1941. The aerial review herein indicates that the Green Swamp water level has not declined as a result of pumpage from the Floridan aquifer since 1941.

Sincerely,

Robert Casper
Robert D. Casper, E.I.
Project Engineer

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1.0 INTRODUCTION

On May 19, 2003, Dave Kincaid and Robert Casper of Devo Engineering visited the Department of Facilities in Lake County (421 West Main Street, Tavares, Florida) to view historical aerial photographs for the purpose of determining whether there has been any significant shift in wetland lines in the Green Swamp that could be related to development impact.

We choose as our viewing area, a portion of wetland near the Southlake Utilities waste water treatment facility, northwest of the intersection of US 27 and US 192. We were able to find aerials for the following years:

- January 1941
- February 1958
- January 1973
- July 1979
- February 1984
- March 1987
- March 1994

The above aerial photographs were supplemented with an online FDOT aerial photograph of the area dated February 1995 which is also used in our evaluation.

In addition to examining the historical and current position of the wetland line separating the Green Swamp from the uplands of the Lake Wales Ridge, we examined a number of reference points, the locations of which are indicated on the attached Figure 11-1.

Feature	Description
A	A narrow depressional feature extending eastward from the swamp. This area is transected (N to S) by what appears to be the remnants of an old trail, which was clearly visible in the earliest aerial photographs, and is still somewhat visible in the February 1995 photograph.
B	A crescent shaped depressional area which was clearly visible in the January 1941 photograph, but which has subsequently become overgrown.
C, D, & E	Small circular depressions, visible for the entire period of record {these are herbacious wetlands}.
F	A semi-circular bend in the wetland limits line.
G	Two small circular areas of vegetation in the wetland, probably cypress domes, near feature "F".
H	An oblong area of vegetation, probably a cypress dome, near feature "A"
I	A linear cut feature extending into the swamp (possibly an old trail) visible from the earliest photos onward.
J	A rim canal which first appeared in the February 1958 photo, not apparent in the January 1941 photo.

Figure 11-2 (attached) shows the area of interest overlain by 5 ft topographic contours.

2.0 HISTORICAL LAND USE

In January 1941, the land use for the upland areas directly east of the Green Swamp appeared to be pasture land with scattered trees. By February 1958, portions of the pasture land had been converted to citrus. The citrus groves were eventually cleared following the hard freezes of 1983 and 1984. Portions of this area have subsequently been developed as subdivision housing.

3.0 WETLAND CONDITIONS

3.1 General

By visual inspection of the aerial photographs, January 1941 appeared to be the wettest of all the years reviewed. Depressional features A, B, C, D, & E had clear signs of standing water, and cypress mounds within the swamp were clearly delineated. The trail cut feature "I" was just visible.

Conditions in February 1958 were similar to January 1941, but water levels appeared to be marginally lower than 1941 levels.

After 1958 (for years 1973, 1979, 1984, 1987 and 1994) the aerials indicate generally drier conditions. Depressional features A, B, C, D, & E did not show signs of standing water, and the water level in the swamp appeared somewhat low. However, a portion of the observed wetland, to the west of feature "A," consistently showed signs of standing water.

In the February 1995 FDOT aerial, water levels in the swamp were up again, similar to 1941/1958 levels, and the depressional features A,C, D, & E again showed signs of standing water. Depressional feature C had by this time become overgrown with trees and is no longer clearly visible.

The quality and format of the available aerial photographs varied somewhat, but the following general, qualitative observations were made.

- January 1941: appears to be the wettest of the aerials observed
- February 1958: appears to be only marginally drier than 1941, but still generally wet
- January 1973: water levels are lower than 1958 water levels, and somewhat dry
- July 1979: appeared slightly wetter than 1973, although still generally dry
- February 1984: appeared slightly wetter than 1979, although still generally dry
- March 1987: appeared slightly drier than 1984
- March 1994: appeared generally dry, but within the range of other dry years observed
- February 1995: appeared wet, with water levels similar to 1941/1958

Most of the aerials observed were produced during the months of January through March of their respective years, which corresponds to the dry season.

Observations of the wetland transition zone from swamp to uplands did not indicate an appreciable or detectable shift in either the location of the transition zone or the lateral extent of the transition zone. Furthermore, the vegetated areas (cypress domes) used as reference points (features "G "and "H") do not appear to have changed significantly during the period of record. **There does not appear to have been any movement in the wetland transition zone for the period of 1941 to present.**

3.2 Rainfall

Exhibit 1below shows the antecedent rainfall conditions for the six (6) month period prior to and including the month in which the aerial photographs were taken. In general, the day of the month on which the photographs were taken is not known. In Exhibit 1, month 6 represents the month in which the photograph was taken, and months 1 through 5 represent the preceding 5 months. (Note: the photographs were taken during different times of year, generally between January and March of their respective years, with the exception of the 1979 aerial which was taken in July.)

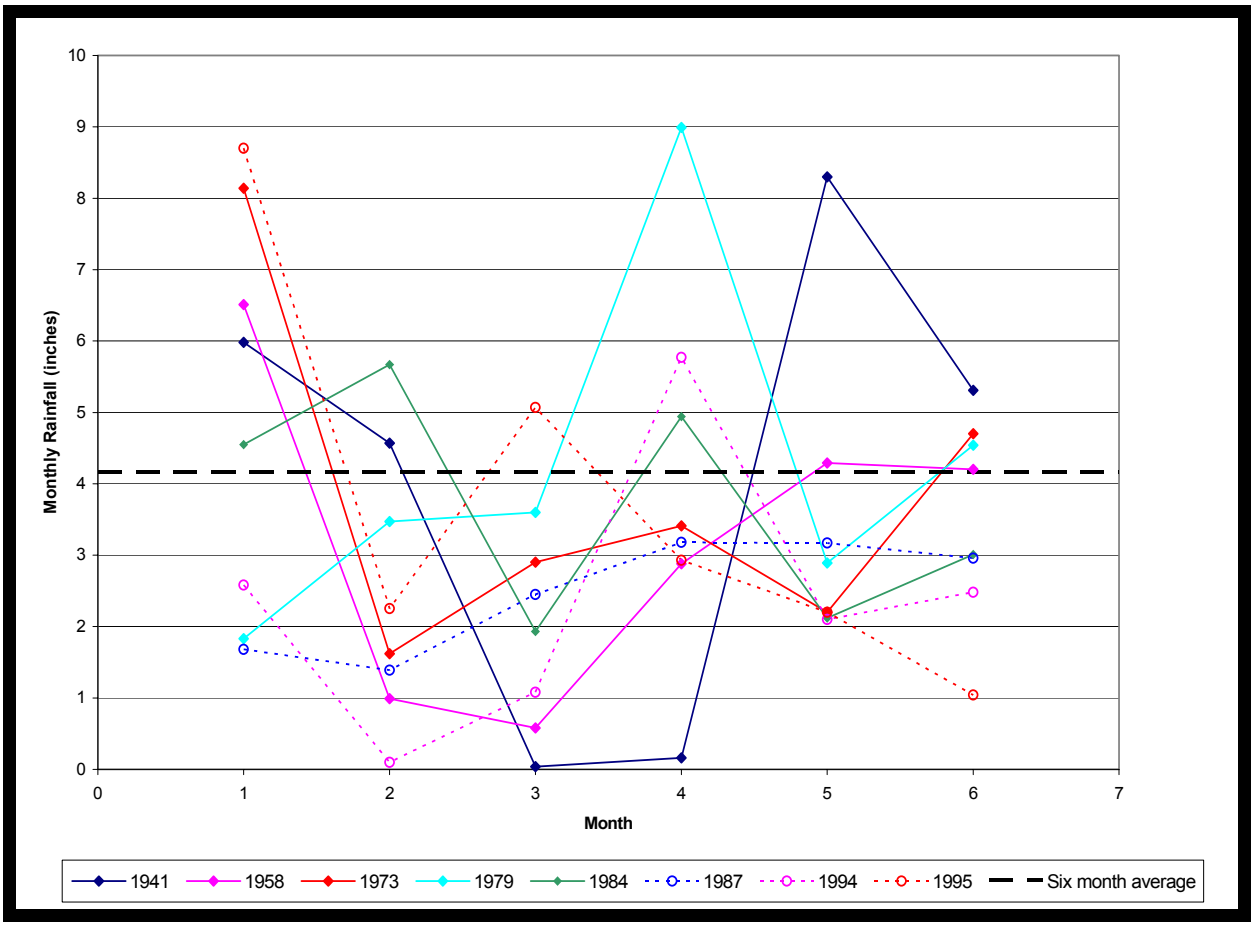

Exhibit 1. Six month antecedent rainfall patterns

The data in Exhibit 1 do not identify any clear cut trends. The following observations can be made:

- In 1941, the month that the photo was taken had above average rainfall, and the previous month had significantly above average rainfall, which followed two very dry months. The year 1941 was wet
- In 1958, rainfall levels are steadily increasing for the three months prior to the photograph, with average rainfall during the month of the photograph. 1958 was observed to be generally wet.
- In 1973, the 4 months prior to the photograph were below average rainfall months, with a noticeable dip in the month prior to the photo. The month the photograph was taken shows rainfall slightly above average. 1973 was observed to be dry in comparison to 1941/1958.
- In 1979, there was significantly above average rainfall in the second month prior to the photograph, dipping in the month before the photo, and slightly above average during the month of the photo. 1979 was observed to be slightly wetter than 1973.
- In 1984, there was below average rainfall during the month of the photograph and the month preceding the photograph. This was preceded by alternating high and low rainfall months. 1984 was observed to be qualitatively wetter than 1979, although the six month rainfall does not correlate well to this observation.
- In 1987, below average rainfall occurred during the 5 months prior to the month in which the photo was taken. 1987 was observed to be drier than 1984.
- In 1994, the rainfall was below average for all but one month. See measured water table elevations in Exhibit 2 for feature "E" in Figure 11-1. Note that the 1994 aerial was shot in March before the onset of summer rains.
- In 1995, the rainfall data shows a generally declining trend, with above average rainfall in two of the first three months. 1995 water levels were observed to be generally high. (See Exhibit 2 for measured water levels which confirm this trend).

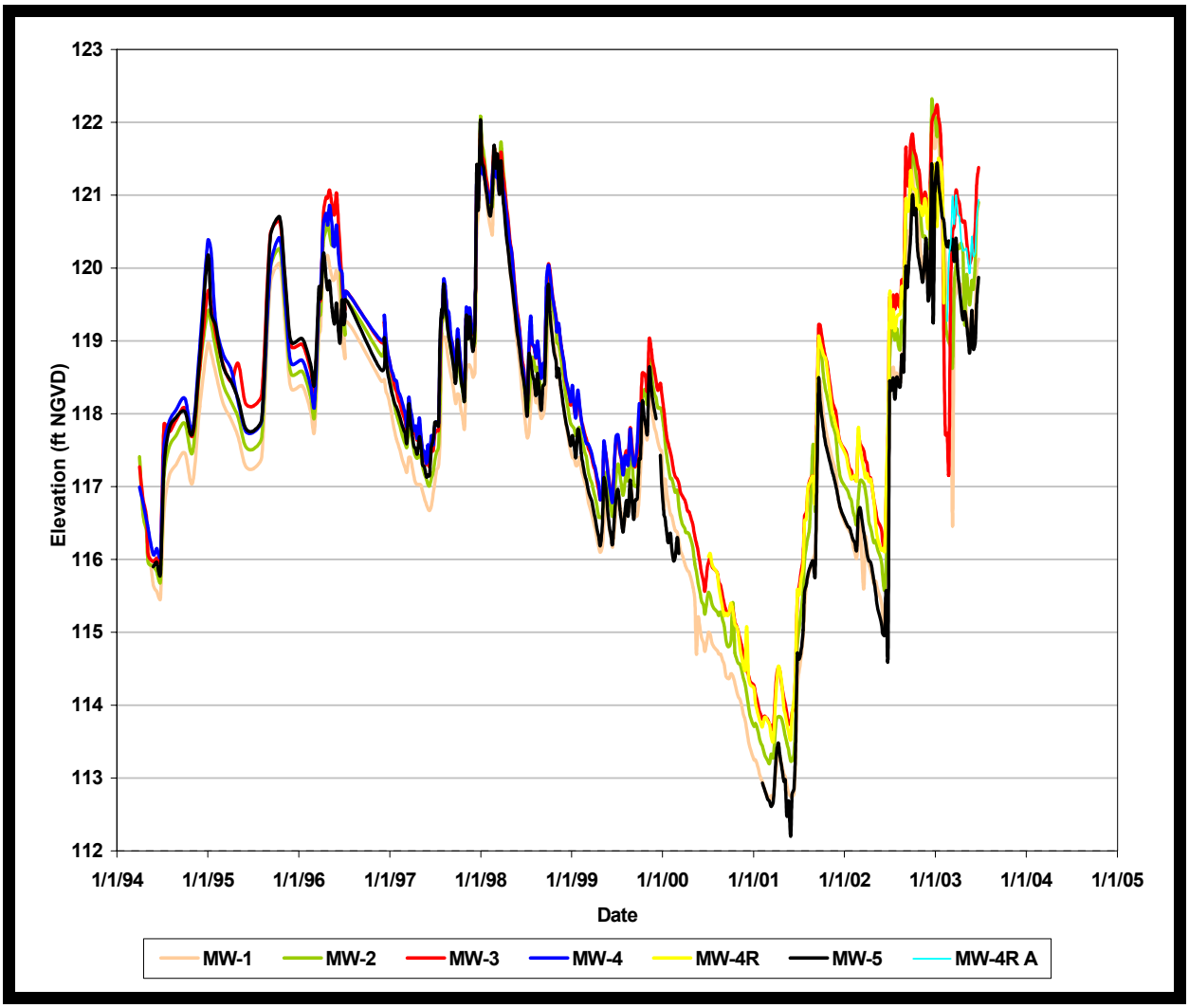

Exhibit 2. Water levels at Southlake Utilities, April 1994 through June 2003.

Exhibit 3 shows a comparison of 12-month, 6-month, and 3-month antecedent rainfall conditions for each of the aerial photographs.

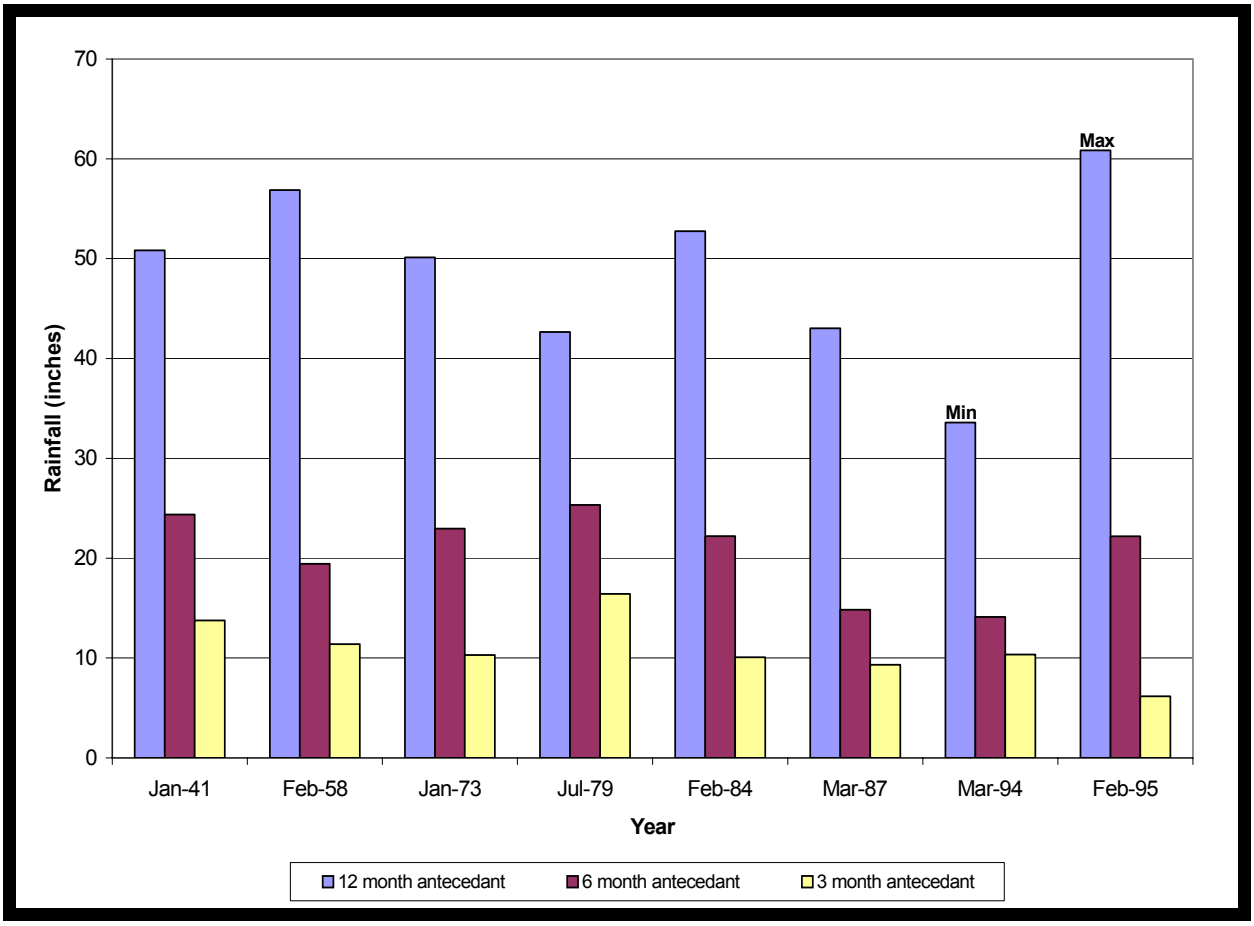

Exhibit 3. 12-month, 6-month and 3-month antecedent rainfall.

This data is also summarized in the following Table 1.

Table 1. Antecedent rainfall conditions						
Date of Aerial Photograph	12 month antecedent rainfall (inches)	6 month antecedent rainfall (inches)	3 month antecedent rainfall (inches)	Deviation from 12 month average (inches)	Deviation from 6 month average (inches)	Deviation from 3 month average (inches)
January 1941	50.84	24.36	13.77	2.00	3.68	2.80
February 1958	56.89	19.45	11.37	8.05	-1.23	0.40
January 1973	50.13	22.97	10.31	1.29	2.29	-0.66
July 1979	42.66	25.32	16.42	-6.18	4.64	5.45
February 1984	52.76	22.22	10.07	3.92	1.54	-0.90
March 1987	43.03	14.83	9.31	-5.81	-5.85	-1.66
March 1994	33.59	14.11	10.35	-15.25	-6.57	-0.62
February 1995	60.85	22.19	6.17	12.01	1.51	-4.80
Average	**48.84**	**20.68**	**10.97**			

Again, there is not a readily easily discernable correlation between rainfall and wetland conditions. The following general observations can be made.

- 1941 had slightly above average 12-month antecedent rainfall, with above average 6-month and 3-month antecedent rainfall
- 1958 was significantly above average for 12-month antecedent rainfall, slightly above average in 6 month antecedent rainfall, and slightly above average for 3 month antecedent rainfall
- 1973 was slightly above average for 12-month antecedent rainfall, with a drying trend in the 3-month antecedent rainfall
- 1979 shows a significant 12-month deficit, but with above average 6-month and 3-month antecedent rainfall.
- 1984 had above average 12-month antecedent rainfall, but with a drying trend in the 3-month antecedent rainfall.
- 1987 shows deficits in 12-month, 6-month and 3-month rainfall

- 1994 shows significantly below average 12-month antecedent rainfall, improving somewhat for the 3-month antecedent period.
- 1995 shows significantly above average 12-month antecedent rainfall, but with drying trend in the 3-month antecedent period

4.0 Depression Feature "E" near Southlake Perc Pond

Depressional feature "E" on Figure 11-1 is located near the Southlake Utilities perc pond. Survey data from that project is overlain on an aerial view of depressional feature "E" in Exhibit 4, below.

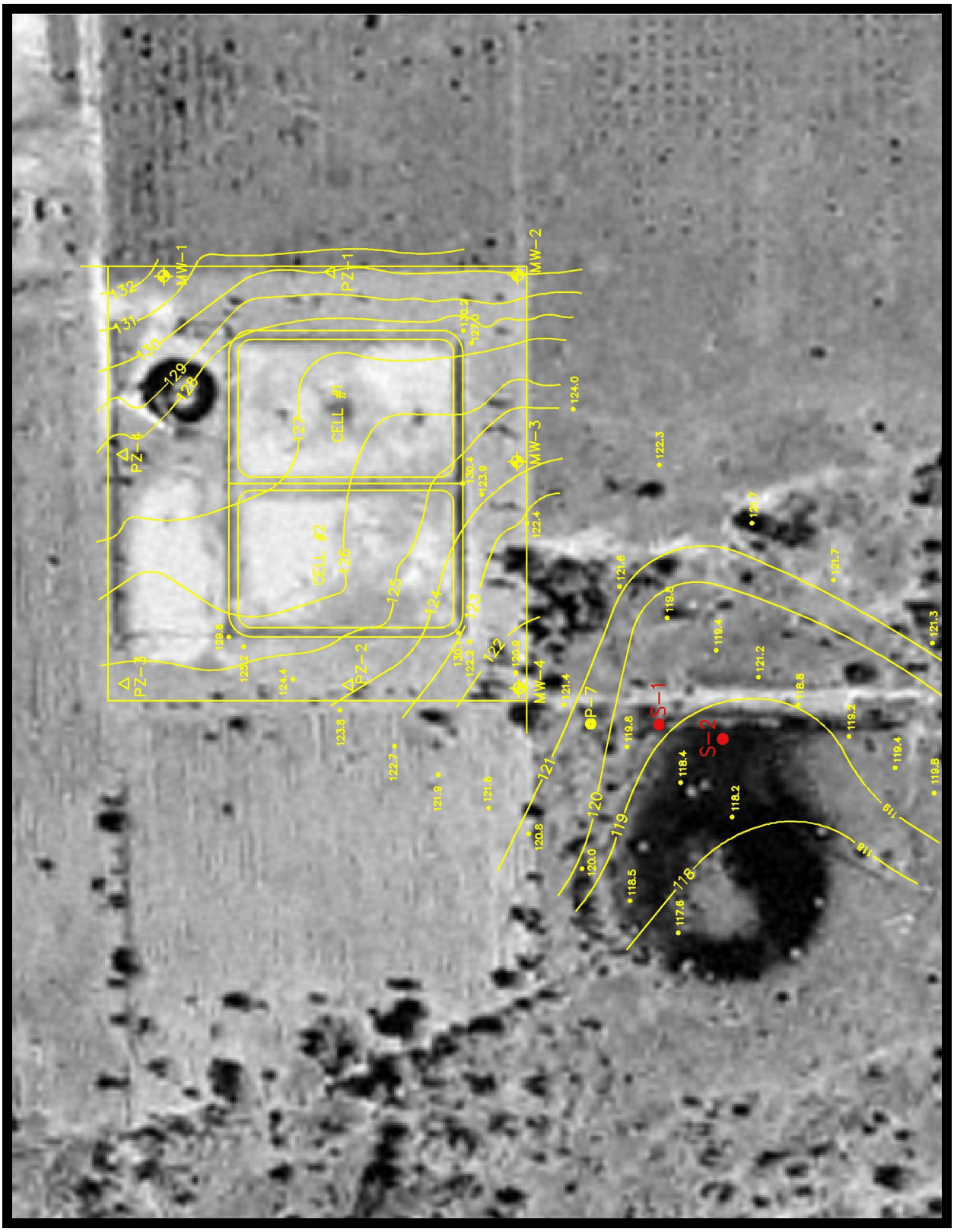

Exhibit 4. Depressional Feature "E" near Southlake perc ponds.

Survey data in depressional feature "E" indicated a range in elevations of between approximately +117.6 and +118.5 feet, which indicates that a drop in water table of roughly one foot at depressional feature "E" is sufficient to dry out the depression.

Measured surface water levels for staff gages S-1 and S-2 are shown in Exhibit 5 (below) along with water table/Floridan level for monitoring well MW-3.

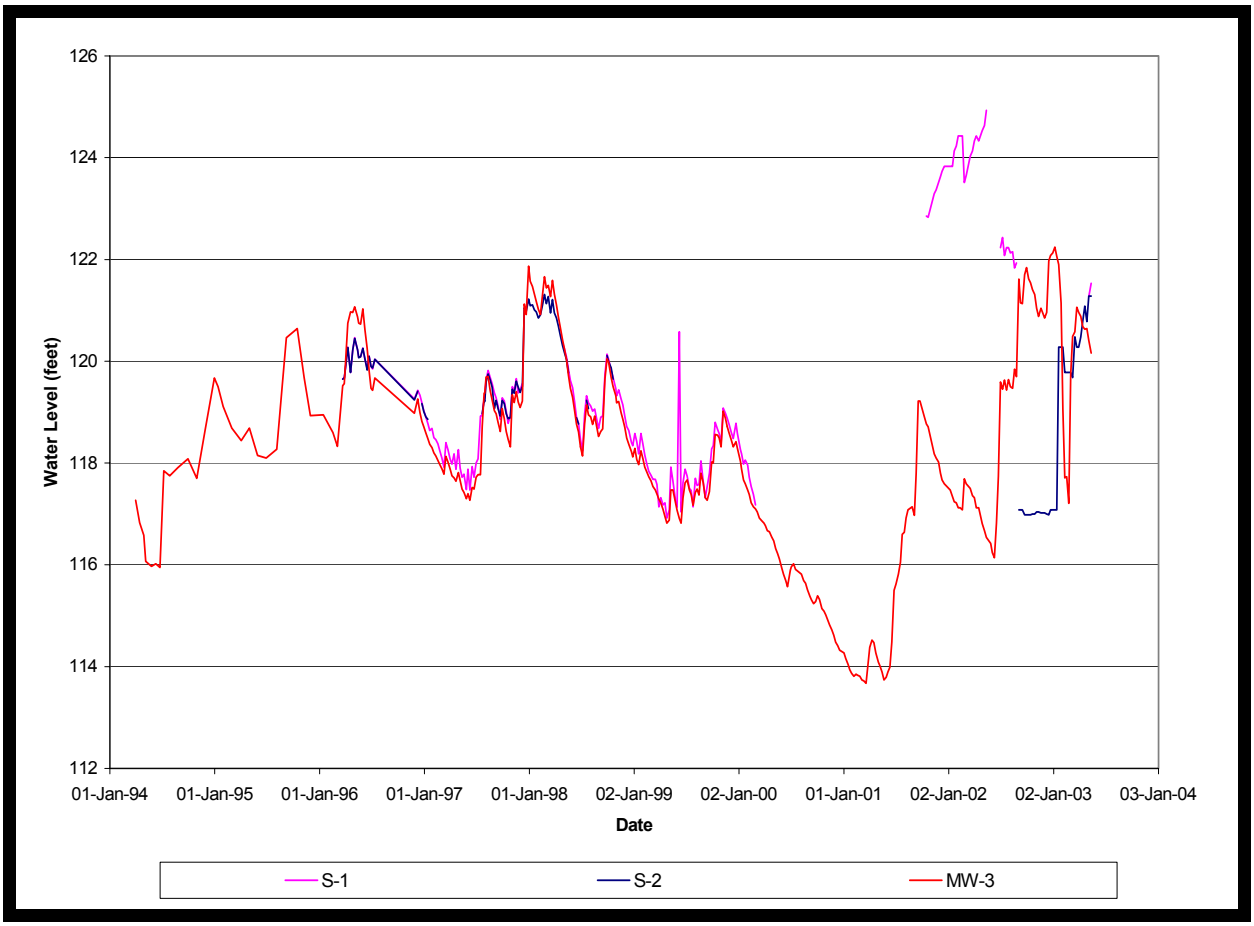

Exhibit 5. Surface water levels for staff gages S-1 and S-2 and aquifer pressure for MW-3

Note that the surface water levels at staff gages S-1 and S-2 closely reflect the Floridan aquifer pressure at MW-3, and that the fluctuation in water levels are sufficient to cause periodic drying of the depression.

On April 1, 1994, the water level at MW-3 was +117.27 feet. Between January 31, 1995 and March 2, 1995 the water level at MW-3 ranged between +119.11 feet and +118.69 feet. This correlates well to the observations that depressional feature "E" was dry in the February 1994 aerial, but wet in the February 1995 aerial.

5.0 REVIEW OF HISTORICAL POTENTIOMETRIC SURFACE IN THE GREEN SWAMP

5.1 Historical Maps of The Upper Floridan Aquifer for the Green Swamp

Exhibits 6 and 7 show the potentiometric surface in the Green Swamp for November 1959 and May 1962, respectively. These figures were originally published in the Report of Investigations No. 42, Hydrology of Green Swamp Area in Central Florida, by R. W. Pride, F. W. Meyer, and R. N. Cherry, Florida Geological Survey, 1966.

The yearly cumulative rainfall for the Clermont 7S weather station is shown in Exhibit 8. The rainfall data indicate that 1959 was a wet year (in a series of years with above average rainfall), and that 1962 was a dry year.

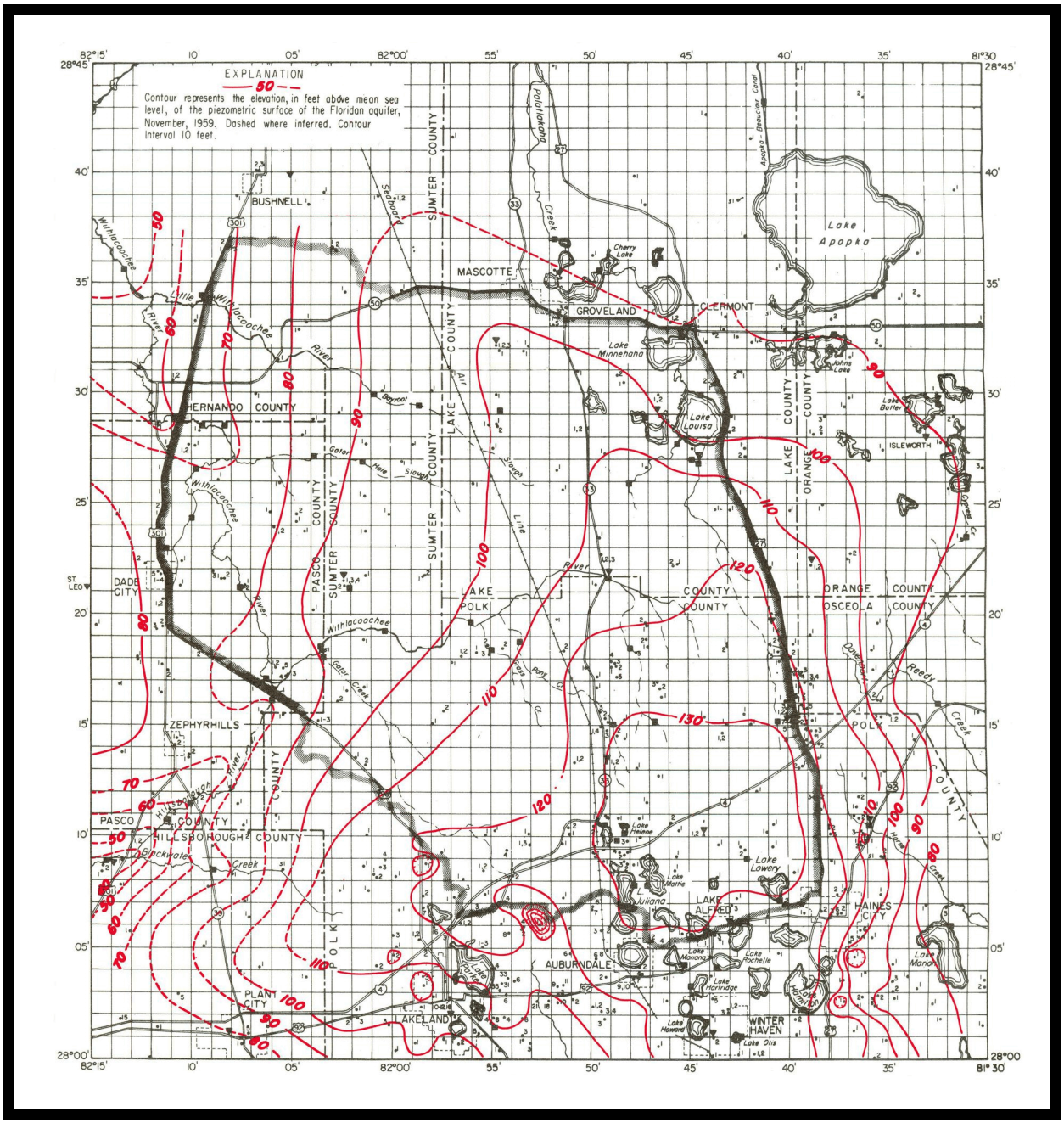

Exhibit 6. Floridan aquifer level in the Green Swamp, Nov 1959.

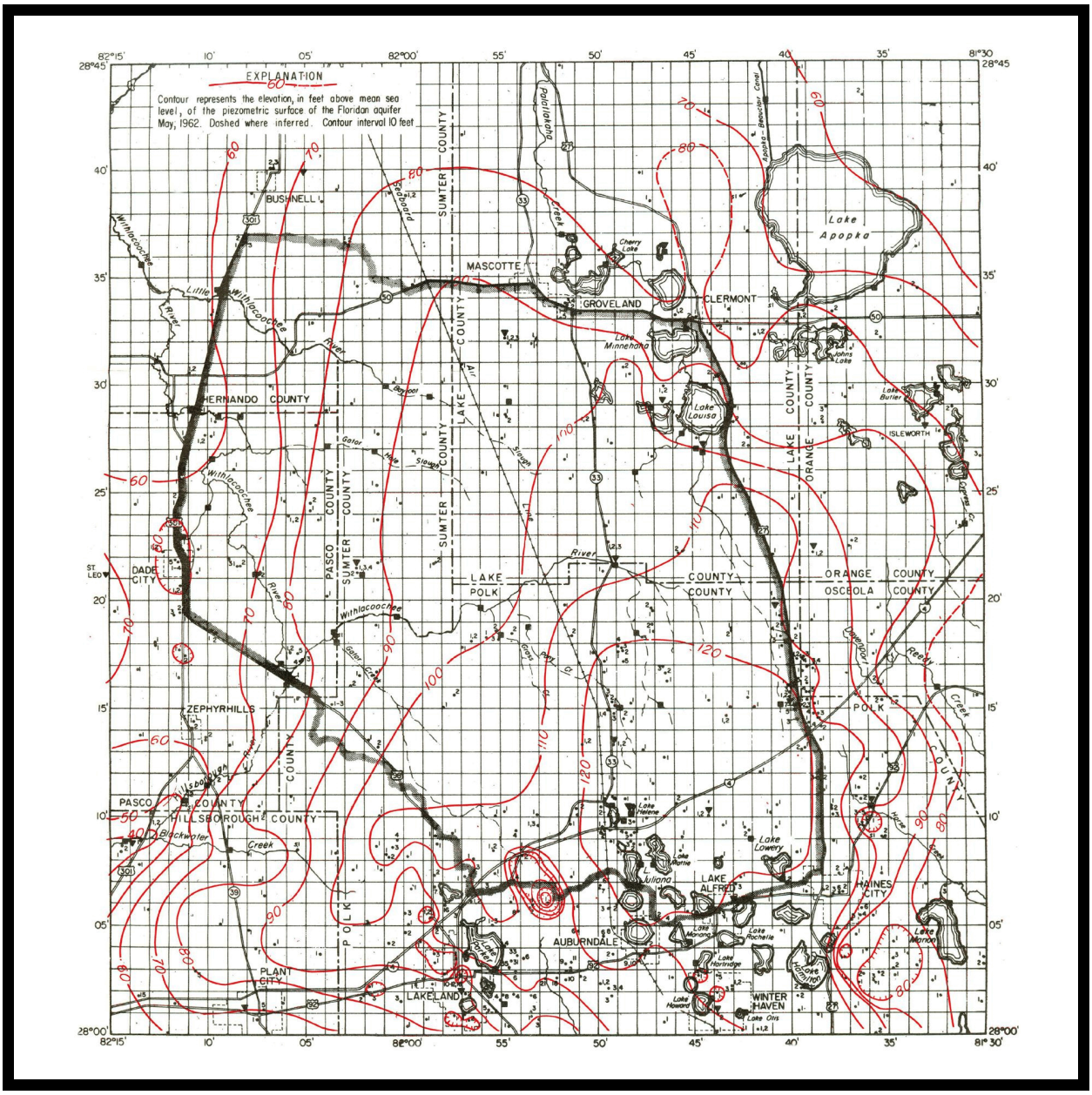

Exhibit 7. Floridan aquifer level in the Green Swamp, May 1962.

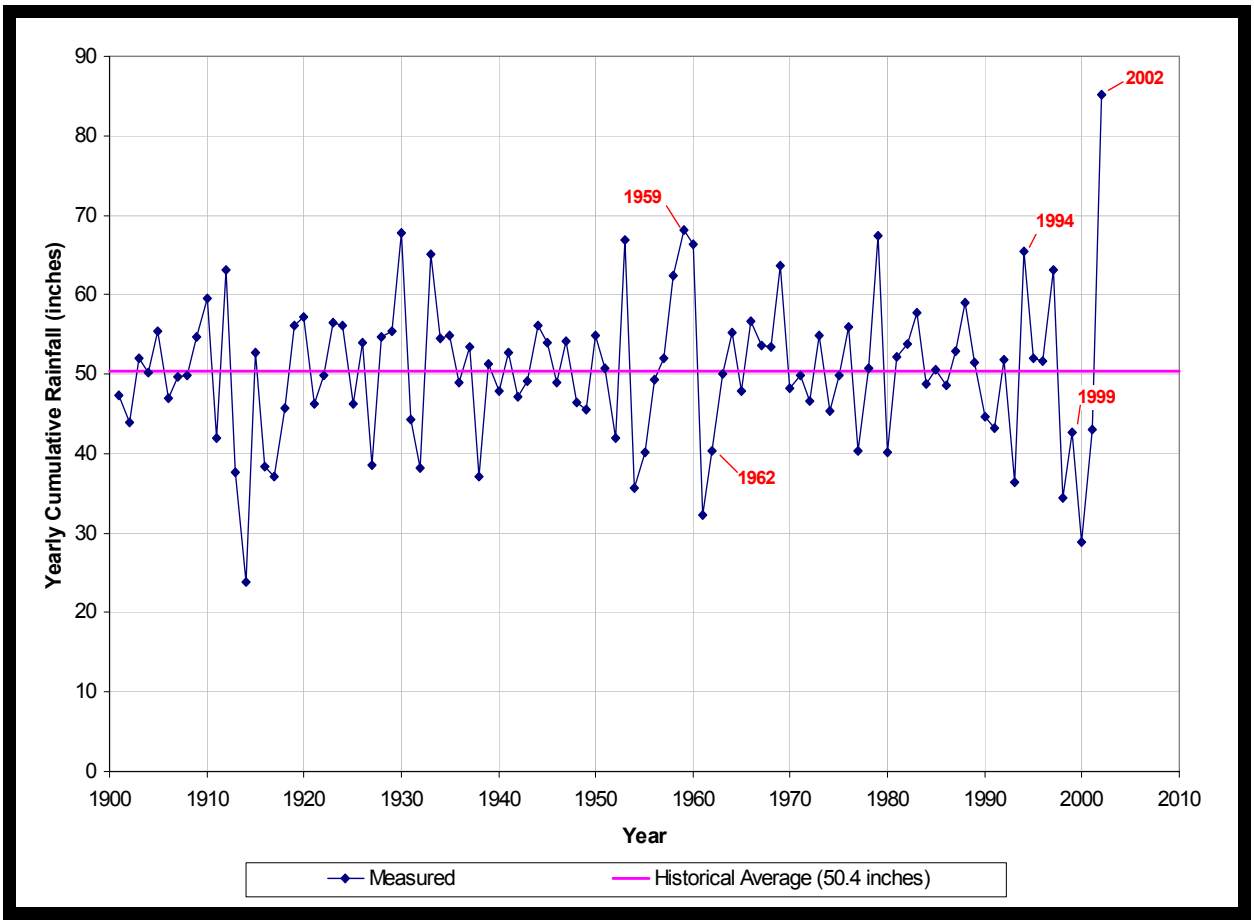

Exhibit 8. Yearly rainfall at Clermont 7S weather station.

Note that the cumulative rainfall for year 2002 (85.1 inches) is unprecedented in the 100-yr period of record for which data is available for the Clermont 7S weather station.

5.2 Selected Dates for Comparison to Historical Pot Surface

For the purpose of comparison of the potentiometric surface in Exhibits 6 and 7 to more recently published potentiometric surface maps, September 1994 was selected to represent a recent wet year, and May 1999 was selected to represent a recent dry year (refer to Exhibit 8). Table 1 (below) summarizes the general rainfall conditions and the dates of the potentiometric maps compared.

Table 2. Selected Dates for Comparison of Potentiometric Surface in the Green Swamp

General Rainfall Conditions	Date of Historical Pot Surface Map	Date of Recent Pot Surface Map Used for Comparison
Wet	November 1959	September 1994
Dry	May 1962	May 1999

5.3 Comparison of Historical and Recent Wet-Year Aquifer Levels

Exhibit 9 (below) shows the cumulative rainfall for the period of December 1 through November 30 for the years 1959 and 1994, as well as the average expected cumulative rainfall based on 50.4 inches per year of average rainfall. These data show the 12-month antecedent rainfall conditions for the representative wet-year potentiometric maps. Note that the 1994 map (to follow) is based on conditions for **September** 1994, whereas the 1959 map is based on conditions for **November** 1959. Nonetheless, the cumulative rainfall plot in Exhibit 9 indicates that both years represent above average rainfall conditions, and that the conditions in 1959 represent a slightly greater excess rainfall than 1994.

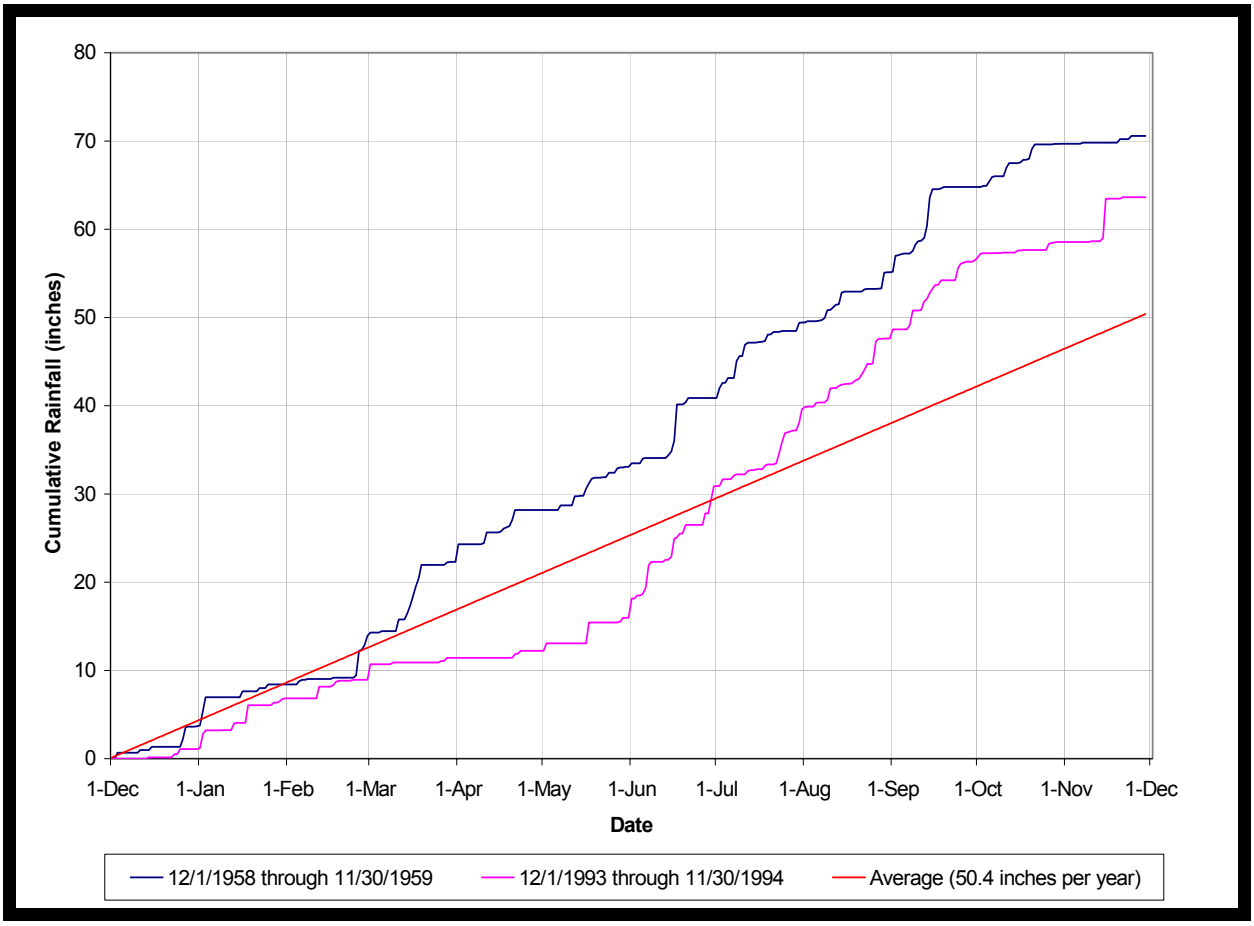

Exhibit 9. 12-month antecedent cumulative rainfall for Nov 1959 and Nov 1994.

Exhibit 10 (below) shows the potentiometric surface of the Upper Floridan aquifer for November 1959 (from Exhibit 6) superimposed on the potentiometric surface for September 1994, representing wet-year conditions.

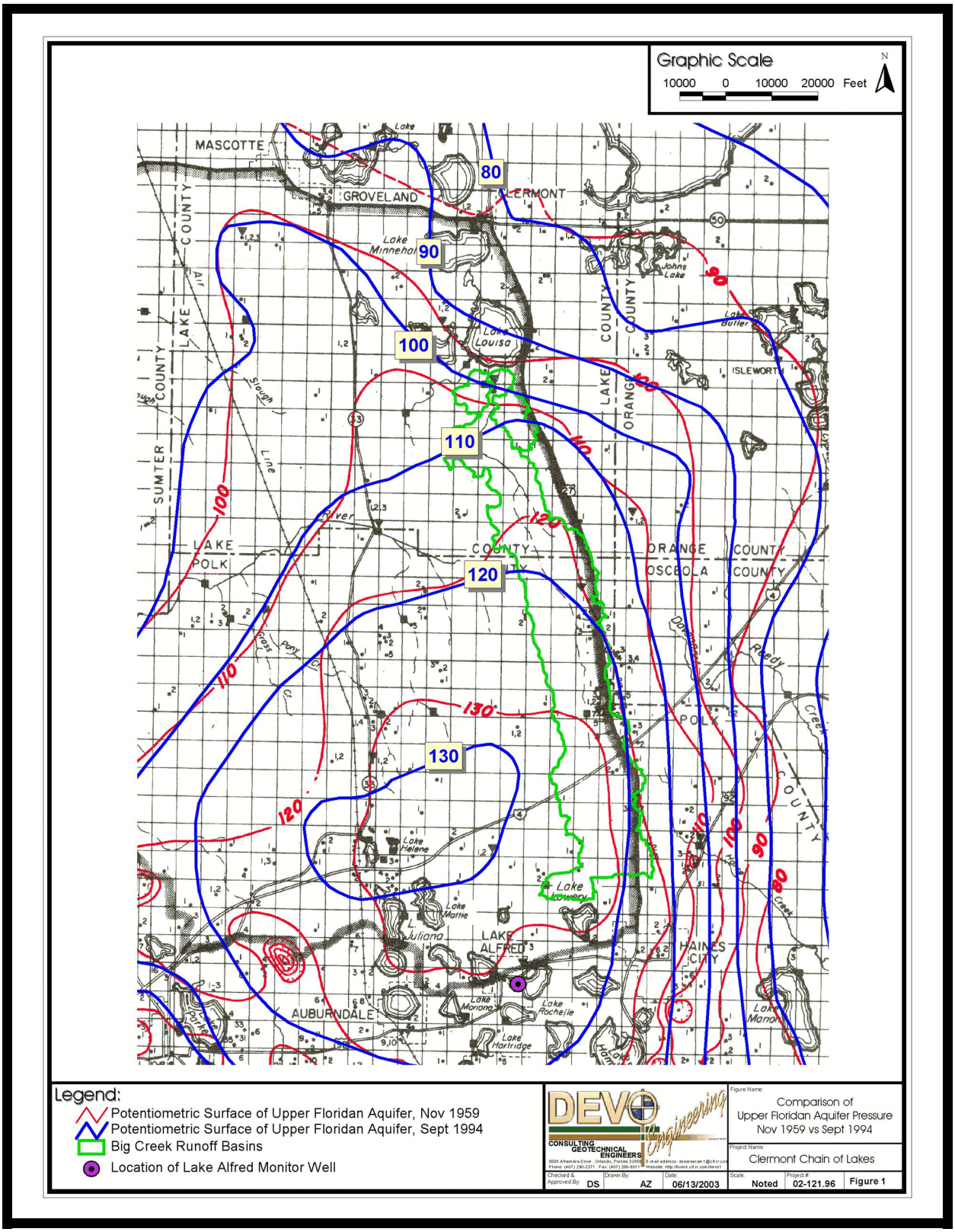

Exhibit 10. Upper Floridan aquifer levels for Nov 1959 and Sept 1994.

5.4 Comparison of Historical and Recent Dry-Year Aquifer Levels

Exhibit 11 (below) shows the cumulative rainfall for the period of June 1 through May 31 for the years 1962 and 1999, as well as the average expected cumulative rainfall based on an assumption of 50.4 inches per year of average rainfall. These data show the 12-month antecedent rainfall conditions for the dry-year potentiometric maps.

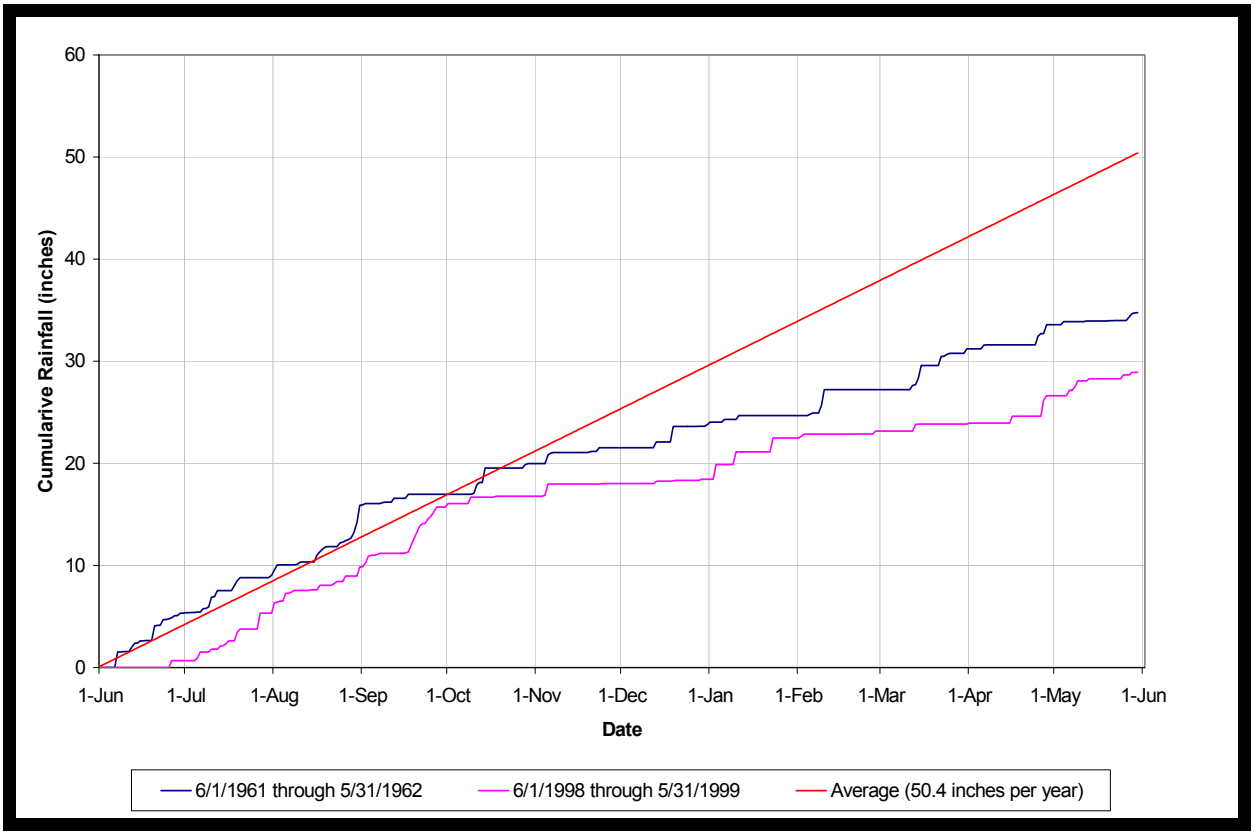

Exhibit 11. 12-month antecedent rainfall for May 1962 and May 1999

Exhibit 12 (below) shows the potentiometric surface of the Upper Floridan aquifer for May 1962 (from Exhibit 7) superimposed on the potentiometric surface for September 1994, representing dry-year conditions.

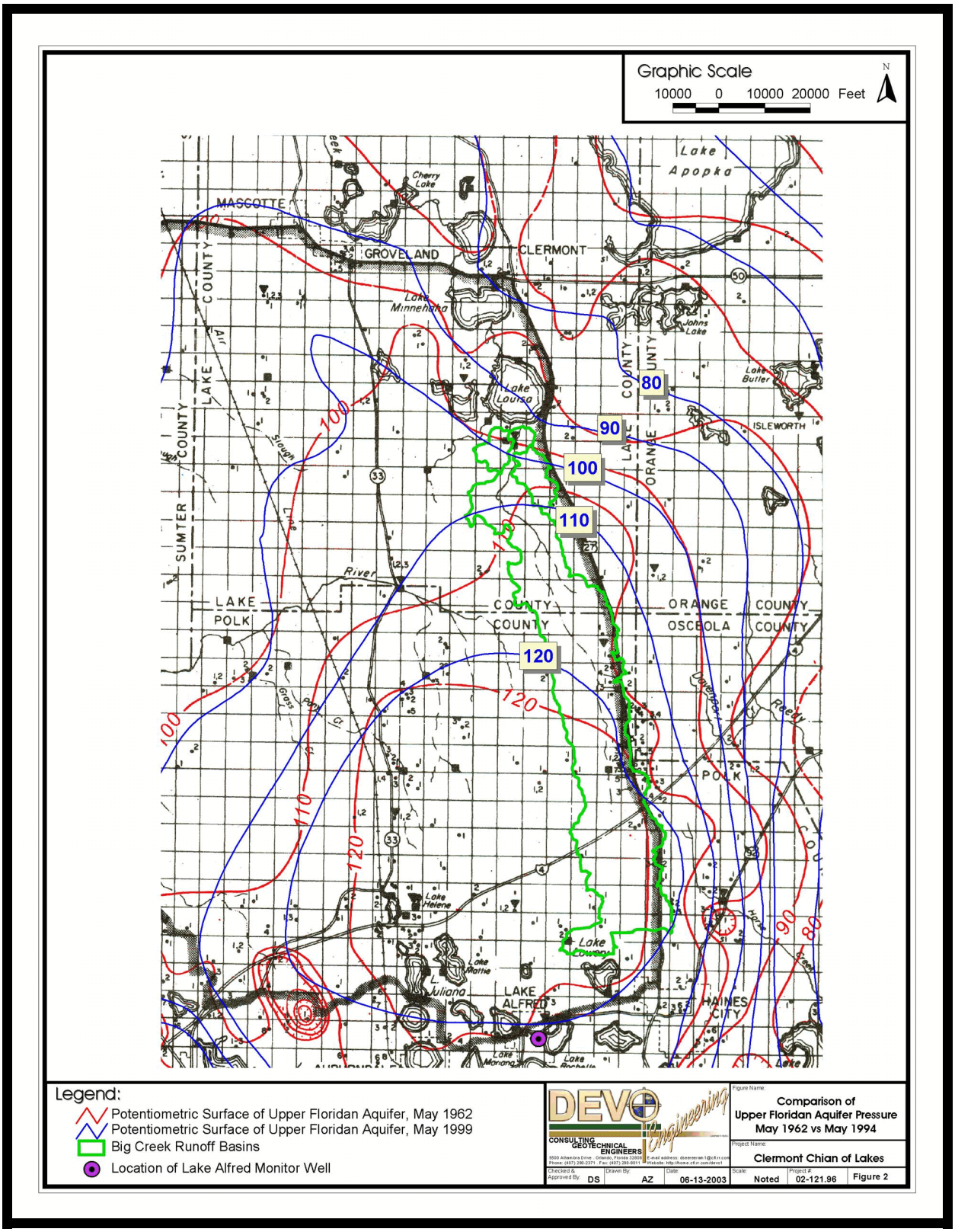

Exhibit 12. Upper Floridan aquifer levels for May 1962 and May 1999.

5.5 Observations on Green Swamp Aquifer Levels

Exhibit 10 and Exhibit 12 suggest that there has been no appreciable change in the potentiometric levels of the Upper Floridan aquifer within the Green Swamp, and in particular the Big Creek basin, between the late 1950's/early 1960's and present, when antecedent rainfall conditions are taken into account.

6.0 FLORIDAN AQUIFER LEVELS AT LAKE ALFRED DEEP WELL

The Lake Alfred deep well (USGS well #280531081431601) is located near the southern edge of the Green Swamp as shown in the preceding Exhibits 10 and 12. Aquifer level data for the Lake Alfred deep well are available for the period of record between May 18, 1971 and May 29, 2003, as shown in Exhibit 13 (below). Although the period of record is somewhat limited, the data do not indicate a trend towards an overall reduction of aquifer levels with time. The data may, in fact, suggest that there has been a slight increase in aquifer pressures, from the mid 1980's through late 1990's, corresponding to the cessation of commercial citrus cultivation in the area, following the hard freezes of 1983/1984 and a reduction in pumping from the Polk County phosphate mines.

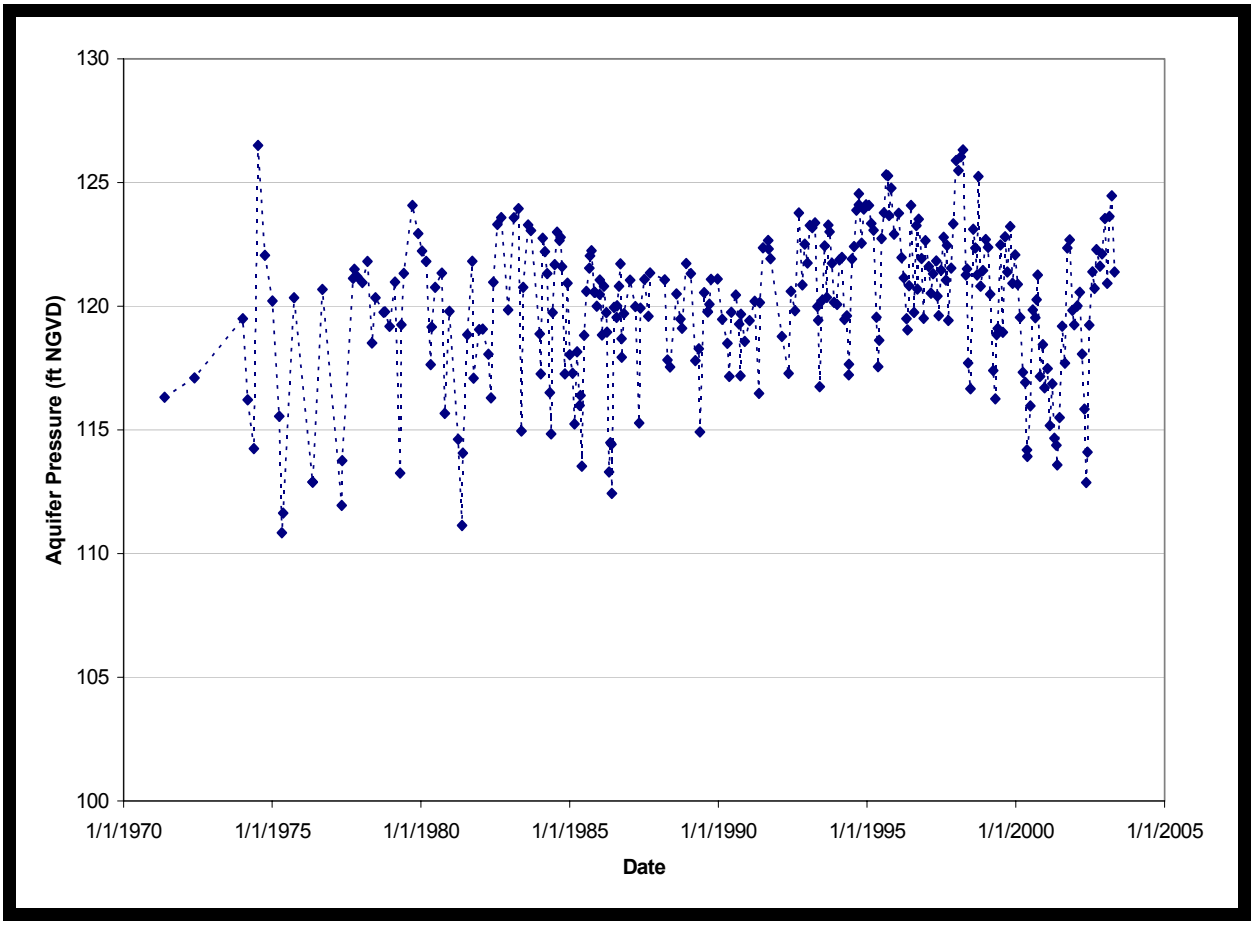

Exhibit 13. Floridan aquifer levels at Lake Alfred deep well.

7.0 CONCLUSIONS

Based on our review of historical aerials, there does not appear to be any change in the Green Swamp wetland limits in the representative area near Southlake Utilities.

In addition, the fluctuation between relative wet and dry conditions in the wetland appears to be within the range of conditions which can be attributed to normal fluctuations in the potentiometric heads in the Floridan aquifer.

A review of potentiometric heads in the Upper Floridan aquifer for the Green Swamp, which includes the contributing runoff basins for Big Creek, does not indicate an appreciable change in aquifer levels between the late 1950's/early 1960's and recent (1990's) aquifer levels, when antecedent rainfall conditions are considered.

This suggests that there has not been any long term drying in the Green Swamp during the period for which aerial photographs were available (1941 to present), which may be attributed to over-pumping of the Floridan aquifer.

FIGURES

NORTH

GRAPHIC SCALE

1 INCH = 1,000 FEET

500 0 250 500 1,000 2,000

A

H

B

C

Southlake
Perc. Ponds

D

E

F

G

J

I

Please note: Photograph taken February 1995

DEVO Engineering

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Phone: (407) 290-2371 . Fax: (407) 298-9011
E-Mail addresss: devo@devoeng.com
Website: http://www.devoeng.com

Figure Name:

Wetland Survey Reference Points

Project Name:

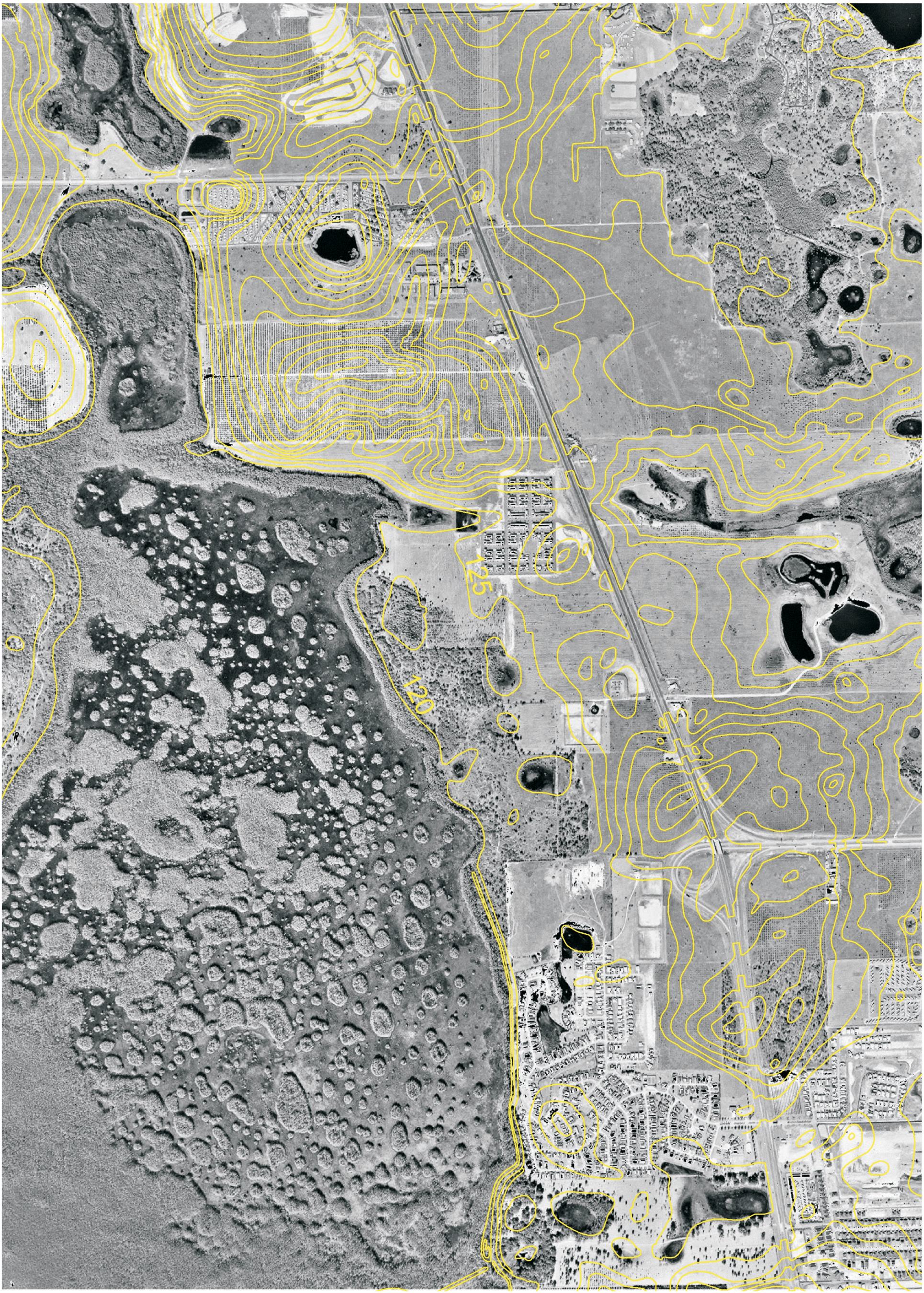
Clermont Chain of Lakes

Checked & Approved By:	Drawn By:	Date:	Scale:	Project #	
DS	AZ	06/25/03	NOTED	02-121.96	FIGURE 11-1

Graphic Scale

500 0 500 1000 1500 2000 Feet

N



Photograph taken February 1995

DEVO Engineering

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Website: http://home.cfl.rr.com/devo1

Figure Name: Five-foot Topographic Contours Wetland Area Near Southlake Utilities

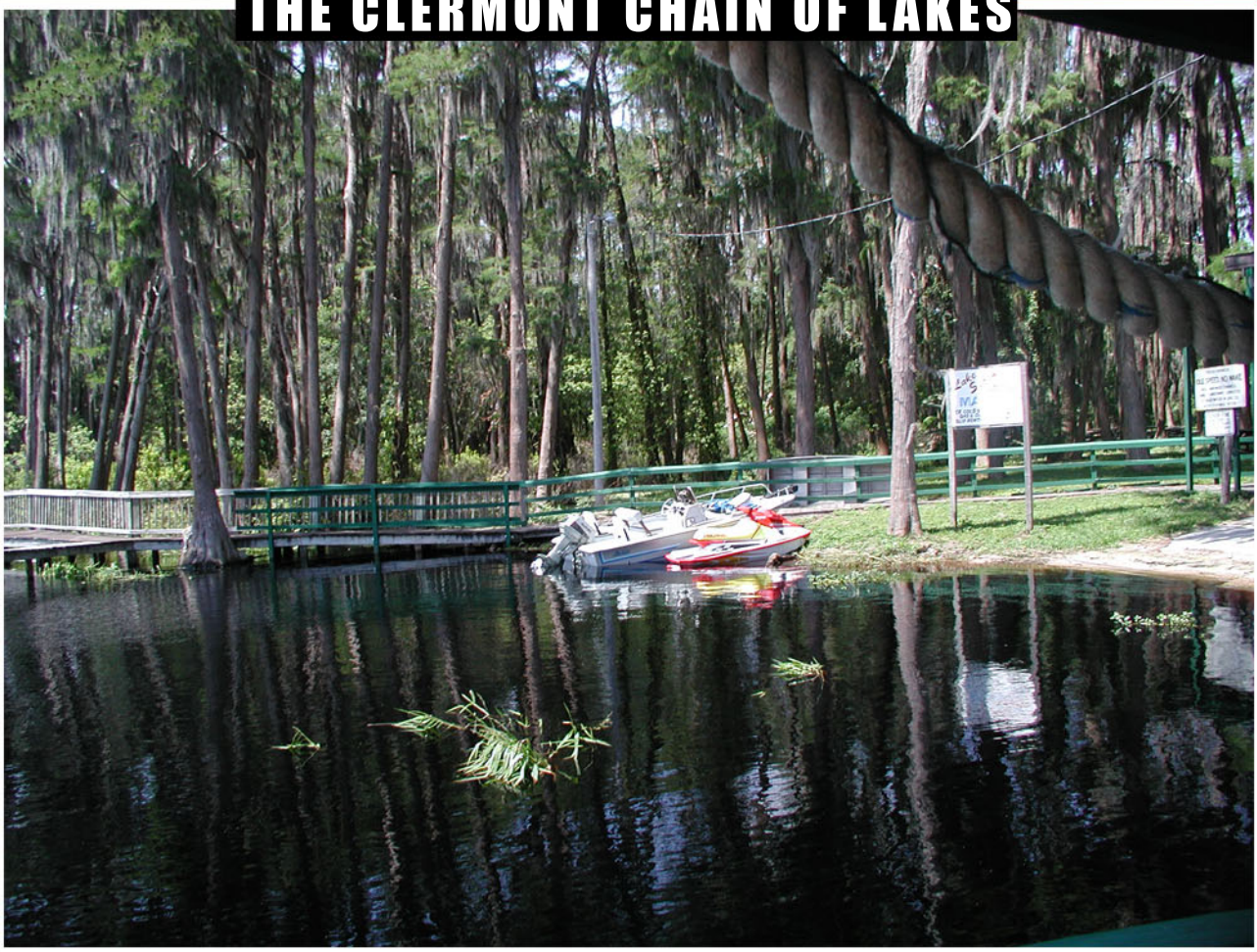
Project Name: Clermont Chain of Lakes

Checked & Approved By:	Drawn By:	Date:	Scale:	Project #:	
DS	AZ	05-21-2003	Noted	02-121.96	Figure 11-2

TECHNICAL MEMO #12: PHOTO SEQUENCE FOR...

GROUND WATER/SURFACE WATER INTERACTION MODELING FOR PORTION OF SOUTH LAKE COUNTY (FL) WHICH ENCOMPASSES THE CLERMONT CHAIN OF LAKES

THE CLERMONT CHAIN OF LAKES



Prepared for

LCWA

Lake County Water Authority

PEC

Professional Engineering Consultants, Inc.

Prepared by

DEVO Engineering

CONSULTING GEOTECHNICAL ENGINEERS

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e-mail: devo@devoeng.com | www.devoeng.com

Date: May 21, 2003	*Devo's Project No.* 02-121.96
To: Lake County Water Authority 107 North Lake Avenue Tavares, Fl 32778-3119 phone: 352-343-3777 fax: 352-343-4259 attention: LANCE LUMBARD	*cc:* Professional Engineering Consultants, Inc. 200 East Robinson Street, Suite 1560 Orlando, FL 32801 phone: 407-422-8062 fax: 407-849-9401 attention: DAVID HAMSTRA, P.E.

Ref:

TECHNICAL MEMO #12
PHOTO SEQUENCE FOR...
GROUND WATER/SURFACE WATER INTERACTION MODELING FOR PORTION OF SOUTH LAKE COUNTY (FL) WHICH ENCOMPASSES THE CLERMONT CHAIN OF LAKES

Dear Mr. Lumbard:

Attached is the sequence of photos taken at various locations within the Clermont Chain of Lakes from July 2002 to April 2003.

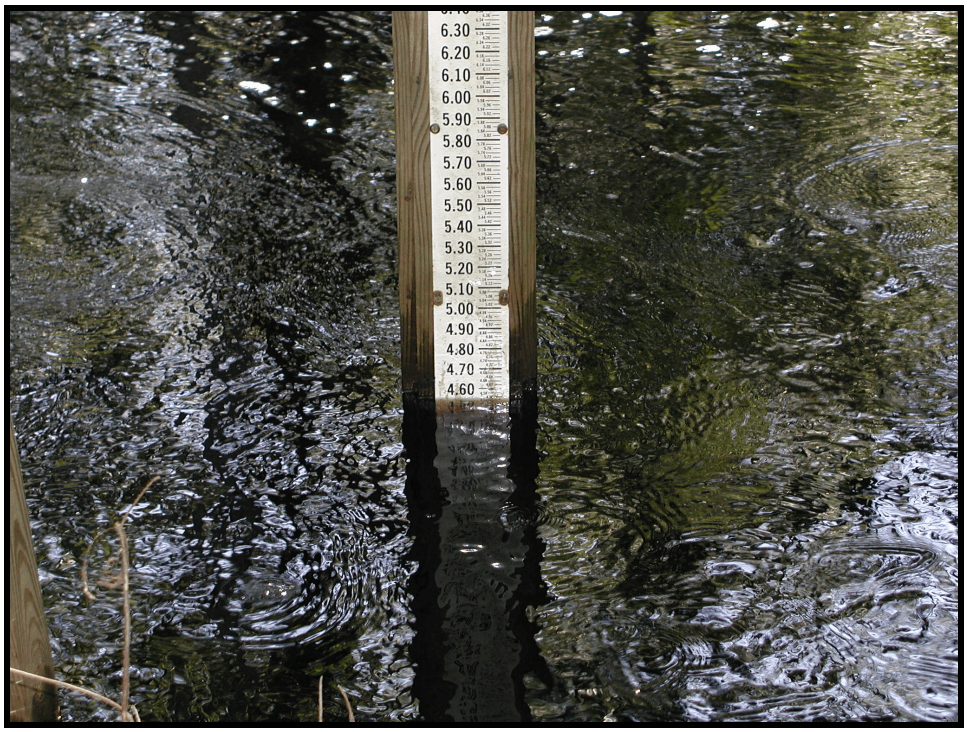
Sincerely,
Robert Casper
Robert D. Casper, E.I.
Project Engineer

PHOTO SEQUENCE

Staff Gage at Big Creek Gaging Station



July 14, 2002



September 10, 2002

STAFF GAGE AT BIG CREEK GAGING STATION *continued...*



January 26, 2003



April 18, 2003

Lake Louisa State Park, Beach



July 14, 2002



September 10, 2002

LAKE LOUISA STATE PARK, BEACH *continued...*



January 26, 2003



April 18, 2003

Crooked River Preserve, Palatlakaha River, Looking North



July 14, 2002



September 10, 2002

CROOKED RIVER PRESERVE, PALATLAKAHA RIVER, LOOKING NORTH *continued...*



January 26, 2003



April 18, 2003

Lake Susan Lodge Dock



July 14, 2002



September 10, 2002

LAKE SUSAN LODGE DOCK *continued...*



January 26, 2003



April 18, 2003

Lake Susan Lodge Boathouse



July 14, 2002



September 10, 2002



January 26, 2003



April 18, 2003

Monte Vista Canal, Looking Towards Crescent Lake



June 10, 2002



September 10, 2002

Monte Vista Canal, Looking Towards Crescent Lake *continued...*



January 26, 2003



April 18, 2003

Monte Vista Canal, Boathouse on Lake Minnehaha



June 10, 2002



September 10, 2002

MONTE VISTA CANAL, BOATHOUSE ON LAKE MINNEHAHA *continued...*



January 26, 2003



April 18, 2003

CR 565 A Bridge, View From Lake Minnehaha Side



June 10, 2002



September 10, 2002

CR 565 A Bridge, View From Lake Minnehaha Side *continued...*



January 26, 2003



April 18, 2003

CR 561A Bridge, Looking Towards Lake Minneola



June 10, 2002



September 10, 2002

CR 561A Bridge, Looking Towards Lake Minneola *continued...*



January 26, 2003



April 18, 2003



June 10, 2002



September 10, 2002



January 26, 2003



April 18, 2003

Cherry Lake Discharge Structure, Upstream Face



June 22, 2002



September 10, 2002

CHERRY LAKE DISCHARGE STRUCTURE, UPSTREAM FACE *continued...*



January 26, 2003



April 18, 2003

TECHNICAL MEMO #13: LIST OF REFERENCES FOR...

GROUND WATER/SURFACE WATER INTERACTION MODELING FOR PORTION OF SOUTH LAKE COUNTY (FL) WHICH ENCOMPASSES THE CLERMONT CHAIN OF LAKES

THE CLERMONT CHAIN OF LAKES



Prepared for

LCWA

Lake County Water Authority

PEC

Professional Engineering Consultants, Inc.

Prepared by

DEVO Engineering

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To: Lake County Water Authority 107 North Lake Avenue Tavares, Fl 32778-3119 phone: 352-343-3777 fax: 352-343-4259 attention: **LANCE LUMBARD**	*cc:* Professional Engineering Consultants, Inc. 200 East Robinson Street, Suite 1560 Orlando, FL 32801 phone: 407-422-8062 fax: 407-849-9401 attention: **DAVID HAMSTRA, P.E.**
LCWA Lake County Water Authority	PEC

Ref:

TECHNICAL MEMO #13
LIST OF REFERENCES FOR...
GROUND WATER/SURFACE WATER INTERACTION MODELING FOR PORTION OF SOUTH LAKE COUNTY (FL) WHICH ENCOMPASSES THE CLERMONT CHAIN OF LAKES

Dear Mr. Lumbard:

Attached are the list of references used in completing this study.

Sincerely,
Robert Casper
Robert D. Casper, E.I.
Project Engineer

References

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Technical Memo 10.1

Quantitative Impact Of Floridan Aquifer Pumping On Clermont Chain Of Lakes Water Levels...



Prepared for

Lake County Water Authority

Professional Engineering Consultants, Inc.

Prepared by

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Date: May 27, 2003	*Devo's Project No.* 02-121.96
To: Lake County Water Authority 107 North Lake Avenue Tavares, Fl 32778-3119 phone: 352-343-3777 fax: 352-343-4259 attention: **LANCE LUMBARD** LCWA Lake County Water Authority	*cc:* Professional Engineering Consultants, Inc. 200 East Robinson Street, Suite 1560 Orlando, FL 32801 phone: 407-422-8062 fax: 407-849-9401 attention: **DAVID HAMSTRA, P.E.** PEC
Ref: **TECHNICAL MEMO 10.1** **QUANTITATIVE IMPACT OF FLORIDAN AQUIFER PUMPING ON CLERMONT CHAIN OF LAKES WATER LEVELS...** **CLERMONT CHAIN OF LAKES STUDY**	

Dear Mr. Lumbard:

The attached technical memo quantifies the impact of ground water withdrawals from the Floridan aquifer on surface water levels in the *Clermont Chain of Lakes* for rainfall periods which are ① normal, ② above average, and ③ below average.

The calibrated continuous simulation model for the Clermont Chain of Lakes--the original setup of which was described in our *Technical Memo #5 – Continuous Simulation Model Results*--predicts that:

❶ during normal and wet rainfall years, the lake levels are virtually indistinguishable for the scenarios with and without groundwater withdrawals from the Floridan aquifer, and

❷ even under the worst of the recent drought conditions {i.e., the period 1998 to 2001}, the model predicts that the lake level would have declined 8.49 ft without

pumping from the Floridan aquifer and 8.75 ft with pumping. This accounts for about 3% of the observed decline which clearly indicates that pumping from the Floridan aquifer is not the primary cause of the drop in Clermont Chain lake levels.

We trust that this memo is written in a clear manner and the modeling results presented answers to the questions which were posed at the outset of this study.

Sincerely,
Robert Casper
Robert D. Casper, E.I.
Project Engineer

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1.0 INTRODUCTION

A modeling simulation was performed to quantify the difference in predicted water surface elevations in the Clermont Chain of Lakes for the following scenarios:

PUMPING (I.E., GROUND WATER WITHDRAWALS FROM FLORIDAN AQUIFER)	RAINFALL	
	DROUGHT	NORMAL
No net ground water withdrawals from Upper Floridan aquifer	✔	✔
Net ground water withdrawals from Upper Floridan aquifer corresponding to existing conditions	✔	✔

For the purpose of this technical memo, the "Floridan aquifer" refers to the "Upper Floridan aquifer" which is described in *Technical Memo #4 titled Hydrogeologic Overview of Study Area – Clermont Chain of Lakes Study.*

The objective of this model is to isolate the maximum surficial aquifer drawdown impacts due to Floridan pumpage and to evaluate if this pumpage is a significant contributor to the observed drop in lake levels. Over the past 10-15 years, the Clermont area has experienced significant growth with former citrus grove land being transformed into commercial/residential/golf course development. Potable and irrigation water needs for these new projects are obtained from wells tapping the Floridan aquifer. There is a concern in the community that the resulting ground water withdrawals from the Floridan aquifer may have caused drawdown impacts in the overlying surficial aquifer which intersects the water bodies forming the Clermont Chain of Lakes.

Predictive simulations were performed using the calibrated continuous hydrologic model documented in *Technical Memo #5 titled "Continuous Simulation Model Results"*. As previously described, this model is developed using the MODFLOW-based Refined Method Module of the PONDS 3.2 software and the selected simulation period is January 1, 1994 through November 30, 2001. This time span covers a range of very wet years and periods of extreme drought; it provides insight into the system hydrology for some very wet and very dry antecedent conditions.

We have made the following conservative and simplifying assumptions in incorporating the Floridan aquifer ground water withdrawal into the model:

- Net ground water withdrawal from the Floridan aquifer is assumed to be derived solely from vertical recharge from the overlying surficial aquifer in the vicinity of the study area. In reality, the Floridan aquifer in the Clermont Chain of Lakes vicinity is recharged by

❶ Lateral flow in the Floridan from areas to south (i.e., Green Swamp),
❷ Vertical downward flow from the overlying surficial aquifer, and
❸ Vertical upward flow from the underlying Lower Floridan aquifer.

This assumption is conservative in that it produces the maximum drawdown impact on the surficial aquifer and the water surface elevations in the Chain of Lakes.

➦ On a county-wide basis, the domestic self-supplied water withdrawals is about 3.2% of the total withdrawal based on USGS studies. We have conservatively assumed that domestic self-supplied water withdrawals component is 10% of the permitted withdrawals within our "boundary of interest" (see Figure 10.1-1).

2.0 TOTAL FLORIDAN AQUIFER GROUNDWATER EXTRACTION RATES IN STUDY AREA

A 2000± ft buffer was drawn around the lakes (starting with Lake Louisa in the south and ending at Cherry Lake in the north) and this "boundary of interest" is shown in Figure 10.1-1 (attached). *(See the attached Appendix A for a discussion of of model boundary selection)*.

The locations of the inventoried wells within and adjacent to the "boundary of interest" is also shown on this basemap. Permitted/estimated pumping rates for these wells are summarized in Table 1 {note: this data was extracted from *Technical Memo #09 - Inventory of Water Use Permits Within Model Domain*}.

The total estimated pumping rate for all permitted wells identified within the buffer zone is 381,684 ft^3/day (not including domestic self-supplied wells). If, as previously discussed, this Floridan withdrawal is 100% replenished by recharge from the overlying surficial aquifer, an areal recharge rate of 1.82 inch/year within the "boundary of interest" is equivalent to the pumpage total in Table 1.

On a county-wide basis, the domestic self-supplied water withdrawals is about 3.2% on average in Lake County (note: this data was presented previously in *Technical Memo #10 – Final - Floridan Aquifer Drawdown Model for Big Creek and Little Creek Basins*). For the purpose of this conservative analysis, we have assumed that the ratio is 10% within the "boundary of interest" and this assumptions increases the vertical recharge rate from 1.80 to 2.00 inch/year.

Note that this pumping rate is slightly lower than the average pumping rate of 3.03 inch/year calculated over the entire model domain (refer to *Technical Memo #10 – Final - Floridan Aquifer Drawdown Model for Big Creek and Little Creek Basins)*.

Table 1. Floridan aquifer wells within 2000 ft. buffer zone (not including self-supplied domestic wells)						
Permit Number	**Estimated Pumping Rate (ft^3/day)**	**X Coordinate (m)**	**Y Coordinate (m)**	**Well Diameter (inches)**	**Station ID**	**Project Name**
1666	327	423,325	3,155,089	4	9440	Green Hollow Nursery
1666	735	423,325	3,155,058	6	18813	Green Hollow Nursery
2478	14,000	423,998	3,158,285	12	9167	City of Clermont
2478	14,000	424,624	3,158,312	12	9168	City of Clermont
2478	9,600	425,410	3,158,061	10	9169	City of Clermont
2594	1,921	418,955	3,163,828	10	9547	Cherry Lake Farms
2594	4,917	419,446	3,164,071	16	9553	Cherry Lake Farms
2594	1,921	419,283	3,164,103	10	9554	Cherry Lake Farms
2700	9,600	427,093	3,153,372	10	9930	Lake Utility Services Inc.
2700	6,400	426,930	3,153,465	8	9931	Lake Utility Services Inc.
2842	4,563	421,765	3,161,531	8	10381	Clergrove
2847	6,405	429,235	3,152,405	10	18880	Vacation Village
2847	4,099	428,881	3,152,345	8	18881	Vacation Village
2849	1,859	422,539	3,159,464	4	10398	Clermont West Sand Mine
2849	14,000	422,539	3,159,557	12	10399	Clermont West Sand Mine
2886	7,568	426,812	3,160,575	8	10512	Oak Valley WTP
2893	1,505	429,696	3,152,279	6	10527	Torchlite Trailer Park
2913	7,834	424,627	3,163,082	12	10569	Palisades
2913	13,928	423,563	3,162,443	16	10570	Palisades
2913	7,834	424,655	3,163,236	12	10571	Palisades
2913	7,834	424,655	3,163,205	12	18907	Palisades
2926	7,990	420,566	3,165,079	10	10592	Mantione Grove
2926	1,278	420,648	3,165,078	4	10594	Mantione Grove
4501	16,011	426,030	3,157,256	8	18858	GOLDEN GROVES #6
50135	31,253	423,697	3,162,134	8	425	Palisades Golf Course
50135	31,253	423,588	3,162,012	8	426	Palisades Golf Course
50135	7,813	423,806	3,162,103	4	427	Palisades Golf Course
50135	17,580	423,672	3,162,473	6	428	Palisades Golf Course
50430	3,194	424,357	3,163,269	10	19885	Umatilla Grove
64455	45,526	428,807	3,153,577	14	9236	The Legends
64455	33,448	428,888	3,153,576	12	9237	The Legends
64455	23,228	428,753	3,153,731	10	9238	The Legends
66769	14,000	421,592	3,164,179	12	31883	Cherry Lake Golf Course at the Summit
66769	1,859	421,807	3,163,747	4	31884	Cherry Lake Golf Course at the Summit
66769	6,400	421,107	3,164,767	8	31885	Cherry Lake Golf Course at the Summit
	381,683	**TOTAL**				

3.0 NET FLORIDAN AQUIFER GROUNDWATER EXTRACTION RATES IN STUDY AREA

A large fraction of the total ground water withdrawn from the Floridan aquifer is returned to the aquifer as recharge. The potable water component is returned to the aquifer via wastewater percolation ponds and septic leachfields. Excess landscape irrigation water also passes the soil-root zone and recharges the aquifer. Net consumption of water is represented by these losses:

- The increase in evapotranspiration (ET) resulting from a change in the vegetative ground cover; for example, the ET for a well watered golf course green will be higher than deforested rangeland on the ridges without artificial irrigation. This difference could be 15 to 20 inches per year (i.e., 35 in/yr vs. 55 in/yr).

- The use of lined ponds or creation of lakes in upland areas has the same net ET loss effect described above.

Some of the net ET losses described above are offset by the addition of impervious area where the predevelopment ET loss is reduced to zero. For example, consider a 100 acre development tract which introduces 50 acres of impervious cover and 50 acres of well irrigated landscape. The predevelopment ET is 35 in/yr while the postdevelopment ET in the impervious area is 0 in/yr and say 55 in/yr in the well irrigated landscape. The net result is as follows:

Predevelopment (natural cover) ET Loss	Postdevelopment ET Loss
[100 acres × 35 in/yr] = 291.7 ac-ft/yr	[50 acres × 55 in/yr] + [50 acres × 0 in/yr] = 229.2 ac-ft/yr

Therefore it is possible for a development to reduce a project site's ET loss by the addition of a relatively large fraction of impervious area and using closed stormwater ponds, as is typical of this area.

Net ground water withdrawal is the total withdrawal less the portion of this withdrawal which is returned to the aquifer by recharge. This fraction is likely not more than 25% when taking into account the above factors. However, we have run the simulations assuming that the net withdrawal is 25%, 50%, 75%, and 100% of the total withdrawal. The corresponding recharge rate reductions are as follows:

Net Withdrawal as a percent of Total Withdrawal	Corresponding Reduction in Recharge Rate to Floridan Aquifer (in/yr)
25%	0.5
50%	1.0
75%	1.5
100%	2.0

4.0 Leakage to Floridan Aquifer - With and Without Pumping

The continuous model calibrated to the existing pumpage at a vertical recharge rate of 6.5 in/yr as described in Technical Memo #5.

Therefore, if the net withdrawal/total withdrawal is 25%, then the vertical recharge loss from the surficial aquifer reduces to 6.0 in/yr from 6.5 in/yr. For the 100% ratio, the vertical recharge rate reduces to 4.5 in/yr which means that there is less of a loss from the surficial aquifer and less drawdown impact.

The calibrated model was run with reduced vertical recharge rates of 4.5, 5.0, 5.5, and 6.0 in/yr to simulate the scenario of no pumpage from the Floridan aquifer. These scenarios will bracket the impact of pumpage on lake levels.

5.0 RESULTS

The results of the continuous simulation model for the period of January 1, 1994 through November 30, 2001 are shown in Exhibit 1 (below), with and without pumping.

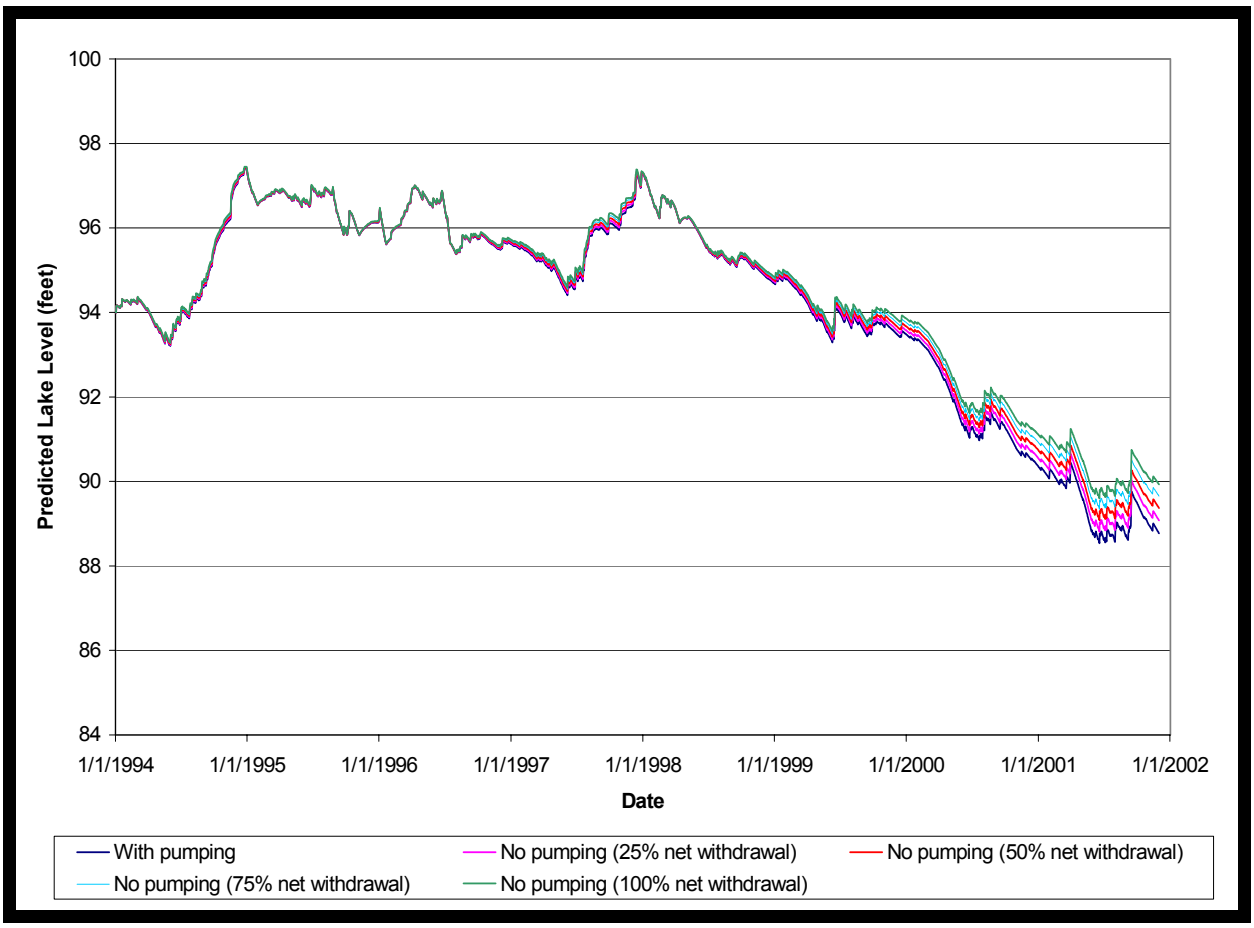

Exhibit 1. Predicted lake levels, with and without pumping.

Exhibit 2 (below) shows the yearly rainfall statistics for the model period of January 1, 1994 through November 30, 2001. As seen in Exhibit 2, years 1995 and 1996 represent average rainfall conditions. Years 1994 and 1997 represent above average rainfall years (wet years), and years 1998 through 2001 represent below average rainfall years (drought years).

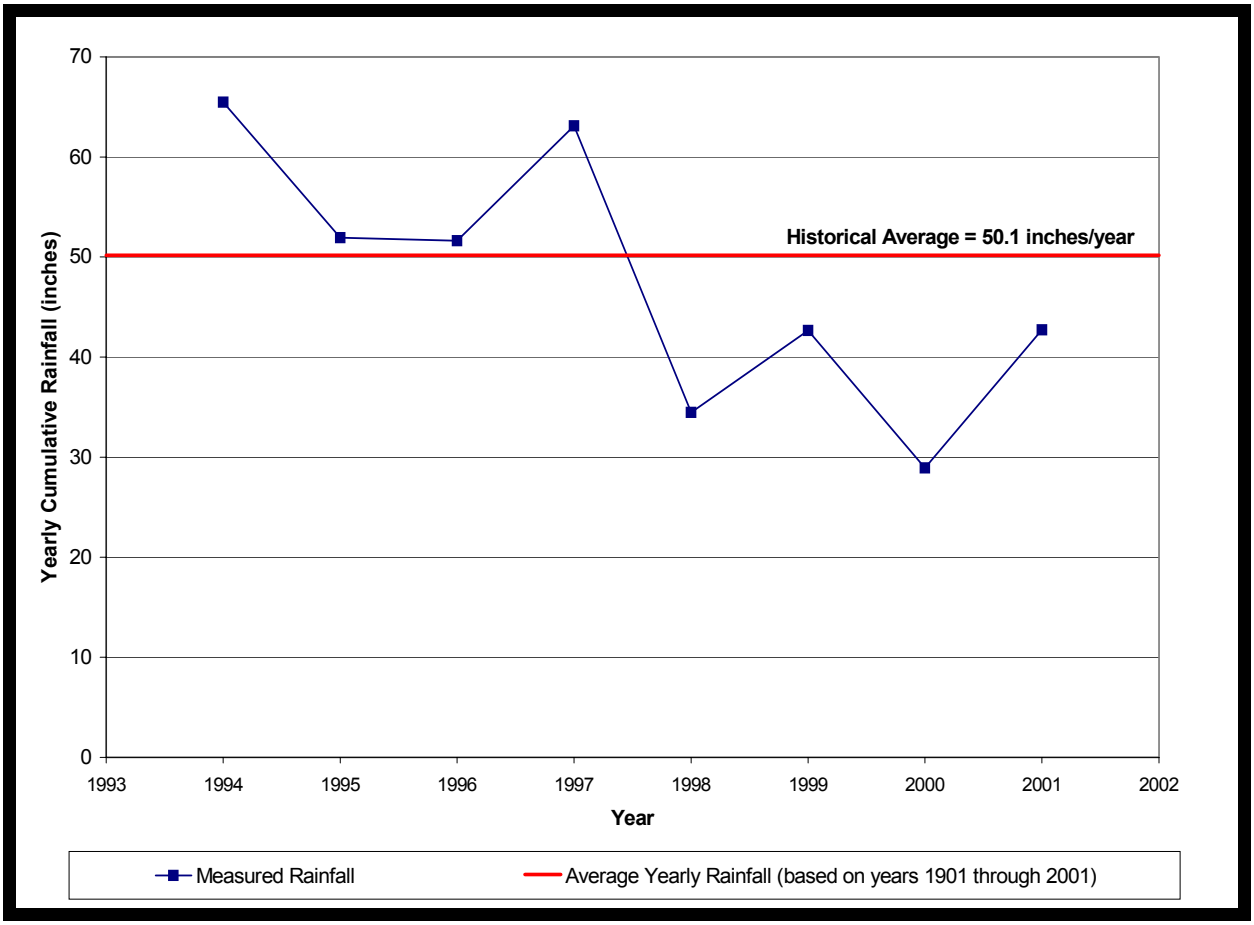

Exhibit 2. Yearly rainfall for Clermont 7S weather station (1994-2001).

As seen in Exhibits 1 and 2, there is virtually no difference in predicted lake levels due to pumpage of the Floridan aquifer during normal and wet years (1994 through 1997). During the drought period of 1998 through 2001, small differences in the predicted lake levels (with and without pumping) become apparent during the last half of 1999. Note that stream flows into Lake Louisa from Little Creek and Big Creek had essentially ceased by June 1999 and May 2000, respectively.

At the lowest predicted lake levels in June 2001, the continuous simulation model predicts a difference of in lake levels of approximately 0.3 feet (for the 25% net withdrawal case), compared to a total drop in lake levels of about 8.7 feet from the peak stage in December 1997 to the low stage in June 2001. This represents a difference in lake levels of approximately 3% due to pumping, at the end of a prolonged three-and-a-half year drought.

The modeled quantitative impact of Floridan aquifer pumpage on the lake levels during the recent drought (between the predicted peak stage in December 1997 and low stage in June 2001) is summarized in Table 2 below, for net withdrawals of 25%, 50%, 75% and 100%.

Table 2. Effect of Aquifer Pumping on Lake Levels for Drought Conditions

Pumping Conditions	Net Withdrawal (Percent)	Reduction to Recharge in Floridan Aquifer (inches)	Modeled Drop in Lake Levels [1] (ft)	Drop in Lake Levels Due to Pumping [2] (ft)	Drop in Lake Levels Due to Pumping (%)
With	N.A.	N.A.	8.75	N.A.	N.A.
Without	25	0.5	8.49	**0.26**	**2.9**
Without	50	1.0	8.24	0.50	5.8
Without	75	1.5	8.01	0.73	8.4
Without	100	2.0	7.79	0.96	11.0

1. Drop in lake levels between predicted peak stage in December 1997 and low stage in June 2001.
2. Difference between Modeled Drop in Lake Levels, with and without pumping.

6.0 CONCLUSIONS

Pumping withdrawals from the Floridan Aquifer, at current pumping rates, do not appear to have a significant effect on lake levels in the Clermont Chain of Lakes. As noted in previous Technical Memos, the Clermont Chain of Lakes relies on the stream inflows of Big Creek and Little Creek to maintain normal water levels within the lakes. During normal and wet years, these stream flows generally exceed the water budget demands of the Clermont Chain of Lakes. Furthermore, the model results indicate that a prolonged period of below average rainfall is required in order detect even a minor difference in the predicted lake levels (with and without pumping of the Floridan aquifer), with very small differences in predicted lake levels becoming apparent after a period of about 1-1/2 years after the onset of recent drought conditions, and a difference of only about 3% (0.3 feet) in lake levels during the worst conditions of the recent drought.

APPENDIX A

DISCUSSION OF MODEL BOUNDARY SELECTION CRITERIA

Discussion of Model Boundary Selection Criteria

In choosing a boundary for ground water modeling, it is first desirable to select a boundary which ① takes advantage of natural ground water divides (no-flow boundaries), such as was done in selecting the boundary conditions for the Floridan aquifer model in Technical Memo #10 of this report. Where there are no natural divides in the ground water domain, it is desirable to select a boundary distance such that ② the time it takes for the an individual water particle to travel from the boundary to the area of interest within the model is greater than the model simulation time.

Note that the modeling effort discussed in this Technical Memo serves to evaluate the drawdown effect of pumping on the surficial aquifer, and the boundary conditions selected for Floridan aquifer model in Technical Memo #10 are not applicable. Therefore, the model boundary was selected to satisfy the secondary boundary selection criteria.

A 2000 foot buffer was used in order to assure that the horizontal travel time for water in the surficial aquifer to travel from the boundary to the lakes is greater than the duration of the model simulation, thereby minimizing the boundary effects. The general form of Darcy's law for large scale flow of water through soil is as follows:

$$q = k\,i\,A \quad \text{or} \quad v = q / A = k\,i$$

where

- **q** Flow rate
- **k** Soil permeability *(20 ft/day for the calibrated continuous simulation model in Technical Memo #5)*
- **i** Hydraulic gradient *(typical value of 0.25% for area lakes)*
- **A** Cross sectional area through which flow occurs
- **v** Flow velocity

The velocity of an individual water particle (seepage velocity) is greater, since it must travel around individual soil particles, and must therefore travel a greater distance, i.e. the distance traveled by an individual water particle in going from point "A" to point "B" is greater than the linear distance between "A" and "B". The seepage velocity of an individual water particle can be expressed, in Darcy's Law, as

$$v_s = k\,i / n$$

where

$\mathbf{v_s}$ Seepage velocity

n Soil porosity *(20% for the calibrated continuous simulation model in Technical Memo #5)*

From the above equation, and given parameter values, the theoretical seepage velocity is approximately 73 ft/year, and the time to travel a distance of 2000 ft is approximately 27 years, which is greater than the model duration of 7.9 years. Note that flow in the surficial aquifer is primarily vertical, through vertical leakage between surficial aquifer and the underlying Upper Floridan aquifer, and that horizontal flow in the surficial aquifer (into or out of lakes) is comparatively less significant.

FIGURES

Graphic Scale

2000 0 2000 4000 6000 8000 10000 Feet

N

Cherry Lake

Wilson Island

Lake Minneola

Minneola

Clermont

Lake Minnehaha

Lake Louisa

Grassy Lake

Groveland

Groveland Municipal Airport

South Clermont

Orange Mountain

Eva Lookout

Lake Arthur

Lake Spencer

Deacon Lake

Shepherd Lake

Sumner Lake

Lake Wash

Black Lake

Pine Island Lake

Lake Susan

Lake Glona

Lake Gary

Lake Nellie

Pretty Lake

Kirkland Lake

Bear Lake

Trout Lake

Brantly Lake

Cypress Lake

Saw Mill Lake

Fern

FLORIDAS TURNPIKE

SEABOARD COAST LINE

T 21 S

T 22 S

T 23 S

Legend:

- Floridan aquifer wells within 2000 foot buffer zone
- Floridan Wells in SJRWMD
- 2000 foot buffer zone

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Figure Name: Floridan Aquifer Wells Near Clermont Chain of Lakes

Project Name: Clermont Chain of Lakes

Checked & Approved By:	Drawn By:	Date:	Scale:	Project #:	
DS	AZ	05-21-2003	Noted	02-121.96	Figure 10.1-1

TECHNICAL MEMO #10.2: HYDROLOGY OF BIG CREEK BASIN

Ground Water / Surface Water Interaction Modeling...

CLERMONT CHAIN OF LAKES,
Lake County, Fl



Prepared for

Lake County Water Authority

Professional Engineering Consultants, Inc.

Prepared by

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Date: June 3, 2003	*Devo's Project No.* 02-121.96
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LCWA Lake County Water Authority	PEC
Ref: **TECHNICAL MEMO #10.2 - HYDROLOGY OF BIG CREEK BASIN GROUND WATER/SURFACE WATER INTERACTION MODELING CLERMONT CHAIN OF LAKES, LAKE COUNTY, FLORIDA**	

Dear Mr. Lumbard:

This Technical Memo discusses the hydrology of the Big Creek basin and our findings relative to its impact on the Clermont Chain of Lakes. These are the key points of this memo:

- ❑ Discharge from Big Creek represents the most significant component of water inflow into the Clermont Chain of Lakes.
- ❑ The watershed contributing to Big Creek is characterized as follows:
  - ☞ Occupies an area of about 39,000 acres which parallels the western flank of the "US Highway 27" portion of the Lake Wales Ridge;

- ☞ Extends as far south as Lake Lowery in Polk County to the south shore of Lake Louisa in Lake County.

- ☞ Watershed is mainly within the Green Swamp.

- ☞ Flow is from south to north with swamp elevations sloping gently down from Lake Lowery to Lake Louisa:

  +130 ft at Lake Lowery up to Interstate Highway 4
  +130 ft to +125 ft from I-4 to Dean Still Road
  +125 ft to +120 ft from Dean Still Road to Sand Mine Road
  +120 ft to +115 ft from Sand Mine Road to Keene Lake
  + 115 ft to +110 ft from Keene Lake to Dixie Lake
  +110 ft to +100 ft from Dixie Lake to Lake Louisa

  From the +115 ft contour, the drop off is sharp but the areas above that are relatively flat.

- ❑ Discharge rates from Big Creek into the Clermont Chain of Lakes depends on the surface water/ground water level in the swamps of the Big Creek Basin. In the Green Swamp zone from +120 ft to +130 ft, these water levels are strongly influenced by the potentiometric surface of the Upper Floridan aquifer since it is an area of relatively high leakage from the surficial aquifer to the Floridan aquifer.

- ❑ Review of historical water table and rainfall data at a monitoring site in the "heart" of the Big Creek basin revealed a strong correlation between the water table and cumulative rainfall deficits. The dramatic decline in water table in the Big Creek basin can be explained by the rainfall deficit and is not a direct result of pumpage from the Floridan aquifer.

We trust that this information is explained in a clear manner for the reader and the implications of the Big Creek watershed on the Clermont Chain of Lakes are now better understood.

Sincerely,



Robert Casper, M.Eng., E.I.
Project Geotechnical Engineer

D

Devo Seereeram, Ph.D., P.E.
Principal Engineer
Florida Registration No. 48303
Date: June 4, 2003

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1.0 BIG CREEK BASIN

The Big Creek Basin is part of the Green Swamp within the Floridan aquifer potentiometric high shown in Exhibit 1.

Based on numerous well logs, deep boreholes, and experience in this portion of the Green Swamp, there is a zone of high leakage to the Floridan aquifer where there are free-draining sands directly overlying the Floridan aquifer. This approximate zone of very high recharge and very effective interconnectivity between the surficial and Floridan aquifers is delineated in Exhibit 2. Note that this high leakage zone is mapped based on our extensive local experience as well as the model calibration described in *Technical Memo #10 – Final - Floridan Aquifer Drawdown Model for Big Creek and Little Creek Basins*. The Big Creek watershed is shaded on Exhibit 2 to shows its size and location relative to the high leakage zone.

The continuous simulation hydrologic model *(Technical Memo #5 – Continuous Simulation Model Results*) clearly identified the stream flows from the Big Creek basin to be the most significant component to maintaining the water levels in the reservoir-like Clermont Chain of Lakes. When inflows from Big Creek is low or zero for extended periods, the water level in the lakes decline rapidly (i.e., vertical leakage and evaporation continue to extract water from the system while there is no replenishment).

The Big Creek basin is intersected by a number of roadway crossings which could potentially restrict the flow of water out of the Green Swamp and/or effect the hydrology within the Big Creek basin. Exhibit 3 shows the locations of four such roadway crossings in Lake County, and the number and size of culverts at each of these locations, based on data obtained from Keith and Schnars, as part of another study within the Green Swamp. The Keith and Schnars study does not include roadway crossings in Polk county which could also influence the hydrology within the Big Creek basin.

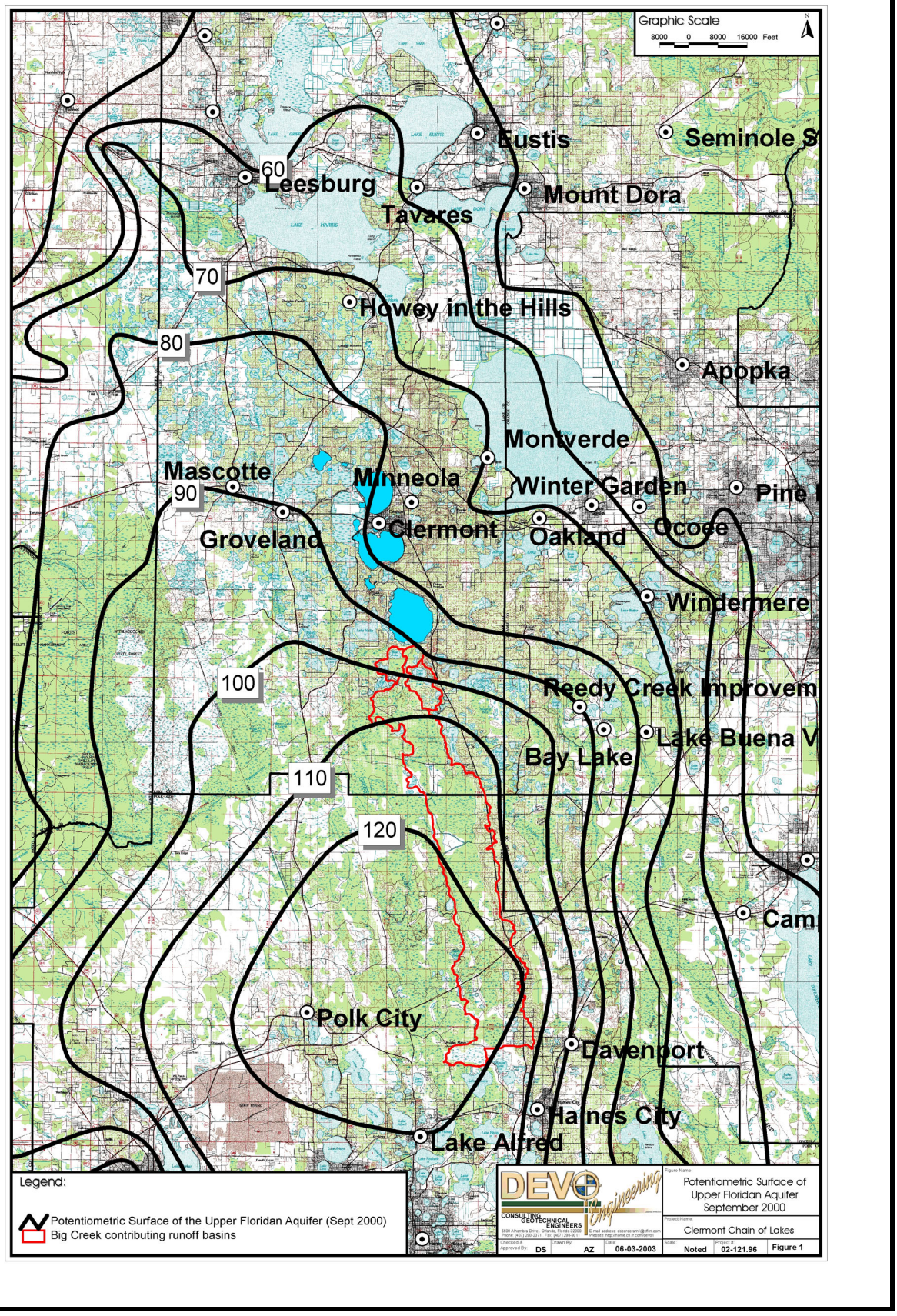

Exhibit 1. Big Creek drainage basins and potentiometric surface of Floridan Aquifer (9/00)

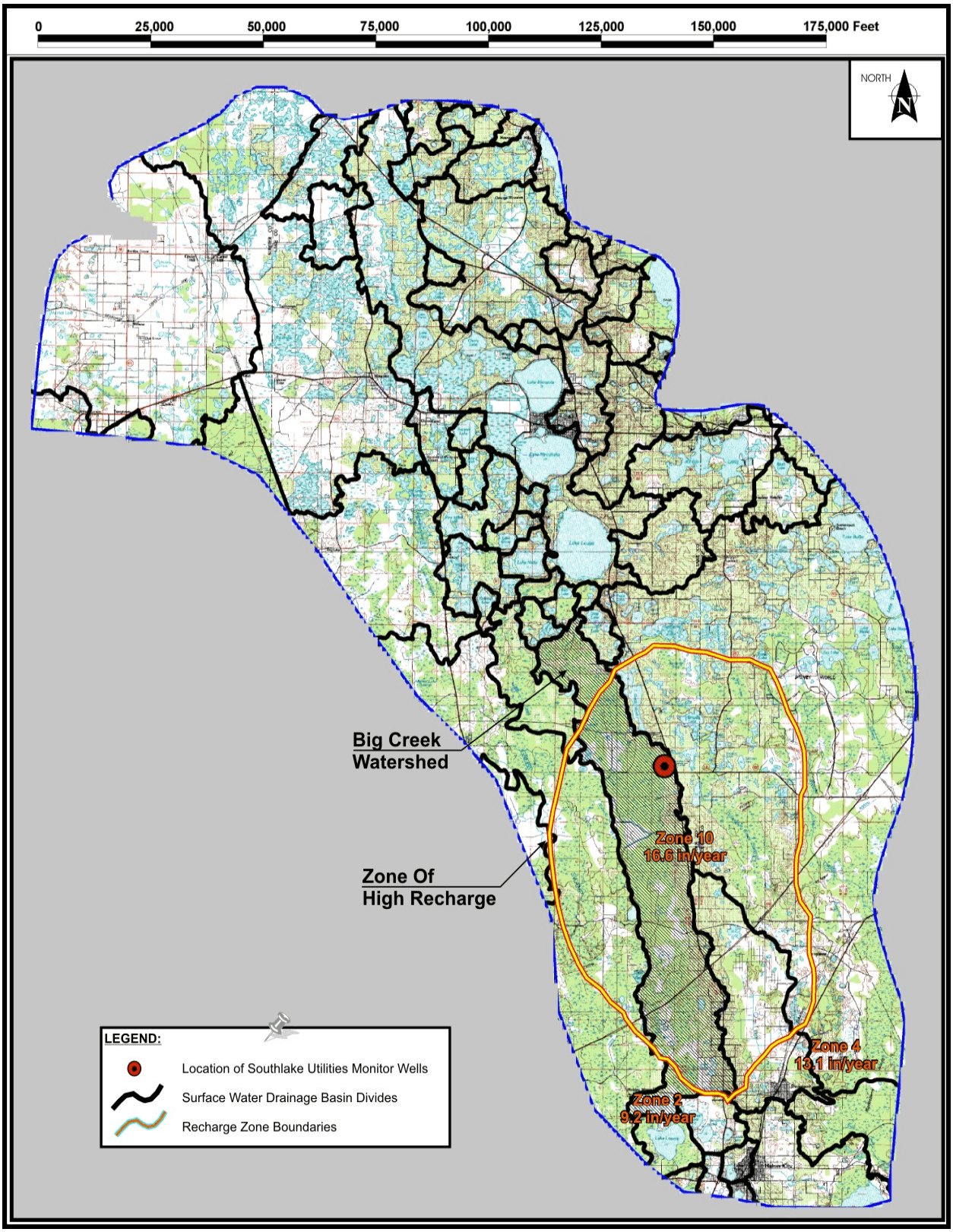

Exhibit 2. Approximate Limits of Zone of High Leakance Zone & Big Creek Watershed

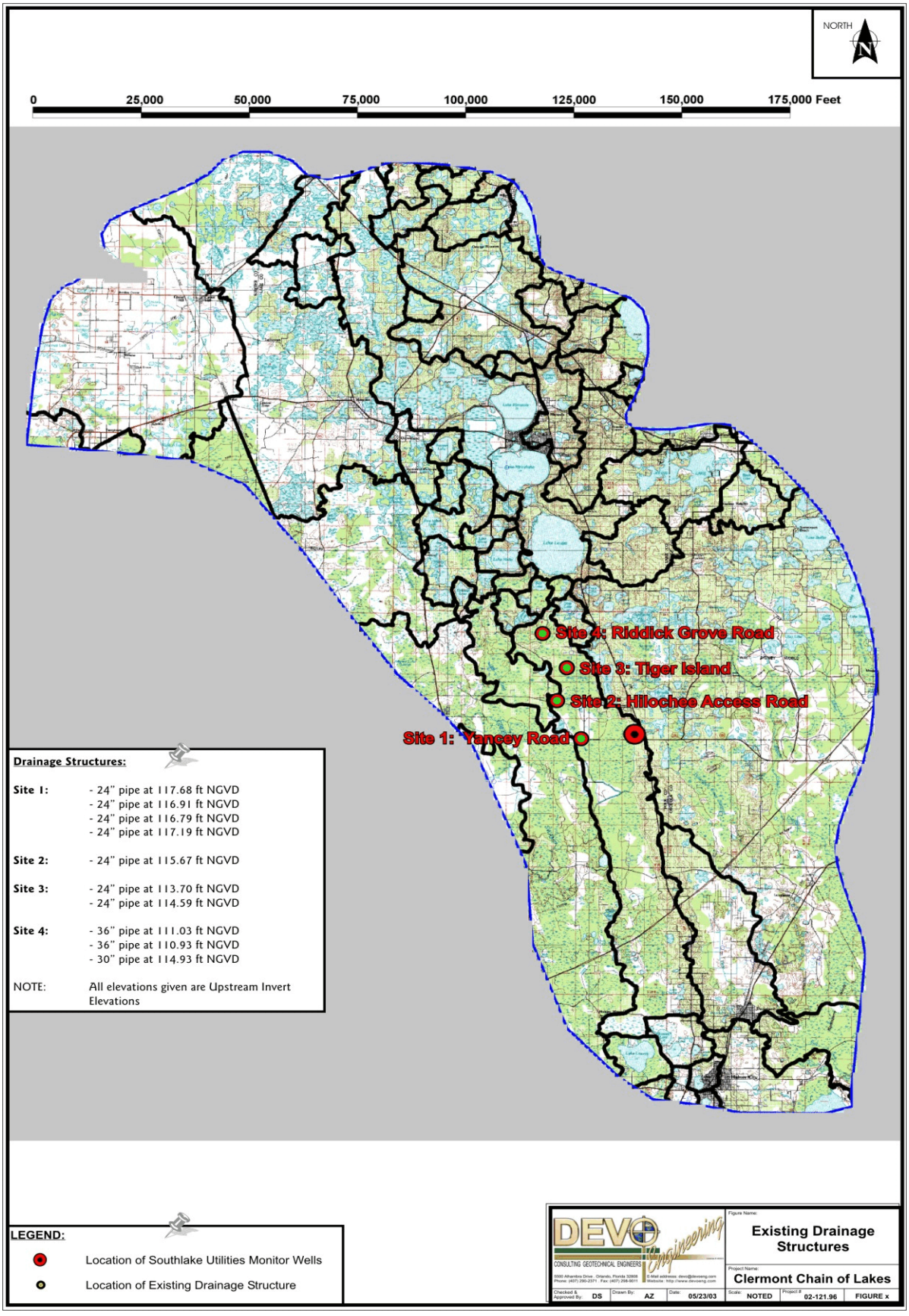

Exhibit 3. Drainage Structures in Big Creek Watershed (Lake County only)

2.0 SOUTHLAKE UTILITES MONITOR WELLS

Since April 1994, our firm has been collecting on a weekly basis ground water level data within the portion of the Green Swamp near the intersection of US 192 and US 27. This is a representative point within the Big Creek Basin. Exhibit 4 shows the location of the monitoring point (Southlake Utilities WWTF) on the USGS quadrangle map, as well as the locations of some other deep wells of interest.

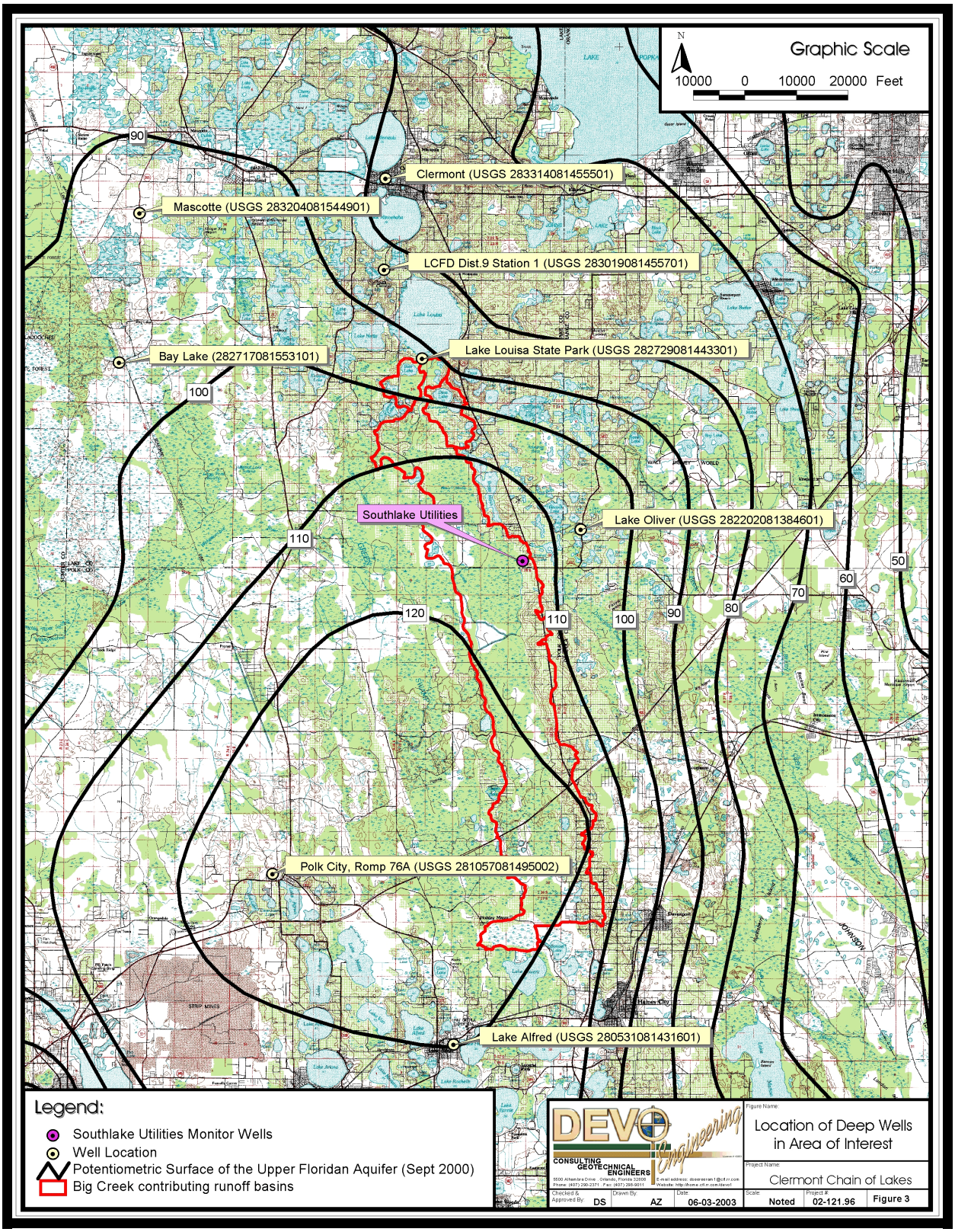

Exhibit 4. Location of Southlake Utilites and other nearby deep wells of interest.

Exhibit 5 shows the measured water levels at Southlake monitor wells for the period of record which spans April 1, 1994 to May 19, 2003. The high water levels are on the order of +122 ft while the low levels were recorded at approximately +112 ft during the pronounced drought of June 2001.

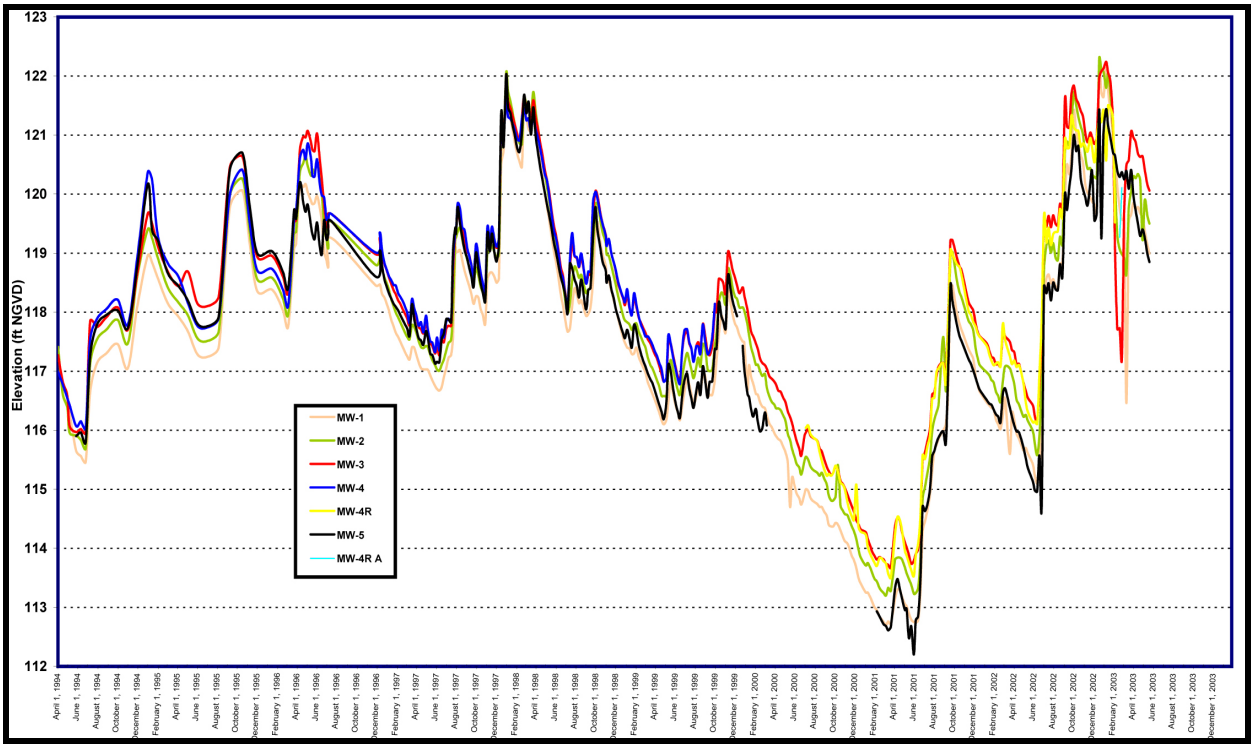

Exhibit 5. Ground Water Levels in Southlake Wells for period Apr 1994 to May 2003

The water level for Southlake Utilites monitor wells (average of all wells) is shown in Exhibit 6, along with the water levels for the other nearby wells shown in Exhibit 4.

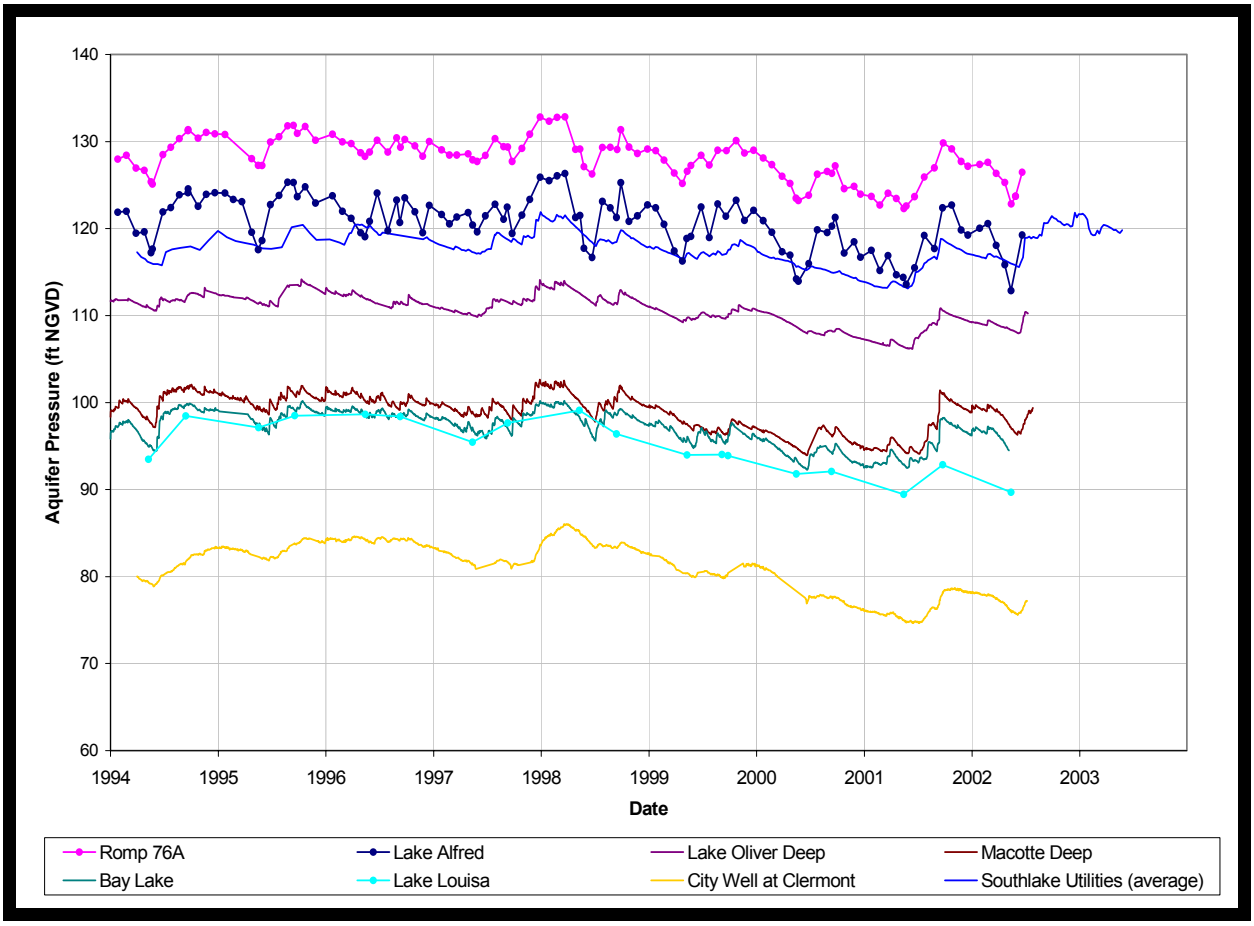

Exhibit 6. Water levels for Southlake Utilities and other nearby wells of interest.

Exhibits 7 and 8 (below) show the ground water levels at Southlake correlated to the discharge rates out of Big Creek into Lake Louisa. The plots in Exhibits 7 and 8 indicate that there is no flow out of Big Creek when the water level at Southlake drops below an altitude of approximately +117.7 ft. As the water level stage in the Green Swamp (at the Southlake location) increases, the flow rate out of Big Creek follows the approximate curve shown in Exhibit 8. These data and results are described in greater detail in *Technical Memo #10 – Final - Floridan Aquifer Drawdown Model for Big Creek and Little Creek Basins*.

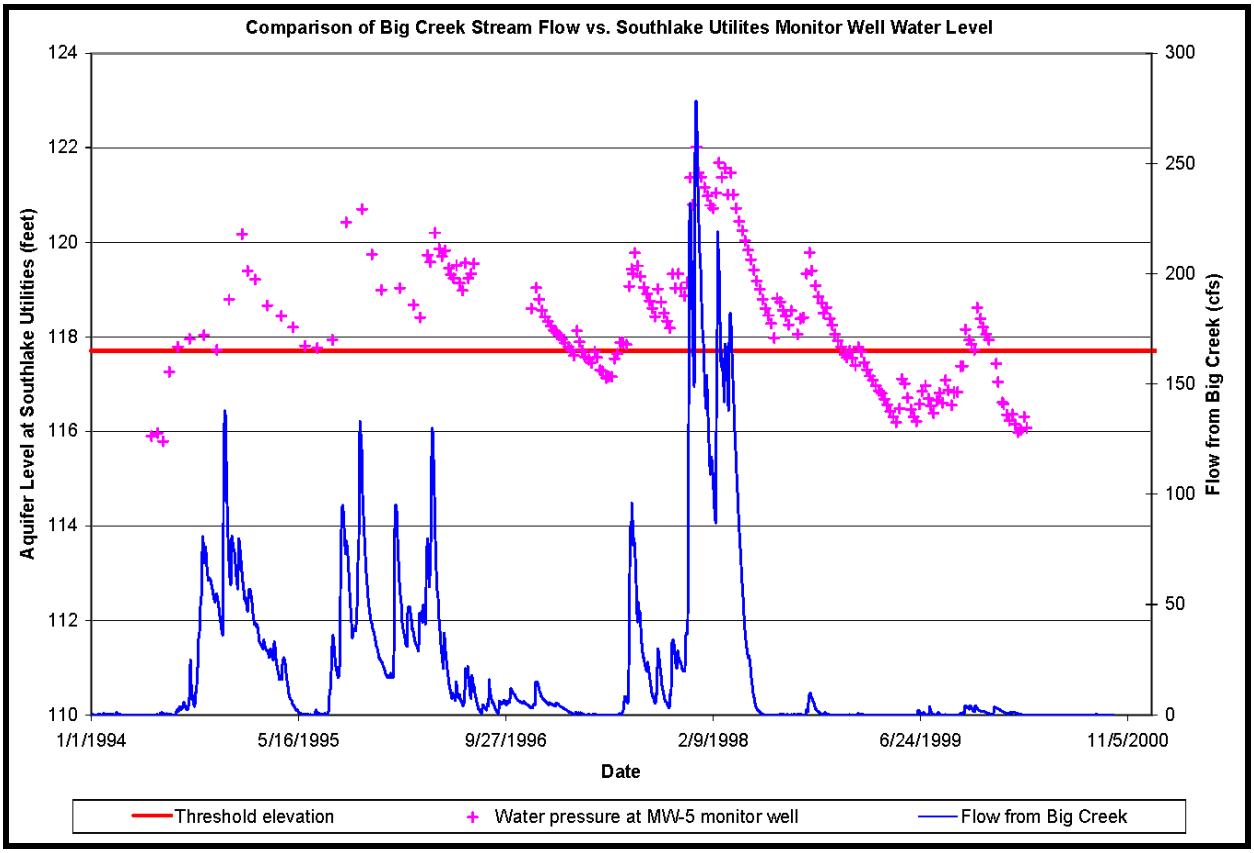

Exhibit 7. Big Creek discharge rate vs. Southlake ground water level.

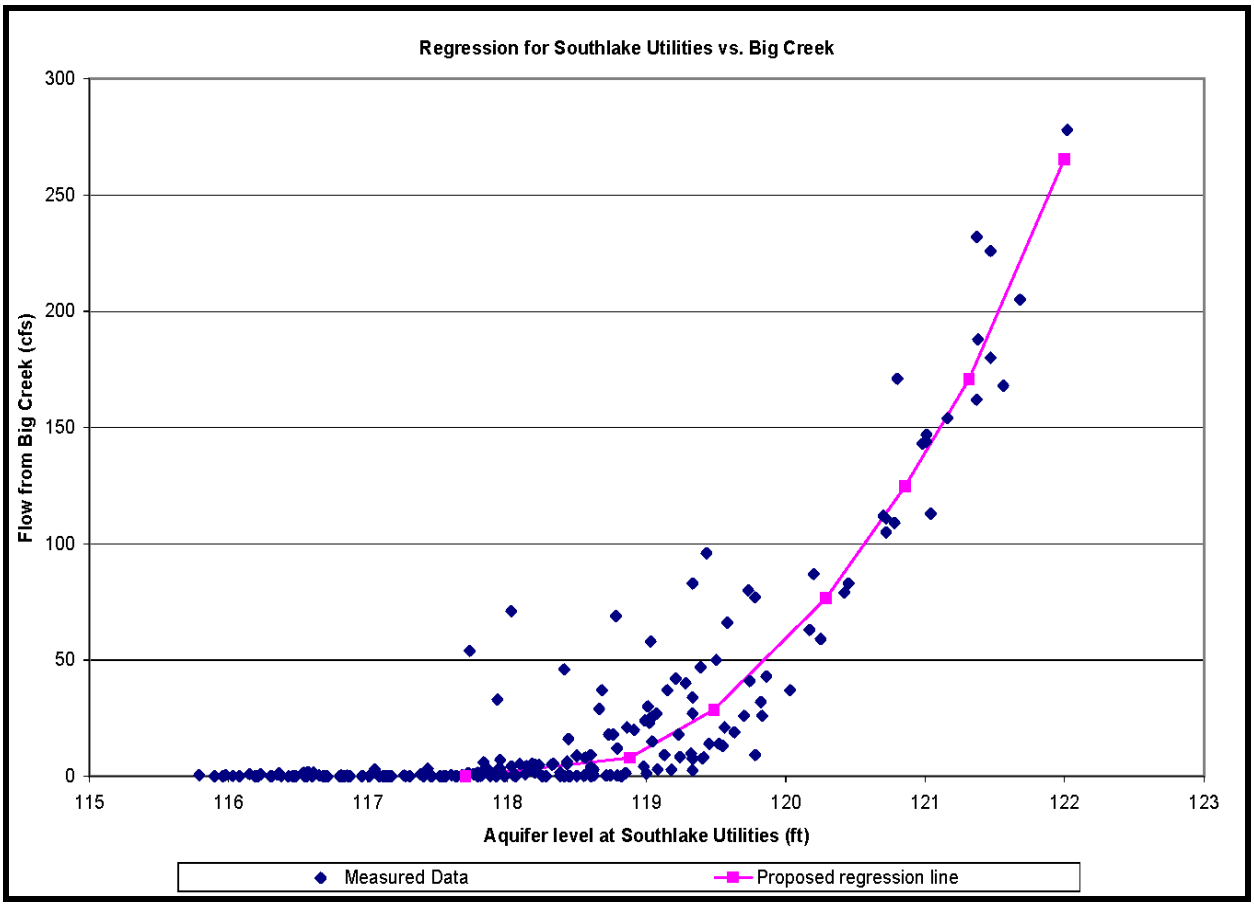

Exhibit 8. Ground water level at Southlake vs. Big Creek flow rates.

3.0 RAINFALL DATA FOR CR 474 AND CLERMONT 7S STATIONS

Exhibit 9 shows the locations of rain gage stations for CR 474 (operated by Lake County Water Authority, LCWA) and the Clermont 7S (operated by NOAA). The rainfall data which we have obtained cover the following periods of record

- ☞ CR 474 - May 3, 1994 through May 1, 2003
- ☞ Clermont 7S - January 1, 1901 through April 30, 2003

The average yearly rainfall for each of these rainfall stations is summarized in Table 1 below.

Table 1. Average Yearly Rainfall (inches)

Period	Clermont 7S	CR 474
January 1, 1901 through April 30, 2003 (long-term historical average)	50.4	N.A.
May 3, 1994 through April 30, 2003 (recent 9-year average)	52.5	50.7

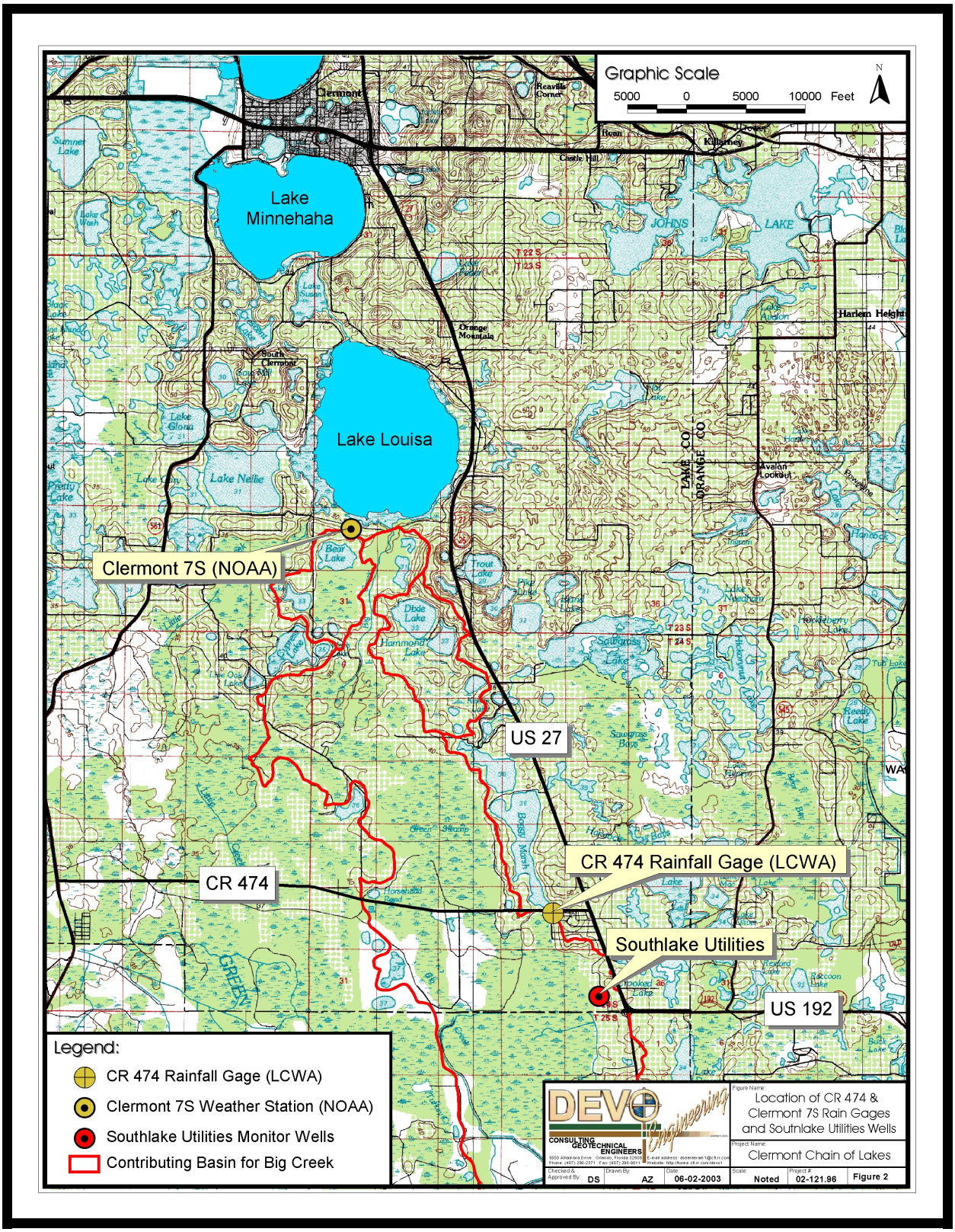

Exhibit 9. Location of CR 474 and Clermont 7S rainfall stations and Southlake Utilities.

The annual rainfall for the Clermont 7S and CR 474 weather stations are shown in Exhibit 10 for the period for which we have data for CR 474. Note that 1994 is for the partial year (May 3 through December 31, 1994).

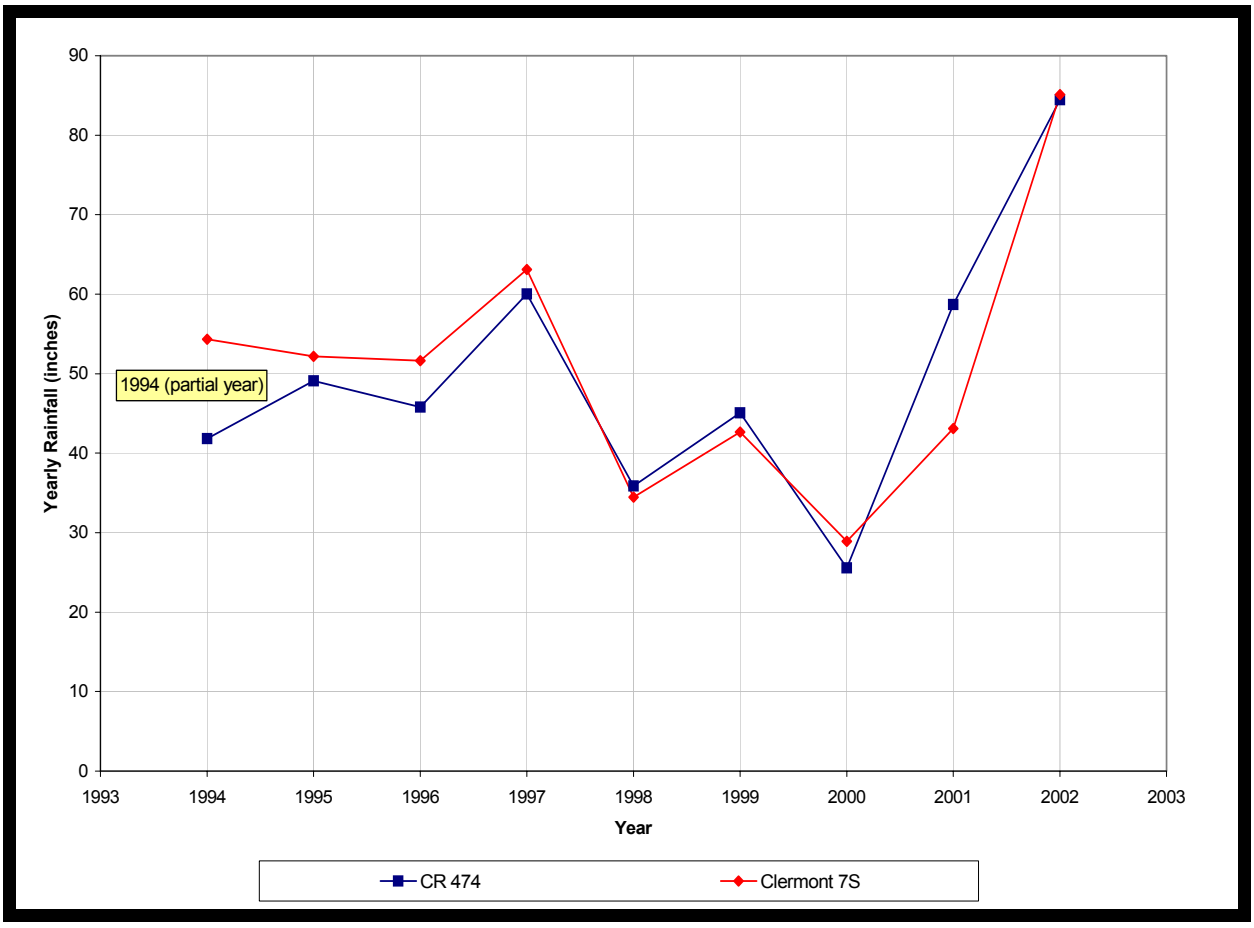

Exhibit 10. Yearly rainfall for CR 474 and Clermont 7S stations (1994-2002)

The cumulative rainfall, beginning May 3, 1994, is shown for the Clermont 7S and CR 474 stations in Exhibit 11. Note that the recorded rainfall at the Clermont 7S weather station was slightly higher than at the CR 474 station, but that both stations follow the same general trend.

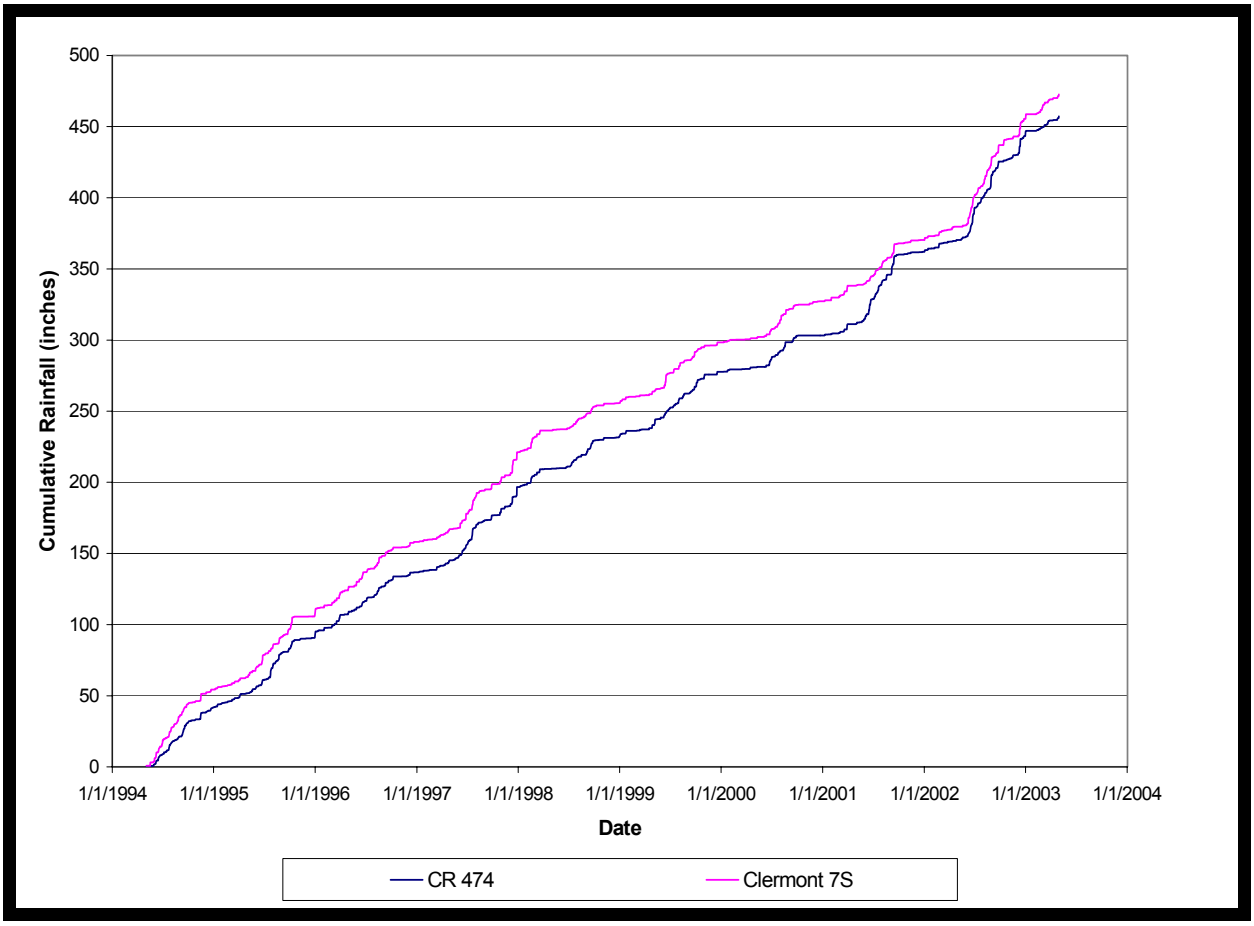

Exhibit 11. Cumulative rainfall for CR 474 and Clermont 7S (5/3/1994 - 4/30/2003)

4.0 CORRELATION BETWEEN CR 474 RAINFALL AND SOUTHLAKE WATER LEVELS

The CR 474 rainfall station data is useful because it is located within the Big Creek basin in close proximity to the Southlake Utilities monitor wells, and the period of record is similar to that of the Southlake Utilities monitor wells. Exhibit 12 (below) plots the water levels at Southlake Utilities (April 1, 1994 to May 19, 2003) and the cumulative rainfall at CR 474 (May 3, 1994 through May 1, 2003), as well as a theoretical average cumulative rainfall based on an assumed 50 in/yr rainfall (100 year long-term average for Clermont 7S weather station) and yearly rainfall totals. This plot clearly shows a severe deficit in cumulative rainfall beginning in late-1999/early-2000 and recovering in roughly the middle of 2002, and the associated drop in aquifer pressure at the Southlake Utilites monitor well cluster.



Exhibit 12. Southlake water levels and CR 474 cumulative rainfall.

The rainfall data in the preceding Exhibit 12 can also be expressed in terms of the deficit in cumulative rainfall, i.e. the vertical distance between the average theoretical cumulative rainfall (based on 50 in/yr of rainfall) and the measured cumulative rainfall at CR 474. This cumulative rainfall deficit is shown in Exhibit 13 (below), along with the water level at Southlake Utilites (average level for all wells). As seen in Exhibit 13, there is a strong correlation between cumulative rainfall deficit and aquifer pressure.

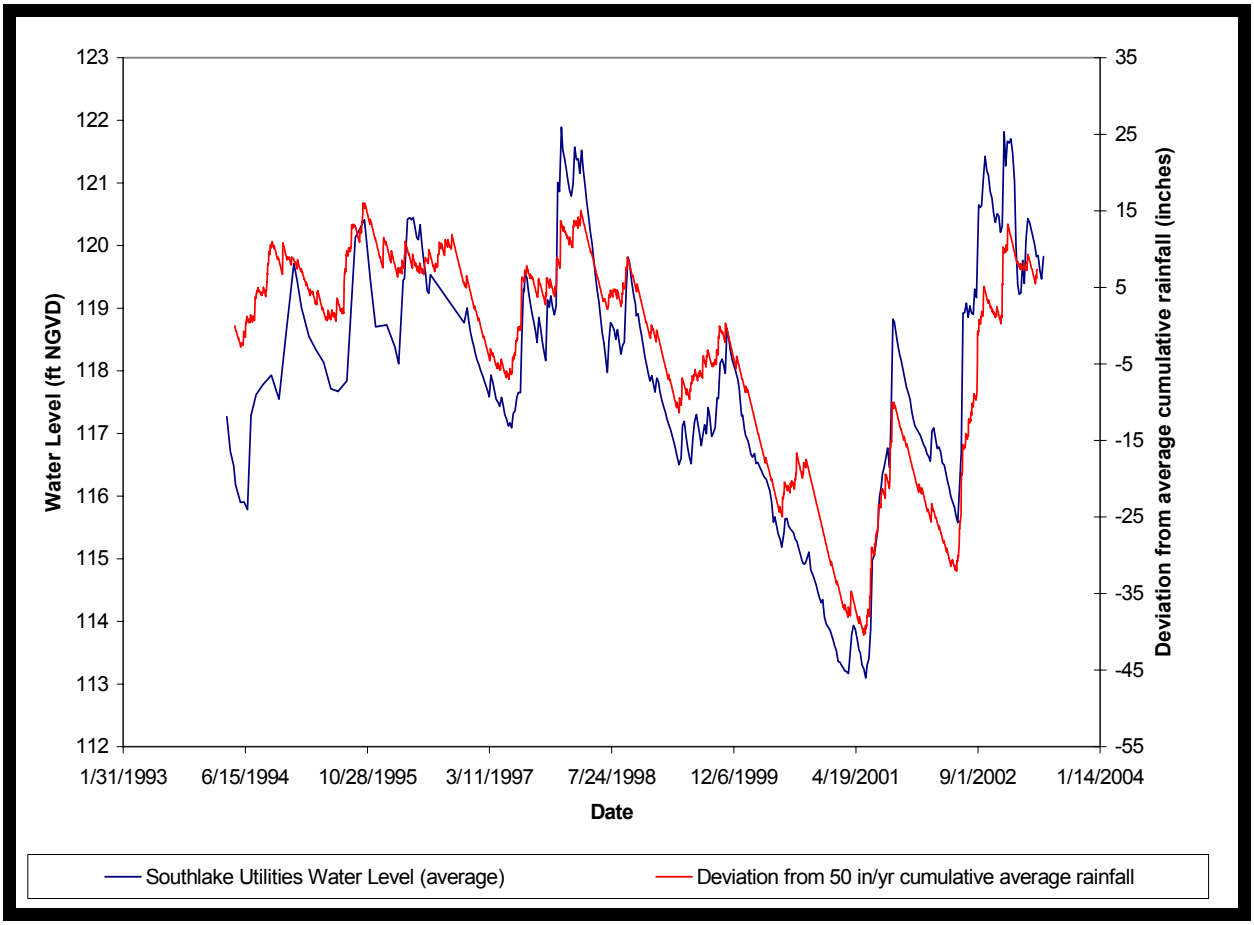

Exhibit 13. Southlake water levels and rainfall deficit at CR 474 (based on 50 in/yr).

The preceding Exhibit 13 was based on the assumption of a long-term average of 50 in/yr rainfall at the CR 474 rainfall station. As seen in the preceding Table 1 and supported by Exhibit 10, the recent nine-year average rainfall for the CR 474 rainfall station (50.7 inches) is slightly less than the Clermont 7S weather station (52.5 inches). This suggests that the long-term average rainfall at CR 474 could also be less than the long-term average rainfall for the Clermont 7S station (50.4 inches). A best fit correlation was performed by varying the assumed long-term average rainfall at CR 474, and comparing the results to the water levels at Southlake Utilites. Exhibit 14 (below) shows the best fit correlation, calibrated to 48.5 inches/year long-term average rainfall at CR 474.

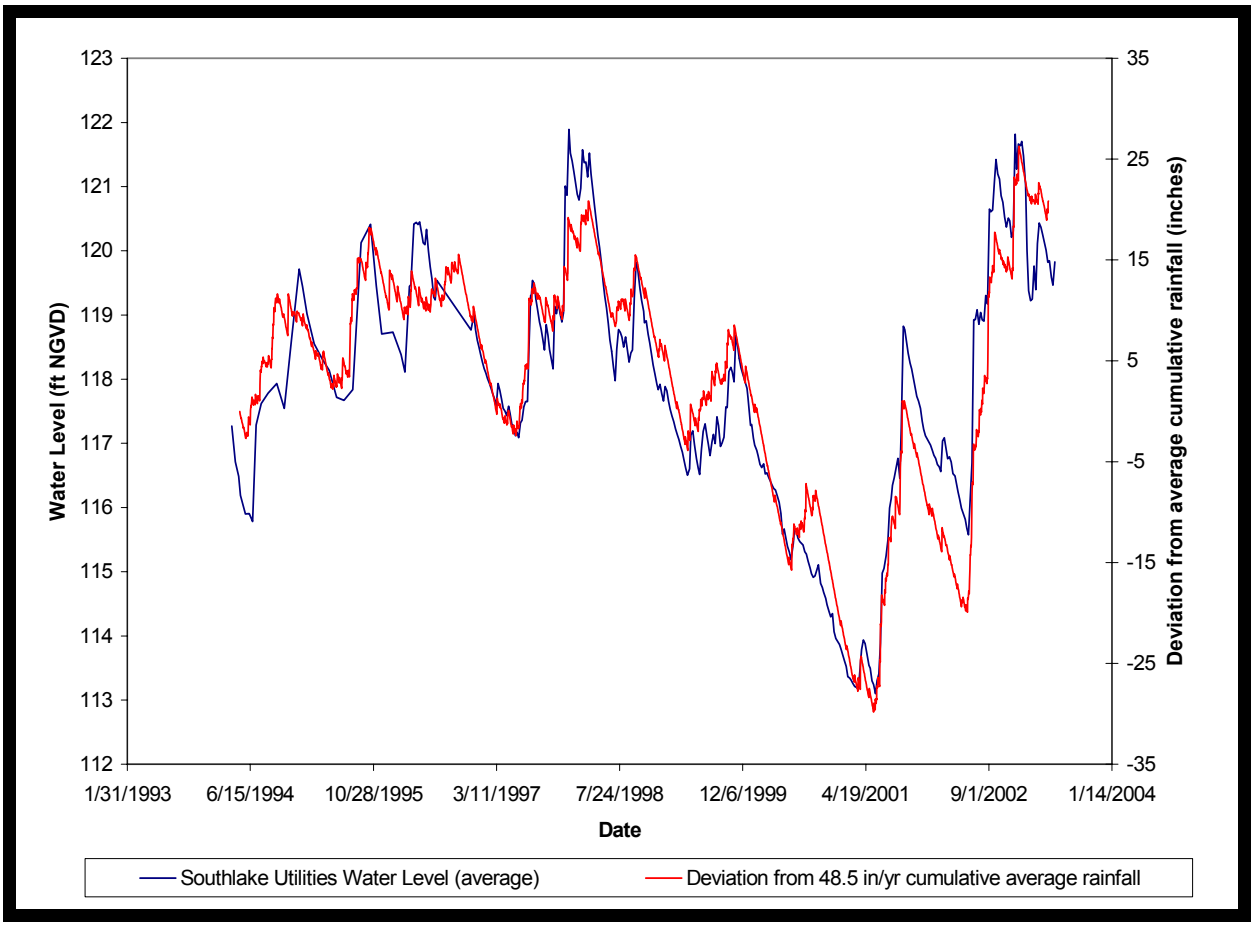

Exhibit 14. Best fit correlation for rainfall deficit at CR 474 and Southlake water levels.

5.0 CONCLUSIONS

The Clermont Chain of Lakes relies on stream inflows from Big Creek and Little Creek to maintain normal water levels throughout the chain, as demonstrated in *Technical Memo #5 – Continuous Simulation Model Results*. The stream flows from Big Creek into Lake Louisa are strongly correlated to potentiometric levels in the Upper Floridan Aquifer, as pointed out in *Technical Memo #10 – Final - Floridan Aquifer Drawdown Model for Big Creek and Little Creek Basins* and herein.

The Southlake Utilites monitor well cluster provides a useful reference point for potentiometric levels within the Big Creek drainage basin. As seen in this Technical Memo, the Floridan aquifer pressures at the Southlake Utilites monitor wells is strongly correlated to the deficit in cumulative rainfall at the CR 474 rainfall station.

The majority of the Big Creek basin is within an area of high recharge where the surficial aquifer and the Upper Floridan aquifer are well connected, and aquifer pressures respond rapidly to deficits in the cumulative rainfall.