Use ArcNLET to Estimate Nitrogen Load from Septic Systems to Indian River Lagoon (part of Main-South canal in Indian River County)

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Study Area: Main-South canal drainage basins of IRC

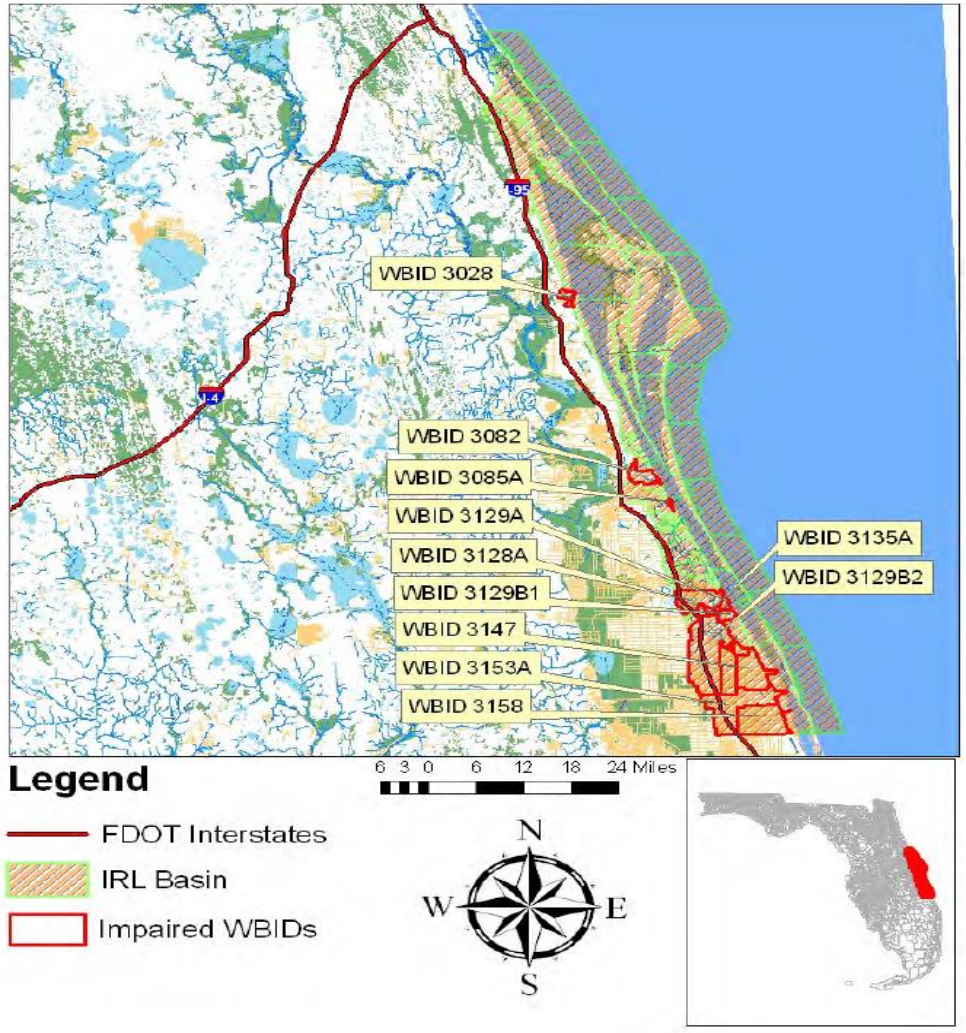
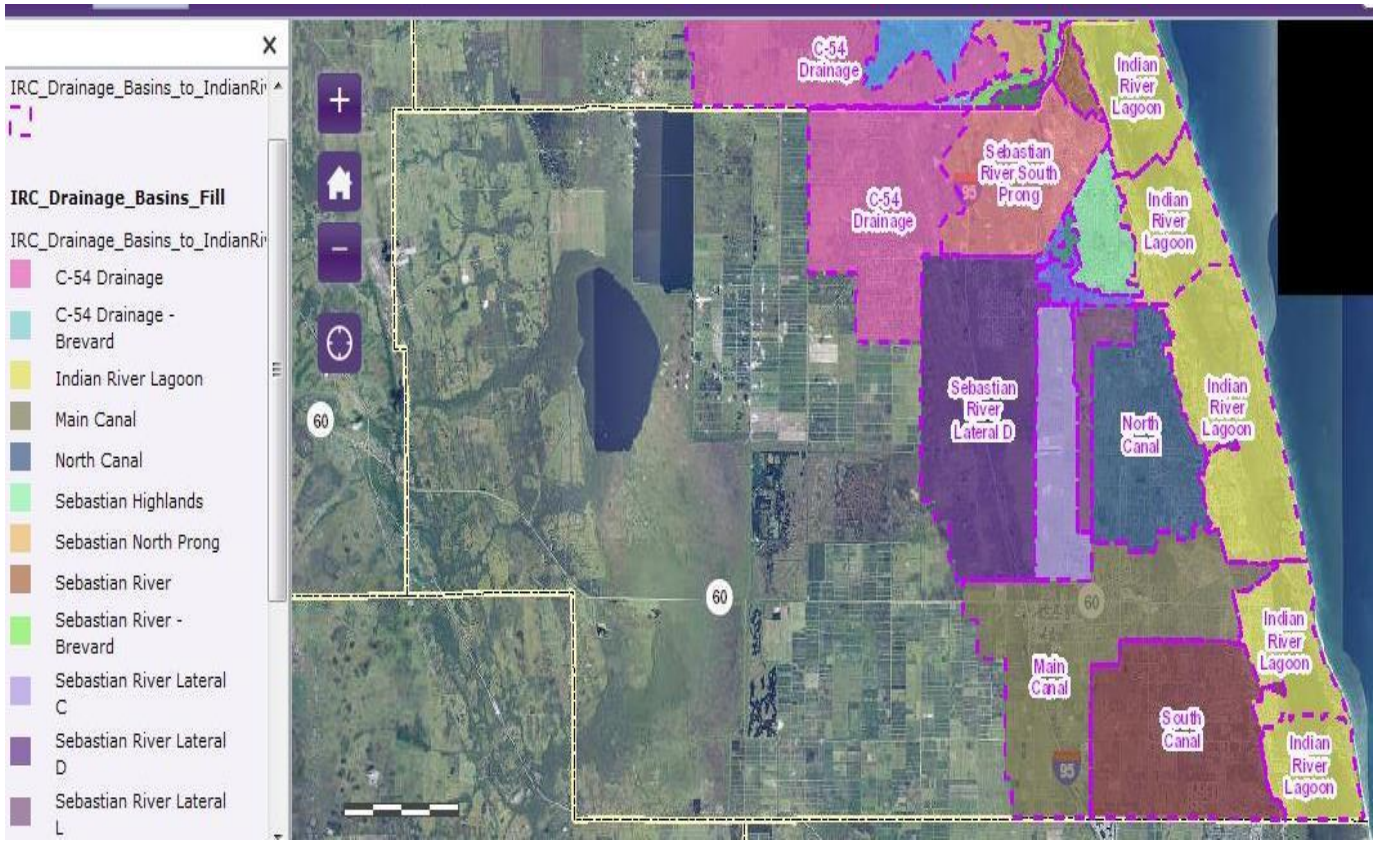


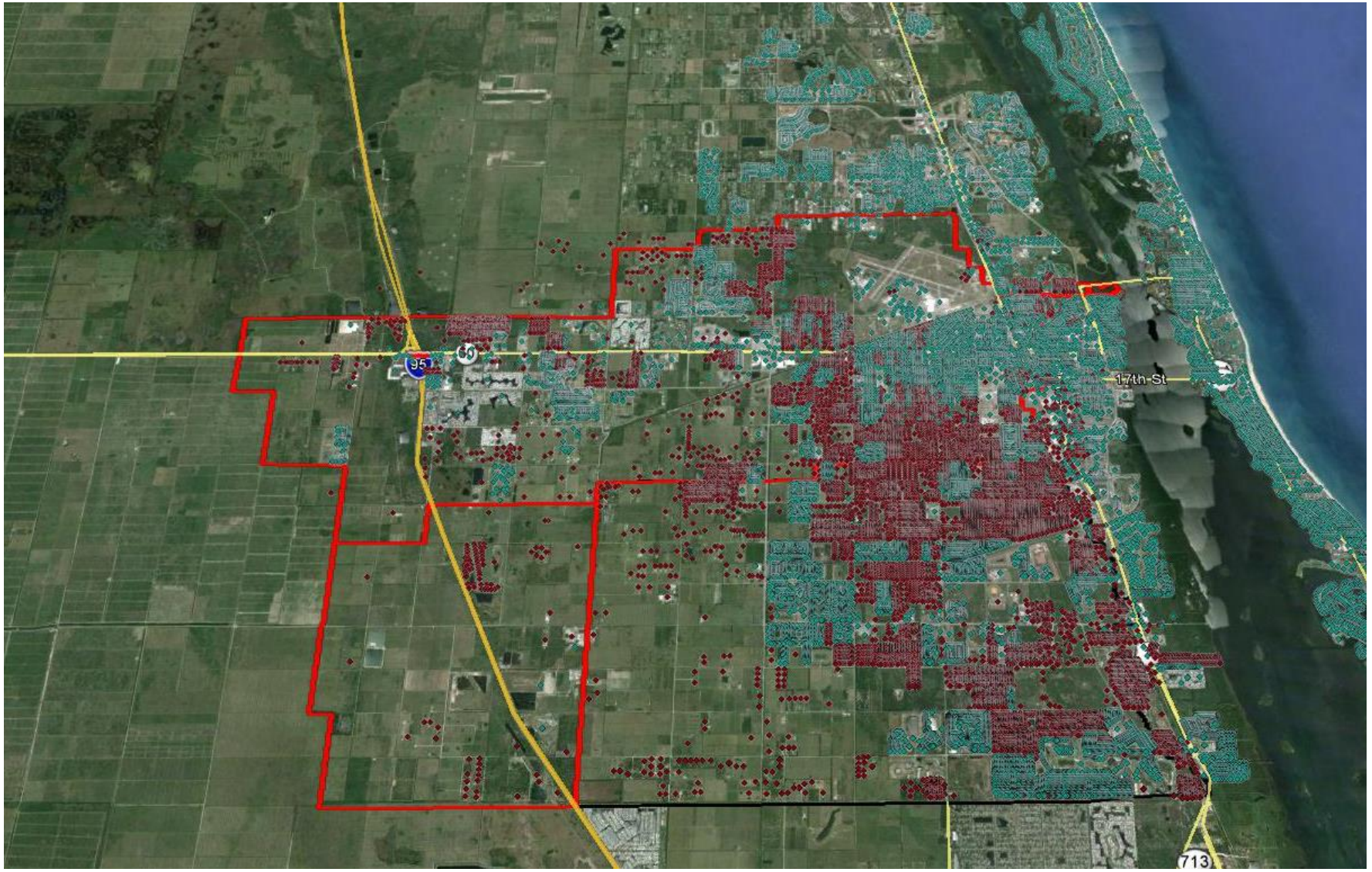
Figure 1.1. Location of Impaired Tributary Segments in the IRL Basin

FDEP BMAP report, 2012



- Estimate nitrogen loads from septic systems in the Main-South canal drainage basins
- The load estimates from the drainage basins can be used directly for TMDL implementation as well to help assess for future septic tank phase-out projects.

Septic tank locations



- No Sewer: **12,735**
- Converted to sewer: **27,171**

➢ Main Canal: **5343**
➢ South Canal: **7392**

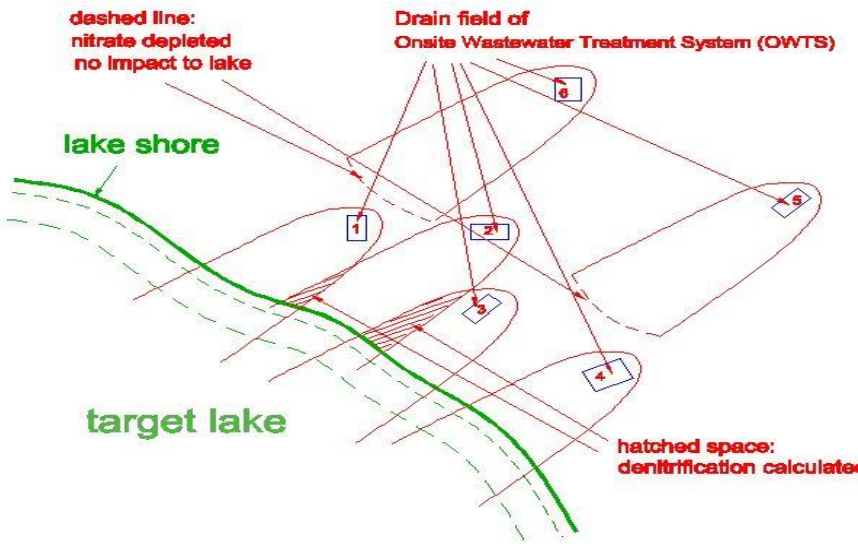
Sources: Will Rice (IRC)

Modeling Procedure

For each site, whenever site-specific data are available,

- Compile historical data to understand groundwater flow and nitrogen transport at the modeling sites.
- Select calibration data of hydraulic head and nitrogen concentration to estimate ArcNLET flow and transport model parameters.
- Calibrate the ArcNLET model.
- Simulate nitrogen transport at the modeling site, using the calibrated model.
- Estimate the nitrogen load.

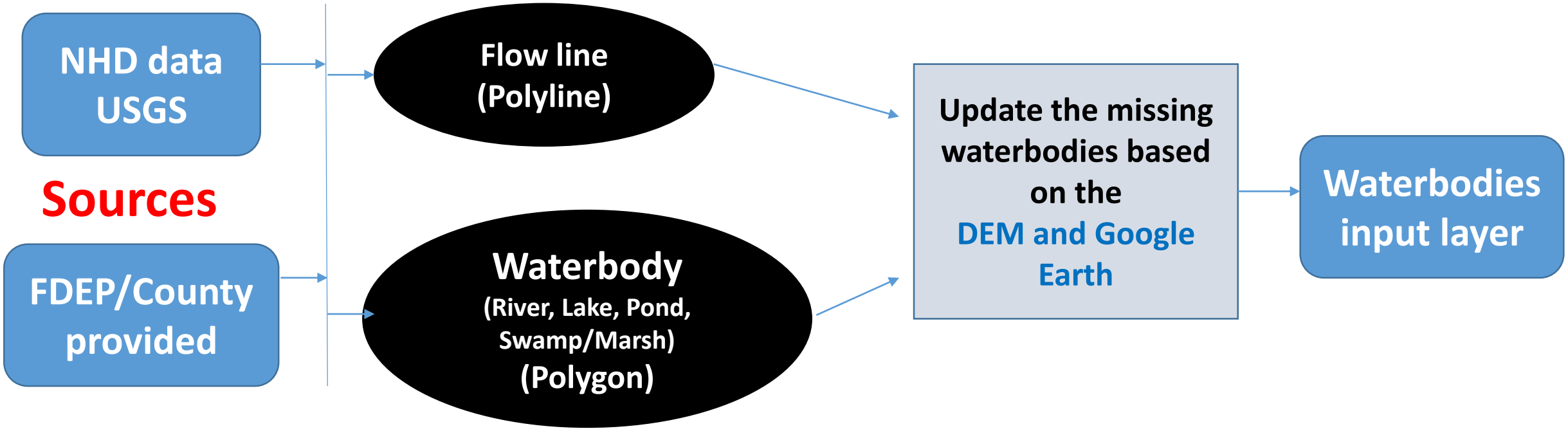
Input Data of ArcNLET



All input data files are in ArcGIS format.

- Locations of septic tanks
- Locations of water bodies
- Topography (DEM: Digital Elevation Model): Process it to obtain water table
- Hydrogeological and transport parameters
  - Smoothing factor (used to process topography)
  - Hydraulic conductivity (from SSURGO)
  - Porosity (from SSURGO)
  - Dispersivity
  - Decay coefficient of denitrification
  - Source load and concentration

Preparation of Input files (GW flow) : **Waterbodies**



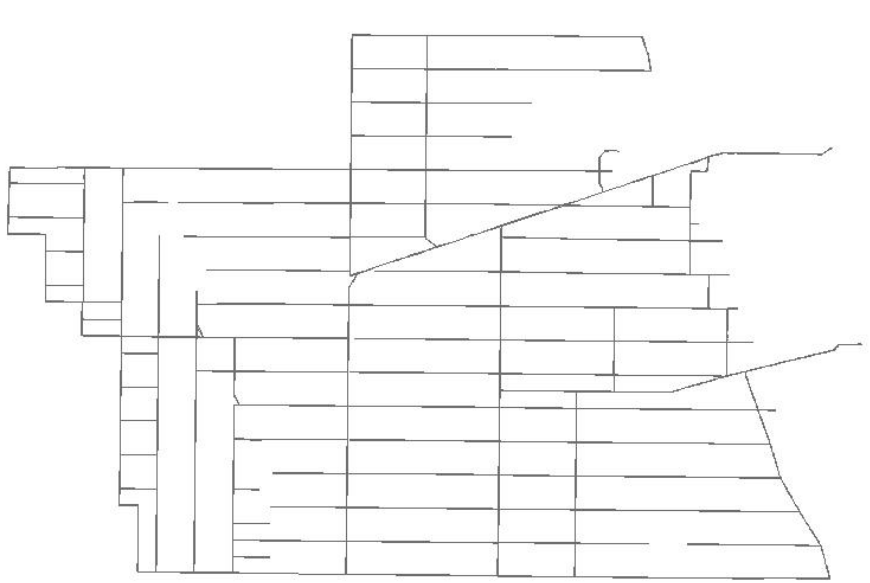
Preparation of Input files (GW flow) : **DEM (Digital Elevation Map)**

Sources :

-LiDAR (**Li**ght **D**etection **A**nd **R**anging) DEM (5ft*5ft or 15ft*15ft)

-NED (National Elevation Datasets) DEM (3m*3m or 10m*10m)

Data sets: **WaterBody** (Canals, lagoon, lakes, swamps)



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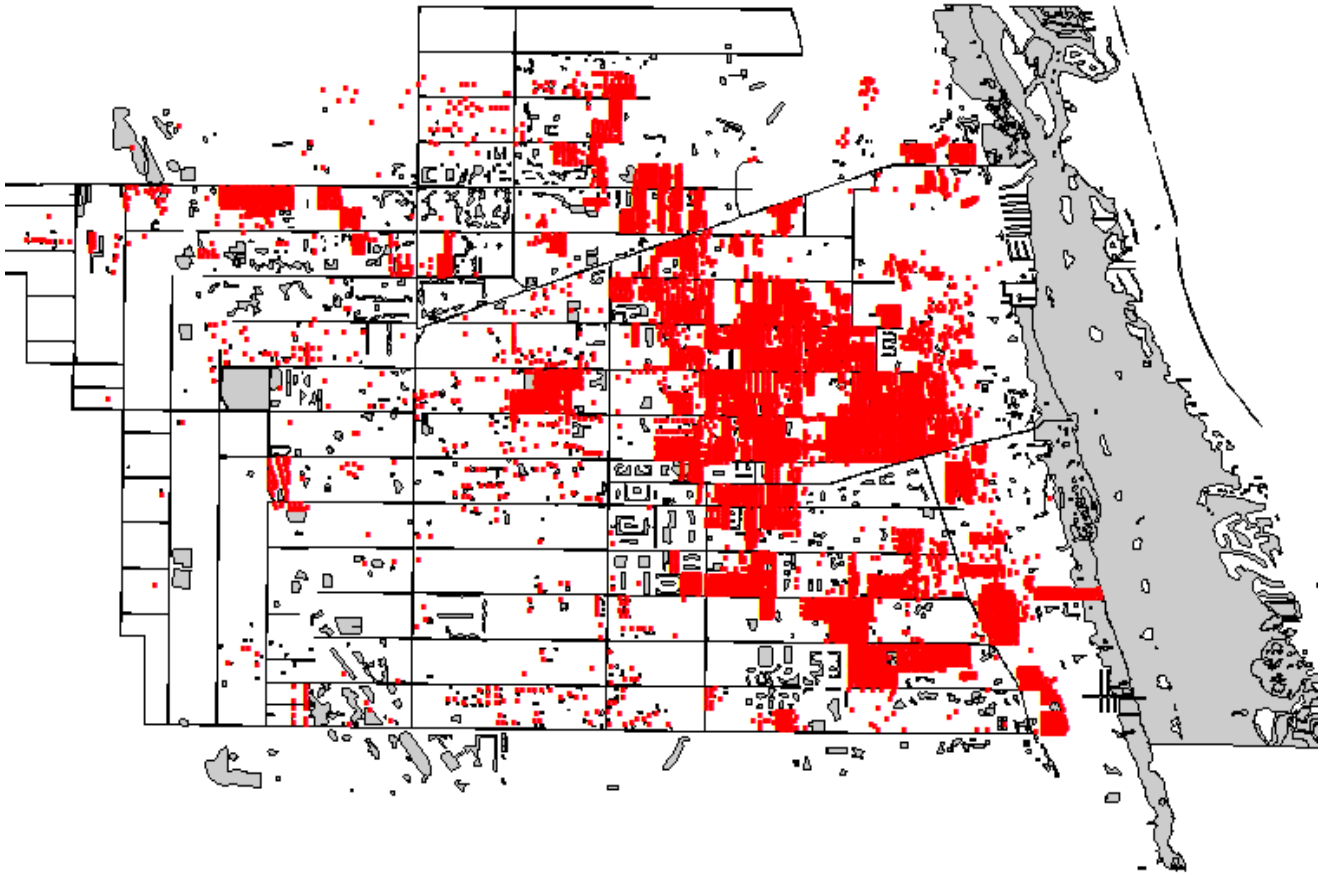
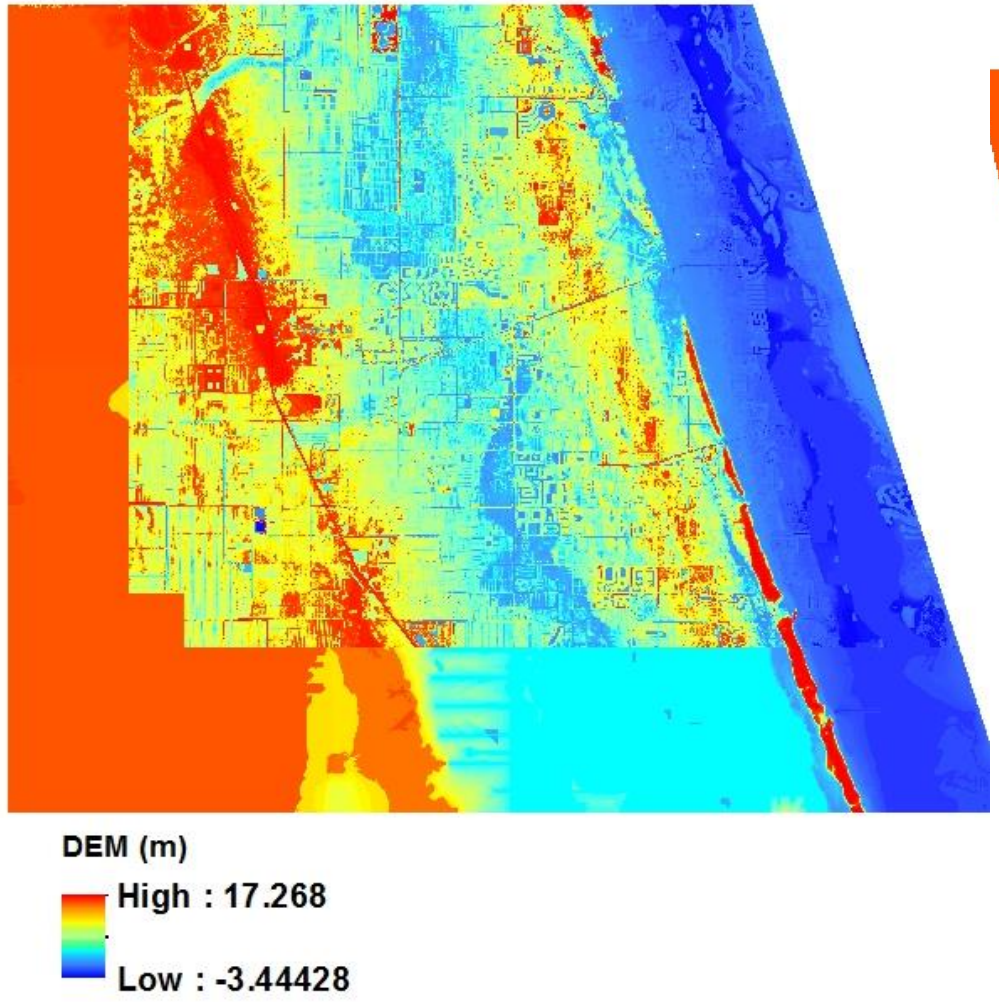


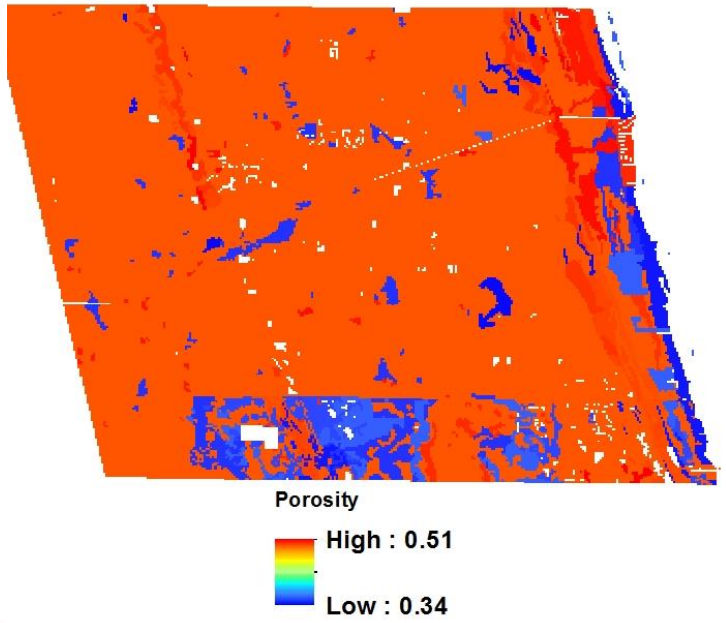
Data sets:

SSURGO: soil data

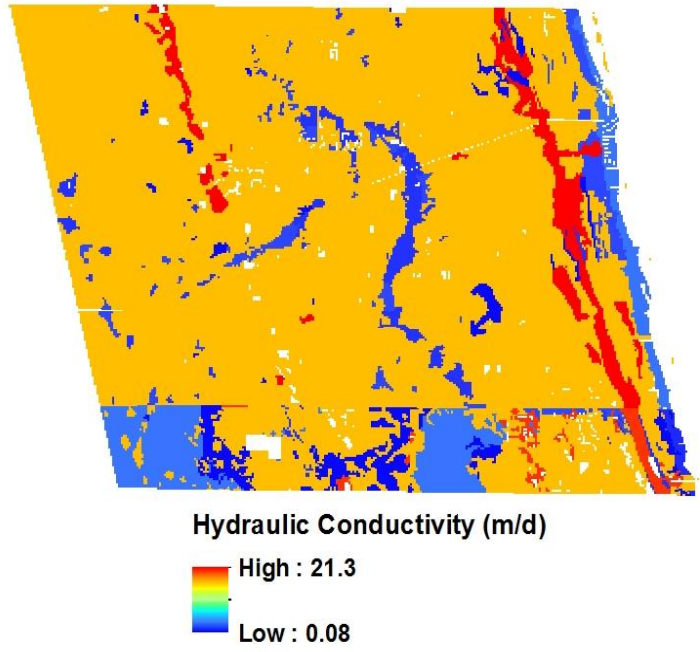
Lidar DEM



Porosity

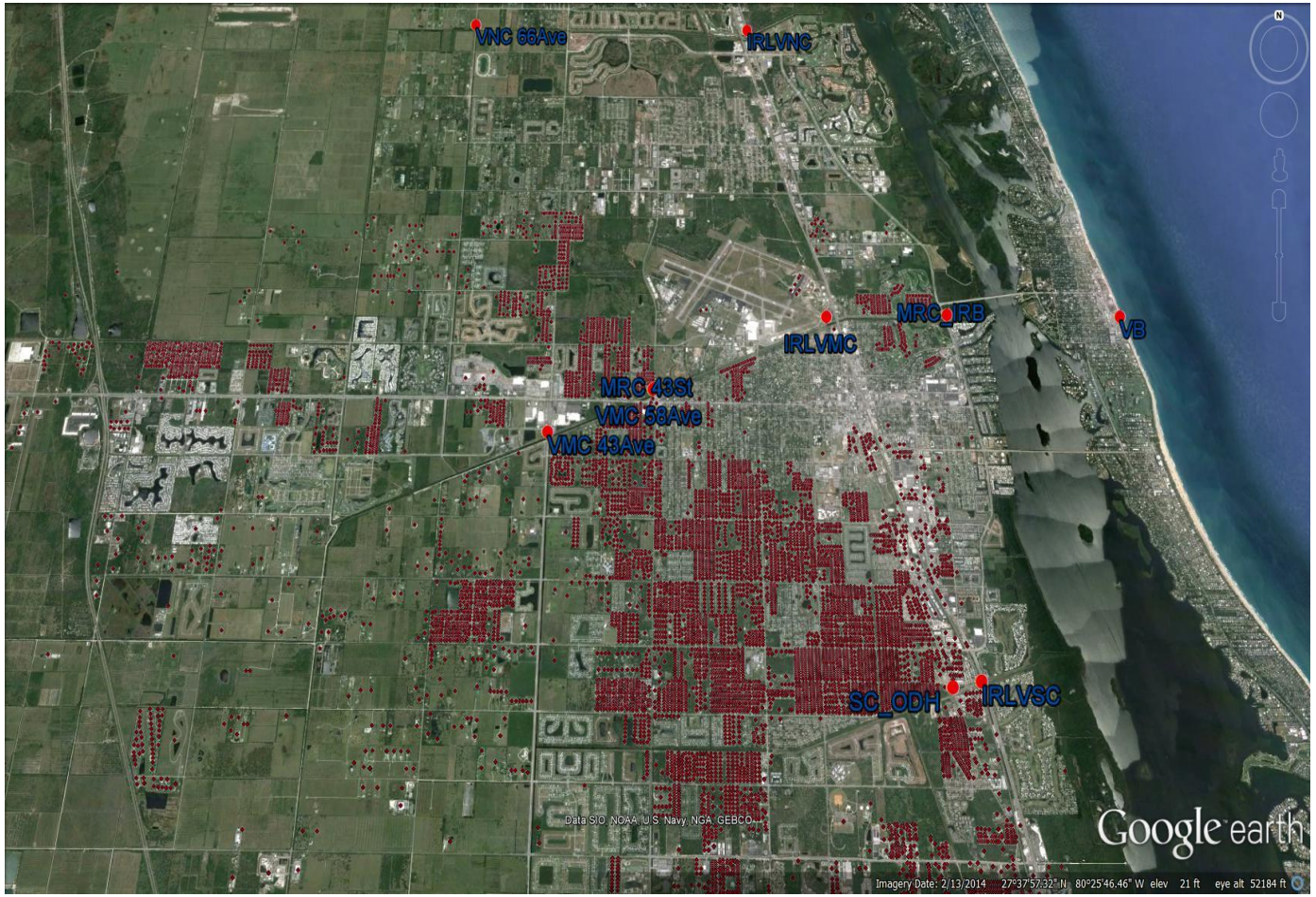


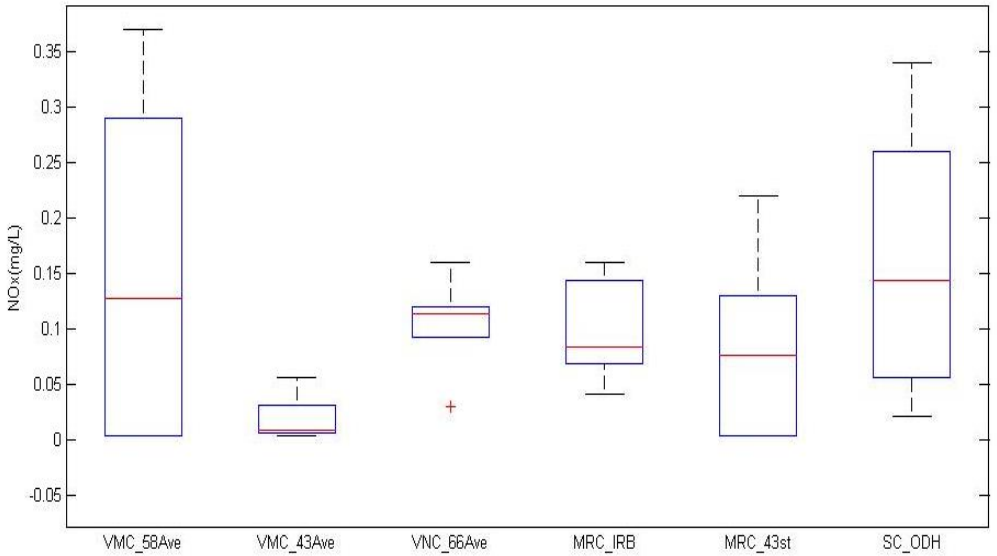
Hydraulic Conductivity

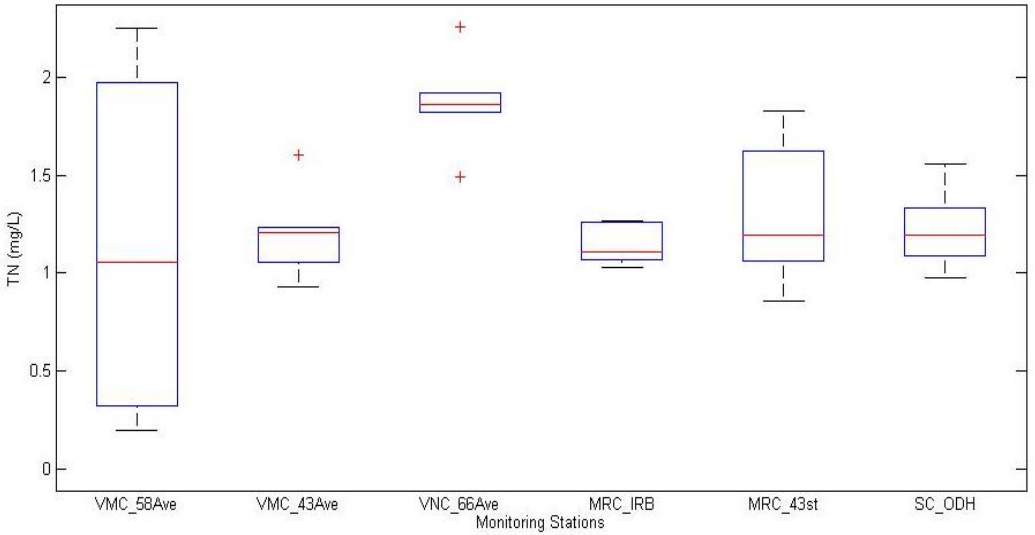


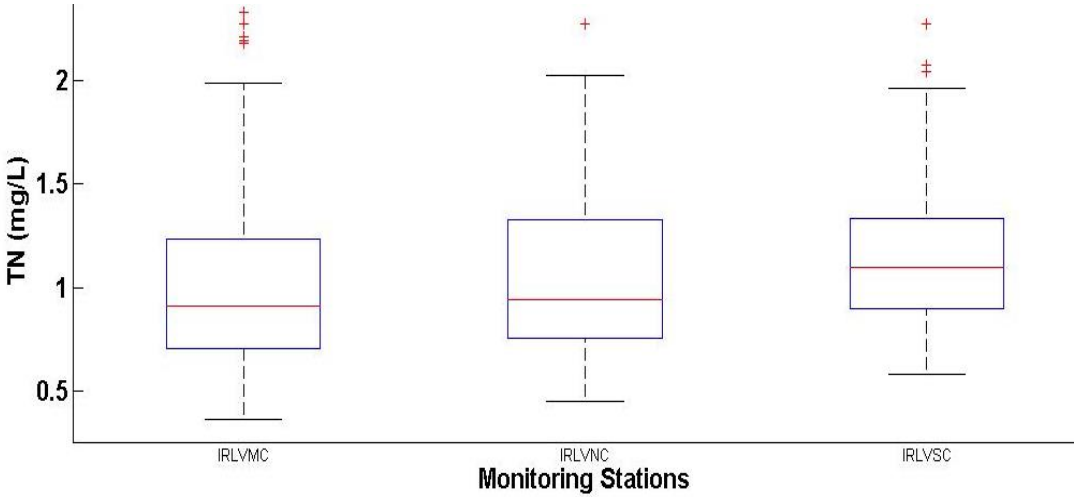
Surface Water Quality

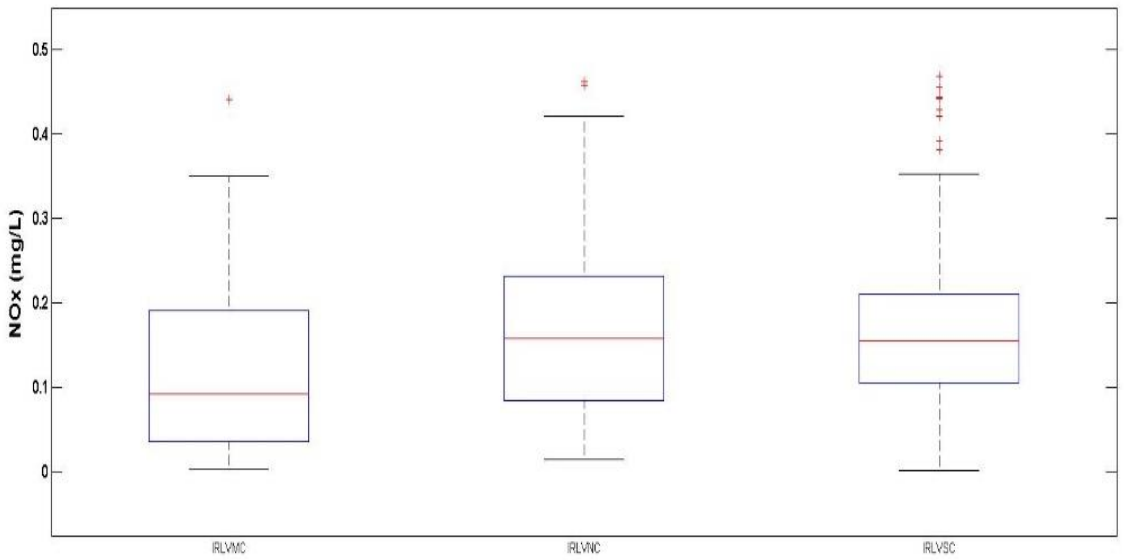
Data sources: Lemonteh Horne, FDEP

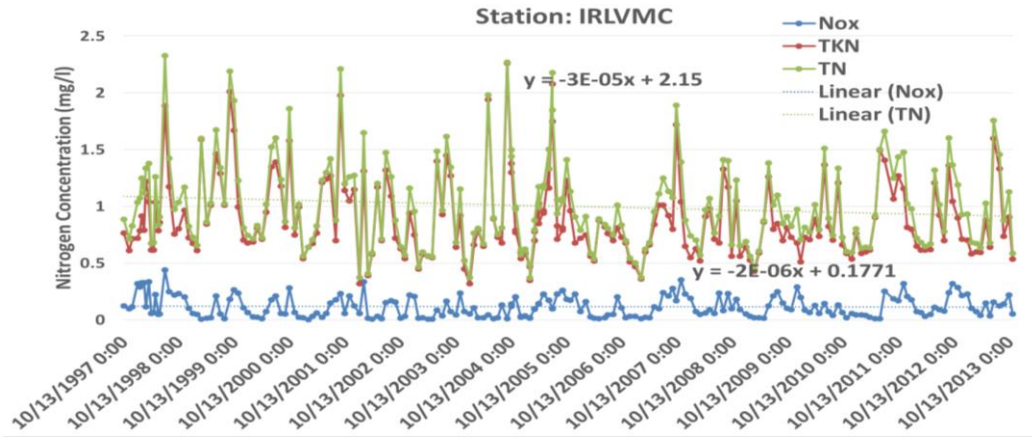


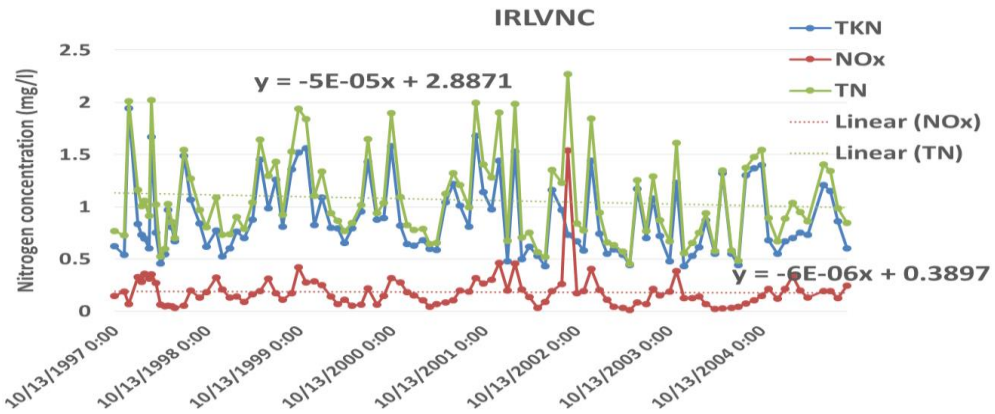


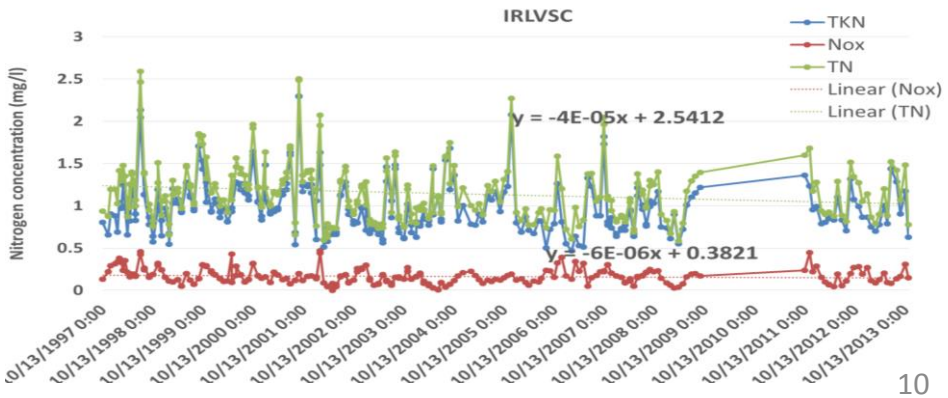



TN (mg/L)
2
1.5
1
0.5
IRLVMC
IRLVNC
IRLVSC
Monitoring Stations


NOx (mg/L)
0.5
0.4
0.3
0.2
0.1
0
IRLVMC
IRLVNC
IRLVSC

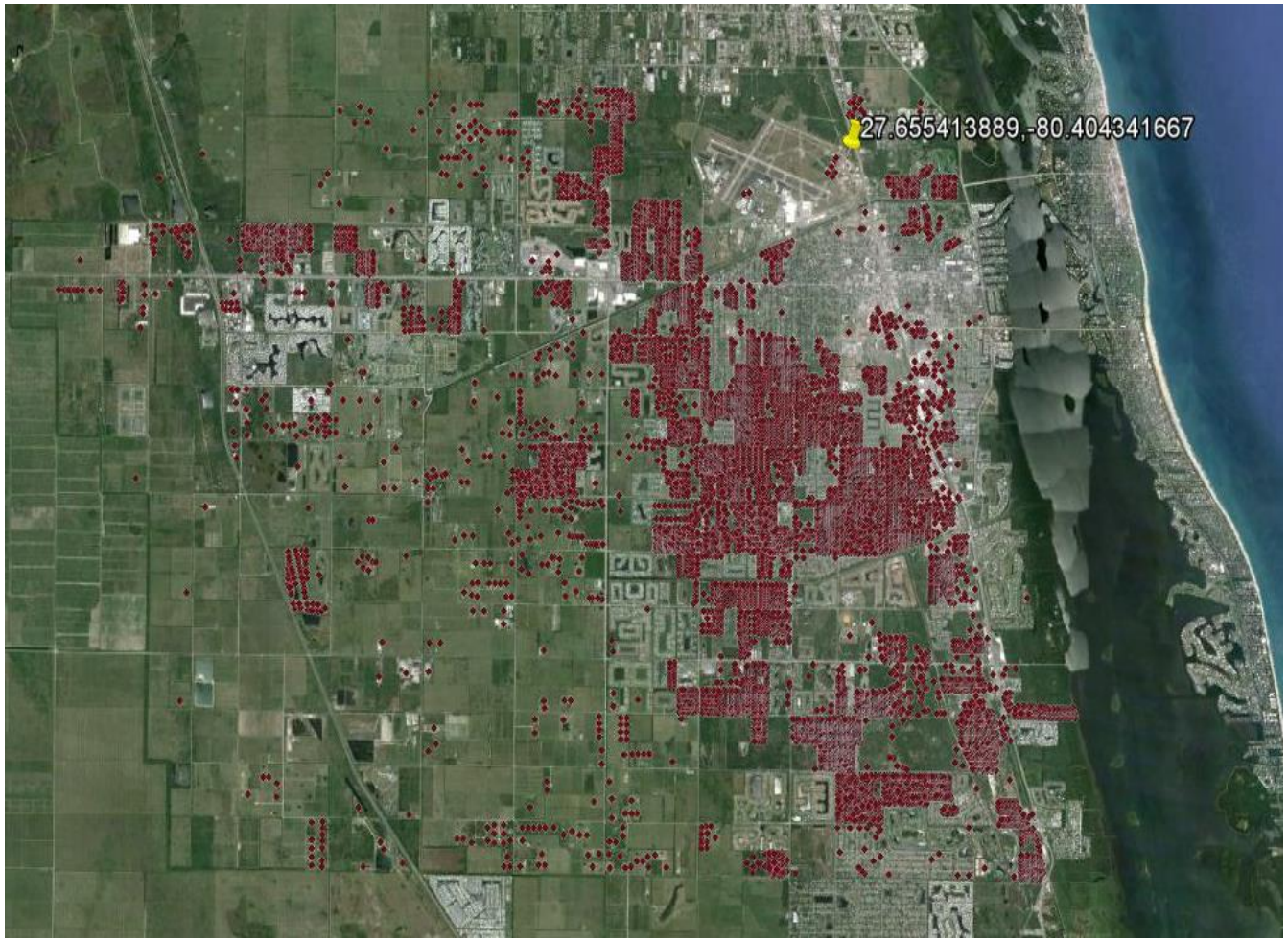

Station: IRLVMC
Nox
TKN
TN
Linear (Nox)
Linear (TN)
y = -3E-05x + 2.15
y = -2E-06x + 0.1771
Nitrogen Concentration (mg/l)
2.5
2
1.5
1
0.5
0
10/13/1997 0:00
10/13/1998 0:00
10/13/1999 0:00
10/13/2000 0:00
10/13/2001 0:00
10/13/2002 0:00
10/13/2003 0:00
10/13/2004 0:00
10/13/2005 0:00
10/13/2006 0:00
10/13/2007 0:00
10/13/2008 0:00
10/13/2009 0:00
10/13/2010 0:00
10/13/2011 0:00
10/13/2012 0:00
10/13/2013 0:00

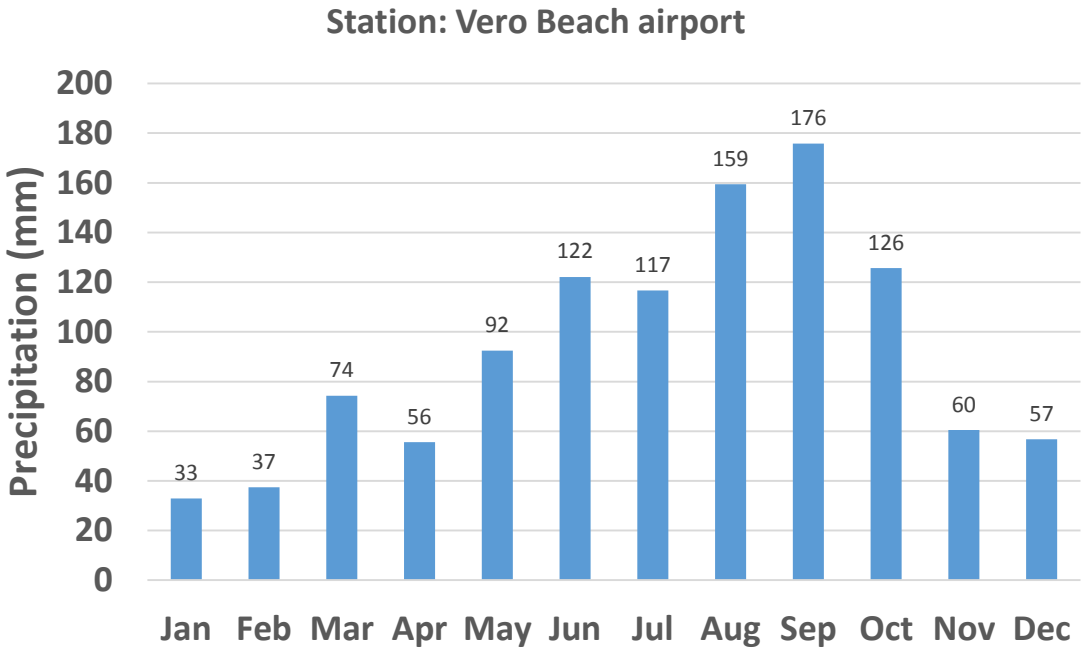

IRLVNC
TKN
NOx
TN
Linear (NOx)
Linear (TN)
y = -5E-05x + 2.8871
y = -6E-06x + 0.3897
Nitrogen concentration (mg/l)
2.5
2
1.5
1
0.5
0
10/13/1997 0:00
10/13/1998 0:00
10/13/1999 0:00
10/13/2000 0:00
10/13/2001 0:00
10/13/2002 0:00
10/13/2003 0:00
10/13/2004 0:00

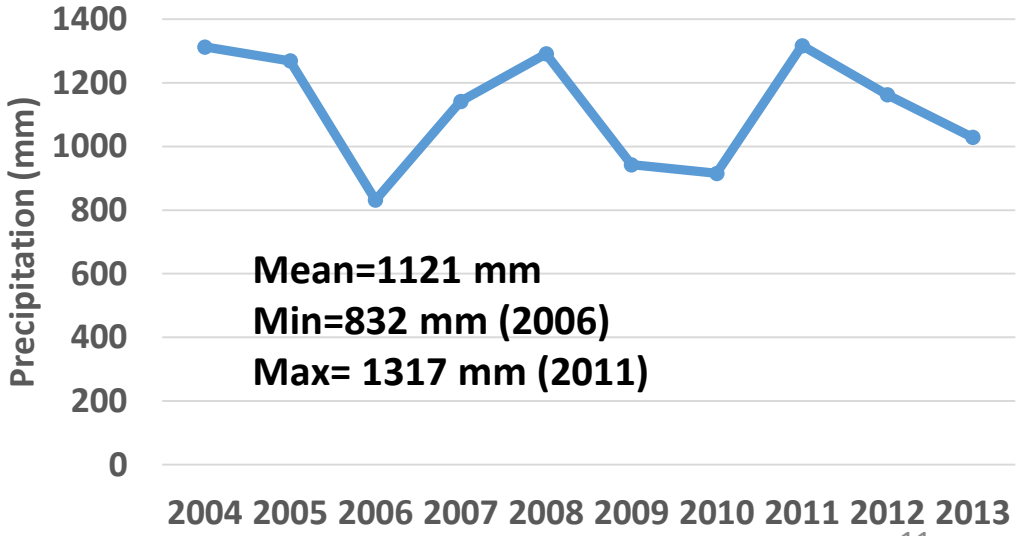

IRLVSC
TKN
Nox
TN
Linear (Nox)
Linear (TN)
y = -4E-05x + 2.5412
y = -6E-06x + 0.3821
Nitrogen concentration (mg/l)
3
2.5
2
1.5
1
0.5
0
10/13/1997 0:00
10/13/1998 0:00
10/13/1999 0:00
10/13/2000 0:00
10/13/2001 0:00
10/13/2002 0:00
10/13/2003 0:00
10/13/2004 0:00
10/13/2005 0:00
10/13/2006 0:00
10/13/2007 0:00
10/13/2008 0:00
10/13/2009 0:00
10/13/2010 0:00
10/13/2011 0:00
10/13/2012 0:00
10/13/2013 0:00

Precipitation data
Station: Vero Beach airport

Sources: SJRWMD

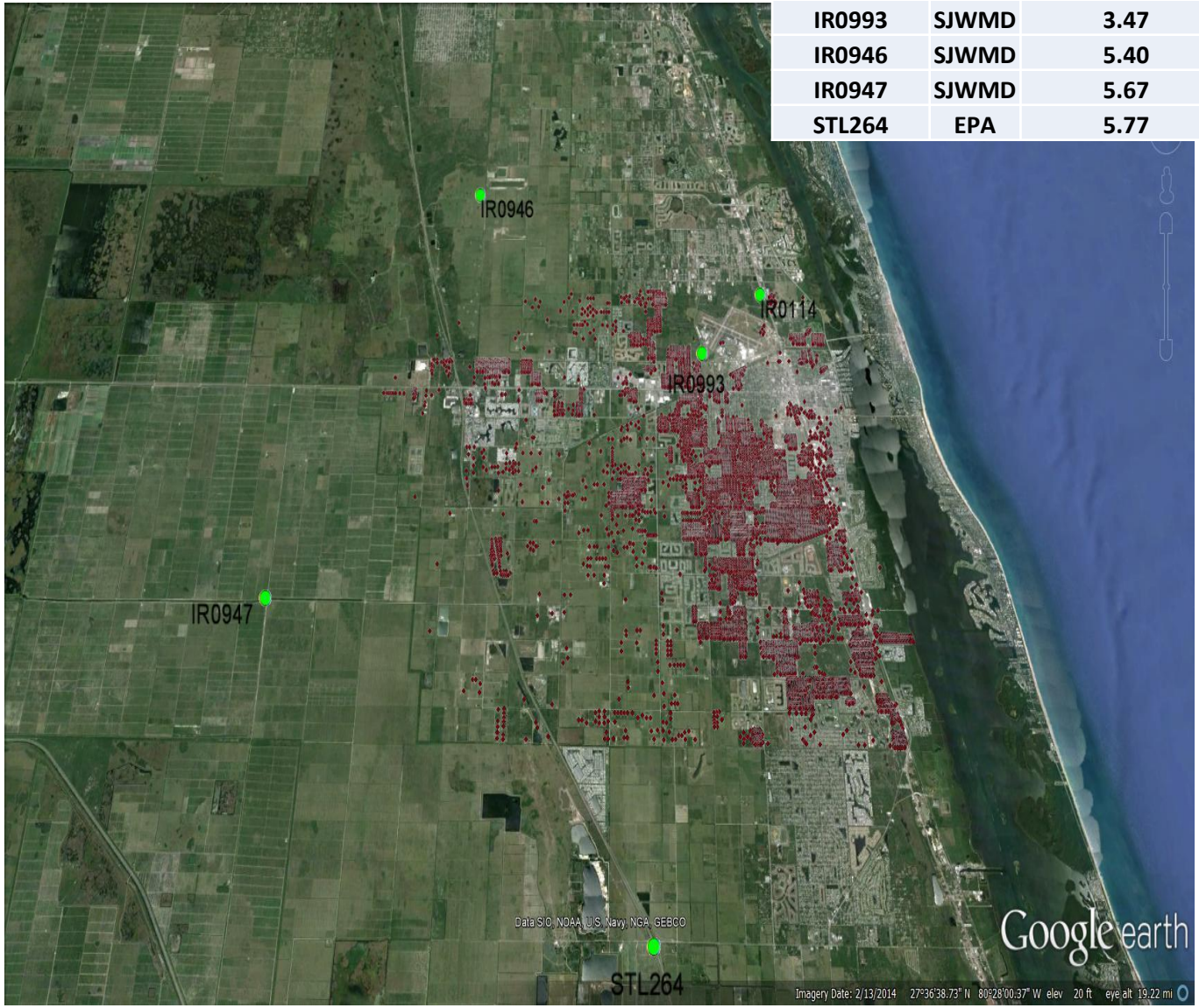


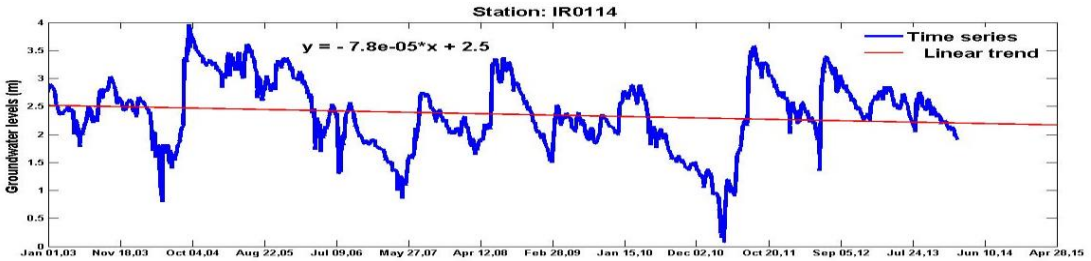


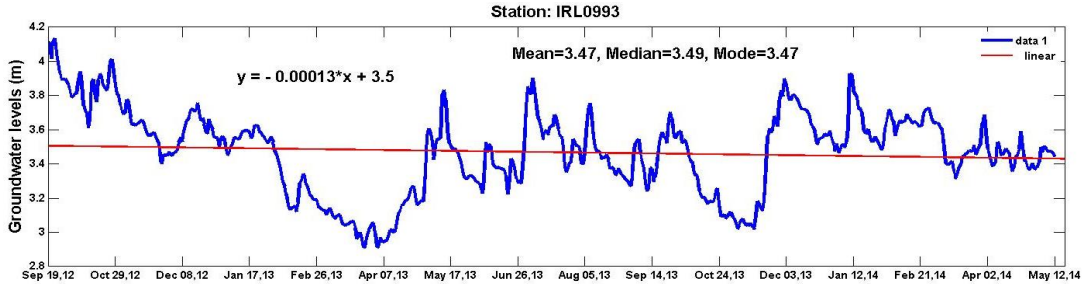


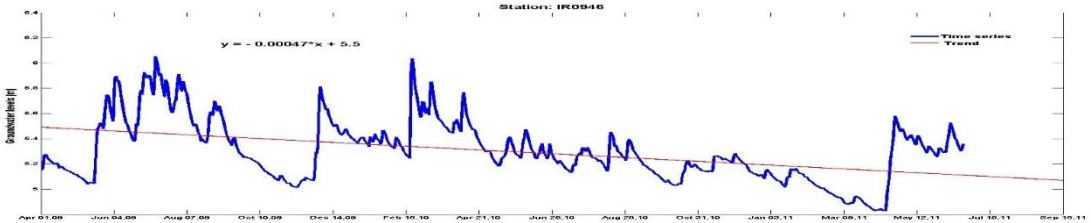
Ground Water Level

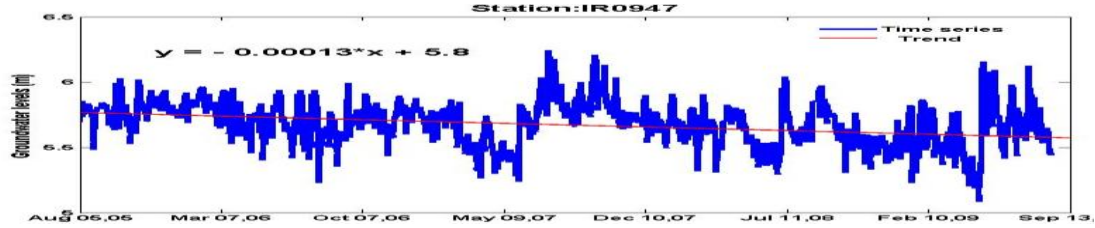
Station	Sources	Mean GWL (m)
IR0114	SJWMD	2.49
IR0993	SJWMD	3.47
IR0946	SJWMD	5.40
IR0947	SJWMD	5.67
STL264	EPA	5.77

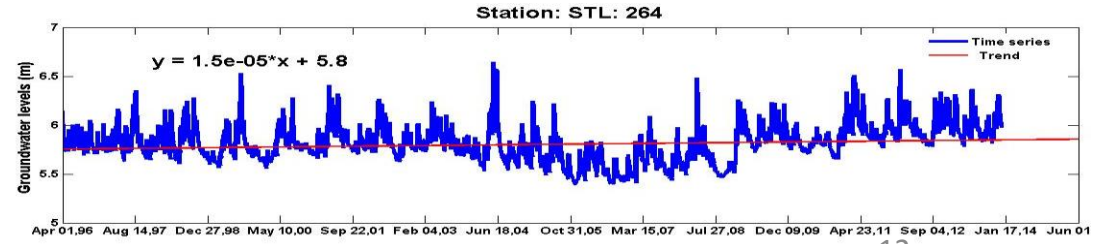






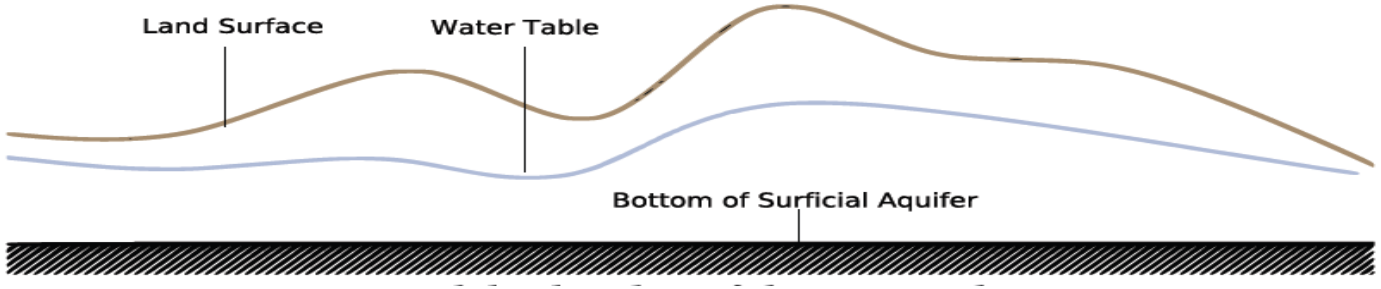




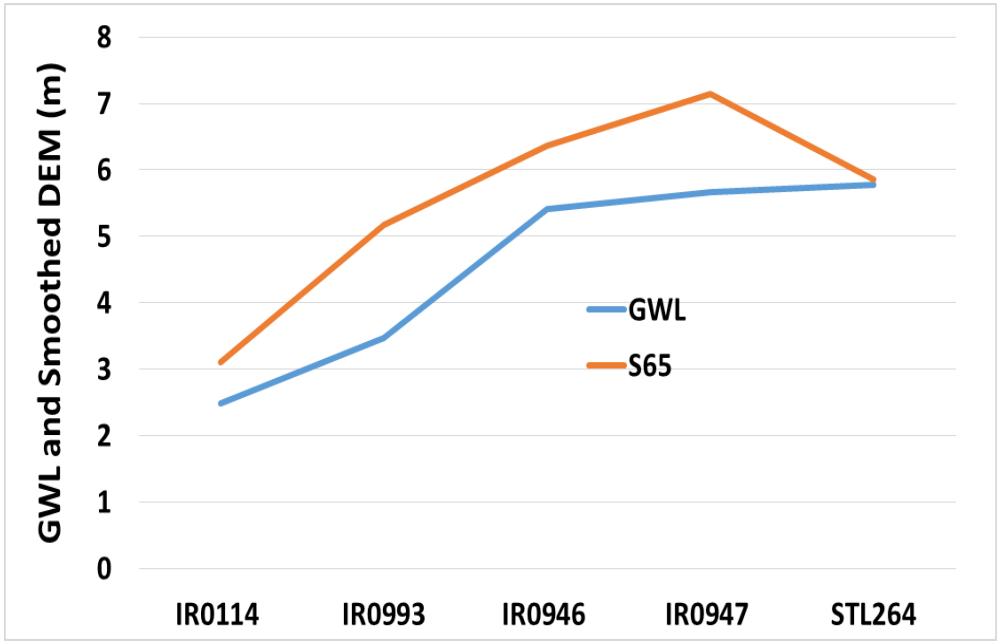


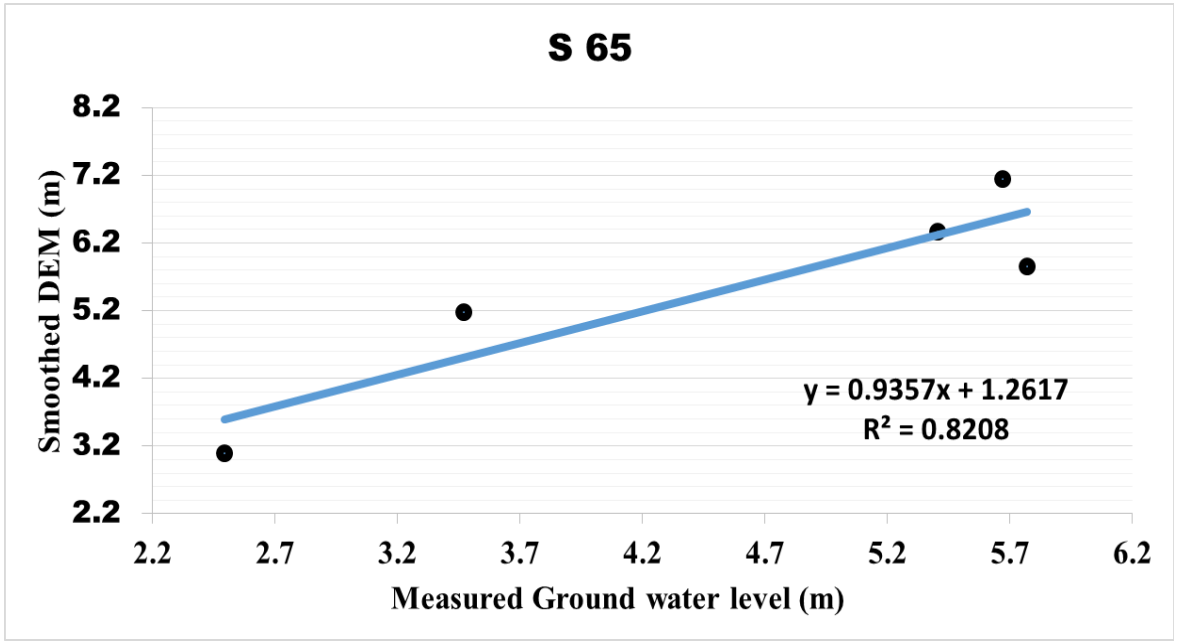
Sources: SJRWMD

Model Calibration Results: Heads



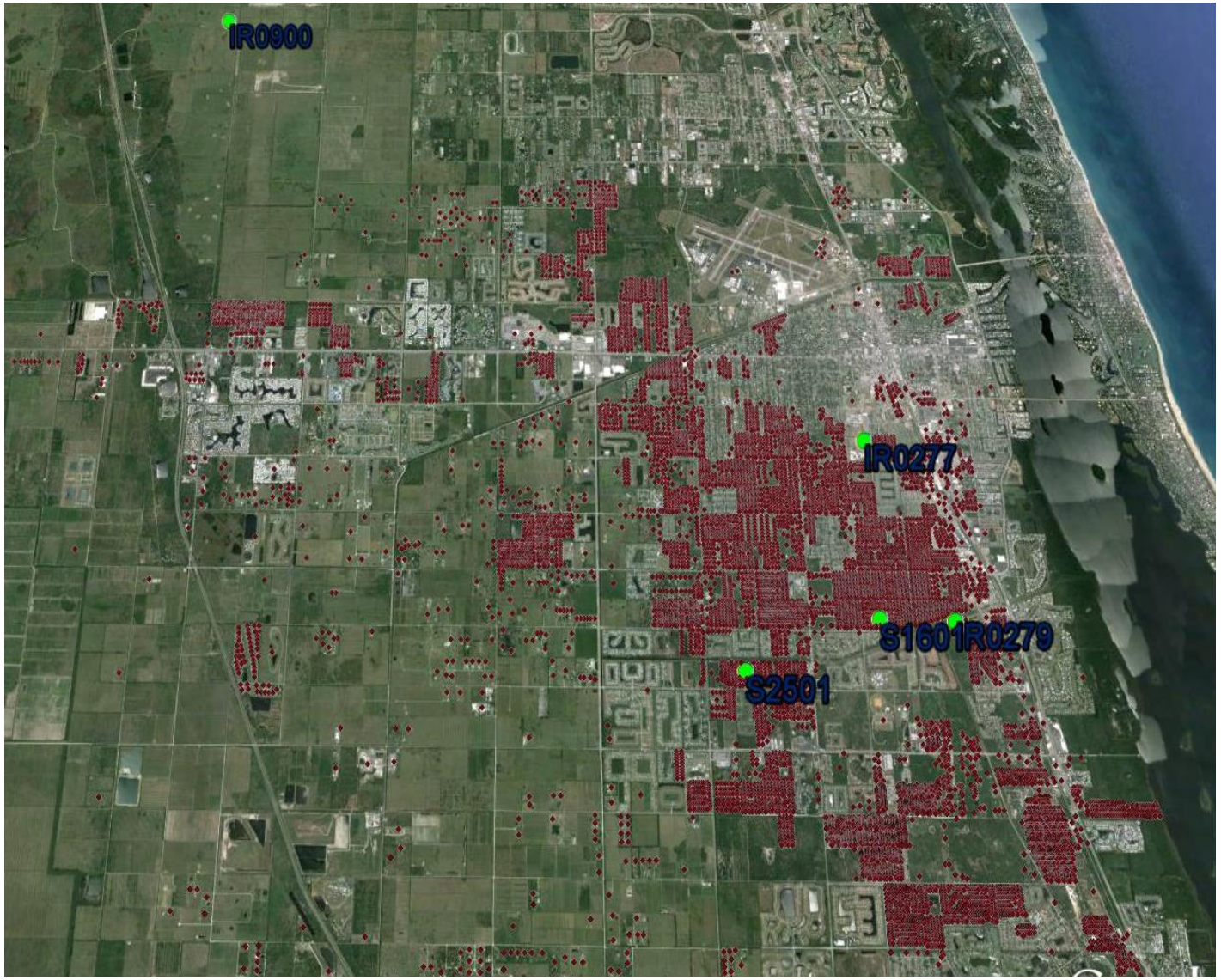
The smoothed DEM agrees well with the mean observed hydraulic head, because the correlation coefficient (0.90) and the slope of linear regression (0.94) are close to one.

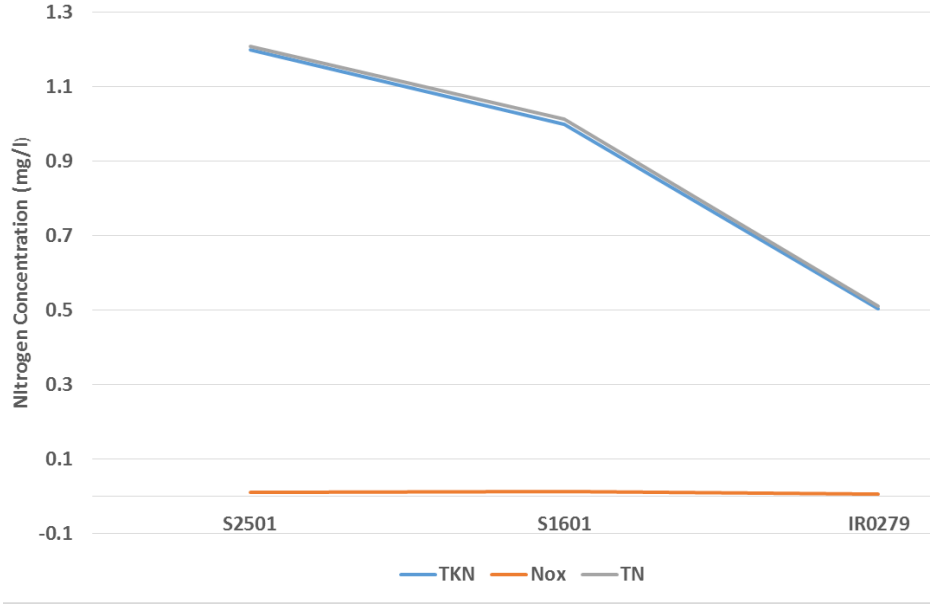




Ground water quality

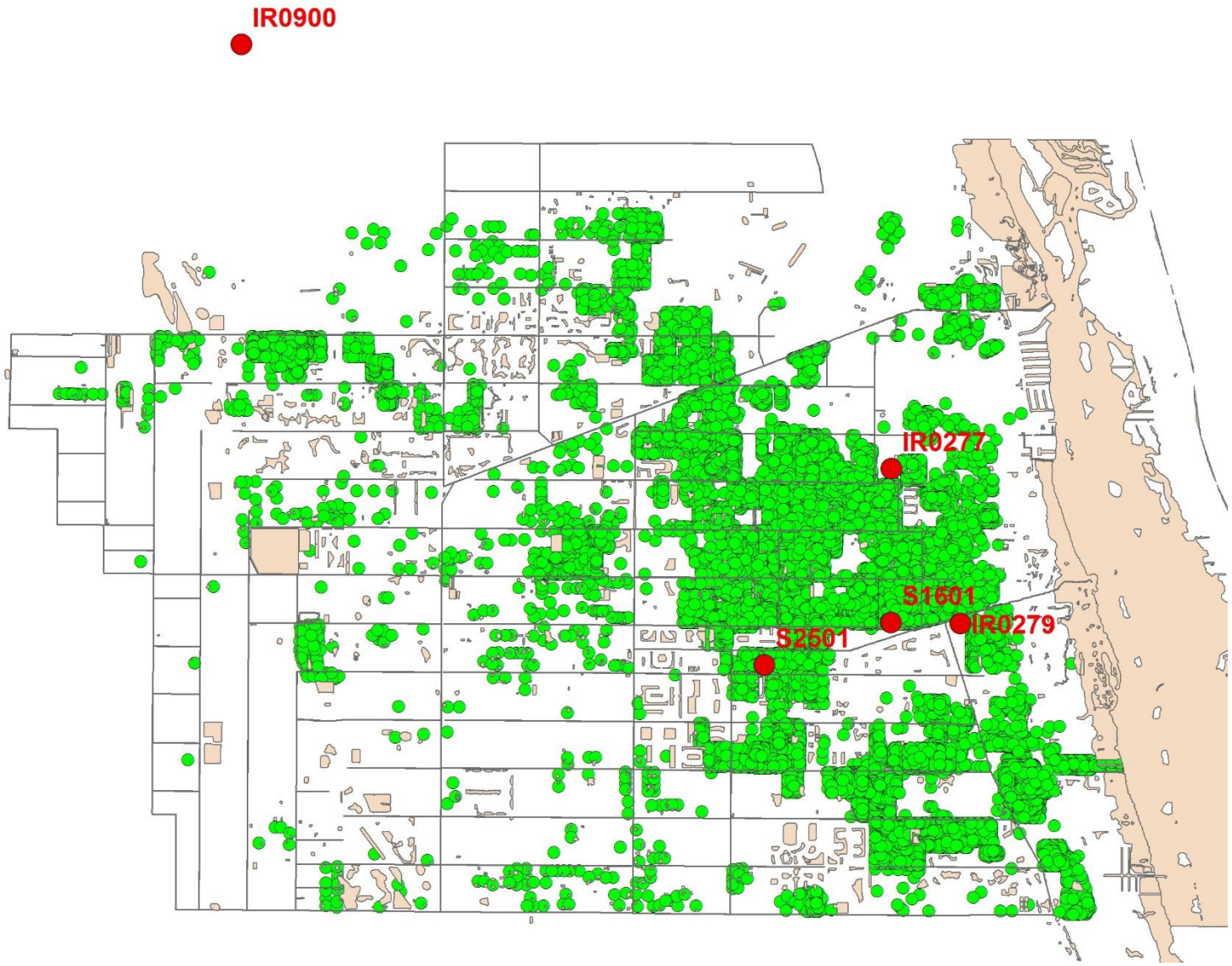
Data sources: James Sylvania, FDEP





Station number	Nitrate+Nitrite, Total (as N)	Ammonia+Organic Nitrogen, Total (as N)	TN
1601	**0.0165**	**0.915**	**0.9315**
IR0279	0.005	0.505	0.51
IR0277	0.0655	-	#VALUE!
2501	**0.01**	**1.2**	**1.21**
IR0900	-	1.2	#VALUE!

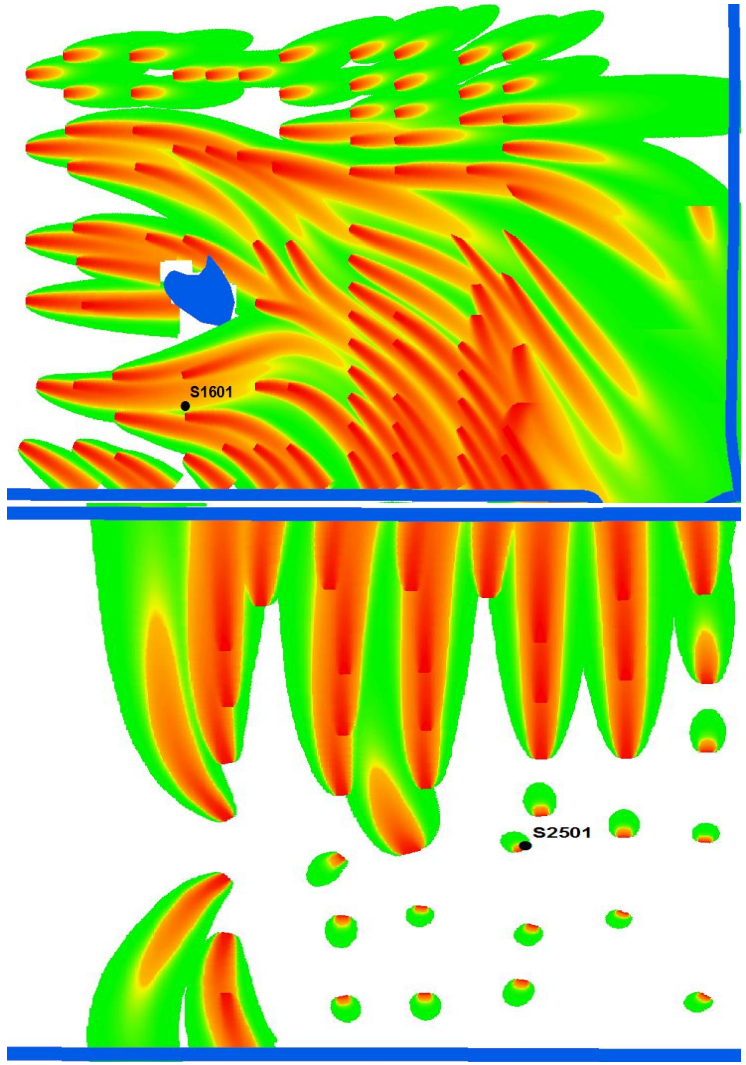
Transport model calibration: Considerations of Well selection



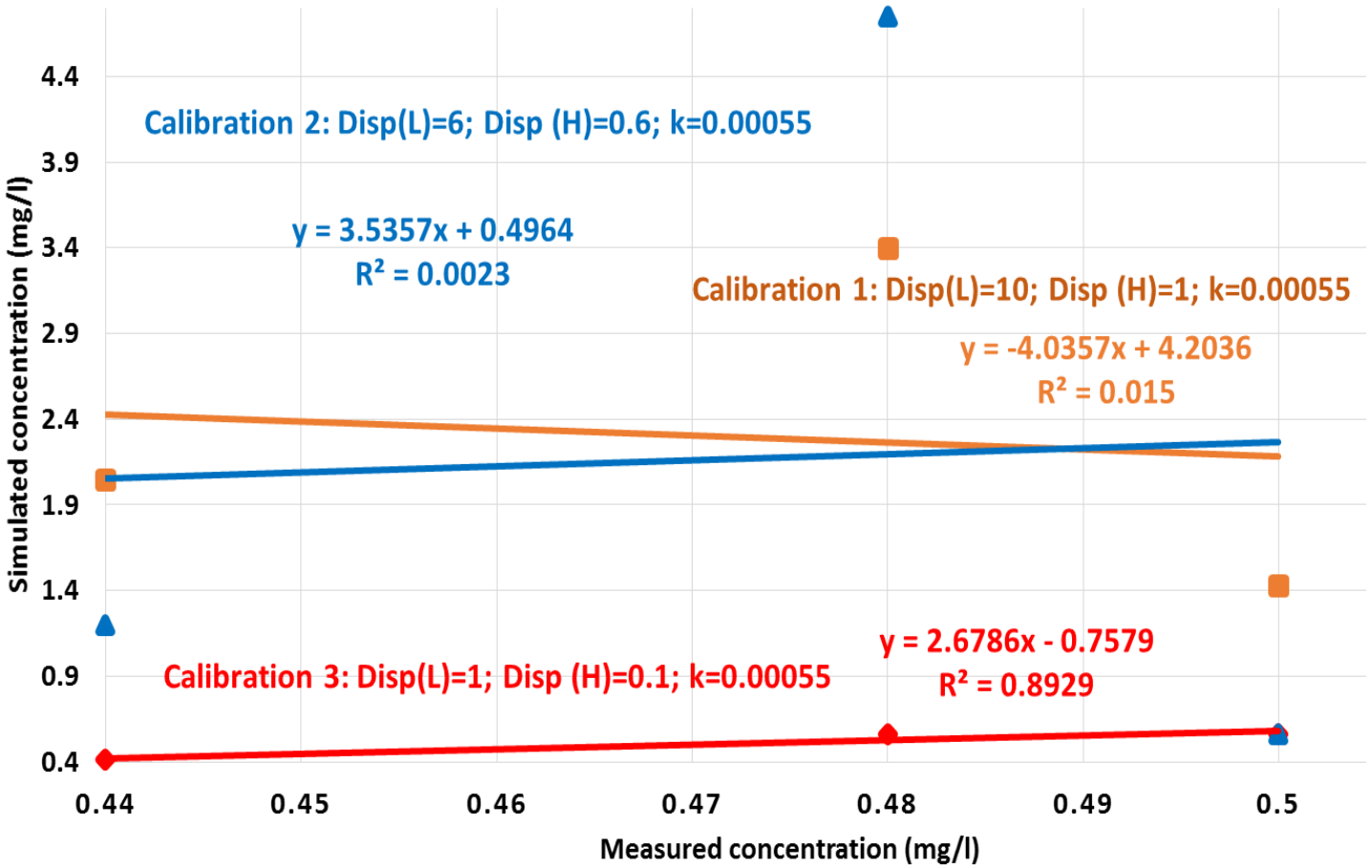
- Within our modeling area
- Monitoring well within the simulated plume
- Recent datasets with the availability of inorganic nitrogen parameters (NO-x and ammonia, total)

Monitoring well S2501 and S1601 satisfy the above criteria, to move forward for transport parameters calibration

Plume concentration (mg/l), Two Wells (S1601 and S2501) and 3 sets of parameters calibration results

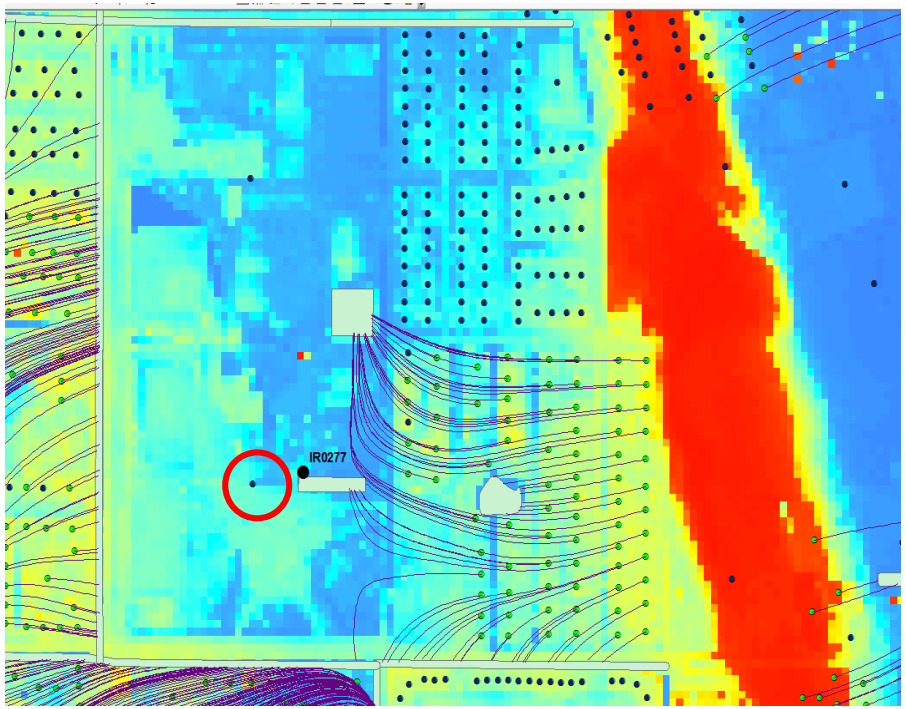


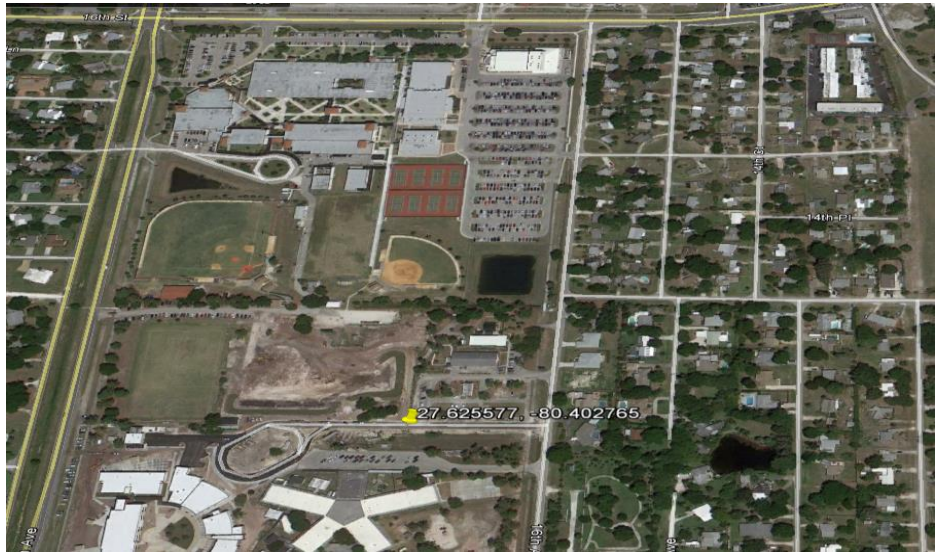
This plume based on the 3rd calibration,
Disp(L)=1; Disp (H)=0.1; k=0.00055 /day



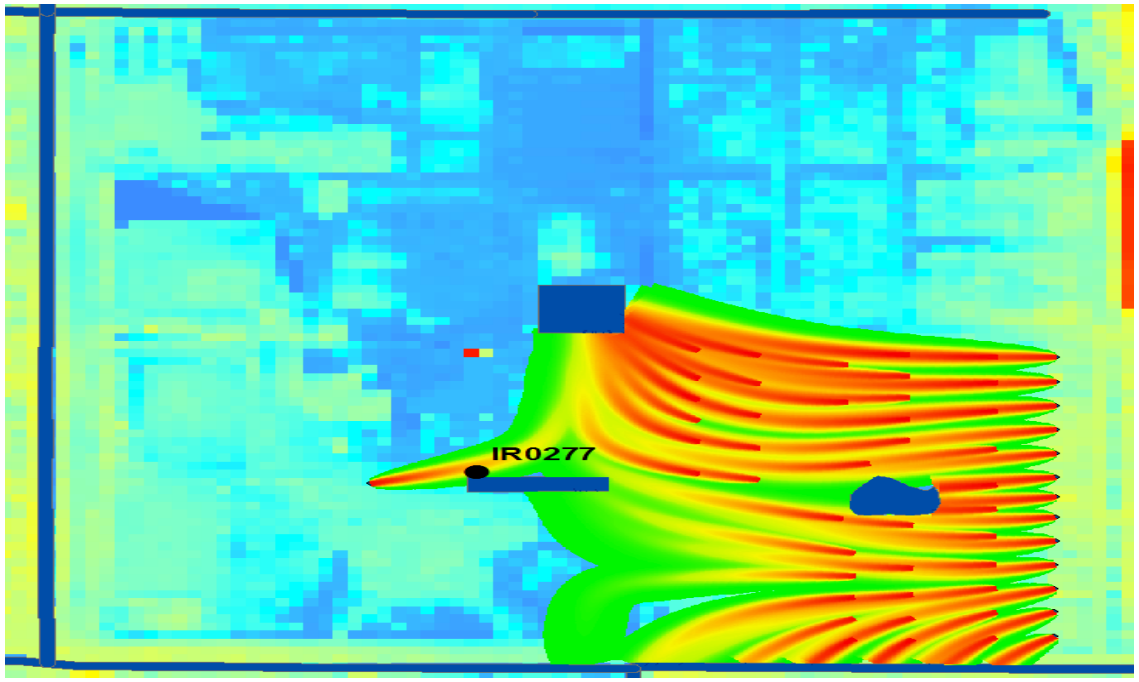
Two Wells (S1601 and S2501) and 3 calibration results

Monitoring well IR0277





STATION_NAME	COLLECTION_DATE	PARAMETER	VALUE (mg/L)
IR0277	04/28/1987	Nitrate+Nitrite, Total (as N)	0.031
IR0277	**02/12/1991**	**Ammonia, Dissolved (as N)**	**0.37**
IR0277	**02/12/1991**	**Ammonia, Total (as N)**	**0.4**
IR0277	**02/12/1991**	**Nitrate+Nitrite, Total (as N)**	**0.10**

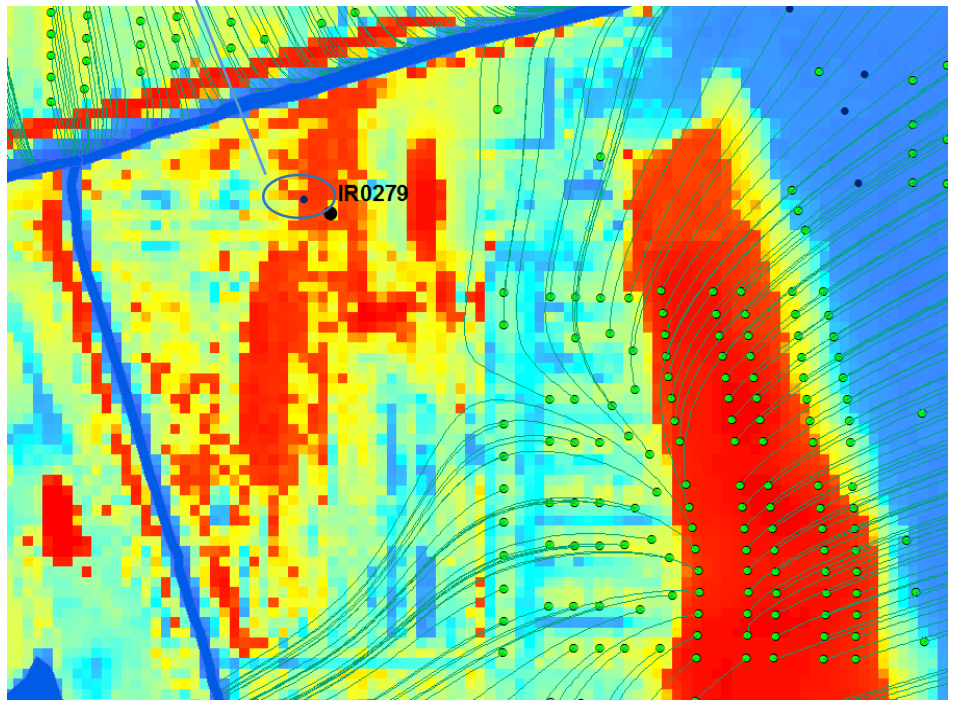


Transport parameters used:

Disp(L)=1m; Disp (H)=0.1m; k=0.00055 /day

Monitoring well IR0279

Removed septic system



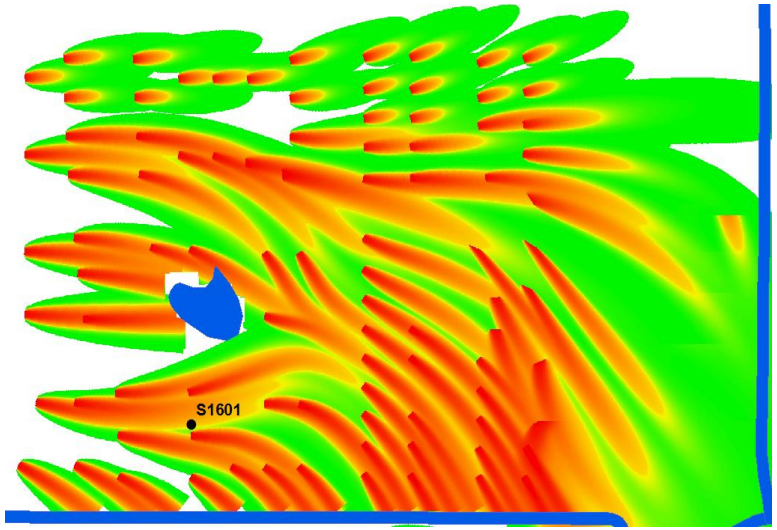
STATION NAME	COLLECTION_DATE	PARAMETER	VALUE (mg/L)
IR0279	11/04/1998	Ammonia, Dissolved (as N)	0.39
IR0279	11/04/1998	Ammonia+Organic Nitrogen, Dissolved	0.52
IR0279	11/04/1998	Ammonia+ Organic Nitrogen, Dissolved	0.49

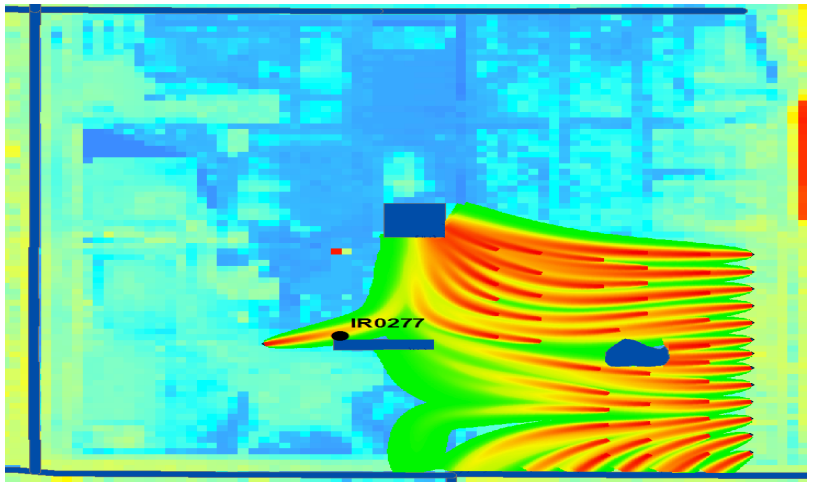
Google earth 2012

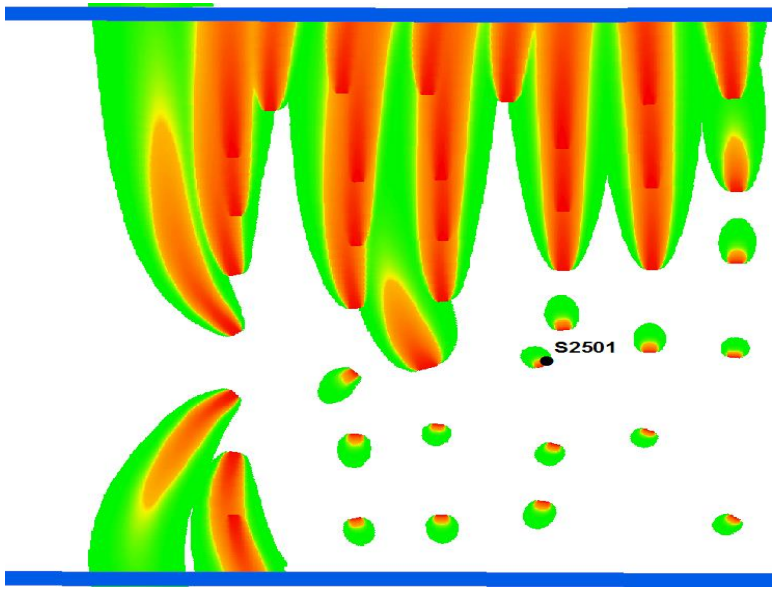
Google earth 1999

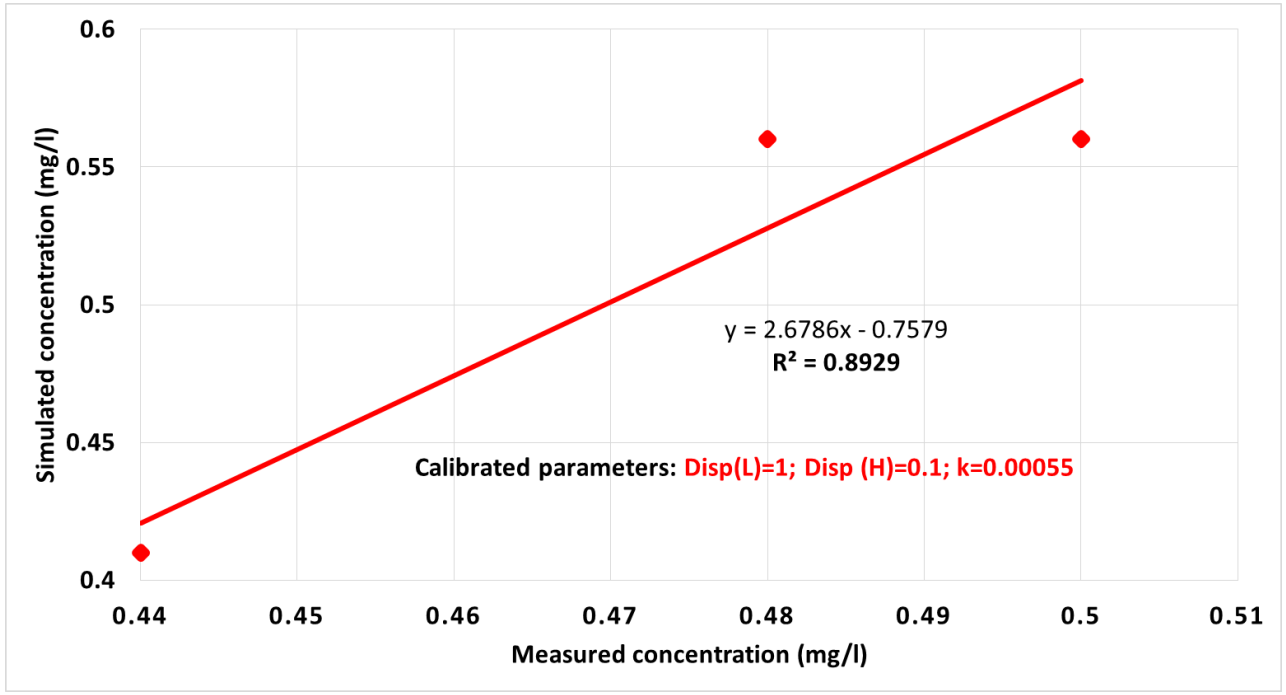
Yellow ribbon shows the well position

Calibration results of **3 wells** (**S1601, S2501 and IR 0277**)

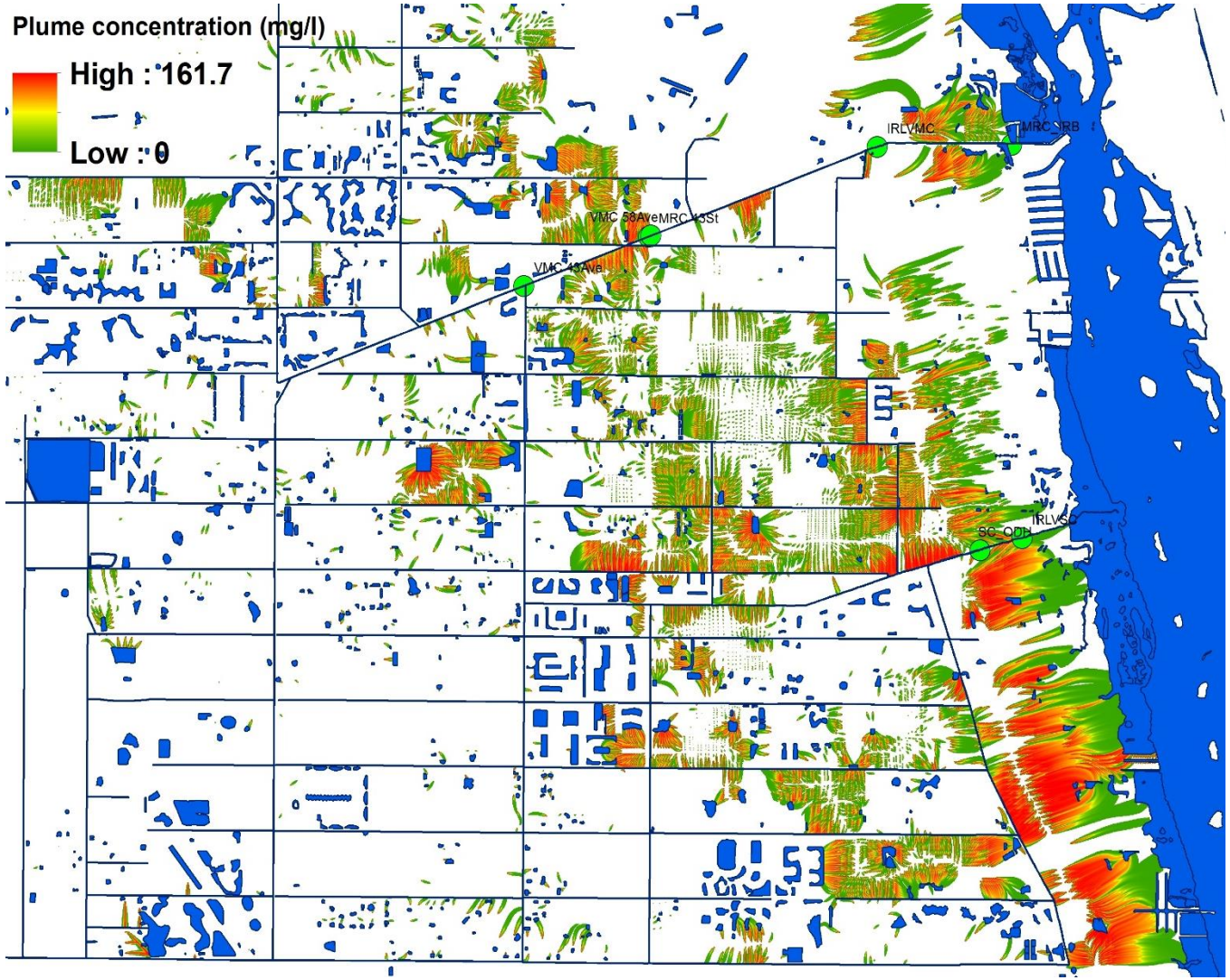








Simulated Nitrogen Plumes

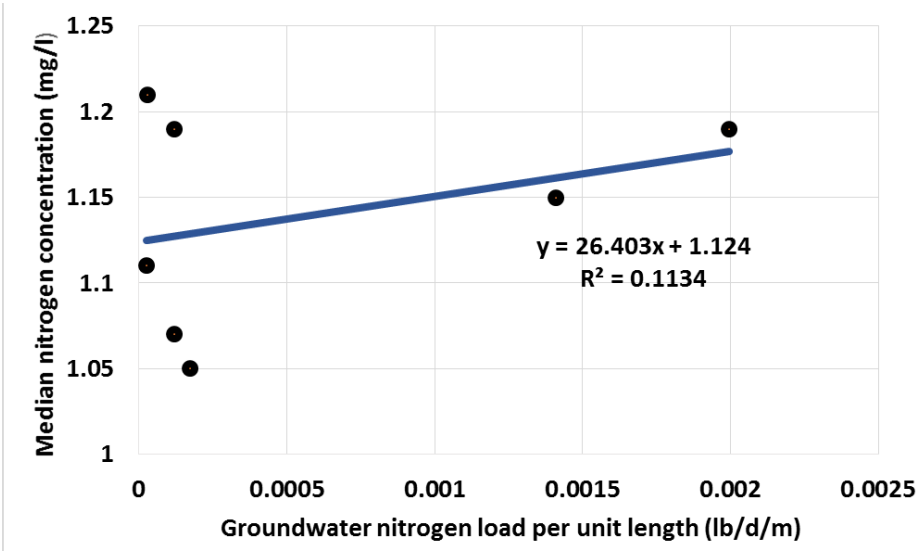


Total loads: **13742 lbs/yr**
Main Canal drainage area: **4549 lbs/yr**
South Canal drainage area: **8922 lbs/yr**

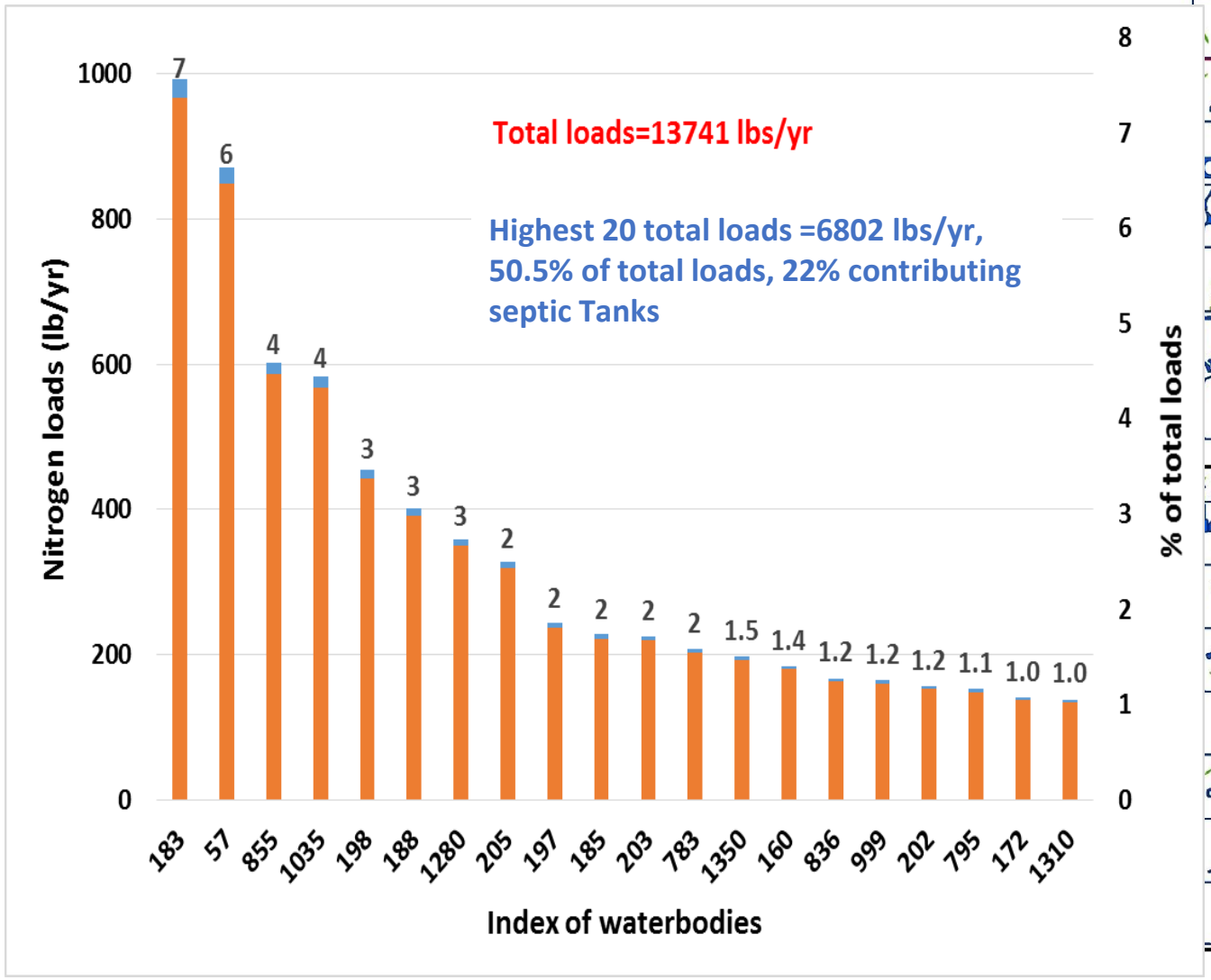
Comparison:

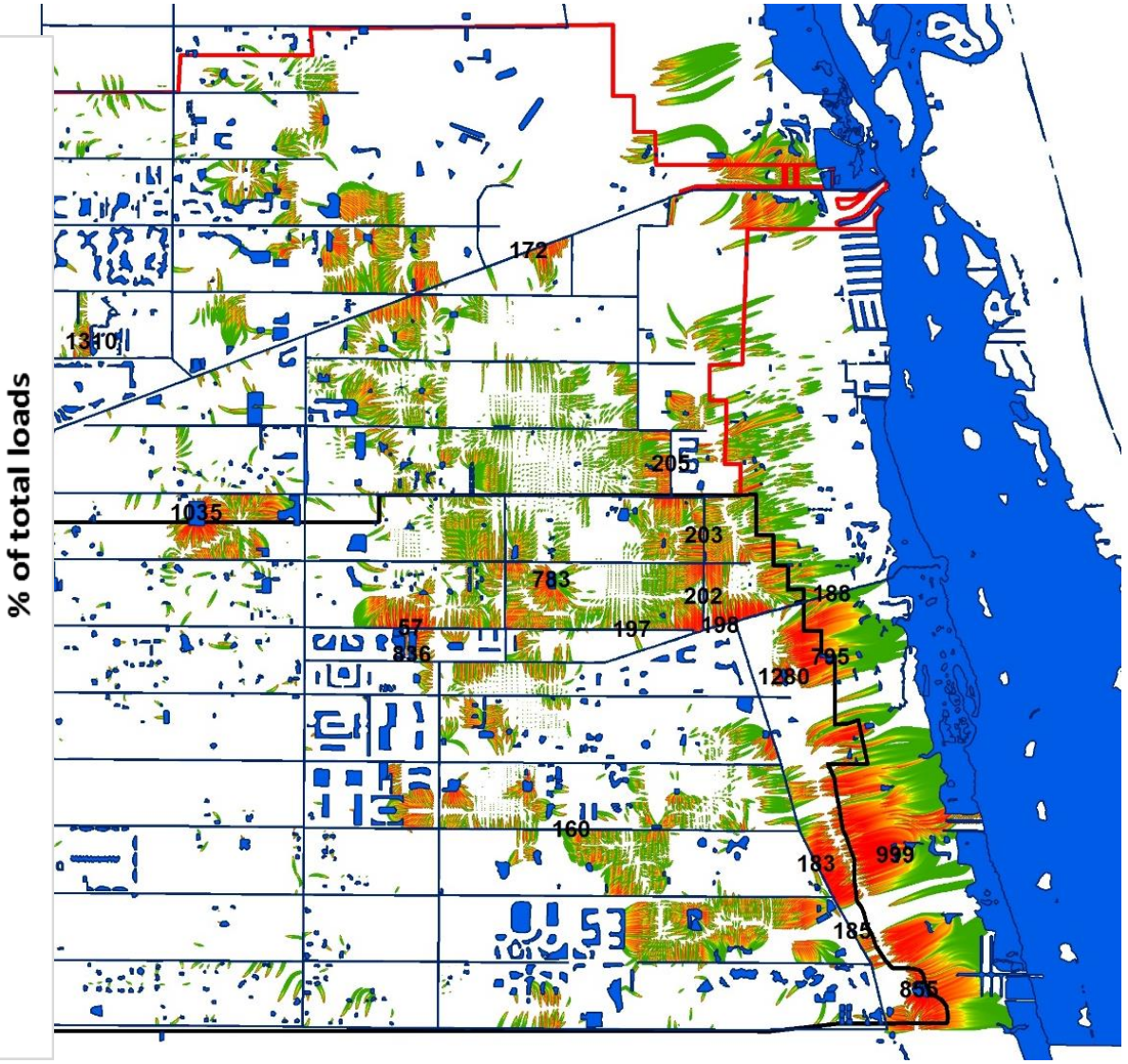
4.5% of BMAP, 2012 estimated TN load

- Septic systems contribute approximated 8.3 million pounds to the Bay, about 5% of the total nitrogen load (USEPA, 2013).

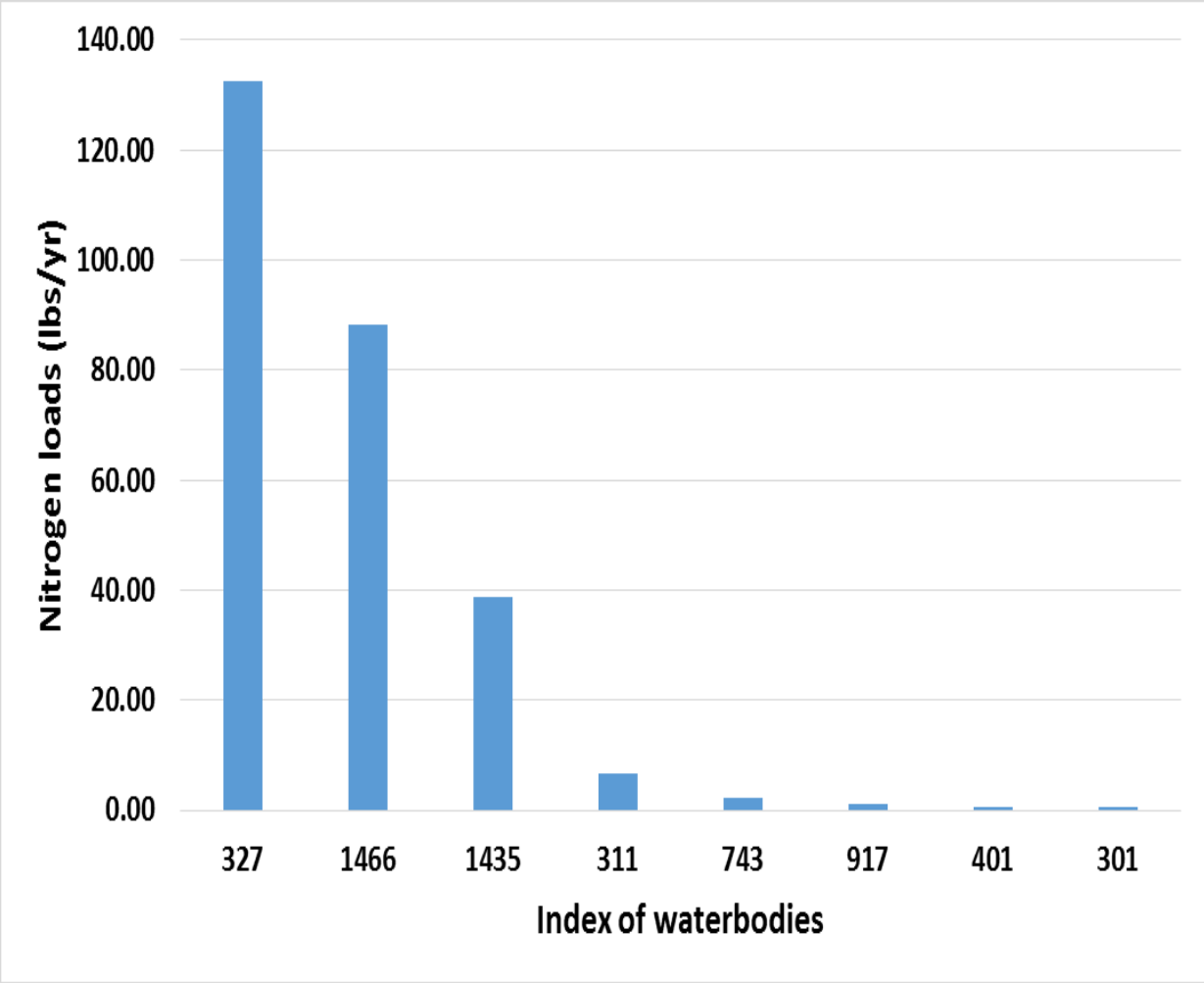


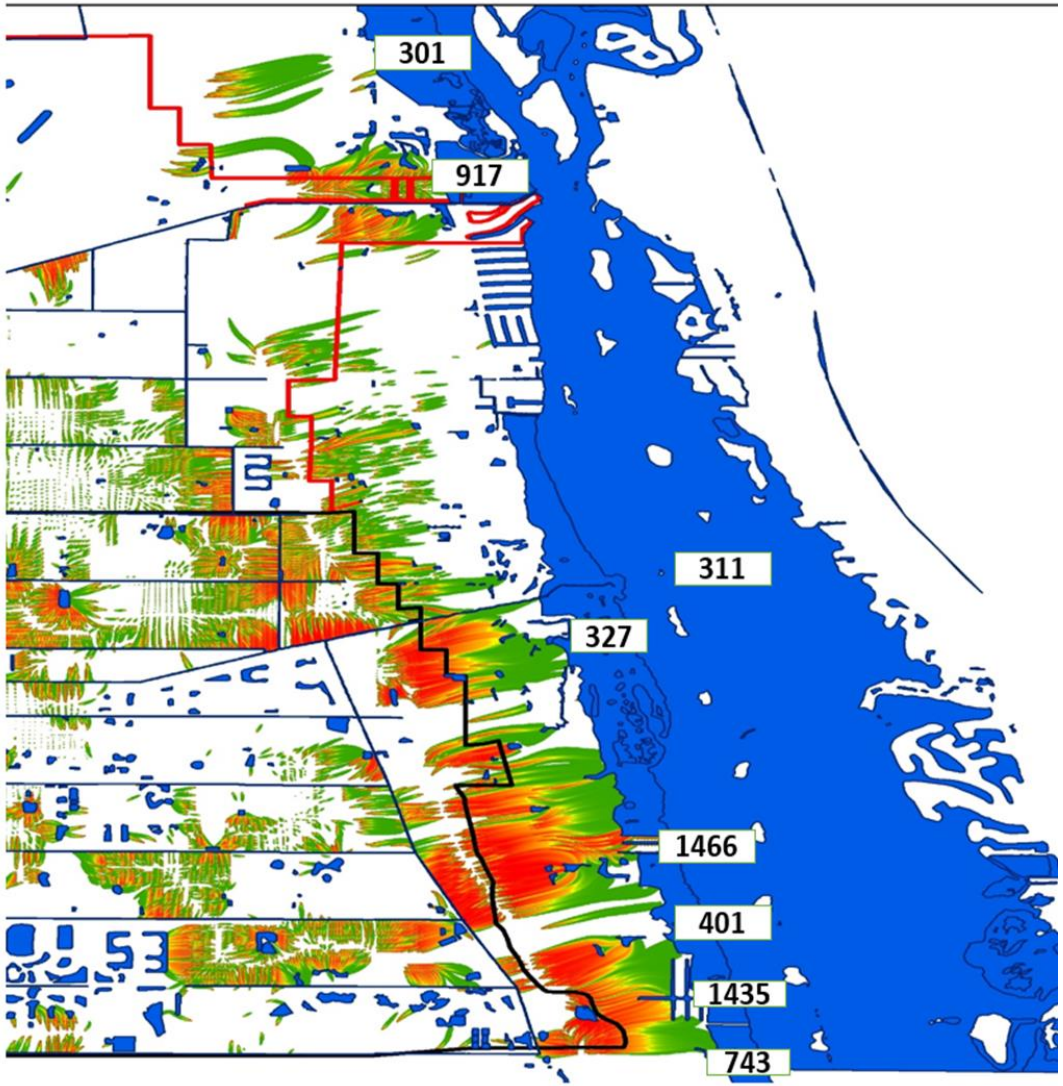
Highest 20 loadings in the Main-South basin area





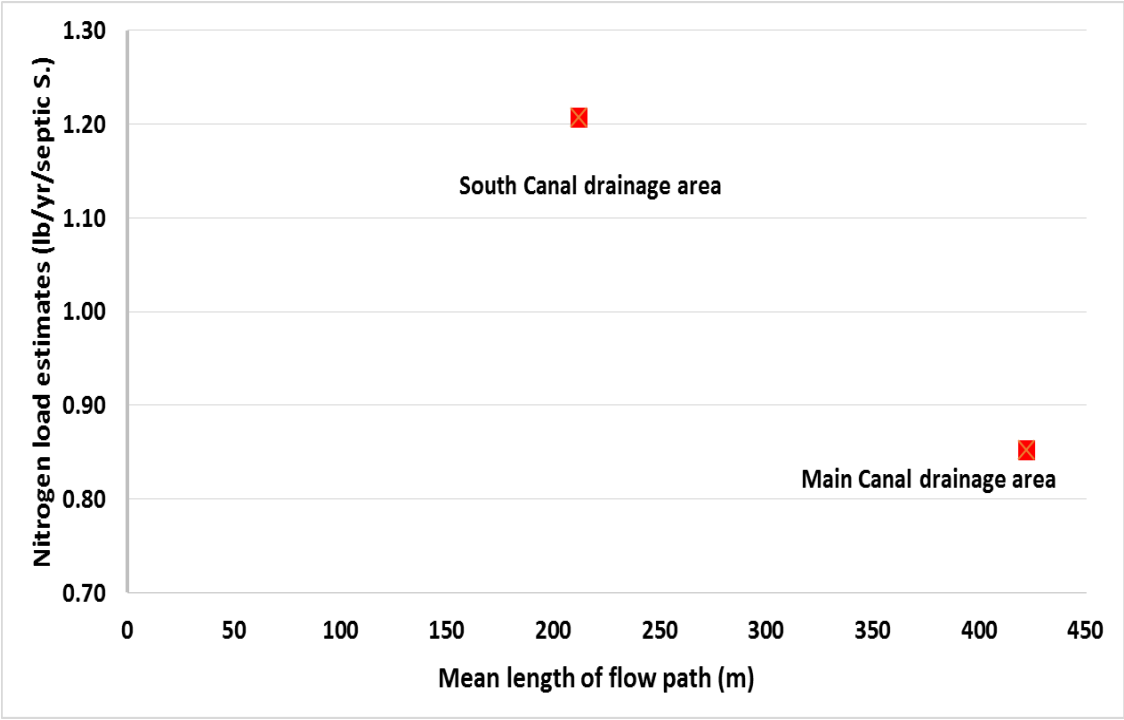
Loadings to Lagoon

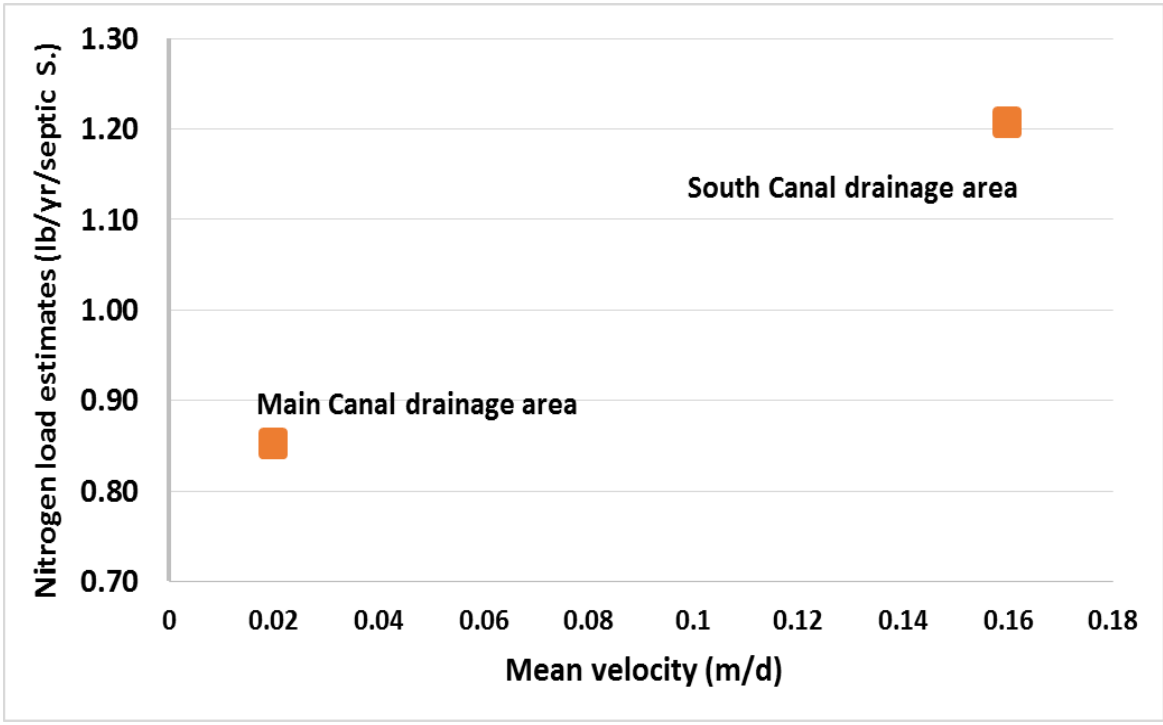




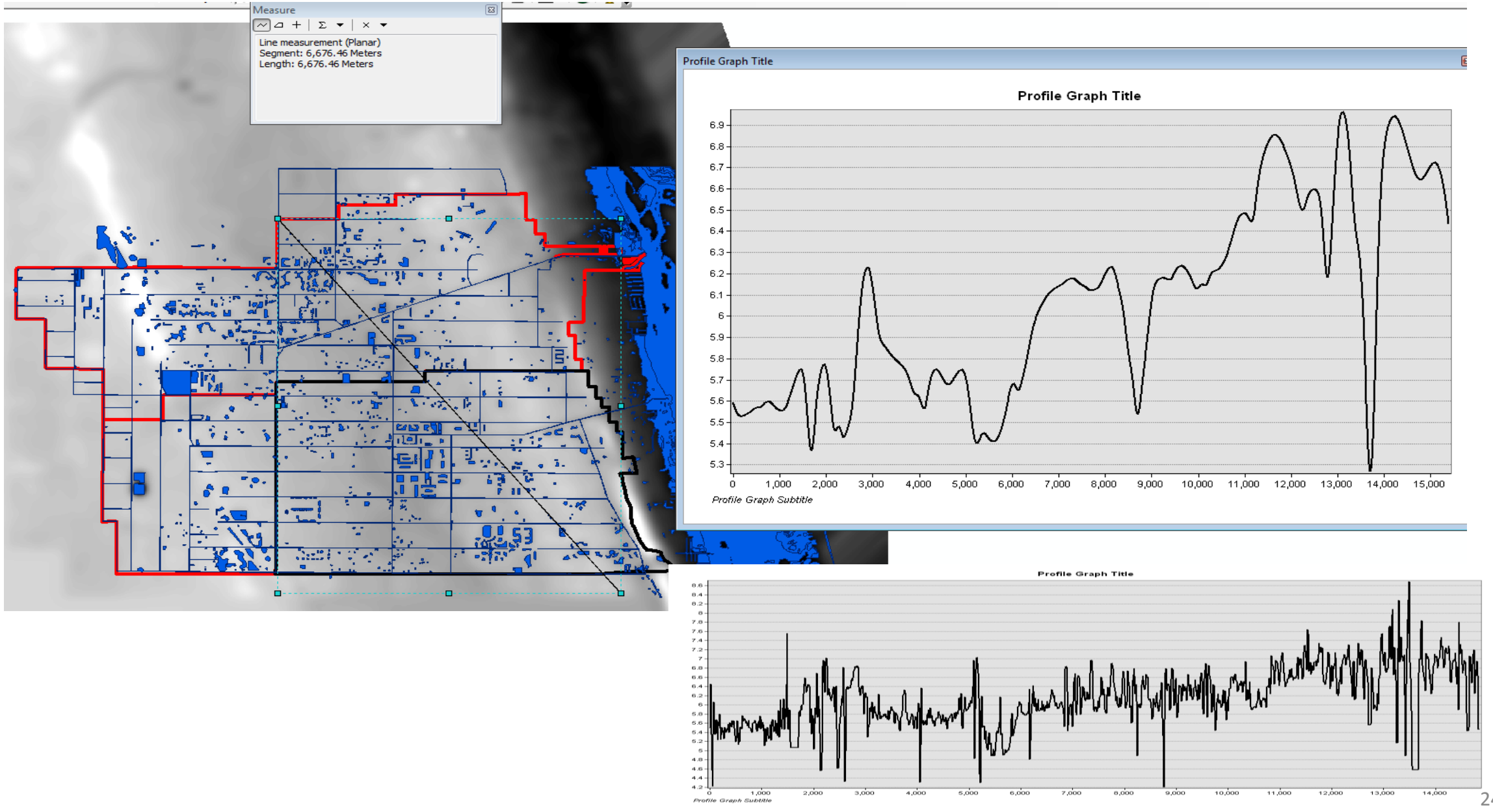
Factors Controlling Load Estimate

- Mean length of flow path (left): long mean length of flow path corresponds to more denitrification and thus less load estimate.
- Mean velocity (right): larger mean velocity results in shorter travel time, less denitrification, and thus more load estimate.



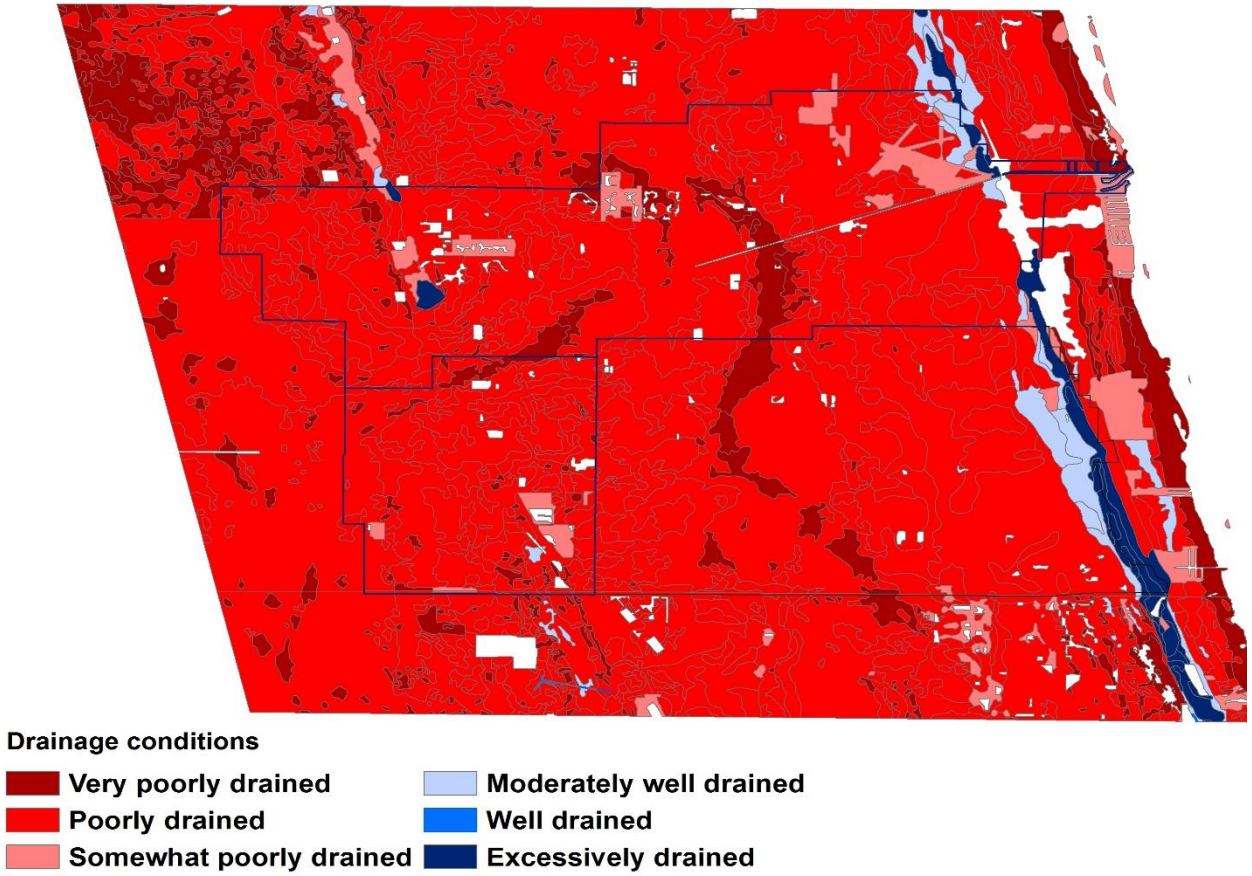


Profile graph: smoothed DEM and Original DEM



Factors Controlling Load Estimate…..(cont'd)

In the South-Main Canal area of IRC, high reduction ratio (90%) may occur because of the poor drainage condition over the area, because nitrogen transport is slower in poorly drained soil than in well-drained soil.

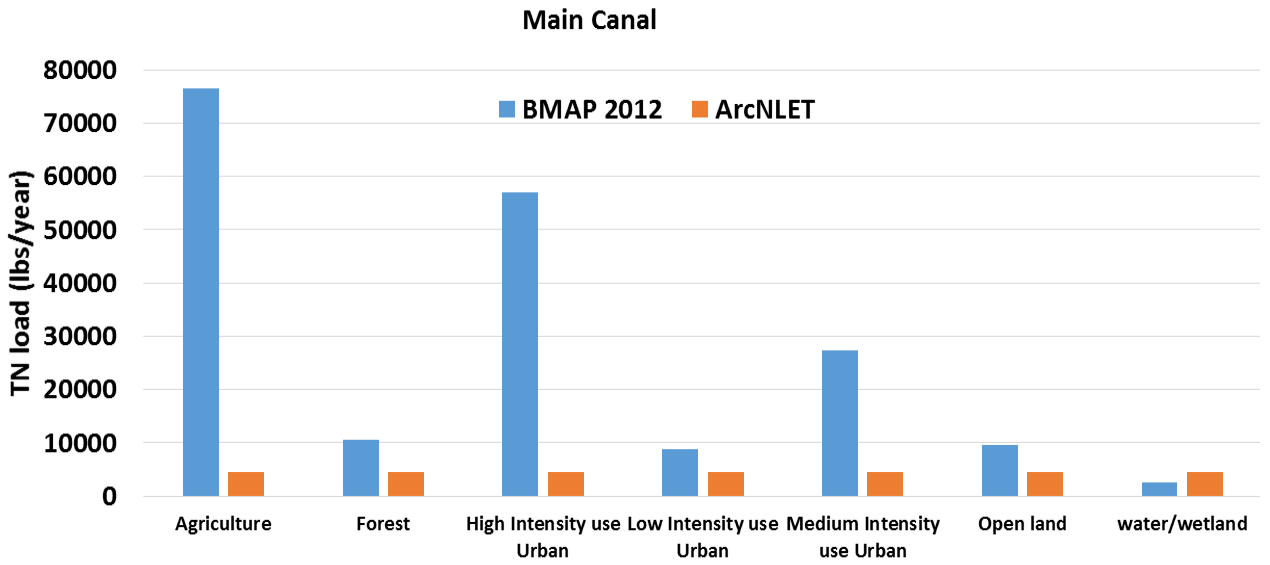


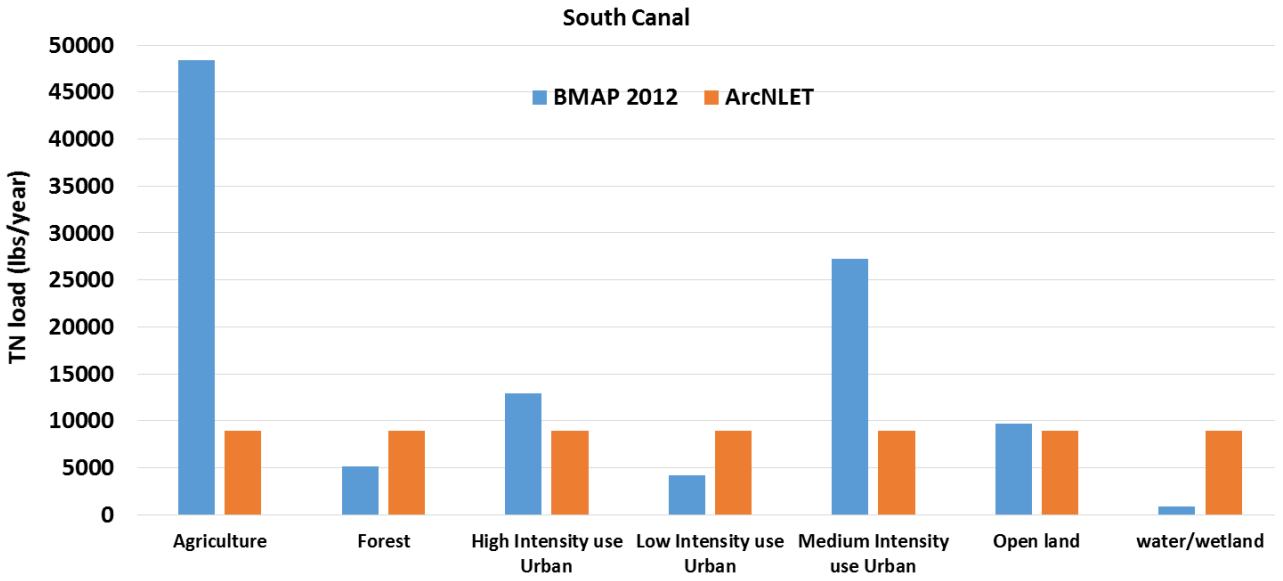
Load comparison: BMAP, 2012 VS ArcNLET

Table 4.13-a. TN Loads from Watersheds of Impaired Water Segments

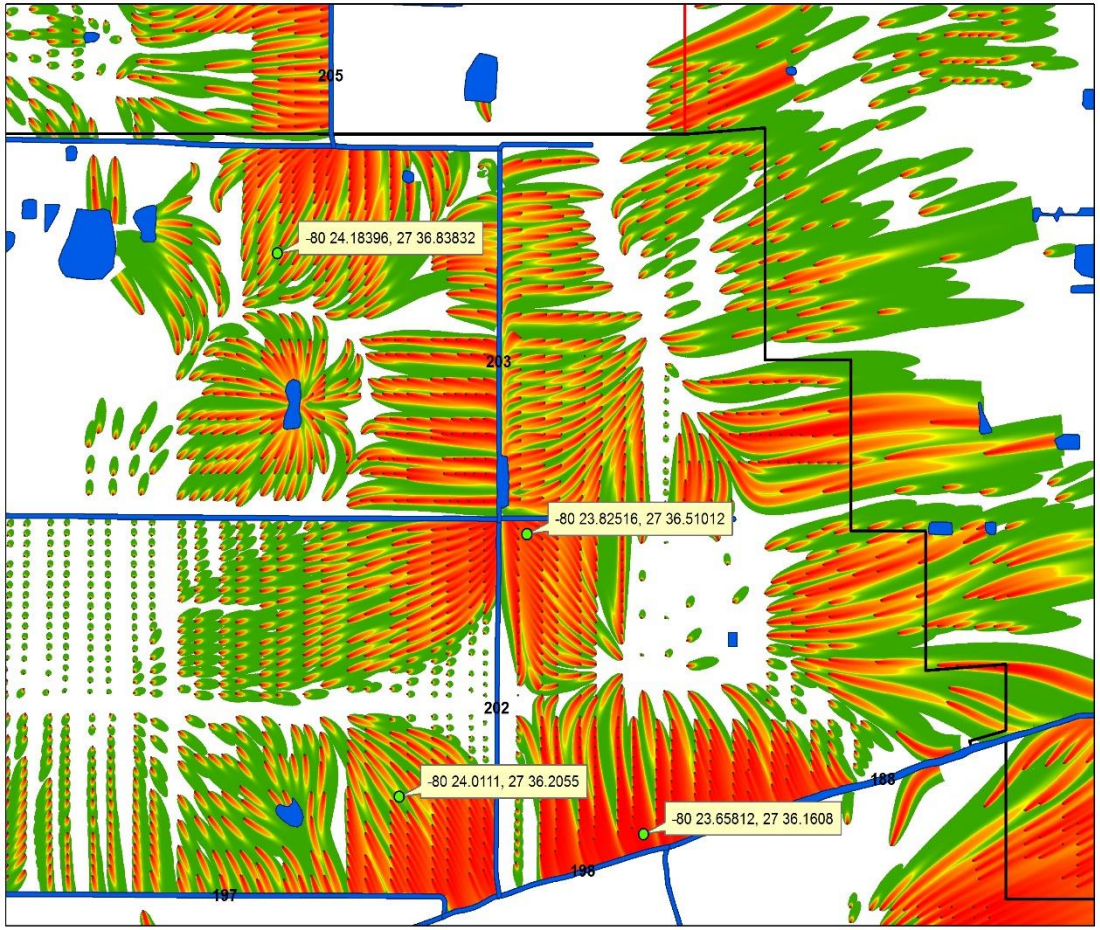
	Addison Creek (WBID 3028)		Eau Gallie River (WBID 3082)		Crane Creek (WBID 3085A)	
Land Use	TN Load	Percent	TN Load	Percent	TN Load	Percent
Agriculture	65.9	1.1%	184.3	0.3%	1,571.6	1.7%
Forest	1,136.6	19.6%	600.8	1.0%	3,187.4	3.5%
High-Intensity use urban	3,447.1	59.3%	45,867.9	77.9%	51,888.1	56.7%
Low-Intensity use urban	284.9	4.9%	2,201.4	3.7%	2,130.9	2.3%
Medium-intensity use urban	438.0	7.5%	6,752.6	11.5%	24,096.4	26.3%
Open land	431.0	7.4%	2,845.1	4.8%	7,775.5	8.5%
Water/Wetlands	6.6	0.1%	408.1	0.7%	814.7	0.9%
Total	5,810.2	100.0%	58,860.3	100.0%	91,464.6	100.0%
	North Prong of Sebastian River (WBID 3128)		South Prong of Sebastian River (WBID 3129A)		Sebastian River (WBID 3129B)	
Land Use	TN Load	Percent	TN Load	Percent	TN Load	Percent
Agriculture	43,179.0	41.2%	100,612.4	43.6%	56,492.6	52%
Forest	13,498.4	12.9%	15,770.0	6.8%	9,932.8	9%
High-Intensity use urban	12,188.1	11.6%	8,205.0	3.6%	9,880.2	9%
Low-Intensity use urban	7,221.3	6.9%	17,948.2	7.8%	2,110.5	2%
Medium-intensity use urban	261.3	0.2%	22,326.5	9.7%	17,313.5	16%
Open land	27,749.0	26.5%	63,692.6	27.6%	10,968.3	10%
Water/Wetlands	807.5	0.8%	2,011.5	0.9%	1,214.6	1%
Total	104,904.6	100.0%	230,566.3	100.0%	107,912.3	100%
	C-54 Canal (WBID 3135)		North Canal (WBID 3147)		Main Canal (WBID 3153)	
Land Use	TN Load	Percent	TN Load	Percent	TN Load	Percent
Agriculture	82,511.3	79.0%	45,706.1	56.6%	76,603.9	39.8%
Forest	9,460.1	9.1%	5,491.0	6.8%	10,512.3	5.5%
High-Intensity use urban	342.6	0.3%	10,242.6	12.7%	56,945.2	29.6%
Low-Intensity use urban	224.2	0.2%	6,766.7	8.4%	8,898.7	4.6%
Medium-intensity use urban	224.6	0.2%	6,172.6	7.6%	27,418.7	14.2%
Open land	9,333.0	8.9%	5,127.9	6.3%	9,595.7	5.0%
Water/Wetlands	2,398.6	2.3%	1,265.9	1.6%	2,491.0	1.3%
Total	104,494.5	100.0%	80,772.7	100.0%	192,465.5	100.0%
	South Canal (WBID 3158)					
Land Use	TN Load	Percent				
Agriculture	48,426.0	44.7%				
Forest	5,149.1	4.7%				
High-Intensity use urban	12,919.8	11.9%				
Low-Intensity use urban	4,170.8	3.8%				
Medium-intensity use urban	27,213.3	25.1%				
Open land	9,680.4	8.9%				
Water/Wetlands	870.0	0.8%				
Total	108,429.4	100.0%				

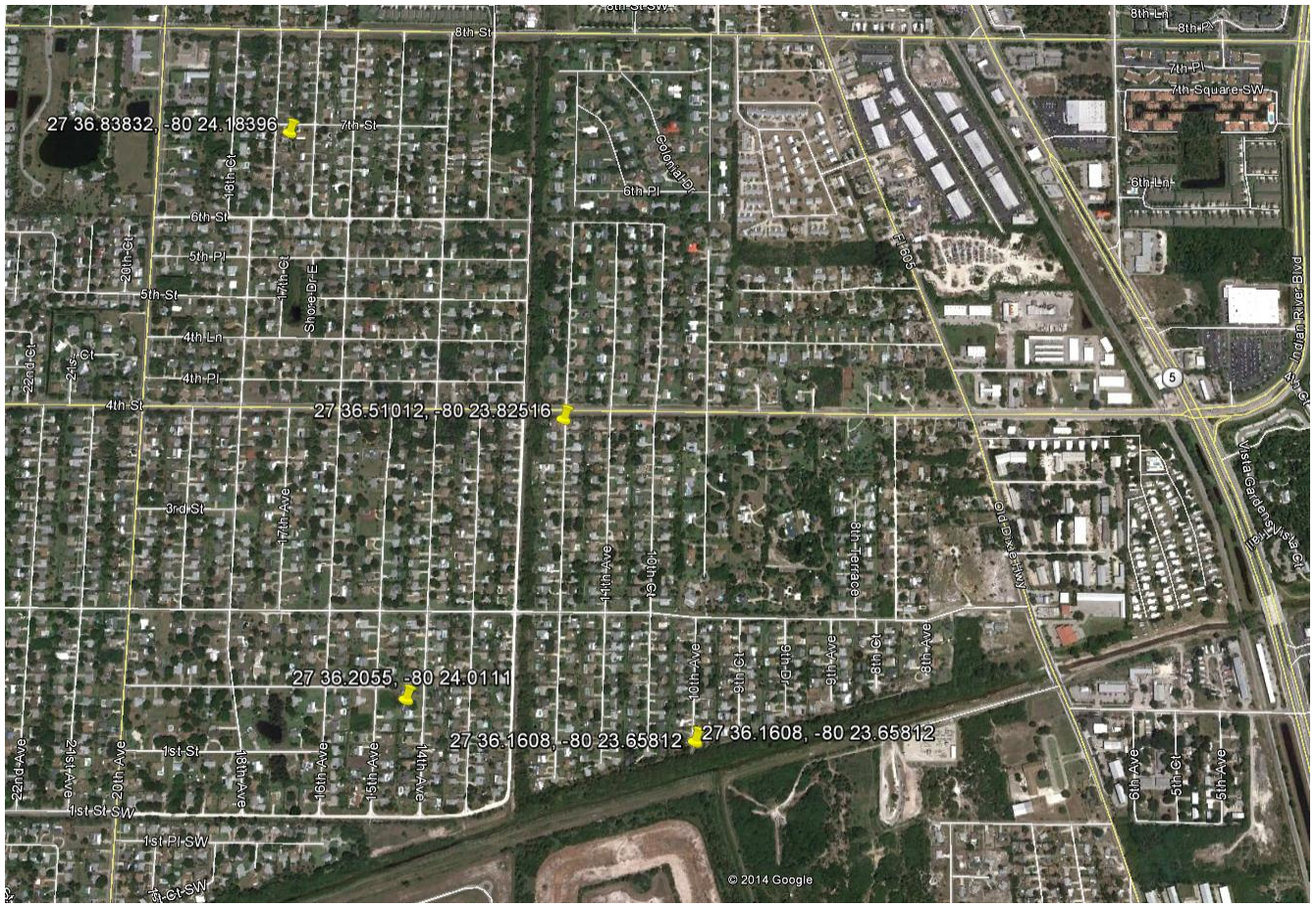
Note: the unit of TN load is lbs/year





Four proposed positions of the monitoring wells for future calibration





Future Work

- Collect the recent monitoring well data of hydraulic head and nitrogen concentration.
- Conduct model calibration and estimate nitrogen load in an iterative manner when new data arrives.
- Separate the nitrate and ammonium load estimation using the newly developed ArcNLET version.
- Evaluate the final load estimates and make management suggestions.

Questions?