SEEPAGE METER PROGRAM

FOR

ST. LUCIE RIVER AND INDIAN RIVER LAGOON

(March,2002 ------ March, 2003)

Submitted to:

South Florida Water Management District (SFWMD)

(Contract Number: C-11835)

Submitted by the following
Co-Principle Investigators:

Thomas V. Belanger and Howell H. Heck
Florida Institute of Technology

and

Cynthia Gefvert (Project Manager) and Steve Krupa
South Florida Water Management District

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Introduction and Objectives

This study, "Seepage Meter Program for the St. Lucie River and Indian River Lagoon", was part of a hydrologic and hydrochemical evaluation of the groundwater/surface water interaction characteristics in the St. Lucie Estuary and Indian River Lagoon. The general objective of this study was to provide necessary information on the groundwater/surface water dynamics in the St. Lucie Estuary and Indian River Lagoon study area to enable the development of Pollutant Load Reduction Goals (PLRG) for the Indian River Lagoon SWIM program. To achieve this general work objective, three specific objectives were identified. These were to:

1) Quantify the exchange of water between groundwater and surface water.

2) Determine the processes controlling groundwater / surface water interactions, and

3) Examine the quality of groundwater in the surficial aquifer and its impact on surface water quality.

General Approach and Rationale

This study was confined to the St. Lucie Estuary and adjacent Indian River Lagoon, as shown in Figure 1. The general approach and rationale involves the use of piezometer clusters, wells, seepage meters and water quality sampling at the six seepage meter transect sites located in the study area. Two of these sites, designated Minton and Lake Manor, were located in the Indian River Lagoon between Ft. Pierce and Jensen Beach, while the other four, designated Club Med, Harbour Ridge, Lutz/MacMillan, and Pendarvis Cove, were located in the St. Lucie River. Piezometer and well clusters allowed head differences and hydraulic gradients (vertical and horizontal) to be calculated under various hydrologic conditions. The seepage meter measurements enabled seepage rate determinations to be made in transects out from the shore at the six sites, under these same hydrologic conditions. Duplicate meters at numerous locations allowed an estimate of precision, and the transect meter locations and sampling schedule allowed the magnitude of aerial and temporal variability to be determined, respectively. A total of 48 conventional meters and 24 piezometers were initially deployed at the six study sites. The Lutz/Macmillan nearshore piezometers had to be replaced and additional piezometers were deployed at the Minton site during the course of the study.

Krupaseep meters were deployed at the Minton, Lutz / MacMillan and Pendarvis Cove sites. Conventional meters provide one data point in time and space, averaged over the meter exposure period. Unlike the conventional meters, the Krupaseep can obtain continuous data. These data were compared to conventional seepage meter data at the same sites, however, Krupaseep data were not provided to Florida Tech in time to be included in the Final Report. Water quality sampling in wells, piezometers, surface water and selected seepage meters

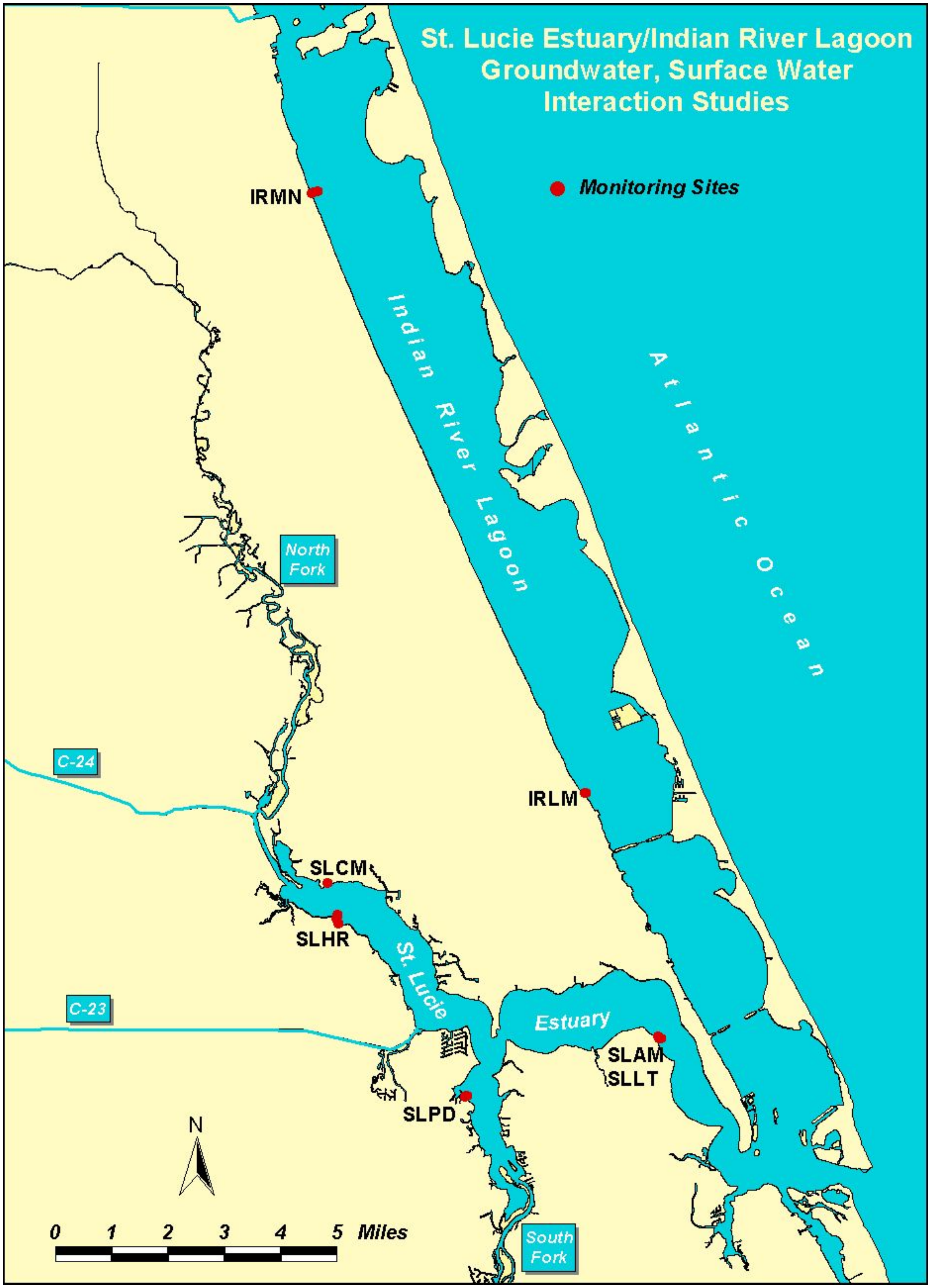


Figure 1. Location of Study Sites.

occurred on selected dates between March 2002 and March 2003. In addition to piezometer and seepage meter data, other collected data on each sampling trip included water levels in wells, surface water elevations, tidal information, weather and other site observations.

The groundwater seepage/recharge at any location is determined by the groundwater configuration in the watershed as well as the sediment leakance (hydraulic conductivity of sediments divided by sediment depth). In order to examine how hydraulic conductivity (K) varies between and within sites in the study area, slug tests were conducted on the wells.

The above described approach allowed our research team to obtain hydraulic gradient data at the six site locations, indicating the seepage or recharge potential, as well as to obtain numerous measurements of actual seepage from seepage meters. Seepage meter data allowed us to correlate seepage with factors such as groundwater levels and gradients, surface water levels, distance from shore, tidal data, etc. Water quality data in adjacent wells and piezometers allowed us to estimate groundwater seepage loading on the receiving surface water.

General Lithology of the Study Area

The subsurface system in central coastal Florida consists of a surficial aquifer and a confined aquifer known as the Floridan Aquifer. The two aquifers are separated by a relatively impermeable formation know as the Hawthorn Formations.

Toth (1987) has described the lithology of the surficial aquifer in great detail. Toth notes that the surficial aquifer includes the Tamiami and Anastasia formations and the surficial aquifer system extends from the water table to about 150 ft. below land surface. It is primarily composed of sand, but contains beds or lenses of limestone, sandstone and shell, which are generally more permeable than sand (Lichtler, 1960). In most areas the aqifer is unconfined and under water table conditions. The aquifer extends from the water table to approximately 150 ft. below the land surface. It is generally a nonartesian aquifer; however, Miller (1980) reports that artesian conditions were noted by Parker (1955) in the vincinity of the study area where discontinuous clay lenses act as confining units. Impermeable and semi-impermeable clays and calcareous clays of the Tamiami and Hawthorn formations uncomformably underlie the surficial aquifer and form its base (Lichtler, 1960).

Toth (1987) reports that the Hawthorn Formation consists of phosphatic clays, limestone, and layers of interbeded sand and shell. He further reports that the Hawthorn Formation is absent from much of Volusia County and from the Northwest corner of Brevard County, but thickens to the southeast, where it attains a localized maximum thickness of 523 feet on the barrier island southeast of Vero Beach. Brown and Reece (1979) report that in Martin County, the Hawthorn Formation has a maximum thickness of 650 feet. Glatzel (1986) has mapped the thickness of the Hawthorn Formation below the Indian River Lagoon and her map confirms the observation of Toth (1987) and Brown and Reece (1979).

The potentiometric surface of the Floridan Aquifer is generally above the ground surface (Phelps, 1984), which indicates that there is a possibility of seepage from the Floridan Aquifer into the surficial aquifer via the Hawthorn Formation, especially in areas where it is thin. Very little seepage through the formation would be expected in areas where the Hawthorn Formation is thick, however, such as study areas in St Lucie and Martin Counties.

Methods / General

Florida Tech shared some responsibilities for equipment installation, servicing and data collection, and sample analysis with District staff. In particular, Florida Tech measured seepage with its meters, and assisted the District with piezometer and Krupaseep monitoring. District staff were responsible for site selection, obtaining land use agreements, installation of monitoring wells, installation and maintenance of electronic instrumentation, performing and analyzing slug tests, and water quality sampling in wells and surface water. The District was responsible for taking measurements with the Krupaseep meter, monitoring the wells and collecting water samples from the Krupaseeps at selected wells. In addition, the District retrieved and tabulated all data, including site description information.

The six groundwater well clusters constructed and instrumented by the SFWMD consist of shallow (~30 ft.), intermediate (~60 ft.) and at some sites deep (~100 ft.) wells. Well layout and construction details are provided in the Appendix A of this report. Harbor Ridge, Lutz/Macmillan and Minton only had 30 and 60 ft. wells while Pendarvis Cove, Lake Manor and Club Med had the additional 100 ft. wells. These wells were to be used for sample collection, standard penetration testing, hydraulic conductivity slug testing, vertical leakance estimation, and groundwater quality sampling. Deep wells assisted in evaluating leakage to the river from the artesian aquifer. The well clusters helped in monitoring short-term responses to river stage and tidal condition and impacts of groundwater quality on the river. Water level data, by site, are presented in Appendix B.

At each site, Florida Tech positioned approximately six to thirteen seepage meters in transects, extending from the shore towards the center of the river. AutoCad scaled plan view and cross section (maps) of seepage meter placement relative to wells and *in situ* piezometers are presented in Appendix C. For estimating precision, duplicate meters were placed next to at least one meter in several different transects. There were approximately 48 total meters allocated among the six sites, with seven duplicate meters.

Water quality samples were collected from the wells, piezometers and the surface water by District staff and/or contractors using sampling protocols described in the District's Field Sampling Quality Manual (12/01/02). The sampling was consistent with procedures outlined in the FDEP surface water and groundwater sampling procedures and followed the requirements under F.A.C. 62-160 (FDEP QA Rule) and the supporting Field Sampling Operating Procedures (SOP's) for the collection of groundwater and surface water samples. Selected water quality data can be used with concurrent seepage rate measurement data to roughly estimate loading. Samples were analyzed for many parameters including: alkalinity, cations, anions, conductivity, salinity, dissolved solids, suspended solids, dissolved organic carbon (DOC), total organic carbon (TOC), dissolved ammonia, nitrate + nitrite (NO_x), total Kjeldahl nitrogen (TKN), soluble reactive phosphate (SRP), total phosphate (TP) and methyl blue active substances (MBAS). Dissolved oxygen (DO), temperature, and specific conductance were measured in the field. Continuous DO data were also available from the District's sensors deployed at each site. Water quality data are presented in Appendix D. Mean, range and 95% confidence intervals for selected water quality parameters are shown in Appendix E.

A. Seepage Meters

1. Lee (1977) Design

Water fluxes through the riverbed were measured directly using seepage meters, a technique cited by EPA as one of the best methods for this purpose (USEPA, 1988). Seepage meters followed the design of Lee (1977), with slight modifications (Figure 2). Each meter consisted of a 55 gallon steel drum cut to produce a hollow cylinder, open at one end, with a surface area of 0.29 m^2. A hole in the top of the meter was connected to a plastic collection (reservoir) bag by a polyethylene tube fitted through a rubber stopper. Dimensions of the Lee (1977) (Belanger meter), USGS and Krupa *et al.* (1998) design seepage meters are shown in Table 1.

Meters were installed without a reservoir bag and left undisturbed for a minimum of one day prior to measurement, allowing time for the initial flow disturbance to subside and the meter to settle into a fixed position. When the meter was ready, a reservoir bag with 1 L of water was attached and the change in volume in the bag was determined over a defined time period. If a meter was not located during sampling a new one was inserted and measured the next day, if possible. Similarly, when bags were lost, measurements were sometimes repeated, if time permitted.

SCUBA techniques were used at deep-water stations. The seepage inflow or outflow was measured in change in volume per square meter per hour (L/m^2-hr). These units are dimensionally equivalent to units of millimeters per hour (mm/hr). Correction factors were applied to the data to correct for flow field disturbance and friction losses within the meter (Erickson, 1981; Cherkauer and McBride, 1988; Belanger and Montgomery, 1992).

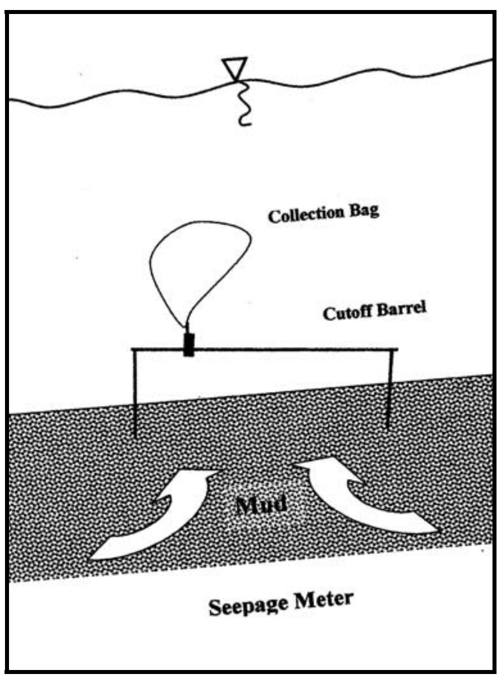


Figure 2. Diagram of a Seepage Meter.

2. Krupaseep Seepage Meter

A different seepage-metering device was designed, built and tested to study the groundwater/ surface water exchange. The dome-shaped seepage meter, termed the Krupaseep after Steve Krupa, the inventor, was fabricated from translucent polycarbonate plastic. A flow meter, installed in a port at the apex of the dome, utilizes heat-pulse technology to measure real-time fluxes in water movement. Electronic data loggers record the flow, as well as water quality data, obtained by sensors located both inside and outside of the dome. Additionally, water quality samples are remotely extracted from inside and outside the dome for laboratory analysis. All of the water quality variables were measured with Yellow Springs Instruments (YSI) Model 600XL sensors calibrated weekly, and logged with a Campbell Scientific CR-10X data logger. Each water quality probe included pH, temperature, dissolved oxygen, specific conductance, and oxidation-reduction potential (ORP) sensors. Depth sensors are located on the outside of each dome (barometrically uncorrected). In addition to the water quality parameters above, the CR-10 logs included barometric pressure, and battery voltages of the CR-10X and the PC. Data recording frequency was every ten minutes on the CR-10X data logger. On-shore computers capture all real-time data. The Krupaseep meter was constructed from ¼-inch (0.984-cm) thick, extruded, lightly smoked polycarbonate plastic and has a 2-inch (5.08-cm) horizontal flange. Dimensions of the Krupaseep meters, as well as other meters, are given in Table 1. Exact construction and measurement details are provided by Krupa (1998).

Table 1. Dimensions of Various Seepage Meter Designs.

Type of Meter		Source of Information	Head Space / Dome Height (Inches)	Horizontal Skirt (Inches)	Skirt Height (Inches)	Diameter (Meters)	Cross Sectional Area (m^2)
Belanger (Lee)		Lee (1977, 1978)	10	N/A	8	0.572	0.26
	Small	Krupa et al. (1998)	10.25	2.25	8	0.648	0.33
	Baby		5	1.75	8	0.457	0.16

B. *In Situ* Piezometers

Shallow (5 ft) and deep (15 ft) ¾ inch *in situ* piezometers were installed in the benthic sediment at nearshore (usually equivalent to location of seepage meter #1) and farshore (usually equivalent to location of seepage meter #3) transect sites. Exact locations are specified in the scaled AutoCad drawings shown in Appendix C. Both shallow and deep piezometers have 1 ft screened intervals with 0.010 slot screen. The piezometers were installed by jetting in a 1 ¼ inch temporary casing outside the piezometer pipe with a 1½ h.p. Honda water pump connected to a 1 ¼ inch hose line. After the ¾ inch piezometer pipe (5 ft sections) was positioned inside the temporary casing, the outside casing was pulled back, allowing sediment to collapse against the pipe and firmly establish the piezometer pipe at the desired depth. After the piezometers were allowed to settle and equilibrate for several days, the head difference between the surface water level (outside piezometer water level) and the groundwater (inside piezometer water level) was routinely measured (ΔH). The vertical gradient can be obtained by dividing the ΔH by the depth of the screen below the sediment surface.

C. Groundwater Well Gradient Calculation Methodology

Darcy's equation defines the movement of water as:

$$V = -ki \quad \text{[Equation 1]}$$

where: V = the theoretical velocity (feet/day)
k = the hydraulic conductivity (feet/day)
i = the gradient (unitless)

Normally, the negative sign in front of the product of the hydraulic conductivity and the gradient shows that water is moving from an area of higher hydraulic head to the lower hydraulic lead in the aquifer. Gradient signs can be calculated arbitrarily and the numerical sign depends on the sign convention used for the gradient calculations. Generally the convention for gradient calculations is to take the down-gradient well minus the up-gradient well levels and divide by the distance which separates them. Obviously, the signs of the gradients can change depending on the direction of flow.

It was decided by the principal investigators in the study that a sign convention of "+" for the value of **"i"** indicates that water is leaving the aquifer and the Indian River Lagoon or St. Lucie River is gaining water. Conversely, the Indian River Lagoon or St. Lucie River is losing water to the aquifer when a "-" sign is used. This sign convention also agrees with the sign convention utilized in the seepage meter measurements and is the normally used convention.

Gradients were calculated using the daily average head for each groundwater well. The water level data were supplied by SFWMD. Each groundwater well (transect) water level was downloaded in a similar format. Transects which had no surface water levels associated with them utilized tail/head water levels from the nearest SFWMD structure. All wells, measuring points, land surface, and staff gages were GPS/surveyed in the 1927 horizontal and 1929 vertical datums.

The construction spreadsheets for wells and *in situ* piezometers are provided in Appendix A of this report, and provide a complete summary of all well construction information; this includes spatial location and elevation. This information was used to calculate the differences in feet between sites (e.g. near to far well clusters, top of well screens differences). Since all well clusters and transects were not located on an east-west coordinate, the Pythagorean theorem was used to calculate horizontal distances between the area of interest (wells, river piezometers, staff gauges). Vertical distances were calculated by using the top of well screen levels (NGVD) for wells and piezometers, and using ground surface elevations for seepage meters. Vertical gradient calculations were only done at areas immediately within a 100 feet radius of the main water level of interest. The gradient calculations were completed using the standard groundwater methodology (Todd, 1980). A gradient in lay terms is defined as the rise over the run (slope). Mathematically, it is defined for horizontal gradients by the equation:

$$i_{(horizontal)} = \left(\frac{(h_1 - \mathrm{h}_2}{\Delta \mathrm{l}}\right) \text{[Equation 2]}$$

where: i = the gradient (unitless)
h_1= the hydraulic head in feet (NGVD) at location 1
h_2= the hydraulic head in feet (NGVD) at location 2

$$\Delta l = \sqrt{(l_1)^2 + (l_2)^2} \quad \text{[Equation 3]}$$

$$\Delta l = \sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2}$$

Where: $l_1 = (x_{1,} y_1)$ = spatial horizontal coordinate of point one
$l_2 = (x_{2,} y_2)$ = spatial horizontal coordinate of point two

As a theoretical example (Figure 3) lets assume the following:

h_1= 32 feet NGVD (St. Lucie River water level)
h_2= 34 feet NGVD (ground water level in well adjacent to the St. Lucie River)
$l_1 = x_{1,} y_1$ = Easting = 444,789 feet, Northing = 110,789 feet
$l_2 = x_{2,} y_2$ = Easting = 444,630 feet, Northing = 110,532 feet

Plugging in the values into Equation 1:

$$i_{(horizontal)} = \left(\frac{(32\,feet - 34\,ft)}{\sqrt{(444{,}789\,feet - 444{,}530\,feet)^2 + (110{,}789\,feet - 10{,}532\,feet)^2}}\right)$$

$$i_{(horizontal)} = \left(\frac{(32\,feet - 34\,ft)}{\sqrt{(159\,feet)^2 + (257\,feet)^2}}\right)$$

$$i_{(horizontal)} = \left(\frac{-2\,feet}{302\,feet}\right)$$

$i_{(\text{horizontal})}$ = -0.0066225

This indicates that the St. Lucie River is losing water to the aquifer.

Similarly, the same example applies for vertical gradients using river piezometer and seepage meter data (Figure 4). The seepage meter and the piezometers are located adjacent to each other.

$$i_{(vertical)} = \left(\frac{h_1 - h_2}{\Delta l}\right) \quad [\text{Equation 4}]$$

Where: i = the gradient (unitless)
h_1= the hydraulic head in feet (NGVD) of the St. Lucie River
h_2= the hydraulic head in feet (NGVD) in the piezometer located beneath the bottom of the river.

The following example applies using the previous horizontal example and the same hydraulic heads, and defining the total distance as the distance from the top of the screen interval of the piezometer to the river bottom surface elevation directly below the bottom of the seepage meter. (Note: all elevations are measured in 1929 NGVD).

Where:
Z_p = vertical elevation of the top of the piezometer screen (NGVD)
Z_m = vertical elevation of the river bottom surface which the seepage meter is mounted in 1929 NGVD.

In this example we will use the following for vertical distance:

Z_p = 16 feet (NGVD)
Z_m = 26 feet (NGVD)

$$i_{(vertical)} = \left(\frac{32\, feet - 34\, feet}{Z_m - Z_p}\right)$$

$$i_{(vertical)} = \left(\frac{34\, feet - 32\, feet}{26\, feet - 16\, feet}\right)$$

$$i_{(vertical)} = \left(\frac{-2\, feet}{16\, feet}\right)$$

$i_{(vertical)}$= (-0.125)

This calculation also indicates that the gradient is downward and the movement of water is into the aquifer from the river.

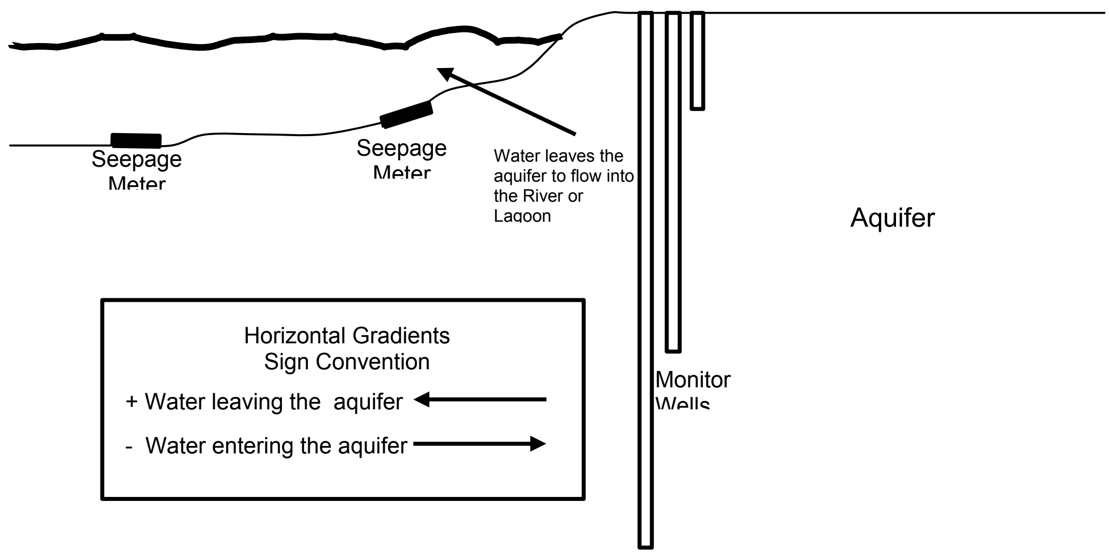


Figure 3. St. Lucie River/Indian River Lagoon Horizontal Gradient Cross Section Diagram. Not to Scale.

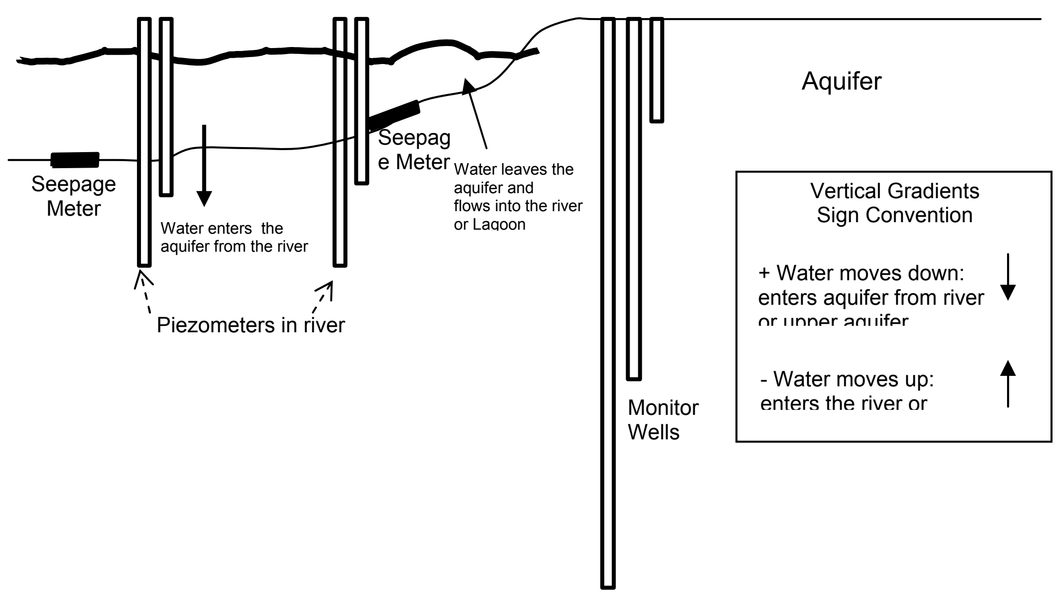


Figure 4. St. Lucie River/Indian River Lagoon Vertical Gradient Cross Section Diagram. Not to Scale

Collaboration and Responsibilities

The contract personnel for the study included two Florida Tech researchers, Dr. Tom Belanger (P.I.) and Dr. Howell Heck (Co-P.I.). Dr. Belanger coordinated all phases of research on this study, and worked closely with District staff in all phases of the project (design, implementation, monitoring, and interpretation).

Drs. Belanger and Heck have worked together on many research projects, including the Dissolved Oxygen Study in the Kissimmee River System (SFWMD contract C-3205). Dr. Belanger has published numerous refereed papers on GW/SW interactions and has completed a flow net/seepage meter comparative study for a central Florida lake (Belanger and Kirkner, 1994). Other relevant publications include Belanger and Connor (1981), Belanger and Mikutel (1985), Belanger (1990), Belanger and Montgomery (1992), and Belanger and Walker (1990). His expertise in groundwater seepage was recognized by others in the field when he was invited to present two papers at a workshop on Submarine Groundwater Discharge in Aquatic Environments at Virginia Tech in 1990. Dr. Heck is a professional engineer with over 20 years of experience in groundwater studies.

Cynthia Gefvert, the District's Project Manager for this study, was assisted by Steve Krupa P. G., and they were responsible for coordinating activities with the contractor. Their responsibilities included scheduling meetings, providing certain equipment for field work, synchronizing sampling events, arranging sample collection and analysis, retrieving and reviewing hydrologic and water quality data collected by the District, and preparing and reviewing reports. They also arranged assistance and participation from other District staff for activities such as research design, fieldwork, sample analysis, data processing, and report review. Steve Krupa also was the designer of the Krupaseep meter, and deployed his meters at the field sites. He and Cynthia Gefvert analyzed Krupaseep data, collected water quality samples from selected wells, and retrieved, graphed and analyzed hydrologic data collected by the District.

Results and Discussion

Before discussing the results, a brief review of significant sources of error in using seepage meters is presented.

A. Sources of Error in Using Seepage Meters

The movement of groundwater into the Indian River Lagoon or St. Lucie river system is controlled by the hydraulic gradient, the hydraulic properties of the aquifer system connected to the river system, and the leakance (hydraulic conductivity/thickness) of the benthic sediments themselves. We've briefly discussed the potential errors involved in this study in defining the first two conditions, which control the total quantity of flow. The distribution of flow across the benthic surface is determined by the last condition (sediment leakance), and is best estimated by point measurements from seepage meters. A lack of properly spaced meters and transects, however, would result in significant errors in estimates of total groundwater seepage from those meters. Generally, temporal variability is less than site to site variability unless water levels fluctuate greatly, as can occur in these systems. Other problems with seepage meters include occasional "bag leak" and "unseated meter" conditions that remain undetected. In general, data from tank tests indicate relative root-mean-square (rms) errors for measurements are < 5% at a particular location once a meter is installed. The meter insertion error is larger but still < 20% (Belanger and Montgomery, 1992). These device errors are small compared to spatial and temporal components of sampling error typically encountered in the field. Data from 120 measurements at duplicate meters located at five locations along a 3-km transect in the Indian River Lagoon indicate excellent field precision, particularly considering that field problems such as clogging of tubing, incomplete sealing in the sediment, etc. may have caused wide variations in some duplicate meter data. At these sites, the rms relative difference between adjacent meters (12%) was small compared to mean square variability over time (108%) (Belanger, 1990). In this study, duplicate meters at some field sites yielded similar data, while others did not. This will be discussed later.

In the past, groundwater seepage estimation has relied primarily on indirect techniques. Groundwater flow near bodies of water can be complicated, and serious misinterpretation of the interaction of water bodies and groundwater can occur due to errors in estimating geological boundaries, hydraulic conductivities, and hydraulic gradients (Winter 1976, 1978, 1981, 1983). The seepage meter (Lee 1977) allows direct measurement of seepage flux and avoids errors, assumptions, and input data associated with indirect techniques, allowing the distribution of seepage along the bottom profile to be portrayed. The seepage meter technique has been recommended by the Environmental Protection Agency (EPA, 1988) and has been established as an accurate and reliable technique through field and tank test studies (Lee 1977, Erickson 1981, Cherkauer and McBride 1988, Belanger and Montgomery 1992).

Any hydrologic budget includes instrumental (device) errors and both spatial and temporal components of sampling error. The former results from measurement with imperfect instruments while the latter results from estimating fluxes in a time-space continuum from site-specific point data (Winter 1981). Meter (device) errors can only be quantified through tank testing under known conditions. Although further testing should be done to determine the source of this decrease in accuracy, it appears that meter:tank and meter:interstitial seepage rate ratios of 0.77 and 0.55, respectively, are accurate for normal seepage rates encountered in the field (0-20 mm h^{-1}). The 0.77 meter:tank flux ratio obtained by Belanger and Montgomery (1992) is similar to the average ratio (0.76) found in tank tests by Erickson (1981) at various flow rates (6.3-61.9 mm h^{-1}) with the same seepage meter design. The lower measured seepage is apparently due to frictional resistance along the internal boundaries of the meter and reservoir bags and head loss induced by the tubing orifice.

Although the variable nature of the seepage rates in tank tests by Belanger and Montgomery (1992) were not expected, the highly nonuniform moisture and solute transport in sandy soils has long been noted. Research by Glass *et al*. (1989 a, b) shows how wetting front stability occurs when water infiltrates into an unsaturated porous medium. When a wetting front becomes unstable "fingers" form and move down through the vadose zone bypassing much of the unsaturated medium. Heterogeneities cause the merger of fingers and the formation of faster, wider fingers, a process not accounted for directly in the linear theory (Glass *et al*. 1989 a, b). Although Glass *et al*. (1989 a, b) discuss how a wetting front moves through unsaturated soil, it is known that these preferred paths of flow persist after the medium is fully saturated, and this phenomenon may have contributed to the tank test variability and probably contributes to field variability as well. Localized variations in seepage rates over short distances have been documented in many field studies (Belanger and Walker 1990; Brock *et al*. 1982; Isiorho and Matisoff 1990; Shaw *et al*. 1990).

For example, data from 33 seepage meters positioned along a 3-km transect across the Indian River lagoon showed site seepage rates varying from –0.013 to 55.2 liters m^{-2} h^{-1} (Belanger and Walker 1990). In Mountain Lake, Florida, a 43-ha lake in which 47 seepage meters were placed, maximum site-to-site variation of –5.1 to + 1.2 liters m^{-2} h^{-1} was measured (Belanger and Kirkner, 1994). The large variations in seepage in the two bodies of water were not expected based on adjacent well and hydrogeologic data, but they are reasonable considering the variety of factors influencing groundwater flow near water bodies and the well-known occurrence of natural springs in the area. In particular, the distribution of groundwater seepage across the sediment surface is greatly influenced by "leakance" (hydraulic conductivity/thickness) of the benthic sediments and the water-table configuration (Winter 1976, 1983; Winter *et al*. 1988; McBride and Pfannkuch 1975).

Although tank test results have established seepage meters as precise measurement devices with relatively constant bias, there is considerable uncertainty and misunderstanding about the design of seepage meter studies and the interpretation of data to obtain useful water budget information. Generally, temporal variability is much less than site-to-site variability (Brock *et al*. 1982; Belanger and Walker 1990), and this should be reflected in the sampling design. However, in systems such as the Indian River Lagoon or St. Lucie River, where water levels may vary several feet in short periods of time due to tidal changes, temporal variability can also be very great. Due to the complexity of groundwater-surface water interactions and variations in the direction and magnitude of seepage rates recorded in a single water body, special concern must be placed on extrapolation of seepage data for entire systems based on a limited number of seepage meters. It is imperative that entire water body seepage estimates be made from a large data set obtained from sites and transects throughout the aquatic system. This was done in this study with the conventional seepage meter, but indicates one problem with the Krupaseep: not enough meters can be deployed simultaneously to accurately represent the system (due to expense). The Krupaseep can, however, capture transient rates produced by tidal variations etc. that would be difficult to measure with the conventional meters, especially at several locations.

Although seepage meters have been established as reliable techniques, as discussed above, two recent articles in scientific journals have cast some doubt on the accuracy of the technique under high flow and wind/wave conditions. Libelo and McIntyre (1999) state that surface water movement due to waves and currents reduce the hydraulic head in the meter, causing a pressure drop that results in erroneously large values of measured seepage flux within the meter. Shinn et al., (2002) believe meters, due to their positive relief on the benthic sediment, are subject to Bernoulli effect in areas where there are significant waves or currents that must be lifted over the meter. The Bernoulli effect causes the meters to artificially advect shallow groundwater, causing an overestimate of true seepage. However, detailed filed studies and tank tests at Florida Tech, designed to thoroughly investigate the above claims under a range of flow, wave and meter height situations did not find inaccuracies due to the high currents and waves (Belanger, 2003). Also, an inspection of the collected field seepage data in this study did not indicate that areas with high flow and /or waves corresponded to high seepage areas. In fact, the reverse was sometimes true. The exact make-up of seepage could include some percentage of recirculated groundwater. Further research is recommended to determine if recirculation occurs and also to conclusively prove or disprove flow and wave effects on seepage meters.

The seepage meter has made it possible to directly measure groundwater input at specific locations, however, nutrient and other chemical parameter loading estimates will not be complete until the water quality of this component has been measured and coupled with seepage rate data (Concentration x Flow = Loading). In this study, our estimate of groundwater quality entering the river system can be obtained by sampling the near-shore wells. Water quality data from wells, piezometers and surface water were obtained following procedures outlined in the District Q/A Plan. This should be considered as only an approximation; however, as this groundwater may travel considerable distances through sediment and undergo changes due to chemical physical and biological processes before entering the river. Pore water analysis in sediments lying below the sediment-water interface, below the hyporheic zone, at locations of known groundwater inflow would be more accurate; but, analytical methods such as pore water squeezing under pressure, *in situ* dialysis and *in situ* "peepers" are difficult, time consuming and expensive to employ. Water from seepage meter bags cannot be sampled directly for nutrient analysis because the residence time of the water in the meters is long relative to processes that would modify the habitat and the seepage water. Seepage meter bag analysis would likely overestimate natural seepage nutrient inputs due to enclosure of the sediments by the meter and the accompanying anaerobic conditions that occur within short time intervals (Belanger and Mikutel, 1985).

B. Site Lithology and Relationship to 30, 60 and 100 foot Wells.

Well log data were obtained from study area wells to describe the general lithology (Miller, 1979). An inspection of the lithology of these wells indicates the surficial aquifer in Martin and St. Lucie Counties is 150 to 200 ft. below land surface, and that the dominant lithology within the surficial aquifer can be broken down into three layers. Generally there is a medium to fine grained sand layer which extends to a depth of approximately 30 to 40 ft.

below MSL, at which point a thin clay layer usually exists. This clay layer is usually only several meters thick, but can vary considerably within a short distance. Although this clay layer is continuous along the north–south direction of the Lagoon, well log data indicate it to be discontinuous in some areas between Ft. Pierce and Stuart. A sand and shell layer which has a thickness of about 100 to 120 ft. connects the thin clay layer (if present) and the Hawthorn Formation.

The above well log information indicates the 30 ft. study wells are most likely located in the medium to fine grained sand layer. It appears the 60 and 100 ft. wells are located in the sand and shell layer, although the very low hydraulic conductivities (K) recorded from the 60 ft. well depths for many of the wells suggests the screened intervals may be located in clay or sandy clay. Since all the study wells were placed in the surficial aquifer, we have no water level data from the upper Floridan Aquifer from this study to indicate if the hydraulic head is higher than the surficial aquifer system, indicating that the area is a "discharge area" for the upper Floridan. Discharge areas have been found elsewhere in the Indian River Lagoon System, such as in Mosquito Lagoon. Very little seepage through the Hawthorn Formation to the surfical aquifer would normally be expected in the study area due to its thickness. However, faulting causing discontinuities in the Hawthorn Formation could allow seepage to occur from the Floridan to the surficial aquifers resulting in high seepage water measured in the Indian River Lagoon seepage meters by Walker (1989) and in this study. A geologic fault parallel to the lagoon has been suggested by several investigators (Lichtler, 1960; Miller, 1986; Schiner et al., 1988). Almasi (1983) hypothesisized that a geologic fault caused a shift in sediments beneath the lagoon. In particular, Schiner et al. (1988) have identified a fault directly beneath the lagoon in Indian River County that could correspond to the shift in sediment observed by Almasi further south. It is probable that groundwater from the lower zone of the surficial aquifer system represents a more important input to the system along its entire length than Floridan input (Phelps, 1990). Hydraulic conductivities for the study area wells are shown in Table 2, along with average well water levels measured on seepage measurement days, although much of the water level data are missing. These data generally indicate higher hydraulic conductivity for Indian River Lagoon sites. Daily mean surface water and well water level data for the study period are presented in Appendix B, although data are limited at many sites. The figures shown in Appendix B substantiate the fact that all three wells are located in the surfical aquifer and that the clay layers likely have discontinuities in them because the various well water elevations, although different, mimic each other and show the same trends.

The following discussion addresses specific well water level data for individual sites (Appendix B). At Club Med, the 60 and 100 ft. well water levels are in phase, while the 30 ft well is more variable and closer to surface water levels. Harbour Ridge shows the 60 and 100 ft. well levels are also in phase, also, with the 60 ft head being lower. At Pendarvis Cove, the 100 and 60 ft. wells are essentially the same, while the 30 ft. well levels are in phase with the 100 and 60 ft. wells, but lower. The surface water at Pendarvis Cove is variable and usually out of phase with the 30 ft. well. The Lutz/MacMillan site is controlled by the surface water and is greatly influenced by tides. The 60 and 30 ft. wells show levels that are highly variable, but the levels mirror surface water levels. The Indian River Lagoon sites, Minton and Lake Manor, are similar. The Minton site shows similar elevation and trends in the 30 and 60 ft. wells. The surface water levels are in phase with well data, but levels are lower. At Lake Manor, all wells and surface water levels are in phase, but the surface water exhibits a more pronounced variability. The 100 ft. well exhibits a much higher

Table 2. Mean Water Levels in Wells on Seepage Measurement Days (NGVD-1929)

Site	Well Depth Approx.	Water Levels on Seepage Measurement Days							Slug Test K (ft/day)
Harbor Ridge									
SLHRG1	60'								4
SLHRG2	30'								35
Club Med							2/2/2003	3/24/2003	
SLCMG1	100'						1.81	1.83	5
SLCMG2	60'						1.87	1.87	6
SLCMG3	30'						1.48	1.27	52
Pendarvis Cove							2/1/2003	3/27/2003	
SLPDG1	100'						0.76	1.47	32
SLPDG2	60'						0.74	1.43	10
SLPDG3	30'						0.59	1.18	158
Lutz/MacMillan		8/15/2002			11/1/2002		2/1/2003	3/25/2003	
SLAMG1	60'	0.66			0.89		0.02	0.57	4
SLAMG2	30'	0.69			0.95		0.06	0.62	122
Minton			10/18/2002	10/26/2002		1/31/203	2/23/2003		
IRMNG1	60'		2.55	2.26		1.31	1.29		9
IRMNG2	30'		2.32	2.00		1.08	1.09		258
Lake Manor				10/26/2002			2/1/2003	3/23/2003	
IRLMG1	100'			3.08			2.36	2.87	363
IRLMG2	60'			2.05			1.29	1.87	21
IRLMG3	30'			1.63			0.86	1.32	134

head than the 60 or 30 ft. wells, indicating artesian conditions, but the 100 ft well levels are also in phase with the shallower wells, indicating breaks in the clay layer.

Figures 5 through 8 present limited water level data for the 100, 60 and 30 ft. wells, and surface water, respectively. Figure 5 shows the Club Med and Lake Manor 100 ft levels in phase with Pendarvis Cove, but with a slightly higher head. The mean 100 ft. water level for Pendarvis Cove was approximately 1.2 ft. NGVD versus an approximate mean of 2.5 ft. NGVD for Club Med and Lake Manor (Fig. 5). The Indian River Lagoon 100 ft. well at Lake Manor was often out of phase with other sites. Except for a couple of days, the two Indian River sites exhibited similar 60 ft. levels, with a mean level of approximately 1.5 ft. NGVD (Fig. 6). Club Med 60 ft. water level data were limited but were highly variable and not in phase with other 60 ft. wells. The Lutz/MacMillan site showed the lowest 60 ft. well water level, averaging approximately 1.0 ft. NGVD, while Harbour Ridge exhibited the highest head with a mean level of approximately 3.0 ft. NGVD, but the levels were not in phase with other sites (Fig. 6). Harbour Ridge exhibited the highest 30 ft. well levels, with an approximate mean of 4.0 ft. NGVD. All other 30 ft. well levels were similar in height but were often out of phase (mean = 1.0 ft. NGVD). The Indian River sites, Lake Manor and Minton, showed 30 ft. well levels that were in phase, but Lake Manor levels were more variable (Fig. 7). Surface water levels were extremely variable at all sites, but least variation was recorded at Pendarvis Cove and most variation occurred at Lutz/MacMillan, Minton and Lake Manor, probably due to tidal influences (Fig. 8).

Although faulting causing breaks in the Hawthorn Formation is possible as discussed above, discontinuities in the thin clay layer in the surficial aquifer could achieve the same result and cause artesian flow conditions from the lower to upper surficial aquifer. This is a more likely scenario and could be a plausible explanation for the high seepage rates measured in this study and also previously by Belanger and Walker (1990) with numerous seepage meters in a transect across the Indian River Lagoon 5 km north of the Jensen Beach Bridge and just north of the Lake Manor Site. In this study, "hot spots" or locations of very high seepage were found which could correspond to locations where breaks in the clay layer exist. Several of these areas resembled springs and exhibited seepage rates in excess of 0.48 m/day and could also be due to breaks or discontinuities in the Hawthorn Formation, although less likely. Geophysical techniques to confirm the presence or absence of these discontinuities are recommended. These features could also explain the high seepage water measured in this study, discussed later, at offshore sites at Lake Manor and Minton in the Indian River Lagoon and Pendarvis Cove in the St. Lucie River. In the Walker (1989) study, average measured seepage across the Indian River Lagoon (0.12 m/day) was considerably higher than other estimates by Pandit and El-Khazen (1990) using a Galerkin finite element model ($7.6x10^{-4}$ – $2.6x10^{-3}$ m/day) and Belanger and Montgomery (1992), who used the USGS 3-D finite difference model ($30x10^{-4}$ m/day). These results point out problems with models that estimate input data and boundary conditions or use input data obtained from wells located various distances from the lagoon. Only direct measurement devices, such as seepage meters, could pinpoint the "hot spots" and use these data in mean seepage calculations.

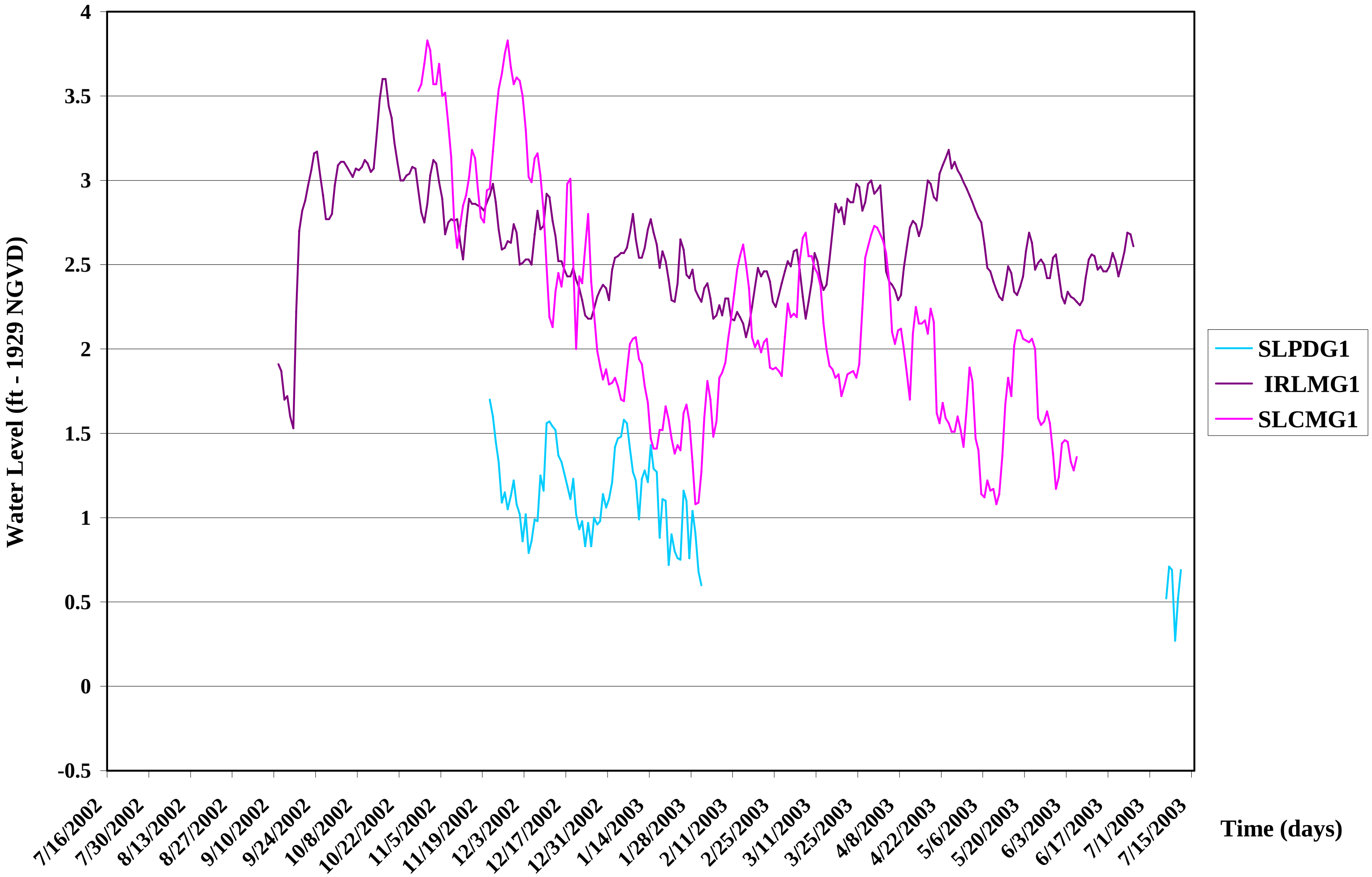


Figure 5. 100-ft Well Water Level Data

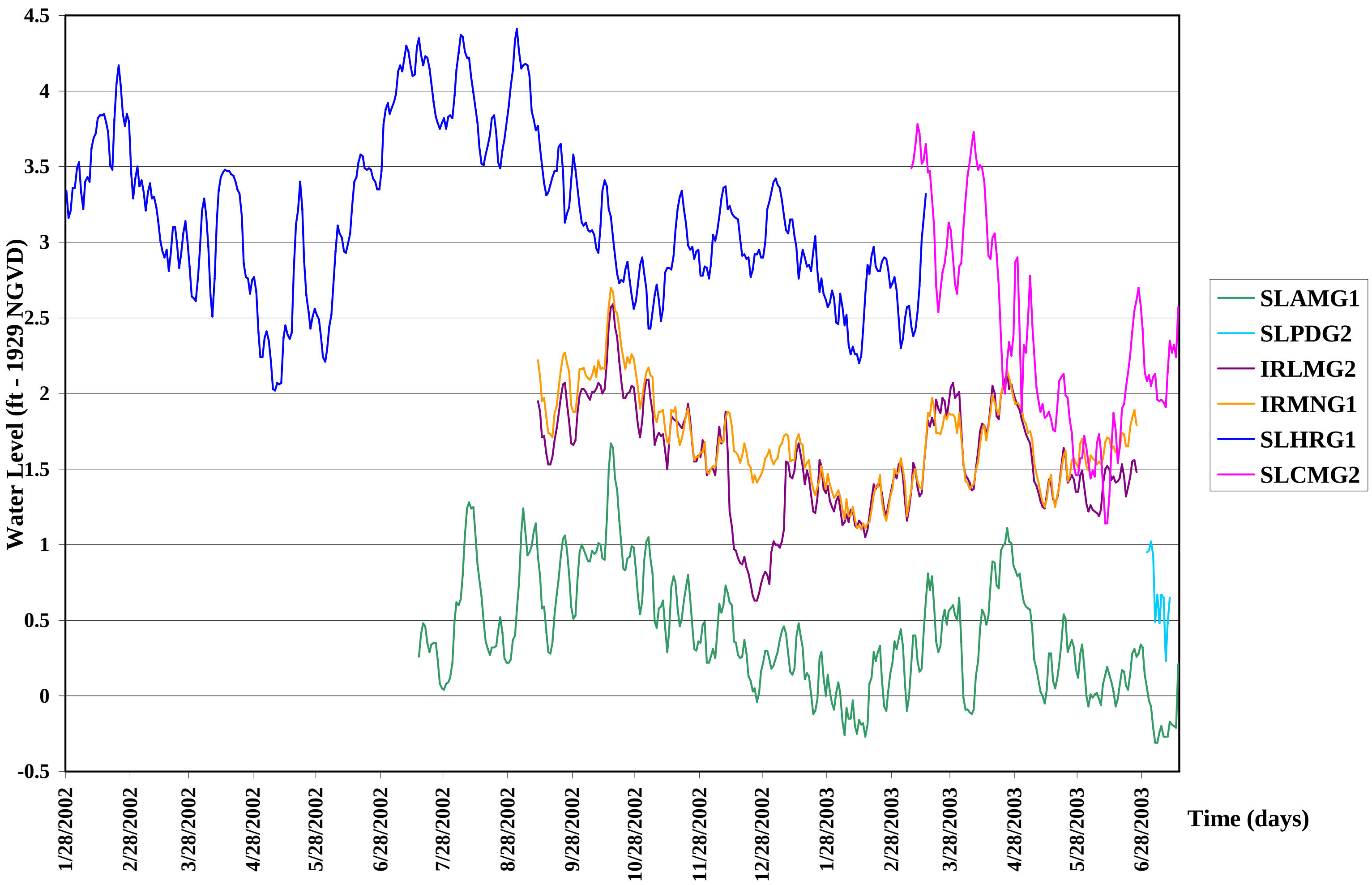


Figure 6. 60-ft Well Water Level Data

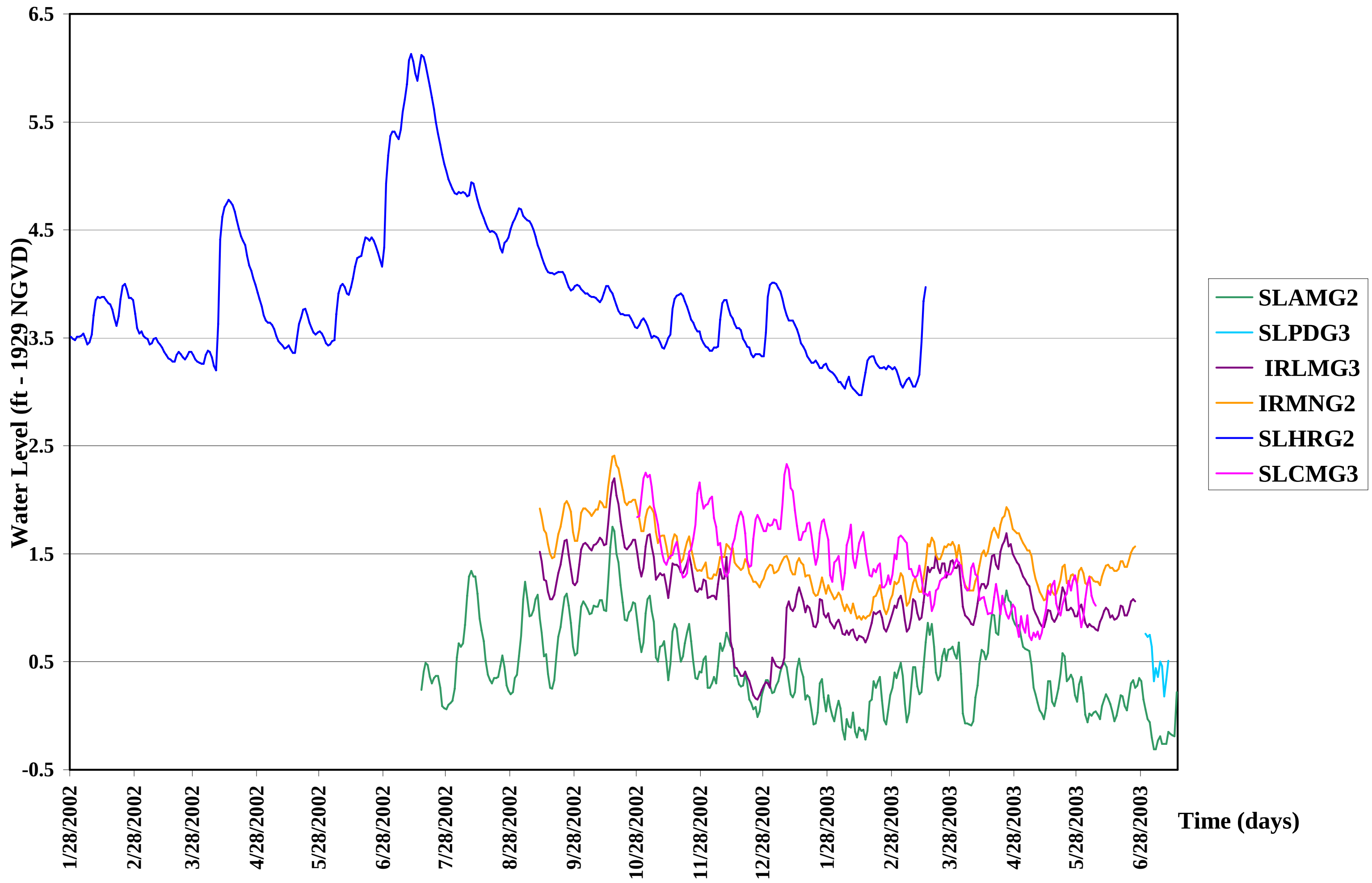


Figure 7. 30-ft Well Water Level Data

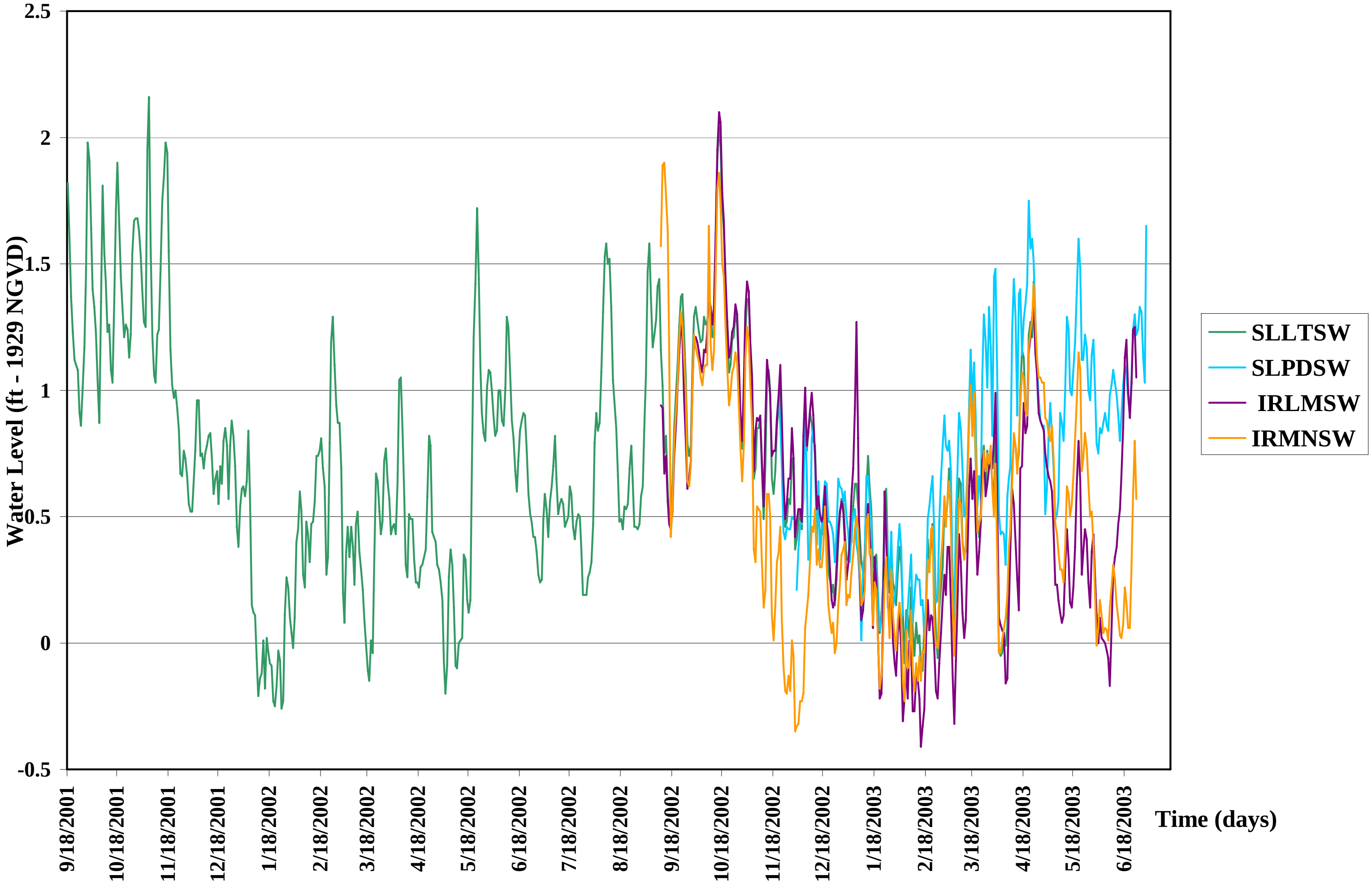


Figure 8. Surface Water Levels at Measurement Sites

III. Water Quality Data

With a few exceptions, the water quality of the wells and surface water at the study sites was good. Water quality data for the four sampling dates from March 2002 to March 2003 are presented in Appendix D. The mean, range, and 95% confidence intervals for selected water quality parameters are shown in Appendix E. Selected mean water quality data from the various wells, piezometers, and surface water sites from the four sampling events between March, 2002 and March, 2003 are summarized in Table 3 and Appendix E. TPO_4, OPO_4 DO, NO_X, Specific Conductance, and TKN means for the Indian River Lagoon and St. Lucie River sites, collectively, are shown in bar graphs presented in Figures 9 through 11.

As can be seen from Table 3, surface water mean TPO_4 was much higher at the St. Lucie River surface water sites (0.183 mg/l) than the Indian River Lagoon surface water sites (.073 mg/l), with the highest mean value occurring at Harbour Ridge (0.279 mg/l). The lower tidal flushing and lower water volume relative to shoreline development may account for the higher TPO_4 levels in the St. Lucie River. High mean ortho-PO_4 levels were found in the SLCMZ3 and SLCMZ4 piezometers, with mean values of 0.345 and 0.385 mg/l, respectively. Mean ortho-PO_4 was also high at SLAMG2 (0.301 mg/l) and SLLTZ4 (0.369 mg/l). NO_X, NH_4 and TKN were fairly low at both St. Lucie River and Indian River Lagoon surface water sites averaging 0.034, 0.036, and 0.7 mg/l, respectively. Mean NO_X was actually 0.0 at both Indian River Lagoon sites, and may be due to uptake by the heavy seagrass growth at these locations. High mean NO_X levels at IRLMG3 and IRLMG1 were due primarily to high recorded levels on 2/6/02 and 12/10/02, respectively. High mean TKN values for SLCMZ3 and SLCMZ4, were also due to the high NH_4 present.

Although On-Site-Detention-Systems (OSDS) are present at both sites, it appears from analyzing the water quality data that the impact is low, especially in the Indian River Lagoon. Bacterial data from Florida Tech graduate student project data taken on 8/28/02 indicate fecal coliform levels at <3 MPN/100ml at all Indian River Lagoon wells as well as piezometers that were 1ft., 5ft., and 15ft. below land surface (BLS) located at the water's edge at the Minton site. A detailed site specific field study at specific OSDS sites would need to be completed to conclusively prove the impact of OSDS in the study area, however.

The St. Lucie River is really an estuary, a river that starts out fresh in the upper reaches in the north and south forks, and mixes with salt water near the mouth. Summer rains and large scale water releases from Lake Okeechobee drastically reduce the salinity. The close proximity of the St. Lucie Inlet usually keeps the salinity of the river fairly stable but the discharges from Lake Okeechobee are so large that they lower salinities in the lagoon itself. The effects can be seen from the surface water specific conductance data from the various sites. Examination of the specific conductance data for the various sites (wells and surface water) reveals that the Lutz/MacMillan site is tidally controlled, as wells and piezometers exhibit similar or even higher specific conductance than the surface water. At the Club Med, Pendarvis Cove and Minton sites the wells and nearshore piezometers are

Table 3. Summary of selected water quality data from wells, surface water and in situ piezometers for sites in the Indian River Lagoon and St. Lucie River. March 2002 through March 2003 (March 2002, August 2002, December 2002, March 2003).

	Site:	Pendarvis Cove						
Parameter	Statistic	SLPDG1	SLPDG2	SLPDG3	SLPDSW	SLPDZ1	SLPDZ3	SLPDZ4
DO	N	4	4	4	4	2	2	2
(mg/L)	Mean	0.34	0.34	0.27	7.46	0.43	1.71	4.58
Sp. Conductance	N	4	4	4	4	3	3	3
(µ-S/cm @ 25° C.)	Mean	574	530	502	19405	559	29489	21613
NO_x	N	4	4	4	4	3	3	1
(mg N/L)	Mean	0.001	0.107	0.061	0.086	0.003	-0.004	0.029
NH_4	N	4	4	4	4	3	3	1
(mg N/L)	Mean	0.338	0.166	0.097	0.050	0.215	2.903	3.230
TKN	N	4	4	4	4	3	3	1
(mg N/L)	Mean	0.5	0.3	0.3	0.8	0.3	3.7	3.7
OPO_4	N	4	4	4	4	3	3	3
(mg P/L)	Mean	0.125	0.080	0.084	0.117	0.133	0.067	0.284
TPO_4	N	4	4	4	4	3	3	1
(mg P/L)	Mean	0.169	0.138	0.153	0.171	0.174	0.155	0.290
DOC	N	4	4	4	4	3	3	1
(mg/L)	Mean	6.6	5.9	4.6	12.7	3.6	11.0	9.2
TOC	N	4	4	4	4	3	3	1
(mg/L)	Mean	6.6	6.0	4.4	13.5	3.5	10.7	9.1
MBAS	N	2	2	2	2	4	4	2
(mg/L)	Mean	0.06	0.04	0.05	0.09	0.04	0.17	0.17

	Site:	Harbour Ridge						
Parameter	Statistic	SLHRG1	SLHRG2	SLHRSW	SLHRZ1	SLHRZ2	SLHRZ3	SLHRZ4
DO	N	4	4	4	2	2	3	3
(mg/L)	Mean	0.33	0.37	6.97	1.54	0.68	0.63	0.50
Sp. Conductance	N	4	4	4	3	3	3	3
(µ-S/cm @ 25° C.)	Mean	520	386	18069	412	532	445	1047
NO_x	N	4	4	4	3	3	3	3
(mg N/L)	Mean	0.003	0.020	0.020	0.004	0.014	0.009	0.060
NH_4	N	4	4	4	3	3	3	3
(mg N/L)	Mean	0.225	0.561	0.058	0.153	0.383	1.055	1.348
TKN	N	3	4	4	3	3	3	3
(mg N/L)	Mean	0.6	0.8	0.8	0.0	0.6	1.2	1.6
OPO_4	N	4	4	4	3	3	3	3
(mg P/L)	Mean	0.174	0.006	0.125	0.057	0.002	0.207	0.200
TPO_4	N	4	4	4	3	3	3	3
(mg P/L)	Mean	0.364	0.017	0.279	0.083	0.014	0.260	0.253
DOC	N	4	4	4	3	3	3	3
(mg/L)	Mean	5.5	5.3	12.3	2.9	5.0	4.5	5.0
TOC	N	4	4	4	3	3	3	3
(mg/L)	Mean	5.3	5.2	12.8	2.9	5.0	4.4	4.9
MBAS	N	2	2	2	2	4	2	4
(mg/L)	Mean	0.00	0.07	0.09	0.02	0.03	0.00	0.03

Table 3 (continued). Summary of selected water quality data from wells, surface water and in situ piezometers for sites in the Indian River Lagoon and St. Lucie River. March 2002 through March 2003 (March 2002, August 2002, December 2002, March 2003).

	Site:	Lutz / MacMillan						
Parameter	Statistic	SLAMG1	SLAMG2	SLLTSW	SLLTZ1	SLLTZ2	SLLTZ3	SLLTZ4
DO	N	4	4	4	3	3	2	3
(mg/L)	Mean	0.73	0.63	7.85	1.20	0.74	1.26	1.16
Sp. Conductance	N	4	4	4	3	3	2	3
(µ-S/cm @ 25° C.)	Mean	44509	42076	34284	42782	2562	47025	44997
NO_x	N	4	4	4	3	3	2	3
(mg N/L)	Mean	-0.004	0.047	0.060	0.013	0.039	-0.020	-0.020
NH_4	N	4	4	4	3	3	2	3
(mg N/L)	Mean	0.886	0.451	0.056	0.465	0.731	0.680	0.573
TKN	N	4	4	4	3	3	2	3
(mg N/L)	Mean	1.1	0.8	0.7	0.8	1.1	0.9	0.8
OPO_4	N	4	4	4	3	3	2	3
(mg P/L)	Mean	0.176	0.301	0.079	0.133	0.064	0.301	0.369
TPO_4	N	4	4	4	3	3	2	3
(mg P/L)	Mean	0.234	0.408	0.120	0.218	0.142	0.347	0.415
DOC	N	4	4	4	3	3	2	3
(mg/L)	Mean	3.7	3.9	7.7	5.2	6.6	3.1	4.1
TOC	N	4	4	4	3	3	2	3
(mg/L)	Mean	3.5	4.1	8.2	5.2	6.7	3.2	4.1
MBAS	N	4	4	4	4	4	4	4
(mg/L)	Mean	0.23	0.29	0.20	0.25	0.06	0.31	0.28

	Site:	Club Med							
Parameter	Statistic	SLCMG1	SLCMG2	SLCMG3	SLCMSW	SLCMZ1	SLCMZ2	SLCMZ3	SLCMZ4
DO	N	4	4	4	4	2	1	3	3
(mg/L)	Mean	0.23	0.21	0.26	7.72	0.67	0.48	0.18	0.16
Sp. Conductance	N	4	4	4	4	2	1	3	3
(µ-S/cm @ 25° C.)	Mean	599	461	478	18831	222	199	18374	22748
NO_x	N	4	4	4	4	2	1	3	3
(mg N/L)	Mean	0.666	0.015	0.675	0.026	0.008	0.013	0.021	-0.013
NH_4	N	4	4	4	4	2	1	3	3
(mg N/L)	Mean	0.257	0.330	0.420	0.037	0.724	5.100	2.050	2.367
TKN	N	4	4	4	4	2	1	3	3
(mg N/L)	Mean	0.5	0.7	0.8	0.8	2.0	7.6	2.5	2.9
OPO_4	N	4	4	4	4	2	1	3	3
(mg P/L)	Mean	0.141	0.223	0.245	0.121	0.095	0.336	0.345	0.385
TPO_4	N	4	4	4	4	2	1	3	3
(mg P/L)	Mean	0.187	0.264	0.300	0.163	0.258	0.120	0.378	0.423
DOC	N	4	4	4	4	2	1	3	3
(mg/L)	Mean	7.8	8.0	6.5	11.8	13.5	40.0	7.0	7.2
TOC	N	4	4	4	4	2	1	3	3
(mg/L)	Mean	8.2	8.1	6.6	12.6	13.0	41.0	7.2	7.1
MBAS	N	4	4	4	3	0	0	4	4
(mg/L)	Mean	0.04	0.03	0.05	0.15	n/a	n/a	0.06	0.16

Table 3 (continued). Summary of selected water quality data from wells, surface water and in situ piezometers for sites in the Indian River Lagoon and St. Lucie River. March 2002 through March 2003 (March 2002, August 2002, December 2002, March 2003).

	Site:	Minton						
Parameter	Statistic	IRMNG1	IRMNG2	IRMNSW	IRMNZ1	IRMNZ2	IRMNZ3	IRMNZ4
DO	N	4	4	4	3	2	3	3
(mg/L)	Mean	0.35	0.29	4.44	1.14	1.87	0.27	0.58
Sp. Conductance	N	4	4	4	3	2	3	3
(µ-S/cm @ 25° C.)	Mean	574	263	48266	10571	429	49940	51875
NO_x	N	4	4	4	3	2	3	3
(mg N/L)	Mean	0.277	0.001	-0.002	0.019	0.002	0.021	0.007
NH_4	N	4	4	4	3	2	3	3
(mg N/L)	Mean	0.318	0.178	0.040	0.691	0.105	1.730	0.667
TKN	N	4	4	4	3	2	3	3
(mg N/L)	Mean	0.6	0.5	0.6	1.0	0.3	2.3	1.1
OPO_4	N	4	4	4	3	2	3	3
(mg P/L)	Mean	0.157	0.008	0.016	0.228	0.090	0.436	0.310
TPO_4	N	4	4	4	3	2	3	3
(mg P/L)	Mean	0.191	0.018	0.069	0.246	0.057	0.519	0.347
DOC	N	4	4	4	3	2	3	3
(mg/L)	Mean	12.1	12.3	4.2	12.0	7.4	13.7	5.3
TOC	N	4	4	4	3	2	3	3
(mg/L)	Mean	12.0	12.6	4.7	12.0	7.5	13.0	5.4
MBAS	N	2	2	2	2	1	2	2
(mg/L)	Mean	0.07	0.06	0.24	0.05	0.07	0.02	0.18

	Site:	Lake Manor						
Parameter	Statistic	IRLMG1	IRLMG2	IRLMG3	IRLMSW	IRLMZ1	IRLMZ3	IRLMZ4
DO	N	4	4	4	4	2	3	2
(mg/L)	Mean	0.24	0.22	0.20	8.36	1.24	0.61	0.66
Sp. Conductance	N	4	4	4	4	3	3	2
(µ-S/cm @ 25° C.)	Mean	616	606	392	46557	396	27911	41836
NO_x	N	4	4	4	4	3	3	3
(mg N/L)	Mean	0.233	0.167	0.159	-0.005	0.040	-0.020	0.005
NH_4	N	4	4	4	4	3	3	3
(mg N/L)	Mean	0.623	0.652	0.336	0.018	1.099	0.876	0.727
TKN	N	4	4	4	4	3	3	3
(mg N/L)	Mean	0.9	1.0	0.6	0.6	1.4	1.0	0.8
OPO_4	N	4	4	4	4	3	3	3
(mg P/L)	Mean	0.418	0.314	0.155	0.026	0.234	0.449	0.178
TPO_4	N	4	4	4	4	3	3	3
(mg P/L)	Mean	0.458	0.476	0.203	0.077	0.301	0.568	0.206
DOC	N	4	4	4	4	3	3	3
(mg/L)	Mean	10.4	9.5	5.9	4.1	7.2	6.0	3.5
TOC	N	4	4	4	4	3	3	3
(mg/L)	Mean	10.4	10.1	5.5	4.6	7.2	5.7	3.6
MBAS	N	2	2	2	2	2	2	2
(mg/L)	Mean	0.05	0.03	0.02	0.29	0.02	0.12	0.27

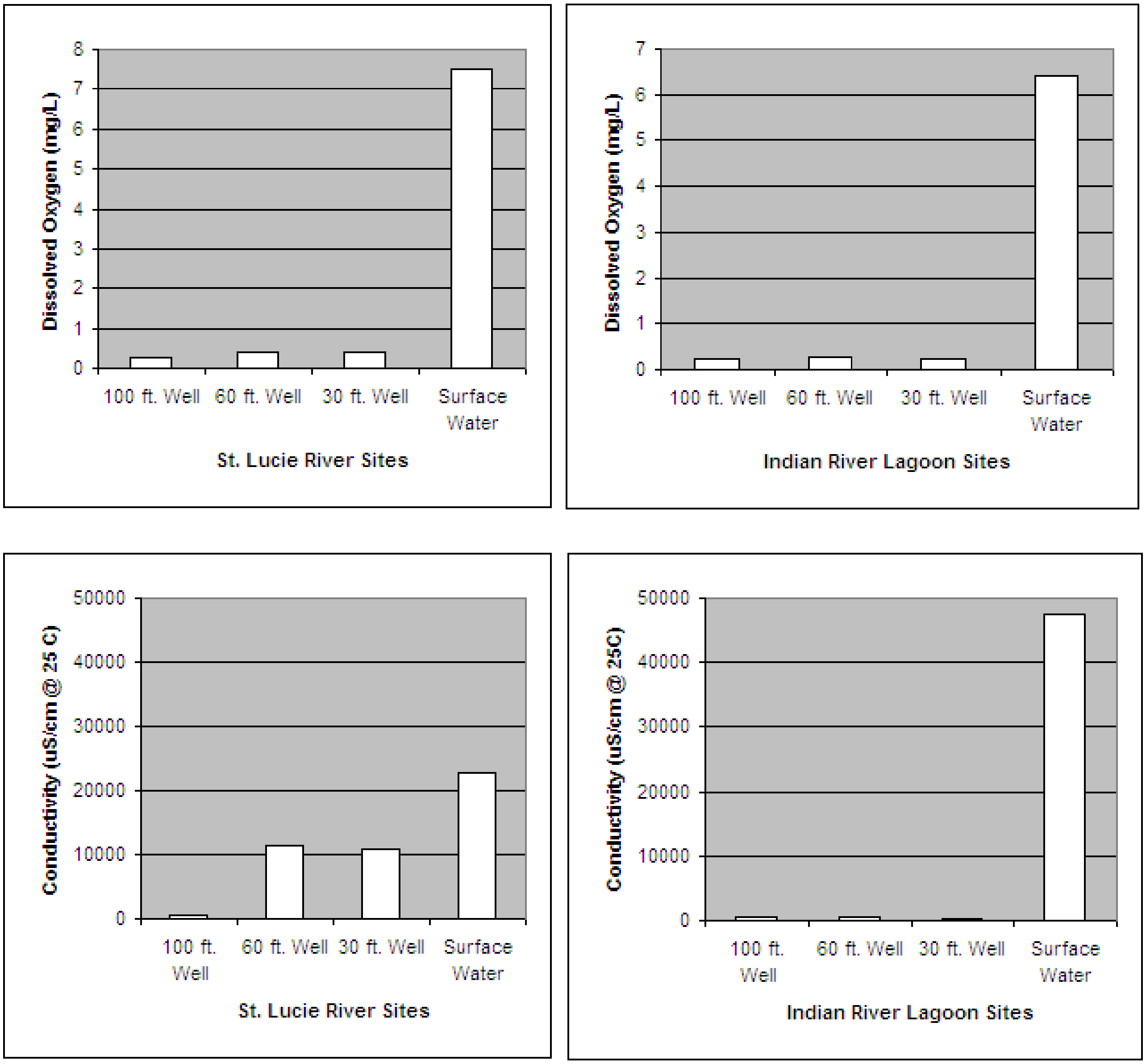


Figure 9. Mean Dissolved Oxygen (mg/L) and Specific Conductance (uS/cm) at St. Lucie River and Indian River Lagoon Sites.

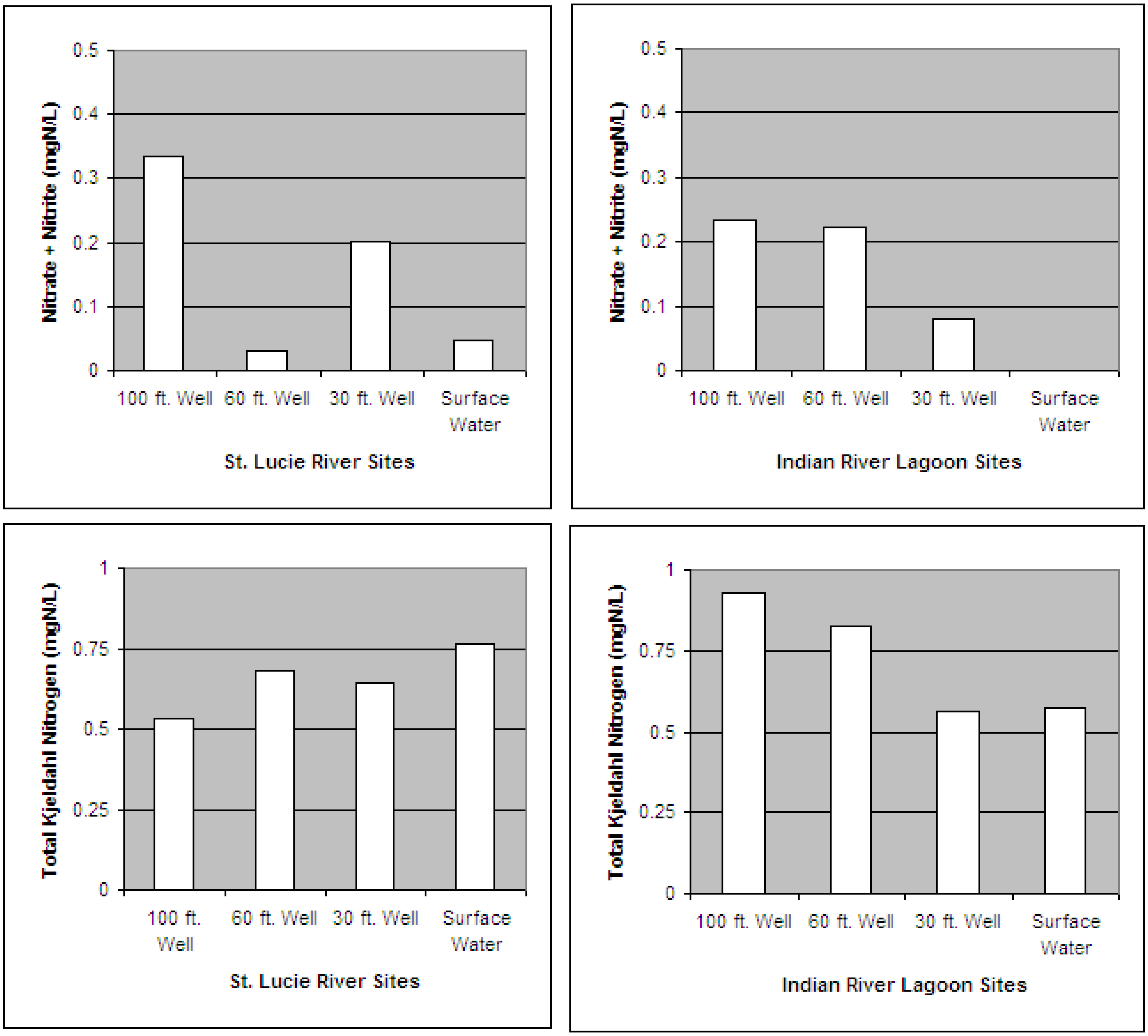


Figure 10. Mean NOx (mg N/L) and Mean TKN (mg N/L) at St. Lucie River and Indian River Lagoon Sites.

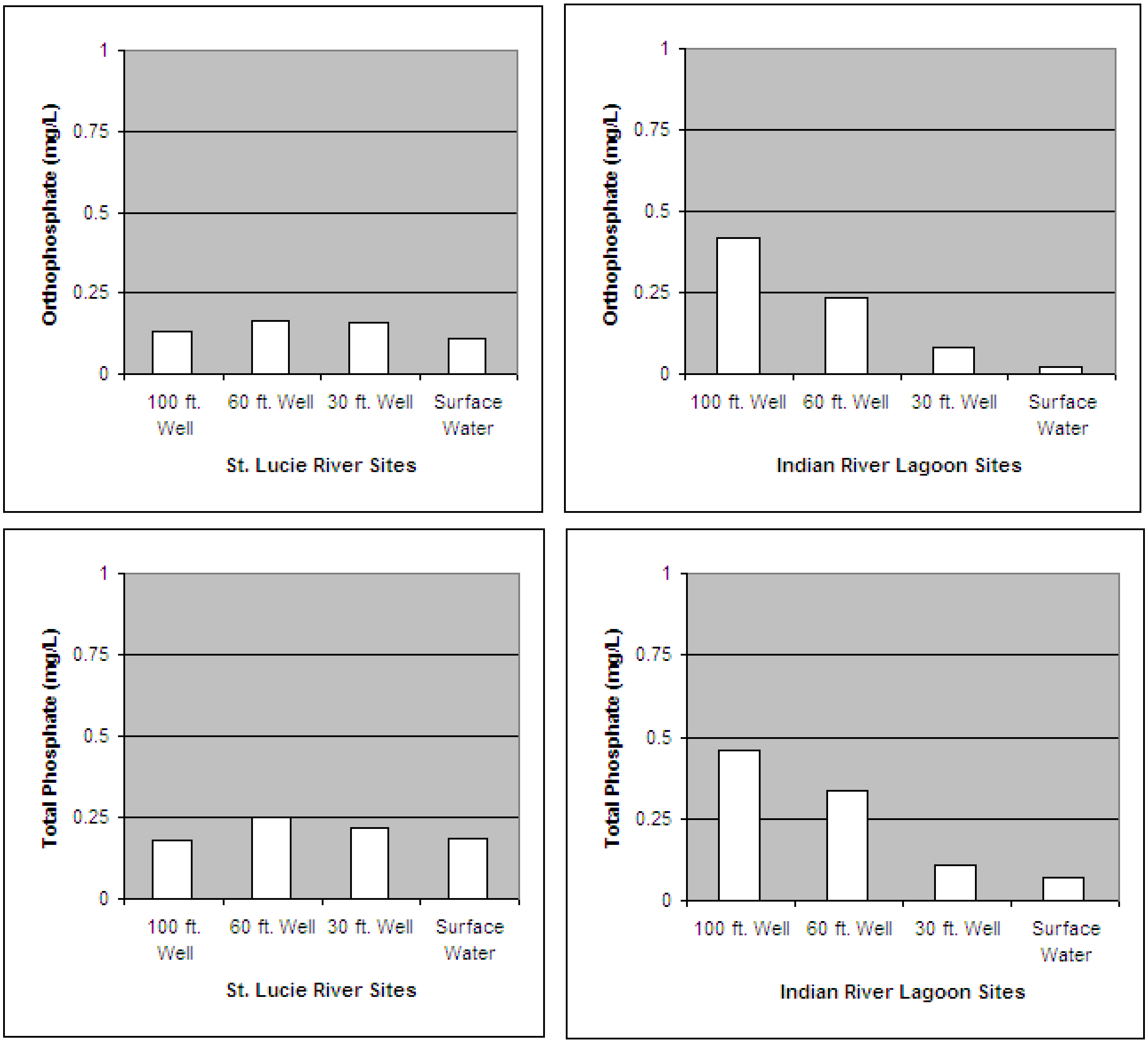


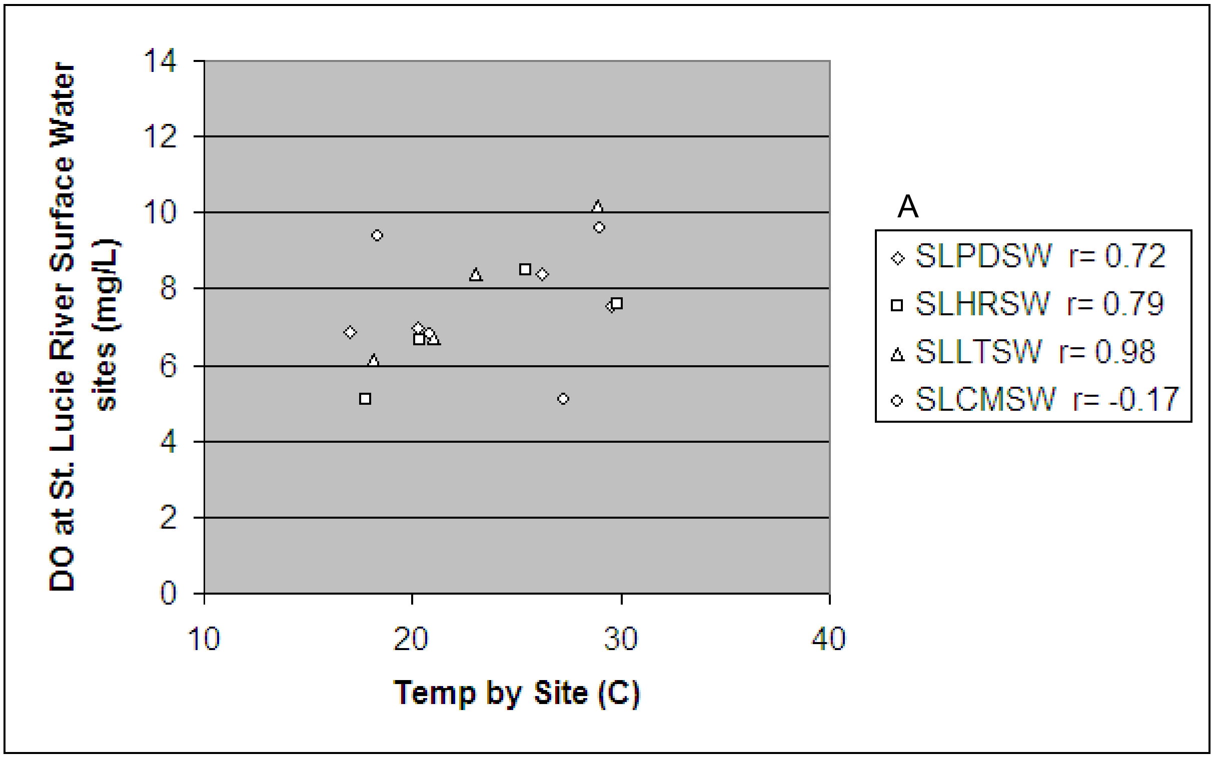
Figure 11. Mean Orthophosphate (mg/L) and Mean Total Phosphate (mg/L) at St. Lucie River and Indian River Lagoon Sites.

located in freshwater and are not influenced by the the surface water, but farshore piezometers appear to be located in the hyporheic zone and show similar or higher specific conductance than the surface water. This is true at Lake Manor, as well, except that the farshore deep (15 ft.) piezometer is not influenced as much. Harbor Ridge showed no surface water influence, as all wells and piezometers (nearshore and farshore) were located in freshwater (Appendix D).

Dissolved oxygen levels were very low in wells, as expected, averaging 0.38 and 0.25 mg/l in the 30 ft. wells for the St. Lucie River and Indian River Lagoon sites, respectively (Fig. 9). The 60 ft. wells averaged 0.40 and 0.29 mg/l, for the above areas, respectively (Fig. 9). Piezometer dissolved oxygen levels were generally low, but were usually much more variable than wells, ranging from 0.16 mg/l for SLCMZ4 to 4.58 mg/l for SLPDZ4. Mean surface water dissolved oxygen levels for the individual sites were fairly high, ranging from 4.44 mg/l for Minton to 8.36 mg/l for Lake Manor. St. Lucie River site mean values ranged from 6.97 mg/l at Harbour Ridge to 7.85 mg/l at Lutz/MacMillan. The Lutz/MacMillan site, however, was highly variable due to the fact that it is influenced by tidal and wind induced wave action more than any other site. At the Indian River Lagoon sites, mean surface water dissolved oxygen was low at Minton (4.44 mg/l) but high at Lake Manor (8.36 mg/l). This may be due to the fact that the Minton shoreline is not influenced as much by tidal flushing as Lake Manor, and tends to accumulate organic matter while receiving less aeration from waves.

Typically, oxygen levels in the Indian River Lagoon and St. Lucie River are higher in the winter and lower in the summer due to the temperature/solubility relationship, and this was found to be true for the Lutz/MacMillan, Harbour Ridge and Pendarvis Cove sites. Runoff from summer rain may wash nutrients from fertilizer and other sources into the water bodies triggering algal growth, and creating oxygen sags in the morning. Low DO areas are more common and much enlarged in the northern Indian River Lagoon, where circulation is limited by causeways and low number of inlets which supply well oxygenated water. Both the Minton and Lake Manor sites, in the southern lagoon area, are near large deep inlets which, through tidal action, bring in oxygenated ocean water and usually keeping the DO above critical levels (>3mg/L). Linear regressions of DO versus temperature were not significant for collective St Lucie River and Indian River Lagoon sites (Fig. 12), but temperature was found to a significant predictor of DO at the Lutz/MacMillan sites ($p<.01$), Harbour Ridge site ($p<.05$), and Pendarvis Cove site ($p<.05$). Water level data for the DO measurement times were not available for comparison, but it is expected that water level and temperature together may be significant predictors of DO. Mean 24 hr surface water level was not significantly related to collective or individual site DO levels, although data were extremely limited.

DOC levels and TOC levels were not extremely high at any site (Table 3). Highest mean TOC levels ranged from 12.6 to 13.5 mg/l, and occurred at Pendarvis cove, Harbour Ridge, Club Med and Minton. DOC comprised more than 90% of the TOC at all sites. Lutz/MacMillan and Lake Manor, the two sites with the greatest tidal flushing influence, exhibited much lower mean TOC values of 8.2 and 4.6 mg/l, respectively. The extremely variable nature of DOC and TOC data, in the surface water, can be observed in the figures presented in Appendix E.



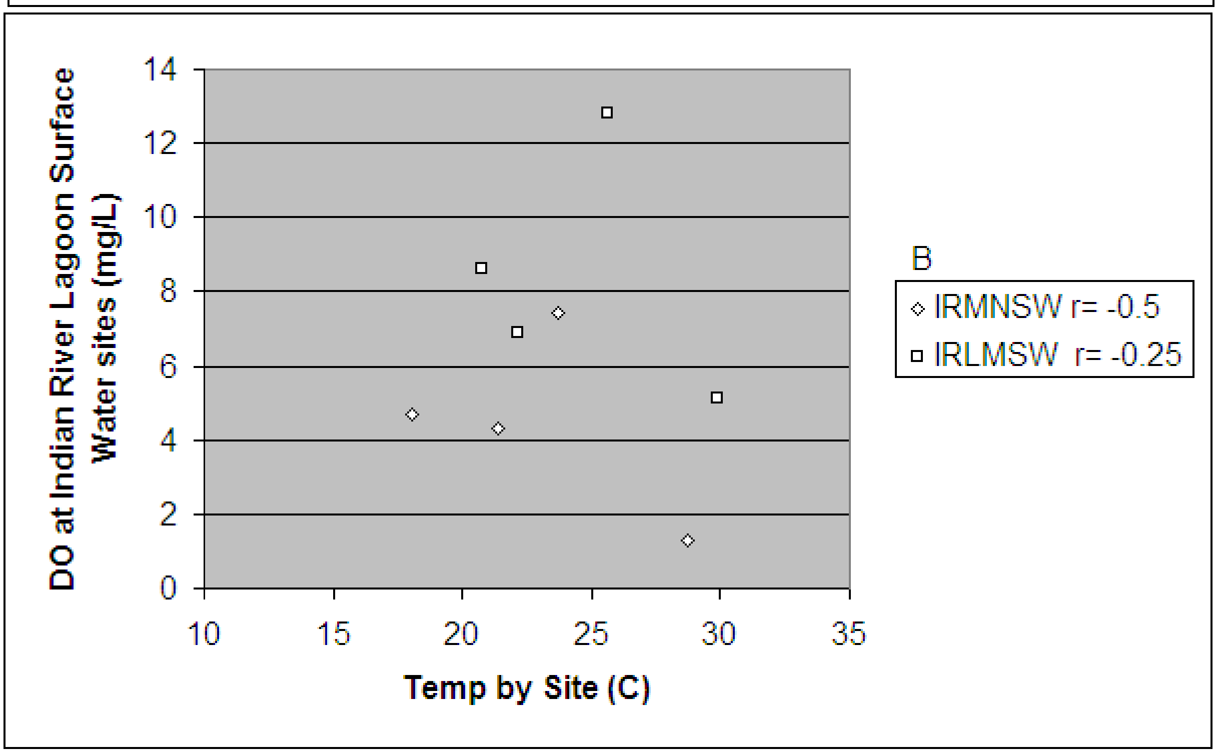


Figure 12. Dissolved Oxygen (mg/L) plotted against Water Temperature (C) for sites at the St. Lucie River (A) and Indian River Lagoon (B).

D. Groundwater/Surface Water Interaction

Seepage meter rate data for the various study sites, sampling dates and meter locations are presented in Tables 4 through 8. Mean transect seepage rates for the Indian River Lagoon (IRL) and St. Lucie River, individual and combined sites, are shown in Figures 13 and 14, respectively. Indian River Lagoon sites generally exhibited higher mean transect seepage than did St. Lucie River sites and this agrees with the high K's measured in the slug tests at the IRL sites. We believe this is primarily due to high rates at the offshore meter sites which may be due to discontinuities in the surficial clay layer separating the upper and lower surficial aquifers as discussed later. Although the Minton site consistently exhibited higher seepage than the Lake Manor IRL site, the two sites usually followed the same trend, except for 10/26/02. Extremely high transect seepage rates of >2500 and >3500 mL/m^2/hr were measured at the Minton site on 8/16/02 and 10/26/02, respectively. High rates generally correspond to high Δh data in the piezometers, while the reverse was true of low seepage rates (Tables 9 through 13). Whether the tide was rising or falling was not important the actual real vertical head difference between piezometer water level and the surface water level was the controlling factor. Lowest seepage at both IRL sites was recorded on 3/31/02 with rates of 316 and 779 mL/m^2/hr for Lake Manor and Minton, respectively. In the St. Lucie River, highest rates always occurred at Pendarvis Cove and ranged from 992 to >>1896 mL/m^2/hr during the study. The highest mean transect rates at Pendarvis Cove were due to extremely high rates occurring at the offshore meters 5 and 6, which may be the result of a hydraulic connection to the lower surfical or Floridan aquifer due to discontinuities in the surficial clay layer or the Hawthorn formation, respectively. Lower St. Lucie River seepage rates occurred at the Lutz/MacMillan site, which often exhibited negative seepage due to the great tidal influence at this site and the groundwater configuration. Mean transect seepage at this site ranged from -260 to 618 mL/m^2/hr. Although tidally controlled, seepage was not statistically related to surface water, perhaps due to the paucity of data points. Mean transect seepage versus surface water level during seepage was not significant at any site, possibly due to a lack of data points. Also, there were too few data points for statistical comparison of groundwater seepage with rainfall data. Available data indicate, however, that the rainfall levels for all sites during the study period were significantly below the yearly 30 year average for the area (54.91 inches), averaging less than 40 inches per year for all sites. (SFWMD. 2003).

In this study, the average transect seepage rates for the St. Lucie River and Indian River Lagoon study areas were 561 and >1517 mL/m^2/hr, respectively. If Pendarvis Cove, which averaged >1331 mL/m^2/hr, is omitted from the St. Lucie River calculation, the average St. Lucie River seepage drops to 176 mL/m^2/hr. We believe Pendarvis Cove is similar to the Indian River Lagoon sites for reasons discussed above. The average seepage rates from a two year study (Belanger et al., 1997) from 49 seepage meters positioned in the northern Indian River Lagoon at sites located throughout Mosquito Lagoon (1251 mL/m^2/hr), was similar to the southern IRL average obtained in this study (>1517 mL/m^2/hr). The Mosquito Lagoon rate was approximately one third the average recorded at Jensen Beach (3850 mL/m^2/hr); however, for a site located close to the Lake Manor transect (Belanger and Walker, 1990). All of the above rates are high and indicate that groundwater seepage is a significant input to the Indian River Lagoon system.

Table 4 Groundwater Seepage Rates for Individual Meter Locations at Club Med / Harbour Ridge Sites (mL/m^2/hr)

Date	3/4/2002	6/1/2002	8/15/2002	10/27/2002	2/2/2003	3/24/2003	
Meter Location							Meter Mean
1	ND	1160	ND	1070	ND	ND	ND
2	45	19	21	39	16	8	25
2A	0	25	0	38	41	16	22
3	531	1815	346	1313	529	28	577
4	ND	852	ND	802	100	-124	408
5	618	ND	0	778	ND	ND	465
6	1327	1181	ND	2838	245	43	1127
7	196	809	-276	ND	355	-135	190
8	38	531	0	385	-10	83	79
9	53	642	120	407	0	432	276
10	129	504	-13	-92	-50	446	154
10A	174	506	ND	ND	-60	223	211
11	ND	ND	0	0	ND	ND	0
Transect Mean	367	794	24	718	150	70	
Overall Site / Transect Mean			354				

Notes: All seepage meter data corrected for frictional resistance losses by multiplying by 1.29 (Belanger and Montgomery, 1990).
Mean computed without shore (#1) meter values and ( ) values.
ND = No Data due to bag leak, shallow water level, lost bag, missing meter, etc.
A = Duplicate meter less that 1 meter away.
( ) = Possible outlying data point.

Table 5. Groundwater Seepage Rates for Individual Meter Locations at Lutz / MacMillan site. (mL/m^2/hr)

Date	3/5/2002	6/2/2002	8/15/2002	11/1/2002	2/1/2003	3/25/2003	
Meter Location							Meter Mean
1	ND	ND	0	130	ND	ND	65
2	-782	-568	-973	-389	574	109	-338
3	-210	-256	ND	-1297	688	-288	-273
4	-156	0	308	116	ND	334	120
5	0	544	206	272	592	-167	241
6	ND	100	ND	ND	ND	ND	100
Transect Mean	-182	-36	-153	-260	618	-3	
Overall Site / Transect Mean			-3				

Notes: All seepage meter data corrected for frictional resistance losses by multiplying by 1.29 (Belanger and Montgomery, 1990).
Mean computed without shore (#1) meter values and ( ) values.
ND = No Data due to bag leak, shallow water level, lost bag, missing meter, etc.
A = Duplicate meter less that 1 meter away.
( ) = Possible outlying data point.

Table 6. Groundwater Seepage Rates for Individual Meter Locations at Pendarvis Cove site. (mL/m^2/hr)

Date	3/5/2002	6/2/2002	8/15/2002	10/27/2002	2/1/2003	3/24/2003	
Meter Location							Meter Mean
1	ND	-284	0	0	0	ND	ND
2	ND	-55	357	0	ND	49	88
3	-178	0	78	42	69	51	10
4	812	0	49	0	0	0	144
5	2813	2548	240	>4100	2983	ND	>2537
6	(522)	>2800	6020	5336	3240	3997	>3653
6A	ND	>1700	1270	ND	ND	ND	1485
Transect Mean	992	1166	1336	>1896	1573	1024	
Overall Site / Transect Mean			>1331				

Notes: All seepage meter data corrected for frictional resistance losses by multiplying by 1.29 (Belanger and Montgomery, 1990).
Mean computed without shore (#1) meter values and ( ) values.
ND = No Data due to bag leak, shallow water level, lost bag, missing meter, etc.
A = Duplicate meter less that 1 meter away.
( ) = Possible outlying data point.

Table 7. Groundwater Seepage Rates for Individual Meter Locations at Lake Manor site. (mL/m^2/hr)

Date	3/6/2002	6/2/2002	8/17/2002	10/26/2002	2/1/2003	3/23/2003	
Meter Location							Meter Mean
1	ND	ND	ND	159	ND	ND	ND
2	-257	-70	322	ND	44	ND	10
3	-664	519	898	1563	296	1028	607
4	-142	3475	3170	1807	ND	2200	2102
4A	-85	ND	2553	>2300	212	3680	>1732
5	-54	ND	2741	149	ND	ND	945
6	1273	ND	1133	817	ND	800	1006
7	>6840	ND	1868	193	710	2108	>2344
8	187	942	ND	ND	ND	ND	565
Transect Mean	>1030	1217	1637	>903	316	1719	
Overall Site / Transect Mean			>1137				

Notes: All seepage meter data corrected for frictional resistance losses by multiplying by 1.29 (Belanger and Montgomery, 1990).
Mean computed without shore (#1) meter values and ( ) values.
ND = No Data due to bag leak, shallow water level, lost bag, missing meter, etc.
A = Duplicate meter less that 1 meter away.
( ) = Possible outlying data point.

Table 8. Groundwater Seepage Rates for Individual Meter Locations at Minton site. (mL/m^2/hr)

Date	3/6/2002	6/3/2002	8/16/2002	10/18/2002	10/26/2002	1/31/2003	3/23/2003	
Meter Location								Meter Mean
1	ND	ND	ND	ND	ND	ND	ND	ND
2	ND	1682	2532		8955	ND	1377	3637
2A	1148	1404	1411		ND	ND	1025	1247
3	1459	3549	1423		2904	ND	239	1915
3A	ND	ND	1117		2140	1169	968	1349
4	>2375	930	1230	1945	2763	575	1608	1904
4A	ND	ND	ND	1195	2180	ND	1857	1744
4B	ND	ND	3434	1728	2881	ND	ND	2681
5	778	1045	1609		4262	402	1273	1562
6	1210	>7395	>7200		5837	522	2697	4144
7	910	1013	4873		>7500	1204	4977	3413
8	265	255	1086		2867	936	2530	1323
9	107	480	482		ND	646	ND	429
10	1172	1652	1872		ND	ND	ND	1565
Transect Mean	>1047	1429	>2503		>3523	779	2093	
Overall Site / Transect Mean			>1896					

Notes: All seepage meter data corrected for frictional resistance losses by multiplying by 1.29 (Belanger and Montgomery, 1990).
Mean computed without shore (#1) meter values and ( ) values.
ND = No Data due to bag leak, shallow water level, lost bag, missing meter, etc.
A = Duplicate meter less that 1 meter away.
( ) = Possible outlying data point.

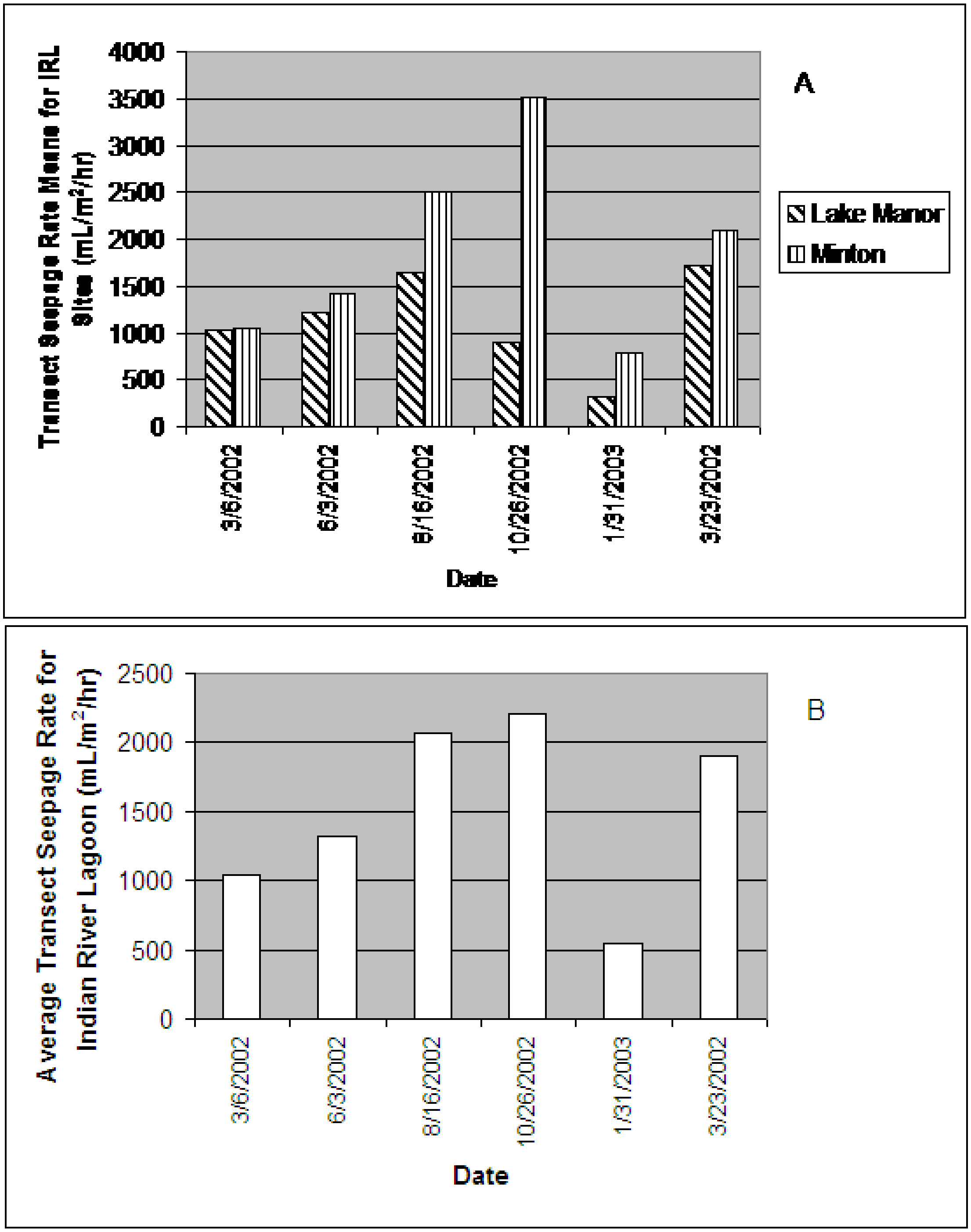


Figure 13. Mean Transect Seepage Rates for the Indian River Lagoon for Individual (A) and Combined (B) sites, by date.

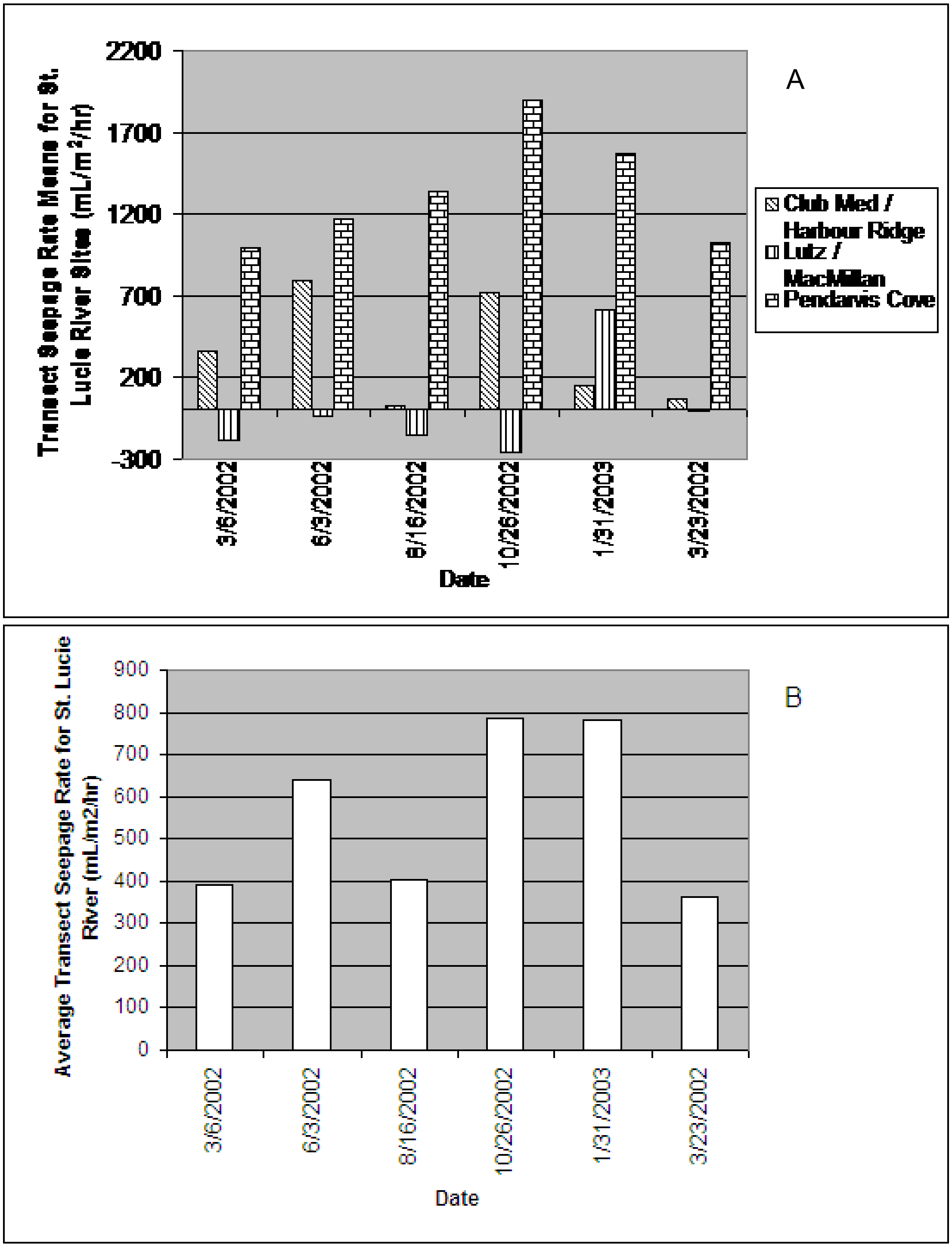


Figure 14. Mean Transect Seepage Rates for the St. Lucie River for Individual (A) and Combined (B) sites, by date.

Table 9 ΔH Data for Shallow (5.0') and Deep (15.0') in situ Piezometers at the Club Med / Harbour Ridge Site.

Measurement Date	Seepage Meter Bag Incubation Period	Hydraulic Gradient Measurement Time and Vertical Gradient ΔH Data (ft.)								Low Tide / High Tide	Tidal Condition
		Club Med				Harbour Ridge					
		Time	Loc.	S	D	Time	Loc.	S	D		
3/4/2002	10:30 - 13:45	12:00	1	0.09	0.14	11:00	1	0.20	0.20	9:36 / 15:00	Rising
			2	0.06	0.09		2	0.33	1.74		
						13:41	1	0.18	0.35		
							2	0.21	0.50		
6/1/2002	13:30 - 17:00	13:50	1	0.10	0.13	13:00	1	0.18	0.95	11:14 / 16:34	Rising
			2	piez reinstall			2	0.14	0.21		
		17:00	1	0.18	0.95						
			2	piez reinstall							
8/15/2002	11:00 -15:00	11:40	1	0.57	0.52	12:34	1	0.22	0.26	11:55 / 17:42	Primarily Rising
			2	0.03	0.00		2	0.30	1.57		
10/27/2002	13:00 - 15:30	No measurement equipment failure				No measurement equipment failure				9:04 / 14:55	Rising
2/2/2003	10:30 - 17:00	12:18	1	0.11	0.13	11:53	1	0.04	0.07	11:47 / 18:37	Primarily Falling
			2	-0.04	-0.04		2	0.19	0.35		
3/24/2003	9:00 - 11:45	10:15	1	0.81	0.90	9:00	1	0.25	0.40	10:32 / 15:51	Rising and Falling
			2	0.04	0.05		2	0.33	0.36		

Notes: S = shallow piezometer (5' ; 1' screen); D = deep piezometer (15' ; 1' screen); Location 1 = nearshore; Location 2 = offshore

Harbour Ridge piezometers: nearshore deep - SLRHRPZ1, nearshore shallow - SLRHRPZ2
offshore deep - SLRHRPZ3, offshore shallow - SLRHRPZ4

Club Med piezometers: nearshore deep - SLRCMPZ1, nearshore shallow SLRCMPZ2
offshore deep - SLRCMPZ3, offshore shallow - SLRCMPZ4

Actual vertical hydraulic gradient may be obtained by dividing the ΔH by the depth of the screened interval below the sediment / water interface (4' for shallow, 14' for deep).

ΔH = change in water level between piezometer and surface water.

Table 10 ΔH Data for Shallow (5.0') and Deep (15.0') in situ Piezometers at the Lutz / MacMillan site.

Measurement Date	Seepage Meter Bag Incubation Period	Hydraulic Gradient Measurement Time and Vertical Gradient ΔH Data (ft.)				Low Tide / High Tide	Tidal Condition
		Time	Loc.	S	D		
3/5/2002	10:15 - 14:45	9:30	1	0.15	0.15	10:38 / 15:42	Rising
			2	0.00	0.00		
		14:05	1	0.10	0.15		
			2	0.00	0.00		
6/2/2002	11:15 - 13:15	10:15	1	destroyed; shifting dock		4:54 / 12:12	Slightly Rising
			2	-0.02	-0.02		
8/15/2002	16:45 - 18:45	18:30	1	0.00	-0.15	11:55 / 17:42	Rising and Falling
			2	-0.15	-0.12		
11/1/2002	12:55 - 16:30	12:45	1	0.08	0.07	9:04 / 14:55	Rising and Falling
			2	0.01	0.07		
		15:05	1	0.09	-0.02	7:18 / 14:30 /19:42	
			2	-0.01	0.00		
2/1/2003	1:30 - 18:00	13:50	1	0.25	0.03	10:51 / 17:57	Falling
			2	0.10	0.00		
3/25/2003	9:15 - 12:00	9:00	1	0.08	0.00	11:44 / 16:46	Falling
			2	-0.07	-0.06		

Notes: S = shallow piezometer (5' ; 1' screen); D = deep piezometer (15' ; 1' screen); Location 1 = nearshore; Location 2 = offshore

Lutz piezometers: nearshore deep - SLRLTZP1, nearshore shallow - SLRLTZP2

offshore deep - SLRLTZP3, offshore shallow - SLRLTZP4

Actual vertical hydraulic gradient may be obtained by dividing the ΔH by the depth of the screened interval below the sediment / water interface (4' for shallow, 14' for deep).

ΔH = change in water level between piezometer and surface water.

Table 11 ΔH Data for Shallow (5.0') and Deep (15.0') in situ Piezometers at the Pendarvis Cove site.

Measurement Date	Seepage Meter Bag Incubation Period	Hydraulic Gradient Measurement Time and Vertical Gradient ΔH Data (ft.)				Low Tide / High Tide	Tidal Condition
		Time	Loc.	S	D		
3/5/2002	10:15 - 16:00	11:30	1	0.07	0.35	10:40 / 16:01	Rising
			2	0.07	0.35		
		15:30	1	0.02	0.28		
			2	0.02	0.28		
6/2/2002	9:30 - 14:00	9:30	1	0.20	0.18	5:13 / 12:14 /17:39	Rising and Falling
			2	0.06	0.02		
		13:00	1	0.10	0.09		
			2	0.07	0.00		
8/15/2002	13:20 - 15:40	13:10	1	0.09	0.42	4:56 / 11:59 /17:46	Rising
			2	0.00	0.00		
10/27/2002	9:00 - 11:00	no measurement equipment failure				9:08 / 14:59	Rising
2/1/2003	14:30 - 16:30	15:15	1	0.21	0.49	11:10 / 17:59	Falling
			2	0.00	0.08		
3/24/2003	12:40 - 15:45	13:00	1	0.42	0.34	10:36 / 15:55	Rising
			2	-0.38	0.10		

Notes: S = shallow piezometer (5' ; 1' screen); D = deep piezometer (15' ; 1' screen); Location 1 = nearshore; Location 2 = offshore
Pendarvis piezometers: nearshore deep - SLRPDPZ1, nearshore shallow - SLRPDPZ2
offshore deep - SLRPDPZ3, offshore shallow - SLRPDPZ4
Actual vertical hydraulic gradient may be obtained by dividing the ΔH by the depth of the screened interval below the sediment / water interface (4' for shallow, 14' for deep).
ΔH = change in water level between piezometer and surface water.

Table 12 ΔH Data for Shallow (5.0') and Deep (15.0') in situ Piezometers at the Lake Manor site.

Measurement Date	Seepage Meter Bag Incubation Period	Hydraulic Gradient Measurement Time and Vertical Gradient ΔH Data (ft.)				Low Tide / High Tide	Tidal Condition
		Time	Loc.	S	D		
3/6/2002	12:15 - 15:00	12:00	1	0.13	0.10	11:17 / 15:00	Rising
			2	0.00	0.08		
		14:15	1	0.01	0.05		
			2	0.00	0.06		
6/2/2002	16:30 - 19:30	18:00	1	0.12	0.19	11:46 / 17:24	Primarily Falling
			2	0.07	0.89		
8/17/2002	12:55 - 14:30	14:00	1	0.28	0.28	6:47 / 13:40	Falling and Rising
			2	0.01	0.12		
10/26/2002	9:00 - 15:30	No measurement equipment failure				8:52 / 14:54	Rising
2/1/2003	9:00 - 12:00	10:10	1	0.01	0.07	5:00 / 10:55	Primarily Rising
			2	0.00	-0.06		
3/23/2003	9:00 - 12:30	8:50	1	0.18	0.19	9:06 / 14:39	Rising
			2	0.03	0.10		
		12:30	1	0.13	0.21		
			2	0.10	0.07		

Notes: S = shallow piezometer (5' ; 1' screen); D = deep piezometer (15' ; 1' screen); Location 1 = nearshore; Location 2 = offshore
Lake Manor piezometers: nearshore deep - IRLLMPZ1, nearshore shallow - IRLLMPZ2
offshore deep - IRLLMPZ3, offshore shallow - IRLLMPZ4
Actual vertical hydraulic gradient may be obtained by dividing the ΔH by the depth of the screened interval below the sediment / water interface (4' for shallow, 14' for deep).
ΔH = change in water level between piezometer and surface water.

Table 13 ΔH Data for Shallow (5.0') and Deep (15.0') in situ Piezometers at the Minton site.

Measurement Date	Seepage Meter Bag Incubation Period	Hydraulic Gradient Measurement Time and Vertical Gradient ΔH Data (ft.)				Low Tide / High Tide	Tidal Condition
		Time	Loc.	S	D		
3/6/2002	10:20 - 16:30	9:42	1	dry	dry	8:12 / 14:18 / 20:37	Primarily Rising
			2	0.05	0.37		
		15:30	1	dry	dry		
			2	0.06	0.08		
6/3/2002	10:40 - 14:00	14:00	1	0.23	0.41	9:36 / 15:53	Rising
			2	0.04	0.06		
8/16/2002	10:30 - 12:00	11:15	1	0.40	0.40	9:30 / 16:07	Rising
			2	0.10	0.10		
10/18/2002	11:45 - 14:45	11:00	1	1.01	0.08	7:24 / 13:26	Rising and Falling
		14:20	1	0.14	0.33		
		11:30	2	0.03	0.00		
			2A	0.08	0.06		
		14:00	2	0.06	0.06		
			2A	0.14	0.15		
10/26/2002	12:00 - 14:30	no measurement equipment failure				5:47 / 12:23 / 14:22	Falling
1/31/2003	14:45 - 17:00	15:45	1	dry	dry	13:41 / 19:45	Rising
			2	0.01	0.00		
			2A	0.05	0.05		
3/23/2003	15:15 - 18:15	17:15	1	0.28	0.31	6:01 / 12:15 / 18:25	Falling
			2	0.00	0.06		
			2A	0.05	0.14		

Notes: S = shallow piezometer (5' ; 1' screen); D = deep piezometer (15' ; 1' screen); Location 1 = nearshore; Location 2 = offshore
Minton piezometers: nearshore deep - IRLMNPZ1, nearshore shallow - IRLMNPZ2
offshore deep - IRLMNPZ3, offshore shallow - IRLMNPZ4
Actual vertical hydraulic gradient may be obtained by dividing the ΔH by the depth of the screened interval below the sediment/ water interface (4' for shallow, 14' for deep).
ΔH = change in water level between piezometer and surface water.

E. Groundwater Seepage versus Selected Environmental Data

Many regressions comparing groundwater seepage to environmental parameters were attempted, but all of them are statistically limited by the lack of data points and therefore they should be viewed with caution. This was due to the fact that seepage rates were only collected bimonthly and well and surface water level data were incomplete. Regressions of mean transect seepage versus piezometer Δh's calculated from nearshore and farshore piezometer water levels to surface water levels were completed and are presented in Figures 15 through 19 for the St. Lucie River and Figures 20 through 22 for the Indian River Lagoon. Mean transect seepage versus total water level drop or rise and mean surface water levels during seepage measurements are shown in Figures 23 and 24. Surface water levels during seepage measurement was regressed against mean transect seepage and shown in Figure 25. Statistically significant regressions are summarized in Table 14. Δh measurement data, along with tidal information, are presented for the seepage measurement periods at the various sites in Tables 9 through 13. Nearshore and farshore piezometer vertical hydraulic gradient measurement data for the St. Lucie and Indian River Lagoon sites are presented in Tables 15 and 16, respectively. The vertical hydraulic gradients are similar to Δh data, but take piezometer depth into account. Horizontal gradient data, calculated from the 30 ft. wells to the 24 hr. mean surface water level and to the actual surface water level during seepage measurement are presented in Tables 17 and 18, respectively. Well water levels on seepage measurement days, and corresponding well slug test (K) values are shown in Table 2. Mean transect seepage rates for the St. Lucie River sites and Indian River sites were regressed against vertical gradient data, as shown in Figures 26 through 29.

A significant inverse relationship was found for the combined Indian River Lagoon sites between mean transect seepage and surface water level during seepage ($r = -0.71$, $p < 0.05$). Significant relationships at the Minton IRL site for mean transect seepage versus Δh's for the nearshore shallow piezometer water level to surface water level ($r = 0.93$, $p < 0.01$) and for the average shallow (nearshore and farshore) piezometer water level versus surface water ($r = 0.94$, $p < 0.01$). For Lake Manor, significant relationships occurred between mean transect seepage and Δh for the nearshore shallow piezometer water level to surface water ($r = 0.86$, $p < 0.05$); the nearshore deep piezometer level to surface water level ($r = 0.84$, $p < 0.05$); the farshore deep level to surface water level, if one of the outlying points is omitted ($r = 0.094$, $p < 0.05$); the mean Δh for shallow piezometers (nearshore and farshore) to surface water level ($r = 0.92$, $p < 0.05$); the mean deep piezometer Δh (nearshore and farshore) if one outlying point is omitted ($r = 0.96$, $p < 0.05$); and the mean surface water level ($r = -0.87$, $p < 0.05$). For the combined Indian River Lagoon sites, significant relationships were found between mean transect seepage rates and deep piezometer level to surface water Δh ($r = 0.78$, $p < 0.05$) and mean shallow piezometer level to surface level Δh ($r = 0.93$, $p < 0.01$). At St. Lucie River sites, significant relationships at the 0.05 level of confidence occurred at Lutz/MacMillan (mean transect seepage versus Δh for nearshore shallow to surface water) and at Pendarvis Cove sites (mean transect seepage vs Δh for nearshore shallow to surface water). The Pendarvis Cove relationship was primarily due to offshore meters 5 and 6, as shown in Figure 18. The Club Med / Harbour Ridge transect

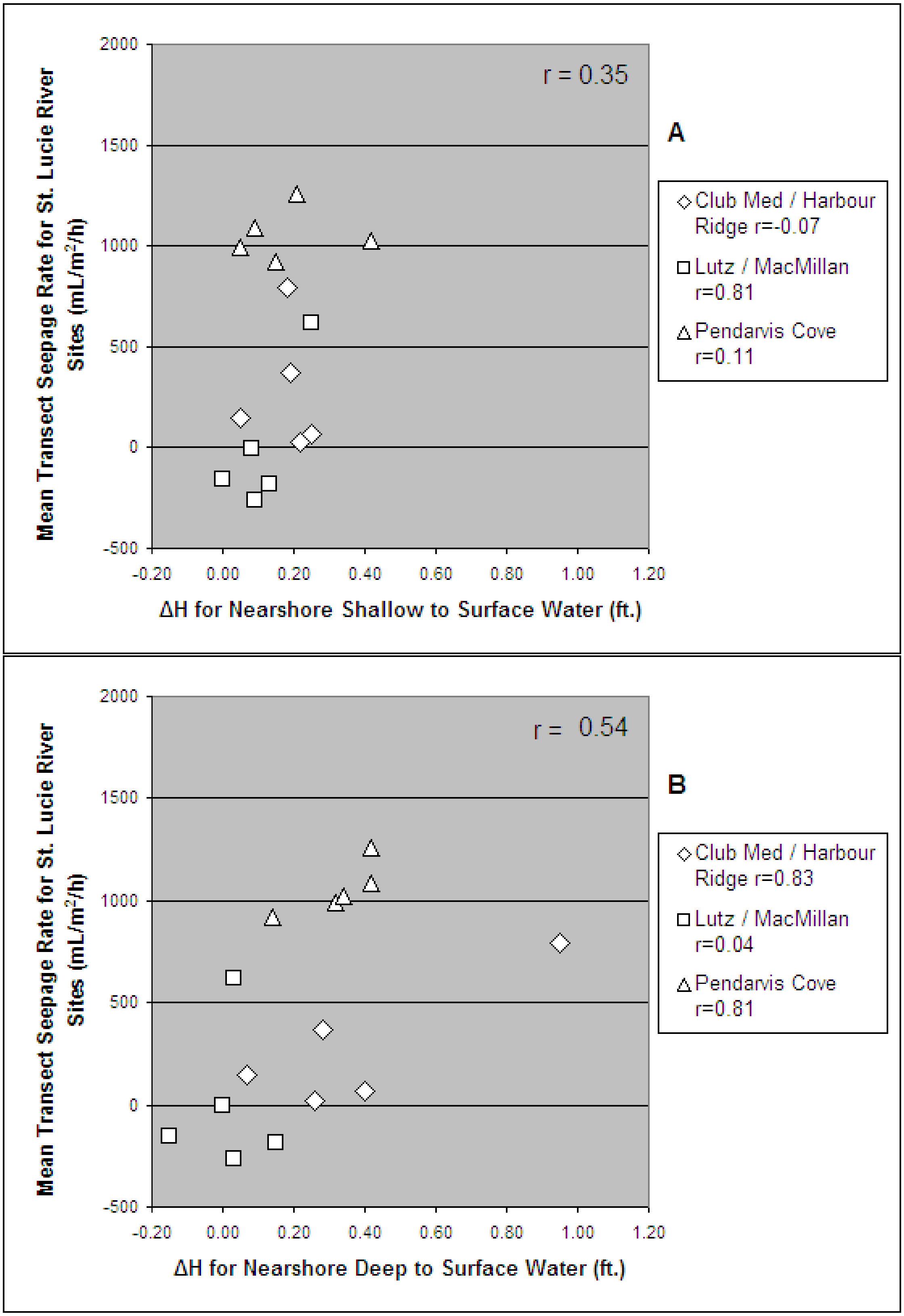


Figure 15. St. Lucie River mean transect seepage rates vs nearshore shallow (A) and deep (B) piezometer ΔH data.

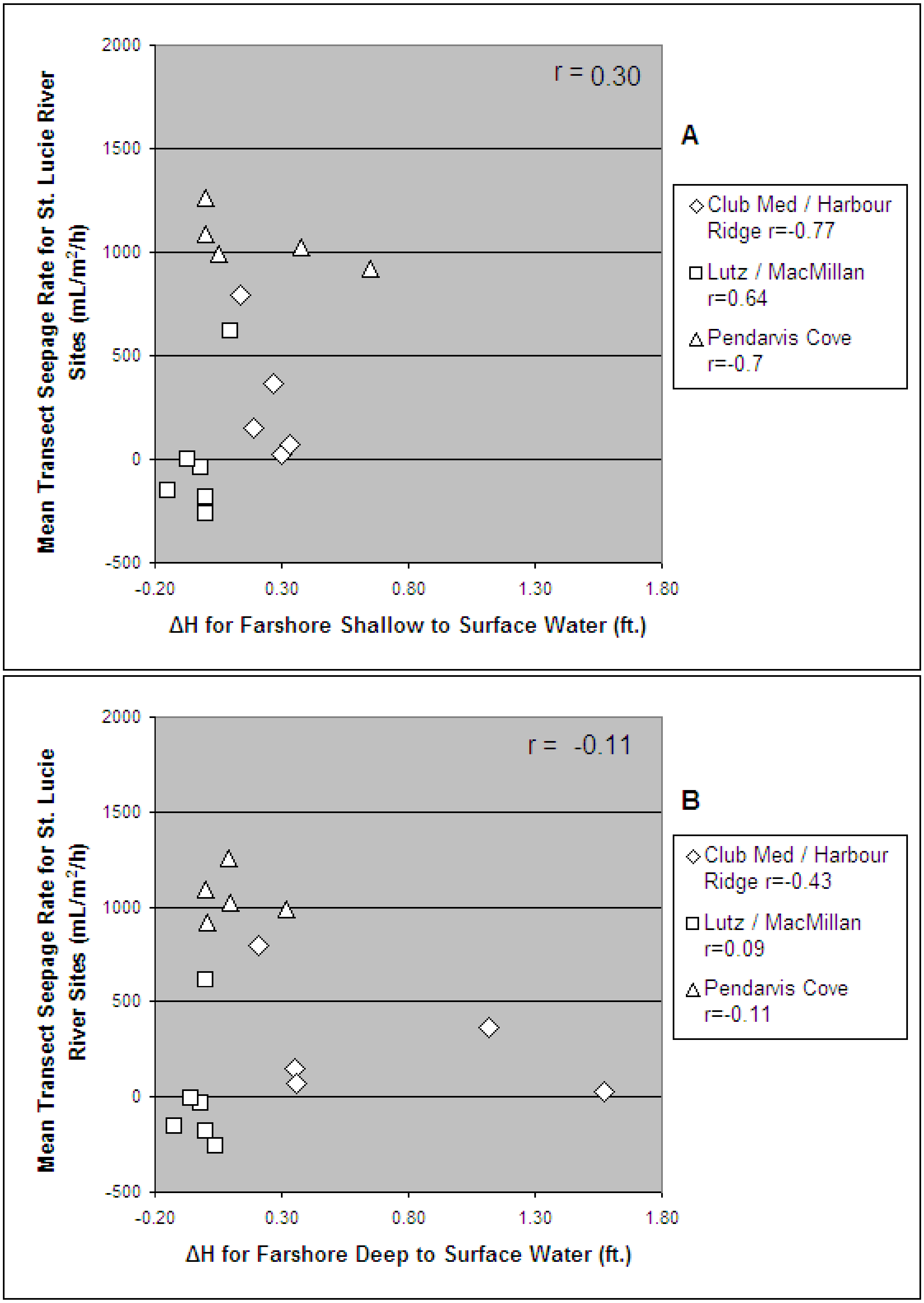


Figure 16. St. Lucie River mean transect seepage rates vs farshore shallow (A) and deep (B) piezometer ΔH data.

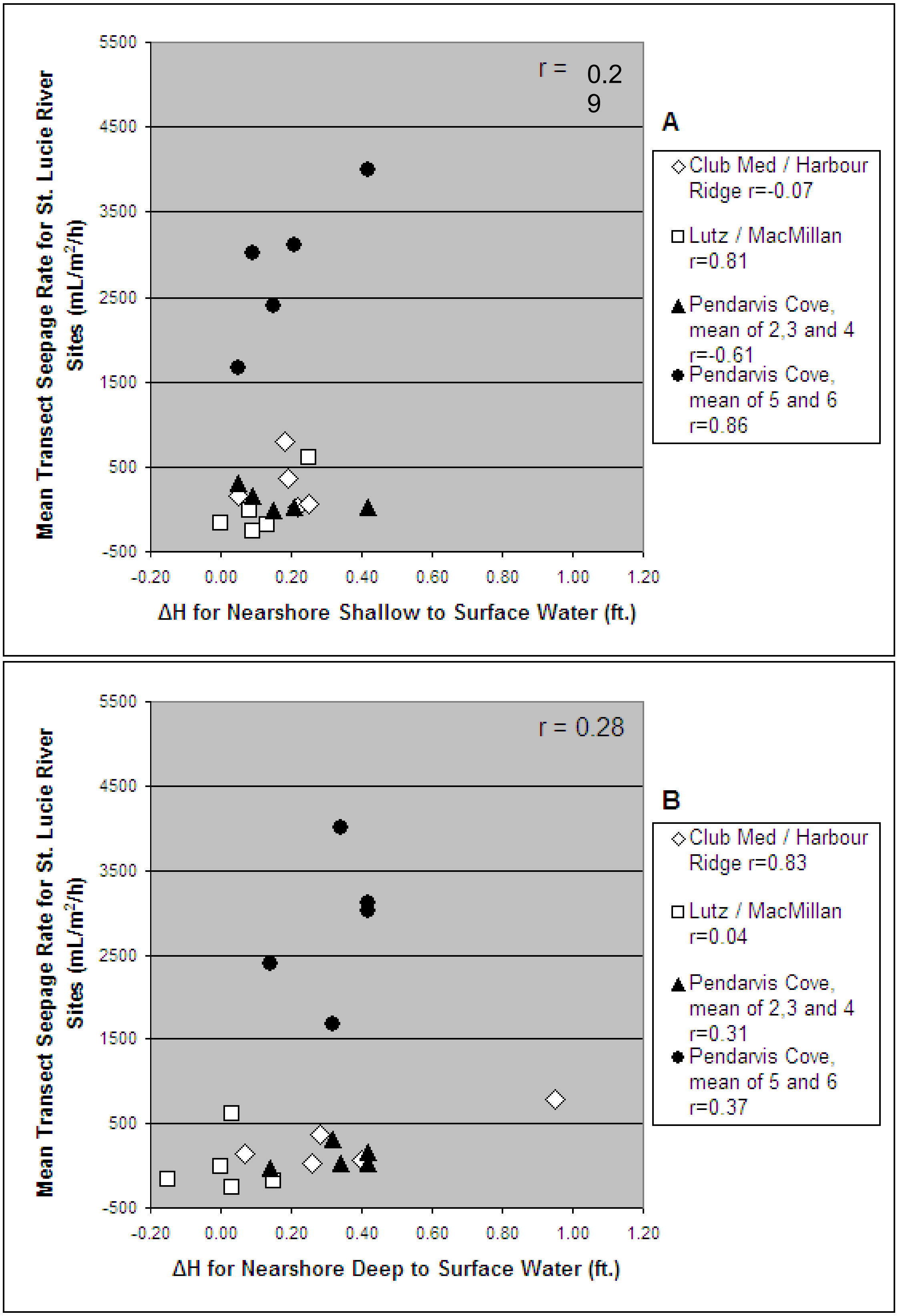
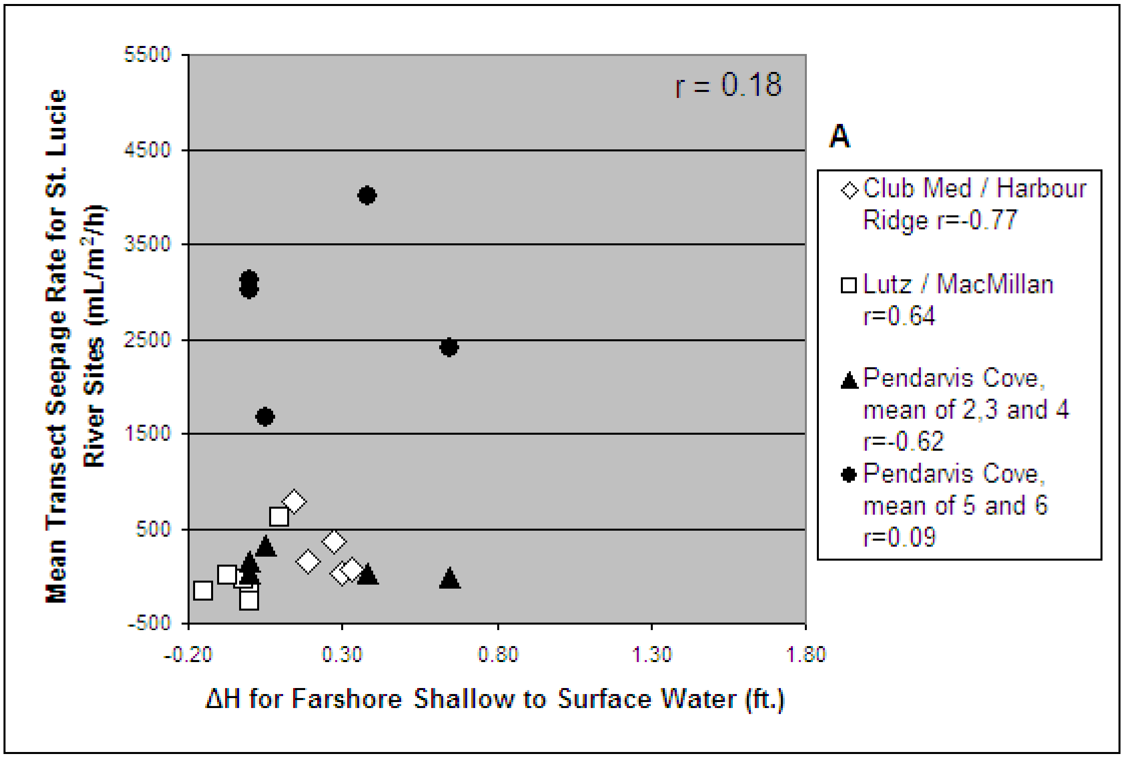


Figure 17. St. Lucie River mean transect seepage rates vs nearshore shallow (A) and deep (B) piezometer ΔH data.



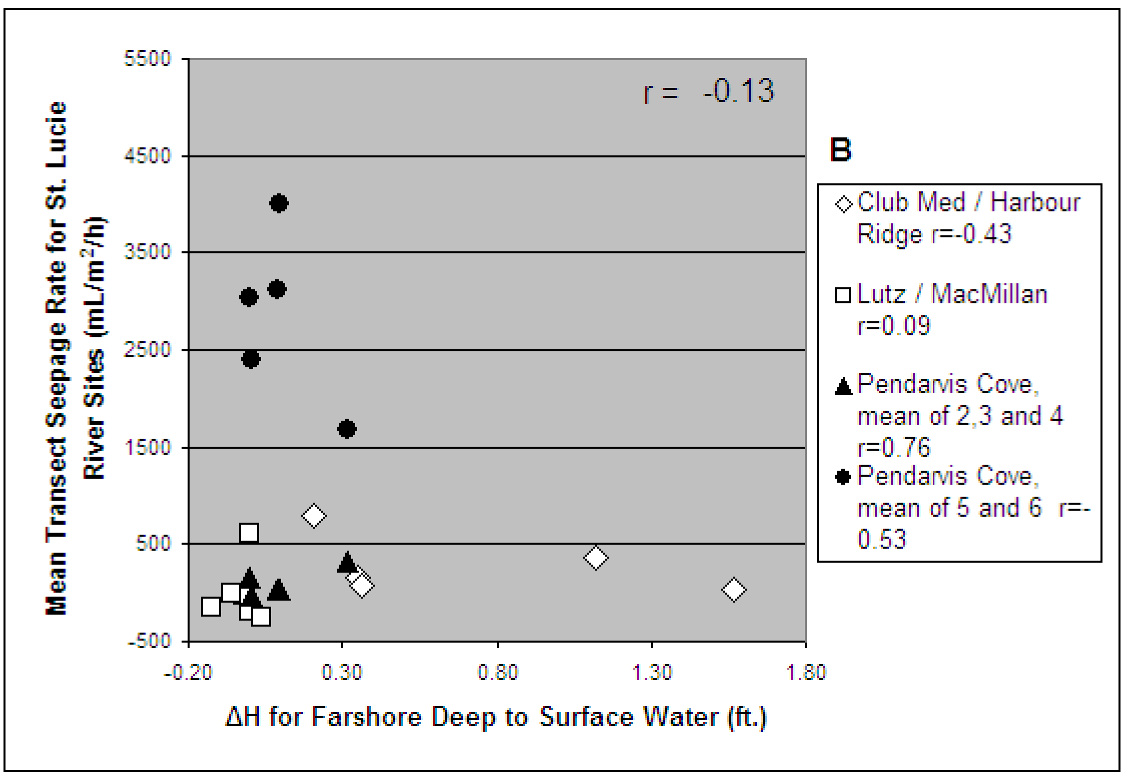


Figure 18. St. Lucie River mean transect seepage rates vs farshore shallow (A) and deep (B) piezometer ΔH data.

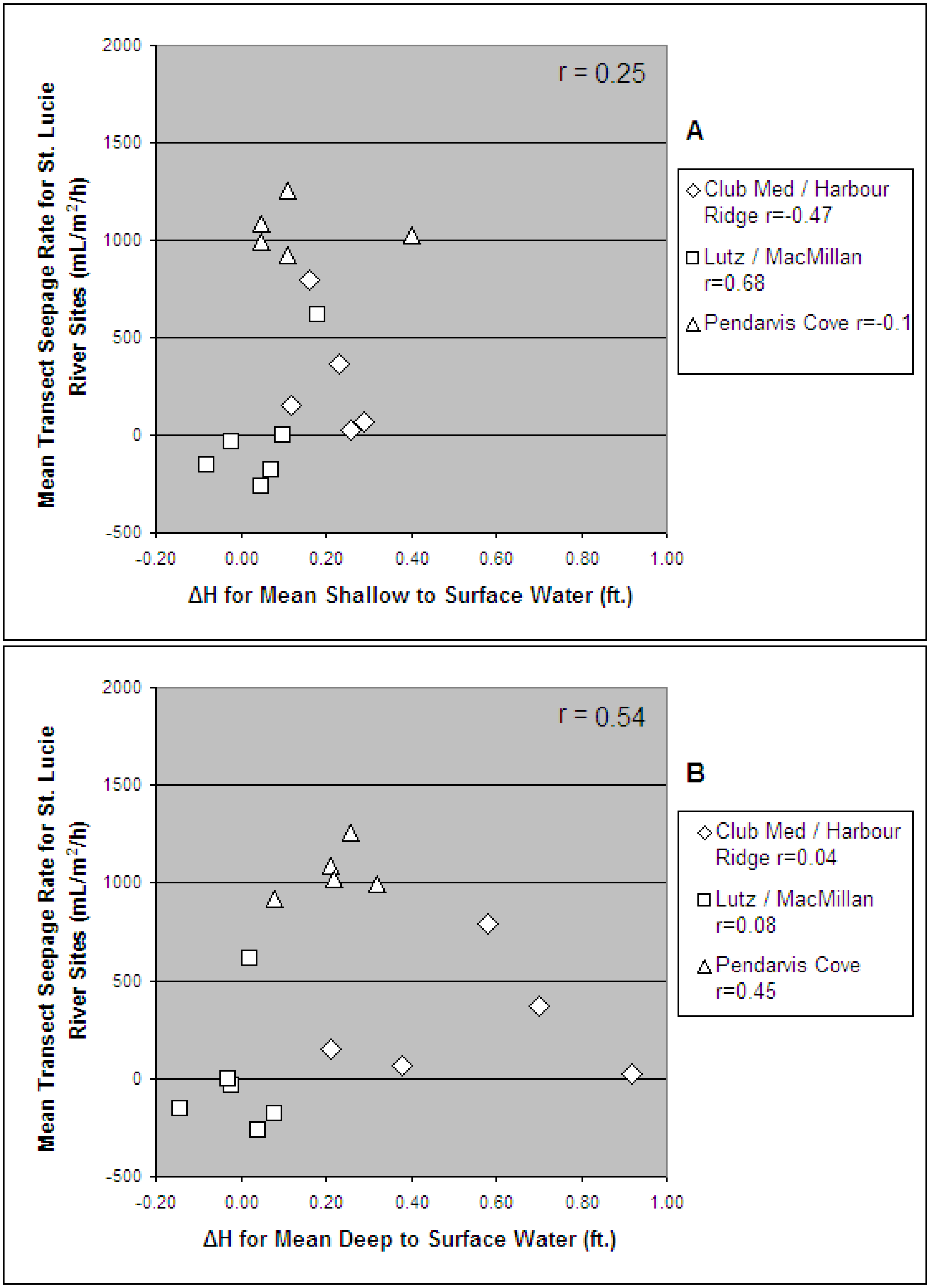


Figure 19. St. Lucie River mean transect seepage rates vs farshore shallow (A) and deep (B) piezometer ΔH data.

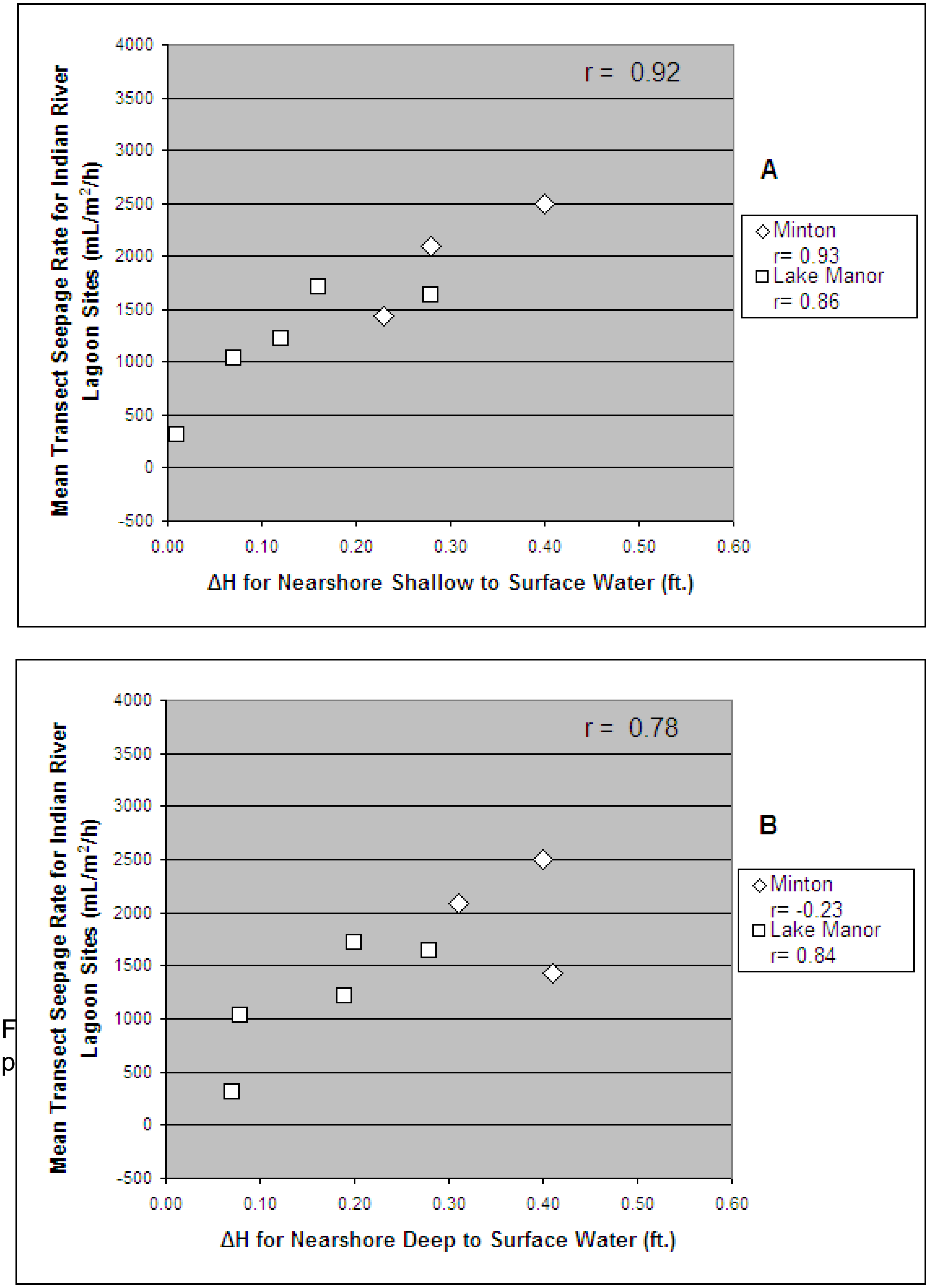


Figure 20. Indian River Lagoon mean transect seepage rates vs nearshore shallow (A) and deep (B) piezometer ΔH data.

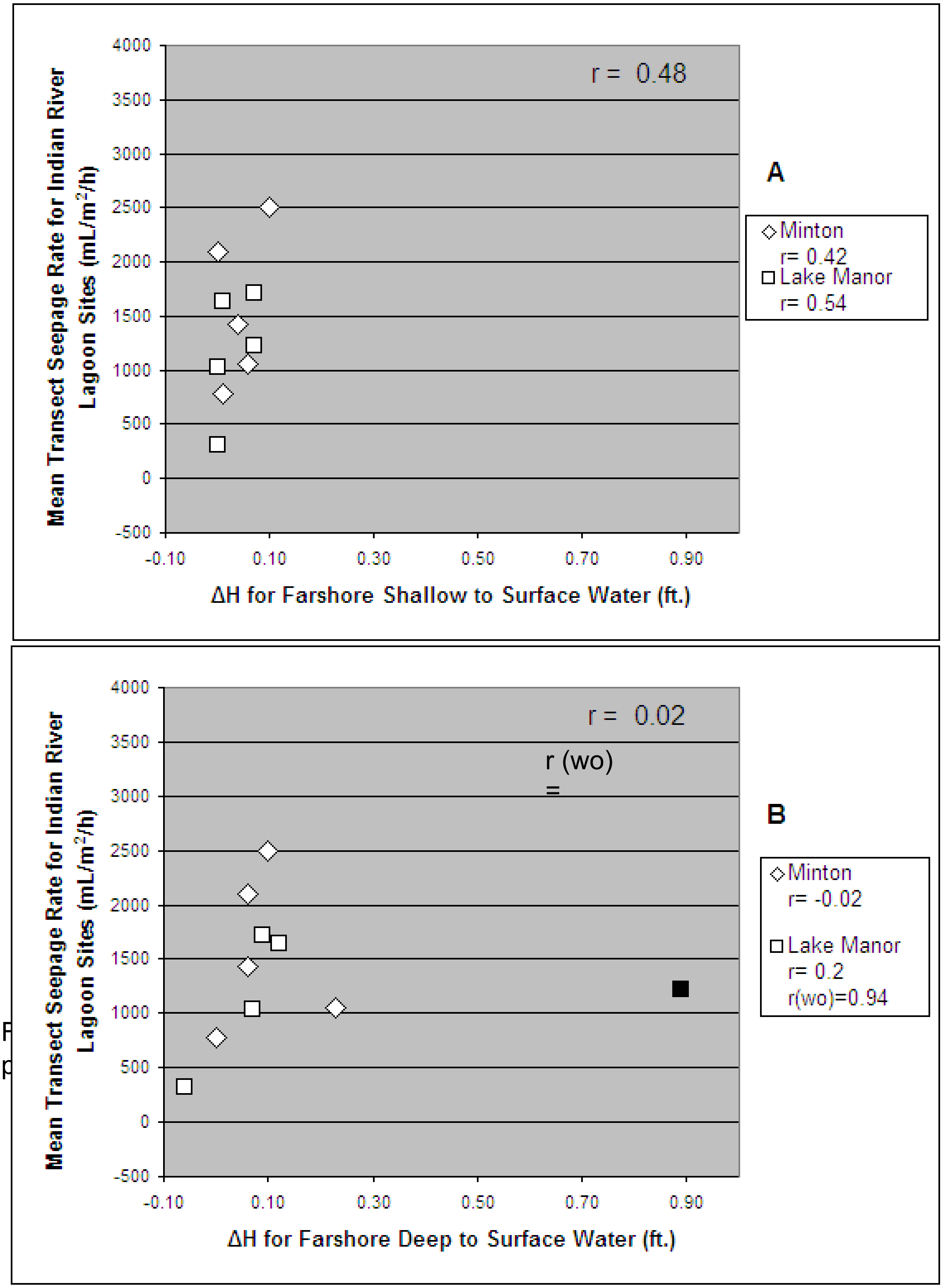


Figure 21. Indian River Lagoon mean transect seepage rates vs farshore shallow (A) and deep (B) piezometer ΔH data.
"r (wo) =" is correlation coefficient without the darkened outlier data point.

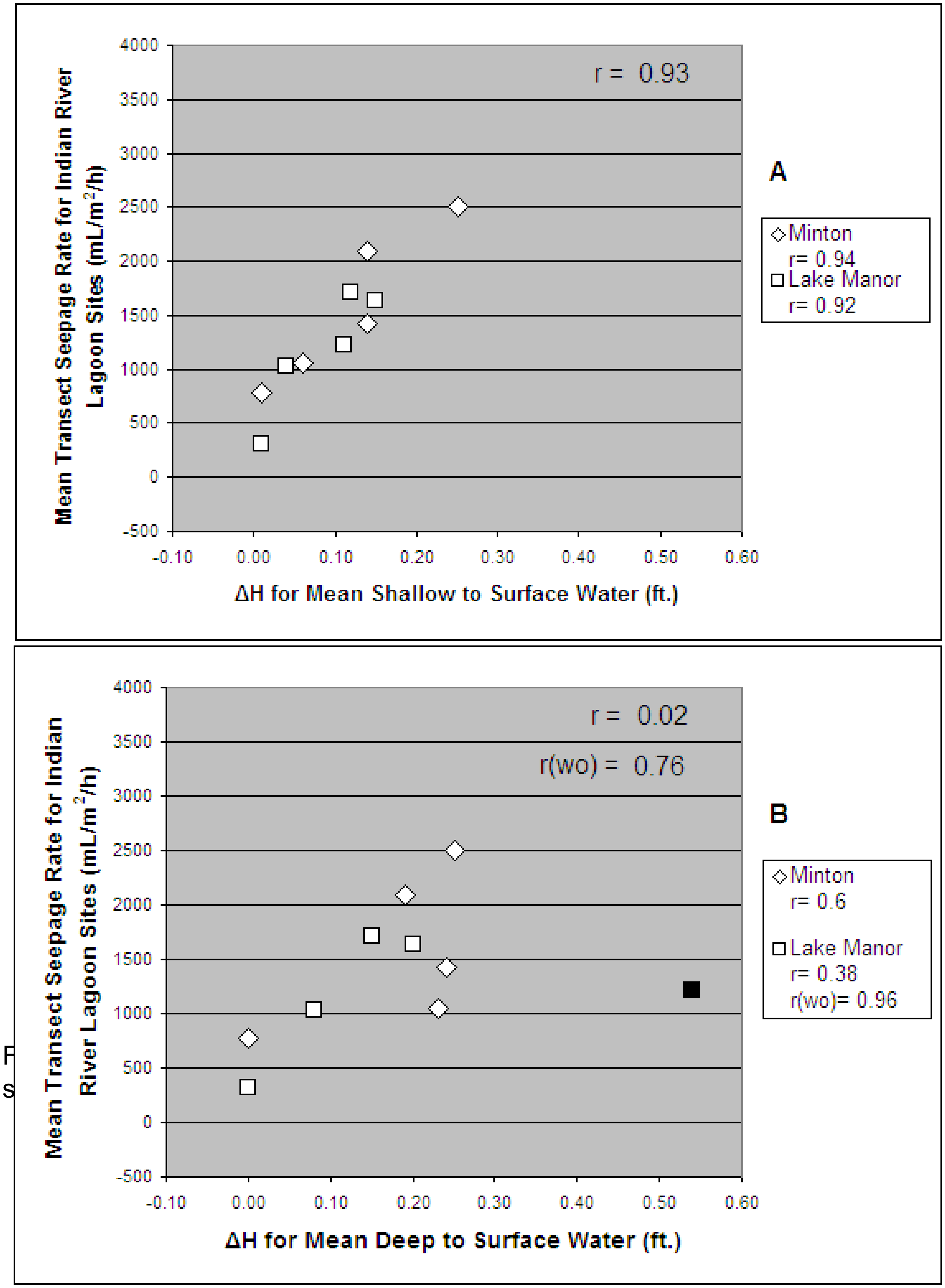


Figure 22. Indian River Lagoon mean transect seepage rates vs mean shallow (A) and deep (B) piezometer ΔH data.
"r (wo) =" is correlation coefficient without the darkened outlier data point.

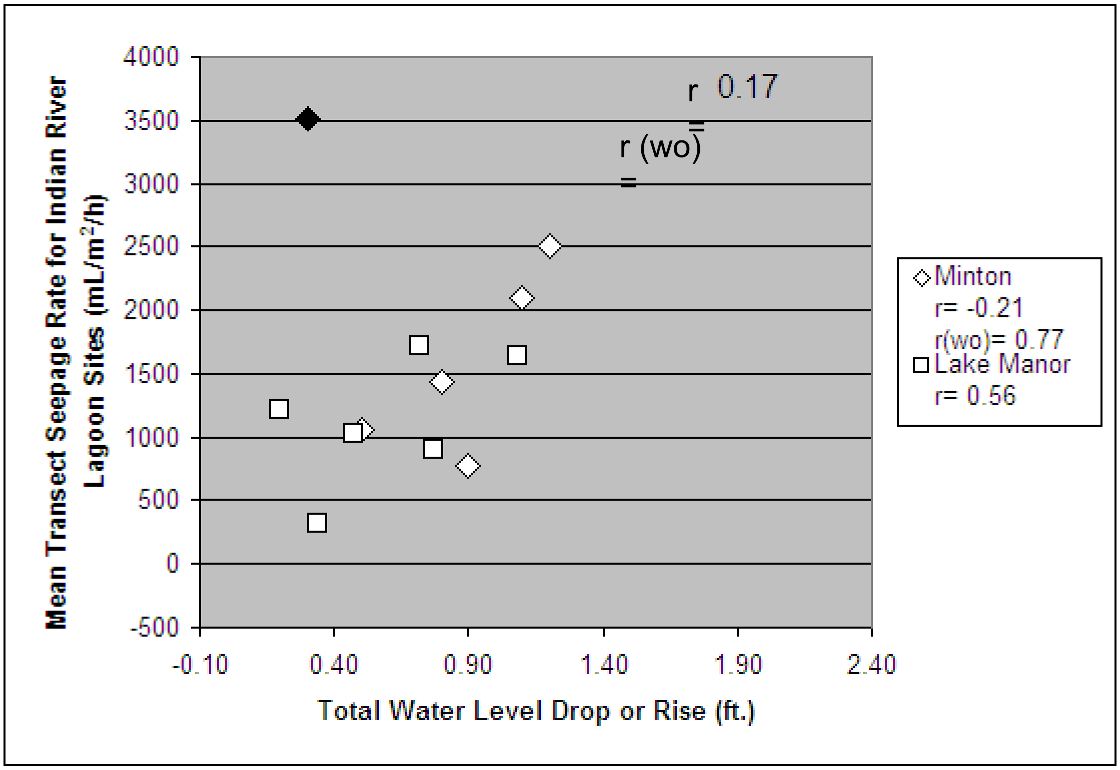


Figure 23. Indian River Lagoon mean transect seepage rate vs total water level drop or rise. "r (wo) =" is correlation coefficient without the darkened outlier data point.

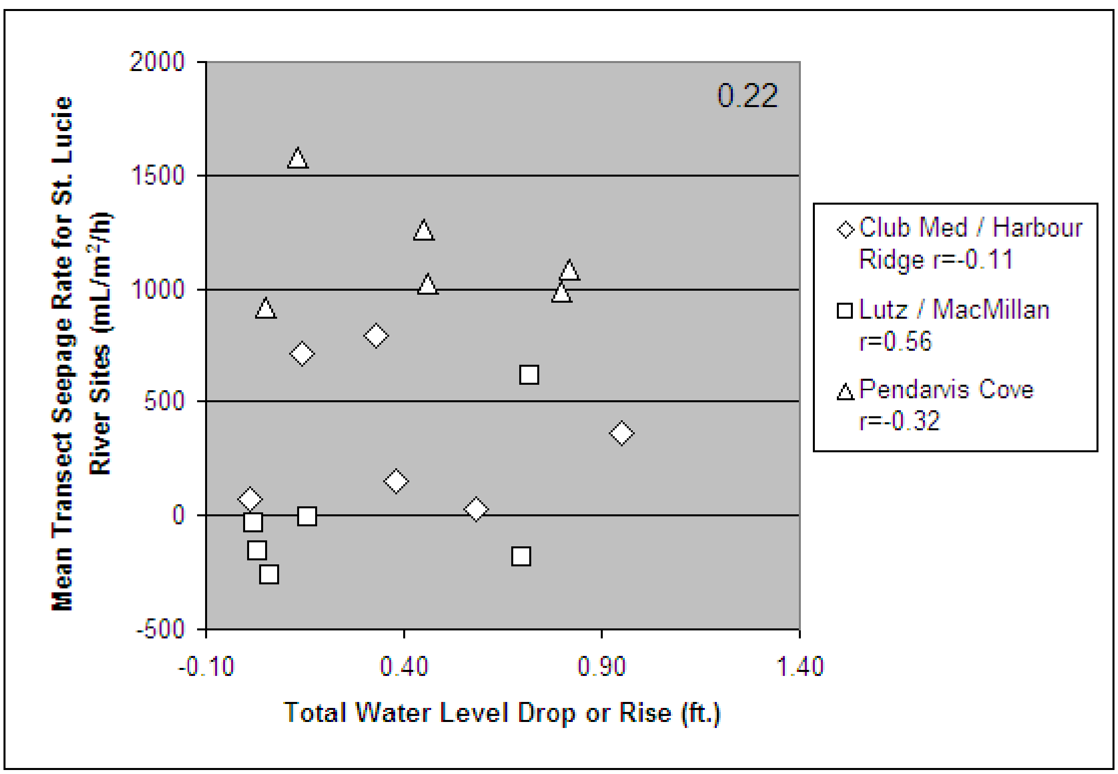
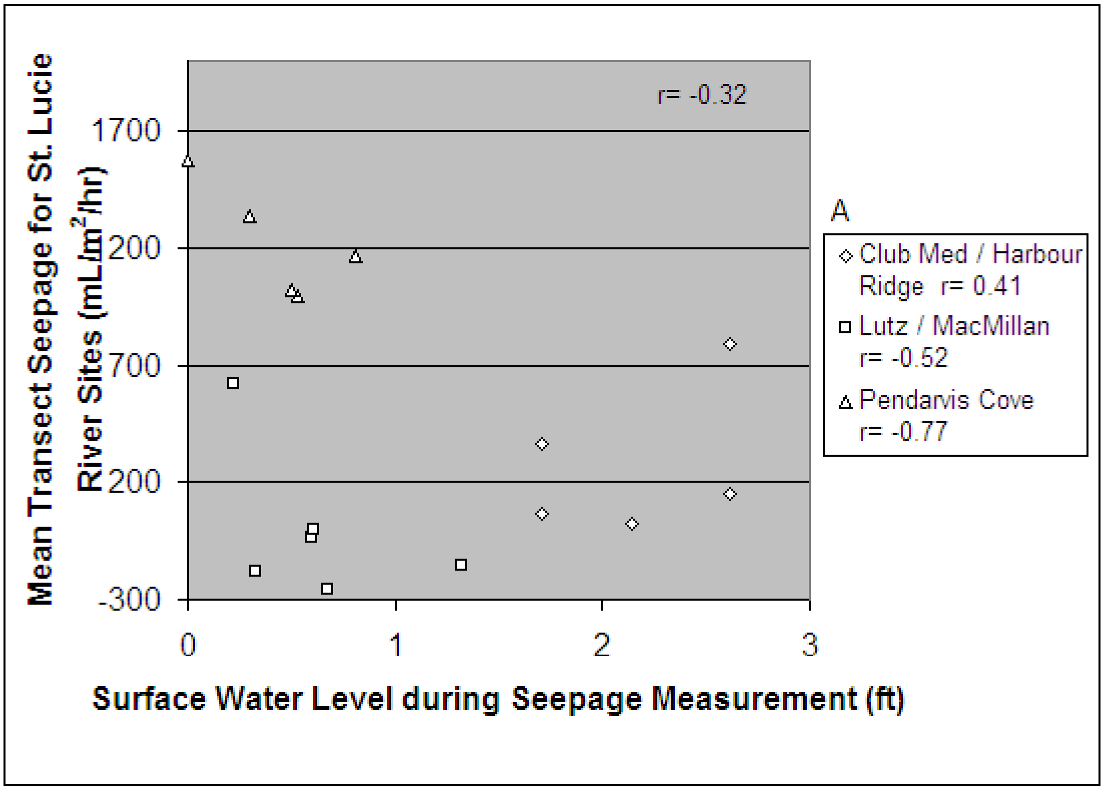


Figure 24. St. Lucie River mean transect seepage rates vs surface water level drop or rise.



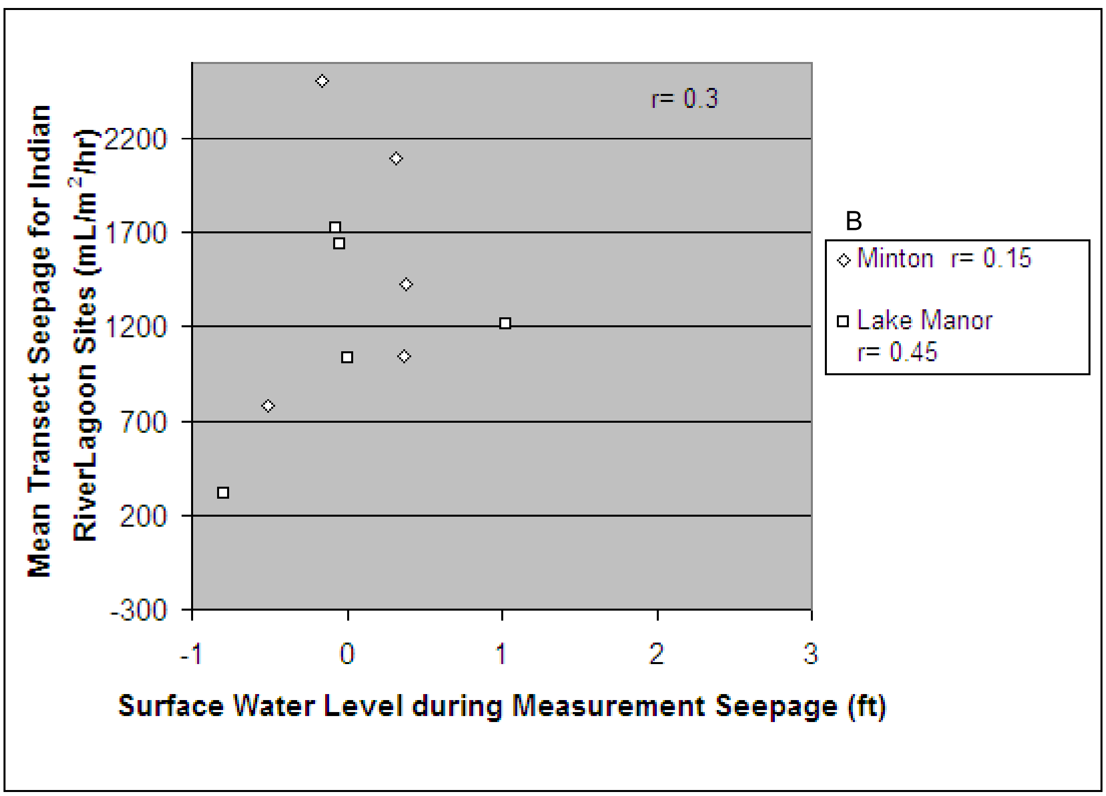


Figure 25. Surface water level during seepage measurement period plotted against Mean Transect Seepage for St. Lucie River sites (A) and Indian River sites (B).

Table 14. Statistically Significant Linear Regressions Relationships between Mean Transect Groundwater Seepage and selected variables.

Site	Regression	Statistical Significance	Notes
Combined IRL Sites	with surface water level during seepage measurement	r= -0.71; p<0.05	
	with Δh for nearshore deep piezometer water level to surface water level	r= 0.78; p<0.05	
	with Δh for nearshore shallow piezometer water level to surface water level	r= 0.93; p<0.01	
Minton	with vertical gradient for farshore shallow piezometer water level to surface water level	r= 0.81; p<0.05	
	with Δh for nearshore shallow piezometer water level to surface water level	r= 0.93; p<0.01	
	with Δh for mean shallow piezometer water level to surface water level	r= 0.94; p<0.01	
Lake Manor	with vertical gradient for nearshore shallow piezometer water level to surface water level	r= 0.85; p<0.05	
	with vertical gradient for nearshore deep piezometer water level to surface water level	r= 0.83; p<0.05	
	with vertical gradient for farshore deep piezometer water level to surface water level	r= 0.93; p<0.01	Without outlier
	with Δh for nearshore shallow piezometer water level to surface water level	r= 0.80; p<0.05	
	with Δh for mean shallow piezometer water level to surface water level	r= 0.92; p<0.01	
	with Δh for mean deep piezometer water level to surface water level	r= 0.96; p<0.01	Without outlier
Lutz/MacMillan	with vertical gradient for nearshore shallow piezometer water level to surface water level	r= 0.91; p<0.01	
	with Δh for nearshore shallow piezometer water level to surface water level	r= 0.81; p<0.05	
	with Δh for nearshore shallow piezometer water level to surface water level	r= 0.81; p<0.05	
Club Med / Harbour Ridge	with Δh for nearshore deep piezometer water level to surface water level	r= 0.83; p<0.05	
	with Δh for nearshore shallow piezometer water level to surface water level	r= 0.86; p<0.05	mean of meters 5&6
Pendarvis Cove	with surface water level during seepage measurement	r= -0.77; p<0.05	
	with Δh for nearshore deep piezometer water level to surface water level	r= 0.81; p<0.05	
	with Δh for nearshore shallow piezometer water level to surface water level	r= 0.86; p<0.05	mean of meters 5&6

Table 15. Nearshore and farshore piezometer vertical hydraulic gradient (unitless), St. Lucie River sites.

Measurement	Club Med				Harbour Ridge				Lutz / MacMillan				Pendarvis Cove			
Date	Time	Loc.	S	D	Time	Loc.	S	D	Time	Loc.	S	D	Time	Loc.	S	D
3/4/2002	12:00	1	0.023	0.010	11:00	1	0.050	0.014								
		2	0.015	0.006		2	0.083	0.124								
					13:41	1	0.045	0.025								
						2	0.053	0.036								
3/5/2002									9:30	1	0.038	0.011	11:30	1	0.018	0.025
										2				2	0.018	0.025
									14:05	1	0.025	0.011	15:30	1	0.005	0.020
										2				2	0.005	0.020
6/1/2002	13:50	1	0.025	0.009	13:00	1	0.045	0.068								
		2	piez reinstalled			2	0.035	0.015								
	17:00	1	0.045	0.068												
		2	piez reinstalled													
6/2/2002									10:15	1	destroyed		9:30	1	0.050	0.013
										2	-0.005	-0.001		2	0.015	0.001
													13:00	1	0.025	0.006
														2	0.018	
8/15/2002	11:40	1	0.143	0.037	12:34	1	0.055	0.019	18:30	1		-0.011	13:10	1	0.023	0.030
		2	0.008			2	0.075	0.112		2	-0.038	-0.009		2		
10/27/2002	No measurement equipment failure				No measurement equipment failure								no measurement equipment failure			
11/1/2002									12:45	1	0.020	0.005				
										2	0.003	0.005				
									15:05	1	0.023	-0.001				
										2	-0.003					
2/1/2003									13:50	1	0.063	0.002	15:15	1	0.053	0.035
										2	0.025			2		0.006
2/2/2003	12:18	1	0.028	0.009	11:53	1	0.010	0.005								
		2	-0.010	-0.003		2	0.048	0.025								
3/24/2003	10:15	1	0.203	0.064	9:00	1	0.063	0.029					13:00	1	0.105	0.024
		2	0.010	0.004		2	0.083	0.026						2	-0.095	0.007
3/25/2003									9:00	1	0.020					
										2	-0.018	-0.004				

Note: Loc = Location; S = Shallow (5.0 ft.); D = Deep (150 ft.).
Vertical gradient calculated from piezometer water level to surface water level.

Table 16. Nearshore and farshore piezometer vertical hydraulic gradient (unitless). Indian River sites.

Measurement	Lake Manor				Minton			
Date	Time	Loc.	S	D	Time	Loc.	S	D
3/6/2002	12:00	1	0.033	0.007	9:42	1	dry	dry
		2		0.006		2	0.013	0.026
	14:15	1	0.003	0.004	15:30	1	dry	dry
		2		0.004		2	0.015	0.006
6/2/2002	18:00	1	0.030	0.014				
		2	0.018	0.064				
6/3/2002					14:00	1	0.058	0.029
						2	0.010	0.004
8/16/2002					11:15	1	0.100	0.029
						2	0.025	0.007
8/17/2002	14:00	1	0.070	0.020				
		2	0.003	0.009				
10/18/2002					11:00	1	0.253	0.006
					14:20	1	0.035	0.024
					11:30	2	0.008	
						2A	0.020	0.004
					14:00	2	0.015	0.004
						2A	0.035	0.011
10/26/2002	No measurement equipment failure				no measurement equipment failure			
1/31/2003					15:45	1	dry	dry
						2	0.003	
						2A	0.013	0.004
2/1/2003	10:10	1	0.003	0.005				
		2		-0.004				
3/23/2003	8:50	1	0.045	0.014	17:15	1	0.070	0.022
		2	0.008	0.007		2		0.004
	12:30	1	0.033	0.015		2A	0.013	0.010
		2	0.025	0.005				

Note: Loc = Location; S = Shallow (5.0 ft.); D = Deep (150 ft.).
Vertical gradient calculated from piezometer water level to surface water level.

Table 17. Calculation of horizontal gradients (i_{horiz}) for 30' wells to 24h mean surface water level.

Club Med													2/2/2003		3/24/2003	
Site	Site ID	Northing	Easting	Δl (ft.)	h (ft.)	i_{horiz}	h (ft.)	i_{horiz}	h (ft.)	i_{horiz}	h (ft.)	i_{horiz}	h (ft.)	i_{horiz}	h (ft.)	i_{horiz}
Surface Water	SLCMSW	1057545.581	883876.073										1.48		1.22	
30'	SLCMG3	1058005.227	883776.635	370.28									1.48	0.000	1.27	0.000

Harbour Ridge									8/15/2002		10/27/2002		2/2/2003			
Site	Site ID	Northing	Easting	Δl (ft.)	h (ft.)	i_{horiz}	h (ft.)	i_{horiz}	h (ft.)	i_{horiz}	h (ft.)	i_{horiz}	h (ft.)	i_{horiz}	h (ft.)	i_{horiz}
Surface Water	SLHRSW	1057783.239	884328.205						0.85		1.19		0.24			
30'	SLHRG2	1054248.321	881512.691	4219.16					4.78	0.001	3.71	0.001	3.18	0.001		

Lutz/MacMillan									8/15/2002		11/1/2002		2/1/2003		3/25/2003	
Site	Site ID	Northing	Easting	Δl (ft.)	h (ft.)	i_{horiz}	h (ft.)	i_{horiz}	h (ft.)	i_{horiz}	h (ft.)	i_{horiz}	h (ft.)	i_{horiz}	h (ft.)	i_{horiz}
Surface Water	SLLTSW	1043521.826	911676.204						0.85		1.22		0.55		0.78	
30'	SLAMG2	1043695.565	911472.239	77.93					0.69	-0.002	0.95	-0.003	0.06	-0.006	0.62	-0.002

Pendarvis Cove													2/1/2003		3/24/2003	
Site	Site ID	Northing	Easting	Δl (ft.)	h (ft.)	i_{horiz}	h (ft.)	i_{horiz}	h (ft.)	i_{horiz}	h (ft.)	i_{horiz}	h (ft.)	i_{horiz}	h (ft.)	i_{horiz}
Surface Water	SLPDWQ	1038084.399	893479.628										0.23		1.05	
30'	SLPDGW3	1038033.148	893395.277	32.70									0.59	0.011	1.18	0.004

Lake Manor											10/26/2002		2/1/2003		3/23/2003	
Site	Site ID	Northing	Easting	Δl (ft.)	h (ft.)	i_{horiz}	h (ft.)	i_{horiz}	h (ft.)	i_{horiz}	h (ft.)	i_{horiz}	h (ft.)	i_{horiz}	h (ft.)	i_{horiz}
Surface Water	LMLSSW	1066510.150	904691.622								1.34		0.04		0.48	
30'	IRLMG3	1066426.427	904544.062	89.66							1.63	0.003	0.86	0.009	1.32	0.009

Minton									10/18/2002		10/26/2002		1/31/2003		2/23/2003	
Site	Site ID	Northing	Easting	Δl (ft.)	h (ft.)	i_{horiz}	h (ft.)	i_{horiz}	h (ft.)	i_{horiz}	h (ft.)	i_{horiz}	h (ft.)	i_{horiz}	h (ft.)	i_{horiz}
Surface Water	IRMNSW	1122699.392	879118.060						1.5		1.15		-0.03		0.07	
30'	IRMNG2	1122623.825	878953.272	-388.71					2.32	-0.002	2.00	-0.002	1.08	-0.003	1.09	-0.003

Table 18. Calculation of horizontal gradients (i_{horiz}) for 30' wells to surface water level during seepage measurement.

Club Med																
Site	Site ID	Northing	Easting	Δl (ft.)	h (ft.)	i_{horiz}	h (ft.)	i_{horiz}	h (ft.)	i_{horiz}	h (ft.)	i_{horiz}	h (ft.)	i_{horiz}	h (ft.)	i_{horiz}
													2/2/2003		3/24/2003	
Surface Water	SLCMSW	1057545.581	883876.073										2.61		1.71	
30'	SLCMG3	1058005.227	883776.635	470.28									1.48	-0.002	1.27	-0.001

Harbour Ridge					3/4/2002		6/1/2002		8/15/2002				2/2/2003			
Site	Site ID	Northing	Easting	Δl (ft.)	h (ft.)	i_{horiz}	h (ft.)	i_{horiz}	h (ft.)	i_{horiz}	h (ft.)	i_{horiz}	h (ft.)	i_{horiz}	h (ft.)	i_{horiz}
Surface Water	SLHRSW	1057783.239	884328.205		1.71		2.61		2.14				2.61			
30'	SLHRG2	1049995.930	881382.499	8325.83	3.59	0.000	3.54	0.000	4.78	0.000			3.18	0.000		

Lutz/MacMillan									8/15/2002		11/1/2002		2/1/2003		3/25/2003	
Site	Site ID	Northing	Easting	Δl (ft.)	h (ft.)	i_{horiz}	h (ft.)	i_{horiz}	h (ft.)	i_{horiz}	h (ft.)	i_{horiz}	h (ft.)	i_{horiz}	h (ft.)	i_{horiz}
Surface Water	SLLTSW	1043521.826	911676.204						1.32		0.68		0.22		0.61	
30'	SLAMG2	1043695.565	911472.239	267.93					0.69	-0.002	0.95	0.001	0.06	-0.001	0.62	0.000

Pendarvis Cove													2/1/2003		3/24/2003	
Site	Site ID	Northing	Easting	Δl (ft.)	h (ft.)	i_{horiz}	h (ft.)	i_{horiz}	h (ft.)	i_{horiz}	h (ft.)	i_{horiz}	h (ft.)	i_{horiz}	h (ft.)	i_{horiz}
Surface Water	SLPDWQ	1038084.399	893479.628										0		0.5	
30'	SLPDGW3	1038033.148	893395.277	98.70									0.59	0.006	1.18	0.007

Lake Manor													2/1/2003		3/23/2003	
Site	Site ID	Northing	Easting	Δl (ft.)	h (ft.)	i_{horiz}	h (ft.)	i_{horiz}	h (ft.)	i_{horiz}	h (ft.)	i_{horiz}	h (ft.)	i_{horiz}	h (ft.)	i_{horiz}
Surface Water	LMLSSW	1066510.150	904691.622										0.79		-0.07	
30'	IRLMG3	1066426.427	904544.062	169.66									1.29	0.003	1.87	0.011

Minton													1/31/2003			
Site	Site ID	Northing	Easting	Δl (ft.)	h (ft.)	i_{horiz}	h (ft.)	i_{horiz}	h (ft.)	i_{horiz}	h (ft.)	i_{horiz}	h (ft.)	i_{horiz}	h (ft.)	i_{horiz}
Surface Water	IRMNSW	1122699.392	879118.060										-0.51			
30'	IRMNG2	1122623.825	878953.272	181.29									1.08	0.009		

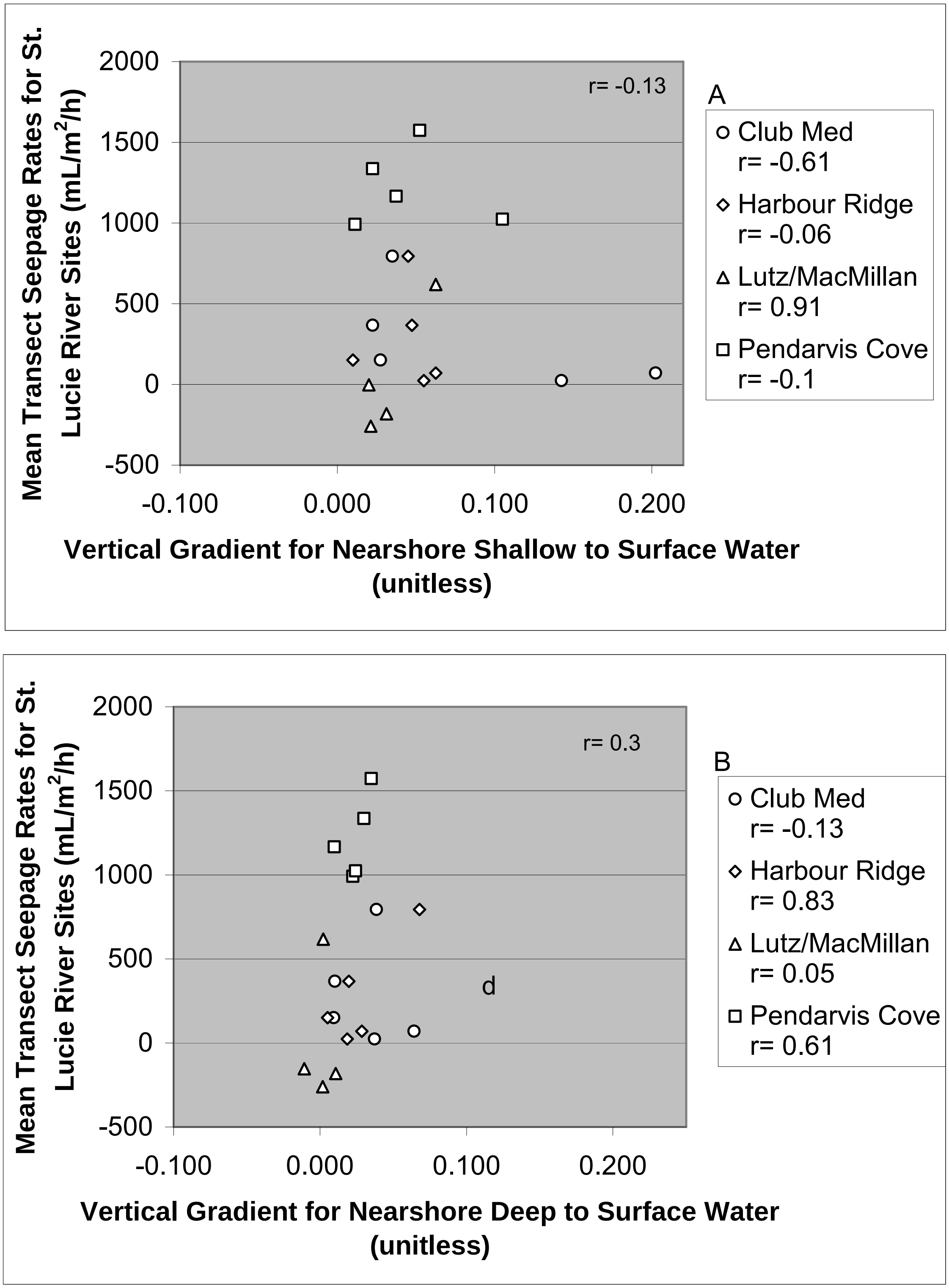
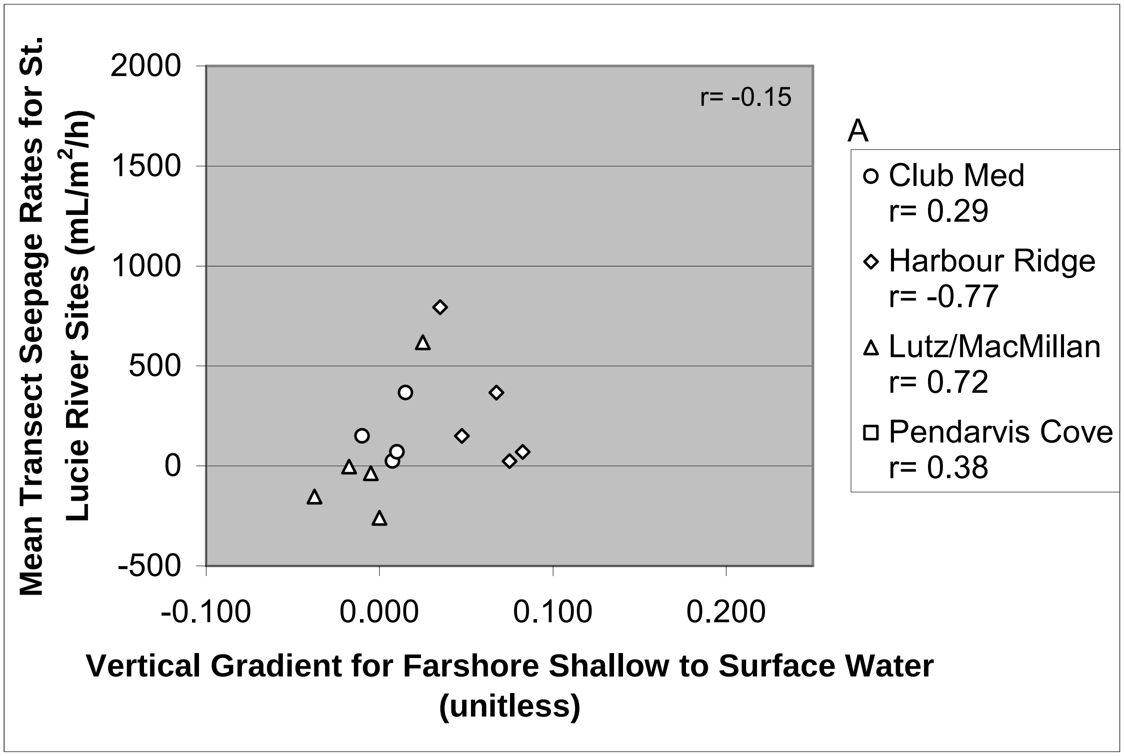


Figure 26. Mean Transect Seepage versus Vertical Gradient (Nearshore to Surface Water) for St. Lucie River shallow (A) and deep (B) sites.



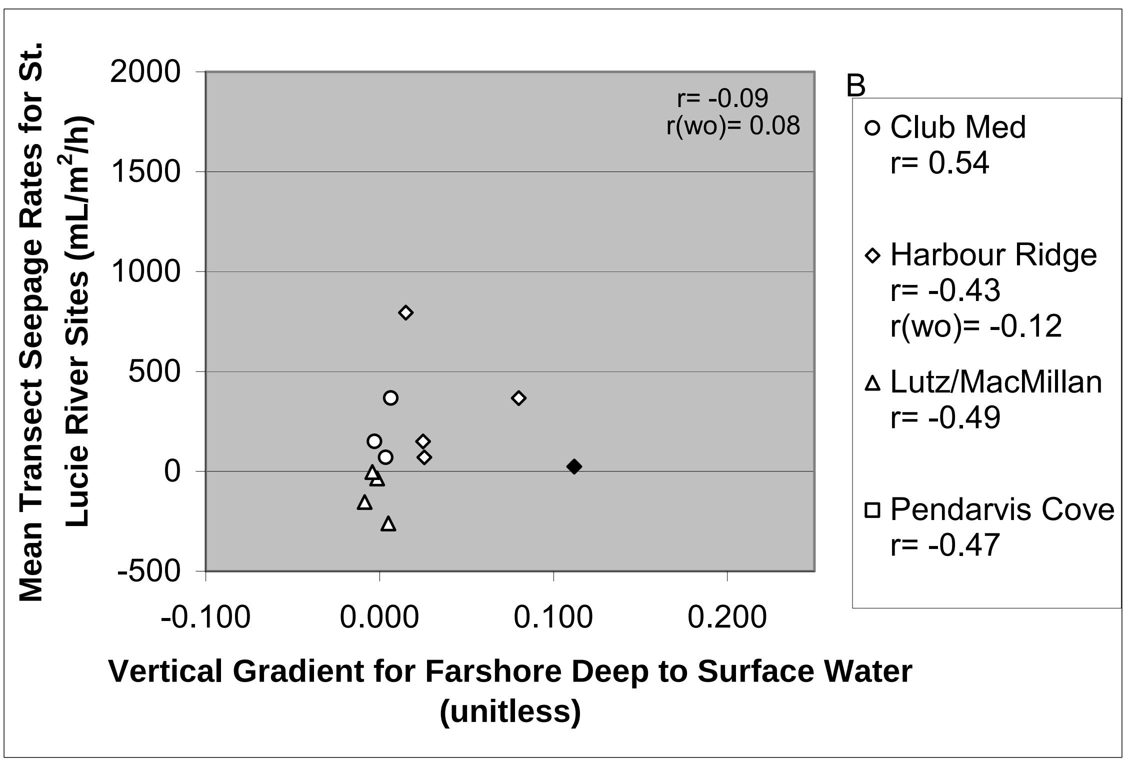
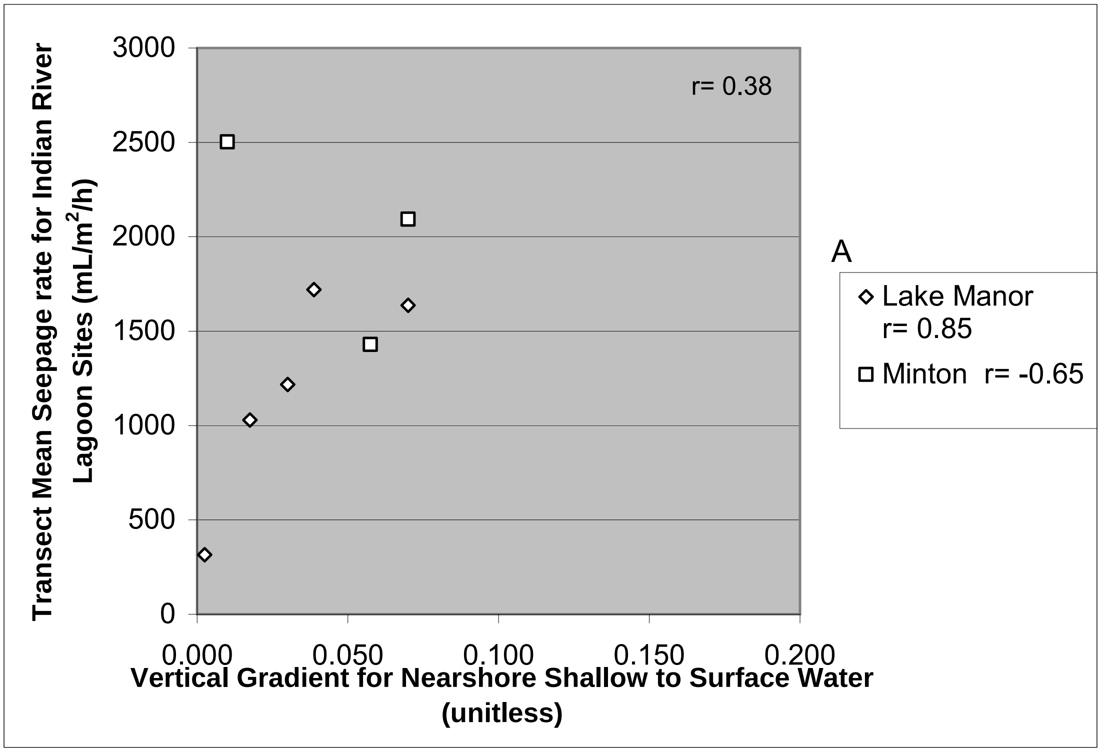


Figure 27. Mean Transect Seepage versus Vertical Gradient (Farshore to Surface Water) for St. Lucie River sites.



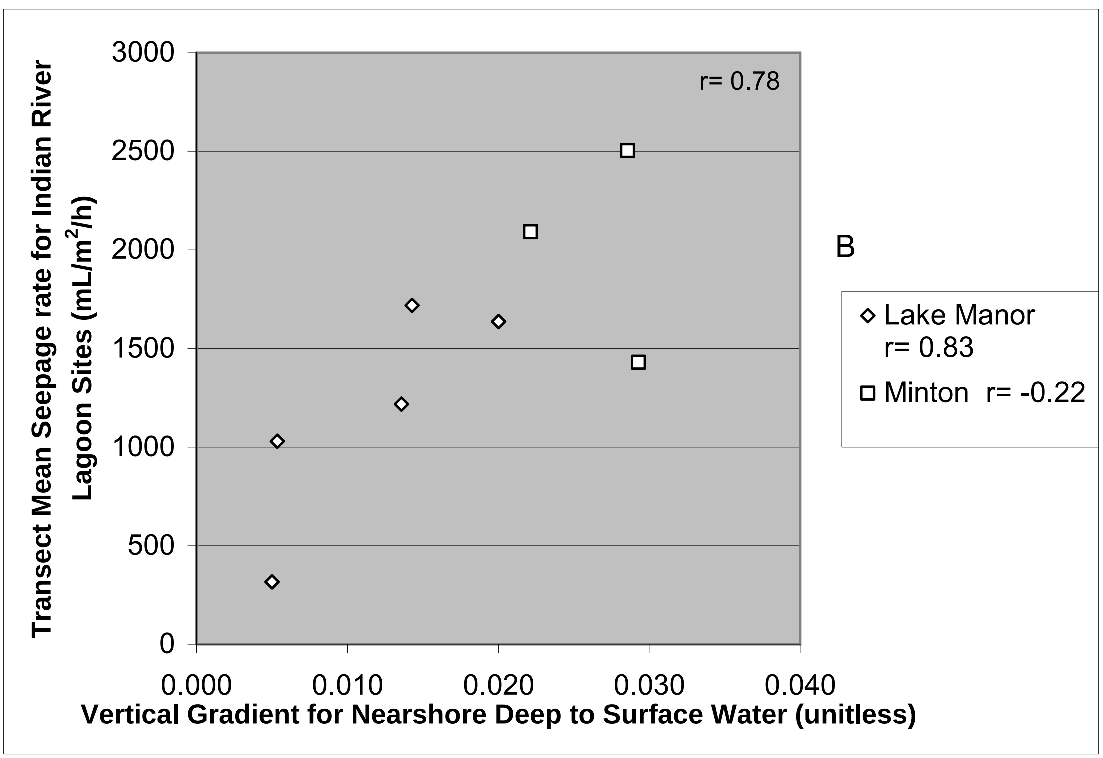
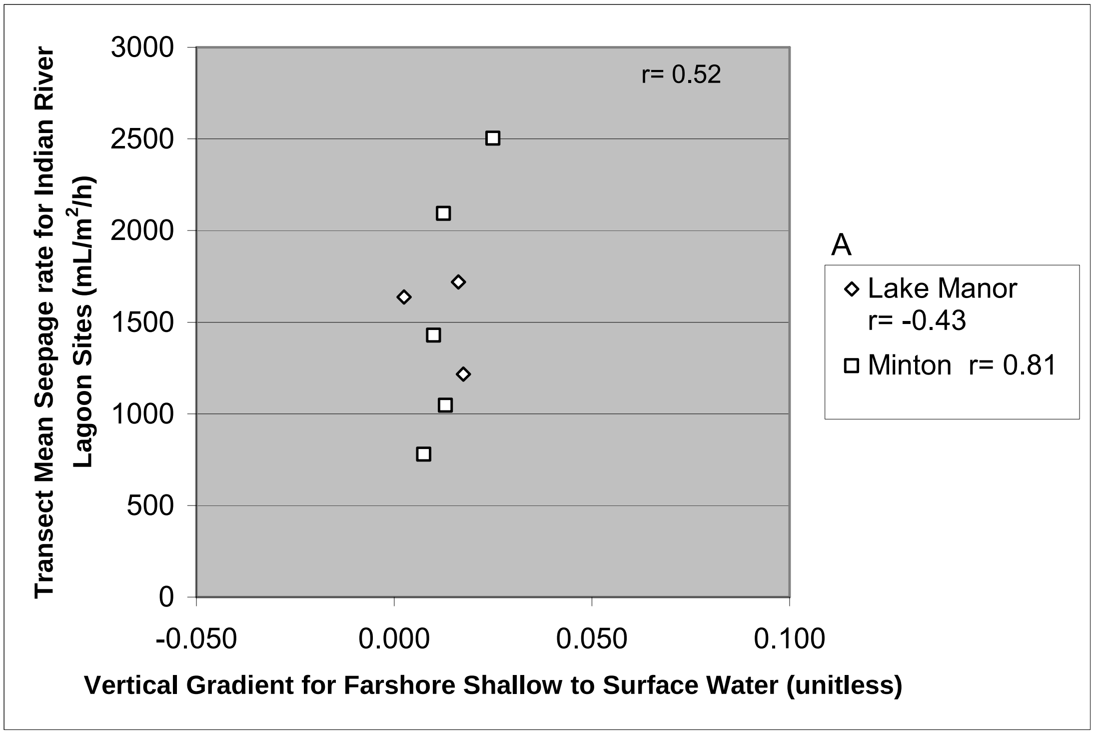


Figure 28. Mean Transect Seepage versus Vertical Gradient (Nearshore to Surface Water) for Indian River Lagoon sites.



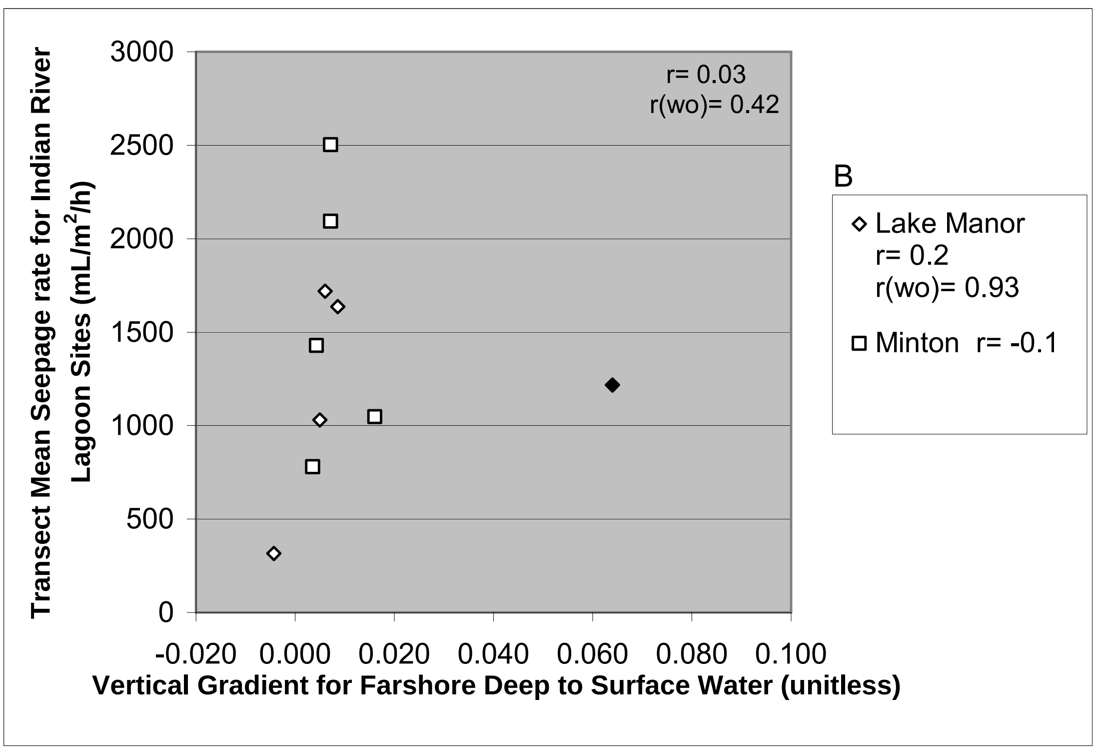
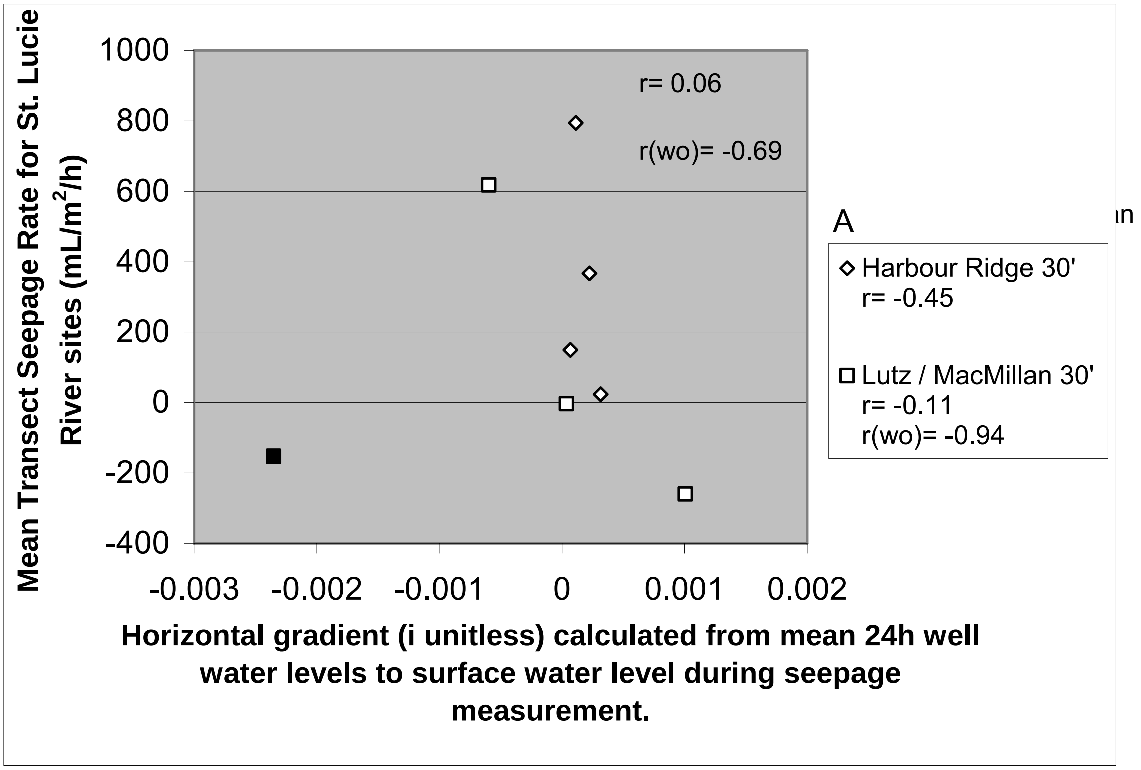


Figure 29. Mean Transect Seepage versus Vertical Gradient (Farshore to Surface Water) for Indian River Lagoon sites.

seepage was significantly associated with the nearshore deep to surface water Δh ($r=0.83$, $p<0.05$).

For the St. Lucie River sites, significant relationships between mean transect seepage and nearshore shallow to surface water ($r= 0.91$, $p<0.01$) and nearshore deep to surface water ($r= 0.83$, $p<0.05$) vertical gradients were found at Lutz/MacMillan and Harbour Ridge, respectively. For Indian River Lagoon sites, significant relationships were found for Lake Manor between mean seepage and vertical gradients calculated from nearshore shallow to surface water ($r= 0.85$, $p<0.05$), nearshore deep to surface water ($r= 0.83$, $p<0.05$) and farshore deep to surface water ($r= 0.93$, $p<0.01$). For Minton, a significant relationship existed between mean transect seepage and the nearshore shallow to surface water vertical gradient ($r= 0.85$, $p<0.05$).

Comparison of mean transect seepage for St. Lucie River sites (with three or more data points) to horizontal gradients calculated from daily average 30 ft. well water levels and mean 24 hr. surface water levels during seepage measurement are presented in Figure 30. There were insufficient data for statistical analysis of IRL sites. Using daily average mean well water level data was done because well levels during exact seepage measurement times were not available. Harbour Ridge data are omitted due to errors in the northing and easting well coordinates. At the other sites, there was a paucity of data due to missing well data, but a negative relationship existed at the Lutz/MacMillan site, if one data point is omitted ($r= -0.94$, $p<0.01$). This indicates greater seepage at lower horizontal gradients and is difficult to explain. However, the use of mean daily average well water level data, the lack of data points and very slight differences in horizontal gradients indicate these comparisons should be viewed with caution.



Insufficient Data for IRL Sites

Figure 30. Horizontal gradients calculated from 24 hour mean well water levels and surface water level during seepage measurement plotted against Mean Transect Seepage Rates for St. Lucie River sites.

F. Krupaseep Data and Comparison to Belanger Meter and Water Level Data.

The Krupaseep was deployed at the Minton, Lutz/MacMillan and Pendarvis Cove sites, and a summary of the maximum, minimum and mean seepage rate data during the deployment times is presented in Table 19. Also,a summary of the March 24 and 25, 2003, Krupaseep data is presented in Figure 31 with water level data (well and surface water). At Pendarvis Cove, the 30 and 100 ft. well water level data follow the same trend as the surface water, although less pronounced. The Krupaseep data generally showed lower seepage rates during water level troughs and higher seepage rates during peaks, although much more oscillation of seepage rates occurred. Near the tidal water level troughs, negative seepage (recharge) was recorded (Fig. 31). The Krupaseep measurements were often highly variable during high tide, sometimes plunging from rates greater than 600 mL/m^2/hr to negative rates. Usually a significant inverse relationship occurs between seepage and tide height, as described by Belanger and Walker (1990). However, these results are the opposite and are difficult to explain (Fig. 32). As Figure 31 shows, a greater head difference between surface water and shallow groundwater occurs at high tide, while the surface and shallow groundwater levels became very similar near low tide, with higher groundwater levels occurring at the trough. Apparently the tidal change is small enough (approximately 1 ft.) and the meter measurement site is far enough offshore (approximately 100 ft.) that factors other than tide are of greater importance.

The closest Belanger meter (BM) to Krupaseep KS-2 at Pendarvis Cove was SM-2, and it showed low rates, with a mean of 49 mL/m2-hr on 3/24/03 during the Krupaseep deployment period. The SM-2 average during the entire study was 88 mL/m2/hr, with a range of –55 to 357 ml/m2/hr. The KS-2 mean was reasonably close (305 mL/m2/hr), but exhibited a much greater range (59-2870 mL/m2/hr) than the SM-2. Ar Minton, deployment times of the two meters did not coincide. The BM meter mean (mean of the two closest meters SM-4 and SM-4A) was 1824 mL/m2/hr and higher than the Krupaseep (KS-1) mean of 423 mL/m3/hr. However, the KS-1 range (-1 to 2281 mL/m2/hr) was higher than the BM range (575-2472 mL/m2/hr). KS-2, at the same site exhibited a mean 613 mL/m2/hr, with a range of 45-2987 mL/m2/hr. The nearest BM mean was 1562 mL/m2/hr, with a range of 402-4262 mL/m2/hr.

Deployment times for the two meter types also did not coincide at the Lutz/MacMillan site. During the entire study the KS-1 mean was 997 mL/m2/hr, compared to a BM mean of –338 mL/m2/hr. The ranges for these two meters were 253 to 3360 and –973 to 574 mL/m2/hr, respectively. The mean for KS-2 was 1032 mL/m2/hr, compared to a BM mean of –273 mL/m2/hr. The range for the KS-2 was –174 to 1061 mL/m2/hr, while the range for the nearest BM was –1291 to 688 mL/m2/hr.

Data are difficult to compare because of differences in deployment times, but it appears that the Krupaseep data often exhibit fairly similar means, but show much greater variability.This may be due, in large part, to the frequency of the Krupaseep readings. A better comparative study should be conducted in the future to compare the meter performances at exactly the same times and locations.

Table 19. St. Lucie Estuary/Indian River Lagoon Groundwater Surface Water Interaction Study Krupaseep Results

Site Name	Deployment Date/Time	Removal Date/Time	Nearest Belanger Reading	Number of Readings	Maximum ml-m2/hr	Mean ml-m2/hr	Minimum ml-m2/hr
Minton							
KS-1 (under dock)	8/17/02 15:00	10/16/02 13:00	SM-4, 4A	6345	2281.14	423.38	1.0
KS-2	8/17/02 15:00	10/16/02 13:00	SM-5, 5A	5173	2987.19	612.93	45.29
Lutz							
KS-1 (north of dock)	11/3/02 17:30	11/25/02 10:10	SM-2	2007	3359.86	997.12	253.17
KS-2	11/3/02 17:30	11/25/02 10:10	SM-3	1655	1061.45	1032	-174.31
Pendarvis Park							
KS-1 (north of dock	3/19/03 1:20	5/19/03 10:00	None	4005	2245	153.8	124.6
KS-2	3/19/03 1:20	5/19/03 10:00	SM-2	3024	2870.0	305.3	38.80

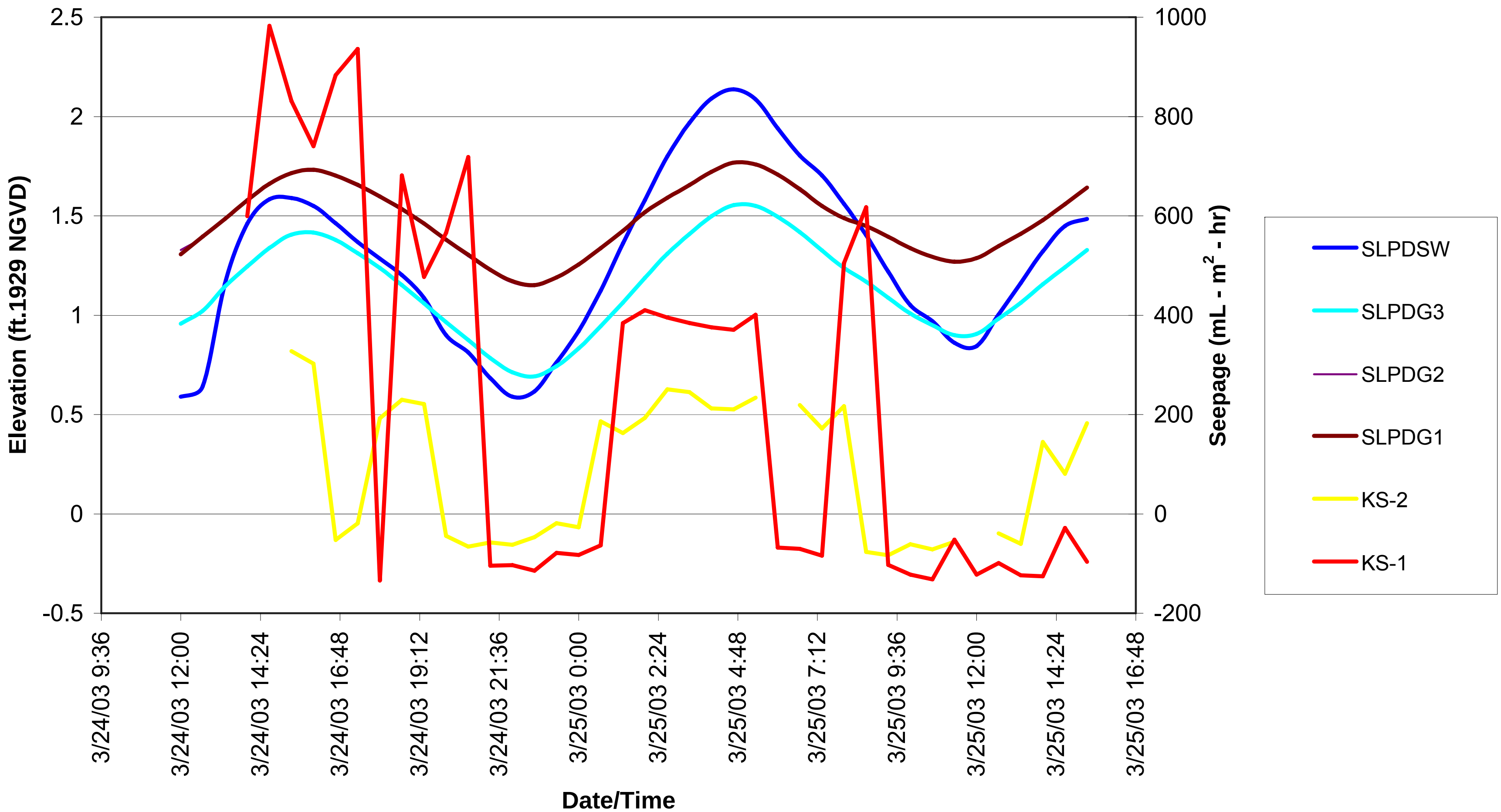


Figure 31. Pendarvis Cove Park Krupaseep Data, March 24 through March 25, 2003 Water Levels and Seepage Rates

Conclusions

- All wells (100, 60, 30 ft.) are located in the sand, shell and limestone surficial aquifer. Thin clay layers separating the lower and upper surficial aquifer regions appear to have discontinuities in them because the various well water levels, although usually different in height, mimic each other exactly and indicate a hydraulic connection. Higher heads in the deeper wells at many sites also indicate artesian conditions caused by breaks in the surficial clay layer.

- High seepage rates previously measured in the area by Belanger and Walker (1990) and also in this study, particularly at selected offshore meters in the Lake Manor, Minton and Pendarvis Cove transects, suggest surficial aquifer clay layer discontinuities, or breaks in the Hawthorn Formation separating the surficial aquifer from the Floridan Aquifer. These discontinuities may be causing artesian conditions and creating "hot spots" of groundwater seepage. Inputs from the Floridan Aquifer are not likely, however, due to the great thickness of the Hawthorn Formation. Geophysical and tracer techniques could be used in the future to pinpoint the source of the seepage water.

- Surface water levels at all sites were extremely variable, but most variation occurred at the Lutz/MacMillan, Minton and Lake Manor sites, due to the greater tidal influence. At these sites, the 60 and 30 ft. well water levels closely mirrored surface water levels.

- The average seepage rate for the St. Lucie River and Indian River Lagoon study areas were 651 and >1517 $mL/m^2/hr$, respectively, and indicate that groundwater seepage is very important to the system. Highest mean transect rates were measured at Pendarvis Cove (>1331 $mL/m^2/hr$) in the St. Lucie River and at Lake Manor (>1137 $mL/m^2/hr$) and Minton (>1896 $mL/m^2/hr$) in the Indian River Lagoon. The Lutz/MacMillan site transect mean ranged from -260 to 618 $mL/m^2/hr$ and often exhibited negative seepage rates due to the local groundwater configuration. Mean transect seepage was inversely related to water level at the Indian River Lagoon sites ($r = -0.71$, $p<0.05$).

- The water quality of the wells and surface water at the study site was generally good. Surface water mean TPO_4 was higher at the St. Lucie River sites (0.183 mg/L) than the Indian River sites (0.073 mg/L). The lower tidal flushing impact and higher shoreline development index for the St. Lucie River may account for the higher TPO_4 levels. Mean surface water dissolved oxygen levels for the various sites ranged from 4.4 mg/L for Minton to 8.36 mg/L for Lake Manor. The Minton transect receives a little less tidal flushing than Lake Manor and, based on a visual inspection, tends to accumulate more organic matter. Temperature was found to be a significant predictor of DO at the Lutz/MacMillan ($p<0.01$), Harbour Ridge ($p<0.05$) and Pendarvis Cove ($p<0.05$) sites. NH_4, NO_x and TKN were fairly low at all sites with NO_x not being detectable at both Indian River Lagoon sites, probably due to uptake by heavy seagrass growth at these locations. High mean NO_x levels (> 0.5mg/L) were found in the 30 and 100 ft. wells at the Club Med site, although reasons for this are unclear.

- Although statistical comparisons were made between mean transect seepage and various hydrologic variables such as well and surface water levels, Δh's, vertical gradients and horizontal gradients, these results should be viewed with caution due to the paucity of data points. Although inconclusive, several significant relationships were found between mean transect seepage and Δh's and/or vertical gradients in shallow and deep (nearshore and farshore) piezometers, and these are identified in this report. The Lake Manor site exhibited the greatest number of significant linear relationships.

- Limited Krupaseep data show rates are highly variable, but are similar to Belanger meter data at lower water levels near the tidal cycle trough. Although variable, rates exhibited a direct relationship with tide height, which is difficult to explain. More comparative data are needed for evaluation purposes.

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Appendix A

Well and Piezometer Layout and Construction Details

As-Built Construction Table For St. Lucie Estuary/Indian River Lagoon Monitor Wells

Site ID	Alias	State Planar Easting 1983 NAD (feet)	Northing 1983 NAD (feet)	Elevation at Benchmark - feet (1)	Measuring Point at TOC - feet (1)	Depth of Well - feet	Elevation at Top of Well Screen - feet (1)	Elevation at Bottom of Well Screen - feet (1)
SLHRG1	Harbour Ridge60'/HR-A	881516.353	1054247.406	13.535	13.415	59.04	-43.63	-45.63
SLHRG2	Harbour Ridge30'/HR-B	881516.353	1054247.406	13.535	13.615	29.79	-14.18	-16.18
SLHRSW	Harbour Ridge SW/HR-SW			-7.11	n/a	n/a	n/a	n/a
SLHRZ1	near shore, deep					16.49		
SLHRZ2	near shore, shallow					9.9		
SLHRZ3	far shore, deep					25.78		
SLHRZ4	far shore, shallow					16.23		
SLPDG1	Pendarvis Park 100'/PCP-A	893392.06	1038042.305		4.395	100.63	-94.24	-96.24
SLPDG2	Pendarvis Perk 60'PCP-B	893393.658	1038037.793		4.405	59.48	-53.08	-55.08
SLPDG3	Pendarvis Park 30'/PCP-C	893395.277	1038033.148		4.405	29.63	-23.23	-25.23
SLPDSW	Pendarvis Park SW/PCP-SW	893479.628	1038084.399	-0.63	n/a	n/a	n/a	n/a
SLPDZ1	near shore, deep					19.96		
SLPDZ2	near shore, shallow					9.9		
SLPDZ3	far shore, deep					19.74		
SLPDZ4	far shore, shallow					5.3		
SLAMG1	Macmillan 60'/AM-A			8.82		60.21	-58.21	-60.21
SLAMG2	MacMillan 30'/AM-B			8.82		?	2.00	0.00
SLLTSW	Lutz SW			6.83	n/a	n/a	n/a	n/a
SLLTZ1	near shore, deep					19.9		
SLLTZ2	near shore, shallow					9.99		
SLLTZ3	far shore, deep					23.31		
SLLTZ4	far shore, shallow					13.86		
IRMNG1	Minton 60'/MI-A			21.13	19.43	58.35	-36.92	-38.92
IRMNG2	Minton 30'/MI-B			21.13	19.48	29.31	-7.83	-9.83
IRMNSW	Minton SW/MI-SW				n/a	n/a	n/a	n/a
IRMNZ1	near shore, deep				7.49	19.88		
IRMNZ2	near shore, shallow				7.52	9.85		
IRMNZ3	far shore, deep				1.99	19.59		
IRMNZ4	far shore, shallow				1.86	9.01		
IRMNS1	Inside small (close) meter							
IRMNS2	Inside baby (far) meter							
IRMNS3	SW at far east end of dock							
IRLMG1	Lake Manor 100'/LM-A	904532.29	1066442.42		7.01	98.42	-89.41	-91.41
IRLMG2	Lake Manor 60'/LM-B	904538.13	1066435.49		7.30	56.70	-47.40	-49.40
IRLMG3	Lake Manor 30'/LM-C	904544.06	1066426.43		7.09	29.47	-20.38	-22.38
IRLMSW	LM-SW	904691.622	1066510.150	-1.35	n/a	n/a	n/a	n/a
IRLMZ1	near shore, deep					15.06		
IRLMZ2	near shore, shallow					5.03		
IRLMZ3	far shore, deep					14.94		
IRLMZ4	far shore, shallow					9.99		
SLCMG1	Club Med 100'/CM-A	880460.45	1058052.58	5.15	4.56	100.17	-93.62	-95.62
SLCMG2	Club Med 60'/CM-B	880457.42	1058048.74	5.15	4.63	57.28	-50.65	-52.65
SLCMG3	Club Med 30'/CM-C	880454.71	1058044.87	5.15	4.66	31.67	-25.01	-27.01
SLCMSW	Club Med SW/CM-SW	880566.888	1057851.010	-1.5	n/a	n/a	n/a	n/a
SLCMZ1	near shore, deep							
SLCMZ2	near shore, shallow							
SLCMZ3	far shore, deep							
SLCMZ4	far shore, shallow							

(1) Elevations are 1929 NGVD

Piezometers: 1 is near shore, deep
2 is near shore, shallow
3 is far shore, deep
4 is far shore, shallow

As-Built Construction Table For St. Lucie Estuary/Indian River Lagoon Monitor Wells

Site ID	Alias	Drilling Contractor	Drilling Method	Geologic Sampling	Drilling Mud	Install Date	Latitude	Longitude	State Planar Easting 1983 NAD (ft)	Northing 1983 NAD (ft)	Well Casing	Slug Test Results (ft/day)	Ground Surface Elevation - feet (1)	Measuring Point at TOC - feet (1)	Depth of Well - feet	Screen Length - feet	Screen Slot Size (inch)	Sand Pack at Screen Interval	Elevation at Top of Well Screen - feet (1)	Elevation at Bottom of Well Screen - feet (1)	Centralizer Used	Owner/ Project Source of Well
SLHRG1	Harbour Ridge60'/HR-A	GFA	Mud Rotary	Continuous	Bentonite	10/30/00	803052.03	272323.16	881382.499	1055005.930	2-in PVC	4	13.63	13.42	59.04	2.00	0.01	yes	-43.62	-45.62	Yes	Gefvert/Krupa
SLHRG2	Harbour Ridge30'/HR-B	GFA	HSA	None	n/a	10/30/00	803052.03	272323.16	881382.499	1049995.930	2-in PVC	35	13.63	13.61	29.79	2.00	0.01	yes	-14.18	-16.18	No	Gefvert/Krupa
SLHRSW	Harbour Ridge SW/HR-SW	n/a	n/a	n/a	n/a				881376.566	1055002.927	n/a		-7.11	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Gefvert/Krupa
SLHRZ1	near shore, deep	Belanger	jetting	n/a	n/a				881342.241	1054700.697	3/4-in PVC		-1.65	1.73	16.49	1.00	0.01	n/a	-12.76	-14.76	n/a	Belanger
SLHRZ2	near shore, shallow	Belanger	jetting	n/a	n/a				881342.241	1054700.697	3/4-in PVC		-1.65	1.73	9.9	1.00	0.01	n/a	-6.17	-8.17	n/a	Belanger
SLHRZ3	far shore, deep	Belanger	jetting	n/a	n/a				881377.703	1055003.976	3/4-in PVC		-7.11	4.97	25.78	1.00	0.01	n/a	-18.81	-20.81	n/a	Belanger
SLHRZ4	far shore, shallow	Belanger	jetting	n/a	n/a				881377.703	1055003.976	3/4-in PVC		-7.11	4.96	16.23	1.00	0.01	n/a	-9.27	-11.27	n/a	Belanger
SLPDG1	Pendarvis Park 100'/PCP-A	GFA	Mud Rotary	Continuous	Bentonite	11/02/00	802702.58	271875.37	893392.060	1038042.305	2-in PVC	32		4.40	100.63	2.00	0.01	yes	-94.23	-96.23	Yes	Gefvert/Krupa
SLPDG2	Pendarvis Perk 60'PCP-B	GFA	HSA	None	n/a	11/06/00	802702.58	271875.37	893393.658	1038037.793	2-in PVC	10		4.41	59.48	2.00	0.01	yes	-53.08		No	Gefvert/Krupa
SLPDG3	Pendarvis Park 30'/PCP-C	GFA	HSA	None	n/a	11/03/00	802702.58	271875.37	893395.280	1038033.148	2-in PVC	158		4.39	29.63	2.00	0.01	yes	-23.24	-25.24	No	Gefvert/Krupa
SLPDSW	Pendarvis Park SW/PCP-SW	n/a	n/a	n/a	n/a				893479.628	1038084.399	n/a		-0.63	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Gefvert/Krupa
SLPDZ1	near shore, deep	Belanger	jetting	n/a	n/a				893454.419	1038067.138	3/4-in PVC		0.17	3.41	19.96	1.00	0.01	n/a	-14.55	-16.55	n/a	Belanger
SLPDZ2	near shore, shallow	Belanger	jetting	n/a	n/a				893454.419	1038067.138	3/4-in PVC		0.17	3.39	9.9	1.00	0.01	n/a	-4.51	-6.51	n/a	Belanger
SLPDZ3	far shore, deep	Belanger	jetting	n/a	n/a				893508.305	1038096.783	3/4-in PVC		-1.63	3.02	19.74	1.00	0.01	n/a	-14.72	-16.72	n/a	Belanger
SLPDZ4	far shore, shallow	Belanger	jetting	n/a	n/a				893508.305	1038096.783	3/4-in PVC		-1.63	2.9	5.3	1.00	0.01	n/a	-0.40	-2.40	n/a	Belanger
SLAMG1	Macmillan 60'/AM-A	GFA	Mud Rotary	Continuous	Bentonite	07/13/01			911471.844	1043693.803	2-in PVC	4	8.95	8.45	60.21	2.00	0.01	yes	-49.76	-51.76	Yes	Gefvert/Krupa
SLAMG2	MacMillan 30'/AM-B	GFA	HSA	None	n/a	07/13/01			911472.239	1043695.565	2-in PVC	122	8.95	8.25	?	2.00	0.01	yes	10.25	8.25	No	Gefvert/Krupa
SLLTSW	Lutz SW	n/a	n/a	n/a	n/a	09/19/01			911676.204	1043521.826	n/a		-4.15	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Gefvert/Krupa
SLLTZ1	near shore, deep	Belanger	jetting	n/a	n/a				911512.305	1043449.430	3/4-in PVC		-0.75	4.69	19.9	1.00	0.01	n/a	-13.21	-15.21	n/a	Belanger
SLLTZ2	near shore, shallow	Belanger	jetting	n/a	n/a				911512.305	1043449.430	3/4-in PVC		-0.75	4.89	9.99	1.00	0.01	n/a	-3.10	-5.10	n/a	Belanger
SLLTZ3	far shore, deep	Belanger	jetting	n/a	n/a				911676.188	1043519.148	3/4-in PVC		-4.15	4.38	23.31	1.00	0.01	n/a	-16.93	-18.93	n/a	Belanger
SLLTZ4	far shore, shallow	Belanger	jetting	n/a	n/a				911676.188	1043519.148	3/4-in PVC		-4.15	4.36	13.86	1.00	0.01	n/a	-7.50	-9.50	n/a	Belanger
IRMNG1	Minton 60'/MI-A	GFA	Mud Rotary	Continuous	Bentonite	07/19/01			878950.141	1122632.125	2-in PVC	9	20.84	20.61	58.35	2.00	0.01	yes	-35.74	-37.74	Yes	Gefvert/Krupa
IRMNG2	Minton 30'/MI-B	GFA	HSA	None	n/a	07/19/01			878953.272	1122623.825	2-in PVC	258	20.84	20.46	29.31	2.00	0.01	yes	-6.85	-8.85	No	Gefvert/Krupa
IRMNSW	Minton SW/MI-SW	n/a	n/a	n/a	n/a				879118.060	1122699.392	n/a		-1.36	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Gefvert/Krupa
IRMNZ1	near shore, deep	Belanger	jetting	n/a	n/a				879029.200	1122670.780	3/4-in PVC		0.24	9.95	19.88	0.5	0.01	n/a	-7.93	-9.93	n/a	Belanger
IRMNZ2	near shore, shallow	Belanger	jetting	n/a	n/a				879029.200	1122670.780	3/4-in PVC		0.24	9.95	9.85	0.5	0.01	n/a	2.10	0.10	n/a	Belanger
IRMNZ3	far shore, deep	Belanger	jetting	n/a	n/a				879525.302	1122840.217	3/4-in PVC		-2.56	4.44	19.59	0.5	0.01	n/a	-13.15	-15.15	n/a	Belanger
IRMNZ4	far shore, shallow	Belanger	jetting	n/a	n/a				879525.302	1122840.217	3/4-in PVC		-2.56	4.42	9.01	0.5	0.01	n/a	-2.59	-4.59	n/a	Belanger
IRMNS1	Inside small (close) meter					08/14/02			879525.302	1122840.217			-2.56	n/a	n/a	n/a	n/a	n/a	n/a	n/a		
IRMNS2	Inside baby (far) meter					08/14/02			879906.204	1122982.120			-6.6	n/a	n/a	n/a	n/a	n/a	n/a	n/a		
IRMNS3	SW at far east end of dock													n/a	n/a	n/a	n/a	n/a	n/a	n/a		
IRLMG1	Lake Manor 100'/LM-A	GFA	Mud Rotary	Continuous	Bentonite	07/25/01			904532.293	1066442.421	2-in PVC	363	7.25	7.01	98.42	2.00	0.01	yes	-89.41	-91.41	Yes	Gefvert/Krupa
IRLMG2	Lake Manor 60'/LM-B	GFA	HSA	None	n/a	07/25/01			904538.130	1066435.491	2-in PVC	21	7.55	7.30	56.70	2.00	0.01	yes	-47.40	-49.40	No	Gefvert/Krupa
IRLMG3	Lake Manor 30'/LM-C	GFA	HSA	None	n/a	07/25/01			904544.062	1066426.427	2-in PVC	134	7.35	7.09	29.47	2.00	0.01	yes	-20.38	-22.38	No	Gefvert/Krupa
IRLMSW	LM-SW	n/a	n/a	n/a	n/a				904691.6216	1066510.150	n/a		-1.35	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Gefvert/Krupa
IRLMZ1	near shore, deep	Belanger	jetting	n/a	n/a				904582.7435	1066435.818	3/4-in PVC		0.25	4.23	15.06	1.00	0.01	n/a	-8.83	-10.83	n/a	Belanger
IRLMZ2	near shore, shallow	Belanger	jetting	n/a	n/a				904582.7435	1066435.818	3/4-in PVC		0.25	4.28	5.03	1.00	0.01	n/a	1.25	-0.75	n/a	Belanger
IRLMZ3	far shore, deep	Belanger	jetting	n/a	n/a				904688.2936	1066511.621	3/4-in PVC		-1.35	4.3	14.94	1.00	0.01	n/a	-8.64	-10.64	n/a	Belanger
IRLMZ4	far shore, shallow	Belanger	jetting	n/a	n/a				904688.2936	1066511.621	3/4-in PVC		-1.35	4.23	9.99	1.00	0.01	n/a	-3.76	-5.76	n/a	Belanger
SLCMG1	Club Med 100'/CM-A	GFA	Mud Rotary	Continuous	Bentonite	08/22/01			880460.450	1058052.579	2-in PVC	5	4.97	4.56	100.17	2.00	0.01	yes	-93.62	-95.62	Yes	Gefvert/Krupa
SLCMG2	Club Med 60'/CM-B	GFA	HSA	None	n/a	08/23/01			880457.423	1058048.744	2-in PVC	6	4.97	4.63	57.28	2.00	0.01	yes	-50.65	-52.65	No	Gefvert/Krupa
SLCMG3	Club Med 30'/CM-C	GFA	HSA	None	n/a	08/23/01			880454.708	1058044.873	2-in PVC	52	4.97	4.66	31.67	2.00	0.01	yes	-25.01	-27.01	No	Gefvert/Krupa
SLCMSW	Club Med SW/CM-SW	n/a	n/a	n/a	n/a				880566.888	1057851.010	n/a		-1.42	6.37	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Gefvert/Krupa
SLCMZ1	near shore, deep	Belanger	jetting	n/a	n/a				880526.207	1058024.678	3/4-in PVC		-0.58	2.36	17.77	1.00	0.01	n/a			n/a	Belanger
SLCMZ2	near shore, shallow	Belanger	jetting	n/a	n/a				880526.207	1058024.678	3/4-in PVC		-0.58	2.3	7.62	1.00	0.01	n/a			n/a	Belanger
SLCMZ3	far shore, deep	Belanger	jetting	n/a	n/a				880567.762	1057850.892	3/4-in PVC		-1.42	5.33	20.5	1.00	0.01	n/a			n/a	Belanger
SLCMZ4	far shore, shallow	Belanger	jetting	n/a	n/a				880567.424	1057850.878	3/4-in PVC		-1.42	4.34	10.9	1.00	0.01	n/a			n/a	Belanger

(1) Elevations are 1929 NGVD

Piezometers: 1 is near shore, deep
2 is near shore, shallow
3 is far shore, deep
4 is far shore, shallow

Data did **not** come from surveying

Missing data - requested from surveying

Well Development Table For St. Lucie Estuary/Indian River Lagoon Monitor Wells

Site ID	Alias	Drilling Method	Drilling Mud	Installation Date	Well Construction Material	Depth of Well - feet	Comments -well development	Pumping rate gpm	Spec Cond uS/cm	pH
SLHRG1	**Harbour Ridge60'/HR-A**	Mud Rotary	Bentonite	10/30/00	2 Inch PVC	59.04	centrifugal pump	~ 0.2	498	7.29
SLHRG2	**Harbour Ridge30'/HR-B**	HSA	n/a	10/30/00	2 Inch PVC	29.79	centrifugal pump; DO 1.14 mg/L	~ 4.2	367	4.61
SLHRSW	**Harbour Ridge SW/HR-SW**	n/a	n/a		n/a	n/a				
SLPDG1	**Pendarvis Park 100'/PCP-A**	Mud Rotary	Bentonite	11/02/00	2 Inch PVC	100.63	Minimal w/BK; w/centrifugal; drawdown ~ 20'; iron smell	0.36	575	7.34
SLPDG2	**Pendarvis Perk 60'PCP-B**	HSA	n/a	11/06/00	2 Inch PVC	59.48				
SLPDG3	**Pendarvis Park 30'/PCP-C**	HSA	n/a	11/03/00	2 Inch PVC	29.63				
SLRPDSW	**Pendarvis Park SW/PCP-SW**	n/a	n/a		n/a	n/a				
SLAMG1	**Macmillan 60'/AM-A**	Mud Rotary	Bentonite	07/13/01	2 Inch PVC	60.21	submersible & Moyno; surged to remove fines; clear & salty	~ 0.2	45270	7.36
SLAMG2	**MacMillan 30'/AM-B**	HSA	n/a	07/13/01	2 Inch PVC	?	centrifugal; water clear and salty; DO 0.28	~ 11	42010	7.23
SLLTSW	**Lutz SW**	n/a	n/a	09/19/01	n/a	n/a				
IRMNG1	**Minton 60'/MI-A**	Mud Rotary	Bentonite	07/19/01	2 Inch PVC	58.35	submersible; surged to clean out fines; DO 0.57 mg/L	~ 0.5	573	7.56
IRMNG2	**Minton 30'/MI-B**	HSA	n/a	07/19/01	2 Inch PVC	29.31	centrifugal; water had light yellow tint; DO 0.23 mg/L	10	300	6.70
IRMNSW	**Minton SW/MI-SW**	n/a	n/a		n/a	n/a				
IRLMG1	**Lake Manor 100'/LM-A**	Mud Rotary	Bentonite	07/25/01	2 Inch PVC	98.42	BK pump	< 1	692	7.02
IRLMG2	**Lake Manor 60'/LM-B**	HSA	n/a	07/25/01	2 Inch PVC	56.70	centrifugal pump	~ 1.2	624	7.18
IRLMG3	**Lake Manor 30'/LM-C**	HSA	n/a	07/25/01	2 Inch PVC	29.47	centrifugal pump	> 5	441	7.42
IRLMSW	**LM-SW**	n/a	n/a		n/a	n/a				
SLCMG1	**Club Med 100'/CM-A**	Mud Rotary	Bentonite	08/22/01	2 Inch PVC	100.17	centrifugal pump; DO 1.01 mg/L	3.75	633	7.04
SLCMG2	**Club Med 60'/CM-B**	HSA	n/a	08/23/01	2 Inch PVC	57.28	centrifugal; surged well - still fines	~ 0.2	636	7.01
SLCMG3	**Club Med 30'/CM-C**	HSA	n/a	08/23/01	2 Inch PVC	31.67	centrifugal; DO 0.66 mg/L	~3.3	594	6.87
SLCMSW	**Club Med SW/CM-SW**	n/a	n/a		n/a	n/a				

(1) Elevations are 1929 NGVD

Benchmark Data - SLR/IRL Project

Site Location	Bench Mark Elevation - feet (1)	Disk Number	Date of Survey	Location of Benchmark Disk
Harbour Ridge - wells	13.535		01/31/01	disk is on ground, on the parking lot (south) side of the west well pad
Pendarvis Park	3.735		01/23/01	on concrete slab of the public restrooms; across from the drinking fountain
MacMillan	8.82			
Lutz	6.83			
Minton	21.13		08/08/01	on concrete well pad
Lake Manor	5.84		06/11/01	on step to dock
Club Med - wells	5.15		09/17/01	on middle well pad

(1) Elevations are 1929 NGVD

Appendix B

Water Level Data, By Site.

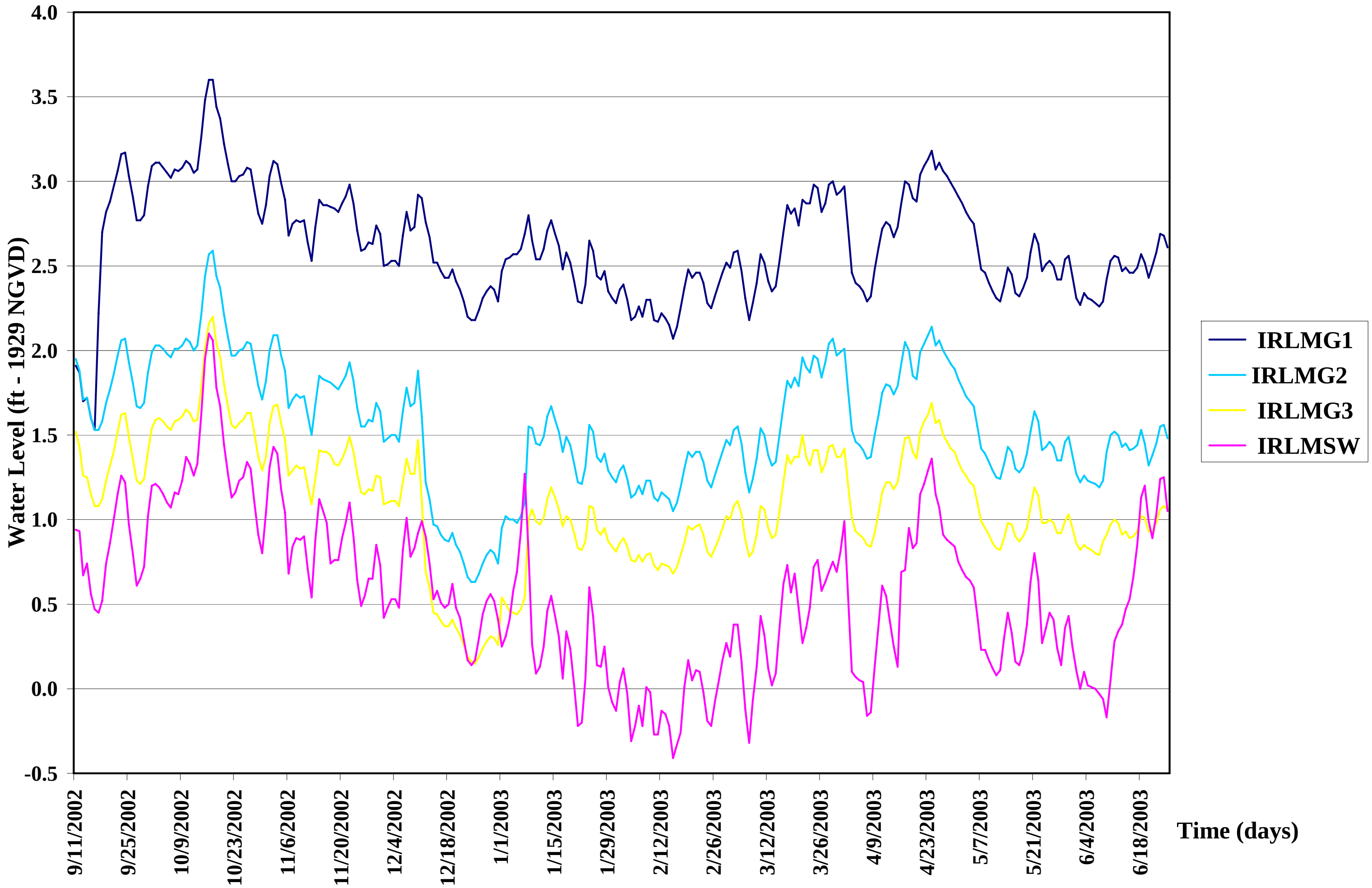


Figure B1. Lake Manor Water Level Data

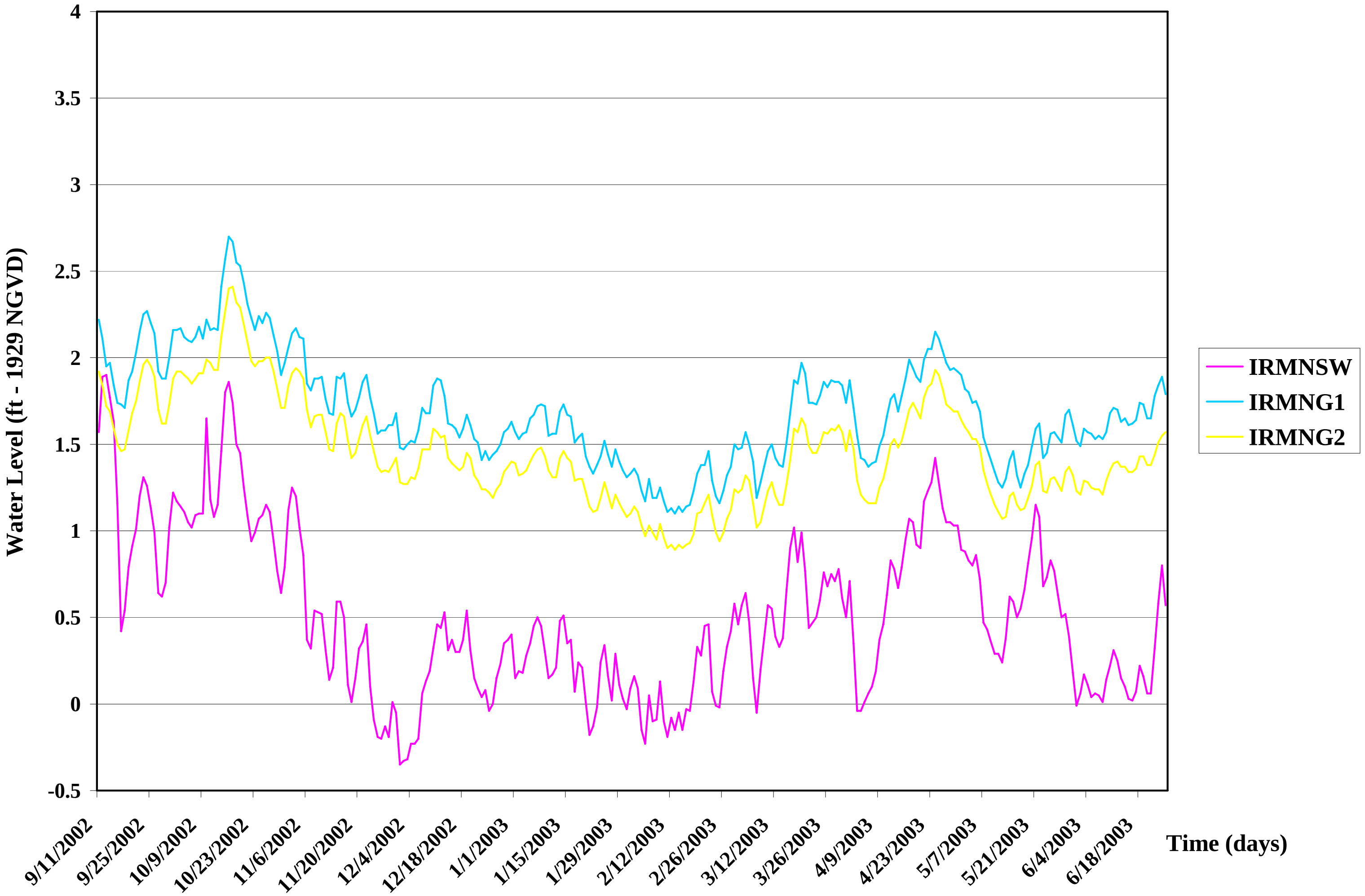


Figure B2. Minton Site Water Level Data

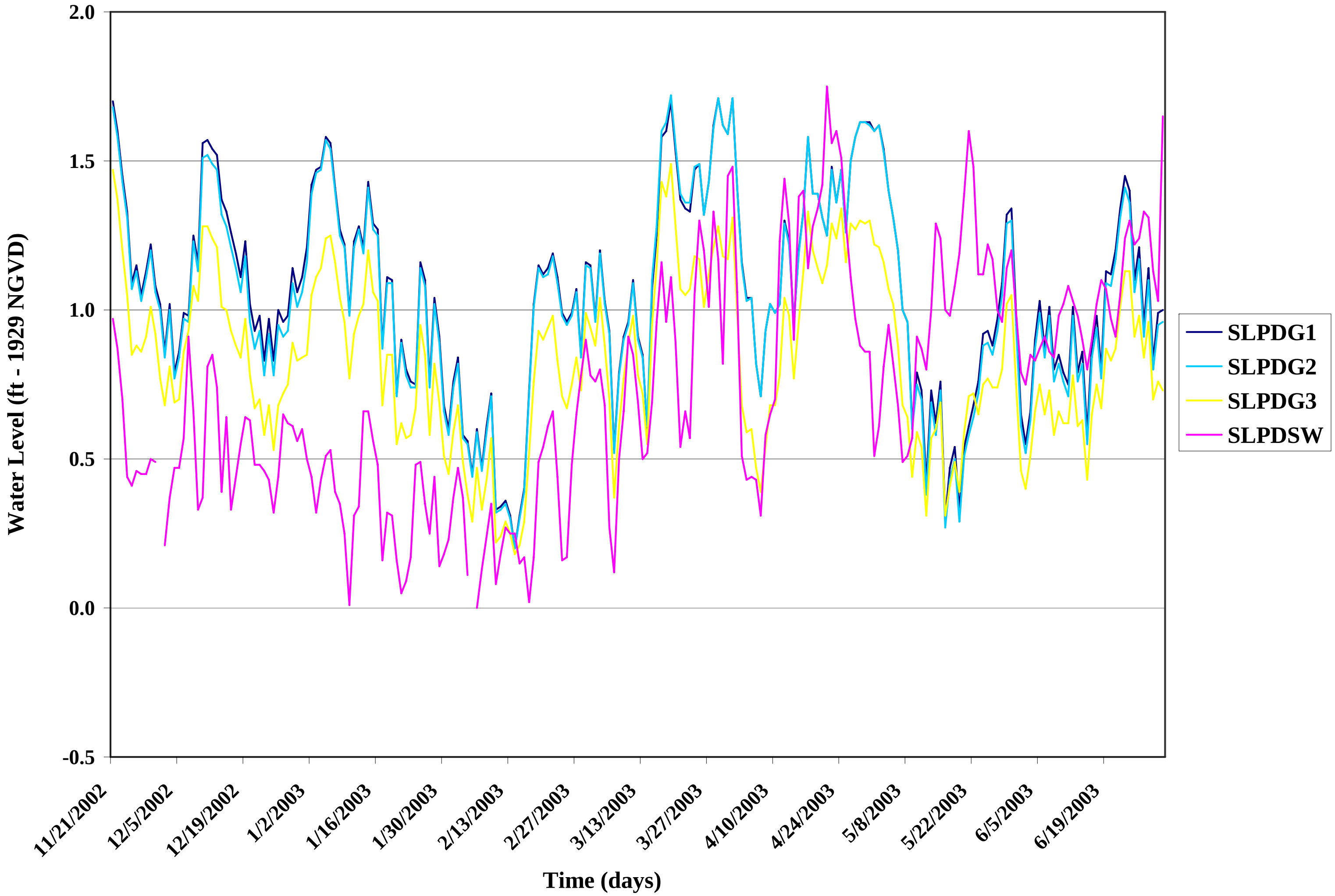


Figure B3. Pendarvis Cove Park Site Water Level Data

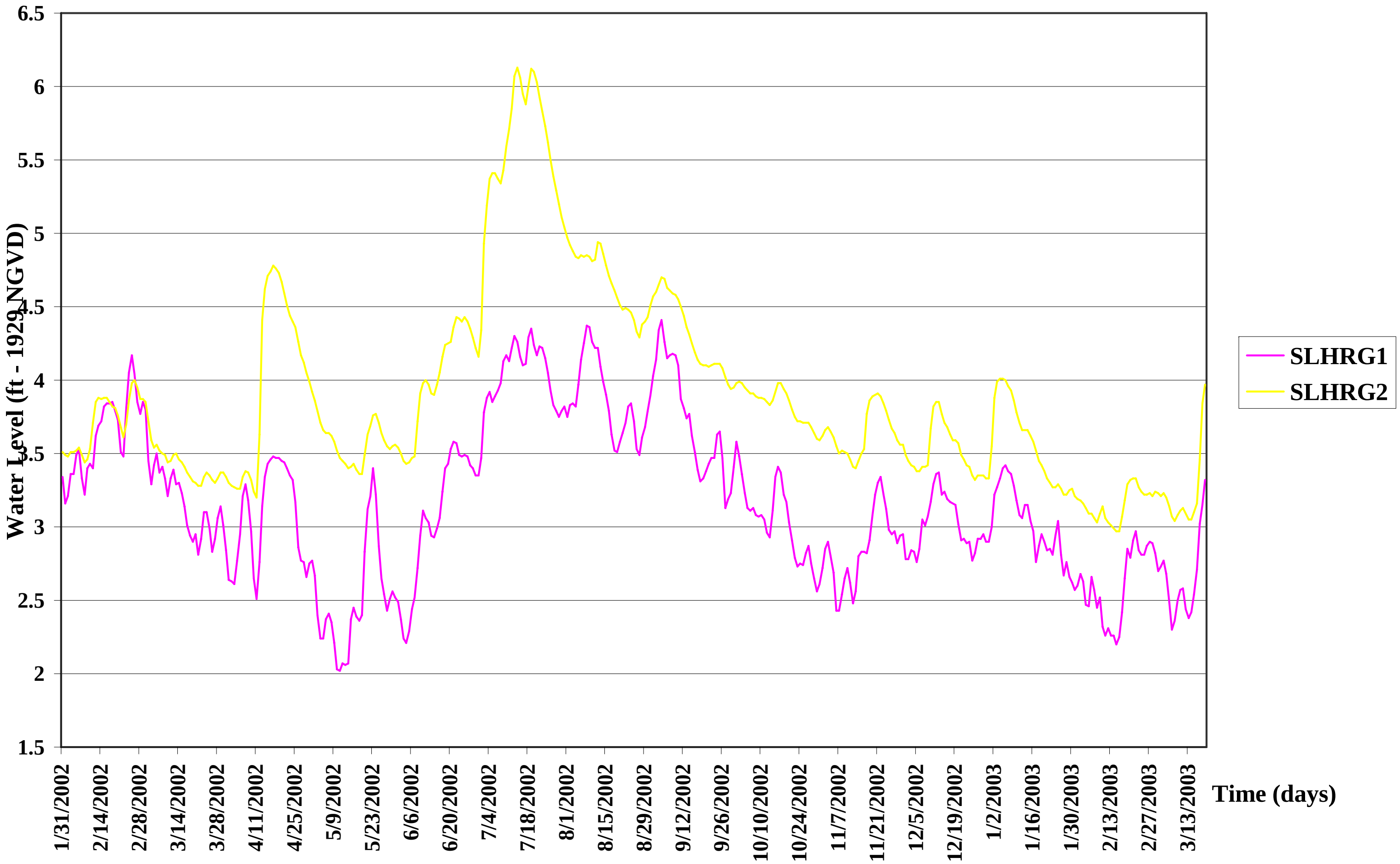


Figure B4. Harbour Ridge Water Level Data

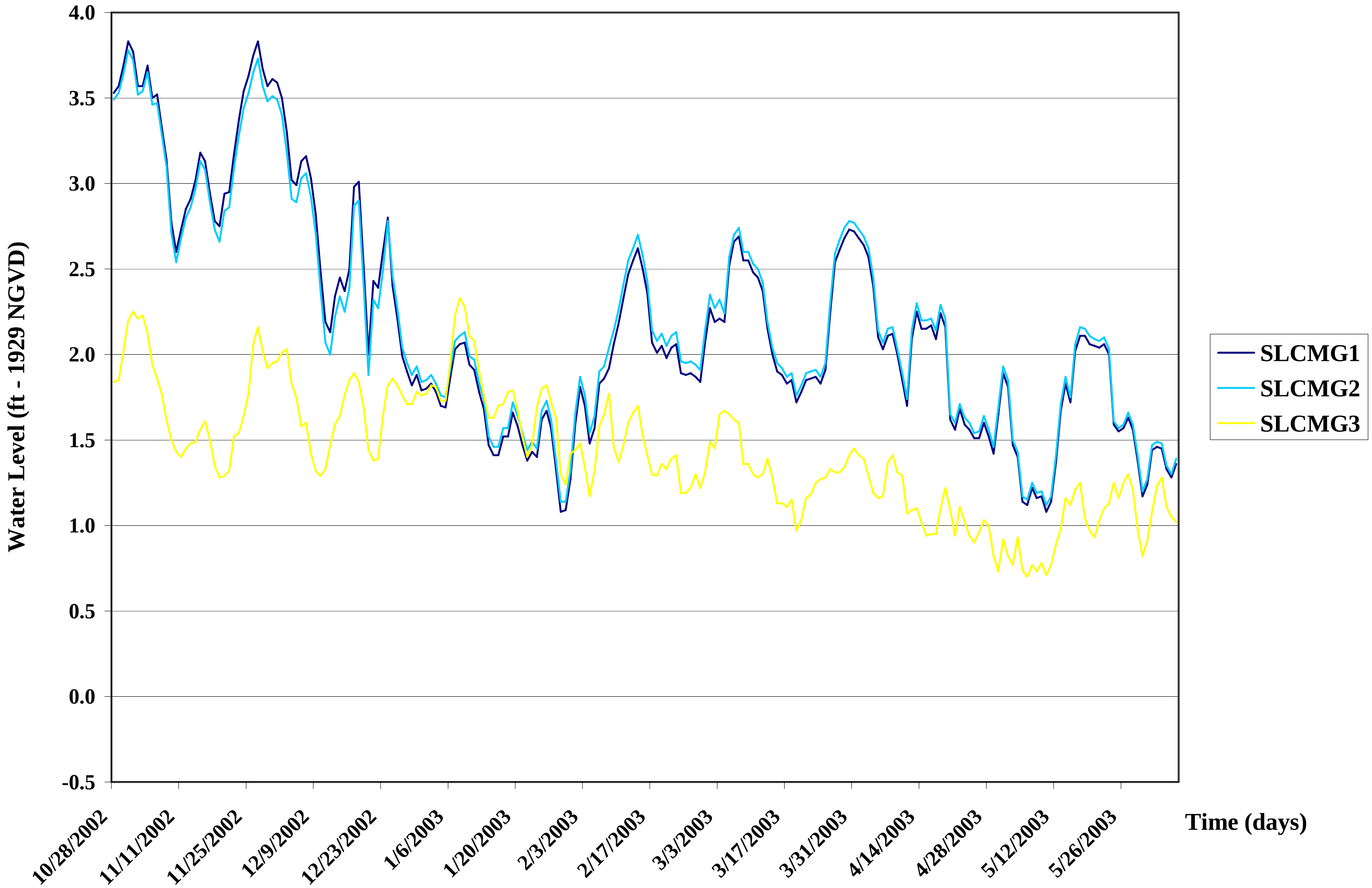


Figure B5. Club Med Site Water Level Data

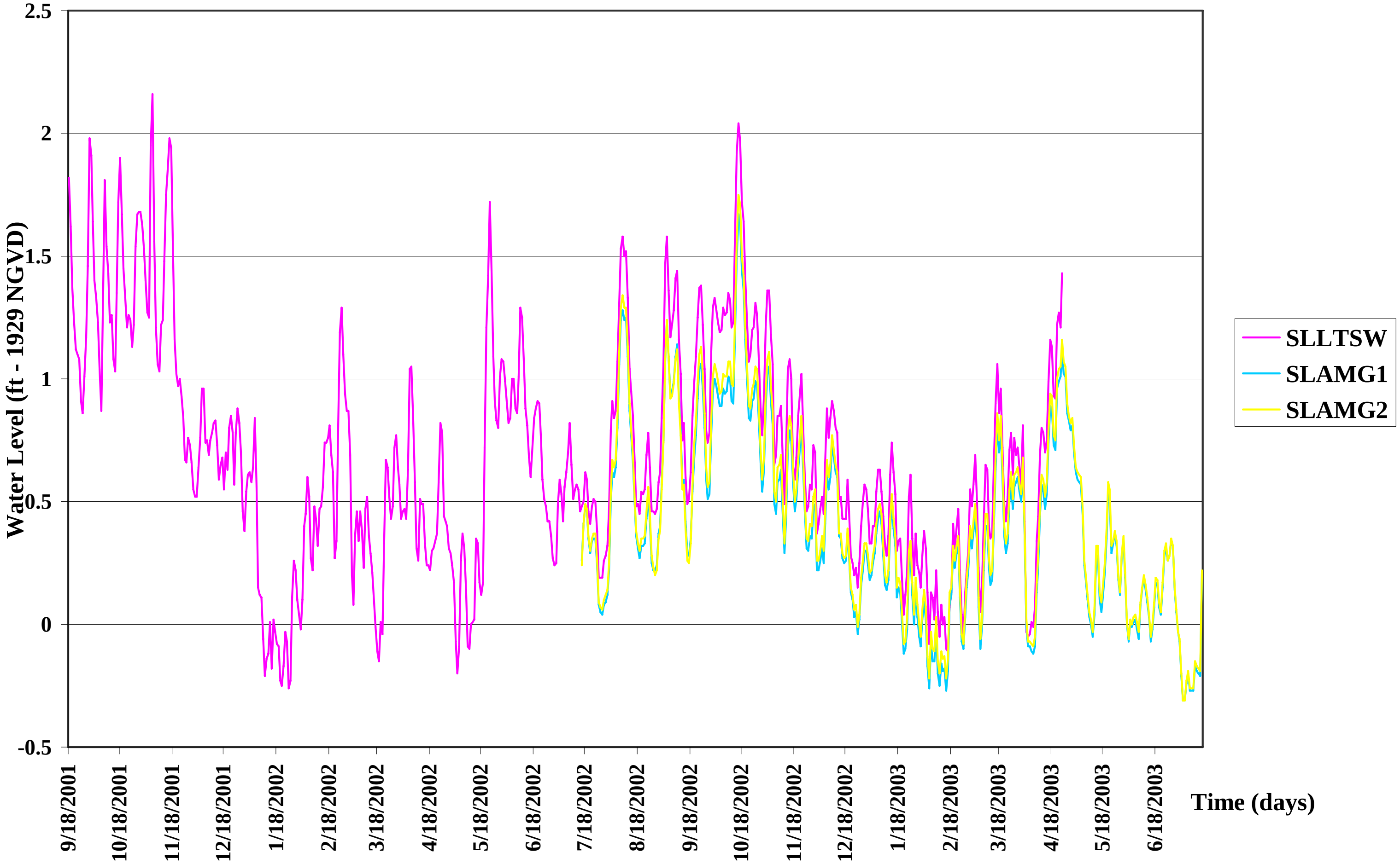
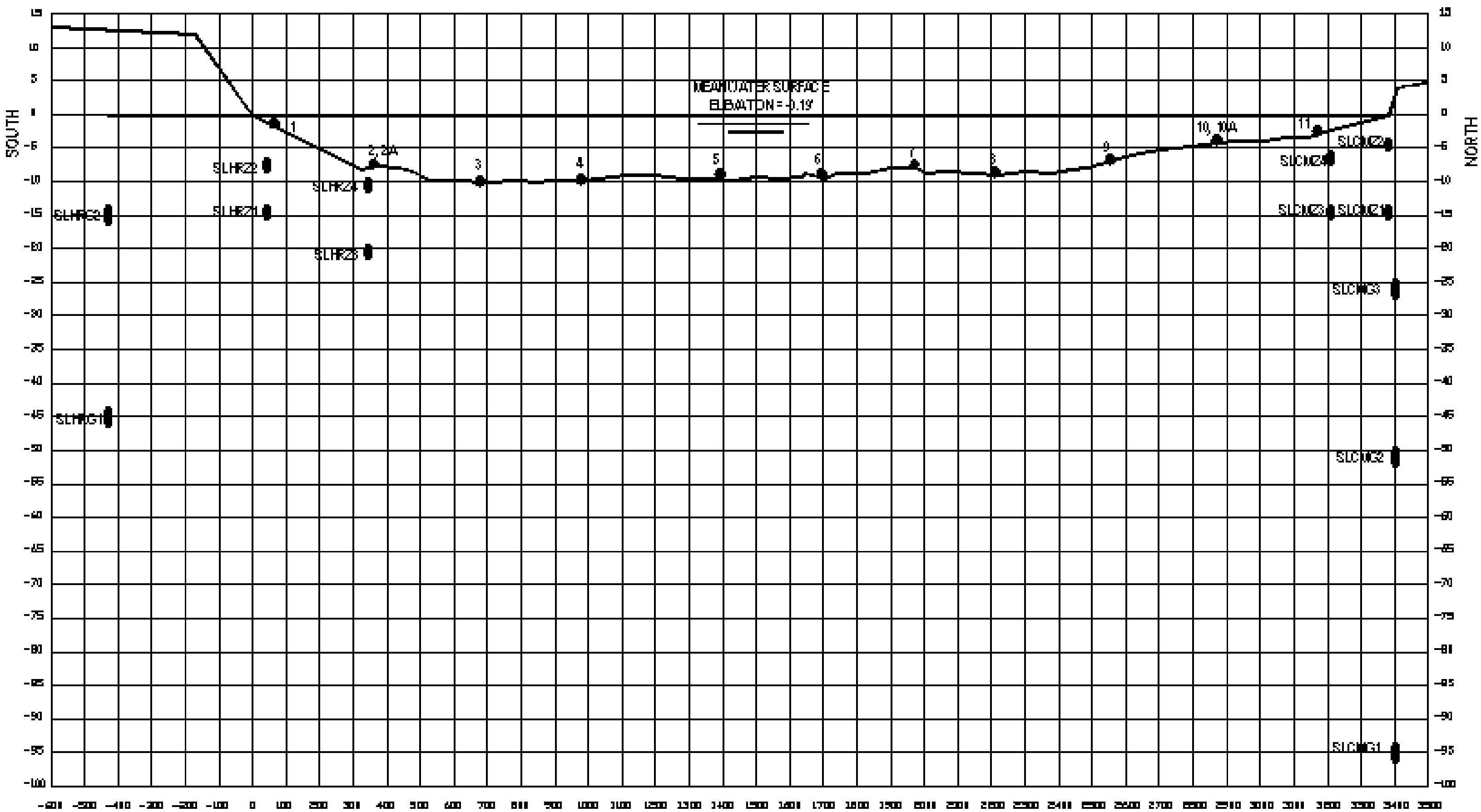


Figure B6. Lutz/McMillan Site Water Level Data

Appendix C

AutoCad Scaled Site Plan View

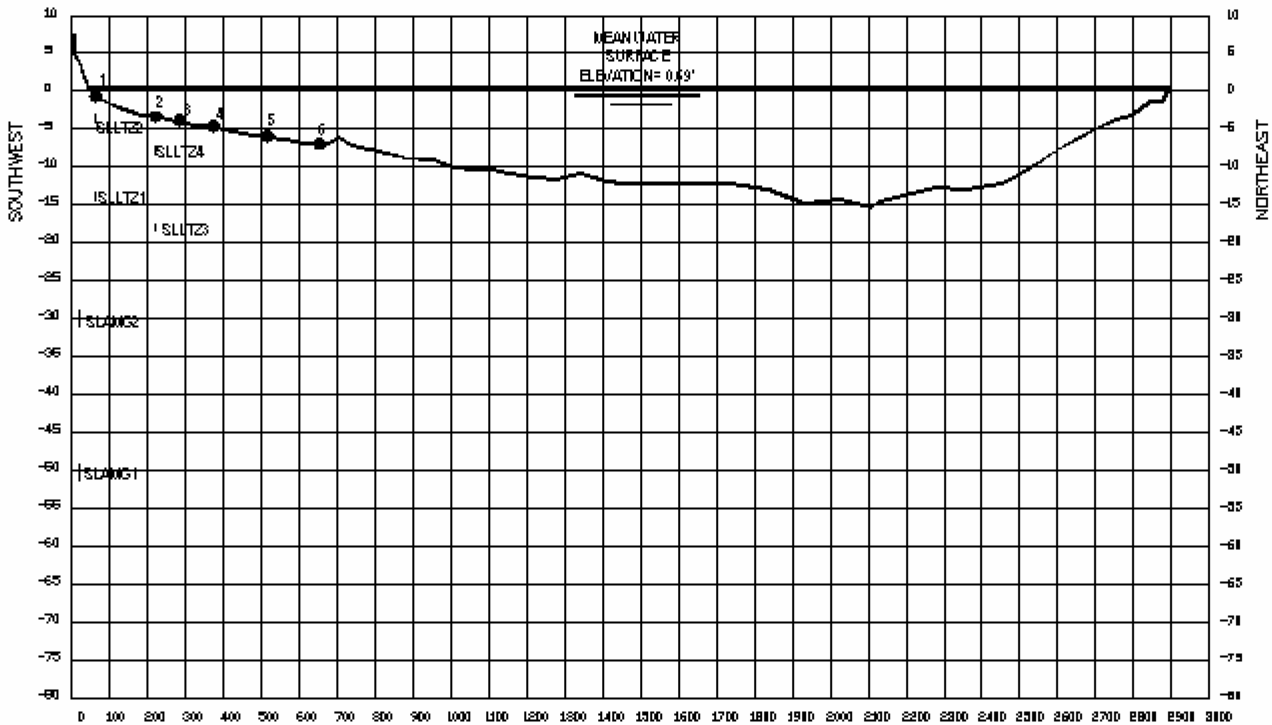
And Cross-Section Maps



Distance in Feet (1983 NAD)
Elevation in Feet (1929 NGVD)

CROSS SECTION
HARBOUR RIDGE/ CLUB MED

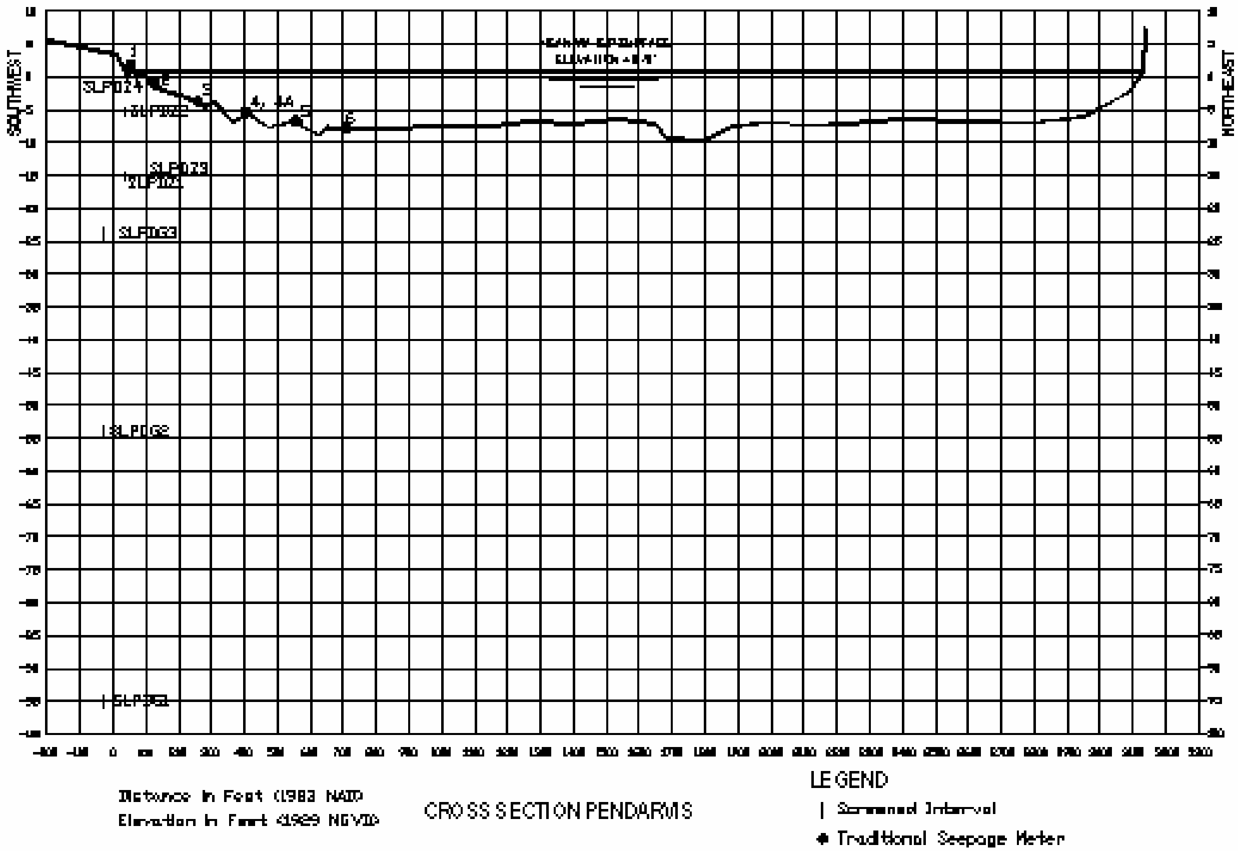
LEGEND
Screened Interval
Traditional Seepage Meter

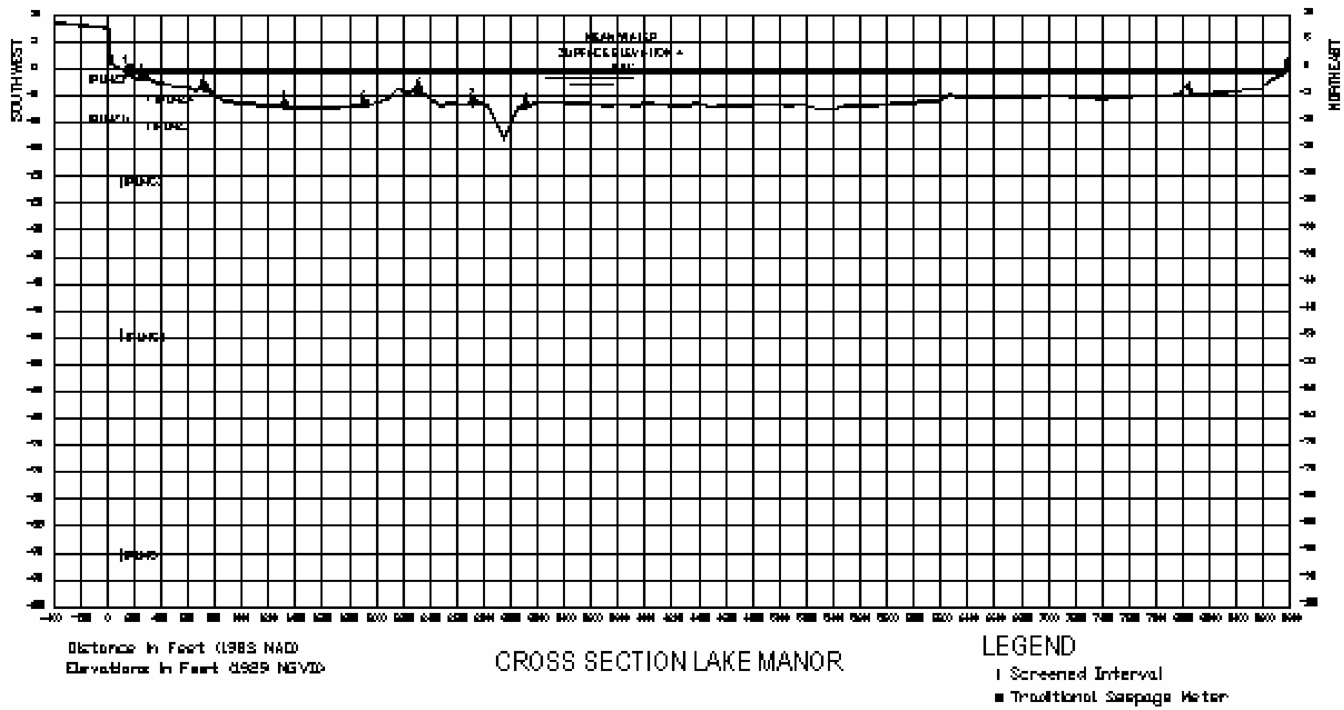


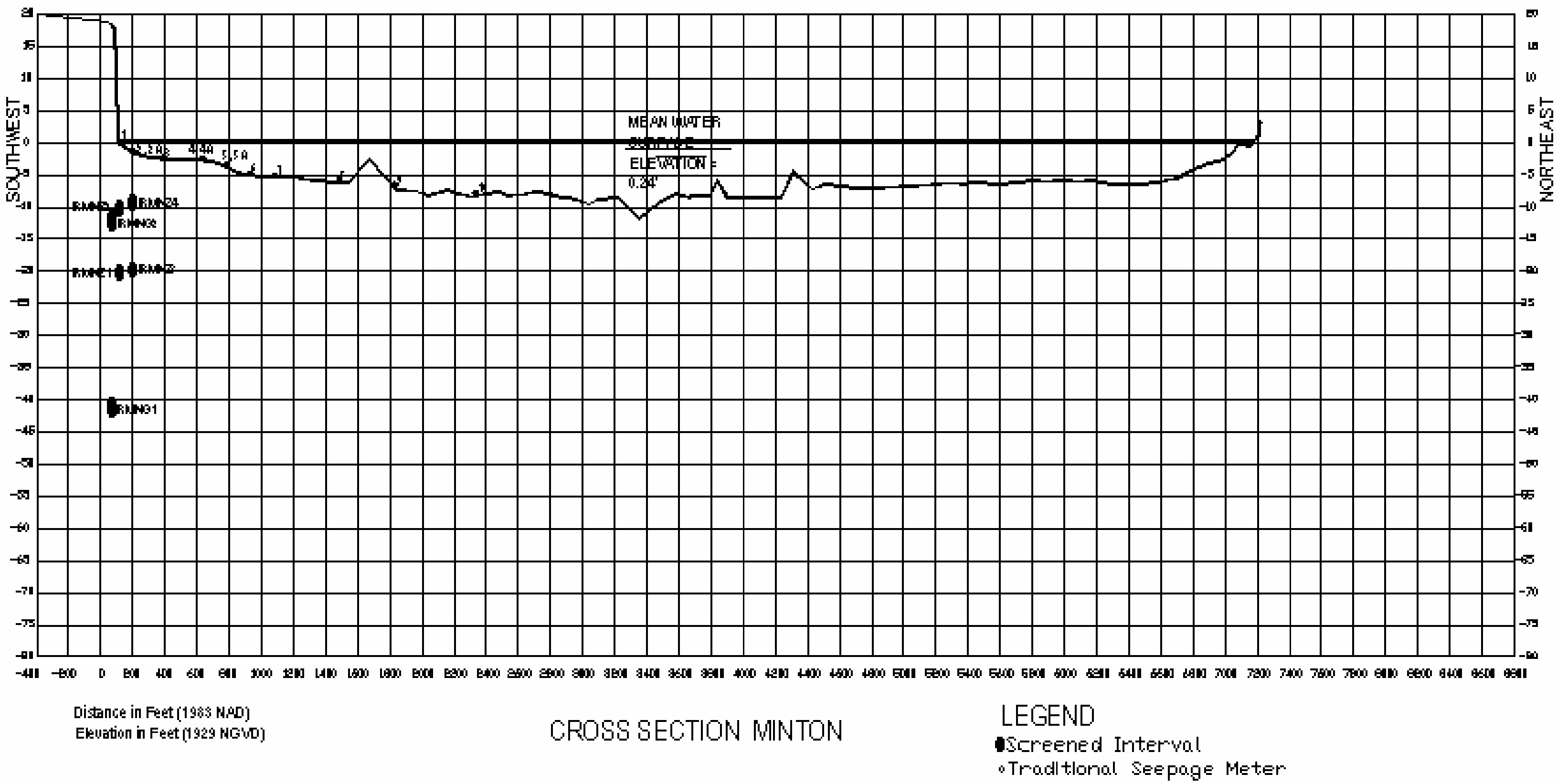
Distance In Feet (1983 NAD)
Elevation In Feet (1929 NGVD)

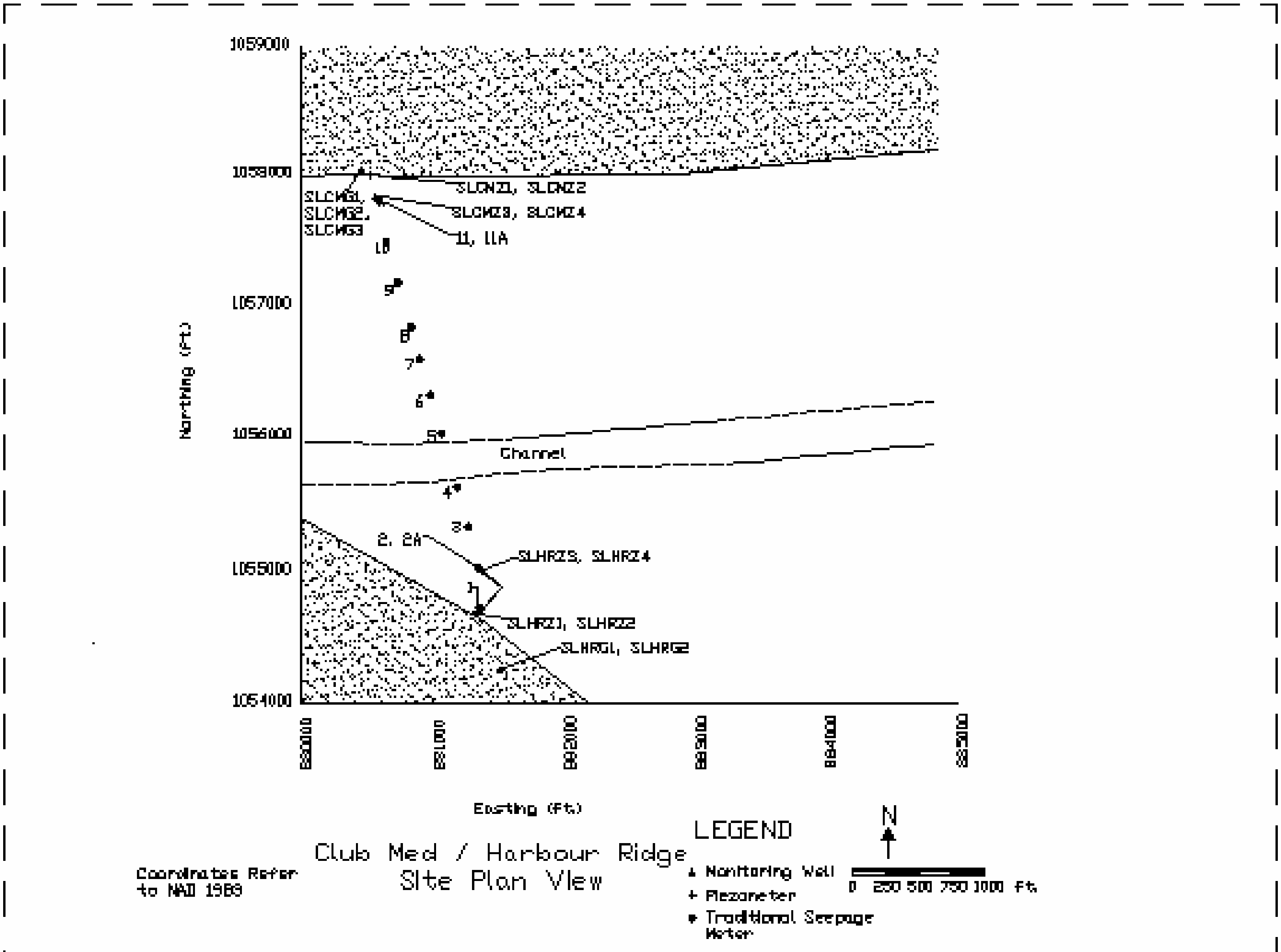
CROSS SECTION LUTZ

LEGEND
| Screened Interval
● Traditional Seepage Meter

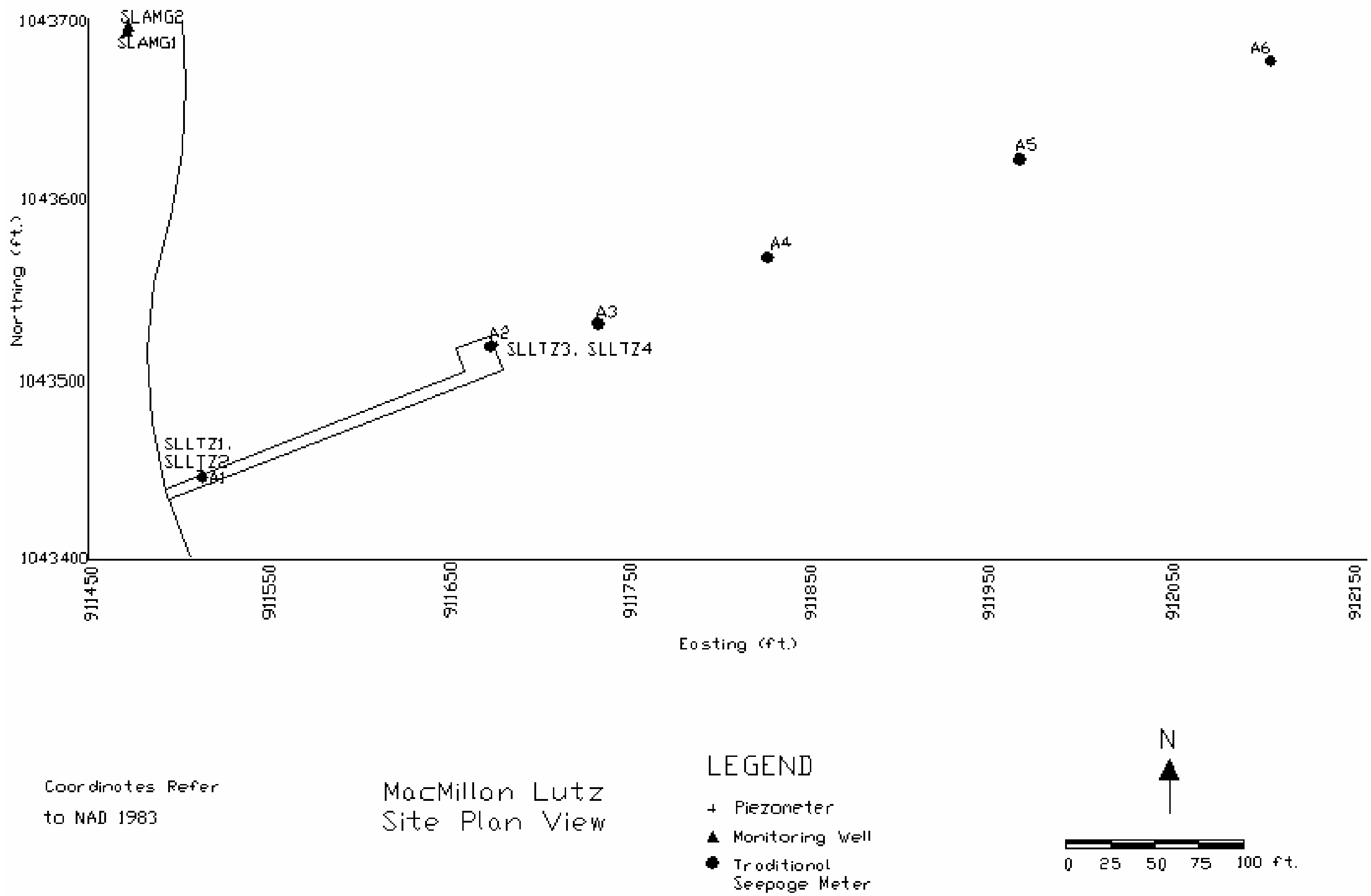

SOUTHWEST
NORTHEAST
SLPD24
SLPD23
SLPD33
SLPD32
4, 4A
Distance in Feet (1983 NAD)
Elevation in Feet (1929 NGVD)
CROSS SECTION PENDARVIS
LEGEND
Screened Interval
Traditional Seepage Meter

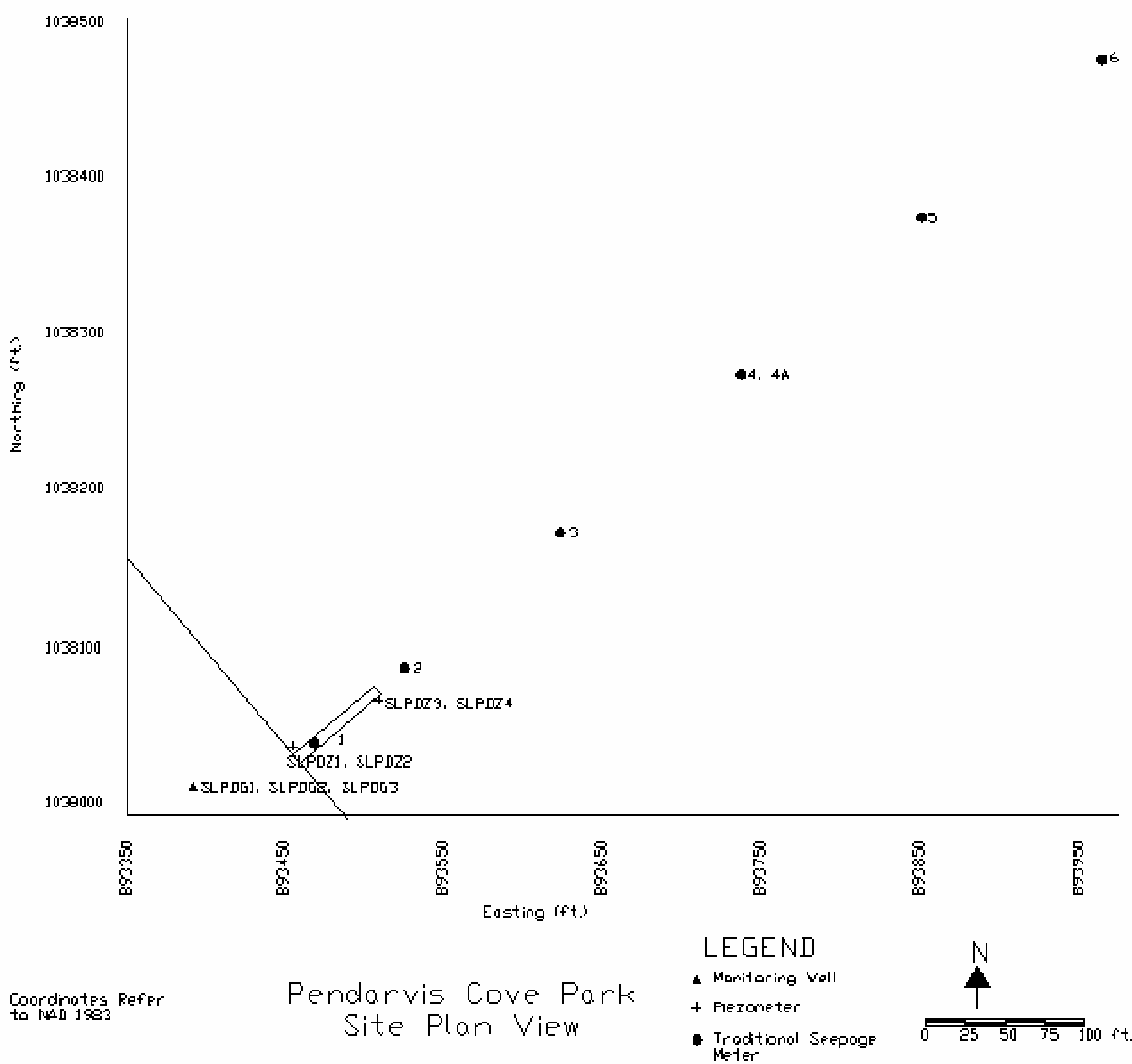

SOUTHWEST
NORTHEAST
Distance in Feet (1983 NAD)
Elevations in Feet (1929 NGVD)
CROSS SECTION LAKE MANOR
LEGEND
Screened Interval
Traditional Seepage Meter


SOUTHWEST
NORTHEAST
MEAN WATER SURFACE ELEVATION = 0.24'
Distance in Feet (1983 NAD)
Elevation in Feet (1929 NGVD)
CROSS SECTION MINTON
LEGEND
Screened Interval
Traditional Seepage Meter

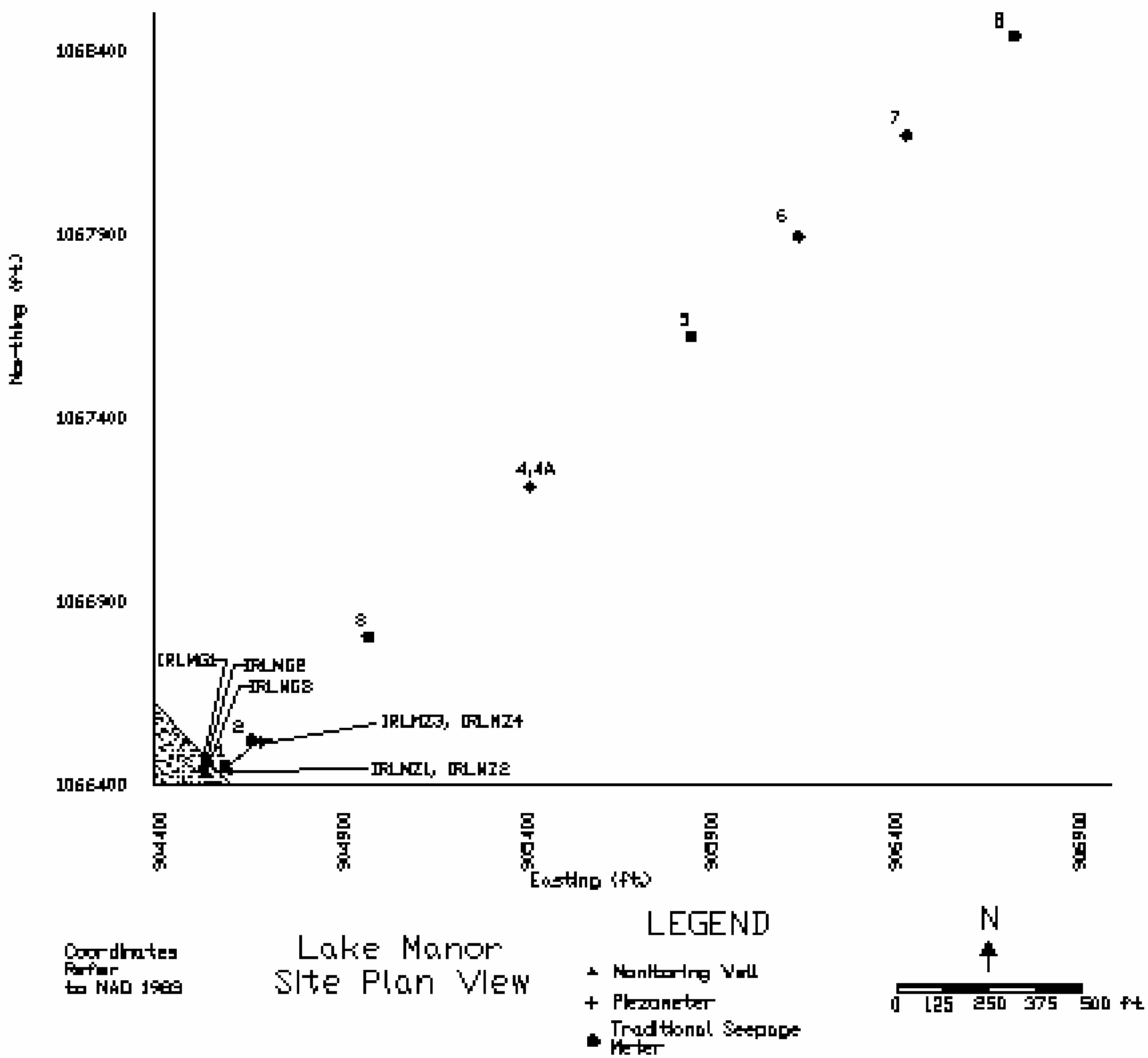


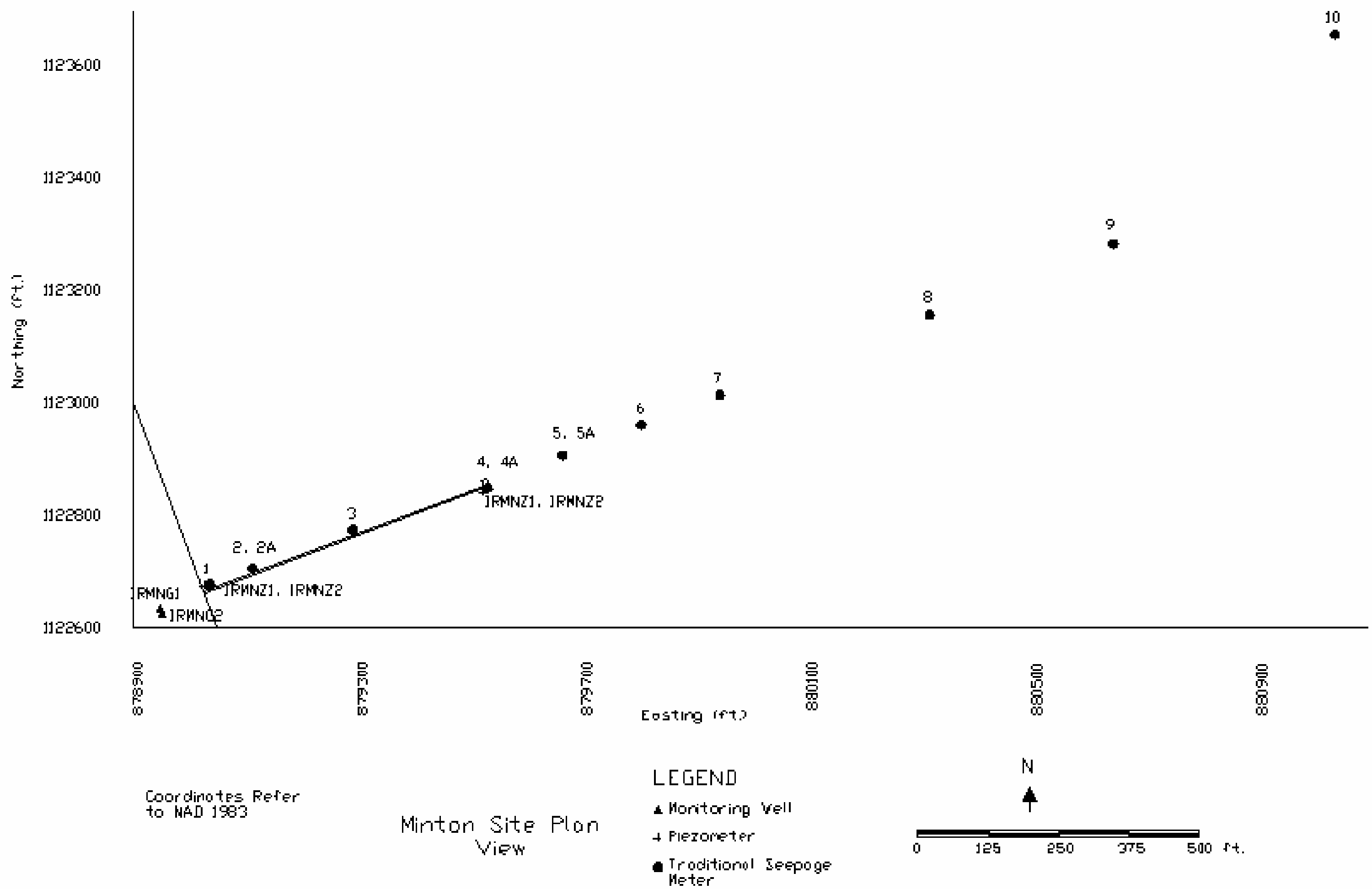
1059000
1058000
1057000
1056000
1055000
1054000
Northing (Ft)
SLCMZ1, SLCMZ2
SLCMG1,
SLCMG2,
SLCMG3
SLCMZ3, SLCMZ4
11, 11A
10
9
8
7
6
5
Channel
4
3
2, 2A
SLHRZ3, SLHRZ4
1
SLHRZ1, SLHRZ2
SLHRG1, SLHRG2
880000
881000
882000
883000
884000
885000
Easting (Ft)
Club Med / Harbour Ridge
Site Plan View
Coordinates Refer
to NAD 1983
LEGEND
Monitoring Well
Piezometer
Traditional Seepage
Meter
N
0 250 500 750 1000 Ft.


SLAMG2
SLAMG1
A6
A5
A4
A3
A2
SLLTZ3, SLLTZ4
SLLTZ1,
SLLTZ2
A1
1043700
1043600
1043500
1043400
Northing (ft.)
911450
911550
911650
911750
911850
911950
912050
912150
Easting (ft.)
Coordinates Refer
to NAD 1983
MacMillan Lutz
Site Plan View
LEGEND
+ Piezometer
▲ Monitoring Well
● Traditional
Seepage Meter
N
0 25 50 75 100 ft.



1038500
1038400
1038300
1038200
1038100
1038000
Northing (ft.)
893350
893450
893550
893650
893750
893850
893950
Easting (ft.)
6
5
4, 4A
3
2
SLPDZ3, SLPDZ4
1
SLPDZ1, SLPDZ2
SLPDG1, SLPDG2, SLPDG3
LEGEND
Monitoring Well
Piezometer
Traditional Seepage Meter
N
0 25 50 75 100 ft.
Coordinates Refer to NAD 1983
Pendarvis Cove Park
Site Plan View


Lake Manor
Site Plan View
LEGEND
Monitoring Well
Piezometer
Traditional Seepage Meter
Coordinates Refer to NAD 1983
Northing (ft)
Easting (ft)
N
0 125 250 375 500 ft



Northing (ft.)
1123600
1123400
1123200
1123000
1122800
1122600
878900
879300
879700
880100
880500
880900
Easting (ft.)
1
2, 2A
3
4, 4A
5, 5A
6
7
8
9
10
IRMNZ1, IRMNZ2
IRMNZ1, IRMNZ2
IRMNG1
IRMNG2
Coordinates Refer
to NAD 1983
Minton Site Plan
View
LEGEND
Monitoring Well
Piezometer
Traditional Seepage
Meter
N
0
125
250
375
500 ft.

Appendix D.

Water Quality Data.

St. Lucie Estuary/Indian River Lagoon: March 2002 Water Quality

TKN = organic nitrogen

Station	Date	Temp	DO	Sp Cond	pH	Salinity	Cl	SO4	Alka	Na	Ca	K	Mg	Cation/anion	TDS	TSS	NOX	NH4	TKN	TDKN	OPO4	TPO4	TDPO4	Tot Fe	TD Fe	DOC	TOC	Tot Mn
		Deg C	mg/L	uS/cm		ppt	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	balance	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	ug/L	ug/L	mg/L	mg/L	ug/L
SLPDG1	3/5/2002	23.97	0.57	565	8.03	0.27	36	-2	246	23.9	98.8	0.99	3.42	3.21	343	19	-0.004	0.341	0.5	0.45	0.125	0.165	0.159	1530	1320	8.1	8.5	38.8
SLPDG2	3/5/2002	24.66	0.72	520	8.11	0.25	27	-2	240	19	94.9	1.04	2.15	2.36	319	11	0.219	-0.005	0.17	0.16	0.021	0.136	0.050	1240	11.8	7.3	7.4	15.3
SLPDG3	3/5/2002	26.08	0.55	493	8.25	0.24	22	-2	228	16	90.9	0.96	1.92	2.75	304	12	0.188	-0.005	0.14	-0.1	0.026	0.136	0.087	1170	24.9	5.8	5.1	17.2
SLPDSW	3/5/2002	16.96	8.39	25440	8.08	15.60	8800	1070	144	4430	190	186	475	-5.12	14500	21	0.037	0.015	0.7	0.36	0.069	0.110	0.086	63	20.9	10.0	11.5	3.8
SLHRG1	3/5/2002	25.71	0.64	517	8.06	0.25	17	-2	244	14.6	95.9	1.62	2.69	3.43	315	47	-0.004	0.235			0.245	0.352	0.260	2540	2060	7.5	7.0	69.6
SLHRG2	3/5/2002	26.53	0.75	356	5.46	0.17	77	40	-0.5	47	5.2	2.57	7.31	-0.10	206	11	-0.004	0.532	0.81	0.64	-0.004	0.049	0.012	3410	3120	5.9	5.8	20.1
SLHRSW	3/5/2002	17.77	8.52	18880	8.27	11.23	6370	769	142	3190	165	132	358	-4.79	10400	37	0.024	0.023	0.59	0.43	0.085	0.150	0.108	221	3.06	11.2	12.3	8.7
SLAMG1	3/6/2002	24.93	2.14	45373	7.05	29.37	17100	2290	152	8390	287	345	987	-6.20	29100	67	0.022	0.907	1.24	1.18	0.164	0.206	0.179	1820	1540	4.5	4.6	193.0
SLAMG2	3/6/2002	24.87	2.08	42763	7.09	27.50	16300	2160	137	8400	270	346	977	-3.88	26100	78	0.013	0.539	1.00	0.86	0.490	0.556	0.527	4960	3800	4.9	6.3	27.0
SLLTSW	3/6/2002	18.14	8.37	40739	7.84	26.08	15500	2090	128	7860	252	323	924	-4.67	26400	58	0.023	0.022	0.66	0.45	0.032	0.077	0.041	293	50	5.3	6.4	0.6
SLCMG1	3/6/2002	24.6	0.25	626	7	0.30	52	6	216	41.2	80.8	7.66	3.28	3.38	408	13	0.485	0.070	0.32	0.13	0.059	0.136	0.103	398	178	8.6	10.3	26.2
SLCMG2	3/6/2002	25.07	0.27	581	6.99	0.28	39	-2	258	29.1	96.8	2.34	3.39	1.78	356	19	-0.004	0.438	0.71	0.49	0.122	0.179	0.173	1170	991	10.1	11.6	25.2
SLCMG3	3/6/2002	25.58	0.29	584	6.92	0.28	24	-2	140	15	71.4	4.27	2.09	13.57	288	13	2.650	0.170	0.70	0.40	0.260	0.354	0.278	616	745	7.4	8.4	9.6
SLCMSW	3/6/2002	18.31	9.36	22591	7.92	13.67	7950	981	132	3910	180	163	423	-6.14	13600	34	0.013	0.028	0.83	0.41	0.076	0.134	0.091	204	-2.5	10.1	11.4	7.7
IRMNG1	3/7/2002	25.2	0.36	588	7.19	0.28	91	13	98	58.4	43.6	2.4	5.25	4.40	288	9	0.967	0.106	0.46	0.60	0.128	0.232	0.229	217	17.7	9.4	9.8	6.4
IRMNG2	3/7/2002	25.4	0.39	314	6.56	0.15	31	9	100	18.1	41.5	1.89	3.42	2.23	194	5	-0.004	0.186	0.42	0.42	0.011	0.018	0.018	519	414	12.4	14.0	6.6
IRMNSW	3/7/2002	18.05	7.43	49342	7.5	31.93	18400	2360	126	8870	277	360	1080	-6.67	32300	110	0.024	0.038	0.80	0.71	0.007	0.06	0.024	281	50	4.5	6.2	3.8
IRLMG1	3/7/2002	24.07	0.31	636	6.96		69	13	181	45.8	79.4	1.58	3.5	3.67	378	16	0.415	0.014	0.28	0.39	0.243	0.326	0.318	218	53.8	10.5	10.4	9.6
IRLMG2	3/7/2002	24.55	0.3	619	6.97	0.30	43	2	194	19.3	108	1.84	3.28	12.30	332	16	0.280	0.331	0.52	0.63	0.256	0.375	0.243	1070	977	10.0	11.6	15.7
IRLMG3	3/7/2002	25.59	0.28	403	7.29	0.19	52	5	108	29.2	49.4	1.15	2.95	3.66	245	12	0.213	0.072	0.30	0.27	0.091	0.229	0.132	619	144	6.3	6.9	3.4
IRLMSW	3/7/2002	20.73	12.62	49622	7.86	32.54	18500	2570	126	9220	286	386	1080	-5.69	31700	78	0.023	0.038	0.56	0.60	0.014	0.055	0.026	368	50	2.8	3.8	1.2

these are correct results; the values in dbhydro are wrong, per Sue Farland

St. Lucie Estuary/Indian River Lagoon: August 2002 Water Quality

Station	Date		Temp	DO	Sp Cond	pH	Salinity	Cl	SO4	Alka	Na	Ca	K	Mg	Cation/anion	TDS	TSS	NOX	NH4	TKN	TDKN	OPO4	TPO4	TDPO4	Tot Fe	TD Fe	DOC	TOC	Tot Mn	MBAS
			Deg C	mg/L	uS/cm		ppt	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	balance	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	ug/L	ug/L	mg/L	mg/L	ug/L	mg/L
SLPDG1	08/26/02		24.54	0.42	555	7.08		36	-2	242	22.9	95.7	0.9	3.3	2.29	307	3	0.007	0.327	0.53	0.46	0.141	0.195	0.161	1480	1400	6.4	6.3	41.2	0.03
SLPDG2	08/26/02		24.92	0.29	513	7.1		27	-2	228	18.1	92.1	0.9	2.2	3.07	308	6	0.011	0.254	0.37	0.45	0.146	0.184	0.142	654	1870	5.8	6.1	41.4	-0.03
SLPDG3	08/26/02		26.09	0.27	485	7.14		21	-2	216	14.8	88.1	0.8	2	3.68	287	7	0.018	0.179	0.38	0.29	0.161	0.253	0.158	1980	1920	4.5	4.2	32.8	-0.03
SLPDSW	08/26/02		29.52	7.57	4131	7.66		1120	190	134	489	62	23.3	64	-11.53	2000	9	0.116	-0.010	1.16	0.87	0.200	0.296	0.218	493	85.6	19.9	22.1	14.3	0.03
SLPDZ1	08/26/02	SAMP	26.5	0.6	588	7.21		36	-0.2	223	15	90	1.1	2.4	-0.83	320	9	0.005	0.222	0.4	0.5	0.188	0.181	0.181	2280	2250	3.9	3.8	25	0.03
SLPDZ1	08/26/02	SS	26.5	0.6	588	7.21		36	-0.2	223	18	90	1.1	2.5	0.45	329	8.1	0.004	0.222	0.4	0.3	0.195	0.179	0.182	2300	2250	4.0	4.1	24	0.03
SLPDZ3	08/26/02	SAMP	27.8	2.8	29048	6.63		10550	1380	329	5040	439	140	641	-5.46	18800	74	0.028	3.11	4.0	1.3	0.087	0.129	0.119	30200	30000	11.0	11.0	55	0.14
SLPDZ4	08/28/02	SAMP	28.2	8.8	1340	8.41		11830	1530	254	5920	345	200	726	-4.21			major ions only				0.28	--	--	--	18		only major ions		
SLHRG1	08/26/02		26.17	0.31	509	7.06		18	-2	244	13.2	93.5	1.3	2.4	1.34	282	7	0.006	0.170	0.3	0.4	0.232	0.279	0.240	3060	2610	5.6	5.1	63.3	-0.03
SLHRG2	08/26/02		26.75	0.38	363	4.54		87	35	8	41.6	4.6	2.2	8	-9.32	223	8	0.023	0.486	0.65	0.66	0.018	0.011	0.011	5320	5400	4.6	4.3	18.6	0.04
SLHRSW	08/26/02		29.84	7.6	1536	7.8		353	82	124	191	70	9.5	26.9	0.55	772	7	0.048	-0.010	1.13	0.8	0.166	0.270	0.174	566	193	19.0	20.6	17.3	0.03
SLHRZ1	08/29/02	SAMP	25.9	2.4	399	5.87		54	38	65	36	35	2.1	3	0.09	257	78	-0.002	0.166	0.3	0.3	0.06	0.156	0.066	2150	2090	2.9	2.9	13	-0.03
SLHRZ2	08/26/02	SAMP	27.1	0.7	526	4.39		67	120	-1	41	6.3	10	20	-4.13	318	35	0.021	0.274	0.6	0.7	0.006	0.038	0.02 U	9620	9480	5.0	5.1	17	-0.1
SLHRZ3	08/26/02	SAMP	26.3	0.9	510	7.06		21	-0.2	241	15	89	1.8	1.8	-1.02	291	5.7	0.007	0.852	0.9	1.1	0.28	0.271	0.274	2260	2250	4.3	4.2	36	-0.1
SLHRZ4	08/26/02	SAMP	26.6	0.6	875	7.04		160	10	249	94	105	4.7	6.3	1.46	556	10	-0.02	1.67	1.9	1.9	0.258	0.247	0.243	1700	1540	5.4	5.5	35	-0.1
SLAMG1	08/27/02		25.41	0.23	46644	7.09		16600	2550	144	8390	361	372	1060	-4.27	26800	20	0.004	0.903	1.19	1.39	0.247	0.287	0.245	1340	1610	3.9	3.5	158.0	0.16
SLAMG2	08/27/02		25.1	0.19	44304	7.17		15800	2250	140	7780	325	338	977	-5.34	27100	29	-0.004	0.503	0.93	0.89	0.448	0.517	0.468	4170	2660	3.5	3.4	6.3	0.24
SLLTSW	08/27/02		28.9	10.17	17124	7.69		5350	817	124	2990	144	113	351	-0.25	9600	16	0.112	0.068	0.91	0.95	0.179	0.238	0.188	50	50	15.2	16.1	6.0	0.05
SLLTZ1	08/27/02	SAMP	26.6	2.5	43689	7.06		15800	2190	124	8160	356	310	992	-3.13	28800	86	-0.02	0.468	0.7	0.7	0.16	0.265	0.202	7770	6510	5.2	5.3	46	0.22
SLLTZ2	08/27/02	SAMP	27.2	0.7	356	6.25		26	8.1	71	12	27	1.4	2.6	-4.43	158	-1	0.005	0.218	0.6	0.5	0.093	0.096	0.094	11400	11100	7.4	7.8	31	0.03
SLLTZ3	08/27/02	SAMP	26.6	2.0	47809	7.36		17650	2420	142	9210	364	350	1080	-3.07	32000	66	-0.02	0.71	0.8	0.9	0.337	0.363	0.367	44	-10	3.1	3.2	119	0.26
SLLTZ4	08/27/02	SAMP	28.5	2.4	47158	7.34		17400	2400	138	9150	353	340	1040	-3.04	31300	87	-0.02	0.824	0.9	0.9	0.456	0.508	0.492	488	267	3.8	3.8	126	0.26
SLCMG1	08/27/02		25.08	0.24	603.3	7.13		48	-2	238	35.5	91.2	3.2	3.7	3.42	325	-2	0.051	0.419	0.63	0.65	0.193	0.210	0.182	1190	1200	8.1	8.1	58.1	0.03
SLCMG2	08/27/02		25.6	0.19	544.9	7.06		35	-2	224	25.4	90.5	2.4	3.5	4.95	310	-2	0.020	0.414	0.67	0.83	0.355	0.379	0.321	802	719	8.5	8.3	22.4	-0.03
SLCMG3	08/27/02		25.97	0.23	575.8	6.99		37	-2	244	20	97.8	2.8	3.1	1.84	305	-2	0.017	0.688	0.96	0.94	0.320	0.356	0.329	2090	2060	7.6	7.4	30.9	0.04
SLCMSW	08/27/02		28.95	9.61	1794	7.62		437	95	144	243	69.6	12.3	33.4	-0.06	969	8	0.015	-0.010	1.16	1.10	0.182	0.234	0.180	429	147	19.7	20.8	14.0	0.05
SLCMZ1	08/27/02	SAMP	26.1	0.6	224	5.49		39	1.5	40	37	2.2	2.2	1.5	-0.78	801	224	0.007	0.652	2.3	1.3	0.112	0.459	0.138	2480	486	14.0	14.0	5	-0.03
SLCMZ2		not done						insufficient water															insufficient water							
SLCMZ3	08/29/02	SAMP	27.4	0.3	18106	6.81		7060	950	290	4010	212	140	464	0.61	13600	34	0.048	3.3	3.7	3.7	0.54	0.543	0.522	8.3	-10	7.5	7.9	29	-0.03
SLCMZ4	08/29/02	SAMP	29.4	0.4	21600	6.93		25	-0.2	246	15	89	1.5	3.1	-2.01	310	9.7	0.002	0.92	1.3	1.2	0.193	0.262	0.239	1550	1470	6.4	6.3	28	0.09
IRMNG1	08/28/02		25.44	0.41	577	7.36	0.29	60	8	192	34.8	85.2	1.8	6.99	5.96	347	8	0.025	0.474	0.83	0.72	0.185	0.204	0.166	249	62.7	13.8	13.2	20.2	0.05
IRMNG2	08/28/02		25.42	0.33	255	6.81	0.12	25	9	90	15.3	34.8	1.7	3.43	0.85	148	6	0.006	0.167	0.49	0.56	0.004	0.023	0.014	470	438	12.7	12.3	61.0	0.05
IRMNSW	08/28/02		28.7	1.29	43307	7.76	28.01	15700	2310	114	8090	302	312	955	-4.04	28200	22	0.007	0.082	0.88	0.85	0.043	0.089	0.058	50	100	6.4	6.2	6.0	0.22
IRMNZ1	08/28/02	SAMP	25.7	2.0	405	7.02		35	7.3	136	23	45	2.2	6.4	-0.24	236	4.7	-0.002	0.292	0.7	0.6	0.147	0.158	0.161	11	9.1	11.0	12.0	4.6	0.07
IRMNZ2	08/28/02	SAMP	26.1	3.2	417	7.26		33	13	118	19	44	3	5	-0.65	456	-1	-0.002	0.11	0.3	0.3	0.093	0.098	0.098		325	7.0	7.1	173	0.07
IRMNZ2	08/28/02	SS	26.1	3.2	422	7.26		33	13	115	19	44	3	5	0.32	455				0.3	0.4	0.092	0.088	0.093		394	7.3	7.2	191	--
IRMNZ3	08/28/02	SAMP	26.5	0.4	48547	6.94		18770	2540	258	9410	439	330	1160	-4.51	33500	104	0.028	2.08	2.8	2.9	0.494	0.667	0.488	248	-10	14.0	14.0	15	0.1
IRMNZ4	08/28/02	SAMP	28.2	1.0	50916	6.98	33.35	20010	2790	143	10000	423	370	1250	-4.61	35300	116	-0.02	0.735	1.1	1.0	0.324	0.346	0.342	33	-10	5.6	5.7	16	0.11
IRMNS1	08/28/02	SAMP	27.4	2.6	22752	8.11	--	17250	2210	381	8860	368	350	1130	-3.14			major ions only				0.928	--	--	--	65		only major ions		
IRMNS2	08/28/02	SAMP	29.2	3.0	45784	7.99	--	17880	2320	242	9270	380	360	1130	-2.90			major ions only				1.68	--	--	--	36		only major ions		
IRMNS3	08/28/02	SAMP	29.0	4.7	43400	7.97	27.89	--	--	121	8310	312	320	990	--	29200	84	-0.02	0.038	0.3	0.2	--	0.071	0.051	110	-10	4.5	4.8	5.9	0.19
IRLMG1	08/28/02		24.3	0.32	620	7.02	0.32	38	-2	270	27.9	110	1.08	3.6	4.46	369	3	0.005	1.070	1.32	1.30	0.539	0.494	0.476	112	58.7	11.5	11.5	28.1	-0.03
IRLMG2	08/28/02		25.88	0.31	614	7.02	0.31	30	-2	300	18.1	112	1.85	3.6	-0.51	358	17	0.007	1.000	1.37	1.27	0.419	0.832	0.373	3270	1140	10.0	10.8	32.8	-0.03
IRLMG3	08/28/02		25.74	0.3	388	7.44	0.19	24	-2	168	14.8	65.5	0.73	2.71	2.07	205	4	0.009	0.587	0.79	0.70	0.208	0.212	0.199	1020	911	5.5	5.5	18.3	0.03
IRLMSW	08/28/02		29.9	5.13	42776	7.91	22.54	15600	2280	118	7700	294	291	913	-6.10	28200	20	-0.004	0.030	0.66	0.69	0.066	0.095	0.071	100	100	6.2	5.9	12.0	0.24
IRLMZ1	08/29/02	SAMP	26.2	1.8	537	7.08		5790	820	269	3120	174	110	383	-1.78	11300	75	0.04	1.41	1.8	1.4	0.294	0.391	0.265	118	-10	8.4	8.5	21	0.03
IRLMZ2		not done					insufficient water		--	--	--	--	--	--	--			insufficient water							insufficient water					
IRLMZ3	08/28/02	SAMP	26.2	1.2	28275	7.10		10240	1390	232	5160	260	190	619	-4.59	18700	49	-0.02	0.844	1.0	1.1	0.466	0.634	0.478	609	-10	6.1	5.1	19	0.08
IRLMZ4	08/28/02	SAMP	28.6	0.7	38071	7.39		14070	1970	187	7290	308	280	873	-3.38	25600	57	-0.02	0.864	1.1	1.0	0.206	0.23	0.225	15	-10	3.6	3.6	8.1	0.22

Past holding time

Results missing

St. Lucie Estuary/Indian River Lagoon: December 2002 Water Quality

Site	Date	Time	Temp	DO	Spec Cond	pH	Salinity	Cl	SO4	Alka	Na	Ca	K	Mg	Cation/anion	TDS	TSS	NOX	NH_4	TKN	TDKN	OPO_4	TPO_4	$TDPO_4$	Fe Tot	Fe - Dis	DOC	TOC	Mn	MBAS
			Deg C	mg/L	uS/cm		ppt	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	balance	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	ug/L	ug/L	mg/L	mg/L	ug/L	mg/L
SLPDG1	12/09/02	13:42	23.88	0.18	539	7.12	--	34	-0.2	243	22	94	0.8	3.1	1.04	334	7	-0.002	0.391	0.6	0.6	0.117	0.136	0.13	1430	1430	5.5	5.5	32	0.08
SLPDG2	12/09/02	14:27	24.63	0.16	497	7.13	--	25	-0.2	231	17	89	0.8	2.1	0.60	306	6.5	0.102	0.123	0.3	0.4	0.049	0.092	0.062	433	489	5.1	4.8	25	0.08
SLPDG3	12/09/02	14:52	26.08	0.16	470	7.14	--	20	-0.2	224	15	85	0.8	1.9	0.41	285	3.4	0.039	0.019	0.3	0.2	0.045	0.083	0.038	6.9	7.3	3.6	3.6	1.9	0.1
SLPDSW	12/09/02	8:30	20.22	6.99	27416	7.58	--	9390	1350	143	5020	255	190	628	-1.25	18000	51	0.092	0.101	0.7	0.9	0.093	0.139	0.137	256	-10	9	8.5	19	0.15
SLPDZ1	12/09/02	12:37	24.97	--	534	7.28	--	38	-0.2	217	16	93	0.8	2	1.16	329	11	0.006	0.203	0.4	0.4	0.136	0.19	0.18	2250	2180	3.4	3.4	27	0.05
SLPDZ2	12/09/03			insufficient water							insufficient water							insufficient water								insufficient water				
SLPDZ3	12/09/02	10:15	25.22	--	29760	6.75	--	10240	1330	320	5250	494	160	676	-1.44	19700	74	-0.02	2.9	3.5	3.4	0.095	0.177	0.152	23800	17700	11	10	61	0.19
SLPDZ4	12/09/02	10:57	22.99	--	31200	6.98	--	11280	1530	295	5860	369	210	749	-2.08	major ions only			-	-	-	0.313	-	-	-	-10		major ions only		
SLHRG1	12/09/02	10:46	25.88	0.2	458	7.18	--	16	0.5	237	13	94	1.2	2.1	2.53	296	72	0.006	0.246	0.7	0.4	0.171	0.324	0.206	3640	299	4.4	4.4	56	-0.1
SLHRG2	12/09/02	11:16	27.12	0.21	367	4.65	0	76	41	2.8	40	5.4	2.3	8.7	-4.41	212	1.3	0.03	0.612	0.9	1	0.005	0.009	0.004	5890	5490	4.9	5	19	0.1
SLHRSW	12/09/02	9:10	20.34	6.66	32380	7.52	20.2	11460	1550	135	6000	287	230	758	-1.93	21300	58	0.029	0.1	0.7	0.8	0.112	0.164	0.136	155	-10	7.9	7.4	21	0.19
SLHRZ1	12/11/02	15:54	25.25	--	400	6.06	0.19	50	30	73	31	38	2.1	3	0.83	228	14	0.01	0.153	-0.2	-0.2	0.056	0.082	0.064	2270	2110	2.7	2.7	15	0.03
SLHRZ2	12/11/02	16:20	24.04	--	552	4.41	0.27	68	120	1.4	43	7.5	8	20	-3.82	328	11	0.015	0.282	0.4	0.6	0.002	0.005	0.008	10600	10100	5.3	5.2	20	0.05
SLHRZ3	12/12/02	12:58	25.16	0.59	823	7.05	0.4	520	60	248	220	132	7.3	19	-7.53	584	7.3	0.014	1.58	1.9	1.9	0.224	0.26	0.262	1950	2070	4.7	4.6	42	-0.1
SLHRZ4	12/12/02	13:25	25.33	0.48	511	7.07	0.25	20	-0.2	234	14	89	1.9	1.9	0.25	299	7.2	0.051	0.754	1	1	0.216	0.273	0.274	2250	2240	4	4.1	38	0.03
SLAMG1	12/10/02	14:29	25.1	0.25	44809	7.25	29.02	17460	2290	142	9130	370	330	1060	-2.86	31300	59	-0.02	0.884	1	1.1	0.136	0.173	0.168	2640	2590	3.3	2.6	111	0.24
SLAMG2	12/10/02	14:57	25.23	0.15	42290	7.25	27.21	15010	1710	113	7710	316	280	903	-3.05	21500	32	0.199	0.239	-0.2	0.4	0.039	0.08	0.159	726	2670	3.7	3.2	32	0.3
SLLTSW	12/10/02	8:40	20.98	6.73	46270	7.88	30.1	20200	2730	123	9390	359	340	1090	-8.89	31900	45	0.073	0.091	0.4	1	0.044	0.075	0.066	93	-20	3.5	3.4	6.9	0.39
SLLTZ1	12/12/02	10:53	25.8	0.32	42337	7.04	27.17	15560	2170	125	8290	408	290	998	-1.52	28100	44	0.08	0.48	1	0.9	0.13	0.21	0.198	7240	7310	5.2	5.1	53	0.28
SLLTZ2	12/12/02	11:22	25.18	0.43	4096	6.59	2.17	1510	120	115	620	288	6.1	33	-3.35	2510	44	0.101	1.07	1.6	1.6	0.068	0.14	0.099	58800	55300	6.2	6.2	175	0.09
SLLTZ3	12/12/02	9:43	25.83	0.28	46932	7.34	30.48	20720	2840	138	9390	414	340	1140	-9.58	32100	33	0.066	0.668	1	1	0.32	0.383	0.374	185	20	3	2.9	173	0.32
SLLTZ4	12/12/02	10:11	24.05	0.34	45544	7.44	29.5	19760	2710	132	9100	407	330	1090	-8.88	31700	85	-0.02	0.489	1	0.9	0.333	0.378	0.38	241	63	4.1	3.9	134	0.32
SLCMG1	12/10/02	10:58 to 1	24.76	0.22	595	7.18	0.3	30	8.4	117	20	50	4.3	2.4	4.54	218	6.5	2.11	0.022	0.4	0.4	0.014	0.05	0.035	220	14	5.3	4.9	5.7	0.06
SLCMG2	12/10/02	11:50	24.87	0.25	274	7.64	0.13	6	5.9	69	5.4	26	1.4	1.3	0.21	130	10	0.04	0.009	0.7	0.4	0.177	0.219	0.183	92	13	4.6	4.5	1.1	0.04
SLCMG3	12/10/02	12:19	25.38	0.35	245	7.56	0.12	8.6	2.8	109	6.8	39	2.6	1.5	-0.88	196	9.6	0.03	0.201	0.5	0.5	0.185	0.219	0.22	90	7.1	3.5	3.3	4.4	0.07
SLCMSW	12/10/02	10:00	20.83	6.84	31490	7.57	19.6	11280	1610	129	5900	266	220	735	-2.48	21000	27	0.047	0.085	0.5	0.5	0.117	0.144	0.13	60	-20	7.3	7.2	20	0.25
SLCMZ3	12/12/02	15:08	25.88	0.1	17925	6.96	10.6	5980	870	237	3160	217	120	421	-1.30	11300	23	0.034	1.37	2	1.9	0.284	0.3	0.266	114	-20	6.6	6.3	27	0.08
SLCMZ4	12/12/02	15:38	24.45	0.04	23365	7.05	14.1	9440	1180	287	4200	263	150	526	-9.78	14900	16	-0.02	3.19	4	3.6	0.52	0.526	0.499	-20	-20	7.3	7.2	36	0.15
IRMNG1	12/11/02	9:43	25.11	0.2	570	7.45	0.29	58	6.7	205	34	81	1.8	6.7	2.16	372	7.6	0.113	0.24	0.6	0.7	0.162	0.166	0.159	113	40	12	12	11	0.08
IRMNG2	12/11/02	10:04	25.69	0.2	225	6.94	0.1	28	1.4	65	15	27	1.8	2.6	3.36	153	10	-0.002	0.17	0.6	0.4	0.008	0.014	0.005	184	346	12	12	4	0.07
IRMNSW	12/11/02	8:40	21.4	4.33	51470	7.73	33.9	20090	2730	127	10570	417	390	1220	-2.73	35300	76	-0.02	0.021	0.2	-0.2	0.032	0.085	0.042	535	-20	3.4	3.2	20	0.25
IRMNZ1	12/11/02	11:57	24.73	0.8	30900	6.78	19.2	10890	1480	153	5540	327	190	673	-3.41	19200	40	0.061	0.843	1.3	1.4	0.153	0.183	0.183	58	59	9.9	9.8	134	0.2
IRMNZ2	12/11/02				insufficient water						insufficient water								insufficient water								insufficient water			
IRMNZ3	12/11/02	10:29	25.24	0.12	51972	7.02	--	18990	2690	219	9690	477	340	1200	-3.61	34000	78	0.056	1.51	1.8	1.4	0.413	0.45	0.42	92	-20	13	12	21	0.03
IRMNZ4	12/11/02	11:05	23.81	0.34	53470	7.11	35.3	20000	2760	128	10430	447	360	1260	-2.75	35400	94	0.06	0.557	1	0.7	0.293	0.326	0.32	34	-20	4.6	4.6	19	0.24
IRLMG1	12/11/02	11:53	24.02	0.19	607	7.06	0.19	38	0.9	260	27	101	1.2	3.3	1.88	361	5.3	0.515	0.468	0.9	1	0.442	0.51	0.495	55	15	9.5	9.5	13	0.09
IRLMG2	12/11/02	12:16	24.55	0.15	603	7.04	0.15	29	-0.2	282	19	110	2.1	3.4	1.61	363	11	0.379	0.368	0.8	1	0.243	0.295	0.25	276	105	8.6	8.6	23	0.06
IRLMG3	12/11/02	12:33	25.93	0.15	399	7.46	0.2	24	0.2	155	15	62	1	2.5	2.65	217	6.2	0.412	0.104	0.6	0.7	0.149	0.181	0.152	137	11	6.6	4.5	14	-0.1
IRLMSW	12/11/02	11:00	22.15	6.88	49250	7.79	32.3	18310	2540	127	9850	396	350	1150	-1.63	33600	90	-0.02	0.023	0.4	0.2	0.044	0.076	0.056	202	-20	4.2	4.1	6.2	0.33
IRLMZ1	12/11/02	14:19	25.53	--	624	7.34	0.3	25	-0.2	270	17	103	1.7	3.5	1.01	335	6.2	0.078	0.942	1.3	1.1	0.222	0.263	0.253	1510	1500	6.5	6.4	32	-0.1
IRLMZ2	12/11/02				insufficient water						insufficient water								insufficient water								insufficient water			
IRLMZ3	12/11/02	13:15	25.29	0.28	29049	7.13	17.9	9650	1500	227	5220	339	170	653	-0.81	18200	48	-0.02	0.94	1.1	1	0.44	0.47	0.468	-20	-20	5.8	5.7	23	0.16
IRLMZ4	12/11/02	13:48	23.25	0.19	45255	7.5	29.3	15810	2180	158	8210	377	300	1020	-2.64	28600	67	0.056	0.722	1	1	0.168	0.199	0.191	31	-20	3.7	3.7	10	0.32

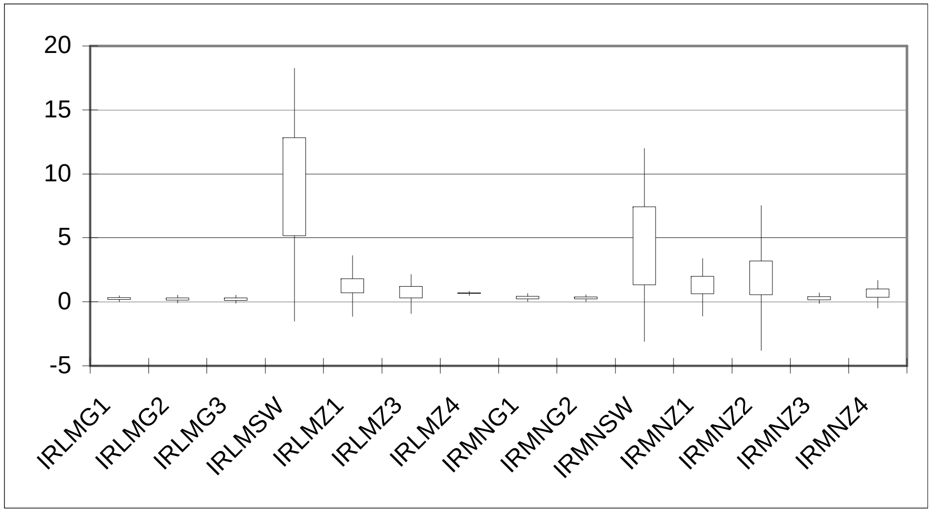
St. Lucie Estuary/Indian River Lagoon: March 2003 Water Quality

Site	Date	Sample #	Temp	DO	Spec Cond	pH	Salinity	Cl	SO4	Alka	Na	Ca	K	Mg	Cation/anion	TDS	TSS	NOX	NH_4	TKN	TDKN	OPO_4	TPO_4	$TDPO_4$	Fe Tot	Fe - Dis	DOC	TOC	Mn	MBAS
			Deg C	mg/L	uS/cm		ppt	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	balance	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	ug/L	ug/L	mg/L	mg/L	ug/L	mg/L
SLPDG1	03/24/03	P14470-2	25.82	0.17	637	7.3	0.31	35	-0.2	241	22	91	0.8	3.1	-0.14	330	32	0.002	0.32	0.5	0.5	0.116	0.18	0.13	1630	1560	6.5	6.2	40	
SLPDG2	03/24/03	P14470-3	25.46	0.17	590	7.29	0.28	26	-0.2	231	17	88	0.8	2.1	-0.13	302	5.4	-0.002	0.293	0.3	0.4	0.102	0.14	0.14	1750	1740	5.5	5.6	34	
SLPDG3	03/24/03	P14470-4	25.81	0.1	558	7.34	0	21	-0.2	224	15	86	0.7	1.9	0.60	278	5.9	-0.002	0.195	0.2	-0.2	0.103	0.14	0.13	1460	1480	4.4	4.6	27	
SLPDSW	03/24/03	P14470-6	26.16	6.88	20632	8.06	12.31	6550	1290	136	3190	169	120	385	-8.02	10800	20	0.097	0.095	0.8	0.7	0.104	0.14	0.12	335	30	12	12	19	
SLPDZ1	03/24/03	P14475-1	23.88	0.25	555	7.17	-	46	0.2	210	16	94	0.8	2.1	0.82	335	5.6	-0.002	0.22	0.2	0.3	0.074	0.15	0.15	2200	2290	3.5	3.4	32	0.03
SLPDZ2				insufficient water												insufficient water														
SLPDZ3	03/24/03	P14475-3	24.26	0.61	29660	6.75	18.36	11210	1830	295	5240	438	140	644	-7.92	17700	64	-0.02	2.79	3.6	3.5	0.019	0.16	0.11	21400	24500	11	11	60	0.19
SLPDZ4	03/24/03	P14475-4	24.83	0.35	32300	6.8	0.35	14480	2010	267	5860	348	200	717	-14.90	19800	30	0.029	3.23	3.7	4	0.258	0.29	0.29	365	492	9.2	9.1	47	0.17
SLHRG1	03/24/03	P14470-7	26.07	0.15	594	7.23	0.29	18	-0.2	243	13	94	1.1	1.8	0.75	301	392	0.004	0.248	0.7	0.2	0.048	0.5	0.18	5570	3630	4.5	4.6	45	
SLHRG2	03/24/03	P14470-8	26.88	0.15	459	4.56	0.27	77	51	-1	40	5.8	2.5	10	-4.64	223	1.2	0.032	0.613	0.8	0.8	0.004	-0.002	-0.002	6520	6560	5.9	6	22	
SLHRSW	03/24/03	P14470-9	25.39	5.09	19478	7.67	11.57	5780	870	134	3060	171	110	363	-2.50	10400	20	-0.02	0.12	0.7	0.7	0.136	0.18	0.16	217	-20	11	11	26	
SLHRZ1	03/24/03	P14475-6	25.34	0.67	436	5.94	-	57	53	61	39	37	2	2.9	-1.17	260	52	0.003	0.14	-0.2	-0.2	0.056	0.01	0.006	2280	2260	3.2	3.2	14	
SLHRZ2	03/24/03	P14475-7	25.27	0.66	519	4.6	-	66	120	-1	39	5.9	13	18	-6.31	294	-1	0.006	0.592	0.8	0.8	-0.002	-0.002	-0.002	11300	11300	4.7	4.7	20	0.04
SLHRZ3	03/24/03	P14475-8	25.17	0.39	507	7.1	-	21	0.2	234	14	89	1.7	1.8	-0.22	299	5.8	0.005	0.734	0.8	0.8	0.118	0.25	0.25	2290	2310	4.6	4.5	36	
SLHRZ4	03/24/03	P14475-9	24.59	0.43	1756	6.98	-	1040	130	235	550	180	16	54	1.50	1510	9.7	0.015	1.62	1.8	1.9	0.127	0.24	0.26	2890	2980	5.6	5	59	0.04
SLAMG1	03/25/03	P14472-7	24.71	0.29	41211	7.1	26.4	17720	2580	147	8990	363	340	1040	-4.85	29300	32	-0.02	0.848	1.1	1.1	0.156	0.27	0.26	1910	2050	3	3.1	163	0.25
SLAMG2	03/25/03	P14472-8	24.63	0.08	38947	7.1	24.78	16600	2390	141	8460	341	320	966	-4.69	27400	44	-0.02	0.524	0.7	0.7	0.227	0.48	0.48	4460	4650	3.6	3.6	28	0.31
SLLTSW	03/25/03	P14472-9,10,11	23.07	6.14	33001	7.8	20.64	12603	1893	127	6757	276	250	769	-2.44	21633	42	0.03	0.044	0.7	0.4	0.06	0.09	0.06	382	20	6.7	6.8	13	0.17
SLLTZ1	03/25/03	P14476-1	25.01	0.77	42320	6.96	27.17	16980	2590	122	8320	373	300	960	-6.64	28200	38	-0.02	0.446	0.6	0.7	0.11	0.18	0.17	7100	7230	5.2	5.3	56	0.24
SLLTZ2	03/25/03	P14476-2	24.83	1.09	3234	6.67	1.69	1290	88	118	570	194	8.6	47	-2.42	2140	45	0.01	0.905	1.1	1.1	0.03	0.19	0.17	40700	41500	6.1	6	107	0.06
SLLTZ3	03/25/03	P14476-3	23.87	0.52	46240	7.34	30.02	20090	2940	135	9370	363	350	1080	-9.13	31200	21	-0.02	0.65	0.9	0.9	0.265	0.33	0.33	70	20	3	3.1	153	0.33
SLLTZ4	03/25/03	P14476-4	24.00	0.74	42290	7.34	27.17	18830	3000	129	8220	325	310	945	-12.80	27000	35	-0.02	0.406	0.6	0.7	0.318	0.36	0.36	71	36	4.4	4.5	129	0.26
SLCMG1	03/25/03	P14472-3	25.13	0.2	571	6.96	0.27	47	-0.2	254	35	91	2.2	3.7	0.29	432	5.1	0.006	0.516	0.8	0.7	0.296	0.35	0.34	2770	2860	9.3	9.5	67	0.04
SLCMG2	03/25/03	P14472-4	25.45	0.12	444	7.03	0.21	30	4	213	21	77	2.4	3.1	-1.03	285	6.9	0.005	0.457	0.8	0.6	0.237	0.28	0.25	322	267	7.8	7.8	12	0.04
SLCMG3	03/25/03	P14472-5	25.7	0.18	508	6.92	0.24	34	0.5	238	18	91	2.4	2.8	-0.89	334	34	0.003	0.691	0.9	1	0.214	0.27	0.24	925	669	7.3	7.2	25	0.04
SLCMSW	03/25/03	P14472-6	27.21	5.07	19448	7.9	11.51	7370	1250	128	3730	183	150	441	-5.42	13200	14	0.03	0.044	0.6	0.5	0.109	0.14	0.12	76	20	10	11	14	0.16
SLCMZ1	03/25/03	P14476-5	24.11	0.73	220	5.56	0.1	40	-0.2	36	33	5.1	1.4	1.3	-0.23	188	28	0.008	0.796	1.7	1.3	0.077	0.056	0.01	1730	1310	13	12	4.2	
SLCMZ2	03/25/03	P14476-6	25.53	0.48	199	5.41	0.09	23	0.5	36	22	1.6	5.4	0.78	-5.28	233	2	0.013	5.1	7.6	7.4	0.336	0.12	0.11	501	513	40	41	1	
SLCMZ3	03/25/03	P14476-7	24.52	0.13	19090	6.9	11.33	6630	1060	224	3410	206	120	438	-3.69	11600	46	-0.02	1.48	1.8	1.7	0.212	0.29	0.23	175	20	6.9	7.5	30	0.08
SLCMZ4	03/25/03	P14476-8	24.93	0.05	23280	7.03	14.06	7950	1190	258	4260	228	160	506	-2.22	14000	9.6	-0.02	2.99	3.4	3.4	0.442	0.48	0.48	20	20	7.8	7.8	44	0.19
IRMNG1	03/26/03	P14473-6	25.29	0.42	561	7.14	-	56	5.6	211	32	78	1.4	6	-0.74	339	-1	0.003	0.45	0.7	0.8	0.152	0.16	0.16	116	101	13	13	24	
IRMNG2	03/26/03	P14473-7	25.25	0.22	258	6.56	-	28	3.9	88	19	31	1.6	2.9	0.54	164	1.8	0.004	0.19	0.6	0.5	0.01	0.015	0.012	672	386	12	12	5.3	
IRMNSW	03/26/03	P14473-9	23.71	4.69	48946	7.94	-	19940	2660	135	10520	399	370	1190	-2.80	34600	42	-0.02	0.02	0.4	0.4	-0.02	0.04	-0.02	200	20	2.6	3	10	
IRMNZ1	03/26/03	P14479-1	25.01	0.61	409	7.01	0.2	38	8.8	133	28	34	2.7	12	0.92	224	2.8	0.004	0.27	0.6	0.6	0.124	0.13	0.12	8.9	8.3	12	12	6.5	
IRMNZ2	03/26/03	P14479-2	25.13	0.53	441	7.08	0.21	28	12	125	18	46	1.9	4.7	-0.22	206	4.9	0.005	0.1	0.3	0.3	0.086	0.015	0.016	512	510	7.8	7.8	272	
IRMNZ3	03/26/03	P14479-3	24.31	0.29	49300	7.02	32.24	20450	2990	221	9590	439	340	1170	-8.22	32200	34	-0.02	1.6	2.2	2.1	0.402	0.44	0.42	34	20	14	13	19	
IRMNZ4	03/26/03	P14479-4	24.61	0.41	51240	7.07	33.66	22900	3520	143	10160	423	360	1210	-11.46	34400	58	-0.02	0.71	1.1	0.9	0.312	0.37	0.33	40	20	5.7	5.8	19	
IRLMG1	03/26/03	P14473-1	24.79	0.16	602	6.89	-	38	-0.2	275	26	102	1	3.2	-0.33	363	5.3	-0.002	0.94	1.3	1.2	0.448	0.5	0.48	108	89	10	10	25	
IRLMG2	03/26/03	P14473-2	25.07	0.1	589	6.86	-	30	-0.2	287	18	109	1.8	3.4	-0.14	366	6.6	0.002	0.93	1.3	1.3	0.339	0.4	0.39	1110	1110	9.2	9.3	25	
IRLMG3	03/26/03	P14473-3	25.7	0.07	379	7.37	-	25	-0.2	163	15	62	0.7	2.5	0.23	225	3.6	0.002	0.58	0.7	0.8	0.17	0.19	0.19	915	913	5.1	5.2	17	
IRLMSW	03/26/03	P14473-5	25.6	8.61	44580	8.11	-	20790	2780	124	9440	372	350	1110	-9.82	30700	83	-0.02	-0.02	0.7	0.3	-0.02	0.08	-0.02	593	20	3.3	4.4	13	
IRLMZ1	03/27/03	P14479-9	26.47	0.68	26.47	7.13	0.68	25	-0.2	263	16	102	1.5	3.6	1.44	324	6.5	0.002	0.944	1.2	1.1	0.187	0.25	0.23	1650	1680	6.7	6.8	32	
IRLMZ2	03/27/03	P14479-10	25.74	1.04	392	7.45	0.19	29	-0.2	153	17	56	1.7	2.2	-1.40	213	5.1	-0.002	0.614	0.8	0.8	0.251	0.28	0.26	227	186	4.2	4.2	8.9	
IRLMZ3	03/27/03	P14479-11	24.36	0.36	26410	7.23	15.97	9280	1310	231	4790	264	170	573	-3.48	16000	39	-0.02	0.805	0.9	1	0.442	0.46	0.47	20	20	6	6.2	21	
IRLMZ4	03/27/03	P14479-12	25.23	0.62	45600	7.45	29.51	16760	2380	145	8580	361	320	1030	-3.91	28800	28	-0.02	0.546	0.4	0.4	0.159	0.19	0.17	20	20	3.2	3.4	12	

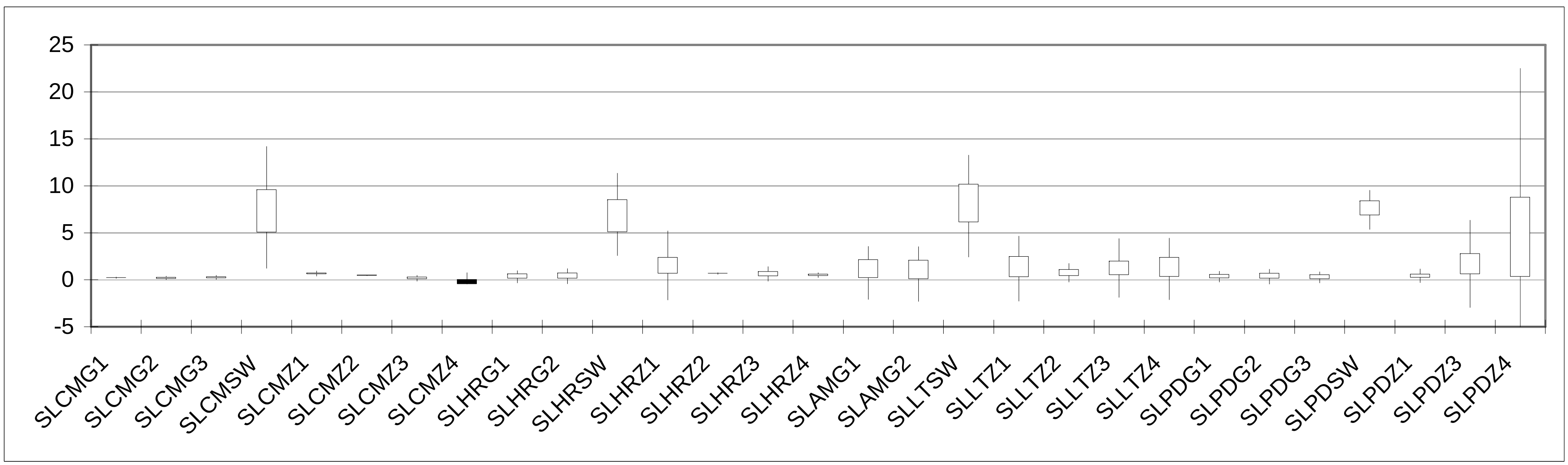
Q	Holding Time Missed
V	EB > 2X MDL
J3	Reversal

Appendix E.

Mean, Range and 99% Confidence Interval for Selected Water Quality Parameter

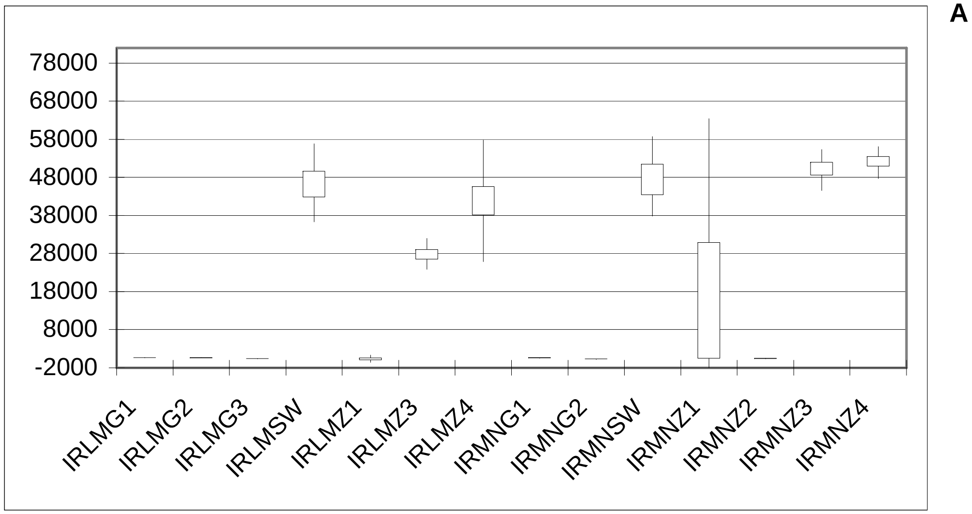


A



B

Figure E1. Mean, Range and approximate 99% confidence interval (3 x Std. Dev.) for Dissolved Oxygen measurements (mg/L). at Indian River Lagoon (A) and St. Lucie River (B) sites.



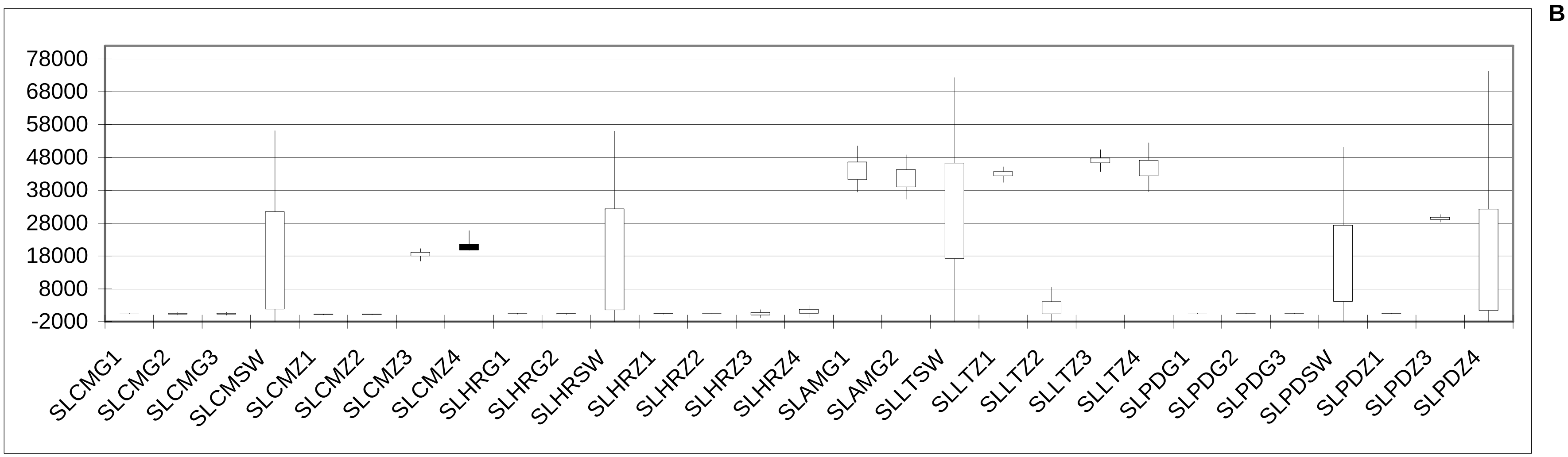
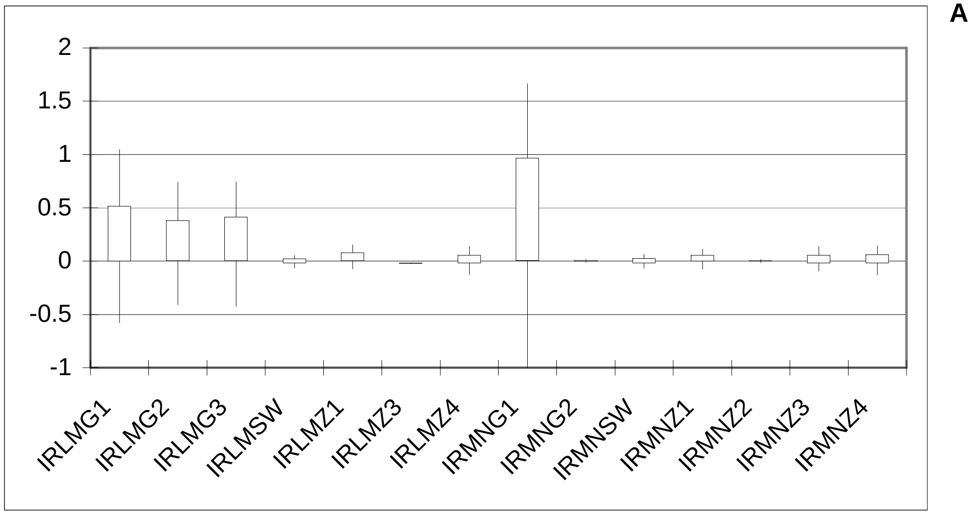


Figure E2. Mean, Range and approximate 99% confidence interval (3 x Std. Dev.) for Specific Conductance measurements (uS/cm) at Indian River Lagoon (A) and St. Lucie River (B) sites.



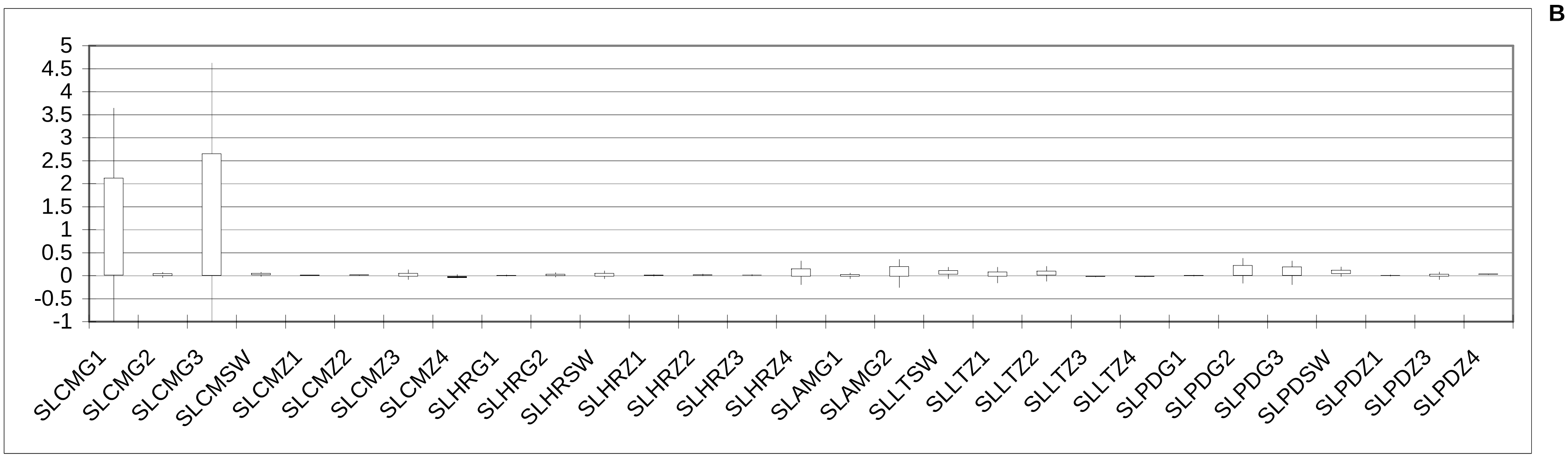
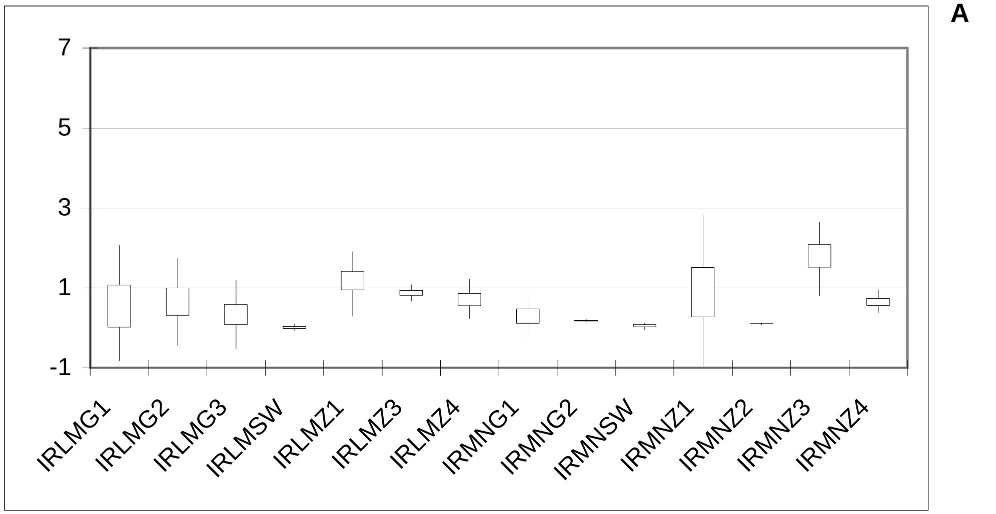


Figure E3. Mean, Range and approximate 99% confidence interval (3 x Std. Dev.) for NOx measurements (mg N/L) at Indian River Lagoon (A) and St. Lucie River (B) sites.



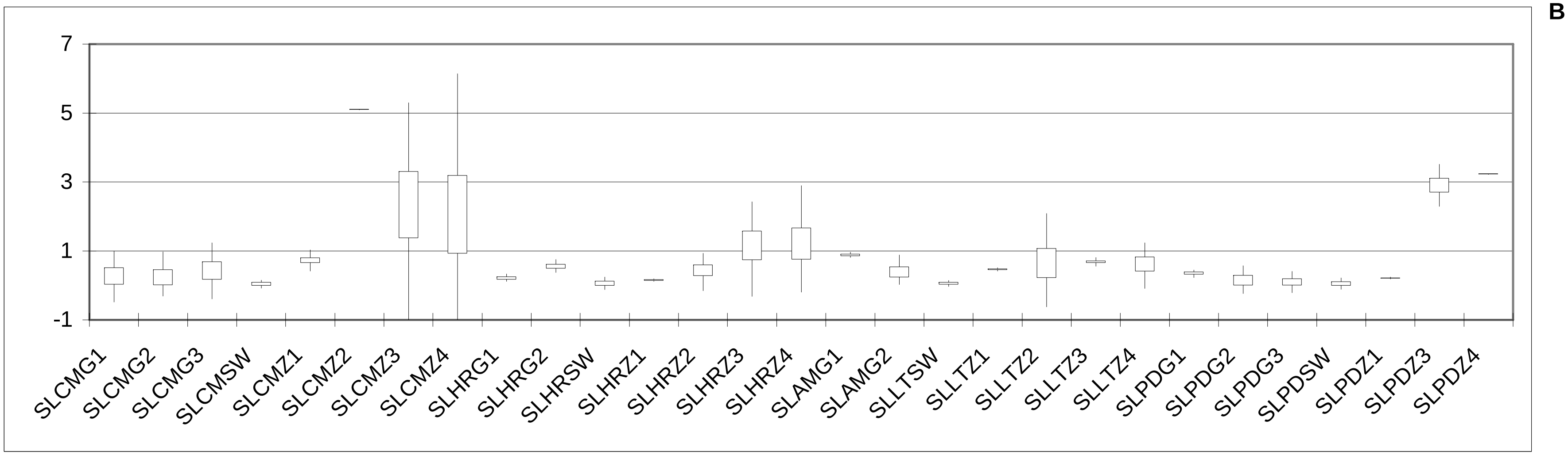


Figure E4. Mean, Range and approximate 99% confidence interval (3 x Std. Dev.) for NH_4 measurements (mg N/L) at Indian River Lagoon (A) and St. Lucie River (B) sites.

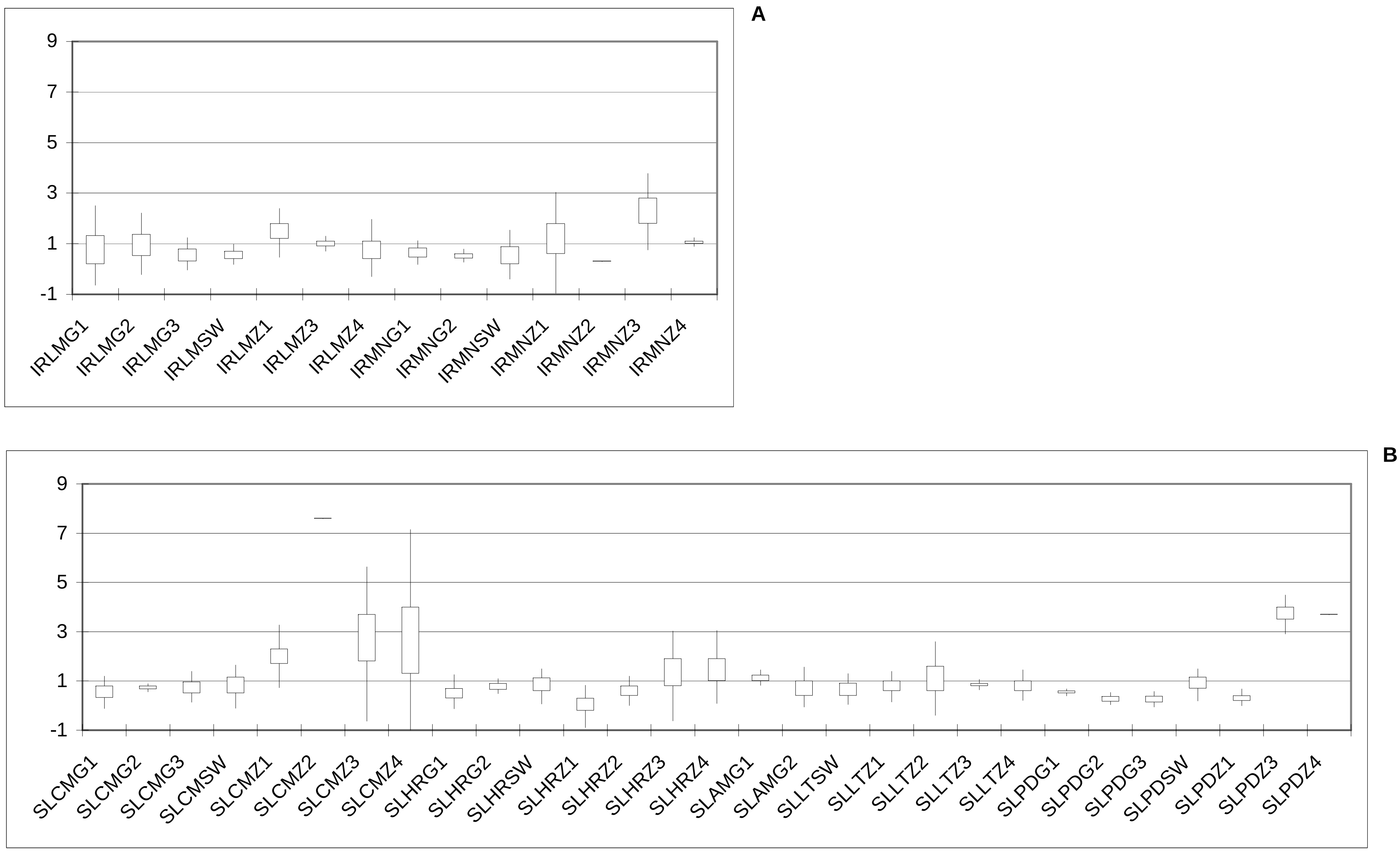
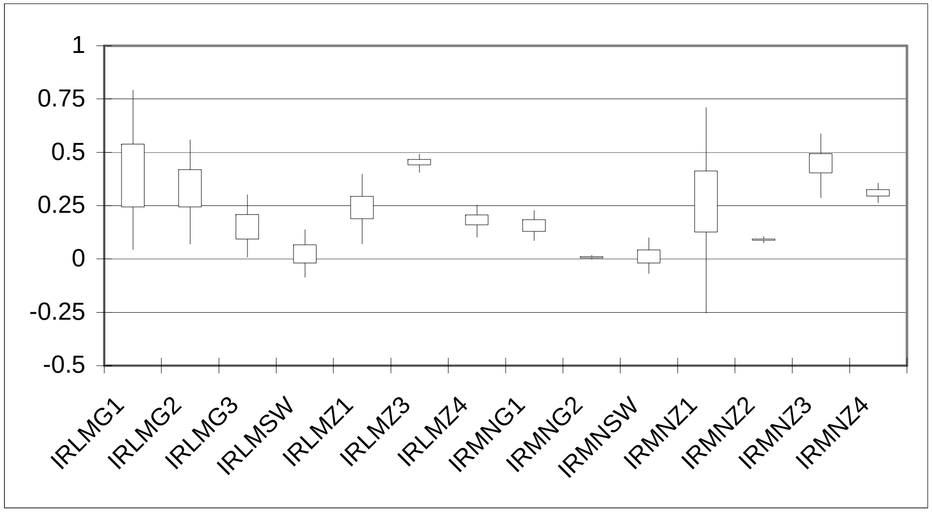


Figure E5. Mean, Range and approximate 99% confidence interval (3 x Std. Dev.) for TKN measurements (mg N/L) at Indian River Lagoon (A) and St. Lucie River (B) sites.

A



B

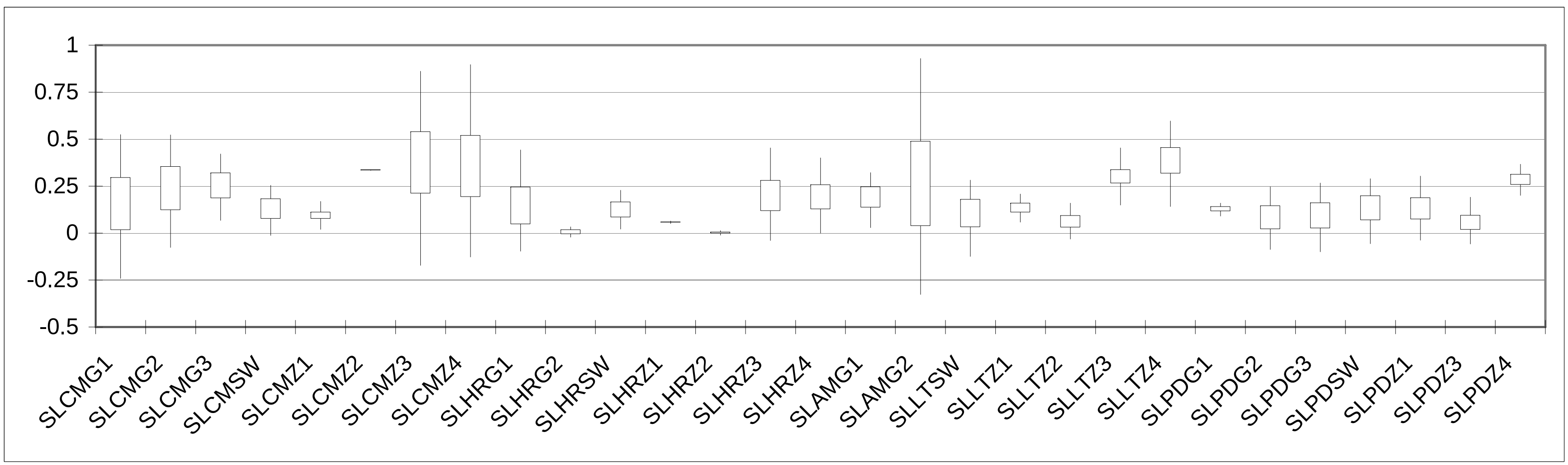
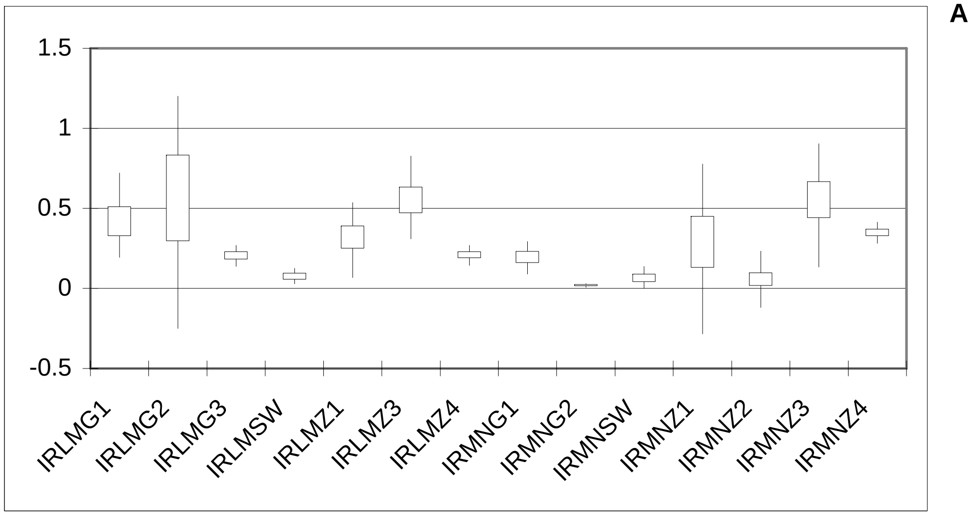


Figure E6. Mean, Range and approximate 99% confidence interval (3 x Std. Dev.) for Orthophosphate measurements (mg/L) at Indian River Lagoon (A) and St. Lucie River (B) sites.



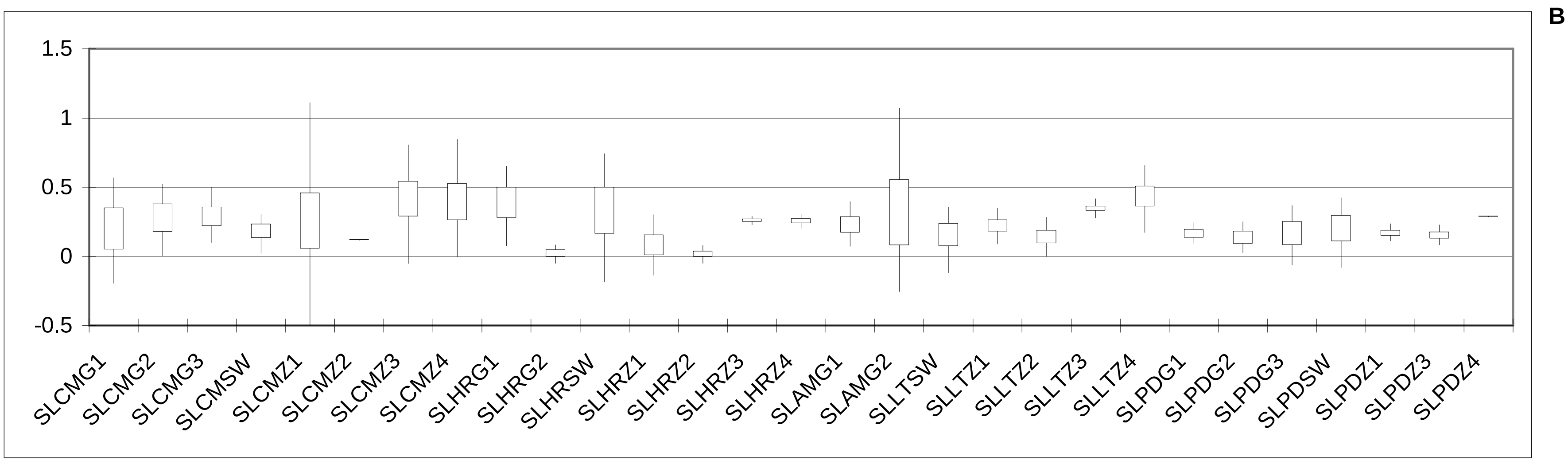
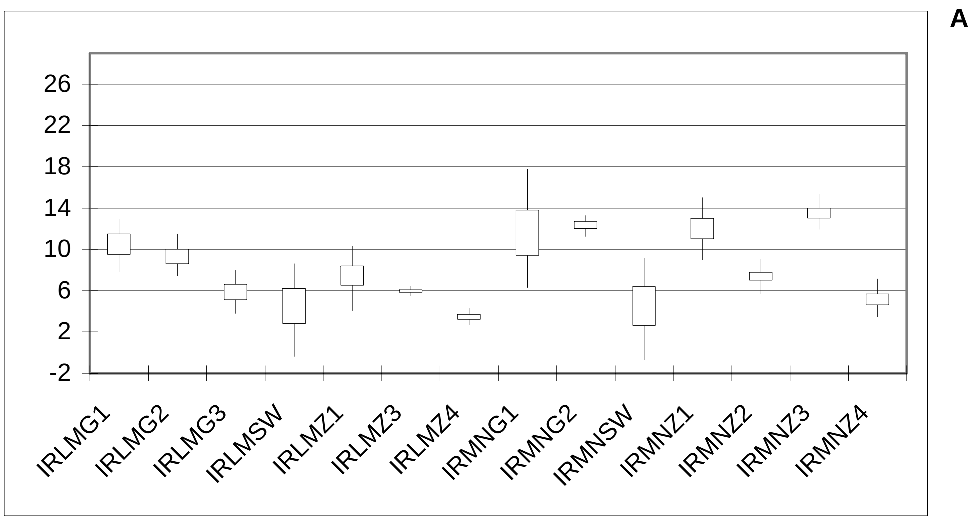


Figure E7. Mean, Range and approximate 99% confidence interval (3 x Std. Dev.) for Total Phosphate measurements (mg/L) at Indian River Lagoon (A) and St. Lucie River (B) sites.



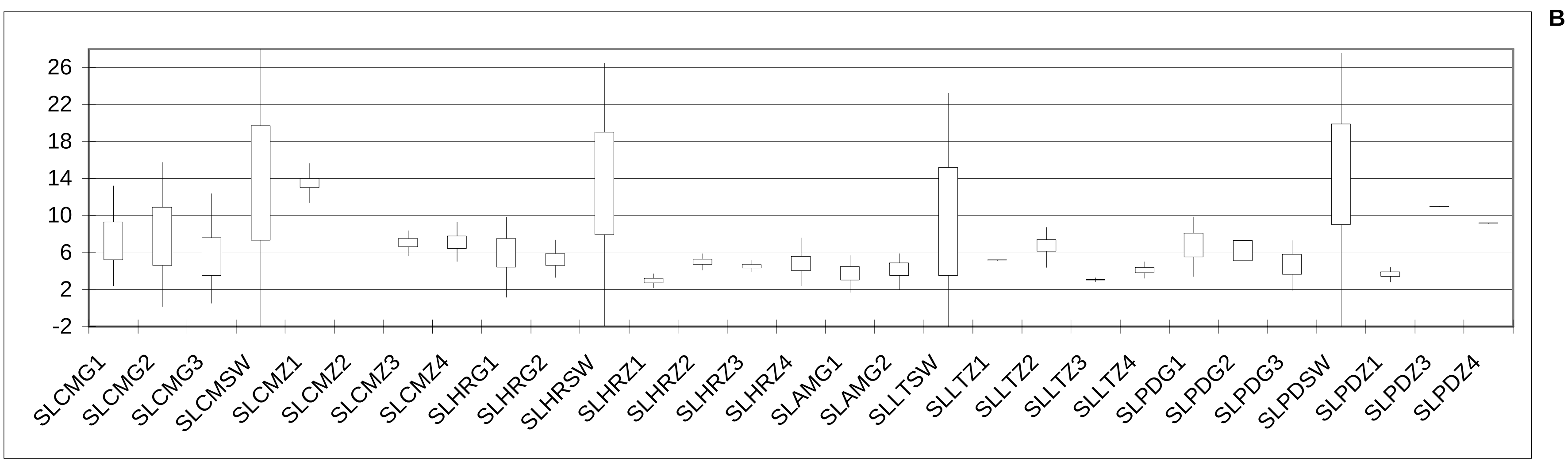
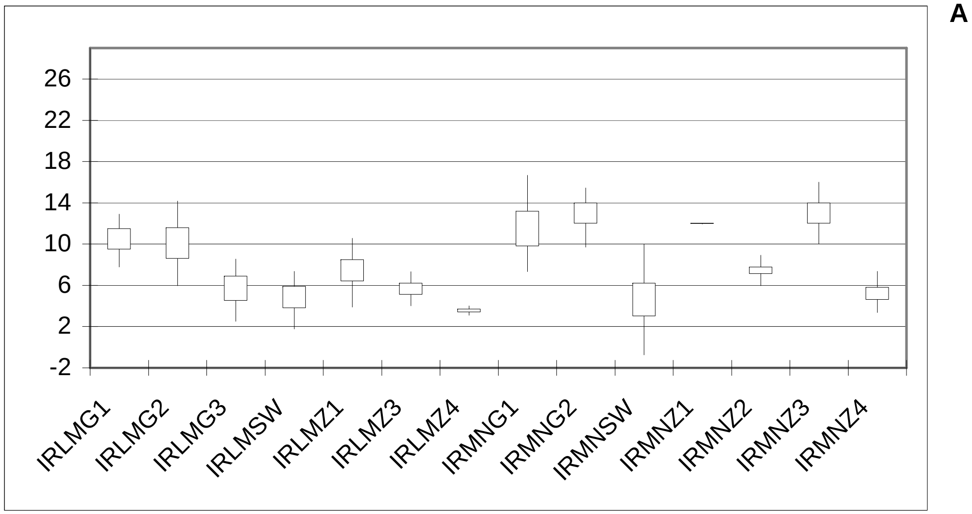


Figure E8. Mean, Range and approximate 99% confidence interval (3 x Std. Dev.) for Dissolved Organic Carbon measurements (mg/L) at Indian River Lagoon (A) and St. Lucie River (B) sites.



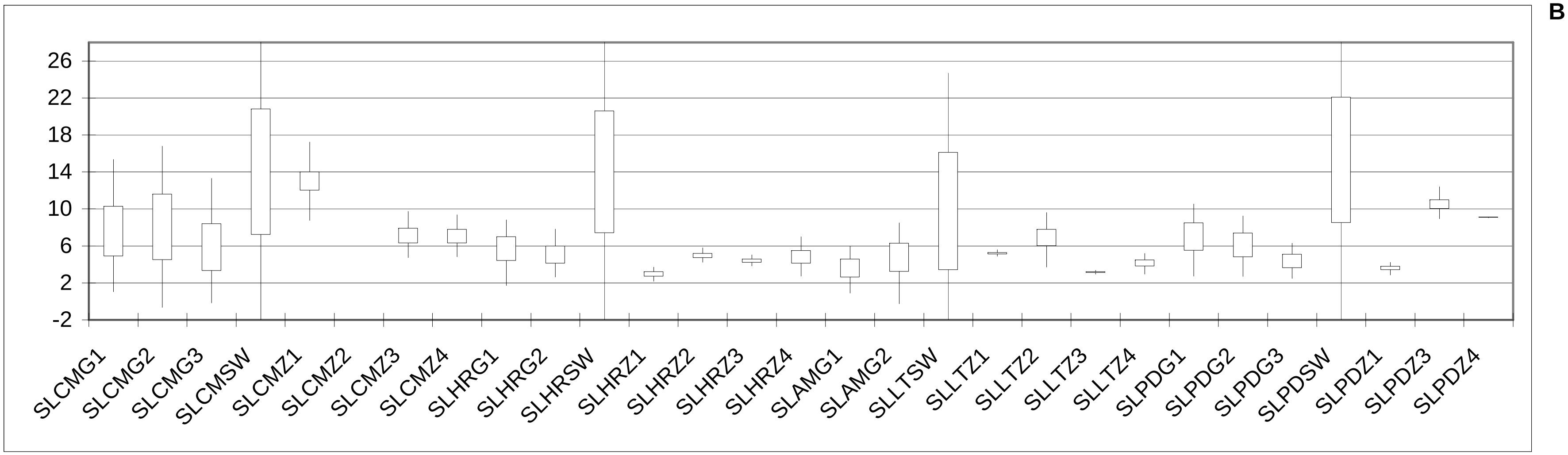
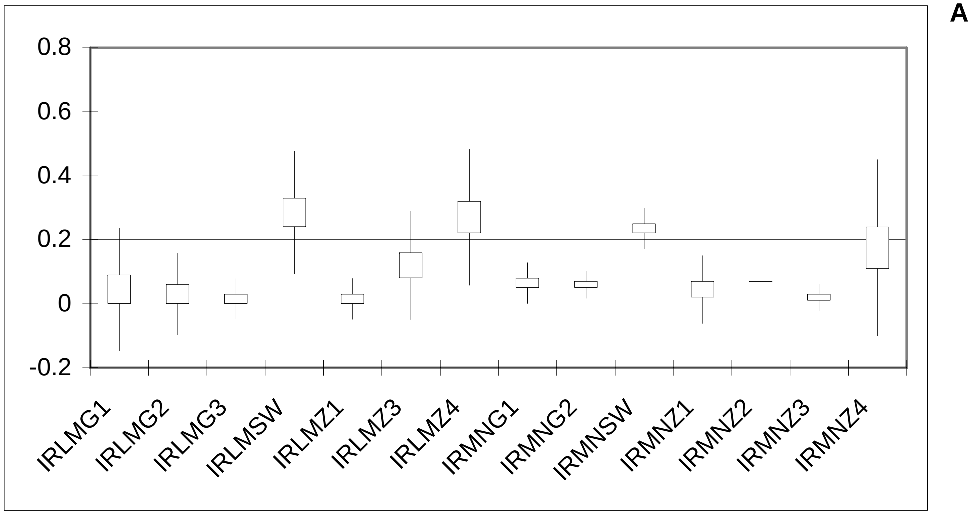


Figure E9. Mean, Range and approximate 99% confidence interval (3 x Std. Dev.) for Total Organic Carbon measurements (mg/L) at Indian River Lagoon (A) and St. Lucie River (B) sites.



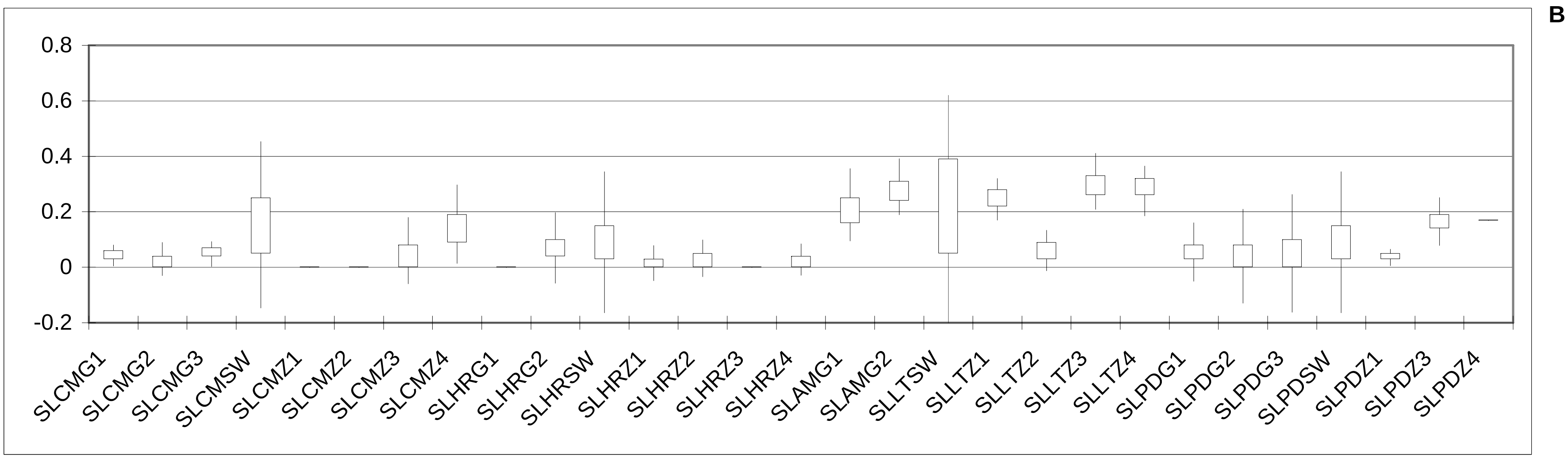


Figure E10 Mean, Range and approximate 99% confidence interval (3 x Std. Dev.) for MBAS measurements (mg/L) at Indian River Lagoon (A) and St. Lucie River (B) sites.