SURVEYOR'S REPORT

Specific Purpose Survey of Wells and Other Features

Tree Island 3AS3

Miami-Dade County, Florida

South Florida Water Management District's

Purchase Order number 4500003040

Keith and Schnars project number 16434.00,

Task 22168

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SURVEYOR'S CERTIFICATION

I hereby certify that this report of Specific Purpose Survey and the accompanying map entitled "Map of a Specific Purpose Survey of Tree Island 3AS3" and dated September 10, 2007, meet applicable portions of the Minimum Technical Standards set forth by the Florida Board of Professional Surveyors and Mappers in Chapter 61-G17, Florida Administrative Code. This report and the map are prepared for the sole and specific use of the South Florida Water Management District and are not assignable.

KEITH and SCHNARS, PA.
L.B. number 1337

By: _____
Loren J. Gibson
Professional Surveyor and Mapper
State of Florida License No. LS6510

Date of Survey:
August 1, 2007

SURVEYOR'S REPORT

PURPOSE

This survey was performed to provide certain horizontal and vertical position information on several wells and other features in the vicinity of Tree Island 3AS3, as well as elevations of the surface of the muck and of the relatively impermeable ground surface beneath the muck. The elevations obtained by this survey are intended to reduce the uncertainty of the differences in elevation among the wells at Tree Island 3AS3.

LOCATION OF PROJECT

Tree Island 3AS3 is located in Miami-Dade County, Florida, approximately 35 miles west of downtown Miami, Florida, and 7 miles north of Tamiami Trail (State Road 41) at that road's point of closest approach to the site.

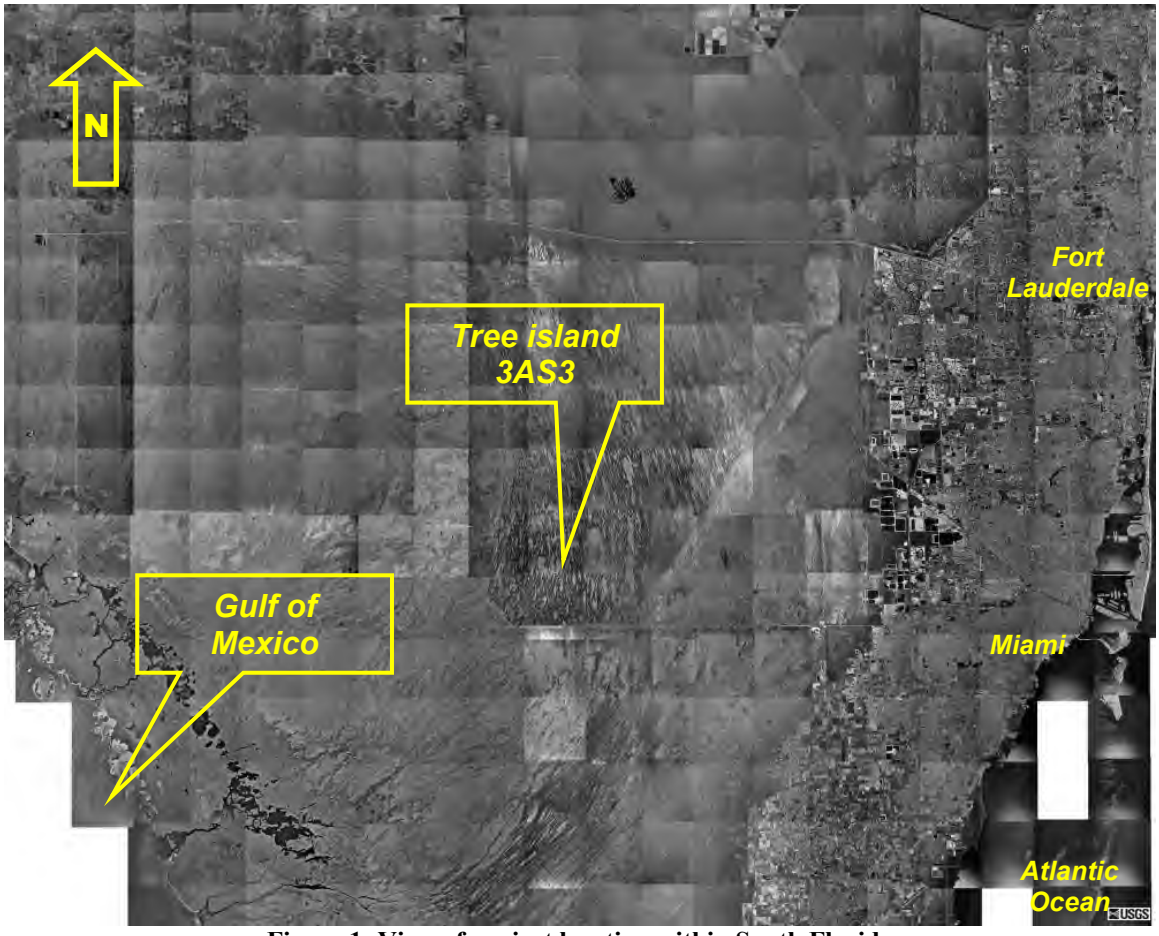

Figure 1: View of project location within South Florida

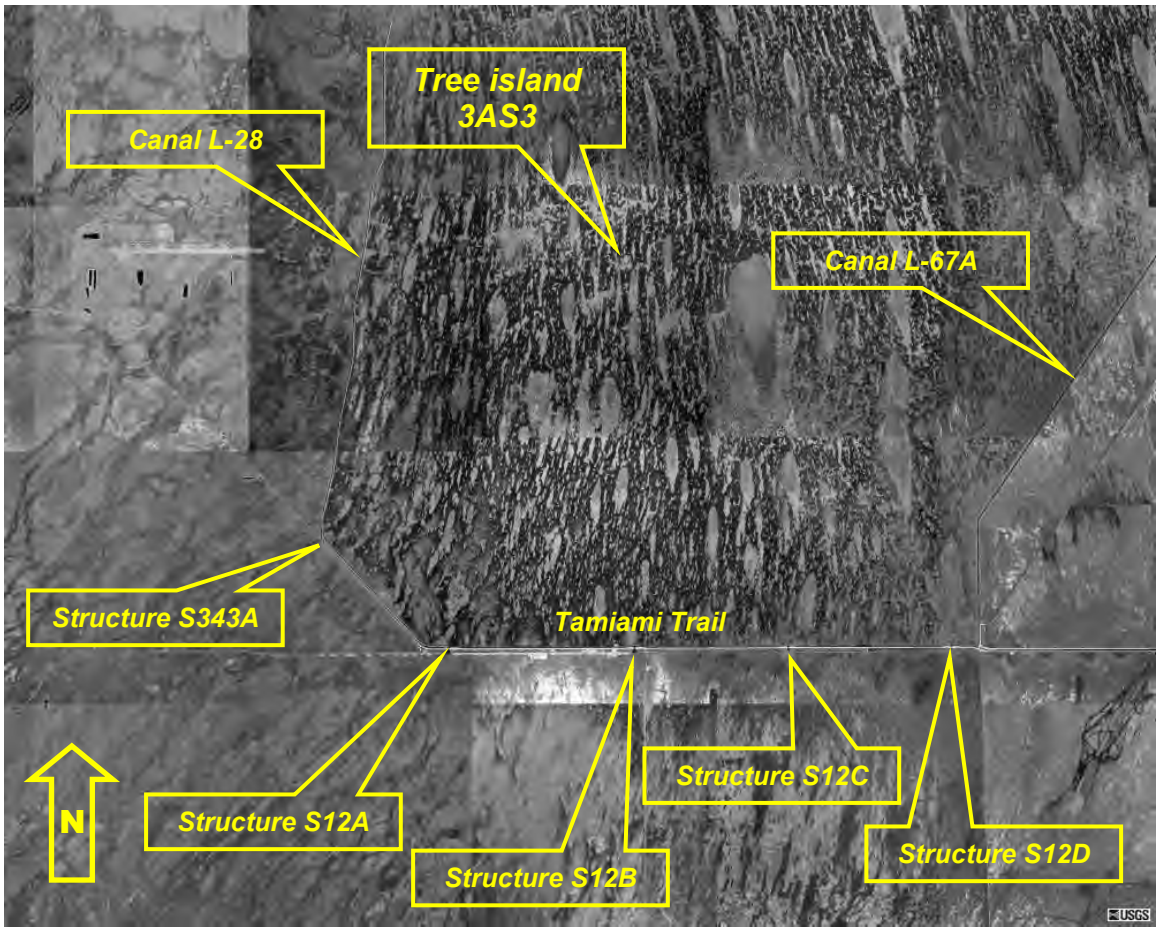

Figure 2: General location of project site (with some nearby features labeled)

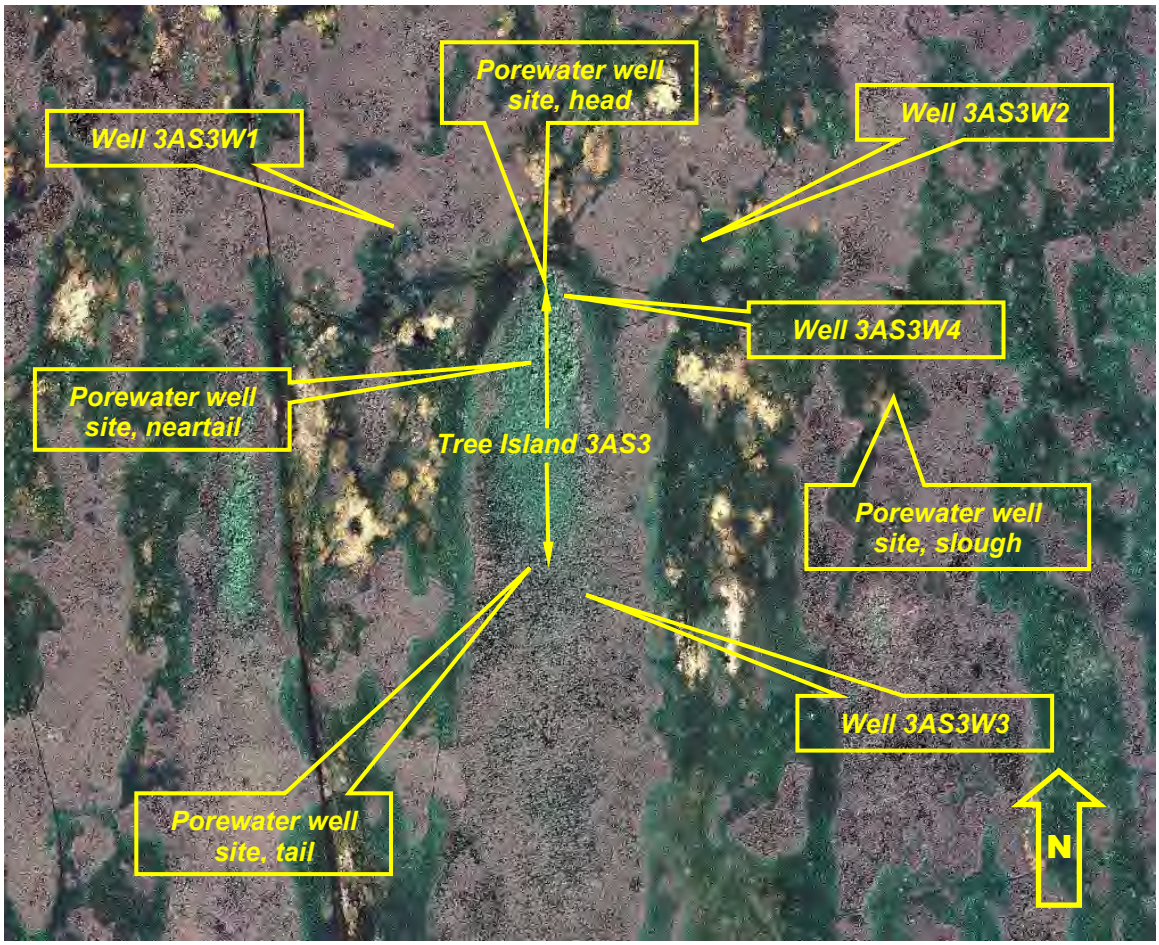

Figure 3: View of site showing approximate positions of major well sites

ADDITIONAL ITEMS DELIVERED TO THE DISTRICT

In conjunction with this formal report, the following items are being delivered to SFWMD:

1. A three-sheet map of this specific purpose survey dated August 30, 2007, and entitled "MAP OF A SPECIFIC PURPOSE SURVEY OF TREE ISLAND 3AS3." That map and this document together constitute the formal report of this specific purpose survey.
2. This report in digital form (PDF format and Microsoft® Office Word format, created with Microsoft® Office Word 2003).
3. Electronic copies (PDF format) of all field notes.
4. Electronic copies of all computation sheets.
5. Autocad® 2004-format CAD file and a PDF format digital file of the three-sheet map (no. 1, above).
6. CORPSMET 95 file.
7. Site photographs.

DATUMS FOR THE PROJECT

Elevations are set out in this report with respect to the North American Vertical Datum of 1988 (NAVD 88) and the National Geodetic Vertical Datum of 1929 (NGVD 29). NAVD 88 elevations were determined by differential leveling (see **LEVELING METHODS**, below) from bench mark 3AS3-GW1, the stainless steel rod monument at well cluster 3AS3W1, located off the northwest side of the tree island. The elevation adopted for 3AS3-GW1 was 2.95 meters (9.678 feet) above NAVD 88. This value was provided by the South Florida Water Management District (data file name *West_Isl.xls*).

Since no published NGVD 29 elevations were available at the site, NGVD 29 elevations have been derived from the NAVD 88 elevations by means of applying a site-wide, uniform datum shift, or offset value, of -0.456 meter (-1.496 feet). The sense of the algebraic sign of this value is NAVD 88 elevation minus NGVD 29 elevation. This value was obtained from the NGS VERTCON model and was computed by both the NGS VERTCON Online web site (*http://www.ngs.noaa.gov/TOOLS/Vertcon/vertcon.html*, accessed May 2007, version 2.0) and by means of the software CORPSCON version 6.0.1 (which itself uses the NGS-developed VERTCON software). This modeled geoid height value is that computed for the latitude and longitude of the approximate center of the tree island.

The horizontal datum used for this survey is the North American Datum of 1983 (NAD 83), and positions are alternatively expressed as geodetic latitude and longitude with respect to that datum or as Cartesian coordinates in the state plane coordinate system, eastern zone for the State of Florida, as defined by NGS. SFWMD provided positions with respect to NAD 83 on several control stations on site. Unless otherwise noted elsewhere in this report, the stations that were used when measuring the horizontal positions of the site features are designated 3AS3-GW1 (the same station noted above as the controlling bench mark) and 3AS3-GW2 (another stainless steel rod monument, at well cluster 3AS3W2). See the section **HORIZONTAL POSITIONS** below for details of the determination of horizontal position of features.

The conversion between meters and feet for this project was governed by the definition of the U.S. Survey Foot: 1200 meters = 3937 U.S. Survey Feet, exactly.[1]

LEVELING METHODS

Three closed 3-wire differential leveling segments were run in order to support the determination of elevations of the features at the site. The first run was a closed circuit which began and ended at bench mark 3AS3-GW1 (field book 1245, p. 2), and had a misclosure of 0.003 feet in magnitude. This loop went through (and thus determined the

[1] An equivalent definition was codified into law in the United States by the Metric Act of 1866, and despite the adoption of the "International foot" conversion since then for other purposes, this remains the convention for much surveying practice in the United States. See, for example, Florida Statues Chapter 177.091(19) for an equivalent definition (available online at *http://www.leg.state.fl.us/statutes/index.cfm?App_mode=Display_Statute&URL=Ch0177/ch0177.htm*).

elevation of) bench mark TREE W N, and also included a temporary bench mark (denoted in the field notes as "TP3") which served to extend elevation control into other areas of the site.

The second leveling run (field book 3, pp. 3–7) began at "TP3" (from the first run), and closed upon bench mark 3AS3-GW1, and the magnitude of misclosure was 0.031 feet. This run included the stainless steel rod bench marks 3AS3-GW2 and 3AS3-GW3, the northwest bolt of the weather station tower's base, and several other turning points which served as additional temporary bench marks for further leveling work.

The third run (field book 1245, pp. 17–18) was a closed loop which started on and closed on the stainless steel rod bench mark TREE W N (whose elevation was obtained from the first loop) and had a misclosure of 0.000 feet in magnitude. This level loop included bench mark TREE W C.

The misclosures of all three level runs were within the client-specified allowable error of closure of ± 0.03 feet $\sqrt{M}$, where M is the length of the loop in miles. Additionally, all loops met the misclosure standard for third order leveling as published by the National Geodetic Survey (NGS),[2] which is defined as ± 12 mm $\sqrt{K}$, where K is the length of the loop in kilometers. (This is equivalent to ± 0.050 feet $\sqrt{M}$, where M is the length of the loop in miles.)

The adjusted elevations from the 3-wire leveling operations were used for subsequent closed single-wire differential leveling operations to determine elevations of the remaining features at the site.

ACCURACY OF DERIVED DIFFERENCES IN ELEVATION

The elevations of the several wells in each of the four major well clusters (3AS3W1, 3AS3W2, 3AS3W3, and 3AS3W4) are set out later in this report (see Table 5). From those tabulated elevations, one can compute the difference in elevation between two given wells taken from two clusters. Due to the measurement process, there is an inherent uncertainty in the value of such a measured difference in elevation. The estimated standard errors of the differences in elevation derived (by subtraction) from the elevations set out in this report are as follows:

- Elevation differences between wells at 3AS3W1 and 3AS3W2: 0.01 foot
- Elevation differences between wells at 3AS3W1 and 3AS3W3: 0.01 foot
- Elevation differences between wells at 3AS3W1 and 3AS3W4: 0.01 foot
- Elevation differences between wells at 3AS3W2 and 3AS3W3: 0.01 foot
- Elevation differences between wells at 3AS3W2 and 3AS3W4: 0.01 foot
- Elevation differences between wells at 3AS3W3 and 3AS3W4: 0.01 foot

[2] Federal Geodetic Control Committee, *Standards and Specifications for Geodetic Control Networks*, September 1984.

These estimated standard errors can be scaled by appropriate expansion factors to obtain uncertainties at other desired confidence intervals, in accordance with the principles of univariate probability and statistics. For example, multiply the standard errors by 1.96 to obtain the uncertainties at the 95% confidence interval. These values represent "plus-or-minus" uncertainties in the differences in elevation between pairs of features. For example, from Table 5 (below) the NAVD 88 elevations of wells 3AS3W1-GW3 and 3AS3W3-GW3 are 9.68 feet and 10.31 feet, respectively. This implies a difference in elevation between the two of 0.63 foot, with 3AS3W3-GW3 being the higher of the two. The estimated standard error of this value is (from the list above) 0.01 foot, and the 95% confidence interval uncertainty would be 0.02 foot. This means that at the 95% confidence interval, the difference in elevation between those two wells lies within the interval 0.61'–0.65', which is ±0.02 foot on each side of the derived value of 0.61 foot.

Appendix D contains a brief description of the computational procedure used to obtain the estimated standard errors reported above.

GROUND ELEVATION DETERMINATION

At the several well sites on and around Tree Island 3AS3, elevations of the "natural ground" (*i.e.*, the top of the muck and organic material) and of the "top of rock" (the hard, more impermeable ground surface beneath the layer of muck) were obtained. The field staff attempted to obtain accurate top of muck elevations by gently setting the shoe of a leveling staff or prism pole (so named for the corner-cube prism target that it carries) onto the material at a location which appeared to be undisturbed, as best as could be judged by visual means. The shoe of the leveling rods used have an approximately rectangular-shaped cross section approximately 1.0 inch by 2.5 inches in size. For one location, the natural ground shot at the porewater well site in the slough (east and north of the tree island), a prism pole was used with an electronic total station to obtain the ground elevation. The bottom of the prism pole was fitted with a flat circular shoe with a diameter of about 2.5 inches. The leveling rod and prism pole feet are illustrated below.

Figure 4: Foot of leveling staff

Figure 5: Side view of the prism pole shoe used for ground elevation measurement

Figure 6: Bottom view of prism pole shoe

In conjunction with measuring the elevation of the top of the layer of organic material, the elevation of the hard ground was estimated by driving a steel rod (typically about eight feet long) with hammer blows until refusal; *i.e.*, until such time as additional hammer blows did not result in driving the rod further into the ground. The elevation of the top of the rod, so driven, was measured, then the known length of the rod used was subtracted from that elevation to obtain the elevation of the hard ground surface at that location.

HORIZONTAL POSITIONS

Most of the measured horizontal positions were determined by means of a Leica TC805 electronic total station with electronic data collection hardware and software (TDS Survey Pro version 4.2 on a TDS Ranger data collector), based on published horizontal positions of stations GW1 and GW2 (field book 1245, p. 19 and accompanying electronic data files named *tree island 16434.**). Several positions were computed from manually recorded angles and distances measured with the total station (field book 1245, pp. 23, 26). Exceptions to the use of the total station will be detailed in the results table below.

RESULTS: LEVELING ON WELL CLUSTERS 3AS3W1, 3AS3W2, 3AS3W3, 3AS3W4

Tabulations of the elevations and other data obtained for the four principal well clusters follow (3AS3W1 to the northwest, 3AS3W2 to the northeast, 3AS3W3 to the south, and 3AS3W4 in the island's "head"). For each well group, a set of differences between elevation values obtained by Keith and Schnars in 2007 and previously obtained

elevation values (recorded on the apparatus on site) is shown. Elevations were determined by means of direct differential leveling using a Wild NA2 automatic optical level.

WELL CLUSTER 3AS3W1

Table 1: Revised elevation values, well cluster 3AS3W1 (northwest side of island)

Well name or other designation	***Existing FDEP elevation (NGVD 29)*** *(1)*	***Existing FDEP elevation (NAVD 88)*** *(2)*	***K&S measured elevation (4/18/07) for this report (NGVD 29)*** *(3)*	***K&S measured elevation (4/18/07) for this report (NAVD 88)*** *(4)*	***Difference (K&S minus FDEP, both datums)*** *(5)*
3AS3W1 ("X" reference mark)	16.18	14.68	16.15	14.65	-0.03
3AS3W1 GW1 (2" PVC ground water well)	14.49	12.99	14.48	12.98	-0.01
3AS3W1 GW2 (3/4" PVC piezometric well)	14.50	13.00	14.50	13.00	0.00
Natural ground (top of muck/organic material)	N/A	N/A	8.4	6.9	N/A
Top of rock	N/A	N/A	4.6	3.1	N/A
Staff gauge (12.00 foot graduation)	12.00	10.50	11.98	10.48	-0.02
FDEP BM GW1 (stainless steel rod)	11.17	9.68	11.17	9.68	0.00

All values shown in Table 1 are in units of feet. The values in the five columns are derived as follows:

Column (1) values are marked on the apparatus on site.

Column (2) values are the respective column (1) values plus the datum offset of -1.496 feet.

Column (3) values are derived from differential leveling observations conducted between April 10, 2007, through April 30, 2007, with this particular cluster being observed on April 18, 2007 (Keith and Schnars field book 1245, p. 8).

Column (4) values are the respective column (3) values plus the datum offset of -1.496 feet.

Column (5) values are obtained by subtracting column (1) values from the corresponding column (3) values; equivalently column (4) values minus column (2) values.

The approximate NAD83 latitude and longitude of well cluster 3AS3W1 is 25º51'26"N, 80º46'17"W, determined by autonomous GPS with a hand-held GPS receiver.

WELL CLUSTER 3AS3W2

Table 2: Revised elevation values, well cluster 3AS3W2 (northeast side of island)

Well name or other designation	*Existing FDEP elevation (NGVD 29)* (1)	*Existing FDEP elevation (NAVD 88)* (2)	*K&S measured elevation (4/18/07) for this report (NGVD 29)* (3)	*K&S measured elevation (4/18/07) for this report (NAVD 88)* (4)	*Difference (K&S minus FDEP, both datums)* (5)
3AS3W2 ("X" reference mark)	16.015	14.519	16.05	14.55	0.04
3AS3W2 GW1 (2" PVC ground water well)	15.975	14.479	16.01	14.51	0.04
3AS3W2 GW2 (3/4" PVC piezometric well)	15.990	14.494	16.00	14.50	0.01
Natural ground (top of muck/organic material)	N/A	N/A	8.1	6.6	N/A
Top of rock	N/A	N/A	4.8	3.3	N/A
FDEP BM 3AS3-GW2 (stainless steel rod)	10.42	8.92	10.46	8.96	0.04

All values shown in Table 2 are in units of feet. The values in the five columns are derived as follows:

Column (1) values are marked on the apparatus on site.

Column (2) values are the respective column (1) values plus the datum offset of -1.496 feet.

Column (3) values are derived from differential leveling observations conducted between April 10, 2007, through April 30, 2007, with this particular cluster being observed on April 18, 2007 (Keith and Schnars field book 1245, p. 9).

Column (4) values are the respective column (3) values plus the datum offset of -1.496 feet.

Column (5) values are obtained by subtracting column (1) values from the corresponding column (3) values; equivalently column (4) values minus column (2) values.

The approximate NAD83 latitude and longitude of well cluster 3AS3W2 is 25º51'25"N, 80º46'04"W, determined by autonomous GPS with a hand-held GPS receiver.

WELL CLUSTER 3AS3W3

Table 3: Revised elevation values, well cluster 3AS3W3 (south side of island)

Well name or other designation	*Existing FDEP elevation (NGVD 29)* (1)	*Existing FDEP elevation (NAVD 88)* (2)	*K&S measured elevation (4/18/07) for this report (NGVD 29)* (3)	*K&S measured elevation (4/18/07) for this report (NAVD 88)* (4)	*Difference (K&S minus FDEP, both datums)* (5)
3AS3W3 ("X" reference mark)	16.14	14.64	16.21	14.71	0.07
3AS3W3 GW1 (2" PVC ground water well)	16.14	14.64	16.21	14.71	0.07
3AS3W3 GW2 (3/4" PVC piezometric well)	16.13	14.63	16.20	14.70	0.07
Natural ground (top of muck/organic material)	N/A	N/A	8.9	7.4	N/A
Top of rock	N/A	N/A	3.3	1.8	N/A
FDEP BM 3AS3-GW3 (stainless steel rod)	11.74	10.24	11.81	10.31	0.07

All values shown in Table 2 are in units of feet. The values in the five columns are derived as follows:

Column (1) values are marked on the apparatus on site.

Column (2) values are the respective column (1) values plus the datum offset of -1.496 feet.

Column (3) values are derived from differential leveling observations conducted between April 10, 2007, through April 30, 2007, with this particular cluster being observed on April 18, 2007 (Keith and Schnars field book 1245, p. 11).

Column (4) values are the respective column (3) values plus the datum offset of -1.496 feet.

Column (5) values are obtained by subtracting column (1) values from the corresponding column (3) values; equivalently column (4) values minus column (2) values.

The approximate NAD83 latitude and longitude of well cluster 3AS3W3 is 25º51'12"N, 80º46'09"W, determined by autonomous GPS with a hand-held GPS receiver.

WELL CLUSTER 3AS3W4

Table 4: Revised elevation values, well cluster 3AS3W4 (on island's "head")

Well name or other designation	*Existing FDEP elevation (NGVD 29)* *(1)*	*Existing FDEP elevation (NAVD 88)* *(2)*	*K&S measured elevation (4/18/07) for this report (NGVD 29)* *(3)*	*K&S measured elevation (4/18/07) for this report (NAVD 88)* *(4)*	*Difference (K&S minus FDEP, both datums)* *(5)*
3AS3W4 ("X" reference mark)	N/A	N/A	15.79	14.29	N/A
3AS3W4 GW1 (2" PVC ground water well)	15.682	14.186	15.75	14.25	0.07
3AS3W4 GW2 (3/4" PVC piezometric well)	15.682	14.186	15.75	14.25	0.07
Natural ground (top of muck/organic material)	N/A	N/A	10.3	8.8	N/A
Top of rock	N/A	N/A	6.2	4.7	N/A
FDEP BM TREE W N (stainless steel rod)	12.172	10.676	12.26	10.76	0.09

All values shown in Table 2 are in units of feet. The values in the five columns are derived as follows:

Column (1) values are marked on the apparatus on site.

Column (2) values are the respective column (1) values plus the datum offset of -1.496 feet.

Column (3) values are derived from differential leveling observations conducted between April 10, 2007, through April 30, 2007, with this particular cluster being observed on April 18, 2007 (Keith and Schnars field book 1245, p. 16).

Column (4) values are the respective column (3) values plus the datum offset of -1.496 feet.

Column (5) values are obtained by subtracting column (1) values from the corresponding column (3) values; equivalently column (4) values minus column (2) values.

RESULTS: HORIZONTAL POSITIONS AND ELEVATIONS

The following table sets out the following information for the FIU wells, SFWMD wells, and other features at Tree Island 3AS3:

1. Horizontal positions expressed in NAD 83 geodetic latitude and longitude and in northing and easting coordinates (units of U.S. Survey Feet) in the Florida State Plane Coordinate System, East zone, NAD 83.
2. Elevations of the reference mark on wells and other features. The units are in feet and set out with respect to both vertical datums (NGVD 29 and NAVD 88).
3. Elevations of the "soft" ground (top of muck/organic material) and of the "hard" ground (the rock or other impermeable ground at the bottom of the muck). Elevations are again in units of feet above NGVD 29 and NAVD 88.

The horizontal positions of the stainless steel rod monuments 3AS3-GW1, 3AS3-GW2, 3AS3-GW3, and 3AS3-GW4 are taken from a Microsoft® Excel spreadsheet file named *West_Isl 6-11-2003 control.xls* furnished by SFWMD. Coordinate values in units of meters in that spreadsheet were converted to units of U.S. Survey Feet and to NAD 83 geodetic latitude and longitude for the table below. All other horizontal positions set out are measured positions. For the water sample site (latitude 25°51'04.82" N, longitude 080°46'00.69" W), the position was provided also by the SFWMD and, for purposes of measuring the elevation of the ground, the field crew navigated to the site by means of a hand-held autonomous GPS receiver to an expected accuracy of approximately 5 meters. (No structure or other marker occupies the site; its location is defined by that latitude and longitude.) The horizontal position of weather station 3AS3WX was provided by SFWMD. The remaining measured horizontal positions, which includes all of the FIU wells, the porewater wells, two SET's, and the HOBO water level gauge, were determined by electronic total station observations from stainless steel rod monuments 3AS3-GW1 and 3AS3-GW2.

Ordinarily one set of hard/soft ground elevations was obtained at the site of each well "cluster," *e.g.*, one hard/soft elevation pair was obtained at the site of adjacent FIU wells N1D and N1S. Any entry of "N/A" in the table means that the data was not obtained.

For well clusters 3AS3W1, 3AS3W2, 3AS3W3, and 3AS3W4, there are ¾-inch and 2-inch PVC well casings (among other features), and these two types of casings are labeled as piezometric wells and ground water wells in the table, respectively.

Table 5: Horizontal positions and elevations

Designation	NAD 83 latitude (north)	NAD 83 longitude (west)	State plane coordinate (northing/Y, U.S. Survey Feet)	State plane coordinate (easting/X, U.S. Survey Feet)	Reference mark elevation (NGVD 29, feet)	Reference mark elevation (NAVD 88, feet)	Hard ground elevation (NGVD 29, feet)	Hard ground elevation (NAVD 88, feet)	Soft ground elevation (NGVD 29, feet)	Soft ground elevation (NAVD 88, feet)	Description
N1D	25° 51' 22.905"	80° 46' 11.710"	553551.5	731828.4	12.42	10.92	5.7	4.2	9.5	8.0	FIU well
N1S	25° 51' 22.922"	80° 46' 11.707"	553553.2	731828.7	13.09	11.59					FIU well
N2D	25° 51' 22.875"	80° 46' 11.452"	553548.4	731852.0	12.06	10.56	6.1	4.6	8.9	7.4	FIU well
N2S	25° 51' 22.900"	80° 46' 11.450"	553551.0	731852.2	13.13	11.63					FIU well
N3D	25° 51' 22.830"	80° 46' 10.882"	553544.0	731904.1	11.92	10.42	6.5	5.0	8.9	7.4	FIU well
N3S	25° 51' 22.854"	80° 46' 10.878"	553546.5	731904.4	12.87	11.37					FIU well
N4D	25° 51' 22.944"	80° 46' 10.262"	553555.7	731960.7	12.17	10.67	6.1	4.6	9.1	7.6	FIU well
N4S	25° 51' 22.959"	80° 46' 10.255"	553557.2	731961.4	13.23	11.73					FIU well
N5D	25° 51' 22.951"	80° 46' 09.986"	553556.4	731985.9	11.75	10.25	6.4	4.9	9.2	7.7	FIU well
N5S	25° 51' 22.972"	80° 46' 09.990"	553558.5	731985.6	13.06	11.56					FIU well
S6D	25° 51' 20.805"	80° 46' 11.940"	553339.4	731807.9	12.44	10.94	6.2	4.7	9.2	7.7	FIU well
S6S	25° 51' 20.826"	80° 46' 11.939"	553341.5	731807.9	13.29	11.79					FIU well
S7D	25° 51' 20.822"	80° 46' 11.665"	553341.2	731832.9	12.23	10.73	6.1	4.6	9.1	7.6	FIU well
S7S	25° 51' 20.844"	80° 46' 11.677"	553343.4	731831.8	13.37	11.87					FIU well
S8D	25° 51' 20.769"	80° 46' 10.564"	553336.0	731933.6	12.36	10.86	6.1	4.6	9.5	8.0	FIU well
S8S	25° 51' 20.783"	80° 46' 10.552"	553337.4	731934.7	13.52	12.02					FIU well
S9D	25° 51' 20.737"	80° 46' 09.450"	553332.9	732035.3	11.87	10.37	5.5	4.0	9.0	7.5	FIU well
S9S	25° 51' 20.767"	80° 46' 09.456"	553336.0	732034.7	12.99	11.49					FIU well
S10D	25° 51' 20.753"	80° 46' 09.236"	553334.6	732054.8	11.93	10.43	5.0	3.5	8.9	7.4	FIU well
S10S	25° 51' 20.780"	80° 46' 09.226"	553337.4	732055.8	13.33	11.83					FIU well
X11D	25° 51' 24.227"	80° 46' 10.644"	553685.1	731925.6	12.39	10.89	6.3	4.8	9.6	8.1	FIU well
X11S	25° 51' 24.227"	80° 46' 10.690"	553685.1	731921.4	13.24	11.74					FIU well
X12D	25° 51' 23.981"	80° 46' 10.704"	553660.3	731920.2	13.80	12.30	5.5	4.0	10.8	9.3	FIU well
X12S	25° 51' 23.992"	80° 46' 10.723"	553661.3	731918.5	14.63	13.13					FIU well
3AS3slough 10–30	25° 51' 19.681"	80° 46' 00.401"	553227.8	732862.1	11.50	10.00	2.4	0.9	7.9	6.4	Porewater well
3AS3slough 40–50	25° 51' 19.688"	80° 46' 00.455"	553228.5	732857.1	12.79	11.29					Porewater well
3AS3slough SET	25° 51' 19.611"	80° 46' 00.456"	553220.8	732857.1	9.24	7.74					SET
3AS3head 10-30	25° 51' 23.911"	80° 46' 10.611"	553653.3	731928.7	14.39	12.90	5.9	4.4	10.3	8.8	Porewater well
3AS3head 40-50	25° 51' 23.936"	80° 46' 10.592"	553655.7	731930.4	15.54	14.04					Porewater well
3AS3neartail 10-30	25° 51' 20.873"	80° 46' 10.953"	553346.4	731898.0	12.60	11.10	6.4	4.9	9.1	7.6	Porewater well
3AS3neartail 40-50	25° 51' 20.842"	80° 46' 10.949"	553343.3	731898.3	14.08	12.58					Porewater well
3AS3neartail SET	25° 51' 20.985"	80° 46' 11.042"	553357.8	731889.8	10.92	9.42					SET
3AS3neartail HOBO	25° 51' 21.005"	80° 46' 11.124"	553359.7	731882.3	15.47	13.97					HOBO water level gauge
3AS3tail 10-30	25° 51' 12.915"	80° 46' 10.327"	552543.1	731956.5	12.37	10.87	4.9	3.4	8.8	7.3	Porewater well
3AS3tail 40-50	25° 51' 12.990"	80° 46' 10.273"	552550.7	731961.5	13.62	12.12					Porewater well
Surface water sampling location southeast of island (no marker)	25° 51' 04.82"	80° 46' 00.69"	551727.4	732838.4	N/A	N/A	4.0	2.5	12.4	10.9	Water sample site (navigated to site by autonomous GPS)
3AS3W1 (well)	(Adjacent to FDEP survey monument 3AS3-GW1; monument position has been published by FDEP)				16.15	14.65	4.6	3.1	8.4	6.9	Surface water well/reference mark in box at top of well
3AS3W1 GW1					14.48	12.98					Ground water well
3AS3W1 GW2					14.50	13.00					Piezometric well
3AS3-GW1	25° 51' 26.33741"	80° 46' 16.98942"	553897.156	731345.601	11.17	9.68					Stainless steel rod monument
3AS3W2	(Adjacent to FDEP survey monument 3AS3-GW2; monument position has been published by FDEP)				16.05	14.55	4.8	3.3	8.1	6.6	Reference mark in box at top of well
3AS3W2 GW1					16.01	14.51					Ground water well
3AS3W2 GW2					16.00	14.50					Piezometric well
3AS3-GW2	25° 51' 25.48582"	80° 46' 04.28270"	553813.216	732506.468	10.46	8.96					Stainless steel rod monument
3AS3W3	(Adjacent to FDEP survey monument 3AS3-GW3; monument position has been published by FDEP)				16.21	14.71	3.3	1.8	8.9	7.4	Reference mark in box at top of well
3AS3W3 GW1					16.21	14.71					Ground water well
3AS3W3 GW2					16.20	14.70					Piezometric well
3AS3-GW3	25° 51' 11.64563"	80° 46' 08.82616"	552415.202	732093.893	11.81	10.31					Stainless steel rod monument
3AS3W4	(Adjacent to FDEP survey monument TREE W N; monument position has been published by FDEP)				15.79	14.29	6.2	4.7	10.3	8.8	Reference mark in box at top of well
3AS3W4 GW1					15.75	14.25					Ground water well
3AS3W4 GW2					15.75	14.25					Piezometric well
TREE W N	25° 51' 23.67630"	80° 46' 10.45346"	553629.537	731943.110	12.26	10.77					Stainless steel rod monument (at 3AS3W4 well cluster)
TREE W C	25° 51' 20.92342"	80° 46' 11.06773"	553351.513	731887.485	11.72	10.23	N/A	N/A	N/A	N/A	Stainless steel rod monument (near the neartail SET markers)
3AS3WX	25° 51' 06.215"	80° 45' 58.543"	551868.6	733034.3	13.24	11.74	N/A	N/A	N/A	N/A	Weather station; elevation is on northwest bolt of tower base

APPENDIX A: ABBREVIATIONS

BM: Bench mark
FDEP: Florida Department of Environmental Protection
FIU: Florida International University
GPS: Global Positioning System (*i.e.*, the U.S. Department of Defense satellite-based navigation and time transfer system)
K&S: Keith and Schnars
L.B.: Licensed surveying and mapping business
N/A: Not applicable
NAD 83: North American Datum of 1983
NAVD 88: North American Vertical Datum of 1988
NGS: National Geodetic Survey
NGVD 29: National Geodetic Vertical Datum of 1929
PVC: Polyvinyl chloride
SET: Sediment Erosion Table
SFWMD: South Florida Water Management District

APPENDIX B: DIAGRAM OF FIU WELL DESIGNATIONS AND LOCATIONS

The figure below is a reproduction of a diagram furnished by SFWMD showing approximate locations of the several FIU wells on the site of Tree Island 3AS3. (Accurate locations are set out in Table 5 in this report.)

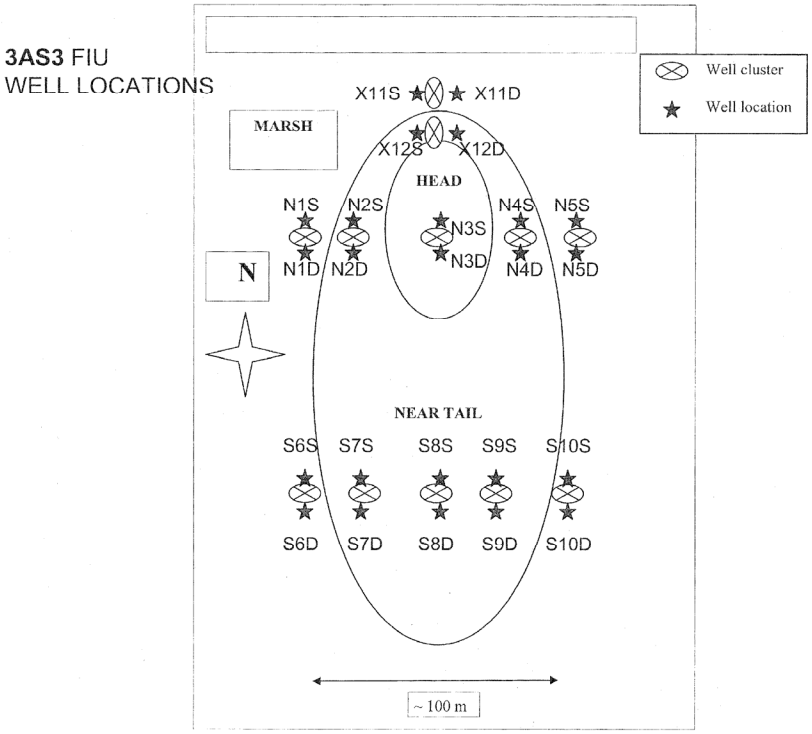

Figure 7: FIU well location diagram

APPENDIX C: PHOTOGRAPHS

Below appears a subset of the photographs taken at the site during this survey.

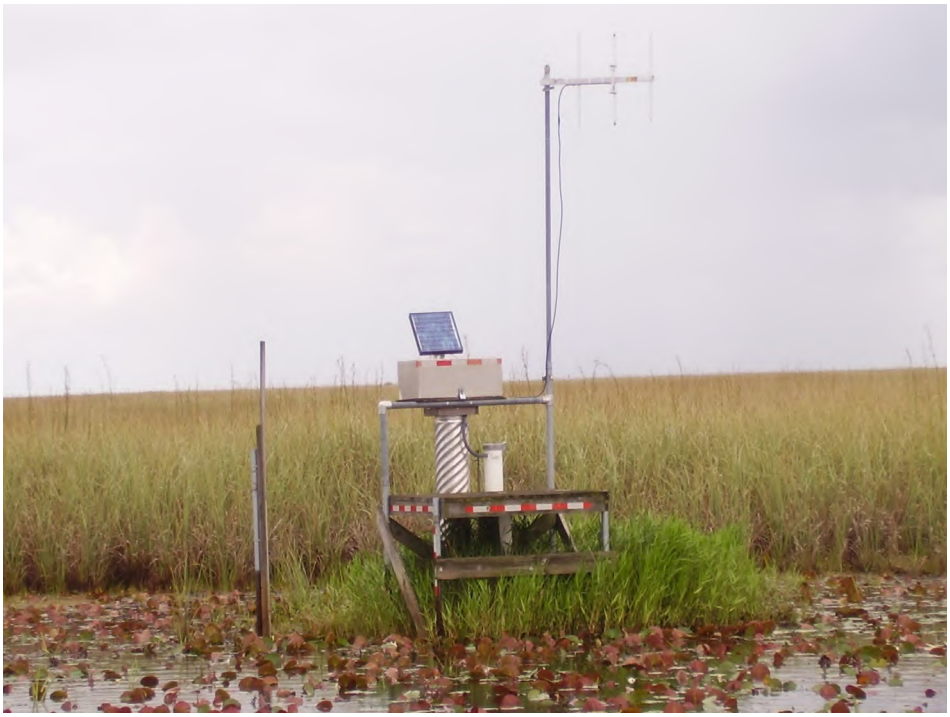

Figure 8: Well cluster 3AS3W1, northwest of island (view looking north)

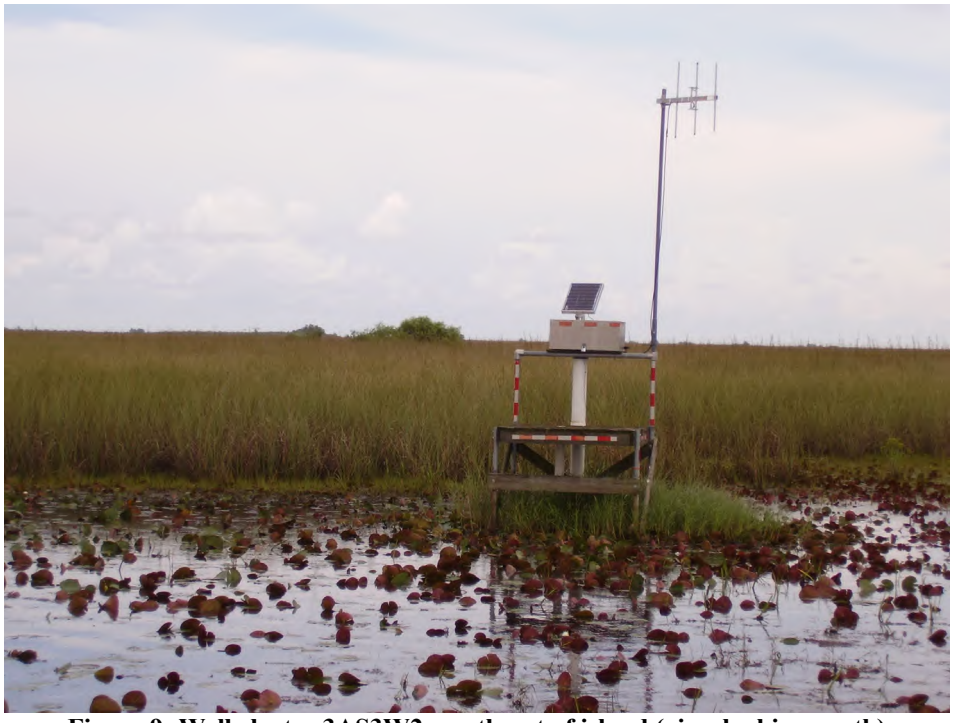

Figure 9: Well cluster 3AS3W2, northeast of island (view looking north)

Figure 10: Well cluster 3AS3W3, south of island (view looking north)

Figure 11: Well cluster 3AS3W4, on head of island

Figure 12: Porewater wells and SET in slough, east of island (view looking north)

Figure 13: Porewater wells (head) (view looking southeast)

Figure 14: Porewater wells, neartail

Figure 15: SET, neartail

Figure 16: Porewater wells, tail

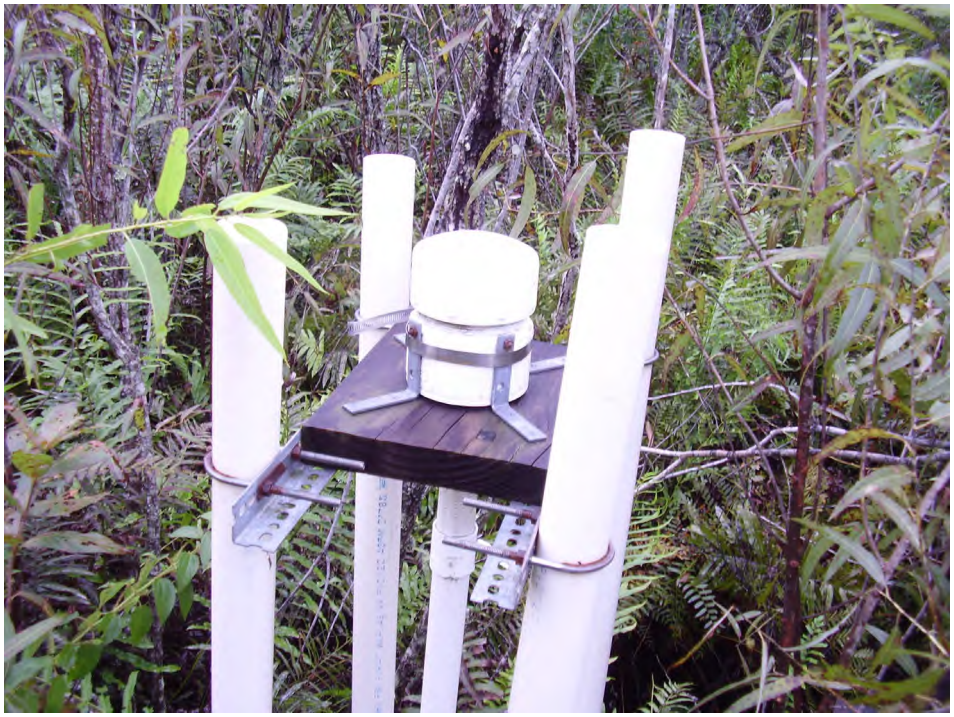

Figure 17: HOBO water level gauge (neartail)

Figure 18: FIU well N1D

Figure 19:FIU well N1S

Figure 20: FIU well N2D

Figure 21: FIU well N2S

Figure 22:FIU well N3D

Figure 23: FIU well N3S

Figure 24: FIU well N4D

Figure 25: FIU well N4S

Figure 26: FIU well N5D

Figure 27: FIU well N5S

Figure 28: FIU well S6D

Figure 29: FIU well S6S

Figure 30: FIU well S7D

Figure 31: FIU well S7S

Figure 32: FIU well S8D

Figure 33: FIU well S8S

Figure 34: FIU well S9D

Figure 35: FIU well S9S

Figure 36: FIU well S10D

Figure 37: FIU well S10S

Figure 38: FIU well X11D

Figure 39: FIU well X11S

Figure 40: FIU well X12D

Figure 41: FIU well X12S

APPENDIX D: DERIVATION OF UNCERTAINTIES IN COMPUTED DIFFERENCES IN ELEVATION

In the section on leveling methods, the estimated standard errors of the differences in elevation between the four major well clusters (obtained by subtraction from the elevations presented in this report) are reported. These standard errors were computed by means of the law of variance-covariance propagation[3] (shortened to "covariance propagation" from this point) and are based upon two assumptions about the measurement procedures used:

1. The two three-wire differential leveling runs which tied together bench marks 3AS3-GW1, 3AS3-GW2, 3AS3-GW3, and TREE W N (the last of which is adjacent to well cluster 3AS3W4) are of "NGS third-order" quality; and
2. That the measured differences in elevation between each of those bench marks and the several adjacent well casings (piezometric well, ground water well, and, if applicable, surface water well) have a standard error of 0.005 feet.

The NGS standards document noted in the section on leveling methods states that a third-order elevation difference (*i.e.*, the difference between the elevations of two surveyed points) has a standard error of $2.0\,\text{mm}\sqrt{K}$, where K is the distance in kilometers between the two points in question, as measured along the path of the leveling operation. Equivalently, this standard error can be expressed 0.0083 feet $\sqrt{M}$, where M is the distance in miles. Given the sight lengths of the leveling operations (which are obtained during reduction of three-wire leveling notes), and assuming that the leveling meets the third order standard of accuracy, the standard error of the observed differences in elevation can be derived and subsequently used in covariance propagation computations.

A full presentation of the covariance propagation computations is omitted from this report.

[3] See, for example, *GPS and Satellite Surveying*, 3rd ed., by Alfred Leick, p. 103.