Mosquito Lagoon Reasonable Assurance Plan (RAP) Watershed Model Development Report

Volusia County and Mosquito Lagoon RAP Stakeholder Group
June 2017

MOSQUITO LAGOON REASONABLE ASSURANCE PLAN (RAP)

WATERSHED MODEL DEVELOPMENT REPORT

Prepared for:

Volusia County
2560 West SR 44
DeLand, Florida 32720

and

Mosquito Lagoon RAP Stakeholder Group

Prepared by:

Jones Edmunds & Associates, Inc.
730 NE Waldo Road
Gainesville, Florida 32641

PE Certificate of Authorization #1841

and

Janicki Environmental, Inc.
1727 Dr. MLK St., N
St. Petersburg, Florida 33704

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BRETT ALAN CUNNINGHAM
LICENSE
No. 46050
STATE OF FLORIDA
PROFESSIONAL ENGINEER

Brett A. Cunningham

Brett A. Cunningham, PE
Florida PE No. 46050

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ACRONYMS AND ABBREVIATIONS

AMC	Antecedent Moisture Condition
ASHI	American Society of Home Inspectors
BMP	Best Management Practices
BOD	Biochemical Oxygen Demand
BRL	Banana River Lagoon
CN	Curve Numbers
DCIA	Directly Connected Impervious Area
DOH	Florida Department of Health
EMC	Event Mean Concentration
ENR	Estuary Nutrient Region
EPA	Environmental Protection Agency
ERP	Environmental Resource Permit
ET	Evapotranspiration
FDEP	Florida Department of Environmental Protection
FLUCCS	Florida Land Use and Cover Classification System
GIS	Geographic Information System
Ia	Initial Abstractions
IRL	Indian River Lagoon
NRCS	Natural Resources Conservation Service
NEXRADSIMPLE	Next-Generation Radar
NPDES	National Pollutant Discharge Elimination System
PET	Potential Evapotranspiration
SIMPLE	Spatially Integrated Model for Pollutant Loading Estimates
SWIL	Spatial Watershed Iterative Loading
SWIS	Subsurface Wastewater Infiltration System
SWMM	Stormwater Management Model
TMDL	Total Maximum Daily Load
TN	Total Nitrogen
TP	Total Phosphorus
TR	Technical Resource
UCIA	Unconnected Impervious Areas
USGS	United States Geological Survey
WWTP	Wastewater Treatment Plant

1 INTRODUCTION

The objective of this portion of the project is to develop a watershed model that reasonably estimates hydrologic and pollutant loads and the effectiveness of projects intended to reduce pollution. As documented in the September 16, 2016 *Watershed Model Selection Technical Memorandum*, Jones Edmunds selected the *Spatially Integrated Model for Pollutant Loading Estimates* (SIMPLE) to achieve this objective. SIMPLE operates in two modes: seasonally and monthly. The seasonal mode (SIMPLE-Seasonal) uses simplified hydrologic methods and computes flows and pollutant loads on a seasonal time scale. The monthly mode (SIMPLE-Monthly) uses a daily time step continuous simulation engine with coupled surface and shallow groundwater flow and collapses the output to the monthly scale. SIMPLE-Monthly was selected for use on this project in part because of the likelihood of Mosquito Lagoon responding to inputs at less than a seasonal scale. Output from SIMPLE-Monthly will be used to help analyze response in Mosquito Lagoon.

This report documents the model input data and assumptions used for the SIMPLE-Monthly simulations.

After the hydrologic model is run, the pollutant loading portion of the model is split into six modules – direct runoff, base flow, wet/dryfall, irrigation, point-source, and septic tank – which may be run together or separately. Each module, along with the data enhancements created for that module, is presented in a separate section of the report.

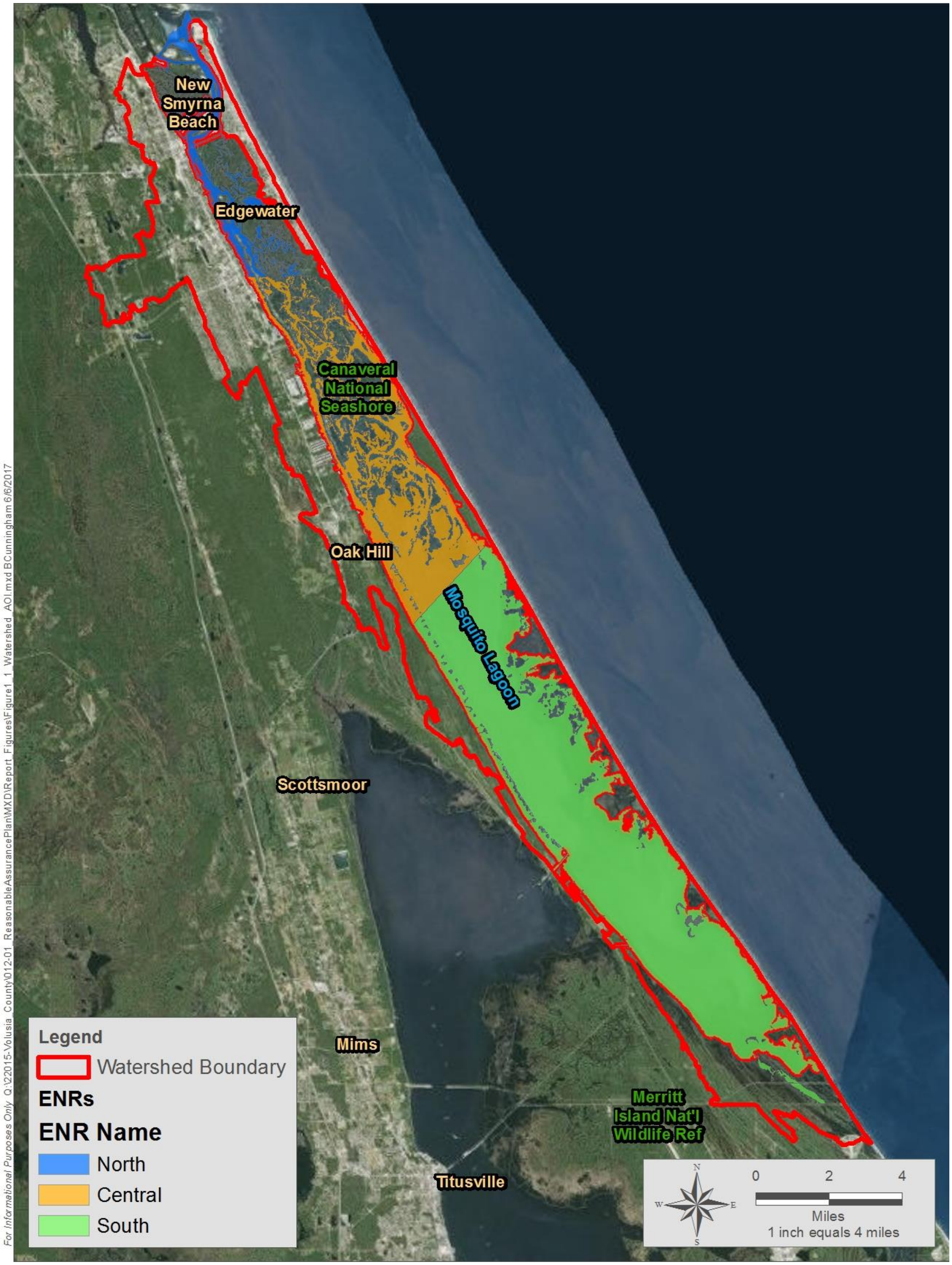
1.1 WATERSHED CHARACTERISTICS

Figure 1-1 shows the Mosquito Lagoon watershed, which encompasses 116.5 square miles. The watershed is approximately 36 miles long along its longest axis. Approximately two-thirds of the watershed area is in Volusia County, with the remainder in Brevard County. Three cities have a significant area in the watershed: Edgewater, New Smyrna Beach, and Oak Hill. A small portion of the Town of Ponce Inlet also lies in the northern edge of the watershed. The watershed area used in this Reasonable Assurance Plan (RAP) does not include some closed basin areas that are along the central-western, southwestern, and southern portions of the watershed border, since these areas do not likely contribute significant load to the watershed.

Slope in the watershed is very flat. The highest elevations at approximately 30 feet, referenced to the North American Vertical Datum of 1988 (NAVD88), are located along the western boundary where the watershed extends west of I-95. Other watershed characteristics are presented throughout the report.

The Florida Department of Environmental Protection (FDEP) subdivided Mosquito Lagoon into three Estuary Nutrient Regions (ENRs) for the purpose of developing numeric nutrient criteria. Figure 1-1 shows these ENRs.

Figure 1-1 Mosquito Lagoon Watershed



2 HYDROLOGIC MODEL

The hydrologic model is a stand-alone, continuous simulation model designed to feed SIMPLE-Monthly calculated runoff, calculated base flow, and rainfall volumes into a hydrologic lookup table used by the main part of the SIMPLE-Monthly model. Decoupling the hydrologic model – which typically only needs to be run once – from the main part of the model significantly reduces the run times for the main part of the model, allowing for more rapid simulations of alternatives.

The hydrologic lookup table contains monthly rainfall, base flow, and runoff values for all unique combinations of rainfall gauge, event-mean concentration (EMC) land use, and hydrologic soil group in Mosquito Lagoon. The hydrologic model was developed to do the following:

- Evaluate the water budget of a watershed using a daily time step.
- Simulate the interaction between infiltration to, evapotranspiration (ET) from, and groundwater flow and leakance from the surficial aquifer.
- Use the nearest rainfall gauge data.
- Regenerate infiltration capacity during dry periods and account for time-variable rates such as ET.

2.1 HYDROLOGIC INPUT DATA

2.1.1 RAINFALL

Historical rainfall data for the period required for the model can be gathered from two sources: rain gauge data or Next-Generation Radar (NEXRAD)-derived data. Rain gauge data requires an adequate spatial distribution of gauges covering the study area for the simulation period. For the Mosquito Lagoon watershed, four rain gauges in or near the watershed cover the desired simulation period. Figure 2-1 shows the gauge locations along with polygons representing the areas of the watershed nearest to the four gauges. We examined the data from the four gauges, looking for significant gaps of missing data or potential gauge error or bias. There were a few small gaps in three of the four gauge records, and we filled the gaps using the data from the nearest gauge. Table 2-1 provides an annual summary of the data. Table 2-1 shows how the gauge data varies between years, as can be expected given the size of the watershed, but we found no obvious bias in any of the gauges.

Given the adequate spatial distribution of rain gauges and the apparent quality of the gauge data, we chose to use the rain gauge data as the preferred option for this model. Rainfall data were exported as daily values into the hydrologic model for each of four gauges for the 2004-2015 simulation period. EMC land use and soils combinations were simulated in each pixel. EMC land uses are explained in Section 4 of this report.

Figure 2-1 Location of Rain Gauges and Nearest Watershed Areas

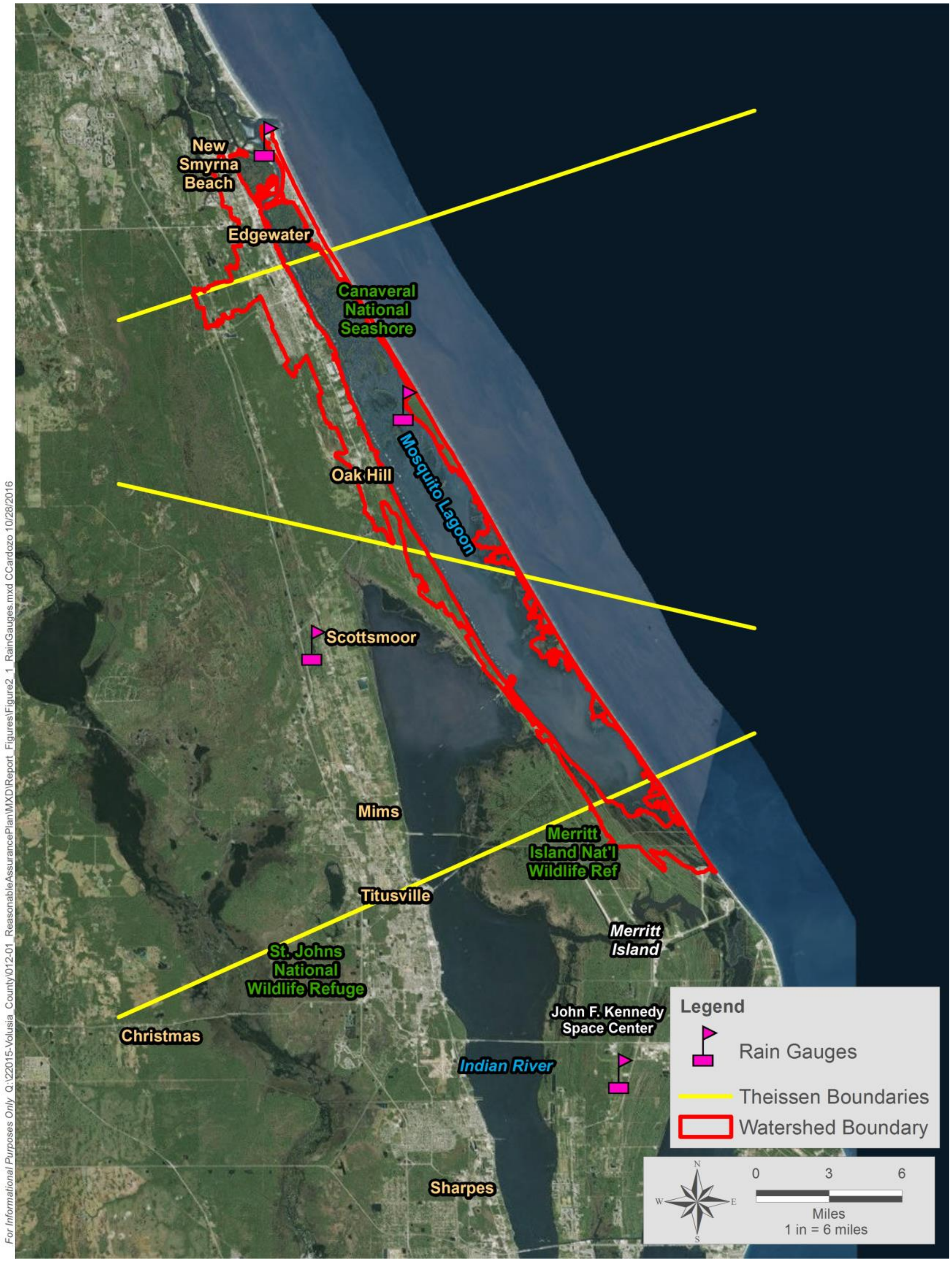


Table 2-1 Annual Summary of Rain Gauge Data

Station Name	Ransom Road at NASA	Ponce Inlet Weather Site at USCG Station	Playalinda at Turtle Mound	Parrish Park at Scottsmore
Station Number	15112758	18073682	1490678	1480674
Year	Annual Rainfall Total (Inches)			
2004	59.39	49.55	44.93	51.98
2005	62.60	49.23	45.33	49.37
2006	35.97	27.19	29.56	36.96
2007	50.86	35.55	42.17	50.15
2008	64.11	35.05	45.81	51.14
2009	39.84	54.38	46.75	42.02
2010	43.62	27.47	33.36	39.38
2011	45.98	35.36	40.82	50.22
2012	44.65	36.76	35.25	48.80
2013	42.36	40.23	39.32	42.01
2014	55.89	61.36	59.54	65.76
2015	42.42	33.20	33.67	42.30
Average (Inches)	48.97	40.44	41.38	47.51
Std Dev (Inches)	9.39	10.79	8.05	7.69

2.1.2 EVAPOTRANSPIRATION

Potential evapotranspiration (PET) losses can be calculated through many methods, such as Penmen-Monteith, Thornthwaite, and Priestly-Taylor. One potential challenge with any method is having adequate data to calculate PET accurately over large temporal and spatial domains. One of the sources for PET that overcomes those issues is the 2-km-by-2-km pixel grid developed by the United States Geological Survey (USGS) Integrated Science Center. The USGS calculated the daily PET pixel data, available for the entire State of Florida, using the Priestly-Taylor method and validated against 18 monitoring locations (Jacobs et al., 2008). The data are currently available from June 1995 through 2015, which covers the simulation period for this project. The data we used for this project are described below.

While this dataset represents an improvement of readily available PET data for large areas, the spatial accuracy from pixel to pixel has yet to be validated. As such, we analyzed the data from pixels encompassing the four rain gauges to quantify the variability from different parts of the watershed. The four rain gauges are in pixels containing a range of land covers and at different distances from the coast, so they appear to be representative of the watershed and are in sync with local measured rainfall. Figure 2-2 graphically compares 1 representative year of data across the four pixels. As can be seen in Figure 2-2, calculated PET differences across the four pixels is less than 1 mm most days.

Figure 2-3 compares the annual totals for the four pixels. As can be seen in Figure 2-3, the maximum difference in annual totals between any two pixels is approximately 5 percent. The annual values for 1995 are lower since the values begin in June instead of January.

The two comparisons presented above suggest that using a finer spatial resolution for the PET has little value as it would have no significant difference in the hydrologic results. Therefore, we applied the PET at each rain gauge pixel as representative of that portion of the watershed.

Figure 2-2 Comparison of PET at Four Rain Gauge Pixels for 1996

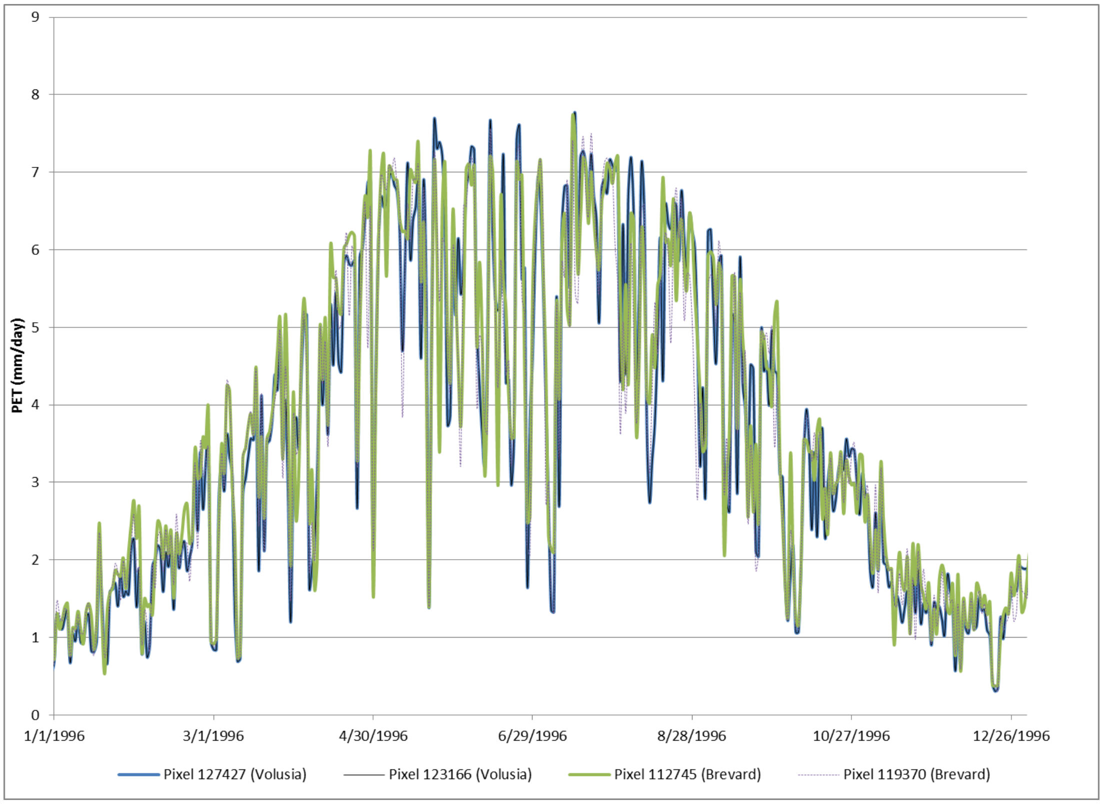
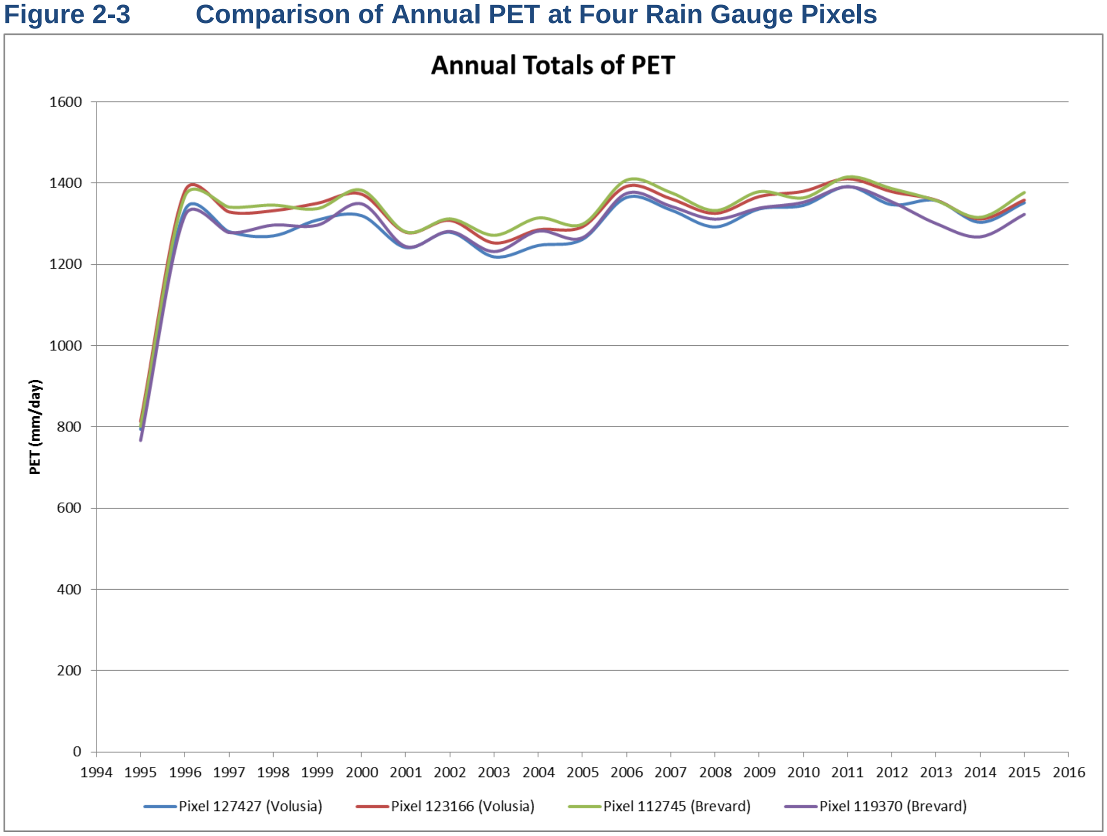


Figure 2-3 Comparison of Annual PET at Four Rain Gauge Pixels



2.1.3 Soils and Groundwater Data

Soil storage information was extracted from the Natural Resources Conservation Service (NRCS) electronic soil survey data. Soil files for Volusia and Brevard Counties were used in part to parameterize the primary groundwater and vadose zone components of the continuous simulation model. Root depth information was based on aerial photography and generalized land uses. Parameters were also compared to those from the SIMPLE-Monthly simulations for Sarasota County, based on similarities in soils and the extensive calibration data available for Sarasota County (Sarasota County Pollutant Loading Model Development (W552) SIMPLE-Monthly Calibration Report, Jones Edmunds, January 2009). Table 2-2 shows these parameters and Table 2-3 provides the percentage of hydrologic soil groups in each ENR.

2.2 Hydrologic Computations

The continuous simulation hydrologic model code is generic to any water budget, although some modules were specifically modified for SIMPLE-Monthly. One simulation was performed for every combination of rain gauge, EMC land use, and hydrologic soil group. The primary water budget equation for SIMPLE-Monthly can be summarized as the following:

Change in Storage = Rainfall – PET – Groundwater (Base) Flow – Direct Runoff

Additional information on the computations is provided in the subsections below.

2.2.1 Runoff and Vadose Zone

Jones Edmunds modeled stormwater runoff and infiltration using a modified version of the Natural Resource Conservation Service's Technical Resource 55 (NRCS TR-55) methodology. The primary modification included the treatment of directly connected impervious area (DCIA) as a separate variable. We generated curve numbers (CN) for the remaining area using TR-55 values for pervious areas (with consideration of the high water tables) and using 98 for unconnected impervious areas (UCIA). The initial CN assignments represent antecedent moisture condition (AMC) II, which is considered normal hydrologic conditions for a given combination of land use and soil type. CNs for AMC I (dry hydrologic conditions) and III (wet hydrologic conditions) were generated based on the AMC II values and Dingman, 1994. Two exceptions to this CN assignment were wetland and water land uses. Both wetland and water land use would be considered impervious in event-based modeling, but since the hydrologic engine is a continuous simulation model, the CNs had to be altered for these land uses to allow for recharge, retention, and ET on an annual basis. This adjustment creates a situation where runoff from a wetland polygon only occurs when the soil profile is at or near saturation. Conversely, the model allows the wetland area to retain runoff during dry conditions.

The AMC was calculated at each time step using the previous time step soil moisture storage. In general terms, if the water table was within 8 inches of the soil surface, the following time step was set to AMC III. If the water table was more than 36 inches beneath the soil surface, the following time step was set to AMC I. All other conditions were set to AMC II. These thresholds were set based on general observations of the modeled water table and their correlation with antecedent rainfall conditions. The actual model logic is slightly more complicated since soil moisture contents are calculated as an average for the entire vadose zone depth. AMC is calculated in the model as follows: If the soil-moisture deficit ([Soil Moisture Content - Wilting Point] * Depth of the Vadose Zone) was less than [Field Capacity - Wilting Point] * 8 inches, the following time step is set to AMC III. If the soil-moisture deficit was greater than [Field Capacity - Wilting Point] * 36 inches, the following time step is set to AMC I. All other conditions are set to AMC II.

Table 2-2 Soils and Groundwater Parameters

Combo ID (FLUCCS HSG)	Surface Water Hydrology												Groundwater Parameters (for Dupuit-Forcheimer)			Vadose Zone Parameters					
	Dry (AMC I) Conditions			Average (AMC II) Conditions				Moist (AMC III) Conditions			DCIA										
	Dry UCIA + Pervious Curve Number	Potential Max Abstraction (S) (inches)	Initial Abstraction (Ia) (inches)	Average UCIA + Pervious Curve Number	Potential Max Abstraction (S) (inches)	Initial Abstraction (Ia) (inches)	Lumped Subbasin ET Coefficient (%)	Moist UCIA + Pervious Curve Number	Potential Max Abstraction (S) (inches)	Initial Abstraction (Ia) (inches)	DCIA (%)	Initial Abstraction for DCIA (Ia) (inches)	Saturated Horizontal Hydraulic Conductivity (feet/day)	Calibration Coefficient (feet/foot)	Aquifer Recharge Rate (feet/day)	Wilting Point (inches/inch)	Field Capacity (inches/inch)	Vadose Zone Moisture at time=0 (inches/inch)	Effective Porosity (ft^3/ft^3)	Fraction of ET Coefficient for Deep Extraction (feet/foot)	Root Zone Depth (feet)
1A	40	15.00	3.000	60	6.67	1.333	0.43	78	2.82	0.564	0	0.0	35	30	0	0.032	0.077	0.0542	0.397	0.7	2
1B	55	8.18	1.636	75	3.33	0.667	0.43	85	1.76	0.353	0	0.0	40	30	0	0.02	0.05	0.035	0.375	0.7	2
1C	66	5.15	1.030	83	2.05	0.410	0.43	92	0.87	0.174	0	0.0	16	30	0	0.041	0.09	0.0657	0.404	0.7	2
1D	75	3.33	0.667	88	1.36	0.273	0.43	95	0.53	0.105	0	0.0	14	30	0	0.082	0.15	0.1158	0.379	0.7	2
2A	20	40.00	8.000	38	16.32	3.263	0.56	57	7.54	1.509	0	0.0	35	30	0	0.032	0.077	0.0542	0.397	0.7	2
2B	41	14.39	2.878	61	6.39	1.279	0.56	79	2.66	0.532	0	0.0	40	30	0	0.02	0.05	0.035	0.375	0.7	2
2C	53	8.87	1.774	73	3.70	0.740	0.56	83	2.05	0.410	0	0.0	16	30	0	0.041	0.09	0.0657	0.404	0.7	2
2D	63	5.87	1.175	80	2.50	0.500	0.56	91	0.99	0.198	0	0.0	14	30	0	0.082	0.15	0.1158	0.379	0.7	2
3A	27	27.04	5.407	46.0	11.74	2.348	0.61	66	5.15	1.030	0	0.0	35	30	0	0.032	0.077	0.0542	0.397	0.7	2
3B	46	11.74	2.348	66	5.15	1.030	0.61	82	2.20	0.439	0	0.0	40	30	0	0.02	0.05	0.035	0.375	0.7	2
3C	57	7.54	1.509	77	2.99	0.597	0.61	87	1.49	0.299	0	0.0	16	30	0	0.041	0.09	0.0657	0.404	0.7	2
3D	66	5.15	1.030	83	2.05	0.410	0.61	92	0.87	0.174	0	0.0	14	30	0	0.082	0.15	0.1158	0.379	0.7	2
4A	44	12.73	2.545	64	5.63	1.125	0.55	81	2.35	0.469	0	0.0	35	75	0	0.032	0.077	0.0542	0.397	0.2	1
4B	56	7.86	1.571	76	3.16	0.632	0.55	86	1.63	0.326	0	0.0	40	75	0	0.02	0.05	0.035	0.375	0.2	1
4C	68	4.71	0.941	84	1.90	0.381	0.55	93	0.75	0.151	0	0.0	16	75	0	0.041	0.09	0.0657	0.404	0.2	1
4D	75	3.33	0.667	88	1.36	0.273	0.55	95	0.53	0.105	0	0.0	14	75	0	0.082	0.15	0.1158	0.379	0.2	1
5A	23	33.48	6.696	41	14.39	2.878	0.55	61	6.39	1.279	0	0.0	35	75	0	0.032	0.077	0.0542	0.397	0.2	1
5B	45	12.22	2.444	65	5.38	1.077	0.55	82	2.20	0.439	0	0.0	40	75	0	0.02	0.05	0.035	0.375	0.2	1
5C	59	6.95	1.390	79	2.66	0.532	0.55	89	1.24	0.247	0	0.0	16	75	0	0.041	0.09	0.0657	0.404	0.2	1
5D	68	4.71	0.941	84	1.90	0.381	0.55	93	0.75	0.151	0	0.0	14	75	0	0.082	0.15	0.1158	0.379	0.2	1
6A	23	33.48	6.696	41	14.39	2.878	0.60	61	6.39	1.279	0	0.0	35	90	0	0.032	0.077	0.0542	0.397	0.7	1
6B	38	16.32	3.263	58	7.24	1.448	0.60	77	2.99	0.597	0	0.0	40	90	0	0.02	0.05	0.035	0.375	0.7	1
6C	49	10.41	2.082	69	4.49	0.899	0.60	84	1.90	0.381	0	0.0	16	90	0	0.041	0.09	0.0657	0.404	0.7	1
6D	54	8.52	1.704	74	3.51	0.703	0.60	84	1.90	0.381	0	0.0	14	90	0	0.082	0.15	0.1158	0.379	0.7	1
7A	34	19.41	3.882	54	8.52	1.704	0.50	74	3.51	0.703	20	0.1	35	90	0	0.032	0.077	0.0542	0.397	0.7	1
7B	50	10.00	2.000	70	4.29	0.857	0.50	85	1.76	0.353	20	0.1	40	90	0	0.02	0.05	0.035	0.375	0.7	1
7C	63	5.87	1.175	80	2.50	0.500	0.50	91	0.99	0.198	20	0.1	16	90	0	0.041	0.09	0.0657	0.404	0.7	1
7D	70	4.29	0.857	85	1.76	0.353	0.50	94	0.64	0.128	20	0.1	14	90	0	0.082	0.15	0.1158	0.379	0.7	1
8A	41	14.39	2.878	61	6.39	1.279	0.40	79	2.66	0.532	30	0.1	35	90	0	0.032	0.077	0.0542	0.397	0.7	1
8B	55	8.18	1.636	75	3.33	0.667	0.40	85	1.76	0.353	30	0.1	40	90	0	0.02	0.05	0.035	0.375	0.7	1
8C	66	5.15	1.030	83	2.05	0.410	0.40	92	0.87	0.174	30	0.1	16	90	0	0.041	0.09	0.0657	0.404	0.7	1
8D	74	3.51	0.703	87	1.49	0.299	0.40	94	0.64	0.128	30	0.1	14	90	0	0.082	0.15	0.1158	0.379	0.7	1

Combo ID (FLUCCS HSG)	Surface Water Hydrology													Groundwater Parameters (for Dupuit-Forcheimer)			Vadose Zone Parameters					
	Dry (AMC I) Conditions			Average (AMC II) Conditions				Moist (AMC III) Conditions			DCIA									
	Dry UCIA + Pervious Curve Number	Potential Max Abstraction (S) (inches)	Initial Abstraction (Ia) (inches)	Average UCIA + Pervious Curve Number	Potential Max Abstraction (S) (inches)	Initial Abstraction (Ia) (inches)	Lumped Subbasin ET Coefficient (%)	Moist UCIA + Pervious Curve Number	Potential Max Abstraction (S) (inches)	Initial Abstraction (Ia) (inches)	DCIA (%)	Initial Abstraction for DCIA (Ia) (inches)	Saturated Horizontal Hydraulic Conductivity (feet/day)	Calibration Coefficient (feet/foot)	Aquifer Recharge Rate (feet/day)	Wilting Point (inches/ inch)	Field Capacity (inches/ inch)	Vadose Zone Moisture at time=0 (inches/inch)	Effective Porosity (ft^3/ft^3)	Fraction of ET Coefficient for Deep Extraction (feet/foot)	Root Zone Depth (feet)
9A	35	18.57	3.714	55	8.18	1.636	0.35	74	3.51	0.703	50	0.1	35	90	0	0.032	0.077	0.0542	0.397	0.5	2
9B	49	10.41	2.082	69	4.49	0.899	0.35	84	1.90	0.381	50	0.1	40	90	0	0.02	0.05	0.035	0.375	0.5	2
9C	58	7.24	1.448	78	2.82	0.564	0.35	88	1.36	0.273	50	0.1	16	90	0	0.041	0.09	0.0657	0.404	0.5	2
9D	70	4.29	0.857	85	1.76	0.353	0.35	94	0.64	0.128	50	0.1	14	90	0	0.082	0.15	0.1158	0.379	0.5	2
10A	35	18.57	3.714	55	8.18	1.636	0.35	74	3.51	0.703	60	0.1	35	90	0	0.032	0.077	0.0542	0.397	0.5	2
10B	49	10.41	2.082	69	4.49	0.899	0.35	84	1.90	0.381	60	0.1	40	90	0	0.02	0.05	0.035	0.375	0.5	2
10C	58	7.24	1.448	78	2.82	0.564	0.35	88	1.36	0.273	60	0.1	16	90	0	0.041	0.09	0.0657	0.404	0.5	2
10D	70	4.29	0.857	85	1.76	0.353	0.35	94	0.64	0.128	60	0.1	14	90	0	0.082	0.15	0.1158	0.379	0.5	2
11A	26	28.46	5.692	45	12.22	2.444	0.51	65	5.38	1.077	10	0.1	35	90	0	0.032	0.077	0.0542	0.397	0.5	2
11B	46	11.74	2.348	66	5.15	1.030	0.51	82	2.20	0.439	10	0.1	40	90	0	0.02	0.05	0.035	0.375	0.5	2
11C	59	6.95	1.390	79	2.66	0.532	0.51	89	1.24	0.247	10	0.1	16	90	0	0.041	0.09	0.0657	0.404	0.5	2
11D	68	4.71	0.941	84	1.90	0.381	0.51	93	0.75	0.151	10	0.1	14	90	0	0.082	0.15	0.1158	0.379	0.5	2
12A	49	10.41	2.082	69	4.49	0.899	0.30	84	1.90	0.381	40	0.1	35	90	0	0.032	0.077	0.0542	0.397	0.5	2
12B	63	5.87	1.175	80	2.50	0.500	0.30	91	0.99	0.198	40	0.1	40	90	0	0.02	0.05	0.035	0.375	0.5	2
12C	74	3.51	0.703	87	1.49	0.299	0.30	94	0.64	0.128	40	0.1	16	90	0	0.041	0.09	0.0657	0.404	0.5	2
12D	78	2.82	0.564	90	1.11	0.222	0.30	96	0.42	0.083	40	0.1	14	90	0	0.082	0.15	0.1158	0.379	0.5	2
13A	87	1.49	0.299	95	0.53	0.105	0.98	98	0.20	0.041	0	0.0	35	5	0	0.032	0.077	0.0542	0.397	0.7	1
13B	90	1.11	0.222	96	0.42	0.083	0.98	98	0.20	0.041	0	0.0	40	5	0	0.02	0.05	0.035	0.375	0.7	1
13C	93	0.75	0.151	97	0.31	0.062	0.98	98	0.20	0.041	0	0.0	16	5	0	0.041	0.09	0.0657	0.404	0.7	1
13D	95	0.53	0.105	98	0.20	0.041	0.98	98	0.20	0.041	0	0.0	14	5	0	0.082	0.15	0.1158	0.379	0.7	1
14A	87	1.49	0.299	95	0.53	0.105	0.94	98	0.20	0.041	0	0.0	35	5	0	0.032	0.077	0.0542	0.397	0.7	1
14B	90	1.11	0.222	96	0.42	0.083	0.94	98	0.20	0.041	0	0.0	40	5	0	0.02	0.05	0.035	0.375	0.7	1
14C	95	0.53	0.105	98	0.20	0.041	0.94	98	0.20	0.041	0	0.0	16	5	0	0.041	0.09	0.0657	0.404	0.7	1
14D	95	0.53	0.105	98	0.20	0.041	0.94	98	0.20	0.041	0	0.0	14	5	0	0.082	0.15	0.1158	0.379	0.7	1
15A	33	20.30	4.061	53	8.87	1.774	0.34	73	3.70	0.740	30	0.1	35	90	0	0.032	0.077	0.0542	0.397	0.5	2
15B	49	10.41	2.082	69	4.49	0.899	0.34	84	1.90	0.381	30	0.1	40	90	0	0.02	0.05	0.035	0.375	0.5	2
15C	63	5.87	1.175	80	2.50	0.500	0.34	91	0.99	0.198	30	0.1	16	90	0	0.041	0.09	0.0657	0.404	0.5	2
15D	70	4.29	0.857	85	1.76	0.353	0.34	94	0.64	0.128	30	0.1	14	90	0	0.082	0.15	0.1158	0.379	0.5	2

Note – Land Use definitions:

1 Open 2 Forest 3 Pasture 4 Agriculture 5 Golf Courses 6 Low-Density Residential 7 Medium-Density Residential 8 High-Density Residential
9 Low-Intensity Commercial 10 High-Intensity Commercial 11 Light Industrial 12 Heavy Industrial 13 Wetlands 14 Water 15 Transportation

Table 2-3 Hydrologic Soil Group Percentages

Estuary Nutrient Region	Hydrologic Soil Group				
	A	B	B/D	C/D	D
North	50%	4%	21%	0%	24%
Central	62%	2%	13%	1%	23%
South	20%	0%	10%	5%	65%

Initial abstractions (Ia) for pervious areas and unconnected impervious areas (UCIAs) were modeled using the relationship of Ia = 0.2S per TR-55 for small watersheds, where S is the potential maximum abstraction. Based on experience with measured data in nearby watersheds, literature values, and the Harvey Harper model, Ia for DCIA was fixed at 0.1 inch. For any time step, if precipitation is less than Ia, no runoff will occur and all rainfall from the pervious area and UCIA will infiltrate. If precipitation exceeds Ia, the ponded depth (precipitation minus Ia) will become runoff according to the following equation for pervious area and UCIA:

$$Q = \frac{(P - 0.2S)^2}{P + 0.8S}$$

In this form of the equation, P represents the entire precipitation for that day. Q is in inches and is converted to a volume using area. For DCIA the entire precipitation depth above Ia becomes runoff. The general relationship can be described as follows: Higher CN values (representing more impervious land uses and/or more poorly drained soils) result in lower S values (potential abstraction, such as infiltration) which in turn results in higher Q (predicted runoff). Lower CN values beget higher S values and lower Q predictions.

Once a volume is infiltrated from the surface, it passes into the vadose zone, which in SIMPLE-Monthly is the zone where soil moisture is allowed to fluctuate between saturated and unsaturated. If soil moisture increases beyond field capacity, the excess volume of water will pass into the saturated portion of the vadose zone, and the depth of the unsaturated portion decreases while the depth of the saturated portion increases. Soil moisture in the unsaturated portion then returns to field capacity. ET from the vadose zone will stop if the soil moisture content drops below the wilting point.

2.2.2 Base Flow

Base flow for SIMPLE-Monthly can be generally defined as channelized flow resulting from a source other than runoff, e.g. lateral groundwater flow following infiltration. The saturated groundwater module required us to use a formula that gave a reasonable base flow response based on the level in the groundwater table depth. The Dupuit-Forcheimer equation was chosen because it has wide application in predicting surficial aquifer groundwater flow. This equation is one of the options used in the Stormwater Management Model (SWMM) and is well documented in the *SWMM Manual* (Huber and Dickinson, 1992). It was implemented in the model as follows:

$$GWFLW = (D1 - BC)^2 * \frac{C * K}{L^2}$$

In this form of the equation, GWFLW is the flow rate from the saturated portion of the vadose zone; D1 is the average depth of the vadose zone; BC is the depth of the receiving water body measured from the bottom of the water body to the bottom of the vadose zone; C is a coefficient that was used to calibrate; K is the saturated horizontal hydraulic conductivity; and L is equivalent to average overland flow length.

GWFLW is set to zero if D1 < BC. D1 is influenced by the infiltrated volume and is adjusted for each time step. D1 is calculated based on the depth of the saturated portion of the vadose zone from the previous time step plus the infiltrated volume at the current time step. The hydraulic conductivity, K, was parameterized using the NRCS soil surveys to obtain representative conductivity values for each hydrologic group. The subbasin length, L, was calculated as 25 percent of the computational unit length. C and BC were determined during calibration, with C allowed to vary between land use while BC was held constant across the watershed.

A deep percolation (leakance) loss was not included in the model since previous studies indicate that if there is a significant flux from the surficial aquifer, the flux is likely upwards into it (Zarillo et al, 2012).

2.2.3 Evapotranspiration

As stated in Section 2.1.2, USGS data were used for PET. Crop coefficients were initially set based on communication with David Sumner at USGS (Swancar, 2006; Swancar, 2007), but were considered a calibration parameter. Crop coefficients are used to calculate PET for individual crops and were used in SIMPLE-Monthly to calculate PET for a given land use from the PET provided by USGS, which is crop independent. The actual ET extracted from the soil profile is varied based on the water table level and soil moisture content of the profile. ET in the rootzone (a depth variable by land use) is calculated as the product of PET and the crop coefficient for the given land use, occurring when the water table level is at or above the rootzone depth. If the water table level is below the rootzone depth, ET varies depending on soil moisture content. If the soil moisture content is above the wilting point, ET is the product of PET, the crop coefficient for the given land use, and a secondary coefficient accounting for deeper extraction. If the soil moisture content reaches the wilting point, no ET occurs. This variable ET calculation method allows for a more accurate ET simulation through time without varying crop coefficients with time.

Two more specific scenarios are also accounted for by the ET module. First, if the water table level is below the rootzone depth and the soil moisture content is above the wilting point but the calculated ET is larger than the available water in the soil profile, then only the available water in the soil profile will be lost to ET. In other words, in this situation ET can reduce the soil moisture content in the soil profile only to the wilting point – not below it. Second, if the soil profile is at the wilting point and rain occurs during this time step, calculated ET is extracted from the calculated infiltration resulting from the rain event.

2.2.4 Results

While the hydrologic analysis takes place on a daily time step, the results are summed over each month for use in portions of the project. Results are reported for land use and soil combinations over a unit subbasin size (ft^3/ft^2 or simply ft). Actual areas used in pollutant loading calculations are determined based on the intersection of land use and soil data in the geographic information system (GIS).

3 POLLUTANT LOADING MODEL

This section of the report describes general information about the pollutant loading portion of SIMPLE-Monthly. This portion of SIMPLE-Monthly accesses the modules discussed in Sections 4 through 8.

The model requires the use of a file-based geodatabase template, where all lookup tables, some input data, and all output tables exist. The geodatabase template is where changes to input data such as EMCs, best management practice (BMP) types and efficiencies, and constituent concentrations for each pollution type may be changed by the user if needed. SIMPLE-Monthly creates a copy of the template unique to the model simulation currently being run. All input data in this output geodatabase (also file-based, rather than personal) is clipped to the basins selected for simulation. Basins in SIMPLE-Monthly are simply the spatial units over which the results are summarized. The actual calculations take place at a much finer scale (i.e., over every unique combination of land use, soils, rainfall area, and BMP coverage).

During a simulation, temporary tables to store interim data and relates between tables and feature classes are populated, and these are intended to be used strictly for model functions rather than by the end-user. The loading results are stored in tables for each source module on a per-basin and per-basin-acre basis.

4 DIRECT RUNOFF MODEL

4.1 DATA AND MODEL DEVELOPMENT

Time-stamping the spatial inputs to the model was necessary to simulate the watershed over an extended period in which significant changes in the watershed occurred. This section describes methods used for time-stamping layers required for the Direct Runoff Module.

4.1.1 LAND USE

Significant development and pollutant reduction projects occurred in portions of the watershed over the simulation period. In terms of land use, development usually means a shift from open, forest, or agricultural land to an urban land use such as medium-density residential development or commercial development. These shifts result in a difference in runoff volumes and pollutant loads, so it is important to track and account for these shifts in the pollutant-loading model. Since most developments take months to years to complete and their progress and completion are not tracked at a fine time scale, recording land use changes yearly was determined to be the most reasonable and practical interval.

GIS land use data exist as a polygon feature class with the most pertinent attributes being the Florida Land Use and Cover Classification System (FLUCCS) code. To be efficient and error-resistant, temporal changes are embedded into the land use data by including two additional attributes: the pre-development condition land use and the date (year) of transition (YR_BUILT) between pre-developed and developed conditions. This method of storage allows land use data from multiple years to be stored in a single feature class and avoids issues related to differences between how polygons were drawn or defined for the same development for different land use feature classes.

The following four sources were used to create a single land use feature class with embedded temporal changes:

- 2004 land use shapefile from SJRWMD.
- 2014 land use geodatabase from SJRWMD.
- Aerial photos from 2004-2014.
- Environmental Resource Permits (ERPs).

To reconcile slight differences between the two land use layers that were not related to actual land use changes (e.g., inconsistencies in the spatial data), the land uses were intersected and the following rules were applied:

- If the 2004 and 2014 land uses were both non-urban or both urban, the 2004 land use was overwritten with the 2014 land use.
- If the 2004 land use was urban and the 2014 land use was non-urban, the 2004 land use was overwritten with the 2014 land use.
- We dissolved sliver polygons that were byproducts of slight differences in digitizing between the two land use databases on the basis of the 2014 land use.

We viewed aerial photographs for polygons with land use changes between the two databases to determine the year the change occurred. Figure 4-1 shows a sample of the resulting shapefile attribute table. Table 4-1 shows the percentage of land use by FLUCCS code description at the beginning of the simulation period, and Table 4-2 shows it at the end of the simulation period. We also evaluated aerial photographs and ERPs for potential changes from 2014 to 2015.

Table 4-1 2004 Land Use Percentages

	Estuary Nutrient Region (%)		
Land Use Description	North	Central	South
Airports	2.2	0.0	0.0
Auto parking facilities	0.0	0.0	0.0
Bays and estuaries	0.0	0.0	2.9
Beaches	0.0	0.0	0.0
Cabbage palm	0.0	0.0	0.1
Cabbage palm hammock	0.0	6.5	2.2
Cemeteries	0.2	0.2	0.0
Citrus groves	0.1	1.4	0.5
Commercial and services under construction	0.0	0.5	0.0
Communications	0.0	0.1	0.0
Community recreational facilities	0.1	0.3	0.0
Coniferous pine	0.7	0.0	0.0
Cypress	0.3	0.7	0.0
Disturbed land	0.1	0.2	0.0
Electrical power facilities	0.1	0.0	0.0
Electrical power transmission lines	0.2	0.0	0.0
Emergent aquatic vegetation	0.0	0.0	0.0
Enclosed saltwater ponds	0.0	0.1	11.2
Field crops	0.0	0.1	0.0
Forest regeneration	0.9	0.0	0.1
Freshwater marshes	0.4	0.1	0.4
Golf course	1.6	0.3	0.0
Governmental (to be used for KSC only)	0.0	0.1	0.9
Herbaceous upland non-forested	2.4	2.6	0.6
High density under construction	0.4	0.3	0.0
High-intensity commercial	5.0	1.3	0.0
Horse farms	0.0	0.3	0.0
Hydric pine flatwoods	0.0	0.0	0.0
Improved pastures	0.2	2.0	0.0
Institutional	2.3	0.7	0.0
Lakes	0.0	0.0	0.0
Low-intensity commercial	1.1	1.6	0.0
Mangrove swamp	0.1	0.0	4.6
Marinas and fish camps	0.2	0.3	0.1
Medium density under construction	0.0	0.4	0.0
Mixed scrub-shrub wetland	1.2	2.4	5.3
Mixed upland non-forested	1.2	1.1	0.7
Mixed wetland hardwoods	3.6	5.7	3.6
Non-vegetated Wetland	0.0	0.0	0.1
Ornamentals	0.0	0.4	0.0

	Estuary Nutrient Region (%)		
Land Use Description	North	Central	South
Other heavy industrial	0.5	0.0	0.0
Other light industry	1.0	0.6	0.0
Other treatment ponds	0.7	0.0	0.0
Parks and zoos	0.3	0.1	0.0
Pine flatwoods	3.3	6.8	1.9
Railroads	0.6	0.0	0.2
Reservoirs	2.2	0.7	0.2
Residential, high density	9.6	6.2	0.0
Residential, low density	4.6	7.3	0.0
Residential, med density	33.3	8.7	0.0
Residential, rural	0.0	0.2	0.0
Roads and highways	1.4	2.0	0.0
Rural land in transition	0.6	0.1	0.0
Saltwater marshes	0.1	2.3	27.6
Sewage treatment plants	0.3	0.0	0.0
Shrub and Brushland	1.1	13.3	23.5
Spoil areas	0.3	0.0	0.1
Streams and waterways	0.1	0.4	0.2
Swimming beach	0.1	0.0	0.0
Transportation	0.0	0.0	0.0
Unimproved pastures	0.0	0.5	0.0
Upland hardwood forest	1.1	1.4	4.6
Upland mixed coniferous/hardwood	7.2	17.0	7.8
Water supply plants	0.1	0.0	0.0
Wet prairies	0.2	0.8	0.3
Wetland forested mixed	6.4	1.6	0.3
Woodland pastures	0.1	0.2	0.0
Xeric oak	0.0	0.1	0.0

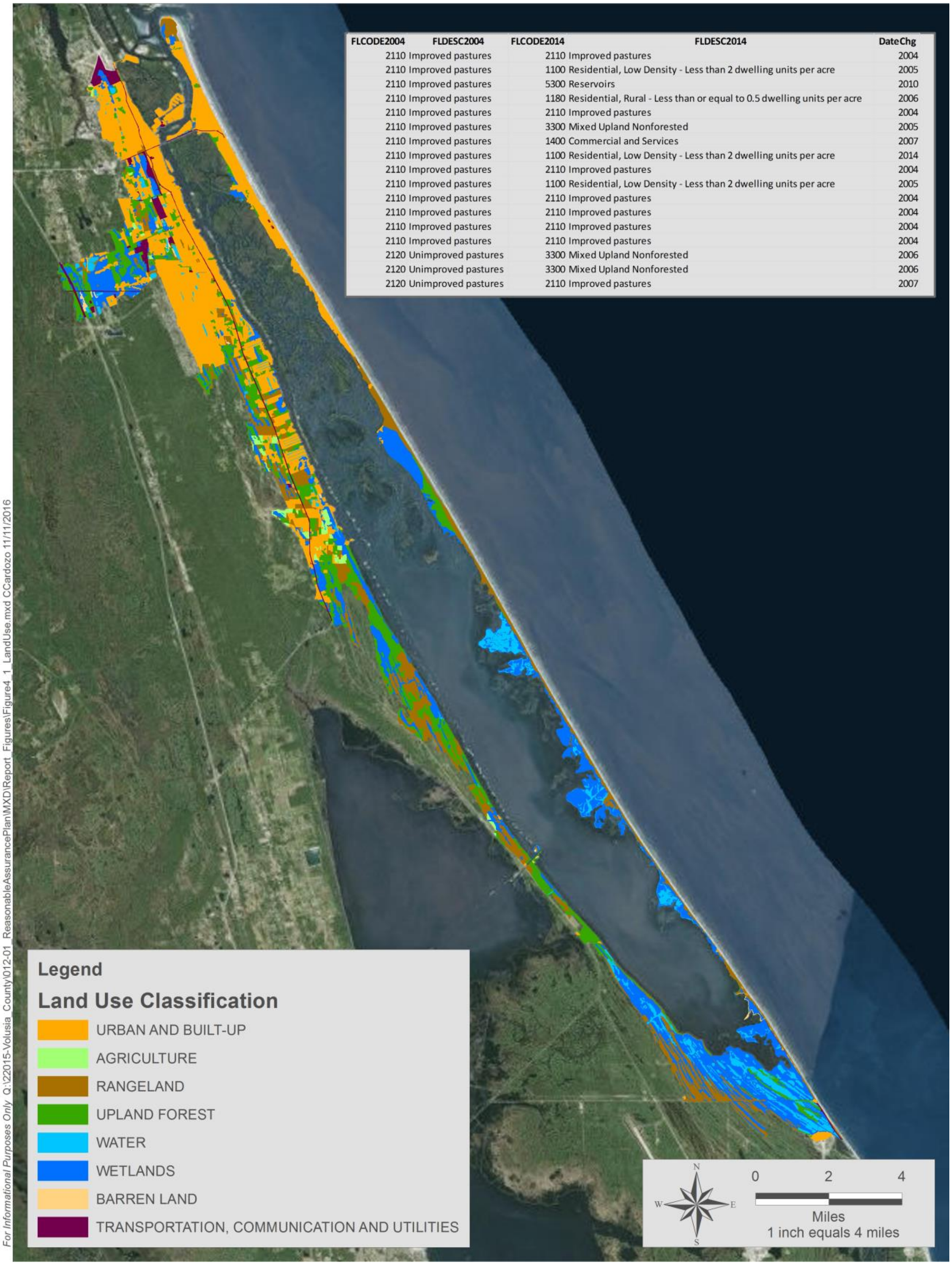
Table 4-2 2015 Land Use Percentages

	Estuary Nutrient Region (%)		
Land Use Description	North	Central	South
Airports	2.3	0.0	0.0
Auto parking facilities	0.0	0.0	0.0
Bays and estuaries	0.0	0.0	3.4
Beaches	0.0	0.0	0.0
Cabbage palm	0.0	0.0	0.1
Cabbage palm hammock	0.0	6.5	2.2
Cemeteries	0.2	0.2	0.0
Citrus groves	0.0	1.3	0.2

Land Use Description	Estuary Nutrient Region (%)		
	North	Central	South
Commercial and services	0.6	0.2	0.0
Commercial and services under construction	0.0	0.2	0.0
Communications	0.0	0.1	0.0
Community recreational facilities	0.1	0.3	0.0
Coniferous pine	0.5	0.0	0.0
Cypress	0.3	0.0	0.0
Disturbed land	0.4	0.1	0.2
Electrical power facilities	0.1	0.0	0.0
Electrical power transmission lines	0.2	0.0	0.0
Emergent aquatic vegetation	0.0	0.0	0.0
Enclosed saltwater ponds	0.0	0.1	11.2
Field crops	0.0	0.1	0.0
Forest regeneration	1.1	0.0	0.1
Freshwater marshes	0.4	0.1	0.4
Golf course	1.6	0.0	0.0
Governmental (to be used for KSC only)	0.0	0.1	0.9
Herbaceous upland non-forested	2.2	2.4	0.6
High density under construction	0.0	0.1	0.0
High-intensity commercial	5.0	1.1	0.0
Horse farms	0.0	0.3	0.0
Hydric pine flatwoods	0.1	0.0	0.0
Improved pastures	0.2	1.5	0.0
Institutional	3.0	0.7	0.0
Lakes	0.0	0.0	0.0
Limerock or dolomite	0.1	0.0	0.0
Low density under construction	0.0	0.1	0.0
Low-intensity commercial	1.0	1.6	0.0
Mangrove swamp	0.1	0.0	4.6
Marinas and fish camps	0.2	0.3	0.1
Medium density under construction	0.0	0.2	0.0
Mixed scrub-shrub wetland	1.1	2.4	5.3
Mixed upland non-forested	1.4	2.5	1.0
Mixed wetland hardwoods	3.5	6.2	3.6
Non-vegetated wetland	0.0	0.0	0.1
Ornamentals	0.0	0.2	0.0
Other heavy industrial	0.4	0.0	0.0
Other light industry	1.1	0.9	0.0
Other recreational	0.0	0.0	0.0
Other treatment ponds	0.7	0.0	0.0
Parks and zoos	0.3	0.4	0.0

Land Use Description	Estuary Nutrient Region (%)		
	North	Central	South
Pine flatwoods	2.8	6.7	1.9
Railroads	0.6	0.0	0.2
Reservoirs	2.5	0.9	0.2
Residential, high density	9.9	6.4	0.0
Residential, low density	5.0	8.0	0.0
Residential, med density	33.6	10.0	0.0
Residential, rural	0.0	0.9	0.0
Roads and highways	1.4	2.0	0.0
Row crops	0.0	0.1	0.0
Rural land in transition	0.0	0.0	0.0
Saltwater marshes	0.1	2.3	27.2
Sewage treatment plants	0.3	0.0	0.0
Shrub and brushland	0.9	13.1	23.5
Spoil areas	0.1	0.0	0.1
Streams and waterways	0.1	0.4	0.2
Surface water collection basin	0.0	0.0	0.0
Swimming beach	0.1	0.0	0.0
Transportation	0.0	0.0	0.0
Upland hardwood forest	1.0	1.4	4.5
Upland mixed coniferous/hardwood	6.5	15.0	7.8
Water supply plants	0.1	0.0	0.0
Wet prairies	0.2	0.9	0.3
Wetland forested mixed	6.2	1.5	0.3
Woodland pastures	0.0	0.2	0.0
Xeric oak	0.0	0.1	0.0

Figure 4-1 Time-Stamped Land Use Shapefile and Attribute Table



FLCODE2004	FLDESC2004	FLCODE2014	FLDESC2014	DateChg
2110	Improved pastures	2110	Improved pastures	2004
2110	Improved pastures	1100	Residential, Low Density - Less than 2 dwelling units per acre	2005
2110	Improved pastures	5300	Reservoirs	2010
2110	Improved pastures	1180	Residential, Rural - Less than or equal to 0.5 dwelling units per acre	2006
2110	Improved pastures	2110	Improved pastures	2004
2110	Improved pastures	3300	Mixed Upland Nonforested	2005
2110	Improved pastures	1400	Commercial and Services	2007
2110	Improved pastures	1100	Residential, Low Density - Less than 2 dwelling units per acre	2014
2110	Improved pastures	2110	Improved pastures	2004
2110	Improved pastures	1100	Residential, Low Density - Less than 2 dwelling units per acre	2005
2110	Improved pastures	2110	Improved pastures	2004
2110	Improved pastures	2110	Improved pastures	2004
2110	Improved pastures	2110	Improved pastures	2004
2110	Improved pastures	2110	Improved pastures	2004
2120	Unimproved pastures	3300	Mixed Upland Nonforested	2006
2120	Unimproved pastures	3300	Mixed Upland Nonforested	2006
2120	Unimproved pastures	2110	Improved pastures	2007

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The next step in processing the land use data was to consolidate the 73 unique FLUCCS codes that exist in the watershed in the 2004 and 2014 GIS layers into a smaller number of land uses for which there are representative EMC data and that have similar runoff characteristics. The basis of the consolidation was largely from the spatial watershed iterative loading (SWIL) modeling for the total maximum daily load (TMDL) revision for Indian River Lagoon and Banana River Lagoon (*Spatial Watershed Iterative Loading (SWIL) Model Methodology Report*, Applied Ecology, 2015). The consolidation is shown in Appendix A. Similarly, EMCs for total nitrogen (TN) and total phosphorus (TP) were taken from the SWIL modeling for the TMDL revision for Indian River Lagoon (IRL) and Banana River Lagoon (BRL). These values were used since no significant watershed water quality data exist for the Mosquito Lagoon, since the IRL is an adjacent watershed with similar land uses and hydrologic characteristics, and since the EMCs from the IRL study have been vetted. BOD_5 was not simulated in the TMDL revision, so we used literature values. Table 4-3 shows the EMCs for the consolidated land uses.

Table 4-3 EMCs for Consolidated Land Uses

Land Use #	Description	BOD	TN	TP
1	Open	1.4	1.15	0.055
2	Forest	1.4	1.15	0.055
3	Pasture	5.1	3.47	0.62
4	Agriculture	3.8	2.61	0.49
5	Golf Courses	3.8	1.87	0.3
6	Low-Density Residential	4.7	1.51	0.18
7	Medium-Density Residential	7.9	1.87	0.3
8	High-Density Residential	11.3	2.4	0.50
9	Low-Intensity Commercial	7.7	1.18	0.18
10	High-Intensity Commercial	11.3	2.4	0.35
11	Light Industrial	7.6	1.2	0.26
12	Heavy Industrial	7.6	1.2	0.26
13	Wetlands	2.63	1.5	0.1
14	Water	1.6	0	0
15	Transportation	5.2	1.37	0.17

4.1.2 Best Management Practices

Consistent with the GIS land use database discussed above, the non-point source BMP feature class tracks temporal changes. Similar to the land use data enhancements, the BMP data incorporate temporal changes with the addition of the date (year) of transition (YR_BUILT) between pre-developed and developed conditions. To maintain consistency with the land use data, the transition dates are generally based on an intersection with the land use data and inheritance of the land use transition date. An exception would be a retrofit BMP.

The necessary attributes for this layer are BMP type and YR_BUILT. BMP type is used to determine removal efficiencies. We determined BMP types by evaluating high-resolution aerial photographs, ERP data, plans provided by stakeholders, and limited field reconnaissance. Areas served by swales were also included in the BMP layer. Programmatic BMPs (e.g., street sweeping and fertilizer ordinances) will be accounted for outside of SIMPLE-Monthly, as will in-Lagoon restoration projects such as dragline ditch restoration. Figure 4-2 shows the spatial coverage of the BMP layer, along with the BMP type. The coverage represents existing BMPs present through July 2016. Table 4-4 shows the removal efficiencies used for BMPs present in the watershed.

Figure 4-2 BMP Layer

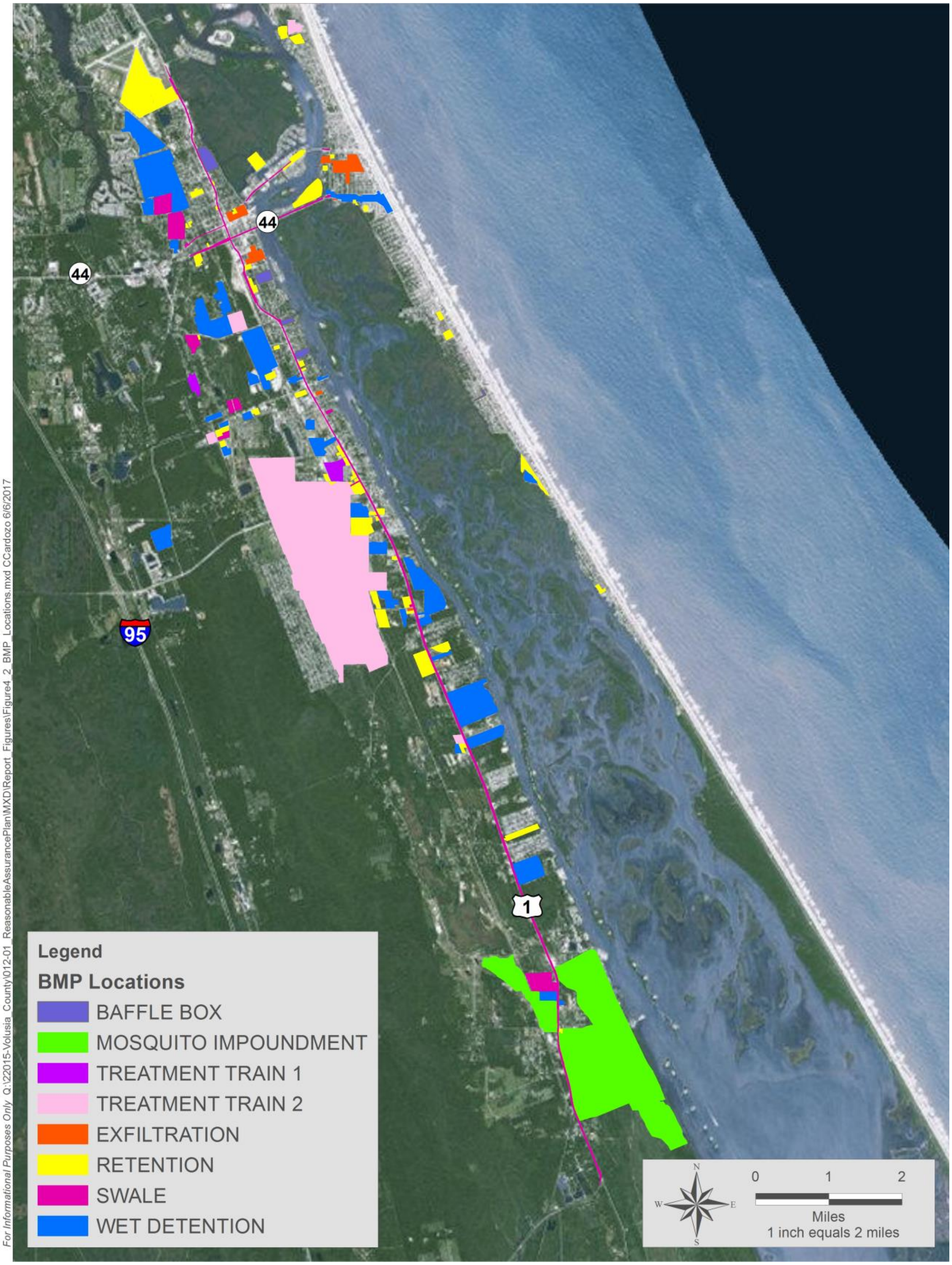

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Table 4-4 BMP Removal Efficiencies

BMP Type	Constituent Removal Efficiency			
	Volume	TN	TP	BOD
Baffle Box (Generation 1)	0	.5	2.3	20
Baffle Box (Generation 2)	0	19	15.5	30
Exfiltration[1,2]	75	75	75	75
Mosquito Impoundment[3]	0	25	50	55
Retention[1,2]	75	75	75	75
Swale[1,2]	25	25	25	25
Treatment Train 1 (swale, wet detention, and possibly baffle box)	25	50	70	75
Treatment Train 2 (swale/retention and wet detention)	75	80	85	90
Wet Detention	20	36	62	70

Notes:

[1]Evaluation of Current Stormwater Design Criteria within the State of Florida. Harper, H. & D. Baker. 2007.
[2]Spatial Watershed Iterative Loading (SWIL) Model Methodology Report. Applied Ecology. 2015.
[3]Based on a 1-week residence time for wet detention and no volume reduction due to groundwater connectivity.

4.2 MODEL ACTION

The Direct Runoff Model operations are as follows:

1. Clip the land use input layer to the selected basins and copy into the output geodatabase. Simplify this layer by compressing each land use polygon (for both pre-development and developed land use) into one of the land use types where EMC data are available. Use the Lookup_LandUseCompress table in the template geodatabase to do so.
2. Clip the input soils layer to the selected basins and copy into the output geodatabase. Intersect the soils layer with the clipped land use layer. Simplify the soil input layer by compressing dual hydrologic soil groups into one of four hydrologic soil groups, based on the most recent land use. Use the Lookup_SoilCompress table in the template geodatabase.
3. Clip all remaining Direct Runoff input layers to the selected basins and copy them into the output geodatabase.
4. Perform a GIS union between the Land Use, Rain Gauge Pixel, Soils, BMP, and Basin feature classes in the output geodatabase. The union results in a new feature class of many polygons called *DirRun,* each carrying all attributes from the included layers.
5. For each polygon in DirRun the model calculates the following equation for each month of the simulation (results are in lb per month for each pollutant):

   *Runoff (inches) * Polygon Area (acres) * EMC (mg/L) * (1-BMP efficiency) * Unit Conversion Factor*

   Example of TN loading for Medium Density Residential treated by wet detention: 2.0 in * 2.0 acre * 2.07 mg/L * (1.0 – 0.27) * 0.2266 = 1.37 lb TN

6. For each month, the results are summed over each basin and reported to an output table. Results are also available in the units of lb/acre/month.

Depending on what month/year the model is simulating, the above equation should use the EMC and runoff values appropriate to whichever land use exists at that time. This logic is important to most of the modules for SIMPLE-Monthly and will be referenced when applicable in the remainder of this report. The model logic is as follows:

- If simulation time < YR_BUILT, use pre-development land use EMC.
- If simulation time >= YR_BUILT, use developed land use EMC.

Each item in the above equation is found in lookup tables in the template geodatabase or the DirRun feature class. The conversion factor is specific to this equation to create results in the units of lb/month, but the user can change this number in an editable .xml file of settings.

4.3 REQUIRED DATA

- User-Input Spatial Data (required field):
  - Basin boundaries (BasinID, area).
  - Soils (Hydrologic Soil Group, area).
  - Time-stamped Land Use (FLUCCS Code, YR_BUILT, area).
  - Time-stamped BMPs (YR_BUILT, area).
  - Rainfall Gauge Polygons (PixelID).
- Reference Tables in Template Geodatabase:
  - Lookup_LandUseCompress: *relate* FLUCCS land use *to* EMC land use *for finding* EMC land use.
  - Lookup_SoilCompress: *relate* hydrologic soil group *to* land use *for redefining* dual class hydrologic soil groups.
  - HydrologyTimeSeries: *relate* unique rain gauge/land use/soil/BMP/Date combination *for finding* runoff volume.
  - Lookup_EMC: *relate* EMC land use *to* pollutant *for finding* concentrations for the following constituents:
    - Biochemical Oxygen Demand (BOD5) (mg/L).
    - Total Nitrogen (as N) (mg/L).
    - Total Phosphorus (mg/L).
  - Lookup_BMPEfficiency: *relate BMP type to* pollutant *for finding* removal rates.
  - Lookup_BMPTreatment: *relate BMP type to* coded value *used with* BMPEfficiency table.
- Results Tables in Template Geodatabase:
  - DirectRunoffLoadfromRainfall_lb_month.
  - DirectRunoffLoadfromRainfall_lb_acre_month.

5 BASE FLOW MODULE

5.1 DATA AND MODEL DEVELOPMENT

Base flow volumes are calculated as part of the hydrologic model described in Section 2. Base flow was calculated for each unique rain gauge/land use/soil combination for the dates available for simulation using the continuous simulation hydrologic model described earlier in this report. This base flow portion of the model uses methodology similar to SWMM hydrology – which has a shallow groundwater routine – but with a better predictive ET calculation. We used this method because it could easily be incorporated into the same hydrology preprocessing step, it is based on established routines, and it keeps infiltration and base flow coupled into the same sets of equations.

Constant concentrations for base flow are used in SIMPLE-Monthly. The nutrient concentrations are based on SWIL modeling for the TMDL revision for the IRL and BRL for reasons similar to the selection for EMCs. Although variation likely exists in the base flow concentrations due to a number of factors such as land use, BMPs, and soil characteristics, insufficient monitoring exists to confidently account for the variation. Therefore, the concentrations used for base flow should be considered as watershed-wide averages. Base flow concentrations are summarized in Table 5-1.

Table 5-1 Base Flow Concentrations

Constituent	TN	TP	BOD
Concentration (mg/L)	0.89	0.12	2.0

5.2 MODEL ACTION

The Base Flow Module operations are as follows:

1. Perform Steps 1 through 4 of the Direct Runoff Module if the DirRun feature class has not yet been created. Use the same model logic to account for simulation time.
2. For each polygon in DirRun, the model calculates the following equation for each month of the simulation, with results shown in pounds per month for each pollutant:

   *Base Flow (inches) * Polygon Area (acres) * Base Flow Concentration (mg/L) * Unit Conversion Factor*

3. For each month, the results are summed over each basin and reported to an output table. Results are also available in the units of lb/acre/month.

5.3 REQUIRED DATA

- User Input Spatial Data (required field):
  - Major drainage basin and bay boundaries (BasinID, area).
  - Soils (Hydrologic Soil Group, area).
  - Time-stamped Land Use (FLUCCS Code, YR_BUILT, area).
  - Rain gauge polygon (Pixel ID).

- Reference Tables in Template Geodatabase:
    - Lookup_LandUseCompress: *relate* FLUCCS land use *to* EMC land use *for finding* EMC land use.
    - Lookup_SoilCompress: *relate* hydrologic soil group *to* land use *for redefining* dual class hydrologic soil groups.
    - HydrologyTimeSeries: *relate* unique rain gauge/land use/soil/BMP/Date combination *for finding* base flow volume.
    - Lookup_BaseflowConcentration: universal concentrations for three simulated constituents.
- Results Tables in Template Geodatabase:
    - BaseflowLoad_lb_month.
    - BaseflowLoad_lb_acre_month.

6 POINT-SOURCE MODULE

6.1 DATA AND MODEL DEVELOPMENT

Two significant wastewater treatment plants (WWTPs) are permitted to discharge treated effluent into the Mosquito Lagoon watershed:

- Edgewater (National Pollutant Discharge Elimination System [NPDES] Permit FL0021431).
- New Smyrna Beach (NPDES Permit FL0172090).

The following excerpts from the City of Edgewater's latest NPDES wastewater permit renewal describe the Edgewater WWTP and its surface water discharge:

> *An existing 2.75 MGD annual average daily flow (AADF) permitted capacity advanced domestic wastewater treatment (AWT) plant consisting of influent screening, grit removal, biological nutrient removal (Bardenpho Process), chemical feed facilities, secondary clarification, tertiary filtration, high level disinfection, with dechlorination and post aeration for surface water discharge, and with aerobic digestion of biosolids for Class B stabilization. The permit includes renewal or replacement of most of the major equipment at the WWTF, addition of a third clarifier, biosolids centrifuge, and generator.*
>
> ***Surface Water Discharge D-001****: An existing 0.83 MGD annual average daily flow discharge to Indian River North (Mosquito Lagoon), Class III Marine waters (WBID# 2924B2), which is approximately 150 feet in length and discharges at a depth of approximately 6.5 feet. The point of discharge is located approximately at latitude 28°59'23" N, longitude 80°53'59" W.*

The following excerpts from the City of New Smyrna Beach's latest NPDES wastewater permit renewal describe the New Smyrna Beach WWTP and its surface water discharge:

> *An existing 7.0 MGD annual average daily flow (AADF) permitted capacity advanced domestic wastewater treatment plant consisting of influent screening, grit removal, 5-stage biological nutrient removal (Bardenpho) system, secondary clarification, chemical feed facilities (including Micro-C), filtration, and chlorination, followed by dechlorination for surface water discharge, and dewatering of biosolids.*
>
> ***Surface Water Discharge D-001****: An existing 0.999 MGD annual average daily flow back-up discharge to Indian River North (Mosquito Lagoon), Class III Marine waters, (WBID# 2924B2) which is approximately 10 feet in length and discharges at a depth of approximately 7.6 feet. The point of discharge is located approximately at latitude 29°'1'50" N, longitude 80°55'2" W.*

Both WWTPs have discharged under their permitted limits in terms of flow and concentrations.

Four NPDES concrete batch plants also exist within the Mosquito Lagoon watershed:

- Florida Rock-Edgewater (NPDES Permit FLG110765).
- Balduf Concrete (NPDES Permit FLG110798).
- Titan Florida Edgewater RMP (FLG 110583).
- CEMEX Construction Materials Florida, LLC – New Smyrna Beach Ready Mix Plant (FLG110670).

The concrete batch plants are permitted under generic permits and are not required to submit discharge monitoring reports (DMRs). The discharges from these plants are not considered significant for the purposes of this project and are not included in the model.

Both WWTPs discussed above plus a third WWTP operated by Volusia County Utilities (NPDES Permit FLA017413) apply reuse within the watershed. Although much of the reuse is lost to evapotranspiration, a portion of the pollutant loads is likely discharged to Mosquito Lagoon. In the absence of definitive data supporting what portion reaches Mosquito Lagoon, we used estimates from the Tampa Bay Reasonable Assurance Plan. In the Plan, reuse volumes were reduced by 90 to 95 percent to account for losses and assimilation. We chose 95 percent for our calculations because the land application rates in this watershed are relatively low. Additionally, only 10 percent of the Volusia County Utilities reuse area is within the Mosquito Lagoon watershed, so we reduced the loads from that source by another 90 percent.

Monthly wastewater effluent/reuse data are applied as model input in the form of a point shapefile containing average flows and concentrations for the three WWTPs under operation or applying reuse in the watershed. Spatial location of the loads is based on effluent/reuse disposal location. Monthly data reported in each WWTP's DMR were incorporated into a time series of flows and concentrations within a lookup table (Lookup_PointSource) housed in the template geodatabase. This lookup table is related to a point-source coverage by an ID field, PS_ID.

Monthly flow and concentration data were obtained from FDEP. Where values were not available, various codes explained the reasons for missing data. The codes used were "C", "B", "9", "E" and blank. According to FDEP, "C" indicates there was no discharge, "9" means that monitoring was not required, "B" indicates values below detection, and "E" was to be treated the same as a blank, meaning no value was recorded. As a result of this feedback, we set all "C" values to 0 since no discharge was detected. For months with a "9", a blank, or an "E," we used a value based on the average of the same month over all other years. For months with a "B," we set the value as half of the detection limit for that particular constituent. Table 6-1 summarizes the annual discharge rates used in the model.

Table 6-1 Annual Point Source Discharge Rates

	Annual Discharge Rate (MGD)				
Year	Edgewater Surface	Edgewater Reuse	New Smyrna Beach Surface	New Smyrna Beach Reuse	Volusia Southeast Reuse
2004	0.61	0.05	1.16	0.25	0.002
2005	0.99	0.03	1.39	0.22	0.002
2006	0.58	0.05	0.27	0.28	0.001
2007	0.62	0.06	0.32	0.29	0.001
2008	0.76	0.04	0.60	0.26	0.002
2009	0.81	0.05	0.13	0.23	0.002
2010	0.58	0.06	0.00	0.35	0.002
2011	0.42	0.08	0.00	0.31	0.002
2012	0.57	0.07	0.00	0.35	0.002
2013	0.49	0.08	0.00	0.24	0.001
2014	0.70	0.09	0.00	0.22	0.002
2015	0.67	0.08	0.00	0.34	0.002

6.2 MODEL ACTION

The Point-Source Module operations are as follows:

1. Clip the point source input layer to the selected basins and copy into the output geodatabase. Use the Lookup_PointSource table in the template geodatabase to determine concentrations and flows for each simulation month.
2. For each point source, the model calculates the following equation for each simulation month:

*Flow (gpm) * Concentration (mg/L) * Unit Conversion Factor*

3. For each month, the results are summed over each basin and reported to the output table. Results are also available in the units of lb/acre/month.

6.3 REQUIRED DATA

- User Input Spatial Data (required field):
  - Basins (BasinID, area).
  - PointSources (PS_ID).
- Reference Tables in Template Geodatabase:
  - Lookup_PointSource: *relate* PS_ID) *for finding* Flow, concentrations.
- Results Tables in Template Geodatabase:
  - PointSourceLoad_lb_month.
  - PointSourceLoad_lb_acre_month.

7 SEPTIC TANK MODULE

7.1 DATA AND MODEL DEVELOPMENT

Some portions of the watershed are served by septic systems. For the SIMPLE-Monthly model, parcels served by septic systems are based on two Florida Department of Health (DOH) datasets and extensive input by Volusia County DOH professionals. The 2015 DOH parcel-based dataset has a WW (i.e., wastewater) attribute that indicates if the parcel is served by sewer, septic, or unknown. The parcels attributed to septic systems are generally labeled as Known Septic or Likely Septic. A previous analysis performed by Volusia County Utilities indicated that the number of septic systems in the watershed should be roughly 3,000. Using just the Known Septic records in the 2015 DOH dataset resulted in significantly fewer than 3,000, and using Known Septic and Likely Septic records resulted in significantly greater than 3,000. As a result, we evaluated the second DOH dataset, which is a point file of septic tank permits from the last several decades. This dataset only has approximately 1,000 points in the watershed. However, it does provide insight into general locations where septic systems likely exist.

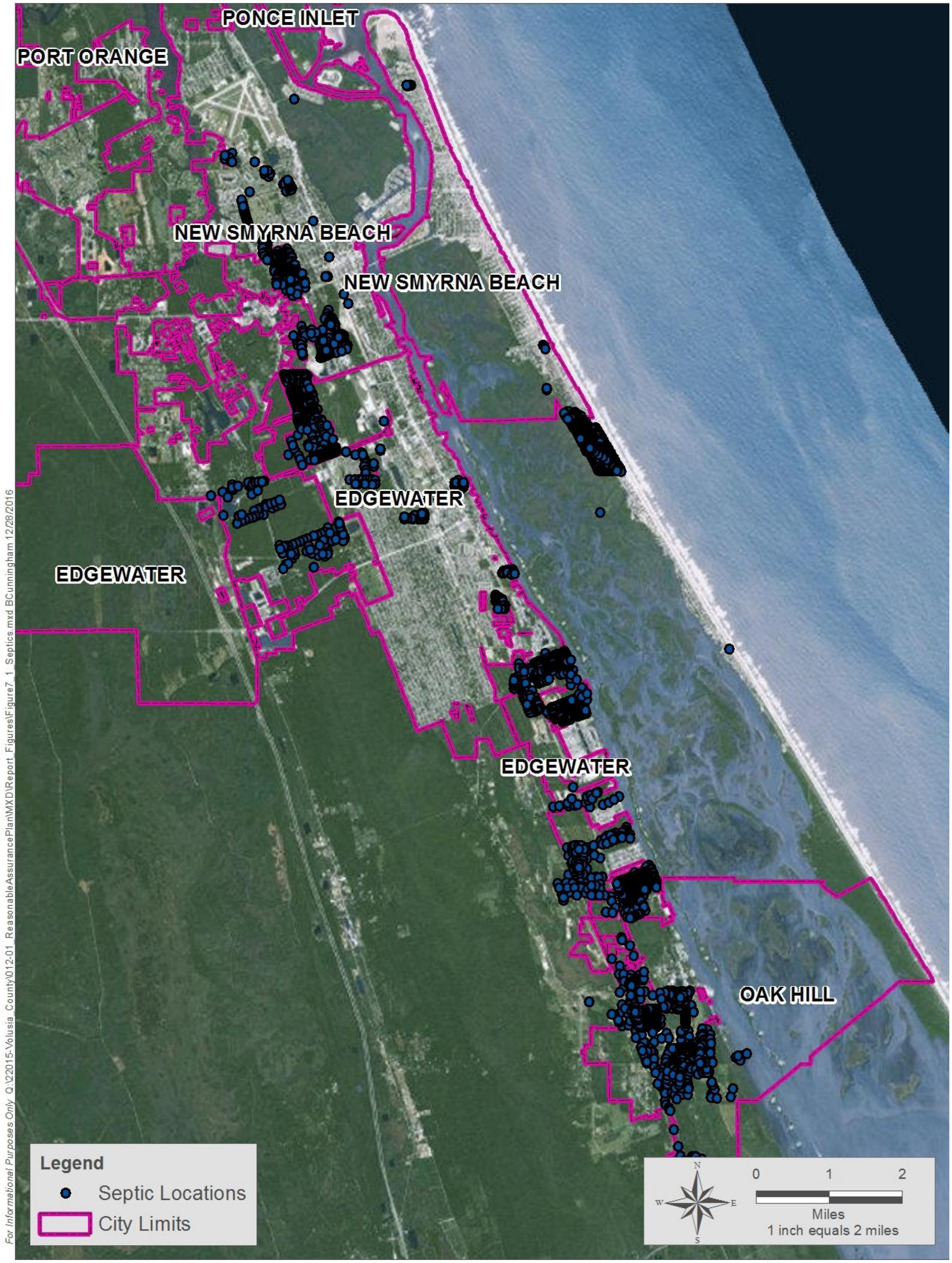
Since septic systems possibly contribute a significant nutrient load to Mosquito Lagoon, it was important to create a more accurate septic system dataset. We accomplished this by receiving detailed input from Volusia County DOH professionals who are very familiar with septic systems in the watershed. In the few cases where they were unsure, they performed field reconnaissance to verify their presence. Of the 9,797 parcels in Volusia County – the only County in the watershed that has septic systems – 2,799 were ultimately identified as having septic systems. A small percentage of these parcels have multiple buildings and likely multiple septic systems, so the total number of septic systems is relatively close to the roughly 3,000 estimated previously by Volusia County Utilities. The septic system dataset likely still contains some small inaccuracies, but the inaccuracies should not have a significant impact on the overall pollutant loading results. Figure 7-1 shows the areas determined to be served by septic systems.

We assigned average flow rates based on whether the tank intersected with a residential land use or nonresidential land use such as schools, institutions, or commercial areas. Flow rates throughout the watershed were assumed to be 100 gallons per day per capita, with an average of 2.5 people per household (resulting in 250 gallons per day for each tank) for residential units (Great Lakes-Upper Mississippi River Board of State Public Health and Environmental Managers, 1990). Non-residential flows vary by the type of land use they serve; however, we calculated a value representative of the entire watershed. The calculation was based on the wastewater fee structure used by New Smyrna Beach (http://ucnsb.org/docs/default-source/customer-service/customer-service-docs/rcfrevisedjan1st2016.pdf).

Rather than only employing a single set of concentrations for working or failing septic tanks, SIMPLE-Monthly can use three sets of concentrations for each scenario. Each tank can be assigned a high, medium, or low concentration depending on the type of soil on which the tank is located, its distance from the nearest conveyance, and other factors. For this analysis, we used two sets of concentrations. The lower concentrations were for septic tanks in excess of approximately 1,000 feet from the Mosquito Lagoon or a ditch/canal that is cut deep enough to likely intercept the groundwater table. Lower concentrations were also used for areas where the intercepted base flow is treated in a surface water storage area before discharge into Mosquito Lagoon. Low and high concentrations were based largely on results of the Hazen and Sawyer study (2015) for the DOH. We used a return fraction of 0.8 based on results from the continuous simulation model to account for volume losses due to evapotranspiration. We used a failure rate of 8 percent based on data from a previous study in Sarasota County in an area with similar conditions (CDM, 1993).

Although septic flows and loads typically manifest in base flow in the watershed, they are kept separated in the model calculations so that they can be reported as an individual component.

Figure 7-1 Areas Determined to be Served by Septic Systems



7.2 MODEL ACTION

The Septic Tank Module operations are as follows:

1. Clip the land use input layer to the selected basin and copy into the output geodatabase. Simplify this layer by compressing each land use polygon (for both pre-development and developed land use) into one of 15 land use types where EMC data are available. Use the Lookup_LandUseCompress table in the template geodatabase to do so.
2. Clip the septic input layer to the selected basin.
3. Perform a GIS intersection between the Land Use, Septic, and Basin feature classes in the output geodatabase. This intersection results in a new feature class, and is labeled Septic, with each point carrying all attributes from the included layers.
4. For each grouping of septic tanks in each concentration classification (either 1 or 3, as designated by the field CONC_ID), the model will calculate the following equation:

   *{[Number of Tanks * Flow (cfs) * Concentration for Working Tanks (mg/L) * Unit Conversion Factor * (1-Average Failure Rate)] + [Number of Tanks * Flow (cfs) * Concentration for Failing Tanks (mg/L) * Unit Conversion Factor * Average Failure Rate]} * ReturnFraction*

   Flow changes depending on the LU_SEP field, which is determined after intersection with Land Use and designates the tank as either residential or non-residential.

5. For each month the results are summed over each basin and reported to an output table. AppliedVolume represents the amount of water applied and Volume represents the fraction that reaches the downstream outfall. All loads are based on the Volume. Results are also available in the units of lb/acre/month.

Each item in the above equation is found in lookup tables in the template geodatabase or the Septic feature class. The conversion factor is specific to this equation to create results in the units of lb/month, but the user has the option to change this number in an editable .xml file of settings.

7.3 REQUIRED DATA

- User Input Spatial Data (required field):
  - Major drainage basin and bay boundaries (BasinID, area).
  - Soils (Hydrologic Soil Group, area).
  - Time-stamped Land Use (FLUCCS Code, YR_BUILT, area).
  - Septic Tanks (location, FAILURE, CONC_ID).
- Reference Tables in Template Geodatabase:
  - Lookup_LandUseCompress: *relate* FLUCCS land use *to* EMC land use *for finding* EMC land use.
  - Lookup_SoilCompress: *relate* hydrologic soil group *to* land use *for redefining* dual class hydrologic soil groups.
  - Lookup_SepticConcentration: *relate* CONC_ID *for finding* low, medium, and high concentrations for both working and failing tanks. Only two concentrations were used for this study, as discussed above.

- Results Tables in Template Geodatabase:
  - SepticLoad_lb_month.
  - SepticLoad_lb_acre_month.

8 ATMOSPHERIC DEPOSITION

Total atmospheric deposition is defined as the sum of wet deposition (rainfall) and dry deposition (gaseous constituent interaction and dust fallout) directly to the surface of the lagoon system. Four data types are needed to estimate total atmospheric deposition to the surface of a water body:

- An estimate of the hydrologic load directly to the surface via precipitation.
- An estimate of the pollutant concentration in that precipitation.
- An estimate of dry deposition from empirical data or model-based estimates.
- An estimate of the surface area of the water body.

The segment-specific hydrologic loads to the surface of the Mosquito Lagoon ENRs via precipitation for the 2004-2015 period were based on the rainfall estimates to each ENR calculated from the Theissen polygons developed for the rainfall sites,in a similar manner to direct runoff.

Long-term data for nitrogen concentrations in rainfall (wet deposition) were available from NADP Site FL99 at the Kennedy Space Center. Monthly precipitation-weighted nitrogen concentrations were obtained for 2004-2015 from the Site. The monthly wet TN deposition was developed by ENR using these data, along with the monthly rainfall over each ENR, as described above. For each month, the rainfall volume and concentration were multiplied to develop the load for each constituent.

At the FL99 Site, no measurements of phosphorus concentrations in rainfall were available, and no measurements to allow estimation of dry deposition of either nitrogen or phosphorus were taken. Additional atmospheric deposition data are available from the SJRWMD Site IRL141 (wet deposition) at Coconut Point in Sebastian Inlet, and from the Clean Air Status and Trends Network (CASTNET) (dry deposition) at the same location. These data were available from August 2001 to December 2006.

Based on the available data, only TN wet deposition was measured for the entire period (FL99). To develop the wet TP, dry TN, and dry TP loads for the entire period, relationships between wet TN load and these other components were developed as follows.

1. We derived a relationship between the wet TP and TN deposition at site IRL141. We applied this relationship using the long-term wet TN deposition at FL99 to derive a long-term wet TP deposition.
2. The CASTNET data provided an estimate of dry TN flux, and combined with the wet TN deposition at IRL141, we derived annual ratios of dry:wet TN deposition. We used the average annual dry:wet TN ratio of 0.28 along with the wet TN deposition at FL99 to estimate dry TN deposition over the entire period.
3. In a similar manner, we combined the CASTNET data for dry TP flux with the wet TP deposition at IRL141 to develop annual ratios of dry:wet TP deposition. The average dry:wet TP ratio was 0.21. We used this ratio and the wet TP deposition estimated at FL99 (Step 1 above) to estimate dry TP deposition over the 2004-2015 period.

9 OUTPUT REPORTING AND RESULTS

In SIMPLE-Seasonal, model output consists of 31 tables (of seasonal or annual loads) and several feature classes. SIMPLE-Monthly provides 18 time-series output tables and additional feature classes such as rain gage pixels. Considerable amounts of spatial output data are available, but the user must build the display of desired output from scratch. Summary data are provided in this section.

Totals for flow volume, BOD_5, TN, and TP are shown in Figures 9-1 through 9-4, respectively, for the three ENRs.

Figure 9-1 Total Flow Volume by ENR for the Simulation Period

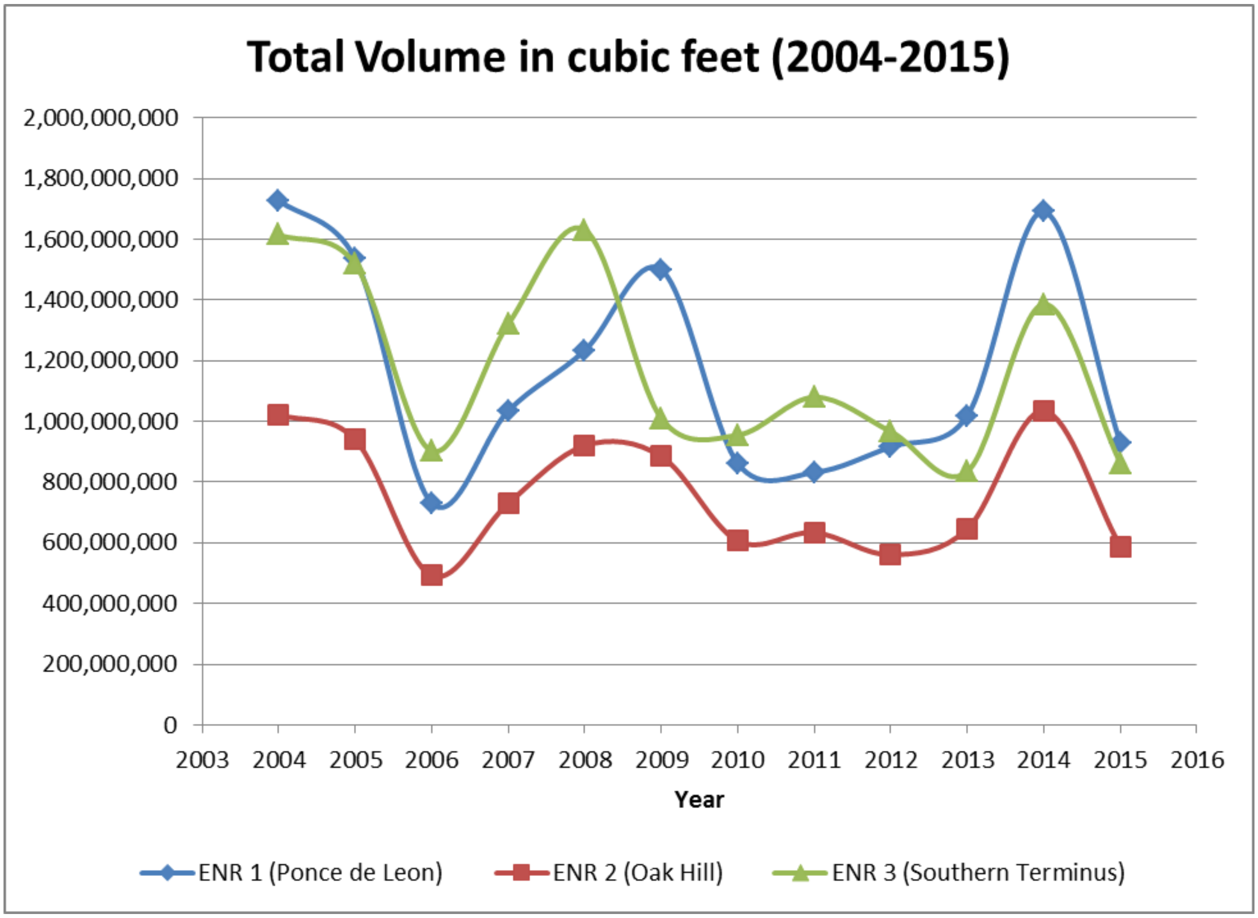


Figure 9-2 BOD Load by ENR for the Simulation Period

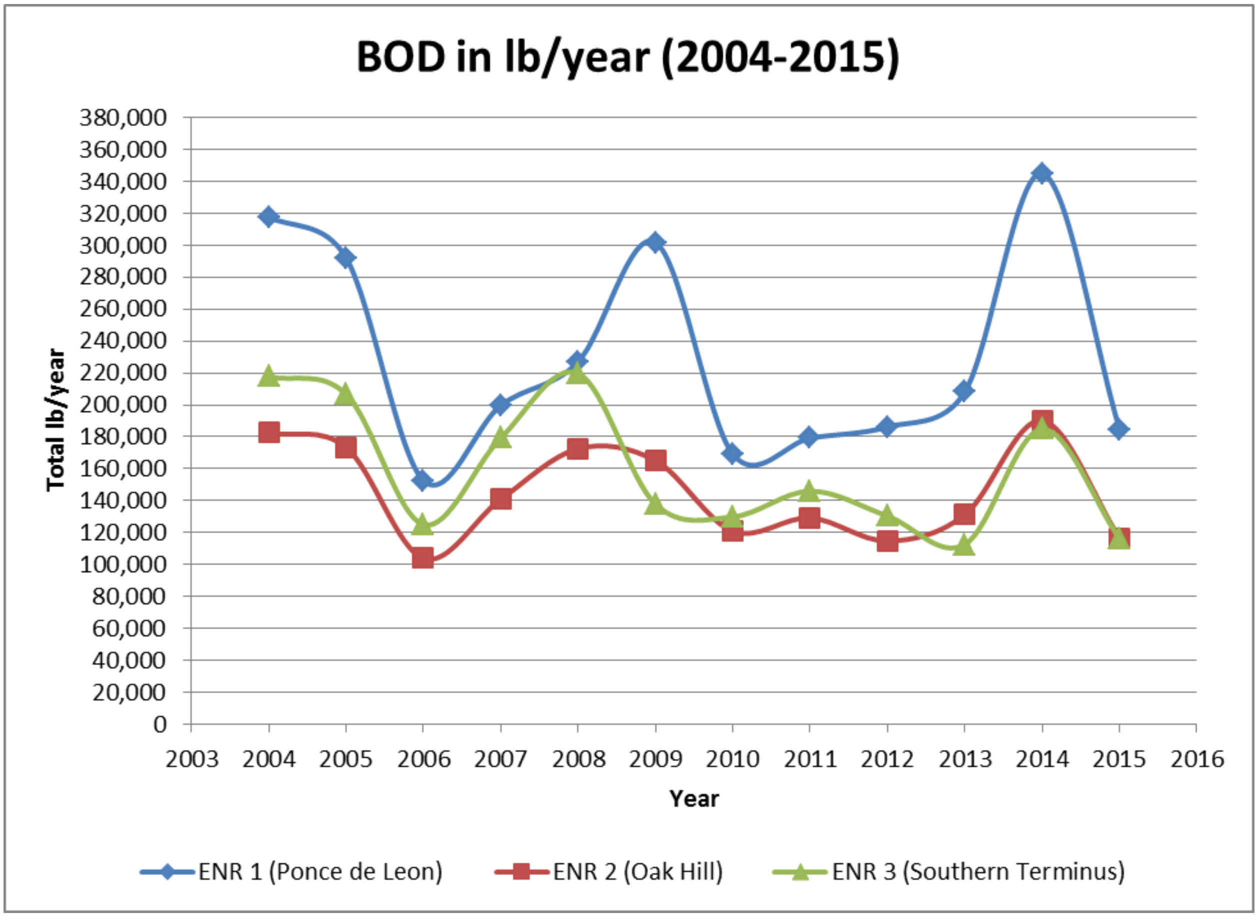


Figure 9-3 TN Load by ENR for the Simulation Period

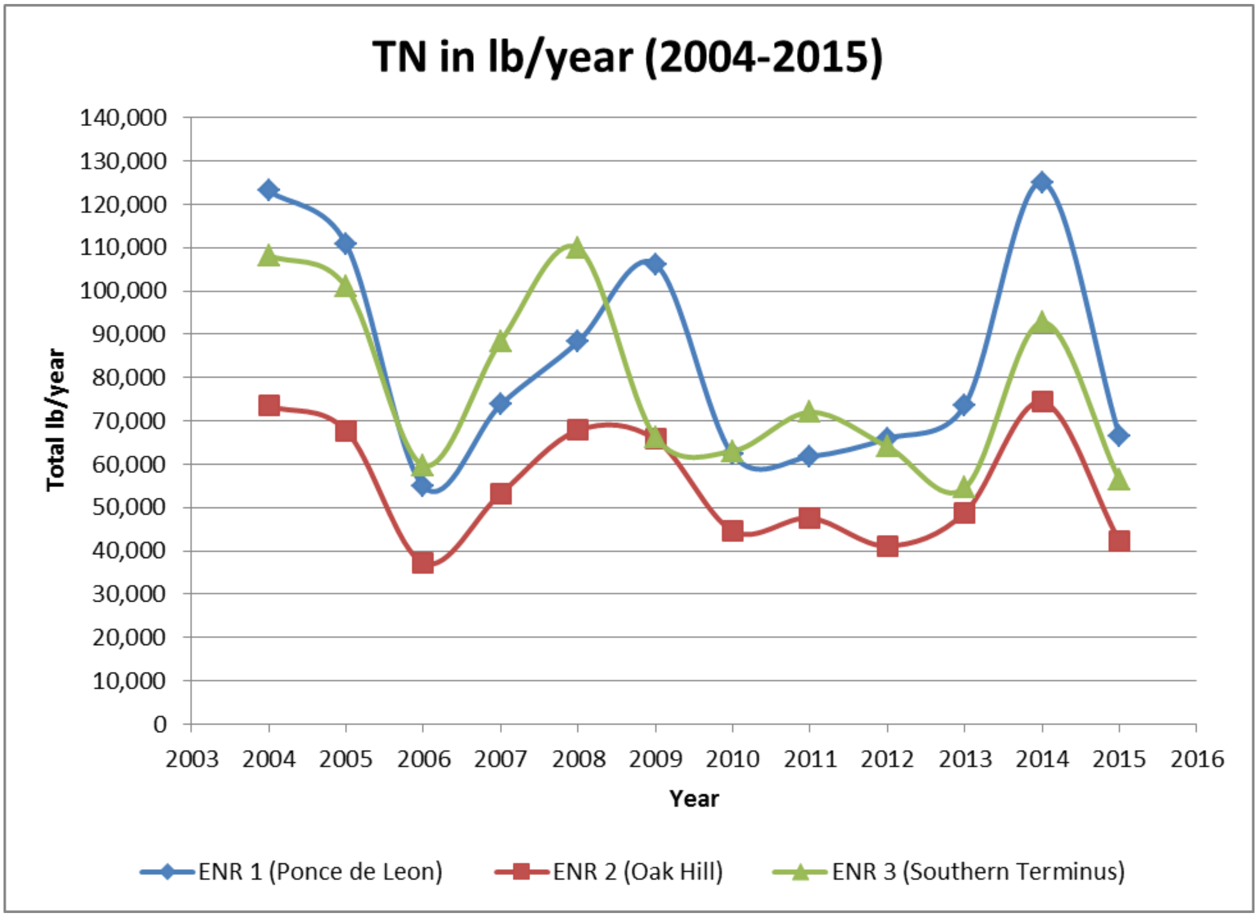
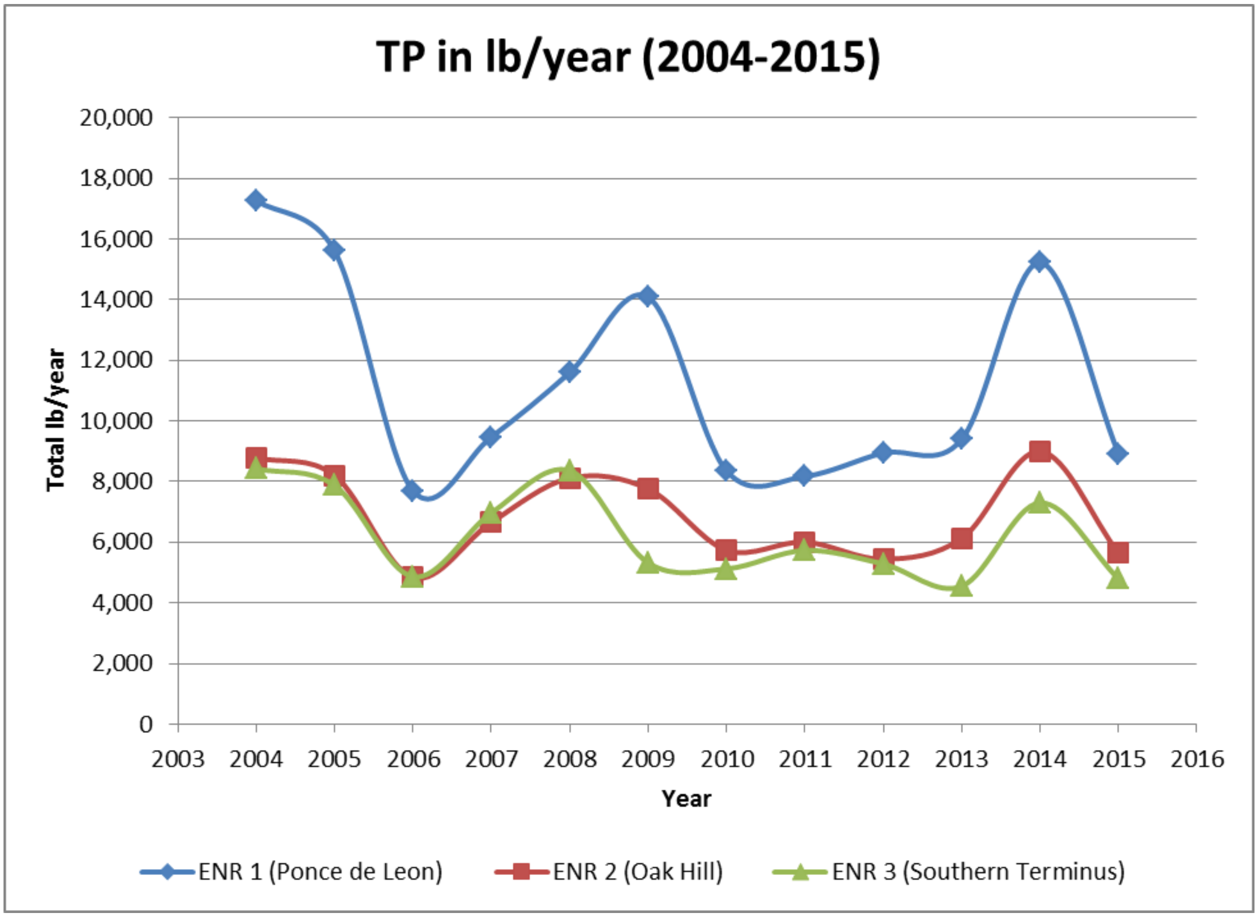


Figure 9-4 TP Load by ENR for the Simulation Period



Percentages of the components of flow volume, BOD_5, TN, and TP for ENR 1 (northernmost ENR) are shown in Figures 9-5 through 9-8, respectively.

Figure 9-5 Percentages of Total Flow Volume for ENR 1 for the Simulation Period

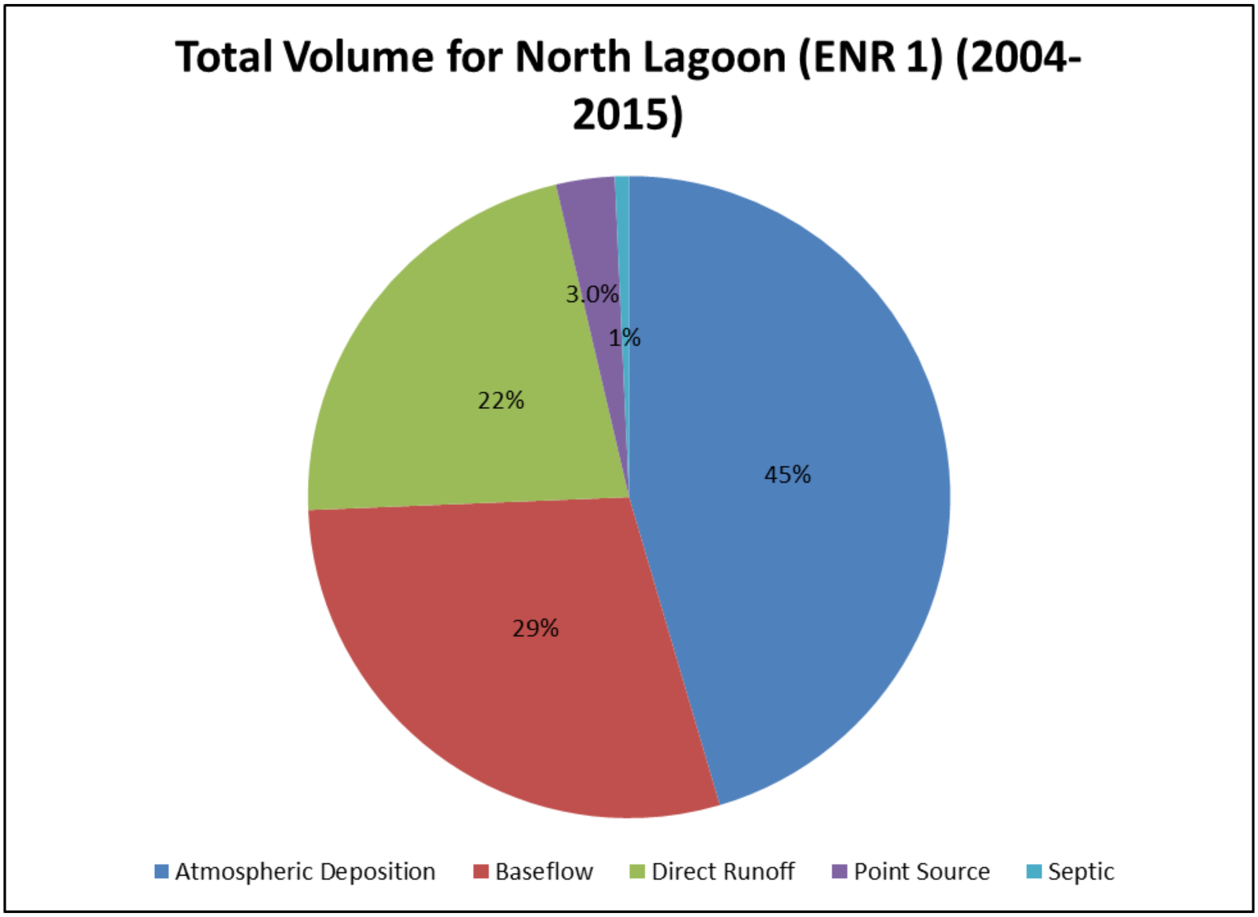


Figure 9-6 Percentages of BOD for ENR 1 for the Simulation Period

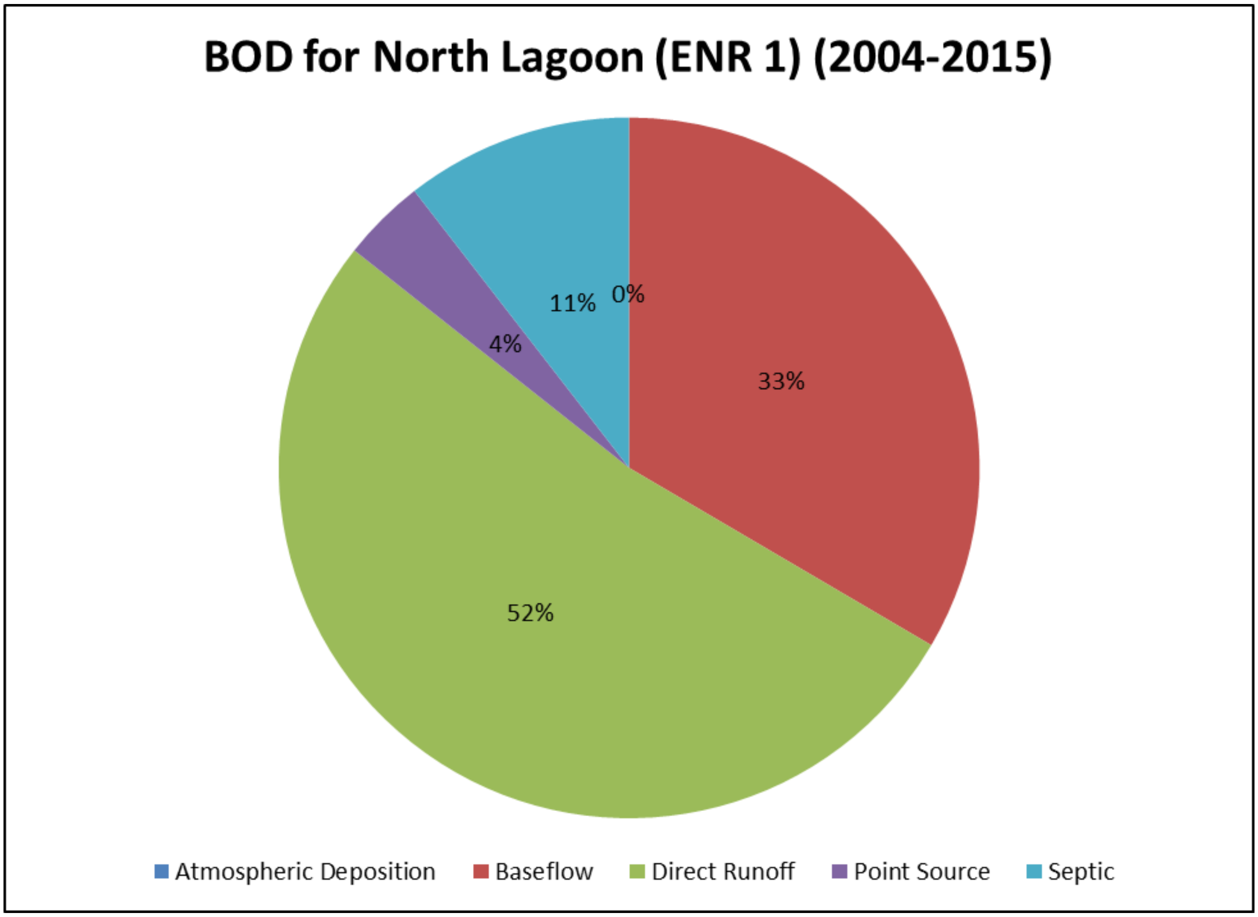


Figure 9-7 Percentages of TN for ENR 1 for the Simulation Period

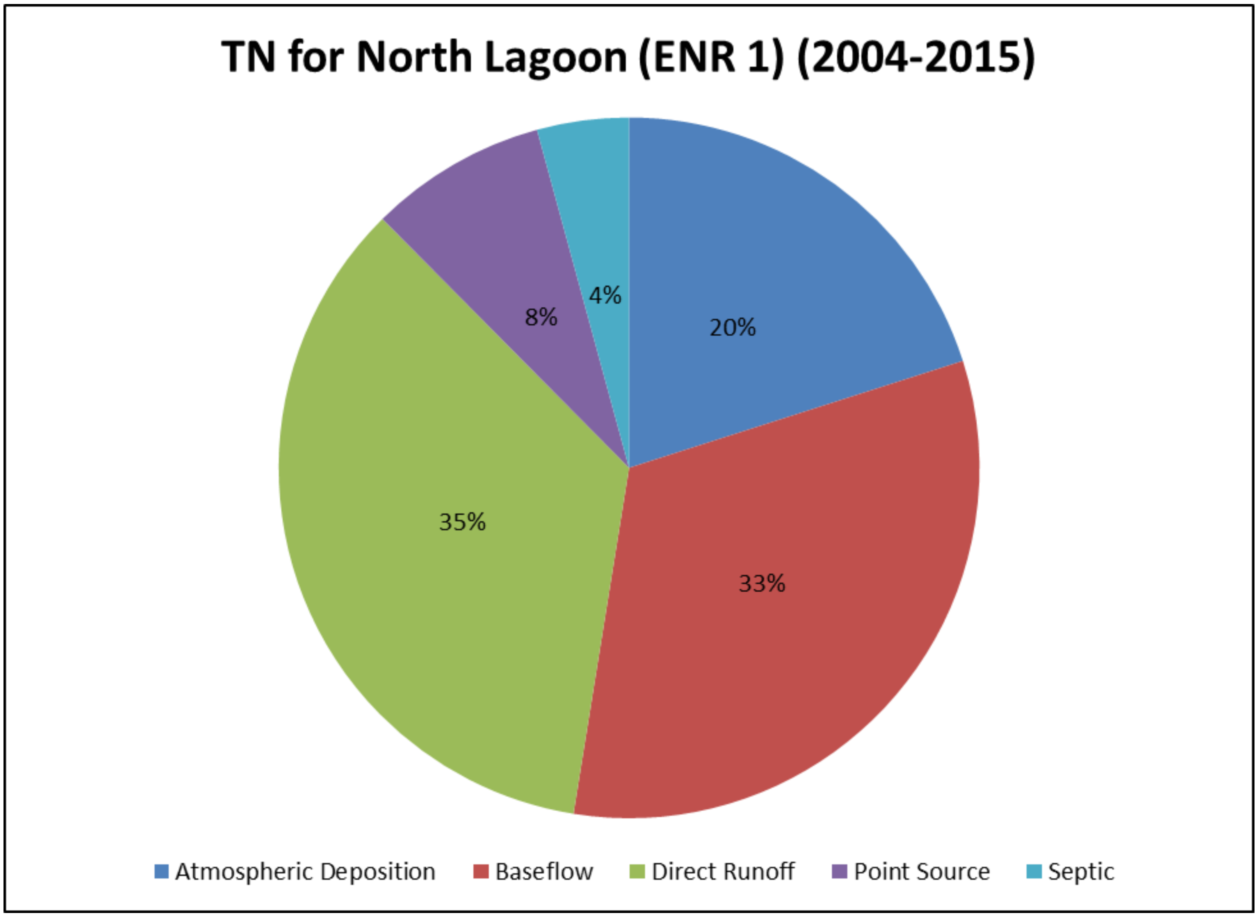
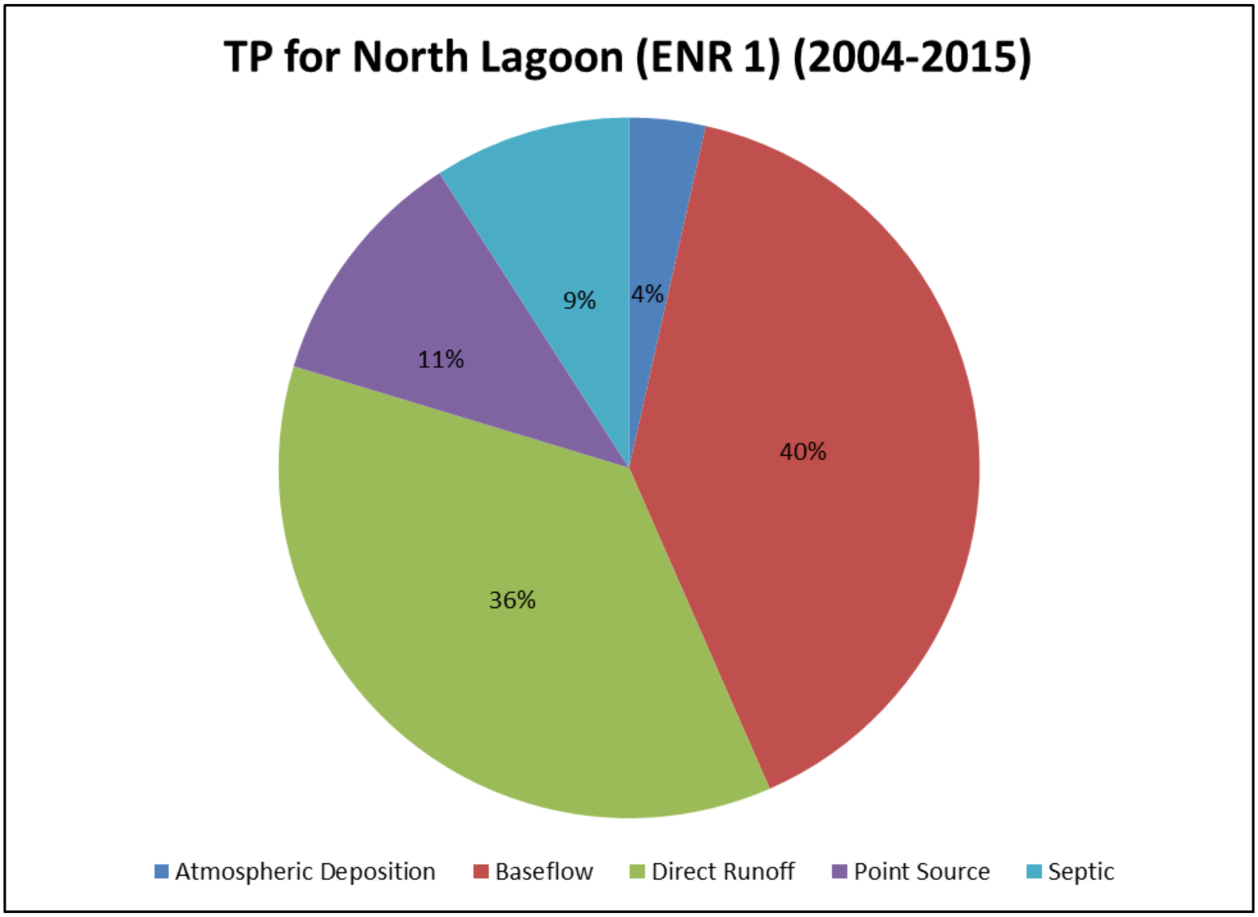


Figure 9-8 Percentages of TP for ENR 1 for the Simulation Period



Percentages of the components of flow volume, BOD_5, TN, and TP for ENR 2 (central ENR) are shown in Figures 9-9 through 9-12, respectively.

Figure 9-9 Percentages of Total Flow Volume for ENR 2 for the Simulation Period

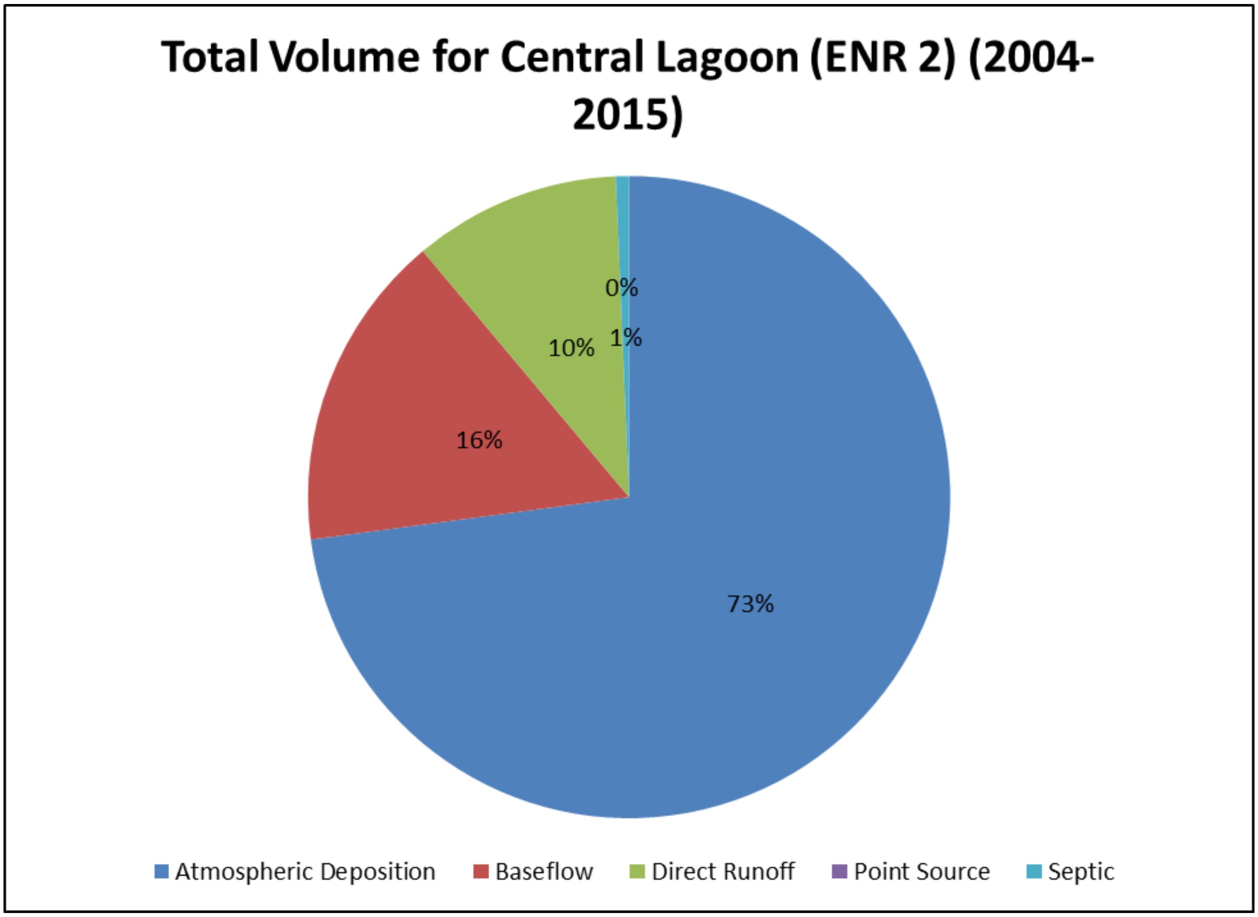


Figure 9-10 Percentages of BOD for ENR 2 for the Simulation Period

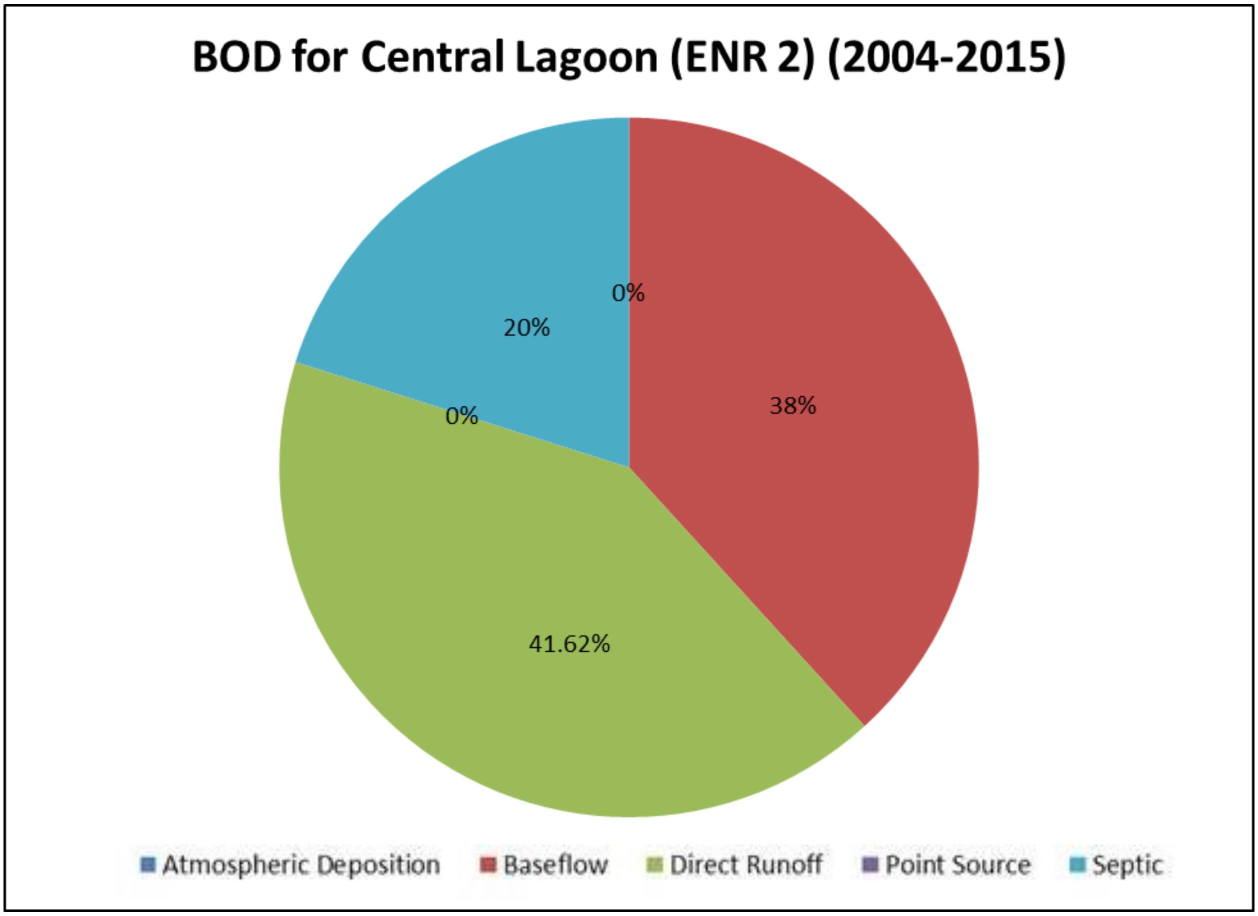


Figure 9-11 Percentages of TN for ENR 2 for the Simulation Period

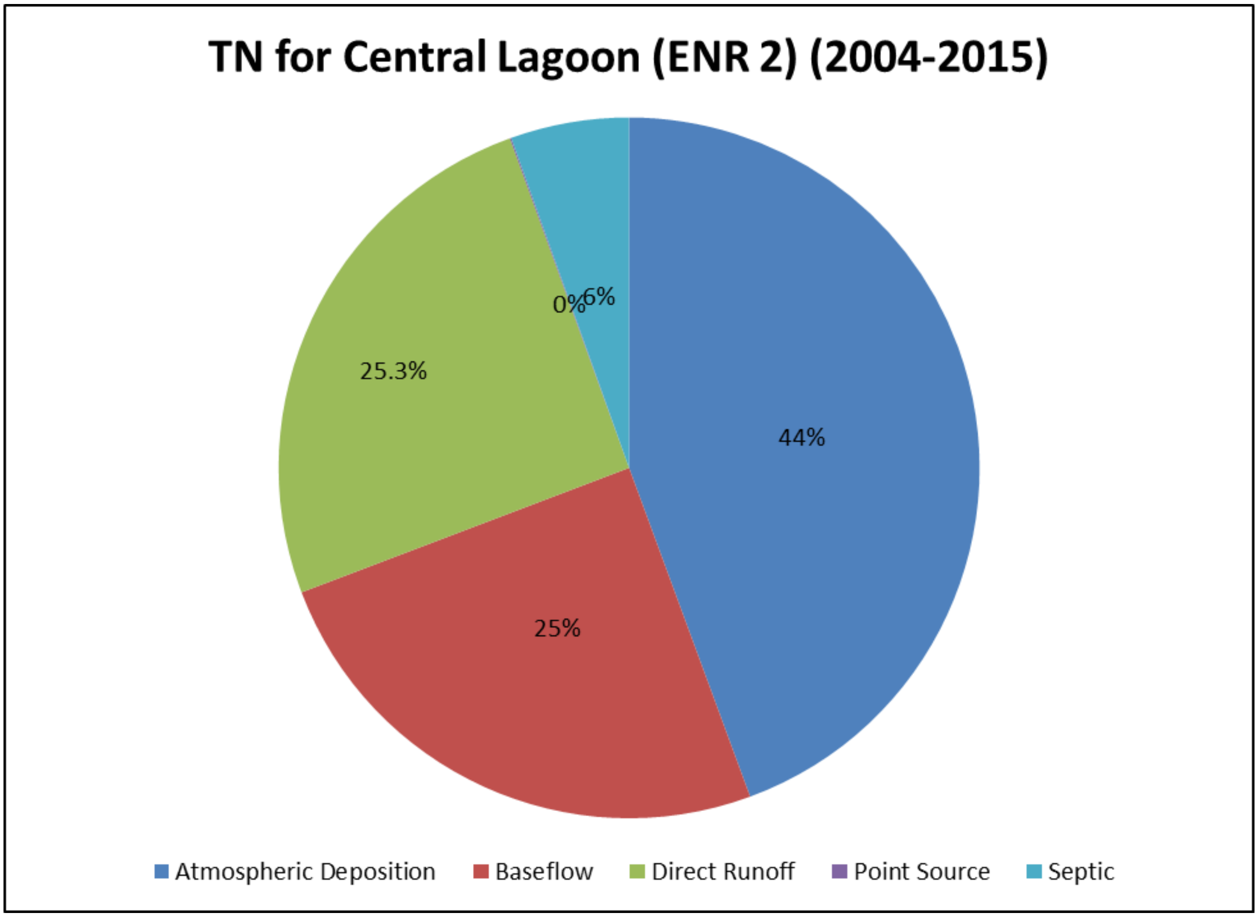
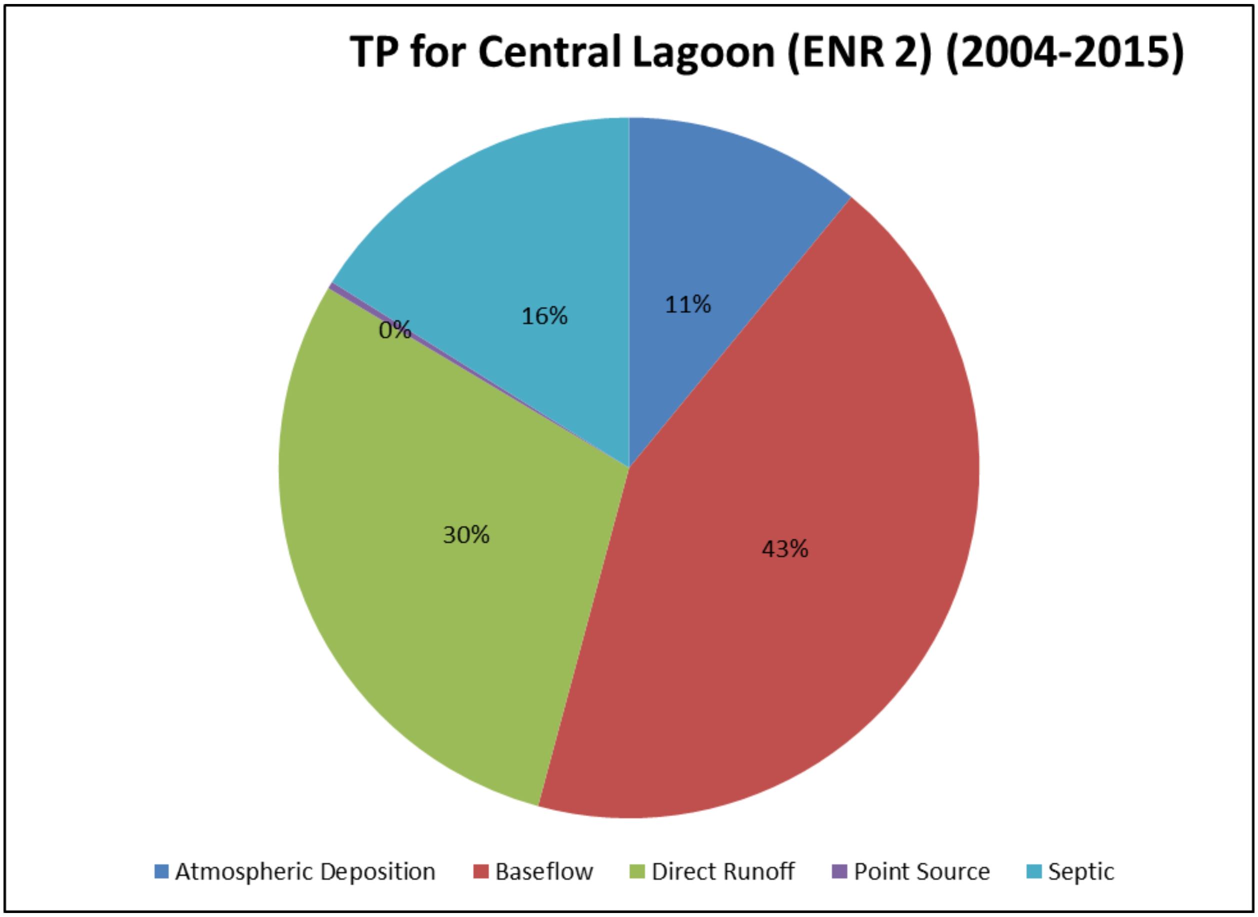


Figure 9-12 Percentages of TP for ENR 2 for the Simulation Period



Percentages of the components of flow volume, BOD_5, TN, and TP for ENR 3 (southernmost ENR) are shown in Figures 9-13 through 9-16, respectively.

Figure 9-13 Percentages of Total Flow Volume for ENR 3 for the Simulation Period

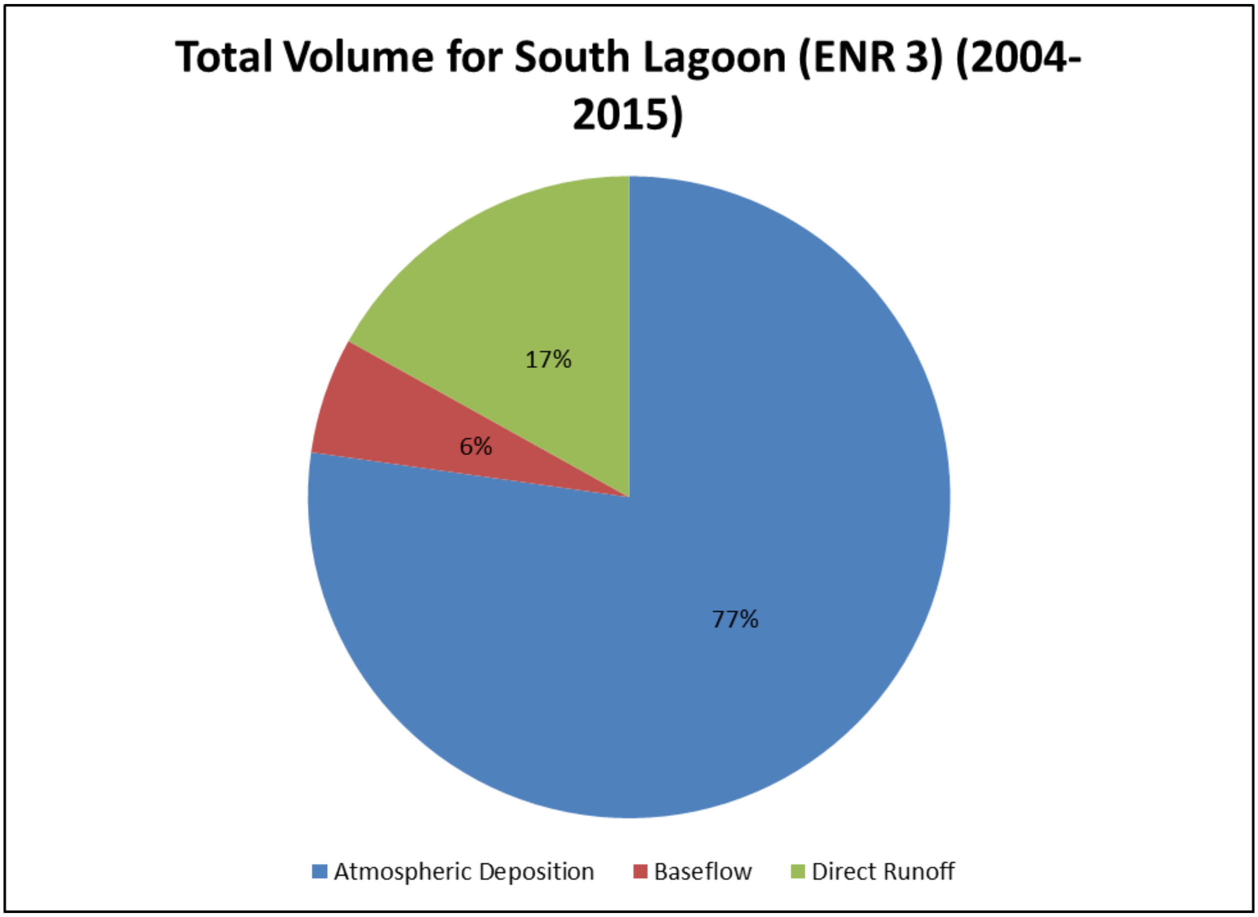


Figure 9-14 Percentages of BOD for ENR 3 for the Simulation Period

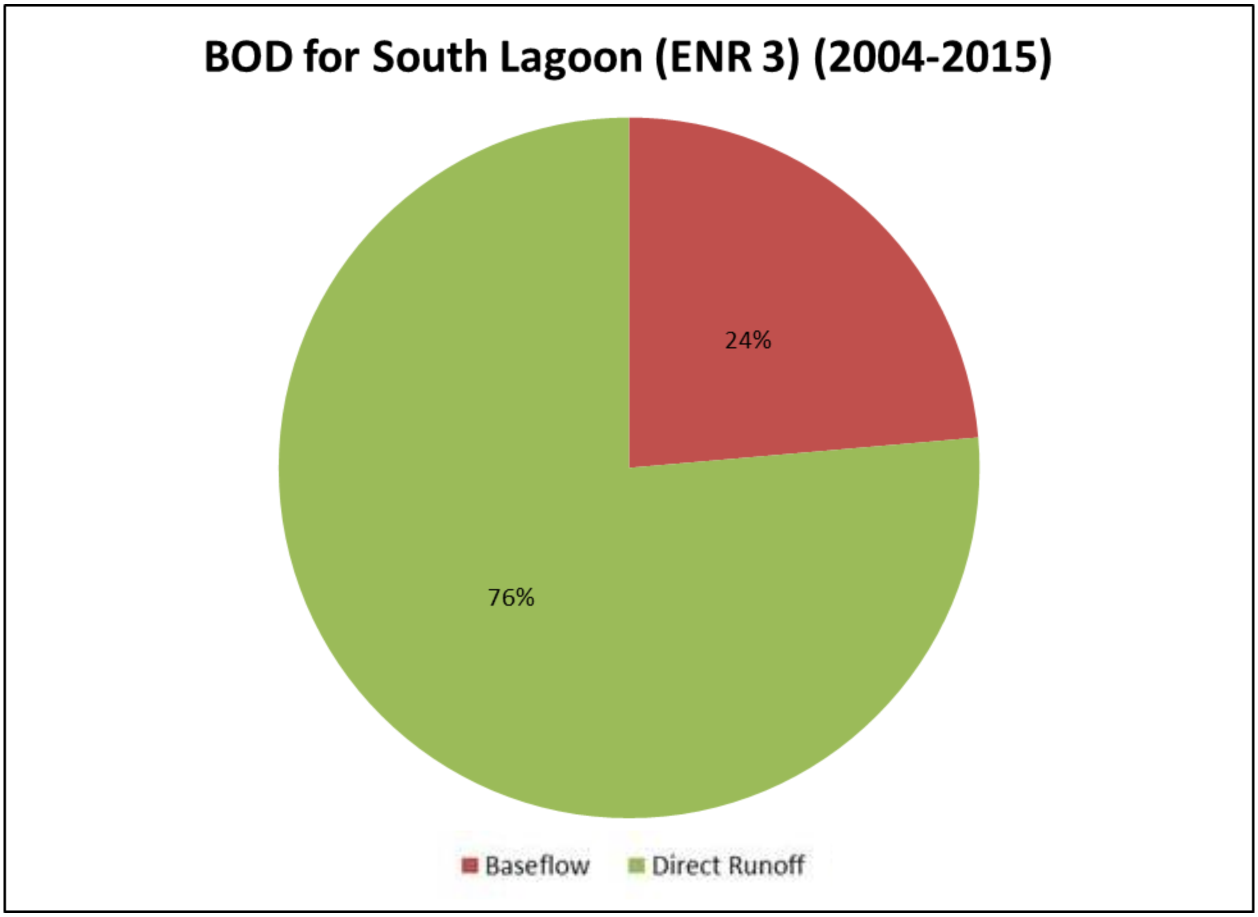


Figure 9-15 Percentages of TN for ENR 3 for the Simulation Period

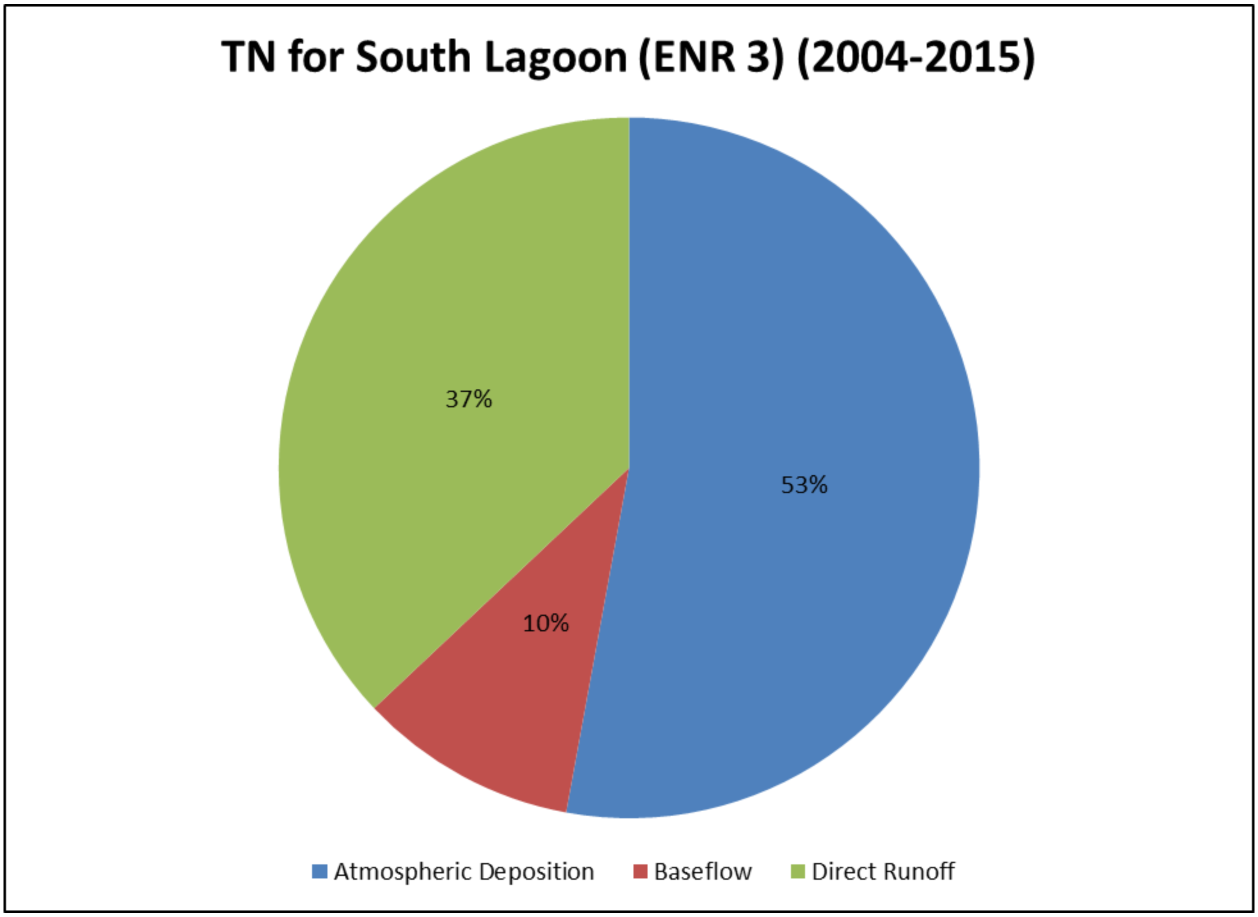
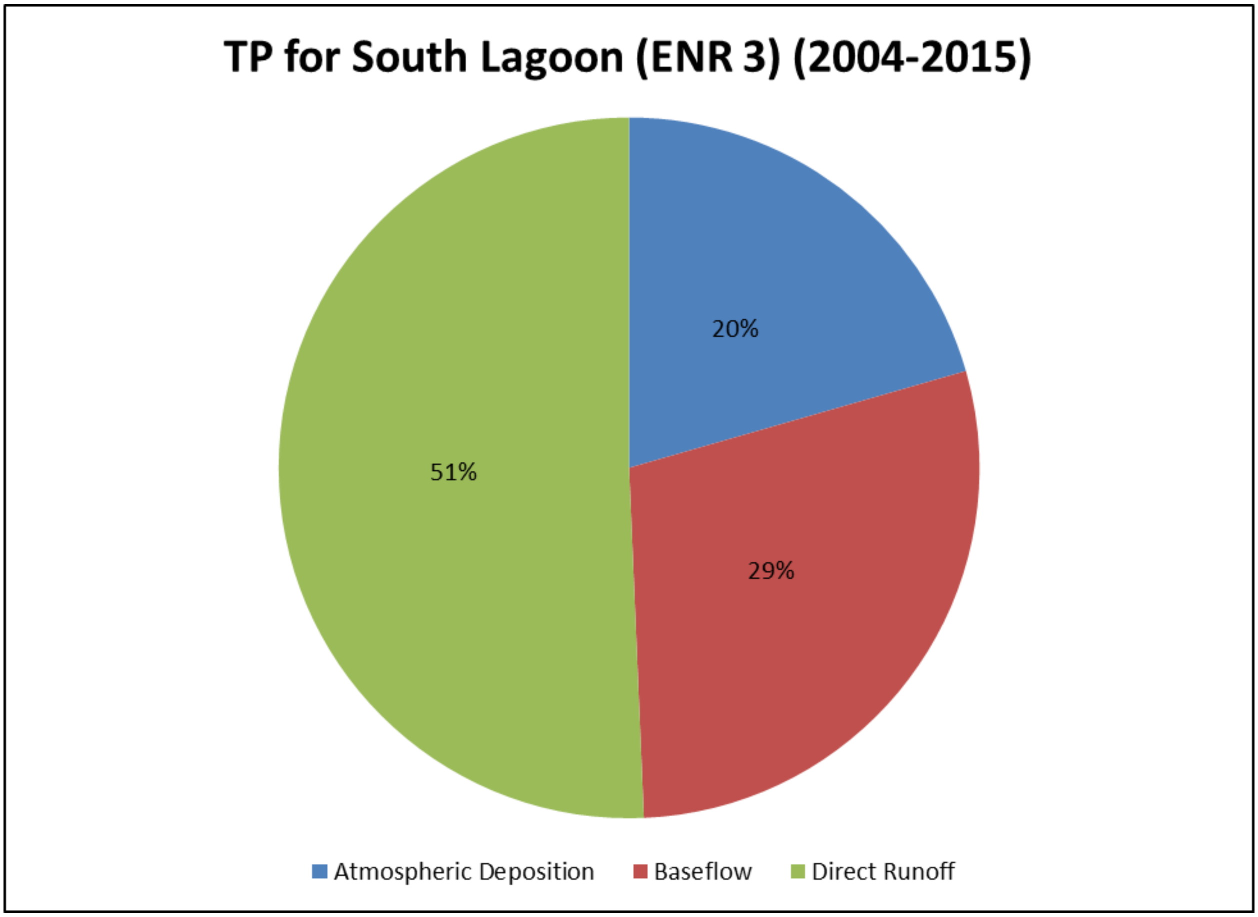


Figure 9-16 Percentages of TP for ENR 3 for the Simulation Period



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Appendix A

Land Use Consolidation

FLUCCS CODE	FLUCCSDESC	LU_COMPRESS
1100	RESIDENTIAL LOW DENSITY - LESS THAN 2 DWELLING UNITS PER ACRE	LOW DENSITY RESIDENTIAL
1180	RESIDENTIAL, RURAL - LESS THAN OR EQUAL TO 0.5 DWELLING UNITS	LOW DENSITY RESIDENTIAL
1190	LOW DENSITY UNDER CONSTRUCTION	LOW DENSITY RESIDENTIAL
1200	RESIDENTIAL MED DENSITY - TWO TO FIVE DWELLING UNITS PER ACRE	MEDIUM DENSITY RESIDENTIAL
1290	MEDIUM DENSITY UNDER CONSTRUCTION	MEDIUM DENSITY RESIDENTIAL
1300	RESIDENTIAL HIGH DENSITY	HIGH DENSITY RESIDENTIAL
1390	HIGH DENSITY UNDER CONSTRUCTION	HIGH DENSITY RESIDENTIAL
1400	LIGHT INTENSITY COMMERCIAL	LOW INTENSITY COMMERCIAL
1401	HIGH INTENSITY COMMERCIAL	HIGH INTENSITY COMMERCIAL
1480	CEMETARIES	OPEN
1490	COMMERCIAL AND SERVICES UNDER CONSTRUCTION	LOW INTENSITY COMMERCIAL
1550	OTHER LIGHT INDUSTRY	LIGHT INDUSTRIAL
1560	OTHER HEAVY INDUSTRIAL	HEAVY INDUSTRIAL
1632	LIMEROCK AND DOLOMITE	HEAVY INDUSTRIAL
1700	INSTITUTIONAL	LIGHT INDUSTRIAL
1750	GOVERNMENTAL	TRANSPORTATION
1810	SWIMMING BEACH	OPEN
1820	GOLF COURSES	GOLF COURSES
1840	MARINAS AND FISH CAMPS	LIGHT INDUSTRIAL
1850	PARKS AND ZOOS	LOW INTENSITY COMMERCIAL
1860	COMMUNITY RECREATIONAL FACILITIES	LOW INTENSITY COMMERCIAL
1890	OTHER RECREATIONAL	LOW INTENSITY COMMERCIAL
2110	IMPROVED PASTURES	PASTURE
2120	UNIMPROVED PASTURES	PASTURE
2130	WOODLAND PASTURES	PASTURE
2140	ROW CROPS	AGRICULTURE
2150	FIELD CROPS	AGRICULTURE
2210	CITRUS GROVES	AGRICULTURE
2430	ORNAMENTALS	AGRICULTURE
2510	HORSE FARMS	AGRICULTURE
3100	HERBACEOUS UPLAND NONFORESTED	FOREST
3200	SHRUB AND BRUSHLAND	OPEN

FLUCCS CODE	FLUCCSDESC	LU_COMPRESS
3300	MIXED RANGELAND	PASTURE
4110	PINE FLATWOODS	FOREST
4200	UPLAND HARDWOOD FOREST	FOREST
4210	XERIC OAK	FOREST
4280	CABBAGE PALM	FOREST
4340	HARDWOOD CONIFER MIXED	FOREST
4410	CONIFEROUS PINE	FOREST
4430	FOREST REGENERATION	FOREST
5100	STREAMS AND WATERWAYS	WATER
5200	LAKES	WATER
5300	RESERVOIRS	WATER
5400	BAYS AND ESTUARIES	WATER
5430	ENCLOSED SALTWATER PONDS WITHIN A SALT MARSH	WATER
6120	MANGROVE SWAMPS	WETLAND
6170	MIXED WETLAND HARDWOODS	WETLAND
6181	CABBAGE PALM HAMMOCK	WETLAND
6210	CYPRESS	WETLAND
6250	HYDRIC PINE FLATWOODS	WETLAND
6300	WETLAND FORESTED MIXED	WETLAND
6410	FRESHWATER MARSHES	WETLAND
6420	SALTWATER MARSHES	WETLAND
6430	WET PRAIRIES	WETLAND
6440	EMERGENT AQUATIC VEGETATION	WETLAND
6460	MIXED SCRUB-SHRUB WETLAND	WETLAND
6500	NON-VEGETATED WETLAND	WETLAND
7100	BEACHES OTHER THAN SWIMMING BEACHES	WATER
7400	DISTURBED LAND	OPEN
7410	RURAL LAND IN TRANSITION WITHOUT POSITIVE INDICATORS OF INTENDED ACTIVITY	OPEN
7430	SPOIL AREAS	OPEN
8100	TRANSPORTATION	TRANSPORTATION
8110	AIRPORTS	TRANSPORTATION
8120	RAILROADS	TRANSPORTATION
8140	ROADS AND HIGHWAYS	TRANSPORTATION
8180	AUTO PARKING FACILITIES	TRANSPORTATION
8200	COMMUNICATIONS	HEAVY INDUSTRIAL
8310	ELECTRICAL POWER FACILITIES	HEAVY INDUSTRIAL
8320	ELECTRICAL POWER TRANSMISSION LINES	HEAVY INDUSTRIAL
8330	WATER SUPPLY PLANTS	HEAVY INDUSTRIAL
8340	SEWAGE TREATMENT PLANTS	HEAVY INDUSTRIAL
8360	OTHER TREATMENT PONDS	WATER
8370	SURFACE WATER COLLECTION BASIN	WATER