Environmental Assessment of the Okeechobee Basin Using WAM

Del Bottcher, Andrew James, and Jeff Hiscock

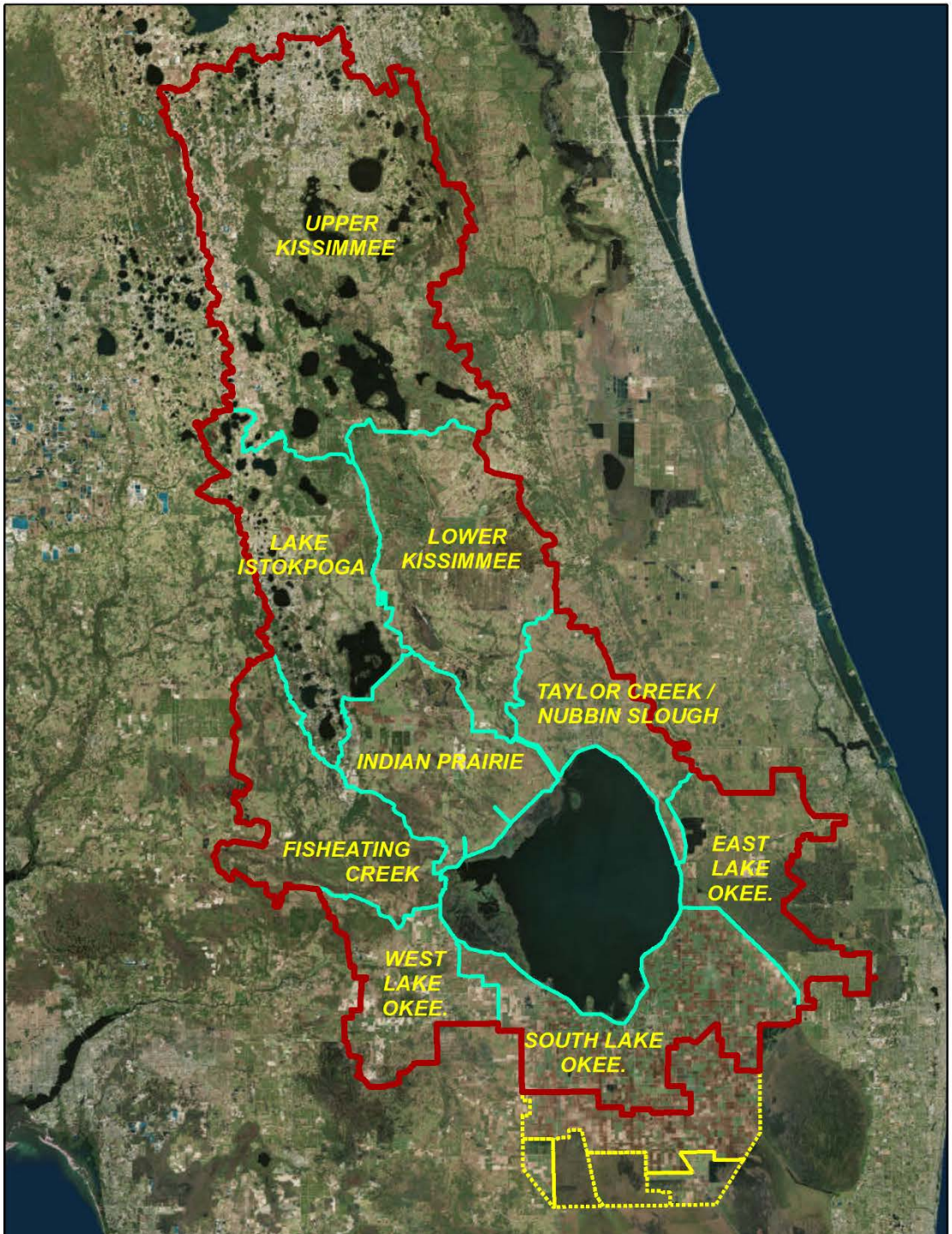
Soil and Water Engineering Technology, Inc.

WAM Discussion Outline

- Introduction
  - What is WAM?
  - Objectives associated with Okechobee BMAP
- Sensitive and Uncertainty Analyses
  - Objectives
  - Satus report
- Southern Sub-Watersheds
  - Project Update
  - Stakeholder Input

Okeechobee BMAP Boundary

with
Sub- Watersheds



Modeling Objective?

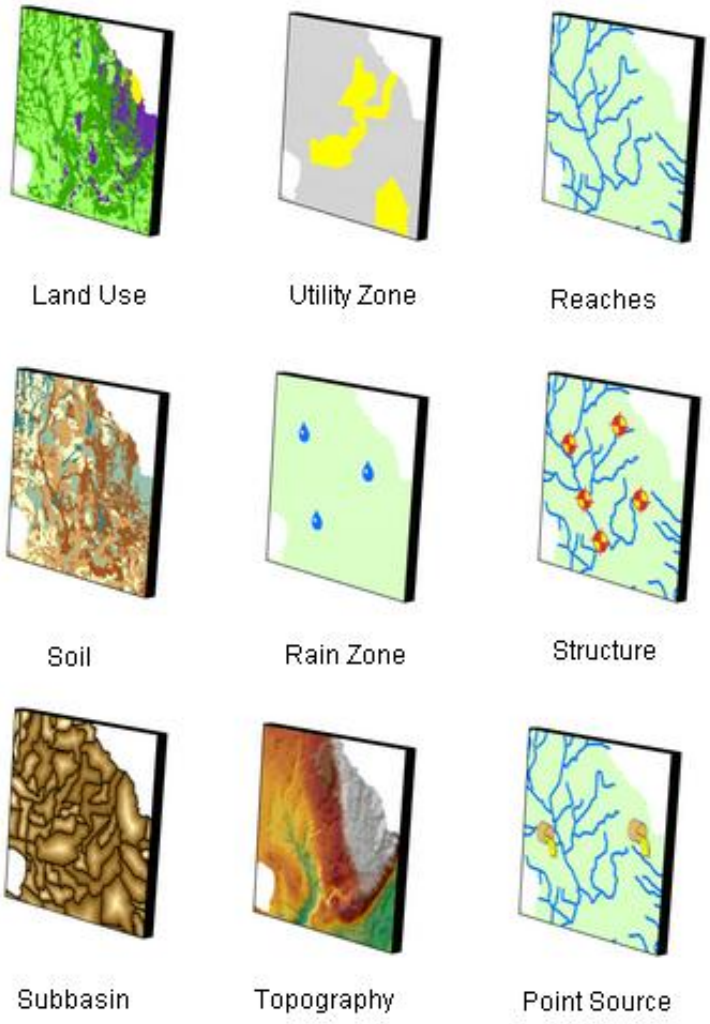
Help inform stakeholders on watershed behavior for better decision making!

- *Quantify water & nutrient contributions by land use*
  - *As influenced by soils, weather, BMPs, and location*
  - *Support FDEP Load Estimator Tool*
- *Evaluate alternative abatement scenarios/projects*
  - *Environmental benefit*
  - *Economic impact*
  - *Environmental response vs. cost*
- *Evaluate impact of new developments / projects*
- *Help set targets for TMDL/BMAP compliance*
- *Evaluate compliance of implemented programs*

Watershed Assessment Model (WAM)

- **Developed specifically for Florida conditions**
- **Simulates surface and groundwater flow, TSS, and nutrient loadings. DO and Chl-a when combined with WASP**
- **GIS based to maximize use of spatial datasets**
- **Detailed field scale land source simulation**
- **Handles complex flow networks**
- **User friendly interface**

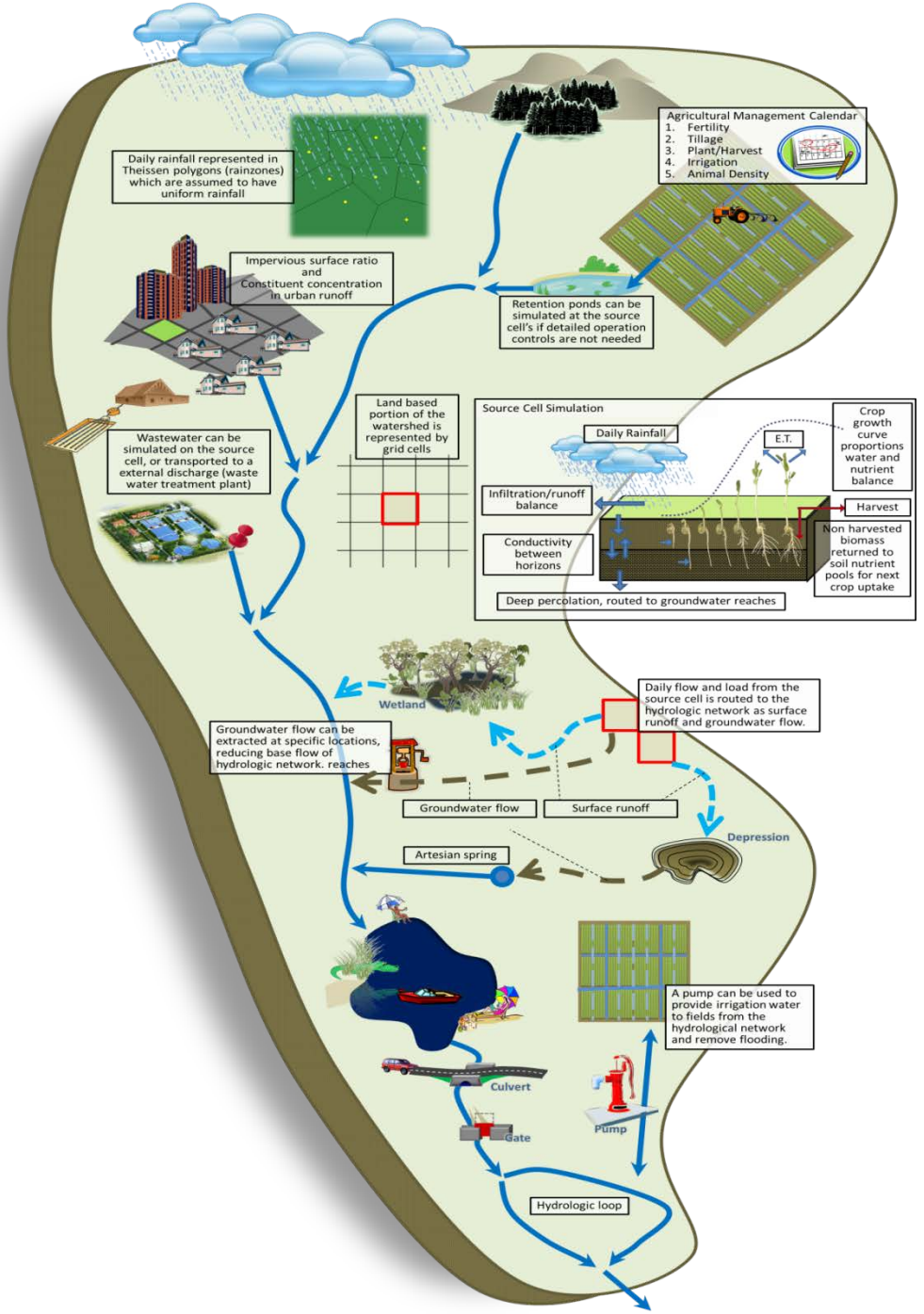
WAM – A GIS Model



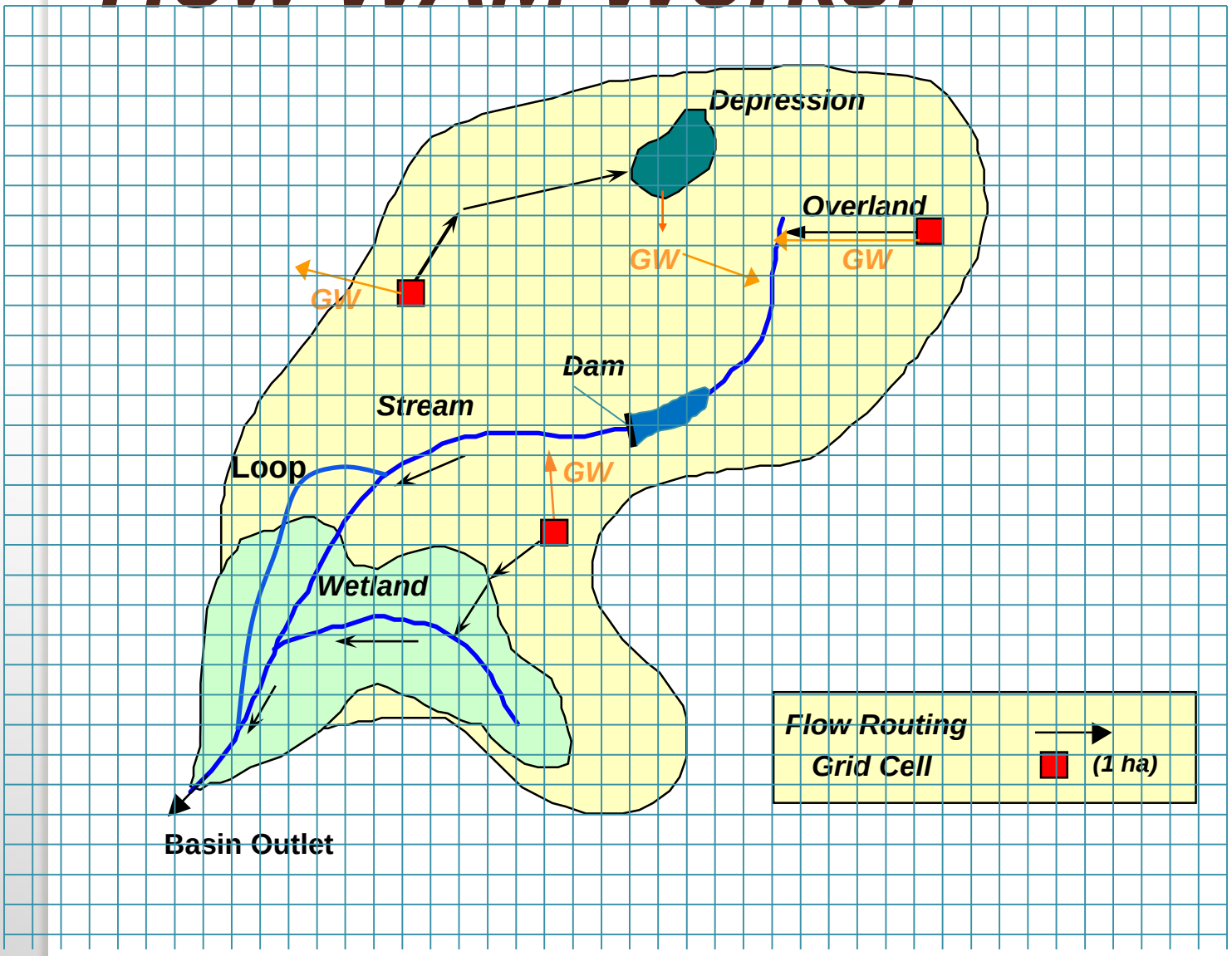
- Provides the convenience to integrate multiple data layers to form a combined data input
- Provides the capability of identifying projects areas that meet multiple criteria

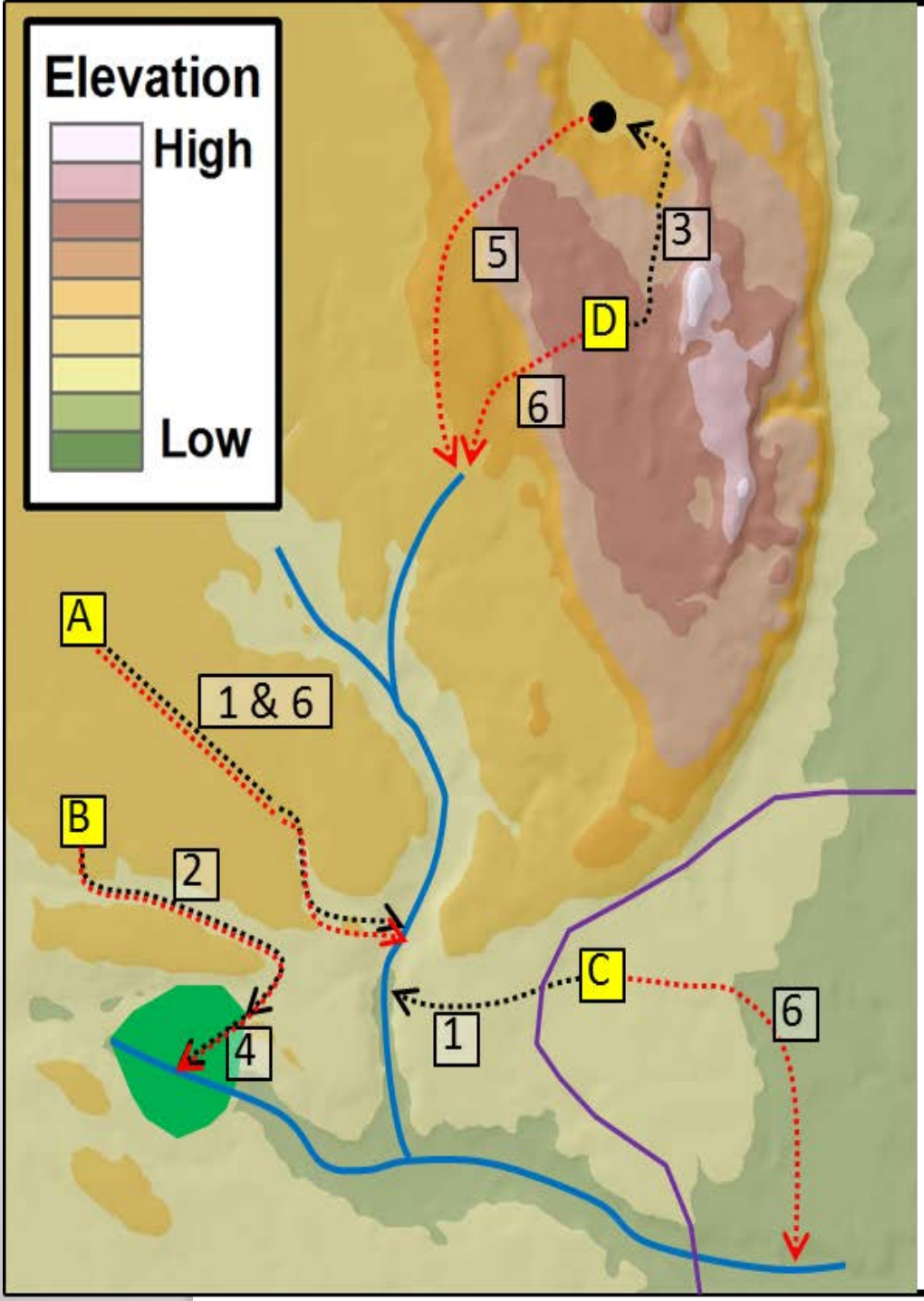
Conceptual Layout of WAM

Processes Handled



How WAM Works!





Key

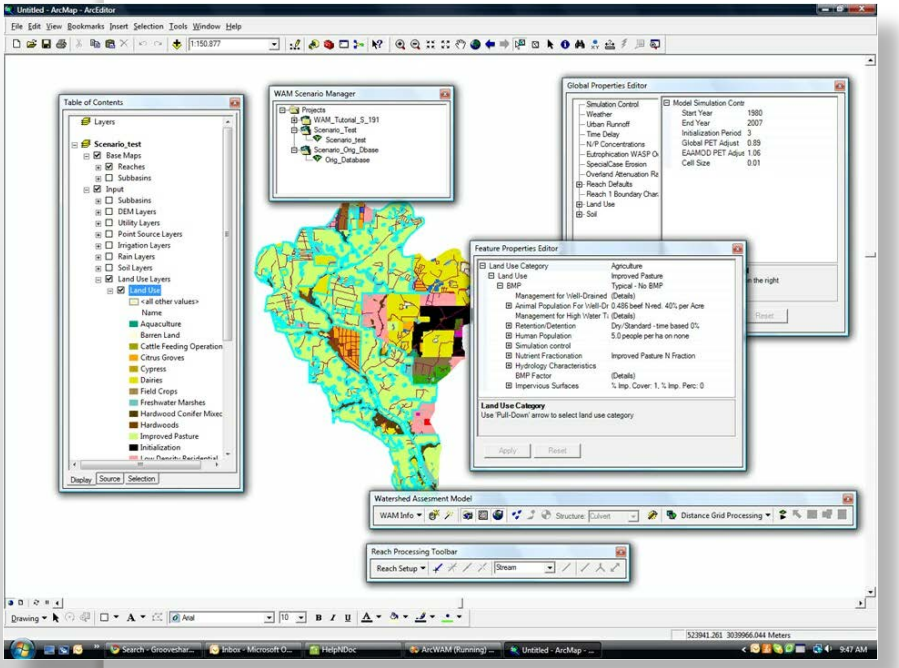
1. Source to nearest Stream
2. Source to Nearest Wetland
3. Source to Nearest Depression
4. Wetland to nearest stream
5. Depression to nearest stream
6. Source to groundwater stream

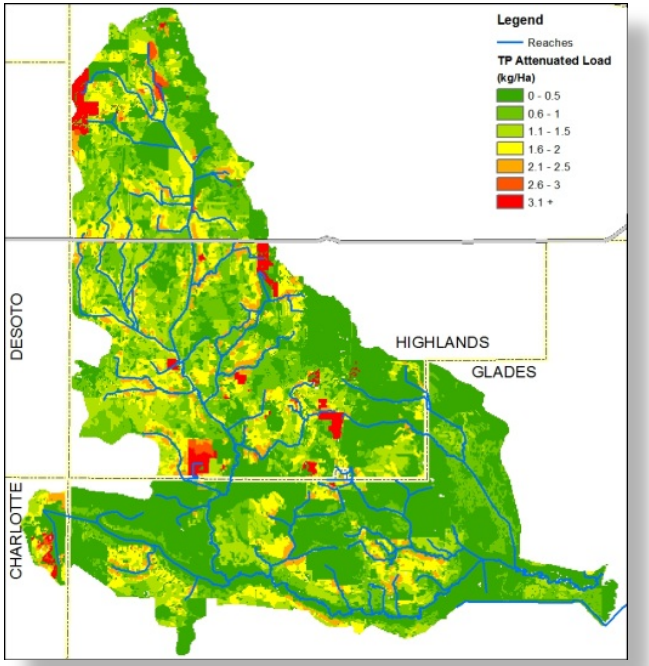
Legend

- Source Cell
- Springshed Boundary
- Surface Runoff
- Groundwater Flow
- Wetland
- Reach
- Depression

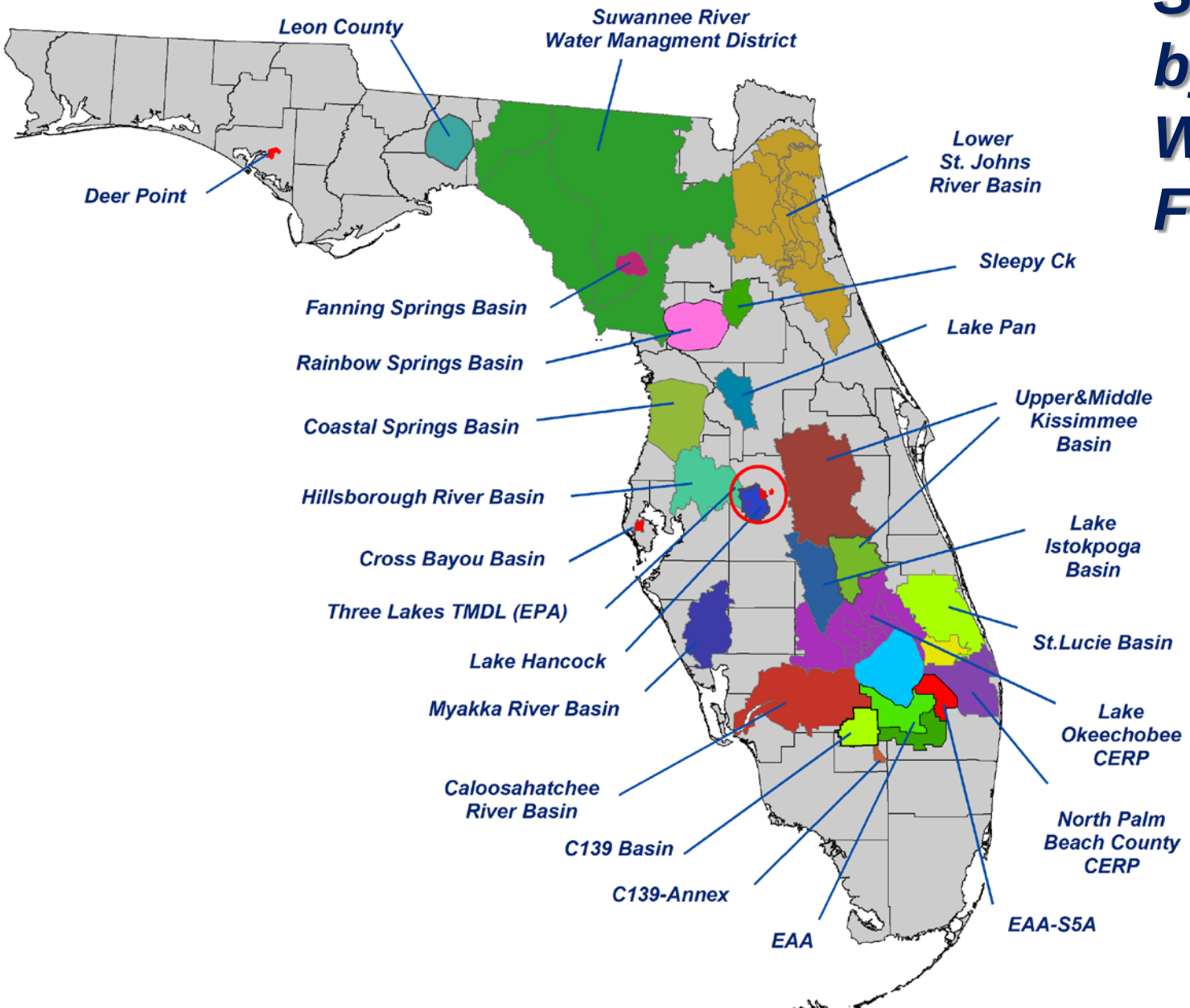
ESRI ArcGIS Interface

- Standardized workflows and tools
- Feature classes stored in geodatabase
- User friendly editing of complex parameter sets
- Simple review and comparison of model inputs & outputs





WAM Projects in Florida



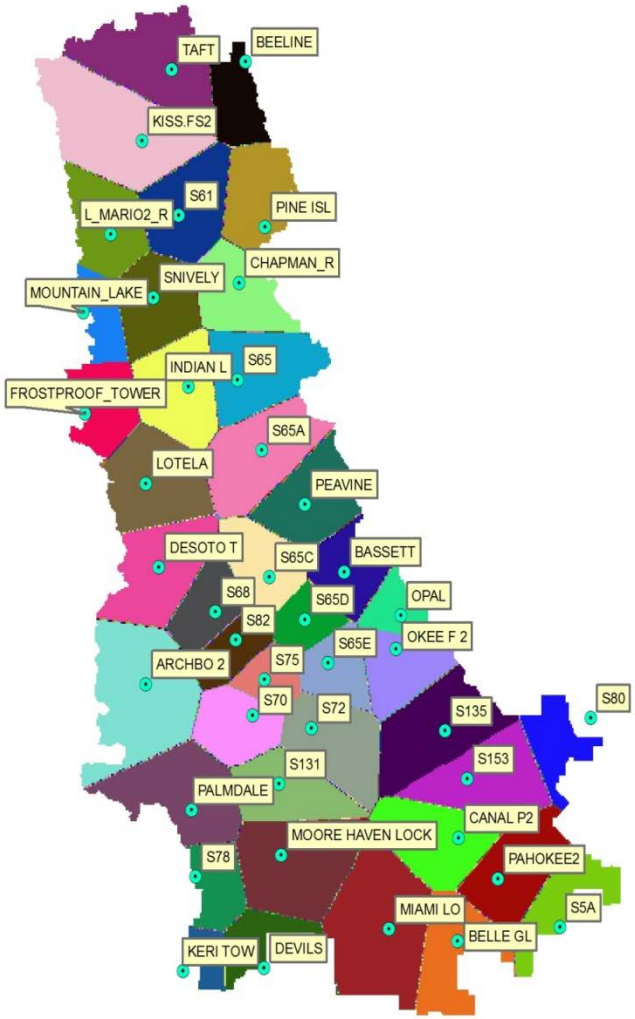
Watersheds Simulated by WAM in Florida

Background of WAM Modeling Activities

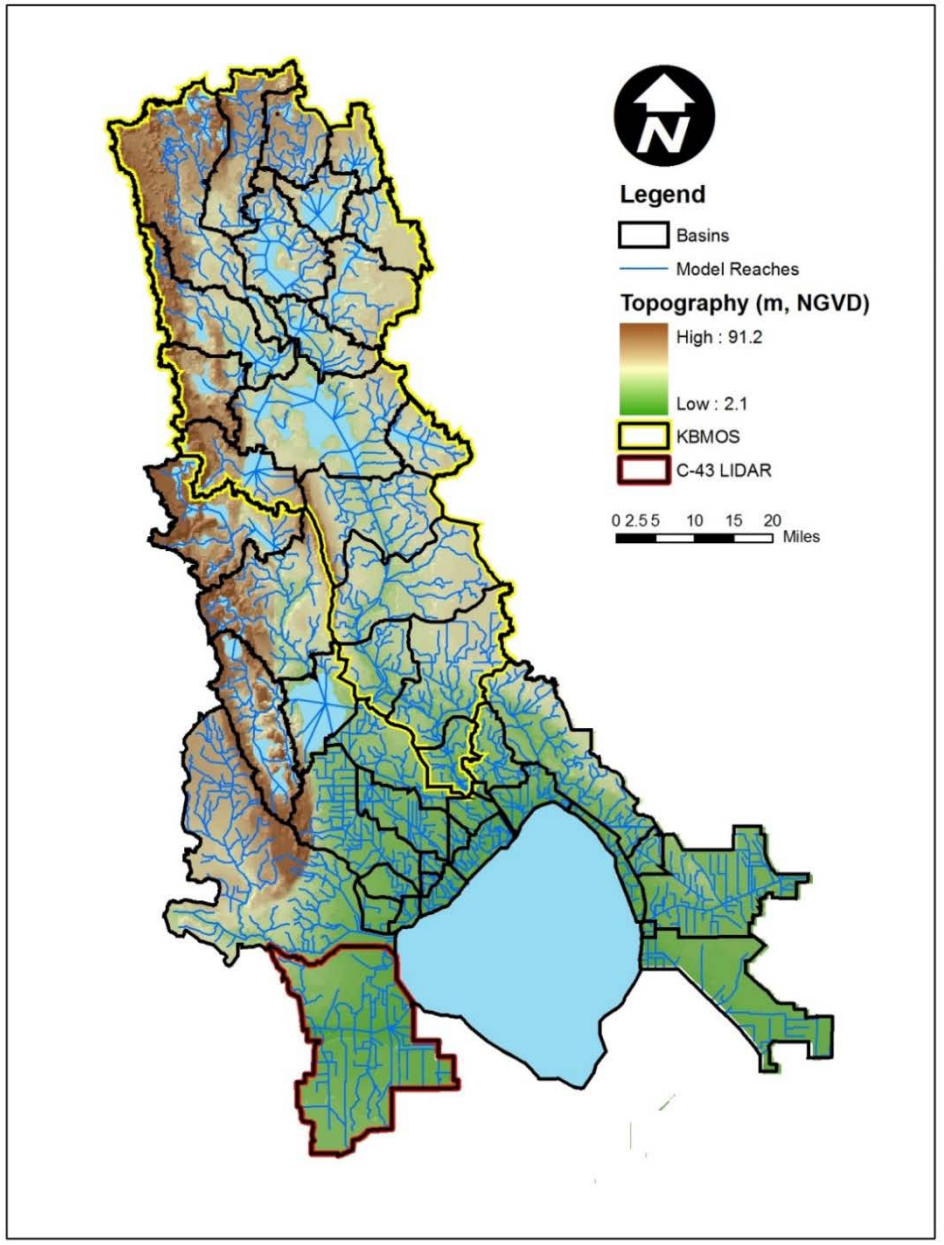
- 2008 - WAM simulation N Okee using 2004/6 land use for rainfall from 1998-2007
- 2012 - WAM simulation N Okee using 2004/6 land use fo rainfall period 1975 -2010
- 2012 - Fisheating Creek modeled for pre-development conditions
- 2013 - Draft pre-developed land use and hydrography for N Okee watershed
- 2014 – FDEP using WAM output for load estimator tool for BMAP
- 2016 – Recalibration Okee Basins through 2013
- 2016 – Sensitivity and Uncertainty Analysis
- 2016 – Modeling of Southern Basins.

NOTE: P is primary focus because it has been identified as the limiting nutrient in Lake Okeechobee

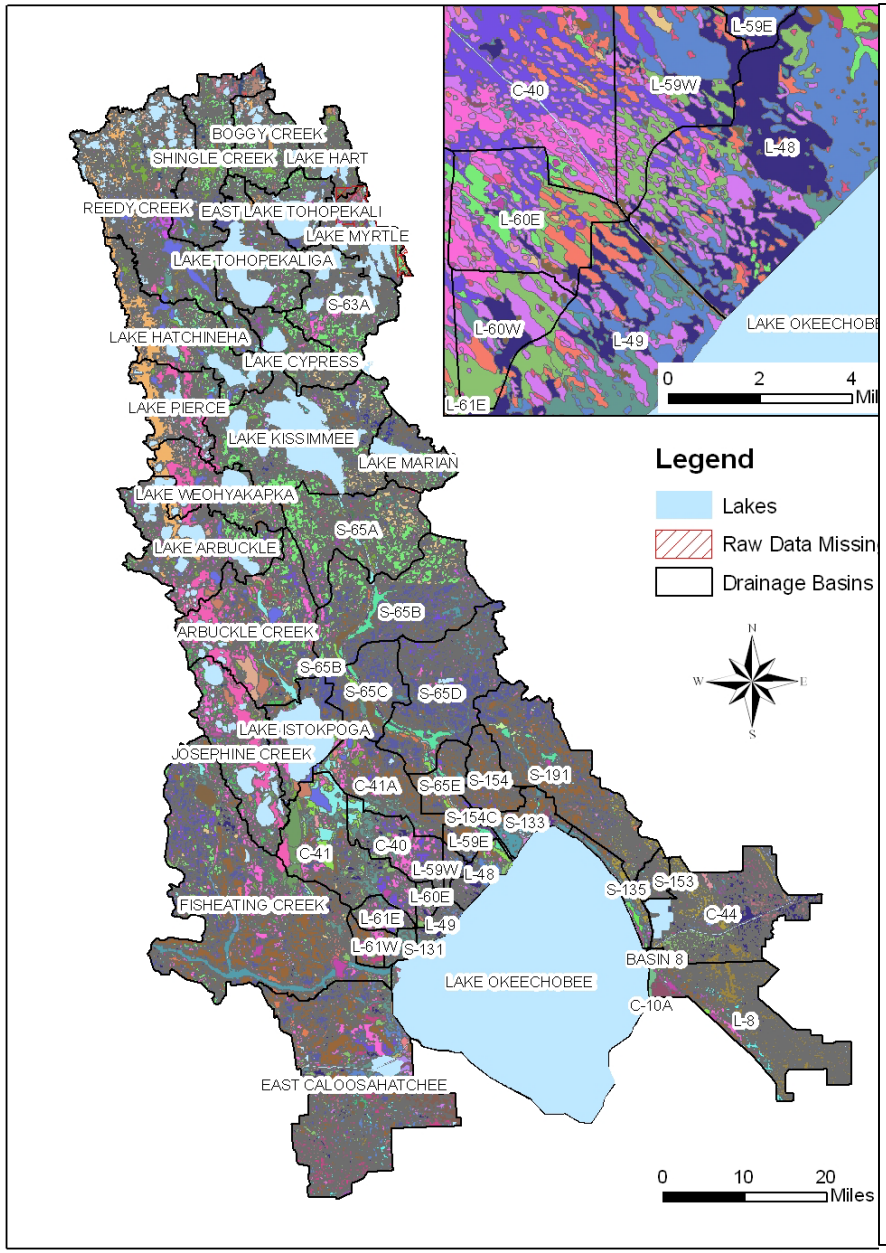
Rainfall Stations



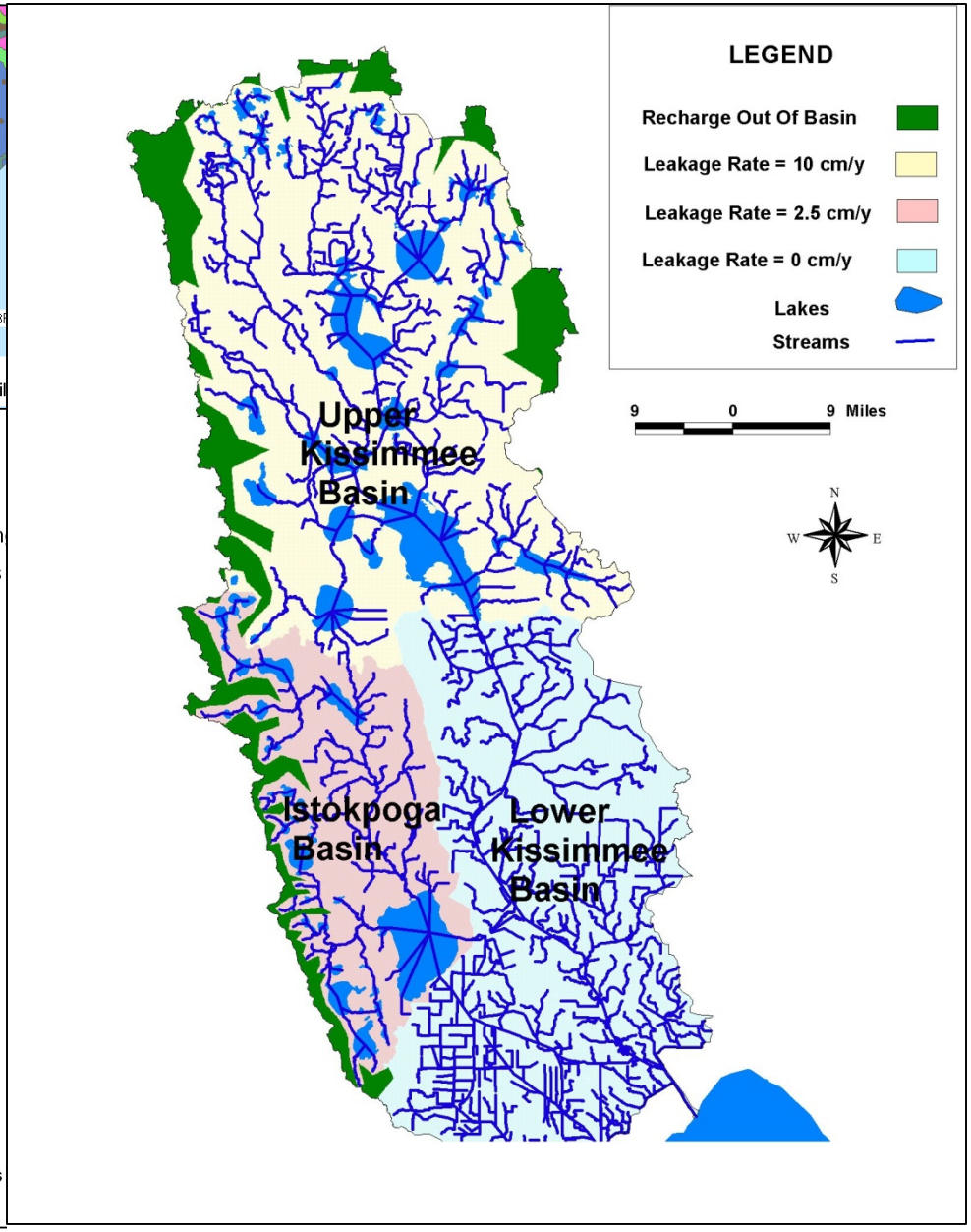
Stream & Topography



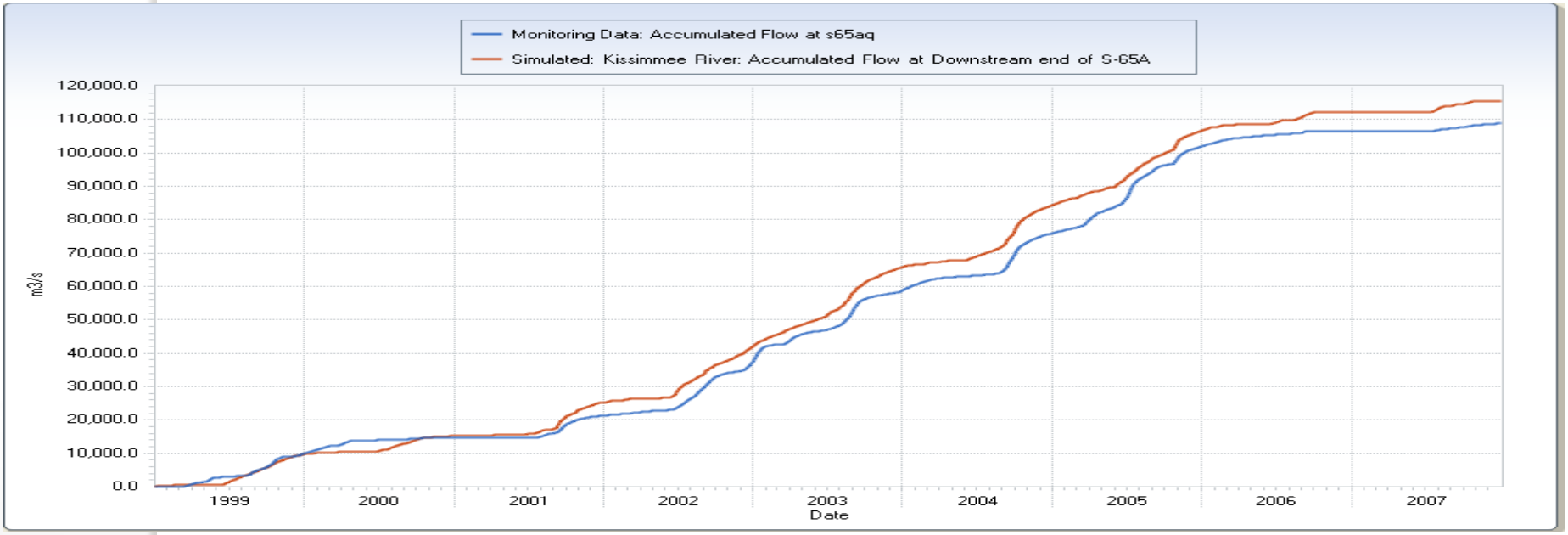
Soils



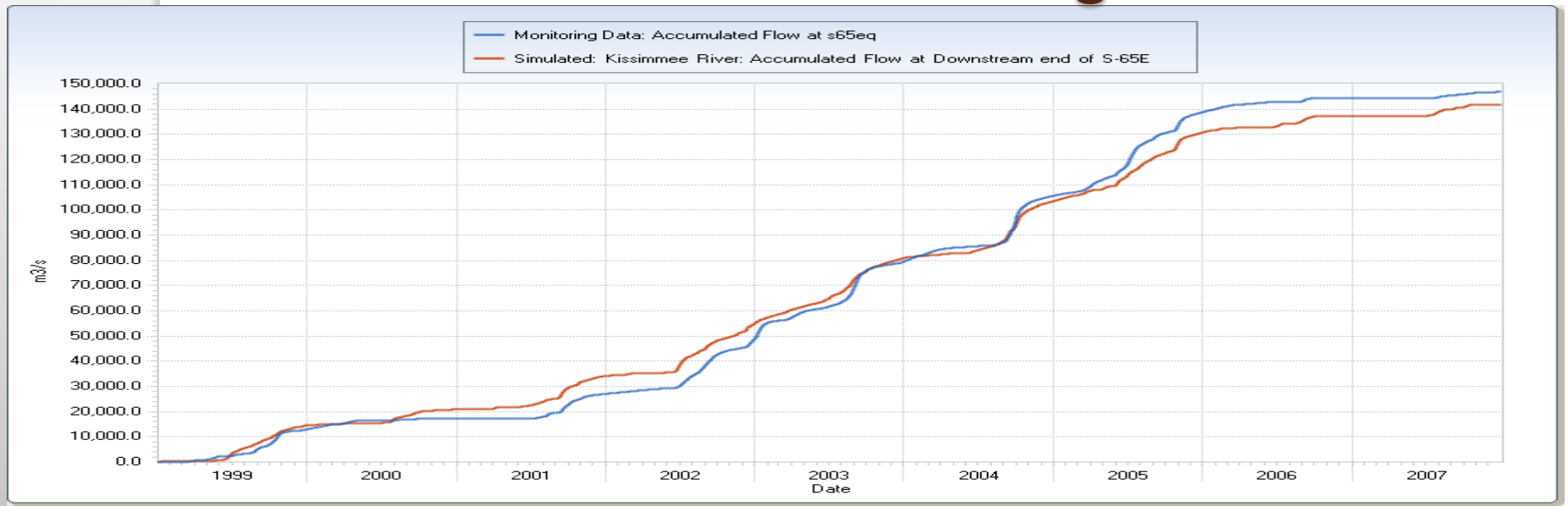
Groundwater Flows



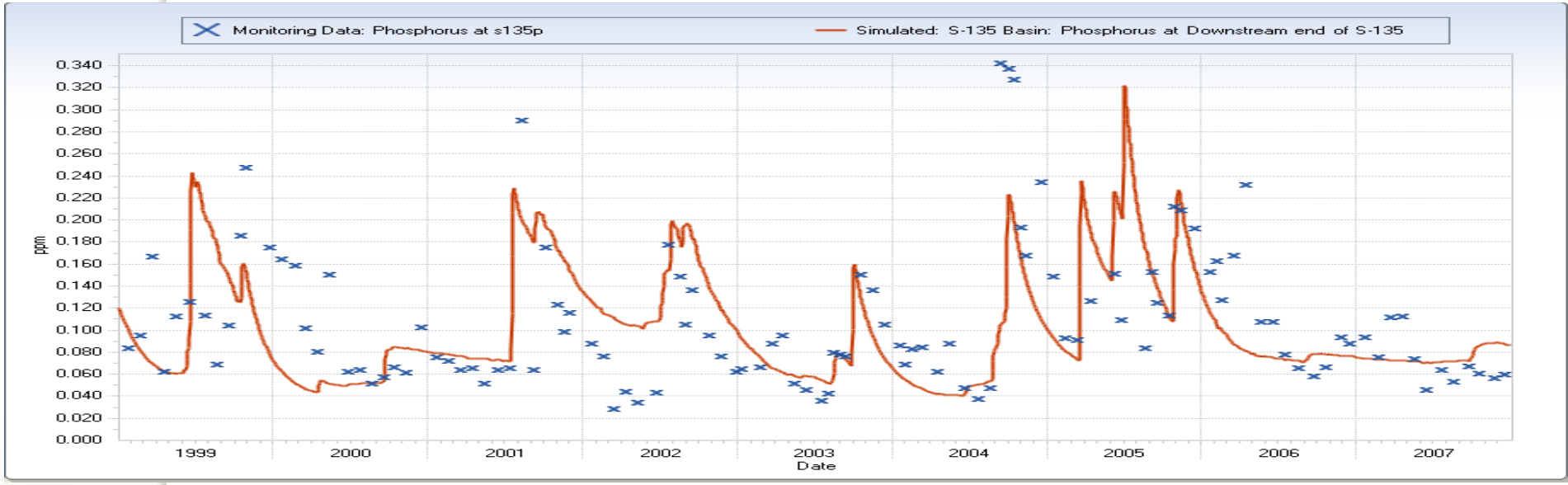
TP Conc. at S65A below Lake Kissimmee



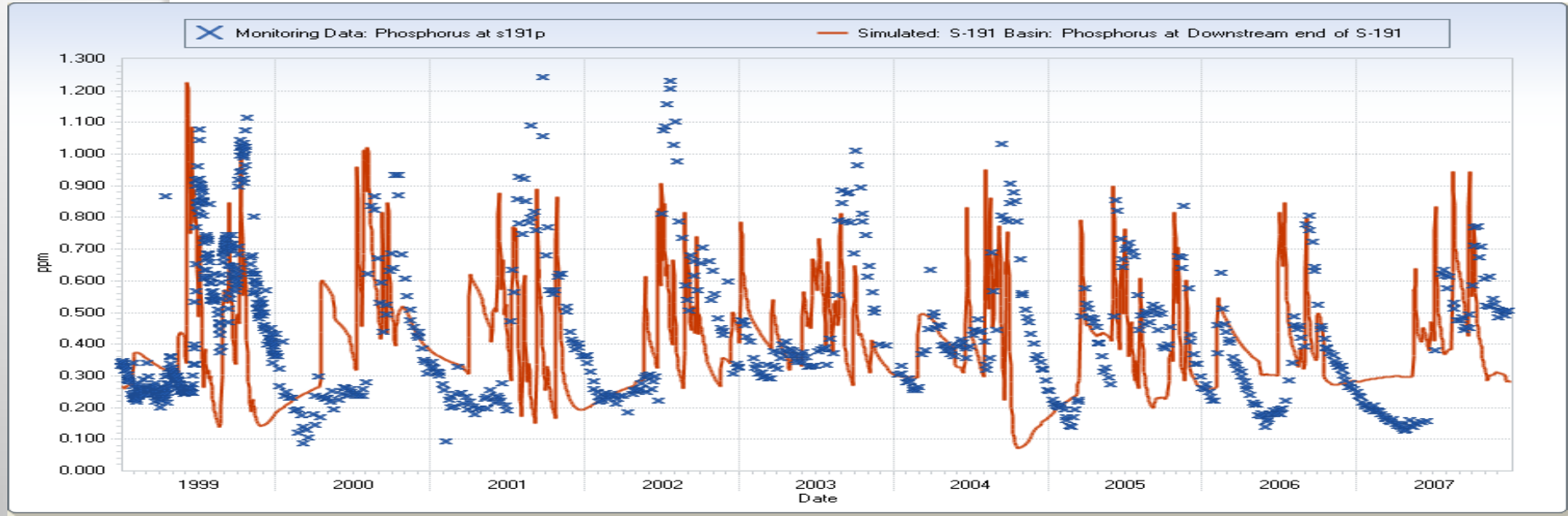
TP Conc. at S65E before entering Lake O



TP Conc. at S-135 near Lake basin



TP Conc. at S-191 on Taylor Ck / Nubbin Slough

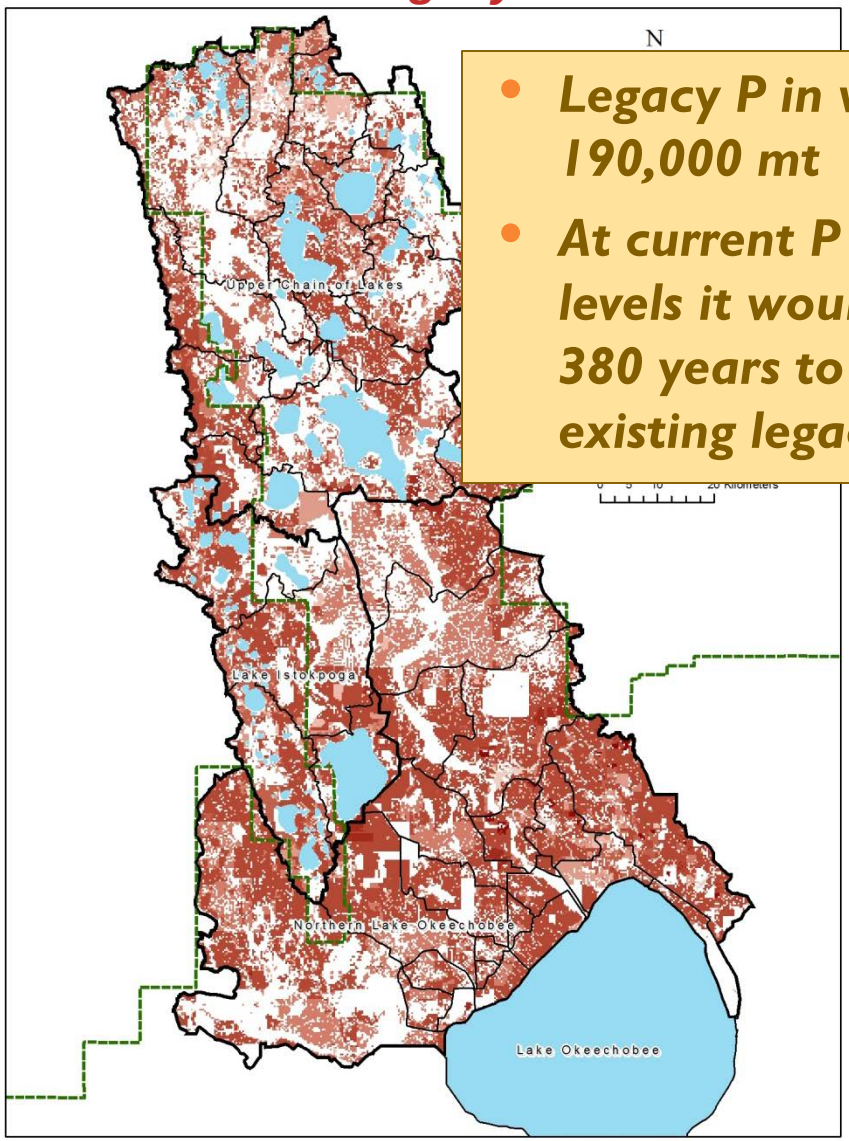


Simulated Flows and TP Loads

Basin	Struct	WAM Reach	Annual Average Flow (m3x106)			Annual Average TP Load (mt)			Years
			Measured	Simulated	% Diff	Measured	Simulated	% Diff	
C-38	S-65	836	974	1021	5%	82.1	83.5	2%	99-07
	S-65A	602	1045	1108	6%	87.4	92.0	5%	99-07
	S-65C	519	1204	1227	2%	96.5	101.7	5%	99-07
	S-65D	87	1318	1343	2%	125.3	137.6	10%	99-07
	S-65E	79	1410	1362	-3%	150.8	153.1	1%	99-07
	S-68	657	346	352	2%	25.4	26.6	5%	99-07
C-43	S-78	2	1201	1195	0%	149	160	7%	99-07
C-44	S-80	5	470	542	15%	102	115	12%	99-07
L-8	L-8 @ C-51	3	108	98	-9%				99-07
	WPB PS2	49				2.1	3	67%	98-02
L-48	S-127	2	12	13	6%	3.0	3.0	-1%	99-07
L-49	S-129	2	14	14	-7%	1.1	1.2	10%	99-07
S-131	S-131	2	11	11	-8%	1.3	1.5	10%	99-07
S-133	S-133	2	23	22	-5%	5.6	6.1	8%	99-07
S-135	S-135	2	22	22	1%	2.8	3.1	10%	99-07
S-191	S-191	2	116	116	0%	72.7	75.3	4%	99-07
FEC	US-27	60	233	239	3%				99-07
	SR-78	4				57.8	52.3	-10%	99-07

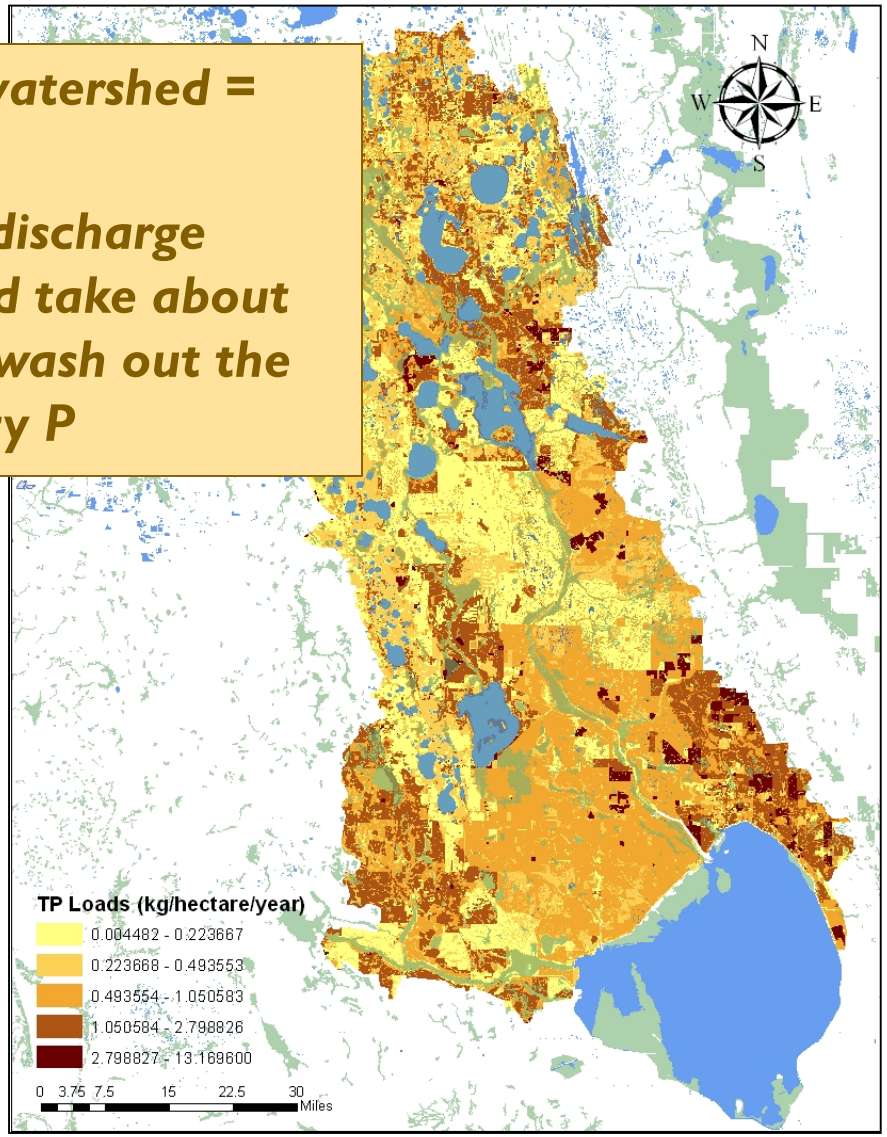
Legacy P versus Runoff P in Okeechobee Watershed

In-Soil Legacy P

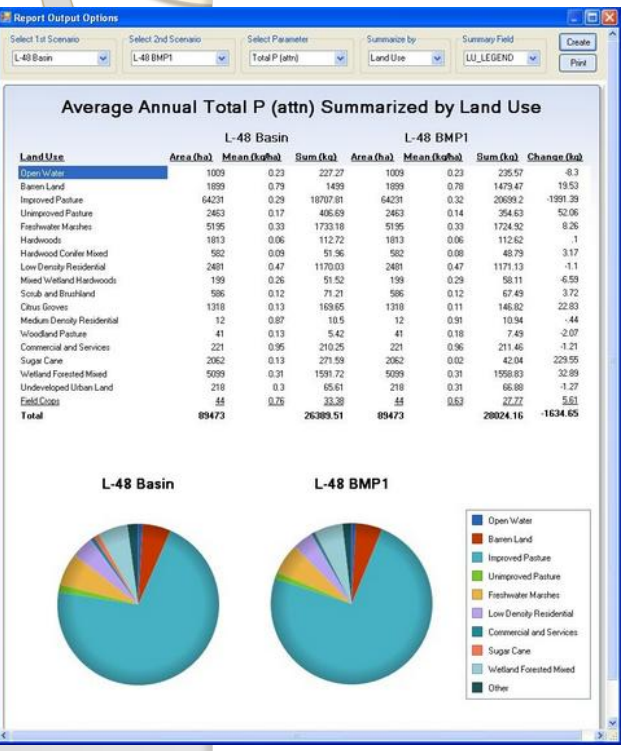


- Legacy P in watershed = 190,000 mt
- At current P discharge levels it would take about 380 years to wash out the existing legacy P

P in Runoff



BMAP Load Estimator Tool

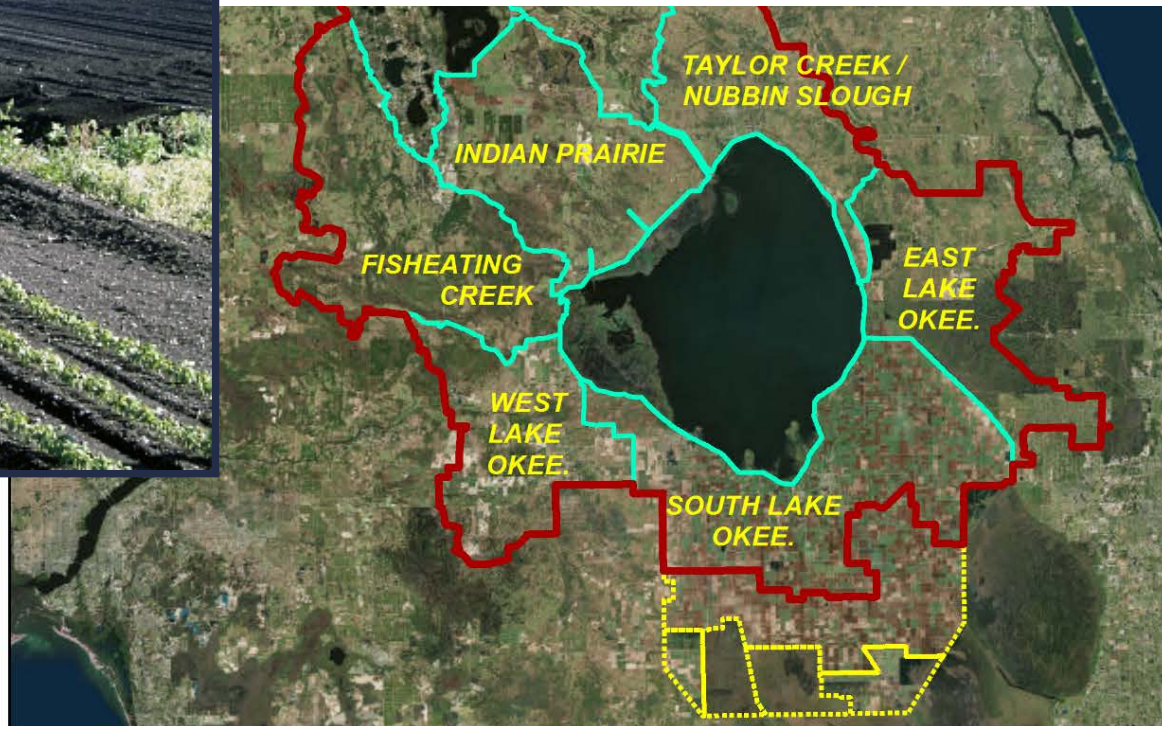


- Develop unit loads at source cells – provided by WAM
- Develop attenuation factor to watershed outlet by comparing measured loads to WAM estimates
- Develop source unit loads for latest land use (2009) and apply attenuation factors to watershed outlets
- Develop fraction of outlet loads attributed to specific land uses

Sensitivity and Uncertainty Analyses

Andy James

WAM Simulation of Southern Okeechobee Sub-Watersheds



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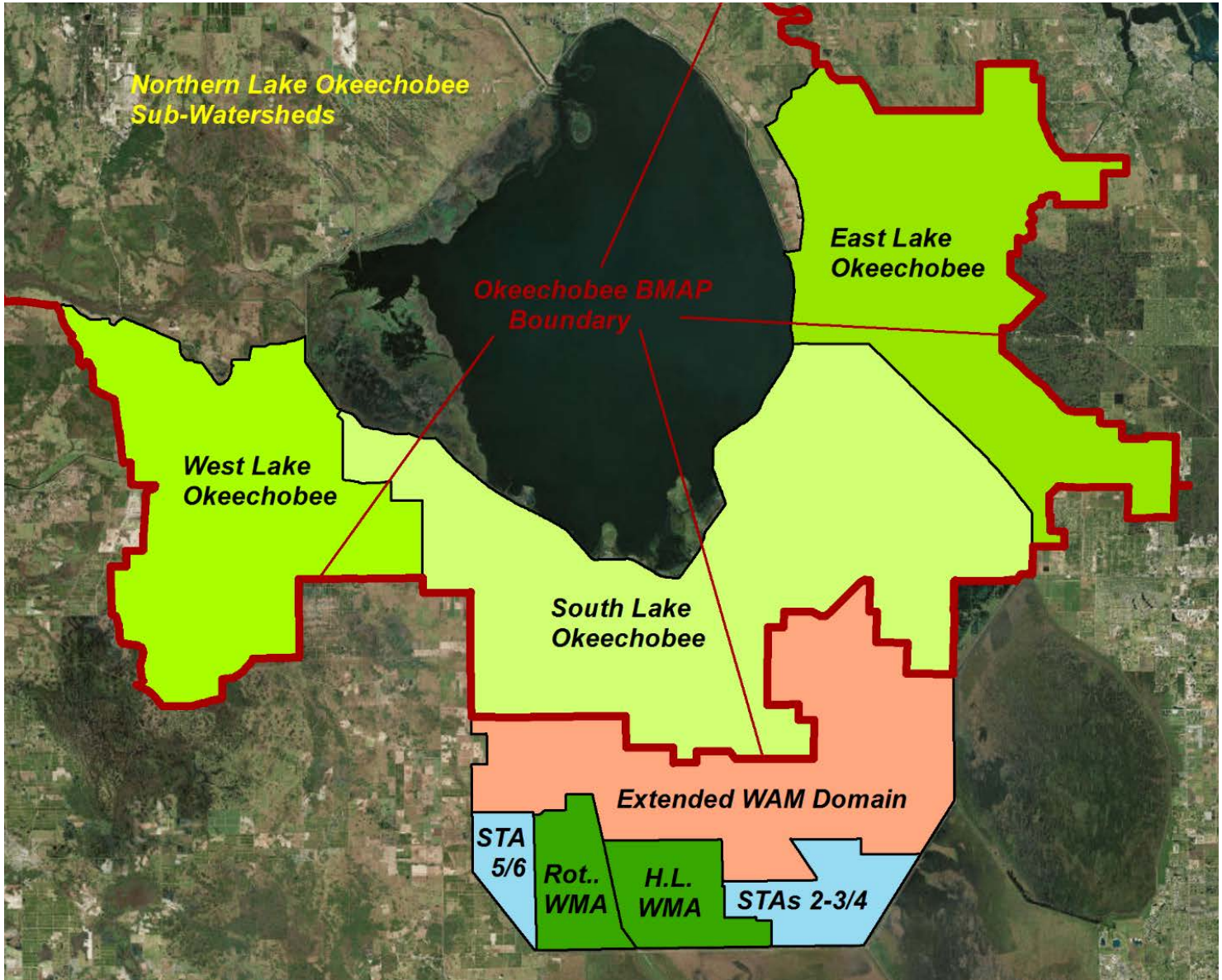
Southern Basins WAM Modeling Objectives

- Fill in the missing sub-watersheds within the Lake Okeechobee BMAP boundary to be consistent with the northern sub-watersheds' objectives.
- Extend FDEP Load Estimator Tool
- Provide a tool for assessing future abatement strategies.
- Model existing and future conditions, i.e. no looking back at historic conditions.
- Focus on sub-watershed level responses to Lake Okeechobee, not farm level.

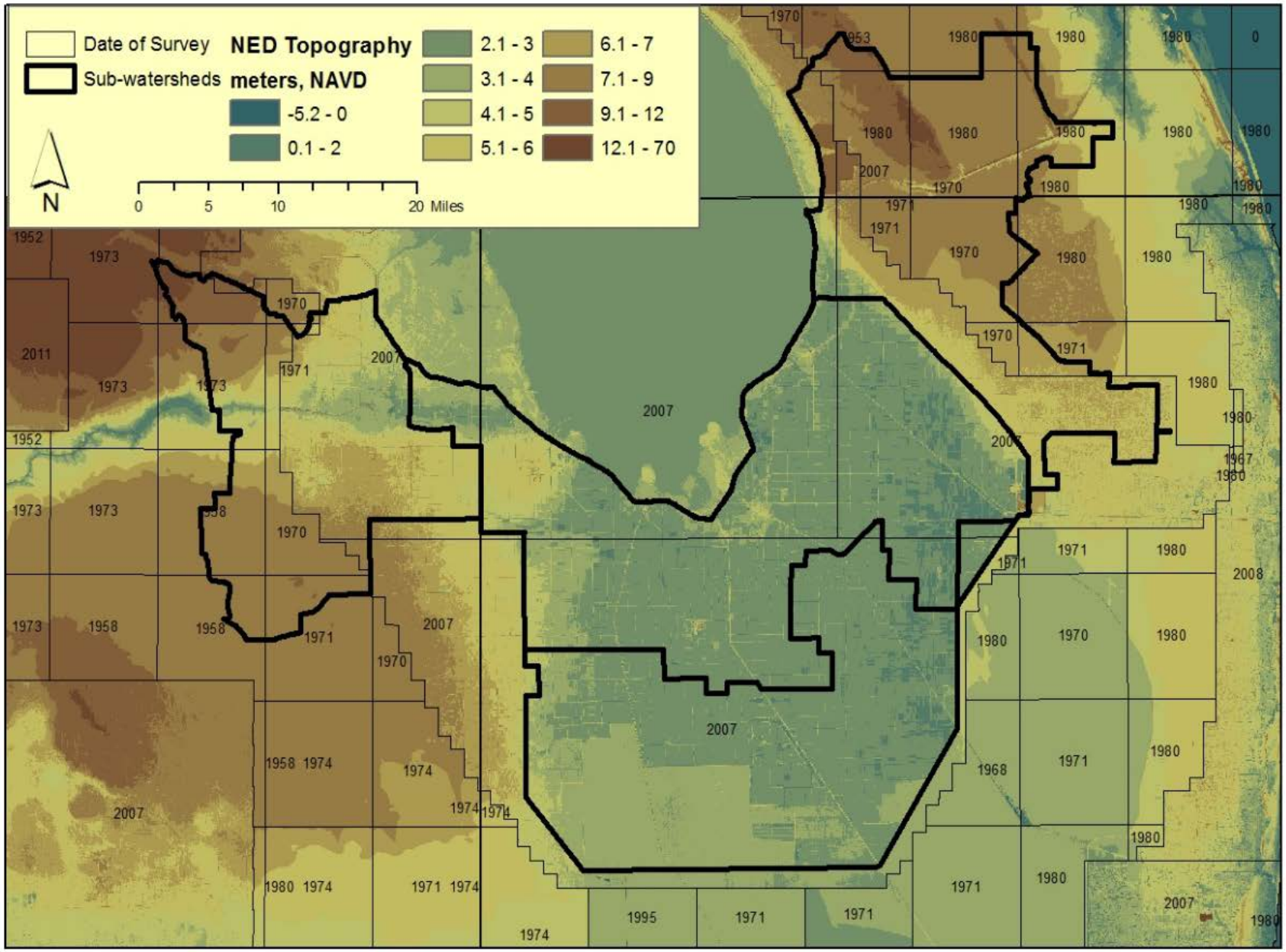
Southern Lake Okeechobee Sub-Watersheds and Extended WAM Domain



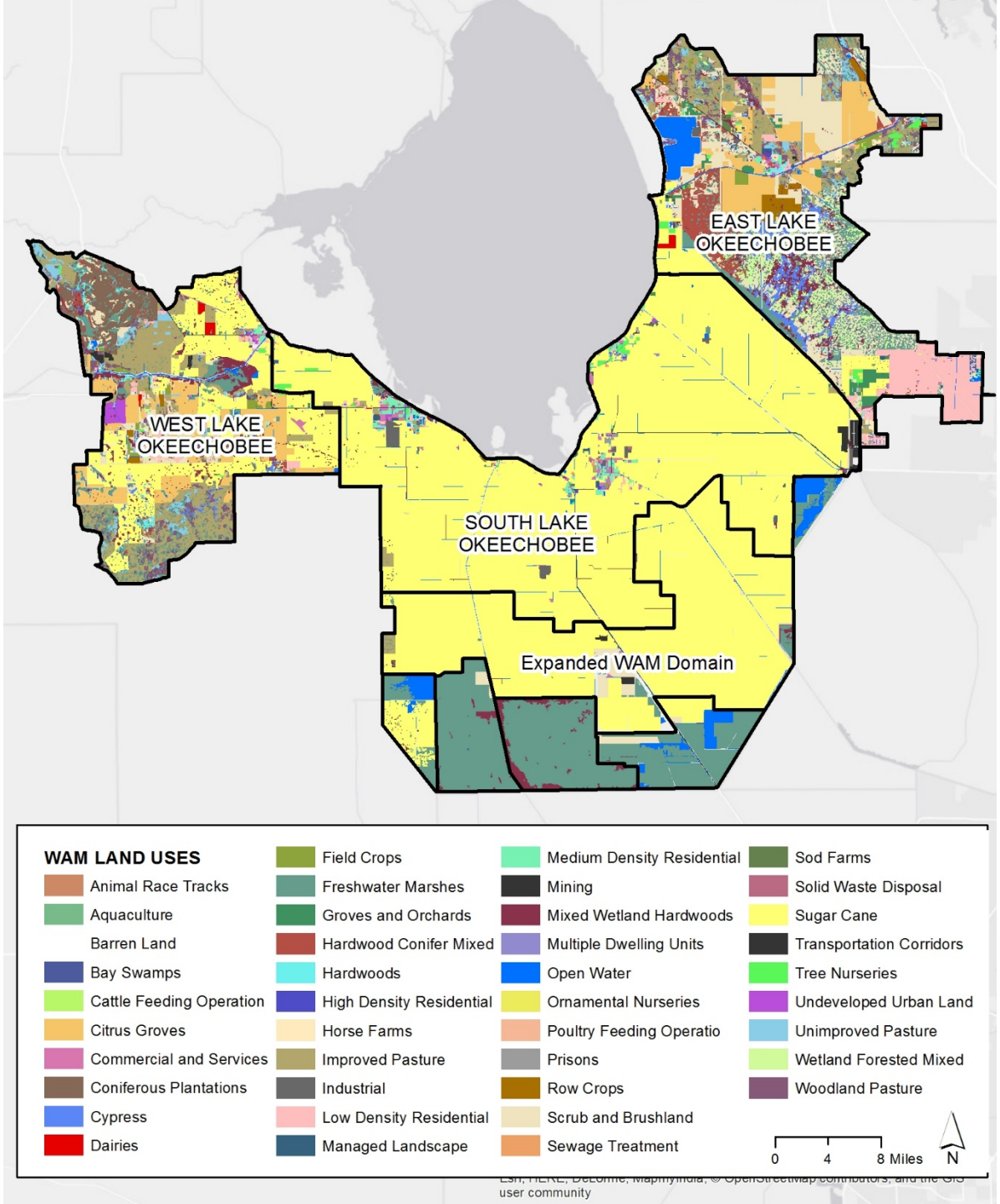
Task 4.1 Data Collection

- Topography
- Land Use
- Soils
- Weather Parameters
- Hydrologic Reaches
- Structures
- Irrigation Sources
- Wastewater Treatment
- Boundary Conditions
- Available Monitoring Data

Topography


Date of Survey
Sub-watersheds
NED Topography
meters, NAVD
-5.2 - 0
0.1 - 2
2.1 - 3
3.1 - 4
4.1 - 5
5.1 - 6
6.1 - 7
7.1 - 9
9.1 - 12
12.1 - 70
N
0
5
10
20 Miles

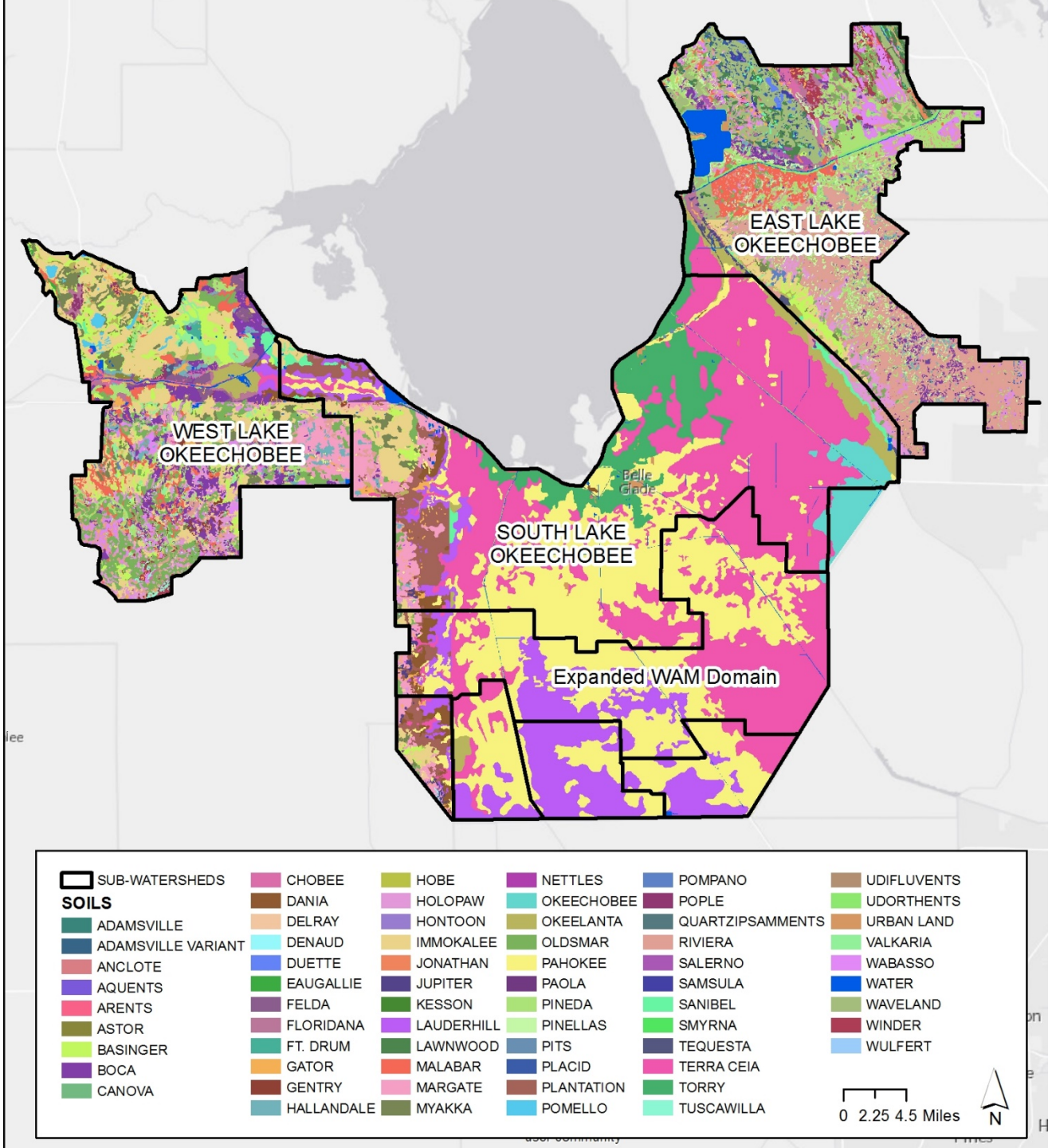
Land Use

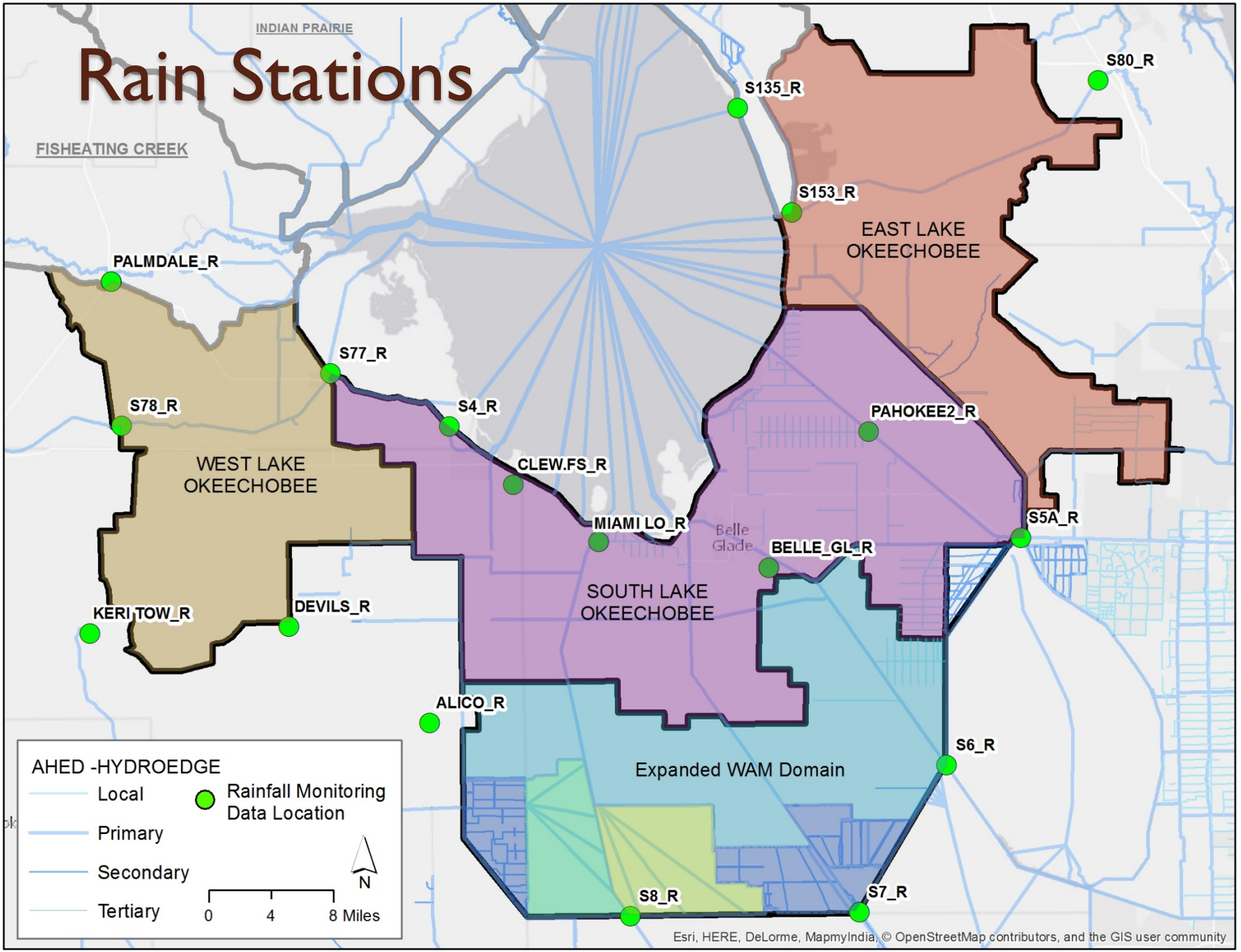

EAST LAKE OKEECHOBEE
WEST LAKE OKEECHOBEE
SOUTH LAKE OKEECHOBEE
Expanded WAM Domain
WAM LAND USES
Animal Race Tracks
Aquaculture
Barren Land
Bay Swamps
Cattle Feeding Operation
Citrus Groves
Commercial and Services
Coniferous Plantations
Cypress
Dairies
Field Crops
Freshwater Marshes
Groves and Orchards
Hardwood Conifer Mixed
Hardwoods
High Density Residential
Horse Farms
Improved Pasture
Industrial
Low Density Residential
Managed Landscape
Medium Density Residential
Mining
Mixed Wetland Hardwoods
Multiple Dwelling Units
Open Water
Ornamental Nurseries
Poultry Feeding Operatio
Prisons
Row Crops
Scrub and Brushland
Sewage Treatment
Sod Farms
Solid Waste Disposal
Sugar Cane
Transportation Corridors
Tree Nurseries
Undeveloped Urban Land
Unimproved Pasture
Wetland Forested Mixed
Woodland Pasture
0
4
8 Miles
N

Dominant Land Uses

Land Use	Area (Acres)	Percent of Subwatershed
Sugar Cane	57860	28.35%
Improved Pasture	35881	17.58%
Citrus Groves	24674	12.09%
Freshwater Marshes	17980	8.81%
Coniferous Plantations	12382	6.07%
Scrub and Brushland	11090	5.43%
Mixed Wetland Hardwoods	9061	4.44%
Woodland Pasture	5913	2.90%
Unimproved Pasture	5507	2.70%
Low Density Residential	3725	1.83%
Hardwood Conifer Mixed	3380	1.66%
Open Water	2166	1.06%
Barren Land	2084	1.02%
Undeveloped Urban Land	1913	0.94%
Cypress	1896	0.93%
Field Crops	1521	0.75%
Hardwoods	1499	0.73%
Dairies	825	0.40%
Commercial and Services	737	0.36%
Mining	724	0.35%
Row Crops	659	0.32%
Tree Nurseries	583	0.29%
Transportation Corridors	498	0.24%

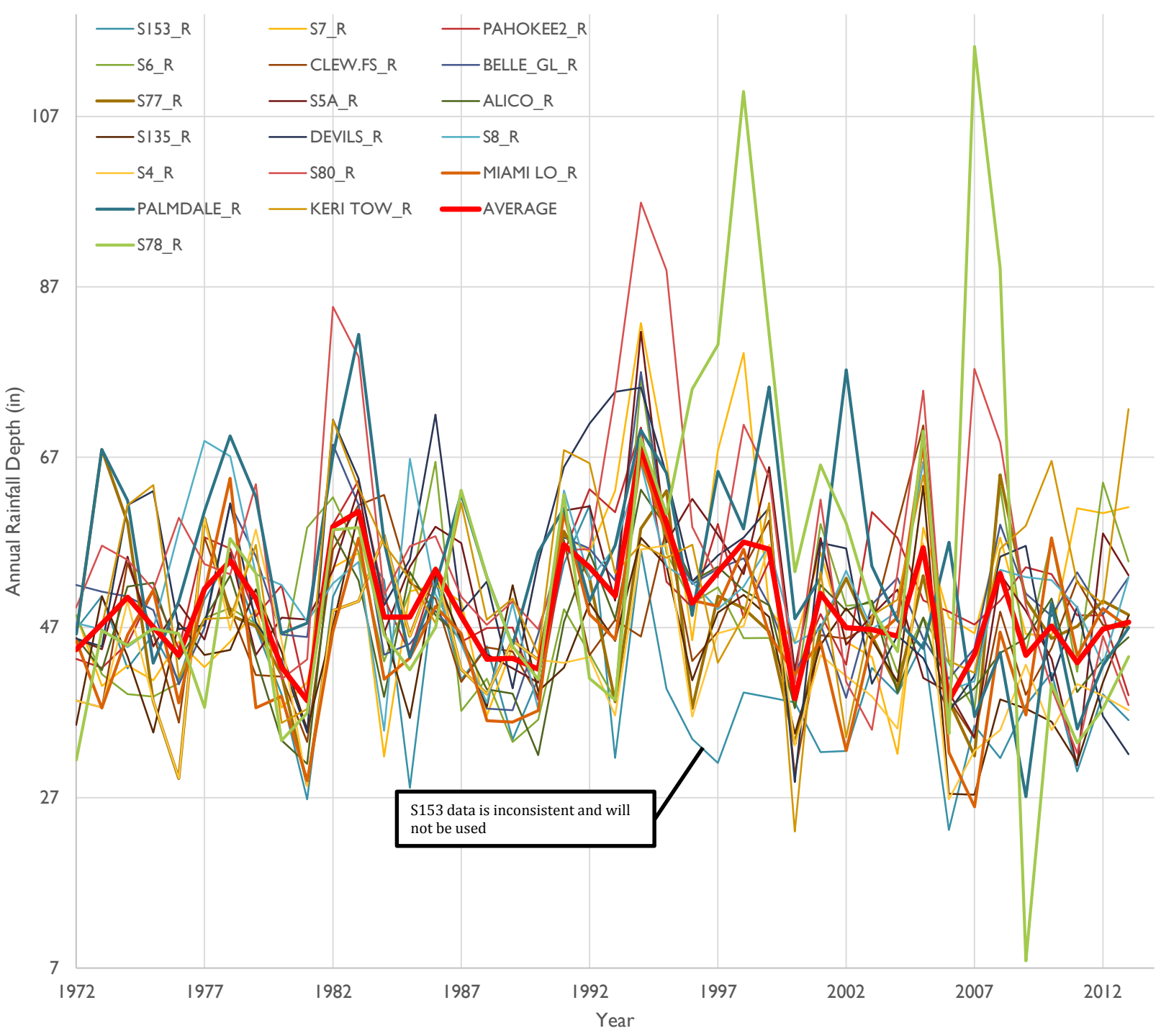
Soils


EAST LAKE OKEECHOBEE
WEST LAKE OKEECHOBEE
SOUTH LAKE OKEECHOBEE
Belle Glade
Expanded WAM Domain
SUB-WATERSHEDS
SOILS
ADAMSVILLE
ADAMSVILLE VARIANT
ANCLOTE
AQUENTS
ARENTS
ASTOR
BASINGER
BOCA
CANOVA
CHOBEE
DANIA
DELRAY
DENAUD
DUETTE
EAUGALLIE
FELDA
FLORIDANA
FT. DRUM
GATOR
GENTRY
HALLANDALE
HOBE
HOLOPAW
HONTOON
IMMOKALEE
JONATHAN
JUPITER
KESSON
LAUDERHILL
LAWNWOOD
MALABAR
MARGATE
MYAKKA
NETTLES
OKEECHOBEE
OKEELANTA
OLDSMAR
PAHOKEE
PAOLA
PINEDA
PINELLAS
PITS
PLACID
PLANTATION
POMELLO
POMPANO
POPLE
QUARTZIPSAMMENTS
RIVIERA
SALERNO
SAMSULA
SANIBEL
SMYRNA
TEQUESTA
TERRA CEIA
TORRY
TUSCAWILLA
UDIFLUVENTS
UDORTHENTS
URBAN LAND
VALKARIA
WABASSO
WATER
WAVELAND
WINDER
WULFERT
0 2.25 4.5 Miles
N

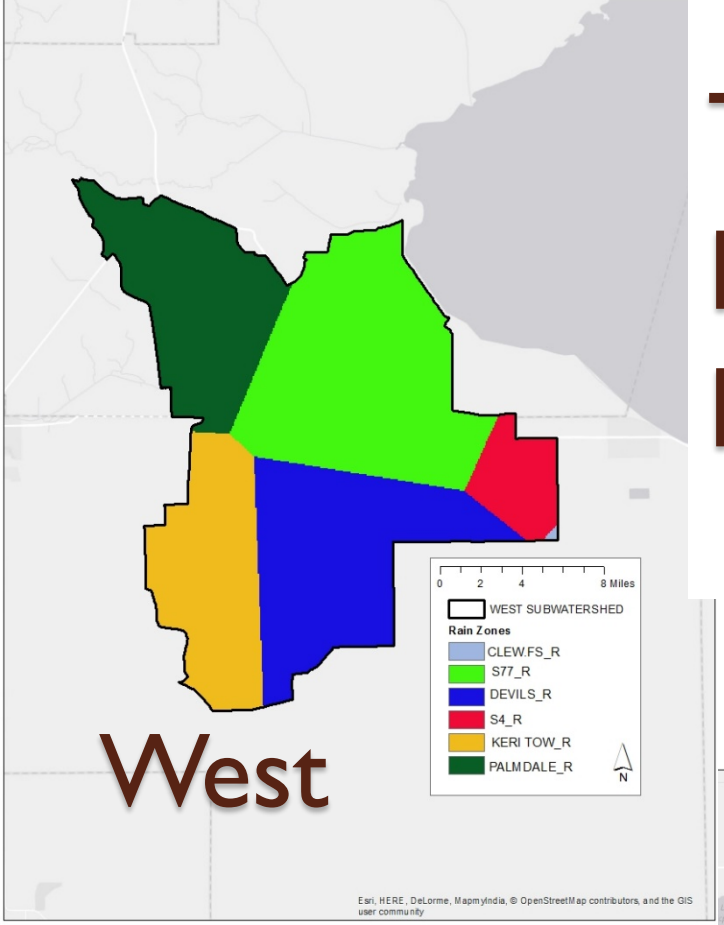

Rain Stations
INDIAN PRAIRIE
FISHEATING CREEK
S135_R
S80_R
S153_R
EAST LAKE
OKEECHOBEE
PALMDALE_R
S77_R
S78_R
S4_R
PAHOKEE2_R
WEST LAKE
OKEECHOBEE
CLEW.FS_R
MIAMI LO_R
Belle
Glade
S5A_R
BELLE_GL_R
SOUTH LAKE
OKEECHOBEE
KERI TOW_R
DEVILS_R
ALICO_R
S6_R
Expanded WAM Domain
S8_R
S7_R
AHED -HYDROEDGE
Local
Primary
Secondary
Tertiary
Rainfall Monitoring
Data Location
N
0
4
8 Miles
Esri, HERE, DeLorme, MapmyIndia, © OpenStreetMap contributors, and the GIS user community

Verifying Raindata

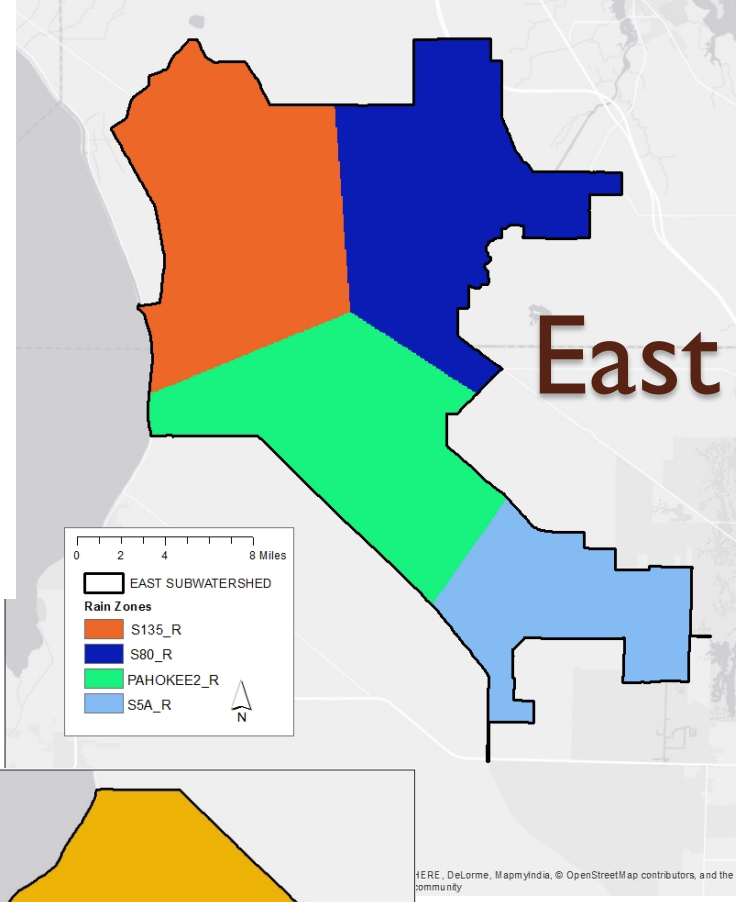
	Station																	
Year	S153_R	S7_R	PAHOKEE2_R	S6_R	CLEW.FS_R	BELLE_GL_R	S77_R	S78_R	S5A_R	ALICO_R	S135_R	DEVILS_R	S8_R	S4_R	S80_R	MIAMI LO_R	PALMDALE_R	KERI TOW_R
1972	46.8	48.5	43.3	48.5	38.4	52	46.3	31.4	45.7	45.8	35.6	45.7	47.5	38.4	49.4	45.4	46.3	44.6
1973	50.7	40.1	42.3	41.5	37.6	51.2	67.9	46.6	44.4	42	50.7	44.8	46.8	37.6	56.6	37.5	67.9	47.1
1974	42.2	42.5	45.1	39.2	54.6	50.6	59.3	44.9	55.3	51.8	43.6	61.4	44.7	50.1	54.9	46.1	61.9	61.4
1975	46.2	40.8	51.3	38.9	46.3	49	38.3	46.9	44.8	52.3	34.7	63	46.9	38.3	51.4	51.4	42.8	63.7
1976	40.8	45.4	44.5	40.5	35.8	40.3	29.3	46.3	49.7	43.3	47.6	46.8	58.4	29.3	59.9	38.1	50.1	41.1
1977	50.3	42.4	57.6	48.1	57.6	46.9	59.8	37.6	45.6	48	43.8	47.3	68.9	59.8	54.5	51.2	60.7	48
1978	55.3	45.3	56.3	49.3	49.1	61.5	48.5	57.4	55.8	53.1	44.4	61.6	67.1	46.7	53.2	64.5	69.5	48.2
1979	47	49.1	48.3	47.4	41.4	55.4	47.1	53.3	43.8	43.5	51.5	47.6	53.3	58.5	63.8	37.6	62.3	56.7
1980	39.1	37.6	51.9	42.7	41.2	46.2	41.4	33.7	48.1	33.7	44.1	43.2	52	45.5	40.9	38.9	46.3	35.8
1981	26.8	40.6	38.5	58.7	33.6	45.9	28.5	37	47.9	31	35	34.7	47.7	28.4	43.3	29	47.5	37.4
1982	50.6	54	59.1	62.3	56.2	68.5	49	58.5	53.7	58.1	47.1	71.4	52.2	49	84.6	46.5	67.1	71.4
1983	56.9	55.8	64.3	55.9	61.4	61.4	50.1	58.7	63.3	52.5	60.5	64.5	54.7	50.1	78.8	57.5	81.4	63.4
1984	52.6	31.9	50.5	43	62.6	43.8	57.8	46.1	46.4	38.9	46.7	49.6	34.9	57.8	50.8	40.9	57	56.8
1985	28.2	51.2	44	51.2	52.3	45.1	46	42	54.1	53.5	36.4	55	66.8	46	56.5	43.4	43.5	52.7
1986	52.7	52	53.5	66.4	50.4	49	54	47	58.8	48.5	53	72	50.9	54	57.7	49.5	51.9	47.5
1987	40.9	50	45.3	37.2	40.6	45.5	42.1	63.1	56.9	45.7	45.6	48.8	45	42.1	50.6	46.3	62.7	61.6
1988	44.8	36.6	46.9	41	44.7	37.5	39.2	52.9	43.8	39.7	37.7	52.4	38.1	39.2	47.3	36	52.9	47.9
1989	33.9	44.8	47	33.5	44.2	37.3	45.5	44.8	42.2	39.2	52	39.9	49.9	45.5	50.1	35.9	44.9	50.4
1990	41	42	38.5	36.2	38.9	46.2	43.2	40.9	40.5	32	39.5	54.6	37.4	43.2	46.8	37.2	55.9	43.9
1991	54.5	57.8	55.8	49.1	57.2	57.6	58.3	62.6	60.7	47.7	42.3	65.9	63.1	42.9	56.1	60.5	61	67.8
1992	61.3	55.9	63.2	43.9	43.8	56.3	52.8	41	61.2	55.8	49.9	71	52.6	43.5	56.2	48.6	50.1	66.3
1993	31.7	63.1	60.5	38.6	47.9	52.5	38.3	38.5	50.1	48	45.4	74.7	56.5	36.7	74.5	45.6	56.7	53.4
1994	56.1	82.8	70.5	76.2	45.9	77	58.6	69.2	81.7	63.2	57.5	75.2	66.2	56.2	96.9	66.9	70.2	56.8
1995	39.8	66.6	52.4	55.8	58.6	57.9	63.1	60.3	57	58.7	54.2	64.9	54.2	56.6	88.9	57.8	65.1	55.2
1996	33.9	45.5	49.4	49.9	43.1	52.1	37.5	75	62.1	52.4	40.8	52.4	52.3	36.5	58.8	50.2	48.4	56.7
1997	31.1	67.7	59.1	51.7	46.5	53.9	50.7	80.2	57.9	54.1	48.7	55.4	49.1	46.3	52.8	49.5	65.3	42.8
1998	39.4	79.2	48.1	45.8	54	55.1	49.3	110	53.3	51.3	50.8	57.6	51.8	47.2	70.8	56.2	58.6	48.3
1999	38.8	49.2	54.8	45.8	59.6	49.6	46.5	81.5	65.8	49.6	48.2	61	56.6	56.7	64.6	46.2	75.2	61.6
2000	38.2	45.2	41.3	38.3	29.7	41.7	33.3	53.5	42	37.5	34.5	28.9	45.2	33.2	40.5	41.5	48	23.1
2001	32.4	55.8	48.6	59.1	46.1	47.4	46.8	66.1	57.5	52	44.9	56.9	46.9	43.8	62	45.3	52.8	53.5
2002	32.5	45.3	42.6	49.5	45.7	38.7	52.8	59.2	45	49	49.3	56.3	53.7	41.3	40.6	32.5	77.2	34.1
2003	42.3	43.5	60.6	49.9	47.4	49.7	46	49.2	48.4	50.2	45.5	40.4	46.8	38.9	35	45.5	54.2	48.4
2004	39.2	32.2	57.5	41.7	59.1	52.8	39.9	44.2	51.4	39.3	40.6	46.1	48.9	35.1	53.5	48.2	47.8	50.3
2005	45.3	58.7	50.2	48.2	70.7	45.7	53.1	70.1	41.1	48.2	63.6	43.4	66.5	56.9	74.8	68.7	44.5	64.9
2006	23.2	48.1	48.9	42.8	38.5	41	38.4	34.5	39.4	37.6	27.5	37.1	39.6	26.8	36.1	32.3	57	43.1
2007	35.5	46.3	47.4	37.4	34	44.5	31.9	115	34.1	39.8	27.4	41.3	40.7	32.5	77.4	25.9	36.6	41.7
2008	31.7	57.6	50.2	63.5	48.9	59.1	64.9	89.2	53.3	44	38.5	55.3	53.8	35	68.7	46.5	44.1	56.3
2009	37.9	46.2	54.1	44	39.1	51	50.2	7.86	49	45.7	37.5	56.6	52.9	42.6	49.6	36.7	27.1	58.9
2010	41.7	46	53.3	57.4	44.6	48.3	45.7	40.4	43.3	50.4	35.9	40.7	52.6	34.9	39.9	57.5	49.9	66.6
2011	30.1	61	48.4	41.8	52.5	53.5	47.1	33.4	30.8	39.4	31.1	49.5	49.4	40.4	32.3	43.7	35.1	52.3
2012	39.2	60.4	48.4	64	47.3	48.5	50.1	37.4	58.1	43.2	40.6	36.6	42.6	39	46	49.2	42.5	49.8
2013	36.1	61.1	39	54.7	47	52.9	48.5	43.6	53.1	45.9	48.4	32.1	52.9	37.3	37.9	47	47	72.7


S153_R
S7_R
PAHOKEE2_R
S6_R
CLEW.FS_R
BELLE_GL_R
S77_R
S5A_R
ALICO_R
S135_R
DEVILS_R
S8_R
S4_R
S80_R
MIAMI LO_R
PALMDALE_R
KERI TOW_R
AVERAGE
S78_R
Annual Rainfall Depth (in)
107
87
67
47
27
7
1972
1977
1982
1987
1992
1997
2002
2007
2012
Year
S153 data is inconsistent and will not be used

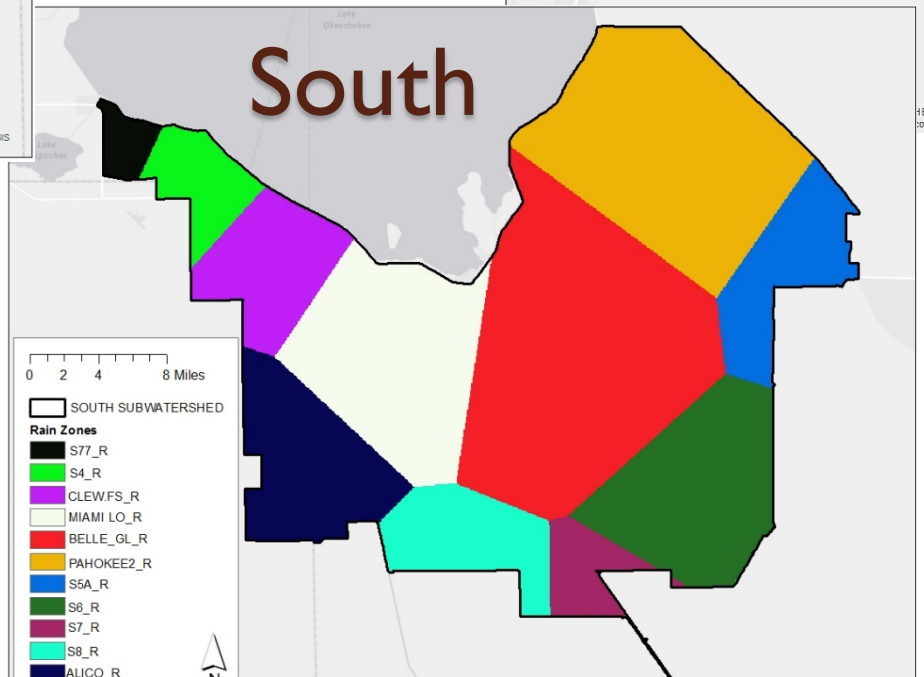
Thiessen Rainfall Rainzones



West

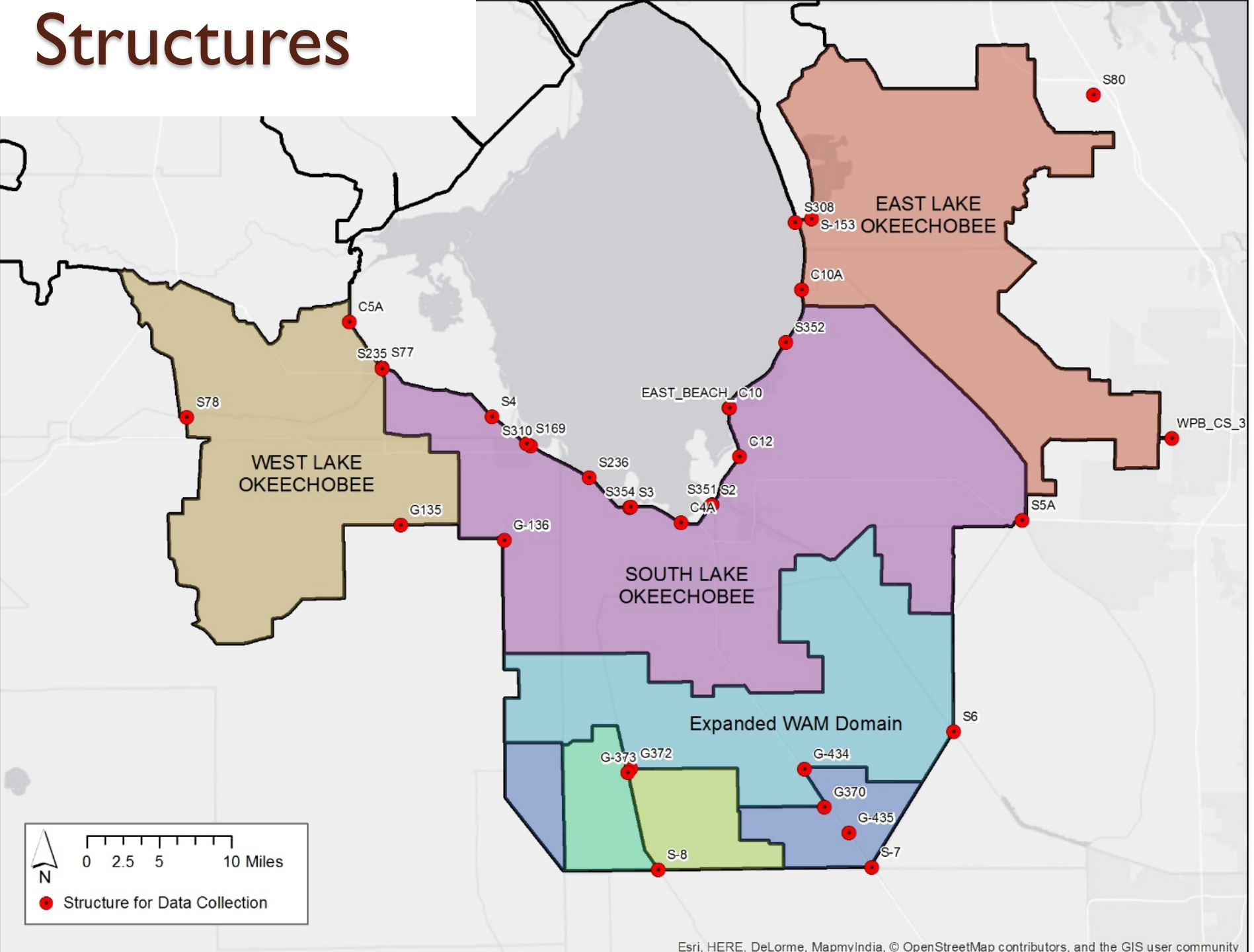


East



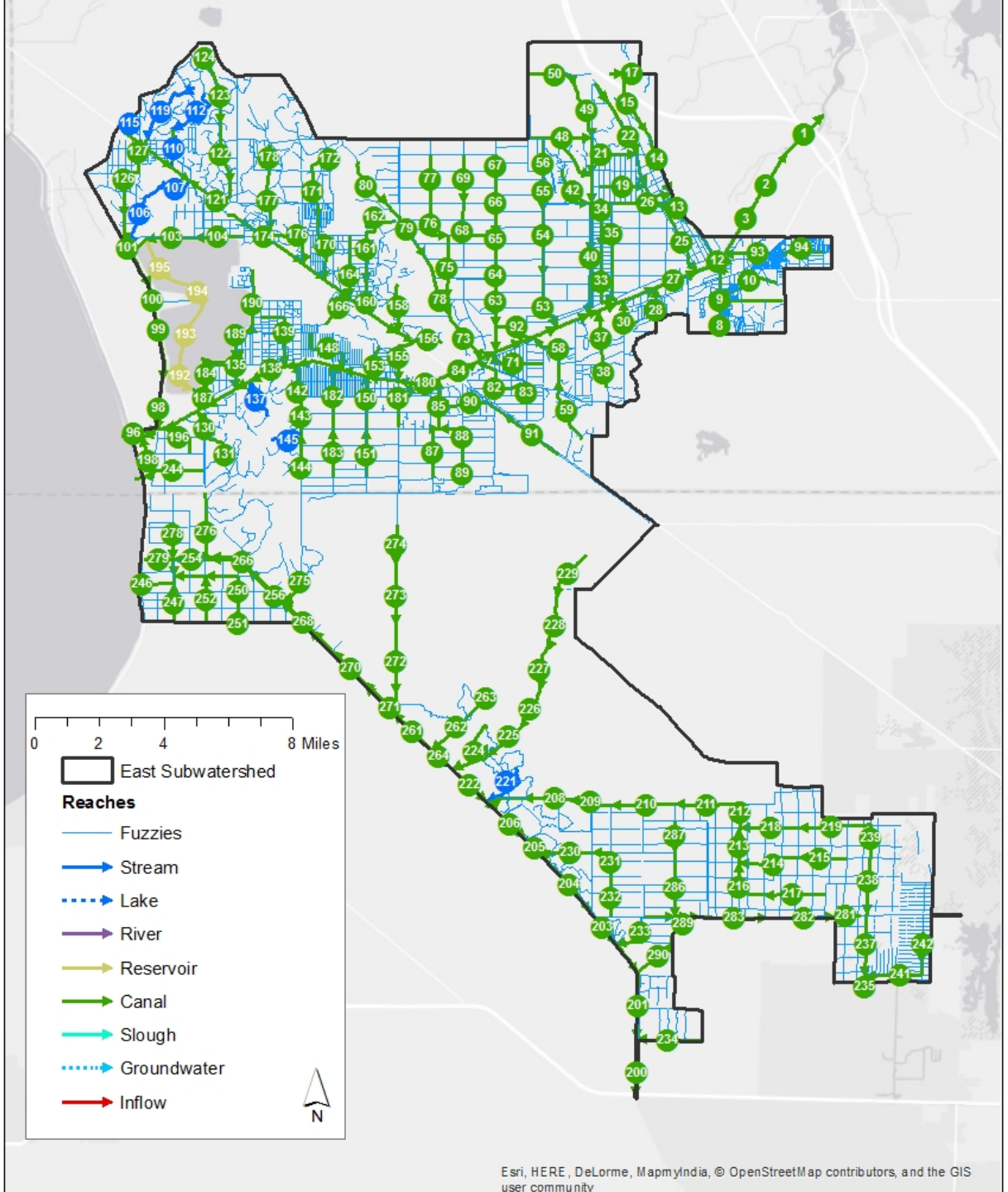
South

Structures


S80
EAST LAKE OKEECHOBEE
S308
S-153
C10A
C5A
S352
S235
S77
S78
S4
EAST_BEACH_C10
WPB_CS_3
S310
S169
C12
WEST LAKE OKEECHOBEE
S236
S354
S3
S351
S2
C4A
S5A
G135
G-136
SOUTH LAKE OKEECHOBEE
Expanded WAM Domain
S6
G-373
G372
G-434
G370
G-435
S-8
S-7
0 2.5 5 10 Miles
N
Structure for Data Collection
Esri, HERE, DeLorme, MapmyIndia, © OpenStreetMap contributors, and the GIS user community

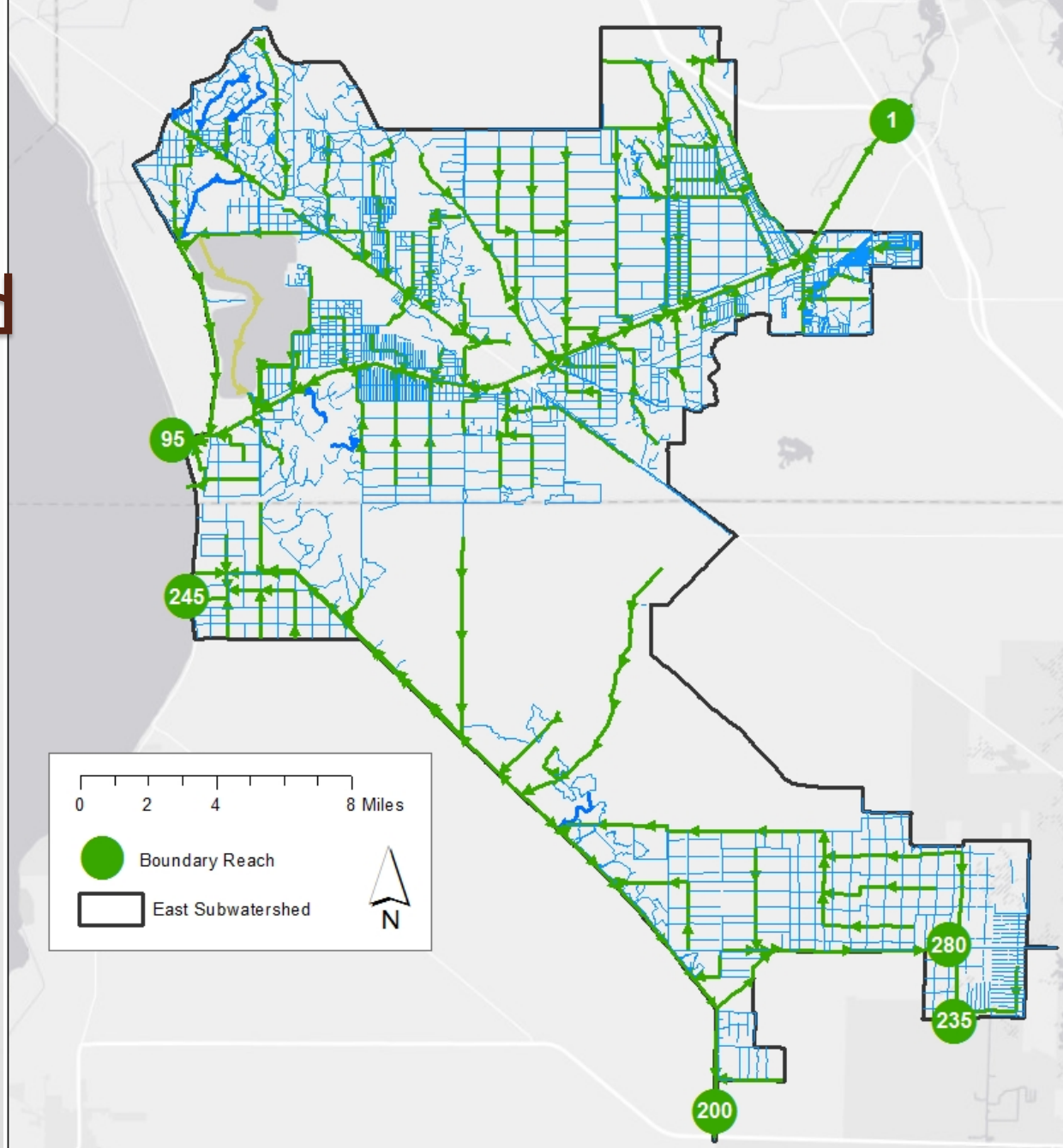
East Okeechobee Sub-Watershed

Calculation Reaches



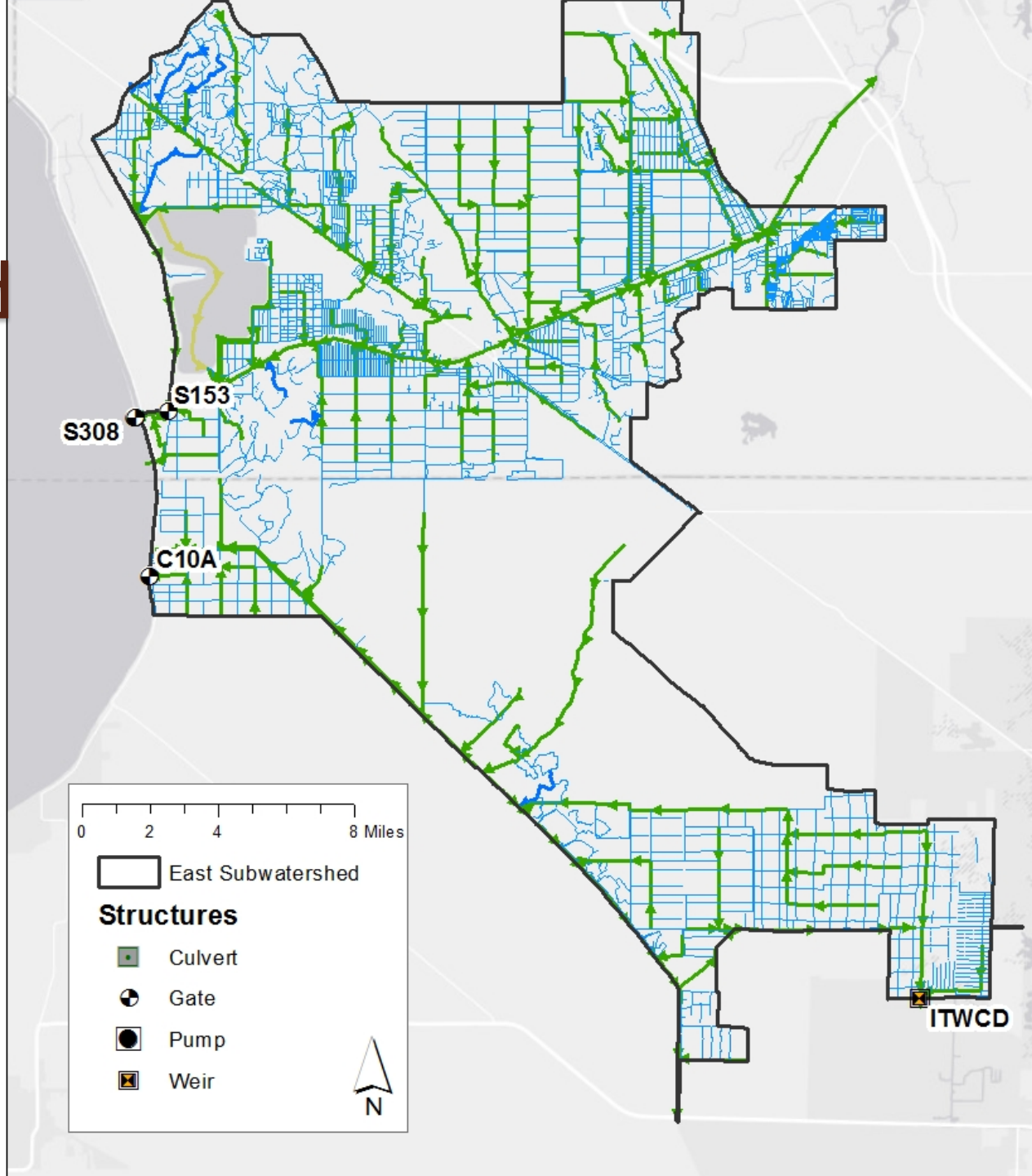
East Okeechobee Sub-Watershed

Boundary Reaches

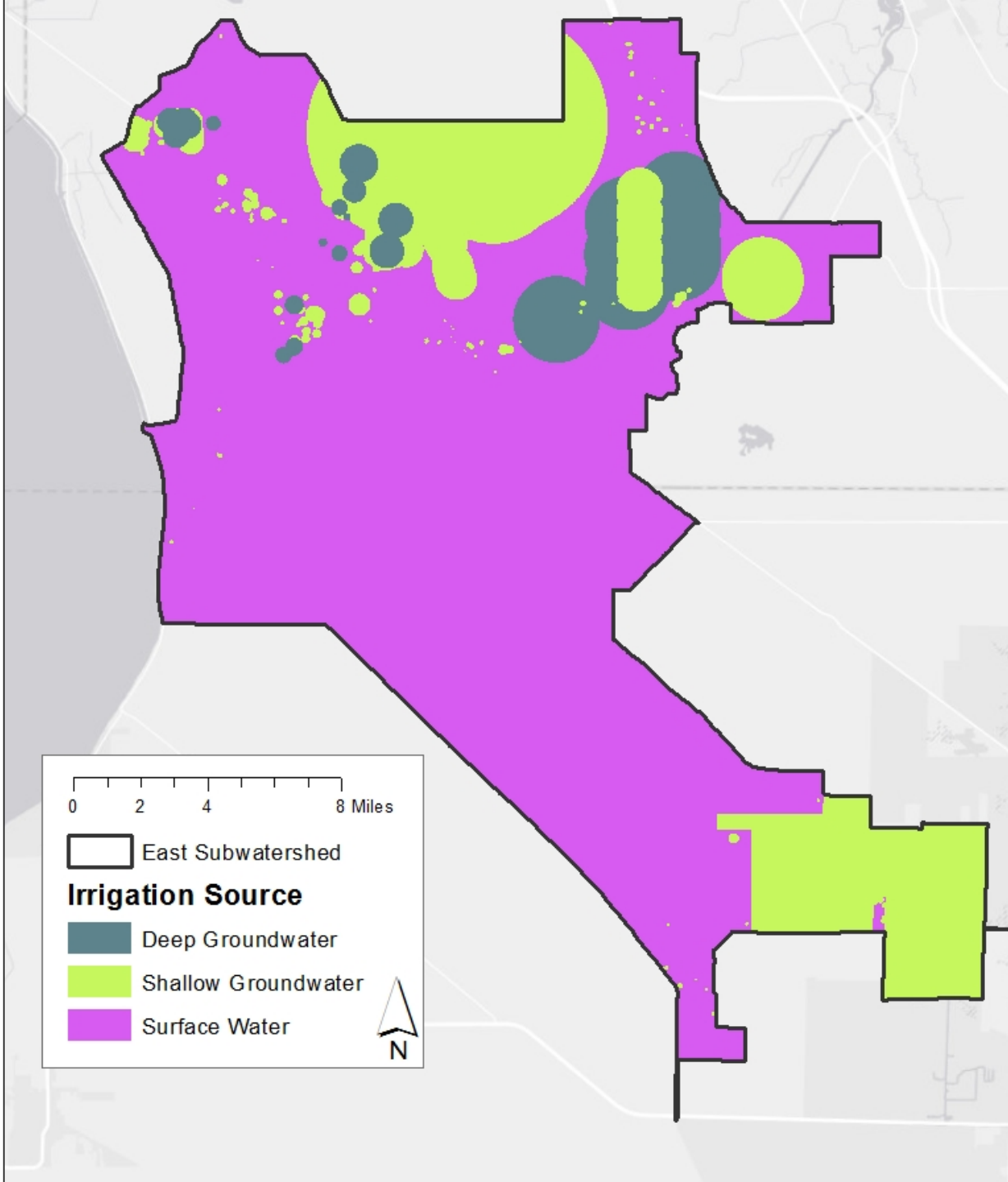


East Okeechobee Sub-Watershed

Simulated Structures

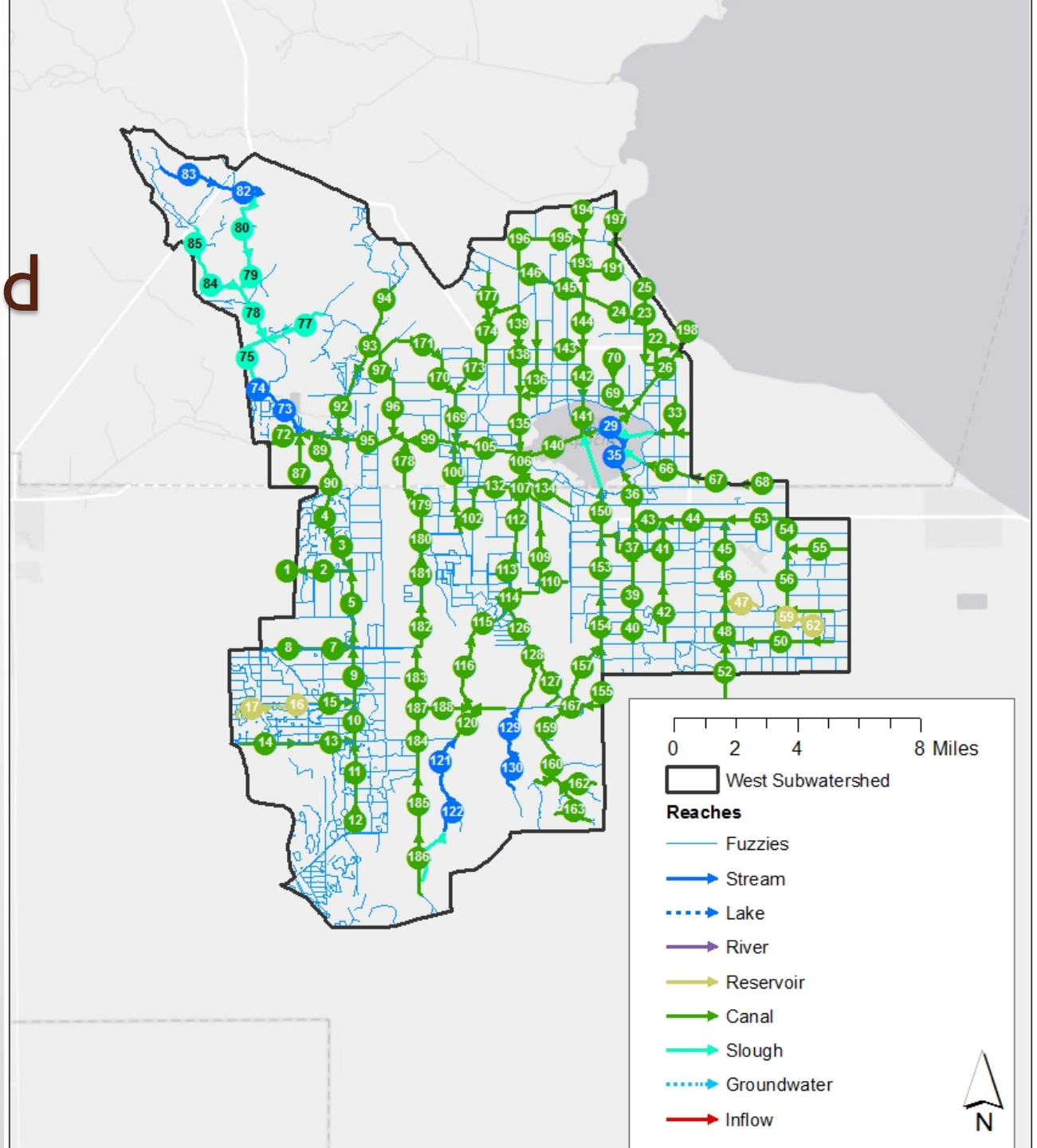


Irrigation Source



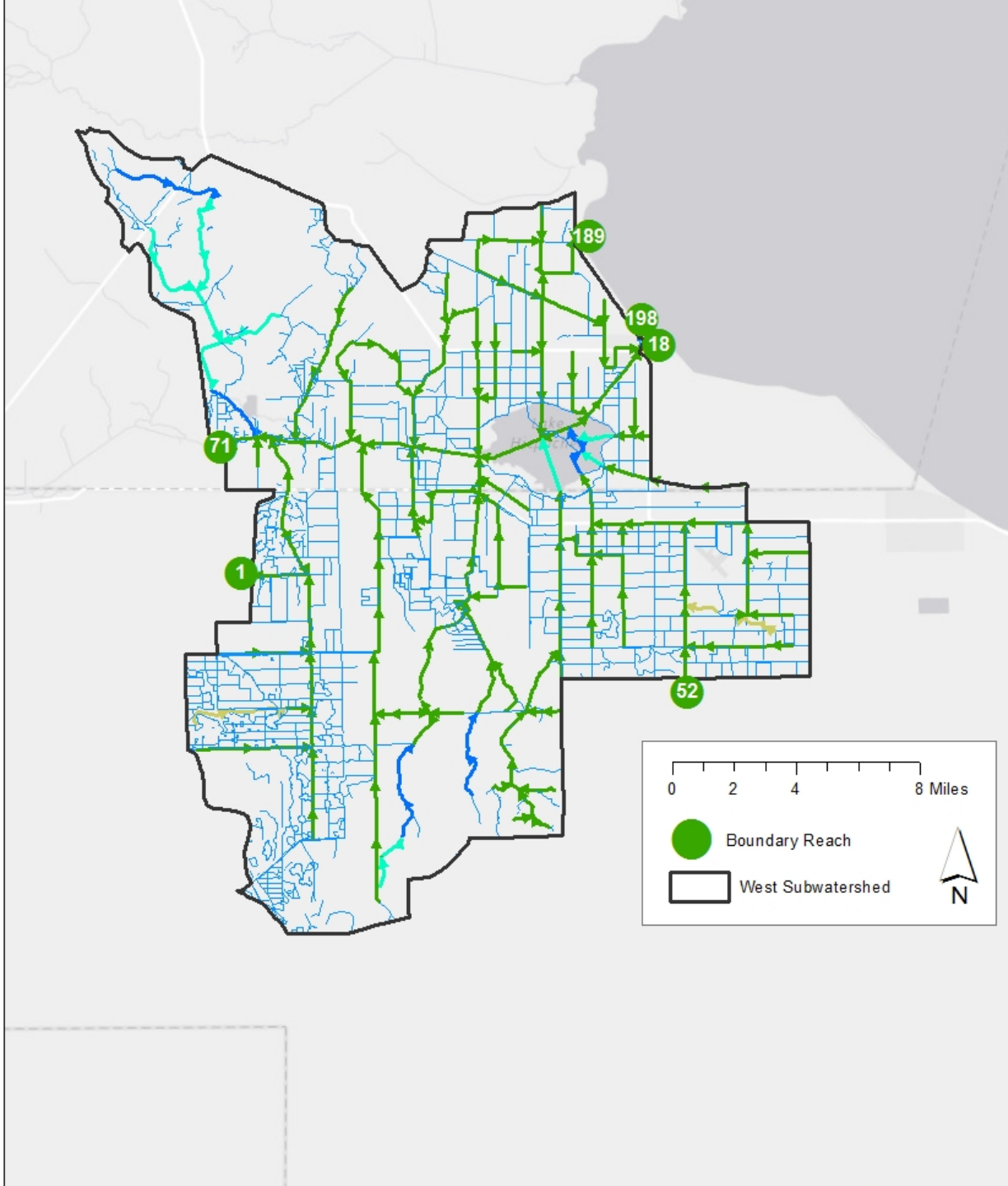
West Okeechobee Sub-Watershed

Calculation Reaches



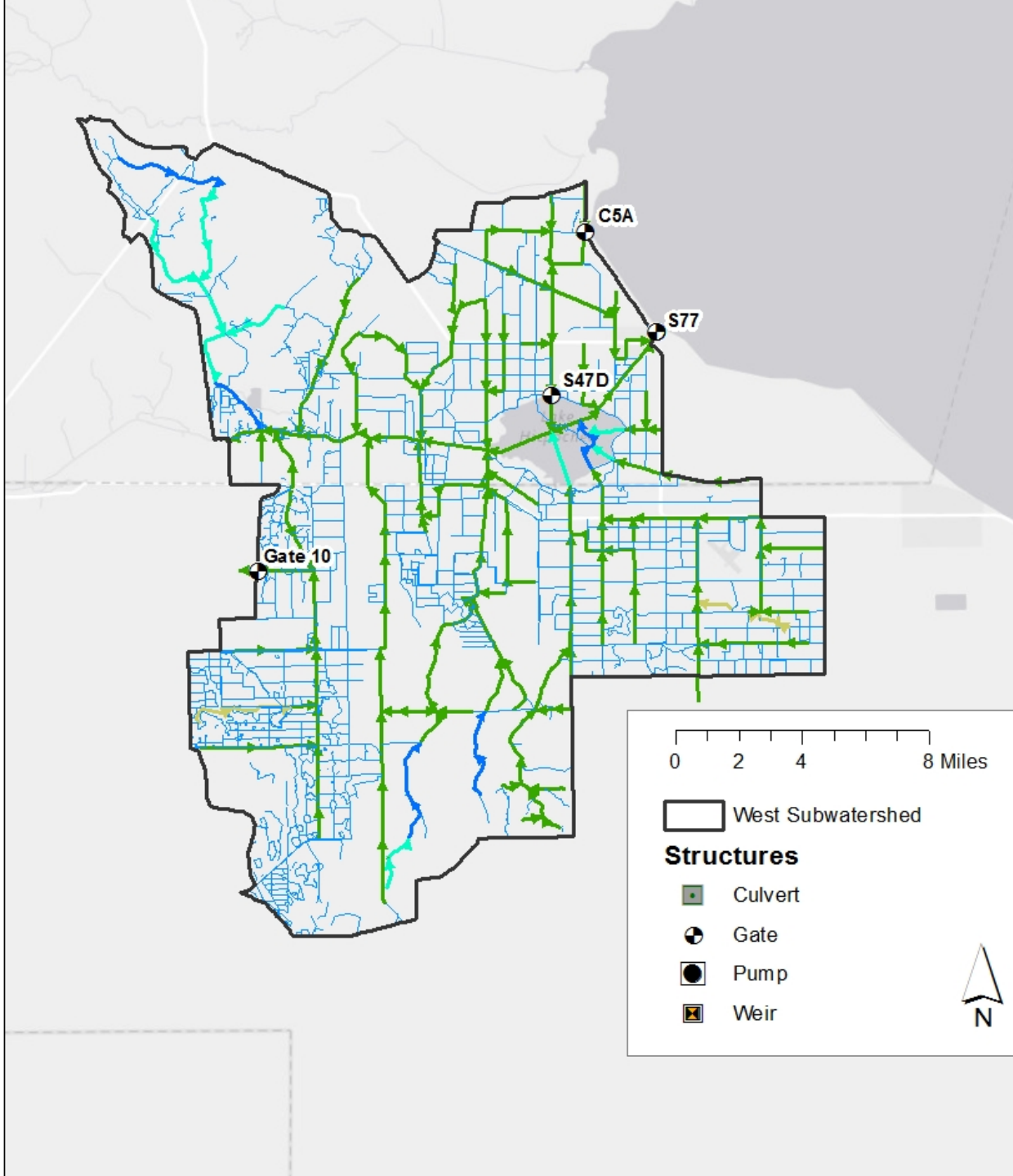
West Okeechobee Sub-Watershed

Boundary Reaches

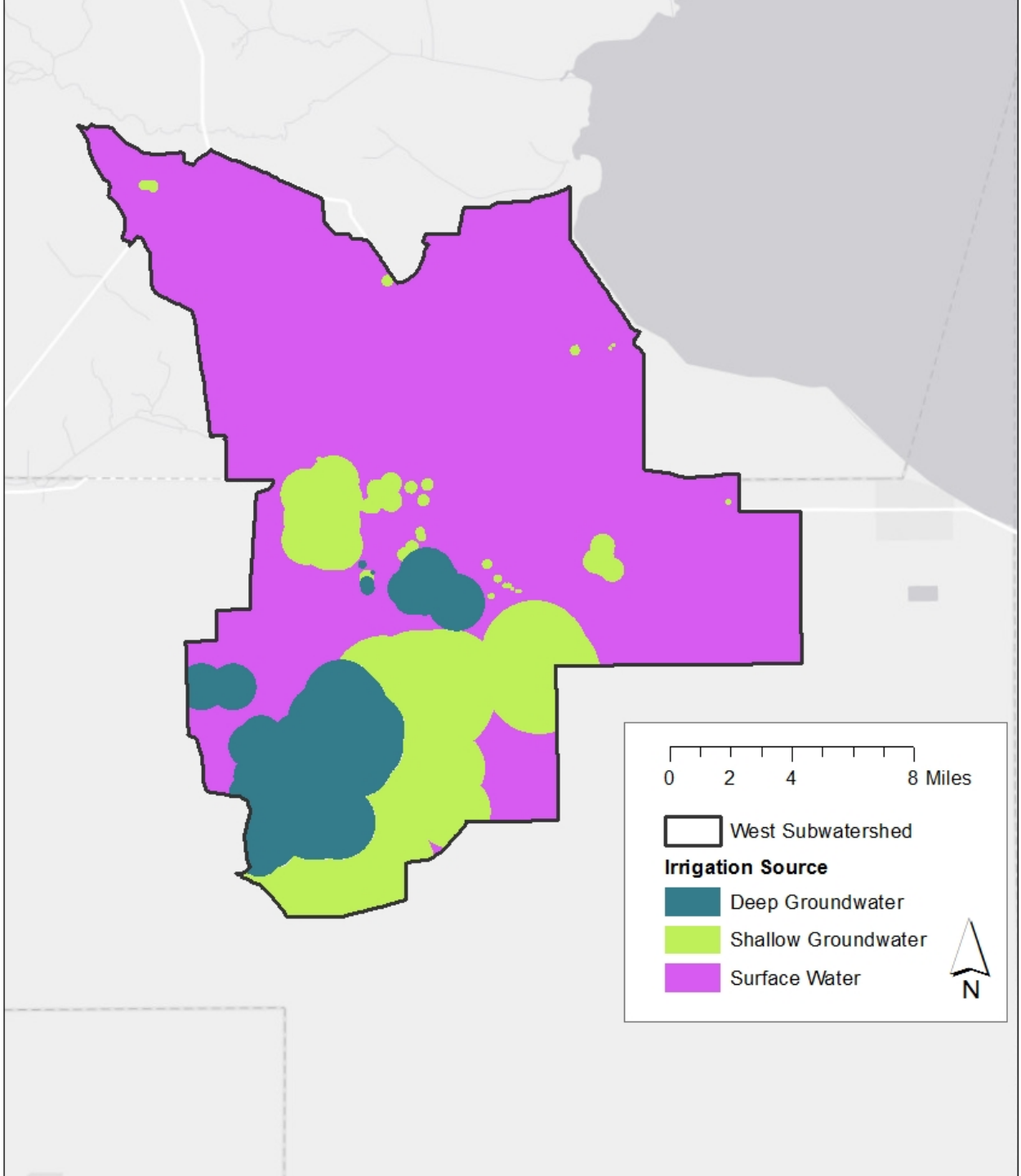


West Okeechobee Sub-Watershed

Simulated Structures

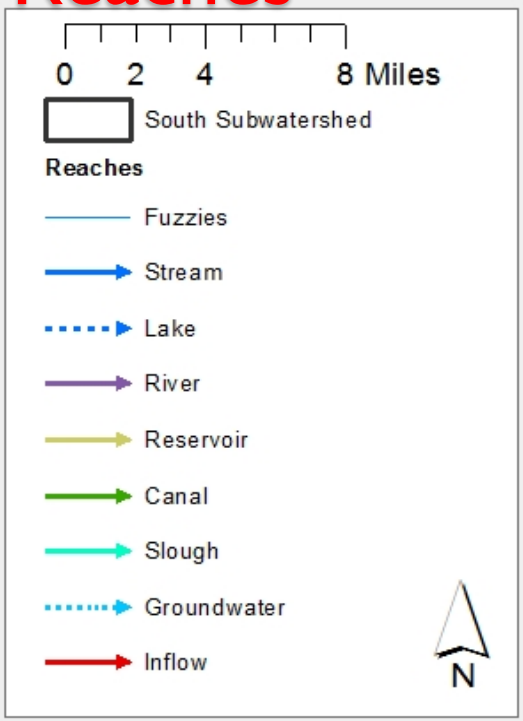


Irrigation Source



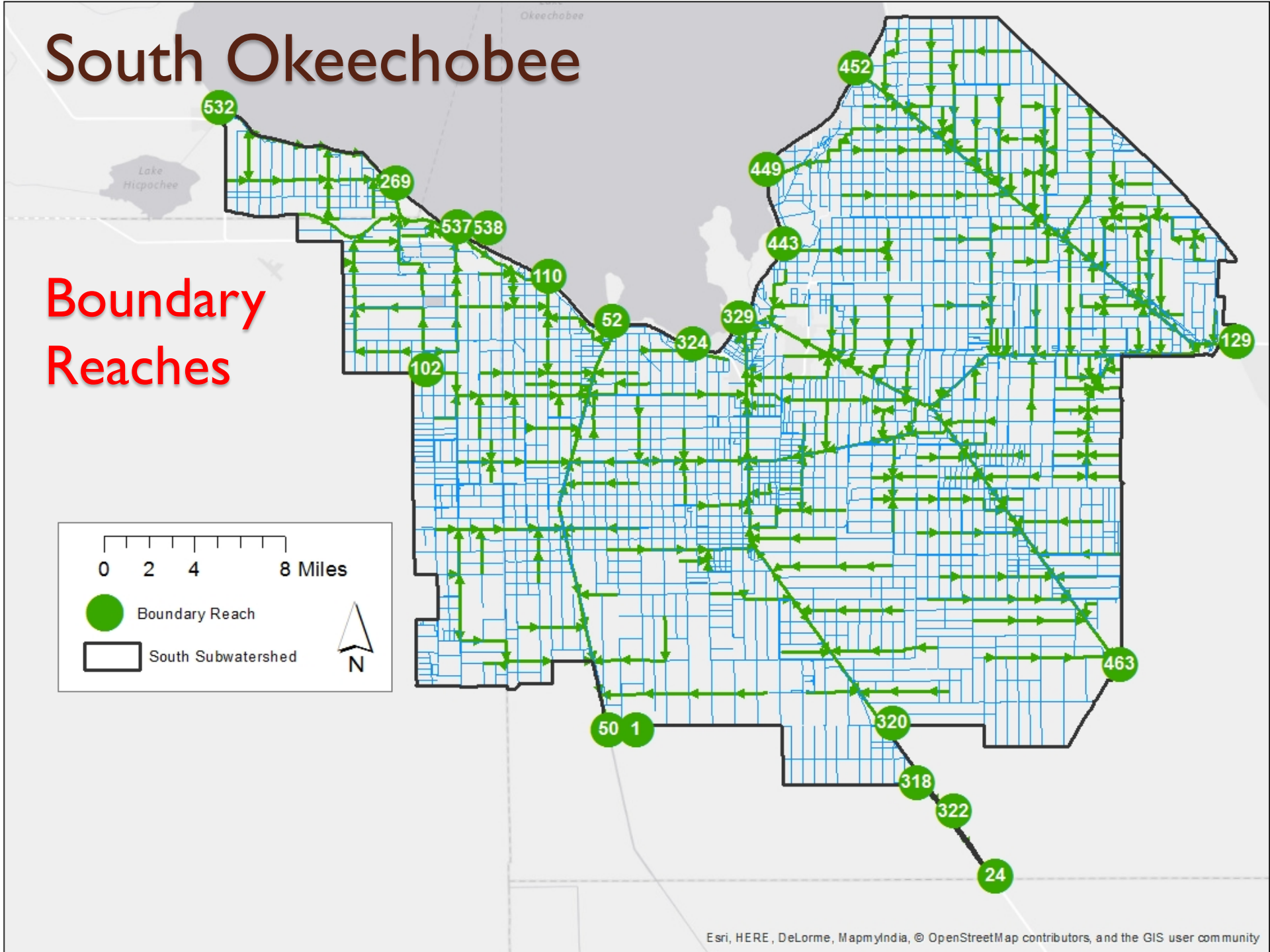
South Okeechobee

Calculation Reaches

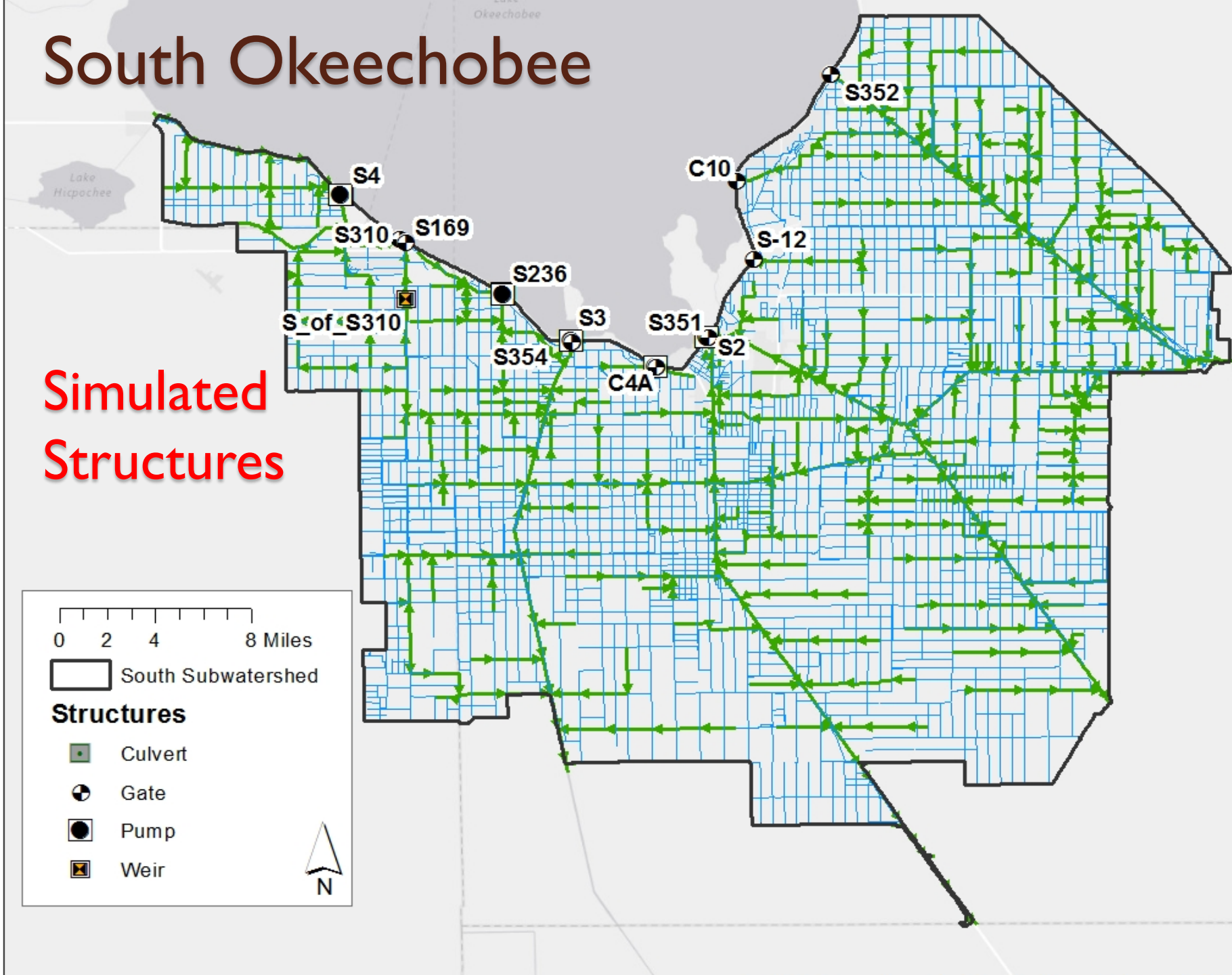


South Okeechobee

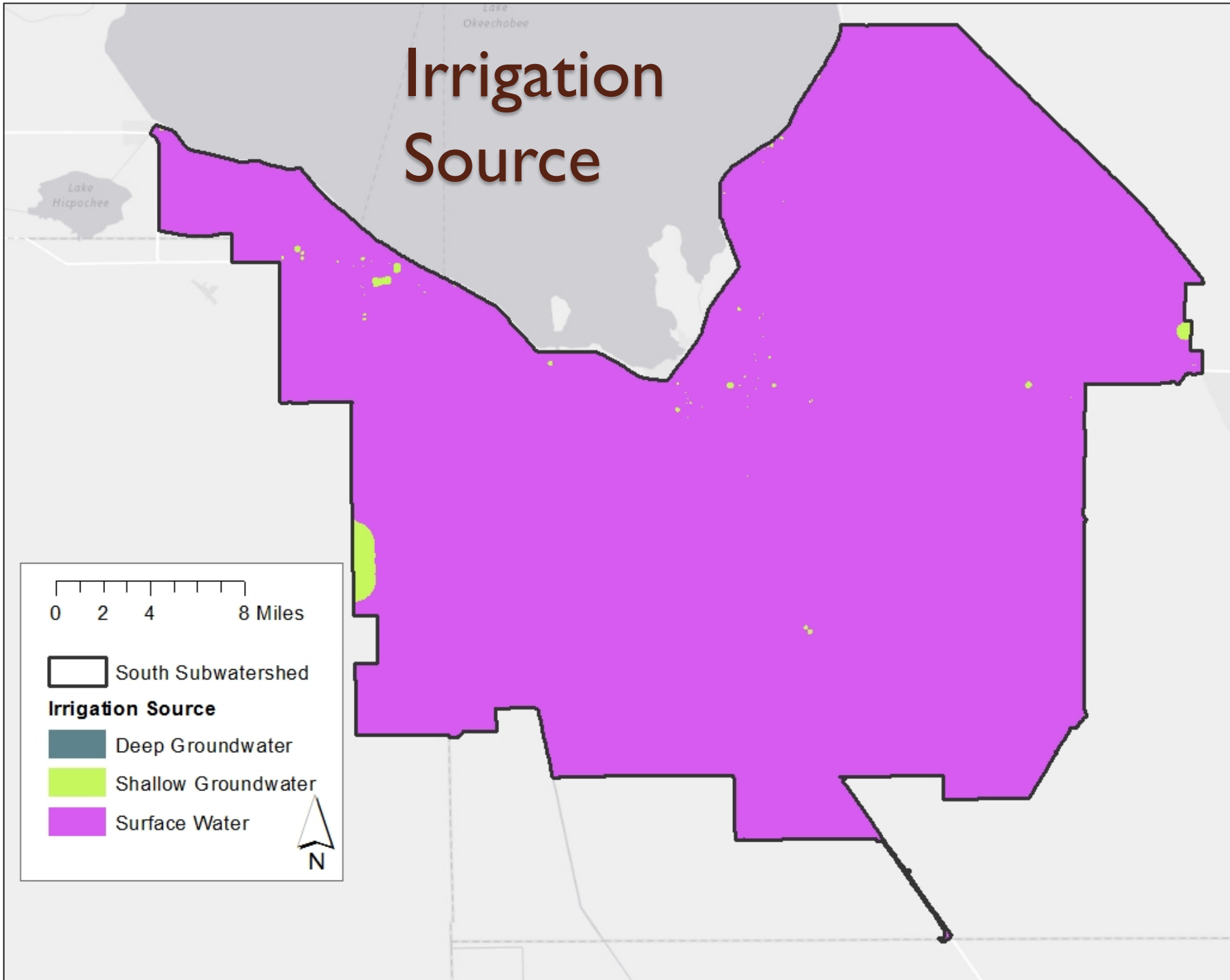
Boundary Reaches



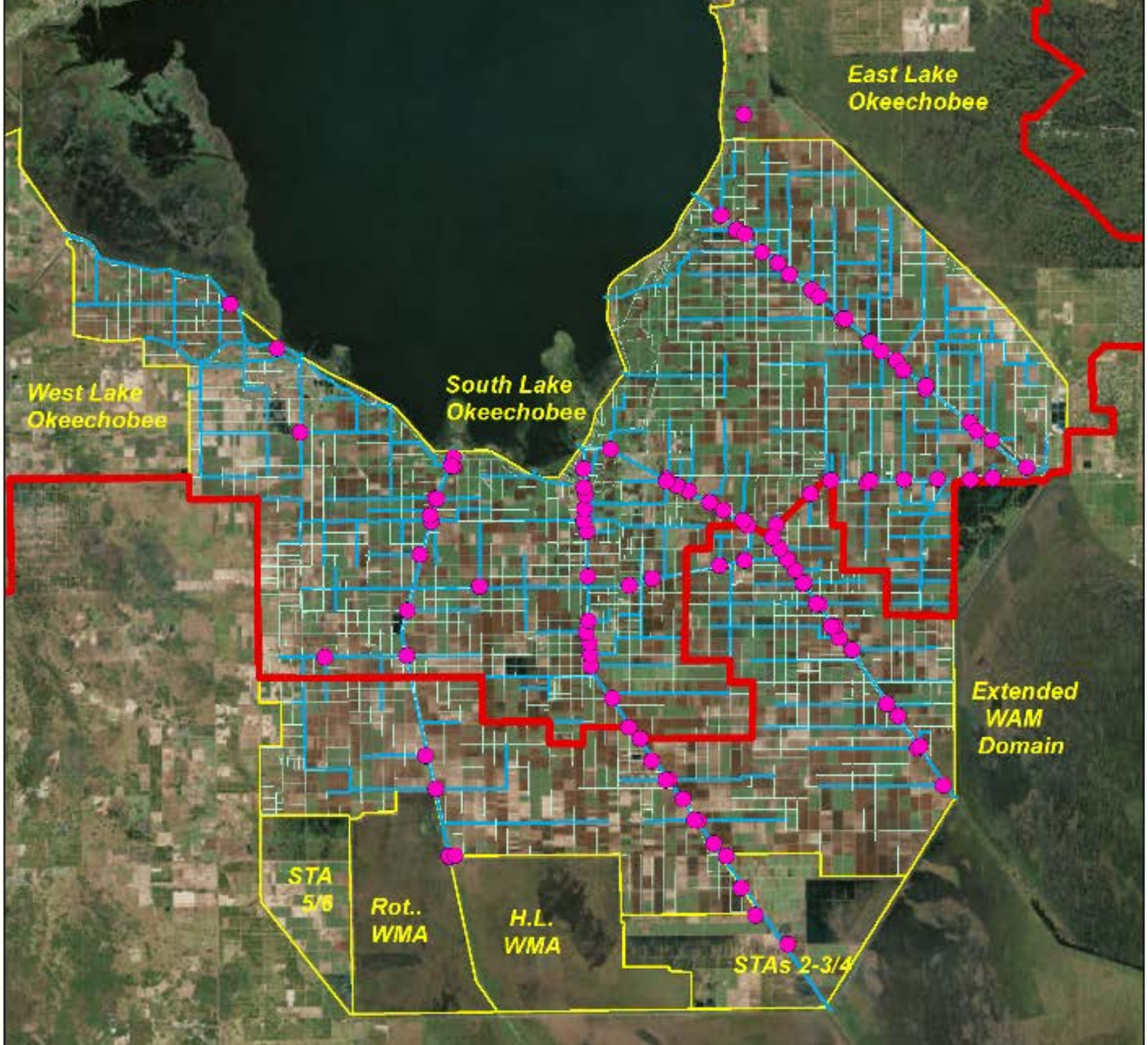
South Okeechobee



Irrigation Source

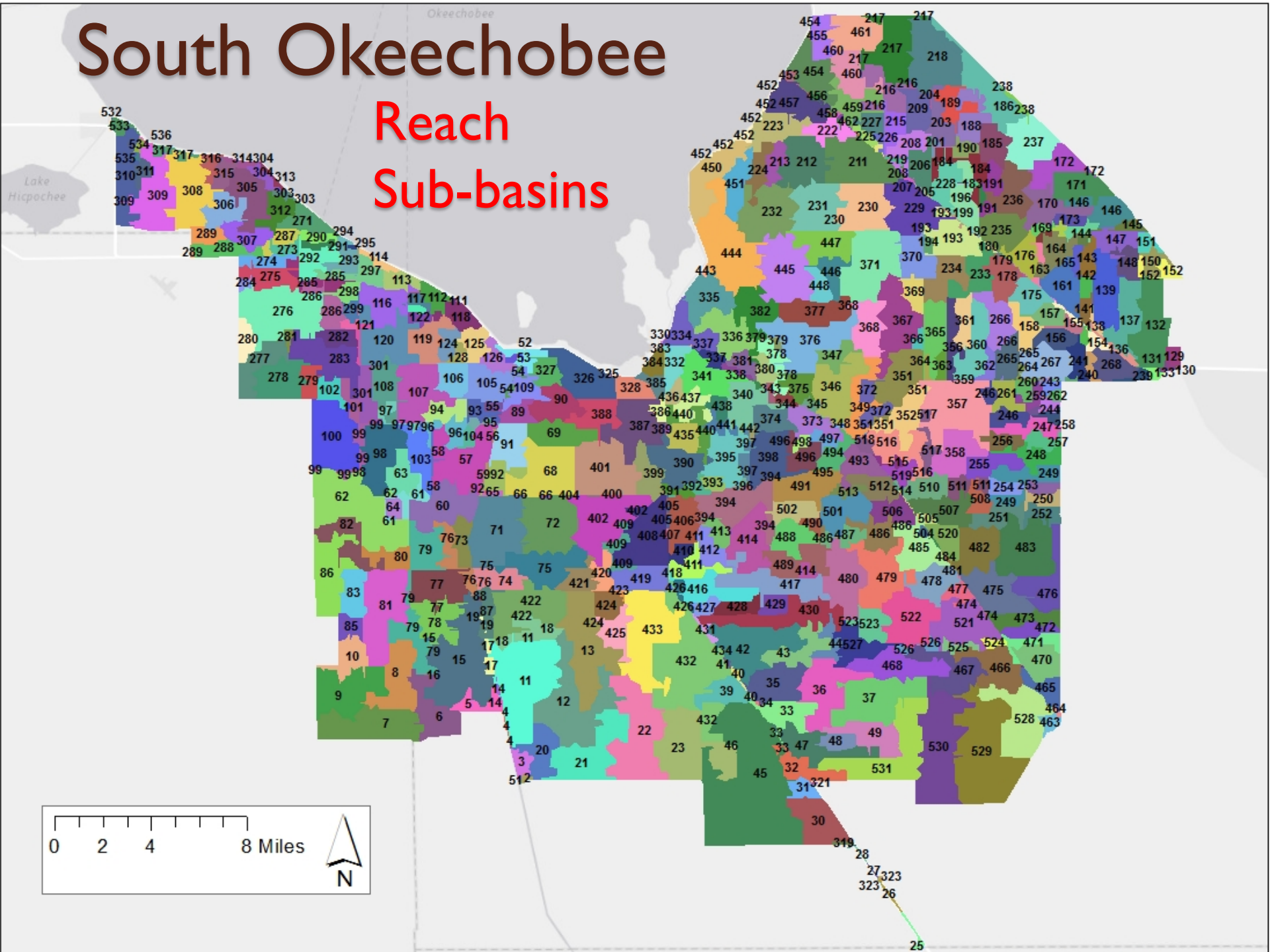


Farm Pumps

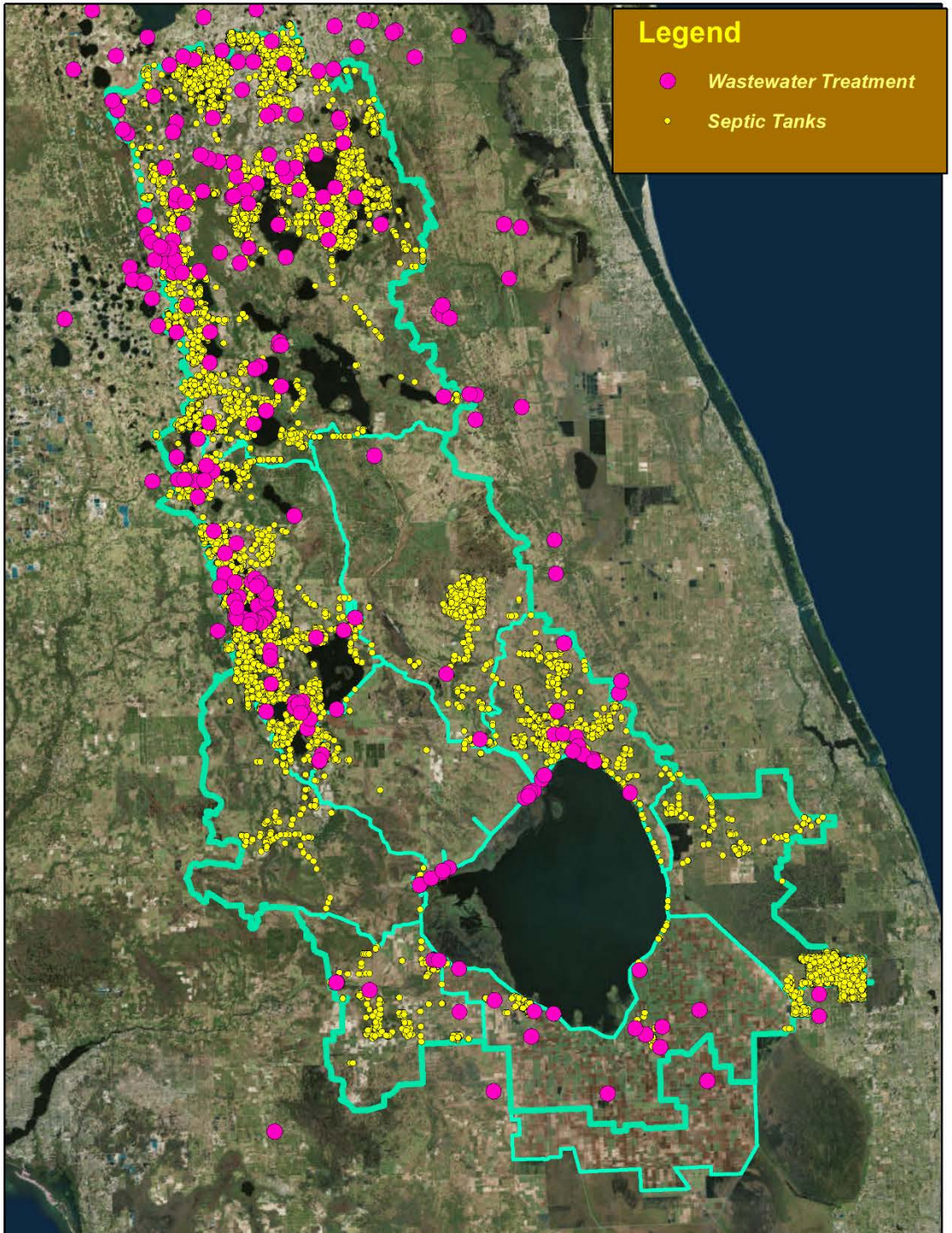

East Lake Okeechobee
West Lake Okeechobee
South Lake Okeechobee
Extended WAM Domain
STA 5/6
Rot.. WMA
H.L. WMA
STAs 2-3/4

South Okeechobee

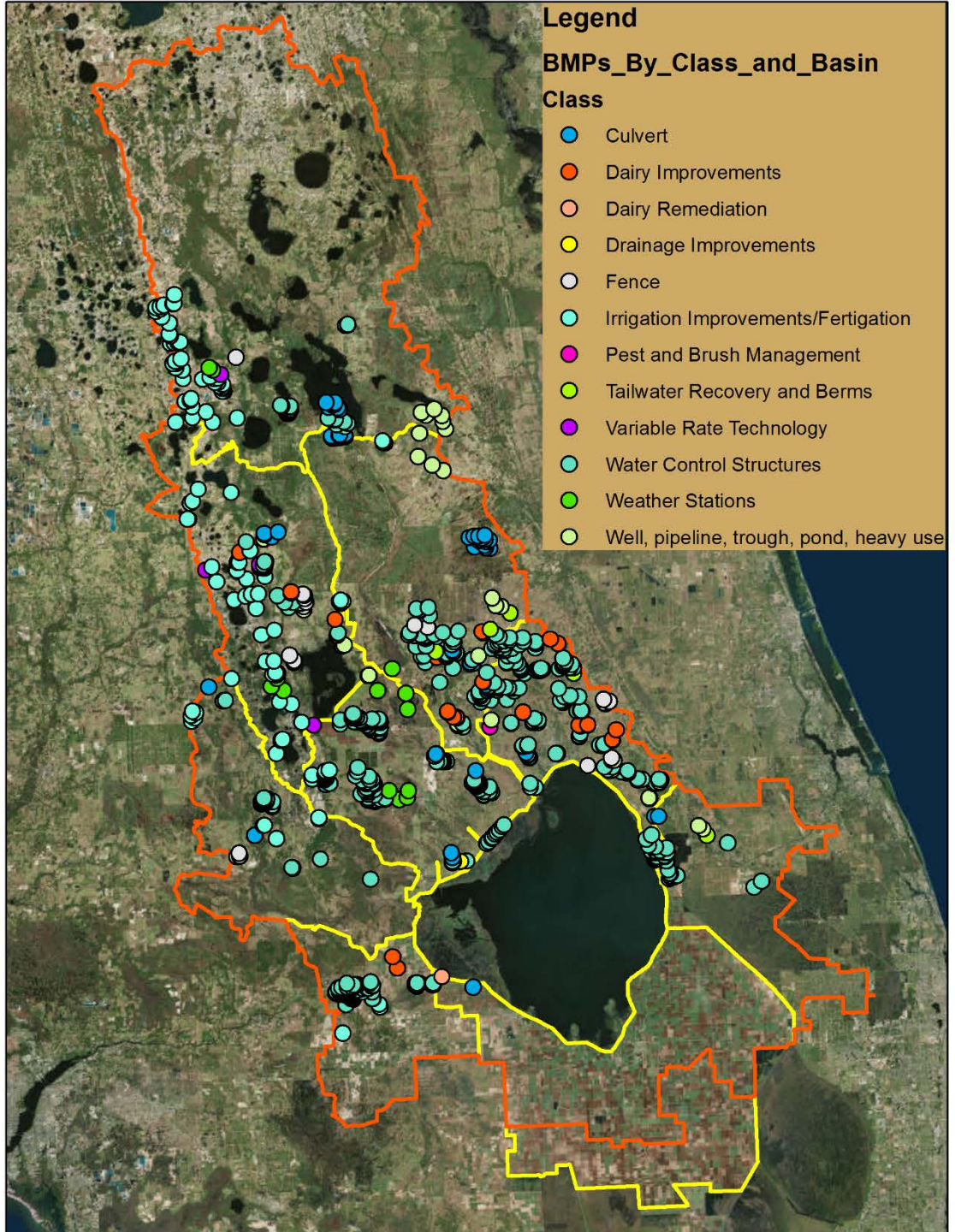
Reach Sub-basins



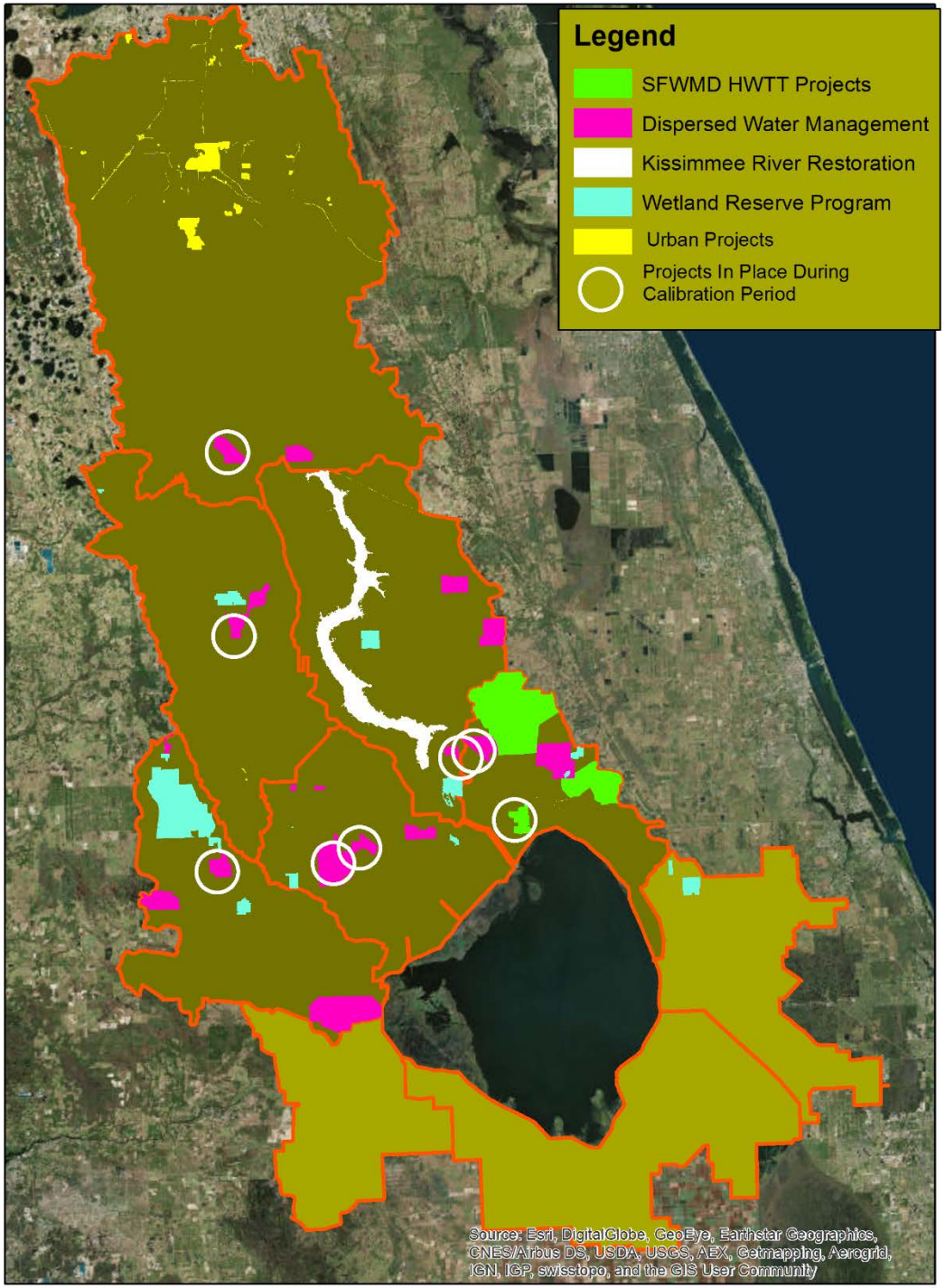
Wastewater Treatment



FDACS BMP Program

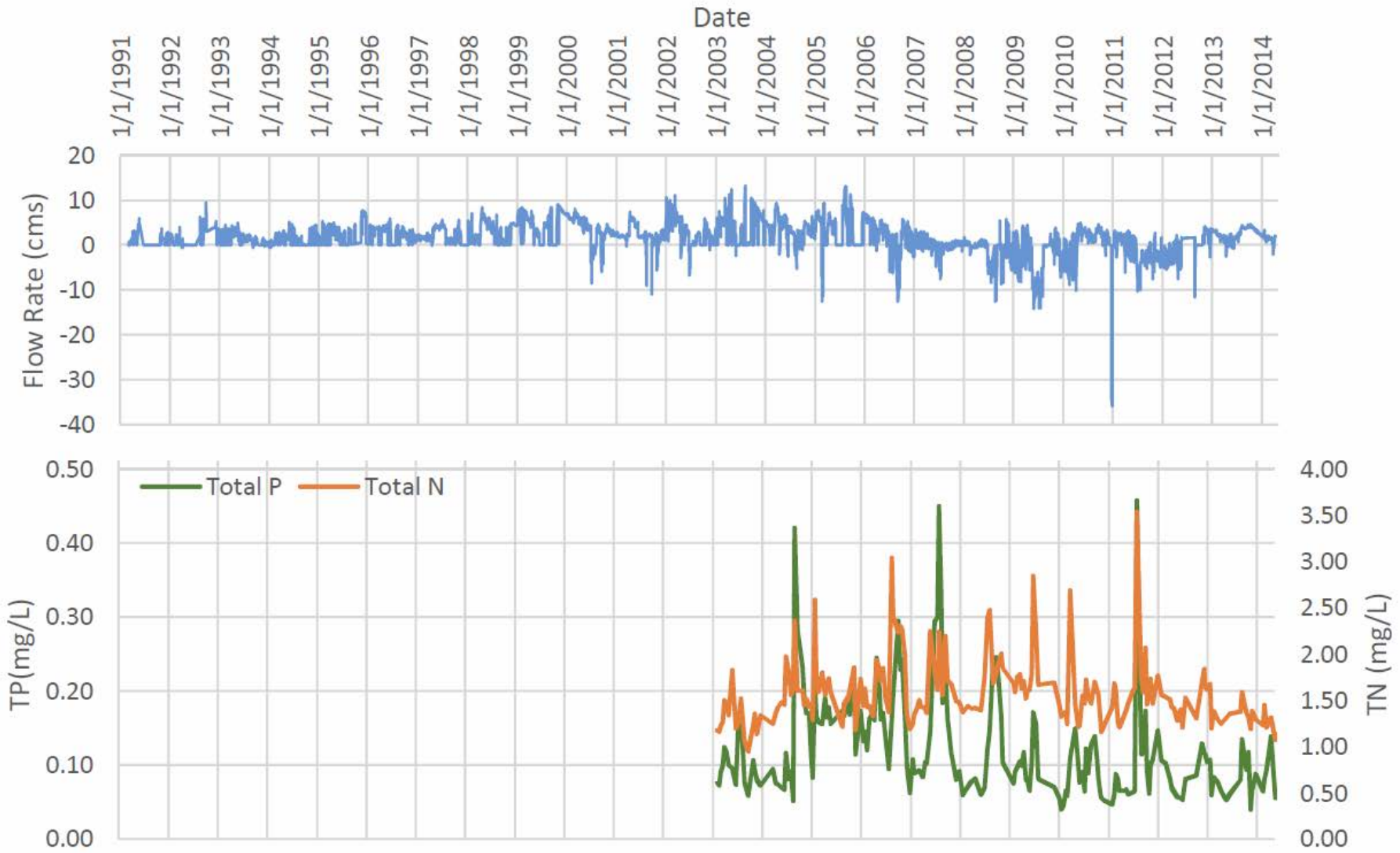


Special Projects



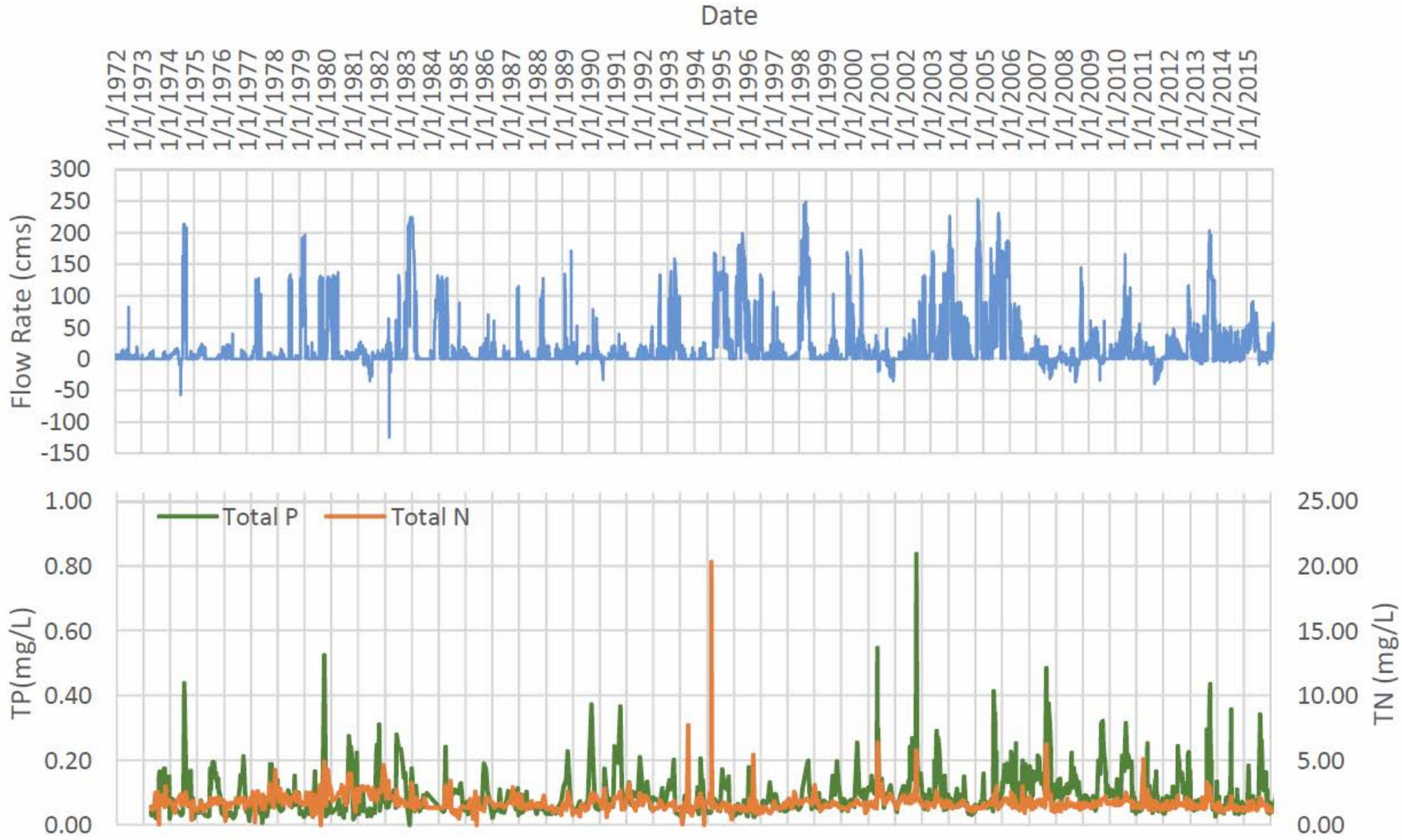
Water Quality Data for Calibration and Verification

Culv5A



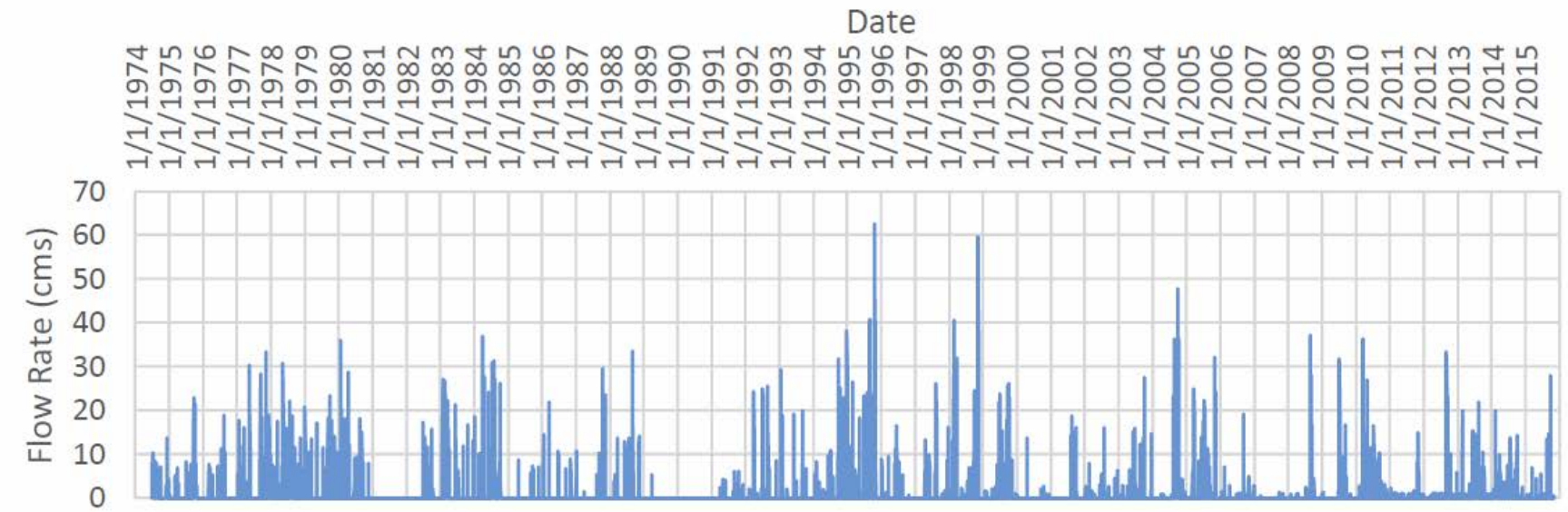
S77

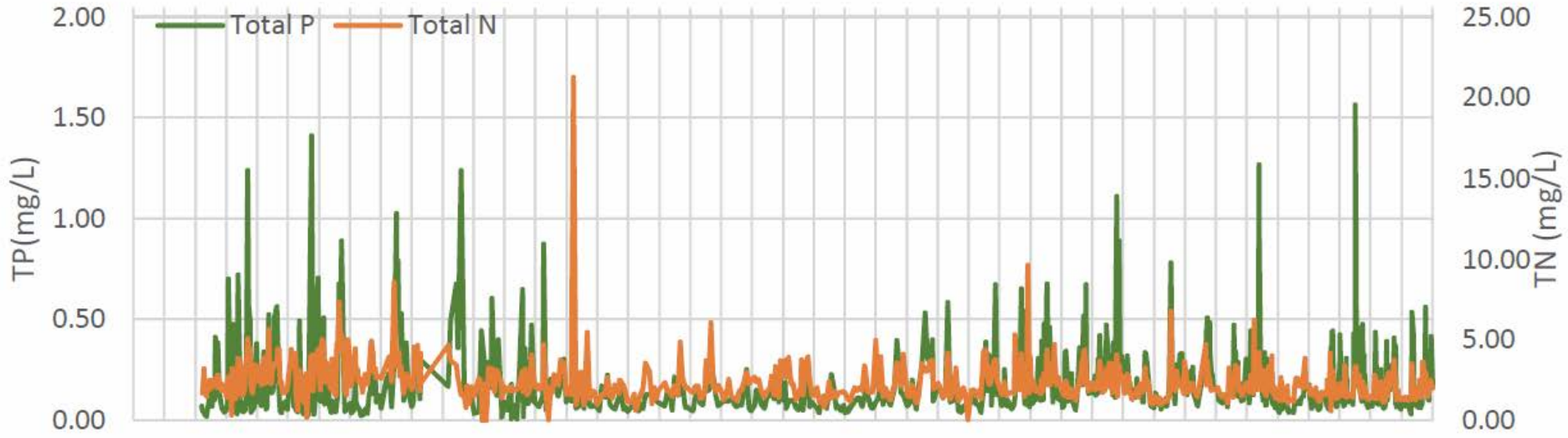
S77 Flow / WQ Data



S4 Flow and WQ Data

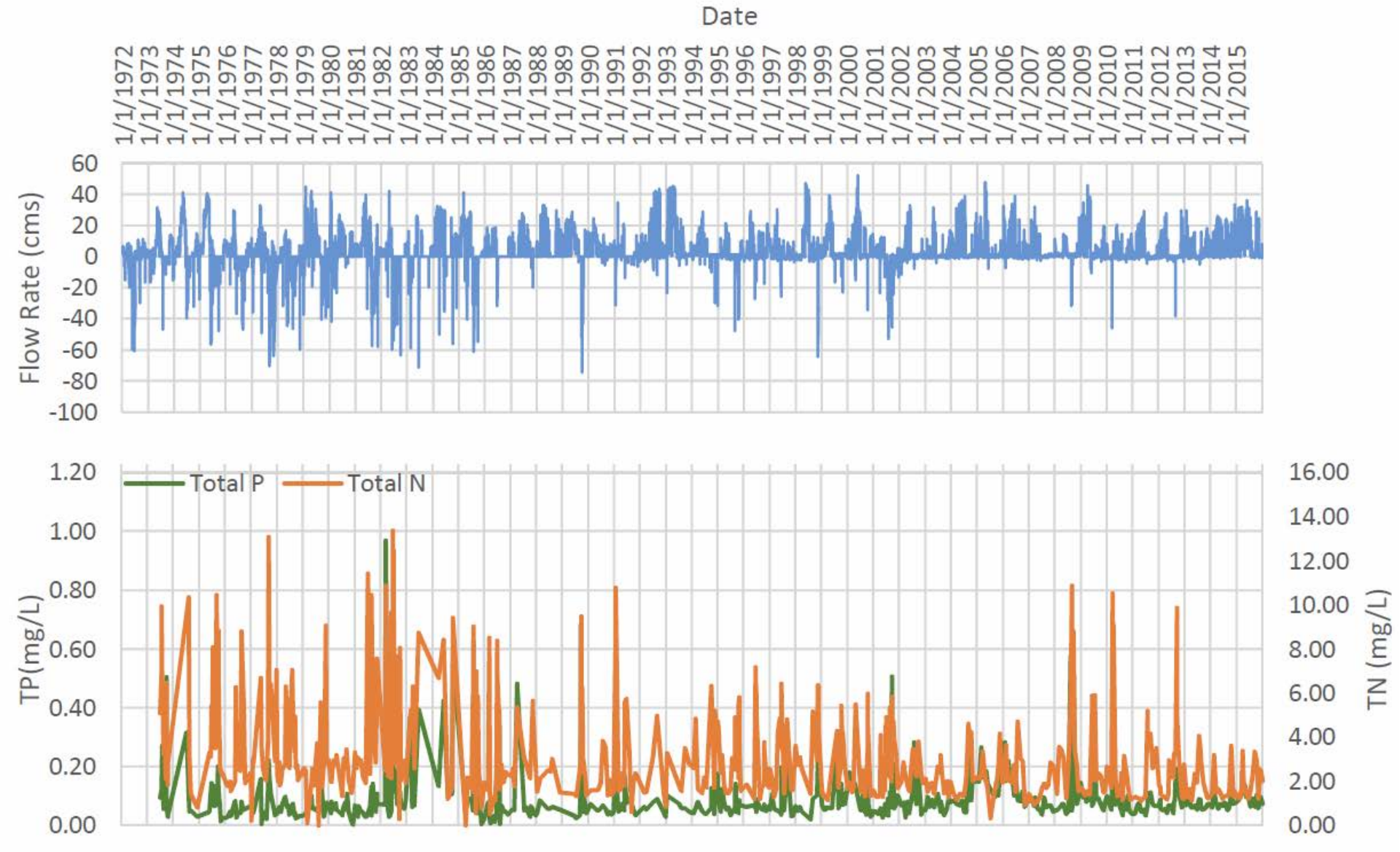
S4





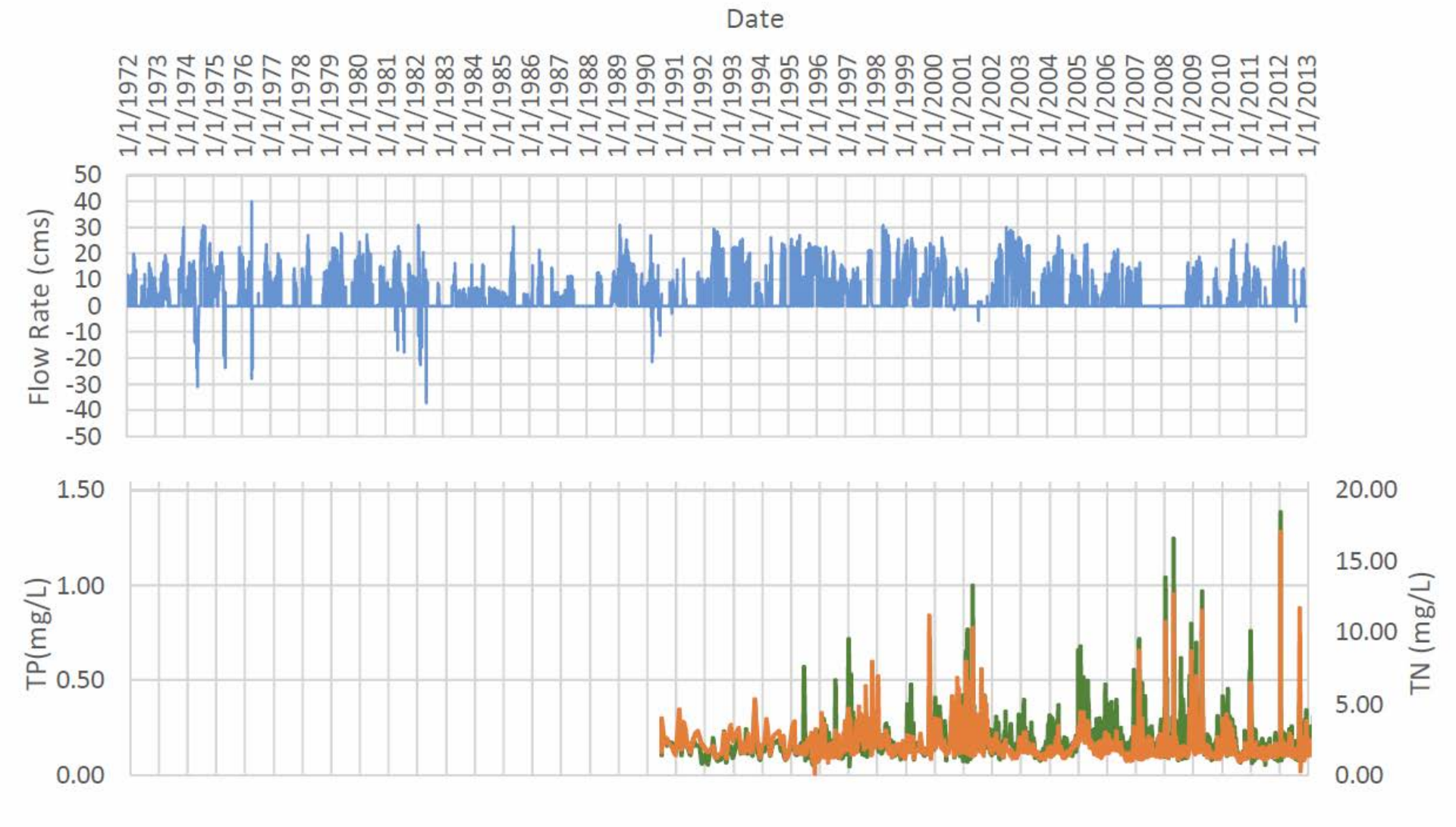
S3 Pump Station

S3



West Palm Beach Canal S-352

S352



Questions

Soil & Water Engineering Technology, Inc.