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Final Report

Cross-Sectional Groundwater Modeling in the Indian River Lagoon (2008-2010)

Submitted to

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Introduction

The Indian River Lagoon (IRL) is located on the east coast of Florida and is protected from the Atlantic Ocean by coastal islands known as the "barrier-island chain". The lagoon is approximately 156 miles long and stretches from Volusia County in the north to Palm Beach County in the south. In 1987, the Surface Water Improvement and Management (SWIM) Act designated the lagoon as a priority water body in need of restoration and special protection. In 1991, the IRL became a part of the National Estuary Program (NEP). The IRL watershed has been modified by urban and agricultural development. The associated land-use change has significant impacts on IRL in terms of both water quantity and quality over a range of temporal and spatial scales. The nature and scale of the impacts depend on the form of the land-use change and its proximity to the lagoon. Evidence suggests that significant amounts of pollutants from on-site disposal (OSD), agricultural areas, urban areas, leaking sewers, and industrial wastes may reach the surficial aquifer and then enter the Indian River Lagoon (IRL).

Objectives

The main objective of the proposed study was to estimate the steady, meteoric groundwater flowrates into the Indian River Lagoon (IRL) at three transverse transects to be identified as part of the study. The estimation was to be done by appropriate, calibrated, single and/or multi layer cross-sectional groundwater flow models. The transects were to be located between the Mosquito Lagoon in the north and Vero Beach in the south part of the lagoon. In addition, a project goal was to determine the salinity of the groundwater below the lagoon at the selected transects. Finally, the study was also required to determine the dissolved nitrogen and phosphorus loads carried into the lagoon via groundwater at the selected transects.

Major Tasks

The list of tasks undertaken to complete the study and the progress within each task is described below:

- 1. Site visits for monitoring well locations and establishment of cross-sections (100% complete):** Three transects were identified in Palm Bay (Valkaria), Titusville (Haulover Canal), and Vero Beach (old Winter Beach) with the help of the SJRWMD. The sections are in relatively rural areas compared to the three transects studies in a previous study (Pandit et al., 2008). The location of the three selected transects, along with the locations of the previously selected transects, described by Pandit et al. (2008), are shown in Figure 1.
- 2. Installation of land based wells (100% complete):** Seven, four, and six land based wells were installed in the mainland and the Barrier Island.

3. **Provide land based well location data to SJRWMD (100% complete)**
4. **Installation of wells under lagoon (100% complete):** Seven groundwater monitoring wells were installed at each of the three transects. Two of these wells are on the shores of the transects while the other five are uniformly distributed along the transect. Piezometers were constructed of $\frac{3}{4}$ inch diameter PVC pipe. A one foot length of slotted pipe, # 10 slot size, was connected to the lower end of each piezometer. In order to prevent sabotage, piezometers installed in the shallow location (0 to 1.75 ft below the lagoon bed) typically terminated a couple of inches above the lagoon bed. Piezometers installed in the deep location (4.5 ft to 6.25 ft below the lagoon bed) typically terminated within two feet of the water surface. The top of the casing was fitted with a threaded connector and an O-ring seal and a cap was screwed onto the top of the piezometer creating a leak proof seal that also protected the threaded section from barnacle growth. During each visit, the cap was removed and a PVC extension pipe was attached to the top of piezometer such that the top of the extension pipe extended above the lagoon surface to take measurements. The piezometers were installed using a jetting technique. A two horsepower centrifugal pump was used to jet a 1 1/4 inch casing into the sediment to the desired depth. The water supply hose was then removed from the casing and the piezometer was inserted into the casing to the desired depth. The casing was slowly removed and sand was packed around the screen. After removing the entire casing, clay chips were poured into the annular space to create a seal. The wells were developed to remove any water introduced during the jetting phase of construction. Piezometer locations were marked with a separate PVC pipe that extended above the lagoon surface and in deep locations a buoy was also anchored to the bottom. All locations were also measured with a hand held Trimble GPS unit.
5. **Surveying of land-based wells (to be done by the District) (100% complete)**
6. **Literature search on aquifer/geologic characteristics at selected transects (100% complete)**
7. **Measurement of transect profile (100% complete):** The lagoon widths and depths, taken between 40 to 60 locations along the transects, are shown in Tables 1 through 3. These data were obtained by traversing the cross-sections by boat and using existing bench marks in the vicinity of these cross-sections to obtain accurate elevation and transect information. The cross-section widths in Palm Bay, Titusville, and Vero Beach are approximately, 9437 ft, 23553 ft, and 7142 ft, respectively.
8. **Collection of soil boring data for hydraulic conductivity measurements (100% complete):** Soil samples were collected at seven locations at each of the three transects. A shallow (0 to 1.75 ft below the lagoon bed) and a deep (4.5 ft to 6.25 ft below the lagoon bed) sample was taken at each location. The location and depth of these sampling points are respectively shown in Tables 4 to 6 for the Palm Bay, Titusville, and Vero Beach transects. The shallow sediment samples were collected by inserting a PVC coring device directly into the sediments and extracting the device and sediment. The deeper sediment samples were collected by first jetting a two inch diameter PVC casing four feet below the lagoon bed.

The coring device was then driven to the desired depth and extracted with the sediment.

9. **Lab testing of soil boring data for hydraulic conductivity estimations (100% complete):** Sediments samples were analyzed in the soils laboratory on the Florida Tech campus for grain size distribution following normal ASTM methods. Plotted grain size distribution curves were used to determine the effective grain size, d_{10} (10% of the particles are finer than this diameter), at each location and these values are shown in Tables 4 to 6 for the Palm Bay, Titusville and Vero Beach transects, respectively. The well-known Hazen's equation ($K = Cd_{10}^2$) was used to calculate the hydraulic conductivity, K , values at each location and these values are also shown in Tables 4 to 6. Values of K at the Palm Bay transect ranged from 21 ft/day to 125 ft/day (Table 4) indicative of medium sand. The hydraulic conductivity range at the Titusville transect was from 10 ft/day to 73 ft/day (Table 5) indicative of fine to medium sand, while the range at the Vero Beach transect was from 16 ft/day to 163 ft/day (Table 6) which is indicative of fine to coarse sand.
10. **Development of hydraulic conductivity distribution underneath the transects (100% completed):** The hydraulic conductivity values shown in Tables 4 through 6 were used to determine the hydraulic conductivity distribution at the three transects using the methodology described by Pandit et al. (2009).
11. **Measurement of ground water levels in land-based wells (100% completed):** The groundwater elevation data in land-based wells, collected during the 12 field trips are shown in Tables 7 through 9.
12. **Measurement of ground water levels in wells under lagoon (100% completed):** The groundwater elevation data in lagoon-based wells at the three transects, collected during the 5 scheduled field trips, are shown in Tables 10 through 12.
13. **Development of equipotential lines underneath the transects (100% completed):** The equipotential lines underneath the three transects were determined using the methodology described by Pandit et al. (2009).
14. **Collection of water quality (nutrient) data (100% completed):** Samples for nutrient analysis were collected using standard USEPA procedures. Wells were purged of three well water volumes before sampling. Wells with low flow were purged until empty. The sample collection also followed the sample handling and chain of custody requirements of Test America Inc., an analytical laboratory in Orlando Florida which did the nutrient analysis. Total Phosphorous and Total Kjeldahl Nitrogen samples were collected and acidified as they have a 30 day holding time. Nutrients concentrations have been measured as scheduled, at each transect, on four different dates between April and August.
15. **Collection of water salinity data in the lagoon wells (100% completed):** Four of the five scheduled trips have been completed and the measured groundwater salinity data are shown in Tables 13 through 15 for the Palm Bay, Titusville and Vero Beach sections. The respective salinity ranges for the three transects are from 0.7 to 33.5 ppt (Table 13), 0.3 to 33.3 ppt (Table 14), and 0.8 to 57.5 ppt (Table 15). These data will be used to determine iso-salinity plots as described by Pandit et al. (2009). In addition, the IRL salinity is also measured at several

locations along the transect, at each of the three transects, and these are presented in Table 16.

16. Lab testing of nutrient samples (100% completed): Measured TKN and TP concentrations for the Palm Bay, Titusville and Vero Beach sites are shown in Tables 17 through 19. The TKN and TP concentrations are also shown in Figures 2 and 3.

17. Model development, calibration and validation (100% completed): A finite difference model similar to the one described by Pandit et al. (2009) was used to determine the groundwater seepages at the three transects. The model calibration and validation procedures were also identical to those described by Pandit et al. (2009). The model calibration results for the Palm Bay transect are shown in Figure 4 while the model validation results are shown in Figures 5 and 6. Similarly, model calibration and validation results for the Titusville and Vero Beach transects are shown in Figures 7 through 9, and Figures 10 through 12, respectively.

18. Nutrient load calculations (100% completed): The groundwater discharges for the months of April, May, July, August and September are shown in Tables 20 through 22 for the Palm Bay, Titusville and Vero Beach transects, respectively. The average groundwater discharges for the three transects were 10.80, 3.63, and 6.98 ft³/day. The groundwater discharges at the Vero Beach transect, during the months of July and August were unusually large due to the high water level in the managed impoundment adjacent to the Indian River Lagoon. The TP and TKN loads during the five visits are shown in Tables 23 through 25, respectively. The average TP loads ranged from 10 to 18 mM/day per meter of lagoon shoreline (96 to 167 mg/day per foot of lagoon shoreline). The average TP loads reported by Pandit et al. (2009) ranged from 1 to 24 mM/day per meter of lagoon shoreline (13 to 229 mg/day per foot of lagoon shoreline). The average TKN loads ranged from 116 to 155 mM/day per meter of lagoon shoreline (495 to 660 mg/day per foot of lagoon shoreline). The average TKN loads reported by Pandit et al. (2009) ranged from 4 to 150 mM/day per meter of lagoon shoreline (16 to 641 mg/day per foot of lagoon shoreline).

References

1. Pandit, A., Heck, H.H., and N. Ali, 2008. "Cross-Sectional Groundwater Modeling in the Indian River Lagoon" Final Report (Draft), Prepared for the Water Resources Department, St. Johns River Water Management District, Florida, Florida Institute of Technology, Melbourne, Fla.
2. Pandit, A., Heck, H.H., and N. Ali, 2009. "Cross-Sectional Groundwater Modeling in the Indian River Lagoon (2007-2008)." Final Report, Prepared for the Water Resources Department, St. Johns River Water Management District, Florida, Florida Institute of Technology, Melbourne, Fla. 277 pages

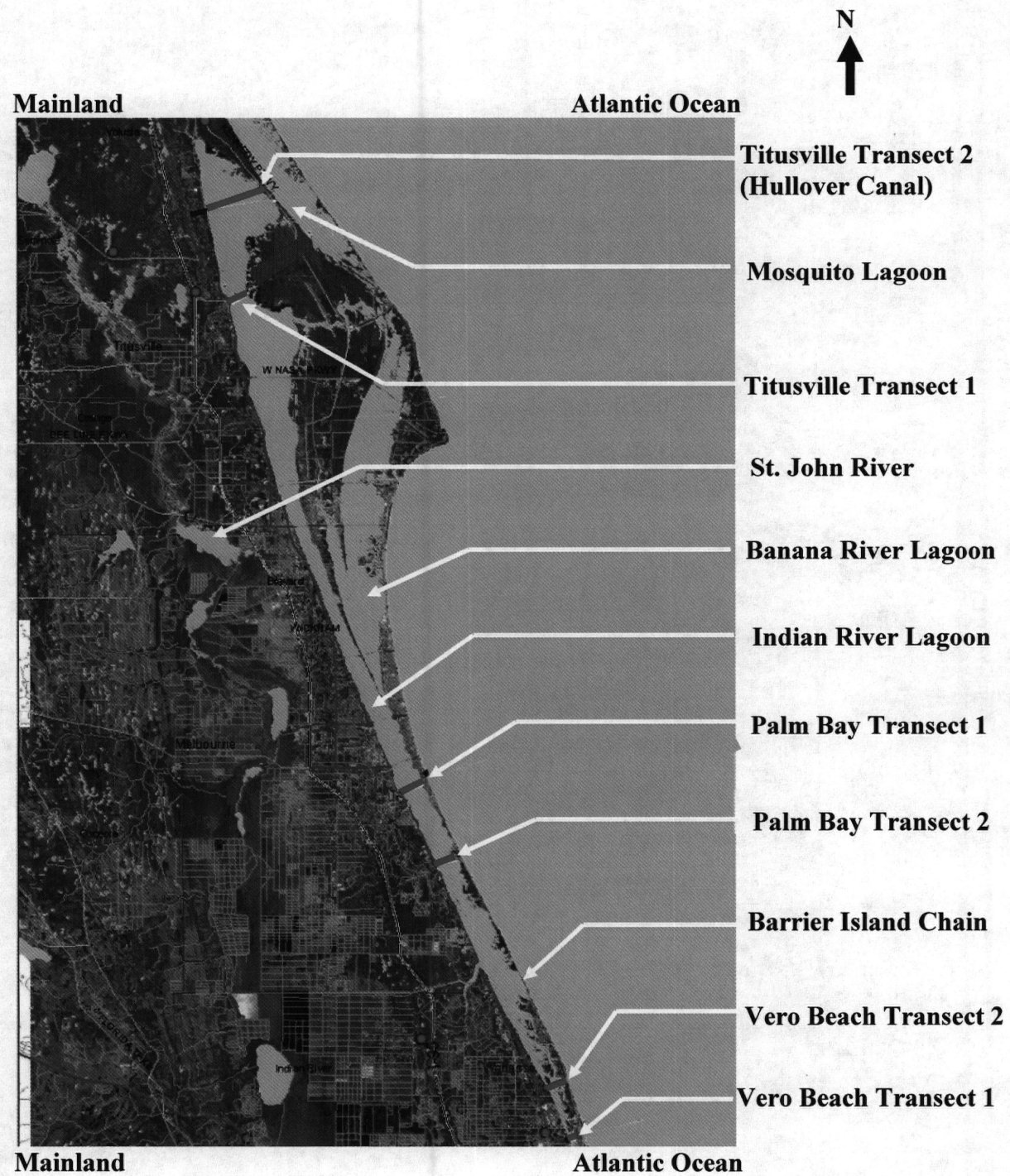
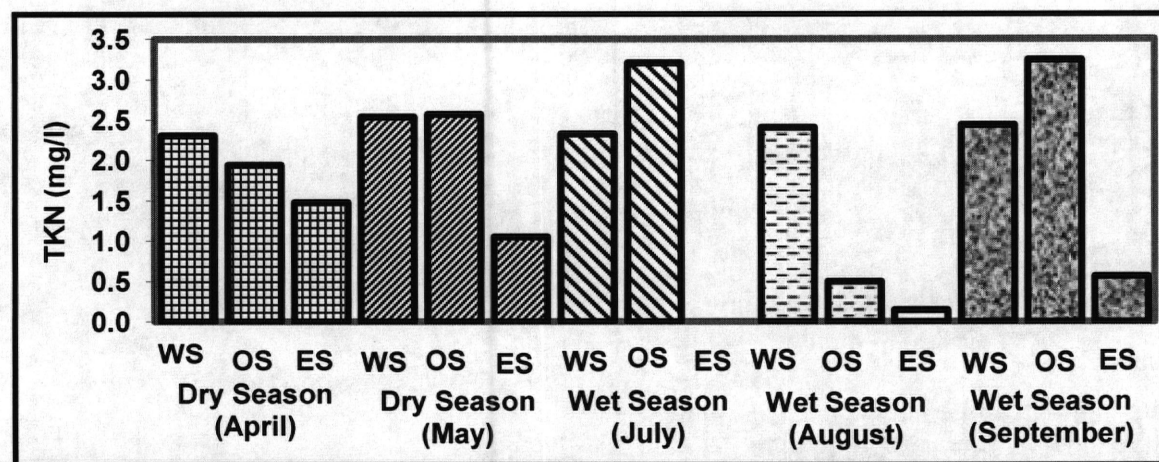
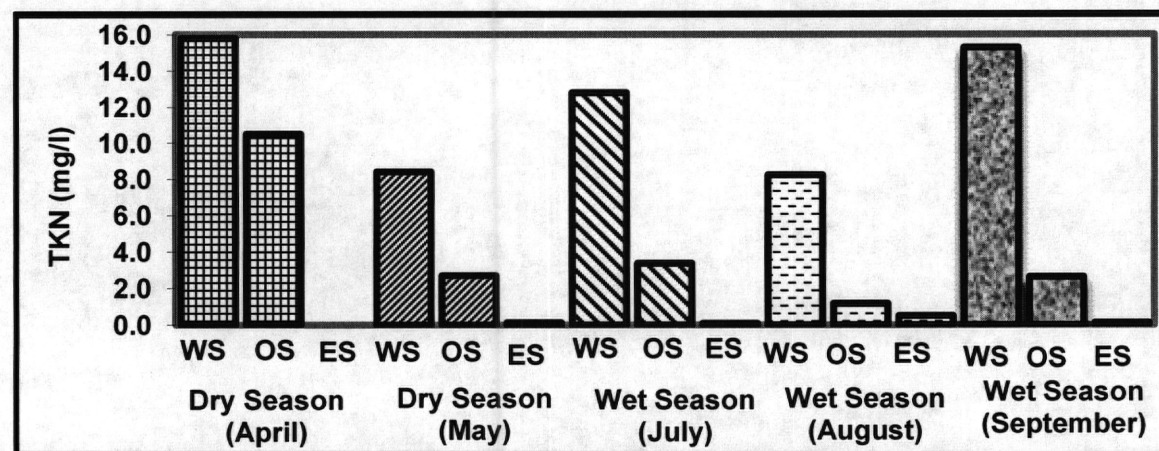


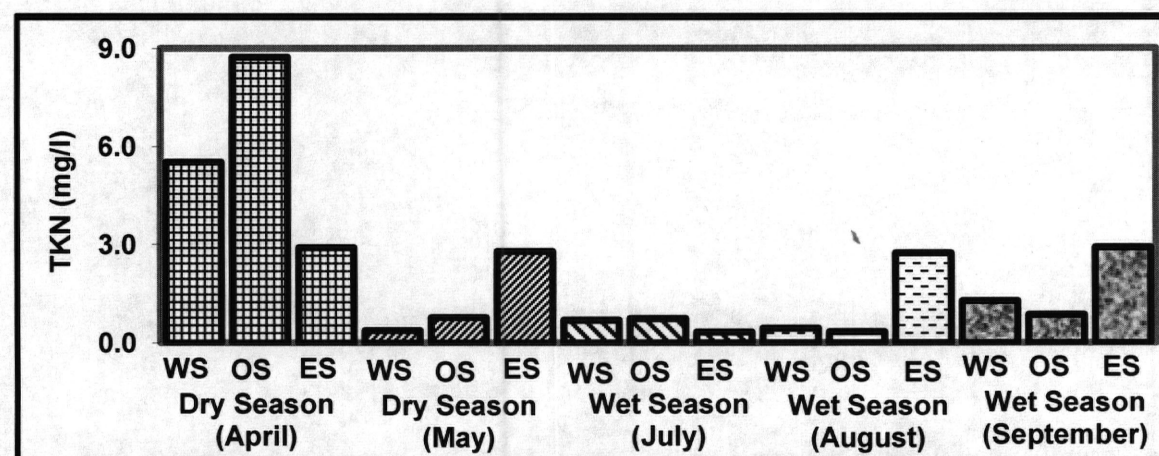
Figure 1. The Indian River Lagoon System and Study Transects, Florida



(a)

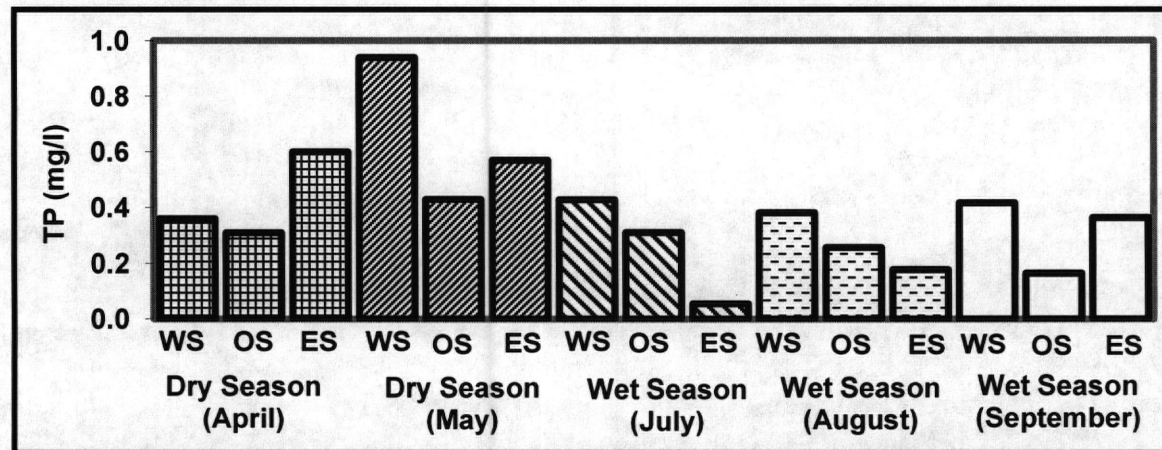


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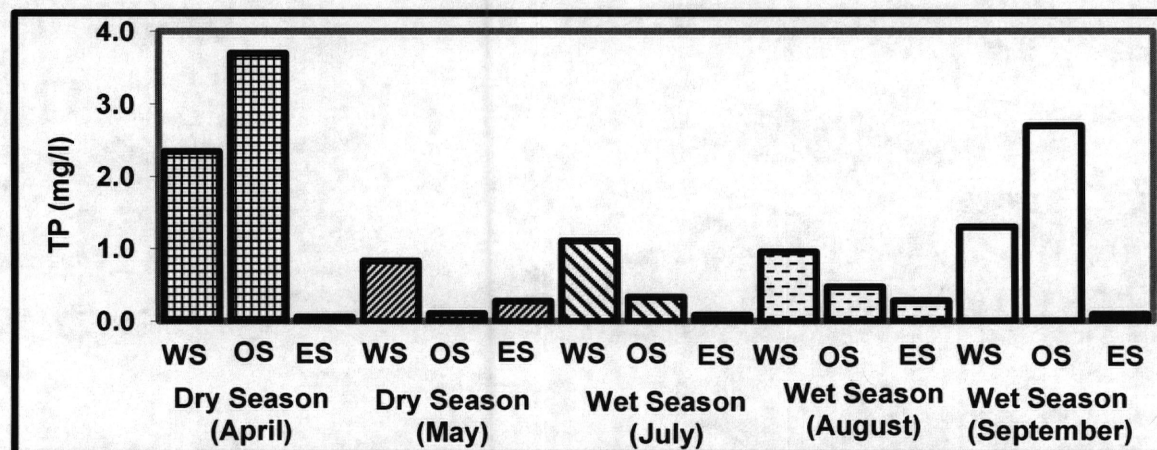


(c)

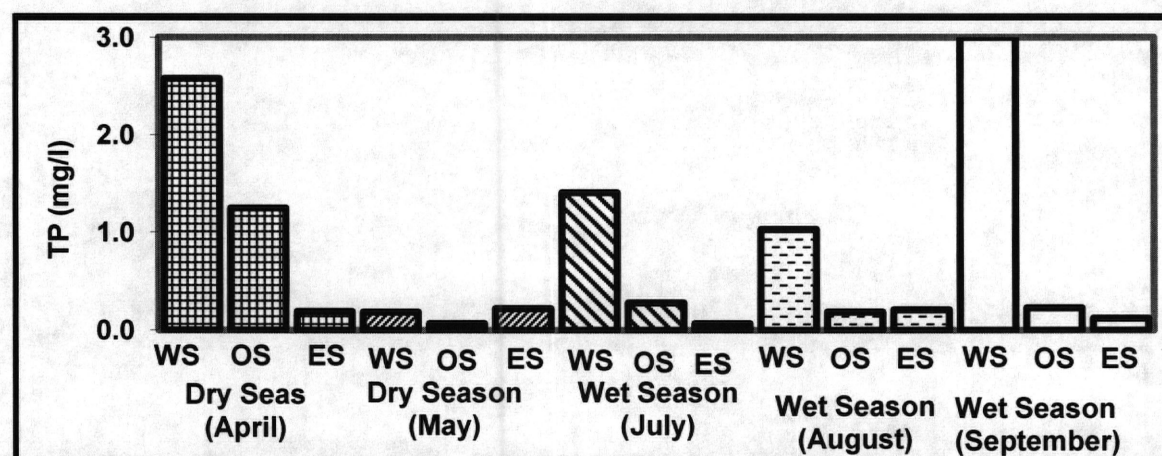
Figure 2. Off Shore and On Shore TKN Concentrations During Dry and Wet Seasons at (a) Palm Bay Transect; (b) Titusville Transect; (c) Vero Beach Transect; WS: West Shore, OS: Offshore, ES: East Shore



(a)

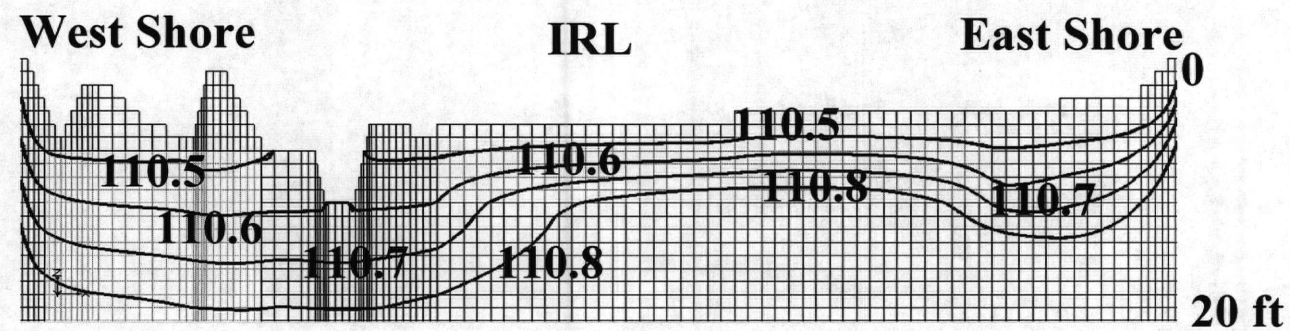


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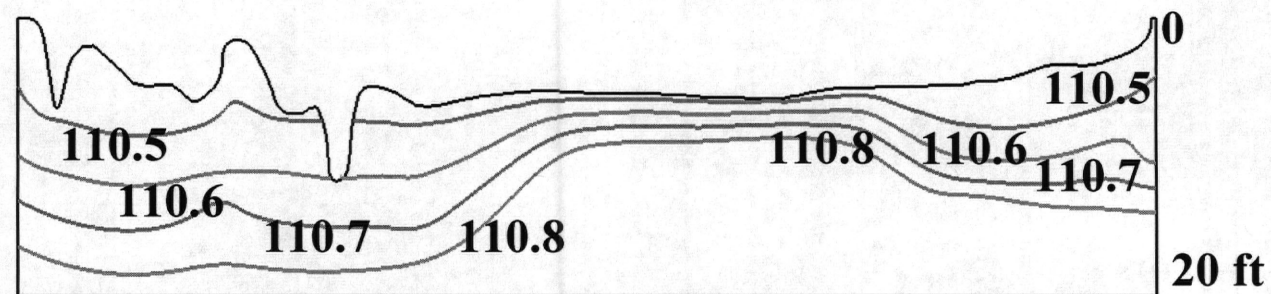


(c)

Figure 3. Off Shore and On Shore TP Concentrations During Dry and Wet Seasons at (a) Palm Bay Transect; (b) Titusville Transect; (c) Vero Beach Transect; WS: West Shore, OS: Offshore, ES: East Shore



(a)



(b)

Figure 4. Comparison of Model-Predicted and Measured Equipotential Lines at the Palm Bay (Valkaria) Transect on April 24, 2009 a).Model Predicted with $K_h = 50$ ft/day, b) Measured Equipotential Lines; Elevations are with respect to Zero NGVD and Equipotential Lines are constructed with the Hawthorn Formation as the datum (Model Calibration)

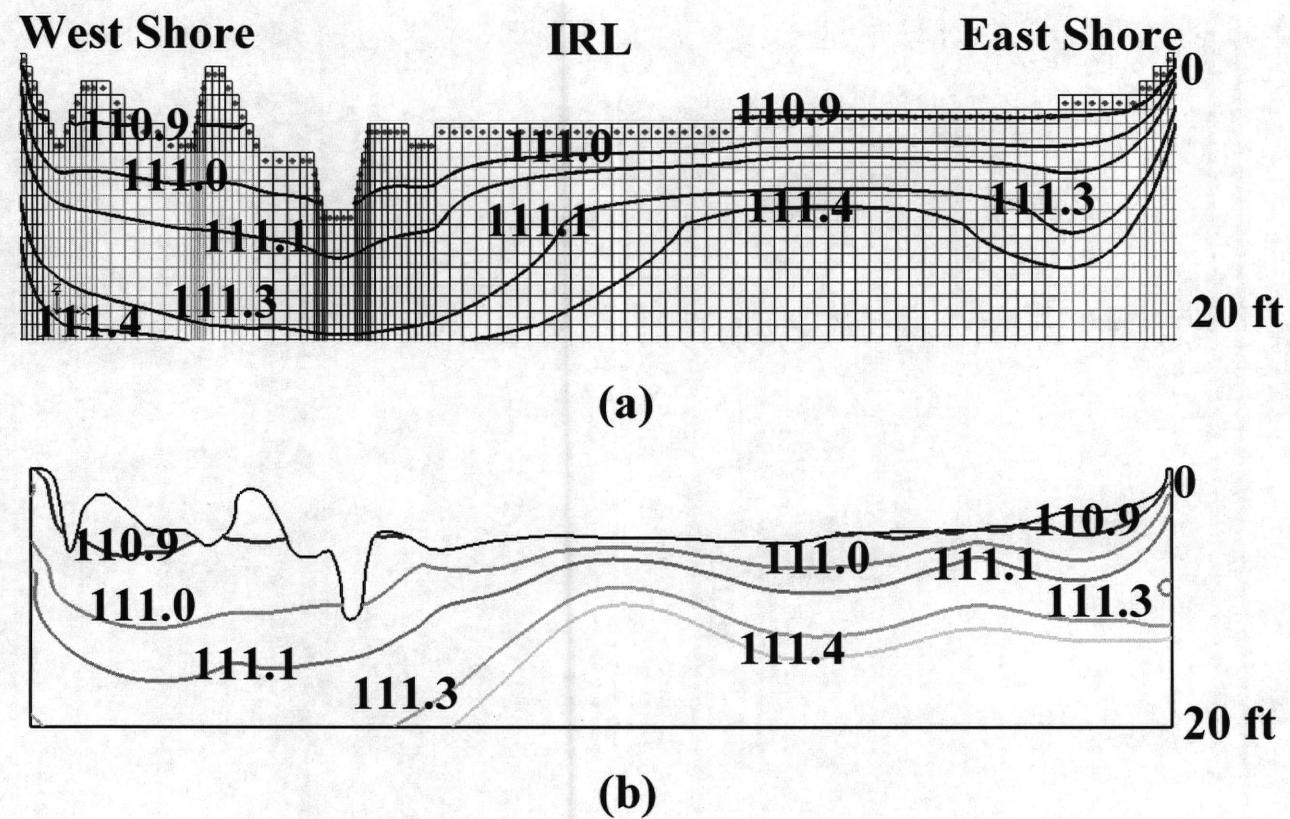


Figure 5. Comparison of Model-Predicted and Measured Equipotential Lines at the Palm Bay (Valkaria) Transect on July 16, 2009 a).Model Predicted with $K_h = 50$ ft/day, b) Measured Equipotential Lines; Elevations are with respect to Zero NGVD and Equipotential Lines are constructed with the Hawthorn Formation as the datum (Model Validation-I)

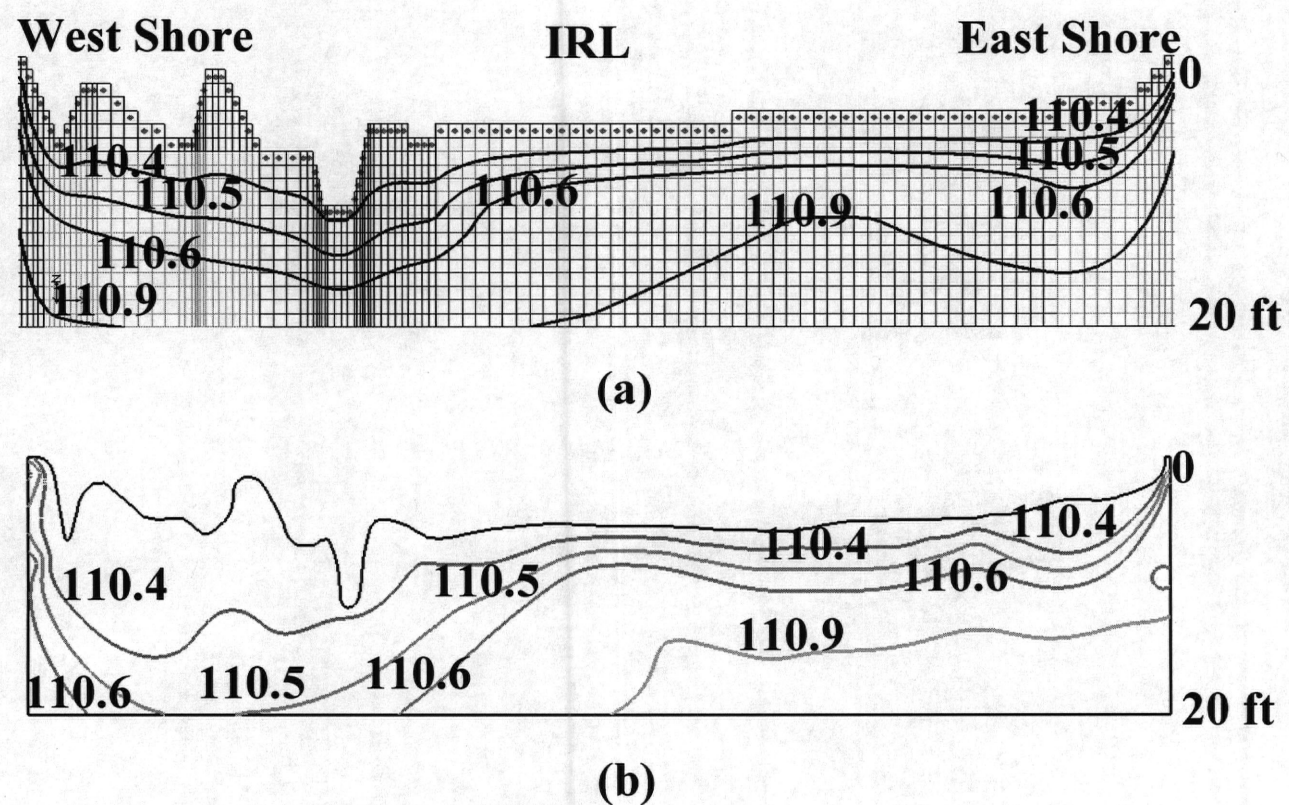


Figure 6. Comparison of Model-Predicted and Measured Equipotential Lines at the Palm Bay (Valkaria) Transect on August 11, 2009 a). Model Predicted with $K_h = 50$ ft/day, b) Measured Equipotential Lines; Elevations are with respect to Zero NGVD and Equipotential Lines are constructed with the Hawthorn Formation as the datum (Model Validation-II)

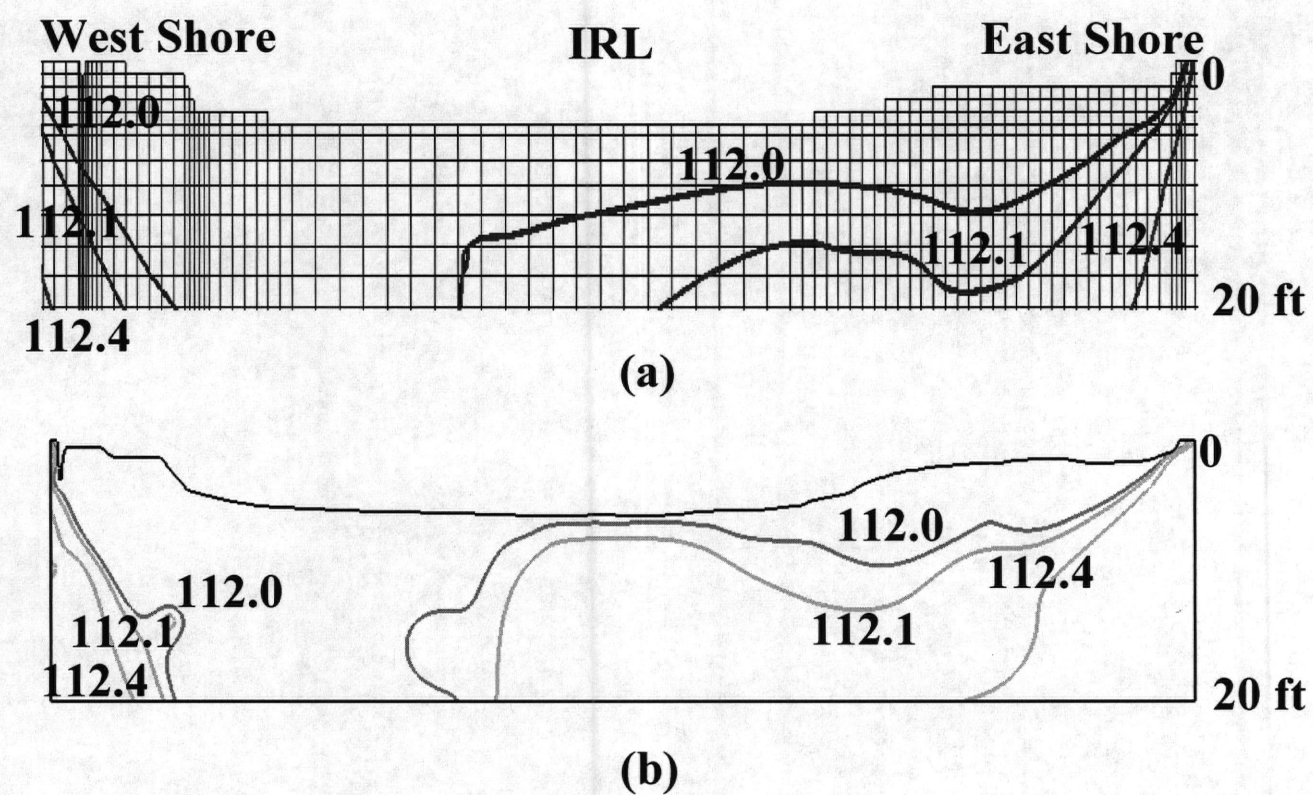


Figure 7. Comparison of Model-Predicted and Measured Equipotential Lines at the Titusville (Haulover Canal Area) Transect on May 23, 2009 a).Model Predicted with $K_h = 40$ ft/day, b) Measured Equipotential Lines; Elevations are with respect to Zero NGVD and Equipotential Lines are constructed with the Hawthorn Formation as the datum (Model Calibration)

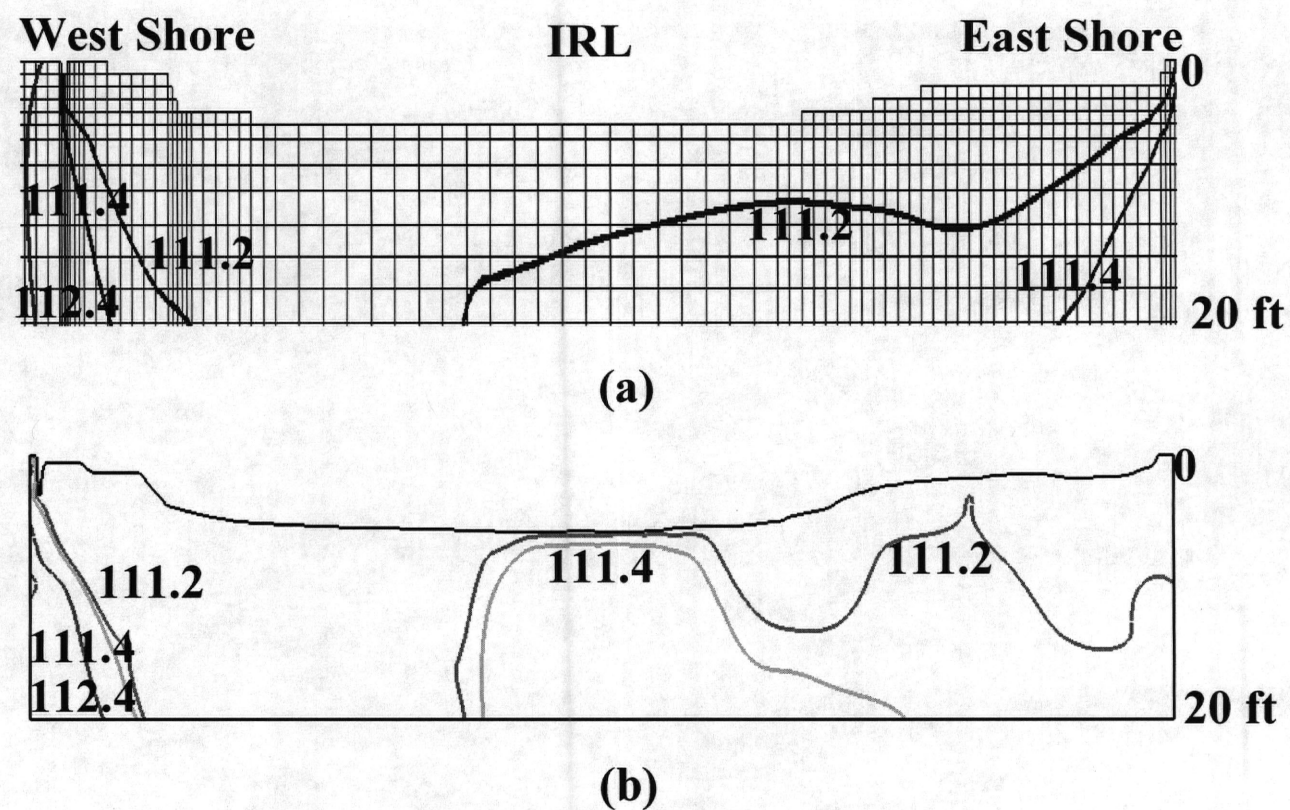


Figure 8. Comparison of Model-Predicted and Measured Equipotential Lines at the Titusville (Haulover Canal Area) Transect on July 15, 2009 a).Model Predicted with $K_h = 40$ ft/day, b) Measured Equipotential Lines; Elevations are with respect to Zero NGVD and Equipotential Lines are constructed with the Hawthorn Formation as the datum (Model Validation-I)

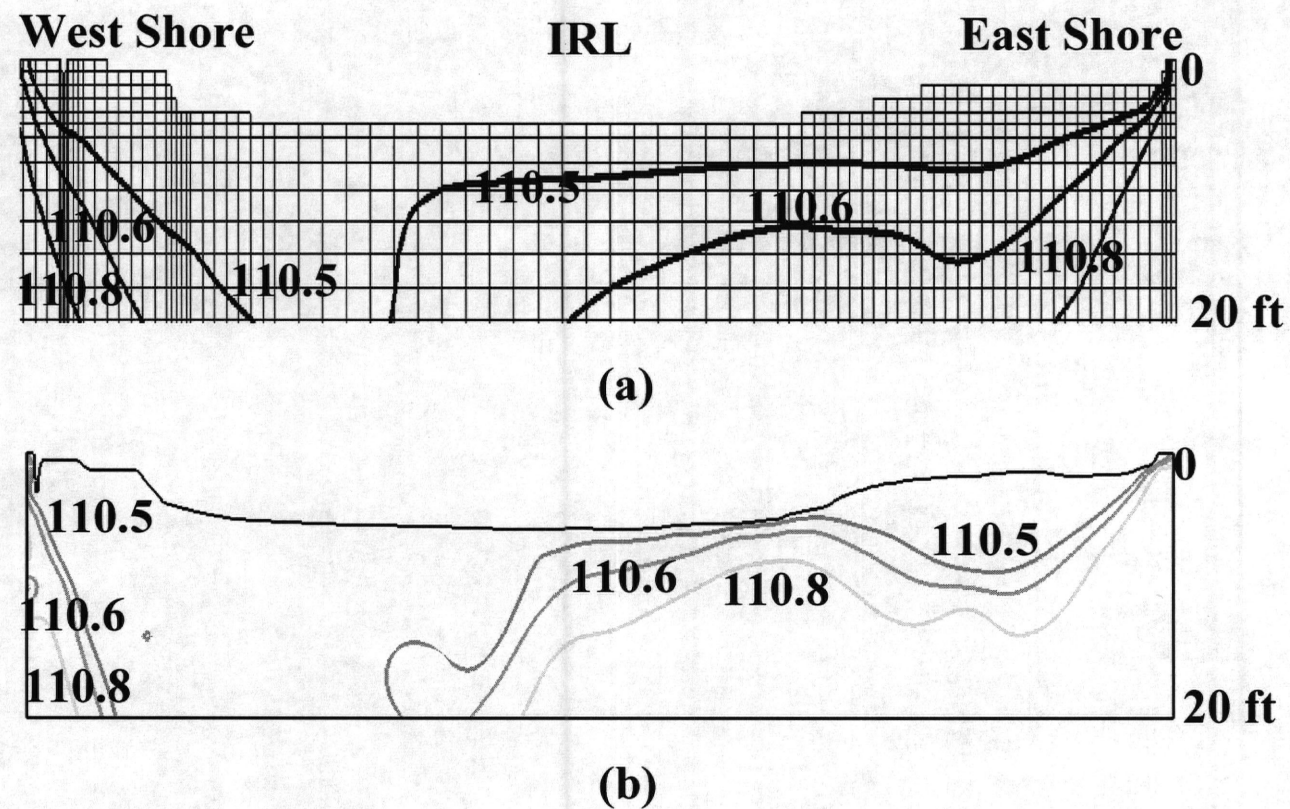


Figure 9. Comparison of Model-Predicted and Measured Equipotential Lines at the Titusville (Haulover Canal Area) Transect on August 15, 2009 a).Model Predicted with $K_h = 40$ ft/day, b) Measured Equipotential Lines; Elevations are with respect to Zero NGVD and Equipotential Lines are constructed with the Hawthorn Formation as the datum (Model Validation-II)

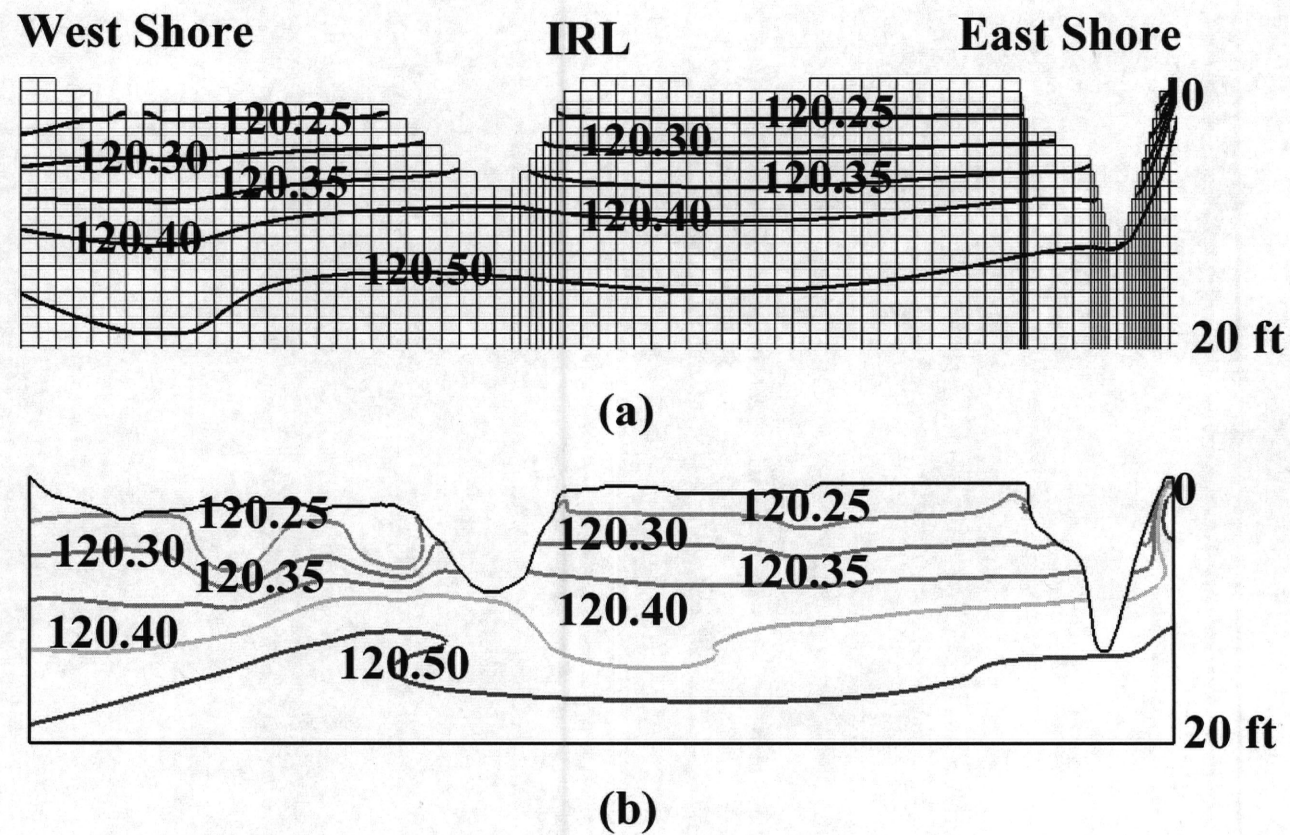


Figure 10. Comparison of Model-Predicted and Measured Equipotential Lines at the Vero Beach (Old Winter Beach) Transect on April 25, 2009 a).Model Predicted with $K_h = 36$ ft/day, b) Measured Equipotential Lines; Elevations are with respect to Zero NGVD and Equipotential Lines are constructed with the Hawthorn Formation as the datum (Model Calibration)

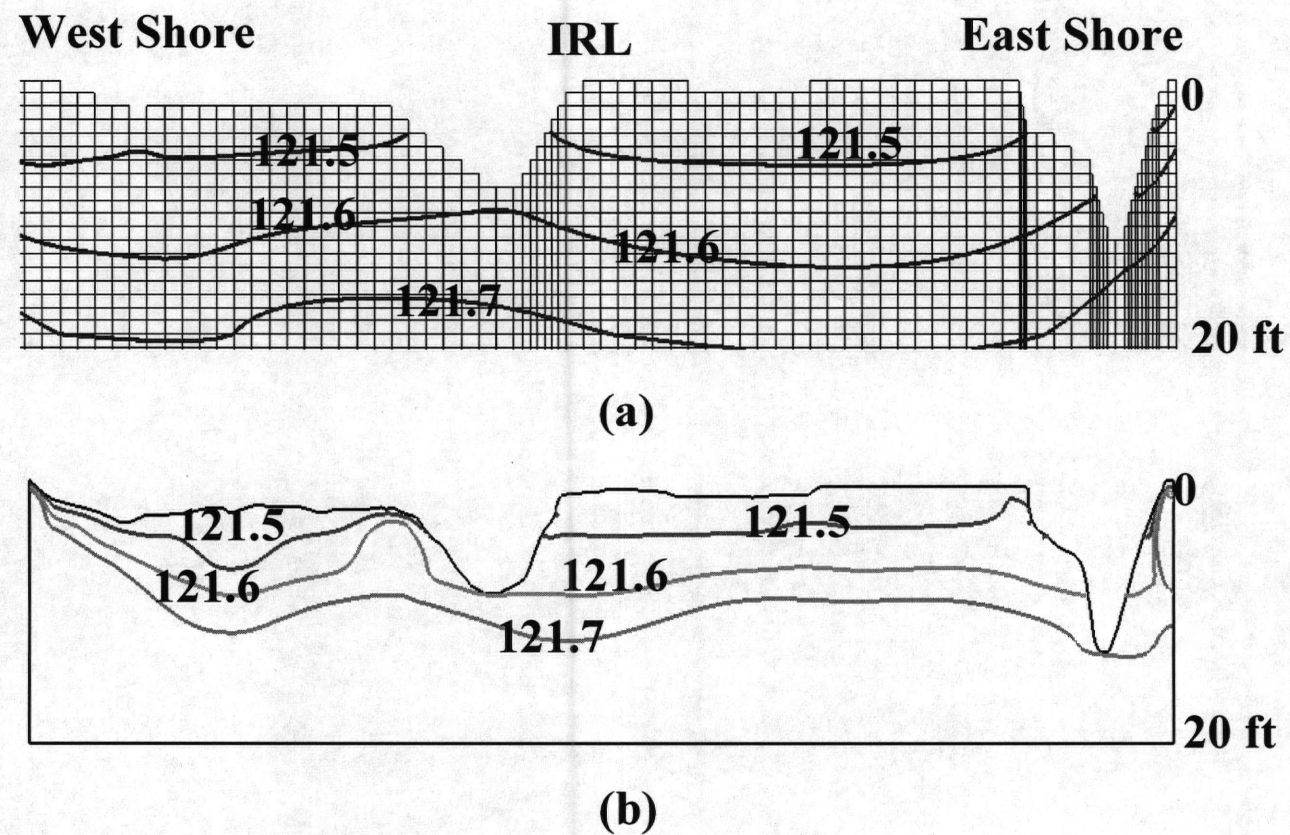


Figure 11. Comparison of Model-Predicted and Measured Equipotential Lines at the Vero Beach (Old Winter Beach) Transect on May 21, 2009 a). Model Predicted with $K_h = 36$ ft/day, b) Measured Equipotential Lines; Elevations are with respect to Zero NGVD and Equipotential Lines are constructed with the Hawthorn Formation as the datum (Model Validation-I)

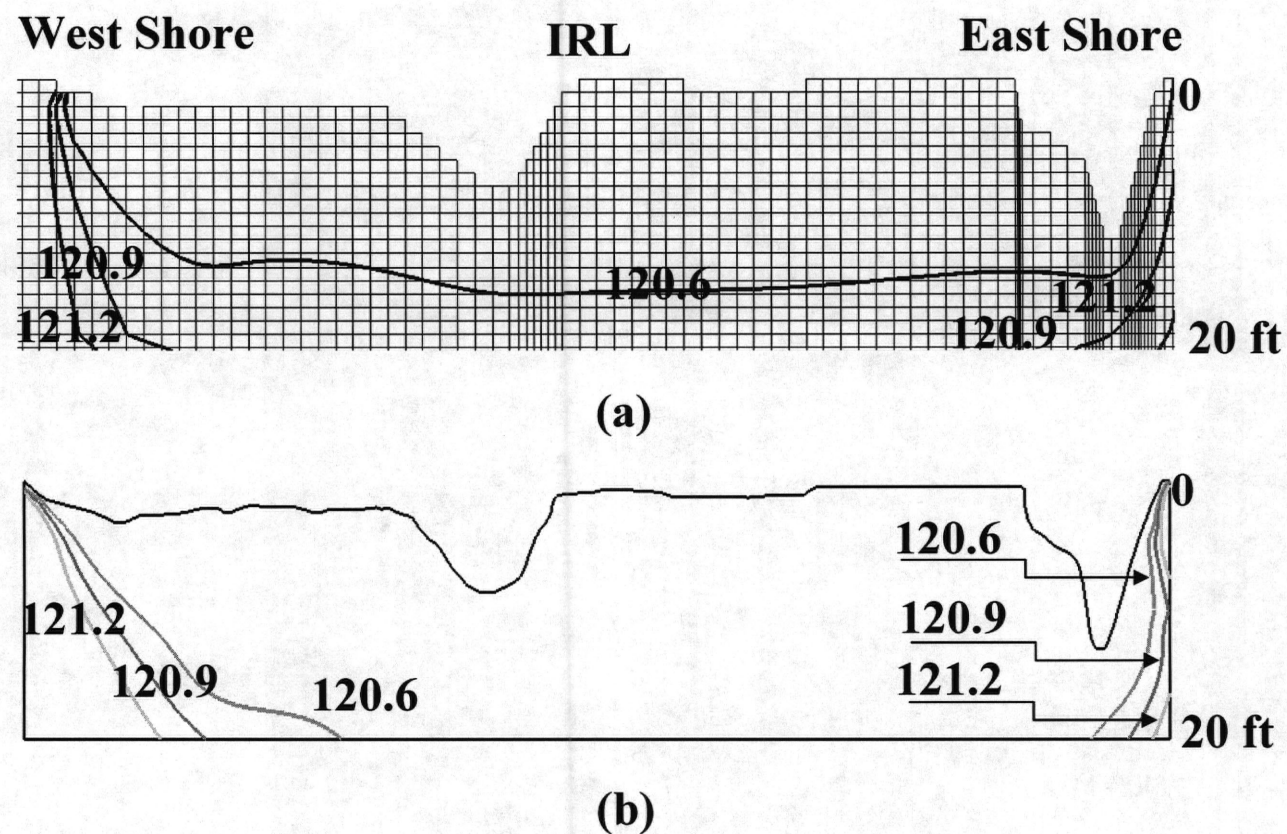


Figure 12. Comparison of Model-Predicted and Measured Equipotential Lines at the Vero Beach (Old Winter Beach) Transect on July 18, 2009 a).Model Predicted with $K_h = 36$ ft/day, b) Measured Equipotential Lines; Elevations are with respect to Zero NGVD and Equipotential Lines are constructed with the Hawthorn Formation as the datum (Model Validation-III)

Table 1. Indian River Lagoon Bed Profile Measured at the Palm Bay
(Valkaria) Transect

Location	Measuring Points UTM 17 Coordinates		Bed Depth from Water Surface (ft)	Distance From West Shore (ft)
	Easting	Northing		
	(ft)			
West shore	1788422	10148615	0.0	0
1	1788491	10148596	1.1	235
2	1788537	10148589	2.2	281
3	1788586	10148593	5.1	331
4	1788632	10148596	7.2	377
5	1788671	10148602	6.6	417
6	1788743	10148609	3.8	489
7	1788786	10148622	3.4	534
8	1788852	10148655	2.8	607
9	1788953	10148652	3.0	709
10	1789078	10148681	4.1	837
11	1789275	10148750	5.6	1046
12	1789514	10148812	5.5	1293
13	1789662	10148862	6.7	1468
14	1789865	10148894	5.4	1654
15	1789931	10148878	2.7	1722
16	1789993	10148891	2.3	1786
17	1790085	10148924	2.5	1883
18	1790148	10148927	3.2	1946
19	1790256	10148960	5.3	2059
20	1790341	10148986	7.3	2148
21	1790502	10149022	7.6	2313
22	1790676	10149101	9.3	2504
23	1790617	10149055	7.2	2578
24	1790558	10149062	7.2	2638
25	1790705	10149124	12.4	2798
26	1790866	10149134	7.7	2959
27	1790814	10149137	11.8	3012
28	1790764	10149157	>12	3065
29	1790915	10149193	6.0	3220
30	1791184	10149239	6.1	3493
31	1791434	10149219	7.1	3743
32	1791844	10149245	6.4	4154
33	1792241	10149357	6.0	4566
34	1792457	10149406	6.0	4788
35	1792657	10149469	6.1	4998
36	1793048	10149518	6.1	5391
37	1793638	10149646	6.4	5996
38	1794124	10149810	6.5	6508
39	1794580	10149875	5.8	6969
40	1795092	10149980	4.8	7491
41	1795554	10150062	5.4	7961
42	1795873	10150164	5.1	8295
43	1796224	10150249	4.1	8657
44	1796535	10150318	4.1	8976
45	1796890	10150374	2.9	9334
46	1796962	10150302	1.5	9437

Measurements were recorded on July 16, 2009

Table 2. Indian River Lagoon Bed Profile Measured at the Titusville
(Haulover Canal) Transect

Location	Measuring Points UTM 17 Coordinates		Bed Depth from Water Surface (ft)	Distance From West Shore (ft)
	Easting	Northing		
	(ft)			
West shore	1692569	10424541	0.0	0
1	1692585	10424541	2.65	16
2	1692572	10424573	3.95	52
3	1692621	10424567	2.52	101
4	1692703	10424600	1.45	190
5	1692792	10424633	1.45	284
6	1692995	10424754	1.55	521
7	1693127	10424908	1.60	724
8	1693281	10425003	1.7	905
9	1693488	10425190	2.0	1183
10	1693776	10425466	2.2	1583
11	1694019	10425659	2.3	1893
12	1694252	10425797	2.2	2164
13	1694573	10425958	3.9	2523
14	1694751	10426063	4.8	2729
15	1695026	10426211	5.1	3042
16	1695492	10426493	5.6	3586
17	1696056	10426801	6.0	4230
18	1696893	10427162	6.2	5141
19	1697959	10427520	6.4	6265
20	1698629	10427730	6.5	6967
21	1699321	10427858	6.6	7671
22	1699528	10427900	6.5	7882
23	1700180	10428274	6.6	8634
24	1701047	10428747	6.7	9621
25	1701932	10429203	6.8	10617
26	1702910	10429646	6.7	11691
27	1703704	10430128	6.8	12619
28	1704547	10430981	6.4	13819
29	1705371	10430981	6.4	14642
30	1706444	10431316	5.7	15766
31	1707113	10431726	5.1	16551
32	1707444	10431955	4.3	16954
33	1707989	10432198	3.6	17551
34	1708681	10432457	3.1	18290
35	1709386	10432743	2.8	19051
36	1709921	10432910	2.8	19611
37	1710669	10433327	2.4	20467
38	1711365	10433602	2.5	21215
39	1712021	10433806	2.8	21902
40	1712503	10433950	2.7	22406
41	1712815	10434124	3.2	22763
42	1713241	10434462	2.6	23307
43	1713363	10434551	1.7	23457
44	1713412	10434633	0.0	23553

Measurements were recorded on July 15, 2009

Table 3. Indian River Lagoon Bed Profile Measured at the Vero Beach (Old Winter Beach) Transect

Location	Measuring Points UTM 17 Coordinates		Bed Depth from Water Surface (ft)	Distance From West Shore (ft)
	Easting	Northing		
	(ft)			
WS MW	1830512	10061998	0.0	0
1	1830597	10062060	1.5	108
2	1830636	10062073	1.8	147
3	1830807	10062156	2.5	336
4	1830886	10062208	2.8	431
5	1830945	10062208	3.1	490
6	1830965	10062277	3.5	562
7	1830968	10062336	3.6	621
8	1831063	10062402	3.0	737
9	1831152	10062467	3.0	847
10	1831276	10062575	2.8	1012
11	1831319	10062592	2.7	1058
12	1831371	10062667	2.5	1149
13	1831434	10062677	2.5	1213
MW # 1	1831493	10062700	2.8	1276
14	1831575	10062762	2.4	1379
15	1831654	10062825	2.3	1479
16	1831706	10062779	2.3	1549
17	1831824	10062894	2.5	1714
18	1831929	10062927	2.8	1824
19	1832034	10062976	2.6	1940
20	1832073	10062956	2.7	1984
21	1832136	10062982	2.5	2051
22	1832192	10062986	2.6	2107
23	1832297	10063002	2.4	2214
24	1832326	10063005	2.6	2243
25	1832365	10063012	2.3	2283
MW # 2	1832382	10062992	4.49*	2309
26	1832405	10063028	2.9	2352
27	1832451	10063041	3.1	2399
28	1832487	10063038	3.2	2436
29	1832516	10063051	3.8	2468
30	1832569	10063084	4.8	2530
31	1832648	10063104	5.6	2611
32	1832697	10063120	6.8	2663
33	1832746	10063140	7.5	2716
34	1832805	10063150	8.4	2776
35	1832884	10063189	9.0	2864
36	1832966	10063199	9.0	2946
37	1833041	10063261	8.4	3044
38	1833120	10063238	7.6	3126
39	1833202	10063274	4.7	3216
40	1833268	10063304	3.3	3288
MW # 3	1833310	10063314	4.80*	3332
40	1833343	10063327	1.5	3367
41	1833455	10063478	1.3	3555
42	1833543	10063573	1.1	3685
43	1833537	10063871	1.3	3983
44	1833576	10063957	1.7	4077
45	1833707	10063963	1.7	4209
46	1833845	10063986	1.6	4348
47	1833986	10064124	1.7	4546
48	1834186	10064049	1.5	4759
MW # 4	1834327	10064016	3.77*	4904
49	1835663	10064239	0.9	6258
WM # 5	1835702	10064255	4.46*	6276
50	1835725	10064242	3.5	6302
51	1835741	10064275	4.3	6339
52	1835771	10064272	4.5	6369
53	1835860	10064341	5.6	6481
54	1835984	10064396	7.0	6617
55	1836066	10064426	13.1	6705
53	1836155	10064423	13.3	6793
54	1836302	10064514	6.1	6967
55	1836385	10064537	3.1	7052
ES MW	1836467	10064501	0.0	7142

Measurements were recorded on April 09, 2009

* Measurements were taken from TOC of monitoring wells instead of IRL Water Surface

Table 4. Hydraulic Conductivity of Soil near the Indian River Lagoon Bed at the Palm Bay (Valkaria) Transect

Location	Soil Sample Collection Point UTM 17 Coordinates		Depth Below Indian River Lagoon Bed Soli Samples Extracted		Effective Grain Size (d_{10}) and Hydraulic Conductivity (K) of Soil using Hazen Equation			
	Easting	Northing	Sample D	Sample S	Sample D		Sample S	
	(ft)		(ft)	(ft)	d_{10} (mm)	K (ft/day)	d_{10} (mm)	K (ft/day)
West Shore	1788422	10148615	4.5 to 6.25	0 to 1.75	0.12	41	0.19	97
1	1789898	10148878	4.5 to 6.25	0 to 1.75	0.11	34	0.21	125
2	1791280	10149213	4.5 to 6.25	0 to 1.75	0.10	28	0.16	68
3	1792707	10149452	3.5 to 5.25	0 to 1.75	0.11	34	0.12	41
4	1794127	10149803	4.5 to 6.25	0 to 1.75	0.09	23	0.09	23
5	1795545	10150033	4.5 to 6.25	0 to 1.75	0.09	23	0.087	21
East Shore	1796988	10150354	4.5 to 6.25	0 to 1.75	0.15	60	0.175	87
Average K					50 ft/day			

Table 5: Hydraulic Conductivity of Soil near the Indian River Lagoon Bed at the Titusville (Haulover Canal) Transect

Location	Soil Sample Collection Point UTM 17 Coordinates		Depth Below Indian River Lagoon Bed Soli Samples Extracted		Effective Grain Size (d_{10}) and Hydraulic Conductivity (K) of Soil using Hazen Equation			
	Easting	Northing	Sample D	Sample S	Sample D		Sample S	
	(ft)	(ft)	(ft)	(ft)	d_{10} (mm)	K (ft/day)	d_{10} (mm)	K (ft/day)
West Shore	1692569	10424541	4.5 to 6.25	0 to 1.75	0.14	52	0.12	37
1	1694501	10425935	4.5 to 6.25	0 to 1.75	0.12	41	0.12	41
2	1371394	10427900	4.5 to 6.25	0 to 1.75	0.07	12	0.12	41
3	1702946	10429646	4.5 to 6.25	0 to 1.75	0.06	10	0.11	32
4	1706470	10431302	4.5 to 6.25	0 to 1.75	0.12	41	0.13	44
5	1709918	10432917	4.5 to 6.25	0 to 1.75	0.13	44	0.13	44
East Shore	1713412	10434639	4.5 to 6.25	0 to 1.75	0.16	73	0.13	44
Average K =					40 ft/day			

Table 6. Hydraulic Conductivity of Soil near the Indian River Lagoon Bed at the Vero Beach (Old Winter Beach) Transect

Location	Soil Sample Collection Point UTM 17 Coordinates		Depth Below Indian River Lagoon Bed Soli Samples Extracted		Effective Grain Size (d_{10}) and Hydraulic Conductivity (K) of Soil using Hazen Equation			
	Easting	Northing	Sample D	Sample S	Sample D		Sample S	
	(ft)	(ft)	(ft)	(ft)	d_{10} (mm)	K (ft/day)	d_{10} (mm)	K (ft/day)
West Shore	1830512	10061998	4.5 to 6.25	0 to 1.75	0.11	31	0.11	31
1	1831493	10062700	4.5 to 6.25	0 to 1.75	0.08	18	0.10	26
2	1832382	10062992	4.5 to 6.25	0 to 1.75	0.08	16	0.07	16
3	1833310	10063314	4.5 to 6.25	0 to 1.75	0.09	23	0.10	28
4	1834327	10064016	4.5 to 6.25	0 to 1.75	0.09	23	0.11	32
5	1835702	10064255	4.5 to 6.25	0 to 1.75	0.11	34	0.11	32
East Shore	1836467	10064501	4.5 to 6.25	0 to 1.75	0.11	32	0.24	163
					Average K		36	ft/day

Table 7. Groundwater Data of Monitoring Wells in Mainland and Barrier Island, at the Palm Bay (Valkaria) Transect

MW #	Monitoring Wells						24-Apr-09		22-May-09		9-Jun-09		16-Jul-09		11-Aug-09		30-Sep-09		28-Oct-09		25-Nov-09		21-Dec-09		26-Jan-10		19-Feb-10		23-Mar-10		
	UTM 17 ¹ Coordinates		Geographic Coordinates		MW TOC ² Elevation NGVD ⁵	Screen Depth ³	Mid Screen Elevation NGVD	GWT depth From MW	GWT Elevation NGVD	GWT depth From MW	GWT Elevation NGVD	GWT depth From MW	GWT Elevation NGVD	GWT depth From MW	GWT Elevation NGVD	GWT depth From MW	GWT Elevation NGVD	GWT depth From MW	GWT Elevation NGVD	GWT depth From MW	GWT Elevation NGVD	GWT depth From MW	GWT Elevation NGVD	GWT depth From MW	GWT Elevation NGVD	GWT depth From MW	GWT Elevation NGVD	GWT depth From MW	GWT Elevation NGVD		
	Easting	Northing	Latitudes	Longitudes																											
		(m)		(degrees)		(ft)		(ft)		(ft)		(ft)		(ft)		(ft)		(ft)		(ft)		(ft)		(ft)		(ft)		(ft)		(ft)	
PB 1	544805	3093141	27.96257	-80.54447	7.83	10.80	-2.98	2.09	5.74	1.56	6.27	-0.27	8.10	0.57	7.26	0.61	7.22	0.32	7.51	1.05	6.78	1.49	6.34	-0.20	8.03	0.40	7.43	0.30	7.53	-0.41	8.24
PB 2	544537	3092980	27.96116	-80.5472	22.84	10.30	12.54	8.67	14.17	8.18	14.66	6.71	16.13	6.93	15.91	6.90	15.94	6.35	16.49	7.15	15.69	7.98	14.86	6.21	16.63	7.30	15.54	7.26	15.58	6.19	16.65
PB 3	544292	3093065	27.96191	-80.54968	22.56	10.80	11.76	5.35	17.21	5.00	17.56	2.67	19.89	3.70	18.86	3.68	18.88	3.27	19.29	3.98	18.58	4.71	17.85	2.82	19.74	3.72	18.84	3.51	19.05	2.00	20.56
PB 4	544300	3092800	27.95957	-80.54961	21.43	10.28	11.15	5.67	15.76	5.22	16.21	3.45	17.98	4.08	17.35	3.94	17.49	3.52	17.91	4.35	17.08	5.80	15.63	2.92	18.51	3.98	17.45	3.66	17.77	2.35	19.08
PB 5	544087	3093032	27.96159	-80.55177	25.40	7.87	17.53	6.98	18.42	6.86	18.54	4.83	20.57	5.25	20.15	5.03	20.37	4.35	21.05	5.10	20.30	5.84	19.56	4.12	21.28	4.72	20.68	4.55	20.85	3.75	21.65
PB BI	548241	3093834	27.96872	-80.5095	13.09	16.70	-3.61	11.28	1.81	10.41	2.68	9.89	3.20	10.92	2.17	10.89	2.20	10.08	3.01	10.29	2.80	9.21	3.88	9.56	3.53	10.67	2.42	10.81	2.28	10.05	3.04
TBM	545023	3092842	27.95988	-80.54226	4.53	NA	NA	2.92	1.61	2.84	1.69	2.35	2.18	2.82	1.71	2.84	1.69	2.66	1.87	2.98	1.55	2.95	1.58	2.58	1.95	2.82	1.71	2.78	1.75	2.25	2.28

1 UTM 17 - Universal Transverse Mercator Zone-17 Coordinates

2 MW TOC - Monitoring Well Top of Casing

3 Screen Depth From Top of Casing of Monitoring Well to The Bottom of Screen

4 Bottom of Screen Elevation in NGVD

5 Elevation is in ft NGVD1929 as provided by SJRWMD Survey Party.

6 NA: not applicable

Table 8. Groundwater Data of Monitoring Wells in Mainland at the Titusville (Haulover Canal Area) Transect

MW #	Monitoring Wells						23-Apr-09		23-May-09		10-Jun-09		15-Jul-09		15-Aug-09		2-Oct-09		25-Oct-09		22-Nov-09		24-Dec-09		24-Jan-10		21-Feb-10		21-Mar-10		
	UTM 17 ¹ Coordinates		Geographic Coordinates		MW TOC ² Elevation NGVD 29	Screen Depth ³	Screen ⁴ Elevation NGVD	GWT depth From MW	GWT Elevation NGVD	GWT depth From MW	GWT Elevation NGVD	GWT depth From MW	GWT Elevation NGVD	GWT depth From MW	GWT Elevation NGVD	GWT depth From MW	GWT Elevation NGVD	GWT depth From MW	GWT Elevation NGVD	GWT depth From MW	GWT Elevation NGVD	GWT depth From MW	GWT Elevation NGVD	GWT depth From MW	GWT Elevation NGVD	GWT depth From MW	GWT Elevation NGVD	GWT depth From MW	GWT Elevation NGVD		
	Easting	Northing	Latitudes	Longitudes																											
	(m)		(degrees)		(ft)		(ft)	(ft)		(ft)		(ft)		(ft)		(ft)		(ft)		(ft)		(ft)		(ft)		(ft)		(ft)			
TV 1	514823	3176936	28.71976	-80.84822	11.04	10.43	0.61	6.80	4.24	3.92	7.12	3.27	7.77	4.7	6.34	3.95	7.09	5.22	5.82	5.85	5.19	6.43	4.61	4.85	6.19	5.21	5.83	3.99	7.05	3.50	7.54
TV 2	514650	3176399	28.71481	-80.85000	12.06	10.82	1.24	5.87	6.19	2.14	9.92	2.67	9.39	3.16	8.90	2.48	9.58	4.22	7.84	5.07	6.99	5.70	6.36	3.81	8.25	3.75	8.31	2.98	9.08	2.79	9.27
TV 3	513724	3176635	28.71695	-80.85948	32.43	16.72	15.71	14.85	17.58	13.80	18.63	12.14	20.29	12.56	19.87	11.88	20.55	12.81	19.62	13.45	18.98	14.11	18.32	13.55	18.88	14.02	18.41	12.97	19.46	11.98	20.45
TV 4	513364	3176644	28.71704	-80.86316	25.21	10.80	14.41	5.64	19.57	3.18	22.03	2.57	22.64	2.77	22.44	2.02	23.19	3.37	21.84	4.10	21.11	4.81	20.40	4.20	21.01	4.74	20.47	3.65	21.56	2.77	22.44

1 UTM 17 - Universal Transverse Mercator Zone-17 Coordinates

2 MW TOC - Monitoring Well Top of Casing

3 Screen Depth From Top of Casing of Monitoring Well to The Bottom of Screen

4 Bottom of Screen Elevation in NGVD

Table 9. Groundwater Data of Monitoring Wells in Mainland and Barrier Island, at the Vero Beach (Old Winter Beach) Transect

MW #	Monitoring Wells						25-Apr-09		21-May-09		11-Jun-09		18-Jul-09		12-Aug-09		3-Oct-09		24-Oct-09		21-Nov-09		28-Dec-09		23-Jan-10		20-Feb-10		20-Mar-10		
	UTM 17 ¹ Coordinates		Geographic Coordinates		MW TOC ² Elevation NGVD 29	Screen Depth ³	Screen ⁴ Elevation NGVD	GWT depth From MW	GWT Elevation NGVD	GWT depth From MW	GWT Elevation NGVD	GWT depth From MW	GWT Elevation NGVD	GWT depth From MW	GWT Elevation NGVD	GWT depth From MW	GWT Elevation NGVD	GWT depth From MW	GWT Elevation NGVD	GWT depth From MW	GWT Elevation NGVD	GWT depth From MW	GWT Elevation NGVD	GWT depth From MW	GWT Elevation NGVD	GWT depth From MW	GWT Elevation NGVD	GWT depth From MW	GWT Elevation NGVD		
	Easting	Northing	Latitudes	Longitudes																											
		(m)		(degrees)		(ft)		(ft)		(ft)		(ft)		(ft)		(ft)		(ft)		(ft)		(ft)		(ft)		(ft)		(ft)		(ft)	
VB 1	557044	3065784	27.71516	-80.42135	16.95	10.82	6.13	7.55	9.40	7.14	9.81	5.17	11.78	4.37	12.58	5.04	11.91	5.51	11.44	6.35	10.60	6.15	10.80	4.98	11.97	5.81	11.14	6.01	10.94	4.15	12.80
VB 2	556785	3066643	27.72293	-80.42393	10.90	6.22	4.68	3.47	7.43	2.08	8.82	1.71	9.19	1.32	9.58	1.86	9.04	2.2	8.70	2.95	7.95	2.73	8.17	1.81	9.09	2.18	8.72	2.25	8.65	1.5	9.40
VB 3	556072	3066632	27.72286	-80.43117	37.52	19.72	17.80	18.21	19.31	18.36	19.16	16.73	20.79	14.52	23.00	14.8	22.72	15.49	22.03	16.95	20.57	16.67	20.85	15.85	21.67	16.58	20.94	17.06	20.46	15.18	22.34
VB BI	560817	3067595	27.73135	-80.38298	9.79	10.82	-1.03	7.48	2.31	7.28	2.51	5.80	3.99	5.92	3.87	6.57	3.22	5.94	3.85	6.46	3.33	6.27	3.52	6.14	3.65	6.85	2.94	6.87	2.92	5.75	4.04
TBM1	557643	3066204	27.71893	-80.41525	23.81	NA	NA	11.65	12.16	11.27	12.54	11.17	12.64	11.00	12.81	11.20	12.61	11.40	12.41	11.47	12.34	11.45	12.36	10.90	12.91	11.10	12.71	10.89	12.92	10.64	13.17
TBM2	555636	3066221	27.71916	-80.43561	5.84	NA	NA	4.18	1.66	4.05	1.79	4.22	1.62	3.95	1.89	4.07	1.77	3.93	1.91	4.15	1.69	4.29	1.55	4.15	1.69	4.14	1.70	4.05	1.79	4.1	1.74

*: to be determined; NA: not applicable
1 UTM 17 - Universal Transverse Mercator Zone-17 Coordinates
2 MW TOC - Monitoring Well Top of Casing
3 Screen Depth From Top of Casing of Monitoring Well to The Bottom of Screen
4 Bottom of Screen Elevation in NGVD

Table 10. Piezometric Heads at the Palm Bay (Valkaria) Transect

Location / #	24-Apr-09		22-May-09		16-Jul-09		11-Aug-09		30-Sep-09	
	MW - D	MW - S	MW - D	MW - S	MW - D	MW - S	MW - D	MW - S	MW - D	MW - S
	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)
West Shore	0.42	0.42	1.66	1.63	0.97	0.92	0.48	0.47	1.59	1.53
1	0.43	0.36	1.76	1.69	0.84	0.80	0.30	0.23	1.51	1.44
2	0.31	0.31	1.53	1.51	*	*	0.82	0.28	1.48	1.45
3	0.64	0.44	1.97	1.83	1.34	0.94	0.94	0.54	1.64	1.47
4	0.81	0.50	2.25	1.73	1.27	0.87	0.87	0.78	1.82	1.41
5	0.93	0.31	2.26	1.91	1.39	1.19	*	*	*	*
East Shore	0.39	0.37	1.63	1.61	0.95	0.93	0.93	0.45	1.60	1.53

*: Wells extracted and data not available

Table 11. Piezometric Heads at the Titusville (Haulover Canal Area) Transect

Location / #	23-Apr-09		23-May-09		15-Jul-09		15-Aug-09		2-Oct-09	
	MW - D	MW - S	MW - D	MW - S	MW - D	MW - S	MW - D	MW - S	MW - D	MW - S
	(ft)		(ft)		(ft)		(ft)		(ft)	
West Shore	0.11	0.38	2.18	2.16	2.18	2.04	0.35	0.62	1.13	1.32
1	0.35	0.39	1.79	1.77	1.03	1.03	0.26	0.31	1.27	1.46
2	0.39	0.43	1.77	1.80	1.03	1.00	0.34	0.32	1.27	1.30
3	0.17	0.40	1.75	1.85	1.35	1.23	0.58	0.37	1.58	1.60
4	0.44	0.44	1.77	1.80	1.02	0.92	0.58	0.48	1.18	1.18
5	0.30	0.27	1.79	1.95	1.12	1.08	0.72	0.37	1.44	1.40
East Shore	0.56	0.46	2.63	2.48	1.15	1.03	0.78	0.63	1.48	1.46

Table 12. Piezometric Heads at the Vero Beach (Old Winter Beach) Transect

Location / #	25-Apr-09		21-May-09		7/18/2009**		7/18/2009***		12-Aug-09		3-Oct-09	
	D	S	D	S	D	S	D	S	D	S	D	S
	(ft)		(ft)		(ft)		(ft)		(ft)		(ft)	
WSA*	*		*		2.20		2.22		2.04		1.29	
West Shore	-0.59	Dry	1.88	1.84	1.67	1.68	1.61	1.60	1.45	1.46	1.30	1.30
1	0.12	0.12	1.39	1.32	0.19	0.36	0.03	0.10	-0.37	-0.27	1.37	1.37
2	0.17	0.07	1.48	1.51	0.26	0.27	0.13	0.21	-0.25	-0.15	1.42	1.60
3	0.02	0.22	1.20	1.45	0.11	0.28	-0.06	0.09	-0.47	-0.29	1.36	1.50
4	0.02	0.16	1.38	1.38	0.45	0.35	0.45	0.35	-0.11	-0.08	1.47	1.51
4A	*	*	*	*		0.86	0.62	0.86	0.62	0.14	1.61	1.58
5	0.11	0.26	1.38	1.51	0.26	0.30	0.12	0.22	-0.28	-0.10	1.48	1.70
East Shore	0.34	0.41	1.66	1.70	0.79	0.81	0.72	0.75	0.19	0.24	1.76	1.83

*: not available; **: Measurements recorded in morning; ***: Measurements recorded in afternoon time

**Table 13 : Salinity Data of Ground Water Samples Collected from the Monitoring Wells
at the Selected Study Cross-Section, Palm Bay (Valkaria)**

Monitoring Well Station #	Distance From West Shore (ft)	Distance From West Shore (miles)	24-Apr-09		22-May-09		16-Jul-09		11-Aug-09		30-Sep-09	
			D	S	D	S	D	S	D	S	D	S
			(PPT)		(PPT)		(PPT)		(PPT)		(PPT)	
West Shore	0	0	0.9	0.8	1.3	1.0	0.9	0.8	1.4	0.7	0.9	0.8
1	1500	0.28	22.0	25.1	21.9	24.3	21.9	21.8	21.4	21.1	21.4	22.1
2	2877	0.54	32.2	32.6	33.5	33.2	NA	NA	24.5	31.5	26.3	30.3
3	4291	0.81	9.9	14.3	9.8	11.6	9.6	10.1	9.5	9.7	9.8	9.7
4	5716	1.08	8.1	18.0	7.6	11.7	7.4	10.0	7.2	8.5	7.2	9.0
5	7126	1.35	7.3	32.9	7.1	31.3	7.1	28.0	NA	NA	NA	NA
East Shore	8572	1.62	16.1	4.0	17.3	6.3	11.4	1.1	10.8	1.9	16.7	10.9

NA: not available

D: Shallow Groundwater Monitoring Well

S: Deep Groundwater Monitoring Well

Note: The salinity in the ocean is normally 36 ppt.

**Table 14 : Salinity Data of Ground Water Samples Collected from the Monitoring Wells
at the Selected Study Cross-Section, Titusville (Haulover Canal Area)**

Monitoring Well Station #	Distance From West Shore (ft)	Distance From West Shore (miles)	23-Apr-09		23-May-09		15-Jul-09		15-Aug-09		2-Oct-09	
			D	S	D	S	D	S	D	S	D	S
			(PPT)		(PPT)		(PPT)		(PPT)		(PPT)	
West Shore	0	0	30.5	14.6	29.8	23.9	28.5	12.5	23.6	12.0	27.5	12.2
1	2383	0.45	31.4	30.5	30.6	30.1	32.0	30.0	28.5	28.1	29.7	28.3
2	7183	1.36	31.5	30.5	30.6	30.5	31.5	27.0	30.0	23.8	30.4	NA
3	10523	1.99	32.0	34.5	32.3	32.5	33.3	32.8	29.0	29.8	30.0	25.5
4	13999	2.65	28.9	34.4	29.0	30.5	29.5	27.0	27.7	24.3	27.7	25.9
5	17424	3.30	28.3	35.5	28.2	35.0	28.5	34.1	28.2	32.2	27.6	32.1
East Shore	20914	3.96	3.0	0.4	6.2	0.4	0.3	0.7	0.3	0.3	0.8	0.3

D: Shallow Groundwater Monitoring Well

S: Deep Groundwater Monitoring Well

Note: The salinity in the ocean is normally 36 ppt.

**Table 15 : Salinity Data of Ground Water Samples Collected from the Monitoring Wells
at the Selected Study Cross-Section, Vero Beach (Old Winter Beach)**

Monitoring Well Station #	Distance From West Shore (ft)	Distance From West Shore (miles)	25-Apr-09		21-May-09		7/18/2009 AM		7/18/2009 PM		12-Aug-09		3-Oct-09	
			D	S	D	S	D	S	D	S	D	S	D	S
			(PPT)		(PPT)		(PPT)		(PPT)		(PPT)		(PPT)	
West Shore	0	0	28.4	NA	15.8	12.9	20.3	18.2	21.3	17.7	13.1	14.2	15.4	15.2
1	1206	0.23	32.9	30.6	34.8	33.0	31.4	21.6	31.1	22.2	32.6	19.6	29.8	22.4
2	1893	0.36	48.7	33.4	48.2	32.8	48.5	33.6	47.5	31.2	48.4	32.8	48.3	28.3
3	2817	0.53	52.3	30.9	53.6	33.6	54.5	24.6	53.9	24.1	53.4	25.5	53.8	22.6
4	3880	0.73	56.5	44.8	55.0	36.4	56.0	43.3	56.0	43.3	54.8	44.1	56.2	41.6
4A	3880	0.73	*	*	*	*	56.5	55.2	56.5	55.2	57.5	56.4	56.4	53.1
5	5196	0.98	47.7	30.4	45.1	30.5	51.5	28.3	50.6	27.8	52.2	26.7	49.7	24.2
East Shore	5960	1.13	1.9	1.3	2.9	1.6	0.9	1.1	0.8	1.0	1.1	1.1	1.0	1.1

D: Shallow Groundwater Monitoring Well

S: Deep Groundwater Monitoring Well

Note: The salinity in the ocean is normally 36 ppt.

Table 16. Salinity Data Of Indian River Lagoon at the Different Study Transects

Location/City	Obsrvation Date	Salinity (PPT) Data of Indian River Lagoon Along Different Study Transects						
		West Shore	1	2	3	4	5	East Shore
Palm Bay (Valkaria)	24-Apr-09	34.9	34.9	35.5	35.9	35.9	36.1	34.9
	22-May-09	29.0	33.0	33.5	33.9	34.0	33.5	33.9
	11-Jun-09	23.9	*	*	*	*	*	*
	16-Jul-09	19.8	26.6	*	27.6	28.0	28.2	27.2
	11-Aug-09	12.5	20.6	21.8	19.0	20.4	*	20.7
	30-Sep-09	22.6	22.8	23.2	23.5	22.9	*	23.3
Titusville (Haulover Canal)	23-Apr-09	36.5	37.4	38.5	37.2	37.6	38.3	*
	23-May-09	19.2	28.0	30.5	30.7	30.9	29.2	28.0
	10-Jun-09	*	*	*	*	*	*	25.5
	15-Jul-09	23.2	27.0	27.4	27.5	27.3	27.8	26.4
	15-Aug-09	11.6	22.6	23.9	24.3	24.0	22.4	25.1
	2-Oct-09	23.0	25.3	26.1	26.0	25.9	23.8	26.0
Vero Beach (Old Winter Beach)	25-Apr-09	*	34.3	30.7	34.6	36.5	31.3	34.6
	21-May-09	26.8	30.4	31.5	31.6	33.2	32.2	33.0
	11-Jun-09	*	21.1	*	*	*	*	*
	7/18/2009 AM	*	17.9	19.3	17.9	16.7	18.3	18.2
	07/18/2009 PM	*	18.6	19.1	18.7	*	21.0	18.6
	12-Aug-09	15.7	17.7	17.8	17.9	21.4	18.6	19.5
	3-Oct-09	25.9	26.5	26.8	27.4	27.0	27.7	27.3

*: not avaiialble

**Table 17. Nutrients Analyses Data of Groundwater Below the
Indian River Lagoon at the Valkaria (Palm Bay) Transect**

Date	Station #	Season	Sampling MW ID	Phosphorus	TKN-N
				(mg/l)	(mg/l)
24-Apr-09	1	Dry	West Shore	0.36	2.31
	2		Well Station # 3	0.31	1.94
	3		East Shore	0.60	1.48
22-May-09	1	Dry	West Shore	0.94	2.54
	2		Well Station # 3	0.43	2.57
	3		East Shore	0.57	1.05
16-Jul-09	1	Wet	West Shore	0.43	2.33
	2		Well Station # 3	0.31	3.21
	3		East Shore	0.06	BDL
11-Aug-09	1	Wet	West Shore	0.38	2.41
	2		Well Station # 3	0.26	0.50
	3		East Shore	0.18	0.15
30-Sep-09	1	Wet	West Shore	0.42	2.44
	2		Well Station # 3	0.17	3.25
	3		East Shore	0.36	0.57

Note: BDL (Below Detection Limit); the detection limit for Total Phosphorus, Nitrite-N, Nitrate-N and Total Kjeldahl Nitrogen were 0.06 mg/l, 0.05 mg/l, 0.05 mg/l and 0.045 mg/l, respectively.

**Table 18. Nutrients Analyses Data of Groundwater Below the
Indian River Lagoon at the Titusville Transect**

Date	Station #	Season	Sampling MW ID	Phosphorus	TKN-N
				(mg/l)	(mg/l)
23-Apr-09	1	Dry	West Shore	2.35	15.8
	2		Well Station # 3	3.70	10.5
	3		East Shore	0.06	BDL
23-May-09	1	Dry	West Shore	0.83	8.42
	2		Well Station # 3	0.11	2.72
	3		East Shore	0.28	0.13
15-Jul-09	1	Wet	West Shore	1.11	12.80
	2		Well Station # 3	0.34	3.38
	3		East Shore	0.09	0.10
15-Aug-09	1	Wet	West Shore	0.96	8.23
	2		Well Station # 3	0.48	1.18
	3		East Shore	0.28	0.52
2-Oct-09	1	Wet	West Shore	1.30	15.30
	2		Well Station # 3	2.70	2.65
	3		East Shore	0.09	0.12

Note: BDL (Below Detection Limit); the detection limit for Total Phosphorus, Nitrite-N, Nitrate-N and Total Kjeldahl Nitrogen were 0.06 mg/l, 0.05 mg/l, 0.05 mg/l and 0.045 mg/l, respectively.

Table 19. Nutrients Analyses Data of Groundwater Below the Indian River Lagoon at the Vero Beach Transect

Date	Station #	Season	Sampling MW ID	Phosphorus	TKN-N
				(mg/l)	(mg/l)
25-Apr-09	1	Dry	West Shore	2.58	5.53
	2		Well Station # 3	1.25	8.73
	3		East Shore	0.19	2.90
21-May-09	1	Dry	West Shore	0.18	0.37
	2		Well Station # 3	0.07	0.77
	3		East Shore	0.22	2.79
18-Jul-09	1	Wet	West Shore	1.41	0.69
	2		Well Station # 3	0.28	0.74
	3		East Shore	0.07	0.33
12-Aug-09	1	Wet	West Shore	1.03	0.45
	2		Well Station # 3	0.19	0.34
	3		East Shore	0.21	2.74
3-Oct-09	1	Wet	West Shore	3.00	1.28
	2		Well Station # 3	0.23	0.86
	3		East Shore	0.13	2.91

Note: BDL (Below Detection Limit); the detection limit for Total Phosphorus, Nitrite-N, Nitrate-N and Total Kjeldahl Nitrogen were 0.06 mg/l, 0.05 mg/l, 0.05 mg/l and 0.045 mg/l, respectively.

**Table 20. Model Predicted Meteoric Groundwater Discharge
per foot of Lagoon Shoreline at the Palm Bay
(Valkaria) Transect**

Year	Month	Sub- Section 1 ft ³ /day	Sub- Section 2 ft ³ /day	Sub- Section 3 ft ³ /day	Total ft ³ /day
2009	April	8.351	0.291	2.119	10.76
2009	May	6.003	0.001	1.195	7.20
2009	July	8.423	0.002	2.633	11.06
2009	August	9.377	0.360	2.584	12.32
2009	September	11.119	0.002	1.529	12.65
Average		8.65	0.13	2.01	10.80
Std. Dev.		1.86	0.18	0.64	2.17

Sub-Section 1: from 3820 ft (west shore) to 6675 ft; length = 2855 ft

Sub-Section 2: from 6675 ft to 9550 ft; length = 2875 ft

Sub-Section 3: from 9550 ft to 12375 ft (east shore); length = 2825 ft

**Table 21. Model Predicted Meteoric Groundwater Discharge
per foot of Lagoon Shoreline at the Titusville
(Haulover Canal Area) Transect**

Year	Month	Sub- Section 1 ft ³ /day	Sub- Section 2 ft ³ /day	Sub- Section 3 ft ³ /day	Total ft ³ /day
2009	April	2.00	0.02	0.82	2.84
2009	May	2.32	0.04	1.02	3.38
2009	July	2.92	0.04	1.04	4.00
2009	August	3.05	0.05	1.53	4.63
2009	September	1.97	0.04	1.26	3.27
Average		2.45	0.04	1.14	3.63
Std. Dev.		0.51	0.01	0.27	0.70

Sub-Section 1: from 8825 ft (west shore) to 16750 ft; length = 7925 ft

Sub-Section 2: from 16750 ft to 24375 ft; length = 7625 ft

Sub-Section 3: from 24375 ft to 32150 ft (east shore); length = 7775 ft

**Table 22. Model Predicted Meteoric Groundwater Discharge
per foot of Lagoon Shoreline at the Vero Beach
(Old Winter Beach) Transect**

Year	Month	Mosquito Impoundment	Sub- Section 1 ft ³ /day	Sub- Section 2 ft ³ /day	Sub- Section 3 ft ³ /day	Total ft ³ /day
2009	April	1.35	1.21	0.72	1.30	4.58
2009	May	0.91	1.91	0.67	0.58	4.07
2009	July	0.23	5.85	1.15	2.44	9.67
2009	August	0.00	8.41	1.24	2.87	12.52
2009	September	1.19	1.24	0.69	0.95	4.06
Average		0.74	3.72	0.89	1.63	6.98
Std. Dev.		0.59	3.25	0.28	0.98	3.89

Mosquito Impoundment: from 6050 ft to 6750 ft, length = 700 ft

Sub-Section 1: from 6750 ft (west shore) to 8750 ft; length = 2000 ft

Sub-Section 2: from 8750 ft to 11250 ft; length = 2500 ft

Sub-Section 3: from 12350 ft to 13275 ft (east shore); length = 925 ft

**Table 23. Nutrient Loads into the Indian River Lagoon
at the Palm Bay (Valkaria) Transect**

Date	TP		TKN-N	
	(mg/day/ft)	(mM/day/m)	(mg/day/ft)	(mM/day/m)
24-Apr-09	124	13	651	153
22-May-09	85	9	416	97
16-Jul-09	175	19	545	128
11-Aug-09	296	31	777	182
30-Sep-09	154	16	910	213
Average	167	18	660	155

**Table 24. Nutrient Loads into the Indian River Lagoon
at the Titusville (Haulover Canal Area) Trans**

Date	TP		TKN-N	
	(mg/day/ft)	(mM/day/m)	(mg/day/ft)	(mM/day/m)
23-Apr-09	137	14	903	212
23-May-09	267	28	934	219
15-Jul-09	9	1	93	22
15-Aug-09	84	9	737	173
2-Oct-09	46	5	610	143
Average	109	12	655	154

**Table 25. Nutrient Loads into the Indian River Lagoon
at the Vero Beach (Old Winter Beach) Transf**

Date	TP		TKN-N	
	(mg/day/ft)	(mM/day/m)	(mg/day/ft)	(mM/day/m)
25-Apr-09	219	23	686	161
21-May-09	106	11	757	177
18-Jul-09	44	5	564	132
12-Aug-09	64	7	343	80
3-Oct-09	47	5	126	29
Average	96	10	495	116