Lemon Bay

WATERSHED MANAGEMENT PLAN

Sarasota County

Southwest Florida Water Management District

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Chapter 4

Water Quality

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4.0 WATER QUALITY

Water quality is a key indicator of the environmental health of estuaries and watersheds. Good water quality promotes a diverse and sustainable natural biota and minimizes risks to human health. Primary water quality constituents of interest in this Watershed Management (WMP) include salinity, dissolved oxygen (DO), nitrogen, phosphorus, chlorophyll, and coliform bacteria. The "quality" of water is largely estimated by the concentrations (or loads) of these constituents. These constituents, in turn, are largely affected by anthropogenic influences throughout the watersheds of most coastal communities. For instance, coastal development has altered the natural hydrology of most coastal watersheds by increasing the amount of impervious surfaces and fragmenting the drainage basins of tidal tributaries, resulting in increased surface water runoff and increased "flashiness" of freshwater inputs into tidal tributaries. These watershed alterations have affected the volume and timing of freshwater inflows into coastal basins, altering natural estuarine salinity patterns and increasing the mass (load) of nutrients and other pollutants into estuarine tributaries. Increased nutrient loads can increase primary production (chlorophyll *a*) in freshwater and estuarine systems and can lead to eutrophication (low DO and high chlorophyll *a*), an indicator of ecosystem degradation. A major goal of this WMP is to characterize water quality throughout the Lemon Bay watershed, identify degraded waters, and evaluate how to improve observed problems within Lemon Bay.

This chapter provides detailed information on the water quality of Lemon Bay including spatial and temporal trends, water quality conditions of concern, establishing water quality targets for water quality indicators, analysis of pollutant loadings, response to pollutant loading, pollutant-loading targets and recommended actions for the proper stewardship of Lemon Bay water quality.

Current water quality monitoring programs conduct monthly sampling events in both the watershed drainage basins and the estuary. The estuarine water quality has been routinely sampled since 1995, while the watershed monitoring program has only been in place since 2006. Historical data were collected in the watershed; however, these programs were discontinued in 1992. Although these historical data are described in this chapter, the relevance of these data to current conditions as well as consistency in methods used in data collection between periods are suspect, and therefore the focus of the water quality assessment is based on recent data (last 10 years) collected between 1998 through 2007. The assessment begins with evaluation of the current conditions and spatial and temporal trends, identifies water quality indicators of concern, and develops water quality targets for these indicators. Assessment of pollutant-loading targets and recommended actions complete the evaluation of how Sarasota County can help to ensure proper stewardship of the valuable natural resources by protecting water quality conditions in Lemon Bay.

4.1 STATUS AND TRENDS

The status and trends of water quality in Lemon Bay and in its major tributaries are discussed in this section.

4.1.1 Estuarine Water Quality

Lemon Bay is a long narrow estuary and appears to have limited tidal exchange with the Gulf of Mexico. Venice inlet to the north is connected to Lemon Bay via a long box cut canal designed to connect Dona and Roberts Bays to Lemon Bay for continuation of the Intracoastal Waterway (ICW). In the southern portion of Lemon Bay in Charlotte County, Stump Pass, a small natural inlet, is the only inlet in Lemon Bay Proper though exchange also occurs via Gasparilla Pass, Gasparilla Sound, and Boca Grande inlet. This section introduces exploratory data analysis by examining descriptive plots and statistics that summarize the spatial distribution patterns within the estuary. Time series plots are used to explore temporal trends, and the Kendall Tau trend test (Reckhow, 1993) is used to objectively assess temporal changes that have taken place in the estuary over the past 10 years in a statistically sound and robust method.

4.1.1.1 Status

The water quality in Lemon Bay was evaluated by first examining the distribution of values and calculating statistics over different temporal scales. Box and whisker plots were generated that compare the overall distribution for water quality parameters within each stratum of the Lemon Bay estuarine sampling segmentation scheme. The box and whisker plots display the preponderance of the distribution beginning with the 5% percentile shown as the lower whisker of the plot as identified in the example provided in Figure 4-1. The 25th percentile is identified by the lower bound of the box, while the center horizontal line represents the median value. The 75th percentile and 95th percentile values are correspondingly represented by the upper bound of the box and whisker, respectively. The box and whisker plots allow the reader to distinguish many characteristics of the data distribution.

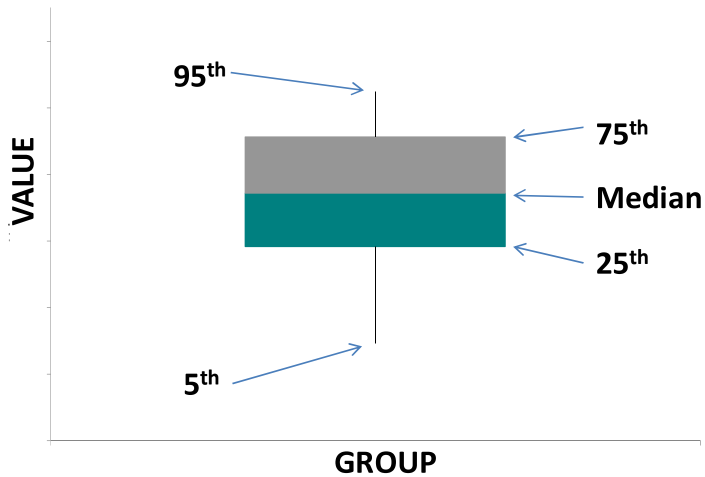

Figure 4-1 Example of a Boxplot Illustrating Aspects of the Data Distribution

The distribution of four common *in situ* water quality constituents in northern Lemon Bay (Figure 4-2) for a 10-year period from 1998 through 2007 is provided in Figure 4-3. Each water quality monitoring stratum within northern Lemon Bay (Stations 1-5) is represented in the boxplot.

Water temperature is evidently quite similar among strata while salinity, bottom DO, and pH exhibit spatial differences. The influence of the Venice Canal and Alligator Creek is evident in these plots as salinity, DO, and pH are reduced in Stratum LB1. Interestingly, DO and pH show nearly identical spatial trends in LB1-LB3, increasing with movement south while salinity is more consistent in these three strata and increases markedly in LB4 and LB5, presumably with the influence of Stump Pass and Gasparilla Sound.

Water quality constituents that represent nutrients (nitrogen and phosphorus) and biological effects (chlorophyll production and light attenuation) were highest in LB2 and LB-3 suggesting that this area receives the largest mixing of freshwater runoff and gulf waters (Figure 4-4). Nitrogen and phosphorus concentrations tended to be highest in LB2 and LB3, while chlorophyll concentrations were highest in LB2–LB4. Interestingly, while TN and chlorophyll *a* concentrations in LB4 remained similar to LB2 and LB3, Total Phosphorus (TP) concentrations and light attenuation were reduced indicating increased light availability in the lower strata associated with the Sarasota-Charlotte County line.

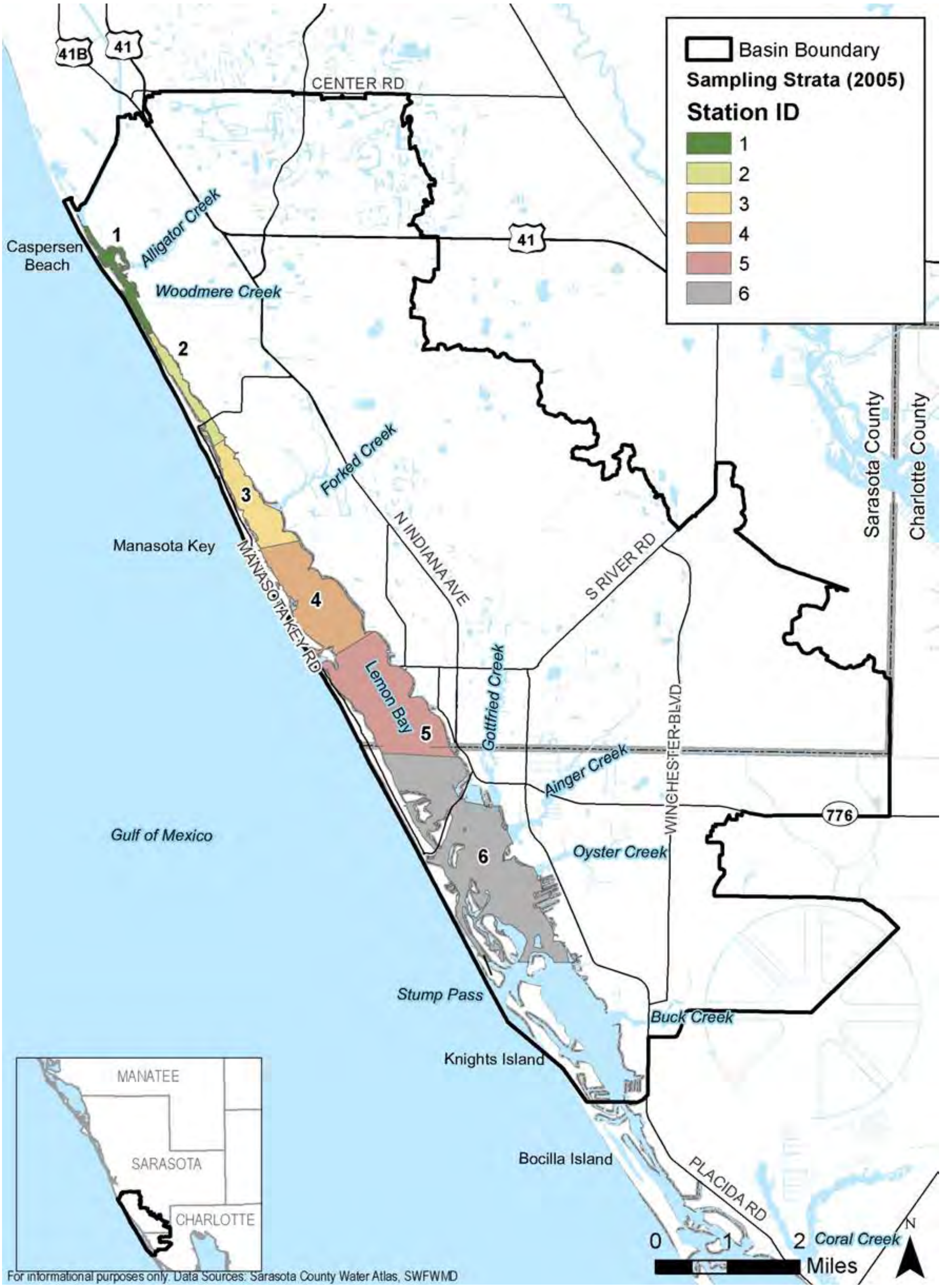

Figure 4-2 Sarasota County Water Quality Sampling Strata in Lemon Bay

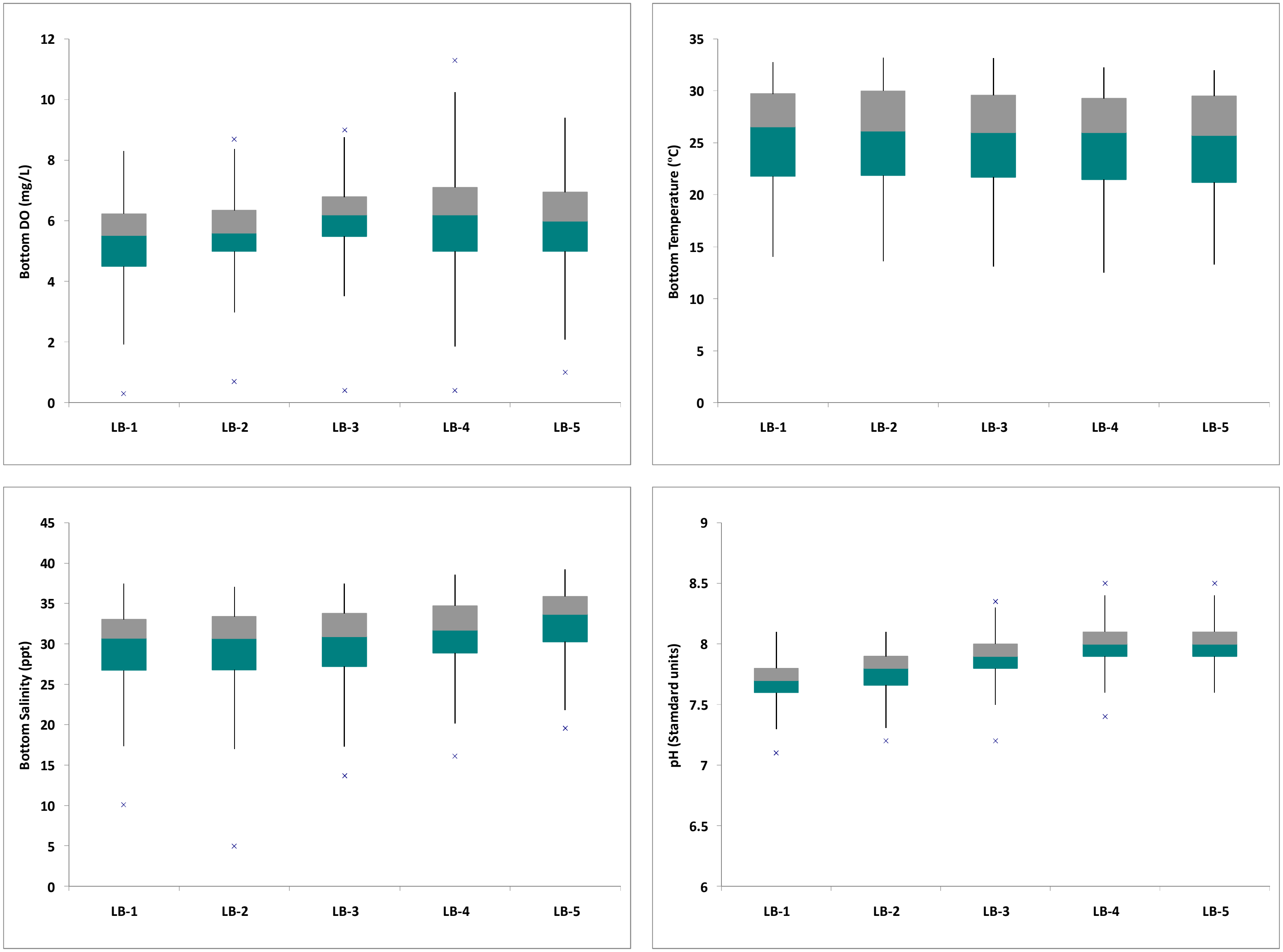

Figure 4-3 Distribution of *in situ* Water Quality Constituents by Stratum in the Sarasota County Portion of Lemon Bay

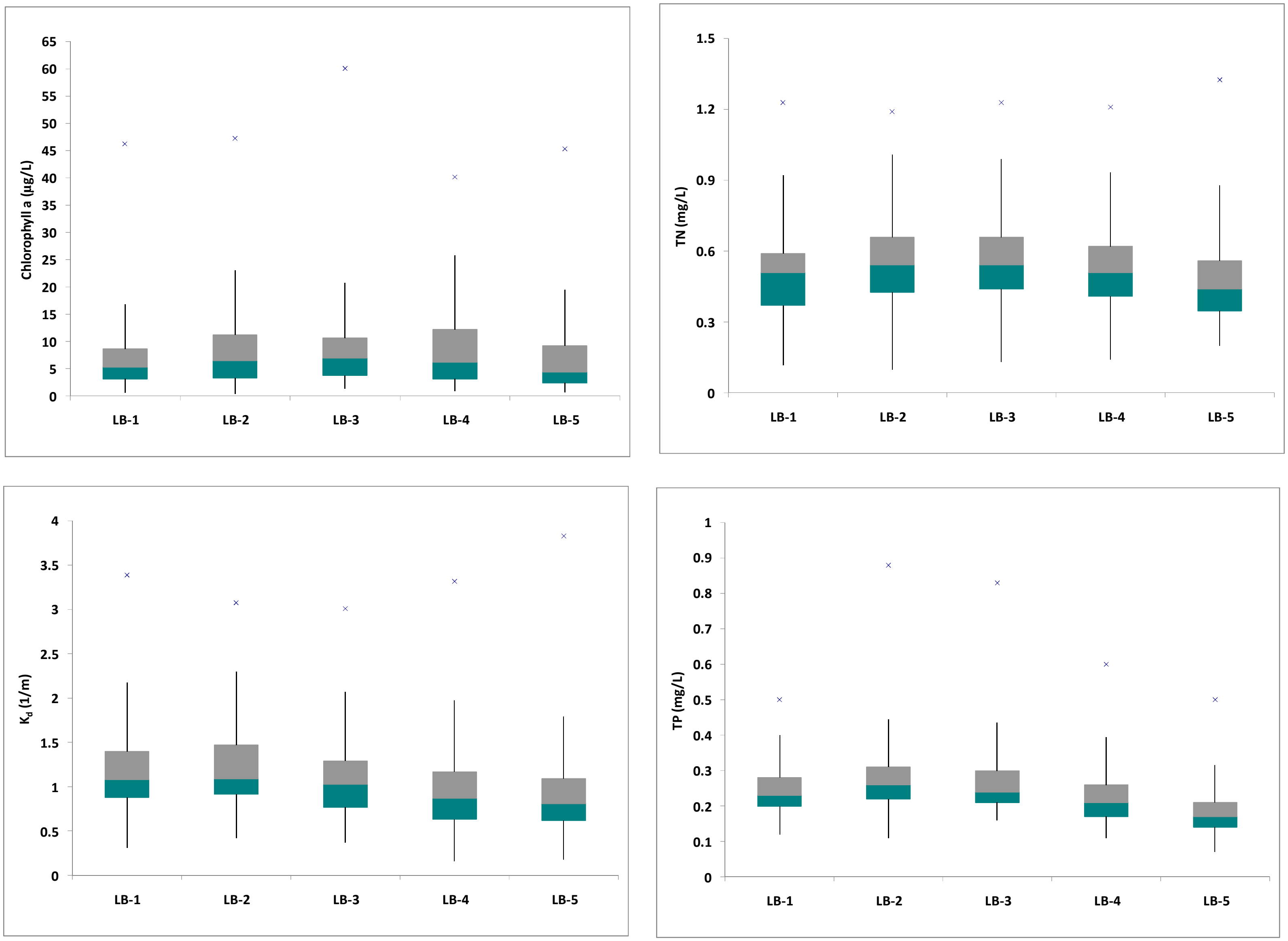

Figure 4-4 Distribution of Nutrient and Biologically Related Water Quality Constituents by Sub-segment Stratum in the Sarasota County Portion of Lemon Bay

4.1.1.2 Trends

Trends in water quality constituents were assessed using graphical plots and the seasonal Kendall Tau trend test (Reckhow, 1993). The Kendall Tau is a non-parametric test that estimates the median slope from all pair-wise comparisons in a time series of data. The statistical test accounts for seasonality and serial autocorrelation before evaluating the statistical significance of the trend in the time series. Therefore, the Kendall Tau is a sophisticated and robust method to evaluate trends in water-quality data that often do not fit the assumptions necessary for the use of parametric statistics (e.g., linear regression).

Time series trends provide information on the temporal variations in water quality and elucidate how changes in environmental conditions such as interannual variations in freshwater inflows impact the water quality constituent of interest. The time scale over which the trend is assessed is important when assessing trends. We chose the last 10 years of data to analyze to this assessment for the following reasons:

- FDEP evaluation uses the previous 7.5 years for evaluation of water quality data for Impaired Waters Rule (IWR) calculations except when assessing conditions relative to historical values.
- Previous analysis suggested that data collected before 1998 in Sarasota County was suspect with respect to several parameters including chlorophyll and light attenuation (PBSJ 2005).
- The data from 1998–2007 were collected by a consistent field crew and analyzed and a single laboratory (Mote Marine Laboratory).

The following water quality constituents were included in the time series analysis:

- Bottom DO
- Surface salinity
- Bottom salinity
- Vertically averaged salinity
- Color
- Biological Oxygen Demand (BOD)
- Corrected chlorophyll *a*
- Light extinction coefficient (Kd)
- Total nitrogen (TN)
- Total Phosphorus (TP)
- Turbidity

Results of the Kendall Tau test in the Sarasota County portion of Lemon Bay suggested that 5 day BOD was significantly improving with a decreasing slope of 0.067 mg/L (Table 4-1). Color, chlorophyll, light attenuation, and turbidity all had negative slopes indicating improving conditions. Surface salinity trends increased while vertically averaged salinity and bottom salinity displayed no trend.

Time series plots with DO, turbidity, salinity, and BOD are provided in Figure 4-5. The smoothed time series trend line is shown on these plots to aid the reader in identifying changes in the moving average value for the water quality constituent. While the moving average trend line is not necessarily linear, the Kendall Tau test is testing for a monotonic trend in the time series. Plots of nutrients (TN and TP) and biologically based constituents (chlorophyll *a* and light attenuation) are provided in Figure 4-6. Nitrogen showed no trend in the Sarasota County section of Lemon Bay, while the other constituents exhibited significant trends in the time series indicative of improving water quality condition. The plots are also informative for examining the covariance of these parameters over time such as the relationship between chlorophyll *a* and light attenuation.

Table 4-1 Results of Seasonal Kendall Tau Trend Test for Selected Constituents in Lemon Bay Based on Data Collected from 1998 through 2007

Parameter	Kendall Tau Slope
Biochemical oxygen demand (BOD) (mg/L)	-0.067
Bottom salinity (ppt)	0.000
Surface salinity (ppt)	0.279
Mean salinity (ppt)	0.000
Bottom Dissolved Oxygen (mg/L)	0.063
Color (PtCo units)	-0.500
Chlorophyll a (µg/L), corrected	-0.420
Light extinction coefficient (K_d) (1/m)	-0.026
Total nitrogen (TN) (mg/L)	0.000
Total phosphorus (TP) (mg/L)	-0.006
Turbidity (NTU)	-0.114
TSS (mg/L)	0.000

*Shading indicates improved water quality.

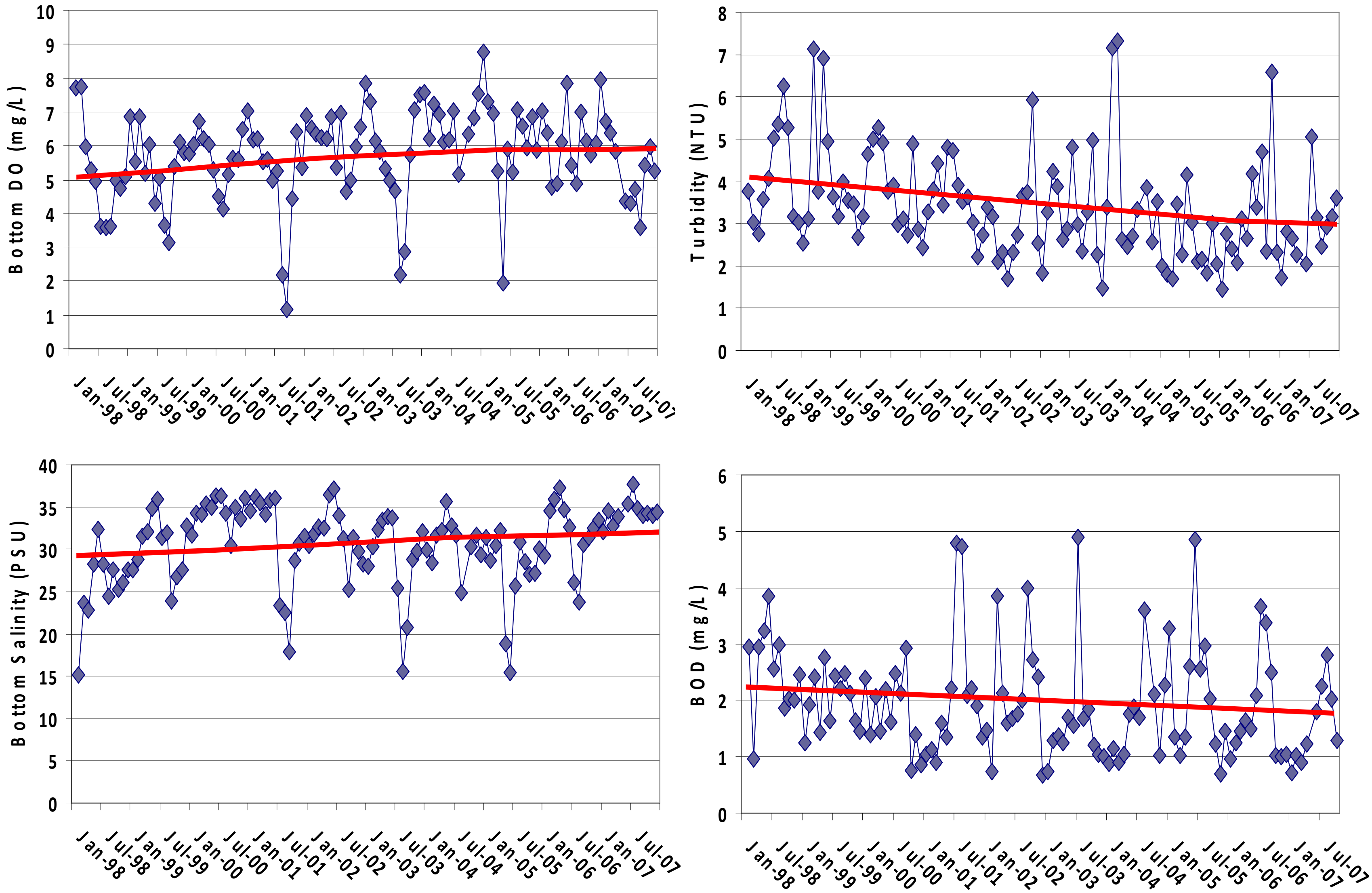

Figure 4-5 Time Series Plots for Dissolved Oxygen, Turbidity, Salinity, and Biochemical Oxygen Demand for Data Collected from 1998 through 2007 in the Sarasota County Portion of the Lemon Bay Estuary

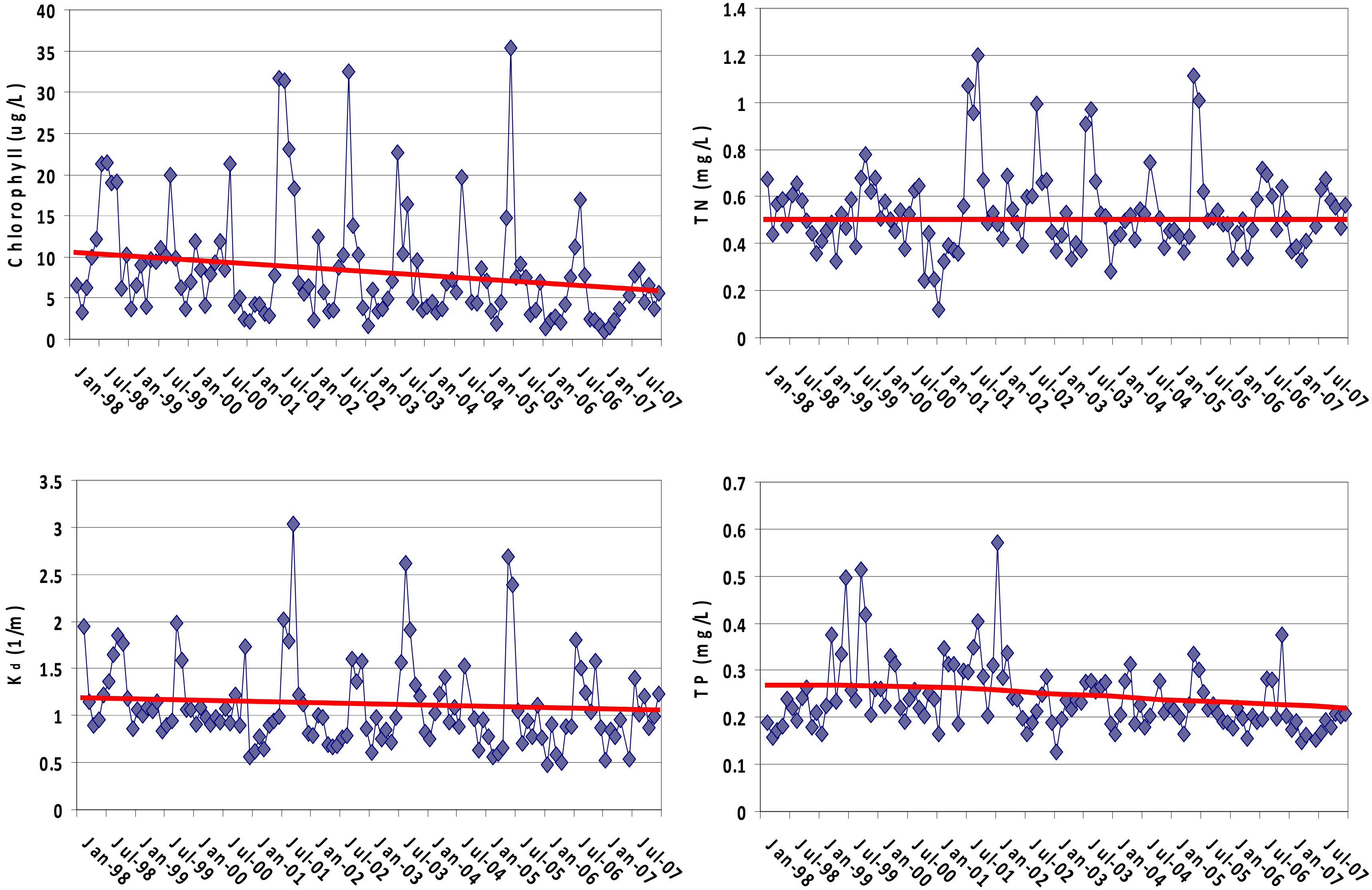

Figure 4-6 Time Series Plots for Chlorophyll *a*, Total Nitrogen, Light Attenuation, and Total Phosphorus for Data Collected from 1998 through 2007 in the Sarasota County Portion of the Lemon Bay Estuary

Estuarine water quality data in the Charlotte County portion of Lemon Bay were also examined for trends. Water quality data were available for nine stations sampled by the Charlotte Harbor Estuaries Volunteer Water Quality Monitoring Network (CHEVWQMN) (Figure 4-7) and a probabilistic sampling design in the open bay portions of Lower Lemon Bay was sampled monthly since 2002 by the Coastal Charlotte Harbor Water Quality Monitoring Network (CCHMN).

Results of the fixed station trend analysis (Table 4-2) suggested that chlorophyll *a* concentrations were decreasing at three stations: LBV002, LBV004, and LBV005. TP concentrations were also decreasing at three stations but increasing at one station (LBV006), while only one station had a significant decreasing trend in TN concentration.

Trends based on the probabilistic sampling in Lower Lemon Bay suggested increasing salinity, decreasing color and decreasing DO in Lower Lemon Bay (Table 4-3). Detailed results for all seasonal Kendall Tau trend tests can be found in Appendix B.

Figure 4-7 Fixed Station Water Quality Sampling Locations Sampled by the CHEVWQMN Program

Table 4-2 Summary of Kendall Tau trend test results for the Charlotte Harbor Estuaries Volunteer Water Quality Monitoring Network (CHEVWQMN)

Station	DO (mg/L)	Salinity (ppt)	Turbidity (NTU)	Chlorophyll a (µg/L)	Color (PtCo units)	TN (mg/L)	TP (mg/L)
LBANG1	0.000	0.000	0.000	0.000	0.000	0.000	0.000
LBOYS1	0.000	0.000	0.000	0.000	0.000	0.000	0.000
LBV001	0.000	0.000	0.000	0.000	0.000	0.000	0.000
LBV002	0.138	-0.410	0.000	-0.473	0.833	0.000	0.000
LBV003	0.000	0.000	-0.152	0.000	0.000	-0.033	-0.006
LBV004	0.000	0.000	-0.180	-0.347	0.000	0.000	-0.005
LBV005	-0.167	0.000	0.000	-0.390	0.000	0.000	-0.005
LBV006	0.000	-1.063	0.000	0.000	2.500	0.000	0.008
LBV007	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table 4-3 Kendall Tau Trend Test Summary for Probabilistic Sampling data Conducted by the CCHMN in Lower Lemon Bay 2002–2007

Parameter	Kendall Tau Slope
Turbidity (NTU)	0.000
Chlorophyll *a* (µg/L)	0.000
Color (Pt Co units)	-3.000
DO (mg/L)	-0.192
Salinity (ppt)	0.379
TN (mg/L)	0.000
TP (mg/L)	0.000
TSS (mg/L)	0.000

4.1.2 Watershed Water Quality

As part of Sarasota County's proactive approach to stewardship of their water quality, the Sarasota County Water Resources Department currently monitors surface water quality at 12 sites within the watershed – three in the Alligator Creek subwatershed, two in the Woodmere Creek subwatershed, three in the Forked Creek subwatershed, and four in the Gottfried Creek subwatershed as shown in Figure 4-8.

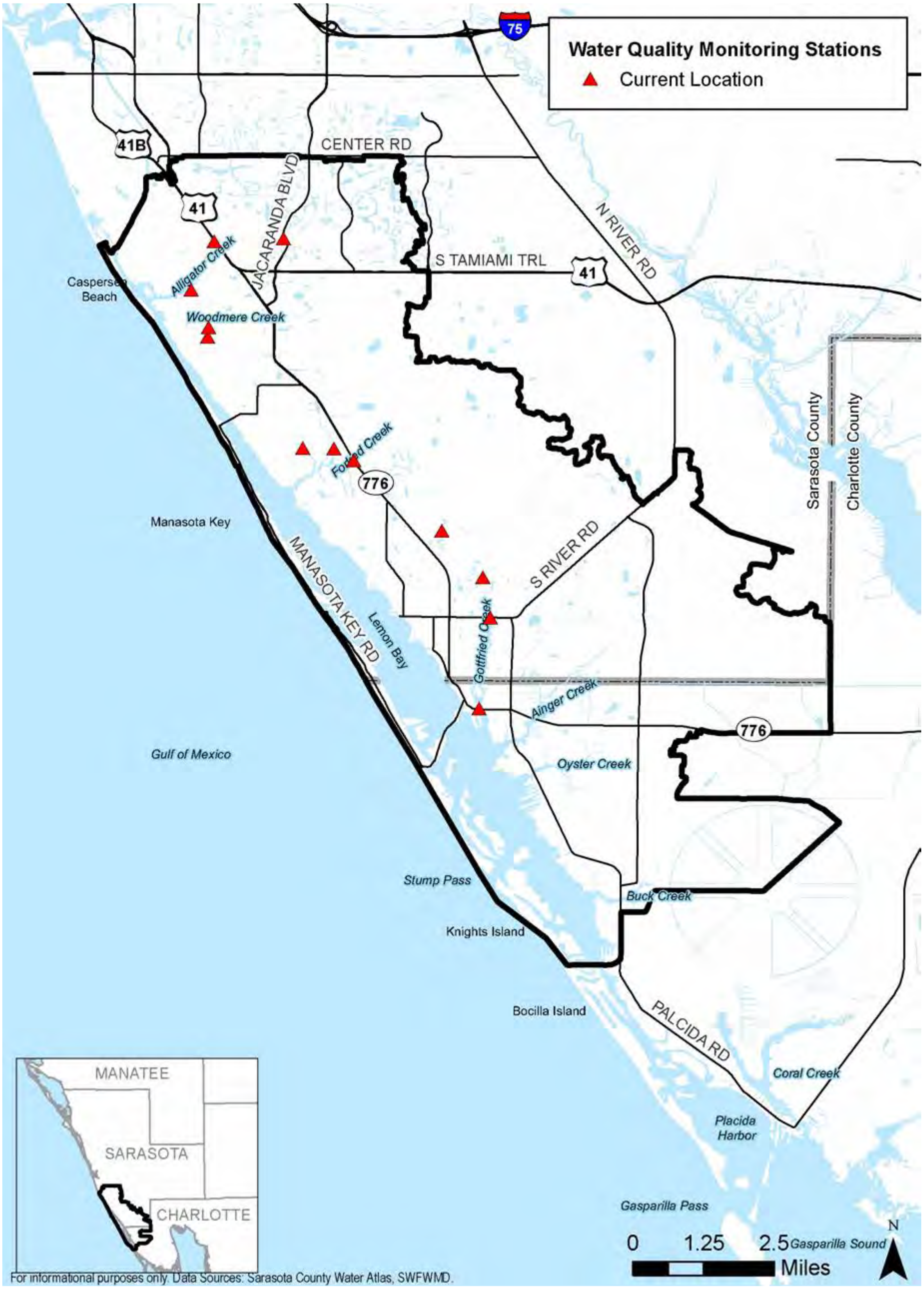

Figure 4-8 Lemon Bay Watershed Water Quality Monitoring Stations (Sarasota County Water Resources)

Historically, other agencies have conducted sampling in the watershed. A review of the County Water Resources Atlas shows that the following sample sites have been used:

- Florida Department of Environmental Protection – 36 sites
- Sarasota County Environmental Services Department – 9 sites
- Charlotte County Environmental Quality Lab – 6 sites
- United States Geological Survey – 6 sites
- Florida Department of Agriculture and Consumer Services – 3 sites
- Florida LAKEWATCH – 3 sites
- Southwest Florida Water Management District – 3 sites

These "historical" sampling programs were initiated after the passage of the Clean Waters Act of 1972 and sampled approximately quarterly between 1973 and 1992. Sampled parameters were similar to those currently sampled. No consistent water quality monitoring data in the Lemon Bay Watershed were collected between 1992 and 2006.

Four representative sites were chosen to compare summary statistics for selected parameters between historical (Table 4-4) and more recent (Table 4-5) data collection efforts. These sites include one station in Alligator Creek at US 41; one station in Forked Creek at state road 776, and two stations in Gottfried Creek, upstream at Wentworth and near the mouth in the Deer Creek tributary. Fecal coliform, TN, and TP concentrations were compared.

The State water quality standard for fecal coliform bacteria in Class III fresh and marine waters is 800 mpn (most probable number) on any day (Chapter 602-302.530, FAC). On average, fecal coliform concentrations were higher than the proposed State standard in both historical data and the more recent data for data collected in Alligator Creek. Historically, Gottfried Creek was below the standard, but recent data suggests that the proposed standard may be exceeded frequently. No recent data were available for fecal coliform at the Forked Creek site (Table 4-5).

Total coliform concentrations in Alligator Creek were also historically higher than the State standard (2700 mpn). In the other creeks, total coliform concentrations did not exceed the State standard frequently. Data on total coliform concentrations are not available for the recent monitoring activity. There are no nutrient criteria currently established under State statute; however, recent TN and TP concentrations were approximately half of their historical values on average except in Gottfried Creek where historical and recent comparisons suggest TP concentrations remain similar.

Many capital improvement projects are currently taking place with the aim to reduce anthropogenic sources of nutrient inputs into Lemon Bay and improve water quality conditions. Wastewater treatment plants that discharge into Lemon Bay are being taken offline. A sediment management plan is being implemented to reduce sediment loads into estuarine receiving bodies. Identifying water quality conditions of concern and developing criteria for these indicators that allow for changes in water quality to be tracked through time as a measure of the success of watershed management efforts are critical to evaluating the success of these watershed management actions.

Table 4-4 Summary Statistics for Select Water Quality Parameters at Representative Fixed Station Locations in the Lemon Bay Watershed between 1972–1992

Station	Value	DO (mg/L)	Fecal Coliform (col/100ml)	Total Coliform (col/100ml)	TN (mg/L)	TP (mg/L)
Alligator Creek at US41	Mean	4.57	614.06	3947.07	1.48	0.39
	Min	1.2	10	100	0.24	0.08
	Max	14.9	5400	80000	3.18	2.3
Forked Creek at 776	Mean	4.9	520.58	1981.53	1.25	0.433
	Min	1.3	10	100	0.18	0.12
	Max	9.7	15000	24000	2.87	1.78
Gottfried Creek at Wentworth	Mean	4.24	330.35	1307.57	1.25	0.56
	Min	1.5	10	100	0.19	0.15
	Max	9	4500	13000	2.59	3.07
Deer Creek at Norton	Mean	4.86	168.12	788	1.05	0.44
	Min	1.1	10	100	0.15	0.12
	Max	8.6	2400	5000	1.99	2.91

Table 4-5 Summary Statistics for Select Water Quality Parameters at Representative Fixed Station Locations in the Lemon Bay Watershed between 2006–2007

Station	Value	Fecal Coliform (col/100ml)	TN (mg/L)	TP (mg/L)
Alligator Creek at US41	Mean	1554.17	0.88	0.20
	Min	10.00	0.29	0.07
	Max	15000.00	1.56	0.30
Forked Creek at 776	Mean		0.69	0.28
	Min		0.39	0.19
	Max		1.62	0.45
Gottfried Creek at Wentworth	Mean	922.50	0.90	0.57
	Min	80.00	0.47	0.24
	Max	2800.00	1.40	1.16
Deer Creek at Norton	Mean	72.50	0.63	0.24
	Min	10.00	0.34	0.14
	Max	120.00	1.26	0.38

4.1.3 Water Quality Conditions of Concern

Lemon Bay has been designated an Outstanding Florida Water (OFW) as a special water and is listed in Chapter 62-302.700(i), FAC (FDEP, 2009c). An OFW is a waterbody designated as worthy of special protection because of its natural attributes. This special designation is intended to protect existing good water quality, i.e., no degradation of water quality is permitted. Most OFWs are areas managed by the state or federal government such as parks, wildlife refuges, preserves, marine sanctuaries, estuarine research reserves, waters within state or national forests, scenic and wild rivers, or aquatic preserves. Generally, the waters within these managed areas are OFWs because the managing agency has requested this special protection. Additionally, a 7,667 acre state aquatic preserve is located within Lemon Bay.

As mandated by the Federal Clean Water Act and the U.S. Environmental Protection Agency (EPA), the FDEP has established criteria for evaluating water quality throughout Florida using a waterbody classification system and evaluative criteria for a host of water quality constituents (Chapter 62-302.530, FAC). FDEP compiles surface water quality data collected throughout Florida using its STORET database and its Waterbody Identification (WBID) system to assess water quality impairment of WBIDs under the IWR (Chapter 62-302.530, FAC).

A TMDL is a scientific determination of the maximum amount of a given pollutant that a surface waterbody can absorb and still meet water quality standards (FDEP, 2009). The basic steps in the TMDL program are as follows:

1. Assess the quality of surface waters—are they meeting water quality standards?
2. Determine which waters are impaired—that is, which ones are not meeting water quality standards for a particular pollutant or pollutants.
3. Establish and adopt, by rule, a TMDL for each impaired water for the pollutants of concern—the ones causing the water quality problems.
4. With extensive local stakeholder input, develop a Basin Management Action Plan (BMAP) that summarizes what actions will be taken by whom to correct impairments.
5. Implement the strategies and actions in the BMAP.
6. Measure the effectiveness of the BMAP, both continuously at the local level and through a formal re-evaluation every 5 years.
7. Change the plan and actions if things are not working.
8. Reassess the quality of surface waters periodically.

The following includes a summary for those waterbodies that have existing TMDLs and a summary of those waterbodies that have been verified impaired but have no existing TMDL.

4.1.3.1 Existing EPA TMDLs in the Lemon Bay Watershed

TMDLs have been established by the EPA for four WBIDs in the Lemon Bay Watershed (Figure 4-9). The TMDLs are shown below with their respective impairments and causative agents.

- Alligator Creek (WBID 2030) nutrients and DO – TN
- Forked Creek (WBID 2039) nutrients - TN
- Woodmere Creek (WBID 2042) nutrients - TN
- Gottfried Creek (WBID 2049) nutrients - TN

Currently, Lemon Bay is a Class III waterbody with designated uses of Recreation, Propagation, and Maintenance of a Healthy, Well-Balanced Population of Fish and Wildlife. The State assesses nutrient impairment using chlorophyll levels in two ways: if an annual average chlorophyll value exceeds 11 µg/L or if the chlorophyll *a* values in 2 consecutive years exceeds historical values by more than 50%.

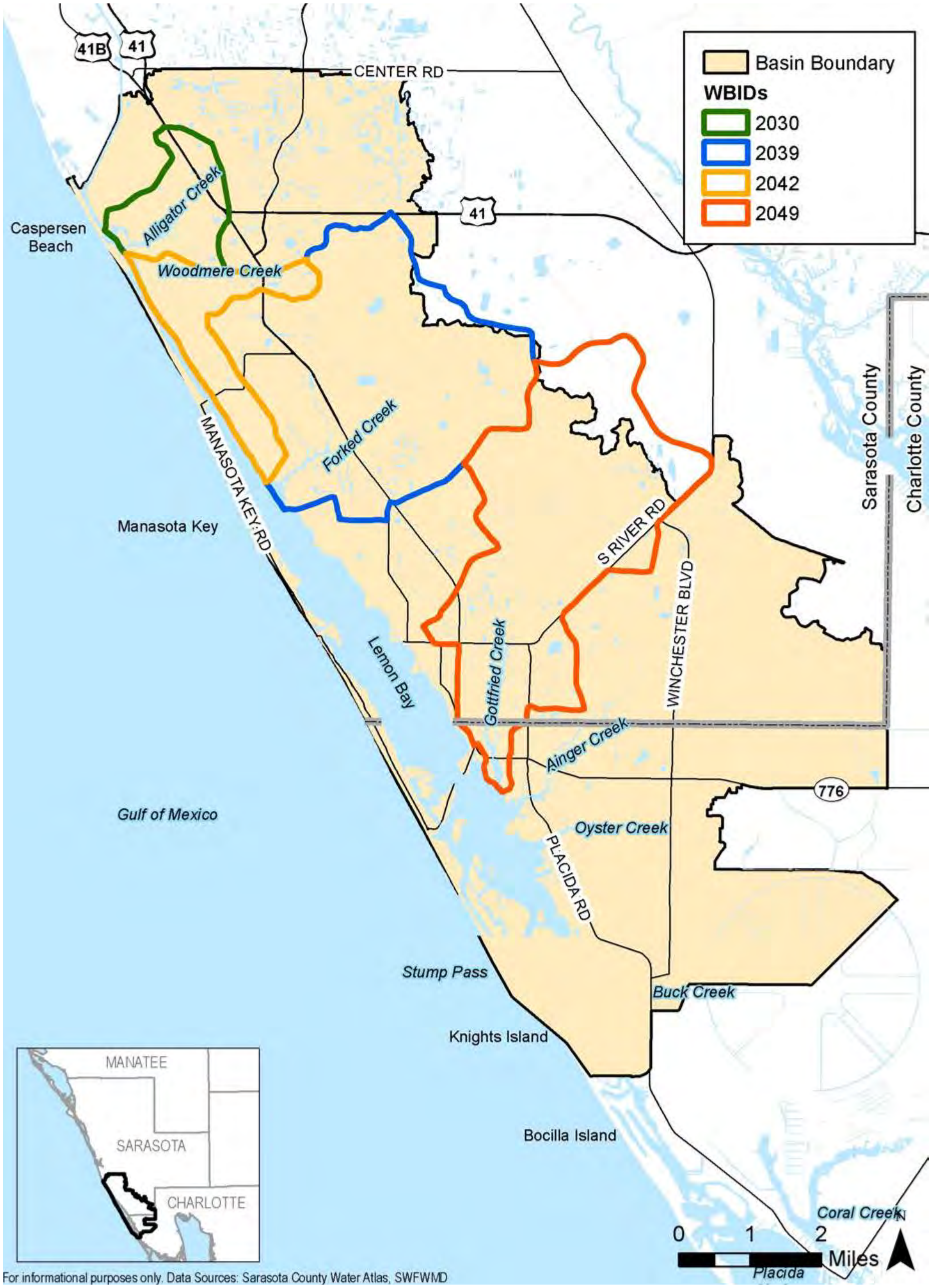

Figure 4-9 Impaired WBIDs within the Sarasota County Portion of the Lemon Bay Watershed

The EPA established TMDLs for Alligator Creek for nutrients and DO in 2005 (EPA, 2006). Nutrient impairment was due to exceedances of the chlorophyll *a* criterion, which was evaluated from the 1998 through 2001 data. Annual average chlorophyll *a* values in Alligator Creek between 1998 and 2001 ranged from 1.0 µg/L in to 48.7 µg/L, with an average of 9.5 µg/L. Chlorophyll *a* levels in Alligator Creek exceeded the threshold 11 times out of 25 samples. Therefore, it is verified as impaired.

To determine the appropriate TMDLs for Alligator Creek, a watershed management model was developed for the study area. The model estimated hydrologic yield as a function of precipitation, land use, and soil type. Land use-specific loadings estimates for TN were developed for the 1998 through 2001 period. The TMDL requirement for this WBID is a 28.2% reduction in annual TN loads, resulting in a decrease from 5,370 kg/year of TN from the 1998 through 2001 period loads to 3,857 kg/year of TN for the target loads.

Alligator Creek was also classified as verified impaired for DO by the EPA in 2005 (EPA, 2006), due to low DO values observed between 1998 and 2000. DO shall not be less than 5.0 mg/L for a 24-hour period, and never less than 4.0 mg/L. DO ranged from 1.2 mg/L to 6.0 mg/L, and averaged 3.4 mg/L. Of the 28 samples collected, 21 were below the DO standard. To address this water quality concern, the same TN load reduction required by Alligator Creek's nutrient TMDL was defined, with the addition of a BOD target load reduction. The existing BOD load is 15,728 kg/year. The TMDL recommends a percent reduction in BOD loads of 57.8%, to 6,632 kg/year.

The EPA established a TMDL for Forked Creek for nutrients in 2005. Impairment was due to exceedances in Algal Growth Potential (AGP) tests conducted in 2005. Results of AGP tests yielded an average of 12.4 mg/L from two tests analyzed in replicate. This value exceeded the EPA standard for AGP tests (10 mg/L) associated with eutrophic waters, which are subject to nuisance algal blooms. The average annual TN load to Forked Creek in 2005 was 4,235 kg/year. To meet the water quality criterion for nutrients, the EPA recommends a 20.0% reduction in TN loads, to 3,387 kg/year.

The EPA established a TMDL for Woodmere Creek (called "direct runoff to the bay" in the EPA TMDL) for nutrients in 2005 (EPA, 2006). Impairment was due to exceedances in AGP tests conducted in 2005. Results of AGP tests yielded values of 11 mg/L and 16.8 mg/L, the latter of which is the average of two tests analyzed in replicate. This value exceeded the EPA standard for AGP tests (10 mg/L) associated with eutrophic waters, which are subject to nuisance algal blooms. The average annual TN load to Woodmere Creek in 2005 was 1,414 kg/year. In order to meet the water quality criterion for nutrients, EPA recommends a 54.7% reduction in TN loads, to 641 kg/year.

The EPA established TMDLs for Gottfried Creek for nutrients and DO in 2005 (EPA, 2006). Nutrient impairment was due to exceedances of the chlorophyll *a* threshold, which was evaluated from the 2002 through 2005 data, and an elevated AGP value from data collected in 2005. Annual average chlorophyll *a* values in Gottfried Creek between 2002 and 2005 ranged from 1.0 µg/L in to 13.1 µg/L out of 3 samples, with an average of 6.1 µg/L. One AGP test yielded a result of 5.1 mg/L. This value was considered to be near the threshold of 6.1 mg/L associated with highly productive waters. EPA determined that these data in concert indicated a high probability of eutrophic waters.

To determine the appropriate TMDLs for Gottfried Creek, the same watershed management model that was used in other basins in the Lemon Bay watershed was applied. Land use-specific loadings estimates for TN were developed for the 2002 through 2005 period. The TMDL requirement for this WBID is a 2.0% reduction in annual TN loads, resulting in a decrease from 3,025 kg/year of TN from the 2002 through 2005 period loads to 2,966 kg/year of TN for the target loads.

Gottfried Creek was also classified as verified impaired for DO by the EPA in 2005, due to low DO values observed between 1998 and 2003. DO ranged from 1.0 mg/L to 8.7 mg/L, and averaged 3.7 mg/L. Of the 27 samples collected, 68% were below the DO standard. To address this water quality concern, the same TN load reduction required by Woodmere Creek's nutrient TMDL was defined, with the addition of a BOD target load reduction. The existing BOD load is 19.2 kg/day. The TMDL recommends a percent reduction in BOD loads of 28.2%, to 16.1 kg/day.

4.1.3.2 Other Impairments within the Lemon Bay Watershed

In 2005, Group 2 Basins were evaluated for exceedances of FAC water quality criteria and, when deemed to be verified impaired, were prioritized as High, Medium, or Low for TMDL development. Group 2 Basins are those watersheds that are assessed for TMDLs during the second year of FDEP's five-year cyclic Basin Assessment program. Group 2 basins were first assessed in 2004 and underwent their second assessment cycle in 2009. Those WBIDs categorized as High Priority were slated for immediate TMDL development in the first cycle of TMDLs in 2005, whereas Medium Priority TMDLs for other impaired WBIDs throughout Lemon Bay were slated for TMDL development in the second cycle in 2009. New verified impaired listings were released in May 2009 and include the following impairments in these WBIDs:

- ❖ Lemon Bay (WBID 1983A)
  - Fecal Coliforms: 34 out of 239 samples exceeded the threshold of 43 MPN (Most Probable Number)/100 mL.
- ❖ North Lemon Bay (WBID 1983A1)
  - Nutrients – Chlorophyll *a*: Annual average chlorophyll *a* values exceeded the 11 µg/L standard for Class 3M waters in 2001 (11.4 µg/L) and in 2005 (11.1 µg/L).
- ❖ Alligator Creek - estuarine (WBID 2030)

   - Nutrients – Chlorophyll *a*: The annual average chlorophyll *a* value in 2007 (18.3 µg/L) exceeded the 11 µg/L standard for Class 3M waters.
- ❖ Alligator Creek - stream(WBID 2030A)
   - Nutrients – Chlorophyll *a*: The annual average chlorophyll *a* value in 2007 (33.3 µg/L) exceeded the 20 µg/L standard for Class 3F waters.
- ❖ Woodmere Creek (WBID 2042)
   - Fecal Coliform: Nine out of 21 samples exceeded the threshold of 400 counts/100 mL.
- ❖ Gottfried Creek (WBID 2049)
   - Fecal Coliform: 16 out of 52 samples exceeded the threshold of 400 counts/100 mL.
   - Nutrients – Chlorophyll *a*: The annual average chlorophyll *a* values did not exceed the 11 µg/L standard for Class 3M waters but nutrients are listed as the causative pollutant for dissolved oxygen in this same waterbody.
   - Dissolved Oxygen - Impaired based on IWR thresholds for total nitrogen, total phosphorus, and biochemical oxygen demand.
- ❖ Buck Creek (WBID 2068)
   - Nutrients – Chlorophyll *a*: The annual average chlorophyll *a* value in 2007 (20.7 µg/L) exceeded the 11 µg/L standard for Class 3M waters.
- ❖ Coral Creek – East Branch (WBID 2078B)
   - Dissolved Oxygen: Twelve out of 28 samples were below the DO standard of 4.0 mg/L.

Coral Creek, which was previously identified as impaired for nutrients due to chlorophyll *a* exceedances in the first cycle of TMDL development in 2005, was delisted for this parameter in the second cycle after it was determined that the original assessment was flawed. FDEP released a TMDL for Coral Creek in June 2009 that addresses the DO impairment.

4.2 WATER QUALITY TARGETS

Arguably the single-most important element of an effective WMP is setting resource protection targets. There are four common approaches to setting targets (Janicki Environmental, 2002):

- ❖ Targets based on historical conditions
- ❖ Targets based on reference system conditions
- ❖ Targets based on regulatory standards
- ❖ Targets based on the environmental requirements of critical resource(s)

Although one approach may be used by itself, a preferred method is to develop potential targets using more than one approach and to look for unifying results among these approaches to guide water quality target selection (Janicki Environmental, 2002, 2003). The following discusses each of the potential approaches:

- Historical conditions—If data that describe water quality in historical (undegraded) conditions exist, then that condition can be used as a restoration target. The use of this approach is typically desirable when historical data are available. However, data comparability is often limited due to sample design and methodological differences between historical and current data.
- Water quality standards—For this approach water quality monitoring data are compared to established standards to identify any samples failing to meet the standards. The presumption is that if water quality does not meet standards, then there is a problem. This approach is straightforward and is acceptable if adopted standards are appropriate. Also, target setting using the standards approach is much less definitive if non-numeric standards are used, for example Florida's nutrient standards. To improve this situation, the FDEP is currently in the process of establishing numeric standards for nutrients (FDEP, 2009a).
- Reference sites—For the reference site method, conditions at an area of interest are compared to similar but undegraded sites. This method is also useful but is difficult to implement, partially because it is often not easy to identify a suitable reference site and real differences between the sites must be identified. EPA uses the reference site method frequently, most often for freshwater systems. The FDEP Stream Condition Index (SCI) is a reference site example (FDEP, 2007). The benefit of this bioassessment approach is that multiple site characteristics (hydrology, water quality, habitat disturbance, etc.) are integrated.
- Resource-based—Resource-based target setting is widely accepted as the preferable approach, as it directly ties water quality to the resource of concern. Resource-based targets have been set for many waterbodies both locally (Tampa Bay, Indian River Lagoon, Caloosahatchee River) (Greening and Janicki, 2006; Tomasko et al., 2001; Steward et al., 2005) and nationally (e.g., Chesapeake Bay Program).

Effective watershed management is typically based on preserving existing features or on restoring degraded areas to desirable conditions. A critical initial step in this process is to determine what resources are most beneficial and should therefore receive priority attention. A resource of concern should be desirable and representative of a larger habitat or system. Its extent and status should be measurable and manageable; that is, there should be an available suite of actions that can be used to foster the resource of concern's sustainability. Given the importance of seagrasses in the Lemon Bay estuary, setting water quality targets based on the requirements for their growth and reproduction is preferred. Seagrass meets all of the above criteria. Seagrasses serve significant functions within the estuarine ecosystem. They help maintain water clarity by trapping fine sediments and particles with their leaves and stabilizing the estuarine sediments with their roots. Seagrasses are very effective at removing dissolved nutrients from water that can enter from land runoff. The removal of sediment and nutrients improve water clarity, thereby improving overall ecosystem health. Seagrasses provide nursery habitats for fish, crustaceans, and shellfish, providing a nursery ground for many recreationally and commercially valuable species. They are also food for organisms that inhabit them and marine mammals such as manatees and waterfowl such as ducks. Human activities can harm seagrasses by degrading estuarine water quality and promoting physical disturbances and algal blooms. Reductions in light availability associated with nutrient inputs and sediments can damage or eliminate seagrass habitat. If seagrass is thriving, then it is likely that the system is in general healthy and extensive (and expensive) monitoring of other indicators may not be necessary. Seagrass can be mapped through field reconnaissance and aerial mapping to track its extent over time. Also, the spatial extent of seagrass growth depends on water clarity which is dependent upon other water quality parameters, including chlorophyll *a*, turbidity, and color.

Seagrass targets for Lemon Bay have been established by the Charlotte Harbor National Estuary Program (CHNEP) (Janicki Environmental, 2009). The process for defining targets for each of the CHNEP segments was based on a comparison of the historical (ca. 1950) seagrass coverage to recent surveys conducted by the SWFWMD. A description of the District mapping effort can be found in Kaufman (2006). The CHNEP defined the seagrass target as the larger of either the historical cover or the average of the recent seagrass surveys.

Figure 4-10 presents the seagrass cover data used to establish the Lemon Bay target. Overall, there has been a small difference (380 acres) between the historical and current seagrass coverage. This reduction occurred in Lower Lemon Bay.

The CHNEP established seagrass restoration and protection targets for the Upper and Lower Lemon Bay segments. The targets were defined as either the baseline acreage (adjusted for non-restorable areas) or the mean annual extent from the recent SWFWMD surveys. These targets are:

- *Upper Lemon Bay*
  - *Protection Target – 1,009 acres*
- *Lower Lemon Bay*
  - *Protection Target – 2,502 acres*
  - *Restoration Target – 380 acres*

In the following discussion, water quality targets based on seagrass success and desirable salinity conditions, and meeting DO standards in Lemon Bay are defined. These targets will be applied to loading-water quality response models to estimate the loading targets to be addressed by the watershed projects and programs.

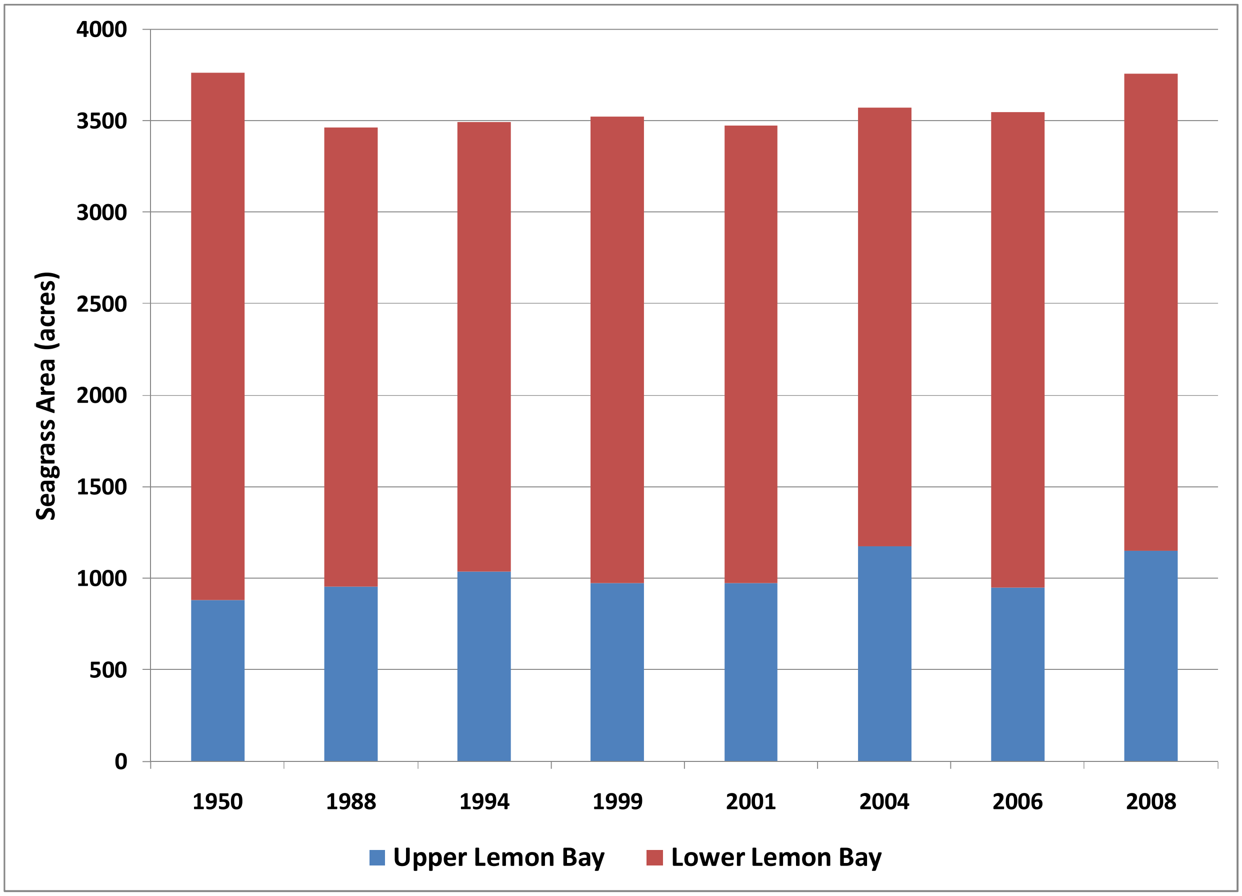

Figure 4-10 Seagrass Cover (acres) from the Historical and Recent Surveys in Lemon Bay

4.2.1 Seagrass-Related and Water Quality Standard-Based Targets

Given the seagrass target for Lemon Bay, the next step in the target setting process is to determine the water quality conditions that are conducive to the protection and restoration of seagrasses. Water clarity, a measure of the amount of sunlight that can penetrate the water, is a significant determinant of seagrass success in a given estuary (Dawes et al., 2004). Clear waters are indicative of a healthy estuary, although many factors impact water clarity. Excess suspended sediments from runoff can negatively impact water clarity. Nutrients, mainly nitrogen and phosphorus, can fuel the growth of photosynthesizing algae. High chlorophyll *a* concentrations can also decrease water clarity. In turn, decreased water clarity can negatively impact seagrass cover, reducing habitat availability to the hundreds of species that depend on them.

Examination of the ambient water quality data shows the interrelationships among chlorophyll, light attenuation, and turbidity in Lemon Bay (Figures 4-11 and 4-12). While light attenuation declines with both increasing chlorophyll and turbidity, more of the variation in light attenuation is related to variation in chlorophyll *a* concentrations as evidenced by the respective coefficients of determination (r^2).

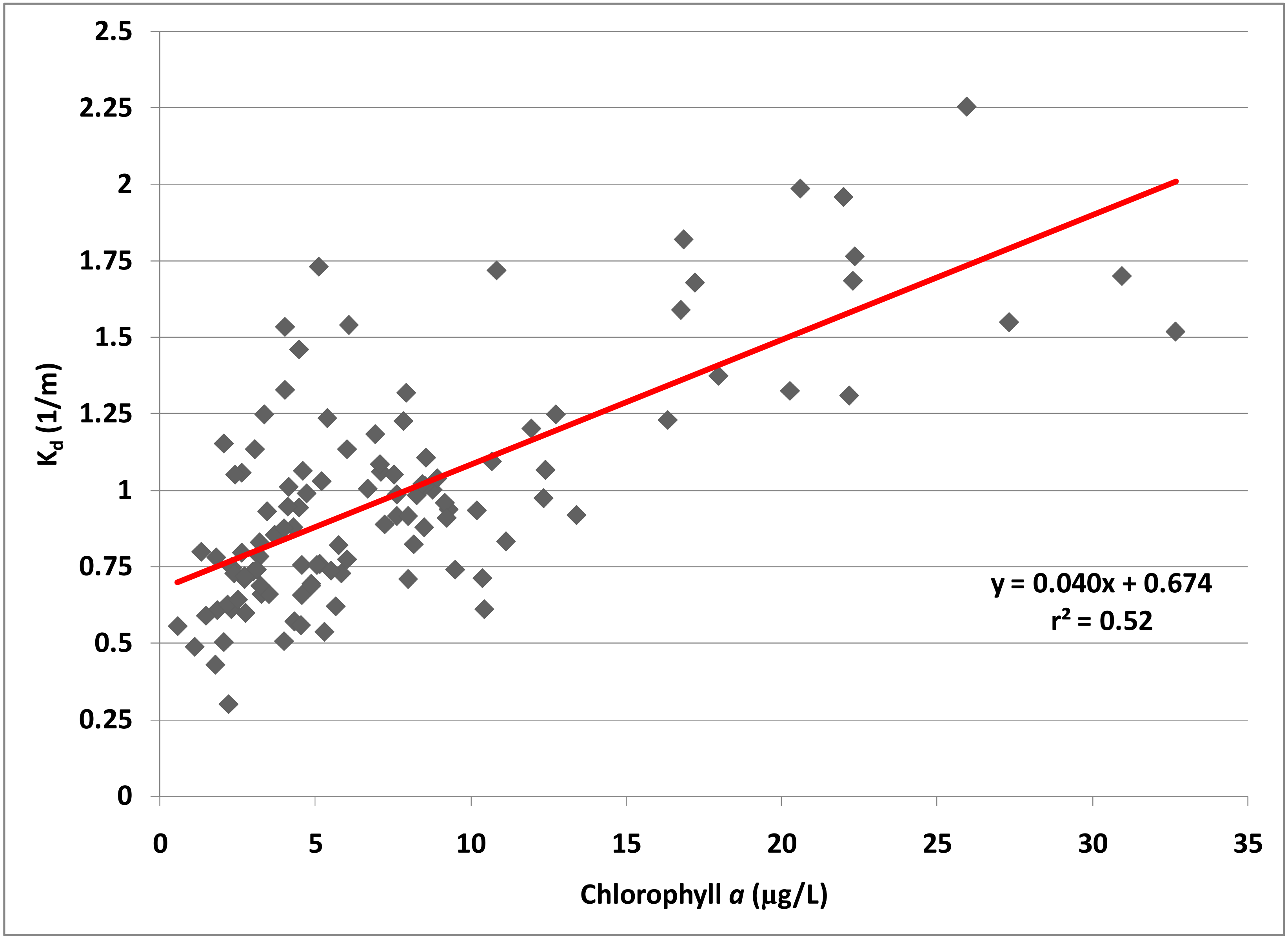

Figure 4-11 Relationship Between Chlorophyll *a* Concentrations and Light Attenuation in Lemon Bay (1998–2007)

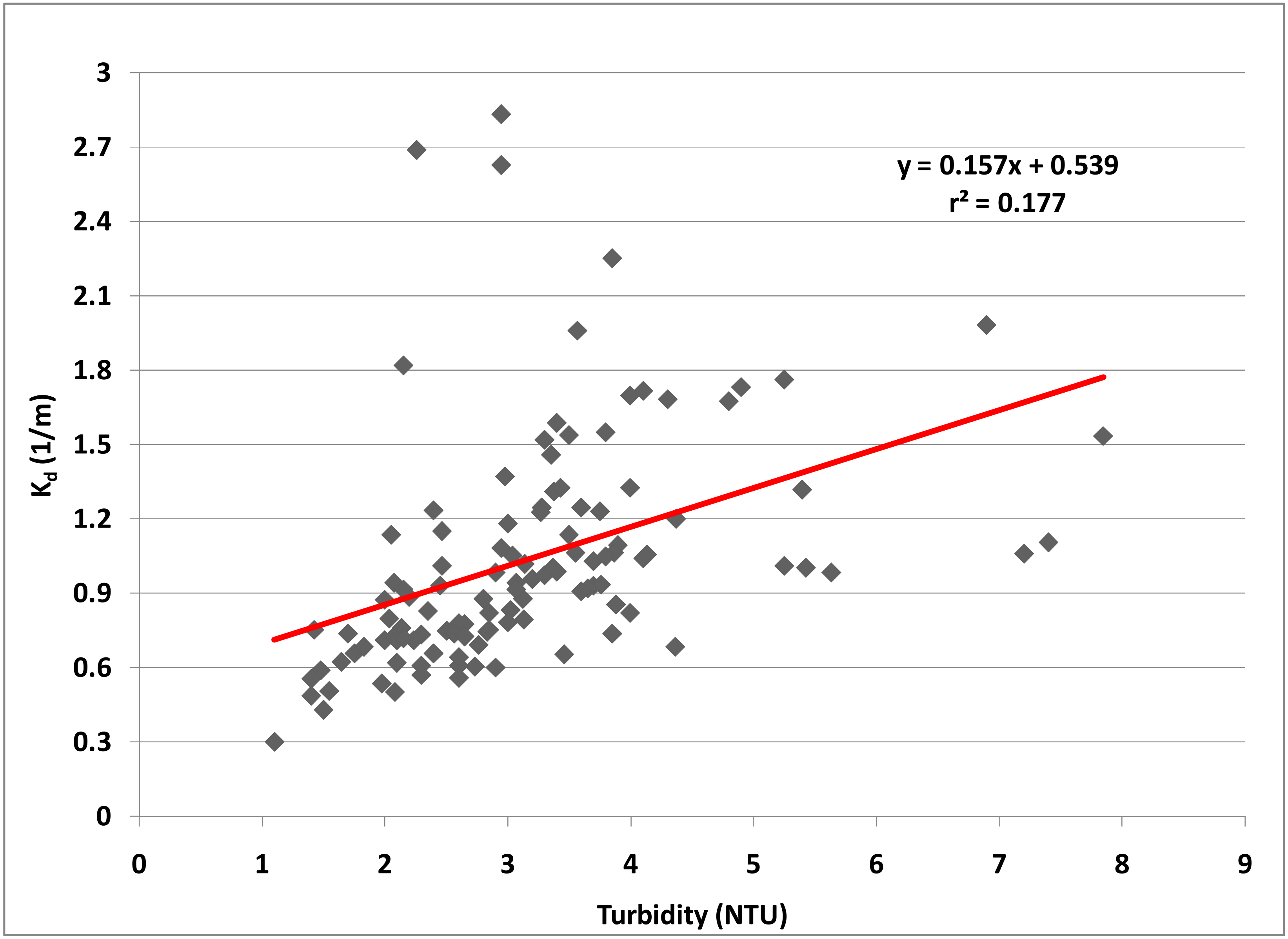

Figure 4-12 Relationship Between Turbidity and Light Attenuation in Lemon Bay (1998–2007)

Water clarity targets were recently suggested for the estuarine waters of Sarasota County (Wessel et al., 2007). These targets were based on a light attenuation target identified by Corbett and Hale (2006) that is protective of seagrasses. Linking this target to the spatial and depth distributions of seagrasses provided segment-specific water clarity targets. This work was completed before the recent establishment of seagrass targets by the SBEP.

As discussed above, the recent seagrass coverage in Lower Lemon Bay was somewhat lower than that estimated for the historical period (ca. 1950). In contrast, the recent seagrass coverage in Upper Lemon Bay was consistently higher than that estimated for the historical period. The latter observation leads to either of two conclusions: the recent water clarity conditions in Upper Lemon Bay are conducive to seagrass growth and reproduction in those waters, or water clarity is not a critical determinant of seagrass cover in Upper Lemon Bay. Since the latter conclusion is not likely, it is reasonable to conclude that the recent water clarity conditions in Upper Lemon Bay are conducive to seagrass growth and reproduction in those waters.

The water quality data available for Lower Lemon Bay are limited to a number of monitoring sites that are less representative of that portion of the bay than are the sites in the upper bay. Therefore, setting water quality targets based on the data from these sites is not recommended.

The following Upper Lemon Bay water quality targets and standard deviations (for chlorophyll *a* and K_d) are:

- Chlorophyll *a* concentration – 7.8 µg/L and 2.2 µg/L
- K_d – 1.07 (m^1) and 0.1 (m^1)
- DO – 4 mg/L

The chlorophyll and K_d levels are the mean conditions during the 2001 to 2007 period, which generally coincides with the period during which the seagrass targets have been set, and represents the recent wide range in rainfall in this region.

The DO target is a water quality standard based target for estuarine waters. Concerns regarding the validity of the existing DO criteria in both fresh and marine waters have been expressed by many, including Sarasota County. Research continues regarding DO in Florida waters, particularly in freshwater streams and estuaries.

The targets and standard deviations defined above have been applied in the development of the watershed report card discussed in Chapter 9.

4.2.2 Salinity Targets

To establish meaningful targets for salinity and eventually freshwater inflows in Lemon Bay, an understanding of how freshwater inflows affect salinity is important. Estuaries are semienclosed coastal bodies of water that have at least one river or stream flowing into them and a connection to the sea. Salinity in estuaries varies from fresher water at the point of the freshwater inflow in the upstream portion of the estuary to more saline water in the downstream portion where the estuary connects to the sea. Circulation patterns, both horizontal and vertical, also influence the spatial variation in salinity observed in estuaries (Figures 4-13 and 4-14).

As expected, increases in freshwater inputs from the watershed result in lower salinities in the estuary, while decreases in freshwater flows results in higher salinities in the estuary. Therefore, estuaries typically have seasonal patterns of higher salinities during the lower flow dry season and lower salinities during the higher flow wet season.

In addition to the seasonal pattern of salinity in estuaries, there is also a daily variation due to the tides. As the tide rises, salinities in the estuary increase as more saline water enters the system from the sea; as the tide falls, salinities decrease (Hardisty, 2007).

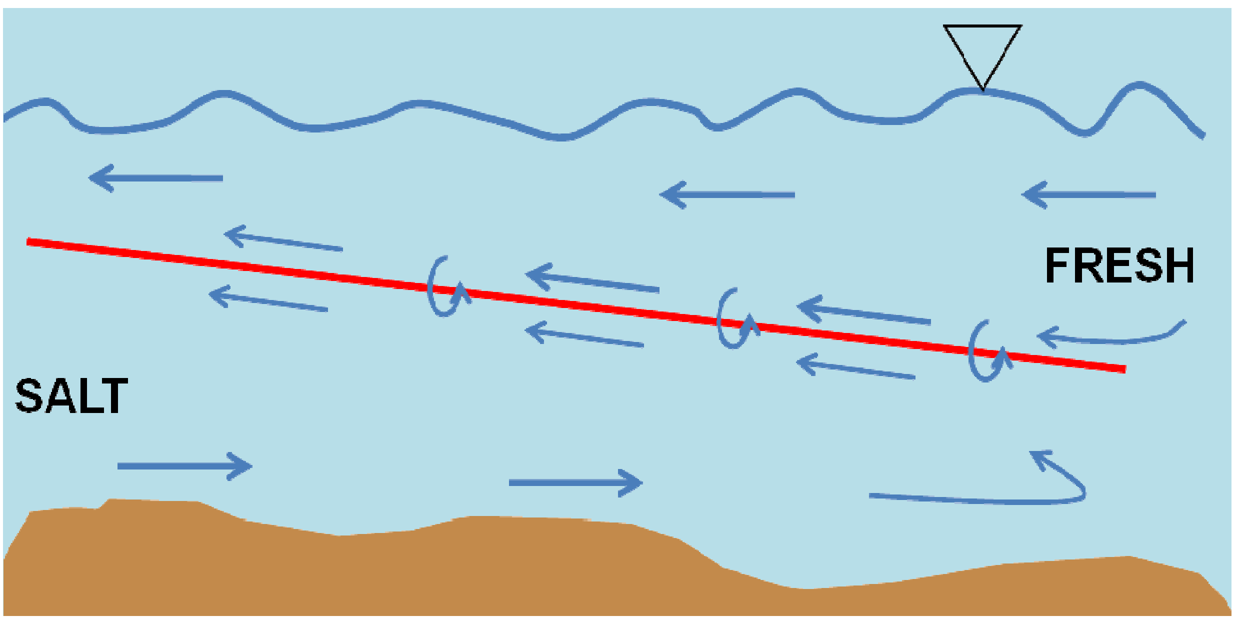

Figure 4-13 Conceptual Depiction of Vertical Tidally-Averaged Circulation Pattern (modified from Goodwin, 1987)

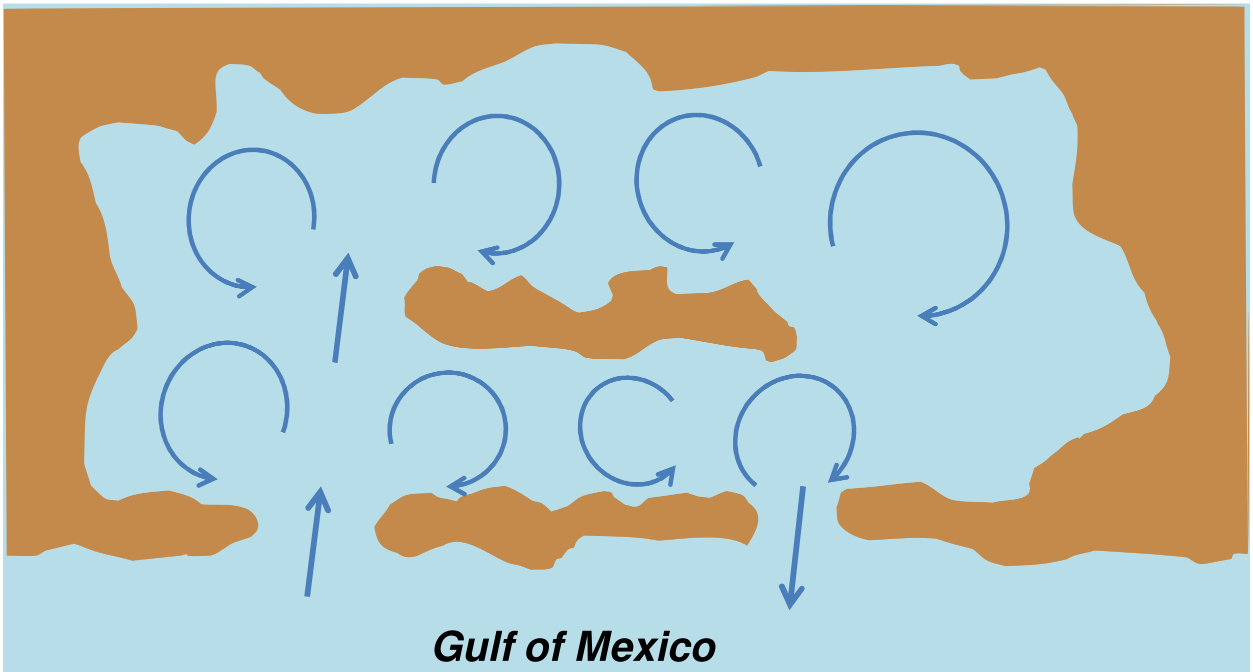

Figure 4-14 Conceptual Depiction of Horizontal Tidally-Averaged Circulation Pattern (modified from Goodwin, 1987)

In addition to influencing salinities in an estuary, freshwater inflows also influence residence time. Residence time represents the amount of time that it takes for the water in the estuary to be replaced. Increases in residence time can result in depleted DO levels and increased accumulation of sediments (Nedwell and Raffaelli, 1999; Wolanski, 2007). Changes in residence time resulting from temporal variation on freshwater inputs have been shown to affect the likelihood of excessive algal blooms (SWFWMD, 2008a; Janicki Environmental, 2008b).

Estuaries provide habitat for many organisms including fishes and benthic macroinvertebrates and therefore are characterized by their high diversity and primary production (Hobbie, 2000). Because salinity in estuaries varies considerably on daily and seasonal time frames, many organisms that inhabit estuaries can tolerate large variations in salinity. However, many of these organisms cannot tolerate completely fresh or very saline water, which is why they inhabit the brackish water of estuaries.

Temporal and spatial variations in salinity can have a direct impact on the composition and distribution of biota within an estuary (Hobbie, 2000; Wolanski, 2007)—for example, fishes (Janicki Environmental 2004a and 2008a; SWFWMD, 2008a) and benthic macroinvertebrates (Janicki Environmental 2007a and 2008b).

Human activity has significantly impacted many estuaries in the United States, often resulting in less available estuarine habitat because of pollution and physical alteration of systems (NRC, 1994). Human activities can lead to either reductions or increases in freshwater inflows to an estuary. Two examples in southwest Florida are the estuarine portion of the lower Hillsborough River and Dona Bay.

Recent analysis has shown that human activity has led to a decline in freshwater inflows to the lower Hillsborough River (SWFWMD, 2008b). The decline in freshwater inflows led to a loss of oligohaline habitat (water less than 5 ppt) in the lower Hillsborough River. To address the reduction in oligohaline habitat in the lower Hillsborough River, the minimum flow for the system was modified to maintain sufficient oligohaline habitat.

In Dona Bay, canal construction in the watershed adjacent to the historical Dona Bay watershed resulted in a large seasonal increase in freshwater inflows to Dona Bay (SWFWMD, 2009). The increase in freshwater inflows has negatively impacted seagrass and oyster populations in Dona Bay. The draft minimum flow for Dona Bay has recommended Minimum Flows Levels that would allow small flow reductions in Fox and Salt Creek.

Since salinity can vary significantly over a wide range of temporal and spatial scales and that many estuarine organisms can tolerate large variations in salinity, defining a salinity *target* must necessarily account for these givens. Therefore, we recommend that a target salinity regime, that accounts for these givens be defined. Target freshwater input targets can then be defined based on the empirical relationship between salinity and freshwater inflows.

4.2.2.1 Relationship between Flows and Salinity in Lemon Bay

In Chapter 4.1.1 we described the individual status and trends of the primary water quality parameters affecting the health and productivity of the Lemon Bay estuary. This includes the waterbody Segments 1–5, and all of the subbasins in Sarasota County. Many of the natural systems described in Chapter 3.2.1 have preferred conditions for success within the natural variation in estuarine systems. For example, the preferred range of salinity for the health and success of oysters has been identified as 14–28 ppt (Kennedy et al., 1996). Salinities less than 10 ppt inhibit the success of oyster larvae, while salinities higher than 30 ppt decrease growth rates and increase the likelihood of parasitic infection (Stanley and Sellers, 1986). Turtle grass, *Thalassia testudinum,* is another species that has salinity preferences within estuarine environments and generally prefers salinities above 20 ppt (Zieman and Zieman, 1989). Many estuarine fish taxa that use the Lemon Bay estuary have preferential salinities as well (Serviss and Sauers, 2002). Therefore, the timing and volume of freshwater inputs into the Lemon Bay estuary are important to providing one of the primary environmental requirements for the success of these important natural resources.

To evaluate the effects of hydrologic loadings on estuarine salinities, monthly freshwater volume estimates from the *Spatially Integrated Model for Pollutant Loading Estimates* (SIMPLE) model were related to empirical data on salinities from the ambient monitoring program. The sum of all monthly freshwater volumes from all basins in the watershed (including direct rainfall to the estuary) was calculated for each month in the time series from 1995 through 2007. These freshwater volumes were then matched to the empirical data averaged monthly across all measurements. The objectives of this process were to:

- Relate hydrologic volumes from SIMPLE model output to estuarine salinities.
- Identify differences in hydrologic loading between historical, current, and future conditions (See the Water Budget Section in Chapter 3 for a description of conditions used in the SIMPLE model).
- Estimate differences in salinities between historical, current, and future conditions.
- Establish potential hydrologic loading targets protective of salinity regimes.

To accomplish this, a predictive linear regression model was developed that estimated the bay-wide average salinity as a function of inflow volumes from the Sarasota County portion of the watershed. The regression included antecedent freshwater inputs including the freshwater volume loading to the estuary in the month preceding the salinity measurement as well as the current month's freshwater volume input. A seasonality term was also included to account for the differential effects of freshwater inputs throughout the year because of evapotranspiration, mixing, and differences in tidal amplitude as the result of the mixed semi-diurnal nature of tides in southwest Florida.
The regression relationship developed based on the empirical data was then used to predict salinities during historical and future conditions such that these hydrologic scenarios could be compared with respect to estimating the changes in estuarine salinity regimes in Lemon Bay based on anthropogenic alterations to land-use characteristics that altered the natural hydrology.

Monthly average salinities in the Sarasota County portion of the Lemon Bay estuary ranged from 10.2 ppt to 37.7 ppt with a median salinity 31.6 ppt based on empirical data. Model predictions suggested that every 1000 acre feet of freshwater introduced into Lemon Bay monthly would decrease the salinity averaged across Segments 1–5 by approximately 1 ppt (Figure 4-15). While Figure 4-15 displays the generalized relationship between freshwater inflows and predicted salinities, the regression equation also depended on the freshwater volume reaching the estuary in the month preceding the salinity measure as well as the time of year when the salinity measurement was taken. The model performed reasonably well for its intended purpose with an r^2 value of 0.66 and 62% of the differences between observed and predicted salinities (i.e., the residuals) were less than 2.5 ppt (Figure 4-16).

The regression described above was used to hindcast the salinity distributions in Lemon Bay under the historical conditions defined in Chapter 3. A cumulative distribution curve was produced to present the historical salinity distributions in Lemon Bay (Figure 4-17). This curve represents the target salinity regime for Lemon Bay.

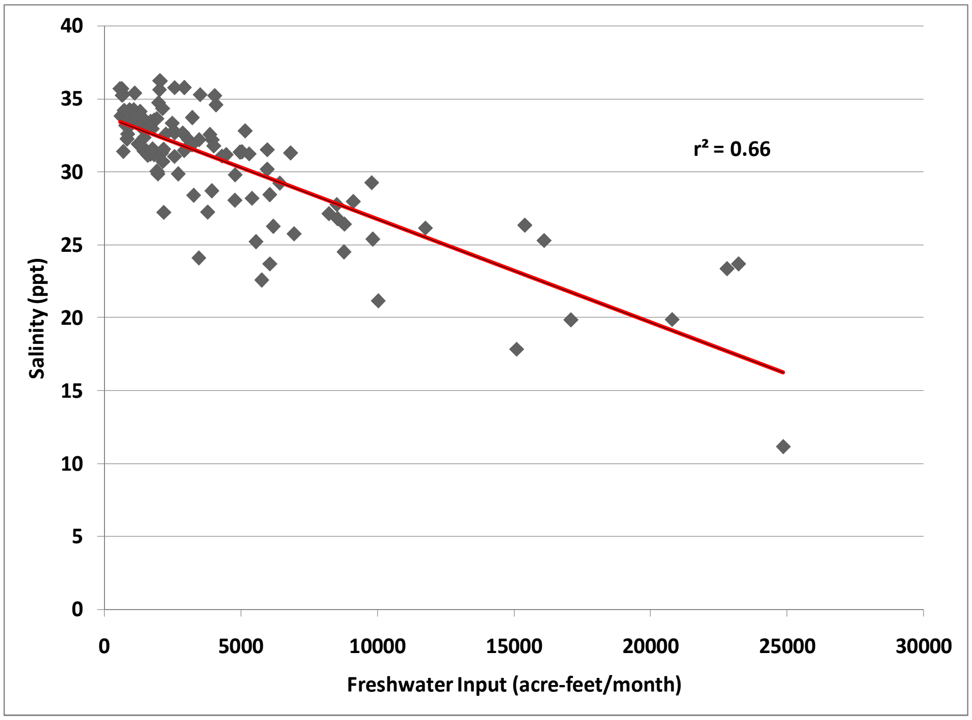

Figure 4-15 Relationship Between Freshwater Volume (acre-feet/month) and Average Predicted Salinities in the Lemon Bay Estuary

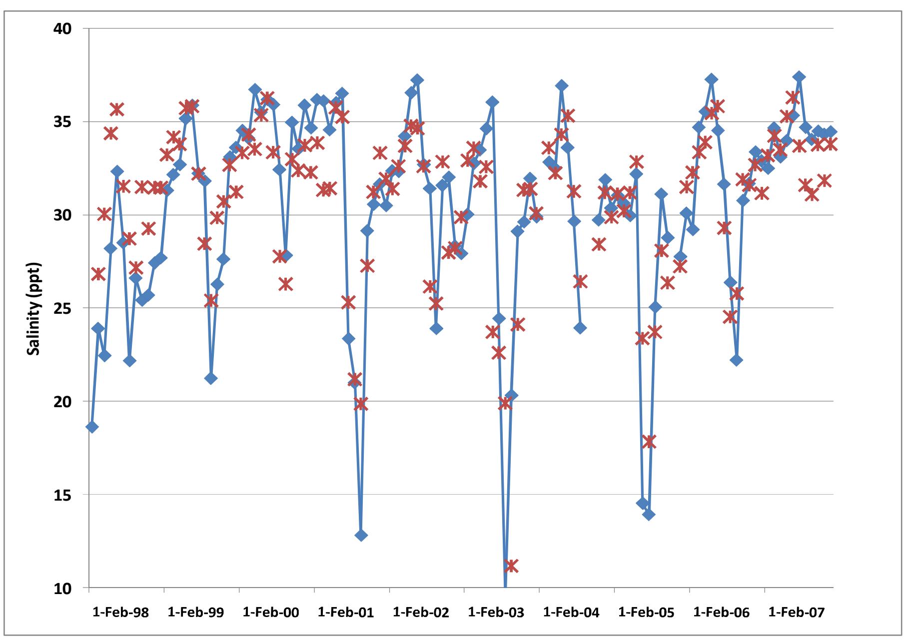

Figure 4-16 Time Series of Predicted (line) and Actual (star) Bay-Wide Salinity Values Between 1998–2007

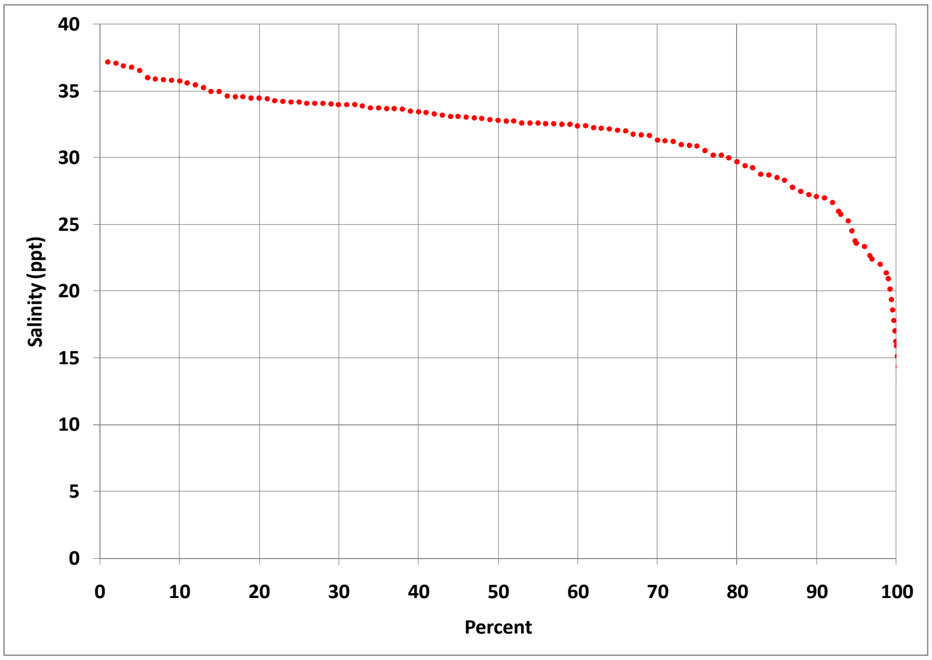

Figure 4-17 Hindcast of Historical Salinity Regime Based on the Relationship Between Historical Flows and Bay-Wide Salinity in the Lemon Bay Estuary

Cumulative distribution curves were produced to describe the differences between the historical and current distributions of hydrologic volumes. The SIMPLE model predictions indicate that current hydrologic volumes to the bay tended to exceed the historical volumes (Figure 4-18). This resulted in historical salinity values that were typically higher than current salinities, and the distribution of salinities has shifted by ca. 2 ppt between historical and current conditions (Figure 4-19). The proposed target water budget for Lemon Bay is therefore, the historical hydrologic regime.

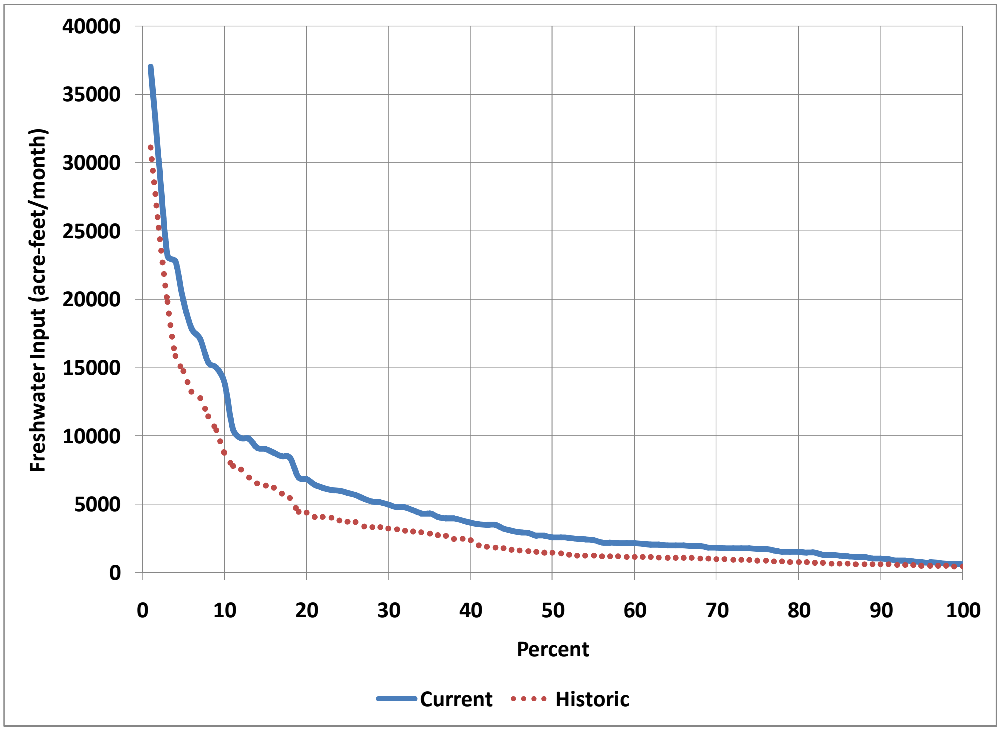

Figure 4-18 Comparison of Historical and Current Freshwater Input Distributions

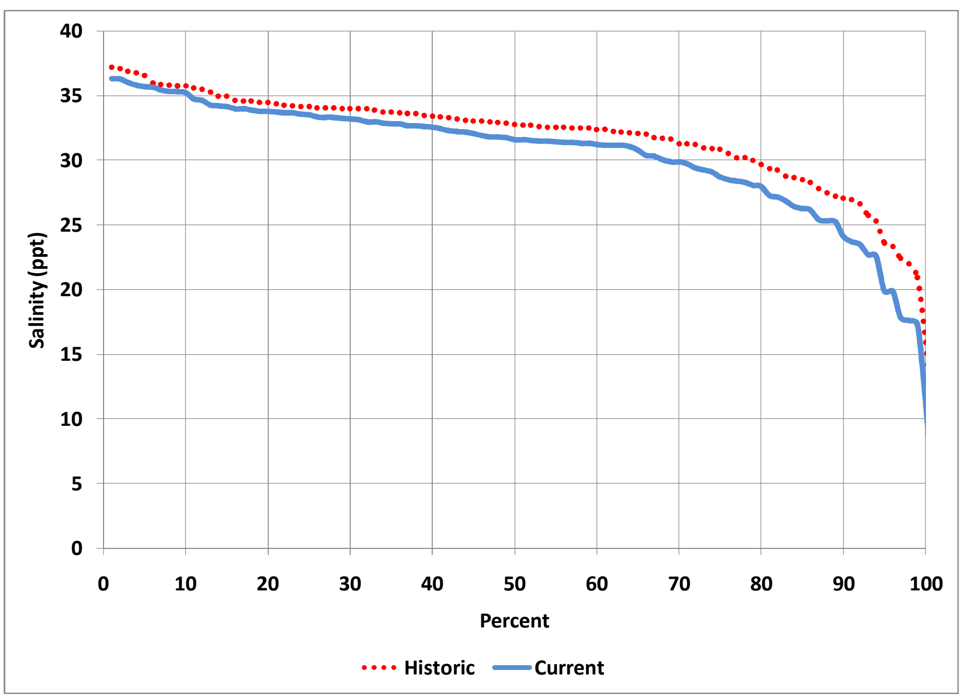

Figure 4-19 Comparison of Historical and Current Salinity Distributions for the Lemon Bay Estuary

A difference of 2.5 ppt was chosen as a conservative estimate of a biologically relevant change in salinity in an estuarine environment given the dynamic nature of salinity variation in an estuarine system. This difference also corresponds with a difference that would be outside the uncertainty of the regression model predictions. The differences between the historical and current conditions was calculated for each date in the time series and tabulated to define the proportion (percent) of days in a month when the difference was larger than 2.5 ppt. Differences in salinity greater than 2.5 ppt occurred primarily in the wet season between August and October, indicating that the greatest changes to estuarine salinities were decreased salinities in the wet season (Figure 4-20).

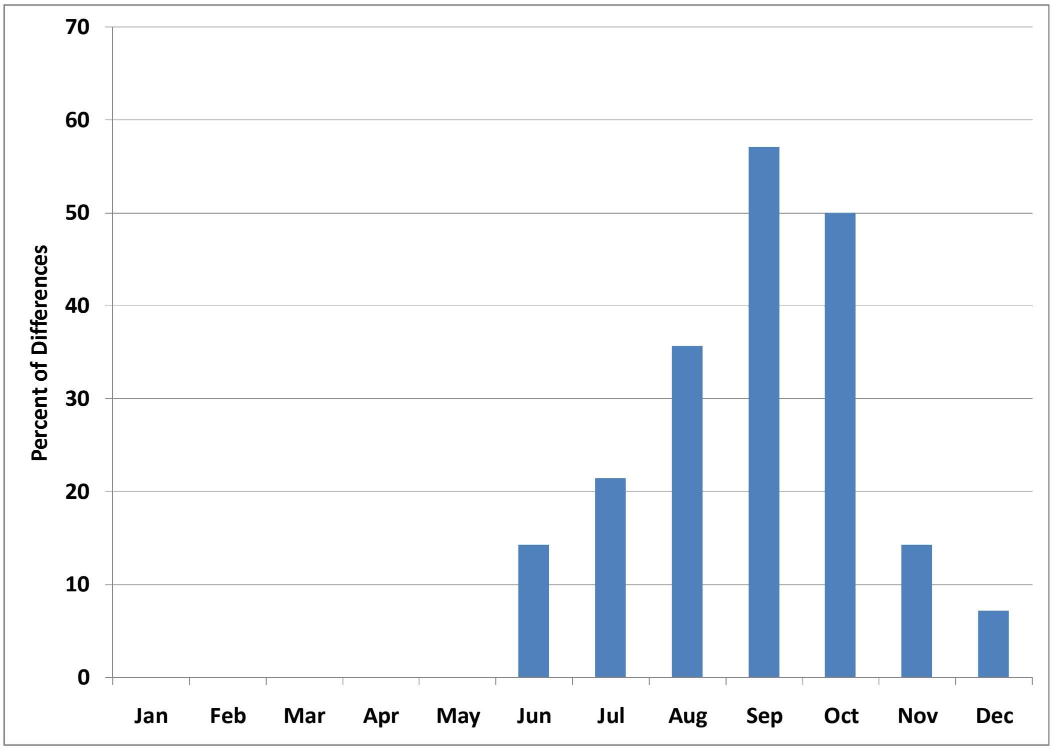

Figure 4-20 Percent of Predicted Differences in Salinity Greater than 2.5 ppt by Month over a 14-Year Simulated Rainfall Record

Despite the observation that salinities were different between historical and current conditions and that those differences appeared to be largest during the summer, the current salinities in Lemon Bay remained in the polyhaline to euhaline range with summertime median and average salinities above 25 ppt throughout Lemon Bay (Figure 4-21). While spatial differences exist with respect to the influence of freshwater volume loadings into Lemon Bay, with lower salinities found in the northern portions of the estuary, these salinities do not appear to be detrimental to the critical natural resources inhabiting the estuary (e.g., mangroves, seagrasses, and oysters). Attempts to mitigate the effects of increased freshwater volumes entering Lemon Bay for retaining historical salinity regimes should concentrate on capturing wet season discharges from the watershed. These aspects of the water budget are described in detail in the watershed portion of the natural systems section dealing with the water budget.

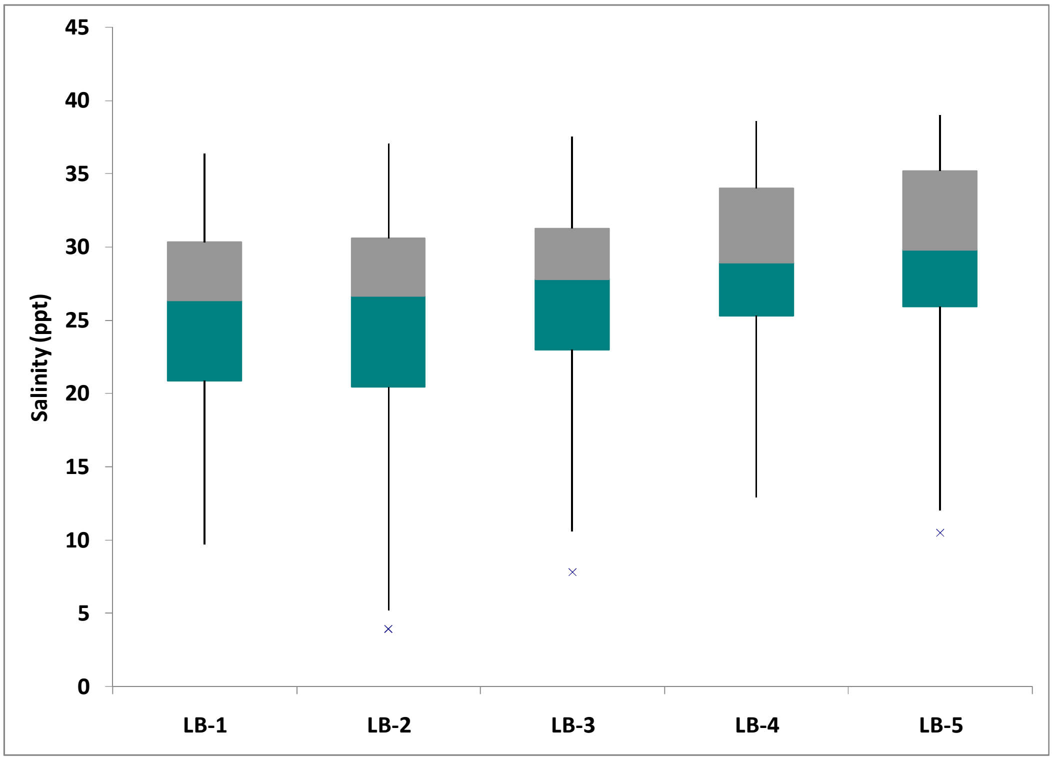

Figure 4-21 Distribution of Summer (i.e., July–October) Salinities in Lemon Bay by Stratum

4.3 POLLUTANT-LOADING ANALYSIS

A thorough understanding of the nature, sources, and spatial and temporal variability in pollutant loads is necessary if an effective watershed plan is to emerge. This understanding will aid in a further understanding of the manner and degree to which the receiving waters will respond to the pollutant loadings.

A generalized conceptual relationship between watershed inputs and water quality responses is provided in Figure 4-22. Altered freshwater inputs can significantly alter salinity patterns in estuaries and alter the community structure of biota within the system. Additionally, estuarine residence time depends on freshwater inputs and can influence the water quality responses in the estuary to changes in watershed loadings.

Since the current concentrations are somewhat higher than historically, the current salinities as a result are correspondingly lower, especially in the summer months.

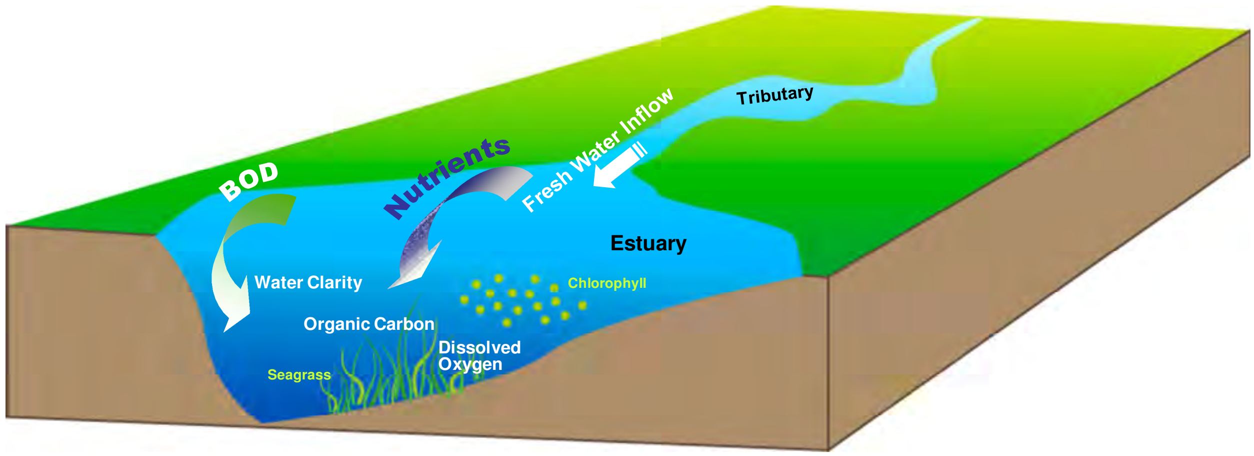

Figure 4-22 Conceptual Illustration of Watershed Loadings and Principal Indicators of Estuarine Health in Florida Estuaries

Water quality in a waterbody is influenced by the pollutants that reach the waterbody. Pollutants come from many sources, including runoff from land, groundwater flows, atmospheric deposition, and point sources. To improve water quality, managers must identify the pollutants that are responsible for the degradation in water quality. For example, in nearby Tampa Bay, nitrogen was identified as the pollutant that was significantly contributing to decreases in water quality in Tampa Bay. This decline in water quality resulted in numerous adverse impacts. The elevated nitrogen loadings contributed to increased chlorophyll concentrations in the bay and a corresponding reduction in water clarity and seagrass abundance. Thus, management actions have been taken to reduce nitrogen inputs into the bay, and these management actions have contributed to an improvement in water quality.

Before management actions are implemented, resource managers must identify the pollutants that are responsible for the degradation of water quality. After the pollutants have been identified, the sources of these pollutants must be identified and quantified. The quantification of loading sources allows managers to focus their resources on those sources that make the greatest contribution to the problem. As expected, not all pollutant sources will be easy to manage. For example, loadings from atmospheric deposition can often originate outside the watershed and can therefore be difficult to manage. Point sources, on the other hand, are discrete sources of pollutant loadings that can generally be located and quantified with certainty.

With many watersheds, direct runoff (also known as nonpoint source runoff) represents a significant amount of the total load from the watershed. Direct runoff is the result of rainfall and is affected by land use and soils. Management of direct runoff is complicated due to the nature of runoff and the number of entities involved. Therefore, to control direct runoff, actions must be taken in concert with landowners and land custodians. This involves individuals from the owner of a single-family home to the city, county, state, and federal governments who are responsible for huge tracts of land including roadways, recreation areas, and conservation areas. State and local governments can also have a significant impact on direct runoff through the adoption of ordinances that relate to construction projects. For example, by requiring adequate water retention areas (retention ponds, swales, etc.) as part of new construction, direct runoff can be greatly reduced as a portion of rainfall is sequestered and allowed to infiltrate the soil instead of directly running off into surface water ways.

4.3.1 Estimation of Pollutant Loading to Lemon Bay

To better understand the influence of loadings to Lemon Bay, a pollutant-loading model, the SIMPLE, was developed for the watershed. Sarasota County contracted with Jones Edmunds & Associates, Inc. to determine hydrologic yield and loading estimates for a wide array of pollutants, including nutrients, metals, coliforms, and—specific to the present analysis—total nitrogen (TN) loads, BOD loads, and total suspended solids (TSS) loads, throughout the watershed. The model's spatial domain is divided into basins and subbasins throughout the watershed, as seen in Figure 4-23. The temporal range for the model's application was from 1995 to 2007, with output produced at monthly intervals, which is roughly equivalent to the response time to these pollutant loads observed in Sarasota County's bays and estuaries (Jones Edmunds, 2008). An in-depth description of the model can be found in Jones Edmunds (2008).

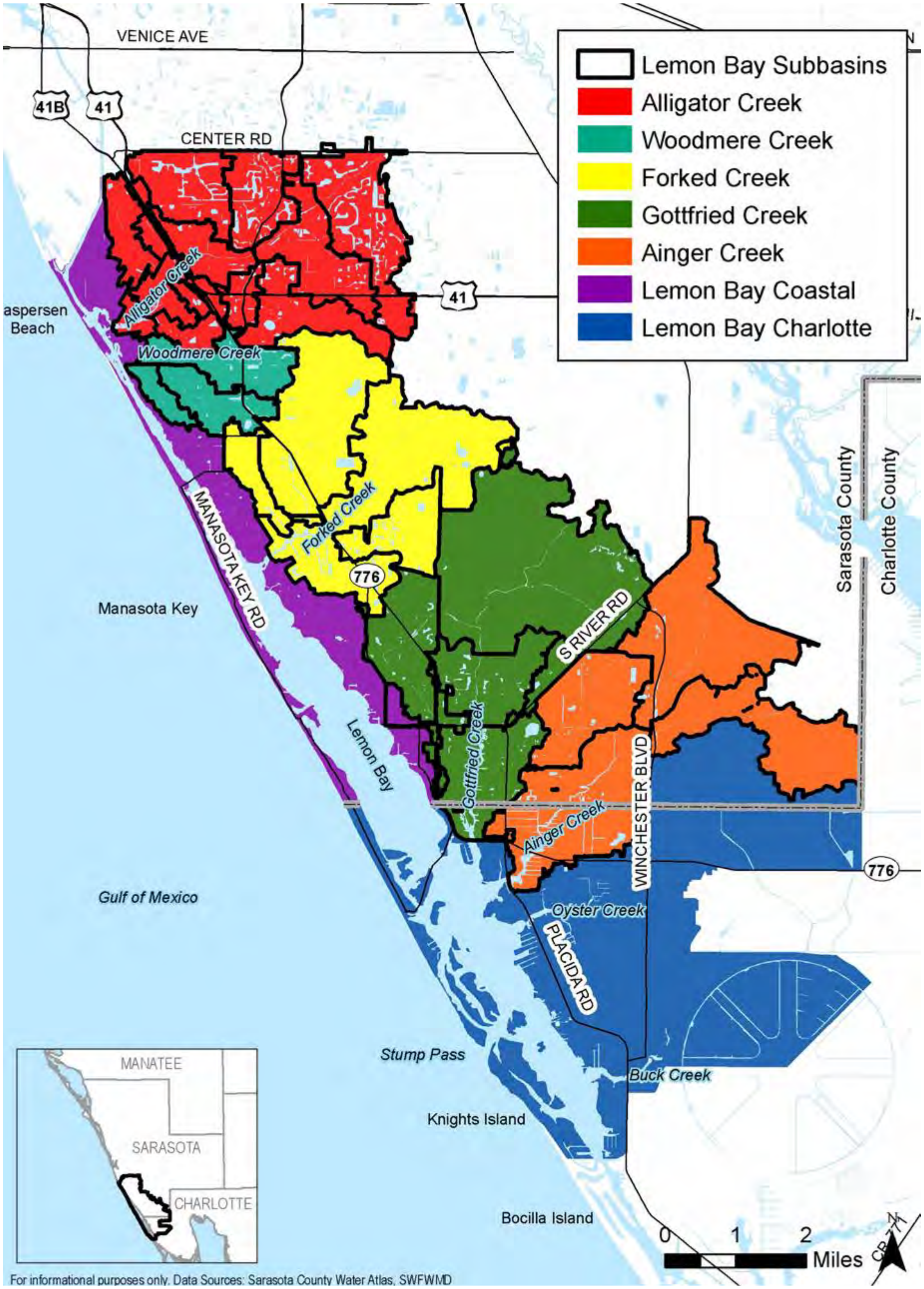

Figure 4-23 Model Spatial Domain Depicting Subbasins and Basins for Lemon Bay

The SIMPLE estimates loads from the following sources:

- Hydrologic model: The SIMPLE incorporates a hydrologic engine originally used in the Braden River Surface Water Resource Assessment (Jones Edmunds, 1997). Input data requirements for the SIMPLE hydrologic model include freshwater flows, NEXRAD rainfall, evapotranspiration rates, water surface elevations, land use, soils, and groundwater data.
- Direct runoff module: To calculate loads based on direct runoff, data on NEXRAD rainfall, land use, soils, and best management practices (BMPs) were integrated into the SIMPLE. Land use data from 1990 and 2004 were used to estimate temporal change in the watershed and to determine runoff coefficients between pre-development and development conditions. Soils were used to estimate infiltration and runoff characteristics in the watershed. The BMP spatial data, like the land use component, were constructed to reflect temporal changes in their coverage between the pre-development and developed conditions. Each unique NEXRAD pixel/land use/soil combination was joined with Event Mean Concentrations to determine loadings estimates.
- Baseflow module: Baseflow was calculated as part of the hydrologic model and was determined as a function of each unique NEXRAD pixel/land use/soil combination, as described in the direct runoff module. This module also includes an evapotranspiration term.
- Irrigation module: This module considers three sources of irrigation water: groundwater/potable, stormwater, and reclaimed water, with different concentrations used for each source. The potable and reclaimed water concentrations were set based on FDEP requirements, while stormwater, which is not yet regulated, was assumed to have concentrations similar to baseflow. The SIMPLE assumed that all residential, agricultural, commercial, and golf course land uses were irrigated.
- Point-source module: This module considers 38 non-delegated wastewater treatment plants (WWTPs) averaging less than 0.05 MGD, and 17 larger, delegated WWTPs, which discharge between 0.1 and 6.0 MGD, in the watershed. The smaller facilities typically serve small communities, campgrounds, and parks, while the delegated point sources serve larger municipalities. The method of calculating point source loadings was based on flow and concentration. Monthly data received from Sarasota County (non-delegated) and FDEP (delegated) were used to calculate loadings for the point source module.
- Septic tank module: Sarasota County provided Jones Edmunds with the spatial location of the approximately 45,000 septic tanks in the County. However, 80,000–90,000 septic tanks are estimated; the undocumented septic tanks were accounted for based on current septic and sewer coverages and the Sarasota County parcel coverage. Average flow rates were based on land use, either residential or non-residential, while three concentration levels were assigned

(high, medium, and low), depending on soil type, the presence of BMPs, and the distance from the nearest conveyance.

Nitrogen loadings due to atmospheric deposition were estimated as follows. *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 bay. Deposition of pollutants to the watershed of the bay is incorporated into nonpoint source loading estimates.

Three data types are needed to estimate total atmospheric deposition:

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

The hydrologic loads to the surface of the bay via precipitation were estimated in the same manner as for the hydrologic modeling effort. NEXRAD-derived rainfall provided by the SWFWMD was used to derive monthly rainfall totals to the bay surface.

Precipitation-weighted mean monthly rainfall TN concentration data were obtained from the National Atmospheric Deposition Program (NADP) Verna Wellfield site in Sarasota County. The TN loadings from precipitation were estimated by multiplying the monthly precipitation-weighted mean TN concentrations from the Verna site and the monthly bay surface hydrologic loads to estimate monthly wet TN loads to the bay.

An estimate of dry deposition was also needed to develop total atmospheric deposition to the bay surface, as the total deposition is the sum of wet (rainfall) and dry deposition. The Sarasota Bay National Estuary Program initiated an intensive atmospheric deposition monitoring program in September 1998 that lasted 1 year. From the atmospheric nitrogen concentration data collected during this 1-year monitoring period, dry deposition was estimated to make up approximately 29% of the total atmospheric deposition directly to the surface of Sarasota Bay (SBNEP, undated).

Another estimate of atmospheric deposition TN loading to the surface of Sarasota Bay was provided by a modeling effort using the CALMET/CALPUFF modeling system (Poor, 1999). The model results predicted that approximately 89% of the total nitrogen deposition to the surface of Sarasota Bay was from dry deposition. The predicted wet deposition to the surface of the bay was an order of magnitude less that that measured at the nearby Verna NADP site (Poor, 1999). Importantly, the modeling effort indicated that Sarasota Bay and Tampa Bay shared the same airshed (EPA, 2000).

Since a longer term record of atmospheric deposition data collection exists for Tampa Bay and since the two bays share the same airshed, dry deposition data collected as part of the Tampa Bay Atmospheric Deposition Study (TBADS) were used for this effort. This study was conducted for a 10-year period (August 1996 through June 2006) and included sampling elements for both wet and dry atmospheric deposition at an intensive monitoring site located on the Gandy Bridge Causeway. The data available from TBADS have been used to estimate atmospheric deposition to Tampa Bay. These data include precipitation nitrogen concentration data, wet and dry deposition rates, and an estimate of the ratio of dry:wet deposition (Poor, 2000; Pribble et al., 2001). Seasonal ratios of dry:wet deposition were derived from the TBADS data, with the wet season ratio of 0.66 indicating that dry deposition makes up approximately 40% of the total deposition in the wet season, and the dry season ratio of 1.05 indicating that dry deposition makes up approximately 51% of the total deposition in the dry season. Both of these seasonal proportions are greater than that from the 1-year Sarasota Bay study, which found 29% of the total deposition was due to dry deposition. However, the lower value from the 1-year Sarasota Bay study may be an artifact of the much shorter data collection period, and the longer-term record from the TBADS study is assumed to provide a more accurate representation of the typical contribution from dry deposition over a longer period of time for the airshed including Sarasota Bay and Tampa Bay.

Using monthly precipitation nitrogen concentrations from the Verna NADP site and the NEXRAD-derived monthly rainfall, the equation for wet deposition of nitrogen is as follows:

$$Nwet_m=[N]_m * H_m$$

where:

$Nwet_m$ = wet deposition of nitrogen for each month m,

$[N]_m$= mean precipitation-weighted nitrogen concentration in the rainfall measured at the Verna Wellfield for each month m, and

H_m= estimated hydrologic load from rainfall for each month m to the bay surface.

Dry deposition was estimated using the TBADS-derived seasonal dry:wet deposition ratio, which was 1.05 for the dry season (months 1-6, 11, and 12) and 0.66 for the wet season (months 7-10), as follows:

$$Ndry_m= \text{Seasonal Deposition Ratio} * Nwet_m$$

where:

$Ndry_m$ = dry deposition of nitrogen for each month m, and

$Nwet_m$ = wet deposition of nitrogen for each month m.

The total atmospheric deposition to a surface of the bay was given as the sum of the wet and dry deposition, as follows:

$$Ntot_m = Nwet_m + Ndry_m$$

where:

$Ntot_m$= total atmospheric deposition of nitrogen for each month m to the surface of the bay.

The monthly TN loadings were then summed over each year to provide annual loadings from atmospheric deposition directly to the surface of the bay.

To calculate hydrologic yield and loadings estimates for subbasins in the Charlotte County portion of the Lemon Bay watershed, land uses were compared between basins in Charlotte County and those for which the SIMPLE had already been developed in Sarasota County. The goal of this exercise was to identify the basins in Sarasota County that have similar land-use characteristics to basins in Charlotte County. After identifying the basins that have similar land-use characteristics, the unit area loadings were extended from Sarasota County basins to apply to the Charlotte County basins.

Based on the land use comparison, the following associations were made in extending Sarasota County unit area yield and loadings to Charlotte County basins:

- The Charlotte County portion of Lemon Bay Proper was based on Subbasin 102.
- The Charlotte County portion of Lemon Bay Coastal, including islands located in the bay, was based on Subbasin 43.
- Coral Creek was based on Ainger Creek.
- Buck Creek was based on Alligator Creek.
- The Charlotte County portions of Oyster, Ainger, and Gottfried creeks were based on Alligator Creek.

The unit areal yields and loads were then multiplied by the total number of acres in each of the Charlotte County basins to determine freshwater yield and loading estimates for these portions of the Lemon Bay watershed.

4.3.1.1 Analysis of the Sources and Temporal and Spatial Variability in Pollutant Loadings to Lemon Bay

An understanding of the relative importance of the sources of pollutant loads to Lemon Bay and the spatial and temporal and temporal variability in these loads provide a critical basis for the WMP development. Given limited resources, knowledge of “How much” and “Where” justifies the appropriate prioritization of management actions.

4.3.1.2 Source Attribution

The majority of the TN loading to Lemon Bay from 1995 through 2007 was from direct runoff (70.4%), base flow (19.5%), and atmospheric deposition (5.3%) (Figure 4-24). The remaining TN loadings were from septic, irrigation, and point sources, accounting for 3.9%, 0.8%, and 0.2%, respectively. There was clear intra-annual variation of the relative contributions of TN loads (Figure 4-25). Direct runoff contributions were greatest during the summer months concurrent with the highest seasonal freshwater inputs. Conversely, during the dry season septic contributions were greater than during the wet season.

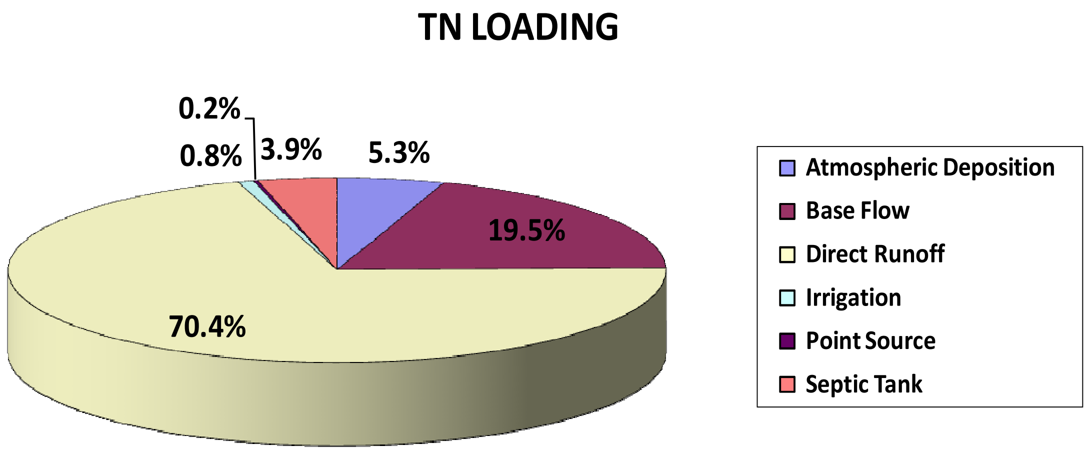

Figure 4-24 Relative Contributions from Each Source of TN Loads to Lemon Bay (1995–2007)

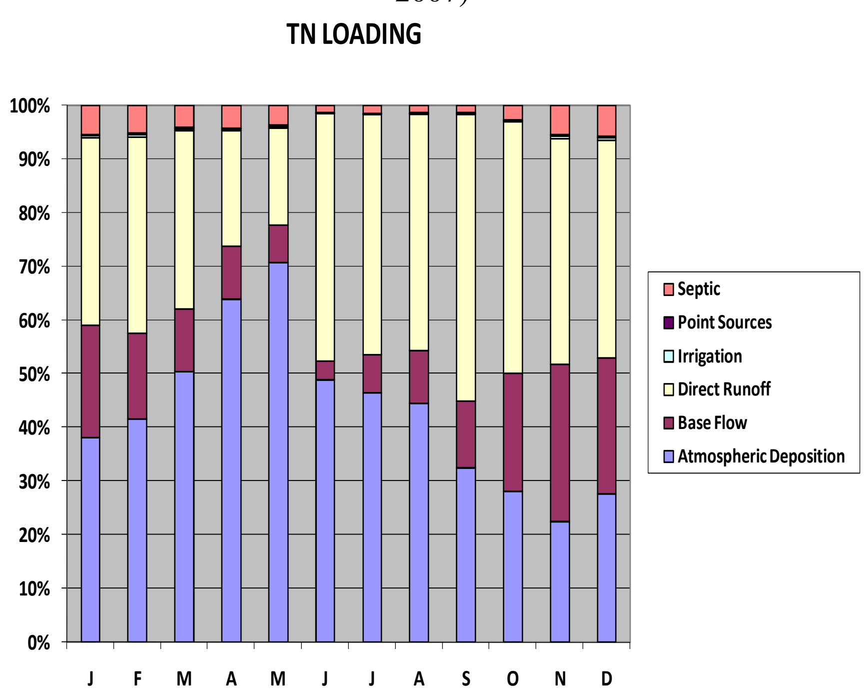

Figure 4-25 Monthly Variation in the Relative Contributions from Each Source of TN loads to Lemon Bay (1995–2007)

Similar analyses of the source attribution of TSS and BOD loads were completed. The majority of the TSS loading was from direct runoff (86%) and base flow (13%) (Figure 4-26). The remaining TSS loadings were from septic, irrigation, and point sources, accounting for 0.8%, 0.1%, and 0.04%, respectively. Seasonally, direct runoff contributions were greatest in the summer while base flow TSS loads were greatest during the dry season (Figure 4-27).

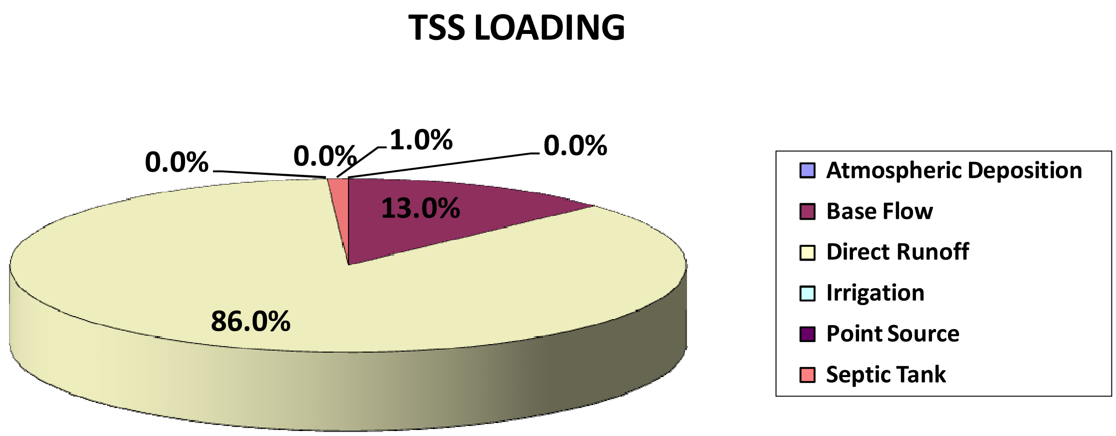

Figure 4-26 Relative Contributions from Each Source of TSS loads to Lemon Bay (1995–2007)

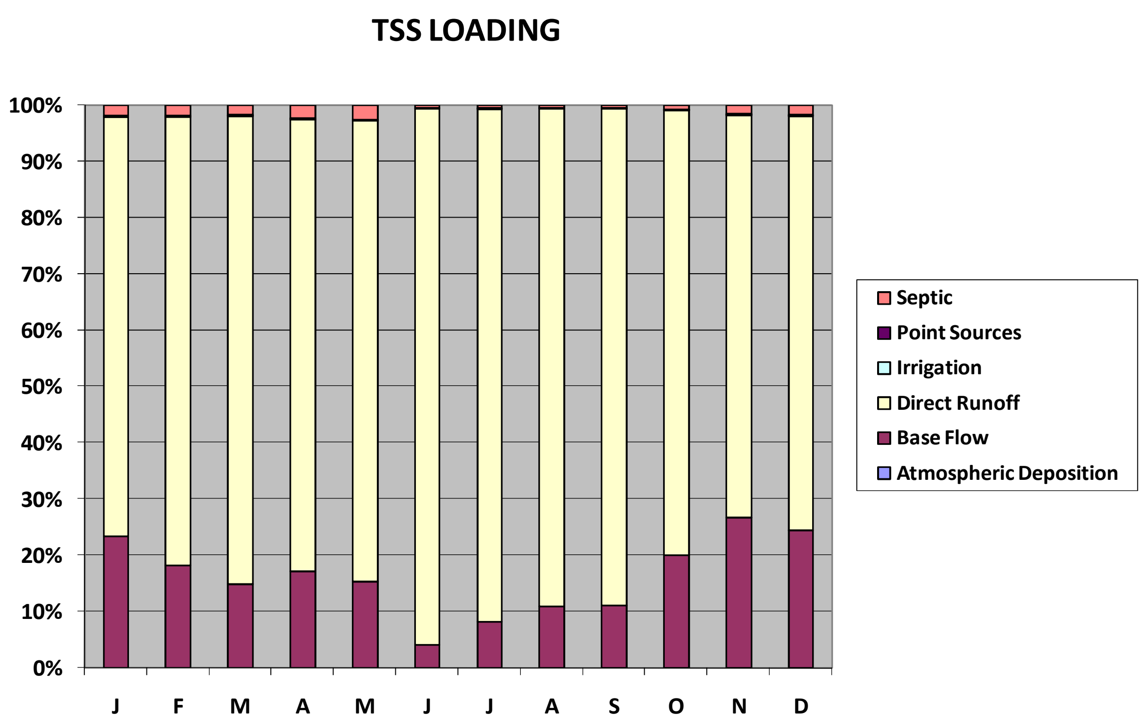

Figure 4-27 Monthly Variation in the Relative Contributions from Each Source of TSS loads to Lemon Bay (1995–2007)

The majority of the BOD loading was from direct runoff (74.6%) and base flow (18.3%) (Figure 4-28). The remaining BOD loadings were from septic, point sources, and irrigation, accounting for 6.6%, 0.3%, and 0.3%, respectively. Seasonal variation in BOD loads from direct runoff and base flow was similar to that observed for both TN and TSS (Figure 4-29).

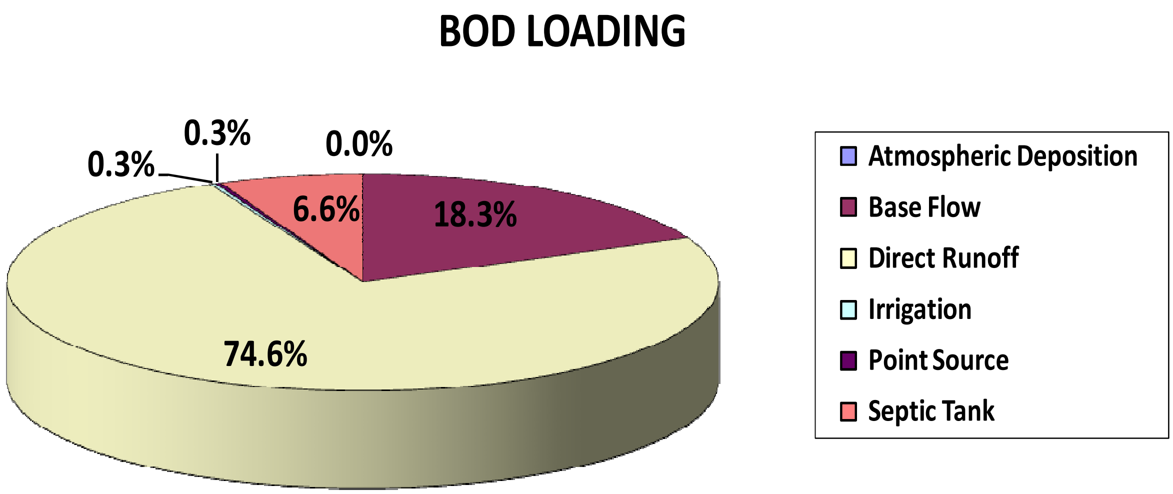

Figure 4-28 Relative Contributions from Each Source of BOD Loads to Lemon Bay (1995–2007)

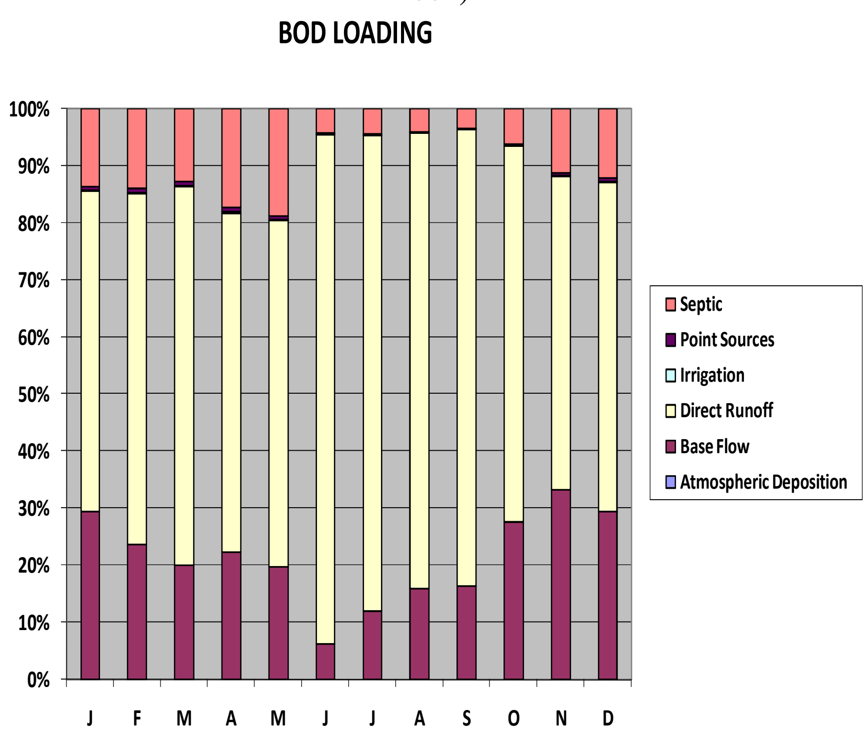

Figure 4-29 Monthly Variation in the Relative Contributions from Each Source of BOD Loads to Lemon Bay (1995–2007)

4.3.1.3

4.3.1.4 Temporal Variability in Pollutant Loads to Lemon Bay

Pollutant loads can vary significantly over time and an understanding of this temporal variability is essential. Longer-term trends in loads can indicate changes in the nature of the watershed draining to the waterbody of concern. Seasonal variation in loads can also be an important determinant of the water quality responses in the receiving waterbody.

The total annual TN loads to Lemon Bay varied significantly from a maximum of 424 tons in 1995 to a minimum of 48 tons in 2007 (Figure 4-30). The average annual TN load to Lemon Bay was 171 tons per year. Since direct runoff is the largest contributor to TN loads, large variations in annual loads are expected as rainfall varies from year to year. As a result of the seasonal variation in rainfall, TN loads are typically higher in the wetter summer months (Figure 4-31).

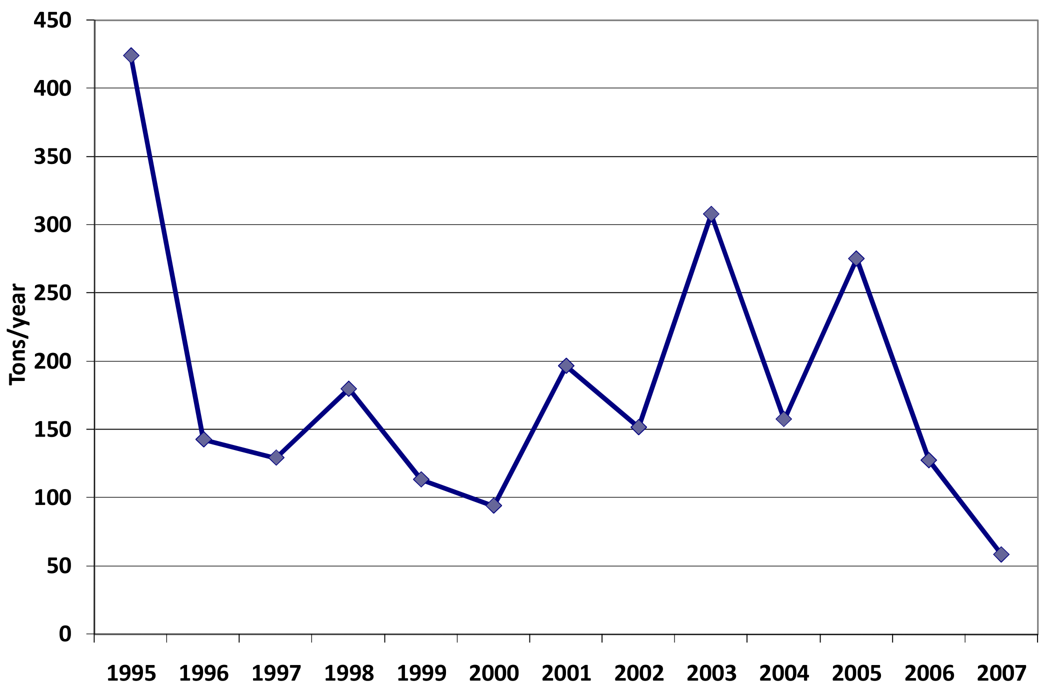

Figure 4-30 Interannual Variation in TN loads to Lemon Bay (1995–2007)

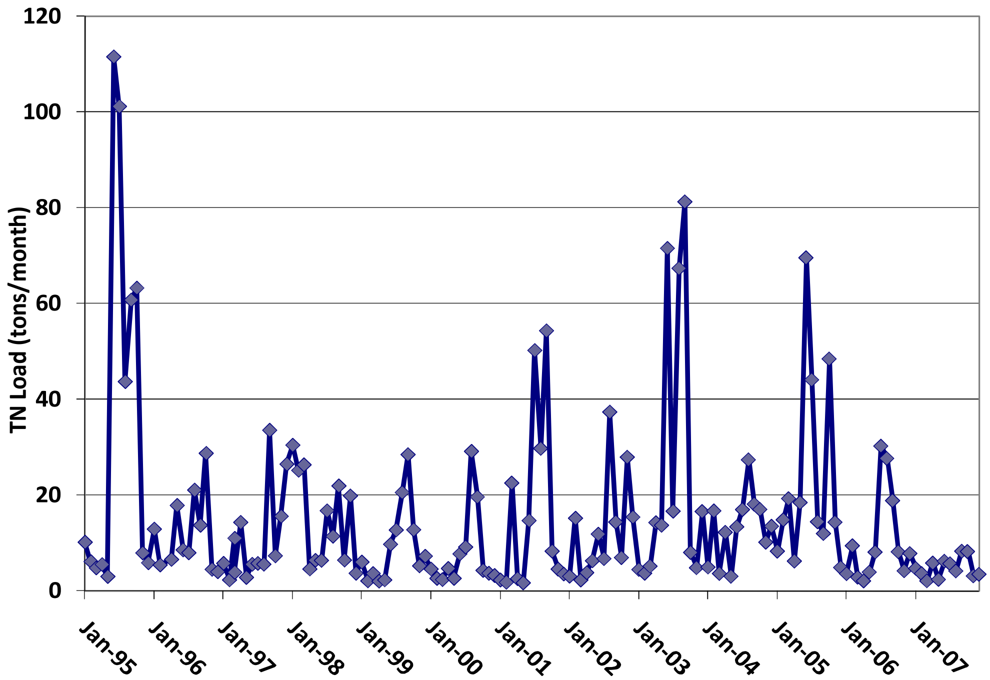

Figure 4-31 Monthly TN loads to Lemon Bay (1995–2007)

The total annual BOD loads to Lemon Bay varied significantly from a maximum of 1239 tons in 1995 to a minimum of 174 tons in 2007 (Figure 4-32). The average annual BOD load to Lemon Bay was 513 tons per year. Since direct runoff is the largest contributor to BOD loads, large variations in annual loads are expected as rainfall varies from year to year. As a result of the seasonal variation in rainfall, BOD loads are typically higher in the wetter summer months (Figure 4-33).

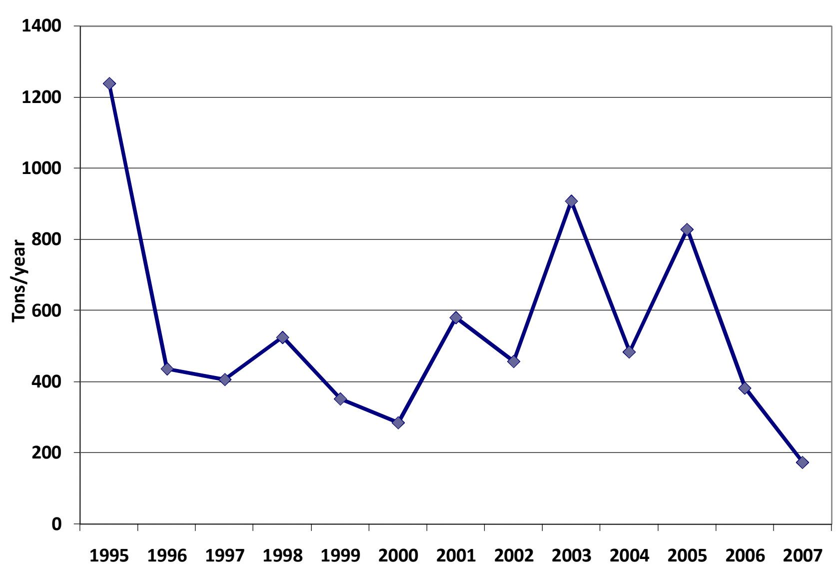

Figure 4-32 Interannual Variation in BOD loads to Lemon Bay (1995–2007)

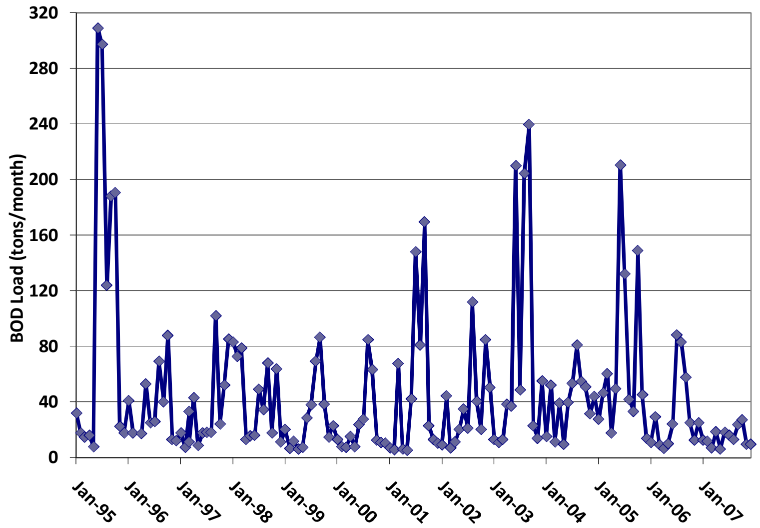

Figure 4-33 Monthly BOD Loads to Lemon Bay (1995–2007)

The total annual TSS loads to Lemon Bay varied significantly from a maximum of 7301 tons in 1995 to a minimum of 787 tons in 2007 (Figure 4-34). The average annual TSS load to Lemon Bay was 2819 tons per year. Since direct runoff is the largest contributor to TSS loads, large variations in annual loads are expected as rainfall varies from year to year. As a result of the seasonal variation in rainfall, TSS loads are typically higher in the wetter summer months (Figure 4-35).

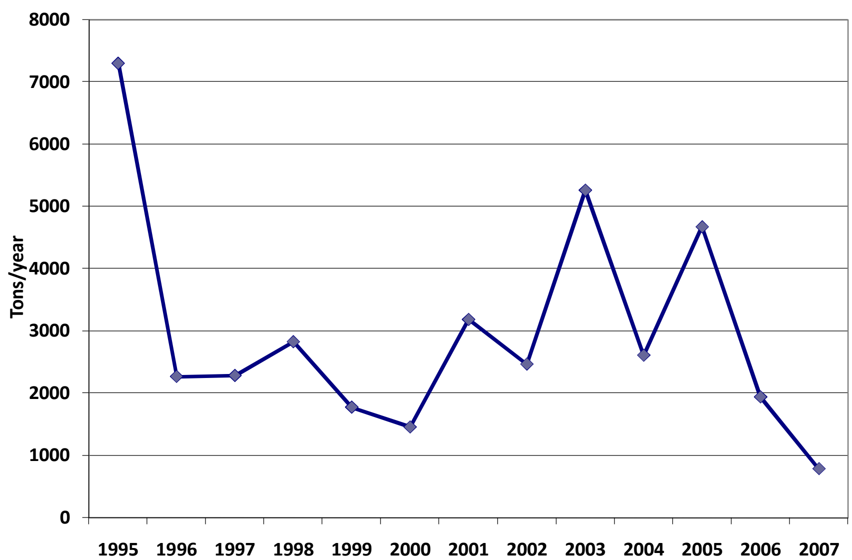

Figure 4-34 Interannual Variation in BOD Loads to Lemon Bay (1995-2007)

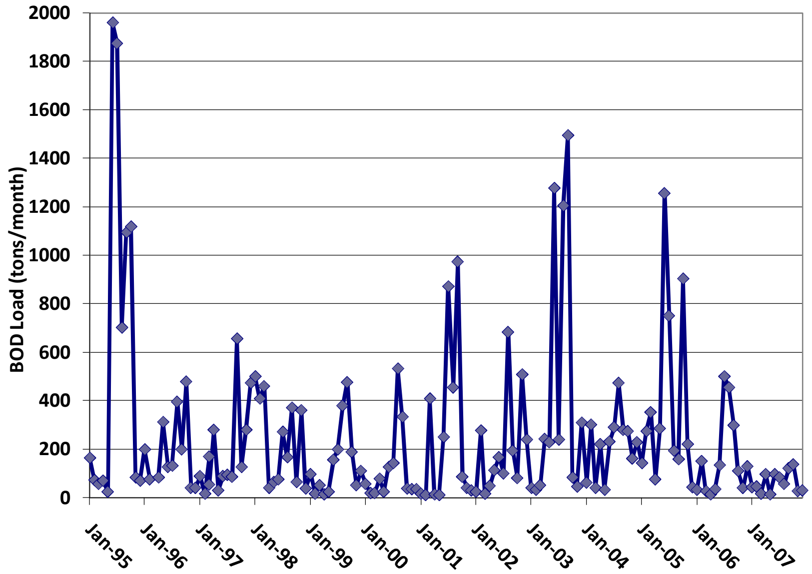

Figure 4-35 Monthly BOD Loads to Lemon Bay (1995-2007)

4.3.1.5 Spatial Variability in Pollutant Loads to Lemon Bay

In addition to an understanding of the temporal variability in pollutant loads, an understanding of the spatial variability in these loads is critical. With this understanding comes the focus for the potential projects and programs to address these loads. The following loading estimates provided by the SIMPLE model are analyzed:

- Total nitrogen (TN) loads
- BOD loads
- Total suspended solids (TSS) loads

The spatial variation in the pollutant-loading estimates is examined in two ways. First, the average annual total loadings (expressed as tons/year) from each basin in the Lemon Bay watershed are discussed. Secondly, unit area loads from each subbasin (expressed as lbs/acre/year) are presented and examined.

A. TN Loads

The average annual TN loads to Lemon Bay are presented in Figure 4-36. Approximately 60% of the TN load to the bay was generated by four basins: Buck, Alligator, Oyster, and Gottfried creeks.

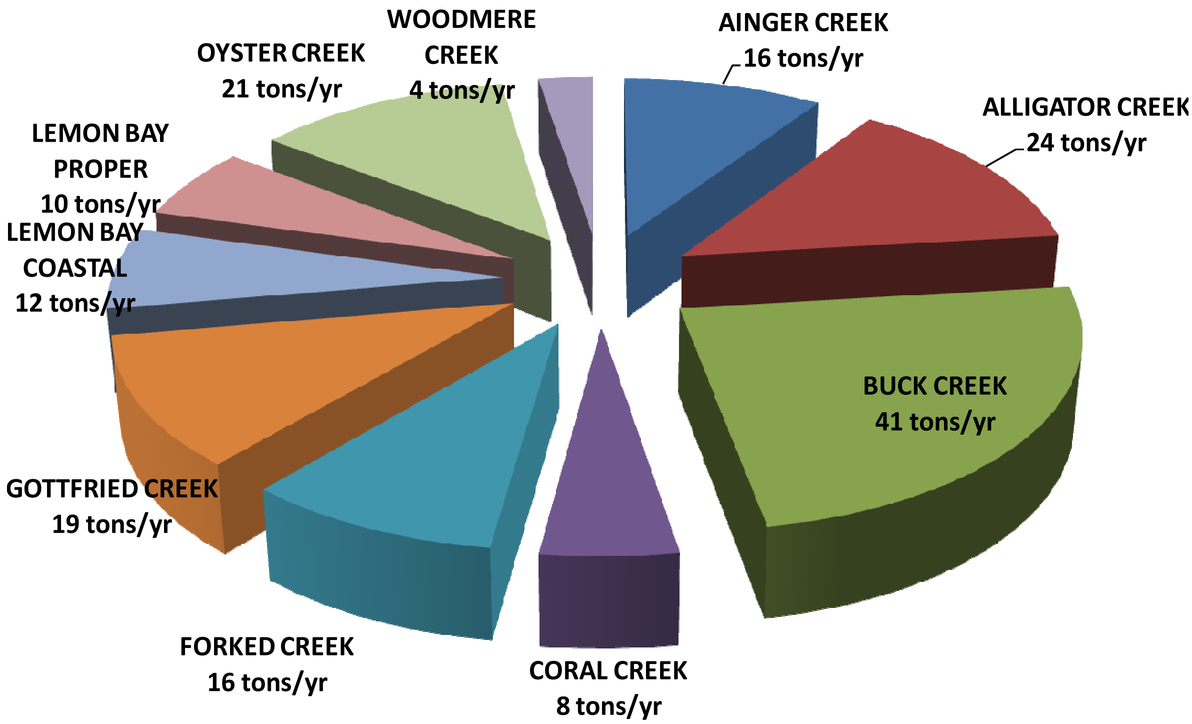

Figure 4-36 Average Annual TN Loads by Basin to Lemon Bay (1995–2007)

Average annual unit area loads were also analyzed for the subbasins of Sarasota County. The average annual unit area TN loads (lbs/acre/year) are highest in Alligator Creek Subbasins 4 and 5, Gottfried Creek Subbasin 34, and Forked Creek Subbasin 25, all of which are located in the watershed's most urbanized regions (Figure 4-37). Of all of the basins, Alligator Creek has the highest proportion of subbasins that have moderate to high unit area loads. As discussed previously, the Alligator and Woodmere creek basins are highly urbanized (>70%). The Ainger, Forked, and Gottfried creek basins have more natural areas (forested and water/wetlands land uses) relative to the highly urbanized basins mentioned above. Unit area TN loads from the majority of subbasins within the Ainger Creek, Gottfried Creek, Forked Creek, and Lemon Bay Coastal basins were relatively low to moderate. The lowest unit area TN loads are found in Subbasins 3, 35, 3 in the Ainger Creek basin, where the largest proportion of forested and water/wetlands land cover exists.

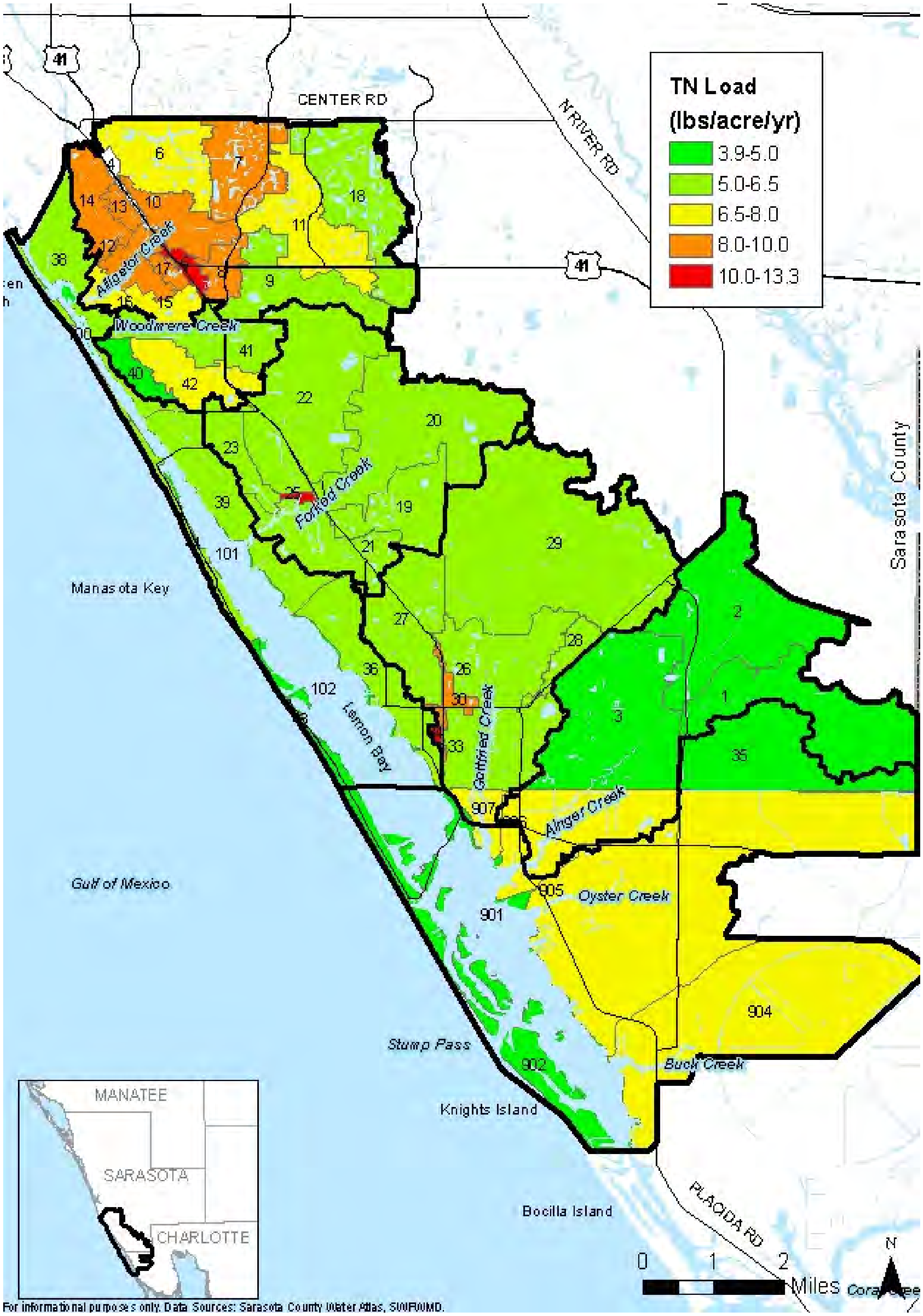

Figure 4-37 Average Annual Unit Area TN Loads (lbs/ac/year) by Subbasin in the Lemon Bay Watershed (1995-2007)

B. BOD Loads

The average annual BOD loads to Lemon Bay are presented in Figure 4-38. Nearly 70% of the total BOD load to the bay was generated in four basins: Buck, Alligator, Oyster, and Gottfried creeks.

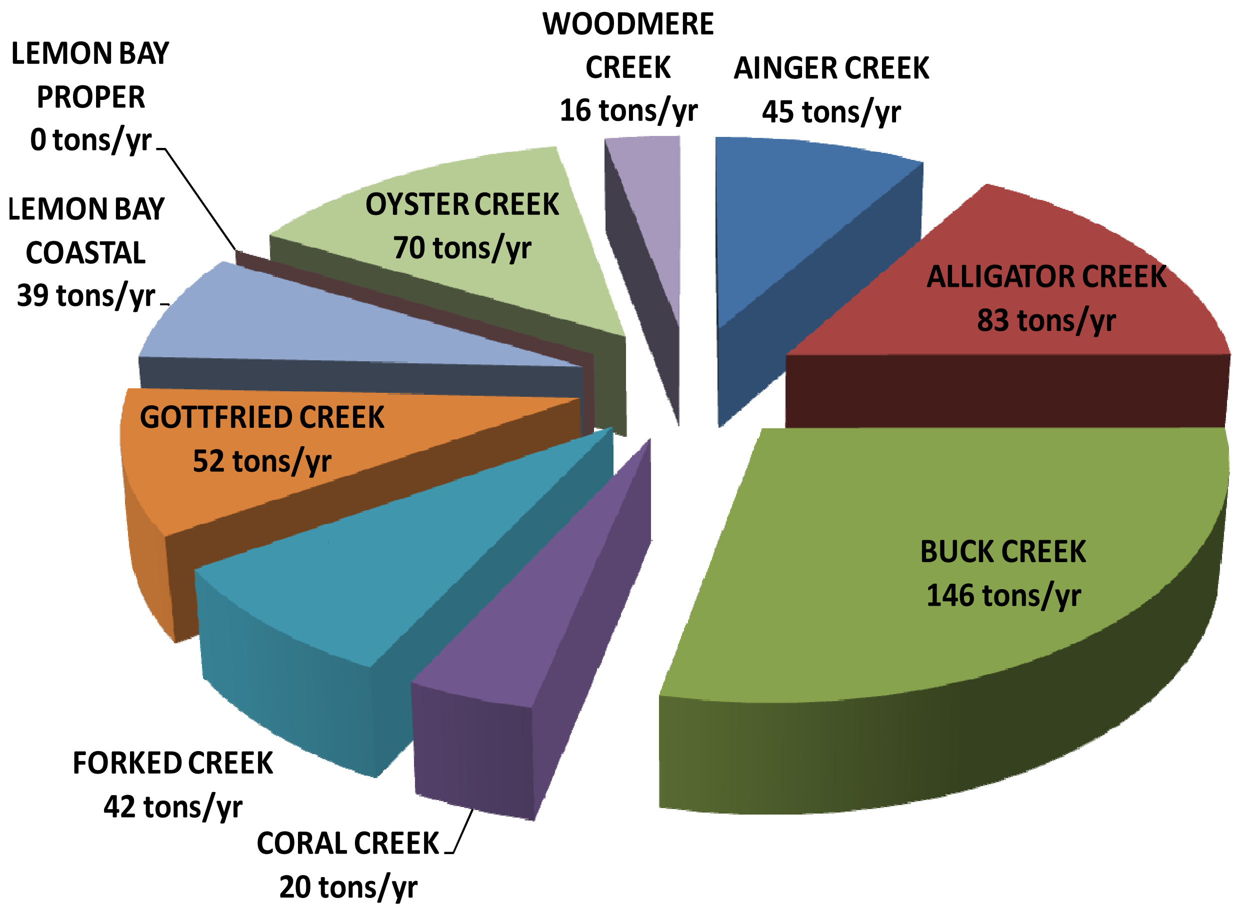

Figure 4-38 Average Annual BOD Loads by Basin to Lemon Bay (1995-2007)

Average annual unit area BOD loads (lbs/acre/year) are highest in the Alligator, Buck, Oyster, and Woodmere creek basins, all of which are located in the watershed's most urbanized regions (Figure 4-39). As shown in Chapter 1, agricultural land uses are most predominant in the Forked and Gottfried creek basins. Unit area TN loads from Forked Creek, Gottfried Creek, and Lemon Bay Coastal basins were relatively low to moderate. The lowest unit area TN loads are found in the Coral and Ainger creek basins, where the largest proportion of forested land cover exists. These results suggest that urbanized basins are more likely to contribute higher BOD loads than those of a more agricultural or natural character.

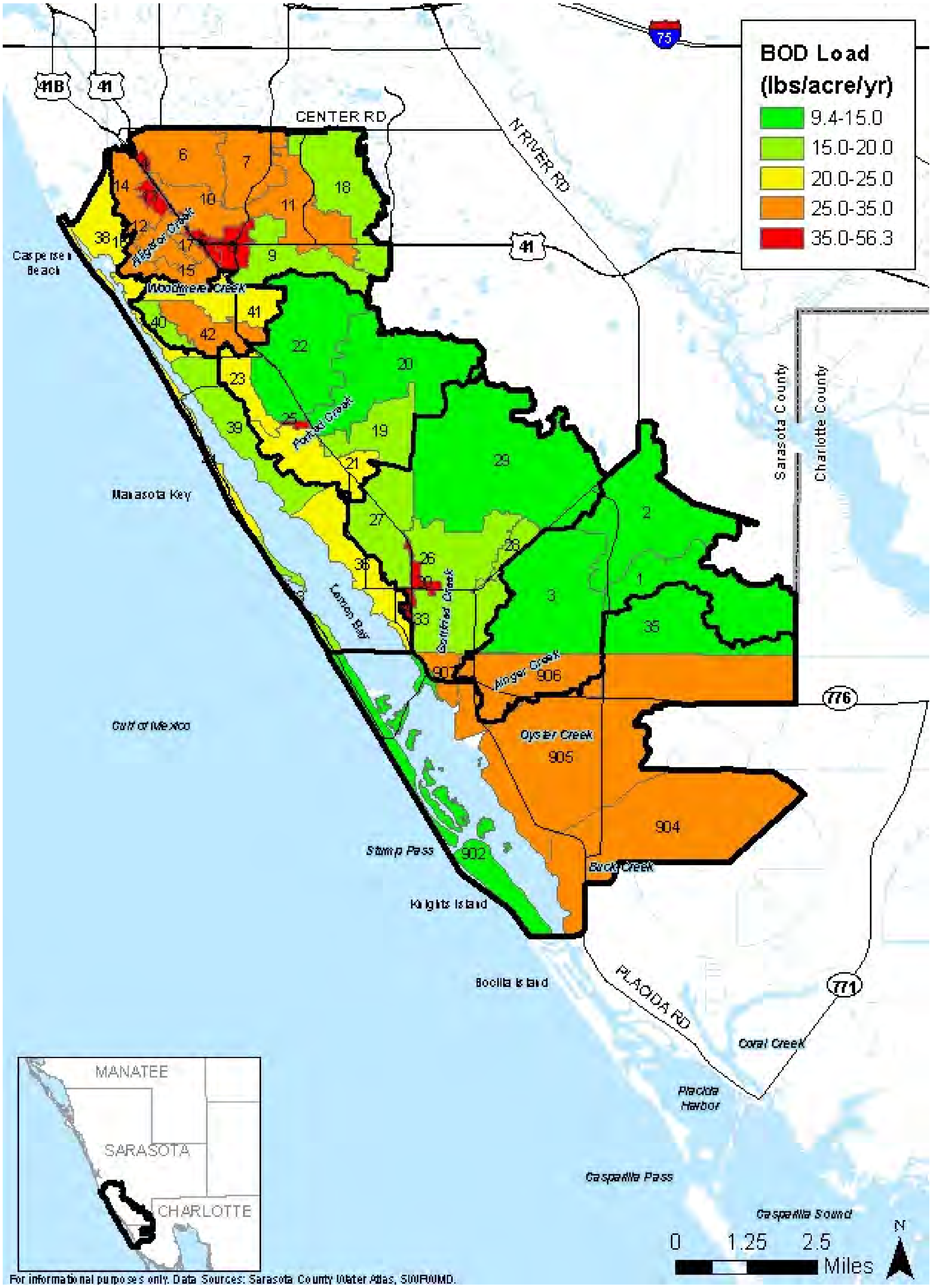

Figure 4-39 Average Annual Unit Area BOD Loads (lbs/ac/year) by Subbasin in the Lemon Bay Watershed (1995-2007)

C. TSS Loads

The average annual TSS loads to Lemon Bay are presented in Figure 4-40. Nearly 70% of the total TSS load to the bay was generated in four basins: Buck, Alligator, Oyster, and Gottfried creeks.

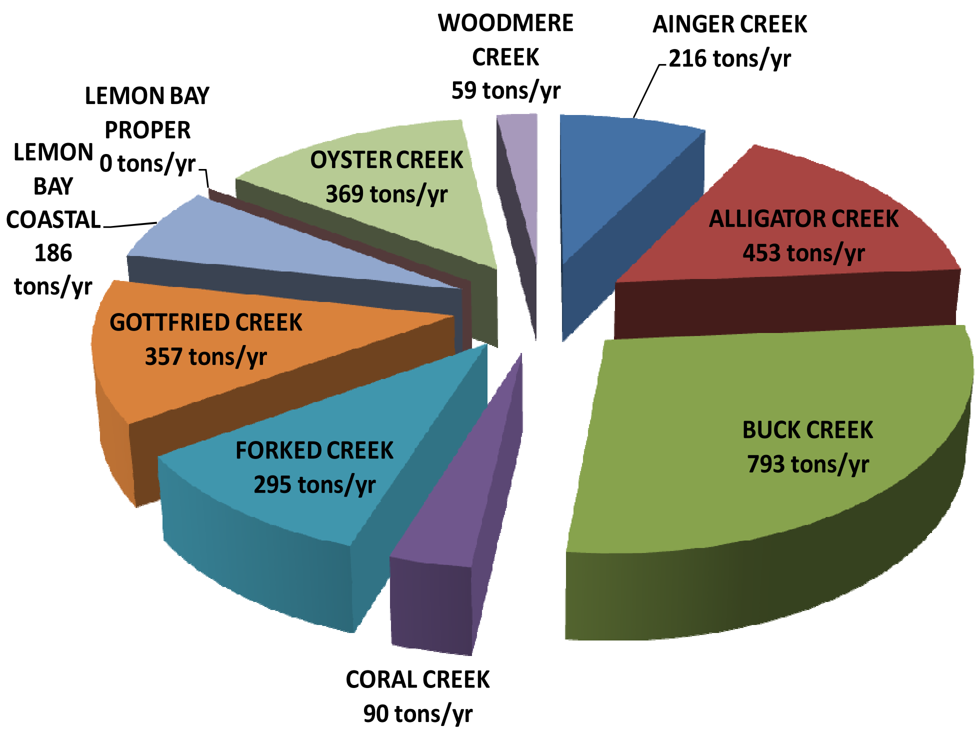

Figure 4-40 Average Annual TSS Loads by Basin to Lemon Bay (1995–2007)

The annual average unit area TSS loadings are shown in Figure 4-41. The highest unit area TSS loadings occur in Alligator and Buck creek basins (140 lbs/acre/year), followed by Oyster Creek (119 lbs/acre/year), Forked Creek (107 lbs/acre/year), and Gottfried Creek (104 lbs/acre/year). Woodmere Creek and Lemon Bay Coastal basins had moderate unit area TSS loadings, 85 and 84 lbs/acre/year, respectively. Ainger and Coral creek basins had the lowest unit area TSS loadings, and they are the basins with the greatest percent of land classified as forested and water/wetlands.

The annual average unit area TSS loadings are shown in Figure 4-41. Subbasins 4, 5, 25, 34, and 8 are the top five subbasins for unit area loadings for both BOD and TSS. These results suggest that urbanization may be a key indicator for likely high values of both constituents, as all five of these subbasins are predominantly urbanized. As with TN and BOD unit area loads, unit area TSS loads from the majority of subbasins within the Ainger Creek, Gottfried Creek, Forked Creek, and Lemon Bay Coastal basins were relatively low to moderate. The smallest per unit area TSS loads are seen in Subbasins 35, 1, and 2, where the proportion of forested land uses is highest.

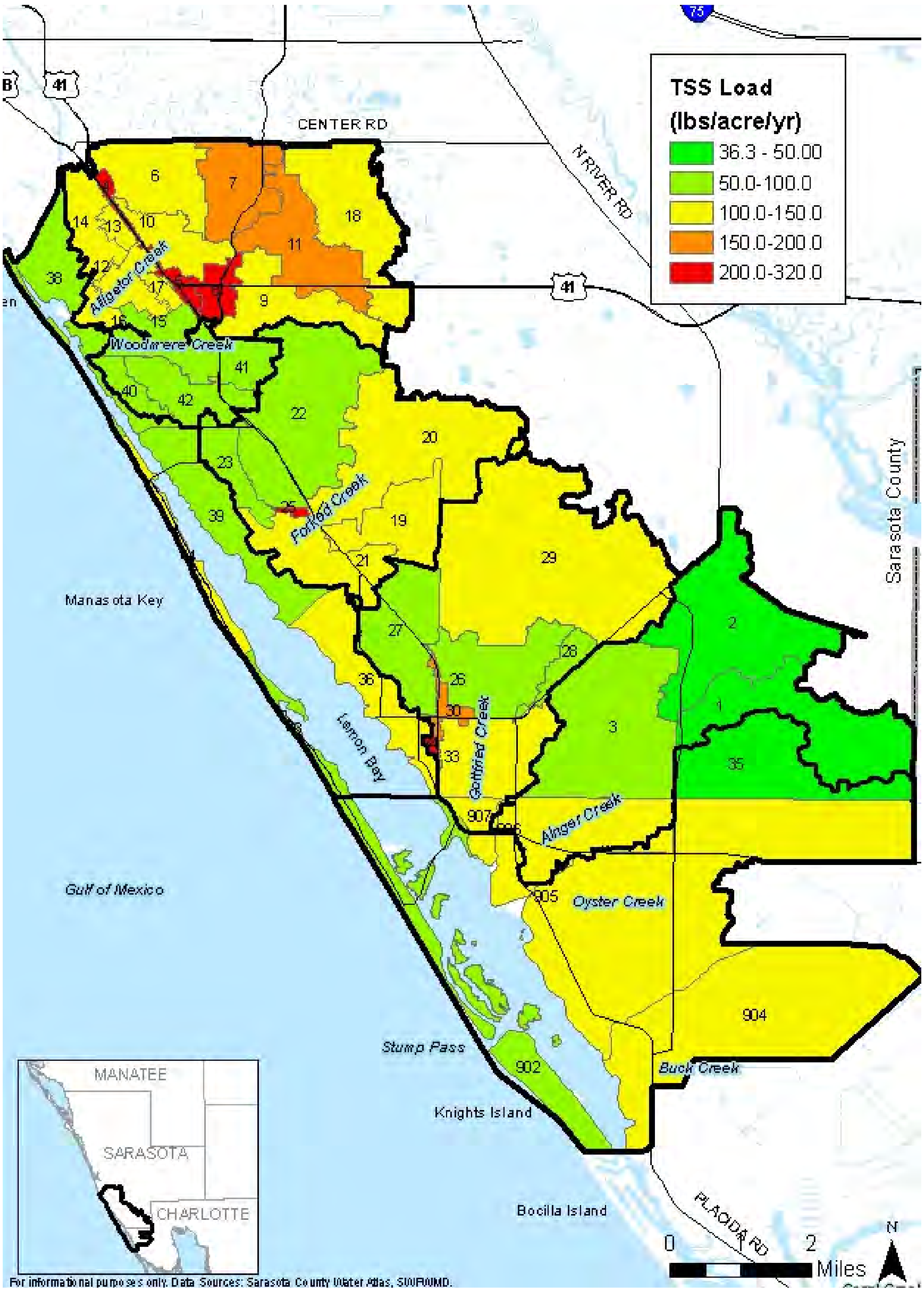
TSS Load
(lbs/acre/yr)
36.3 - 50.00
50.0-100.0
100.0-150.0
150.0-200.0
200.0-320.0
CENTER RD
N RIVER RD
Alligator Creek
Woodmere Creek
Forked Creek
Gottfried Creek
Ainger Creek
Oyster Creek
Buck Creek
Lemon Bay
Manasota Key
Gulf of Mexico
Stump Pass
Knights Island
Bocilla Island
PLACIDA RD
Sarasota County
MANATEE
SARASOTA
CHARLOTTE
0
2
Miles
N
For informational purposes only. Data Sources: Sarasota County Water Atlas, SWFWMD.

Figure 4-41 Average Annual Unit Area TSS Loads (lbs/ac/year) by Subbasin in the Lemon Bay Watershed (1995-2007)

The following conclusions can be drawn from the observations of spatial variability in pollutant loadings:

- Generally, the largest basins (Buck, Alligator, Oyster, and Gottfried creeks) are consistently the largest contributors of hydrologic yields and pollutant loads.
- The most urbanized basins generally have the highest unit area hydrologic yields.
- The highest unit area TN loads are observed in the highly urbanized basins of Buck, Alligator, Oyster, and Woodmere creeks.
- As with TN unit area loads, high values of BOD unit area loads are seen in the most urbanized portions of the watershed.
- High TSS unit area load estimates are seen in the more urbanized regions, while lower TSS unit area loads are seen in the basins that have greater proportions of forested and water/wetlands land classifications.
- These results will help target priorities for BMP development.

4.4 ANALYSIS OF THE RESPONSES IN LEMON BAY TO POLLUTANT LOADINGS

4.4.1 Nutrient Loading to Estuaries

The consequences of increased nutrient loading to an estuary include increased episodes of noxious blooms, reductions in aquatic macrophytes communities, and hypoxia and/or anoxia, often leading to substantial shifts in ecosystem processes (Nixon, 1995; National Research Council, 2000; Cloern, 2001; Paerl et al., 2003). Nitrogen and phosphorus are the nutrients of greatest concern because they most often control eutrophication and their inputs are often anthropogenic (Paerl et al., 2003). The single largest global change in the N cycle results from synthetic inorganic fertilizers that became widely used after the 1950s. In addition to widespread use of fertilizers, increased use of fossil fuels and production of N-fixing crops have dramatically increased nitrogen loading across the globe (Seitzinger et al., 2002).

Before the 1990s in the United States, phosphorus loading was dominated by point sources, specifically wastewater. With the successful effort to reduce P loading in wastewater, non-point-source loading has increased in significance (Howarth et al., 2002). As in most estuarine systems (National Research Council, 2000), N is the limiting nutrient in Tampa Bay. Strong empirical evidence based on annual water quality sampling in the region and bioassay results points to the importance of nitrogen in controlling algal biomass and growth in this estuary (Johansson, 1991). Therefore, the focus of nutrient reduction in Tampa Bay is N loading. Currently, no specific nutrient-reduction laws are mandated by any U.S. government agency, although certain mandates under the Clean Water Act are acting to implement water quality standards and reduce TMDLs (Boesch, 2002). Every watershed is unique, and standards must account for the individual characteristics of each. This makes enacting and implementing nutrient-reduction strategies very difficult, especially given the need to determine how to achieve locally desired resource-management goals.

The EPA's National Estuary Programs have been instrumental in establishing site-specific goals and implementing these goals through the participation of national, regional, and local agencies; governments; and private entities. The central process of eutrophication is not a single focused issue but rather a multitude of factors that combine to cause water quality issues that change depending on ecosystem location and sources of pollution. One commonly used way to assess and control eutrophication is to identify indicators, such as seagrass growth and coverage and primary production, for managing estuarine systems. Light availability is the principal factor limiting seagrass distribution (Gallegos, 2001). Managing primary production as a result of increased nitrogen loading has a direct effect on surface irradiation depth. For example, in the Chesapeake Bay, Dennison, and others (1993) established habitat requirements for submerged aquatic vegetation based on TSS, chlorophyll *a* concentrations, and median photosynthetically active radiation. A similar management approach was also used in the Indian River Lagoon (Gallegos and Kenworthy 1996; Kenworthy and Fonseca, 1996) and Tampa Bay (Janicki and Wade, 1996; Greening and Janicki, 2006).

The Sarasota Bay Estuary Program (SBEP) is developing a scope of work that will define the methodology to be used to set water-quality targets for the Sarasota Bay system. In addition, FDEP will be establishing numeric nutrient criteria for estuarine waters over the next year. We expect these criteria to be expressed as loadings and to include an adjustment for variation in residence times.

4.4.2 Influence of Circulation and Residence Times

Understanding the relationship between nutrient loading and estuarine response requires knowing the potential influence of estuarine circulation and residence times. Estuarine circulation is driven primarily by tidal exchange and freshwater inflow and results in the transport of water quality constituents (e.g., salinity, nutrients, DO) within the system. The passes connecting Sarasota Bay to the Gulf of Mexico provide avenues for tidal exchange, with the resulting circulation within the estuarine system depending on the locations and sizes of these passes. This section briefly summarizes circulation within the system, including discussion of the simulated effects of the opening of Midnight Pass.

The northern region of the Sarasota Bay system connects to Tampa Bay through Anna Maria Sound. South of Anna Maria Sound, Longboat Pass connects the north end of Sarasota Bay to the Gulf, with New Pass connecting to the Gulf near the southern end of Sarasota Bay. Big Sarasota Pass provides the largest connection to the Gulf, between Sarasota Bay and Roberts Bay, and Venice Inlet is south of Little Sarasota Bay. Midnight Pass provided a connection to the Gulf near the middle of Little Sarasota Bay until 1983, when the pass was closed (ATM and ECE, 2004). South of Venice Inlet the ICW connects the Sarasota Bay system to Lemon Bay, which is tidally influenced by the Gulf through Stump Pass in the southern third of Lemon Bay.

The strongest currents in the system are found in the passes during incoming and outgoing tides, with the areas between the passes generally experiencing much weaker currents (Sheng, 1992). A three-dimensional model of tidal circulation in the Sarasota Bay system developed by Sheng and Peene (1991) showed that the areas between the passes, where the tidal signals entering from adjacent passes meet, are areas of very small current velocities. Consequently, these areas have relatively poor flushing rates. Modeling efforts identified Palma Sola Bay, Middle Sarasota Bay, and Middle Little Sarasota Bay as having the lowest flushing rates in the Sarasota Bay system (Sheng, 1992).

Lemon Bay is connected to Dona and Roberts Bay and the Venice Inlet to the north via the ICW. Stump Pass connects Lemon Bay to the Gulf of Mexico near the southern end of the bay. The bay is very shallow, with a maximum depth of less than 2 m, with the exception of the dredged ICW. Freshwater inflows to the system are from several tidal creeks. Flushing rates are likely relatively large in the area adjacent to Stump Pass near the southern portion of Lemon Bay. We expect that there is poorer flushing in the northern portion of the bay, as the northern region is removed from Stump Pass so that the tidal signal is diminished from the south, and a reduced tidal signal is likely coming through the ICW connection to the north. Flushing rates in the northern portion of the Lemon Bay are likely more strongly influenced by freshwater inflows from Alligator Creek, Woodmere Creek, and Forked Creek than are flushing rates in the southern portion of the bay near Stump Pass.

4.4.3 Nutrient Loading and Its Impact on Estuaries

Tides and rivers offer a constant flow of water and nutrients that provide a beneficial environment for primary producers that form the base of the maritime food web. Watershed-driven nitrogen inputs from watersheds adjacent to coastal and estuarine waters can have significant impact on estuarine function. High rates of nutrient inputs from the land often stimulate very high rates of primary productivity. Due to high primary productivity, estuaries provide breeding and nursery grounds for many species of fish and shellfish. Hundreds of marine organisms, including commercially viable fish and shellfish such as shrimp, crabs, and trout, depend on estuaries during different stages of their lifecycles to provide valuable habitat (EPA, 1999).

In estuarine systems functioning without large anthropogenic disturbances, dissolved nutrients in river discharge constitute the primary nutrient source for many estuaries that receive significant freshwater input. Since the 1970s many scientists and managers have been studying the deterioration of estuarine ecosystems via increases in nutrient loads and accompanying eutrophication (Paerl et al., 2006; Bricker et al., 2008; Fisher et al., 2006). The targeting of nutrient inputs from other points sources such as sewage outfalls and industrial effluent was met with much success, yielding improved water quality following implementation of advanced waste water treatment (Greening and Janicki, 2006). Unfortunately, population growth and the growing need for agricultural output have led to an increase in non-point-source pollution. It is estimated that human activity has increased the total rate of formation of reactive nitrogen globally by 33 to 55% through increases in agriculture via synthetic fertilizer (Howarth, 2008). Increases in reactive nitrogen have also resulted from increases in the encouragement of biological nitrogen fixation associated with agriculture and the inadvertent creation of reactive nitrogen through reaction with oxygen as fossil fuels are burned (Howarth, 2008; Paerl et al., 2006).

Excess nitrogen in estuarine ecosystems has led to increased rates of primary production, termed *eutrophication* (Nixon, 1995). Understanding the impacts of eutrophication and how anthropogenic impacts affect the structure and function of estuaries continues to be a research goal for scientists and managers worldwide (Paerl et al. 2006). Eutrophication has resulted in documented cases of reduced biodiversity, habitat degradation, and food web alterations (Nixon, 1995; Rabalais and Turner, 2001; Paerl et al., 2006; Bricker et al., 2008). Large-scale drivers of estuarine productivity include non-point and point source inputs from the watershed, riverine flow, and atmospheric deposition.

Symptoms of water quality decline are typically chlorophyll *a* and microalgae, low DO, loss of submerged aquatic vegetation, and occurrences of Harmful Algal Blooms (HABs) (Bricker et al., 2008) Chlorophyll *a*, a pigment used in photosynthesis, serves as a measure of biomass (abundance) of phytoplankton in estuaries. Planktonic algae provide a food source of filter-feeding bivalves (oysters, mussels, scallops, clams) and zooplankton (including the larvae of crustaceans and finfish). Chlorophyll *a* concentrations can also be used as a measure of overall ecosystem health. High amounts of chlorophyll *a* in estuarine waters are a primary indicator of nutrient pollution because excess nutrients fuel the growth of algae. High chlorophyll *a* values can have adverse impacts on aquatic life and human recreation.

DO is a very important limiting factor impacting estuarine systems. DO can be used as an indicator of the health of the ecosystem. Cultural eutrophication (nutrient excess leading to overproduction of microalgae and associate trophic imbalances) is common in estuaries near human population centers. Under conditions of eutrophication, DO can exhibit extreme diel cycles. Photosynthesis via algae elevates DO levels in the water during the day, but at night when respiration is high the DO can drop dangerously low. Eutrophication can lead to periodic or long-term hypoxia (water column oxygen concentrations less than 2 mg O_2/L) and anoxia in estuarine ecosystems. Fishes, crabs, and shrimp will attempt to move away from hypoxic conditions, and few marine animals survive in prolonged exposure to it. DO levels are often quite variable in estuarine system due to fluctuations in temperature, salinity, basin morphology, and overall productivity.

Seagrasses serve significant functions. They help maintain water clarity by trapping fine sediments and particles with their leaves, and they stabilize the estuarine sediments with their roots. Seagrasses are very effective at removing dissolved nutrients from water that can enter from land runoff. The removal of sediment and nutrients improves water clarity, thereby improving overall ecosystem health. Seagrasses offer habitats for fish, crustaceans, and shellfish, providing a nursery ground for many recreationally and commercially valuable species. They are also food for organisms that inhabit them and marine mammals such as manatees and waterfowl such as ducks. Human activities can harm seagrasses by degrading estuarine water quality and promoting physical disturbances and algal blooms. Reductions in light availability associated with nutrient inputs and sediments can damage or eliminate seagrass habitat.

How any particular estuary will respond to excess nitrogen loading depends on numerous factors including freshwater inflow, residence time, and clarity or light attenuation (Howarth and Marino, 2006). Estuarine nutrient concentrations depend on freshwater inflow because freshwater is a source of nutrients. The rate of freshwater inflow can influence hydraulic residence time and hence the time available for nutrients to react in the estuary (Bricker et al., 2008). Flow may affect chlorophyll by increasing chlorophyll abundance via enhanced nutrient supply, changing the location of peak chlorophyll abundance or decreasing chlorophyll abundance and residence time. During times of low freshwater inflow, the chlorophyll maximum is typically located farther upstream than during times of high flow. Low flow also allows a longer residence time for chlorophyll and other nutrients. Longer residence times tend to promote slower-growing taxa, which include dinoflagellates, cyanobacteria, and HABs (Pickney et al., 1999). Increased nutrient loading is associated with higher flows and is typically followed by increased algal biomass. During high flow conditions, flushing is more rapid and residence time in the river is reduced (Flannery et al., 2002; Jassby et al., 1995). These conditions tend to favor fast-growing phytoplankton such as chlorophytes (green algae) and various flagellates (Pinckney et al., 1999) At times, depending on the morphology of the river, high flows can be excessive. Very high flows may not result in higher chlorophyll abundance due to the relationship between the residence time of water in the system and uptake and growth rates of the phytoplankton community. Reductions in flow can also impact community composition with less-desirable species such as HABs occurring during times of low flow and longer residence times (Bricker et al., 2008).

Water clarity is a measure of the amount of sunlight that can penetrate the water. Water clarity is measured with a device called *a Secchi disk*. The measurement, named the *Secchi depth*, is the measure of water clarity and the depth at which sunlight is able to penetrate the water. Clear waters indicate a healthy estuary, although many factors impact water clarity. Excess suspended sediments from runoff and rainfall can negatively impact water clarity. Nutrients, mainly nitrogen and phosphorus, can fuel the growth of photosynthesizing algae. High chlorophyll *a* concentrations associated with high algal biomass can decrease light penetration, decreasing water clarity. Decreased water clarity can negatively impact the estuary in many ways. Reduced light transmission can decrease seagrass abundance, which can affect the entire food web. Decreases in seagrass reduce habitat to the hundreds of species that depend on the seagrass.

The successful management of coastal ecosystems requires long-term monitoring and accurate quantitative tools for managers, scientists, and the public at the local and regional levels to easily understand and apply basic principles of ecosystem management. Wide-scale nutrient reduction aimed at controlling ecosystem scale eutrophication needs to span freshwater and marine ecosystems. Additionally, managers must recognize that primary productivity and growth responses could take longer times (years to decades) for improved water quality but that implementing these reductions is imperative.

4.4.4 Response in Lemon Bay to Variation in Nutrient Loading

The nexus between understanding the relationship between nutrient loading and response in the estuary and effective resources management is the ability to develop a tool that quantitatively links loading and response. The approaches that have been taken to develop such tools have ranged from complex, mechanistic models (EPA, 1995; Cerco and Cole, 1995; EPA, 2001; EPA, 2006) to empirical models (Boynton et al., 1995; Boynton et al., 1996; Brush et al., 2002). Empirical modeling approaches have been used for several Florida estuaries, including Tampa Bay (Janicki and Wade, 1996), Sarasota Bay (Tomasko et al., 1996), Lemon Bay (Tomasko et al., 2001) and Indian River Lagoon (Steward and Green, 2007).

We have used an empirical approach to quantify the relationship between nutrient (nitrogen) loading and chlorophyll *a* in Lemon Bay. The data used to develop this empirical model have been examined earlier in this chapter. These include the loading data provided by the SIMPLE model for 1998 to 2007 and ambient water quality data provided by the County's monthly monitoring program.

Initially, a series of potential loading variables were calculated:

- Current month loading
- Lagged monthly loading (e.g., last month's load)
- Cumulative monthly loading (e.g., the sum of the last months' loads)

The variation in these potential explanatory variables was compared to the variation in mean monthly chlorophyll concentrations. We found that the relationship between this month's mean chlorophyll and the cumulative load from this month and the previous month provided the best fit model. Monthly-specific intercept terms were then added to the model to account for the effect of seasonal variation in water temperature and incident light on chlorophyll *a*. Given the same monthly TN loads, we expect that chlorophyll *a* concentrations should be highest during the summer months when water temperature and incident light are greatest.

A plot of the relationship between the natural log transformed chlorophyll *a* and 2-month cumulative TN loads is given in Figure 4-42. A multiple regression technique was applied to these data. The slope of the overall model was significantly greater than 0 ($p < 0.0001$) and the coefficient of determination (R^2) was 0.50. Therefore, the variation in TN loads from the Lemon Bay watershed accounted for 50% of the variation in chlorophyll *a* concentrations in the estuary. Figure 4-43 presents a plot of the observed chlorophyll *a* concentrations from Lemon Bay and those predicted by the regression on TN loads.

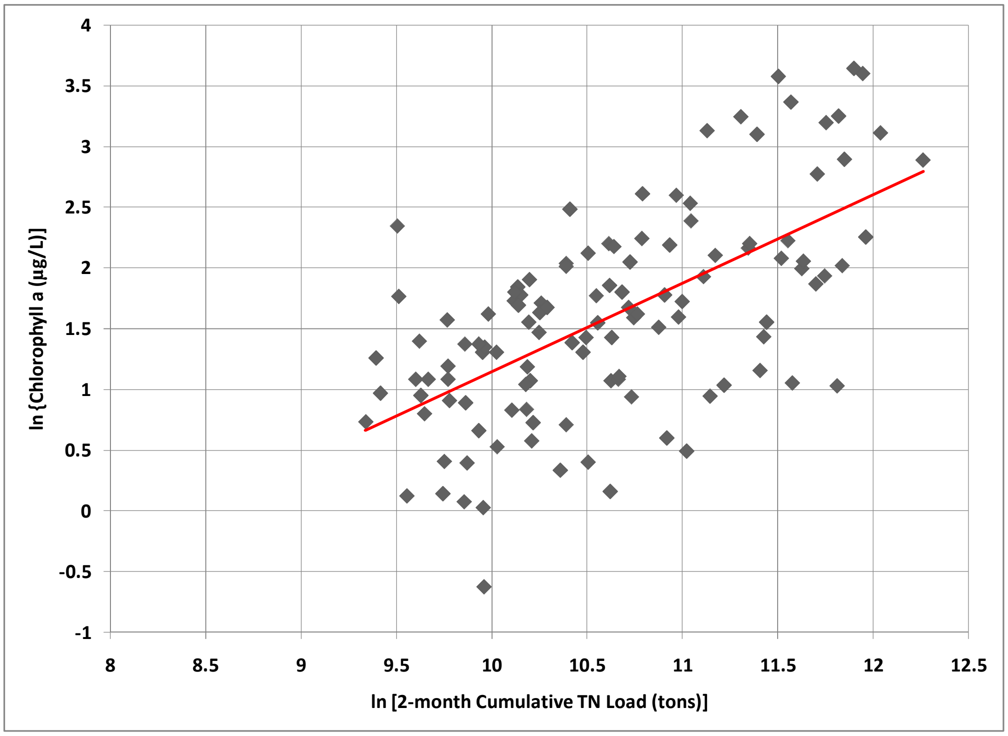

Figure 4-42 Relationship Between ln-Transformed Chlorophyll *a* and 2-Month Cumulative TN Loads Data from Lemon Bay (1998–2007)

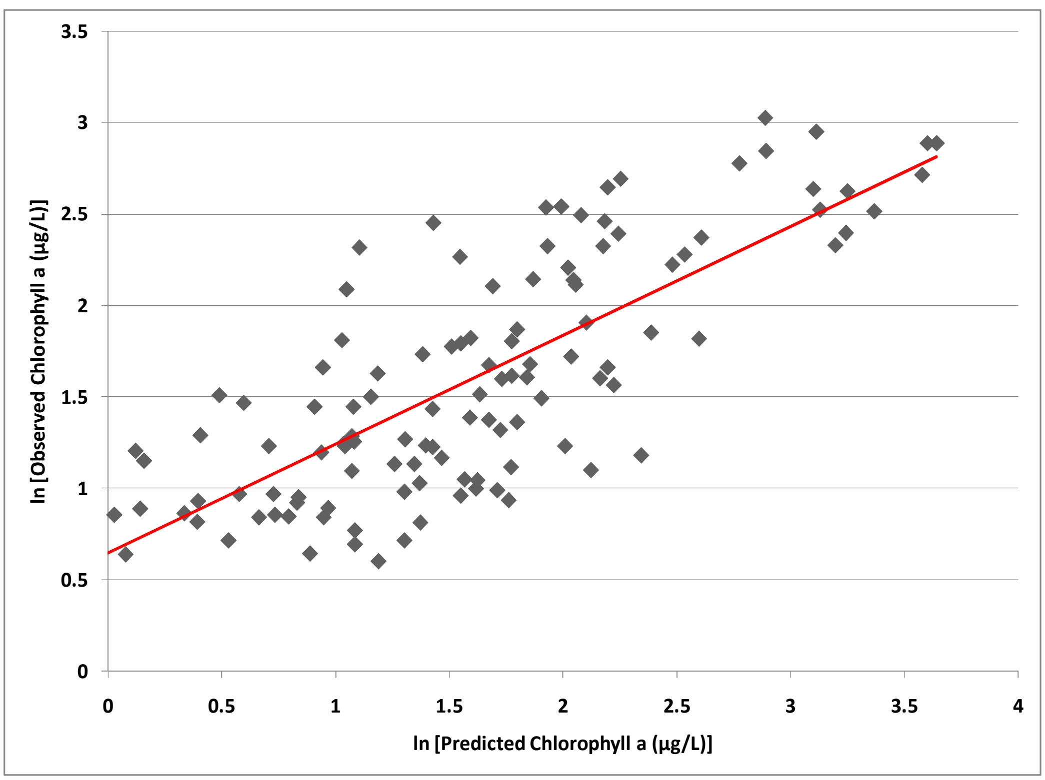

Figure 4-43 Comparison of Predicted and Observed Chlorophyll *a* Concentrations from Lemon Bay (1998–2007)

Further analysis of the chlorophyll-TN load relationship included an examination of the residuals (the differences between the predicted and observed chlorophyll concentrations). We examined plots of the residuals against potential confounding variables to identify any apparent patterns. If there is no relationship between the residuals and any confounding variable, the plot will show more or less equal probability of either under- or over-predictions across the range of values of the confounding variable. This diagnostic tool can identify whether inclusion of any of these variables may improve the model predictions. In this case the plot of the model residuals with the mean monthly turbidity in Lemon Bay shows a clear pattern (Figure 4-44). The probability of an over-prediction increased with increasing turbidity.

Given these results, the model was reformulated to include the effect of turbidity. As before, the slope of the overall model was significantly greater than 0 ($p < 0.0001$) and the R^2 increased to 0.66. Therefore, the new model accounts for nearly 70% of the variation in chlorophyll *a* concentrations in the estuary. Figure 4-45 presents a plot of the observed chlorophyll *a* concentrations from Lemon Bay and those predicted by the regression on TN loads.

The results of the empirical modeling approach indicate that the management of nitrogen loading from the Lemon Bay watershed will be essential if future changes in the watershed lead to potential increases in loads.

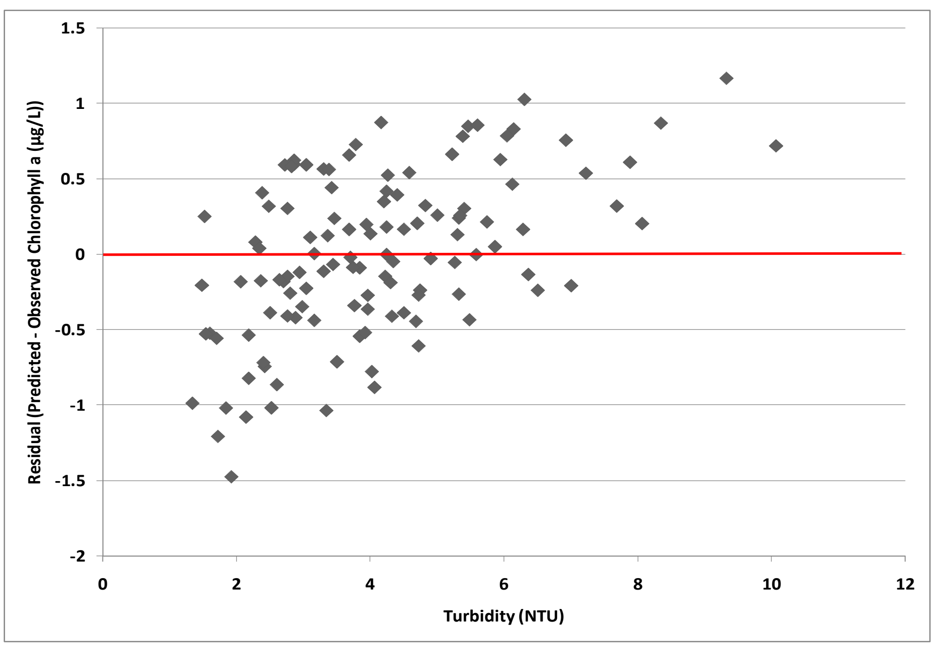

Figure 4-44 Comparison of Residuals from the Chlorophyll-TN Load Model for Lemon Bay to Mean Monthly Turbidity Concentrations

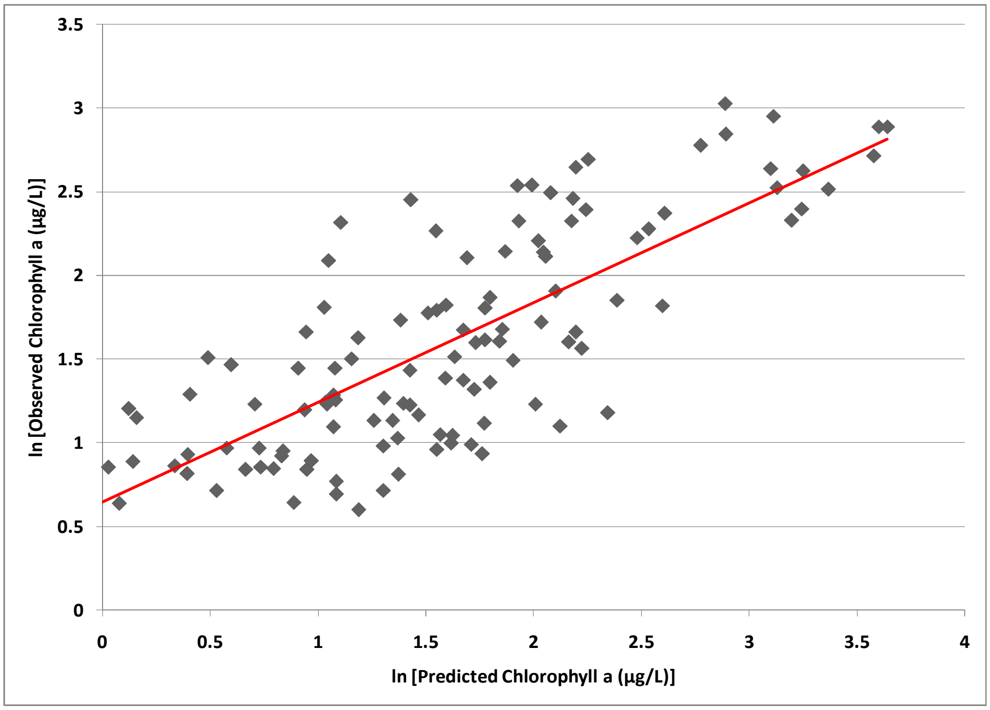

Figure 4-45 Comparison of Observed Chlorophyll *a* Concentrations from Lemon Bay to the Predicted Concentrations from the Model Including Mean Monthly Turbidity

4.4.5 Relationship Between Water Quality in Lemon Bay Tributaries to Variation in Pollutant Loading

As discussed above, several tributaries in the Lemon Bay watershed have been identified and verified as impaired, including Alligator Creek, Forked Creek, and Woodmere Creek. The following examines the water quality data from these tributaries and links them to loading estimates from the SIMPLE model.

Alligator Creek has been identified as impaired due to low DO and elevated chlorophyll. Figure 4-46 presents a time series of Alligator Creek DO data from the FDEP Impaired Waters database. Most of the available data were collected before 1993. DO excursions below 4 mg/L are apparent during both that period and during the recent data collection. Figure 4-47 presents the relationship between DO and BOD loading from the Alligator Creek basin. There is no clear relationship between DO and BOD loading during the period for which both data types were available. Similarly, there was no apparent relationship between chlorophyll *a* and TN loadings In Alligator Creek (Figure 4-48).

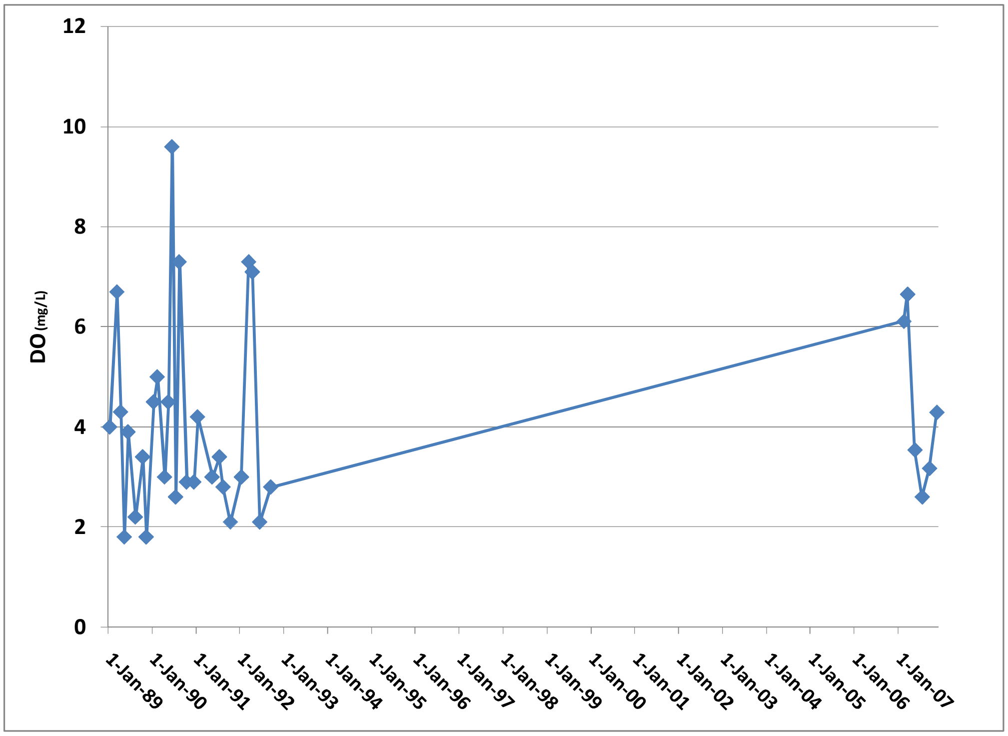

Figure 4-46 Time Series of DO Concentrations from Alligator Creek

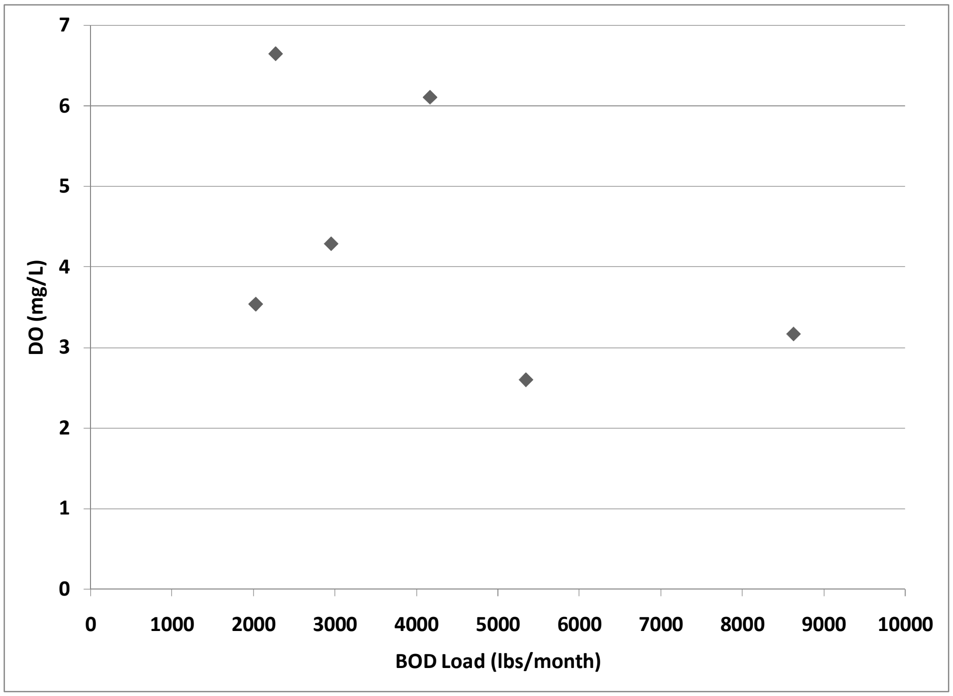

Figure 4-47 Relationship Between DO Concentrations and BOD Loadings from Alligator Creek Basin

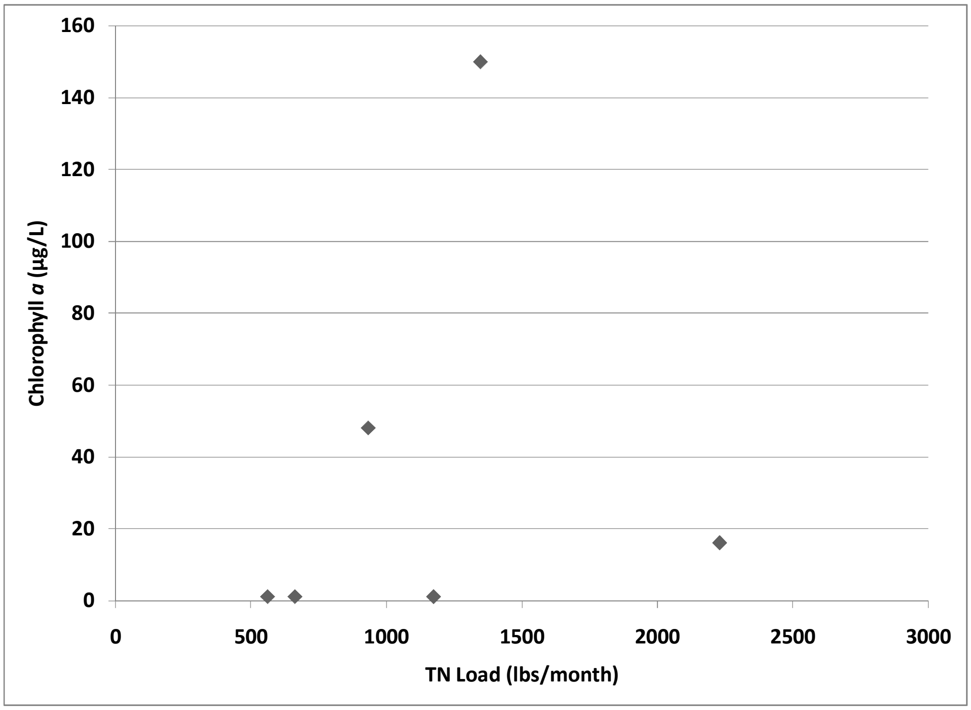

Figure 4-48 Relationship Between Chlorophyll *a* Concentrations and TN Loadings from Alligator Creek Basin

Forked Creek has been identified as impaired due to elevated chlorophyll *a* concentrations. The chlorophyll *a* data in the FDEP Impaired Waters database included a number of both corrected and uncorrected values (Figure 4-49). There are very apparent discrepancies in these data, including much higher corrected values. This is unexpected since the correction for phaeophytin should result in lower concentrations than the uncorrected estimates. Also, the highest chlorophyll *a* concentrations, both corrected and uncorrected, were observed when TN loads were relatively low (Figure 4-50). Setting a TMDL will therefore be problematic for this waterbody.

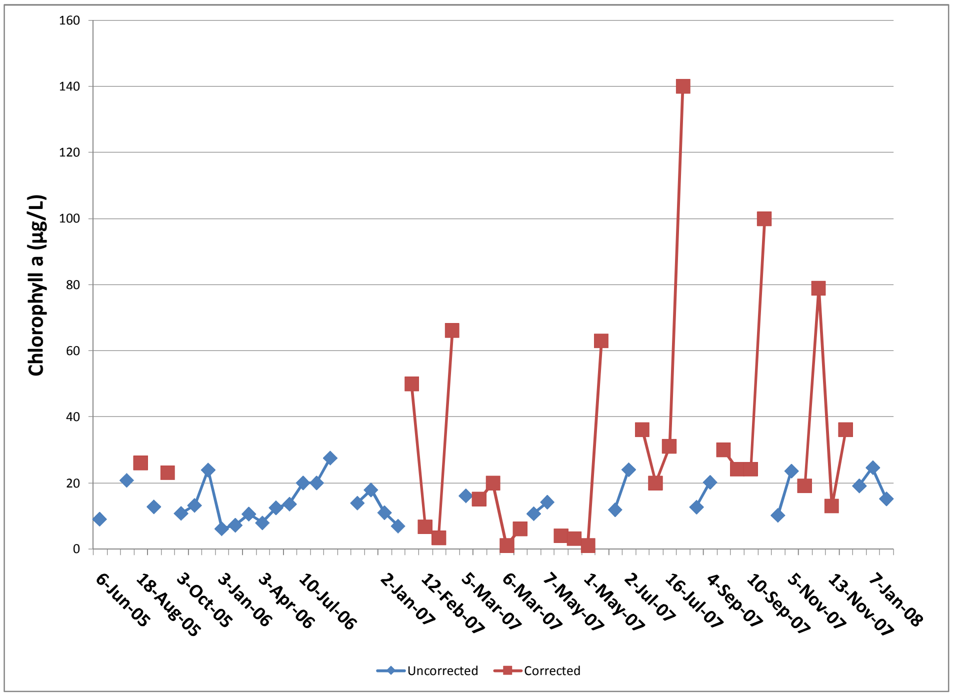

Figure 4-49 Relationship Between Corrected and Uncorrected Chlorophyll *a* Cata from Forked Creek

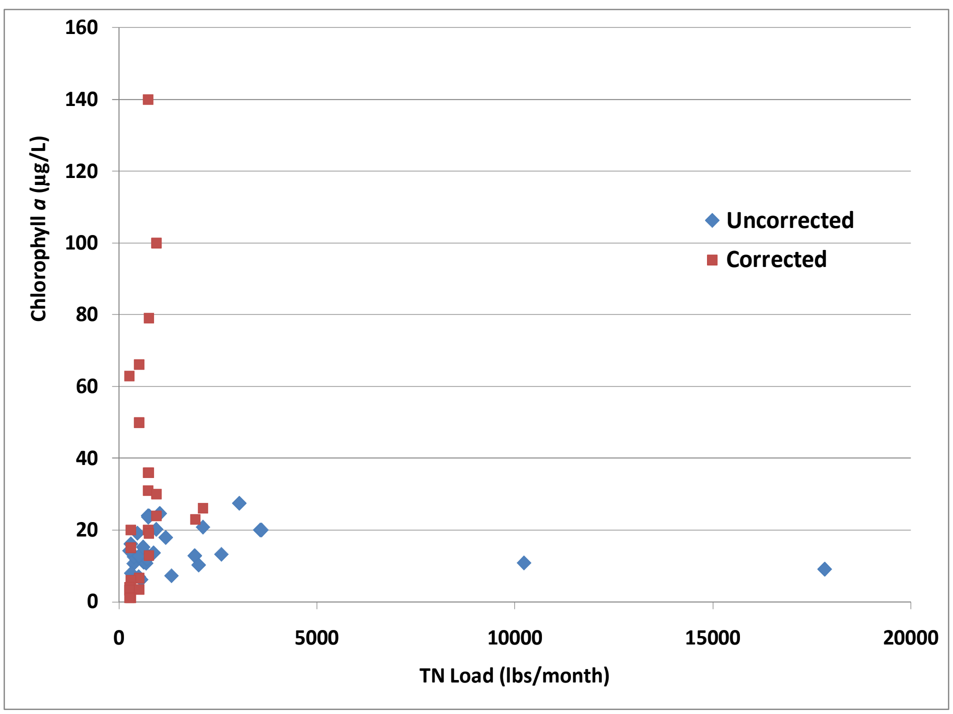

Figure 4-50 Relationship Between Chlorophyll *a* and TN Loads from Forked Creek

Woodmere Creek has been identified as impaired due to elevated chlorophyll *a* concentrations. Figure 4-51 presents a time series of Woodmere Creek chlorophyll *a* data from the FDEP

Impaired Waters database. With the exception of two dates, the chlorophyll *a* concentrations were less than 20 µg/L. Figure 4-52 presents the relationship between chlorophyll *a* concentrations and TN loading from the Woodmere Creek basin. There is no clear relationship between chlorophyll *a* concentrations and TN loading during the period for which both data types were available.

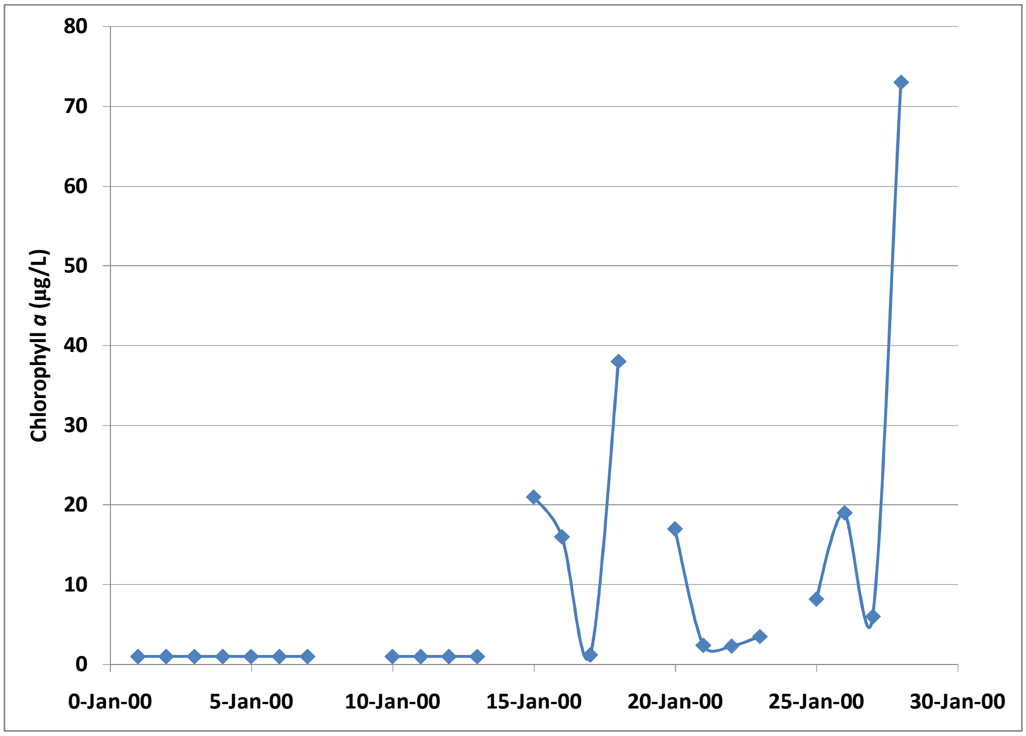

Figure 4-51 Time Series of Chlorophyll *a* Concentrations in Woodmere Creek Basin

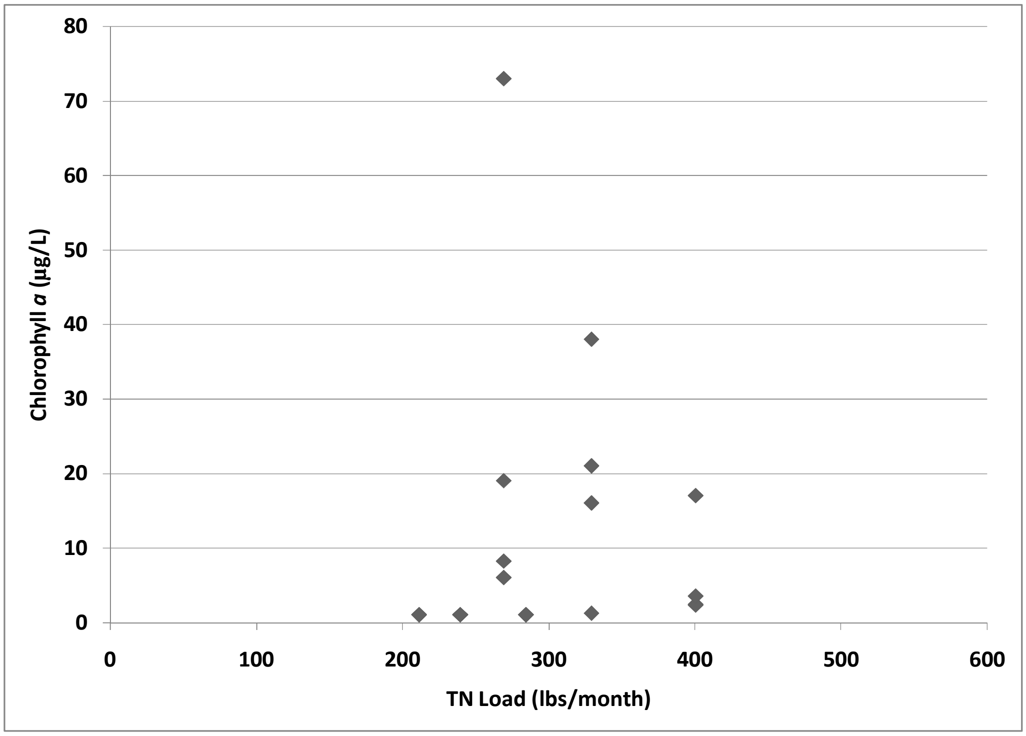

Figure 4-52 Relationship Between Chlorophyll *a* Concentrations and TN Loadings from Woodmere Creek Basin

4.4.6 Freshwater and Pollutant-Load Targets and Reduction Goals for Lemon Bay

As discussed in Section 4.2.2.1, comparing the historical and current water budgets shows that wet season flows are greater under current conditions. This increase in flow results in a modest change in salinity in Lemon Bay. Projects or programs that can contribute to a reduction of wet season flows (i.e., during August through October) should be considered.

Also as discussed in Section 4.2, the recent seagrass coverage in Lemon Bay meets or exceeds that estimated for the historical period (ca. 1950). Based on these observations, the chlorophyll *a* concentration target is 7.8 µg/L and the K_d target is 1.07 (1/m). The chlorophyll and K_d levels are the mean conditions during 2001 to 2007, which generally coincide with the period during which the seagrass targets have been set and represent the recent wide range in rainfall in this region.

The analyses presented above indicate that meeting the chlorophyll *a* target for Lemon Bay will depend on managing nitrogen loading to the bay. It logically follows that if the current water quality conditions have been adequate to maintain seagrass coverage at desired levels, the nitrogen loading is also at levels adequate to maintain the chlorophyll *a* concentrations at or near their desired levels. Therefore, the proposed nitrogen loading target is 95 tons/year, which is the average TN load for the period 2001–2007.

The proposed nitrogen loading target is 95 tons/year.

4.4.7 Comparison of the Proposed Nitrogen Loading Target to Future Nitrogen Loading to Lemon Bay

Future loading estimates were developed following the methodology presented in Chapter 3, Section 3.1.2.1. The SIMPLE model was used to develop estimates for what is essentially a "built-out" scenario. This entailed applying a land-use coverage that reflected build-out conditions where all "developable" polygons in the 2006 land-use coverage not classified as an environmentally sensitive land was converted to medium-density residential with a wet detention BMP (35% removal efficiency for total nitrogen). Current BMPs, septic tank removal, and irrigation practices were also applied to the future load scenario. Future changes in atmospheric deposition follow methods used recently to estimate future atmospheric deposition loads to Tampa Bay (Janicki Environmental, 2008). Finally, the same rainfall record used to estimate the current loadings was used to drive the model. While many potential stormwater control rules/policies are currently under discussion and review, none of these has been applied to this "built-out" scenario. Therefore, if any of these rules/policies are implemented, it can be expected that future loads will be less than those used in our analyses.

Figure 4-53 compares the current and future TN loads to Lemon Bay. The built-out scenario loads are predicted to be consistently higher than the current loads. Clearly there are years when the 95 tons/year target is exceeded under both scenarios. This is not unexpected as year-to-year rainfall variation strongly influences the temporal variability in nitrogen loading. It was shown previously that the interannual variation in chlorophyll *a* concentrations reflects the variation in rainfall. An important observation is that while there are years when rainfall and nitrogen loads are relatively high and there is a concomitant increase in chlorophyll *a,* the bay responds (i.e., chlorophyll *a* concentrations drop) when the rainfall and nitrogen loads recede.

The average annual difference in the built-out nitrogen loads and the target is 15 tons/year if wet detention is the predominant BMP. This means that maintenance of desirable chlorophyll *a* concentrations in Lemon Bay will depend on precluding this potential 21 tons/year increase. There are two critical considerations when evaluating these estimates. First, as discussed above, this is a build-out condition that if it is to occur will be in the distant future. Second, there will be years when the target is exceeded. Examining the monitoring data collected by the County will help in understanding why an exceedance has occurred and whether the bay is trending in an unwanted manner.

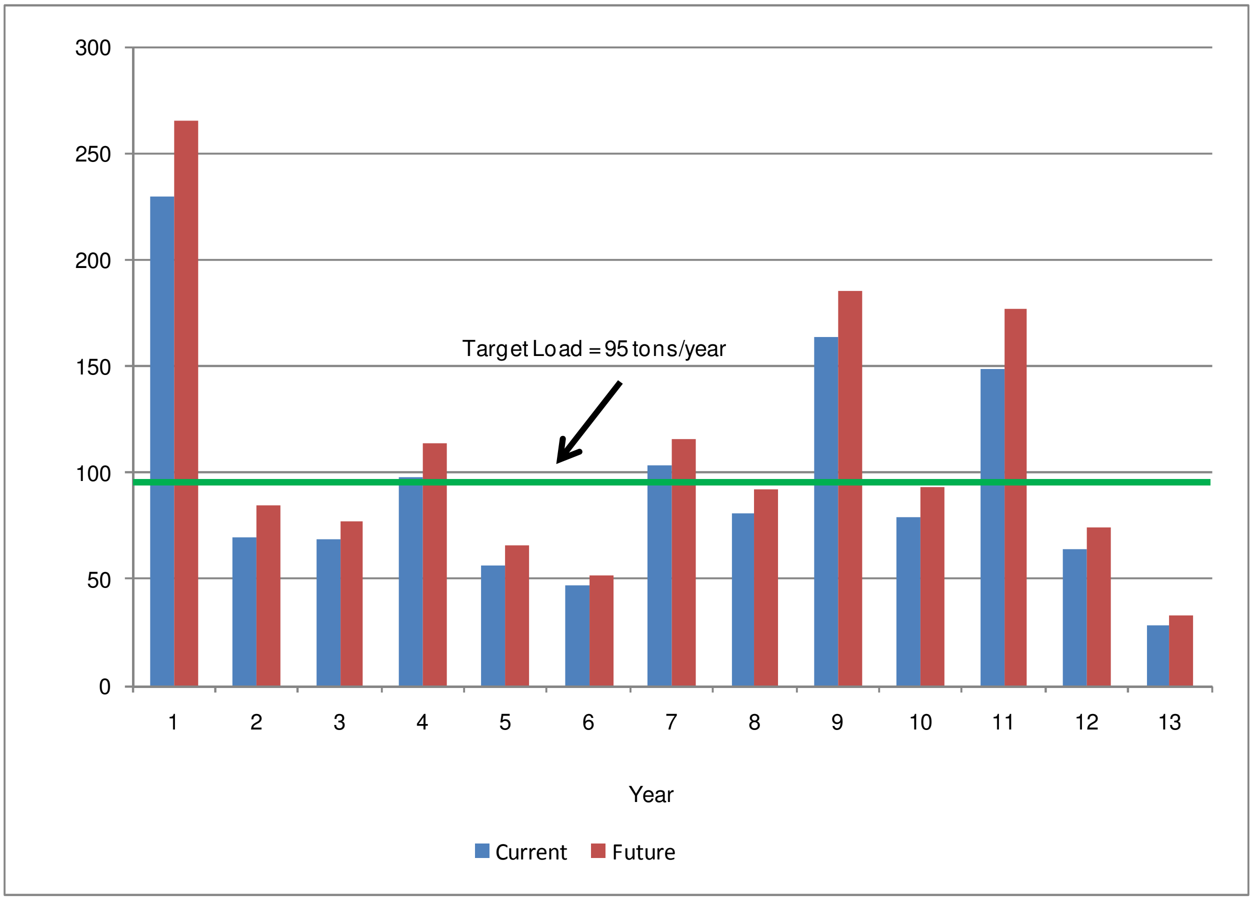

Figure 4-53 Comparison of Current and Future Annual Loads to the Target TN Load for Lemon Bay

4.5 CONCLUSIONS AND RECOMMENDATIONS

Conclusions and recommendations regarding water quality in Lemon Bay include the following:

- Overall, water quality in Upper Lemon Bay is good as evidenced by the chlorophyll *a* concentrations, water clarity, and resulting seagrass coverage.
- While the nitrogen loads to Lemon Bay exceed the target loads when rainfall is high, the bay responds in the following year with lower chlorophyll *a* concentrations and nitrogen concentrations. Further research into the interrelationships between chlorophyll *a* concentrations and nitrogen loads to water residence times in the estuary can provide insight into the bay's responses to varying nitrogen loads.
- Comparison of the historical and current hydrologic regimes for Lemon Bay shows higher volumes under current conditions. This has apparently resulted in somewhat lower current salinities. Despite the observation that salinities were different between historical and current conditions and that those differences appeared to be largest during the summer, the current salinities in Lemon Bay

remained in the polyhaline to euhaline range with summertime median and average salinities above 25 ppt. The historical hydrologic regime is recommended as the target water budget for Lemon Bay.

4.5.1 Recommended Water Quality Improvement Programs

4.5.1.1 Septic Replacement Program

Septic systems have the potential to contribute significant pollutant loads to the primary receiving waters in the Lemon Bay watershed. The highest concentrations of septic systems in the watershed are located in the upland areas closest to Lemon Bay in the Alligator Creek, Woodmere Creek, Forked Creek, and Gottfried Creek basins.

The lots served by onsite septic systems in the Alligator Creek and Woodmere Creek basins are in the Sarasota County service area. This portion of the County is commonly referred to as South Venice. The South Venice area was originally platted in the 1950s. The area is also served by private well, encompasses approximately 3,300 acres, and is considered a medium-density residential area with approximately 8,000± lots. Approximately 85% of the lots in this area use a septic system to dispose of wastewater.

The South Venice area was included in the South County Wastewater Improvement Program (SCWIP), which evaluated whether existing wastewater treatment practices affect water quality in the project area (Roberts Bay Nort, Little Sarasota Bay, Blackburn Bay, and Upper Lemon Bay) and recommended that Sarasota County provide central sewers for those sub-areas with average acreage sizes less than 0.5 acres (Hazen and Sawyer, 2004)

The SCWIP recommendation to replace septic systems in certain areas is based on their analysis of compliance with Ordinance No. 83-83, which relates to the design, construction, installation, utilization, operation, maintenance, and repair of septics. The SCWIP found that only 24% of all developed parcels (3,052 out of 12,653) have been permitted post 1983 and thus meet current code separation requirements. SCWIP also determined that the majority of the soil types found in the project area are severely limited for use of conventional septic system drainfields due to high groundwater.

We further recommend the continuation of the Septic Replacement Program for portions of Lemon Bay based on the SCWIP evaluation and recent fecal coliform TMDLS (see Section 5.1.2.2). Fecal coliforms may pose a special health risk for infants, young children, and people with severely compromised immune systems (epa.gov). Septic systems that are not properly installed or maintained can increase fecal coliform counts in Lemon Bay and its tributaries.

The lots served by onsite septic systems in the Forked Creek, Gottfried Creek, and Lemon Bay Charlotte basins are in the Englewood Water District (EWD) service area. EWD developed a master plan to provide sanitary sewer service in 1988. As of January 2010, 82% of all EWD customers are connected to a central sewer system.

4.5.1.2 Street Sweeping Recommendations

Street sweeping is a proven, effective practice to improve water quality. The effectiveness of street sweeping and its value as a County maintenance practice is discussed in detail in Chapter 7. Projects LBWQ03, 10, and 13 highlight how street sweeping can be implemented to improve water quality. Street sweeping for water quality improvement should be evaluated further and should take into account County funding for maintenance practices, local and state jurisdictions related to streets and highways, and the implementation recommendations presented in Chapter 7, such as sweeping frequency related to season. Program recommendations are not ranked with the other project recommendations in this chapter but are further evaluated in Chapter 8.

We recommend street sweeping in three basins in the Lemon Bay Watershed—Alligator Creek, Forked Creek, and Gottfried Creek. While street sweeping in general is beneficial, these three areas have been identified as hot spots for TSS, TP, and TN in the watershed, and bi-monthly street sweeping in these basins will improve water quality, habitat, and flood control conditions by removing sediments and their associated pollutants from streets before they enter the stream systems.

A. LBWQ03 (LBS09) – AC: General Street Sweeping

The US 41 transportation corridor shows the highest TSS, TP, and TN loads in lb/ac/yr (Figure 4-54 and Table 4-6) in the watershed.

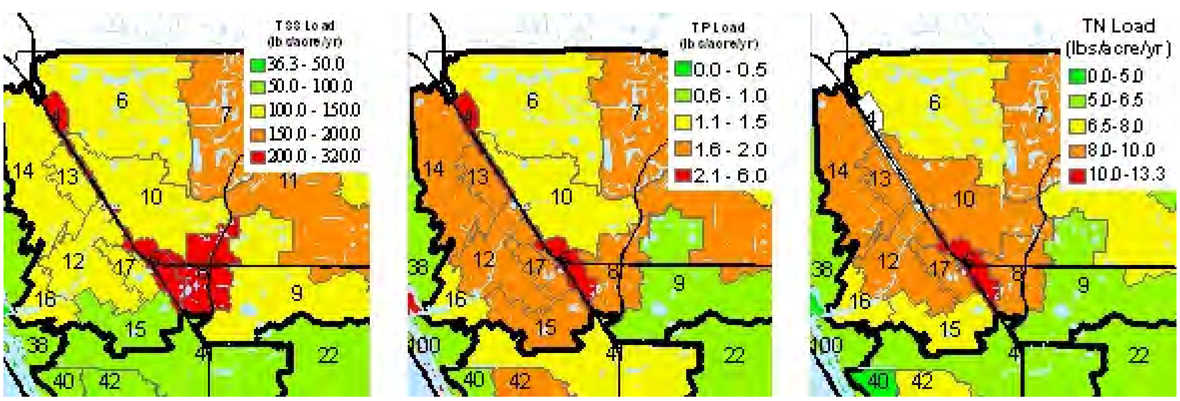

Figure 4-54 TSS, TP, and TN Loads Along US41 in the Alligator Creek Basin

B. LBWQ10 (LBS18) – FC: General Street Sweeping

Two of the subbasins in Forked Creek ranked 3 and 10 for TSS, one subbasin ranked 1 in TP, and one subbasin ranked 4 in TN lb/ac/yr in the watershed. See Table 4-6 for pollutant-load values from the SIMPLE model.

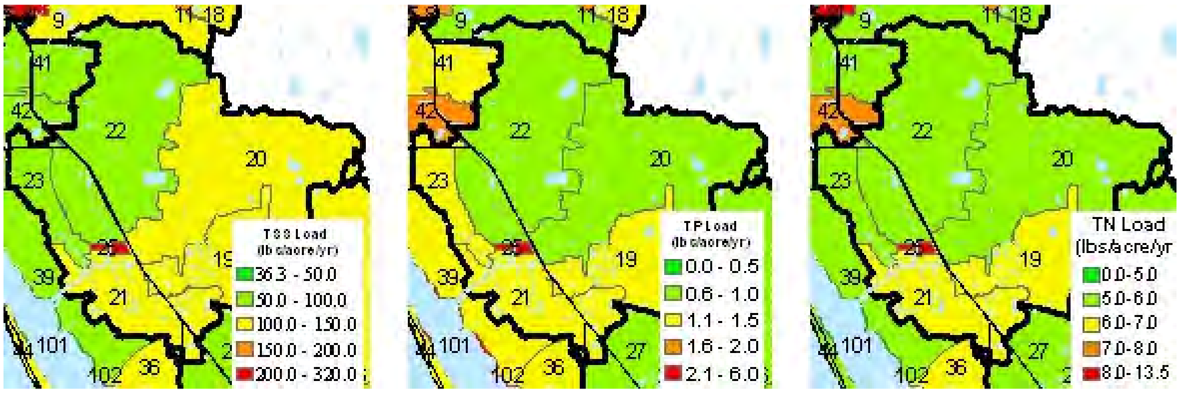

Figure 4-55 Forked Creek TSS, TP, and TN Loads

C. LBWQ13 (LBS21) – GC: General Street Sweeping

The limited space available in this traffic corridor will not readily accommodate traditional stormwater BMPs. Sand from the roadways is a large contributor to the TSS pollutant load. Metals and toxic organic chemicals from vehicle usage that are attached to sediment particles can also be removed by street sweeping. The subbasins ranked 4 and 7 (Figure 4-56 and Table 4-6) in TSS lb/ac/yr runoff in the watershed.

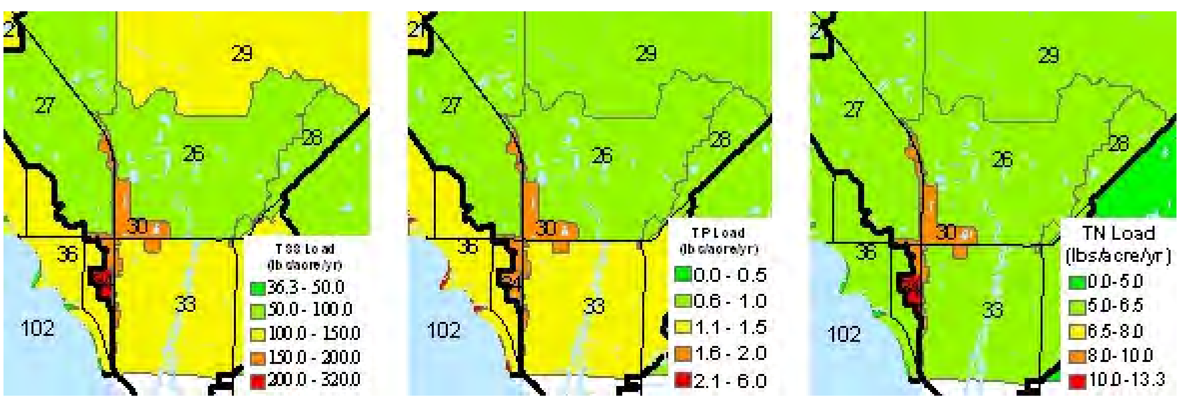

Figure 4-56 Gottfried Creek TSS, TP, and TN Loads

4.5.1.3 Recommended Water Quality Improvement Projects

A. Introduction

Jones Edmunds identified potential water quality improvement opportunities in the Lemon Bay watershed with a focus on improving the watershed's water quality functions. Five potential sites were identified by Jones Edmunds based on a GIS desktop assessment using available digital datasets. Fourteen sites were initially identified as part of the Sediment Management Plan but were reclassified to water quality projects during the analysis. Detailed information for the reclassified sites can be found in Appendix C. However, a brief summary, cost estimate, and ranking are provided in this section.

B. Methods

1. Data Compilation and Analysis

Jones Edmunds used GIS to compile and review data developed from the Pollutant Loading Model results together with aerials and other base data obtained from the Sarasota County GIS library and SWFWMD. Specifically, these datasets included the following:

- Jones Edmunds pollutant-load results (TSS,TP, and TN)
- 1948 USDA aerials
- 2007 SWFWMD aerial imagery
- Public- and Agency-owned lands
  - SWFWMD
  - Airport Authority
  - Hospital
  - School Board
  - Federal
  - State
  - City

2. Field Investigations

Jones Edmunds conducted site visits to the water quality improvement sites in October 2008 to characterize the project areas and to identify and determine potential water quality treatment options. Site investigations for the reclassified sediment projects are detailed in Appendix C.

3. Quantifying Pollutant-Load Removal

The results of the SIMPLE model were used to calculate pollutant-loading rates in pounds per acre per year by catchment area. To calculate the range of pollutant removal by BMP, the loading rates were multiplied by the contributing area to create a pounds-per-year value. The pounds-per-year values were multiplied by the minimum and maximum reported efficiencies for the BMP to give a range of potential pounds per year of pollutant removed from stormwater runoff.

4. Opinions of Probable Cost

Cost of treatment was an important evaluation criterion for each site. Once the type of treatment method was determined, Jones Edmunds calculated the cost to implement the specific type of treatment activity. Some sites were determined to benefit large acreages with minimal cost for treatment, whereas other sites would require more costly treatment methods for a small amount of water quality improvement.

5. Site Ranking

Sites with a low cost to implement and high pollutant removal estimate were ranked higher than sites with a high cost and low pollutant removal estimates. Sites were ranked 1 through 12, with 1 being the highest ranked. To develop the ranking, Jones Edmunds divided the project cost by the high and low value in the range of pollutant removal estimates for each project to get a high and low cost per pound of pollutant removal. The high and low costs per pound of removal were averaged. The average cost per pound of removal is the value that was used to rank the sites.

4.5.1.4 Recommended Projects

Five potential water quality improvement sites were identified during the initial GIS desktop assessment. Fourteen projects were identified during the Sediment Management Plan analysis. The locations of these projects are shown in Figure 4-57. Three of the sediment projects are discussed in Appendix C as general program recommendations for street sweeping some projects were combined or not recommended. As a result, 12 potential water quality improvement projects were identified and assessed within Lemon Bay watershed. The following sections describe site evaluations, proposed elements, and benefits for each project. Pollutant removal estimates, conceptual level opinion of probable costs, and ranking for each site are summarized in Tables 4-6, 4-7, and 4-8. The project names include the water quality conceptual project id (LBWQXX), the sediment project ID (LBSXX), if applicable, the basin initials (e.g. AC represents Alligator Creek), and the site name.

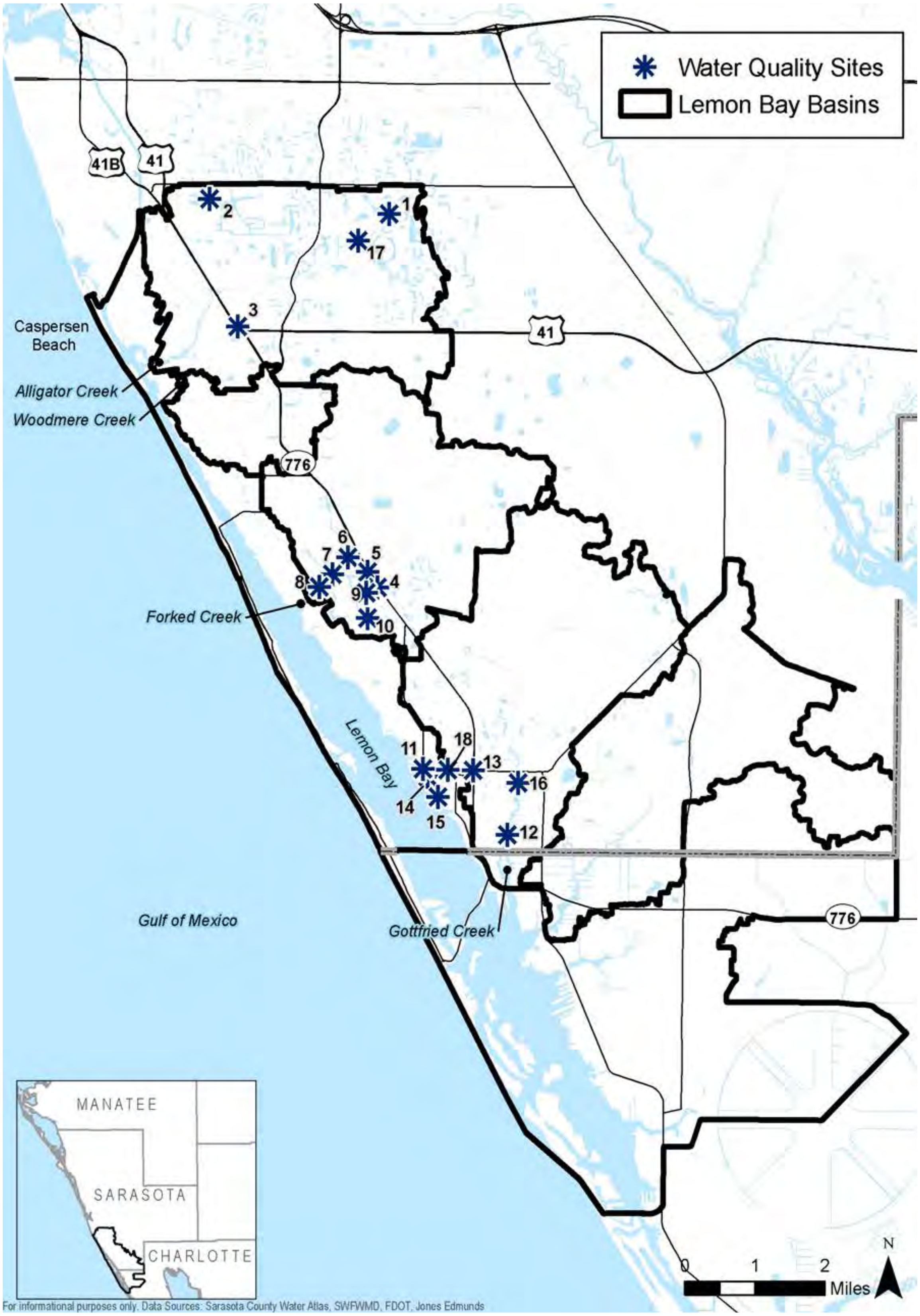

Figure 4-57 Lemon Bay Watershed Water Quality Improvement Site Locations

A. LBWQ01 – AC: Alligator Creek Stream Restoration

Figure 4-58 Alligator Creek Historical Stream Restoration Aerial Map

1. Site Evaluation

Historical aerials show the flowpath of Alligator Creek previous to 1950 was more sinuous adjacent to Venice East Blvd. Restoring the historical flow regime will reduce velocities thus encouraging nutrient uptake and settling.

2. Proposed Project Elements

❖ Re-create the historical flowpath of Alligator Creek by installing strategic blocks to reroute water employing low-impact construction techniques involving minimal earthwork and clearing.

3. Project Benefits

A sinuous channel will reduce flow velocities through the system, thus providing a higher level of riparian treatment.

Figure 4-59 1944: Natural Creek and Floodplain

Figure 4-60 1948: Ditching for Agriculture

Figure 4-61 Existing Creek Rerouted Through Pipes, Stormwater Ponds, Drop Structures, and Ditches

Figure 4-62 Comparison of Alligator Creek 1944, 1948, Existing

B. LBWQ02 (combined with LBS04) – AC: Lake Magnolia and Banyan Drive

Figure 4-63 Lake Magnolia and Banyan Drive Aerial Map

1. Site Evaluation

The Banyan Drive stormwater pond discharges to Lake Shamrock/Lake Magnolia, which is currently being evaluated by Sarasota County for water quality improvements. The pond currently provides limited treatment for an approximately 40-acre drainage area. A geotechnical evaluation of the site will determine if a biofiltration, bioretention, or linear wet pond would be most appropriate. The site for the sediment removal box is the discharge to the lake for a 30-acre basin.

2. Proposed Project Elements

- Construct a bioretention system.
- Add an additional control structure to discharge into the lake system.

3. Project Benefits

The bioretention system will provide a higher level of treatment to a drainage area of approximately 40 acres and improve the water quality of the discharge to the impaired lake system.

C. LBWQ04 - FC: Waterford Drive

Figure 4-64 Waterford Drive Aerial Map

1. Site Evaluation

A 1700-ft channel discharges to a Forked Creek tributary through a 15-inch culvert at this location. The channel segment carries runoff from approximately 30 acres of a medium-density residential area. The swale is the only water quality treatment BMP.

2. Proposed Project Elements

- ❖ Replace drainage swale with a biofiltration system.
- ❖ Install a control structure at the outfall.

3. Project Benefits

The benefits of biofiltration include decreased surface runoff, increased groundwater recharge, and increased pollutant removal through a variety of processes.

D. LBWQ05 – FC: Lemon Bay Plaza

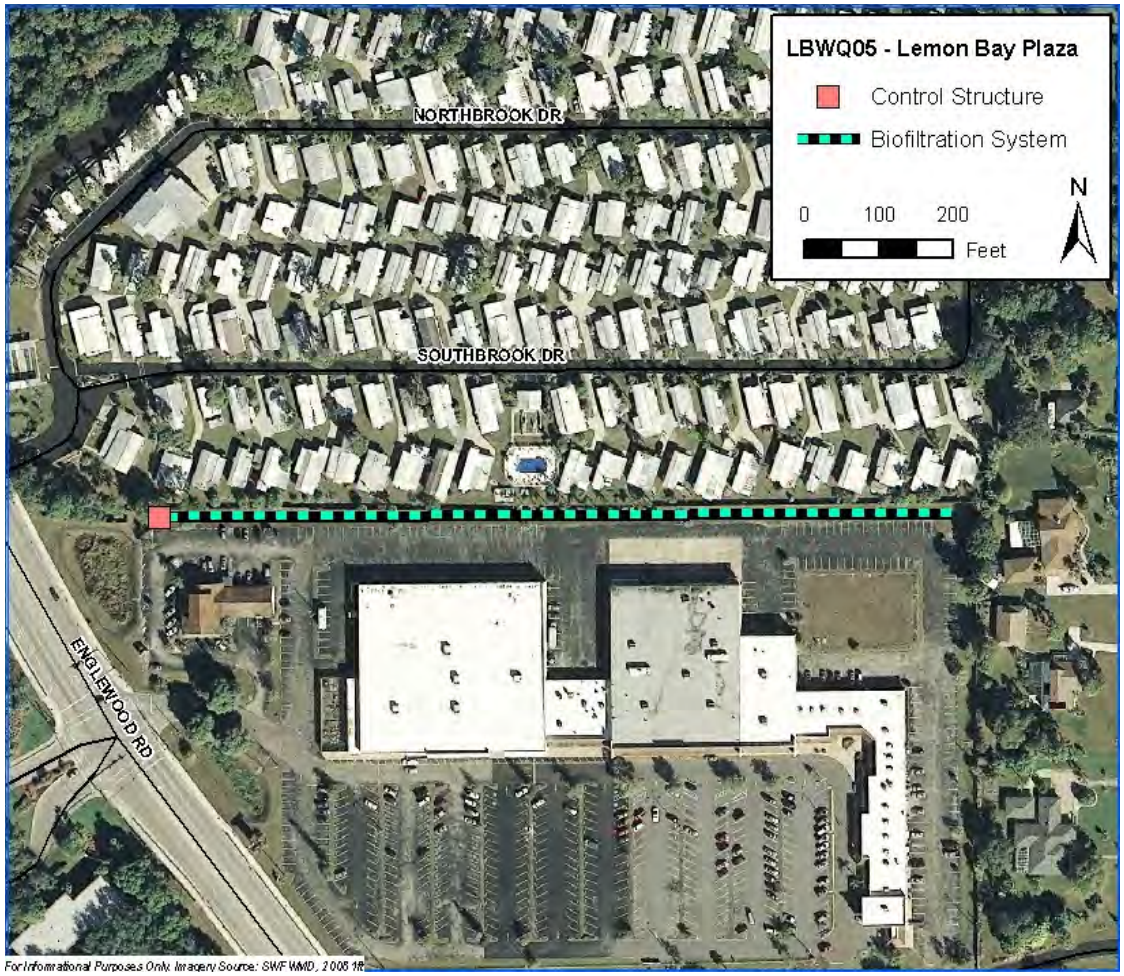

Figure 4-65 Lemon Bay Plaza Aerial Map

1. Site Evaluation

Approximately 10 acres of impervious area including rooftops, parking lots, and truck loading areas from Lemon Bay Plaza drains to a Ditch Bottom Inlet (DBI) system at the north end of the site. The system discharges directly to Forked Creek.

2. Proposed Project Elements

❖ Replace DBI system with a biofiltration system.

3. Project Benefits

The benefits of biofiltration include decreased surface runoff, increased groundwater recharge, and increased pollutant removal through a variety of processes.

E. LBWQ06 (LBS13) – FC: Overbrook Drive

Figure 4-66 Overbrook Drive Aerial Map

1. Site Evaluation

The bridge west of Forked Creek Drive on Overbrook Road was replaced in 2008. Accumulated sediment south of the bridge is visible in 2007 aerial photographs. Stormwater runoff flows directly to the channel through a driveway culvert/roadside swale system. Overbrook Road is in good repair, but several of the local neighborhood roads are pitted and graveled with accumulated sediment on the pavement and at the edge of the pavement.

2. Proposed Project Elements

- ❖ Construct a stormwater treatment pond.

- ❖ Build supporting infrastructure.

3. Project Benefits

The retention pond will capture roadway runoff and reduce the sediment and pollutant loads reaching the canal system.

F. LBWQ07 (LBS14) – FC: Fairview Drive

Figure 4-67 Fairview Drive Aerial Map

1. Site Evaluation:

Fairview Drive ends in a small roundabout less than 40 feet from Forked Creek. Residential properties line the street and the small area between the roundabout, and the creek provides a local-scale opportunity for stormwater treatment.

2. Proposed Project Elements

- ❖ Add a stormwater pond at the end of the roadway to provide treatment to stormwater runoff.
- ❖ Add bioretention swales for treatment.

3. Project Benefits

The contributing area is 1.2 acres and a stormwater pond would retain and provide treatment for local roadway runoff in this neighborhood.

G. LBWQ08 (LBS15) – FC: Bridge Street

Figure 4-68 Bridge Street Aerial Map

1. Site Evaluation

Bridge Street ends less than 100 feet from Forked Creek. The flow travels down the slope of the roadway directly to the creek.

2. *Proposed Project Elements*

- ❖ Construct a dry stormwater pond at the end of the roadway to provide stormwater runoff treatment.
- ❖ Add mangroves and riprap to the shoreline to provide additional stability.

3. *Project Benefits*

Within the 100 feet that is currently overland flow, a small stormwater pond would retain the roadway runoff from small rain events, reducing the amount of pollutants being carried directly to the creek.

H. LBWQ12 (LBS20) – GC: Cortes Drive

Figure 4-69 Cortes Drive Aerial Map

1. *Site Evaluation*

This site is located at the end of Cortes Drive off of South Oxford Drive. A drop inlet with a pipe discharging directly to the tidally-influenced creek is located between the end of the cul-de-sac and the mangroves. The roadway is in poor condition with accumulated sediment and gravel on the surface and along the edge of pavement. Much of the sediment on the roadway is crumbling roadway material.

2. Proposed Project Elements

- ❖ Add a stormwater pond at the end of the roadway to provide treatment to stormwater runoff.
- ❖ Add bioretention swales to provide attenuation and treatment.
- ❖ Replace damaged discharge structure.

3. Project Benefits

A stormwater pond will capture roadway runoff and reduce pollutants from reaching the canal system.

I. LBWQ14 (LBS23) – LBC: Cherokee Drive

Figure 4-70 Cherokee Drive Aerial Map

1. Site Evaluation

Stormwater runoff from the sloped roadway flows directly to Lemon Bay at this location. Swales with driveway culverts are located on both sides of the road and discharge directly to the bay as well.

2. Proposed Project Elements

- ❖ Construct a stormwater pond.
- ❖ Add riprap and erosion control along the shoreline.
- ❖ Regrade roadside swales.

3. Project Benefits

The small stormwater pond will capture roadway runoff and reduce pollutants reaching the canal system.

J. LBWQ15 (LBS24) – LBC: Magnolia Avenue

Figure 4-71 LBC: Magnolia Avenue

1. Site Evaluation

A large wetland, located to the east of Magnolia Avenue, provides some treatment for stormwater runoff.

2. Proposed Project Elements

- Treat limestone on West Palm Grove Avenue.
- Construct a stormwater pond.
- Create a bioswale on the east side of Magnolia Avenue for additional treatment of stormwater runoff.

3. Project Benefits

The small stormwater pond will capture roadway runoff and reduce pollutants from reaching the canal system. Bioswales serve to remove sediment and nutrients in runoff by slowing overland flow.

K. LBWQ16 (LBS19) – GC: Court Street-Langsner Street

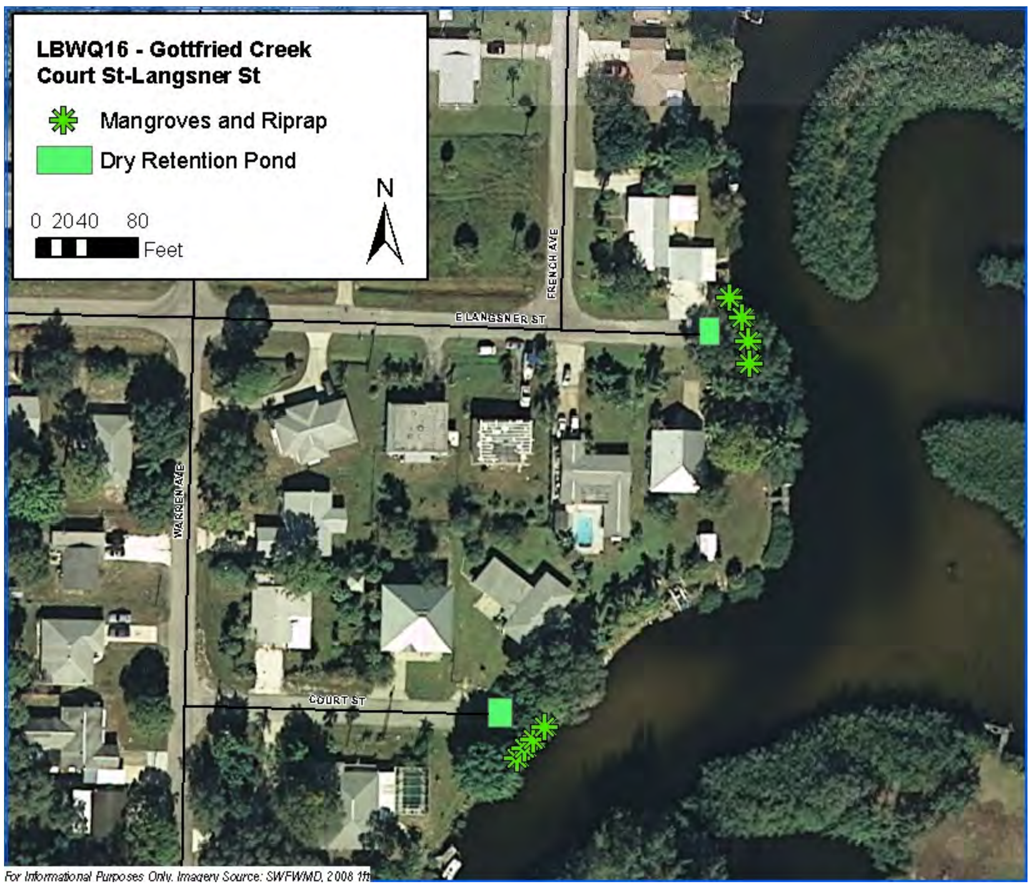

Figure 4-72 Court Street-Langsner Street Aerial Map

1. Site Evaluation

Court and Langsner Streets are roadways that end within 100 feet of Gottfried Creek. The roadways are in poor repair and have excess gravel and fine sediment accumulated on the surface. The roadways are sloped to direct stormwater runoff directly to the creek without treatment.

2. Proposed Project Elements

❖ Add dry retention ponds at the end of the roadway to provide treatment.

- ❖ Add mangroves and riprap to the shoreline to provide additional stability.

3. Project Benefits

The small dry pond will capture roadway runoff and reduce pollutants from reaching the canal system. Mangroves will provide additional bank stabilization.

L. LBWQ17 (LBS25) – AC: Venice Boulevard Low Impact Development (LID)
This project was evaluated and designed by others.

1. Site Evaluation

Venice East Blvd is between Center Road and US 41 and is surrounded by medium-density residential on the north end, commercial development on the south end, and Alligator Creek in the center. The location for the demonstration project was chosen because of the diversity of the terrain and proximity to the creek. The proposed project intends to demonstrate the effectiveness of bioretention areas.

2. Proposed Project Elements

- ❖ Plant a wide vegetative palette.
- ❖ Develop soil amendments.

3. Project Benefits

The proposed project intends to demonstrate the effectiveness of bioretention areas and will demonstrate techniques which can be used to retrofit existing neighborhood streets that currently have no stormwater treatment.

M. LBWQ18 (LBS26) LBC: Dearborn Street

This project was evaluated and designed by others.

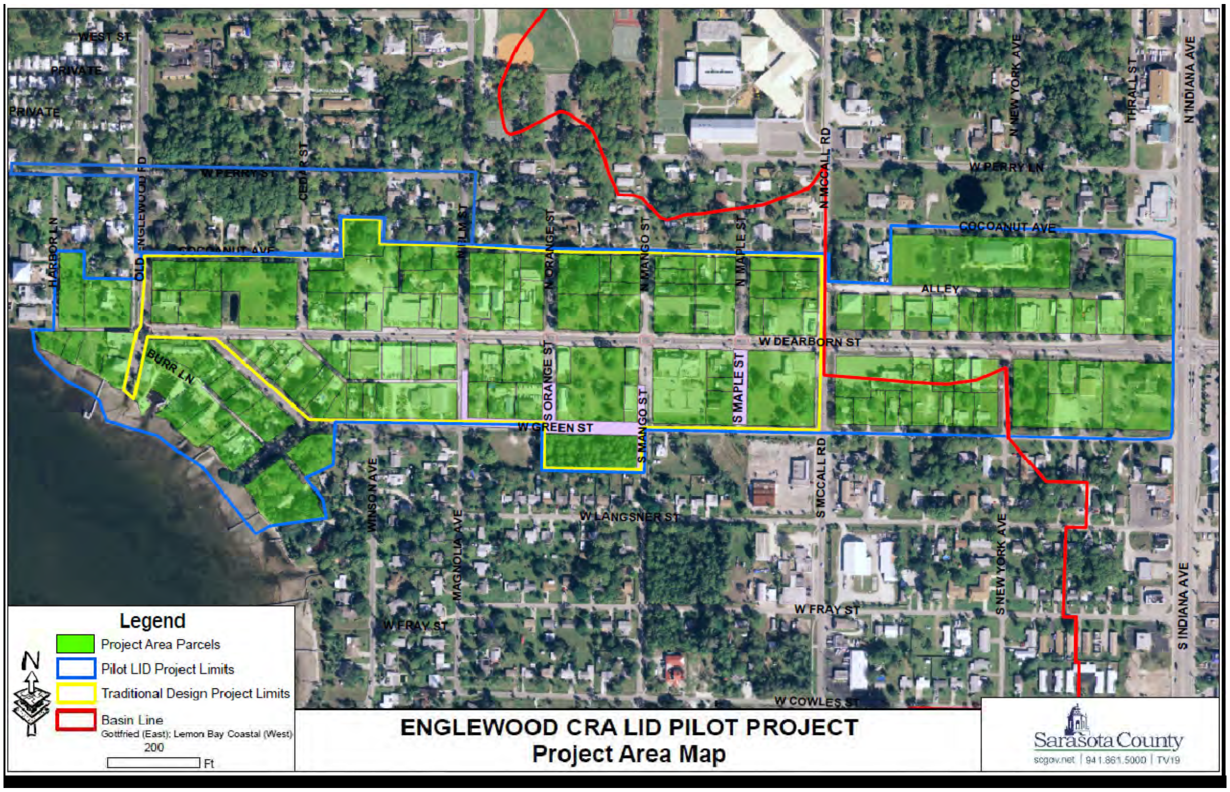

Figure 4-73 Dearborn Street Aerial Map

1. Site Evaluation

This area is designated as the *Englewood Community Redevelopment Area* and includes the area parallel to West Dearborn Street from CR 776 west to Lemon Bay bound by Cocoanut Avenue on the north and Green Street on the south. Stormwater runoff receives minimal treatment before discharging to Lemon Bay. As part of the redevelopment, the County is moving forward with the Dearborn Street Low-Impact-Development Pilot Project to provide stormwater treatment from this area within the right-of-way and County-owned parcels. The project encompasses approximately 50 acres.

2. Proposed Project Elements

- ❖ Replace existing ditch system with bioretention areas.
- ❖ Add vegetated swales, engineered soils, and perforated pipe all surrounded by an impermeable liner.
- ❖ Provide for cistern use, stormwater harvesting, and pervious pavement.

3. Project Benefits

The proposed project intent is to capture the runoff as close to the source as possible in bioretention areas. The bioretention areas will capture roadway runoff and reduce pollutants from reaching the bay.

4.5.1.5 Results and Discussion

A. Pollutant-Load Removal Estimates

Jones Edmunds reviewed the spatial results of the SIMPLE mode to determine hot spots for TN, TP, and TSS in the watershed. The hot spots were part of the GIS desktop analysis used to identify potential projects. Table 4-6 summarizes the average annual loading in each subbasin. Figures 4-74, 4-75, and 4-76 show the conceptual project sites in relation to the spatial results of the average annual loads by subbasin for TN, TP, and TSS.

The results of the SIMPLE model were used to calculate normalized pounds per acre per year value by catchment area. To calculate the range of pollutant removal by BMP, the normalized results by catchment from the SIMPLE model were multiplied by the contributing area to create a pounds-per-year value. The pounds-per-year values were multiplied by the minimum and maximum reported efficiencies for the BMP to give a range of potential pounds per year of pollutant removed from stormwater runoff. Table 4-6 shows the estimated range of pounds per year of pollutant removed by the proposed BMP.

Table 4-6 Annual Average Pollutant Loads (lb/ac/yr) and Rank

Subbasin ID	Basin Name	ICPR Group	Area (ac)	TSS (lb/ac/yr)	TSS Rank	TP (lb/ac/yr)	TP Rank	TN (lb/ac/yr)	TN Rank
1	AINGER CREEK	AIC-EAST	1548.33	42.19	39	0.43	39	4.78	36
2	AINGER CREEK	AIC-NRTH	1958.70	44.33	38	0.44	38	4.41	38
3	AINGER CREEK	AIC-STH	2052.44	52.58	36	0.62	37	3.92	39
4	ALLIGATOR CREEK	AC-41NW	73.18	319.98	1	2.24	2	13.34	1
5	ALLIGATOR CREEK	AC-41SE	113.51	277.32	2	2.20	3	12.22	2
6	ALLIGATOR CREEK	AC-BRIAR	815.10	102.96	23	1.44	16	7.18	17
7	ALLIGATOR CREEK	AC-JAC	721.57	162.03	8	1.72	8	8.24	12
8	ALLIGATOR CREEK	AC-LAT1	243.22	228.95	5	1.54	13	9.19	5
9	ALLIGATOR CREEK	AC-LAT2	799.60	105.68	21	0.87	29	5.32	31
10	ALLIGATOR CREEK	AC-LOW	457.47	128.81	14	1.38	17	8.29	11
11	ALLIGATOR CREEK	AC-MID	948.17	198.82	6	1.73	7	7.82	14
12	ALLIGATOR CREEK	AC-SVMD	323.12	134.66	11	1.59	11	8.37	10
13	ALLIGATOR CREEK	AC-SVNE	101.81	127.60	15	1.85	5	9.11	6
14	ALLIGATOR CREEK	AC-SVNW	446.02	114.39	17	1.72	9	8.44	9
15	ALLIGATOR CREEK	AC-SVSE	235.42	96.77	25	1.58	12	8.00	13
16	ALLIGATOR CREEK	AC-SVSW	138.56	130.08	13	1.46	15	7.61	15
17	ALLIGATOR CREEK	AC-TRPN	88.53	142.18	9	1.78	6	8.85	8
18	ALLIGATOR CREEK	AC-UP	1293.83	118.10	16	1.13	22	5.32	30
19	FORKED CREEK	FC-BOCA	719.31	130.14	12	1.19	19	6.10	20
20	FORKED CREEK	FC-EAST	1952.02	101.54	24	0.82	31	5.59	26
21	FORKED CREEK	FC-LOWER	813.19	140.45	10	1.35	18	6.34	18
22	FORKED CREEK	FC-MID	1966.30	92.27	28	0.81	32	5.28	33
23	FORKED CREEK	FC-WEST	382.66	90.89	29	1.08	23	5.95	21
25	FORKED CREEK	LBP-FC	29.12	262.44	3	2.46	1	10.11	4
26	GOTTFRIED CREEK	GC-MID	942.70	71.19	35	0.86	30	5.29	32
27	GOTTFRIED CREEK	GC-NOLAT	1007.38	87.79	32	0.99	27	5.65	24
28	GOTTFRIED CREEK	GC-RIVER	213.49	88.70	30	0.70	36	5.51	28
29	GOTTFRIED CREEK	GC-UPPER	3758.43	109.70	19	0.81	33	5.25	34
30	GOTTFRIED CREEK	GC-776	148.63	182.90	7	1.54	14	8.87	7
33	GOTTFRIED CREEK	GC-LOWER	941.71	109.83	18	1.00	26	5.48	29
34	GOTTFRIED CREEK	GC-LOWER	25.80	247.30	4	1.86	4	10.56	3
36	LEMON BAY COASTAL	LBC-LOWER	886.92	109.15	20	1.14	21	6.28	19
38	LEMON BAY COASTAL	LBC-UPPER	895.18	95.54	26	0.96	28	5.64	25
39	LEMON BAY COASTAL	LBC-MID	977.88	71.73	34	1.02	25	5.56	27
40	WOODMERE CREEK	LBP-WC	220.86	50.86	37	0.72	35	4.85	35
41	WOODMERE CREEK	WC-NORTH	696.78	88.13	31	1.16	20	5.93	22
42	WOODMERE CREEK	WC-SOUTH	557.05	94.50	27	1.65	10	7.37	16
43	LEMON BAY COASTAL	LBC-LOWER	219.60	71.96	33	0.79	34	4.73	37
44	LEMON BAY COASTAL	LBC-MID	278.78	104.77	22	1.04	24	5.78	23

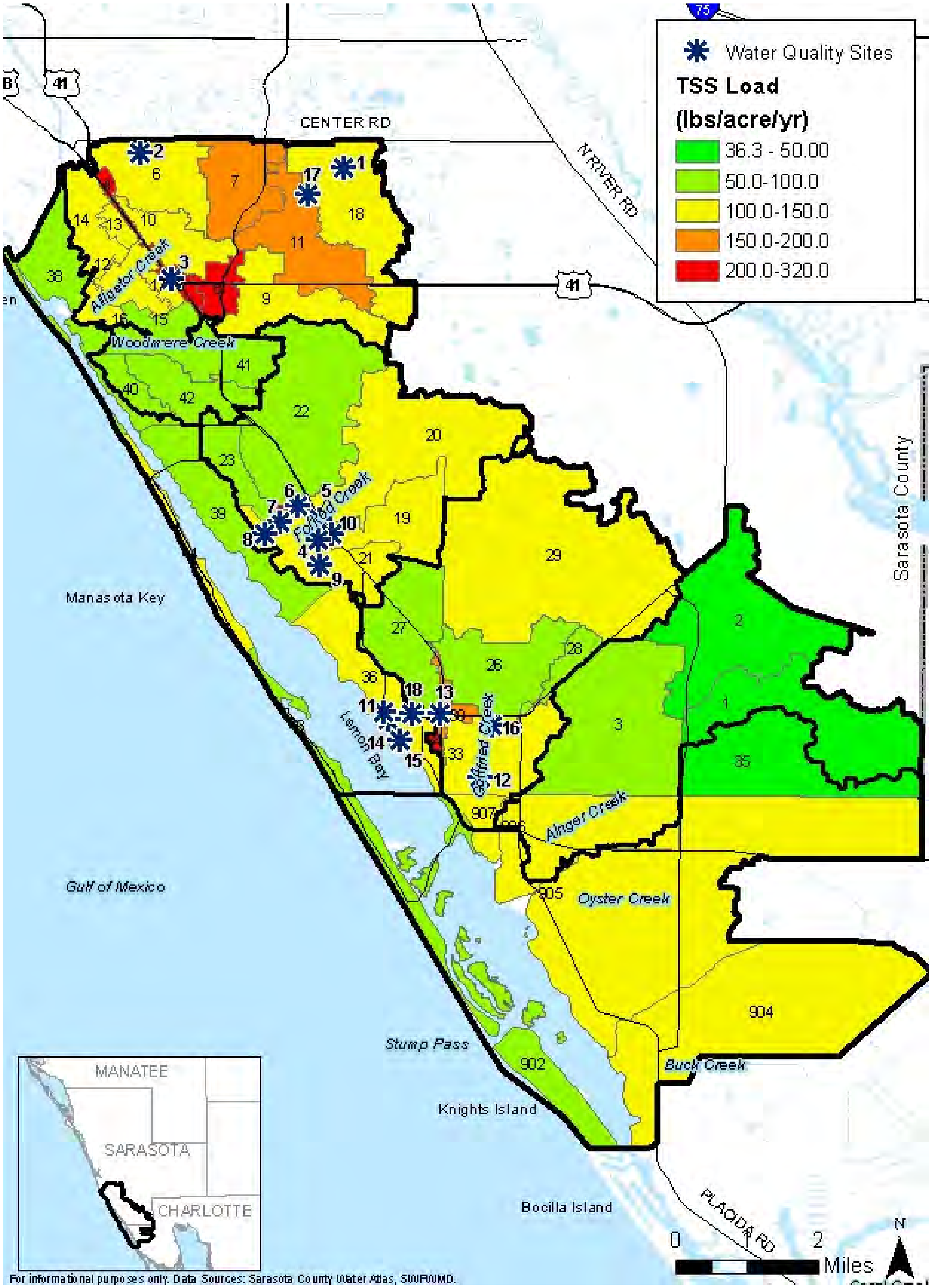

Figure 4-74 Lemon Bay Watershed Water Quality Conceptual Site Locations Overlaid on the Average Annual TSS Load per Unit Area Results

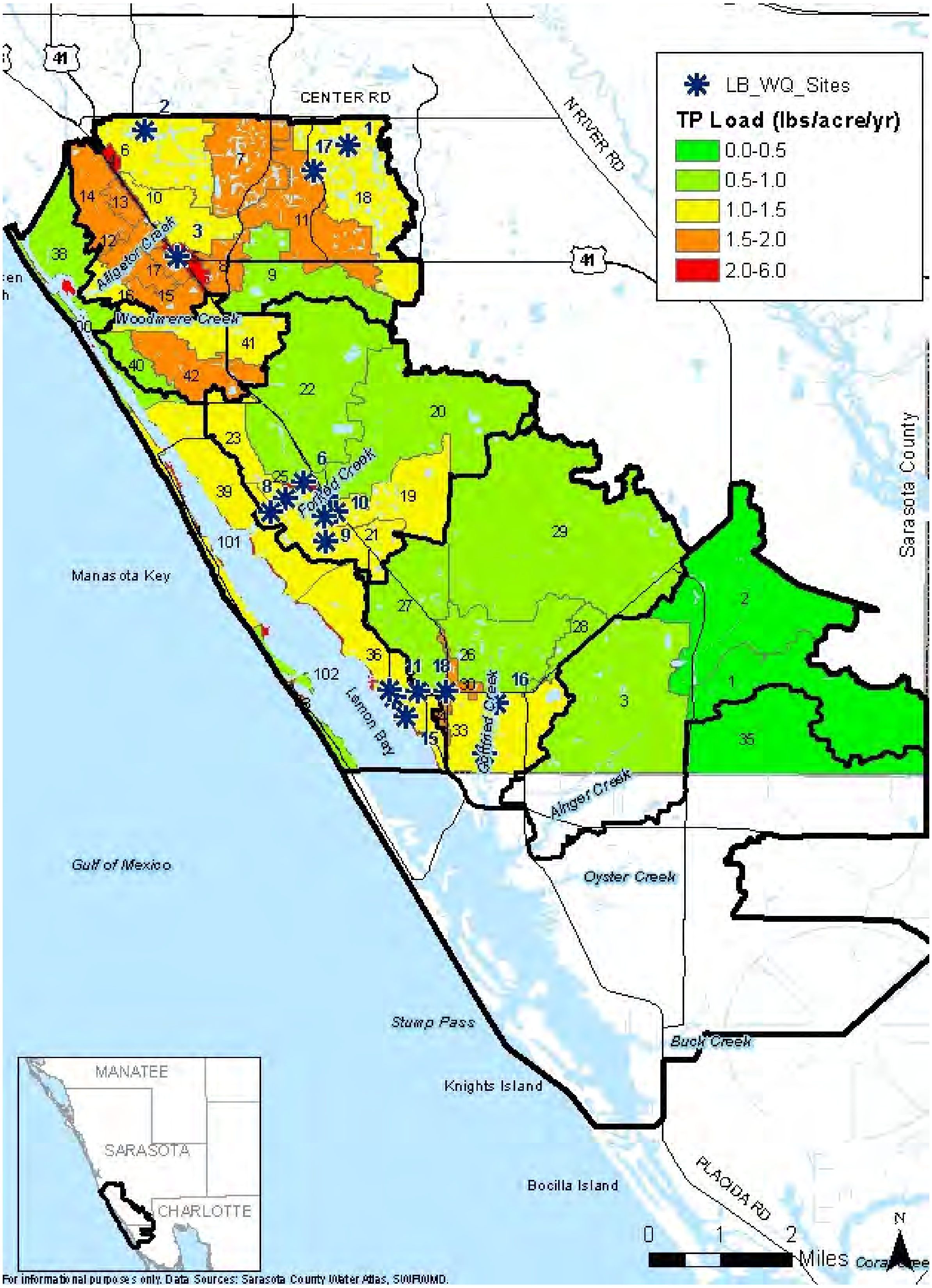

Figure 4-75 Lemon Bay Watershed Water Quality Conceptual Site locations Overlaid on the Average Annual TP Load per Unit Area Results

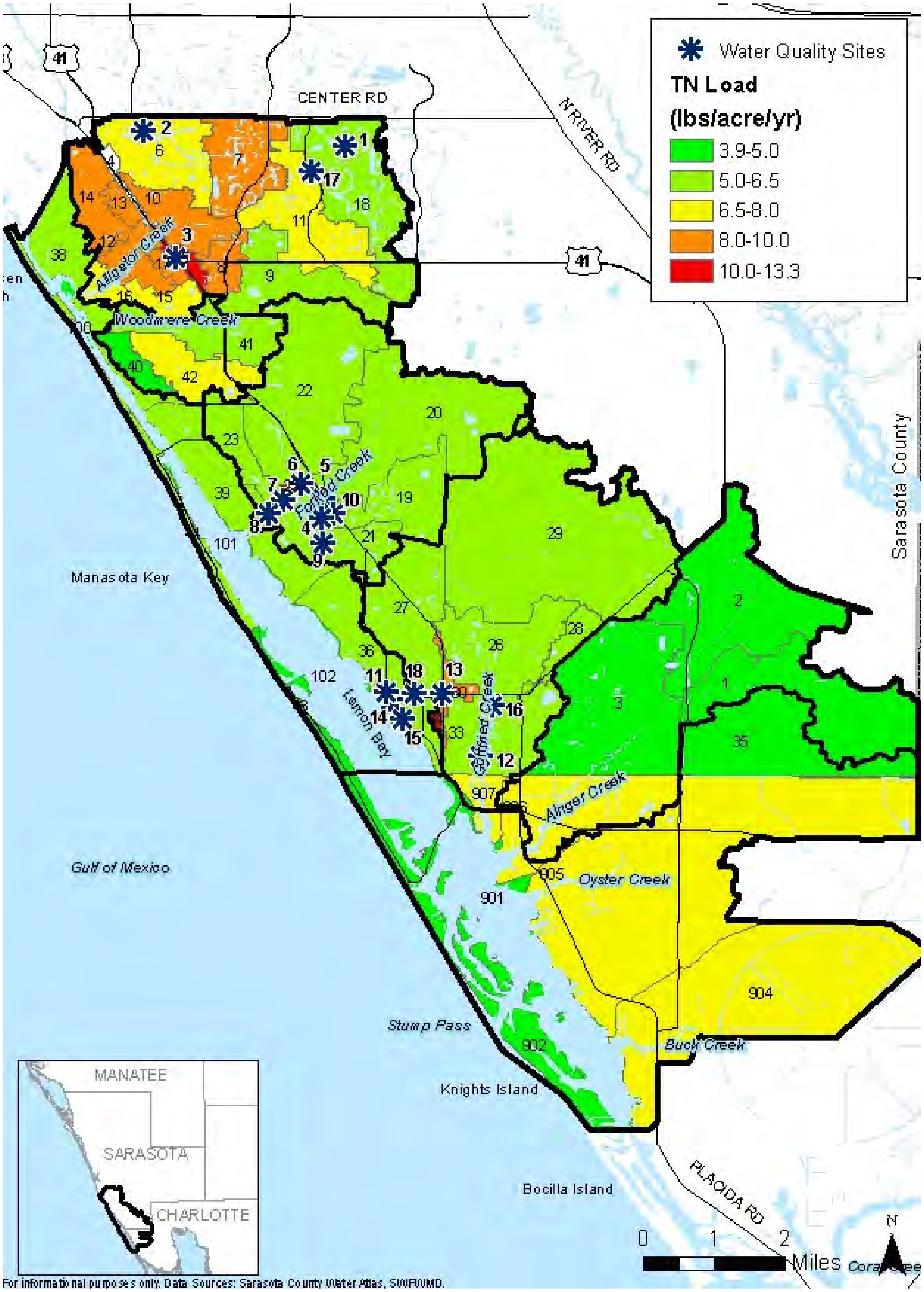

Figure 4-76 Lemon Bay Watershed Water Quality Conceptual Site Locations Overlaid on the Average Annual TN Load per Unit Area Results

Table 4-7 Estimated Pollutant-Load Removal by Proposed BMP

Project ID	Basin	Project Name	BMP Type	Estimated Drainage Area	Estimated Pollutant Removal (lb/yr) (rounded)		
					Total Suspended Solids	Total Phosphorus	Total Nitrogen
LBWQ01	Alligator Creek	Stream Restoration	Sinuous Channel	50.0	600 - 6900	0 - 5	50 - 210
		Total			600 - 6900	0 - 5	50 - 210
LBWQ02	Alligator Creek	Lake Magnolia & Banyan Dr	Bioretention System	40.0	800 - 3300	0 - 5	110 - 170
(LBS04)			Sediment Removal Structure	30.0	1200 - 2300	0 - 5	30 - 60
		Total			2000 - 5600	0 - 5	145 - 230
LBWQ03	Alligator Creek	General	Street Sweeping	190.0	15700 - 31000	50 - 100	500 - 1100
(LBS09)		Total			15700 - 31000	50 - 100	500 - 1100
LBWQ04	Forked Creek	Waterford Dr	Biofiltration System	30.0	2500 - 4100	0 - 0	100 - 150
		Total			2500 - 4100	0 - 0	100 - 150
LBWQ05	Forked Creek	Lemon Bay Plaza	Biofiltration System	10.0	800 - 1300	0 - 0	0 - 50
		Total			800 - 1300	0 - 0	0 - 50
LBWQ06	Forked Creek	Overbrook Dr	Stormwater Treatment Pond	10.0	1400 - 2500	5 - 20	0 - 70
(LBS13)		Total			1400 - 2500	5 - 20	0 - 70
LBWQ07	Forked Creek	Fariview Dr	Dry Retention Pond	1.2	100 - 200	0 - 10	0 - 10
(LBS14)		Total			100 - 200	0 - 10	0 - 10
LBWQ08	Forked Creek	Bridge St	Dry Retention Pond	1.0	100 - 100	0 - 5	0 - 10
(LBS15)		Total			100 - 100	0 - 5	0 - 10
LBWQ10	Forked Creek	General	Street Sweeping	25.0	1000 - 1900	0 - 10	35 - 80
(LBS18)		Total			1000 - 1900	0 - 10	35 - 80
LBWQ12	Gottfried Creek	Cortes Dr	Dry Retention Pond	2.5	200 - 300	0 - 5	10 - 15
(LBS20)			Bioswale	2.5	100 - 200	0 - 5	5 - 10
		Total			300 - 500	0 - 5	15 - 25
LBWQ13	Gottfried Creek	General	Street Sweeping	56.0	3100 - 6000	10 - 20	110 - 250
(LBS21)		Total			3100 - 6000	10 - 20	110 - 250
LBWQ14	LB Coastal	Cherokee St-Dearborne St	Dry Retention Pond	0.5	0 - 100	0 - 5	0 - 5
(LBS23)		Total			0 - 100	0 - 5	0 - 5
LBWQ15	LB Coastal	Magnolia Ave	Dry Retention Pond	0.7	100 - 100	0 - 5	0 - 5
(LBS24)			Bioswale	5.0	100 - 400	0 - 5	10 - 20
			Limestone Treatment	0.7	10 - 40	0	0
		Total			200 - 600	0 - 5	15 - 25
LBWQ16	Gottfried Creek	Court St-Langsner St	Dry Retention Pond	3.5	300 - 400	0 - 3	15 - 20
(LBS19)		Total			300 - 400	2 - 3	15 - 20

B. Conceptual Level Cost Estimates

Table 4-8 Conceptual Level Estimates of Probable Cost

Project ID	Description	Total Project Cost+	Construction Cost	Engineering Design Services*	Annual Maintenance Cost
LBWQ01	AC: Alligator Creek-Venice Blvd	$142,000	$109,000	$33,000	$0
LBWQ02	AC: Lake Magnolia and Banyan Dr	$771,000	$628,000	$143,000	$4,700
LBWQ04	FC: Waterford Dr	$468,000	$381,000	$87,000	$1,500
LBWQ05	FC: Lemon Bay Plaza	$430,000	$350,000	$80,000	$1,500
LBWQ06	FC: Overbrook Dr	$334,000	$272,000	$62,000	$0
LBWQ07	FC: Fairview Dr	$44,000	$17,000	$27,000	$2,500
LBWQ08	FC: Bridge St	$69,000	$41,000	$28,100	$1,500
LBWQ12	GC: Cortes Dr	$43,000	$16,000	$27,000	$2,500
LBWQ14	LBC: Cherokee Dr	$73,000	$45,000	$28,000	$1,000
LBWQ15	LBC: Magnolia Ave	$56,000	$29,000	$27,000	$2,500
LBWQ16	GC: Court St-Langsner St	$62,000	$34,000	$28,000	$1,000

+ Total Project Cost includes Mobilization and Contingency costs along with Construction Costs and Engineering Design Services

* Design Services include Survey, Geotechnical Investigation, Engineering Design, and Permitting

C. Ranking of Potential Projects

Table 4-9 Ranking of Potential Projects

Project ID		Location	Pollutant Removal Estimate (lb/yr) TSS		TP		TN		Total		Total Project Cost	Cost per lb/yr Range		Average $/lb	Rank
LBWQ12	LBS20	GC: Cortes Dr	300	500	0	5	15	25	315	530	$43,000	$135	$81	$109	1
LBWQ01		AC: Alligator Creek Stream Restoration	600	6,900	0	5	50	210	650	7,115	$142,000	$219	$20	$119	2
LBWQ04	LBS04 *	FC: Waterford Dr	2,500	4,100	0	0	100	150	2,600	4,252	$468,000	$180	$110	$145	3
LBWQ16	LBS19	GC: Court St-Langsner St	300	400	0	5	15	20	315	425	$62,000	$198	$147	$171	4
LBWQ15	LBS24	LBC: Magnolia Ave	200	600	0	5	15	25	215	630	$56,000	$261	$89	$175	5
LBWQ06	LBS13	FC: Overbrook Dr	1,400	2,500	5	20	0	70	1,405	2,590	$334,000	$238	$129	$183	6
LBWQ02		AC: Lake Magnolia and Banyan Drive	2,000	5,600	0	5	145	230	2,145	5,835	$771,000	$359	$132	$246	7
LBWQ07	LBS14	FC: Fairview Dr	100	200	0	10	0	10	100	220	$44,000	$442	$201	$320	8
LBWQ05		FC: Lemon Bay Plaza	800	1,300	0	0	0	50	800	1,349	$430,000	$538	$319	$428	9
LBWQ08	LBS15	FC: Bridge St	100	100	0	5	0	10	100	115	$69,000	$719	$625	$645	10
LBWQ14	LBS23	LBC: Cherokee Dr	0	100	0	5	0	5	1	110	$73,000	$73,000	$664	$36,832	11