FINAL

WATER QUALITY TARGET REFINEMENT PROJECT

Task 4: Pollutant Loading Estimates Development

Interim Report 4

Prepared for:

Charlotte Harbor National Estuary Program
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June 2010

FOREWORD

This report was prepared by Janicki Environmental, Inc. for the Charlotte Harbor National Estuary Program in fulfillment of Task 4 of the Water Quality Target Refinement Project.

ACKNOWLEDGMENTS

We wish to thank the staffs of the Fort Myers and Tampa offices of the Florida Department of Environmental Protection for the assistance rendered in retrieving point source data. We sincerely appreciate the help of the following in obtaining data and providing advice for this project: Charles Kovach and Jennifer Nelson of the FDEP with point source data collection and all the county, city, and industrial facility representatives who patiently reviewed, revised, and provided data for accurate estimation of point source loadings to the estuary.

EXECUTIVE SUMMARY

Background

Charlotte Harbor was nominated as an “estuary of national significance” in 1995, and was subsequently accepted into the National Estuary Program. The Charlotte Harbor National Estuary Program (CHNEP) completed its Comprehensive Conservation and Management Plan (CCMP) in 2000, and updated it in 2008.

One of the initial achievements of the CHNEP management conference was to identify priority problems for the CHNEP area. The priority problems that were identified included the following, among others (CHNEP, 2008):

- Hydrologic Alterations: Changes to the hydrology of the area have adversely impacted the quantity and timing of freshwater inflows to the estuary, including the hydrologic function of the floodplain system.

- Water Quality Degradation: Changes to water quality result from pollution from all sources in the watershed and from atmospheric deposition directly to the water surface of the estuary.

- Fish and Wildlife Habitat Loss: Population growth and concomitant land use changes have resulted in degradation and elimination of habitats, including loss of natural shorelines and invasive species incursion.

The CHNEP management conference then developed six program goals to provide focus for the CCMP. The goals are as follows (CHNEP, 2008):

1. Improve the environmental integrity of the CHNEP area.
2. Preserve, restore, and enhance seagrass beds, coastal wetlands, barrier beaches, and functionally related uplands.
3. Reduce point and non-point sources of pollution to attain desired uses of the estuary.
4. Provide the proper fresh water inflow to the estuary to ensure a balanced and productive ecosystem.
5. Develop and implement a strategy for public participation and education.
6. Develop and implement a formal Charlotte Harbor management plan with a specified structure and process for achieving goals for the estuary.

Quantifiable objectives were developed to address the three priority problems and the program goals. Included in these quantifiable objectives was one for submerged aquatic vegetation. Objective FW-1 states “…*native submerged aquatic vegetation should be maintained and restored at a total extent and quality no less than caused by natural variation*…” (CHNEP, 2008).

It is widely accepted that nutrient (nitrogen and phosphorus) enrichment of coastal water bodies can adversely affect submerged aquatic vegetation such as seagrasses by reducing light penetration. Seagrass coverage is related to seagrass light requirements, which in turn are dependent upon water clarity. Water clarity is dependent upon several factors, including chlorophyll *a* concentration, which is related to external loadings of nutrients to the estuary. Color and turbidity also impact water clarity, most importantly in tidal rivers nearest the source of organic materials, and act as confounding factors in the relationship between nutrient loadings and water clarity.

In accordance with Objective FW-1, pollutant loadings for the period 1995-2007 were estimated as described in this document. The results of this work will facilitate the examination of the relationships between nutrient loading and water clarity, and also allow nutrient load targets to be established based on water clarity targets. The water clarity targets are currently being established by CHNEP based on seagrass light requirements.

The water clarity targets are currently being established by CHNEP based on seagrass light requirements. The primary goal of this effort is to establish targets designed to maintain and/or restore seagrass acreage to its historical extent. While the extent of seagrass in the study area may be governed by a variety of processes including erosion, salinity changes, biological perturbations, prop scarring and sedimentation, water clarity is thought to be the principal controlling factor in the long term health of seagrasses in the study area. Therefore, management level water clarity targets that are related to the light requirements of seagrass are also being developed to allow managers to correlate changes in water clarity conditions and seagrass conditions over time.

The pollutant loading targets will prove valuable in addressing other environmental programs, such as implementing Basin Management Action Plans for impaired waters under the Total Maximum Daily Load (TMDL) program and assisting in the currently developing numeric nutrient criteria.

Study Area

The loading estimates cover a large area. The Charlotte Harbor National Estuary Program (CHNEP) watershed contains three large rivers: the Peace River, the Myakka River, and the Caloosahatchee River, as well as areas that discharge directly to a number of coastal lagoons. The watershed for the CHNEP extends over approximately 4300 square miles, and ranges from the northern end of the Peace River basin in Polk County to the southern end of the Estero Bay basin in Lee County and Collier County.

The CHNEP area is comprised of 14 different bay segments, as shown in Figure ES-1. These segments, along with their watersheds, are delineated based on hydrologic, ecologic, and management characteristics. The 14 bay segments include:

- Dona and Roberts Bays,

- Upper Lemon Bay,
- Lower Lemon Bay,
- Cape Haze,
- Bokeelia,
- West Wall of Charlotte Harbor,
- East Wall of Charlotte Harbor,
- Tidal Myakka River,
- Tidal Peace River,
- Pine Island Sound,
- Matlacha Pass,
- San Carlos Bay,
- Tidal Caloosahatchee River, and
- Estero Bay.

Figure ES-1. CHNEP bay segments and Water Management District boundaries.

The bay segments represent reporting units which possess relatively homogeneous conditions with respect to variations in water quality, and to resultant seagrass success within the estuary (CHNEP, 2009). The segments contain a wide diversity of land covers and uses, ranging from the Tidal Peace River with large areas of agriculture and open land, to the urbanized coastal segments such as Upper and Lower Lemon Bay and Matlacha Pass, to relatively undeveloped segments with extensive wetlands such as Cape Haze and the West Wall.

The loading report includes:

- a description of the CHNEP area, including the hydrology, land use, and soils of the watershed of each bay segment;
- a summary of the methods utilized to develop loadings from each source category (atmospheric deposition, nonpoint sources, septic tanks, and point sources) to each segment;
- a listing of the results for each segment, by loading source category, for 1995-2007; and
- a description of the CHNEP Best Management Practice Calculator.

Methods

The loading report contains detailed information about each bay segment and its watershed. Segment hydrology, land use, and soils are the most important physical characteristics for the purpose of developing the loading estimates, as described below.

Hydrology – Hydrologic alterations, or physical changes to hydrologic features, can greatly alter the timing, volume, and distribution patterns of surface water inflows. Activities that can affect area hydrology may include channelization of natural streams, filling floodplains, and altering surface water flow patterns by digging new channels, canals, or open water areas, grading drainage areas to re-direct surface runoff, or otherwise altering drainage basin boundaries.

Land Use – Under pre-development conditions, rainfall was more likely to remain on the ground where it fell into depressional storage areas and would remain on-site to be taken up by vegetation, evaporate, or infiltrate into the soil. Urban and agricultural development of large areas of the study area has reduced these natural functions. The segments were categorized using the following generalized land use types, as identified in the SWFWMD and SFWMD GIS coverages.

- Urban,
- Mining,
- Open Lands,
- Agriculture,
- Wetlands, and
- Water.

Soils – Soils are also important in determining how much runoff a given amount of rainfall will yield. Soils with high clay content or a shallow water table will generate more runoff than deep sandy soil. Development can profoundly alter the runoff-generating characteristics of soil. Excavation, filling, or draining may radically change the runoff patterns because of altered soils.

Hydrologic, land use, and soils information was used to generate monthly loadings of total nitrogen (TN), total phosphorus (TP), total suspended solids (TSS), and biochemical oxygen demand (BOD) for each segment for the 1995-2007 period. All applicable pollutant sources were examined. The "total load" to each bay segment was the sum of the atmospheric deposition load to the segment water surface plus loads originating within the watershed. Calculated "watershed loads" included nonpoint sources, septic tanks, and point sources. Thus, the categories of total loading sources examined were:

- atmospheric deposition,
- nonpoint sources,
- septic tanks, and
- domestic and industrial point sources.

Previous loading estimates for the CHNEP (Coastal Environmental, 1995) included estimates of groundwater and springs loadings to the estuary. The contributions of loadings from these sources were negligible, 0.5% or less of the total load to the system. Therefore, background loadings from groundwater and springs were not estimated herein. The segment-specific load estimates from atmospheric deposition, nonpoint sources, and point sources were developed using methods that were used in previous loading estimates for Charlotte Harbor, Lemon Bay, and Tampa Bay. Septic tank loading estimates used more refined and detailed data and methods than had been available for previous loading studies for the area.

Results

The results of the pollutant and hydrologic loading analyses include annual loads, monthly/seasonal loads, and loading sources for TN, TP, TSS, and BOD. First, loads for the entire CHNEP area were summarized, followed by a similar review of loads for each of the 14 watershed segments. Finally, a discussion of spatial and temporal trends observed in the data was presented.

Annual TN total loads for the entire CHNEP area for the period 1995 through 2007 ranged from 2099 (2007) to 18,289 (2005) tons/year (Table ES-1). Loads were generally higher during years of higher rainfall, reflecting higher nonpoint source and atmospheric deposition inputs. For the period of data used, wetter years included 1995, 1997, 1998, 2003, and 2005. Dryer years included 1996, 2000, 2001, 2006, and 2007.

Monthly total TN loads for the same period were generally higher during the June – September wet season, especially in those basins with a high proportion of nonpoint source runoff and/or atmospheric deposition. The wet season total TN loads averaged 1437 tons/month, and dry season total loads averaged 504 tons/month. Total TP, TSS, and BOD loads had generally similar annual and monthly patterns as TN.

Table ES-1. Annual loadings to the CHNEP area.

Year	TN Load (tons/year)	TP Load (tons/year)	TSS Load (tons/year)	BOD Load (tons/year)
1995	16,883	3262	111,164	40,833
1996	5289	948	28,790	12,139
1997	7555	1621	46,521	19,800
1998	12,890	2864	69,746	34,288
1999	7957	1363	37,284	17,135
2000	3822	586	21,230	7921
2001	9406	2034	55,498	22,623
2002	10,411	2159	53,173	25,150
2003	14,008	3260	83,742	37,710
2004	12,584	3324	67,993	31,550
2005	18,289	3798	125,568	39,468
2006	5989	1194	30,603	13,683
2007	2099	492	10,427	6265

The major TN contributor to the CHNEP area was nonpoint source (70.4%), as shown in Figure ES-2. Contributions from septic tanks, atmospheric deposition, domestic point sources, and industrial point sources were 2.5%, 6.3%, 0.6%, and 20.2%, respectively.

Nonpoint source was also the major TP contributor (68.4%). Contributions from septic tanks, atmospheric deposition, domestic point sources, and industrial point sources were 1.0%, 0.5%, 1.8%, and 28.3%, respectively.

The major TSS contributor was nonpoint source (95.2%). Contributions from septic tanks, atmospheric deposition, domestic point sources, and industrial point sources were 0.0 %, 0.0%, 1.6%, and 3.2%, respectively.

The most significant source of BOD was nonpoint source (90.1%). Contributions from septic tanks, atmospheric deposition, domestic point sources, and industrial point sources were 0.0%, 0.0%, 2.3%, and 7.7%, respectively.

Total loads (from all sources) for each of the CHNEP watershed segments were also assessed individually. Data for the period 1995 through 2007 were used for the analyses. Annual loads, monthly/seasonal loads, and loading sources for TN, TP, TSS, and BOD were estimated.

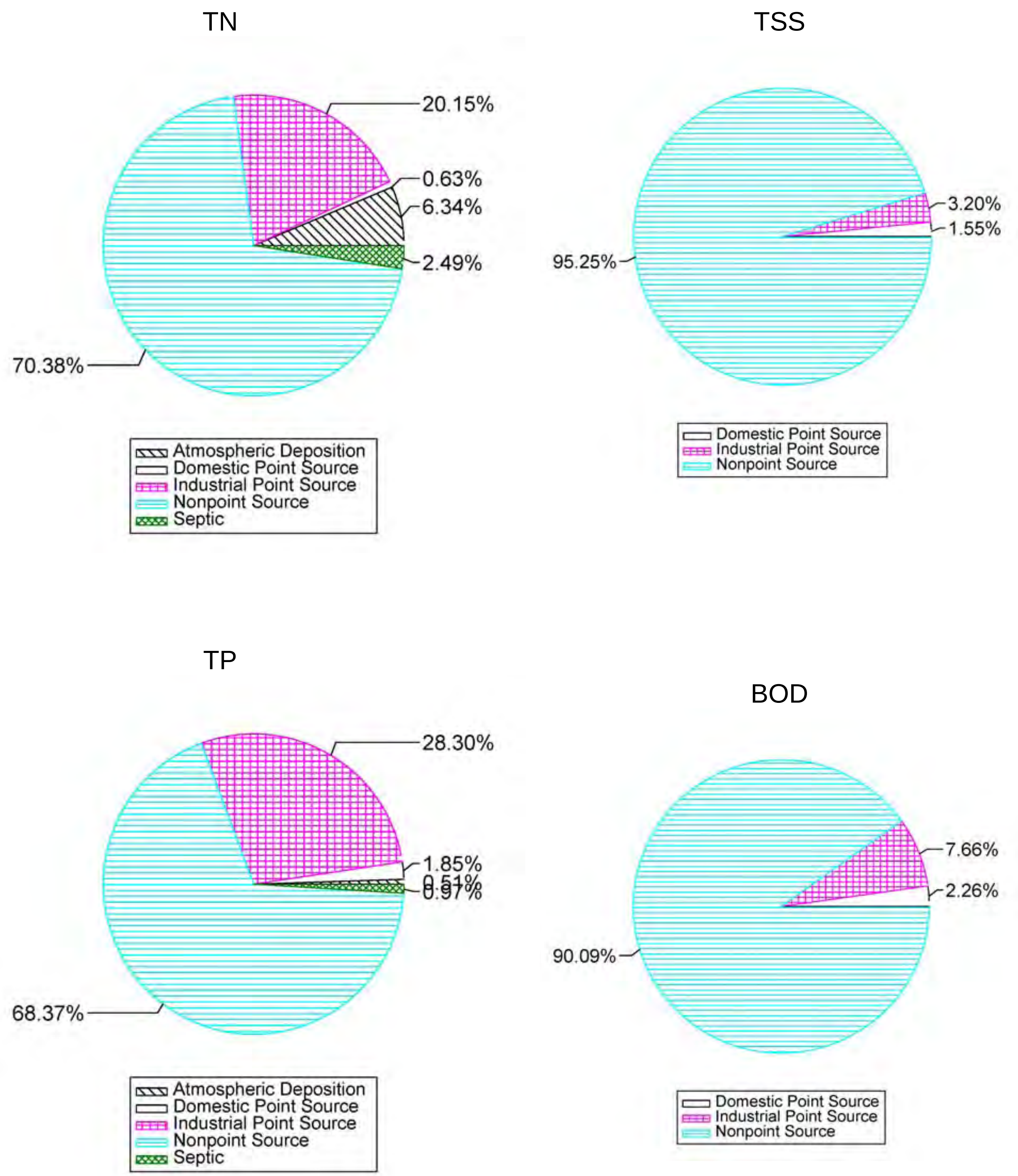

Figure ES-2. Load sources in the CHNEP.

It is not surprising that the highest total TN annual loads were from the largest segments. The Tidal Peace River, Tidal Caloosahatchee River, and Tidal Myakka River segments had the largest TN loads of 3228; 4093; and 878 tons/year, respectively.

However, the Tidal Caloosahatchee River load also included discharges from Lake Okeechobee. To adjust the load to better represent local contributions, loads from upstream of the local drainage area (above control structure S-79) were subtracted from the final loads. The resultant TN load was about 25% of the original Tidal Caloosahatchee River load. Of the coastal segments Estero Bay had the largest TN load (433 tons/year). The smallest TN loads were from the segments with the smallest land area, including Cape Haze (51 tons/year) and the West Wall (47 tons/year).

The pattern of monthly TN loads was relatively similar for all segments, with higher loadings during the summer wet season (June through September). No segment had enough load from septic tanks and point sources to overpower the seasonal variation of atmospheric deposition and nonpoint source loadings except the Tidal Peace River, which had a 60% contribution from industrial point sources compared to a 32% load from nonpoint sources.

The pattern of source contribution of TN loads followed one of two general patterns. Atmospheric deposition was the major source of TN in coastal segments with high open water to upland ratios. The West Wall (94% of the total load), Pine Island Sound (87%), Bokeelia (74%), San Carlos Bay (75%), and Cape Haze (67%) all fit this pattern. Segments with large land areas compared to open water had the highest contributions of nonpoint source TN loading. Included in this group were Dona and Roberts Bay (95%), Tidal Caloosahatchee River (97%), Tidal Myakka River (96%), Upper Lemon Bay (87%), and Estero Bay (91%). Both domestic and industrial point sources had low TN loadings, only a few percent at most. The one exception was Tidal Peace River, which had a 61% contribution of TN from industrial point sources. This large point source load is primarily the result of emergency discharges from mining facilities during a few years for climatological reasons, especially in preparation for Hurricane Charlie in 2004.

Annual TP loads followed the same general pattern as for TN loadings. The highest total TP annual loads were from the largest segments. The Tidal Peace River, Tidal Caloosahatchee River, and Tidal Myakka River segments had the largest TP loads of 1282, 394, and 222 tons/year, respectively. As with TN in the Tidal Caloosahatchee River, loads from upstream of the local drainage area were subtracted from the final loads. The resultant TN load was about 25% of the original Tidal Caloosahatchee River load. Of the coastal segments Estero Bay had the largest TP load (54 tons/year). The smallest TP loads were from the segments with the smallest land area, including Cape Haze (2.6 tons/year) and the West Wall (1.1 tons/year).

TP loads also followed the TN load pattern and were a function of precipitation. Loads were generally higher during months of higher rainfall, reflecting higher nonpoint source and atmospheric deposition inputs.

The pattern of monthly TP loads was relatively similar for all segments, with higher loadings during the summer wet season (June through September). No segment had enough load from septic tanks and point sources to overpower the seasonal variation of precipitation and runoff, although the Tidal Peace River segment had a 45.7% contribution from industrial point sources to 50.5% from nonpoint sources. .

Nonpoint sources were the largest contributor to TP loads in all segments but one (West Wall at 33%, with a atmospheric deposition contribution of 67%). Contributions for the other 13 segments ranged from 50% (Tidal Peace River) to 99% (Tidal Caloosahatchee River and Tidal Myakka River). Dona and Roberts Bay, East Wall, Estero Bay, and Lower and Upper Lemon Bay also all had nonpoint source contributions of TP of greater than 90%. Atmospheric deposition had the highest contribution in the West Wall (67%) and Pine Island Sound (41%). Septic tank loads were relatively highest in Matlacha Pass (7.1%) and Upper Lemon Bay (2.1%). The only significant point source load was industrial sources in Tidal Peace River (45.7%).

Annual TSS loads followed the same general pattern as for TN loadings. The highest total TSS annual loads were from the largest river segments. The Tidal Peace River, Tidal Caloosahatchee River, and Tidal Myakka River segments had the largest TSS loads of 17,200, 22,384, and 5701 tons/year, respectively. As with TN in the Tidal Caloosahatchee, loads from upstream of the local drainage area were taken out of the final loads, yielding a reported TN load of about 25% of the load for the entire Caloosahatchee/Okeechobee system. Of the coastal segments Estero Bay had the largest TSS load (3994 tons/year). The smallest TSS loads were from the segments with the smallest land area, including Cape Haze (180 tons/year) and the West Wall (27 tons/year).

TSS loads were also a function of precipitation, although rainfall itself is not a source of TSS. Loads were generally higher during months of higher rainfall, reflecting higher nonpoint source and atmospheric deposition inputs.

The pattern of monthly TSS loads was relatively similar for all segments, with higher loadings during the summer wet season (June through September). No segment had enough load from point sources to overpower the seasonal variation of runoff.

Nonpoint sources contributed at least 99% of all TSS loads to all segments except the Tidal Peace River. There is no TSS in rainfall or septic tank effluent, and point sources flows and concentrations are low, so nonpoint source is the major contributor. Tidal Peace River was the only segment with domestic and industrial point sources contributions above 1% (4.6% and 11%, respectively).

Annual BOD loads followed the same general pattern as for other loadings. The highest total BOD annual loads were from the largest river segments. The Tidal Peace River, Tidal Caloosahatchee River, and Tidal Myakka River segments had the largest BOD loads of 11,171, 6367, and 2762 tons/year, respectively. As with other loads in the Tidal Caloosahatchee River, loads from upstream of the local drainage area were taken out of the final loads, yielding a BOD load of about 25% of the original load. Of the coastal segments Estero Bay had the largest BOD load (1212 tons/year). The smallest BOD loads were from the segments with the smallest land area, including Cape Haze (53 tons/year) and the West Wall (9.2 tons/year). BOD loads were also a function of precipitation and runoff. Loads were generally higher during months of higher rainfall, reflecting higher nonpoint source loads.

The pattern of monthly BOD loads was relatively similar for all segments, with higher loadings during the summer wet season (June through September). No segment had enough loading from point sources to overpower the seasonal variation of runoff.

Nonpoint sources contributed over 99% of all BOD loads to all segments except Tidal Peace River. There is no BOD in rainfall or septic tank effluent after infiltration, and point sources flows and concentrations are low, so nonpoint source is the major contributor. Only the Tidal Peace River segment had a measureable industrial point source BOD contribution (16%), and Tidal Peace and Caloosahatchee Rivers were the only segments with a measureable domestic point source contribution (4.2% and 1.0%, respectively).

Other analyses of the loads were conducted. The loading parameter “yield”, also known as the unit area load, refers to the amount of a chemical that a watershed generates per unit area for a given time period. A typical measure of yield is pounds per acre per year (lb/ac/yr). Using this metric, we can compare large and small watershed segments with respect to how many pounds of TN, for example, a segment generates for each acre, on average, over a year.

For these analyses pollutant loadings from the Tidal Caloosahatchee River were adjusted to remove inflows from Lake Okeechobee. Because hydrologic and pollutant loadings upstream of Structure S-79 in the Caloosahatchee River do not originate within the historical boundaries of the watershed, those loadings have been deleted from the segment load. The higher average annual TN yields originate both in larger riverine segments including Tidal Peace, Myakka, and Caloosahatchee Rivers, and Estero Bay, and smaller coastal segments (Dona and Roberts Bay and Upper and Lower Lemon Bay) also show high yields. This demonstrates that segment size does not dictate yield values. The higher yields for the small segments (Dona and Roberts Bay and Upper and Lower Lemon Bay) may be attributable to the higher number of septic tanks close to coastal waters, and higher percentage of urban land use.

The TN delivery ratio a measure of the watershed nutrient load divided by the hydrologic load and is used to determine the mass of pollutant in a given volume of water (e.g., nonpoint source loading). The TN delivery ratio is greatly influenced by the land use and cover composition in a watershed. The loading results clearly show a decreasing trend (r^2 = 0.81) in TN delivery ratio as wetland coverage increases. This trend strongly suggests that wetlands generate less nitrogen on a unit area basis, and/or that wetlands act as a nutrient sink and hold TN entering the wetland from upland sources.

Table ES-2. TN Delivery Ratio for CHNEP bay segments.

CHNEP Bay Segment	TN Delivery Ratio	Segment Land to Water Ratio
Dona and Roberts Bays	1.68	100
Upper Lemon Bay	1.81	7.5
Lower Lemon Bay	1.80	7.4
Cape Haze	1.20	1.5
Bokeelia	1.29	0.5
West Wall of Charlotte Harbor	1.25	0.3
East Wall of Charlotte Harbor	1.31	2.8
Tidal Myakka River	1.30	55
Tidal Peace River	1.79	114
Pine Island Sound	1.65	0.4
Matlacha Pass	1.02	4.8
San Carlos Bay	1.14	0.6
Tidal Caloosahatchee River	1.62	20
Estero Bay	1.21	21

The TN delivery ratio compared to estuary area ratio can be used to predict the severity of impact that TN loading can have on an estuary. The higher the delivery ratio and smaller the estuary area, the higher the potential for adverse impacts will be. The Tidal Peace River and Dona and Roberts Bay segments have the two largest watershed land to estuary water ratio, and also fairly high TN delivery ratios and thus could be most vulnerable to adverse impacts from poor water quality. Tidal Myakka River also has a high ratio. All the other segments have area ratios of 20 or less, with the lowest values seen for the coastal segments.

Best Management Practices Calculator

The final section of the report describes a Best Management Practice (BMP) tool. BMPs are actions that are implemented in order to improve an ecosystem. The goal of BMPs is generally the reduction of pollutant loadings. This can be achieved by reducing pollutant concentrations and/or reducing hydrologic loadings. The CHNEP requires a method to estimate the impact of future changes to the watershed, including land use changes and projects that are being proposed or projects that are being implemented as part of their ongoing effort to reduce loadings to Charlotte Harbor. The BMP tool calculates potential changes to pollutant loadings based on land use changes and use of Best Management Practices (BMPs).

The model is driven by a data base of physio-hydro-chemical data that are specific to the Charlotte Harbor watershed. Model inputs include:

- land use,
- soils,
- watershed basin boundaries,
- monthly precipitation for wet, average, and dry years for each basin, developed from 1995 through 2007 data.
- USGS gaged flow data where available,
- land use-specific runoff coefficients and event mean concentrations for TN, TP, TSS and BOD, and
- performance effectiveness for a variety of BMPs.

Using these data, existing conditions loadings can be estimated for a segment. The model user then inputs information about a proposed activity (project location, size, land use change, BMPs proposed, etc.). The model is then adjusted to integrate these changes, and future conditions can be estimated. The difference in existing and future loadings is the net pollutant input to be managed.

The BMP tool model will allow the CHNEP to better predict the impact of future changes to the watershed. The tool will also allow direct comparison of proposed projects, which will assist managers in identifying the most cost effective method of achieving loading reductions.

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1 INTRODUCTION

The Charlotte Harbor estuarine system is located in southwest Florida (Figure 1-1) and includes 224,000 acres (230 square miles) of estuaries downstream from a 2,760,000 acre (4,313 square mile) watershed. The CHNEP is a partnership of citizens, elected officials, resource managers and commercial and recreational resource users working to improve the water quality and ecological integrity of the greater charlotte Harbor watershed. A cooperative decision-making process is used within the program to address diverse resource management concerns in the study area.

The Charlotte Harbor National Estuary Program (CHNEP) watershed contains three large rivers: the Peace River, the Myakka River, and the Caloosahatchee River, as well as areas that discharge directly to a number of coastal lagoons. The watershed for the CHNEP ranges from the northern end of the Peace River basin in Polk County to the southern end of the Estero Bay basin in Lee County and Collier County. Section 1 of this report includes a description of the CHNEP, a discussion of the relationship between loadings, water quality, and seagrass coverage, a brief discussion of Total Maximum Daily Loads (TMDLs) and numeric nutrient criteria, and provides the objectives of the work effort reported in this document.

1.1 Description of Program

Charlotte Harbor was nominated as an “estuary of national significance” in 1995, and subsequently accepted into the National Estuary Program. The CHNEP has completed a Comprehensive Conservation and Management Plan (CCMP), and is now implementing this plan.

One of the initial achievements of the CHNEP management conference was to identify priority problems for the CHNEP area. The management conference consists of the Citizens’ Advisory Committee, the Technical Advisory Committee, the Management Committee, the Policy Committee, and the Program Office. The priority problems that were identified included the following, among others (CHNEP, 2008):

- Hydrologic Alterations: Changes to the hydrology of the area have adversely impacted the quantity and timing of freshwater inflows to the estuary, including the hydrologic function of the floodplain system.

- Water Quality Degradation: Changes to water quality result from pollution from all sources in the watershed and from atmospheric deposition directly to the surface of the estuary.

- Fish and Wildlife Habitat Loss: Population growth and concomitant land use changes have resulted in degradation and elimination of habitats, including loss of natural shorelines and invasive species incursion.

Figure 1-1. Bay segments and watershed of the CHNEP, and Water Management District Boundaries.

The CHNEP management conference developed program goals to guide the management plan. The goals are as follows (CHNEP, 2008):

1. Improve the environmental integrity of the Charlotte Harbor study area.
2. Preserve, restore, and enhance seagrass beds, coastal wetlands, barrier beaches, and functionally related uplands.
3. Reduce point and non-point sources of pollution to attain desired uses of the estuary.
4. Provide the proper fresh water inflow to the estuary to ensure a balanced and productive ecosystem.
5. Develop and implement a strategy for public participation and education.
6. Develop and implement a formal Charlotte Harbor management plan with a specified structure and process for achieving goals for the estuary.

Quantifiable objectives were developed to address the three priority problems and the program goals. Included in these quantifiable objectives is one for submerged aquatic vegetation, Objective FW-1, which states "…native submerged aquatic vegetation should be maintained and restored at a total extent and quality no less than caused by natural variation…" (CHNEP, 2008). In accordance with this objective, pollutant loadings for 1995-2007 are estimated as described in this document to facilitate the examination of the relationships between nutrient loading and water clarity, and allow nutrient load targets to be established based on water clarity targets.

The water clarity targets are currently being established by CHNEP based on seagrass light requirements. The primary goal of this effort is to establish targets designed to maintain and/or restore seagrass acreage to its historical extent. While the extent of seagrass in the study area may be governed by a variety of processes including erosion, salinity changes, biological perturbations, prop scarring and sedimentation, water clarity is thought to be the principal controlling factor in the long term health of seagrasses in the study area. Therefore, management level water clarity targets that are related to the light requirements of seagrass are also being developed to allow managers to correlate changes in water clarity conditions and seagrass conditions over time.

1.2 Discussion of Relationship between Loadings and Seagrass

A paradigm relating nutrient loadings to seagrass coverage has been utilized in the Tampa Bay Estuary Program (TBEP) effort to manage loadings to Tampa Bay (Janicki and Wade, 1996). A similar paradigm is applicable to the CHNEP area, as shown in Figure 1-2 below. Seagrass coverage is related to seagrass light requirements, which in turn are dependent upon water clarity. Water clarity is dependent upon several factors, including chlorophyll concentration, which is related to external loadings of total nitrogen to the estuary. Color and turbidity also impact water clarity, most importantly in tidal rivers nearest the source of organic materials, and act as confounding factors in the relationship between nutrient loadings and water clarity.

1.3 Nutrient Loading Sources

As in previous loading estimates performed for Charlotte Harbor, Lemon Bay, and Tampa Bay (Zarbock et al., 1994; 1996; Coastal Environmental, 1995; Pribble et al., 2001; Poe et al., 2005; Janicki Environmental, 2008a; Jones Edmunds, 2009), estuary

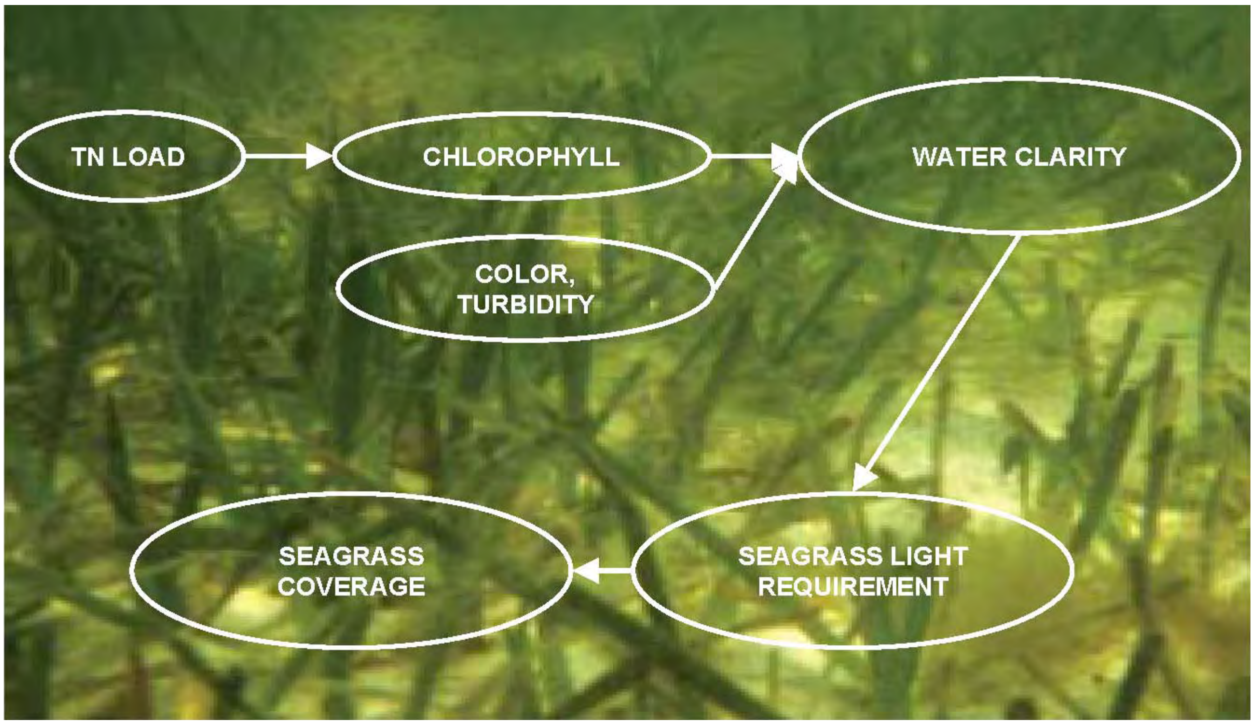


Figure 1-2. Paradigm relating nutrient loads to seagrass coverage in the CHNEP estuary.

loadings of total nitrogen (TN), total phosphorus (TP), total suspended solids (TSS), and biochemical oxygen demand (BOD) were developed for several sources. The loading sources examined were:

- atmospheric deposition directly to the surface of the estuary,
- nonpoint sources,
- septic tanks (on-site sewage treatment and disposal systems, OSTDS), and
- domestic and industrial point sources (wastewater treatment facilities and industrial facility discharges).

A previous loading development effort for the CHNEP (Coastal Environmental, 1995) included estimates of groundwater and springs loadings to the estuary, but found that the contributions of loadings from these sources with respect to the total loadings to the system were negligible, 0.5% or less of the total load to the system. Loadings from groundwater and springs, therefore, were not estimated for this current effort.

1.4 TMDLs and Numeric Nutrient Criteria

Two rulemaking efforts underway by the Florida Department of Environmental Protection (FDEP) and the US Environmental Protection Agency (EPA) must be considered when developing management plans for future activities within the CHNEP watershed. FDEP and EPA are developing Total Maximum Daily Loads (TMDLs) for impaired waterbodies throughout the state, including the estuarine and freshwater portions of the CHNEP area. EPA is also developing numeric nutrient criteria for freshwater streams, lakes, and springs in the state, and for canals in south Florida. These revised criteria will be used to identify impaired waters in the future. The development of loading estimates by the CHNEP will serve as additional information available as TMDLs and numeric nutrient criteria are developed.

1.4.1 TMDLs

Section 303(d) of the Federal Clean Water Act (CWA) requires states to develop lists of impaired waters, defined as those waters of the state not meeting state water quality standards. The Florida Legislature enacted the Florida Watershed Restoration Act (FWRA) in 1999, to protect the waters of Florida with the development of TMDLs as required by the CWA. A TMDL is defined as the maximum amount of a pollutant that a water body can receive and still meet water quality standards. The FWRA also established a process to identify and list impaired waters, as required by the CWA.

The FDEP has been and is continuing to develop TMDLs for waterbodies identified on the 303(d) list which have been subsequently verified as impaired. The TMDL development process includes opportunities for stakeholder comment and legal recourse, and culminates in development of a Basin Management Action Plan (BMAP). The BMAP is a plan for restoring the water body so that it is no longer impaired, with the focus on reducing pollutant loadings to meet levels identified as the TMDL. Strategies included in a BMAP may involve actions such as setting permit limits on wastewater facilities and implementation of stormwater Best Management Practices (BMPs) in both urban and agricultural areas, among others.

TMDLs and associated BMAPs have been and are being developed for various portions of the CHNEP watershed, including portions of the Peace River watershed, the Myakka River watershed, and the Caloosahatchee River watershed. A draft TMDL for Dissolved Oxygen (DO) has been proposed by FDEP for Coral Creek – East Branch, in the Cape Haze watershed (Laskis, 2006). The loading estimates reported in this document and subsequent efforts to define relationships between pollutant loadings and water quality in the estuarine portion of the CHNEP will provide valuable input to determination of TMDLs.

1.4.2 Numeric Nutrient Criteria

The FDEP began development of numeric nutrient standards in December 2001. The FDEP formed a technical advisory committee and an agency work group to assist in identifying appropriate nutrient standards. DEP conducted a number of workshops and meetings and several studies were conducted since 2002.

In 2008, several environmental groups filed suit against the U.S. Environmental Protection Agency (EPA) in Federal District Court alleging that EPA had determined in 1998 that Florida's current narrative nutrient standard did not comply with the Clean Water Act and that EPA had not established numeric nutrient standards pursuant to Section 303(c)(4)(B) of the Clean Water Act. As a consequence of this lawsuit, EPA sent DEP a letter on January 14, 2009 finding that DEP's narrative nutrient standard did not comply with the Clean Water Act and directing the State of Florida to develop its own numeric nutrient standards for rivers and lakes by January 2010 and estuarine and coastal waters by January 2011 or EPA would adopt its own numeric standards. In August 2009, these groups and EPA agreed to a Consent Decree formally establishing these deadlines and EPA will be responsible for establishing these criteria.

EPA published draft numeric nutrient criteria for lakes, springs, canals, and streams on January 14, 2010 and is currently accepting comments on the proposed criteria (EPA, 2010). The draft criteria for streams address the protection of both in-stream resources and downstream resources. To achieve this end, EPA developed protective pollutant loads for most estuaries in Florida, including Charlotte Harbor.

The protective load is the average annual nutrient load that could be delivered to an estuary without impairing its designated uses. EPA then estimated protective loads, and nutrient concentrations for the streams and rivers that discharge into that estuary that, if achieved, are expected to result in nutrient loading that do not exceed the protective load. These concentrations, called "downstream protection values" or DPVs, depend on the protective load for the receiving estuary. Because the approach accounts for in-stream processes for nutrient cycling, higher DPVs may be appropriate in stream reaches where a significant fraction of nutrients is permanently removed within the reach before delivery to the estuary.

The DPVs were developed using a computer model called SPAtially Referenced Regressions on Watershed attributes, or SPARROW (Hoos and McMahon, 2009) which was developed by the U.S. Geological Survey. The specific model that was used to develop DPVs in Florida estuaries was the South Atlantic, Gulf, and Tennessee (SAGT) regional SPARROW model. The model was developed at appropriate temporal and spatial scales to simulate conditions in all surface waters throughout the southeast U.S., and it applies to all waters that flow to Florida's estuaries. Thus, it is to be expected that small-scale phenomenon that may affect nutrient loading in a particular CHNEP segment may not be reflected in the model.

The numeric criteria that are accepted should depend upon the quantitative relationship between nutrient loads and chlorophyll *a*. The critical chlorophyll *a* endpoints depend upon the relationship between chlorophyll *a* and seagrasses or some other appropriate environmental condition such as dissolved oxygen (DO). This approach, therefore, depends upon identification of an appropriate endpoint for chlorophyll *a* as it relates to either seagrasses or the probability of a low DO condition.

The results of this pollutant loading report will be used to help set loading limits for Charlotte Harbor. Given the importance of seagrasses and its relationship to chlorophyll *a* levels in the CHNEP, the initial effort in the development of numeric nutrient criteria is the identification of chlorophyll *a* endpoints. In those CHNEP segments where seagrasses are less prominent, the relationship between and chlorophyll a and DO will be investigated.

1.5 Objective

As discussed in Section 1.1 above, reducing water-borne pollution to the estuary is a major goal of the CHNEP, as is preserving, restoring, and enhancing seagrass beds in the estuary. Section 1.2 above summarized the quantitative relationships that have been developed between nutrient loads to the estuary and seagrass health. Thus, a crucial step in ensuring the sustainability of CHNEP seagrasses is to control TN and TP loadings to the estuary. To this end, developing accurate estimates of TN and TP loading must be made. In addition, estimating TSS and BOD loads provide other valuable information to assist resource managers in focusing activities to protect and improve the health of the coastal systems.

The objective of this report is to provide monthly and annual loading estimates by source for TN, TP, TSS, and BOD for 1995-2007 to each segment and from each basin within the segments' watershed. The monthly estimates of loadings to each segment will allow the future examination of relationships between segment loadings and segment chlorophyll concentrations at a time scale sufficient to develop nutrient loading targets commensurate with segment-specific water clarity targets.

1.6 Report Contents

The following sections present a description of the CHNEP area, and the methods and results of the 1995-2007 loading estimates. These sections include:

- a description of the CHNEP area, including the hydrology, land use, and soils of the watershed of each of the segments;
- a summary of the methods utilized to develop loadings from each source category (atmospheric deposition, nonpoint sources, septic tanks, and point sources) to each segment; and

- a listing of the results for each segment, by loading source category, for 1995-2007, and
- a description of a BMP tool that will be used to estimate potential changes to pollutant loadings resulting from changes to land uses or from BMP implementation.

2 DESCRIPTION OF CHNEP AREA

The CHNEP area is comprised of 14 different bay segments, as shown in Figure 1-1. These segments, along with their watersheds, are delineated based on hydrologic, ecologic, and management characteristics. The 14 bay segments and their acronyms are:

- Dona and Roberts Bays (DARB),
- Upper Lemon Bay (ULB),
- Lower Lemon Bay (LLB),
- Cape Haze (CH),
- Bokeelia (BK),
- West Wall of Charlotte Harbor (WW),
- East Wall of Charlotte Harbor (EW),
- Tidal Myakka River (TMR),
- Tidal Peace River (TPR),
- Pine Island Sound (PIS),
- Matlacha Pass (MP),
- San Carlos Bay (SCB),
- Tidal Caloosahatchee River (TCR), and
- Estero Bay (EB).

The bay segmentation scheme in the CHNEP is designed to function as a way to take account of the various ecosystem factors that are important to the CHNEP region and its inhabitants. This segmentation scheme is the result of an effort to subdivide the CHNEP area into separate reporting units which represent relatively homogeneous conditions with respect to variations in water quality and to resultant seagrass protection and restoration within the estuary (CHNEP, 2009; Janicki Environmental, 2009).

The study area watershed is further divided into gaged and ungaged areas. Gaged areas are stream reaches and their drainage areas located upstream of monitoring sites at which stream flow and/or water quality is measured. Measured data representing gaged area conditions can be used in making estimates of hydrologic and pollutant loadings. Ungaged areas of the watershed are downstream of the monitoring sites. Because no measured data are available for ungaged areas, other methods must be used to simulate conditions. The areal extents of gaged and ungaged portions of the watersheds for each of the 14 bay segments are presented in Appendix A. Methods used to estimate ungaged flows and loads are presented in Section 3.

To understand current hydrologic conditions in the CHNEP area it is important to recognize how changes in the watershed have affected freshwater inflows and pollutant loadings to the estuaries. Three of the main types of changes to the watershed that have contributed to altered flows and loads include:

Hydrology – Hydrologic alteration, or physical changes to hydrologic features, can greatly alter the timing, volume, and distribution patterns of surface water inflows. Activities that can affect area hydrology may include

- channelization of natural streams, which can result in increased peak flows during storm events, decreased low flows during dry periods, and reduced habitat value;
- filling floodplains, which reduces natural on-site water storage and can also contribute to higher peak flows, reduced low flows, and habitat destruction; and
- altering surface water flow patterns by digging new channels, canals, or open water bodies, grading drainage areas to re-direct surface runoff, or otherwise altering drainage basin boundaries. Changing the extent of drainage area boundaries can have significant effects on receiving waters, as the volume of freshwater inflow can be greatly increased in one estuary segment, with an accompanying decrease in adjoining waters.

The following sections present brief descriptions of the hydrology of each bay segment and its watershed, including a characterization of the major hydrologic features and boundaries of the watershed, and a description of the open water portion of each bay segment. The major receiving water of the CHNEP area is Charlotte Harbor. This large estuary has three major freshwater inputs: the Myakka, Peace, and Caloosahatchee Rivers, and discharges to the Gulf of Mexico. Other estuarine features within the CHNEP boundary include coastal lagoons such as Lemon and Estero Bays, and large passes such as Pine Island Sound and Matlacha Pass. Smaller systems such as the anthropogenically-altered Dona and Roberts Bay in the north, the extensive coastal wetlands of Cape Haze, Bokeelia, and the East and West Walls of Charlotte Harbor, and San Carlos Bay to the south reflect the overall natural diversity of the CHNEP region.

Hydrologic GIS data for the northern portion of the CHNEP watershed were obtained from the Southwest Florida Water Management District (SWFWMD). GIS data for the southern portion of the watershed were obtained from the South Florida Water Management District (SFWMD).

Land Use – Under un-developed conditions, rainfall is more likely to remain on the ground to be retained in depressional storage areas and be taken up by vegetation, evaporated, or infiltrated into the soil. Development of large areas of the study area has reduced these natural functions. Agricultural use often requires filling natural depressions, leveling topographic features, removing native vegetation, draining open water and wetlands, and channelizing small streams. Urbanization often resulted in similar land alterations, as well as the introduction of impervious area (pavement, roofs, etc.) that prevents any on-site storage or infiltration. Usually, the more agricultural or urban land in a watershed, the more altered the surface water hydrology is compared to un-developed conditions.

The following section provides a brief description of the current land use in the watersheds of each bay segment, with an emphasis on the major types of land uses found in each region and their relative coverages, as well as the influences that the respective land uses have on freshwater inflows and pollutant loadings. Land uses were aggregated into six broad categories:

- Urban,
- Mining,
- Open Lands,
- Agriculture,
- Wetlands, and
- Water.

The “Urban” category consists of residential, commercial, industrial, institutional, transportation, and utilities land uses. “Mining” includes all extractive mining land uses as mapped by SWFWMD and SFWMD, in this study area mainly open pit phosphate mining. “Open Lands” consist of range lands, barren lands, pastures, and upland forests. “Agriculture” includes groves, feedlots, nurseries, and row and field crops. There is very little, if any, aquaculture in the CHNEP area. “Wetlands” consists of all freshwater and saltwater wetlands, as well as tidal flats as mapped by SWFWMD and SFWMD.

“Freshwater” is a separate watershed land use, but saltwater within the bay segments was excluded from all watershed land use analyses. The Florida Land Use and Cover Classification System (FLUCCS) codes that comprise each land use category are presented in Appendix B.

The 2007 land use GIS data for the northern portion of the CHNEP watershed were obtained from the SWFWMD. GIS data for the southern portion of the watershed were obtained from the SFWMD, for the period 2003-2004. Land uses for each of the 14 segments of the CHNEP watershed are presented in Table 2-1.

Soils – Soils can greatly influence the behavior of runoff. Soil types, as mapped and described by the USDA Natural Resources Conservation Service (NRCS), are classified based on their potential to produce runoff, based on porosity and infiltration characteristics (CHNEP, 1999). As such, soils play an integral role in the rate at which surface runoff reaches receiving waterbodies. The runoff-producing attributes of soils are categorized using hydrologic soil groups (HSG), and include the following groups:

Group A – soils are usually sandy with a low water table, with high infiltration rates and low runoff potential;

Group B – soils with moderate infiltration rates and low to moderate runoff potential;

Group C – soils with low infiltration rates and moderate to high runoff potential; and

Group D – soils are often clayey, and/or have a water table close to the surface, with very low infiltration rates and high runoff potential (CHNEP, 1999).

Table 2-1. Land use distribution in CHNEP segment watersheds.

Watershed		LAND USE (2007 SWFWMD; 2003/4 SFWMD)						
		Agriculture	Freshwater	Mining	Open Lands	Urban	Wetlands	Total
Donna and Roberts Bay	Acres	3,492	2,655	251	25,739	19,557	9,980	61,673
	Percentage	5.7	4.3	0.4	41.7	31.7	16.2	100.0
Upper Lemon Bay	Acres	0	795	0	5,022	9,897	1,962	17,676
	Percentage	0.0	4.5	0.0	28.4	56.0	11.1	100.0
Lower Lemon Bay	Acres	0	1,221	126	15,073	14,656	3,865	34,941
	Percentage	0.0	3.5	0.4	43.1	41.9	11.1	100.0
Cape Haze	Acres	0	628	311	5,196	1,190	12,077	19,402
	Percentage	0.0	3.2	1.6	26.8	6.1	62.2	100.0
Bokeelia	Acres	0	710	0	8,710	1,108	5,644	16,172
	Percentage	0.0	4.4	0.0	53.9	6.9	34.9	100.0
West Wall	Acres	0	130	0	257	205	3,984	4,579
	Percentage	0.0	2.8	0.0	5.6	4.5	87.1	100.0
East Wall	Acres	685	3,409	340	29,074	12,050	15,791	61,349
	Percentage	1.1	5.6	0.6	47.4	19.6	25.7	100.0
Tidal Myakka	Acres	26,361	8,234	2,989	207,165	54,415	86,723	385,866
	Percentage	6.8	2.1	0.8	53.7	14.1	22.5	100.0
Tidal Peace River	Acres	228,273	58,171	161,655	641,855	152,208	235,324	1,477,486
	Percentage	15.5	3.9	10.9	43.4	10.3	15.9	100.0
Pine Island Sound	Acres	721	356	3	4,314	2,634	11,231	19,259
	Percentage	3.7	1.8	0.0	22.4	13.7	58.3	100.0
Matlacha Pass	Acres	1,921	4,277	0	13,857	25,591	17,449	63,095
	Percentage	3.0	6.8	0.0	22.0	40.6	27.7	100.0
San Carlos Bay	Acres	0	1,726	0	863	2,583	64,27	11,599
	Percentage	0.0	14.9	0.0	7.4	22.3	55.4	100.0
Tidal Caloosahatchee River	Acres	16,359	26,993	1,292	161,418	90,011	60,406	356,477
	Percentage	4.6	7.6	0.4	45.3	25.3	16.9	100.0
Estero Bay	Acres	21,007	8,245	5,698	57,397	44,788	92,537	229,671
	Percentage	9.1	3.6	2.5	25.0	19.5	40.3	100.0

Agricultural or urban development of an area can alter the hydrologic characteristics of a soil, effectively changing its HSG. Some soils are given dual hydrologic groups such as A/D, B/D, or C/D. These are given for certain wet soils that can feasibly be drained for agricultural or urban use, but does not indicate whether or not the area is developed. The first letter applies to the altered, drained condition, the second to the natural, undrained condition. Only soils that are rated D in their natural condition are assigned to dual classes.

Soils GIS data for the northern portion of the CHNEP watershed were obtained from the SWFWMD, using soil surveys published between 1989 and 1992. Soils GIS data for the southern portion of the watershed were obtained from the SFWMD, consisting of data from soil surveys completed between 1971 and 1998. Note that the SFWMD soils data do not contain the HSG A/D and B/D dual designations. This results in significant portions of the southern portion of the CHNEP area (Matlacha Pass, Tidal

Caloosahatchee River, and Estero Bay in particular) being designated as having HSG D when in fact there are large areas that are developed and would be designated A/D or B/D if SFWMD applied the dual HSG ratings. This likely has some effect on pollutant and hydrologic loadings as the D rating results in higher nonpoint source loading and higher septic tank failures. Also, small portions of each dataset contain soils which are designated undetermined.

In this chapter, the hydrology, land use, and soils of the bay segments and their watersheds are described. Each segment is discussed separately as follows.

2.1 Dona and Roberts Bay

2.1.1 Hydrology

The Dona and Roberts Bay bay segment is comprised of the open water estuary, primarily Dona and Roberts Bay proper (Figure 2-1). The surface area of this segment is approximately 617 acres based on GIS data obtained. The watershed is approximately 61,673 acres, or 96.4 square miles (mi^2). This results in a watershed to water ratio of 100, which is high relative both to historical conditions, and to other CHNEP segments.

The main feature in the Dona and Roberts Bay watershed is Cow Pen Slough, which drains into Dona Bay. Cow Pen Slough did not always flow into Dona Bay. Analysis of historical surveys shows that Cow Pen Slough once flowed east to the Myakka River (SWFMWD, 2008). However, efforts to curb the flooding that impacted local pastures and rangelands were pursued through a series of hydrologic modifications, which rerouted Cow Pen Slough from the Myakka River system south and west into Dona Bay (SWFWMD, 2007). These alterations have resulted in Dona Bay's watershed area increasing nearly five-fold. The corresponding increase in the amount of freshwater entering the Dona Bay system and leaving the Myakka River has had significant effects on conditions in the respective estuaries, including increased flushing and circulation above historical conditions (SWFWMD, 2007).

2.1.2 Land Use

The Dona and Roberts Bay watershed land use types are presented in Table 2-1 and in Figure 2-2. Open lands and urban areas are the predominant land use types found in the watershed, with urban land uses especially prominent at its southern extent. These urbanized areas represent the southern extent of the Sarasota-Bradenton Metropolitan Area. Wetlands, although greatly diminished from pre-development conditions, are located throughout the watershed, while agricultural lands are found mostly in the middle portion of the Dona and Roberts Bay watershed. These land use changes reflect activities that have caused significant alterations to the freshwater flows and pollutant loading to the estuary.

2.1.3 Soils

Soil HSGs of the Dona and Roberts Bay watershed are presented in Figure 2-3. The B/D group is the dominant soil type. Groups C and D are seen extensively throughout the drainage basin as well. The isolated areas of Groups A and B are located in the southern end of the watershed, and are likely remnants of sandy shorelines and barrier islands.

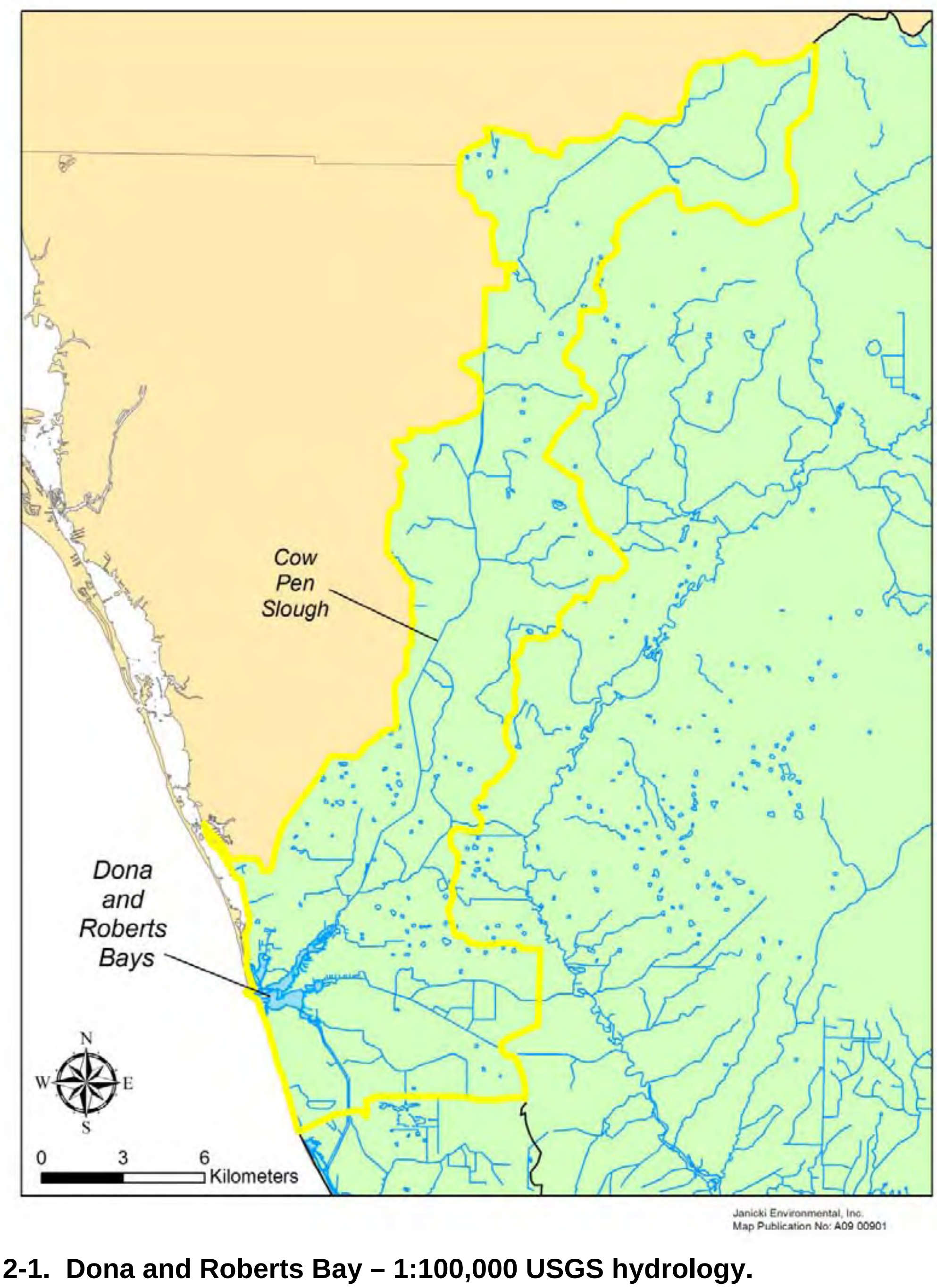


Figure 2-1. Dona and Roberts Bay – 1:100,000 USGS hydrology.

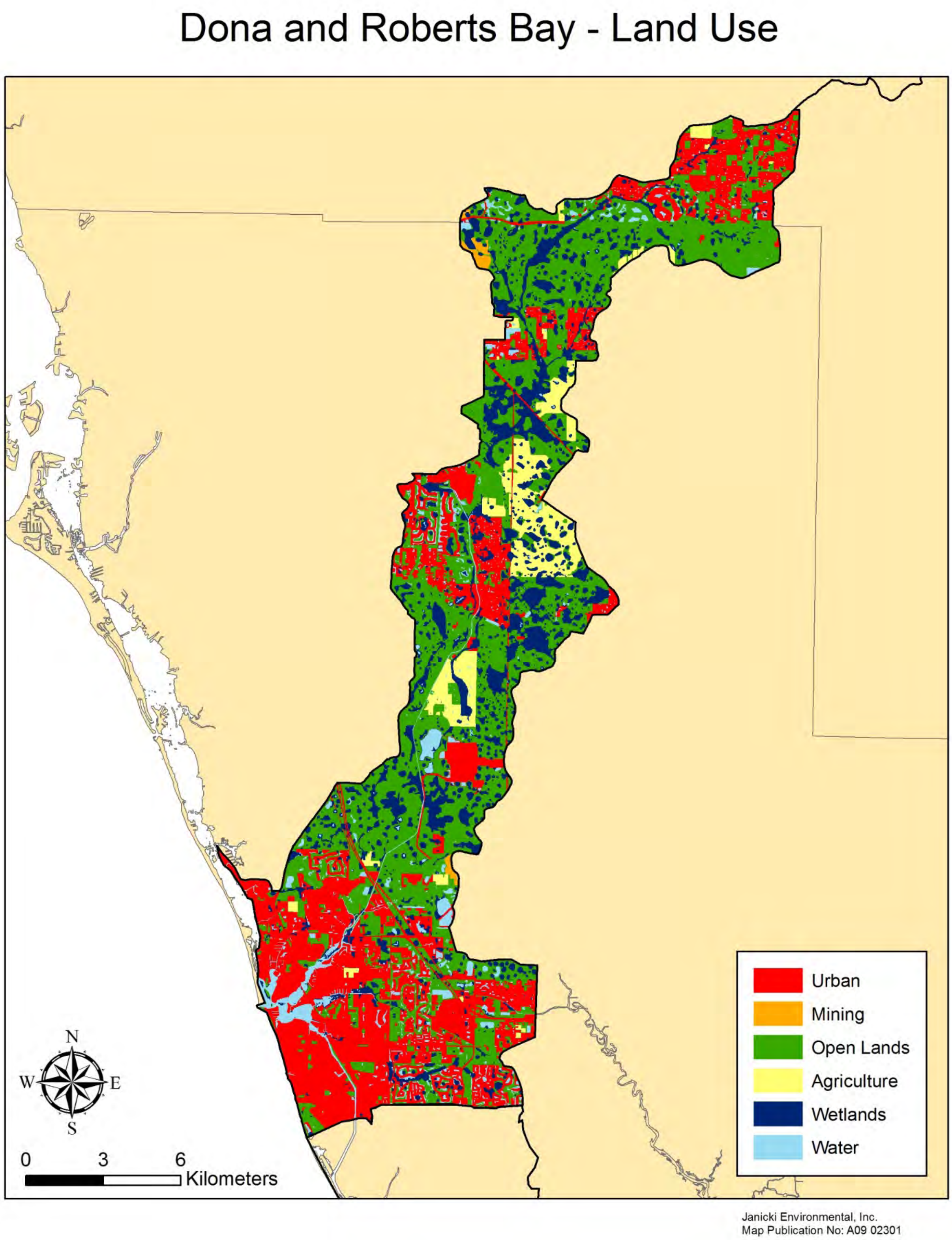


Figure 2-2. Dona and Roberts Bay land use types.

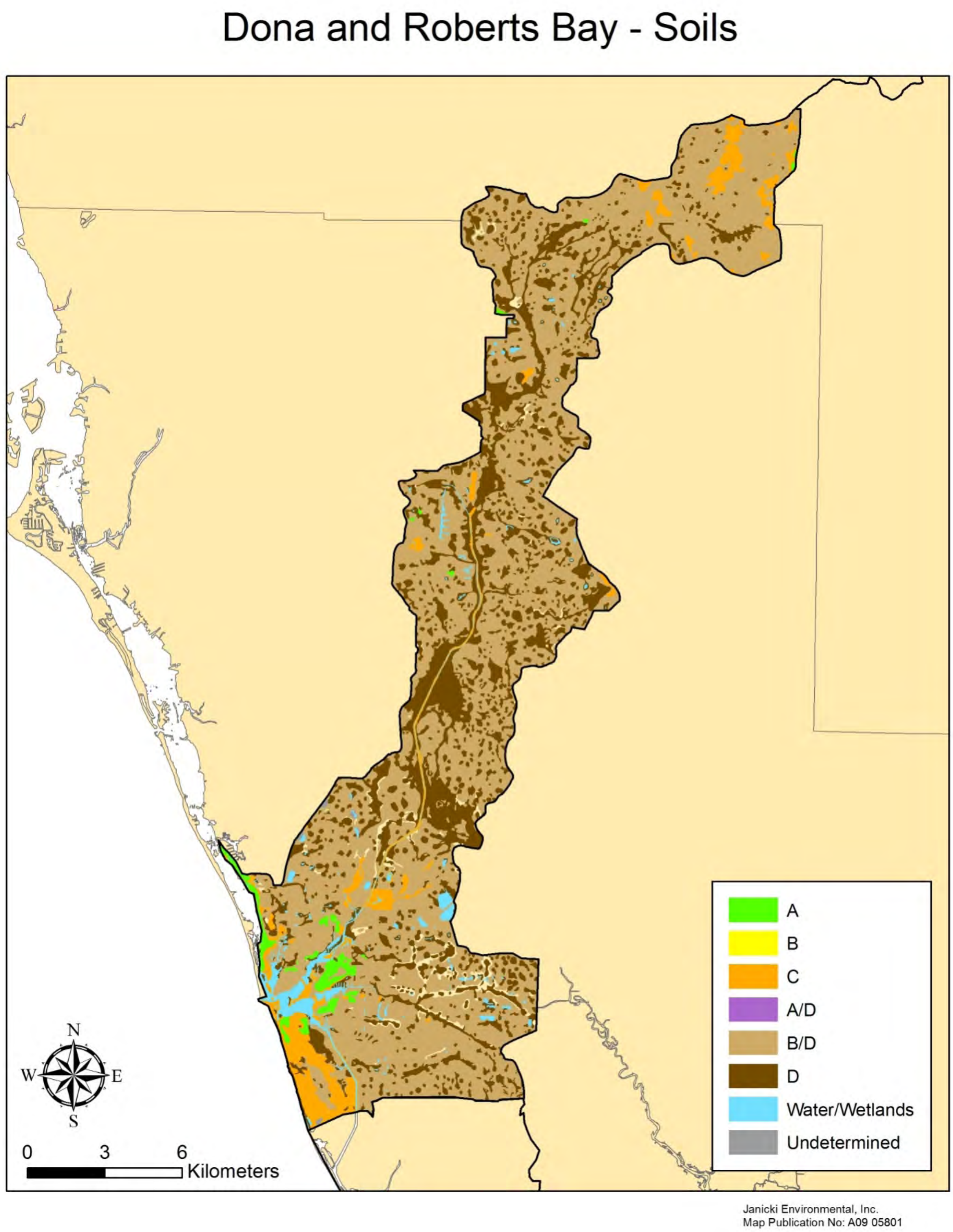


Figure 2-3. Dona and Roberts Bay soil HSGs.

2.2 Upper Lemon Bay

2.2.1 Hydrology

The Upper Lemon Bay segment is the northernmost portion of Lemon Bay and consists of approximately 2,357 acres of open water (Figure 2-4). The Upper Lemon Bay watershed has approximately 17,676 acres or 27.6 mi^2. This results in a watershed to water ratio of 7.5, which is intermediate with respect to other bay segments. The Upper Lemon Bay segment is hydraulically connected to the north, via the Intracoastal Waterway, to Dona and Roberts Bay.

A few small tidal creeks drain into Upper Lemon Bay, including Alligator, Woodmere, and Forked Creeks; however, these creeks are not major freshwater inputs. Coastal wetlands supplement the freshwater inflows to Lemon Bay after they have been inundated and yield freshwater flows, as sheetflow, into the estuary.

Lemon Bay is considered a coastal lagoon ecosystem, running parallel to the coastal barrier islands on the west and the Florida mainland shoreline on the east. Lemon Bay has limited connectivity with the Gulf of Mexico to the west, only through a series of passes in between the coastal barrier islands.

Because of the small watershed area with only a few freshwater inflows it can be anticipated that Upper Lemon Bay has a relatively small freshwater inflow. Also, one would expect very limited estuarine circulation to dilute and process pollutant loads because of the limited tidal connectivity.

2.2.2 Land Use

The Upper Lemon Bay watershed land use types are presented in Table 2-1 and in Figure 2-5. Urban land uses cover the greatest area of the Upper Lemon Bay watershed, with much urbanization along the coast which would generate higher loads than would be expected for pre-development conditions. Open lands and wetlands are most common in the eastern portion of the watershed.

2.2.3 Soils

Soil HSGs of the Upper Lemon Bay watershed are presented in Figure 2-6. Soils in the Upper Lemon Bay watershed are largely classified as either Group D or B/D, indicating a high potential for runoff throughout the drainage basin, if soils are not drained. Higher porosity soils (Groups A and C) are found in the northern areas of the watershed, and generally closer to the coast.

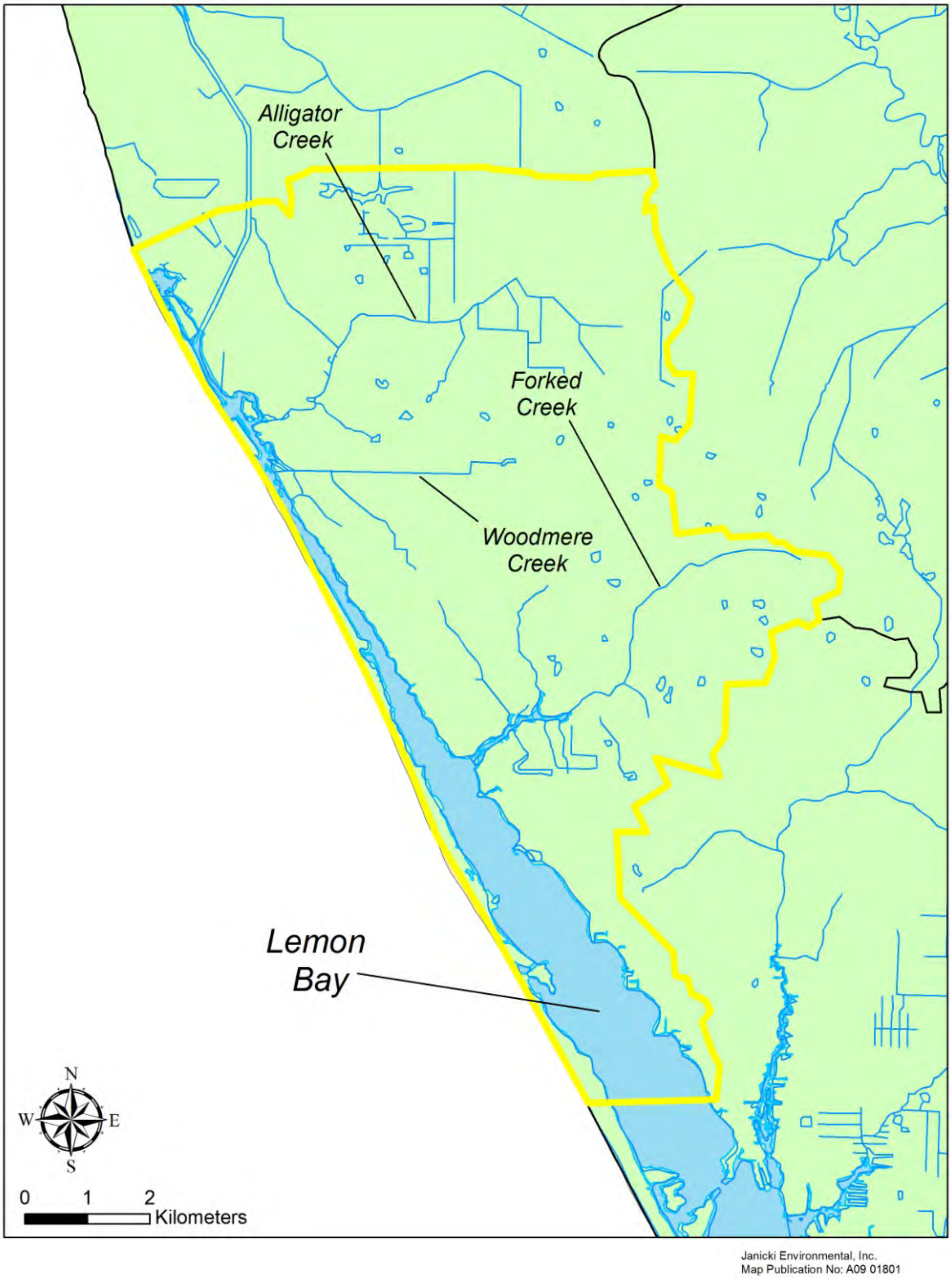


Figure 2-4. Upper Lemon Bay – 1:100,000 USGS hydrology.

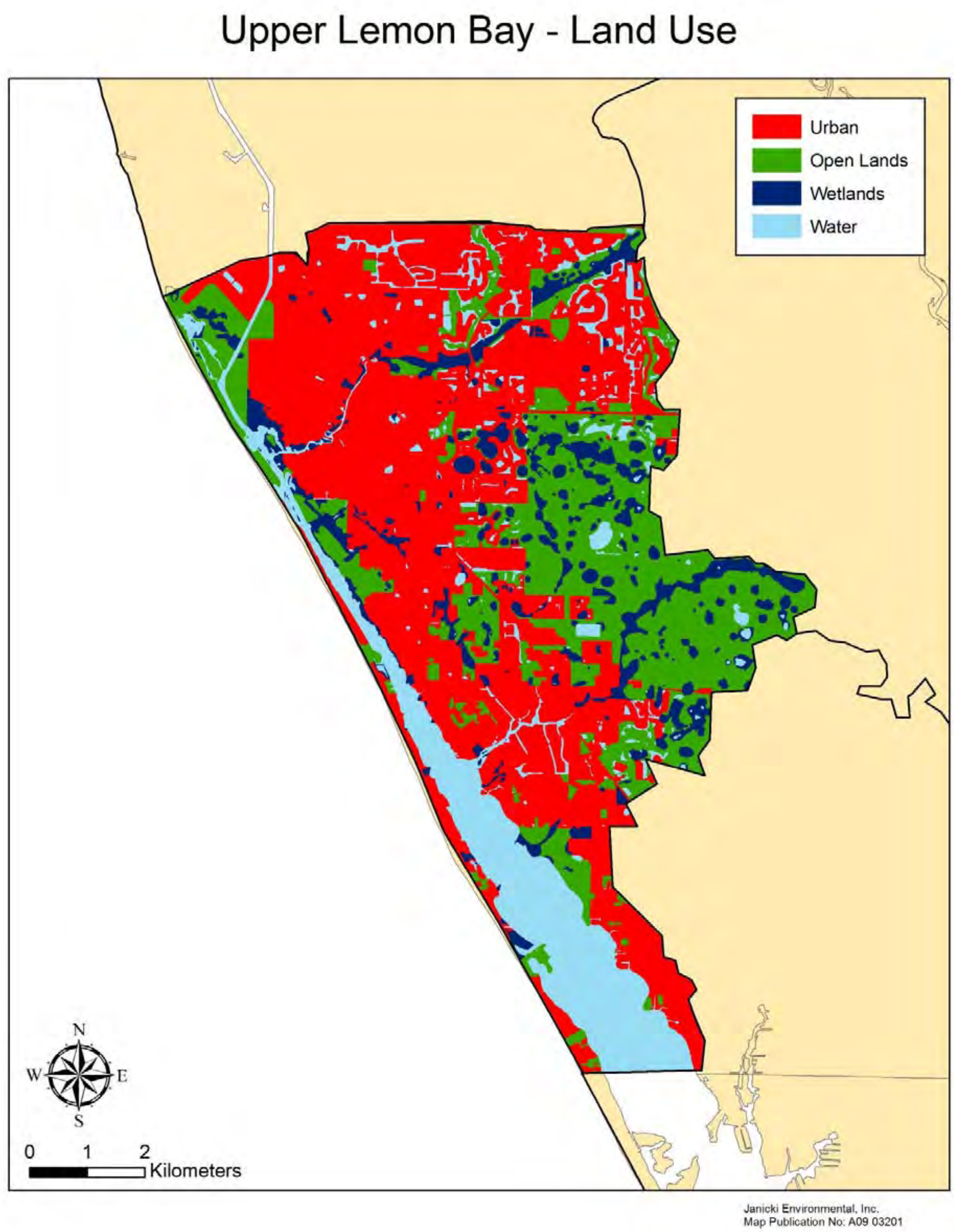


Figure 2-5. Upper Lemon Bay land use types.

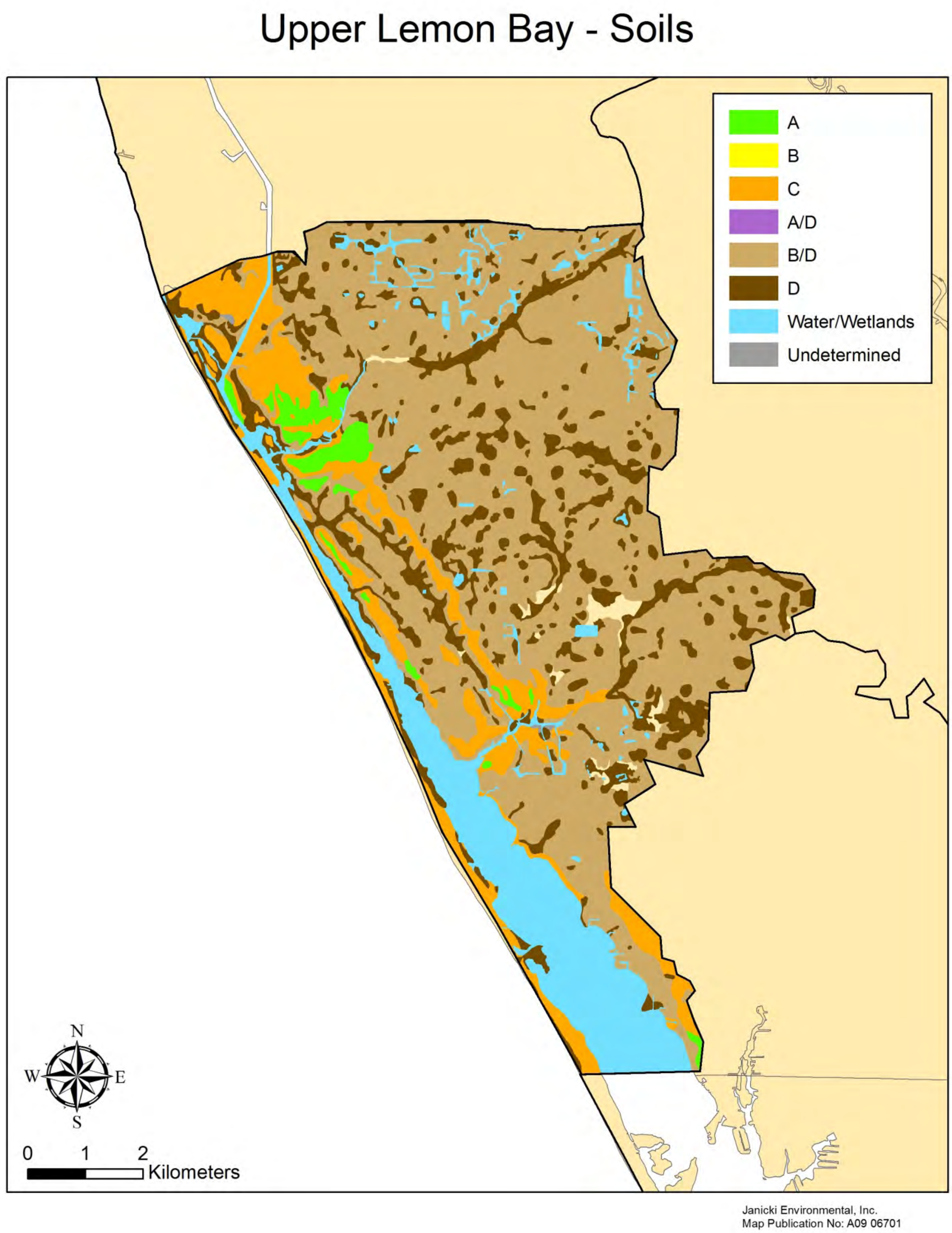


Figure 2-6. Upper Lemon Bay soil HSGs.

2.3 Lower Lemon Bay

2.3.1 Hydrology

Lower Lemon Bay is the southernmost portion of Lemon Bay and consists of approximately 4,713 acres of open water (Figure 2-7). The Lower Lemon Bay segment is connected to the south, via the Intracoastal Waterway, with Gasparilla Sound, a primary feature in the Cape Haze bay segment. Several creeks drain into Lower Lemon Bay, including Ainger, Oyster, and Buck Creeks.

The watershed's surface area is approximately 34,941 acres, or 54.6 mi^2. This results in a watershed to water ratio of 7.4, about the same as Upper Lemon Bay. Although large areas of the upper watershed are in relatively natural state, significant dredging and channelization has occurred in coastal areas, especially to the south. This would be expected to contribute to higher peak wet season flows, as discussed above.

A significant hydrologic feature in the Lower Lemon Bay watershed is the Rotonda, a closed series of dredged canals within the community of Rotonda West. The canal network of the Rotonda resembles an incomplete circle. The Rotonda is bounded by wetlands to its south. Buck Creek historically drained a portion of the Rotonda but a control structure at the west boundary of the Rotonda now restricts freshwater flow to the west. . The capture of freshwater in the hydraulically isolated Rotunda canals has reduced the volume of freshwater entering the estuary from pre-development conditions, which reduces flushing and circulation.

Circulation in Lower Lemon Bay does benefit from Stump Pass, which facilitates tidal flows between the bay and the Gulf of Mexico. Stump Pass is very dynamic inlet. Several flood-tidal deltas in Lemon Bay near the inlet have been stabilized over the years and are covered with extensive seagrasses. Some .of the deltaic deposits have become intertidal and are vegetated with mangroves. There is significant southerly longshore drift at Stump Pass that was closing off the inlet and prompted recent dredging.

2.3.2 Land Use

The Lower Lemon Bay watershed land use types are presented in Table 2-1 and in Figure 2-8. Open lands have the highest coverage within the Lower Lemon Bay watershed. Open lands and wetlands are more common in the northern and eastern portions of the watershed. Lower Lemon Bay is slightly less urbanized than Upper Lemon Bay, but the urbanized areas are still located primarily near the coast.. As with Upper Lemon Bay, the urban lands will generate higher freshwater flows and pollutant loads than under pre-development conditions.

2.3.3 Soils

Soil HSGs of the Lower Lemon Bay watershed are presented in Figure 2-9. Similar to Upper Lemon Bay, the Lower Lemon Bay watershed is predominantly Group D or B/D soils. Additionally, Group A and C soils are also located near the coast the Rotonda and other communities in the eastern region of the watershed, likely signifying moderate runoff potential.

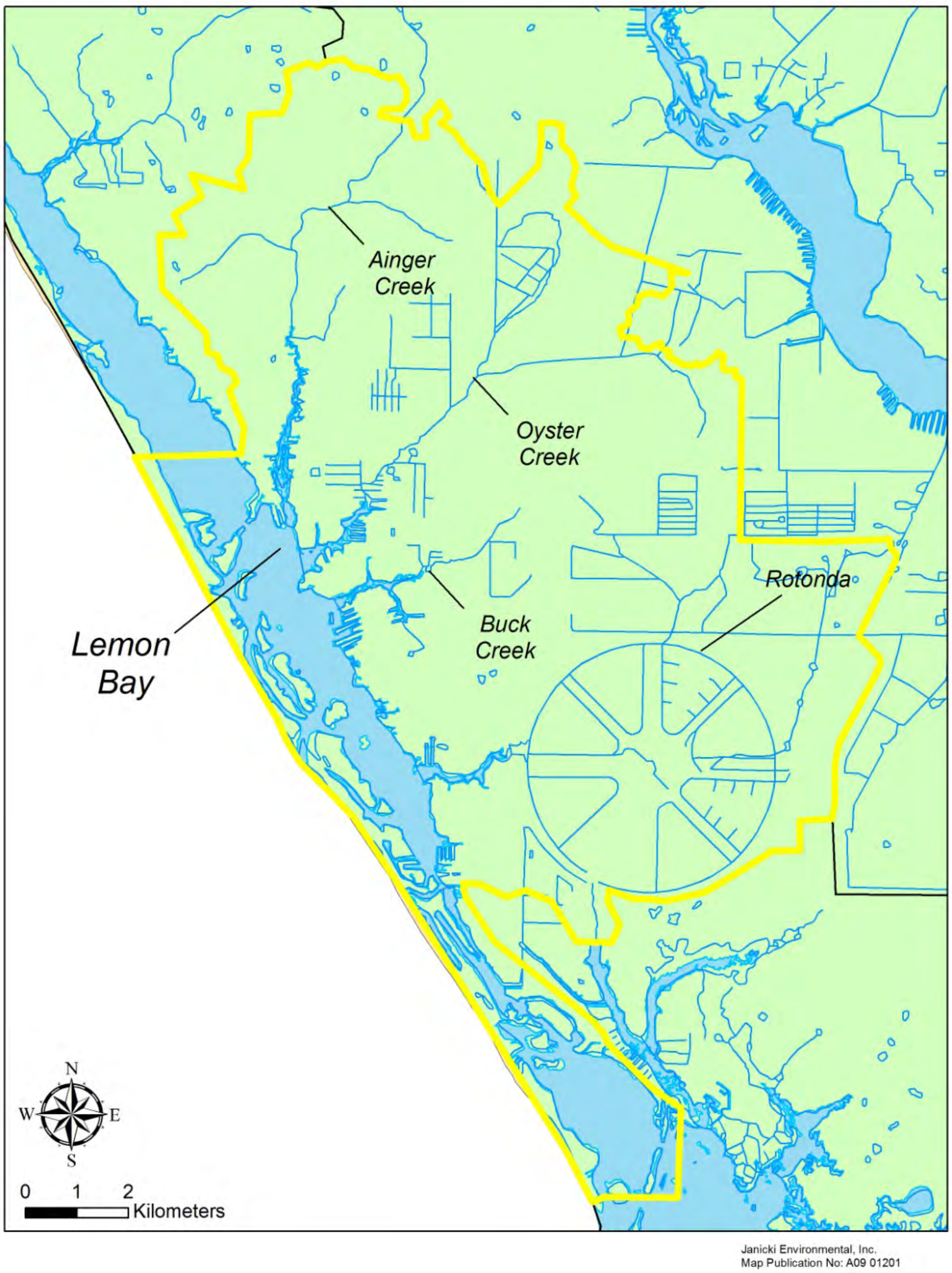


Figure 2-7. Lower Lemon Bay – 1:100,000 USGS hydrology.

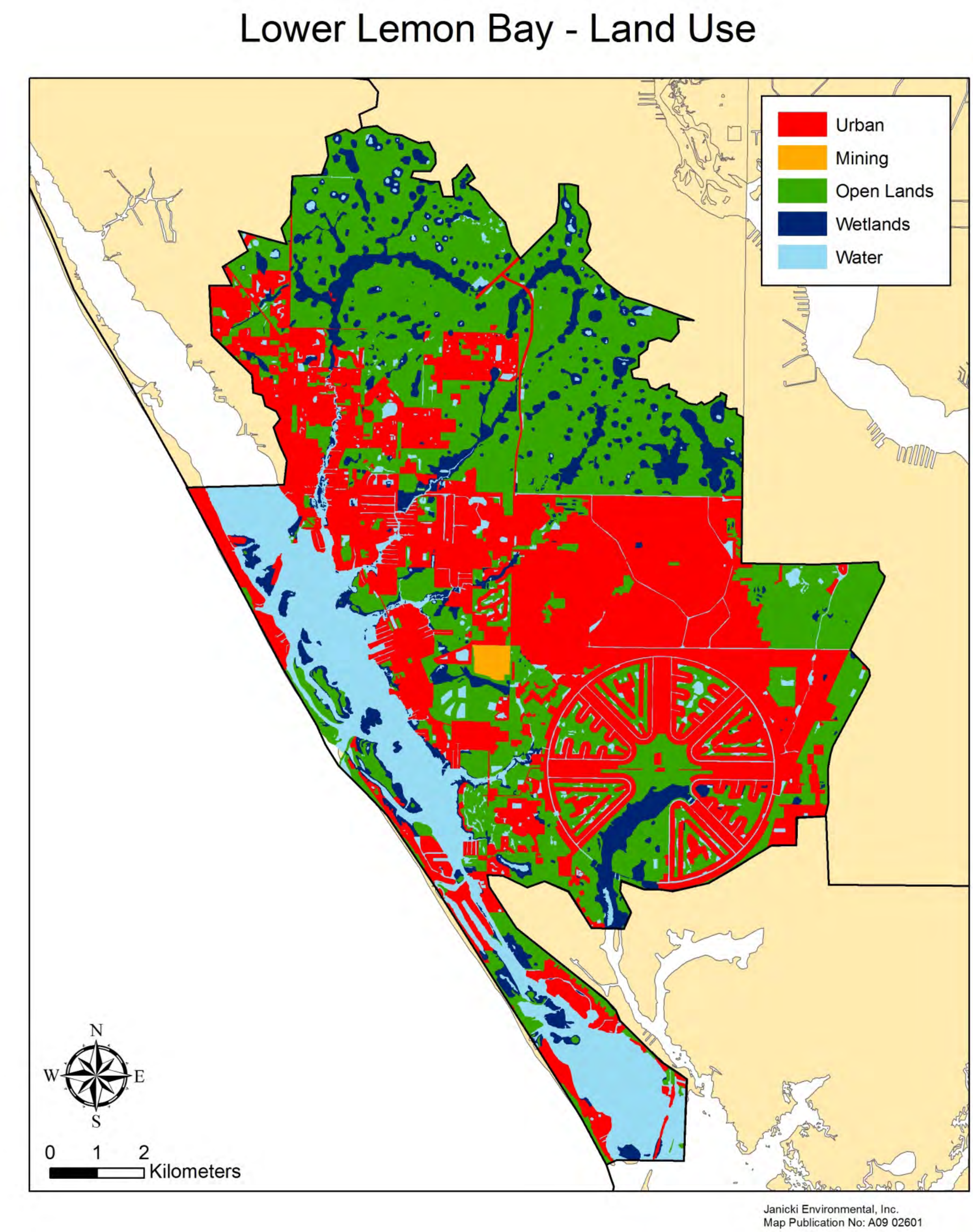


Figure 2-8. Lower Lemon Bay land use types.

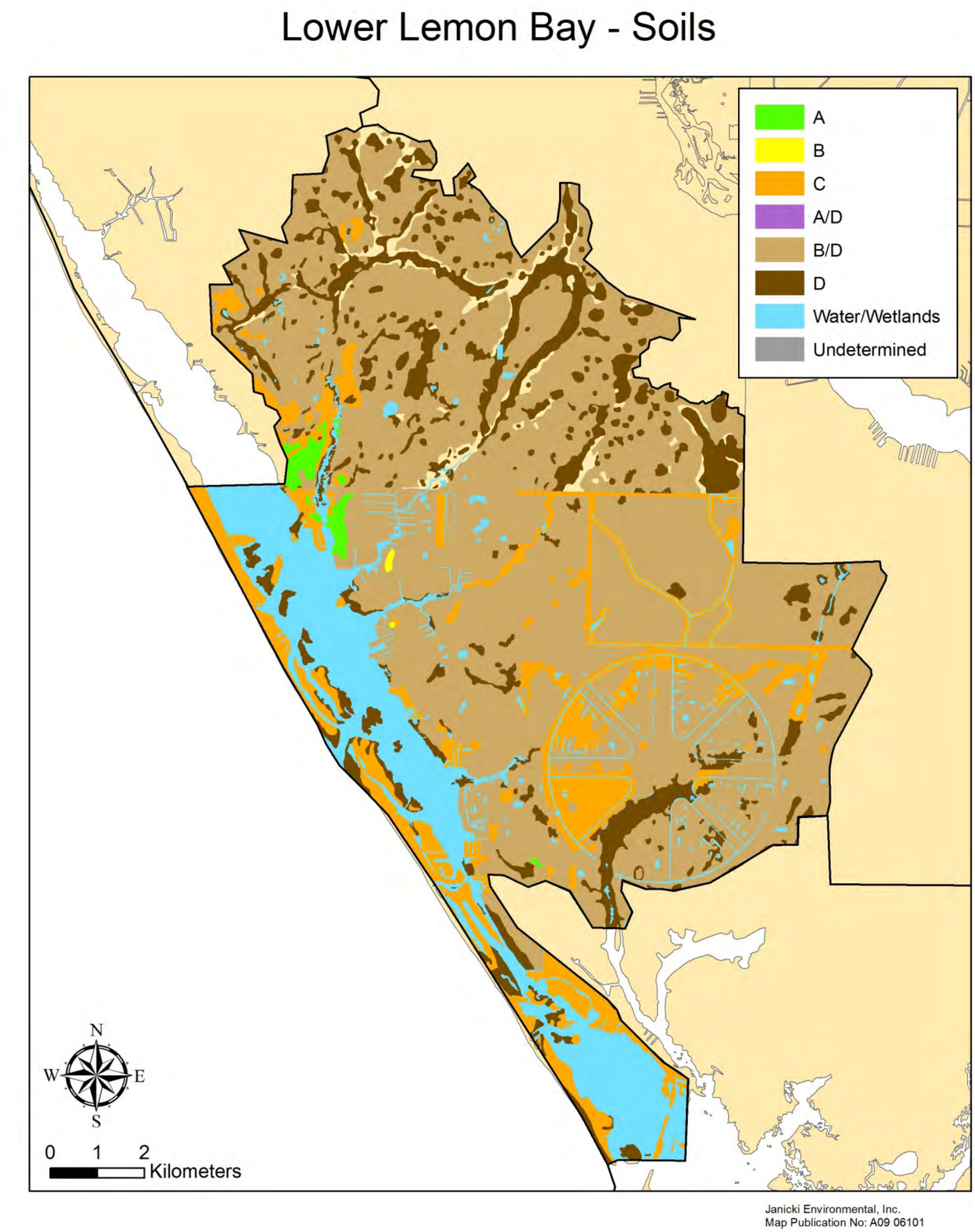


Figure 2-9. Lower Lemon Bay soil HSGs.

2.4 Cape Haze

2.4.1 Hydrology

The Cape Haze bay segment includes the northwest open water portion of Charlotte Harbor proper and Gasparilla Sound, and is approximately 13,106 acres (Figure 2-10). It is bounded on the west by coastal barrier islands and Lower Lemon Bay. The surface area of the Cape Haze watershed is approximately 19,402 acres, or 30.3 mi^2. This results in a watershed to water ratio of 1.5, which is fairly low compared to other bay segments.

The Cape Haze watershed does not have any major freshwater inputs to Charlotte Harbor or Gasparilla Sound. Coral Creek, in the northwest portion of the Cape Haze watershed, historically drained a portion of the Rotonda. However, a dam was constructed across the creek just south of the southern boundary of the development, greatly restricting freshwater flow into the estuary. The majority of the land cover within the watershed is classified as wetlands. The primary source for freshwater inputs to the Gasparilla Sound estuary is direct precipitation and sheet flow from the coastal wetlands.

Water quality in Gasparilla Sound is profoundly influenced by tidal interaction with the Gulf of Mexico. The sound opens into Charlotte Harbor near its mouth at Boca Grande Pass, and strong currents flush the sound daily with water from the gulf and Charlotte Harbor. Therefore, controlling pollutant loadings to areas with larger contributing watersheds will have a great influence on water quality in the sound.

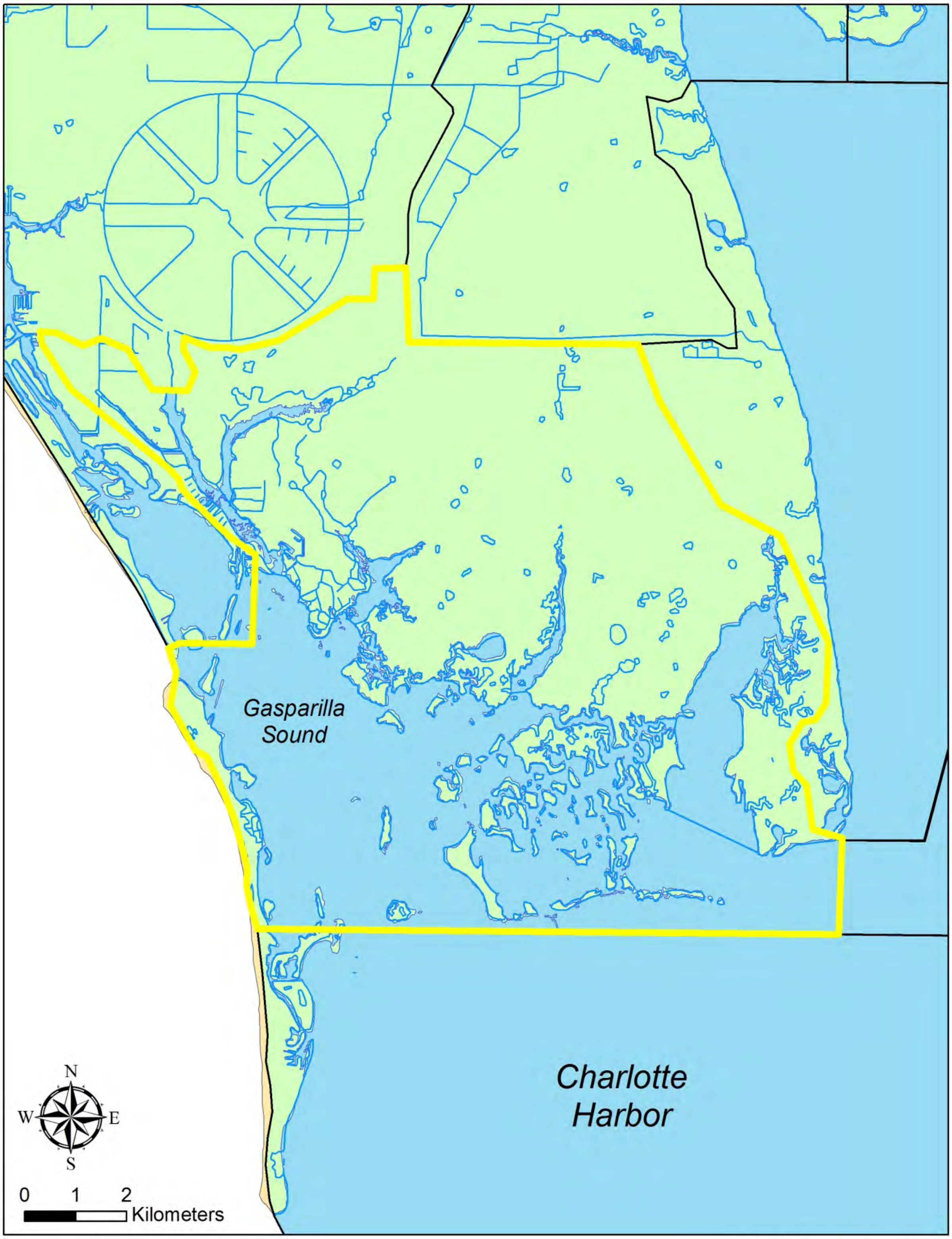
2.4.2 Land Use

The Cape Haze watershed land use types are presented in Table 2-1 and in Figure 2-11. Water and wetlands are the defining land uses for this largely undeveloped region within the CHNEP watershed. Open lands extend northward from the wetlands that characterize the southern and central portions of the Cape Haze watershed.

Small areas of human activity, including urban and mining land uses, are seen in the north and west. Because of the limited development in this basin, small unit pollutant loads (pounds of pollutant per acre) would be expected.

2.4.3 Soils

Soil HSGs of the Cape Haze watershed are presented in Figure 2-12. The Cape Haze soils reflect the land uses observed above. The high amount of wetlands is observed in the Cape Haze watershed. To the north of these extensive wetlands, Group D and B/D soils are the major soil type, with small pockets of Groups B and D located near waterbodies and wetlands.



Janicki Environmental, Inc.
Map Publication No: A09 00801

Figure 2-10. Cape Haze – 1:100,000 USGS hydrology.

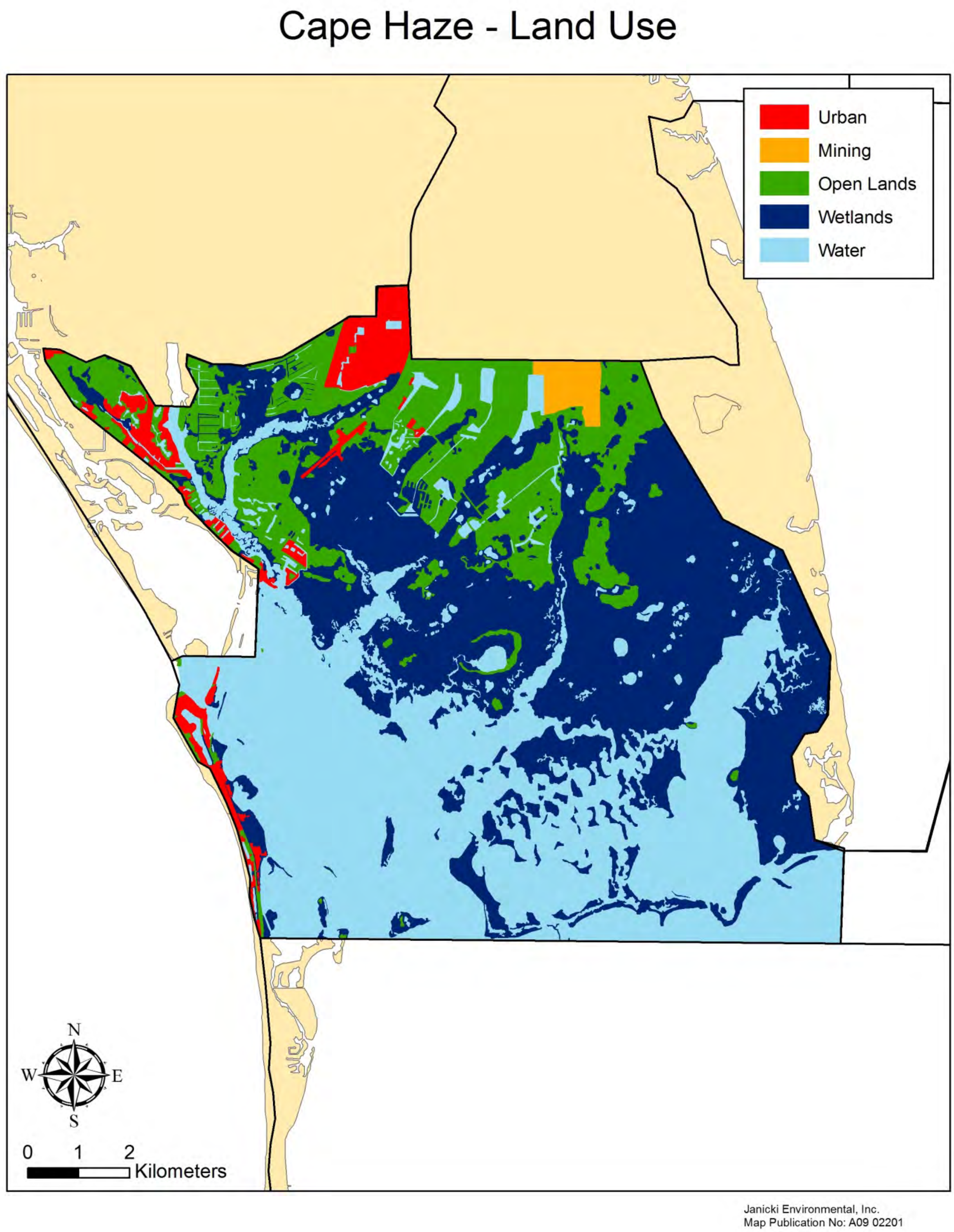


Figure 2-11. Cape Haze land use types.

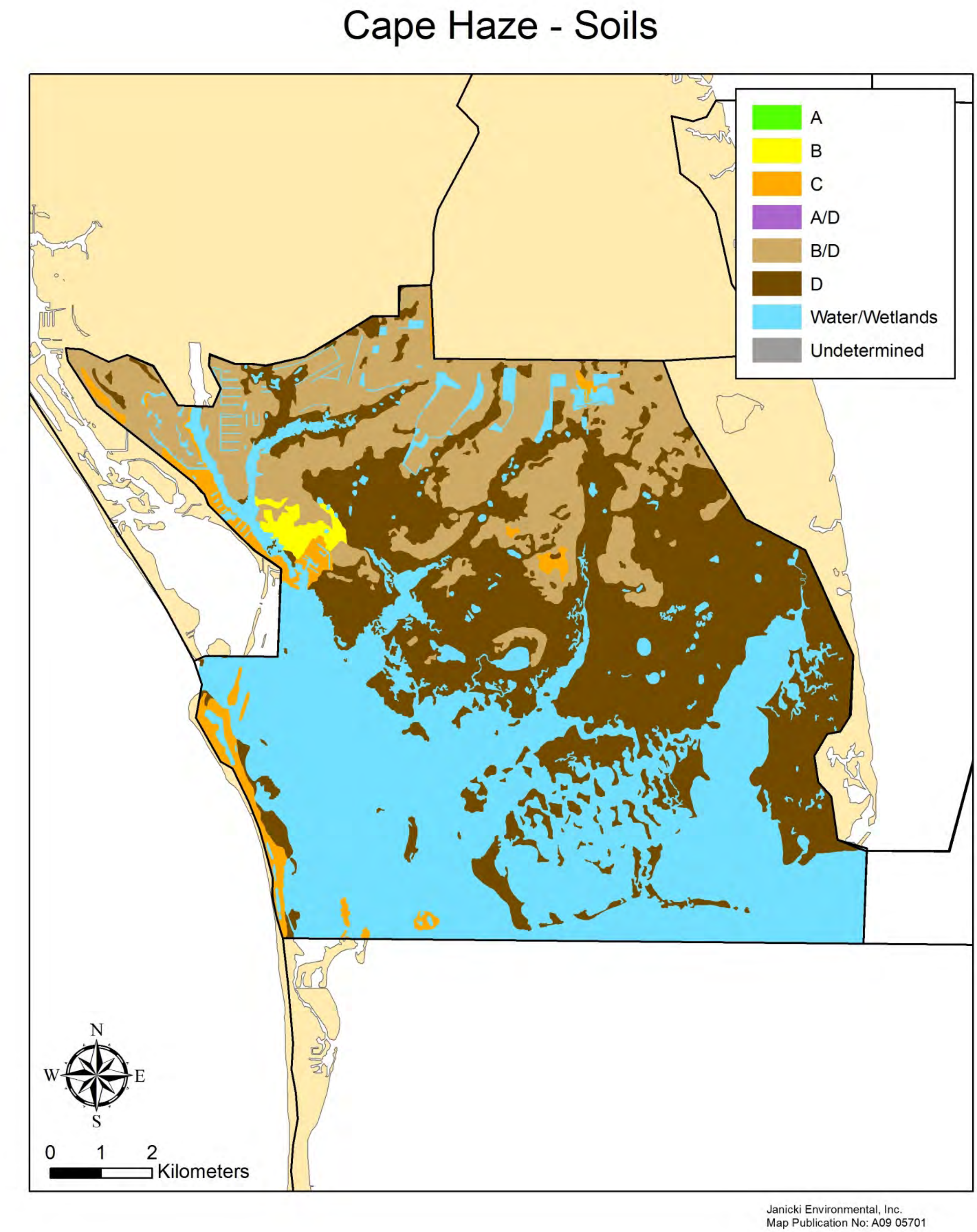


Figure 2-12. Cape Haze soil HSGs.

2.5 Bokeelia

2.5.1 Hydrology

The Bokeelia bay segment contains the lower portion of the Charlotte Harbor estuary (Figure 2-13). The open water portion of the segment (33,331 acres) is much larger than its direct watershed, which is approximately 16,172 acres, or 25.3 mi^2. This results in a watershed to water ratio of 0.5, making inflows from the watershed largely insignificant on a regional level.

It is bounded on the west by coastal barrier islands between the estuarine portion of Charlotte Harbor and the Gulf of Mexico and to the south by a narrow strip of northern Pine Island. The Bokeelia watershed lacks major hydrologic features, and receives freshwater from a series of small tidal creeks and man-made canals along its eastern shore, as well as direct precipitation.

This portion of Charlotte Harbor is a major mixing zone, where freshwater from the upper bay segment watershed mixes with salt water from the Gulf of Mexico. Major sources of freshwater include the Peace River, and water from the Caloosahatchee River that has mixed with estuarine waters in Matlacha Pass.

2.5.2 Land Use

The Bokeelia watershed land use types are presented in Table 2-1 and in Figure 2-14. This segment is predominantly comprised of the open waters of Charlotte Harbor. Its watershed is largely undeveloped, consisting mostly of open lands and wetlands.

Areas of urbanization can be observed on the coasts and scattered in the eastern portion of the watershed. As with the Cape Haze segment, the small basin area, limited development, and extensive wetlands in this basin should result in small unit pollutant loads (pounds of pollutant per acre).

2.5.3 Soils

Soil HSGs of the Bokeelia watershed are presented in Figure 2-15. Bokeelia soils are almost exclusively Group D soils, reflecting large areas of wetlands and high water table. The runoff potential for the eastern portion of the watershed is high, as a result. The coastal barrier islands of the western boundary have slightly more porous soils as they are comprised largely of Group C soils.

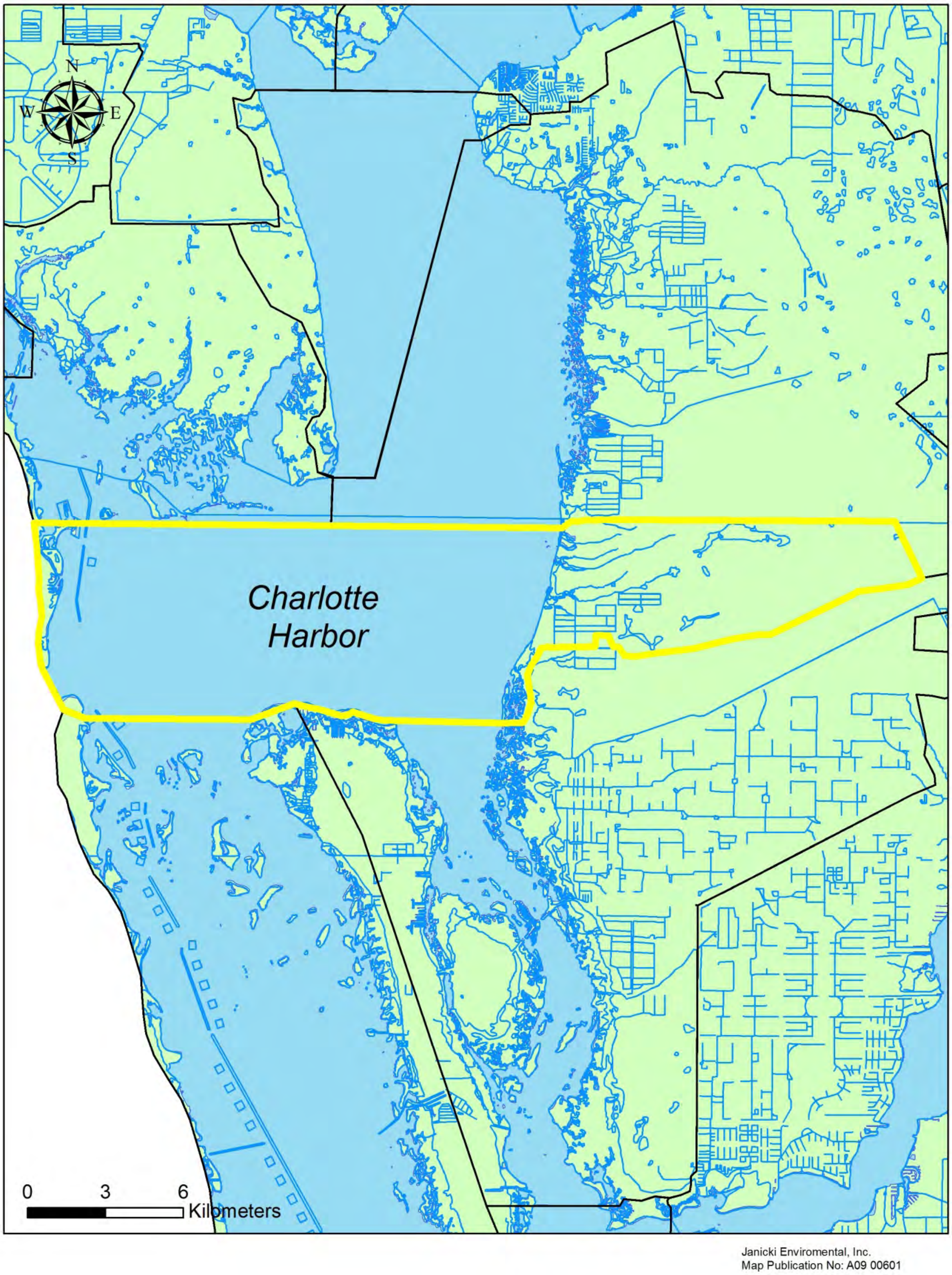


Figure 2-13. Bokeelia – 1:100,000 USGS hydrology.

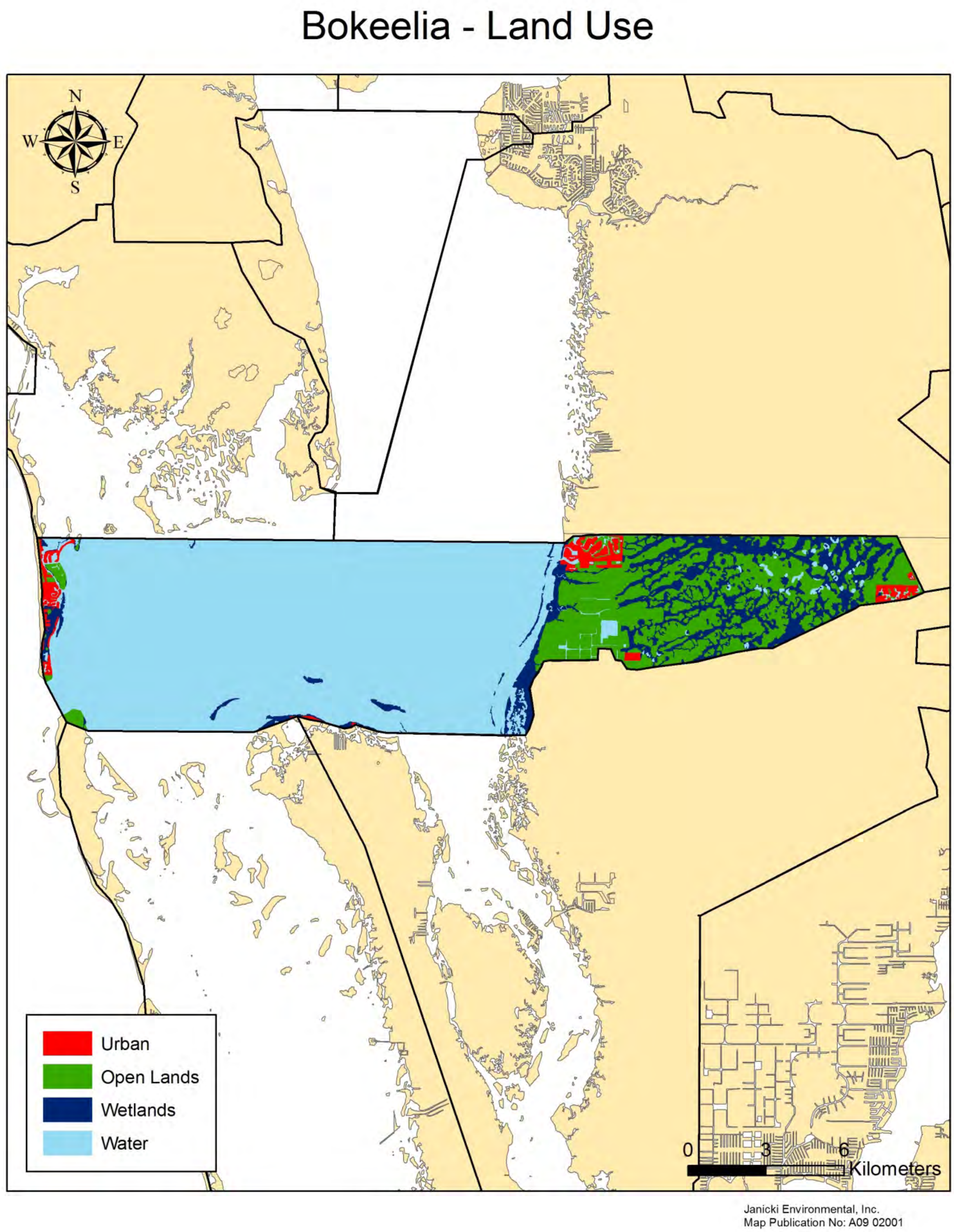


Figure 2-14. Bokeelia land use types.

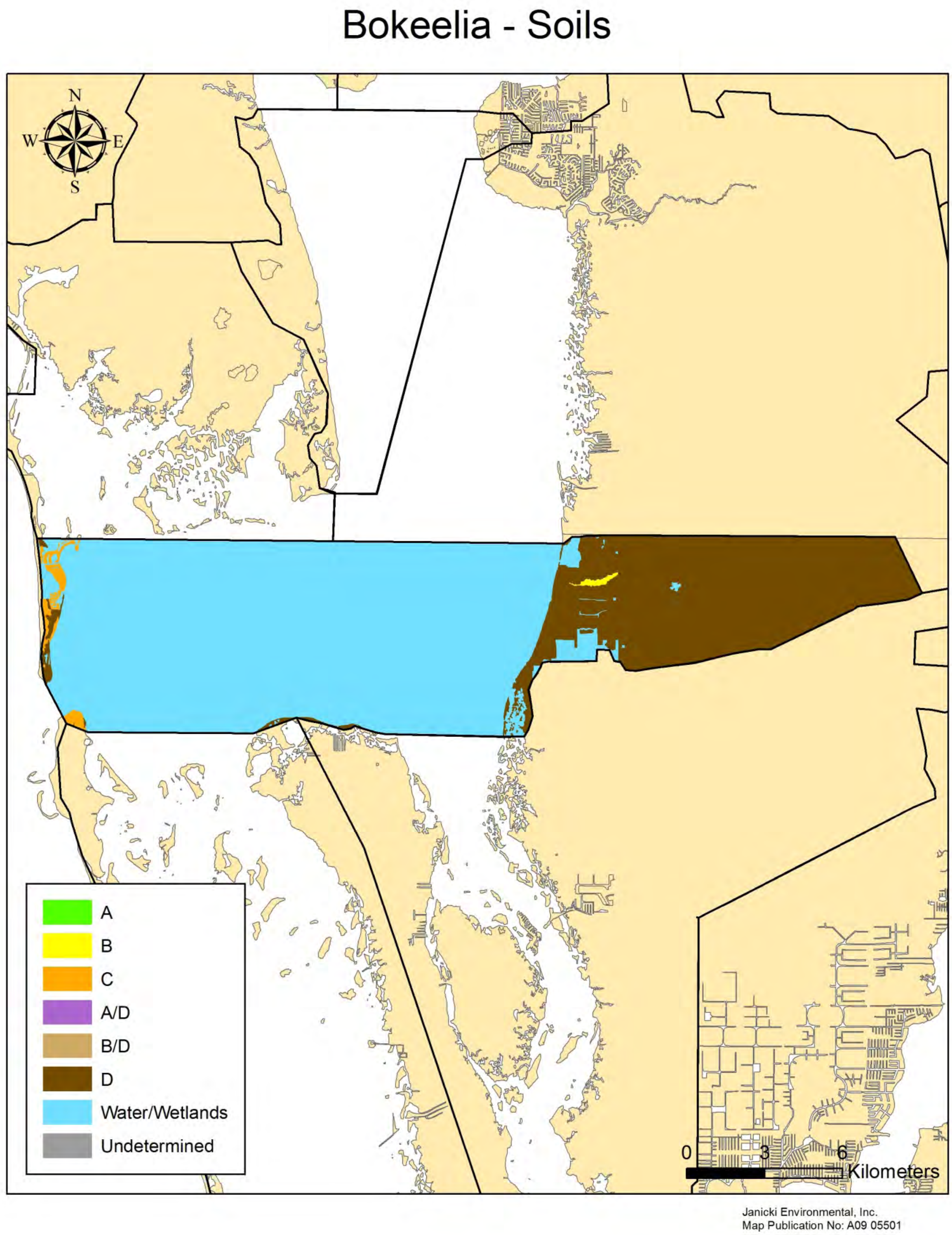


Figure 2-15. Bokeelia soil HSGs.

2.6 West Wall of Charlotte Harbor

2.6.1 Hydrology

The West Wall bay segment includes a significant portion of northern Charlotte Harbor (Figure 2-16). The Tidal Myakka River and Tidal Peace River bay segments flow into the West Wall segment from the north. The open water area of the segment is approximately 16,701 acres, while the watershed is approximately 4,579 acres, or 7.2 mi^2. This results in a watershed to water ratio of 0.3, making inflows from the watershed relatively insignificant on a regional basis.

The West Wall watershed is characterized by small tidal creeks on its western shore and the man-made canals of the Punta Gorda Isles community on its eastern shore. The western portion of the watershed is largely covered in coastal wetlands, resulting in freshwater inflow patterns that mirror those of its westerly neighbor, Cape Haze. . This portion of Charlotte Harbor is also a major mixing zone, where freshwater from the upper bay segment watershed mixes with salt water from the Gulf of Mexico.

Direct freshwater inflows to this segment from the tributary area are very small compared to inflows to the estuary from adjoining segments, especially the Tidal Peace and Myakka Rivers. Circulation and flushing are good in the estuary due to the high river inflows and connection to the open water harbor.

2.6.2 Land Use

The West Wall watershed land use types are presented in Table 2-1 and in Figure 2-17. The West Wall bay segment has a small watershed in relation to its open water. Of the watershed that exists for this bay segment, it is almost completely characterized as wetlands, with a small amount of urbanization on its eastern shore and a few scattered pockets of open lands. As with the Cape Haze and Bokeelia segments, the small basin area, limited development, and extensive wetlands in this basin should result in small unit pollutant loads (pounds of pollutant per acre) and total loads.

2.6.3 Soils

Soil HSGs of the West Wall watershed are presented in Figure 2-18. The small watershed of the West Wall has mostly Group D soils, despite being heavily covered with wetlands. Small amounts of Group C soils can be seen on both sides of the watershed.

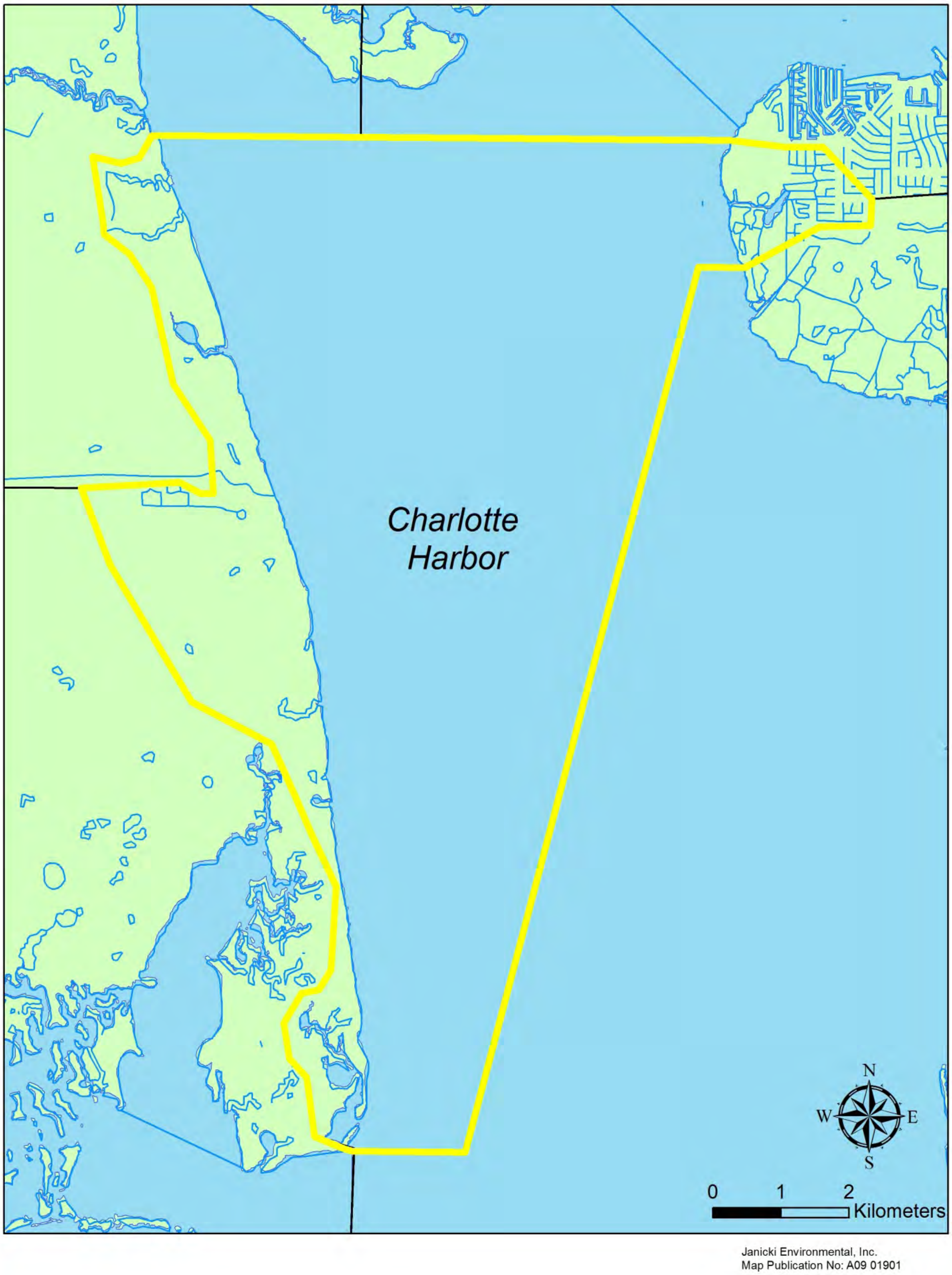


Figure 2-16. West Wall – 1:100,000 USGS hydrology.

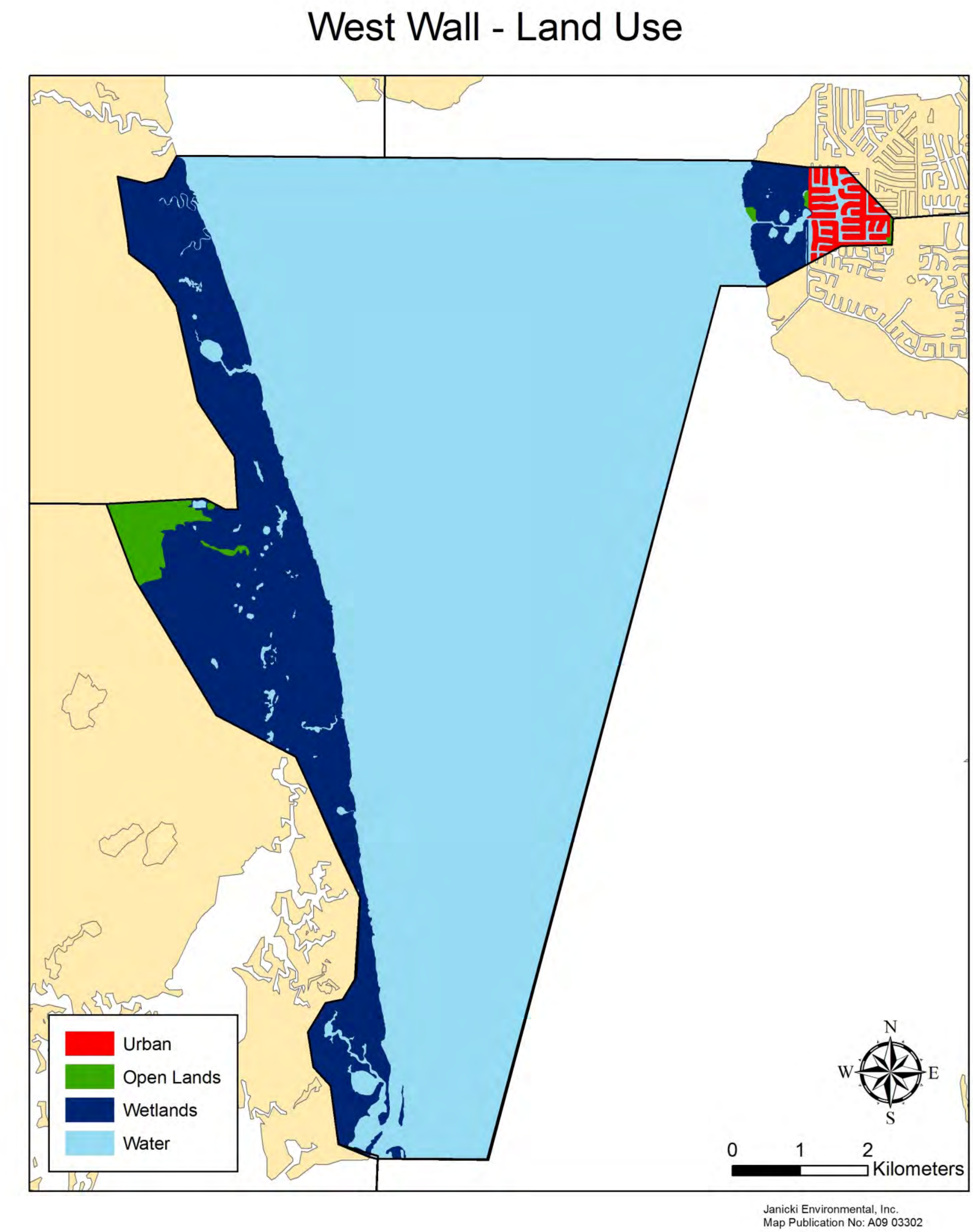


Figure 2-17. West Wall land use types.

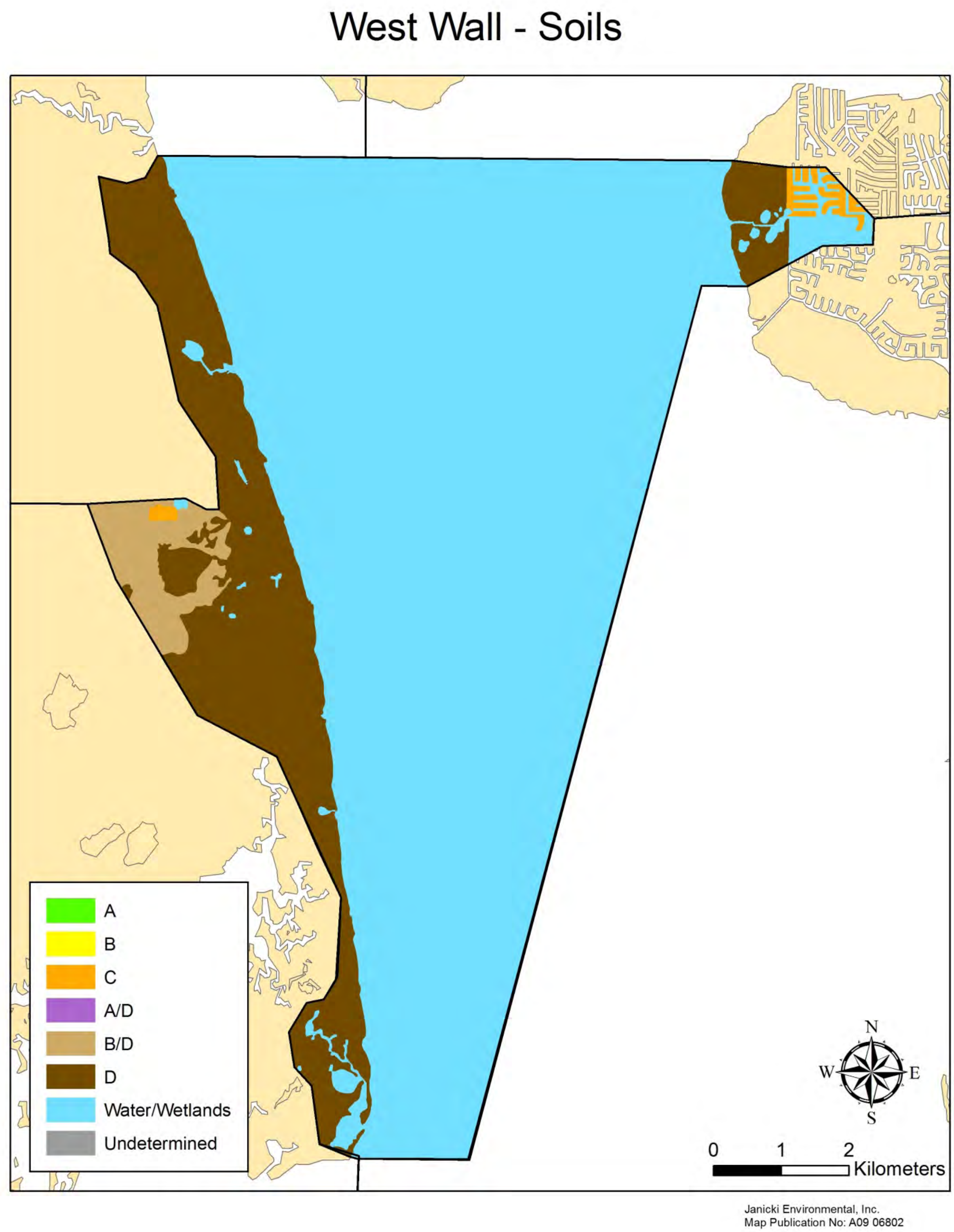


Figure 2-18. West Wall soil HSGs.

2.7 East Wall of Charlotte Harbor

2.7.1 Hydrology

The East Wall bay segment contains the eastern half of northern Charlotte Harbor (Figure 2-19). It is bordered on its west by the West Wall and to its south by Bokeelia. The East Wall bay segment proper is approximately 21,910 acres. Its watershed is approximately 61,349 acres (95.8 mi^2). This results in a watershed to open water area ratio of 2.8, relatively low compared to other bay segments in the CHNEP area.

In its northern portions, the East Wall watershed contains the City of Punta Gorda, which has an extensive network of canals serving its residential developments. Similarly, man-made canals of the Burnt Store community exist along the southern shore of East Wall, albeit on a smaller scale. In between these two communities are coastal wetlands, where water levels are augmented by natural tidal streams as well as some additional man-made canals flowing from the east.

2.7.2 Land Use

The East Wall watershed land use types are presented in Table 2-1 and in Figure 2-20. The East Wall watershed contains a wide array of land uses. Coastal wetlands predominate along the harbor, with range land encompassing much of the southern and eastern portion of the watershed and wetlands located throughout, and particularly along the coast.

Urbanization generally follows the US 41/I-75 corridor, and is most prominent in the north, in the City of Punta Gorda, and along Burnt Store Road on the southern coast. The coastal urban areas will have the most influence on pollutant loading to the estuary. Pockets of agriculture and mining exist throughout the watershed away from the coast.

2.7.3 Soils

Soil HSGs of the East Wall watershed are presented in Figure 2-21. The soils of the East Wall are largely of Group D or B/D, indicating low infiltration/high runoff characteristics for most of the watershed. Soils with higher infiltration rates (Groups A, B, and C), along with some areas of inland water/wetlands are found in the northern portions of the watershed.

It should be noted that the northern portion of the segment is in SWFWMD, and dual HSG classifications (B/D, C/D) are used. The southern portion of the segment is in SFWMD jurisdiction where only single HSG classes are available.

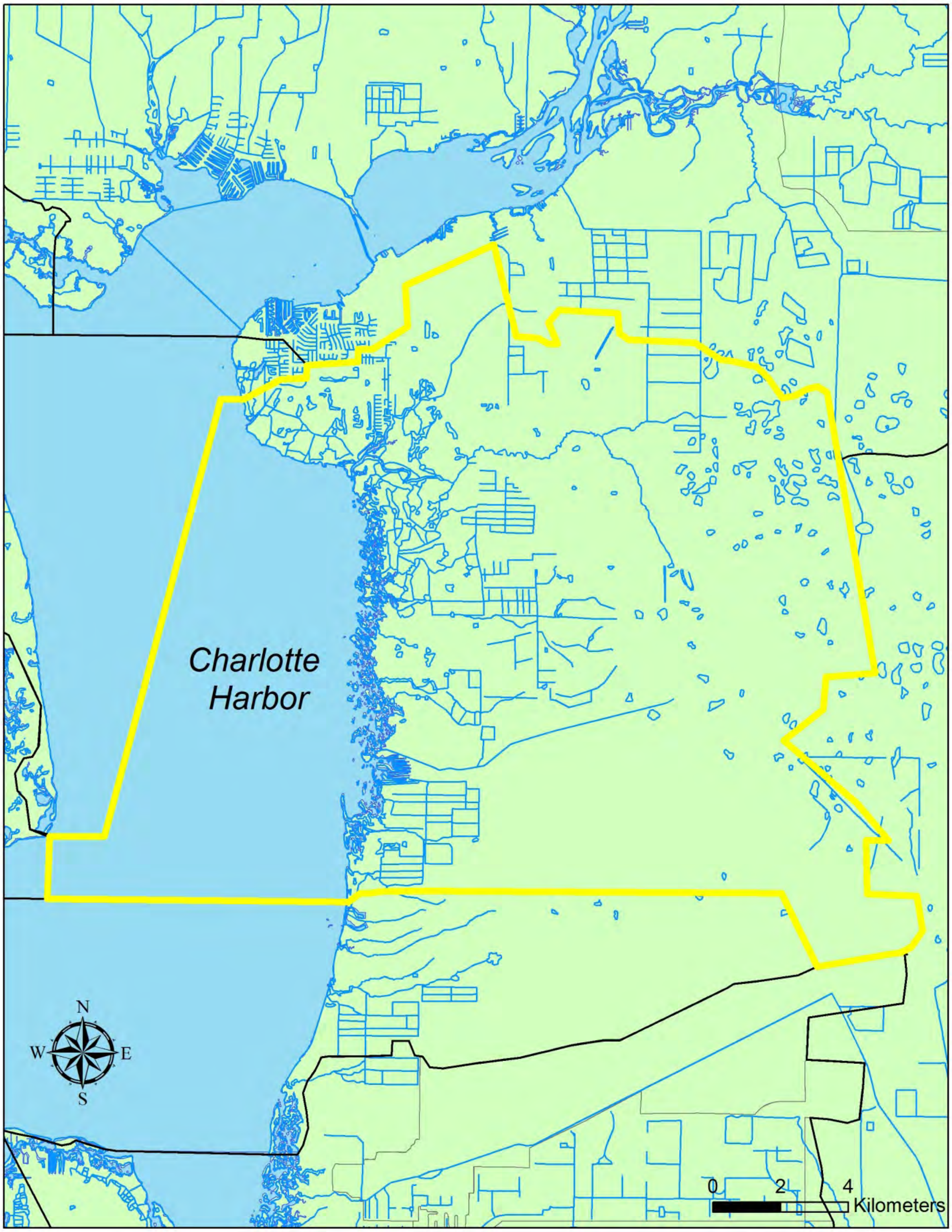


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Figure 2-19. East Wall – 1:100,000 USGS hydrology.

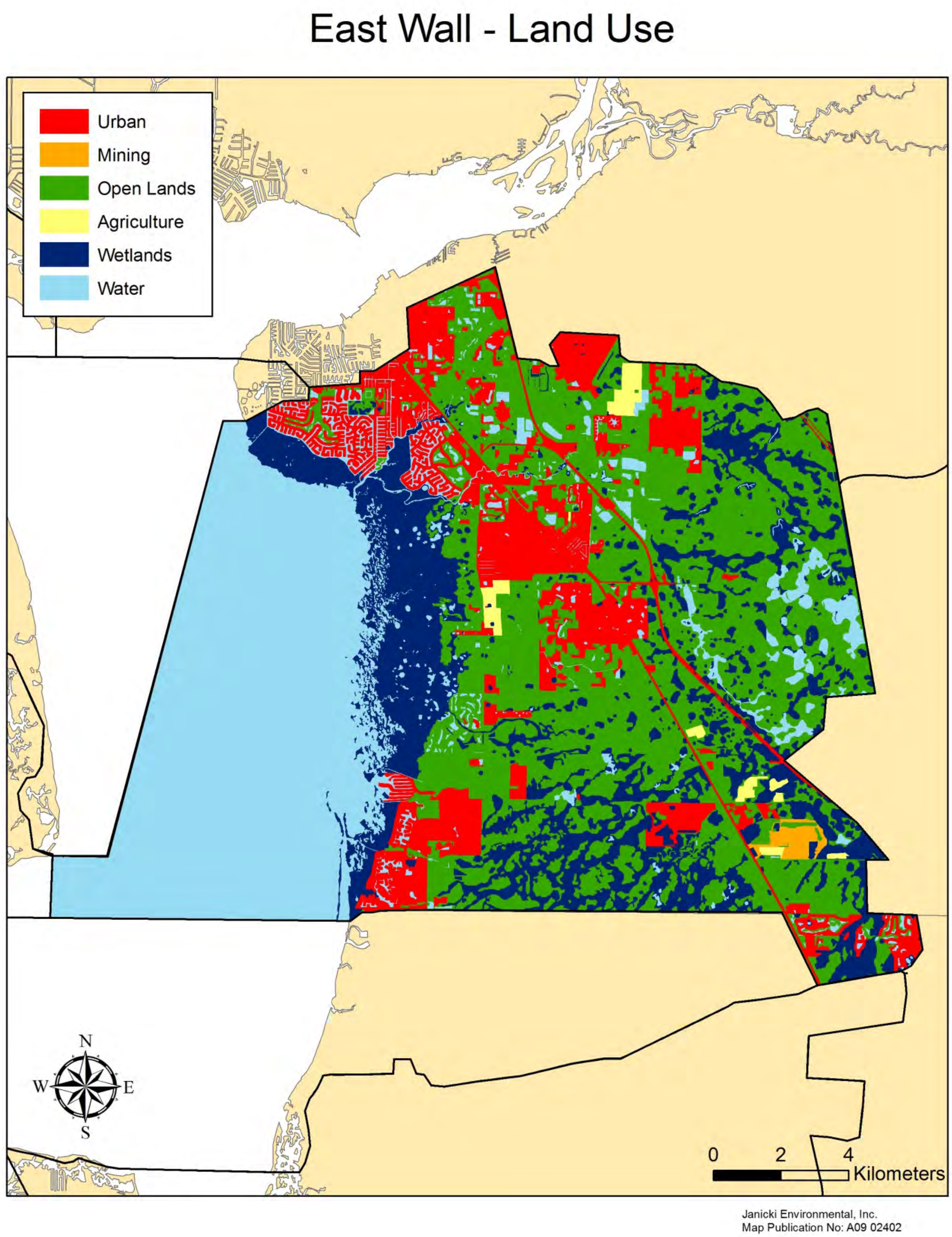

Figure 2-20. East Wall land use types.

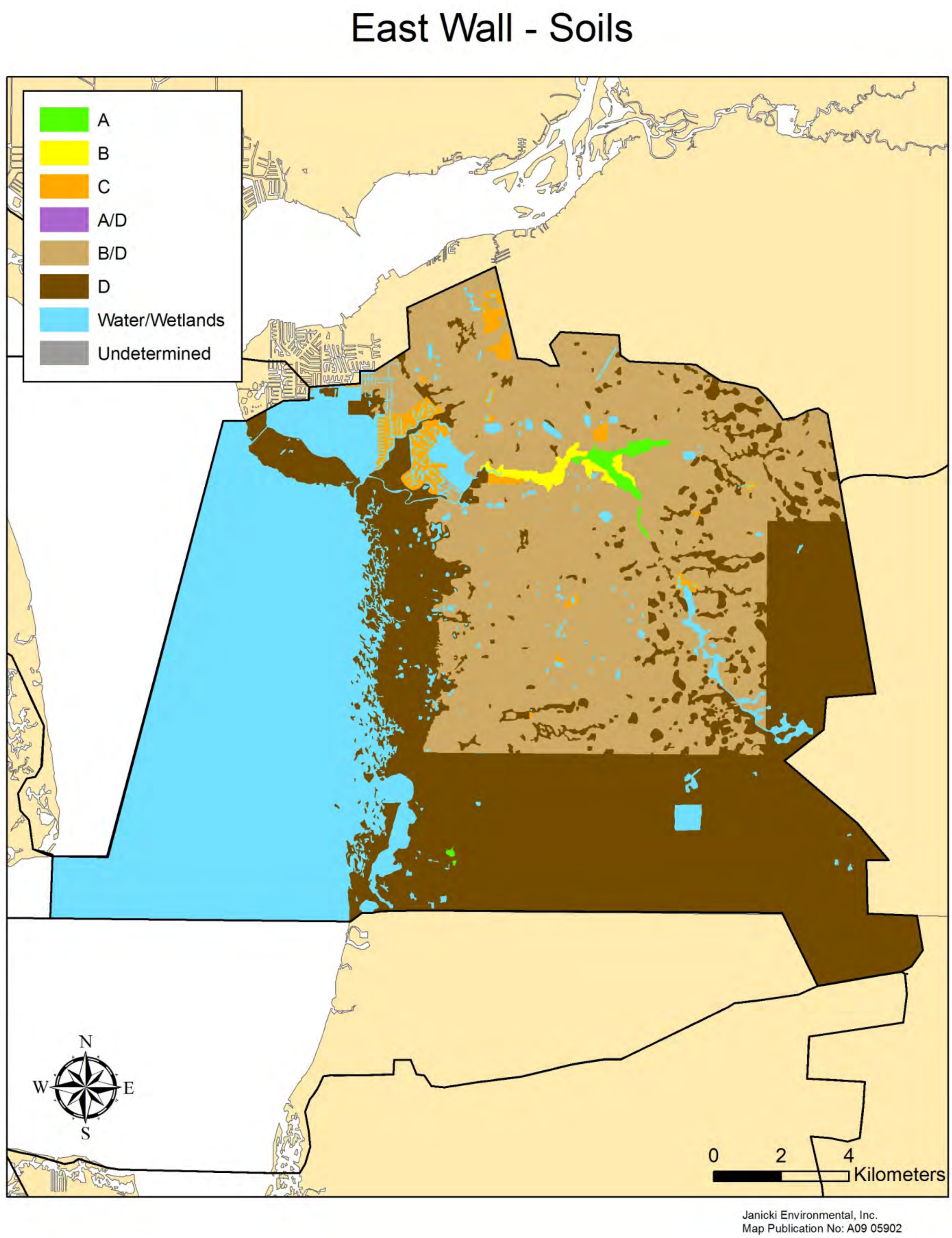

Figure 2-21. East Wall soil HSGs.

2.8 Tidal Myakka River

2.8.1 Hydrology

The Tidal Myakka River bay segment includes the mouth of the Myakka River (Figure 2-22). The Myakka River proper drains into Charlotte Harbor at its northern end, with an approximate bay segment open water surface area of 7,055 acres. In relation to the bay segment proper, the Tidal Myakka River watershed is large, at approximately 385,866 acres, or 603 mi^2. This results in a watershed to open water area ratio of 55, high compared to most others in the CHNEP area and generating relatively high runoff per rainfall unit.

The dendritic Myakka River is a regionally large river that is a significant source of freshwater inflow to the Charlotte Harbor estuary. It flows southwest nearly 66 miles from its source at Myakka Head to Charlotte Harbor (SWFWMD, 2005). Major tributaries to the Myakka River include Big Slough and Deer Prairie Creek. The hydrology of Myakka River is influenced by the Flatford Swamp, which is located immediately upstream from the USGS flow gage on the Myakka River at Myakka City, as well as the extensive freshwater wetlands in the basin. A number of small creeks have their confluence with the Myakka River at Flatford Swamp, which functions to slow the movement of the water in the system, leading to higher evapotranspiration and groundwater influx rates. Although the Myakka River watershed is relatively large with respect to others in the CHNEP and has experienced some stream channelization, the numerous wetlands help to moderate peak flows to the receiving waters. Agricultural irrigation has been identified as contributing to river flows (SWFWMD, 2005).

The USGS gage at Myakka River near Sarasota has been in operation measuring streamflow discharges since 1937. The long-term mean flow of the Myakka River at this gage is 254 cubic feet per second (cfs), with a median flow of 234 cfs. Between 1995 and 2007, the Myakka River near Sarasota gage had a maximum annual average of 586 cfs, occurring in 2003, a wet year for the region. The 2007 drought produced the minimum annual average flow observed in the study period, with an average of 66 cfs at this gage. Other active USGS gages on the Myakka River include site 02298488 (Myakka River upstream of Youngs Creek (period of record 1998 – current), site 02298606 (Myakka River near Myakka City (period of record 2001 – current), site 02298606 (Myakka River at Myakka City (period of Record 1977 – current), and Myakka River near Sarasota (period of record 1936 – current).

2.8.2 Land Use

The Tidal Myakka River watershed land use types are presented in Table 2-1 and in Figure 2-23. The vast majority of the Tidal Myakka River watershed is natural land, as open lands and wetlands can be observed throughout the drainage basin, particularly in its central reaches. Urbanization is most predominant in the southern portion of the watershed, where the City of North Port is located. Agriculture is a major land use in the northern portion of the watershed, with some mining also observed. As stated above, the many wetlands in the basin have a significant effect on freshwater flow volume and timing to Charlotte Harbor.

2.8.3 Soils

Soil HSGs of the Tidal Myakka River watershed are presented in Figure 2-24. The Tidal Myakka River watershed consists of the entire array of soil groups. While it is largely characterized by Groups D and B/D like most of the CHNEP watershed, Tidal Myakka River also includes a significant number of patches of soils with lower runoff potential (Groups A, B, and C) in the northern reaches of its watershed. A large region of Group A/D can also be observed in the southern extent, in the developed areas of the City of North Port. The D soils reflect the many wetlands in the basin. Although soils with HSG of D have higher runoff rates in general, storage in the wetlands helps to moderate downstream flow rates.

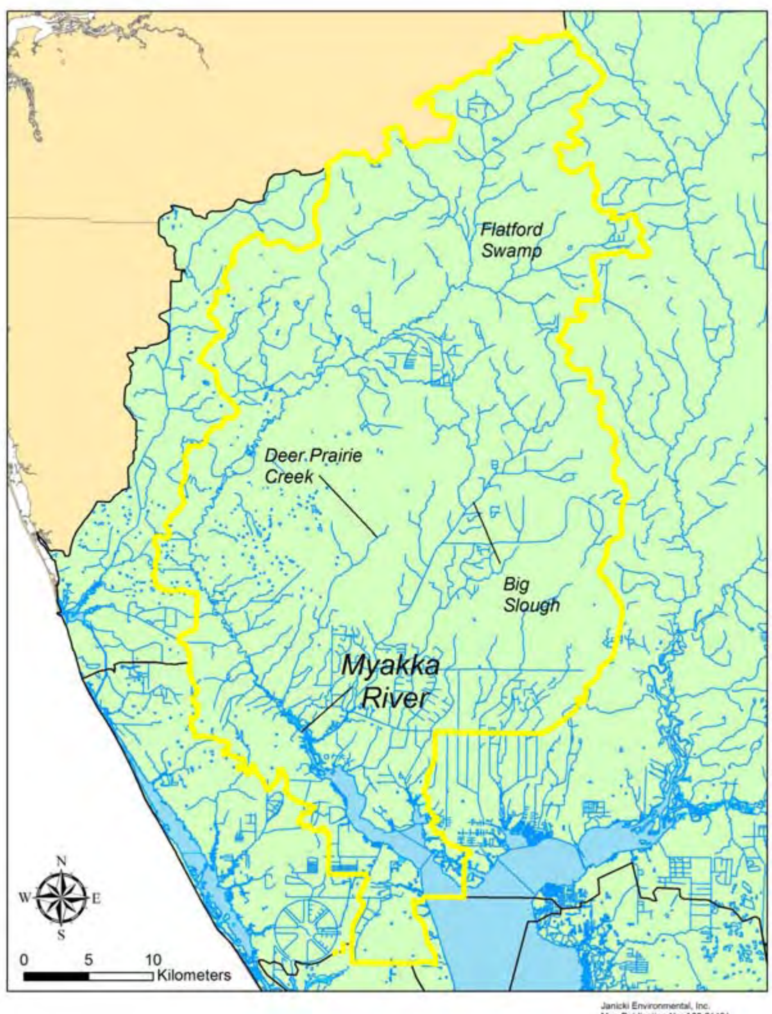

Figure 2-22. Tidal Myakka River – 1:100,000 USGS hydrology.

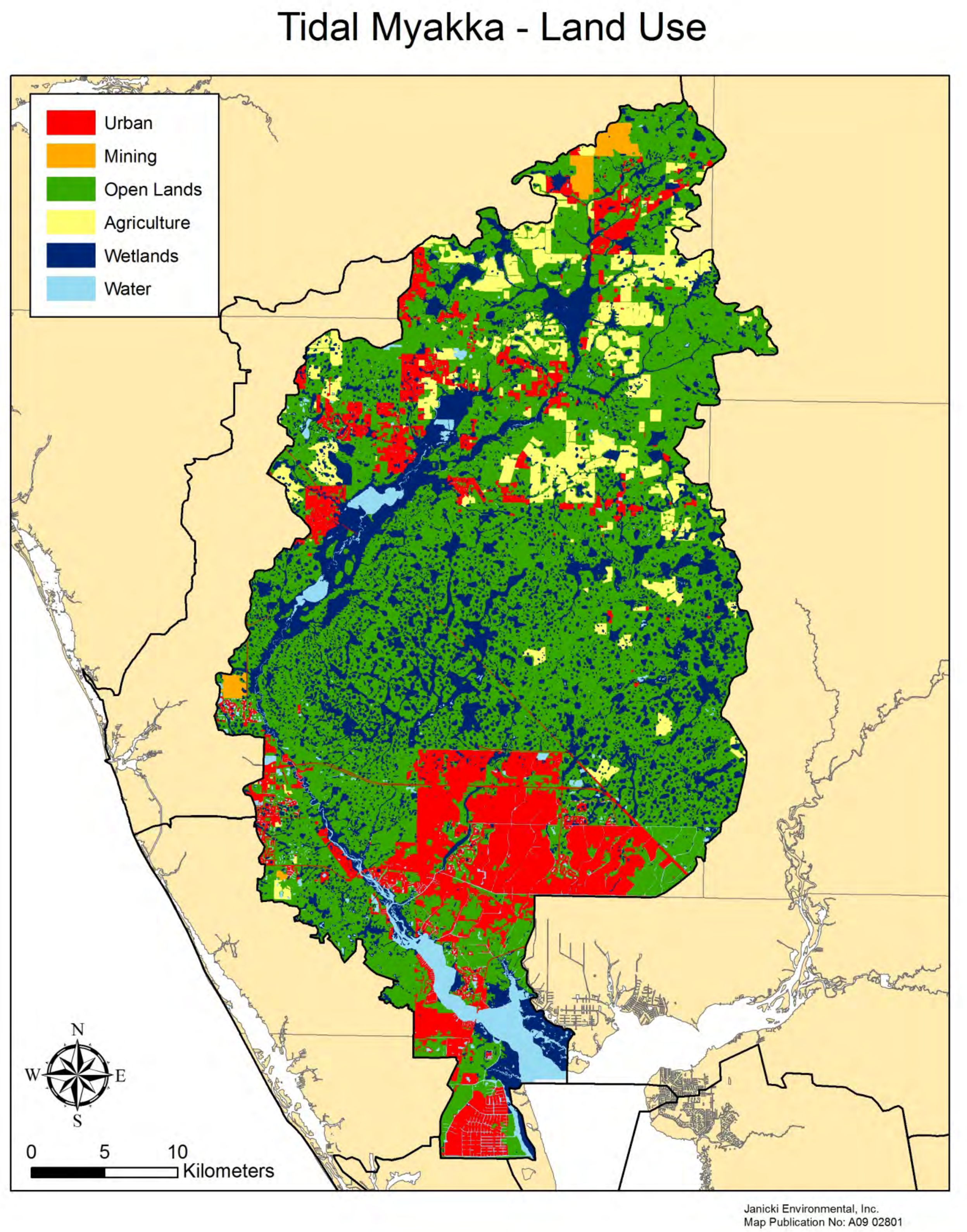

Figure 2-23. Tidal Myakka River land use types.

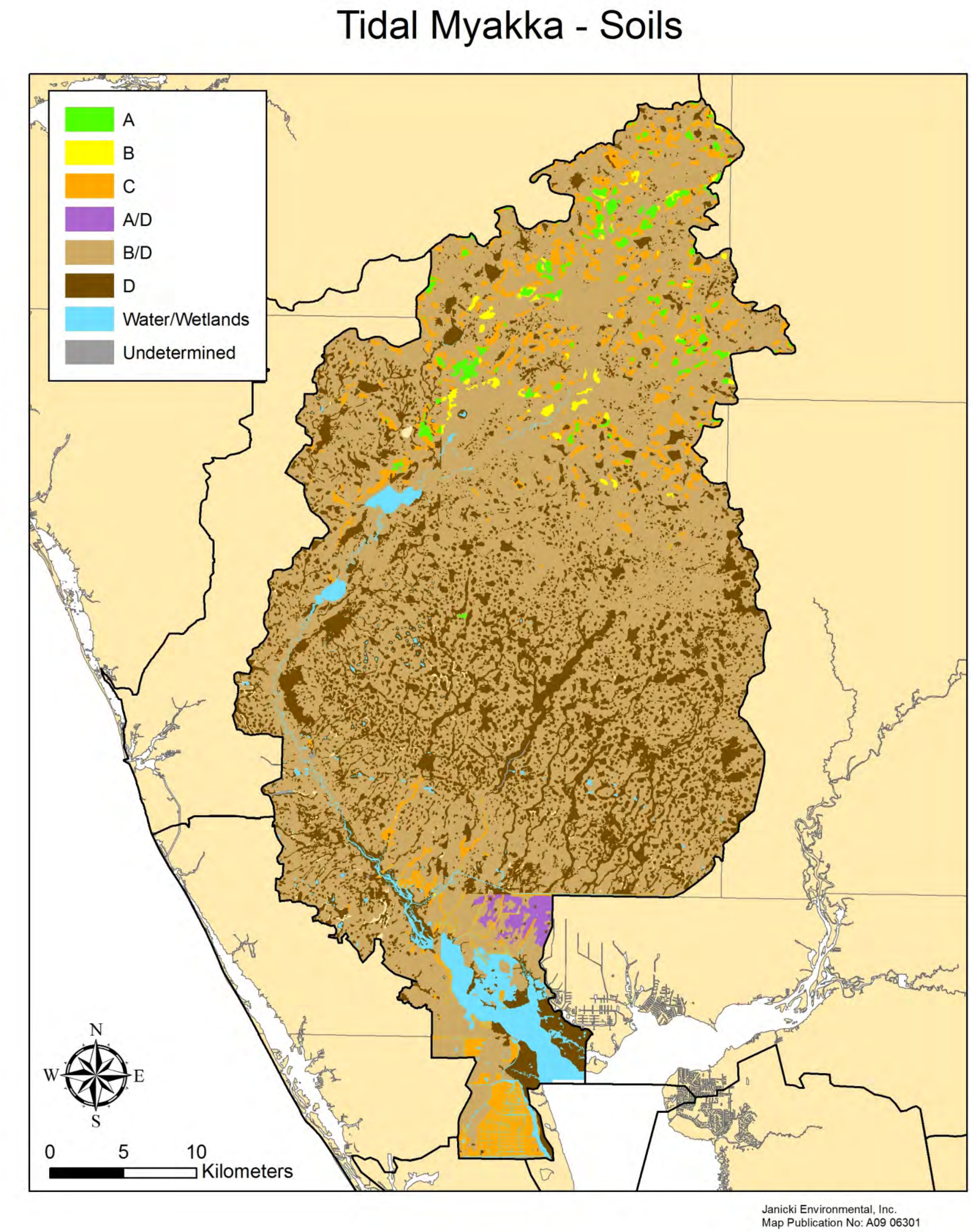

Figure 2-24. Tidal Myakka River soil HSGs.

2.9 Tidal Peace River

2.9.1 Hydrology

The Tidal Peace River segment includes the entire Peace River, the largest tributary of the CHNEP watershed (Figure 2-25). The bay segment proper is comprised of the estuarine portion of the Peace River and Shell Creek. It has an open water surface area of approximately 12,894 acres and is connected to Charlotte Harbor at its southern boundary. Its watershed has a surface area of approximately 1,477,486 acres or 2,308 mi^2, which is the largest of all of the 14 bay segment watersheds in the study area. This results in a watershed to open water area ratio of 114, the highest ratio compared to others in the CHNEP area and generating high runoff per rainfall unit.

The Peace River meanders 120 miles from its source in the Green Swamp to its mouth at Port Charlotte. There are several large tributaries in the river's dendritic network, including Joshua Creek, Payne Creek, Charlie Creek, Horse Creek, and Shell Creek. It is the major source of freshwater inflow to Charlotte Harbor. The Peace River headwaters are in the Green Swamp, a vast series of inland wetlands comprising approximately 560,000 acres in parts of Polk, Lake, Sumter, Hernando and Pasco counties. Periods of extreme drought can occasionally cause the Green Swamp to become dry and reduce Peace River flows in its northern reaches to zero (SWFWMD, 2007). A multitude of lakes, where flow is dictated by control structures, are located adjacent to the Green Swamp in the northern extent of the watershed in central Polk County.

There are several long-term USGS flow gages on the Peace River and its tributaries. The Peace River has three USGS gages on the main stem of the river:

- Peace River at Bartow,
- Peace River at Zolfo Springs, and
- Peace River at Arcadia.

The Peace River at Bartow is the most upstream gage and has been operational since 1940. Over the period of record, Peace River at Bartow has a long-term mean flow of 223 cfs and a median flow of 182 cfs. The maximum annual average flow for the study period occurred in 2004, when the average annual flow was 514 cfs. The year 2004 was marked by four hurricanes crossing the Florida peninsula. The minimum annual average flow was 16 cfs, in 2007, with flows also low in the drought years of 2000, 2001, and 2006.

Farther downstream is the USGS gage, Peace River at Zolfo Springs. This gage has been operational since 1934, and has a long-term mean flow of 618 cfs and a median flow of 576 cfs. The maximum annual average flow from 1995 to 2007 was 1,150 cfs, which occurred in 1998, a year considered to have had a strong El Nino event influencing rainfall throughout Florida. The minimum annual average flow was 84 cfs in 2000, a drought year.

The most downstream USGS flow gage on the Peace River is at Arcadia, with flows reflecting the increase in flows that occurs farther downstream on the river in relation to the upstream gages. This gage was first operated in 1931 and has a long-term average flow of 1,065 cfs and a median flow of 1,012 cfs. Between 1995 and 2007, the maximum annual average occurred in 2005 (1,860 cfs) while the minimum annual average was 139 cfs in the drought year of 2000.

The following large tributaries of the Peace River also have long-term USGS flow gages:

- Payne Creek,
- Charlie Creek,
- Joshua Creek,
- Horse Creek, and
- Shell Creek.

The USGS gage at Payne Creek has been operational since 1975. The mean flow for the period of record is 116 cfs, while the median flow is 98 cfs. The maximum annual average flow during the study period occurred in 2004, when the mean flow was 258 cfs. This was attributable in part to the effects of Hurricane Charlie and other large storms. The minimum annual average flow occurred in 2000, when flows averaged 20 cfs. Flows were also low during 2007, with an average annual flow of 31 cfs.

The Charlie Creek USGS gage first operated in 1951. During the period of record, the long-term mean flow was 262 cfs and the median flow was 234 cfs. Between 1995 and 2007, the average annual flows peaked at 515 cfs in 2004, while the minimum was 24 cfs, in 2000. Droughts resulted in low-flow years in 2000 and 2006-07.

The USGS gage at Joshua Creek began in 1951, with a long-term mean flow of 110 cfs and a long-term median flow of 103 cfs. Over the study period of 1995 to 2007, the maximum annual average flow of 223 cfs occurred in 2005, a wet year within the Peace River basin, and a continuation of the high, hurricane-driven flows seen in the previous year. The minimum average annual flow of 41 cfs occurred in the very dry year 2000, with 2007 being nearly as dry (42 cfs).

Horse Creek flows have been measured by the USGS since 1951 as well. The long-term average flow on Horse Creek is 194 cfs, with a median of 177 cfs. The average annual flows from 1995 to 2007 reflect a variety of hydrologic years. The maximum annual average flow was 416 cfs in 2003, followed closely by the hurricanes of 2004, when flows averaged 403 cfs. The drought year of 2007 produced an average flow of 23 cfs on Horse Creek, the minimum value of the study period.

The USGS gage at Shell Creek has been operational since 1972. Much of the watershed is impounded by a man-made dam, and the creek serves as a potable water source for nearby communities. It has a long-term mean flow 347 cfs and median of 296 cfs. Based on these values, Shell Creek is the most significant contributor of flow to the Peace River, outside of the main stem of the river. The maximum annual average flow for the study period was 821 cfs, in 1995, whereas the minimum annual average of 115 cfs occurred in 2000. In 2007, another major drought year, flows averaged 116 cfs on Shell Creek.

2.9.2 Land Use

The Tidal Peace River watershed land use types are presented in Table 2-1 and in Figure 2-26. While open lands and wetlands have the highest proportions of land use in the Tidal Peace River watershed, significant amounts of developed land exist throughout. The northwestern portion of the watershed is dominated by active or closed phosphate mines and represents the vast majority of the mining land uses in the entire CHNEP watershed. Phosphate mining results in reclaimed area, or large open water pits. Because of the extraction of material from the landscape, reclaimed lands are often at lower topographic elevation than before mining. This may result in on-site storage and reductions in freshwater inflows down river.

The urbanized areas of central Polk County to the north and Port Charlotte to the south also affect segment hydrology and loadings. Large-scale agricultural operations also comprise a major portion of the Tidal Peace River drainage basin, particularly in the south, and may influence surface runoff flows as discussed in the beginning of this section. Many lakes, which are characteristic of the Polk County landscape, are also seen in the northern portion of the segment watershed.

2.9.3 Soils

Soil HSGs of the Tidal Peace River watershed are presented in Figure 2-27. The soil types of the Tidal Peace River are the most diverse of any of the 14 bay segment watersheds in the CHNEP study area. The heavily mined northern areas of the watershed are characterized by Group A soils, with some Group C and D interspersed. This soil distribution is likely to lead to lower runoff rates due to the higher porosity of Group A soils, which consist of sands and gravels, generally. Towards the south, the soils of the Tidal Peace River watershed resemble the rest of the CHNEP watershed: mostly Group D or B/D, with some patches of Group A and C near waterbodies and wetlands. The B/D soils reflect the potential for draining large areas of “open land”, much of which is pasture and rangeland. The lakes which dot the landscape of the northern reach of the watershed are also designated. It should be noted that most of the segment is in SWFWMD, that uses dual HSG classifications (B/D, C/D) and the southwestern portion of the segment is in SFWMD that uses only single HSG classes.

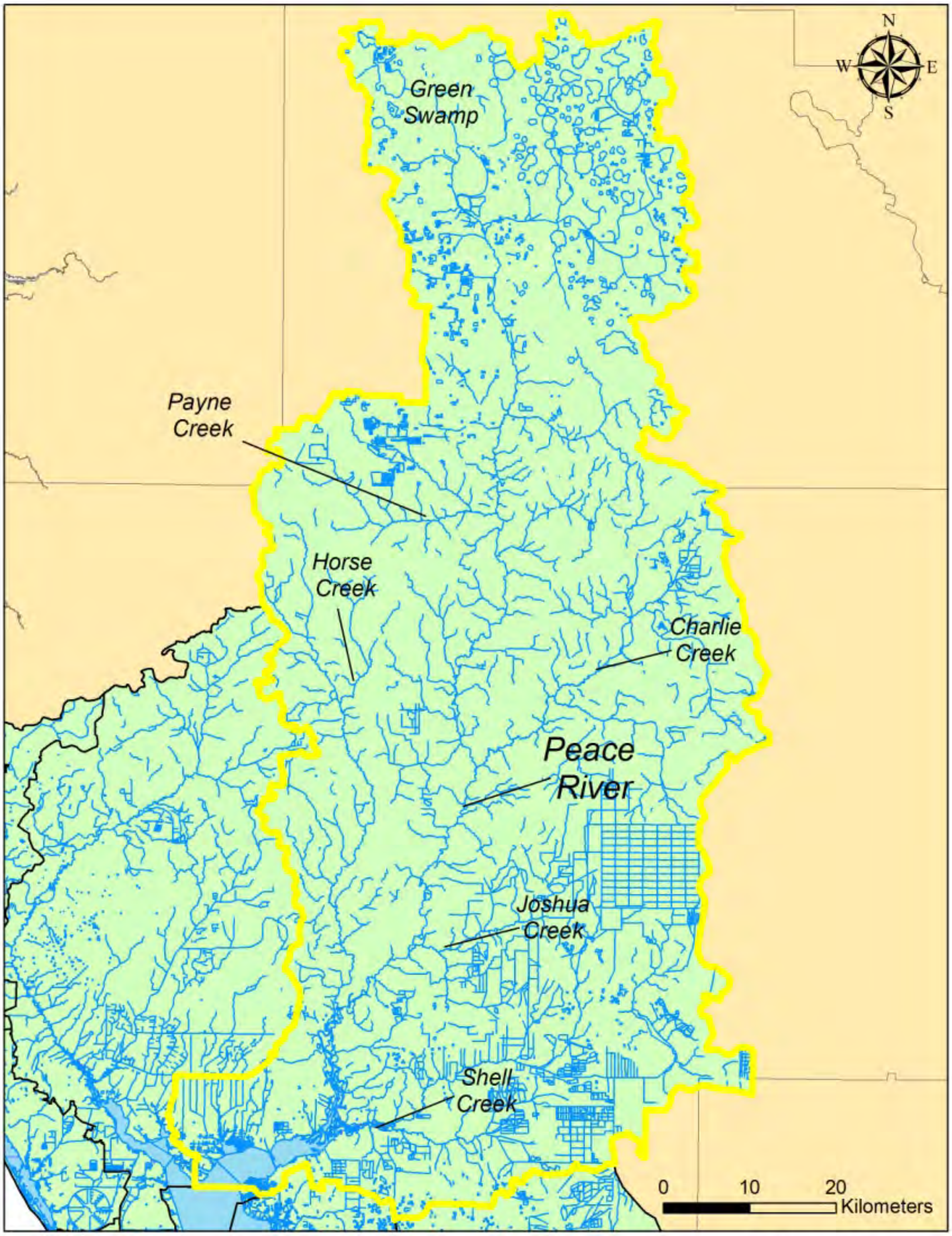

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Figure 2-25. Tidal Peace River – 1:100,000 USGS hydrology.

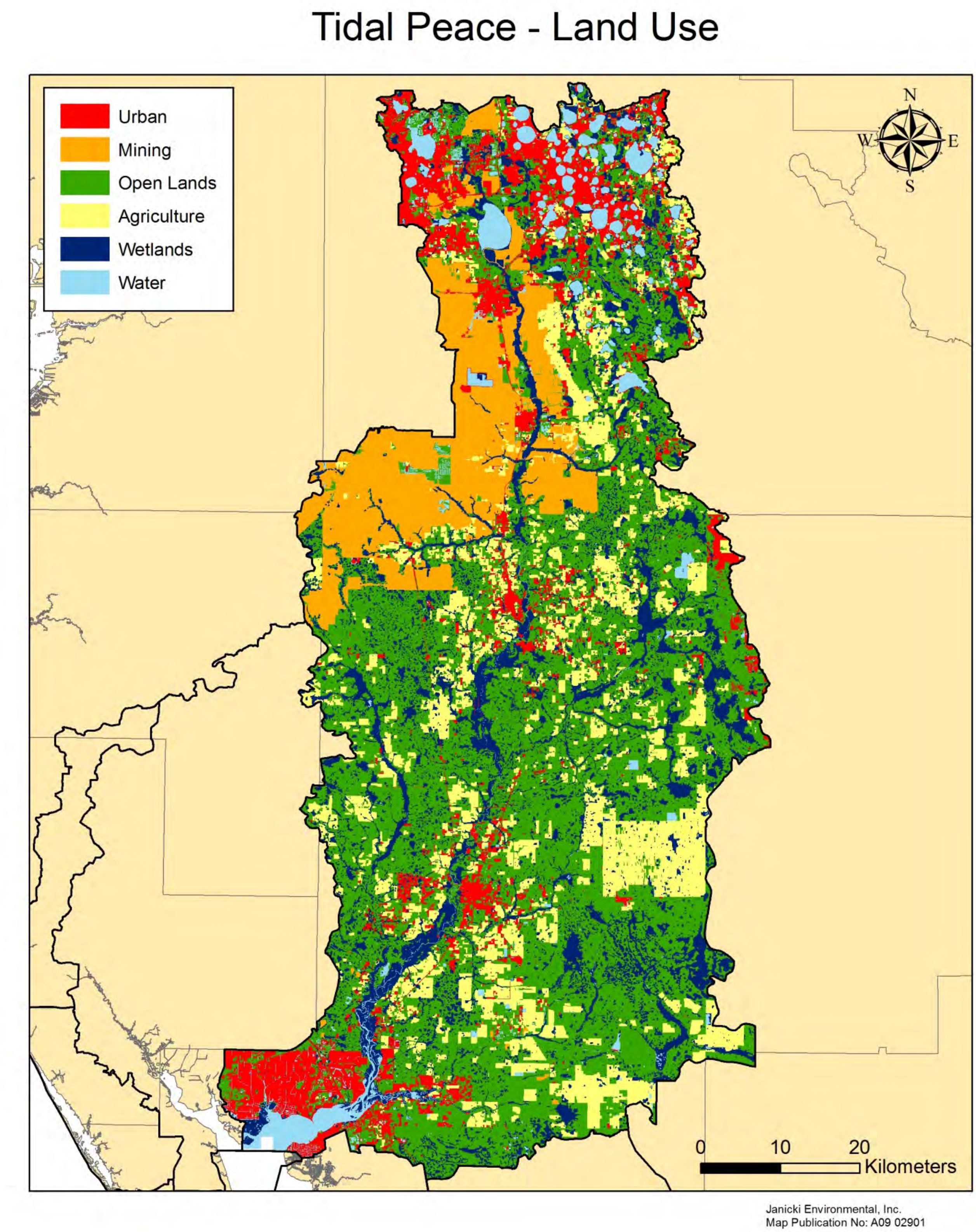

Figure 2-26. Tidal Peace River land use types.

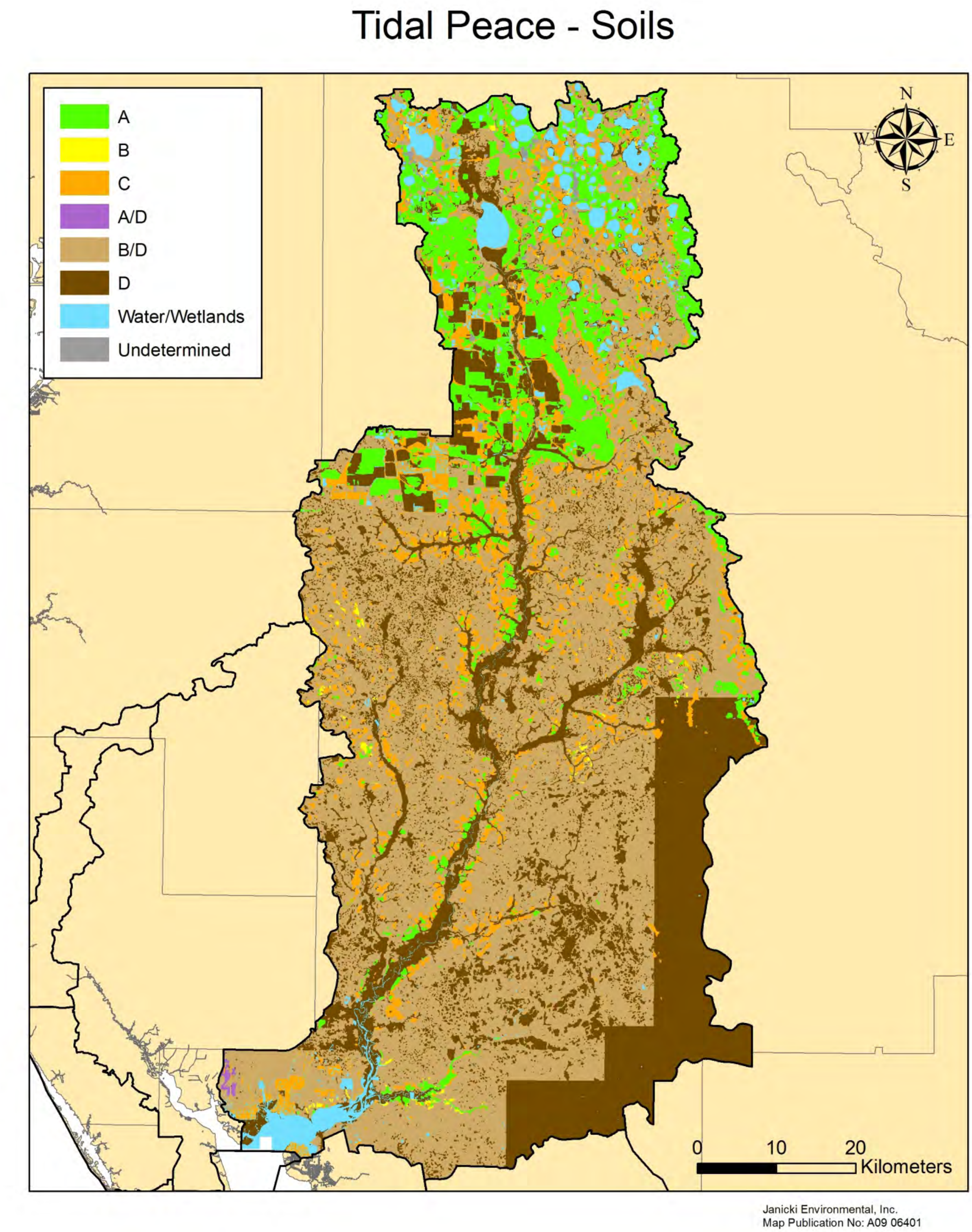

Figure 2-27. Tidal Peace River soil HSGs.

2.10 Pine Island Sound

2.10.1 Hydrology

The Pine Island Sound bay segment consists of the Pine Island Sound estuary and a fringing watershed. It is bounded on the north by the Bokeelia bay segment in Charlotte Harbor, to the east by Pine Island, to the west by various barrier islands and the Gulf of Mexico, and to the south by Sanibel island and San Carlos Bay (Figure 2-28). The surface area of the open water bay segment is approximately 50,483 acres. Its comparatively small watershed, is approximately 19,259 acres, or 30.1 mi^2. This results in a watershed to open water area ratio of 0.4, one of the lowest ratios compared to others in the CHNEP area and generating low runoff per rainfall unit.

With the islands of Pine Island, Captiva, Sanibel, and numerous other smaller barrier islands comprising its surrounding watershed, there are minimal amounts of freshwater entering the bay segment from streams or overland flow. However, with coastal wetlands on either side of Pine Island Sound, freshwater inputs can be received from the watershed when the wetlands become inundated and flow into the open water as sheetflow.

2.10.2 Land Use

The Pine Island Sound watershed land use types are presented in Table 2-1 and in Figure 2-29. Pine Island Sound has a small watershed in relation to the surface area of its bay segment, resulting from the fact that only portions of Pine Island, Sanibel Island, and the coastal barrier islands comprise its watershed.

Within the watershed, wetlands line the coasts, along with urban land. Some open lands and agriculture are located in the central areas of Pine Island on the eastern portion of the watershed, and in the northwest, which is designated as a state park. Like some of the other coastal segment tributary areas, the small watershed area ensures that very little freshwater will enter the estuary directly and the most influence on water quality will be tidal circulation from adjoining estuary segments.

2.10.3 Soils

Soil HSGs of the Pine Island Sound watershed are presented in Figure 2-30. The Pine Island Sound watershed has soils with lower infiltration rates throughout its extent. On the eastern side, on Pine Island proper, Group D soils are prevalent. On the coastal barrier islands to the south and west, which include Captiva and Sanibel, a mix of Group C and D soils are seen. Inland water/wetlands are observed on Pine Island and Sanibel.

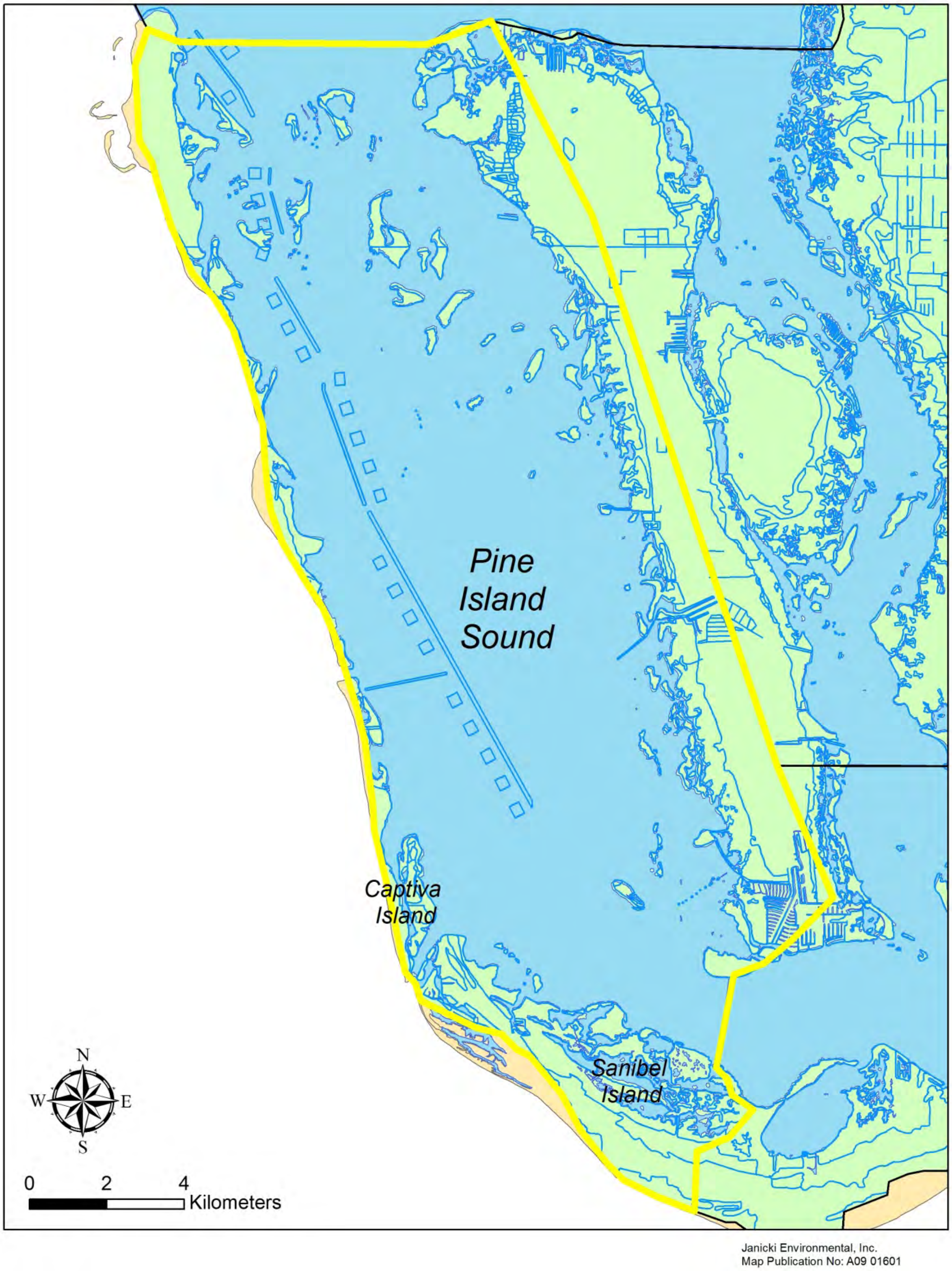

Figure 2-28. Pine Island Sound – 1:100,000 USGS hydrology.

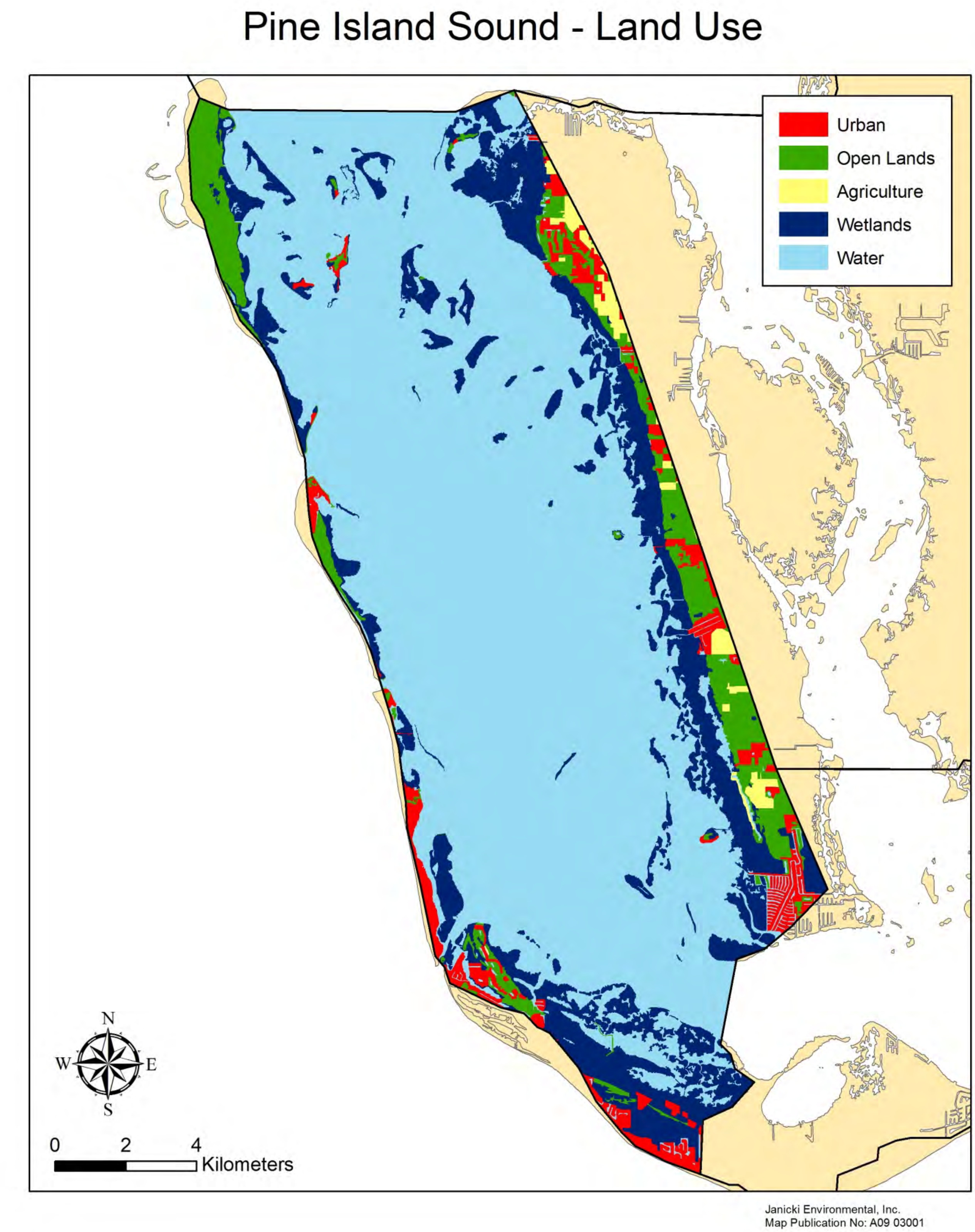

Figure 2-29. Pine Island Sound land use types.

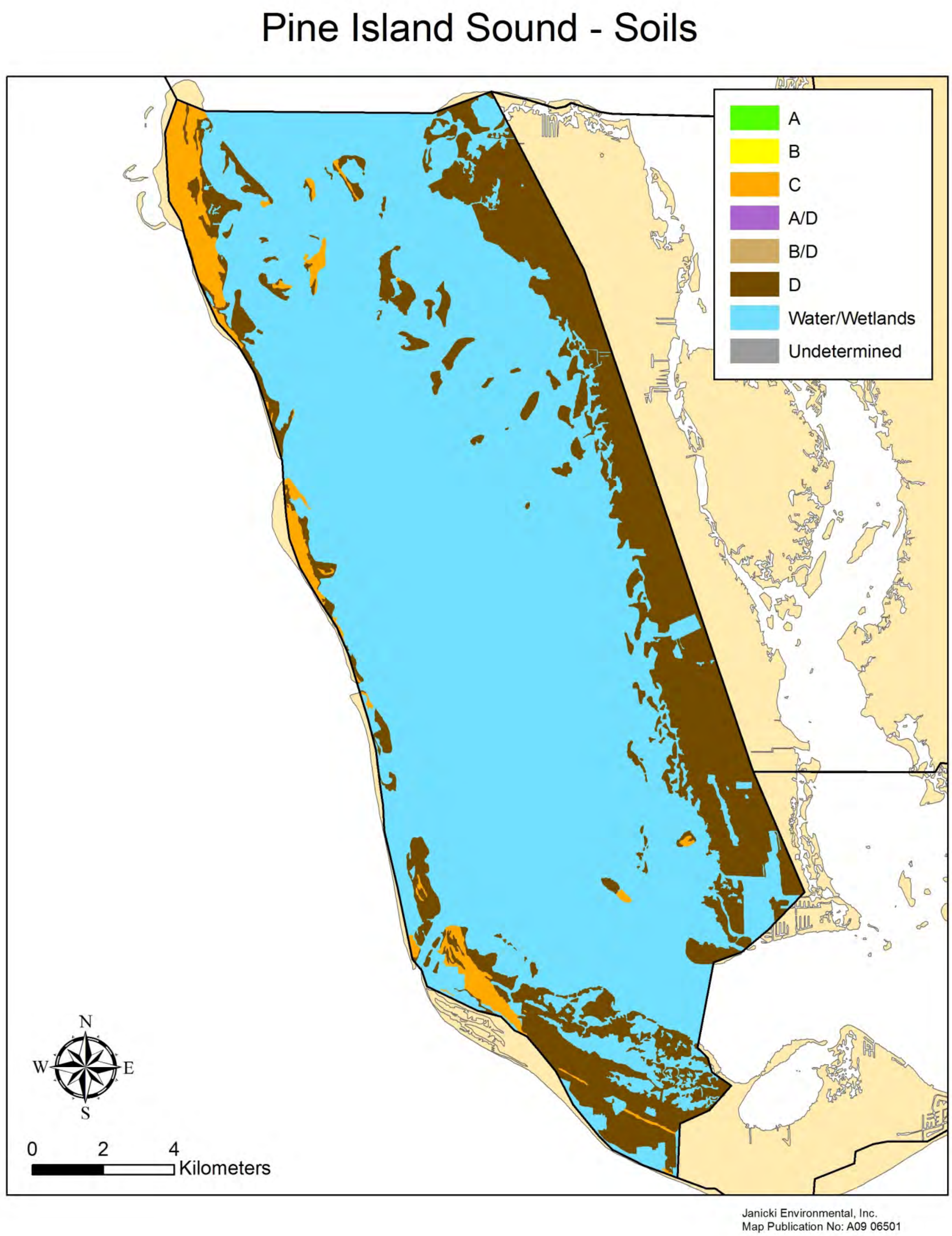

Figure 2-30. Pine Island Sound soil HSGs.

2.11 Matlacha Pass

2.11.1 Hydrology

This bay segment connects Charlotte Harbor to San Carlos Bay at the mouth of the Caloosahatchee River (Figure 2-31). It is bounded on the west by Pine Island and on the east by the City of Cape Coral. Its watershed includes an extensive network of man-made waterways in Cape Coral, which drain into Matlacha Pass. The open water surface area of Matlacha Pass is approximately 13,190 acres, and its watershed is approximately 63,095 acres, or 98.6 mi^2. This results in a watershed to open water area ratio of 4.8, intermediate compared to others in the CHNEP area. The eastern watershed of Matlacha Pass has been heavily altered by human activities. The canal network in Cape Coral includes over 400 miles of navigable waterways, all of which drain either to Matlacha Pass or the Caloosahatchee River to the south (City of Cape Coral, 2009). Many of these canals, such as Gator Slough and Horseshoe, Hermosa, and Shadroe Canals, are controlled by weirs that regulate the passage of water into the coastal wetlands buffering the canals from Matlacha Pass. These structures are particularly useful in times of high flows, where diversions are used to sustain agricultural operations and for wetlands maintenance.

The relatively large watershed and highly channelized conveyance system promote high peak runoff rates during rain events. A “spreader canal” was constructed along the shoreline to intercept runoff from the residential canal system, with the intent of treating and distributing the water to coastal mangroves in the pass via sheet flow over the west side of the canal. The west canal bank has developed a series of breaches that allow water to flow into the mangroves at a few concentrated locations, rather than be evenly distributed along the entire 7-mile canal length.

2.11.2 Land Use

The Matlacha Pass watershed land use types are presented in Table 2-1 and in Figure 2-32. The Matlacha Pass watershed is heavily urbanized, as the City of Cape Coral, the most populous city within the CHNEP watershed, is located on its eastern shore. The coastal urban lands, with the dredged canal system, would be expected to generate significant runoff rates. The control structures in the main canals consist of fixed weirs and cannot be easily raised to retain additional water. Wetlands are prevalent directly along the shores of Matlacha Pass. Open lands are primarily located to the north of the City of Cape Coral, while some small patches of agriculture exist on Pine Island to the west.

2.11.3 Soils

Soil HSGs of the Matlacha Pass watershed are presented in Figure 2-33. The soils of Matlacha Pass are greatly influenced by the network of man-made canals which characterize the City of Cape Coral in the watershed's eastern extent. Large expanses of inland water/wetland soil types are located within otherwise near-uniform coverage by Group D soils. It should be noted that the single HSG "D" designation for the eastern watershed does not reflect the altered drainage capabilities of the soils resulting from the canals. The soils would likely be designated B/D is a dual HSG were used as described in Section 2.0.

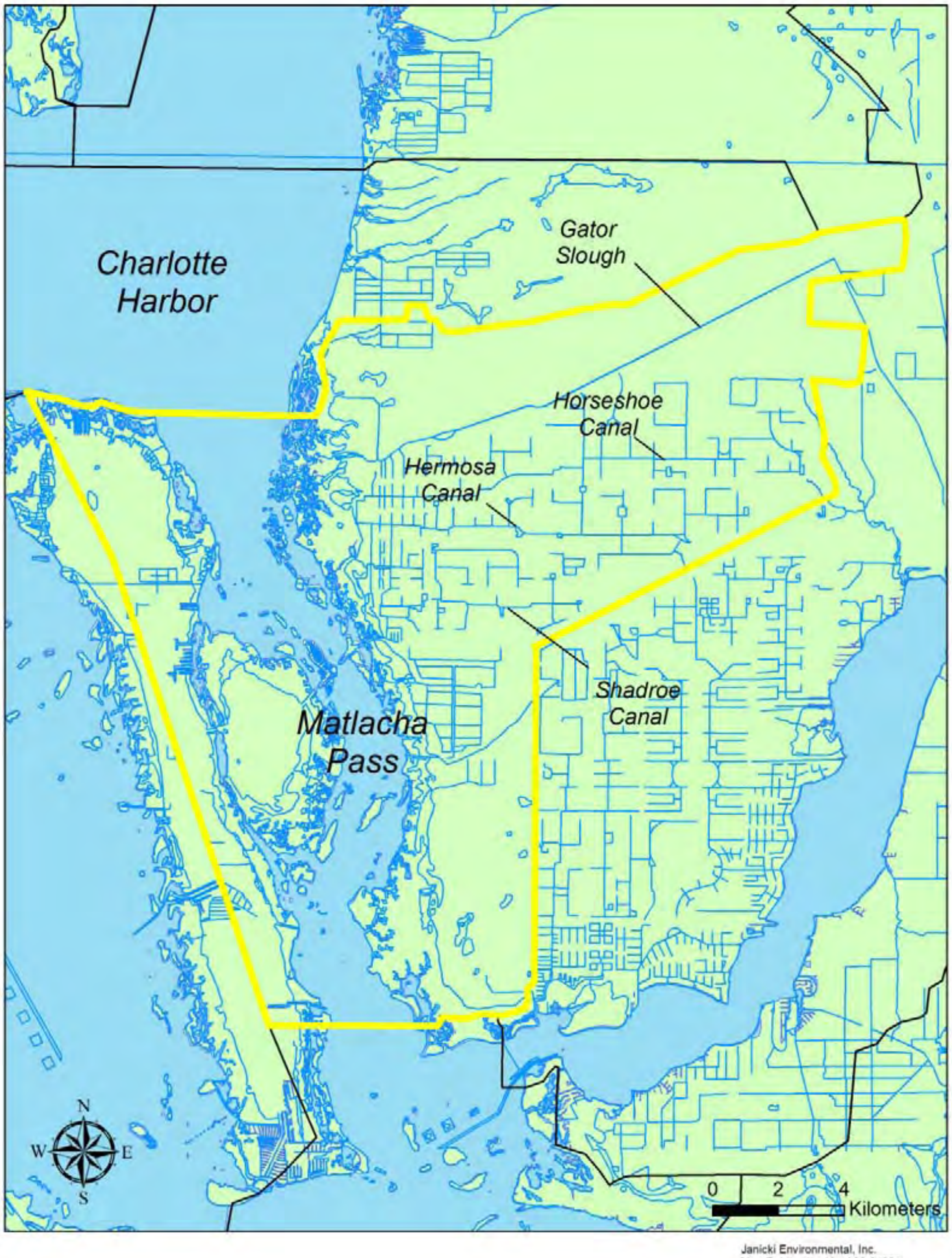

Figure 2-31. Matlacha Pass – 1:100,000 USGS hydrology.

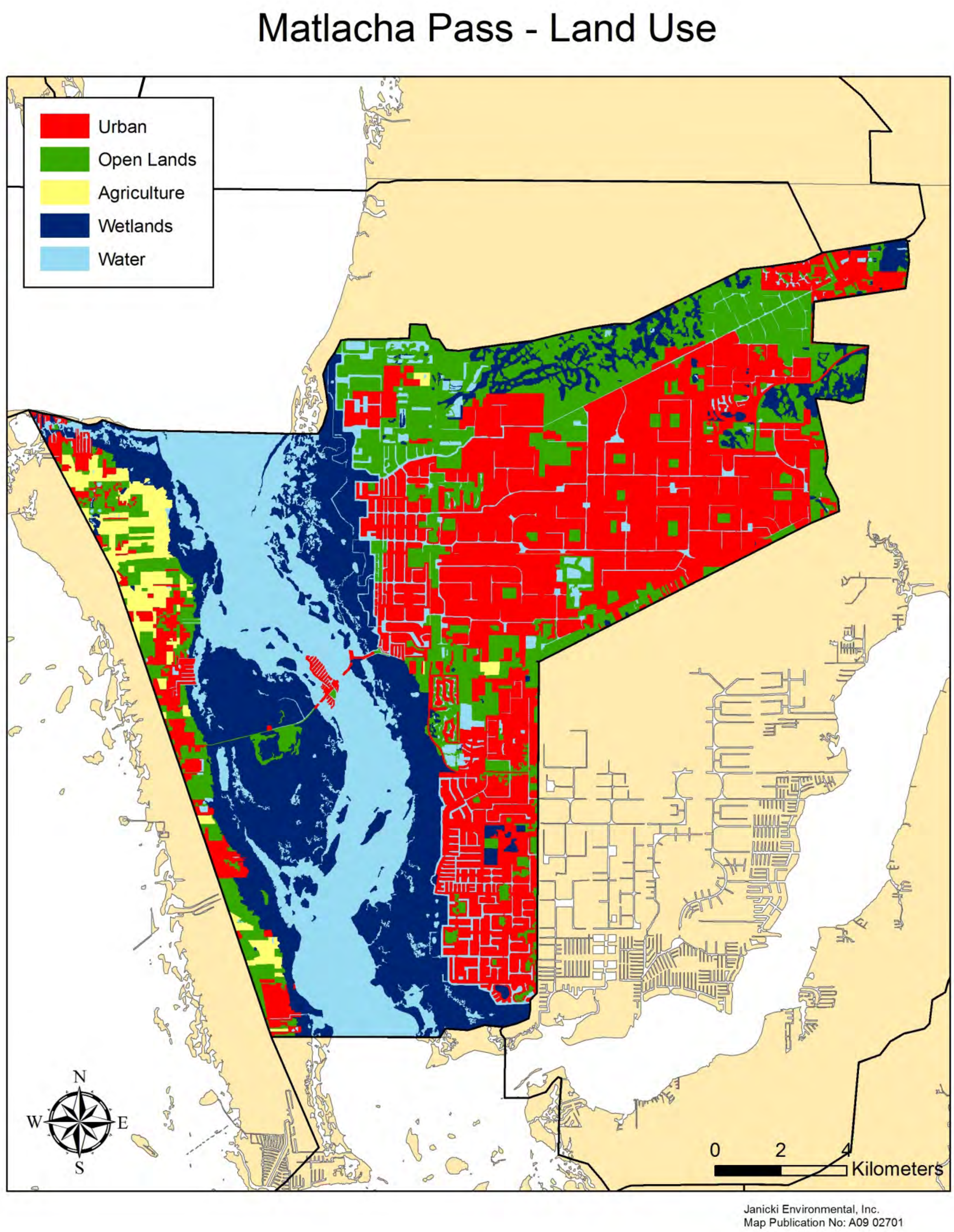

Figure 2-32. Matlacha Pass land use types.

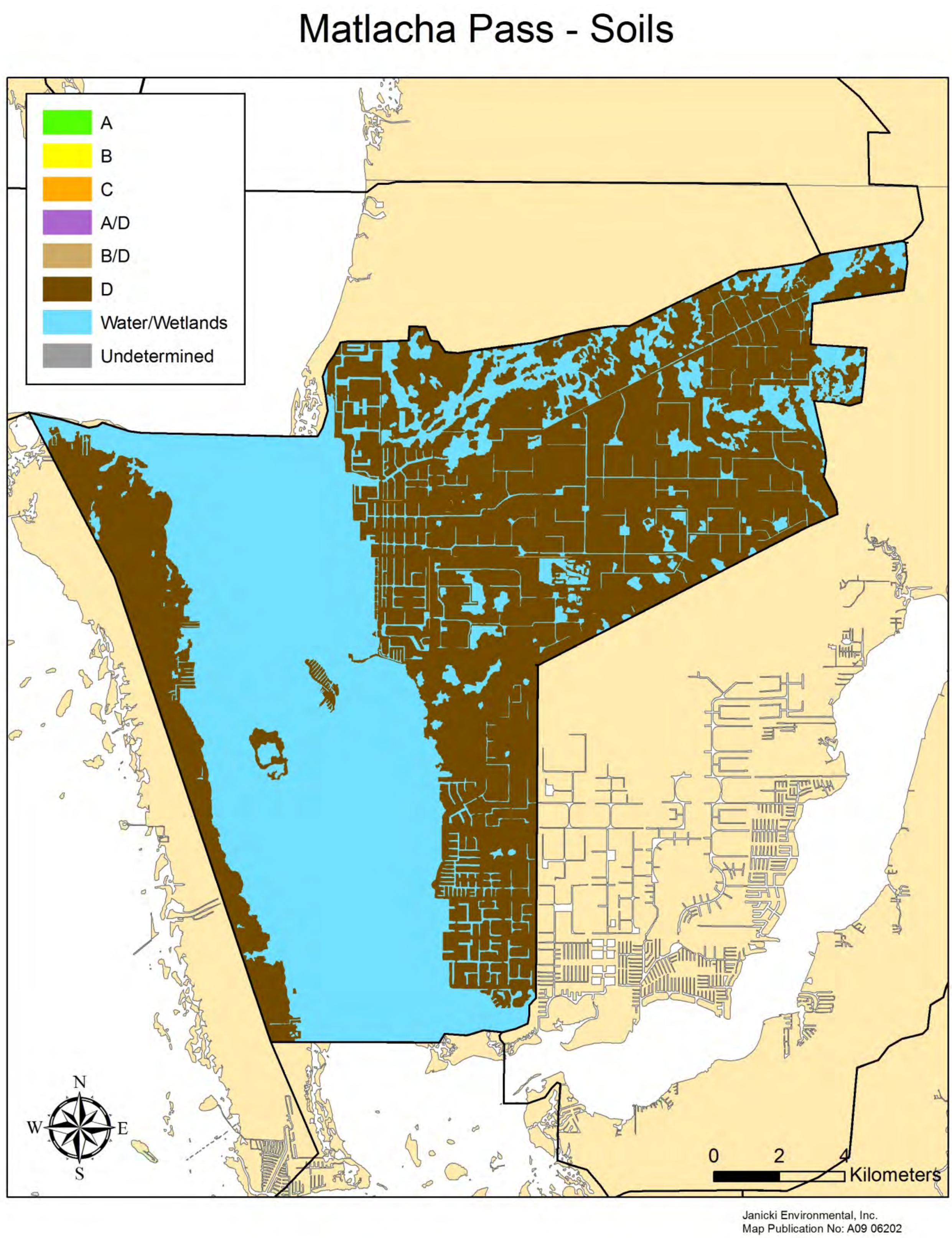

Figure 2-33. Matlacha Pass soil HSGs.

2.12 San Carlos Bay

2.12.1 Hydrology

The San Carlos Bay bay segment is an embayment located between Pine Island Sound to the west, Matlacha Pass to the north, the Caloosahatchee River to the east, and the Gulf of Mexico and Estero Bay to the south (Figure 2-34). Its watershed is comprised of areas of the mainland, Pine Island, and coastal barrier islands. The bay segment has a surface area of approximately 19,921 acres, while the watershed is approximately 11,599 acres, or 18.1 mi^2. This results in a watershed to open water area ratio of 0.6, one of the lower ratios compared to all others in the CHNEP area and generating low runoff per rainfall unit.

The southern boundary of San Carlos Bay, on the Gulf of Mexico, is the largest pass along the outer CHNEP boundary between Estero Bay and Charlotte Harbor proper. This interface factors into the mixing and flushing of the southern open water portion of the CHNEP area. With the freshwater of the Caloosahatchee River and the advective forces coming in from the Gulf of Mexico converging with the waters of the neighboring passes (Pine Island Sound and Matlacha Pass), San Carlos Bay functions as a hydrological crossroads in this region of the CHNEP. Thus inflows from the watershed proper are not significant compared to the other segments' inputs.

2.12.2 Land Use

The San Carlos Bay watershed land use types are presented in Table 2-1 and in Figure 2-35. The San Carlos Bay bay segment has a relatively small watershed in relation to its open water surface area. Wetlands, the largest non-water land use type, are located along the shore and near-shore areas, with small pockets of open lands generally located proximal to these wetlands. The urban land uses are seen at the southern tip of Pine Island, Sanibel Island, and the western tip of the Florida mainland, the latter of which represents the western extent of the communities of Fort Myers and Fort Myers Beach.

2.12.3 Soils

Soil HSGs of the San Carlos Bay watershed are presented in Figure 2-36. The San Carlos Bay watershed is largely covered by wetlands. The predominant soil types in the watershed are Group D soils, with some portions of Sanibel also covered by Group C soils. A generally high rate of runoff can be expected throughout the San Carlos Bay watershed. Like other segments in SFWMD jurisdiction, soils with A "D" HSG would likely be classified as B/D if a dual system HSG was used.

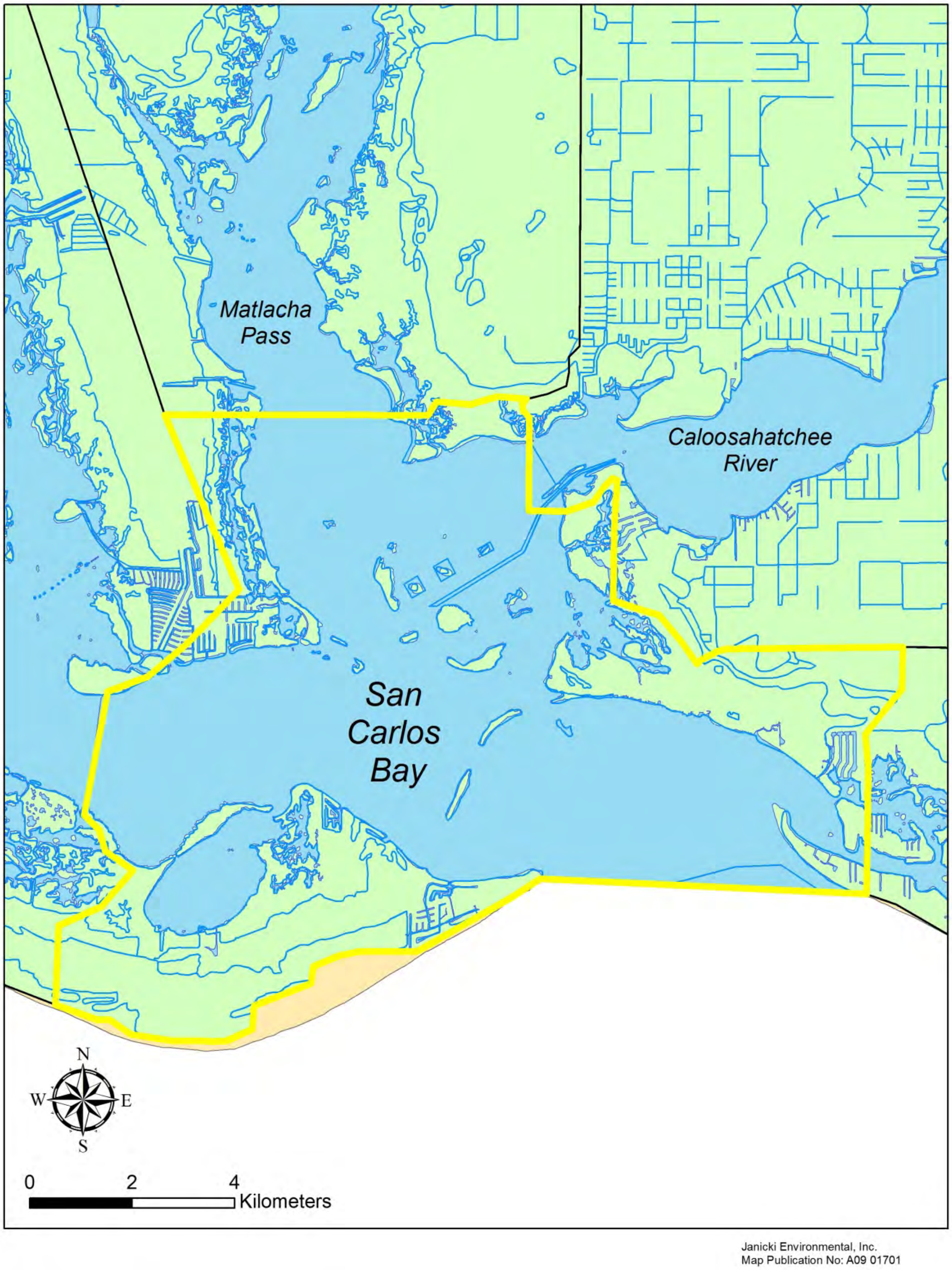

Figure 2-34. San Carlos Bay – 1:100,000 USGS hydrology.

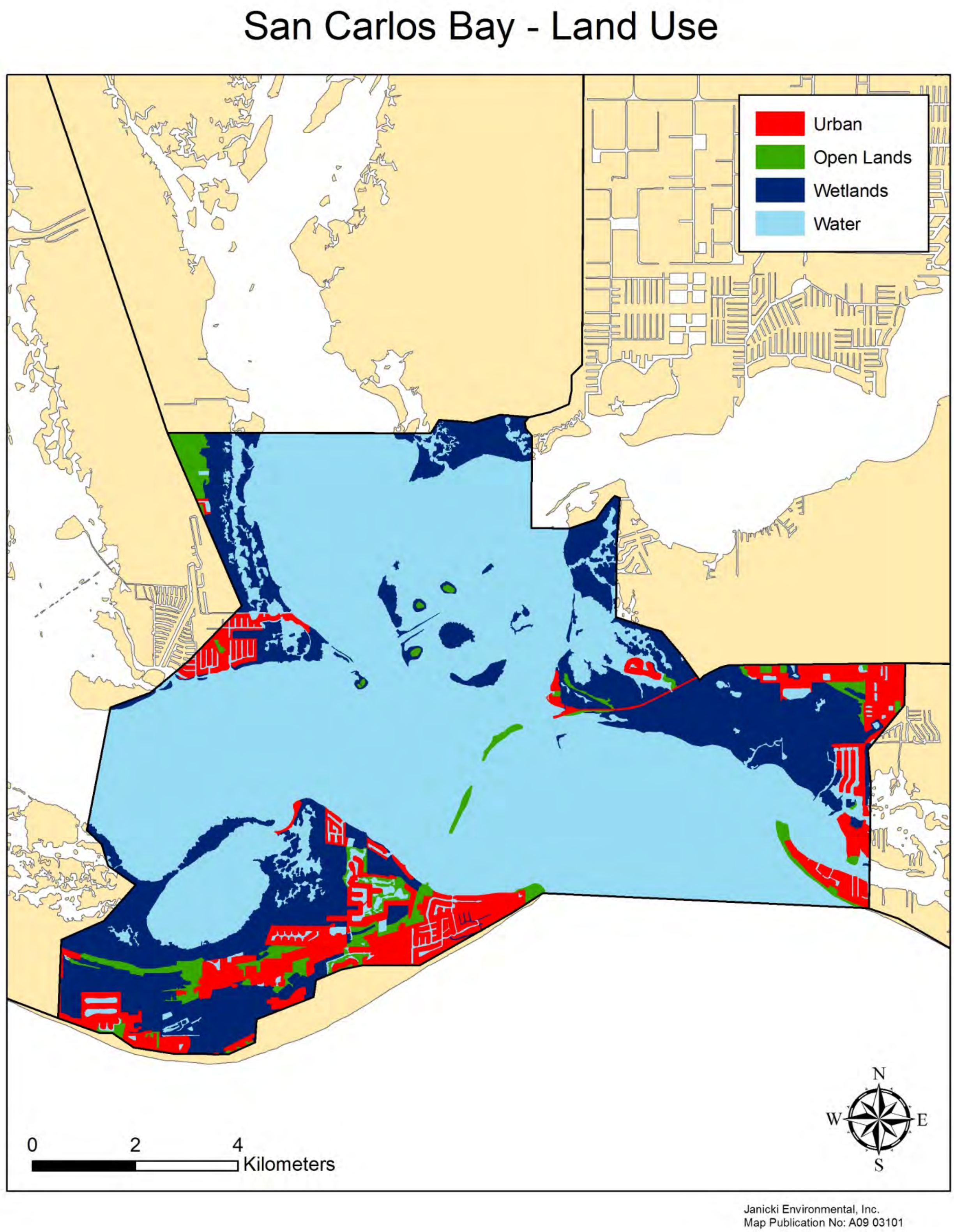

Figure 2-35. San Carlos Bay land use types.

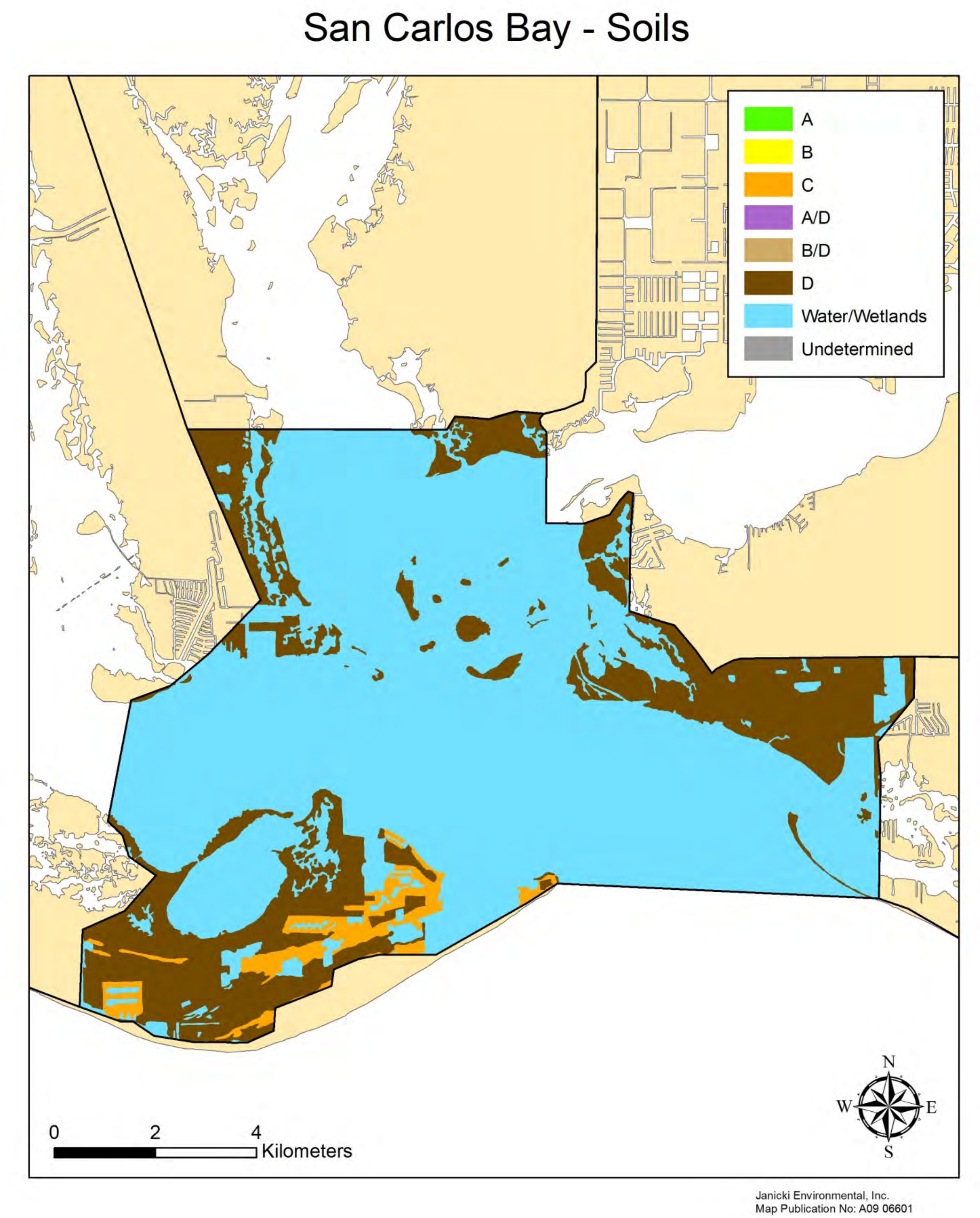

Figure 2-36. San Carlos Bay soil HSGs.

2.13 Tidal Caloosahatchee River

2.13.1 Hydrology

The Tidal Caloosahatchee River bay segment's dominant feature is the estuarine portion of the Caloosahatchee River, which drains to the west into San Carlos Bay (Figure 2-37). The bay segment proper is approximately 16,760 acres, while the watershed is approximately 356,477 acres, or 557 mi^2. This results in a watershed to open water area ratio of 20, one of the higher ratios compared to others in the CHNEP area. However, this ratio is not valid for comparison with other segments because flows include discharges from Lake Okeechobee which is outside the historical watershed.

The Caloosahatchee River is a major freshwater input into the estuarine waters of San Carlos Bay. The flows on the Caloosahatchee River are controlled by a structure known as S-79 at the far eastern boundary of the Tidal Caloosahatchee River watershed. A series of canals link Lake Okeechobee to the Caloosahatchee River. Flows at S-79 are regulated in order to help manage water levels on Lake Okeechobee, thus river flows are not directly proportional to local rainfall. The Orange River is a major tributary to the Caloosahatchee River, which also has several smaller streams and man-made canals draining into it on its northern bank. Telegraph Swamp is a large wetland located in the upstream portion of the watershed.

The USGS flow gage at S-79 on the Caloosahatchee River has been operating since 1967. Over the period of record, S-79 has a long-term mean flow of 1,731 cfs and a median flow of 1,316 cfs. The maximum mean annual flow for the period of 1995-2007 occurred in 2005 and was recorded as 5,166 cfs. The minimum mean annual flow (131 cfs) occurred in a drought year, 2007. The additional flows from Lake Okeechobee make this segment a major source of freshwater.

2.13.2 Land Use

The Tidal Caloosahatchee River watershed land use types are presented in Table 2-1 and in Figure 2-38. Urban land is located nearest to the Caloosahatchee River and open lands and wetlands are more common as distance increases from the Caloosahatchee River. The large cities of Cape Coral and Fort Myers are on the northern and southern banks, respectively, of the Tidal Caloosahatchee River bay segment. The largest agricultural areas are seen in the northern and eastern portions of the watershed, as urban development becomes less marked. As with other coastal basins, urban growth close to the estuary will have a greater impact on pollutant loading than inland development. Because of the relatively large watershed and high ratio of coastal urban development in the Tidal Caloosahatchee River, this watershed should be considered a major pollutant loading source to the system.

2.13.3 Soils

Soil HSGs of the Tidal Caloosahatchee River watershed are presented in Figure 2-39. Group D soils (SFWMD classification) are located throughout the Tidal Caloosahatchee River watershed, leading to high runoff rates in this drainage basin. Water/wetlands extend northward from the Caloosahatchee River, specifically in the canal-rich areas of the City of Cape Coral. Small pockets of soils with lower runoff potential can be observed along the banks of the Caloosahatchee River in the eastern portion of the watershed.

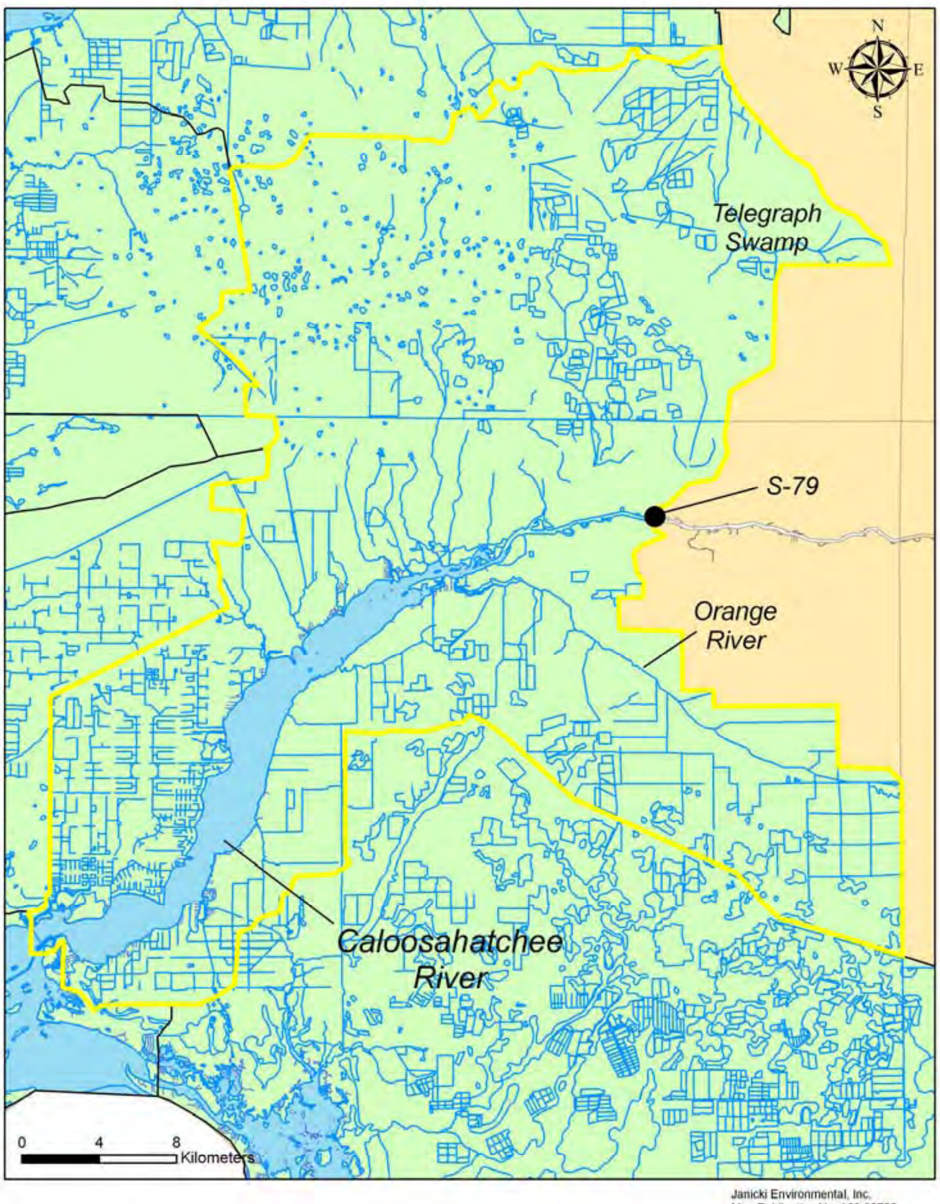

Figure 2-37. Tidal Caloosahatchee River – 1:100,000 USGS hydrology.

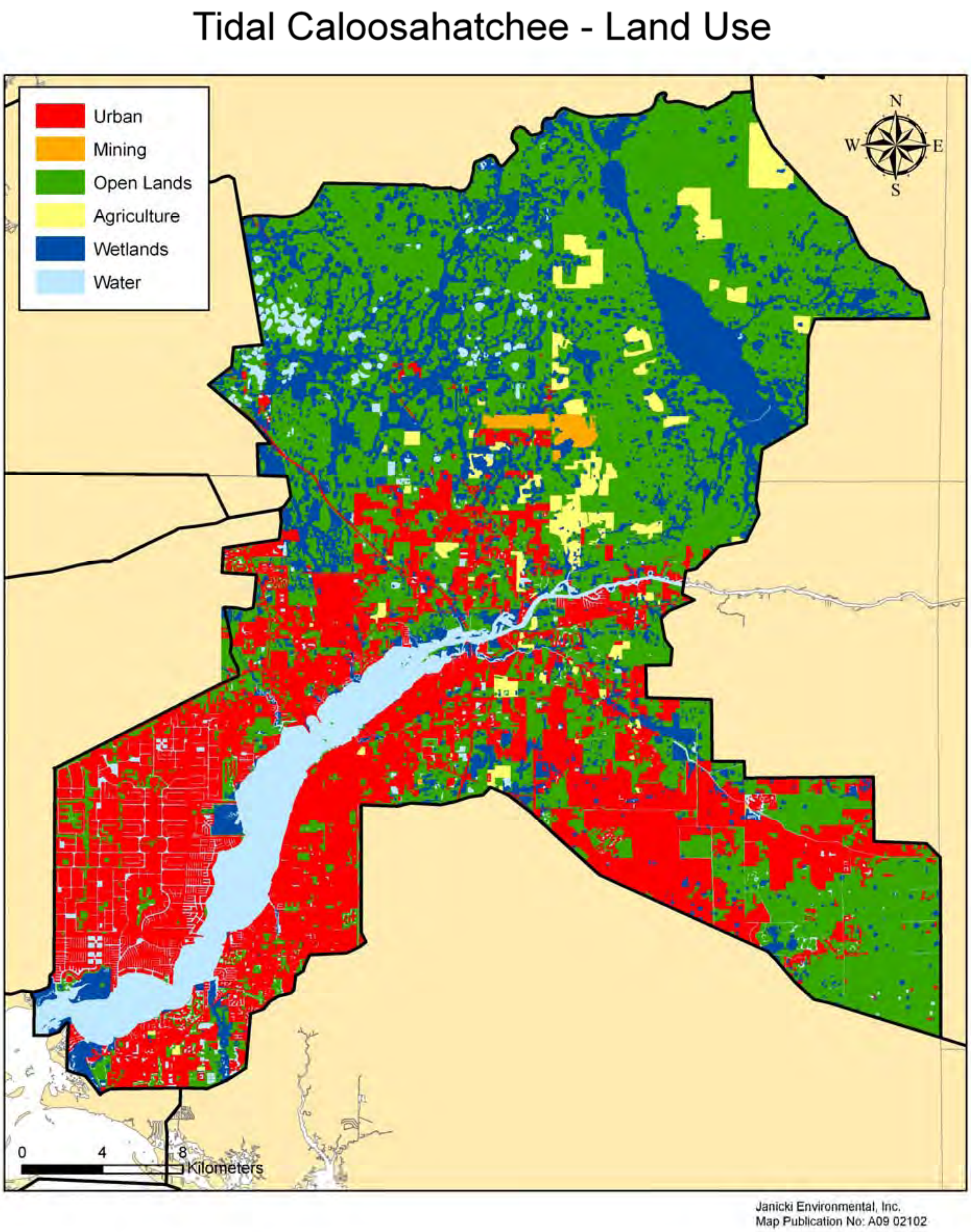

Figure 2-38. Tidal Caloosahatchee River land use types.

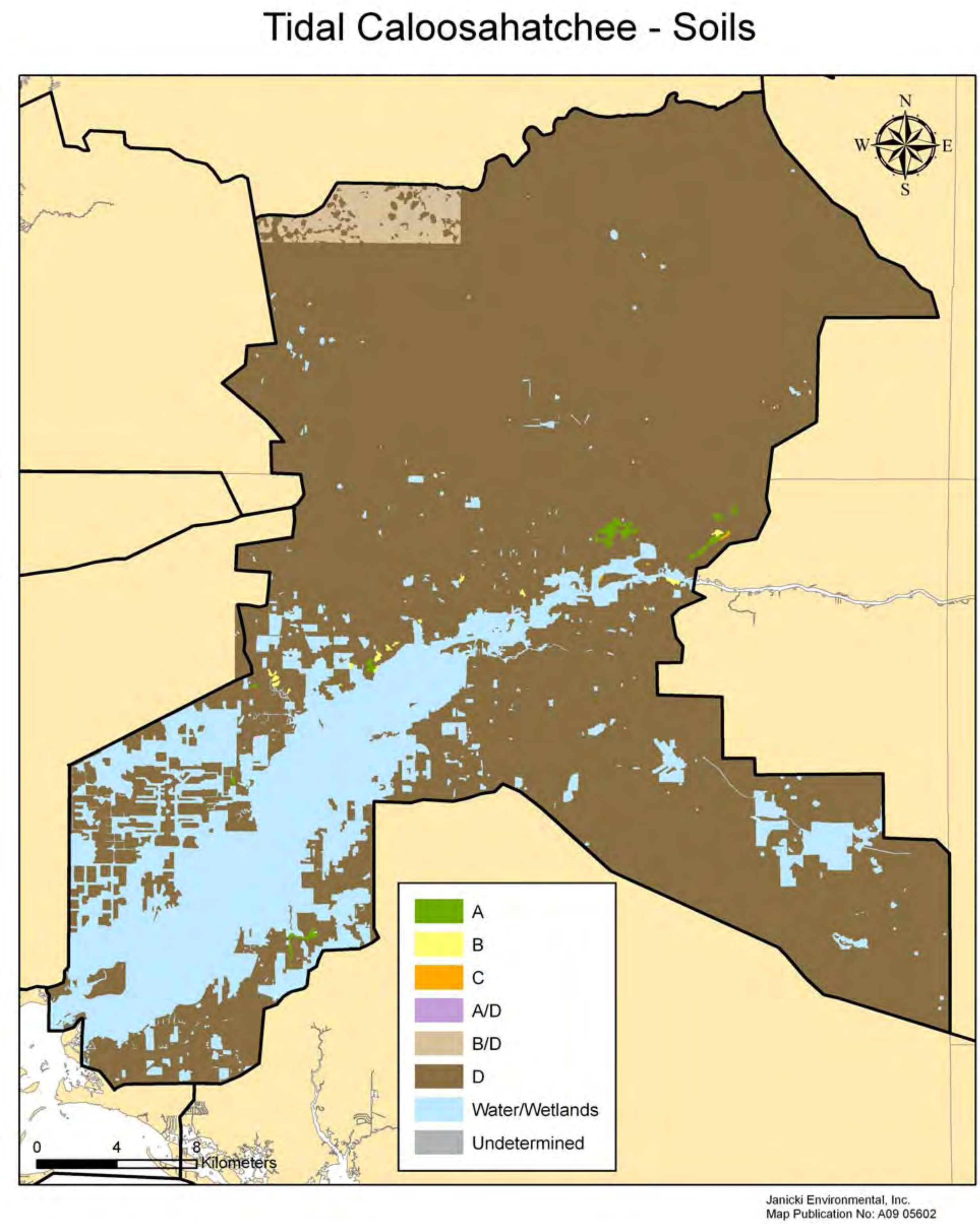

Figure 2-39. Tidal Caloosahatchee River soil HSGs.

2.14 Estero Bay

2.14.1 Hydrology

The Estero Bay bay segment is bounded on the north by San Carlos Bay and is the southernmost of the 14 bay segments in the CHNEP watershed (Figure 2-40). The Estero Bay bay segment surface area is approximately 10,813 acres, with its watershed covering approximately 229,671 acres, or 359 mi^2. This results in a watershed to open water area ratio of 21, relatively high compared to others in the CHNEP area and generating moderate runoff per rainfall unit.

Estero Bay, like Lemon Bay, is a coastal lagoon that has limited connectivity with the Gulf of Mexico on the west. Four rivers, which function as freshwater inputs to Estero Bay, drain into the estuary: Estero River, Imperial River, Six Mile Cypress, and Ten Mile Canal. Coastal wetlands along the shores of Estero Bay augment hydrologic inputs to the system. The watershed is also characterized by a large network of man-made canals serving the communities throughout the Estero Bay drainage basin.

2.14.2 Land Use

The Estero Bay watershed land use types are presented in Table 2-2 and in Figure 2-41. Wetlands cover the largest amount of surface area in the Estero Bay watershed, with large numbers of wetlands located on the eastern shores of Estero Bay and along the southern and eastern boundaries of the drainage basin.

Open lands are the next most prevalent land use, and are located nearly evenly throughout the watershed. The urban areas of Fort Myers and Estero are located in the western portion of the watershed and to the east of Estero Bay proper. Agriculture becomes a significant land use east of these communities, with some pockets of mining also located in this region.

2.14.3 Soils

Soil HSGs of the Estero Bay watershed are presented in Figure 2-42. The soils of Estero Bay are largely of the Group D type (SFWMD classification), indicating high runoff potential throughout the Estero Bay watershed. Soils of higher porosity (Groups A, B, and C) are located closer to Estero Bay proper, although sporadically in this region. Some areas if inland water/wetlands are also observed away from Estero Bay.

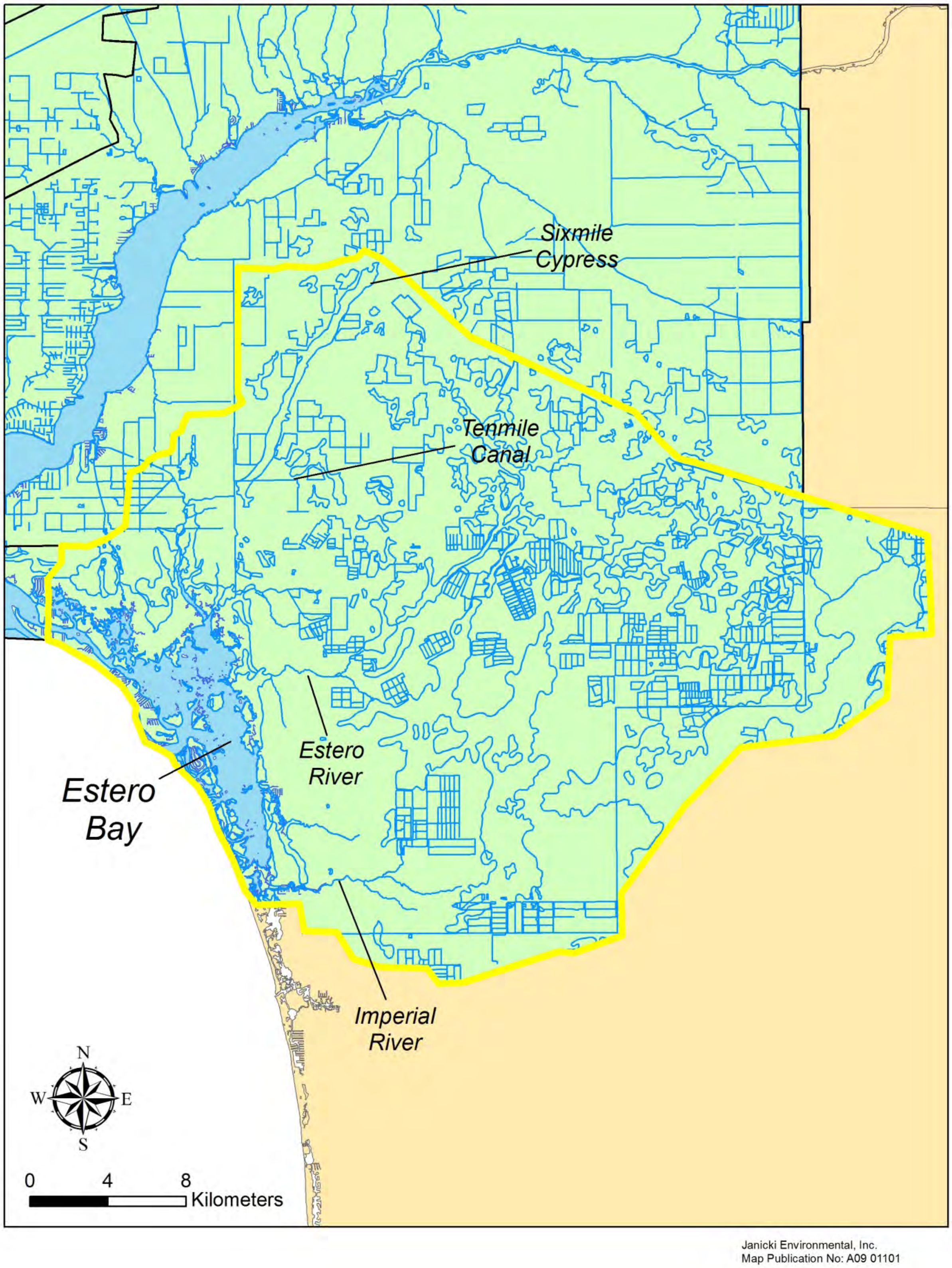

Figure 2-40. Estero Bay – 1:100,000 USGS hydrology.

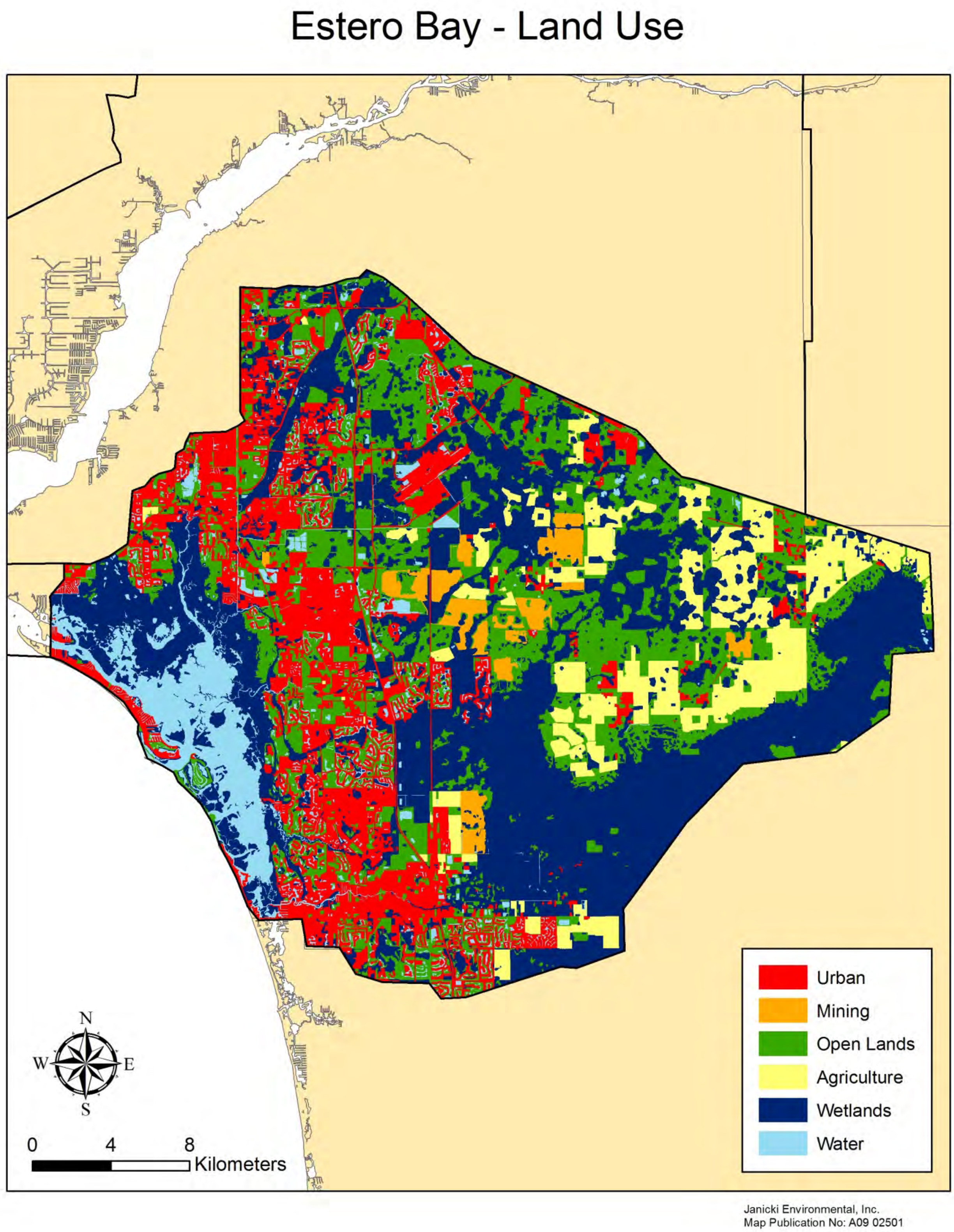

Figure 2-41. Estero Bay land use types.

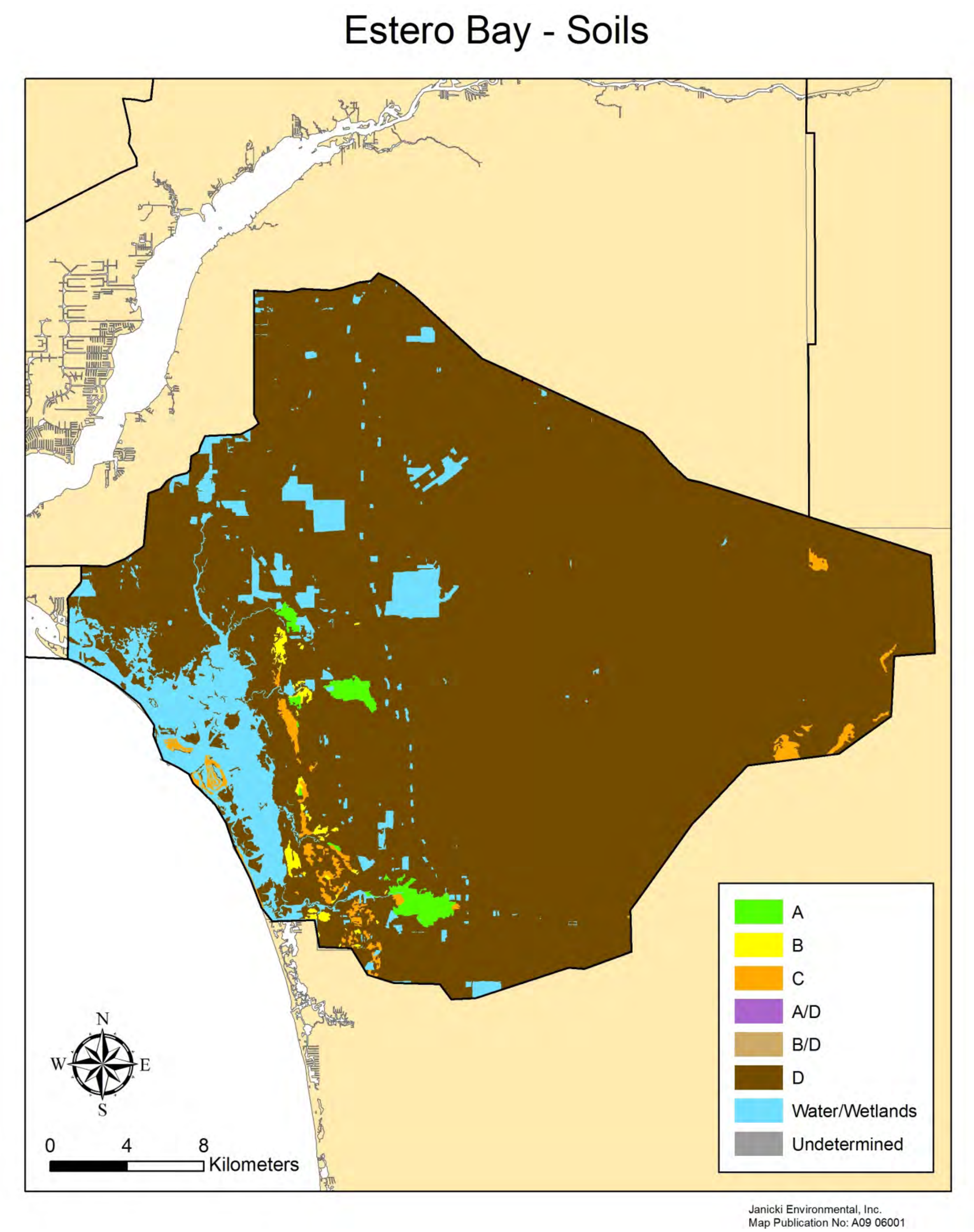

Figure 2-42. Estero Bay soil HSGs.

3 METHODS

This section summarizes the methods utilized to estimate hydrologic and pollutant loadings from each source category for each segment of the CHNEP.

3.1 Identification of Sources

As in previous loading estimates performed for Charlotte Harbor, Lemon Bay, and Tampa Bay (Zarbock et al., 1994; 1996; Coastal Environmental, 1995; Pribble et al., 2001; Poe et al., 2005; Janicki Environmental, 2008a; Jones Edmunds, 2009), loadings of total nitrogen (TN), total phosphorus (TP), total suspended solids (TSS), and biochemical oxygen demand (BOD) were developed for several sources.

The “total load” to each segment is the sum of the direct atmospheric deposition load to the segment water surface and loads from the segment watershed (“watershed load”). Loads from the watershed include those from nonpoint sources, septic tanks, and point sources. Thus, the categories of total loading sources examined were:

- wet and dry atmospheric deposition,
- nonpoint sources,
- septic tanks, and
- domestic and industrial point sources.

Annual and monthly loadings were estimated for each segment for the 1995-2007 period from all applicable sources. Previous loading estimates for the CHNEP (Coastal Environmental, 1995) included estimates of groundwater and springs loadings to the estuary. The contributions of loadings from these sources were negligible, 0.5% or less of the total load to the system. Therefore, loadings from groundwater and springs were not estimated for this current effort. The methods used to develop the loading estimates are provided below.

3.2 Atmospheric Deposition Loads

Total atmospheric deposition is defined as the sum of wet deposition (rainfall) and dry deposition (gaseous constituent interaction and dust fallout) directly to the estuarine water surface of each bay segment.

There are three data types needed to estimate total atmospheric deposition:

- an estimate of the hydrologic load directly to each segment via precipitation;
- an estimate of the pollutant concentration in that precipitation; and
- an estimate of dry deposition, either from empirical data or model-based estimates, to each segment.

The segment-specific hydrologic load to the surface of each segment via precipitation was estimated in the same manner used in previous loading estimates for Charlotte Harbor, Lemon Bay, and Tampa Bay (Zarbock et al., 1994 and 1996; Coastal Environmental, 1995; Pribble et al., 2001; Poe et al., 2005; Janicki Environmental, 2008a; Jones Edmunds, 2009). To estimate total precipitation to each segment surface, an inverse distance-squared method was applied to data from 23 National Weather Service (NWS), 24 Southwest Florida Water Management District (SWFWMD), and 22 South Florida Water Management District (SFWMD) rainfall monitoring sites in or near the Charlotte Harbor National Estuary Program watershed. This method of estimating rainfall to a segment accounts for regional patterns while giving more emphasis to local conditions. Total monthly precipitation data were obtained from the long-term stations identified in Table 3-1. The locations of these stations are provided in Figure 3-1. It should be noted that some of the stations listed in Table 3-1 that were used to estimate precipitation are located outside the CHNEP area. These stations were used to bracket the spatial area of interest and to reduce potential “edge effects” for areas along the CHNEP boundary. Total monthly precipitation values were estimated for each segment for the 1995-2007 period.

Using this method the total monthly precipitation for each segment was computed as follows:

$$\hat{p}_j = \frac{\sum_{k=1}^{K_j} p_k \left(\frac{1}{D_k^2} \right)}{\sum_{k=1}^{K_j} \left(\frac{1}{D_k^2} \right)}$$

where

$\hat{p}_j$ = estimated total monthly precipitation for the jth segment’s water surface,

K_j = number of rainfall stations within 50 kilometers of the geographic center of the jth segment,

p_k = total monthly precipitation at the kth rainfall station, and

D_k = the distance (meters) between the geographic center of the jth segment and the kth rainfall station.

TN concentrations in precipitation were obtained from the National Atmospheric Deposition Program (NADP) Verna Wellfield site in north-central Sarasota County, shown in Figure 3-1. This is the nearest site providing long-term data of nitrogen concentration in rainfall.

To estimate wet deposition of phosphorus and dry deposition of both nitrogen and phosphorus, ratios and relationships developed from the Tampa Bay Atmospheric Deposition Study (TBADS) were utilized. This program, that continued to run from 1996 to 2006, included sampling of both wet and dry deposition at an intensive monitoring site located on the Gandy Bridge Causeway adjacent to Middle Tampa Bay.

Table 3-1. Precipitation stations in the CHNEP area used to estimate rainfall.

Site Name	Site ID	Agency
Arcadia	080228	NWS
Archbold Biological St.	080236	NWS
Avon Park 2 W	080369	NWS
Bartow	080478	NWS
Bradenton 5 ESE	080945	NWS
Clermont 9S	081641	NWS
DeSoto City 8SW	082288	NWS
Devils Garden	082298	NWS
Ft. Green 12 WSW	083153	NWS
Fort Myers FAA/AP	083186	NWS
Kissimmee 2	084625	NWS
La Belle	084662	NWS
Lake Alfred Exp Stn	084707	NWS
Lakeland 2	084802	NWS
Moore Haven Lock 1	085895	NWS
Mountain Lake	085973	NWS
Myakka River SP	086065	NWS
Parrish	086880	NWS
Plant City	087205	NWS
Punta Gorda 4 ESE	087397	NWS
Venice	089176	NWS
Wauchula	089401	NWS
Winter Haven	089707	NWS
951EXT_R	951EXT_R	SFWMD
ALVA_FAR_R	ALVA_FAR_R	SFWMD
BCBNAPLE_R	BCBNAPLE_R	SFWMD
BIRPWS2	BIRPWS2	SFWMD
COCO1_R	COCO1_R	SFWMD
COCO3_R	COCO3_R	SFWMD
CORK_HQE	CORK_HQE	SFWMD
CORK_R	CORK_R	SFWMD
FPWX	FPWX	SFWMD
GTRSLU_R	GTRSLU_R	SFWMD
LABELLE_R	LABELLE_R	SFWMD
NAPLES_R	NAPLES_R	SFWMD
POPASH_R	POPASH_R	SFWMD
S47B_R	S47B_R	SFWMD
S70_R	S70_R	SFWMD
S75_R	S75_R	SFWMD
S75WX	S75WX	SFWMD

Table 3-1. Precipitation stations in the CHNEP area used to estimate rainfall.

Site Name	Site ID	Agency
S78_R	S78_R	SFWMD
S79_R	S79_R	SFWMD
SLEE_R	SLEE_R	SFWMD
VENUS_R	VENUS_R	SFWMD
WHIDDEN3_R	WHIDDEN3_R	SFWMD
ROMP 48 THATCHER	1054	SWFWMD
ROMP 87 PROVIDENCE	1254	SWFWMD
ROMP 60 MULBERRY	1314	SWFWMD
ROMP 123 STARLING	1374	SWFWMD
ROMP 31 CARLTON	1434	SWFWMD
ROMP TR 7-1 BOWLEES CREEK	1454	SWFWMD
ROMP 23 MYAKKA CITY	1474	SWFWMD
ROMP 28X LAKE PLACID	1494	SWFWMD
ROMP TR 5-1 LAUREL PARK	1514	SWFWMD
ROMP 19 MACARTHUR	1534	SWFWMD
ROMP 17 (HORSE CREEK)	1554	SWFWMD
ROMP 16 (JOSHUA CREEK)	1574	SWFWMD
ROMP TR 3-1 PT LONESOME	1594	SWFWMD
ROMP 11 SHELL CREEK	1614	SWFWMD
BAKER CANAL	1734	SWFWMD
LAKE HAMILTON	1754	SWFWMD
LAKE HANCOCK	1774	SWFWMD
LAKE HENRY	1814	SWFWMD
ROMP 89 GREEN SWAMP	1834	SWFWMD
ROMP 61 LAKE MEDARD	1854	SWFWMD
ROMP 88 ROCK RIDGE	1874	SWFWMD
LAKE GIBSON	2434	SWFWMD
COLEY	6070	SWFWMD
LK THONOTOSASSA FLINT CRK	6814	SWFWMD

The TBADS provides an estimate of the ratio of dry-to-wet deposition, and TN and TP data from this study were used to develop a relationship between TN and TP deposition. The ratio of dry-to-wet deposition and the relationship between TN and TP deposition were assumed to be the same for the data collected at the Verna Wellfield site for the purposes of estimating deposition to the CHNEP area.

The equation for wet deposition of nitrogen by segment and month is:

$$Nwet_{m,s}=[N]_m * H_{m,s},$$

where:

$Nwet_{m,s}$ = wet deposition of nitrogen (kg/month) for each month *m* and segment *s*,

$[N]_m$	=	mean precipitation-weighted nitrogen concentration (g/m^3) in the rainfall measured at the Verna Wellfield for 1995 through 2007, for each month *m*, and
$H_{m,s}$	=	estimated hydrologic load (m^3/month) from rainfall for each month *m* and segment *s*.

Dry deposition was estimated using the TBADS-derived seasonal dry-to-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:

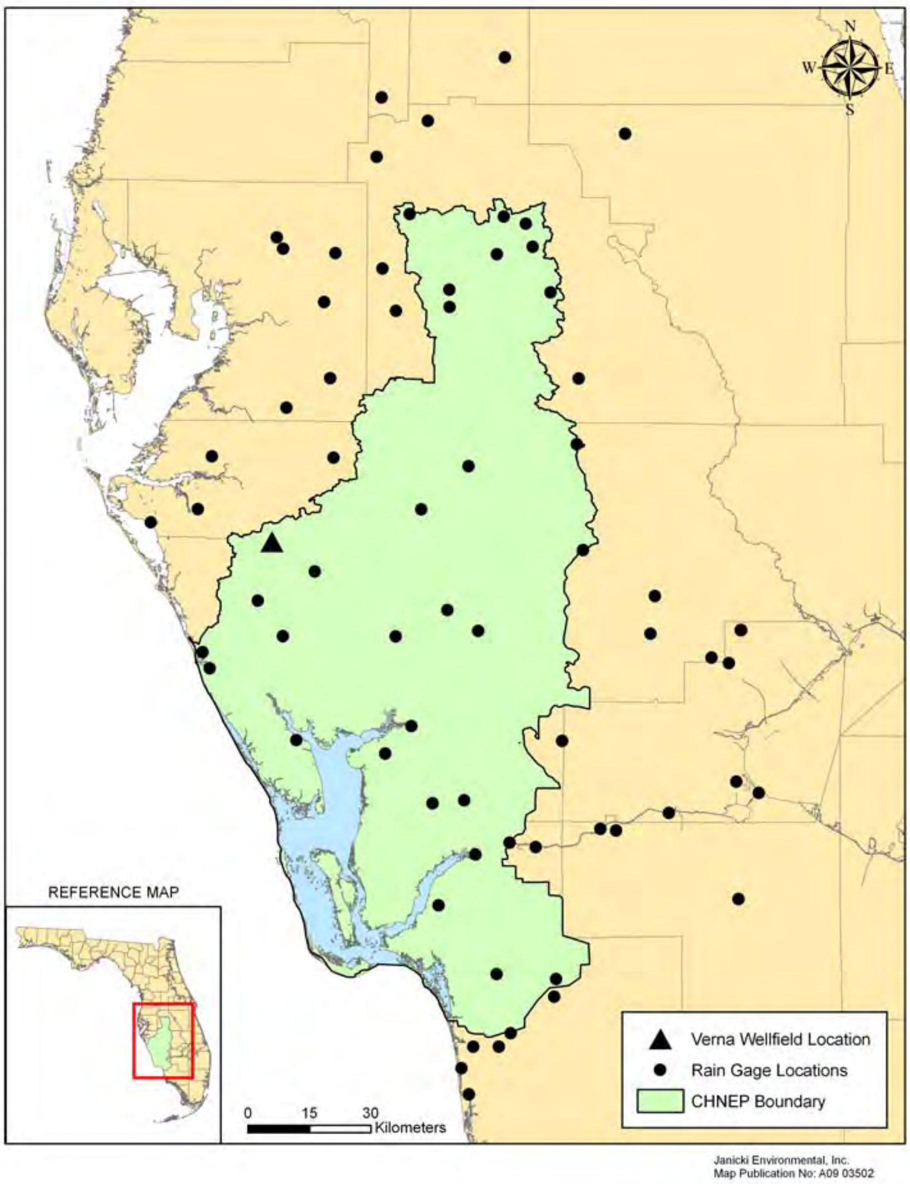

Figure 3-1. Locations of precipitation stations used for estimating rainfall and atmospheric deposition.

$Ndry_{m,s}$ = Seasonal Deposition Ratio * $Nwet_{m,s}$,

where:

$Ndry_{m,s}$ = dry deposition of nitrogen (kg/mo) for each month *m* and bay segment *s*, and

$Nwet_{m,s}$ = wet deposition of nitrogen (kg/month) for each month *m* and bay segment *s*.

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

$$Ntot_{m,s} = Nwet_{m,s} + Ndry_{m,s},$$

where:

$Ntot_{m,s}$ = total deposition of nitrogen (kg/month) for each month *m* and bay segment *s*.

The estimation of phosphorus deposition utilized the same equations. Wet phosphorus concentrations were estimated by the relationship between TN and TP concentrations in rainfall at the TBADS site, applied using the TN concentration data from the Verna site. Estimates of dry deposition of TP were obtained using the same seasonal dry-to-wet ratios as utilized for estimation of TN deposition.

3.3 Watershed Loads

As discussed above, watershed loads include nonpoint sources, septic tanks, and point sources. For gaged portions of the watershed with measured water quality, the total watershed load is estimated by the product of the observed flow and water quality, as discussed in more detail below. To attribute the gaged watershed load to source categories, any loads attributable to septic tanks and/or point sources must be separated from the nonpoint source loads. This process is described in the following sections. As noted above, background groundwater and springs loadings were previously estimated to be negligible (less than 0.5%) of the total load and are not included in the current estimates. Groundwater loadings from septic tanks are included as a separate source, as described in Section 3.3.2.

3.3.1 Nonpoint Sources

Nonpoint source pollutant loadings result from nonpoint source from the CHNEP watershed and base flow from the rivers draining to the segments. The estimated nonpoint source loadings for the 1995-2007 period were derived using methods similar to those utilized for previous loadings estimates performed for the CHNEP (Coastal

Environmental, 1995; PBS&J, 1999) and for the Tampa Bay Estuary Program (TBEP) (Zarbock et al., 1994 and 1996; Pribble et al., 2001; Poe et al., 2005; Janicki Environmental, 2008a). The SWFWMD 2007 land use and SFWMD 2005 land use were utilized for developing the 1995-2007 nonpoint source loadings estimates.

Nonpoint source TN, TP, TSS, and BOD loadings for the gaged and ungaged portions of the watershed were estimated for the period 1995-2007. The methods for estimating loadings from gaged basins and ungaged basins are described below. Maps showing the locations of the gaged and ungaged portions of the watersheds for each segment are provided in Appendix A.

The methods for estimating pollutant loadings from gaged and ungaged basins of the watershed are presented in Figure 3-3. The method shown in Figure 3-3 on the left side of the diagram is used for those gaged basins for which both measured flow and water quality data exist. The adjacent method to the right in the middle of the diagram is used for those gaged basins for which measured flow data exist, but for which no measured water quality data exist.

The third method, to the far right of Figure 3-3, is used for ungaged basins, for which neither flow nor water quality data are measured. Each of these methods is described below. Streamflow data were obtained from the USGS. Water quality data were obtained from the City of Cape Coral, FDEP, Lee County, Shell Creek Hydro-Biological Monitoring Program (HBMP), SFWMD, and SWFWMD.

Gaged Basins with Measured Streamflow and Water Quality Data. Measured streamflow data and measured water quality data were used to estimate nonpoint source loadings from the gaged basins for which both data types existed. As shown in Figure 3-3, pollutant loadings from these basins were estimated by multiplying measured monthly flows (Q) at stream gage sites by pollutant concentrations (WQ) measured at the same site, yielding monthly pollutant loads at each gaged point.

The pollutant concentration for any missing month at a stream gage was estimated either by interpolating between the nearest preceding and succeeding months, or by using the annual average concentration. Pollutant loads were estimated on a monthly basis. Data from the sites provided in Table 3-2 were used to estimate gaged area loadings.

To derive the nonpoint source loading estimates using this method, the loading contributions of domestic and industrial point sources (DPS and IPS) and septic tanks in the gaged basins were subtracted from the total watershed loadings estimates. This provided estimates of the loadings from nonpoint sources only. Nonpoint source loads from gaged areas were further discretized to estimate loads by land use type. The land use-specific nonpoint source flows and loads were partitioned by applying runoff coefficients and event mean concentrations (EMCs) for each land use to equal the total nonpoint source load, given the relative number of acres of each land use in a bay segment.

Gaged Basins with Measured Streamflow but no Water Quality Data. Measured streamflow and estimated water quality data were used to estimate nonpoint source loadings from the gaged basins for which measured water quality data did not exist. As in previous loading estimates, derivation of pollutant loadings from these basins involved utilization of streamflow data and data from GIS coverages for land use and basin boundaries, wet and dry season land use-specific runoff coefficients, and land use-specific water quality concentrations.

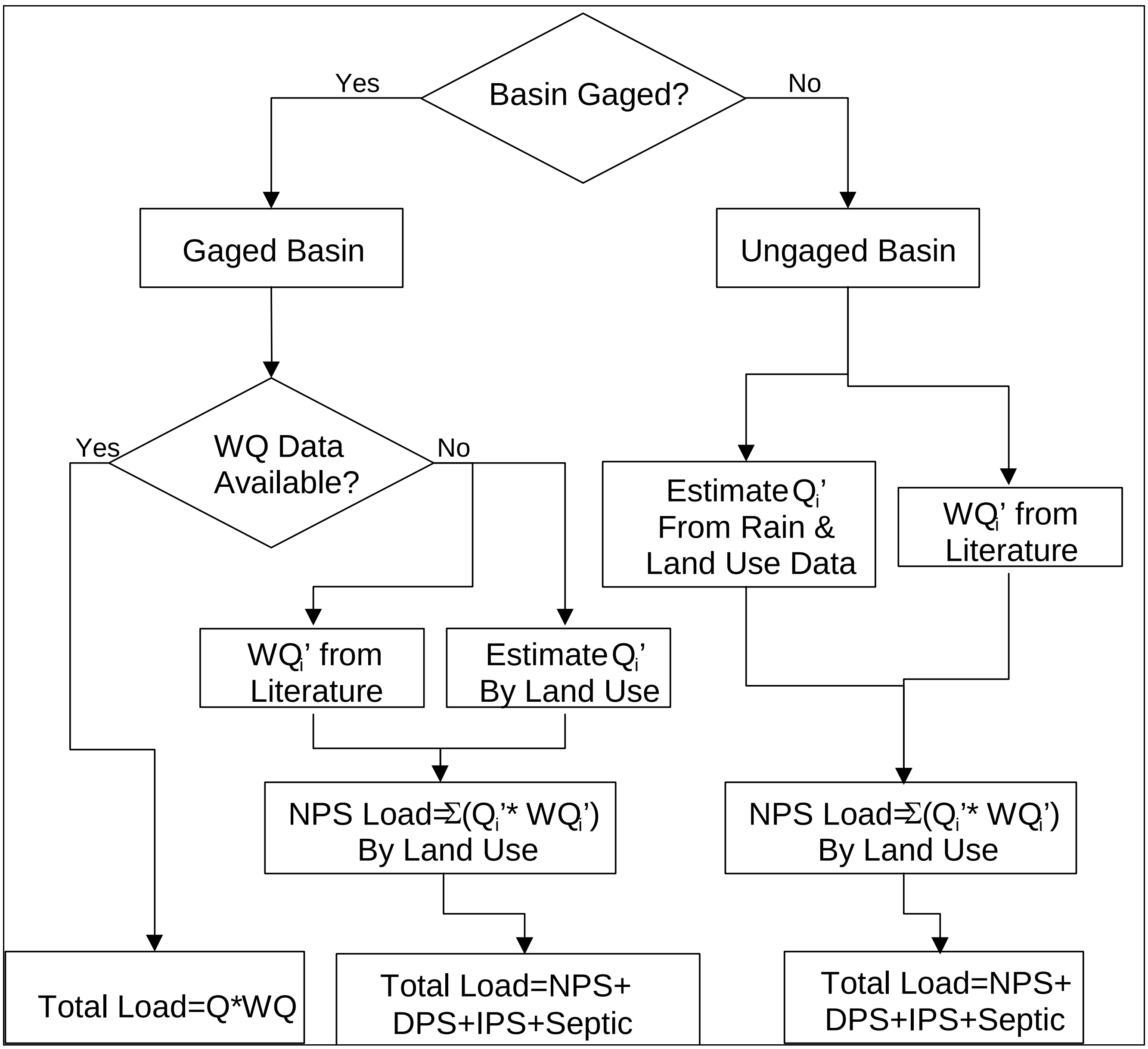

Figure 3-2. Process for estimating watershed loadings from gaged and ungaged basins.

Table 3-2. Stream flow gage stations and associated water quality stations.

Segment	Stream Gage Site Name	Streamflow (Agency/Site)	Water Quality (Agency/Site)
Tidal Myakka River	Myakka River near Sarasota	USGS/02298830	SWFWMD and USGS/Myakka River near Sarasota
	Big Slough Canal	USGS/02299410	SWFWMD/Big Slough Canal @ Myakka City
	Deer Prairie Creek	USGS/02299120	SWFWMD/Deer Prairie Creek above Myakka River
Tidal Peace River	Peace River at Bartow	USGS/02294650	SWFWMD and USGS/Peace River @ Bartow
	Peace River at Zolfo Springs	USGS/02295637	SWFWMD and USGS/Peace River @ Zolfo Springs
	Payne Creek	USGS/02295420	USGS/Payne Creek
	Charlie Creek	USGS/02296500	USGS and FDEP/Charlie Creek
	Peace River at Arcadia	USGS/02296750	USGS and FDEP/Peace River @ Arcadia
	Horse Creek	USGS/02297310	SWFWMD and USGS/Horse Creek near Arcadia
	Joshua Creek	USGS/02297100	SWFWMD and USGS/Joshua Creek @ Nocatee
	Shell Creek	USGS/02298202	Shell Creek HBMP/3
Matlacha Pass	Gator Slough at SR 765	USGS/02293264	Lee County/GATRGR30
	Horseshoe Canal	USGS/02293346	Cape Coral/160
	Hermosa Canal	USGS/02293347	Cape Coral/190
	Shadroe Canal	USGS/02293345	None
Tidal Caloosahatchee River	S-79	USGS/02292900	Lee County/CES01, CES03, CES04, CES06 SFWMD/S79
	San Carlos Canal	USGS/02293241	Cape Coral/390
	Courtney Canal	USGS/02293243	None
	Aries Canal	USGS/02293240	None
	Whiskey Creek	USGS/02293230	Lee County/WHISGR10
Estero Bay	Tenmile Canal	USGS/02291673	Lee County/10MIGR20
	Sixmile Cypress	USGS/02291669	Lee County/SIXMILE5
	North Branch Estero River	USGS/02291580	Lee Count/47A-28GR
	South Branch Estero River	USGS/02291597	None
	Spring Creek	USGS/02291524	Lee County/48-25GR
	Imperial River	USGS/02291500	Lee County/IMPRGR70, IMPRGR80

Land use information was obtained from the SWFWMD GIS coverages for 2007 and SFWMD GIS coverages for 2005, and classified according to the Florida Land Use and Cover Classification System (FLUCCS) (FDOT, 1985). Land uses were aggregated into 21 categories (Appendix B) for loading calculations. Basin delineations were developed from existing watershed boundaries obtained from the CHNEP.

As shown in Figure 3-3, for each land use category (i), specific water quality concentrations (WQ_i') were obtained from the literature (Appendix D). Runoff from each land use category was estimated by apportioning the nonpoint source gaged streamflow among the constituent land use categories in the basin. The nonpoint source streamflow was derived from the gaged basin flow by subtracting any domestic and industrial point source (DPS and IPS) contributions and any septic tank contributions from the gaged flow. The apportionment of the nonpoint source flows to each land use category was accomplished as follows:

$$Q_i' = \frac{Q_n A_i R_i}{\sum_i A_i R_i}$$

where:

Q_i'= total nonpoint source flow (m^3/month) from land use category *i*,

Q_n= total nonpoint source flow (m3/month) from the gaged basin,

A_i = area of land use category *i* in gaged basin, and

R_i = runoff coefficient for land use category *i* for the month, representing fraction of rainfall that runs off of the land (Appendix E).

Nonpoint source pollutant loadings from these basins were estimated by multiplying the monthly nonpoint source flows apportioned to each land use category (Q_i') by the land use-specific pollutant concentrations (WQ_i'), yielding monthly pollutant loadings from each land use category in the basin. The monthly pollutant loadings from all land use categories were then summed over the basin to provide an estimate of the total nonpoint source pollutant loadings from the basin.

Ungaged Basins. An empirical model was developed to estimate streamflow from ungaged basins. This model was developed using NWS, SWFWMD, and SFWMD rainfall data, SWFWMD 2007 and SFWMD 2005 land use GIS coverages, and seasonal land use-specific runoff coefficients (Appendix E). The estimated streamflow from the ungaged basins was then used with land use-specific water quality concentrations (Appendix D) to estimate pollutant loads from ungaged areas of the watershed. Land uses were aggregated into 21 categories for loading calculations (Appendix B).

The empirical model developed for this effort provides estimates of land use-specific runoff from ungaged portions of the watershed. The empirical model was developed using measured flows from five gaged basins in the watershed, each of which is relatively unaffected by withdrawals, point source discharges, and/or agricultural irrigation. The five gaged basins include the following:

- Charlie Creek,
- Horse Creek,
- Big Slough,
- 10 Mile Canal, and
- Whiskey Creek.

Monthly streamflow for each of the basins was apportioned to the land use areas within the basin, using the same methodology as described above. Land use-specific runoff per unit area per inch of rainfall was estimated for each month of the 1995-2007 period, and averaged over the five basins for each of the land uses for each month (Appendix C). The resulting monthly runoff rates were applied to the five gaged basins used to develop the values, as a comparison of predicted and observed runoff. The relationships between predicted and observed runoff were significant, with an overall r^2 of 0.87. The monthly land use-specific values of runoff per unit area per inch of rainfall were then applied to the ungaged basins to predict nonpoint source runoff for each month of the 1995-2007 period, using monthly rainfall specific to each ungaged basin.

As shown in Figure 3-3, for each land use category (i), specific water quality concentrations (WQ_i‘) were obtained from the literature (Appendix D). Runoff (Q_i’) from each land use category was estimated by the empirical model. The product of the literature-based land use-specific water quality concentrations and the estimated runoff from each land use category was summed over each basin to provide the nonpoint source pollutant loadings from each basin.

3.3.2 Septic Tanks

Septic tanks, also known as on-site sewage treatment and disposal systems (OSTDS), can be a potentially significant loading source of nitrogen and phosphorus to coastal ecosystems (Charlotte Harbor Environmental Center - CHEC, 2003). It was estimated that, in 2004, 22% of the total nitrate (NO_3) loadings to the nearby Wekiva River basin originated from OSTDS (MACTEC, 2007). In largely rural Marion County, in north-central Florida, the NO_3 load originating from septic tanks was estimated to be fourteen times greater than the load coming from domestic wastewater treatment facilities (Kuphal, 2005).

Approximately 2.3 million, or about 26 percent, or about Florida households use OSTDS (Briggs et al., 2008), (CHEC, 2003). The percentage of households using OSTDS is approximately 42% in the Peace and Myakka River basins which comprise a large portion of the CHNEP watershed (CHEC, 2003). Septic system management plans are generally run by individual counties, however, less than one percent of Florida systems fall under an active management program (Briggs et al., 2008).

In order to determine the estimated TN and TP loads from OSTDS, the following data were obtained:

- number of active septic tanks in the study area,
- average rate of failure of septic tanks in the study area,
- average number of people in a household using a septic tank,
- average influent TN and TP load entering a septic tank,
- average effluent TN and TP load leaving a working septic tank
- average effluent TN and TP load leaving a failing septic tank, and
- vertical and horizontal soil attenuation rates of TN and TP.

In 2009, the Florida Department of Health (FDOH) developed a GIS coverage containing point location data for septic tanks throughout Florida. OSTDS were identified as lots with OSTDS permits, or developed parcel outside areas with identified sanitary sewer service (FDOH, 2009). Septic tanks classified as “Closed” were removed from the coverage and further data analysis. Remaining data were joined to county and CHNEP segment basin boundary coverages. Note that the basins for two CHNEP bay segments, Cape Haze and West Wall, are excluded from this analysis as only seven OSTDS were identified within their boundaries. The counties which had septic tank data used in this study are shown in Figure 3-4.

Figures 3-5 through 3-8 show the distribution of active OSTDS, as well as the difference in OSTDS densities amongst the counties located within the study area. Each county has distinct management plans as to septic tank development, including goals concerning the use of septic tanks, both currently and in the future. For example, Figure 3-7 clearly shows the difference between Sarasota County and Charlotte County OSTDS densities along the county line. This particular difference may reflect the difference in land uses between the two counties, as Sarasota is more highly urbanized and therefore more likely to have central sewer system infrastructure. However, Sarasota County is also in the midst of an ongoing project to replace OSTDS in many of its neighborhoods with central sewer lines, currently replacing approximately 14,000 septic tanks in the Phillippi Creek watershed alone (Sarasota County, 2009). Charlotte County is in the process of expanding its central sewer service area Charlotte County, 2009a); however, a near-term focus is on upgrading the treatment levels for new and existing OSTDS while reducing the proportion of OSTDS installed for new developments (Charlotte County, 2009a and b).

Total counts of OSTDS were summed by segment watershed as shown in Table 3-3. OSTDS densities were calculated by dividing the number of OSTDS by bay segment watershed area, also shown in Table 3-3. The basin draining Upper Lemon Bay had the highest density of OSTDS in the study area, with 64/mi^2, followed by Lower Lemon Bay and Matlacha pass (30 and 28/ mi^{2,} respectively). The CHNEP segments with the lowest OSTDS densities were Bokeelia and Estero Bay (1.5 and 2.6/mi^2 respectively).

Estimated loadings from OSTDS were calculated differently for operating units and failed units. It was assumed that loads from failed OSTDS left the site mainly through surface flow, as most failures result in system back-ups, ponding, and surface runoff. Loads from operating OSTDS were assumed to be mainly via groundwater, as an operating unit releases material from its drainfield to infiltrate vertically and then horizontally in the soil.

The magnitude of loadings from operating OSTDS were first estimated. Data from the 2000 U.S. Census on average household size by county were used to calculate the number of people using septic tanks in each segment watershed (assuming one septic tank per household). The estimates in Table 3-4 are similar to those used in other OSTDS loading studies, which range from 2.5 to slightly over 3.0 (Bauman and Schafer, 1985; Maizel et al., 1997; EPA, 2002;

Figure 3-3. Counties with septic tanks located within the CHNEP study area boundary.

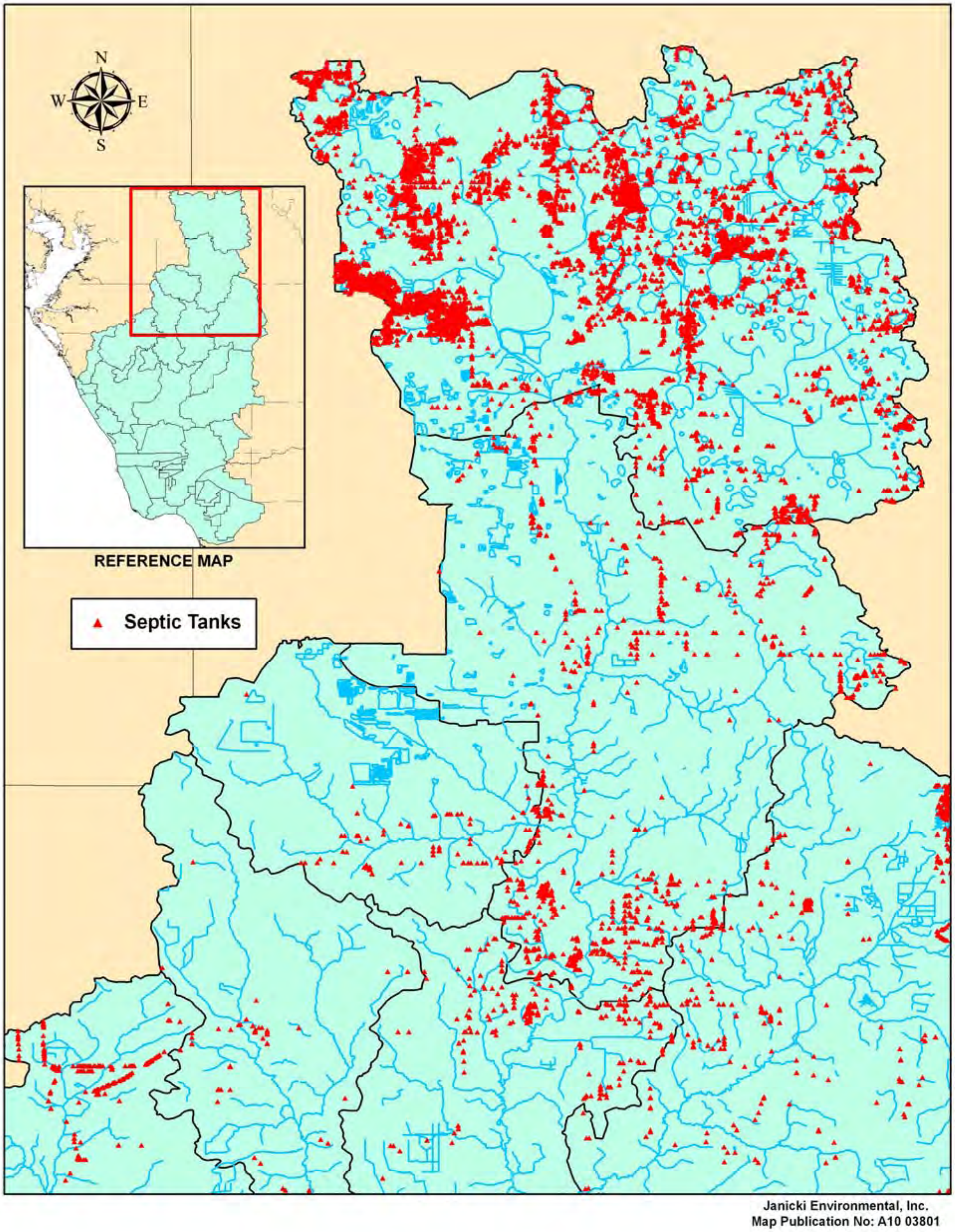

Figure 3-4. Location of septic tanks in the northern portion of the CHNEP watershed.

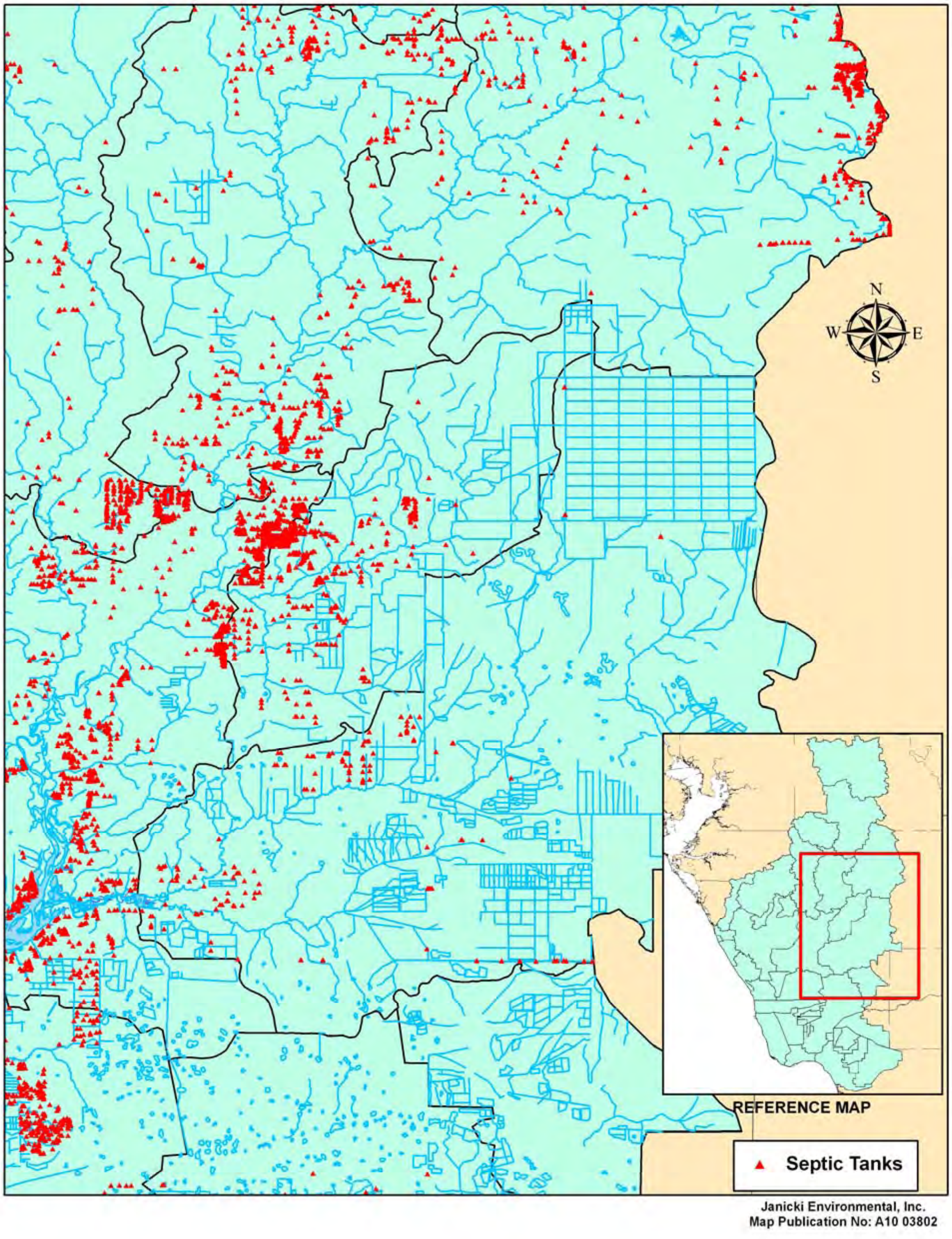

Figure 3-5. Location of septic tanks in the eastern portion of the CHNEP watershed.

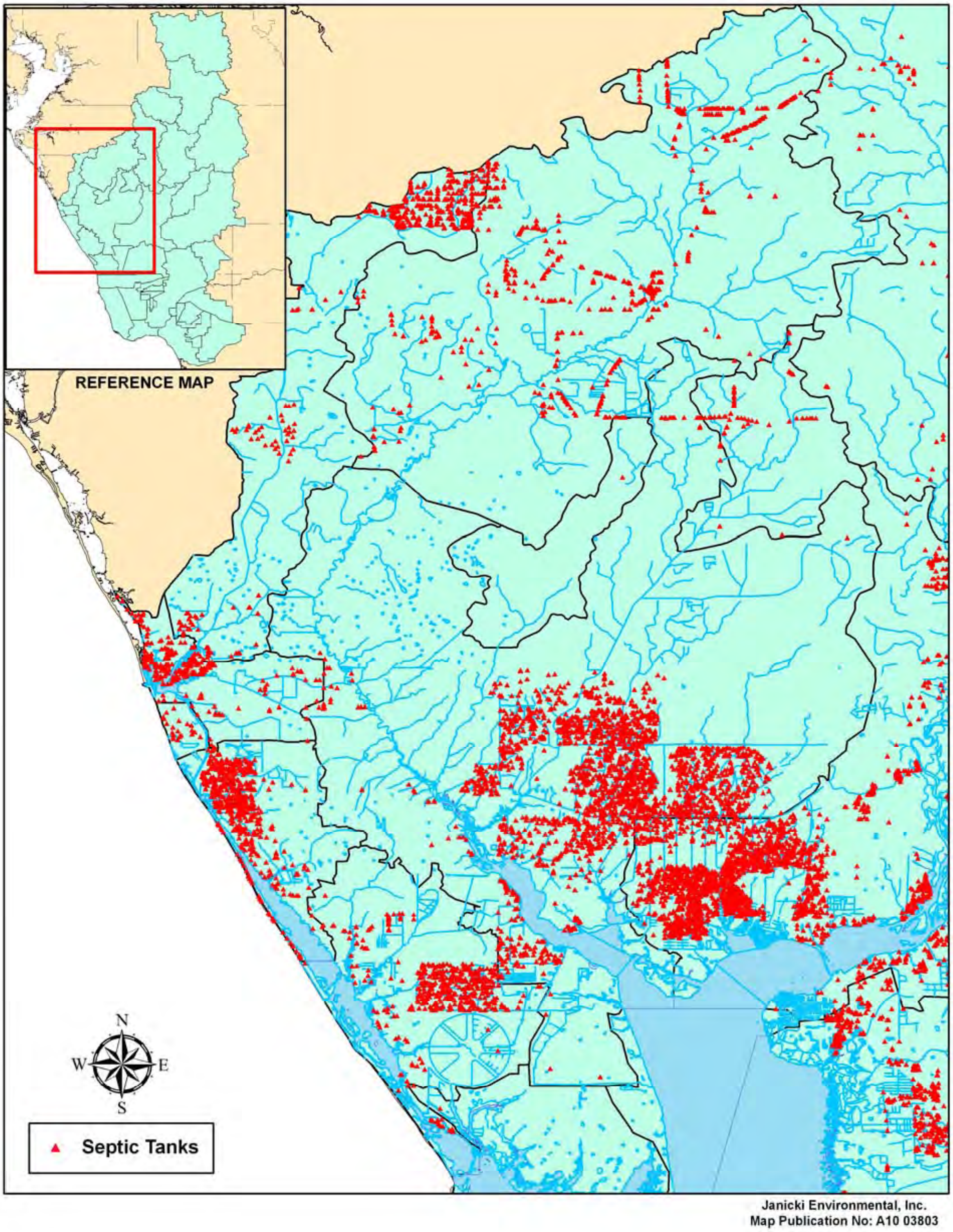

Figure 3-6. Location of septic tanks in the western portion of the CHNEP watershed.

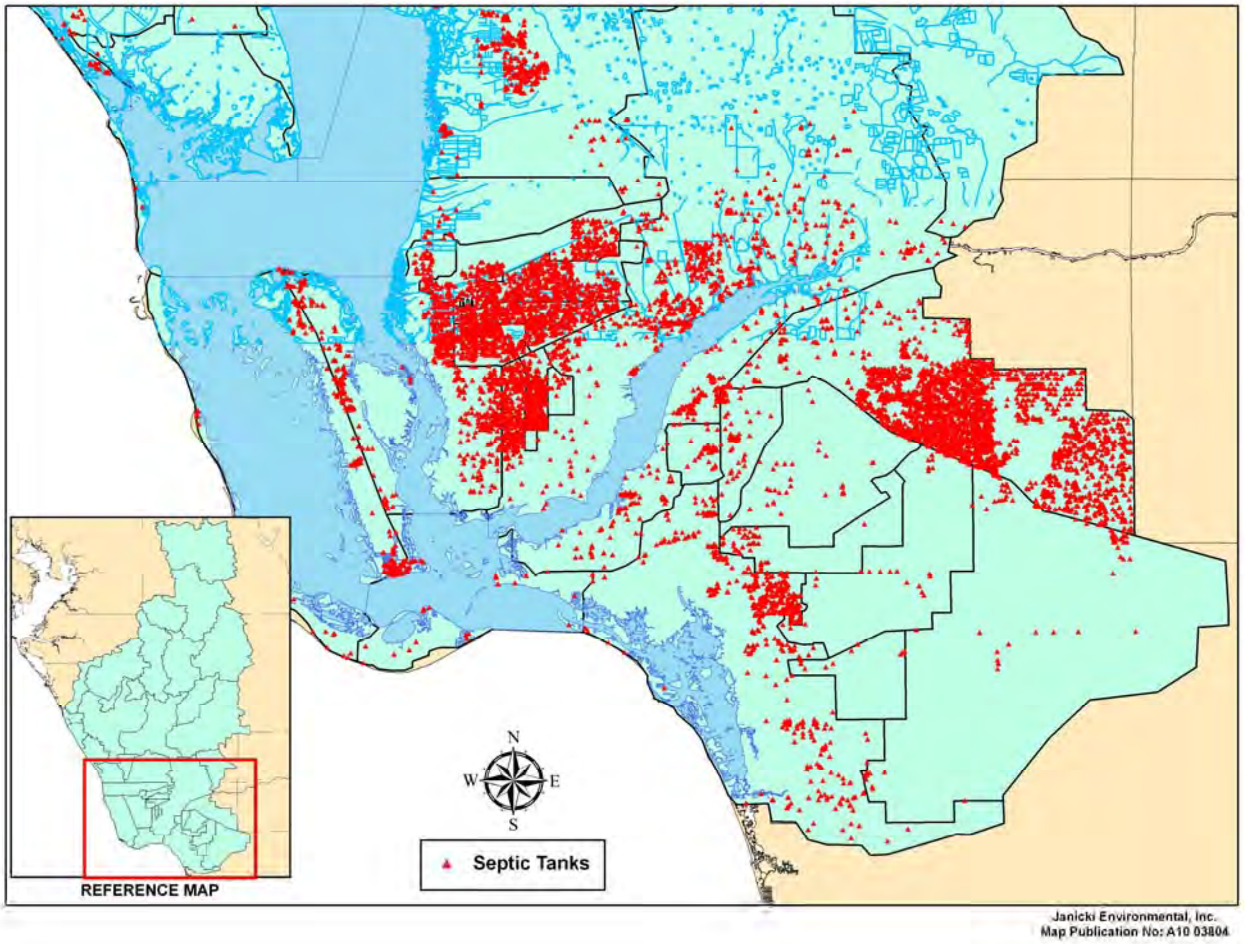

Figure 3-7. Location of septic tanks in the southern portion of the CHNEP watershed.

Table 3-3. Total number and density of septic tanks by bay segment watersheds

Segment	Total Number	Mi^2	Septic Tanks/Mi^2
Bokeelia	37	24.6	1.5
Dona and Roberts Bays	1089	96.6	11.3
East Wall	563	96.9	5.8
Estero Bay	917	357.7	2.6
Lower Lemon Bay	535	17.8	30.1
Matlacha Pass	2778	99.2	28.0
Pine Island Sound	178	29.5	6.0
San Carlos Bay	72	15.3	4.7
Tidal Caloosahatchee River	5779	530.8	10.9
Tidal Myakka River	3782	603.0	6.3
Tidal Peace River	23,296	2303	10.1
Upper Lemon Bay	580	9.0	64.4

Table 3-4. Average household size within the CHNEP (U.S. Census, 2000).

County	Average Capita per Household
Charlotte	2.18
Lee	2.31
Sarasota	2.13
Manatee	2.29
Polk	2.52
Hardee	3.06
Highlands	2.30
Collier	2.39
De Soto	2.70

Jones Edmunds, 2009). The number of people using OSTDS throughout the study area was estimated by multiplying the reported number of households using OSTDS by the average number of people per household.

Per capital TN and TP loading rates to the OSTDS were then determined. CHEC (2003) estimated that an average of 9.2 lbs of TN/person/year and 1.2 lbs of TP/person/year are produced as influent to septic systems, based on EPA (2002) estimates. Based on the local information included in the CHEC (2003) study, those per capita loading rates were used in the current analysis.

Similar loading rates for TN have been estimated elsewhere. The Chesapeake Bay Program (Maizel et al., 1997) suggested a range for annual per capita TN loads from 4.8 lbs of TN/person/year to 13.6 lbs of TN/person/year, ultimately applying a rate of 9.35 lbs of TN/person/year in their study. The Marion County Planning Department (Kuphal, 2005) quantified nitrate loadings throughout the county, and estimated loads of 11.3 lbs of NO_3/person/year. NO_3 comprises 85% of the weight of TN, or about 13.3 lbs of TN/person/year in Marion County (Kuphal, 2005). Bauman and Schafer (1985) estimated per capita annual TN loads to be approximately 8.2 lbs of TN/person/year, based on a household size of 3.0 people per household. The EPA estimated that the concentration of TN entering septic systems is four to seven times that of TP (EPA, 2002).

The individual loading rates of nitrogen (9.2 lb TN/person/year) and phosphorus (1.2 lb TP/person/year) to OSTDS (CHEC, 2003) were then multiplied by the number of people using septic tanks in each bay segment watershed, yielding total TN and TP loads leaving septic tanks throughout the study area.

Finally, groundwater loads into absorption (drain) fields coming from working OSTDS were estimated. The groundwater TN loads originating from operating OSTDS were estimated by multiplying the per capita TN load times the number of OSTDS times the number of people per household. This yielded the total load entering the OSTDS. To estimate the resultant load to receiving groundwater the load was multiplied by both a vertical transfer rate, estimated by CHEC (2003) to be 0.41 for TN, and a horizontal transfer rate, estimated to be 0.1 The vertical transfer rate accounts for uptake of pollutants in the soil prior to OSTDS discharge reaching the water table. The horizontal transfer rate accounts for further attenuation as the effluent moves away from the site.

This removal rate was determined by Anderson et al. (1994) and has been used by the EPA (2002). The above attenuation rate contrasts with the overall 80% removal rate used by Coastal Environmental (1995) in the estimation of septic tank loads to Charlotte Harbor. CDM (1992a) used a 50% soil removal rate for the Sarasota Bay watershed.

The 0.1 horizontal transfer rate means that 90% of the TN is attenuated by the soil adjacent to drainfields as the effluent migrates towards a receiving waterbody. CDM (1992b) estimated that 90% of nitrogen is removed by soils within 1700 feet of horizontal movement from septic tank to receiving waterbodies in Port Charlotte. By comparison, in the nearby Wekiva River watershed, an 80% reduction of TN was estimated to occur within 90 feet downgradient of a septic system drainfield (Aley IV et al., 2007). Based on the local information used to develop the CDM (1992b) attenuation rate, and the average distance of OSTDS units from a receiving water body (Table 3-5), the CDM value was used to estimate OSTDS loadings.

Table 3-5. Average distance of septic tanks from receiving waterbodies.

Segment	Average Distance (ft)
Bokeelia	386
Dona and Roberts Bays	612
East Wall	341
Estero Bay	504
Lower Lemon Bay	508
Matlacha Pass	447
Pine Island Sound	396
San Carlos Bay	172
Tidal Caloosahatchee River	518
Tidal Myakka River	566
Tidal Peace River	938
Upper Lemon Bay	620

The groundwater TP load was estimated in a similar manner to TN, except that the vertical transfer rate for TP was estimated to be 0.025 by CHEC (2003), and no horizontal transfer rate was used for estimating groundwater TP loads. The 0.025 vertical transfer rate is equivalent to a 97.5% soil attenuation rate.

A similar TP soil removal rate of 90% was used by Coastal Environmental (1995) for Charlotte Harbor and CDM (1992a) for Sarasota Bay. Because so much phosphorus is attenuated through vertical transfer, the soil is an effective filter and removes the horizontal plume effect observed with nitrogen (Waller et al., 1987).

The impact of failed septic tanks on loads to receiving waterbodies in the CHNEP area was then estimated. Estimates of OSTDS failure rates vary greatly among the estimates available. EPA (2002) reported state-specific OSTDS failure rates ranging from less than one percent (Arizona, Utah, Wyoming) to 50 percent or above (Missouri, Minnesota). An estimated failure rate for Florida of 1 – 2% was reported for Florida; however, due to an approximate five year average lag time between system malfunction and actually reporting its failure and fixing it, CHEC (2003) suggested a 5%-10% statewide failure rate. Soil type has also been determined to have significant impacts on failure rates (CHEC, 2003; Jones Edmunds, 2009). Soils with the highest amount of sand, representing soil hydrologic groups (SHG) A and B, were assumed to have lower failure rates. OSTDS on soils with SHGs of C and D, with lower proportions of sand and higher amounts of clay have higher failure rates. Based on local soil hydrologic groups, a failure rate of 10% percent was given to OSTDS located on soils with SHG of A. OSTDS located on soils with SHG of B, C or D were assigned a failure rate of 30%, similar to the CHEC (2003) failure rates.

A delivery ratio for pollutants from failed septic tanks reaching surface water bodies was estimated by CHEC (2003) to be 0.8. This means that 80% of the TN load coming from failed septic tanks is estimated to reach a receiving water body. The surface TP load was estimated by multiplying the total TP load by the same septic tank failure factor and a delivery ratio of 0.5. These delivery ratios were used in this assessment.

In summary, OSTDS loads to bay segments were developed by estimating loads from operating and failed septic tanks. Total loads leaving operating septic tanks via groundwater were estimated, and a delivery ratio was applied to estimate the load reaching the receiving bay segment. Loads from failed OSTDS used delivery ratios to estimate loadings to bay segments via surface water. Loads from operating and failed OSTDS were summed to yield to total OSTDS loads as reported in Section 4.

3.3.3 Domestic Point Sources

The following section describes the data and methods used to estimate pollutant loadings from domestic point sources

3.3.3.1 Background

Point sources of hydrologic and pollutant loadings are defined as discharges that originate at a discrete location, such as from a pipe or a small, definable land area (such as for land application of treated wastewater effluent). Domestic sources include publicly and privately owned wastewater treatment plants.

3.3.3.2 Methods

The estimated pollutant loadings from domestic point sources were derived using the same methods as used in previous loading estimates for the Tampa Bay watershed (Zarbock et al., 1994; 1996; Pribble et al., 2001; Poe et al., 2005; Janicki Environmental, Inc., 2008a). Domestic point sources identified for use in estimation of 1995-2007 loadings are shown in Table 3-6, and include all direct surface discharges and all land application discharges with an annual average daily flow of 0.1 million gallons per day (mgd) or greater.

Domestic point sources were identified by reviewing FDEP point source discharge locations in relation to the CHNEP boundary. These sources were first checked to identify which sources were operational during the 1995-2007 period, with those that were not operational during this period removed from the list. These locations were used to create an ArcGIS coverage, and then mapped and reviewed by FDEP staff. The domestic point sources in the CHNEP boundary with an average daily flow of 0.1 mgd or greater were identified with the assistance of FDEP Southwest District (Tampa) and FDEP South District (Fort Myers) office staff.

Data sources used to estimate domestic point source discharge and concentration data to CHNEP bay segments for 1995-2007 are as follows:

- Monthly Operating Reports (MOR) and Discharge Monitoring Reports (DMR) obtained from the Tampa and Fort Myers offices of the FDEP; and

- MOR and DMR data obtained directly from the domestic wastewater treatment facilities for those data not obtained from the FDEP.

A database of domestic point source discharge information was developed, including monthly discharge rates and TN, TP, TSS, and BOD concentration data. Both surface water dischargers and facilities with land application of effluent were included. Monthly data from major domestic point source dischargers (Table 3-6) were included.

The database was subjected to quality control measures to ensure that the most accurate flows and concentrations obtainable were used in the loading estimates. The entries were scanned for incongruous data points. Obvious outliers (such as flows of two or three orders of magnitude higher than the design capacity of the facility) were removed from the record. Incomplete records existed for most domestic wastewater treatment plants, with facilities reporting flow rate and concentrations for TN, TP, TSS, and BOD on a monthly basis, when available. Attempts were made to locate sources of valid data to replace missing or invalid values, often by contacting facility personnel directly.

For those data gaps that could not be filled with actual recorded data, two methods were used to complete the record, depending upon the amount of data missing:

- If 1-3 consecutive months of data were missing, discharge and/or pollutant concentrations were set to those of the last month for which values existed.

- If data from more than 3 consecutive months were missing, discharge and/or pollutant concentrations were set to the monthly averages of the 1995-2007 record; no data fills were made for facilities missing entire years.

In some cases, a form of nutrient other than total nitrogen was reported. For example, if both total nitrogen and nitrate nitrogen were recorded for some months at a facility, but only nitrate nitrogen was recorded for most months, the average ratio of nitrate to total nitrogen was calculated for those months with both values. The resulting ratio was applied to the other months, resulting in an estimate of total nitrogen for those months. If only nitrate nitrogen data existed, then total nitrogen concentration was set to the reported concentration of nitrate nitrogen. No quantitative analysis of the potential underestimate of the resulting TN loading from facilities without TN data has been performed.

Table 3-6. Domestic point sources in the CHNEP boundary (1995-2007).

Facility Name	Bay Segment
Auburndale Allred WWTP	Tidal Peace River
Charlotte Harbor Water Association	Tidal Peace River
City of Arcadia - William Tyson WWTF	Tidal Peace River
City of Cape Coral - Everest WRF	Tidal Caloosahatchee River
City of Cape Coral - ROWTP	Matlacha Pass
City of Punta Gorda WWTP	Tidal Peace River
City of Winter Haven, WWTP #3 - Wahneta	Tidal Peace River
Florida Cities - Waterway Estates AWWTP	Tidal Caloosahatchee River
Fort Myers Beach Sewage Treatment Plant	Estero Bay
Fort Myers Central AWWTF	Tidal Caloosahatchee River
Fort Myers South AWWTF	Tidal Caloosahatchee River
Gasparilla Island Water Association	Lower Lemon Bay
Lee County Utilities - Fiesta Village	Tidal Caloosahatchee River
Venice- Eastside WWTP	Dona and Roberts Bays

If no data for a certain parameter were available for a facility and it was known or suspected that loadings of that chemical did occur, then other similar facilities were examined. Typical or averaged data from these facilities were used to fill data gaps if no other source of information was available. This method was chosen as an alternative to showing missing data for loads from major point sources.

Many of the inventoried domestic facilities utilize direct surface discharge for effluent disposal. Surface water inputs from domestic point sources were estimated for both the gaged and ungaged basins of the watershed, expressed as a volume per unit time, such as million gallons per day (mgd).

The flows from each point source were assigned to the subbasin that receives the discharge, allowing the aggregation of point source flows for each major drainage basin and each bay segment. All of the effluent released via surface discharge was assumed to reach Charlotte Harbor. Domestic point source loadings were subtracted from the total gaged nonpoint source loads, discussed later, to avoid double counting of point source loadings originating upstream of gages.

Estimates of point source pollutant loading for surface water discharges were obtained by multiplying the reported mean monthly concentration of the pollutant of concern and the mean monthly discharge volume. With appropriate conversion factors, this calculation yields a mass per unit time, such as tons per year of pollutant (TN, TP, TSS, or BOD).

3.3.4 Industrial Point Sources

3.3.4.1 Background

Industrial point sources include dischargers of process water and other effluent not categorized as domestic sewage. In the CHNEP area, industrial point sources include mainly facilities related to the phosphate industry and electrical power generation.

3.3.4.2 Methods

The estimated pollutant loadings from industrial point sources were derived using the same methods as used in previous loading estimates for the Tampa Bay watershed (Zarbock et al., 1994; 1996; Pribble et al., 2001; Poe et al., 2005; Janicki Environmental, Inc., 2008a). Industrial point sources identified for use in estimation of 1995-2007 loadings from process water and stormwater discharges are shown in Table 3-7, and include all direct surface discharges with an average daily flow of 0.1 mgd or greater.

Industrial point sources were identified by reviewing FDEP point source discharge locations in relation to the CHNEP boundary. These sources were first checked to identify which sources were operational during the 1995-2007 period, with those that were not operational during this period removed from the list. These locations were used to create an ArcGIS coverage, and then mapped for FDEP staff review. The industrial point sources in the CHNEP boundary with an average daily flow of 0.1 mgd or greater were identified with the assistance of FDEP Southwest District (Tampa) and FDEP South District (Fort Myers) office staff.

Data sources used to estimate process water and stormwater industrial point source discharges and loadings to CHNEP bay segments for 1995-2007 are as follows:

- MORs and DMRs obtained from the Tampa and Fort Myers offices of the FDEP; and
- MOR and DMR data obtained directly from the industrial wastewater treatment facilities and mining facilities for those data not obtained from the FDEP.

A database of industrial point source discharge information was developed, listing monthly discharge rates and TN, TP, TSS, and BOD concentration data. Both surface water dischargers and facilities with land application of effluent were included. Monthly data from major industrial point sources (Table 3-7) were included.

The database was subjected to quality control measures to ensure that the most accurate flows and concentrations obtainable were used in the loading estimates. The entries were scanned for incongruous data points. Obvious outliers (such as flows of two or three orders of magnitude higher than the design capacity of the facility) were removed from the record. Attempts were made to locate sources of valid data to replace missing or invalid values, often by contacting facility personnel directly.

For those data gaps that could not be filled with actual recorded data, two methods were used to complete the record, depending upon the amount of data missing, as follows.

- If 1-3 consecutive months of data were missing, discharge and/or pollutant concentrations were set to those of the last month's for which values existed.

- If data from more than 3 consecutive months were missing, discharge and/or pollutant concentrations were set to the monthly averages of the 1995-2007 record; no data fills were made for facilities missing entire years.

In some cases, a form of nutrient other than total nitrogen was reported. For example, if both total nitrogen and nitrate-nitrogen were recorded for some months at a facility, but only nitrate-nitrogen was recorded for most months, the average ratio of nitrate to total nitrogen was calculated for those months with both values. The resulting ratio was applied to the other months, resulting in an estimate of total nitrogen for those months. If only nitrate-nitrogen data existed, then total nitrogen concentration was set to the reported concentration of nitrate-nitrogen. If no data for a certain parameter were available for a facility and it was known or suspected that loadings of that chemical did occur, then other similar facilities were examined. Typical or averaged data from these facilities were used to fill data gaps if no other source of information was available. This method was chosen as an alternative to showing missing data for loads from major point sources.

Table 3-7. Industrial point sources in the CHNEP study area (1995-2007).	
Facility Name	**Bay Segment**
Florida Power and Light – Fort Myers Plant	Tidal Caloosahatchee River
Florida Distillers	Tidal Peace River
Florida's Natural Growers	Tidal Peace River
Ridge Generating Station	Tidal Peace River
Larsen Memorial Plant	Tidal Peace River
Lakeland McIntosh Power Plant	Tidal Peace River
Tampa Electric Co. - Polk Power Station	Tidal Peace River
Hardee Power Station	Tidal Peace River
Mosaic Fertilizer - Noralyn/Phosphoria/Clear Springs	Tidal Peace River
Mosaic Fertilizer - Ft. Meade Mine	Tidal Peace River
Mosaic Fertilizer - Bartow Chemical Plant	Tidal Peace River
US Agri-Chemicals - Ft. Meade	Tidal Peace River
US Agri-Chemicals - Bartow Plant	Tidal Peace River
Mosaic Fertilizer - Ft. Green/Payne Creek Mine	Tidal Peace River
Mosaic Fertilizer - Hookers Prairie Mine	Tidal Peace River
CF Industries - Hardee	Tidal Peace River
CF Industries - Hardee Complex	Tidal Peace River
Mosaic Fertilizer - Four Corners Mine	Tidal Peace River
Bartow Phosphogypsum Stack	Tidal Peace River

Most of the inventoried industrial facilities utilize direct surface discharge for effluent disposal. Surface water inputs from industrial point sources were estimated for both the gaged and ungaged basins of the watershed, expressed as a volume per unit time, such as mgd. The flows from each point source were assigned to the subbasin that receives the discharge, allowing the aggregation of point source flows for each major drainage basin and each bay segment. All of the effluent released via surface discharge was assumed to reach the Charlotte Harbor system. As for domestic point source loadings, industrial point source loadings in gaged basins were subtracted from the total gaged loads to avoid double counting of point source loadings originating upstream of gages.

Estimates of industrial point source pollutant loading for surface water discharges were calculated by multiplying the reported concentration of the pollutant of concern and the discharge volume. With appropriate conversion factors, this calculation yields a mass per unit time, such as tons of pollutant per year (TN, TP, TSS, or BOD).

A review of the load analysis results in Section 4 reveals a very large contribution of TN and TP loads by industrial point sources in the Tidal Peace River bay segment. The large contribution of industrial point sources to the total loadings is largely a result of extremely high discharges that were made during a few years due to climatological factors. During 2004 especially, in preparation for Hurricane Charlie and following storms, emergency discharge orders by the FDEP resulted in very high discharges from the mining facilities in the Tidal Peace River watershed. These discharges were high enough to affect the source attribution for this bay segment for the entire 1995 through 2007 period.

4 RESULTS OF LOADING ANALYSIS

The results of the pollutant and hydrologic loading analyses are presented in this chapter. Relevant information includes annual loads, monthly/seasonal loads, and loading sources for TN, TP, TSS, BOD, and freshwater. Estimating pollutant loading, especially TN, is an essential step in setting water quality targets and water clarity targets to protect seagrasses. As summarized in Chapter 1.2, TN loadings can be used to predict chlorophyll concentrations in open water bodies. Chlorophyll, along with color and turbidity, can provide a measure of water clarity which is a critical determinant of seagrass growth. Higher chlorophyll, color, and turbidity reduce water clarity which limits the depth to which seagrass can grow. There is thus a technically defensible, although multi-step, relationship between nutrient loadings and seagrass coverage.

Loads for the entire CHNEP area are reviewed, followed by a summary of loads for each of the 14 watershed segments. Finally, loadings to the segments are compared using different metrics to help assess loading characteristics. Data for the period 1995 through 2007 were used for the analyses. Throughout this chapter the term ”total load” refers to pollutant loadings from all sources including nonpoint, point (domestic and industrial), direct atmospheric deposition to the estuary, and septic tanks (referred to as OSTDS in Section 3). The term “watershed load” refers to pollutant loading originating in the watershed but not the open water estuary, and thus does not include atmospheric deposition.

4.1 Loads for the Entire CHNEP Area

Loads from all sources for TN, TP, TSS, and BOD to the entire CHNEP area are discussed collectively in this section. The CHNEP area includes 14 estuarine segments and their tributary watersheds, as discussed in Section 2. Loads for the entire CHNEP area were developed by combining loads from all sources for all segments. Information to be gained from these analyses includes insight into how pollutant loadings can change over years (inter-annual variability) to illustrate long-term trends in loadings and how loads are related to environmental factors such as rainfall. Secondly, how loadings respond to seasonal signals such as rainfall (intra-annual variability) also provides valuable data useful to resource managers.

Finally, total loads are presented by source category. Showing the relative proportion of TN, TP, TSS, and BOD load contributions by nonpoint sources , atmospheric deposition, domestic point sources (wastewater plant discharges), industrial point sources, and septic tanks illustrates which sources are most important on a regional basis and likely deserve the most attention.

Figure 4-1(top) shows annual TN total loads for the entire CHNEP area for the period 1995 through 2007. Total TN loads ranged from 18,289 (2005) down to 2099 (2007) tons/year. Loads were generally higher during years of higher rainfall, reflecting higher nonpoint source and atmospheric deposition inputs. For the period of data used, wetter years included 1995, 1997, 1998, 2003, and 2005. Dryer years included 1996, 2000, 2001, 2006, and 2007. Annual watershed loadings generally followed the same pattern as total loads. Figure 4-1 (middle) shows average monthly total TN loads for the same period. Loads were higher during the June – September wet season, especially in those basins with a high proportion of nonpoint source runoff and/or atmospheric deposition. The wet season total TN loads averaged 1437 tons/month, and dry season total loads averaged 504 tons/month. Figure 4-1 (bottom) shows the pollutant input sources of TN total loads for the entire CHNEP area. The major TN contributor was nonpoint source (70%). Contributions from septic tanks, atmospheric deposition, and industrial point sources were 2.5%, 6.3%, 0.6%, and 20%, respectively. Domestic point sources were by far the least significant contributor on a regional basis, with only a 0.4% share of TN loads. Figure 4-2 (top) shows annual TP total loads for the entire CHNEP area for the period 1995 through 2007. Total TP loads ranged from 4004 (2005) to 527 (2007) tons/year and reflect annual rainfall amounts as discussed above.

Figure 4-2 (top) shows total annual TP loads for the entire CHNEP area for the period 1995 through 2007. TP loads ranged from 3798 (2005) to 492 (2007) tons/year. Figure 4-2 (middle) shows average monthly TP loads for the same period. As with TN, loads were higher during the June – September wet season. The wet season TP loads averaged 301 tons/month, and dry season loads averaged 108 tons/month. Figure 4-2 (bottom) shows the pollutant input sources of TP total loads for the entire CHNEP area. The major TP contributor was nonpoint source (68%). Contributions from septic tanks, atmospheric deposition, domestic point sources, and industrial point sources were 1.0%, 0.5%, 1.9%, and 28%, respectively. The higher industrial TP loads originated mainly in the Peace River basin from phosphate industry discharges.

Figure 4-3 (top) shows annual TSS loads for the entire CHNEP area for the period 1995 through 2007. TSS loads ranged from 125,568 (2005) to 10,427 (2007) tons/year. Figure 4-3 (middle) shows average monthly TSS loads for the same period. Loads were higher during the June – September wet season. The wet season TSS loads averaged 8492 tons/month, and dry season TSS loads averaged 2886 tons/month. Figure 4-3 (bottom) shows the pollutant input sources of TSS total loads for the entire CHNEP area. The major TSS contributor was nonpoint source (95%). Contributions from septic tanks, atmospheric deposition, domestic point sources, and industrial point sources were 0.0 %, 0.0%, 1.5%, and 3.2%, respectively.

Figure 4-4 (top) shows annual BOD total loads for the entire CHNEP area for the period 1995 through 2007. Total BOD loads ranged from 39,468 (1995) to 6265 (2007) tons/year. Figure 4-4 (middle) shows average monthly BOD loads for the same period. Loads were higher during the June – September wet season. The wet season BOD loads averaged 3454 tons/month, and dry season BOD loads averaged 1240 tons/month. Figure 4-4 (bottom) shows the pollutant input sources of BOD total loads for the entire CHNEP area. The major BOD contributor was nonpoint source (90%). Contributions from septic tanks, atmospheric deposition, domestic point sources, nonpoint sources, and industrial point sources were 0%, 0%, 2.3%, and 7.7%, respectively.

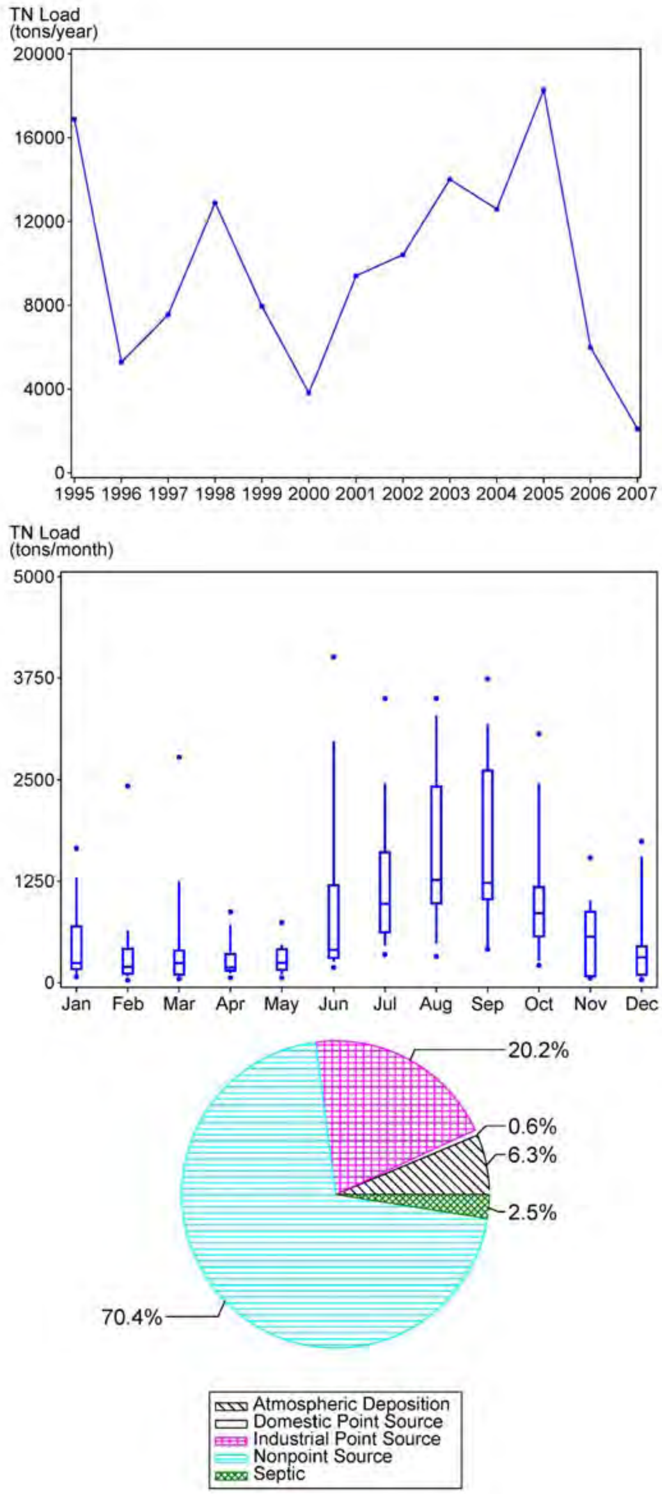

Figure 4-1. Entire CHNEP area – TN loads: annual, monthly, and by source.

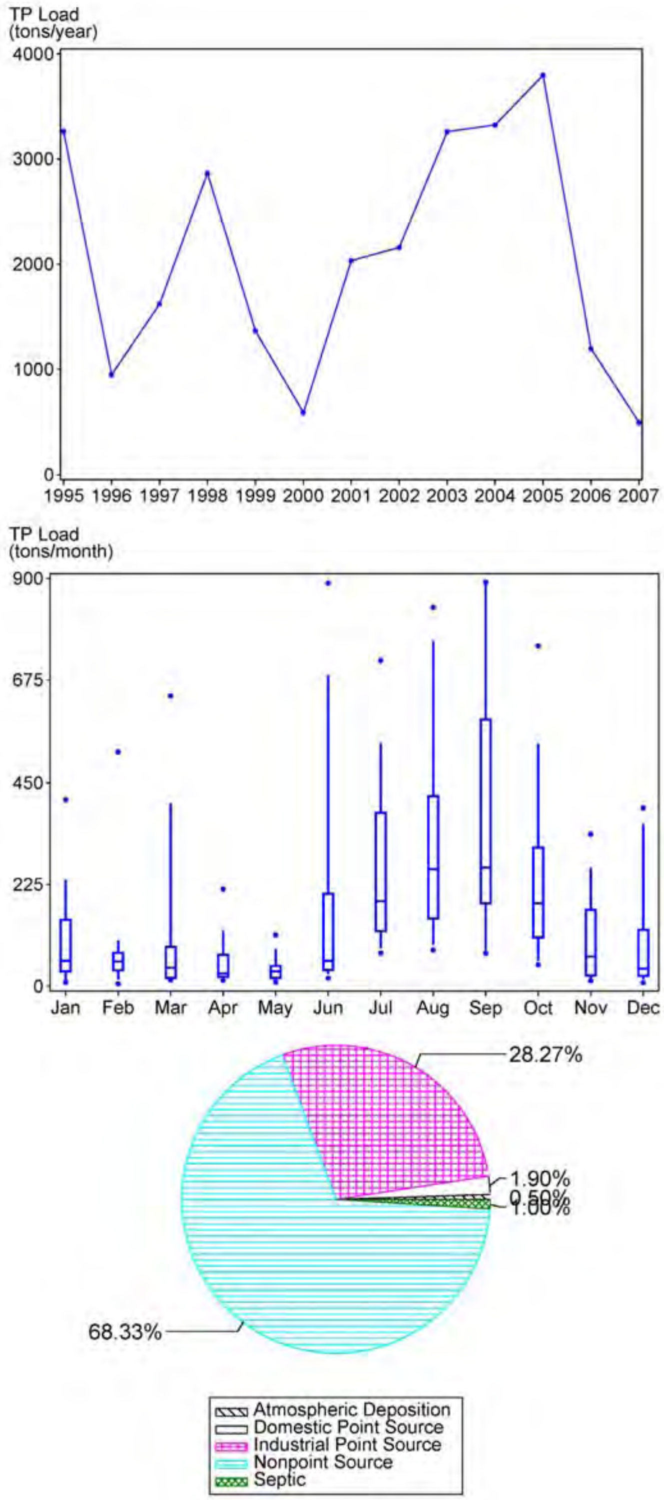

Figure 4-2. Entire CHNEP area – TP loads: annual, monthly, and by source.

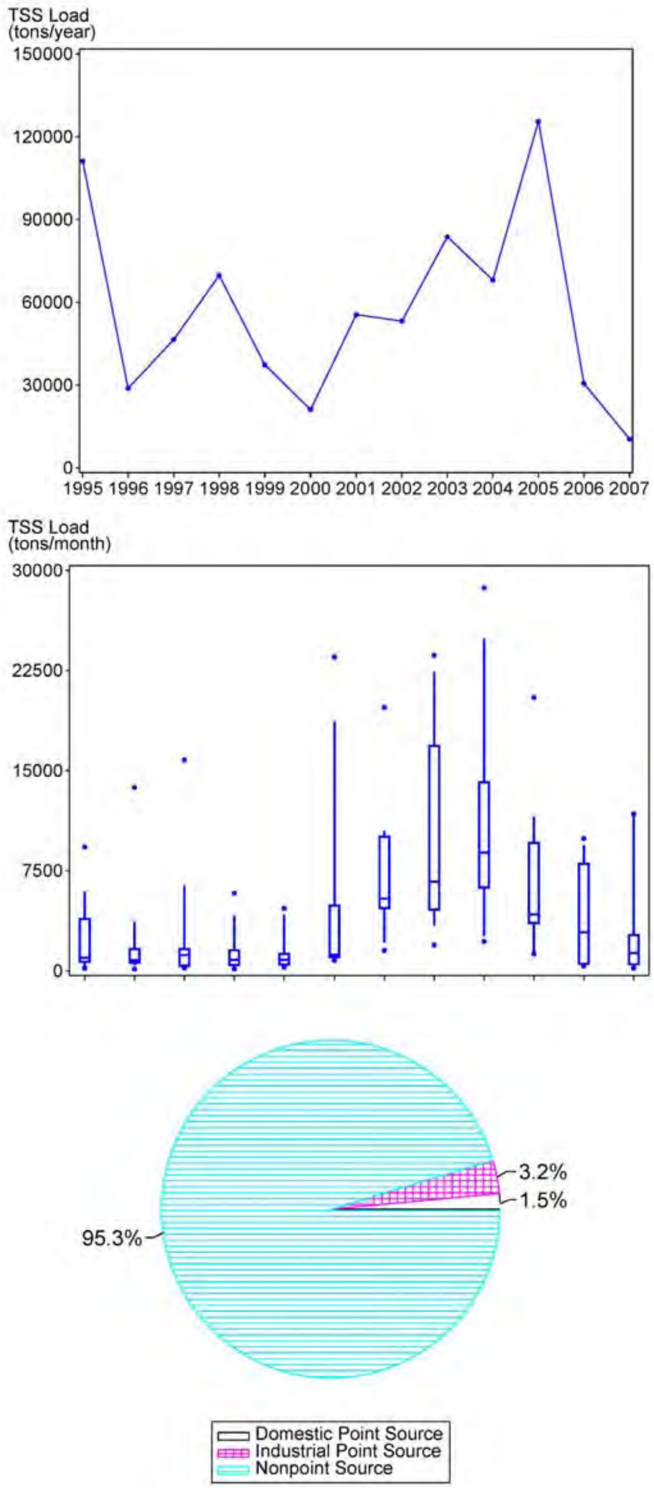

Figure 4-3. Entire CHNEP area – TSS loads: annual, monthly, and by source.

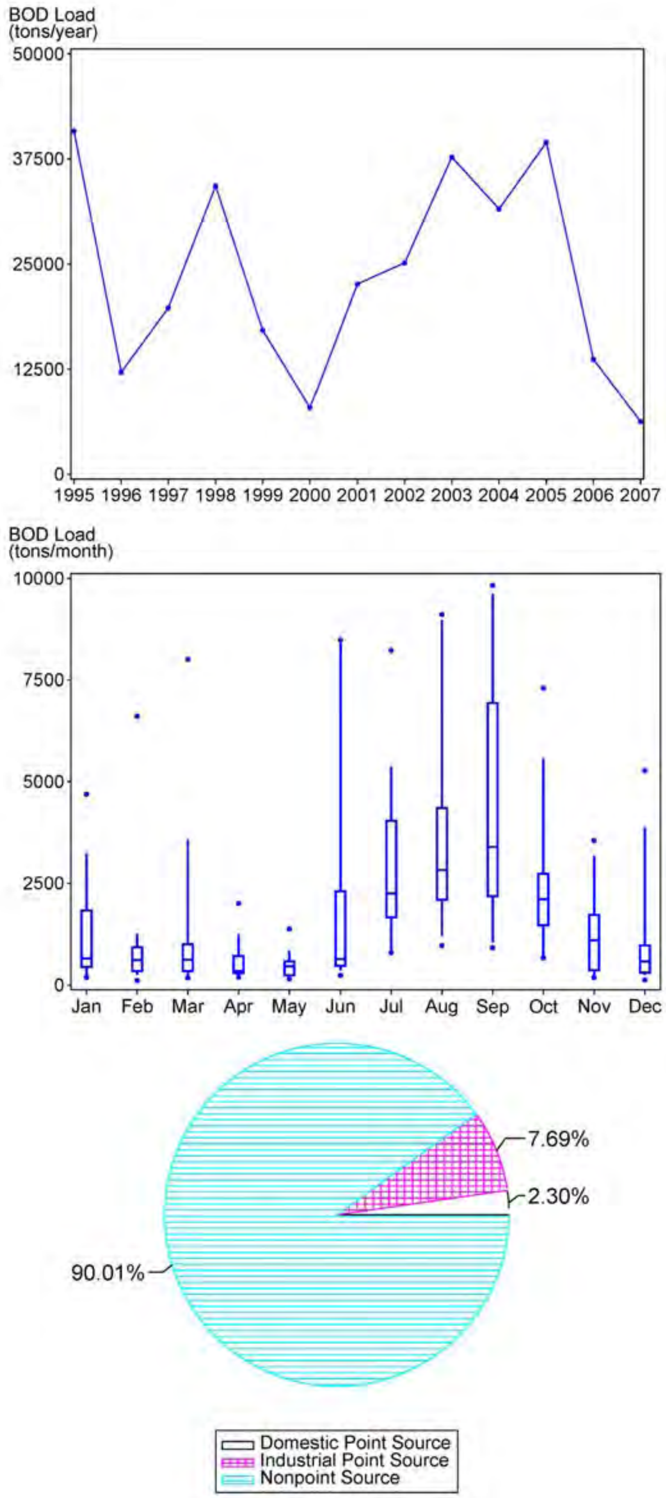

Figure 4-4. Entire CHNEP area – BOD loads: annual, monthly, and by source.

4.2 Loads by Segment

Pollutant loads (from all sources) for each of the CHNEP watershed segments are discussed below. Data for the period 1995 through 2007 were used for the analyses. Annual loads, monthly/ seasonal loads, and loading sources for TN, TP, TSS, and BOD are presented. The magnitudes of segment loads are largely a function of the segment size, as well as watershed to estuary area, land use, and magnitude of point source discharges.

Segments with larger drainage areas generate higher nonpoint source loads, and segments with large open water areas have larger atmospheric deposition. Identifying the larger loading sources (segments) allows focusing ecological protection actions on regions with the highest loadings. Exceptions to this may occur when a segment contains high point source loadings or many septic tanks near water bodies, as described in Chapter 3.

It should be noted that the annual and monthly load figures have the same general shape for all parameters and segments. This is because most of the TN, TP, TSS, and BOD loadings are from nonpoint sources and are therefore determined in large from precipitation patterns. Thus, years with higher annual rainfall have higher total loadings than drier years, and wet season months (June through September) generally have higher loadings than dry season months. These patterns are generally consistent throughout the CNHEP area

4.2.1 Dona and Roberts Bays

Figure 4-5 (top) shows annual TN total loads for Dona and Roberts Bay for the period 1995 through 2007. Total annual loads range from 339 (1995) to 53 (2007) tons/month. Loads were generally higher during months of higher rainfall, reflecting higher nonpoint source and atmospheric deposition inputs.

For the period of data used, wetter years included 1995, 1997, 1998, 2003, and 2005. Dryer years included 1996, 2000, 2001, 2006, and 2007. Annual watershed loadings generally followed the same pattern as total loads.

Figure 4-5 (middle) shows average monthly TN total loads for the same period. Loads are higher during the June – September wet season, due to high nonpoint source runoff. The wet season total TN loads (all sources) average 30.1 tons/month, and dry season total loads average 8.8 tons/month.

Figure 4-5 (bottom) shows the sources of TN total loads. The major contributor was nonpoint source (95%) (due to the high watershed to estuary area ratio). Septic tanks (3.2%), atmospheric deposition (0.8%), and the only point source identified in this bay segment: Venice- Eastside WWT (0.9%) accounted for the remainder.

Figure 4-6 (top) shows annual TP total loads for Dona and Roberts Bay for the period 1995 through 2007. Total loads range from 66 (1995) to 8.9 tons/year (2007).

Figure 4-6 (middle) shows average monthly TP loads for the same period. The wet season total loads average 5.8 tons/month, and dry season loads average 1.6 tons/month.

Figure 4-6 (bottom) shows the sources of TP total loads. The major contributor was nonpoint source (97%). Septic tanks (1.4%), atmospheric deposition (0.1%), and domestic point sources (1.8%) account for the remainder.

Figure 4-7 (top) shows annual TSS total loads for Dona and Roberts Bay for the period 1995 through 2007. Total loads range from 4003 (1995) to 593 tons/year (2007).

Figure 4-7 (middle) shows average monthly TSS loads for the same period. The wet season loads average 343 tons/month, and dry season loads average 102 tons/month.

Figure 4-7 (bottom) shows the sources of TSS total loads. The nonpoint sources contributed 99.9% of the load, and the domestic point source 0.1%.

Figure 4-8 (top) shows annual BOD total loads for Dona and Roberts Bay for the period 1995 through 2007. Total loads range from 1198 (1995) to 179 (2007).

Figure 4-8 (bottom) shows average monthly BOD loads for the same period. The wet season loads average 103 tons/month, and dry season loads average 31 tons/month.

Figure 4-8 (bottom) shows the sources of BOD total loads. The nonpoint sources contributed 99.5% of the load, and the domestic point source 0.5%.

It should be noted that the annual and monthly load figures have the same general shape for all parameters and segments. This is because most of the TN, TP, TSS, and BOD loadings are from nonpoint sources and are therefore determined in large from precipitation patterns. Thus, years with higher annual rainfall have higher total loadings than drier years, and wet season months (June through September) generally have higher loadings than dry season months. These patterns are generally consistent throughout the CNHEP area.

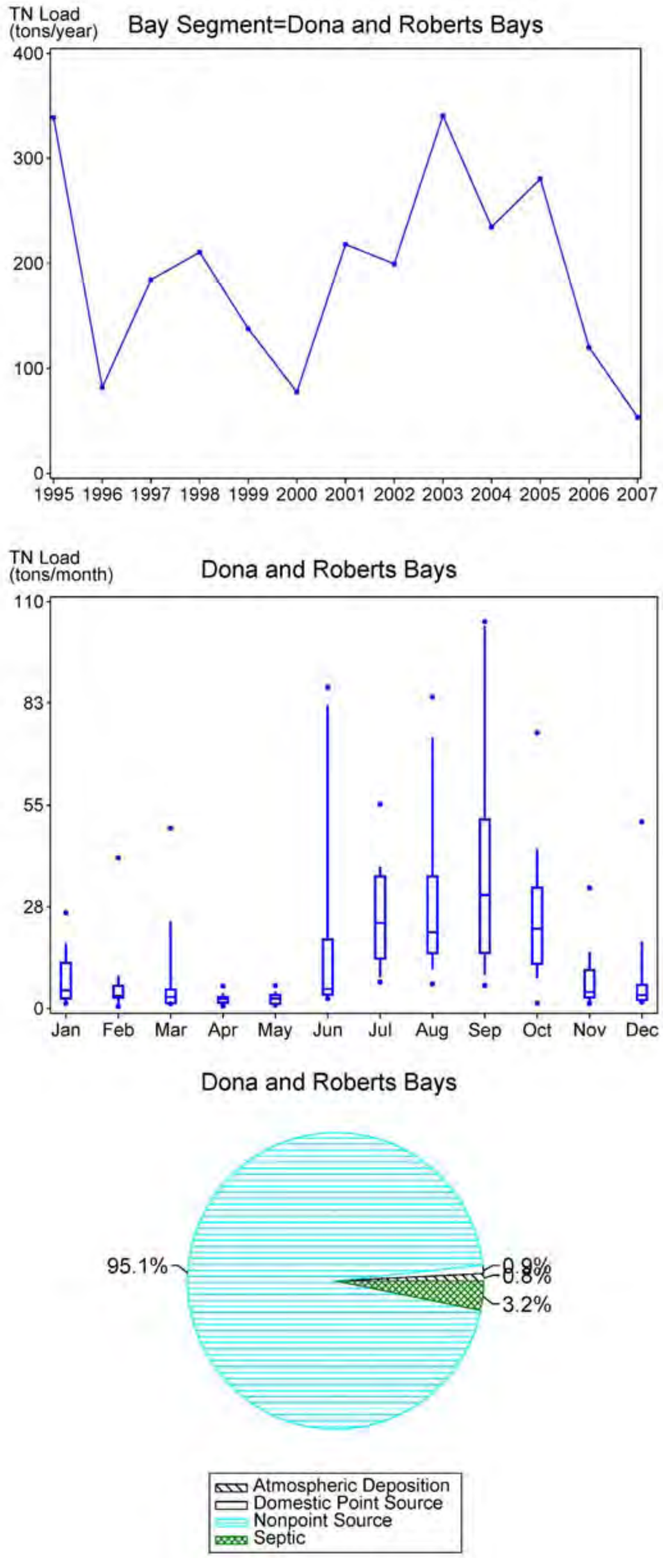

Figure 4-5. Dona and Roberts Bay: TN loads: annual, monthly, and by source.

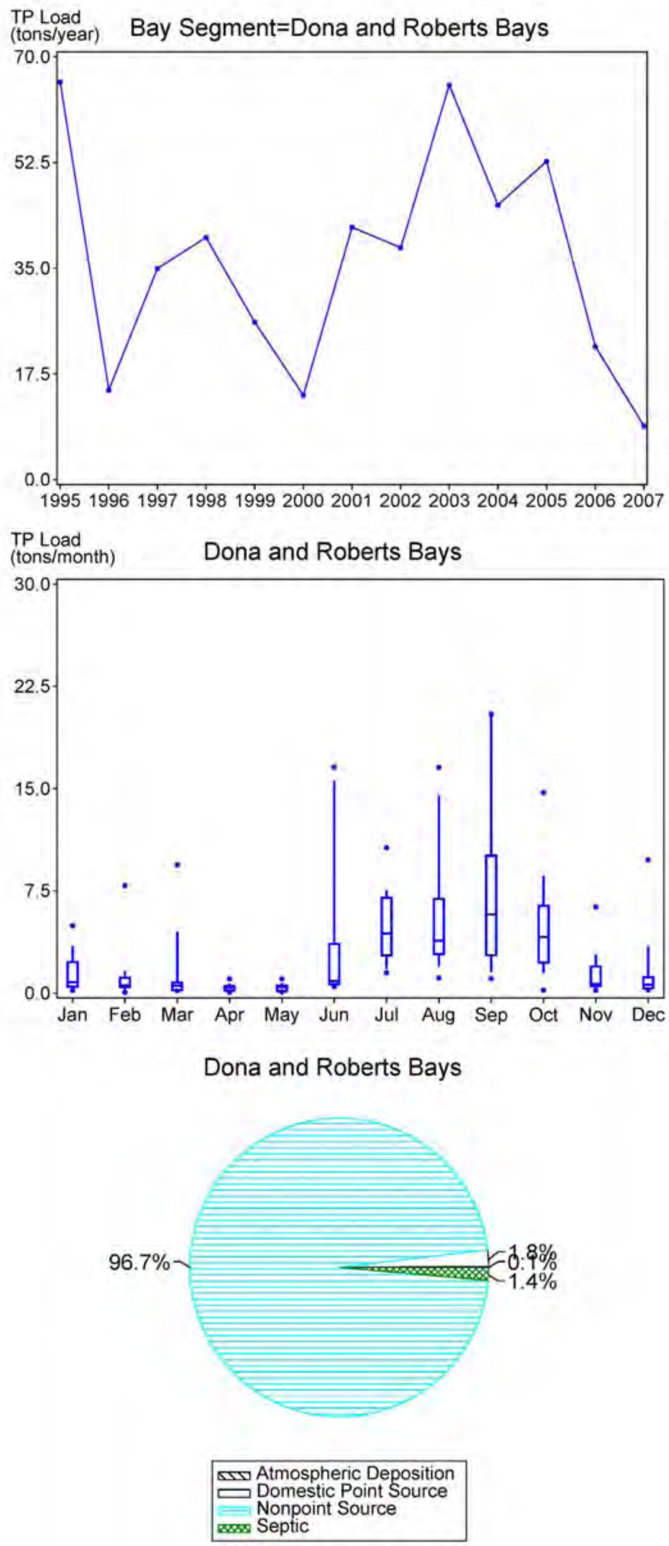

Figure 4-6. Dona and Roberts Bay – TP loads: annual, monthly, and by source.

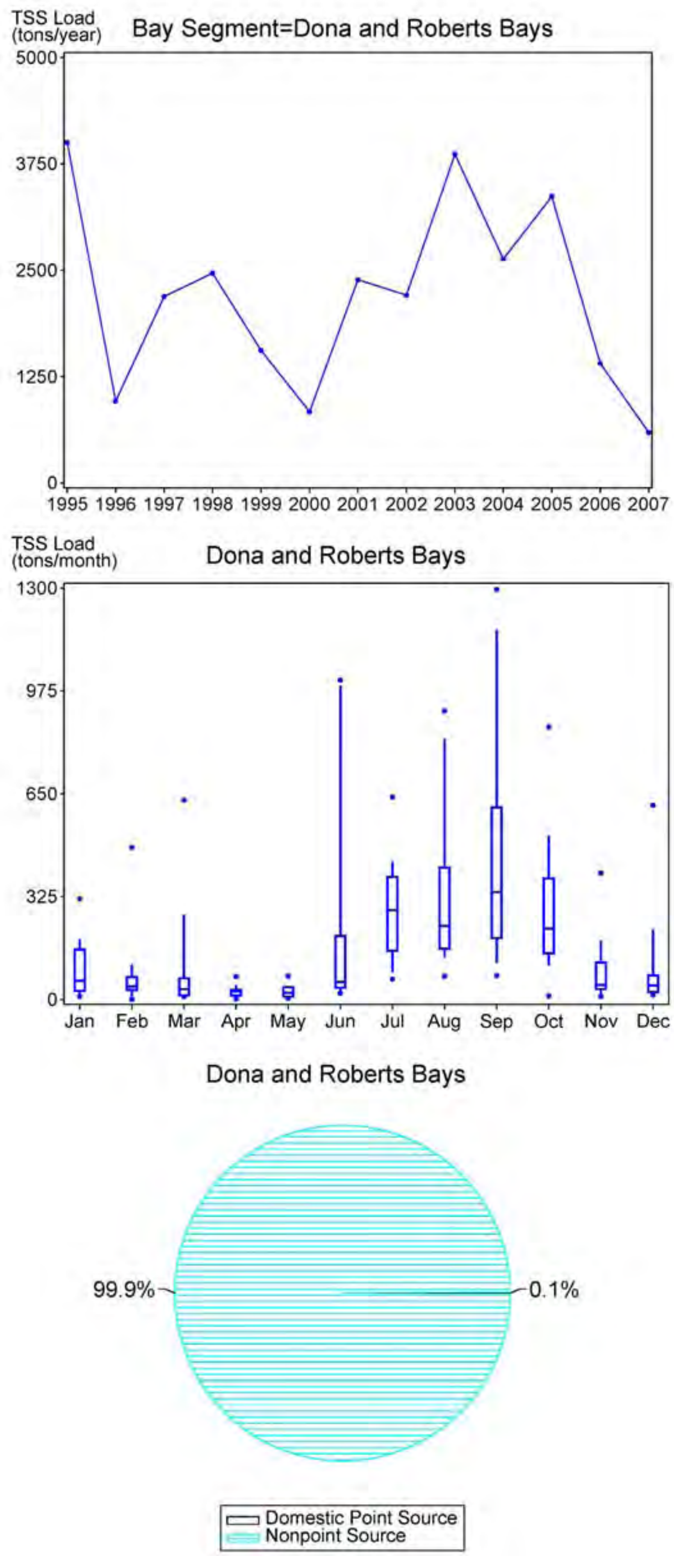

Figure 4-7. Dona and Roberts Bay – TSS loads: annual, monthly, and by source.

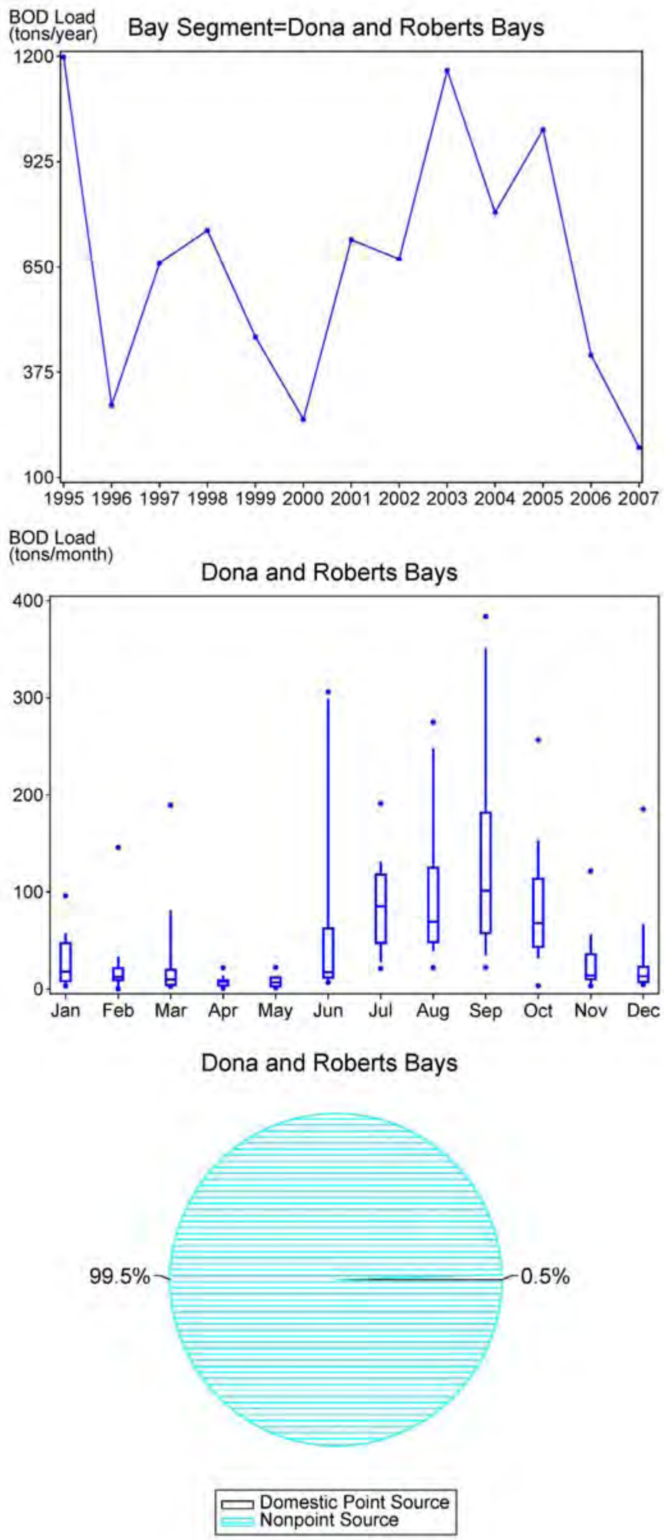

Figure 4-8. Dona and Roberts Bay – BOD loads: annual, monthly, and by source.

4.2.2 Upper Lemon Bay

Figure 4-9 (top) shows annual TN total loads for Upper Lemon Bay for the period 1995 through 2007. Total loads range from 119 (1995) to 25 tons/year (2007). Loads were generally higher during years of higher rainfall, reflecting higher nonpoint source and atmospheric deposition inputs. For the period of data used, wetter years included 1995, 1997, 1998, 2003, and 2005. Dryer years included 1996, 2000, 2001, 2006, and 2007. Annual watershed loadings generally followed the same pattern as total loads.

Figure 4-9 (middle) shows average monthly TN total loads for the same period. Loads were higher during the June – September wet season, due to high nonpoint source runoff and/or atmospheric deposition. The wet season total loads average 10.3 tons/month, and dry season total loads average 3.3 tons/month. Figure 4-9 (bottom) shows the sources of TN total loads. The major contributor was nonpoint source (87%) (due to the high watershed to estuary area ratio). Other sources included atmospheric deposition (8.9%) (due to the relatively low watershed to estuary area ratio) and septic tanks (4.5%). There are no domestic or industrial point sources in this bay segment.

Figure 4-10 (top) shows annual TP total loads for Upper Lemon Bay for the period 1995 through 2007. Total loads range from 21 (1995) to 3.7 tons/year (2007). Figure 4-10 (middle) shows average monthly TP loads for the same period. The wet season loads average 1.8 tons/month, and dry season loads average 0.6 tons/month. Figure 4-10 (bottom) shows the sources of TP total loads. The major contributor was nonpoint source (97%). Other sources included atmospheric deposition (<1%) and septic tanks (2.2%).

Figure 4-11 (top) shows annual TSS total loads for Upper Lemon Bay for the period 1995 through 2007. Total loads range from 1656 (1995) to 280 tons/year (2007). Figure 4-11 (middle) shows average monthly TSS loads for the same period. The wet season loads average 138 tons/month, and dry season loads average 43 tons/month. Figure 4-11 (bottom) shows the sources of TSS total loads. The only contributor is nonpoint source.

Figure 4-12 (top) shows annual BOD total loads for Upper Lemon Bay for the period 1995 through 2007. Total loads range from 461 (1995) to 76 tons/year (2007). Figure 4-12 (middle) shows average monthly BOD loads for the same period. The wet season loads average 38 tons/month, and dry season loads average 12 tons/month. Figure 4-12 (bottom) shows the BOD sources. The only contributor was nonpoint source.

It should be noted that the annual and monthly load figures have the same general shape for all parameters and segments. This is because most of the TN, TP, TSS, and BOD loadings are from nonpoint sources and are therefore determined in large from precipitation patterns. Thus, years with higher annual rainfall have higher total loadings than drier years, and wet season months (June through September) generally have higher loadings than dry season months. These patterns are generally consistent throughout the CNHEP area.

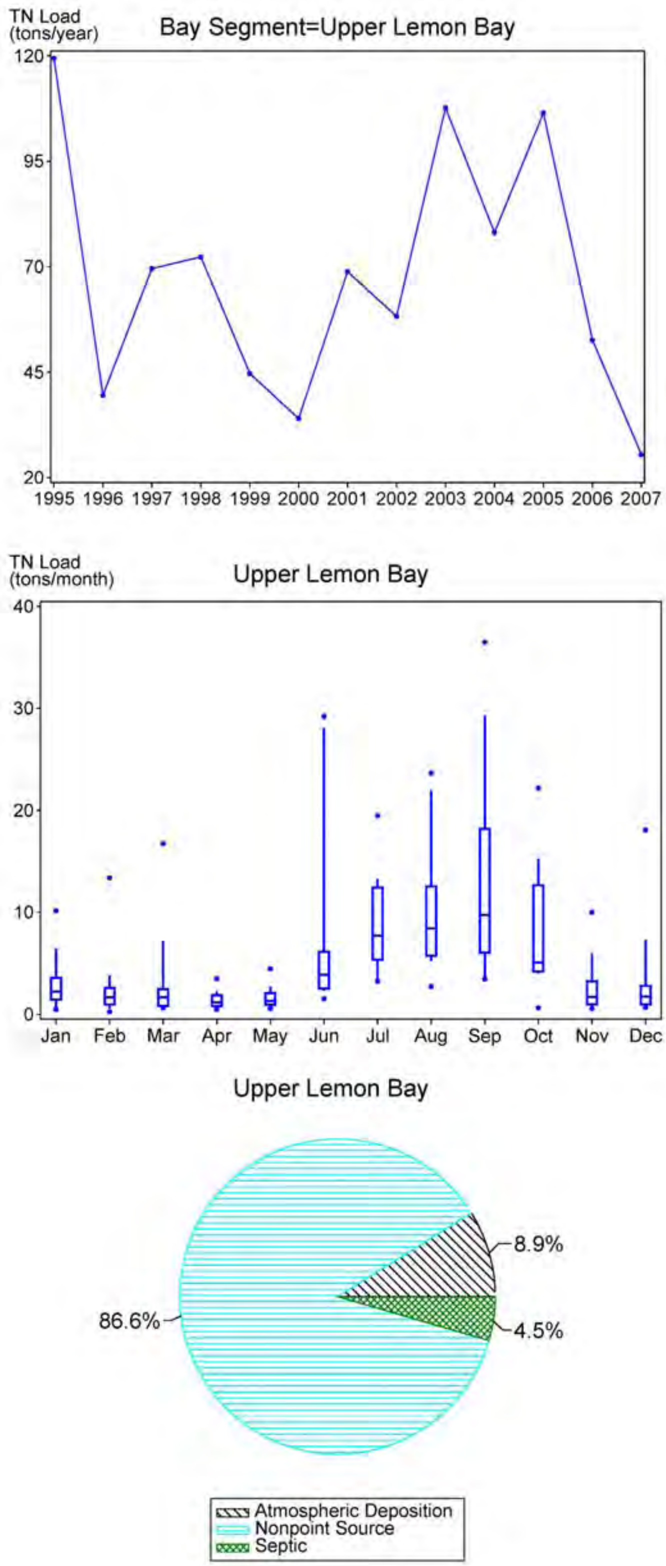

Figure 4-9. Upper Lemon Bay – TN loads: annual, monthly, and by source.

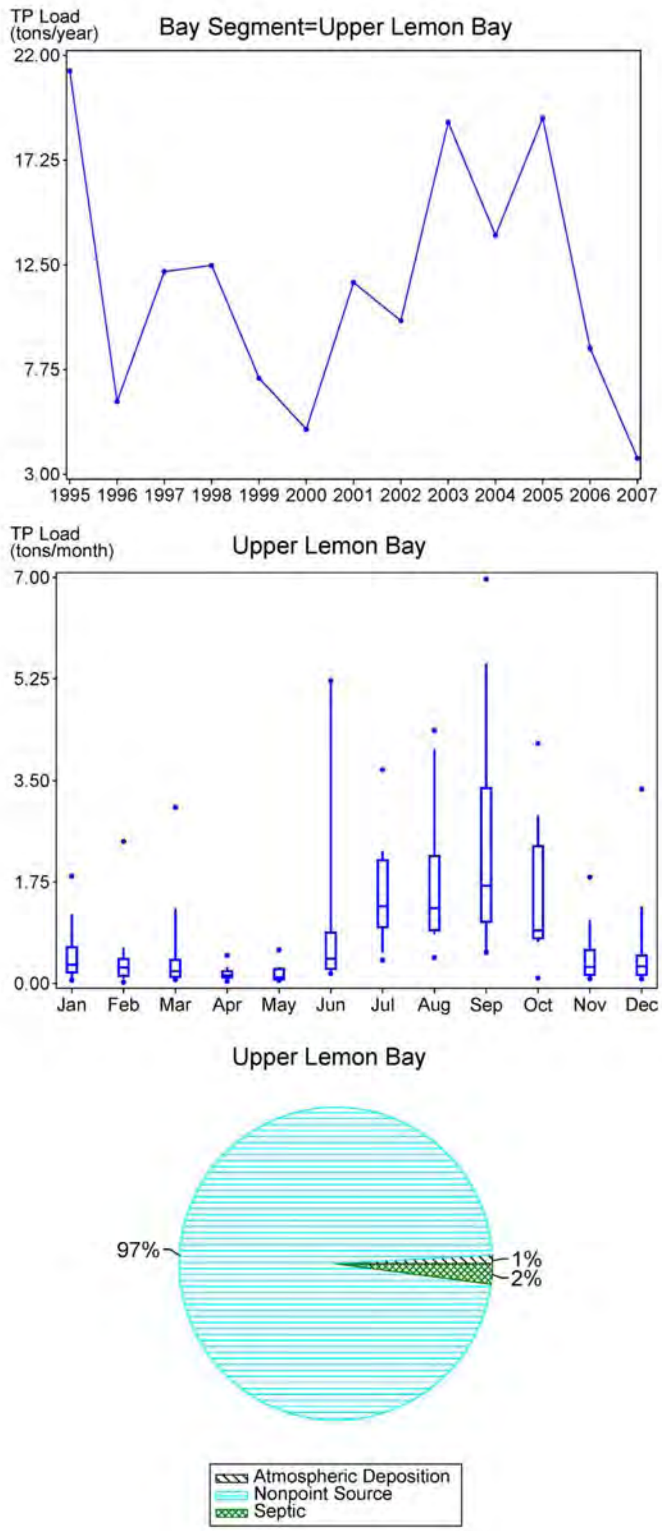

Figure 4-10. Upper Lemon Bay – TP loads: annual, monthly, and by source.

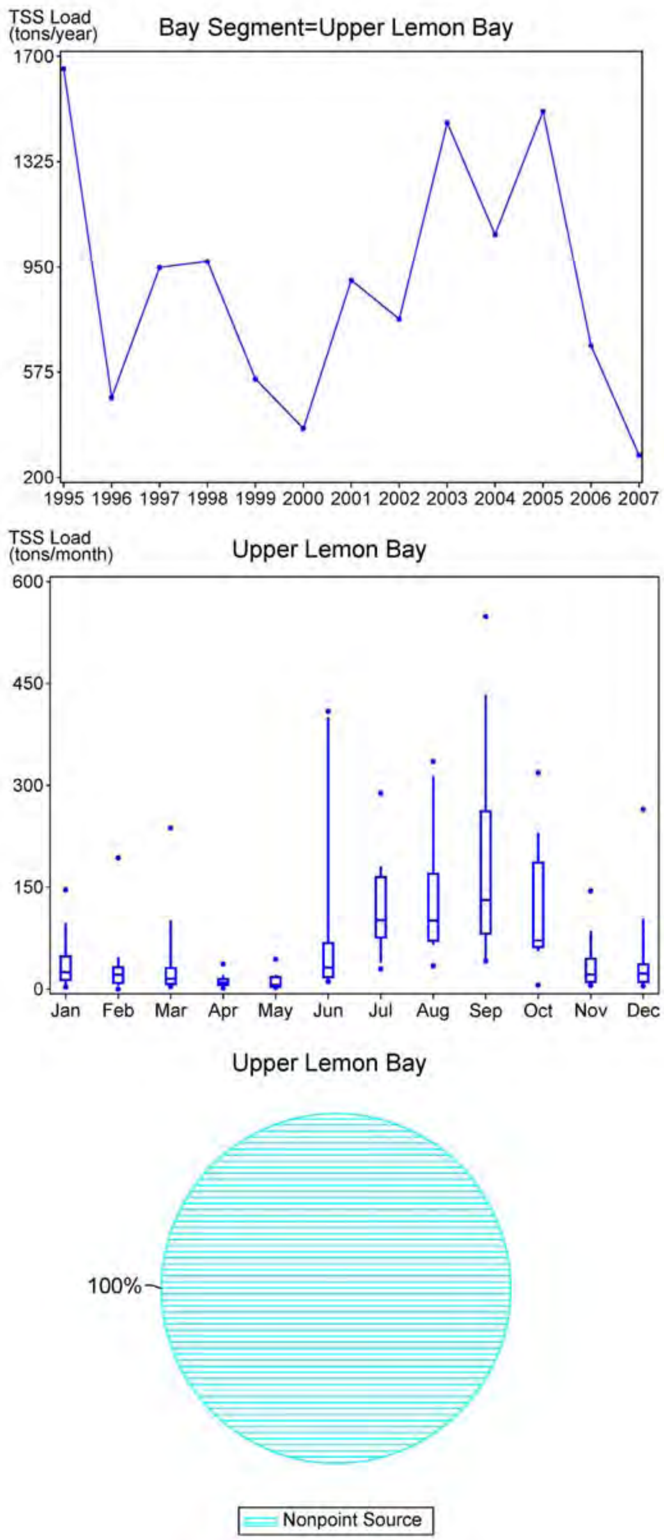

Figure 4-11. Upper Lemon Bay – TSS loads: annual, monthly, and by source.

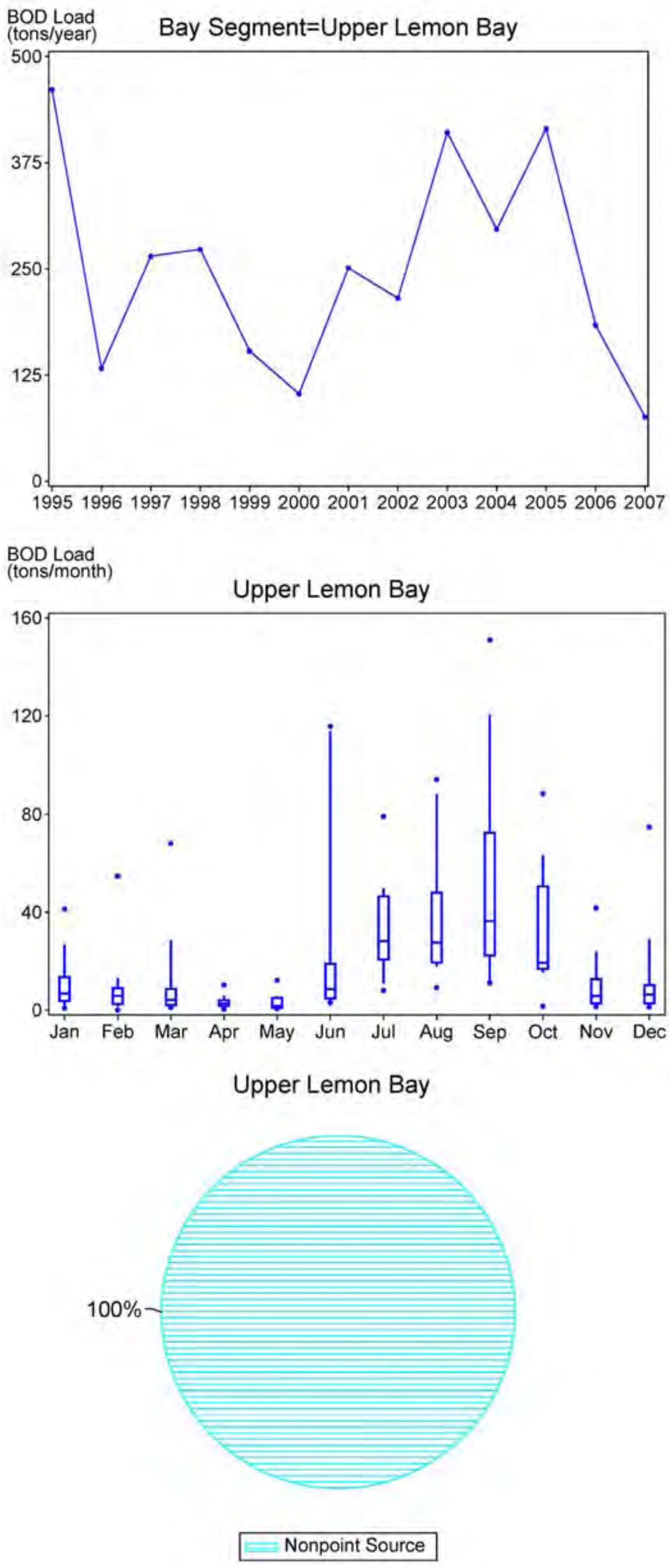

Figure 4-12. Upper Lemon Bay – BOD loads: annual, monthly, and by source.

4.2.3 Lower Lemon Bay

Figure 4-13 (top) shows annual TN total loads for Lower Lemon Bay for the period 1995 through 2007. Total loads range from 162 (1995) to 29 tons/year (2007). Loads were generally higher during years of higher rainfall, reflecting higher nonpoint source and atmospheric deposition inputs. For the period of data used, wetter years included 1995, 1997, 1998, 2003, and 2005. Dryer years included 1996, 2000, 2001, 2006, and 2007. Annual watershed loadings generally followed the same pattern as total loads.

Figure 4-13 (middle) shows average monthly TN total loads for the same period. Loads were higher during the June – September wet season, due to high nonpoint source runoff and/or atmospheric deposition. The wet season total loads average 15 tons/ month and dry season loads average 4.2 tons/month. Figure 13 (bottom) shows the sources of TN total loads. The major contributor was nonpoint source (84%) (due to the high watershed to estuary area ratio). Other sources included atmospheric deposition (13%), septic tanks (3%), and domestic point source Gasparilla Island Water Association and Rotunda West Utilities Corp (0.2%).

Figure 4-14 (top) shows annual TP total loads for Lower Lemon Bay for the period 1995 through 2007. Total loads range from 25 (1995) to 3.4 tons/year (2007). Figure 4-14 (middle) shows average monthly TP loads for the same period. The wet season loads average 2.3 tons/month, and dry season loads average 0.6 tons/month. Figure 14 (bottom) shows the sources of TP total loads. The major contributor was nonpoint source (96%). Other sources included atmospheric deposition (1.5%) and septic tanks (1.7%), and the domestic point sources (0.8%.

Figure 4-15 (top) shows annual TSS total loads for Lower Lemon Bay for the period 1995 through 2007. Total loads range from 1985 (1995) to 250 tons/year (2007). Figure 4-15 (middle) shows average monthly TSS loads for the same period. The wet season loads average 179 tons/month, and dry season loads average 48 tons/month. Figure 15 (bottom) shows the sources of TSS total loads. The only contributor was nonpoint source except 0.01% from the domestic point sources.

Figure 4-16 (top) shows annual BOD total loads for Lower Lemon Bay for the period 1995 through 2007. Total loads range from 496 (2005) to 63 tons/year (2007). Figure 4-16 (middle) shows average monthly BOD loads for the same period. The wet season loads average 45 tons/month, and dry season loads average 12 tons/month. Figure 4-16 (bottom) shows the only source of BOD total loads, nonpoint source.

It should be noted that the annual and monthly load figures have the same general shape for all parameters and segments. This is because most of the TN, TP, TSS, and BOD loadings are from nonpoint sources and are therefore determined in large from precipitation patterns. Thus, years with higher annual rainfall have higher total loadings than drier years, and wet season months (June through September) generally have higher loadings than dry season months. These patterns are generally consistent throughout the CNHEP area.

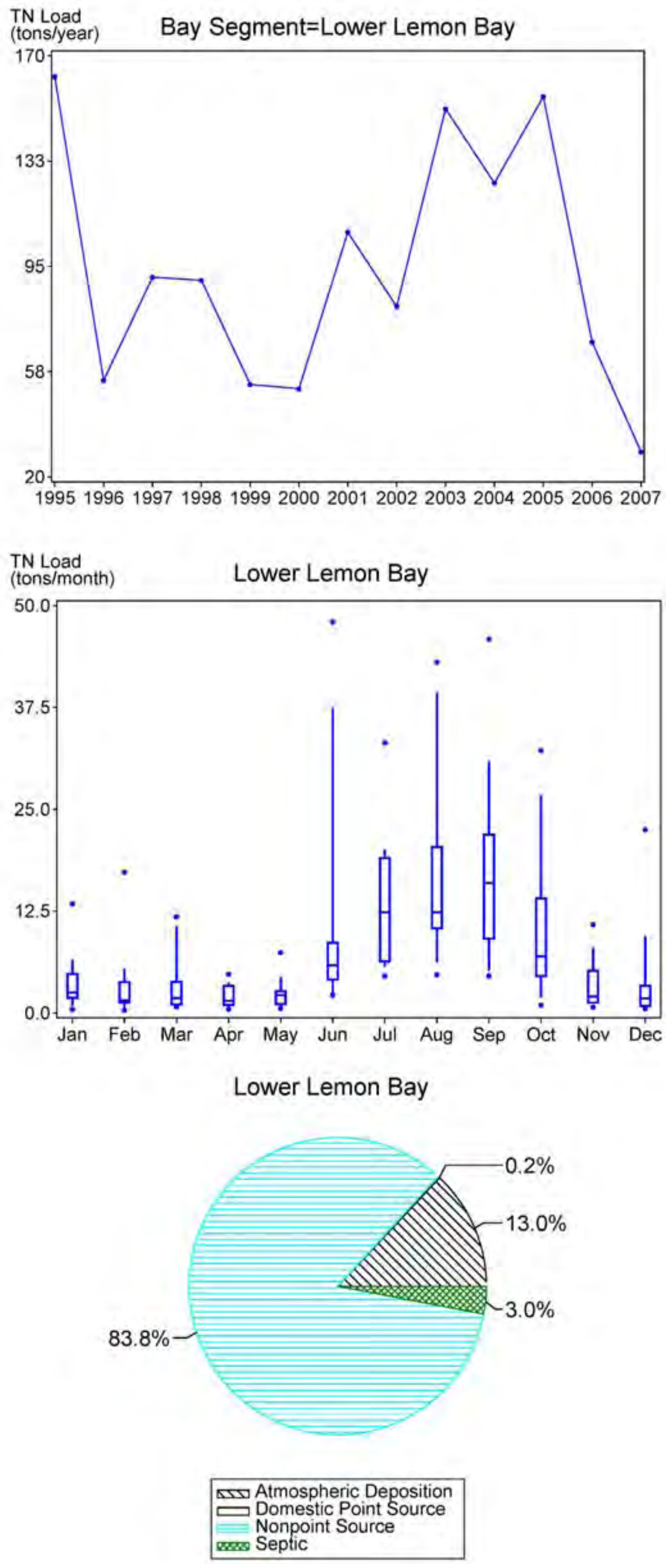

Figure 4-13. Lower Lemon Bay – TN loads: annual, monthly, and by source.

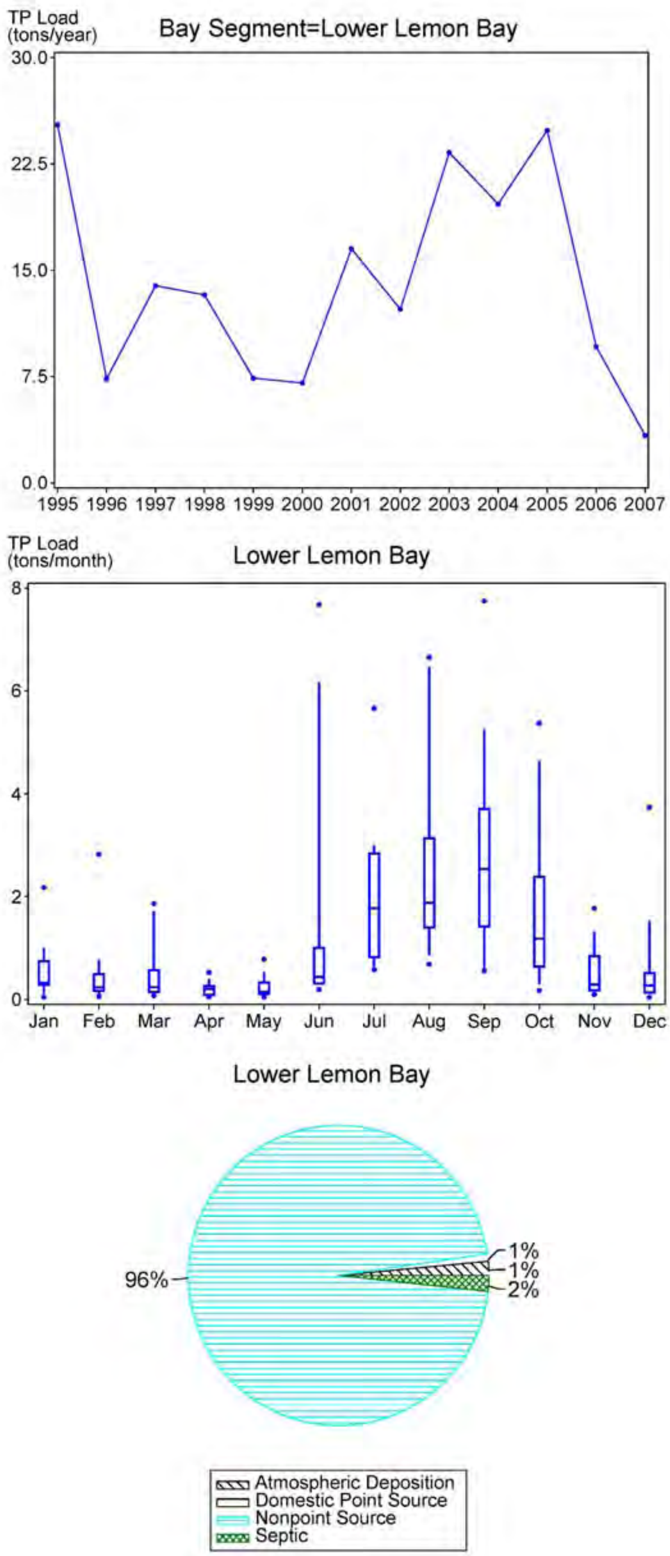

Figure 4-14. Lower Lemon Bay – TP loads: annual, monthly, and by source.

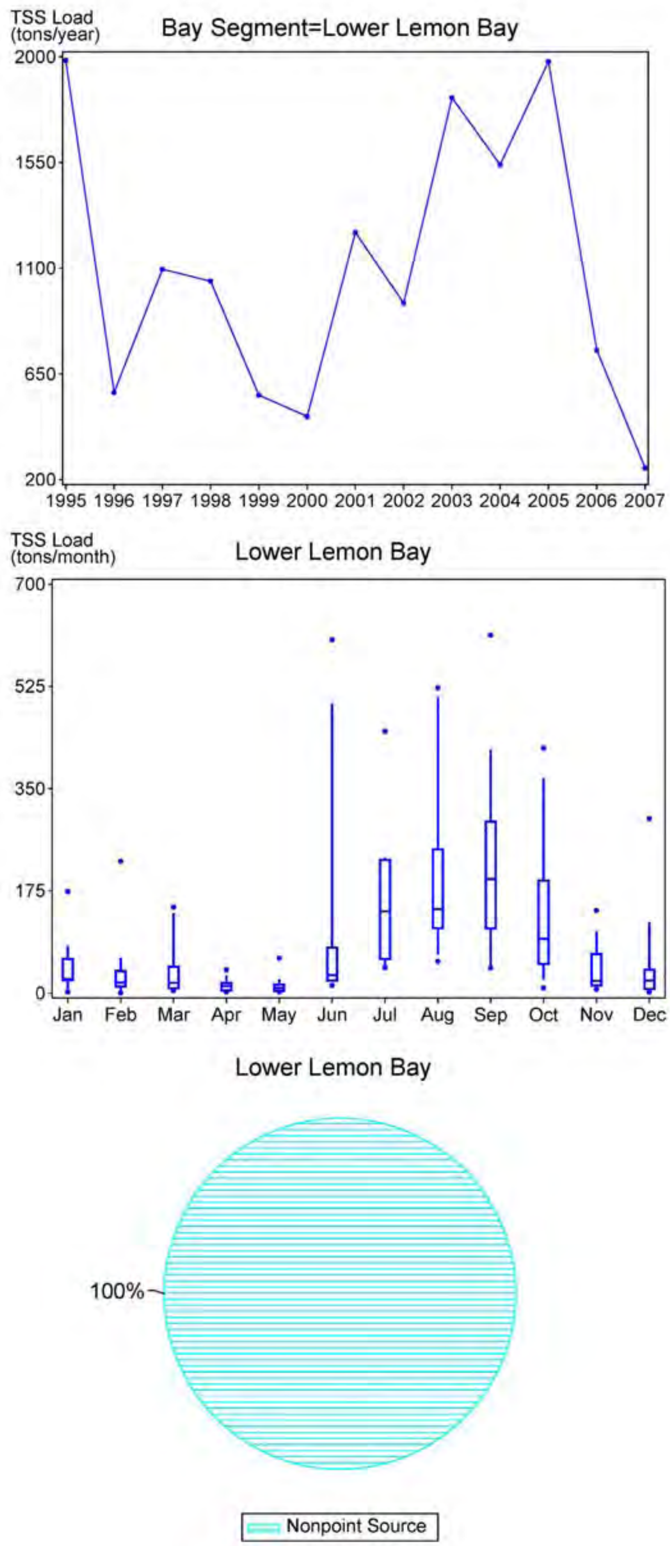

Figure 4-15. Lower Lemon Bay – TSS loads: annual, monthly, and by source.

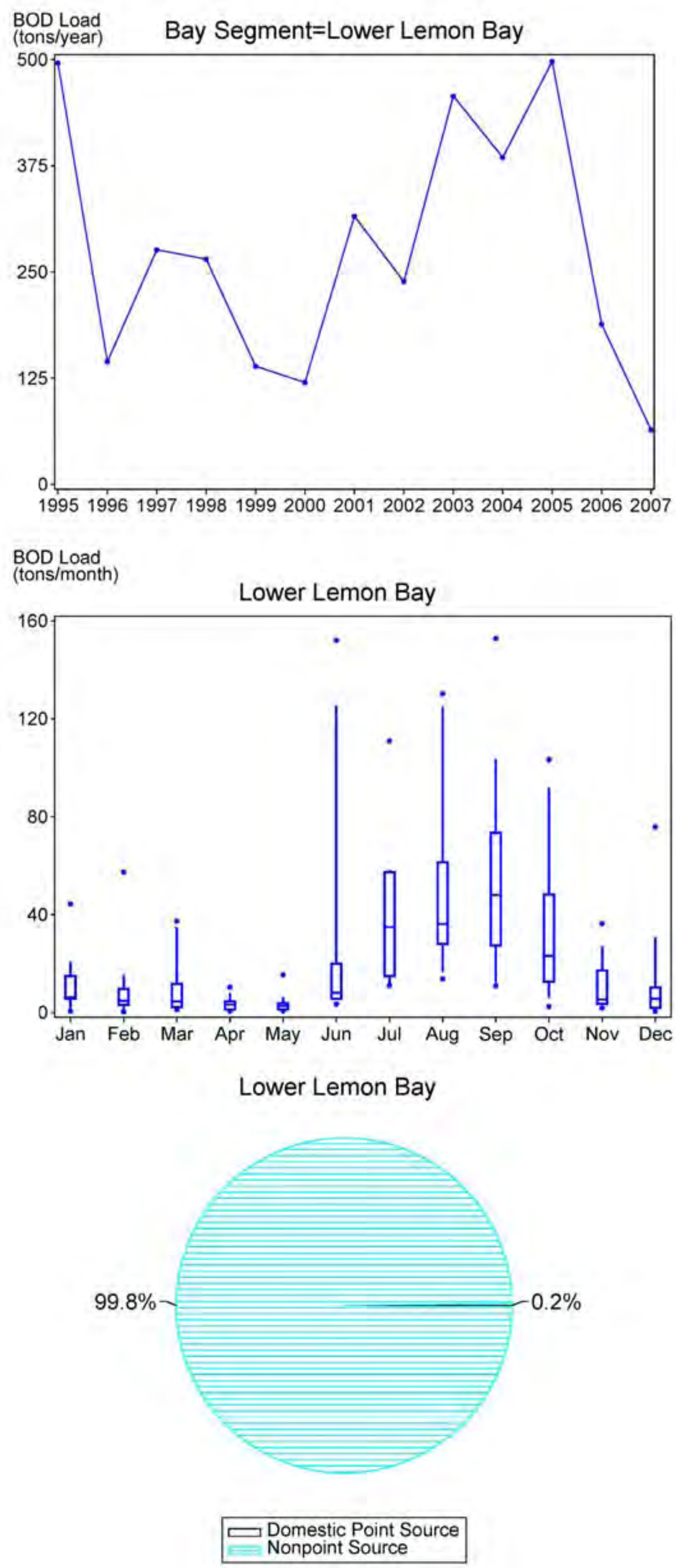

Figure 4-16. Lower Lemon Bay – BOD loads: annual, monthly, and by source.

4.2.4 Cape Haze

Figure 4-17 (top) shows annual TN total loads for Cape Haze for the period 1995 through 2007. Total loads range from 80 (1995) to 30 tons/year (2007). Loads were generally higher during years of higher rainfall, reflecting higher nonpoint source and atmospheric deposition inputs. For the period of data used, wetter years included 1995, 1997, 1998, 2003, and 2005. Dryer years included 1996, 2000, 2001, 2006, and 2007. Annual watershed loadings generally followed the same pattern as total loads.

Figure 4-17(middle) shows average monthly TN total loads for the same period. Loads were higher during the June – September wet season, due to high nonpoint source runoff and/or atmospheric deposition. The wet season total loads average 8.2 tons/ month, and dry season loads average 2.3 tons/month. Figure 4-17 (bottom) shows the sources of TN total loads. The major contributor was atmospheric deposition (67%) (due to the relatively low watershed to estuary area ratio). The other contributor was nonpoint source (33%). There are no domestic or industrial point sources in this bay segment.

Figure 4-18 (top) shows annual TP total loads for Cape Haze for the period 1995 through 2007. Total loads range from 4.6 (1995) to 0.8 tons/year (2007). Figure 4-18 (middle) shows average monthly TP total loads for the same period. The wet season loads average 0.5 tons/month, and dry season loads average 0.1 tons/month. Figure 4-18 (bottom) shows TP load sources. The major contributor was nonpoint source (78%). Other sources was atmospheric deposition (22%) and septic tanks (<0.1%).

Figure 4-19 (top) shows annual TSS total loads for Cape Haze for the period 1995 through 2007. Total loads range from 338 (1995) to 36 tons/year (2007). Figure 4-19 (middle) shows average monthly TSS loads for the same period. The wet season loads average 30 tons/month, and dry season loads average 7.6 tons/month. Figure 19 (bottom) shows the sources of TSS total loads. The only contributor was nonpoint source.

Figure 4-20 (top) shows annual BOD total loads for Cape Haze for the period 1995 through 2007. Total loads range from 98 (1995) to 11 tons/year (2007). Figure 4-20 (middle) shows average monthly BOD loads for the same period. The wet season loads average 8.7 tons/month, and dry season loads average 2.3 tons/month. Figure 20 (bottom) shows the sources of BOD total loads. The only contributor was nonpoint source (100%).

It should be noted that the annual and monthly load figures have the same general shape for all parameters and segments. This is because most of the TN, TP, TSS, and BOD loadings are from nonpoint sources and are therefore determined in large from precipitation patterns. Thus, years with higher annual rainfall have higher total loadings than drier years, and wet season months (June through September) generally have higher loadings than dry season months. These patterns are generally consistent throughout the CNHEP area.

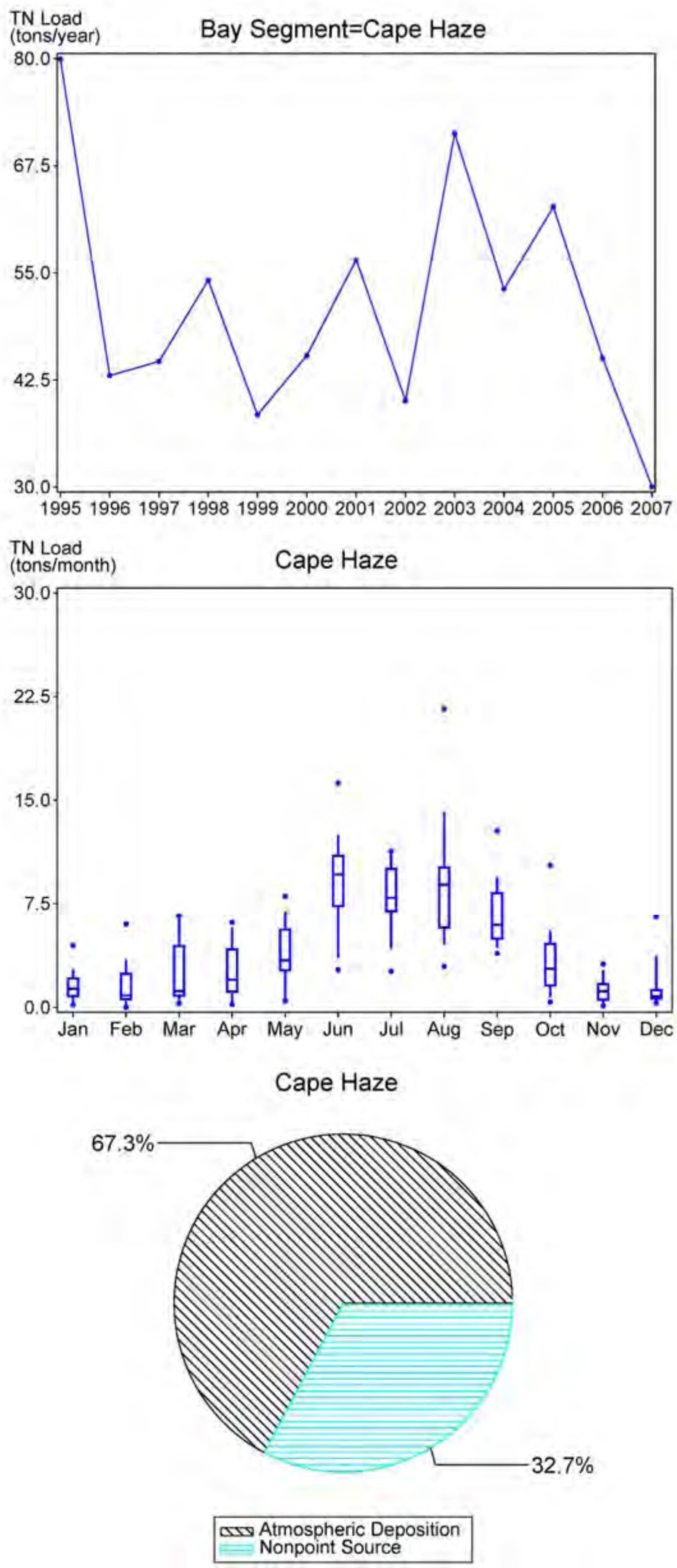

Figure 4-17. Cape Haze – TN loads: annual, monthly, and by source.

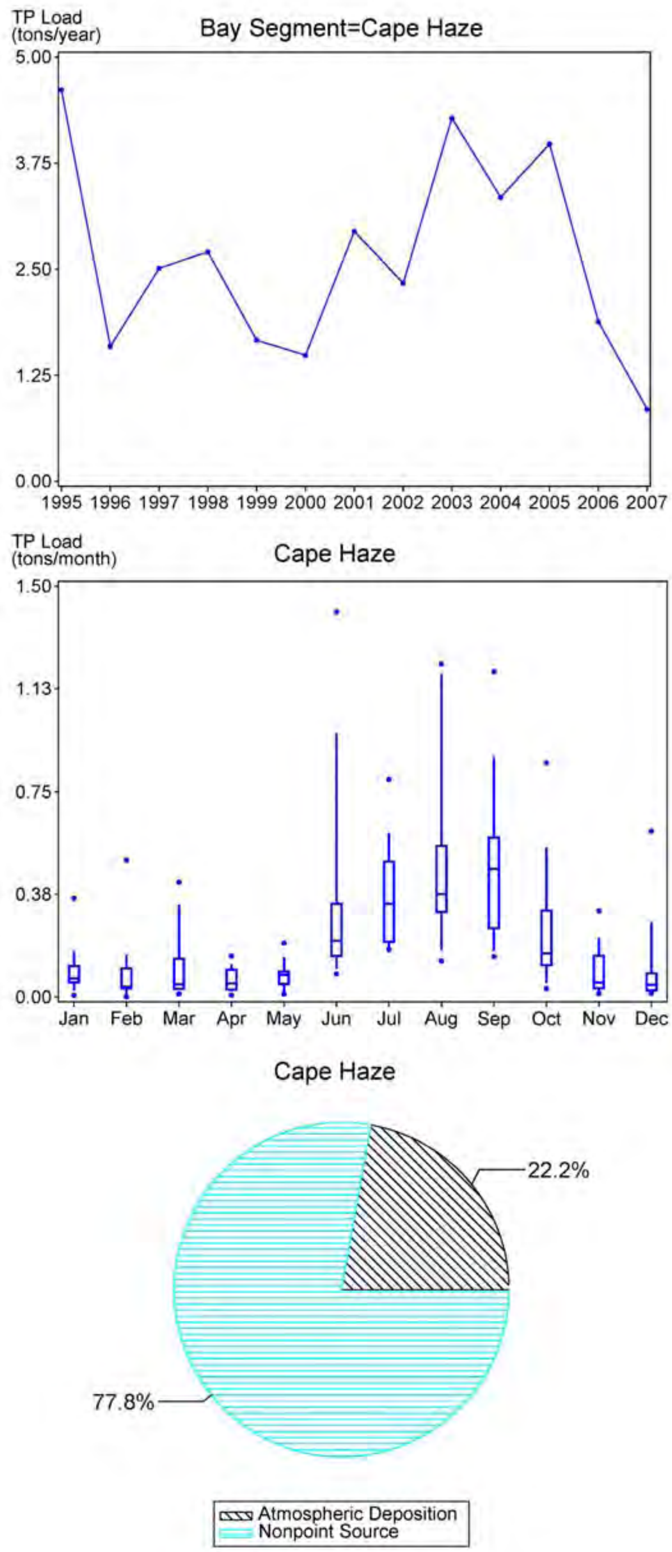

Figure 4-18. Cape Haze – TP loads: annual, monthly, and by source.

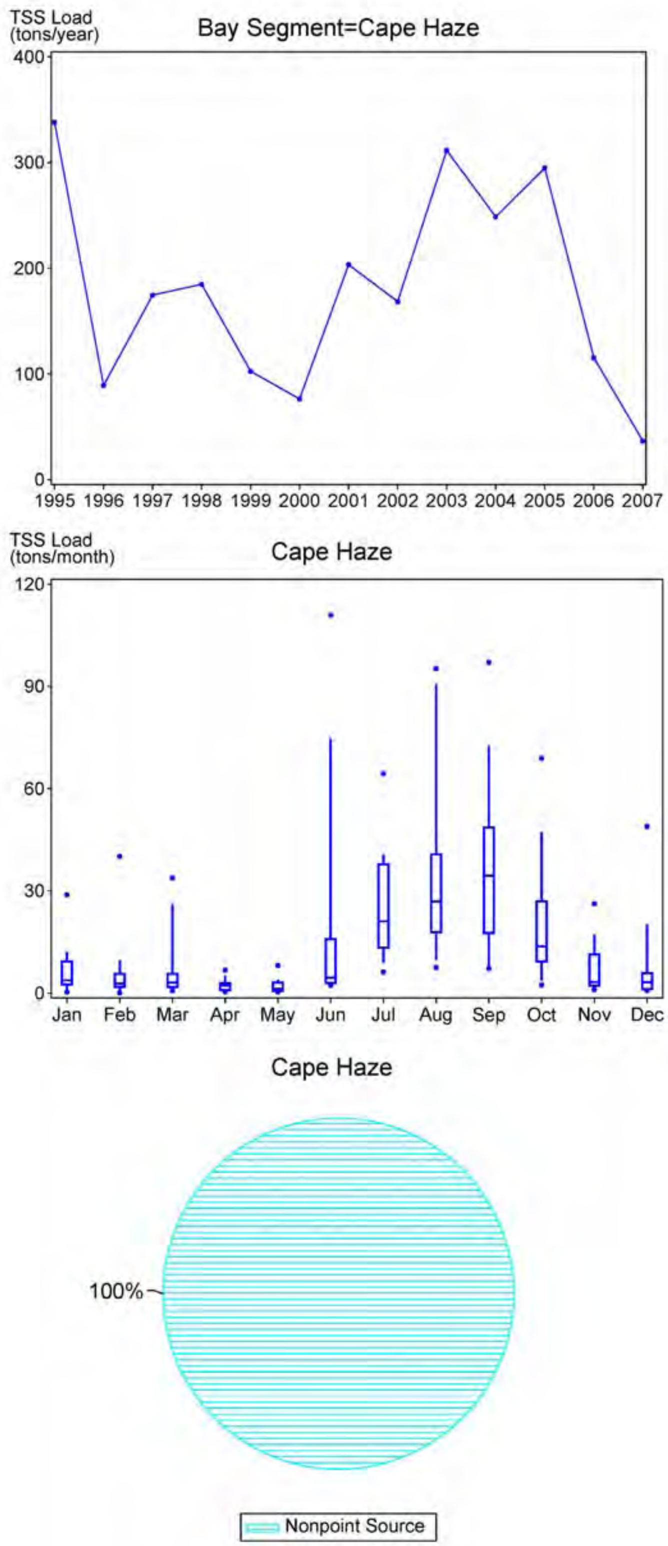

Figure 4-19. Cape Haze – TSS loads: annual, monthly, and by source.

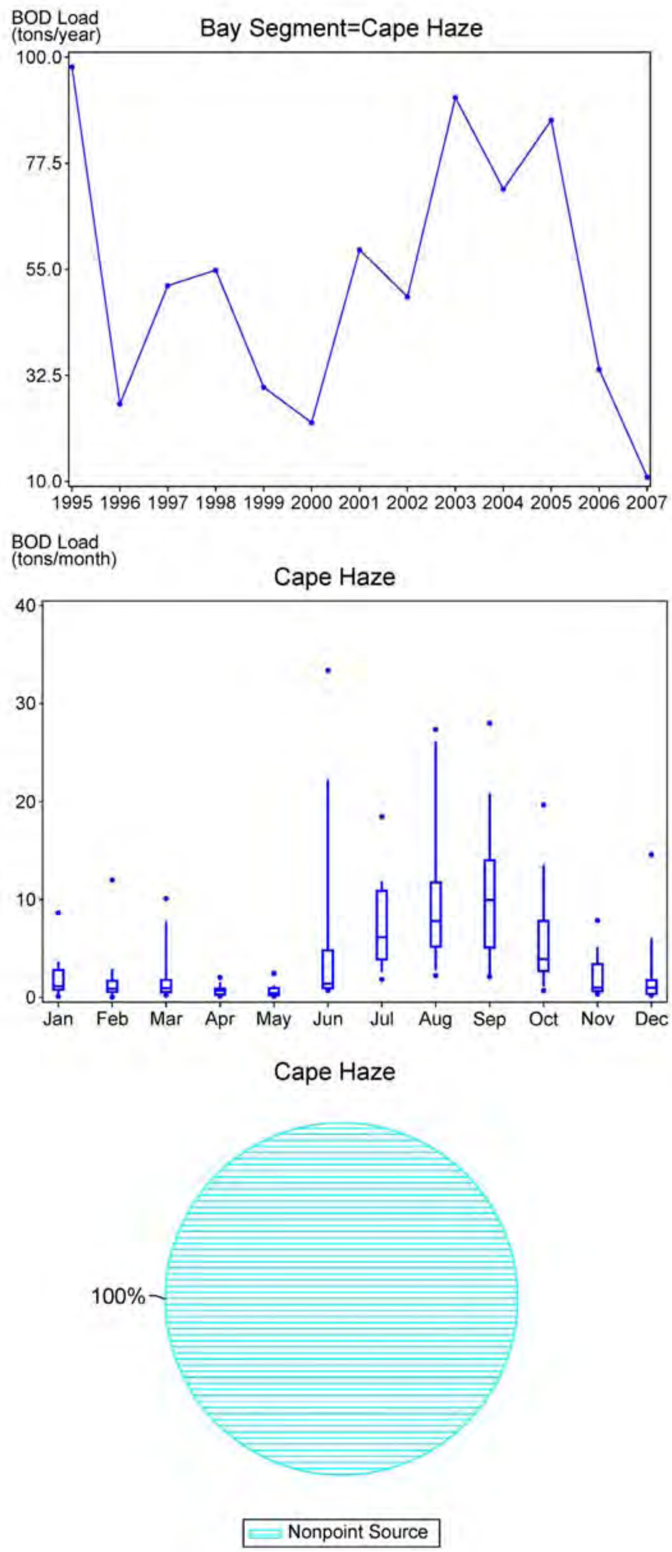

Figure 4-20. Cape Haze – BOD loads: annual, monthly, and by source.

4.2.5 Bokeelia

Figure 4-21 (top) shows annual TN total loads for Bokeelia for the period 1995 through 2007. Total loads range from 190 (1995) to 79 tons/year (2007). Loads were generally higher during years of higher rainfall, reflecting higher nonpoint source and atmospheric deposition inputs. For the period of data used, wetter years included 1995, 1997, 1998, 2003, and 2005. Dryer years included 1996, 2000, 2001, 2006, and 2007. Annual watershed loadings generally followed the same pattern as total loads.

Figure 4-21 (middle) shows average monthly TN total loads for the same period. Loads were higher during the June – September wet season, due to high nonpoint source runoff and/or atmospheric deposition. The wet season total loads average 20 tons/month, and dry season loads average 5.5 tons/month. Figure 4-21 (bottom) shows the sources of TN total loads. The major contributor was atmospheric deposition (74%) due to the relatively low watershed to estuary area ratio. Other sources included nonpoint source (26%) and septic tanks (<1%). There are no domestic or industrial point sources in this bay segment.

Figure 4-22 (top) shows annual TP total loads for Bokeelia for the period 1995 through 2007. Total loads range from 9.1 (1995) to 2.6 tons/year (2007). Figure 4-22 (middle) shows average monthly TP loads for the same period. The wet season loads average 09 tons/month, and dry season loads average 0.2 tons/month. Figure 4-22 (bottom) shows the sources of TP total loads. The major contributor was nonpoint source (71%). Other sources included atmospheric deposition (29%) and septic tanks (<1%).

Figure 4-23 (top) shows annual TSS total loads for Bokeelia for the period 1995 through 2007. Total loads range from 535 (1995) to 69 tons/year (2007). Figure 4-23 (middle) shows average monthly TSS loads for the same period. The wet season loads average 48 tons/month, and dry season loads average 12 tons/month. Figure 4-23 (bottom) shows the sources of TSS total loads. The only contributor was nonpoint source.

Figure 4-24 (top) shows annual BOD total loads for Bokeelia for the period 1995 through 2007. Total loads range from 181 (1995) to 23 tons/year (2007). Figure 4-24 (middle) shows average monthly BOD loads for the same period. The wet season loads average 16 tons/month, and dry season loads average 4.0 tons/month. Figure 24 (bottom) shows the sources of BOD total loads. The only contributor was nonpoint source (100%).

It should be noted that the annual and monthly load figures have the same general shape for all parameters and segments. This is because most of the TN, TP, TSS, and BOD loadings are from nonpoint sources and are therefore determined in large from precipitation patterns. Thus, years with higher annual rainfall have higher total loadings than drier years, and wet season months (June through September) generally have higher loadings than dry season months. These patterns are generally consistent throughout the CNHEP area.

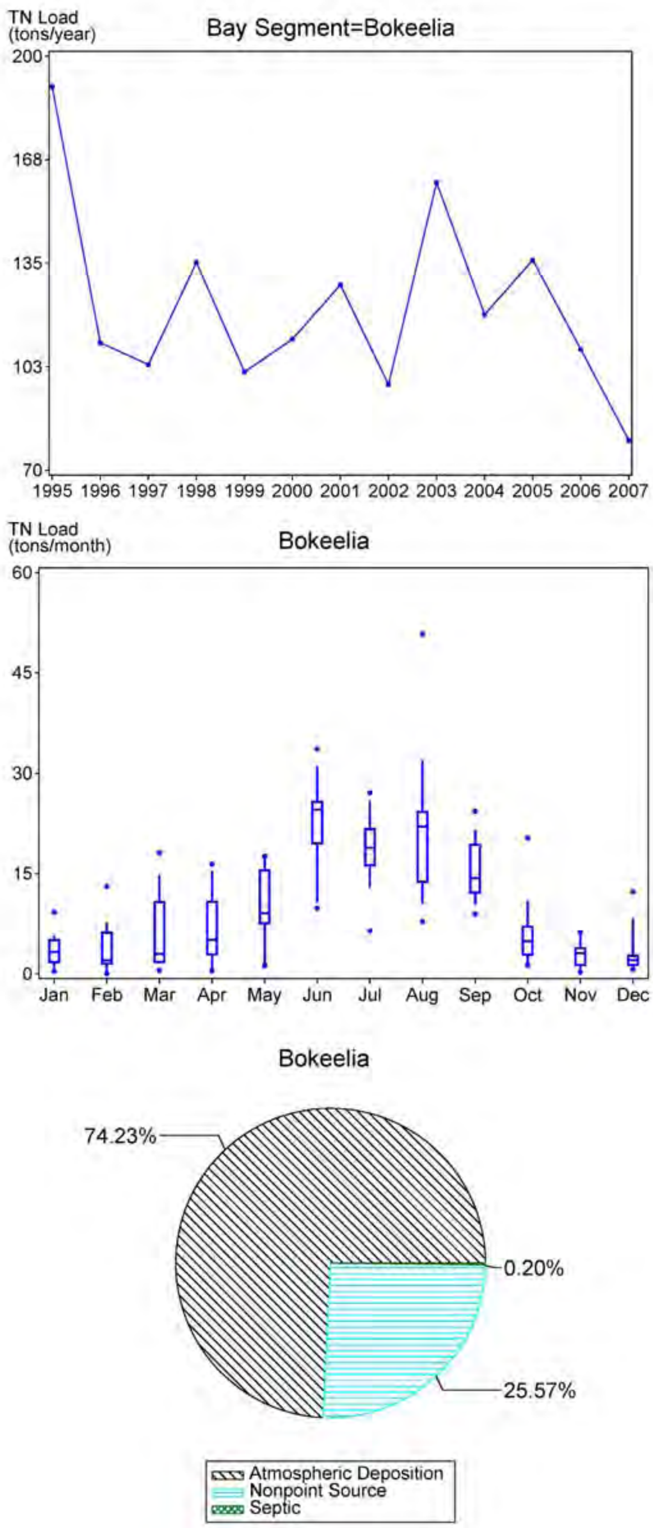

Figure 4-21. Bokeelia – TN loads: annual, monthly, and by source.

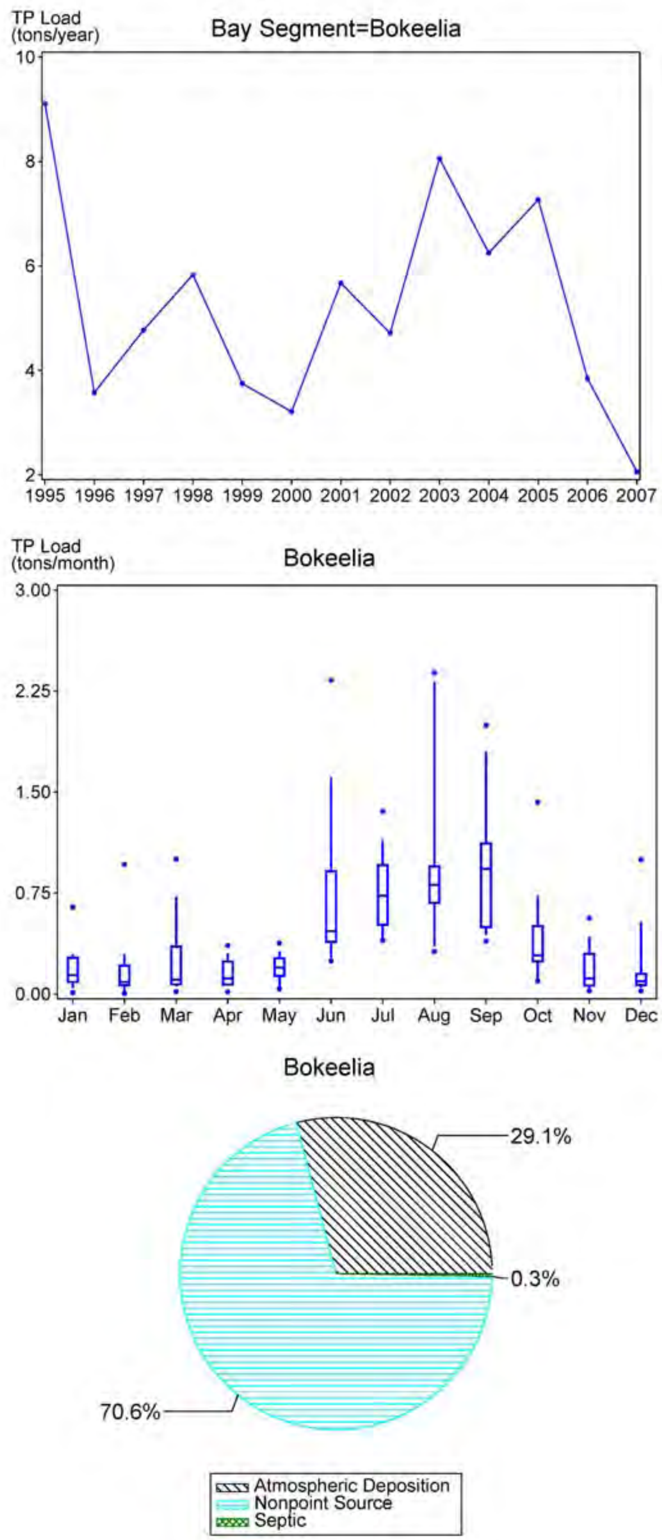

Figure 4-22. Bokeelia – TP loads: annual, monthly, and by source.

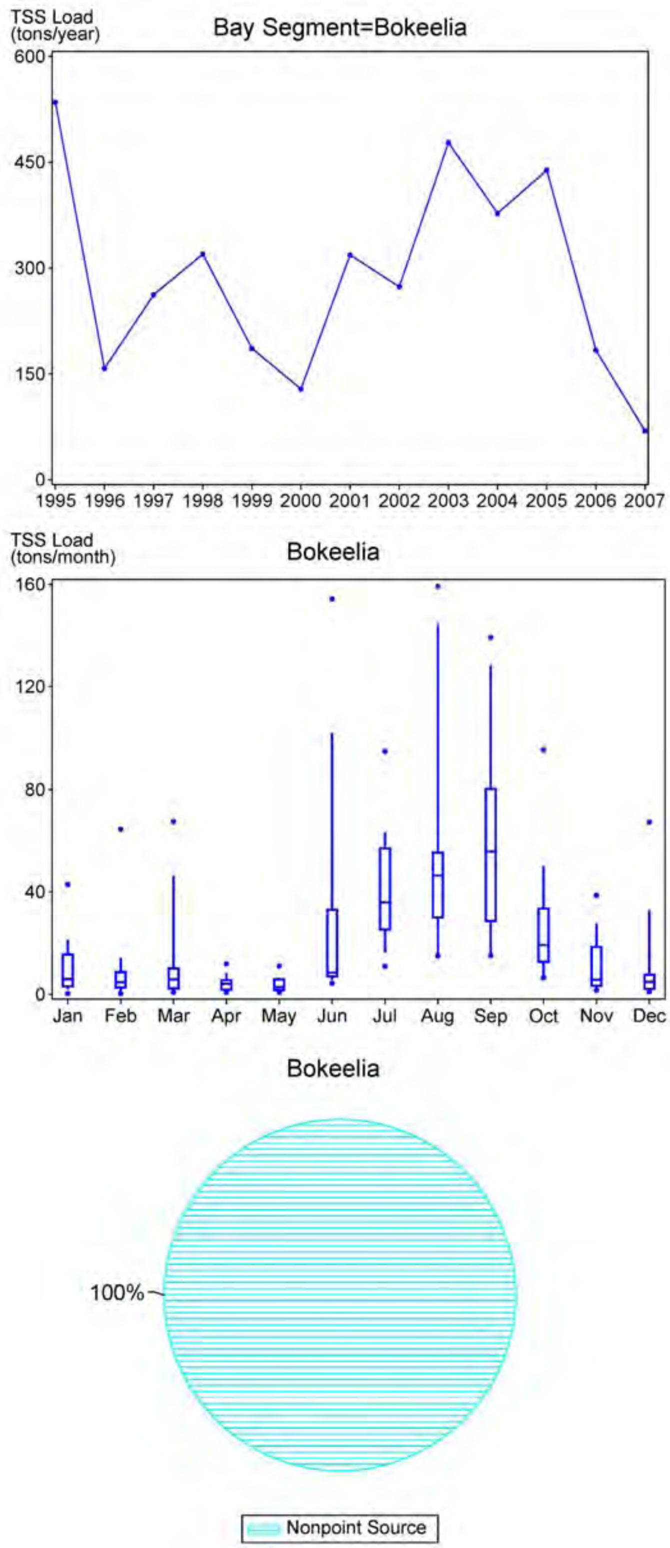

Figure 4-23. Bokeelia – TSS loads: annual, monthly, and by source.

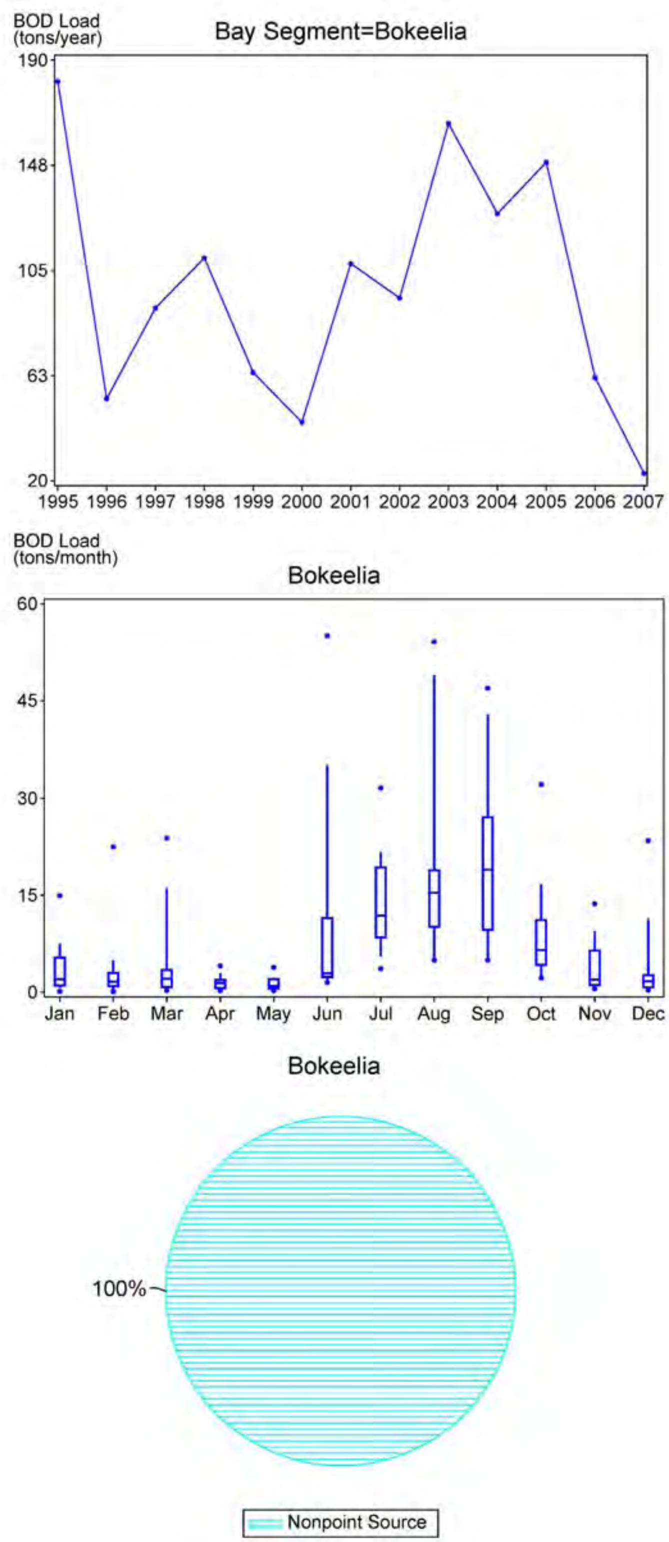

Figure 4-24. Bokeelia – BOD loads: annual, monthly, and by source.

4.2.6 West Wall

Figure 4-25 (top) shows annual TN total loads for West Wall for the period 1995 through 2007. Total loads range from 71 (1995) to 33 tons/year (2007). Loads were generally higher during years of higher rainfall, reflecting higher nonpoint source and atmospheric deposition inputs. For the period of data used, wetter years included 1995, 1997, 1998, 2003, and 2005. Dryer years included 1996, 2000, 2001, 2006, and 2007. Annual watershed loadings generally followed the same pattern as total loads.

Figure 4-25(middle) shows average monthly TN total loads for the same period. Loads were higher during the June – September wet season, due to high nonpoint source runoff and/or atmospheric deposition. The wet season total loads average 7.4 tons/month, and dry season loads average 2.2 tons/month. Figure 25 (bottom) shows the sources of TN total loads. The major contributor was atmospheric deposition (94%) (due to the very low watershed to estuary area ratio). Other sources included nonpoint source (6%). There are no domestic or industrial point sources in this bay segment.

Figure 4-26 (top) shows annual TP total loads for West Wall for the period 1995 through 2007. Total loads range from 1.7 (1995) to 0.6 tons/year (2007). Figure 4-26 (middle) shows average monthly TP loads for the same period. The wet season load average 0.2 tons/month and dry season loads average 0.1 tons/month. Figure 4-26 (bottom) shows the sources of TP total loads. The major contributor was atmospheric deposition (67%). Other sources included nonpoint source (33%).

Figure 4-27 (top) shows annual TSS total loads for West Wall for the period 1995 through 2007. Total loads range from 48 (1995) to 7.5 tons/year (2007). Figure 4-27 (middle) shows average monthly TSS loads for the same period. The wet season loads average 4.4 tons/month and dry season loads average 1.2 tons/month. Figure 4-27 (bottom) shows the sources of TSS total loads. The only contributor was nonpoint source.

Figure 4-28 (top) shows annual BOD total loads for West Wall for the period 1995 through 2007. Total loads range from 16 (1995) to 2.3 tons/year (2007). Figure 4-28 (middle) shows average monthly BOD loads for the same period. The wet season loads average 1.5 tons/month, and dry season loads average 0.4 tons/month. Figure 4-28 (bottom) shows the sources of BOD total loads. The only contributor was nonpoint source (100%).

It should be noted that the annual and monthly load figures have the same general shape for all parameters and segments. This is because most of the TN, TP, TSS, and BOD loadings are from nonpoint sources and are therefore determined in large from precipitation patterns. Thus, years with higher annual rainfall have higher total loadings than drier years, and wet season months (June through September) generally have higher loadings than dry season months. These patterns are generally consistent throughout the CNHEP area.

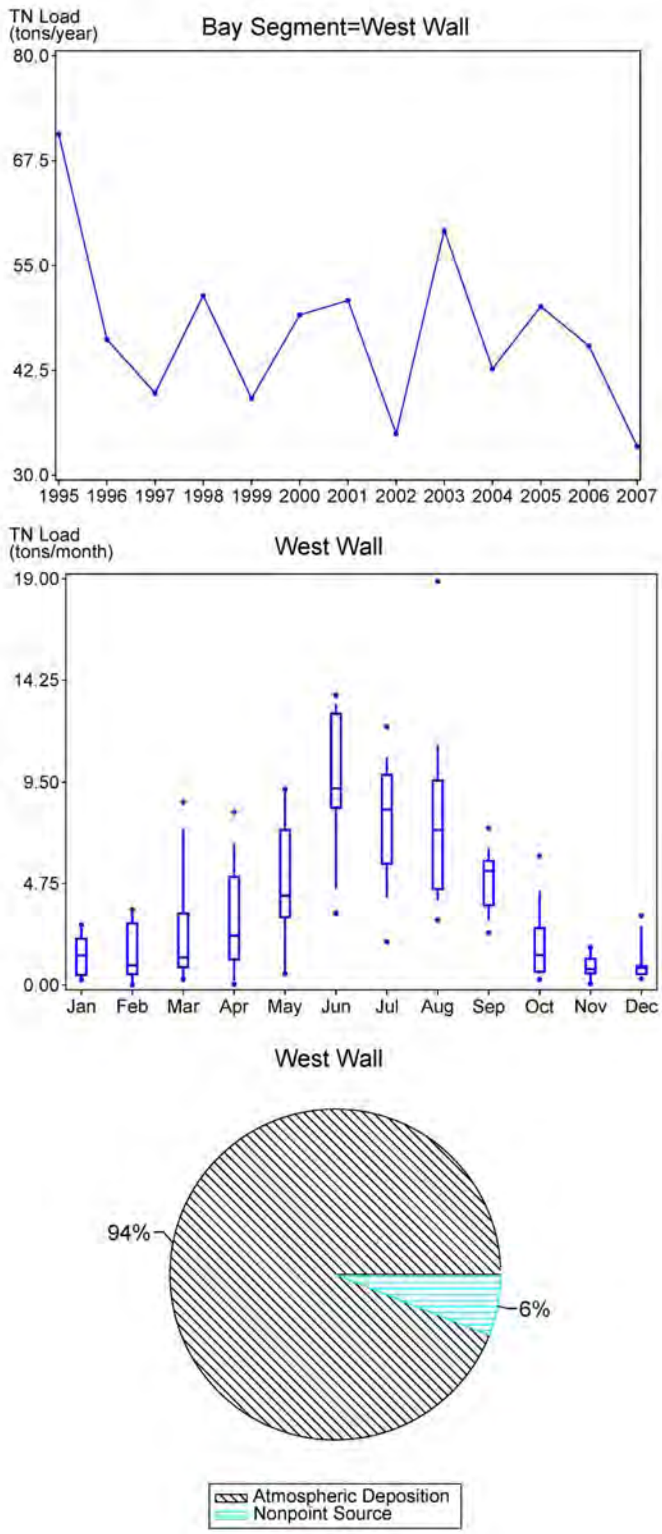

Figure 4-25. West Wall – TN loads: annual, monthly, and by source.

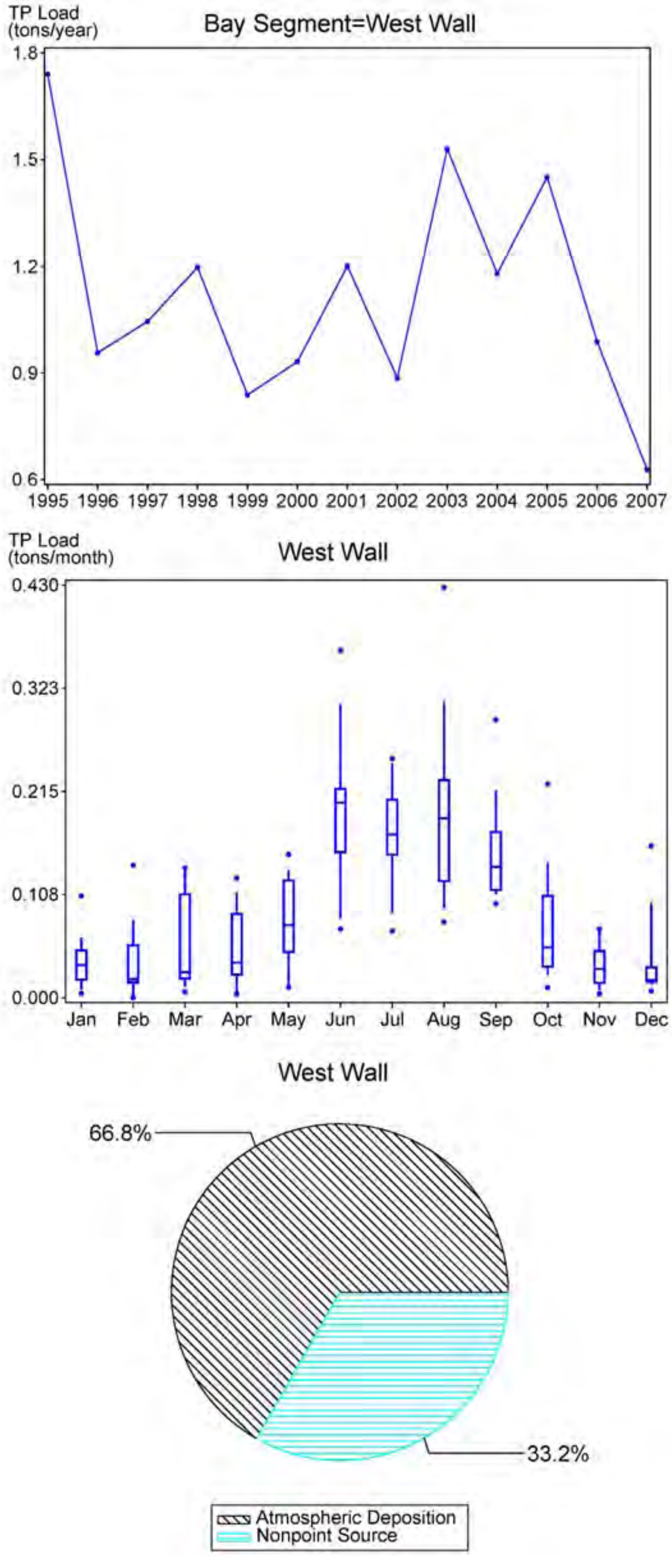

Figure 4-26. West Wall – TP loads: annual, monthly, and by source.

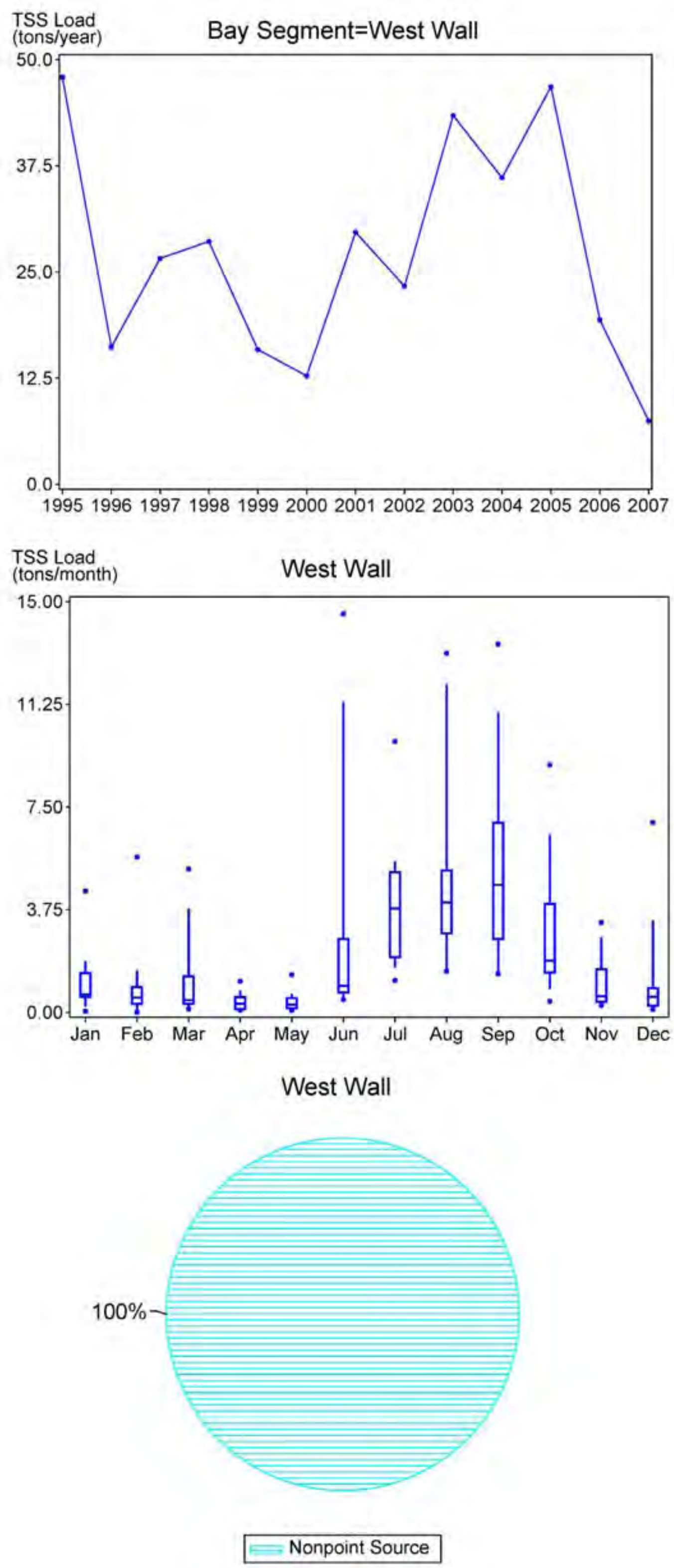

Figure 4-27. West Wall – TSS loads: annual, monthly, and by source.

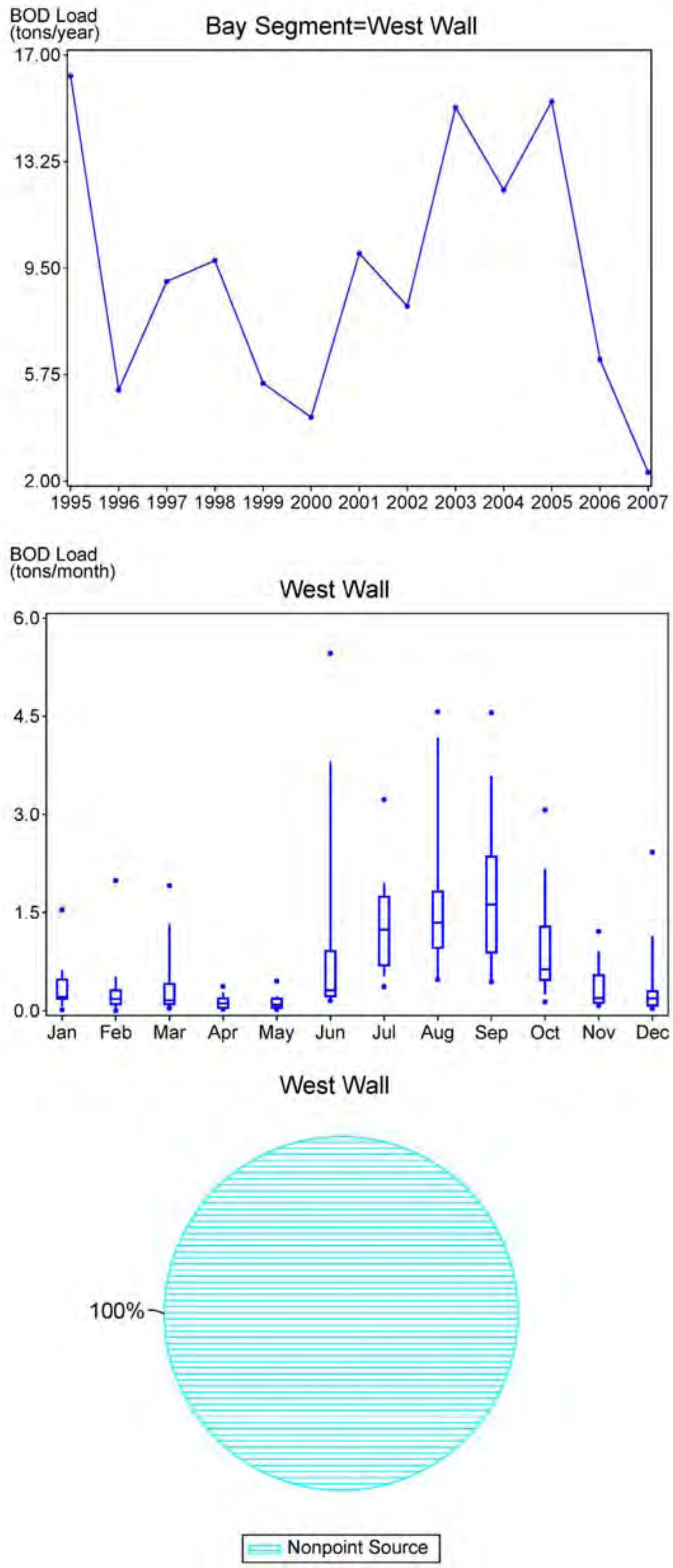

Figure 4-28. West Wall – BOD loads: annual, monthly, and by source.

4.2.7 East Wall

Figure 4-29 (top) shows annual TN total loads for East Wall for the period 1995 through 2007. Total loads range from 328 (1995) to 75 tons/year (2007). Loads were generally higher during years of higher rainfall, reflecting higher nonpoint source and atmospheric deposition inputs. For the period of data used, wetter years included 1995, 1997, 1998, 2003, and 2005. Dryer years included 1996, 2000, 2001, 2006, and 2007. Annual watershed loadings generally followed the same pattern as total loads.

Figure 4-29 (middle) shows average monthly TN total loads for the same period. Loads were higher during the June – September wet season, due to high nonpoint source runoff and/or atmospheric deposition. The wet season total loads average 30 tons/month, and dry season loads average 8.1 tons/month.

Figure 4-29 (bottom) shows the sources of TN total loads. The major contributor was nonpoint source (66%). Other sources included atmospheric deposition (32%) and septic tanks (2.6%). There are no domestic or industrial point sources in this bay segment.

Figure 4-30 (top) shows annual TP total loads for East Wall for the period 1995 through 2007. Total loads range from 38 (1995) to 4.8 tons/year (2007). Figure 4-30 (middle) shows average monthly TP loads for the same period. The wet season loads average 3.3 tons/month, and dry season loads average 0.8 tons/month. Figure 4-30 (bottom) shows the sources of TP total loads. The major contributor was nonpoint source (94%). Other sources included atmospheric deposition (5.1%) and septic tanks (1.3%).

Figure 4-31 (top) shows annual TSS total loads for East Wall for the period 1995 through 2007. Total loads range from 2693 (1995) to 321 tons/year (2007). Figure 4-31 (middle) shows average monthly TSS loads for the same period. The wet season loads average 230 tons/month, and dry season loads average 59 tons/month. Figure 31 (bottom) shows TSS total load sources. The only contributor was nonpoint source.

Figure 4-32 (top) shows annual BOD total loads for East Wall for the period 1995 through 2007. Total loads range from 789 (1995) to 94 tons/year (2007). Figure 4-32 (middle) shows average monthly BOD loads for the same period. The wet season loads average 67 tons/month, and dry season loads average 18 tons/month. Figure 32 (bottom) shows the sources of BOD total loads. The only contributor was nonpoint source (100%).

It should be noted that the annual and monthly load figures have the same general shape for all parameters and segments. This is because most of the TN, TP, TSS, and BOD loadings are from nonpoint sources and are therefore determined in large from precipitation patterns. Thus, years with higher annual rainfall have higher total loadings than drier years, and wet season months (June through September) generally have higher loadings than dry season months. These patterns are generally consistent throughout the CNHEP area.

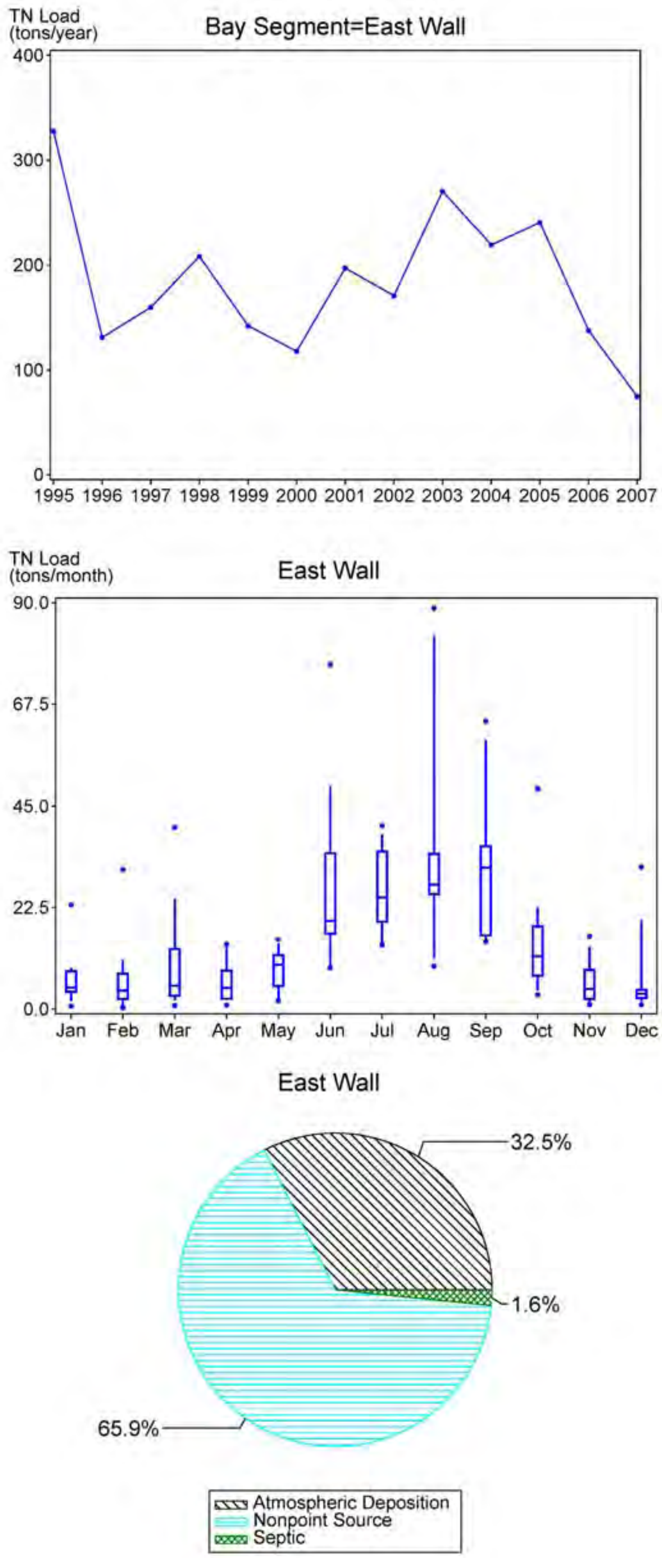

Figure 4-29. East Wall – TN loads: annual, monthly, and by source.

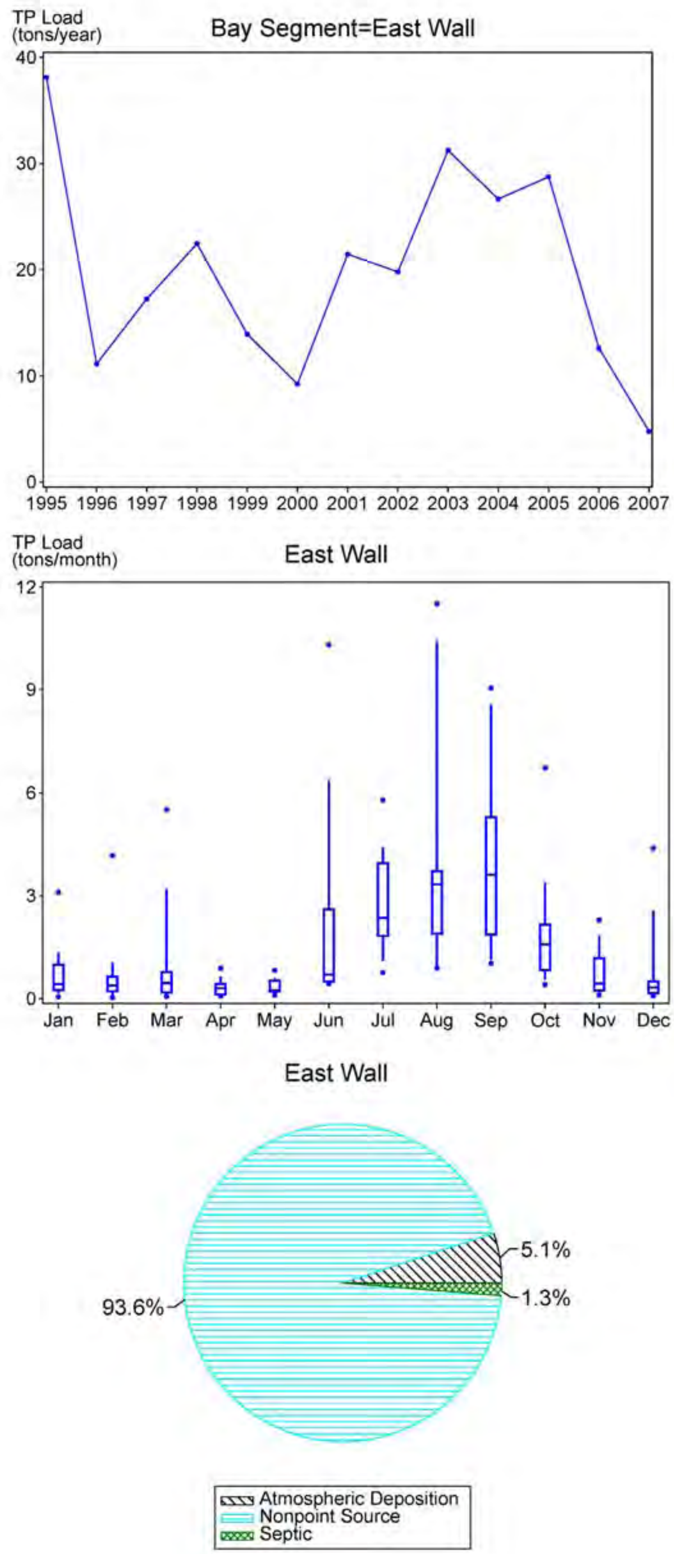

Figure 4-30. East Wall – TP loads: annual, monthly, and by source.

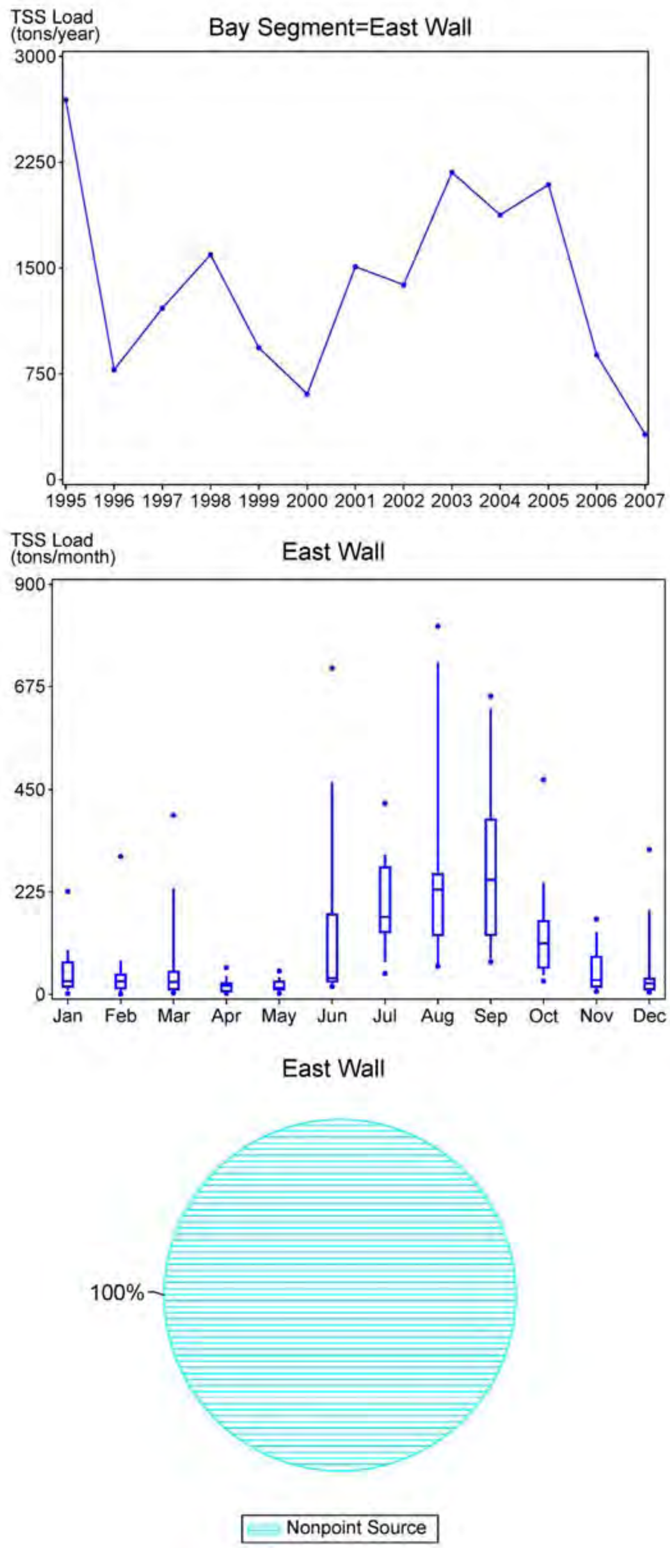

Figure 4-31. East Wall – TSS loads: annual, monthly, and by source.

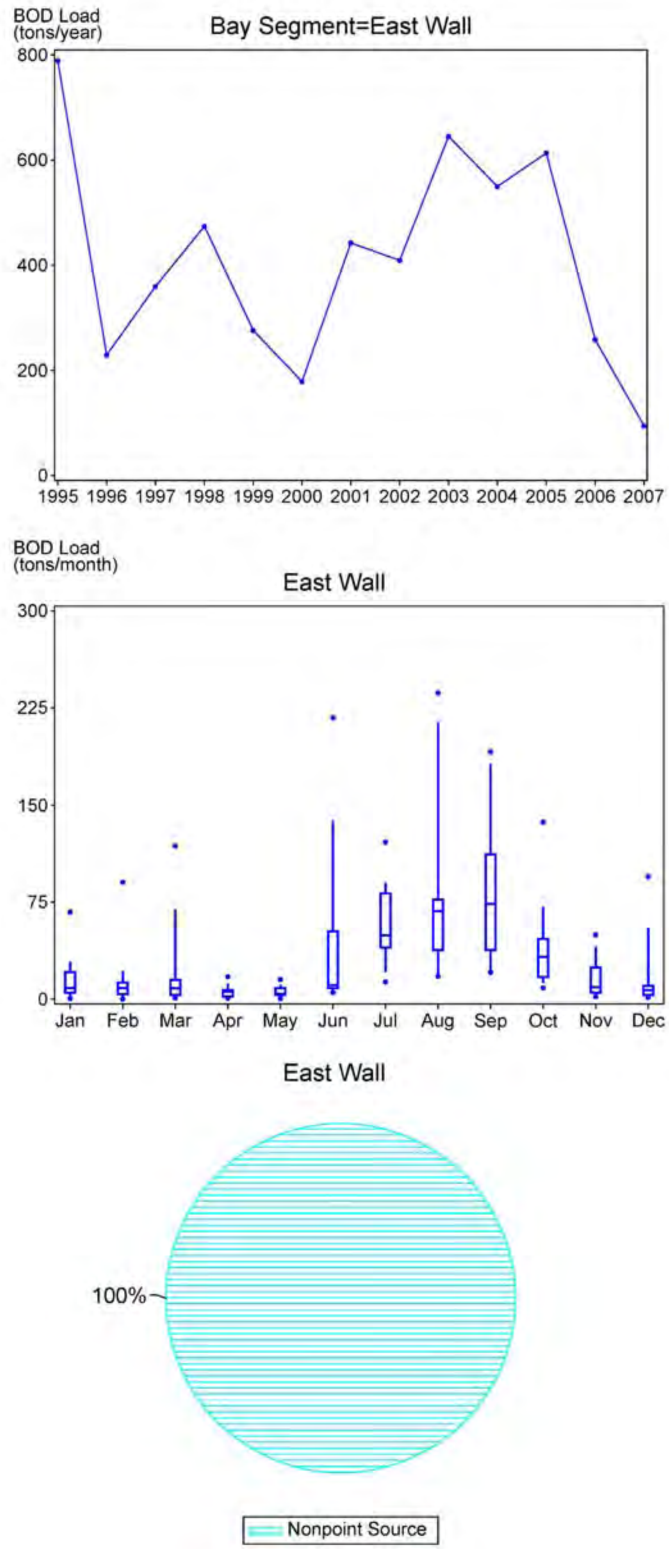

Figure 4-32. East Wall – BOD loads: annual, monthly, and by source.

4.2.8 Tidal Myakka River

Figure 4-33 (top) shows annual TN total loads for Tidal Myakka River for the period 1995 through 2007. Total loads range from 1594 (2003) to 257 tons/year (2007). Loads were generally higher during years of higher rainfall, reflecting higher nonpoint source and atmospheric deposition inputs. For the period of data used, wetter years included 1995, 1997, 1998, 2003, and 2005. Dryer years included 1996, 2000, 2001, 2006, and 2007. Annual watershed loadings generally followed the same pattern as total loads. Figure 4-33 (middle) shows average monthly TN total loads for the same period. Loads were higher during the June – September wet season, due to high nonpoint source runoff and/or atmospheric deposition. The wet season total loads average 141 tons/month, and dry season loads average 40 tons/month. Figure 4-33 (bottom) shows the sources of TN total loads. The major contributor was nonpoint source (96%). Other sources included atmospheric deposition (2.1%) and septic tanks (2.2%). There are no domestic or industrial point sources in this bay segment.

Figure 4-34 (top) shows annual TP total loads for Tidal Myakka River for the period 1995 through 2007. Total loads range from 418 (2003) to 57 tons/year (2007). Figure 4-34 (middle) shows average monthly TP loads for the same period. The wet season loads average 36 tons/month, and dry season loads average 9.9 tons/month. Figure 34 (bottom) shows the sources of TP total loads. The major contributor was nonpoint source (99%). Other sources included septic tanks (<1%) and atmospheric deposition (<1%).

Figure 4-35 (top) shows annual TSS total loads for Tidal Myakka River for the period 1995 through 2007. Total loads range from 10,942 (2003) to 1604 tons/year (2007). Figure 4-35 (middle) shows average monthly TSS loads for the same period. The wet season loads average 937 tons/month, and dry season loads average 244 tons/month. Figure 4-35 (bottom) shows the sources of TSS total loads. The only contributor was nonpoint source.

Figure 4-36 (top) shows annual BOD total loads for Tidal Myakka River for the period 1995 through 2007. Total loads range from 5130 (2003) to 694 tons/year (2007). Figure 4-36 (middle) shows average monthly BOD loads for the same period. The wet season loads average 431 tons/month, and dry season loads average 130 tons/month. Figure 4-36 (bottom) shows the sources of BOD total loads. The only contributor was nonpoint source.

It should be noted that the annual and monthly load figures have the same general shape for all parameters and segments. This is because most of the TN, TP, TSS, and BOD loadings are from nonpoint sources and are therefore determined in large from precipitation patterns. Thus, years with higher annual rainfall have higher total loadings than drier years, and wet season months (June through September) generally have higher loadings than dry season months. These patterns are generally consistent throughout the CNHEP area

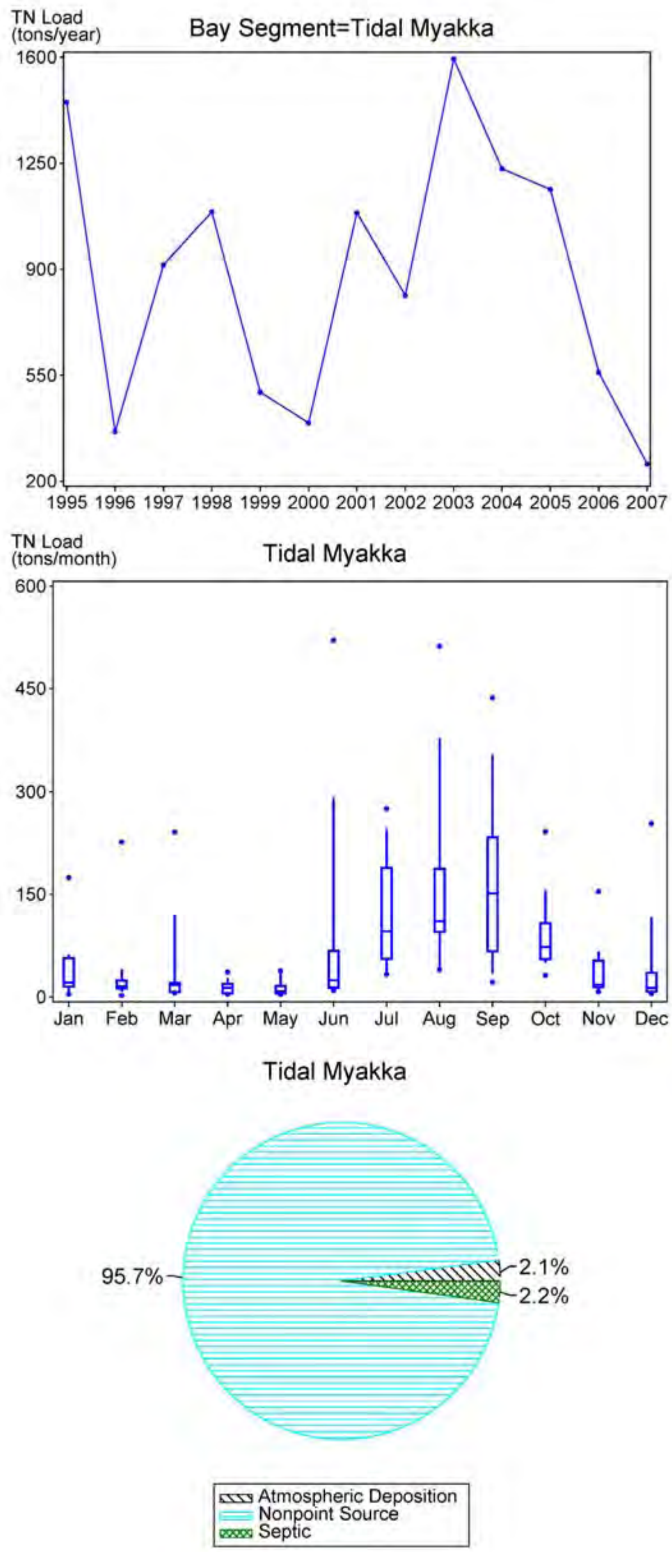

Figure 4-33. Tidal Myakka River – TN loads: annual, monthly, and by source.

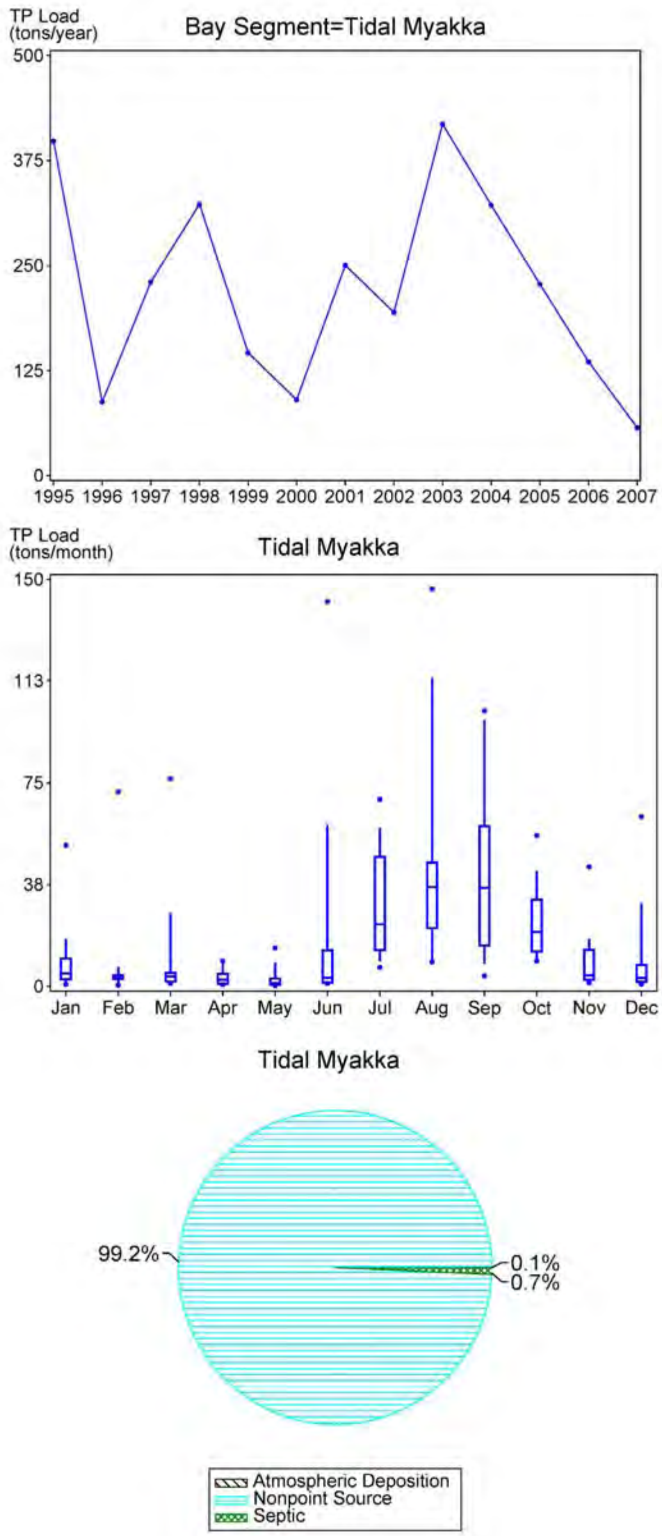

Figure 4-34. Tidal Myakka River – TP loads: annual, monthly, and by source.

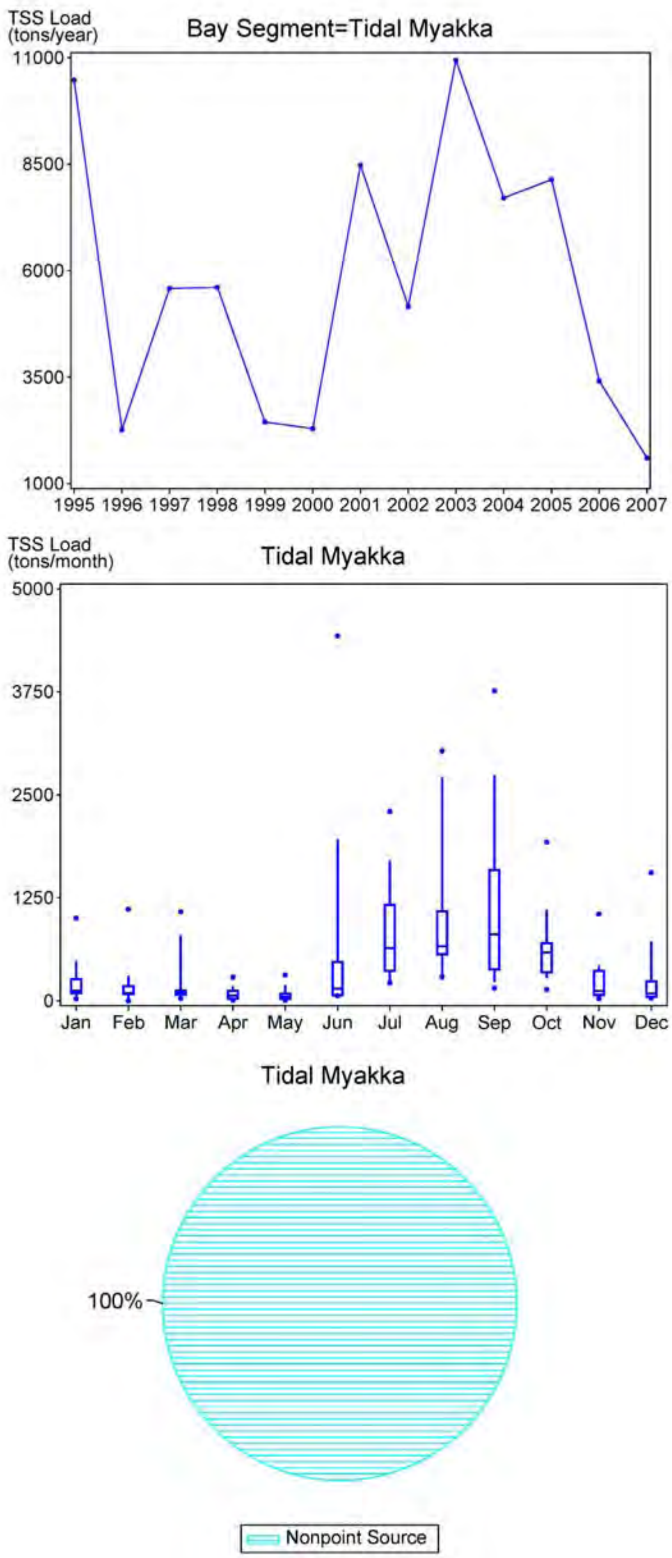

Figure 4-35. Tidal Myakka River – TSS loads: annual, monthly, and by source.

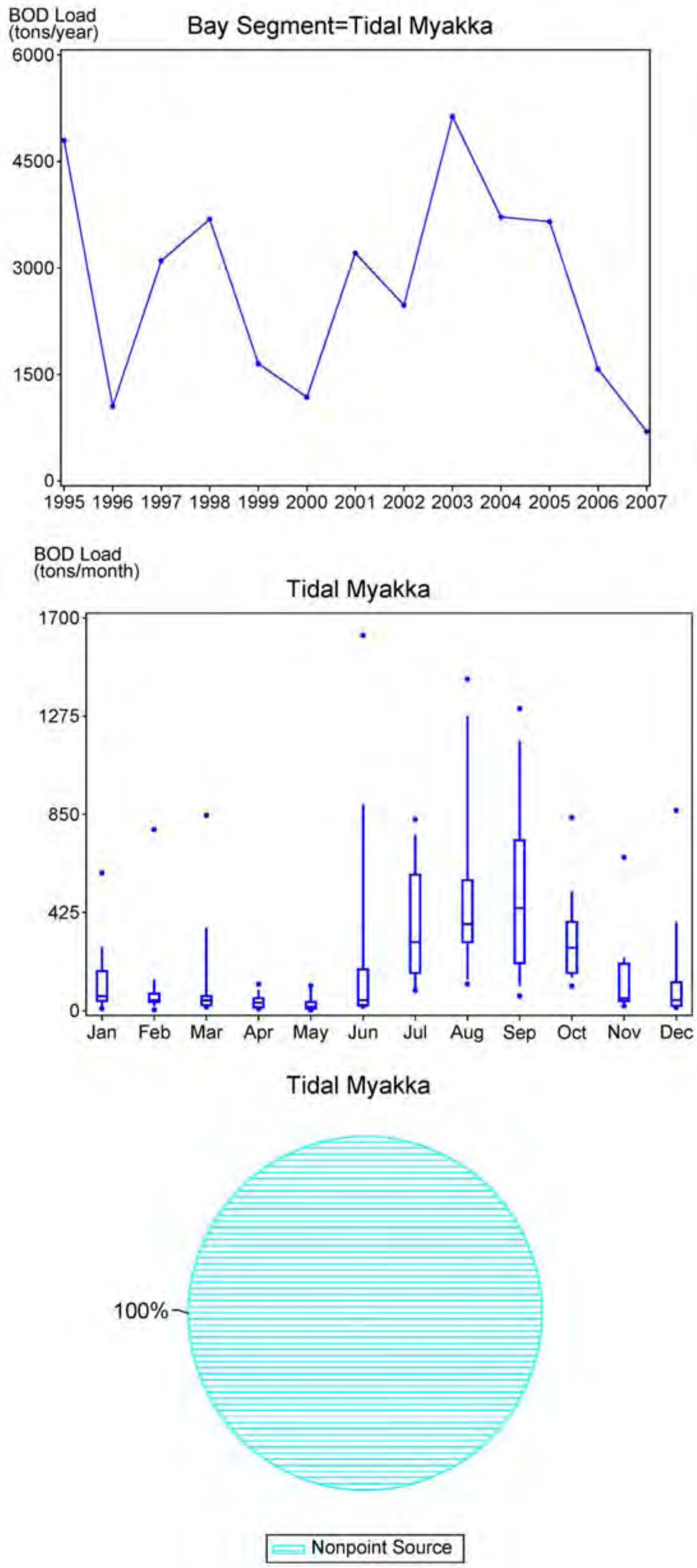

Figure 4-36. Tidal Myakka River – BOD loads: annual, monthly, and by source.

4.2.9 Tidal Peace River

Figure 4-37 (top) shows annual TN total loads for Tidal Peace River for the period 1995 through 2007. Total loads range from 5077 (1995) to 629 tons/year (2007). Loads were generally higher during years of higher rainfall, reflecting higher nonpoint source and atmospheric deposition inputs. For the period of data used, wetter years included 1995, 1997, 1998, 2003, and 2005. Dryer years included 1996, 2000, 2001, 2006, and 2007. Annual watershed loadings generally followed the same pattern as total loads. Figure 4-37 (middle) shows average monthly TN total loads for the same period. The wet season total loads average 483 tons/month, and dry season loads average 162 tons/month. Loads were higher during the June – September wet season, due to high nonpoint source runoff and/or atmospheric deposition. Figure 4-37 (bottom) shows the sources of TN total loads. The contributors included nonpoint source (32%), atmospheric deposition (1.1%), septic tanks (5.0%), domestic point sources, (<1%), and industrial point source (61%). There are several domestic and industrial point sources in this bay segment as shown in Tables 3-6 and 3-7.

The large contribution of industrial point sources to the total loadings is largely a result of extremely high discharges that were made during a few years due to climatological factors. During 2004 especially, in preparation for Hurricane Charlie and subsequent storms, emergency discharge orders by the FDEP resulted in very high discharges from the mining facilities in the Tidal Peace River watershed. These discharges were high enough to affect the source attribution for this bay segment for the entire 1995 through 2007 period.

Figure 4-38 (top) shows annual TP total loads for Tidal Peace River for the period 1995 through 2007. Total loads range from 2409 (2004) to 203 tons/year (2000). Figure 4-38 (middle) shows average monthly TP loads for the same period. The wet season loads average 175 tons/month, and dry season loads average 72 tons/month. Figure 4-38 (bottom) shows the sources of TP total loads. The major contributor was nonpoint source (50%). Other sources included septic tanks (1.0%), atmospheric deposition (<0.1%), domestic point source (2.7%), and industrial point source (46%). As with TN loadings, the high contribution of industrial point sources to the total is in large part a reflection of high discharges during a few years following emergency discharge orders by FDEP in preparation for hurricanes.

Figure 4-39 (top) shows annual TSS total loads for Tidal Peace River for the period 1995 through 2007. Total loads range from 32,563 (2005) to 2603 tons/year (2007). Figure 4-39 (middle) shows average monthly TSS loads for the same period. The wet season loads average 2491 tons/month, and dry season loads average 905 tons/month. Figure 4-39 (bottom) shows TSS sources, which include nonpoint source (85%), domestic point source (4.6%) and industrial point source (11%).

Figure 4-40 (top) shows annual BOD total loads for Tidal Peace River for the period 1995 through 2007. Total loads range from 17,706 (1998) to 2491 tons/year (2000). Figure 4-40 (middle) shows average monthly BOD loads for the same period. The wet season loads average 1561 tons/month, and dry season loads average 616 tons/month. Figure 4-40 (bottom) shows the sources of BOD total loads which include nonpoint sources (80%), domestic point sources (4.2%) and industrial point sources (16%).

It should be noted that the annual and monthly load figures have the same general shape for all parameters and segments. This is because most of the TN, TP, TSS, and BOD loadings are from nonpoint sources and are therefore determined in large from precipitation patterns. Thus, years with higher annual rainfall have higher total loadings than drier years, and wet season months (June through September) generally have higher loadings than dry season months. These patterns are generally consistent throughout the CNHEP area.

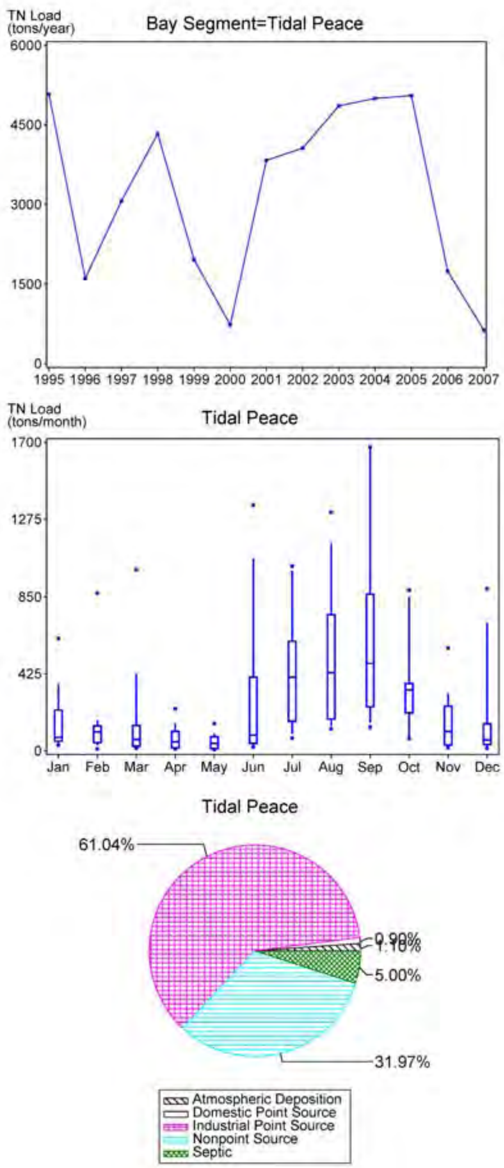

Figure 4-37. Tidal Peace River – TN loads: annual, monthly, and by source.

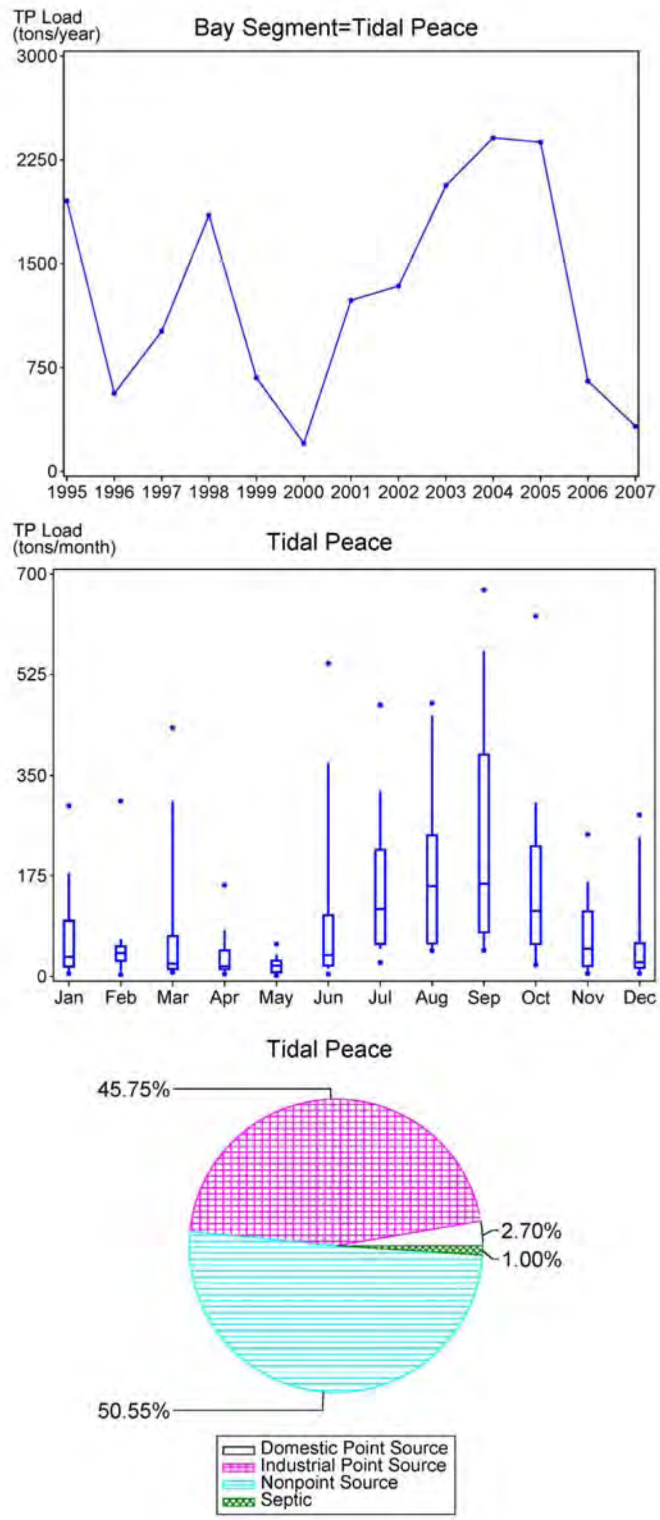

Figure 4-38. Tidal Peace River – TP loads: annual, monthly, and by source.

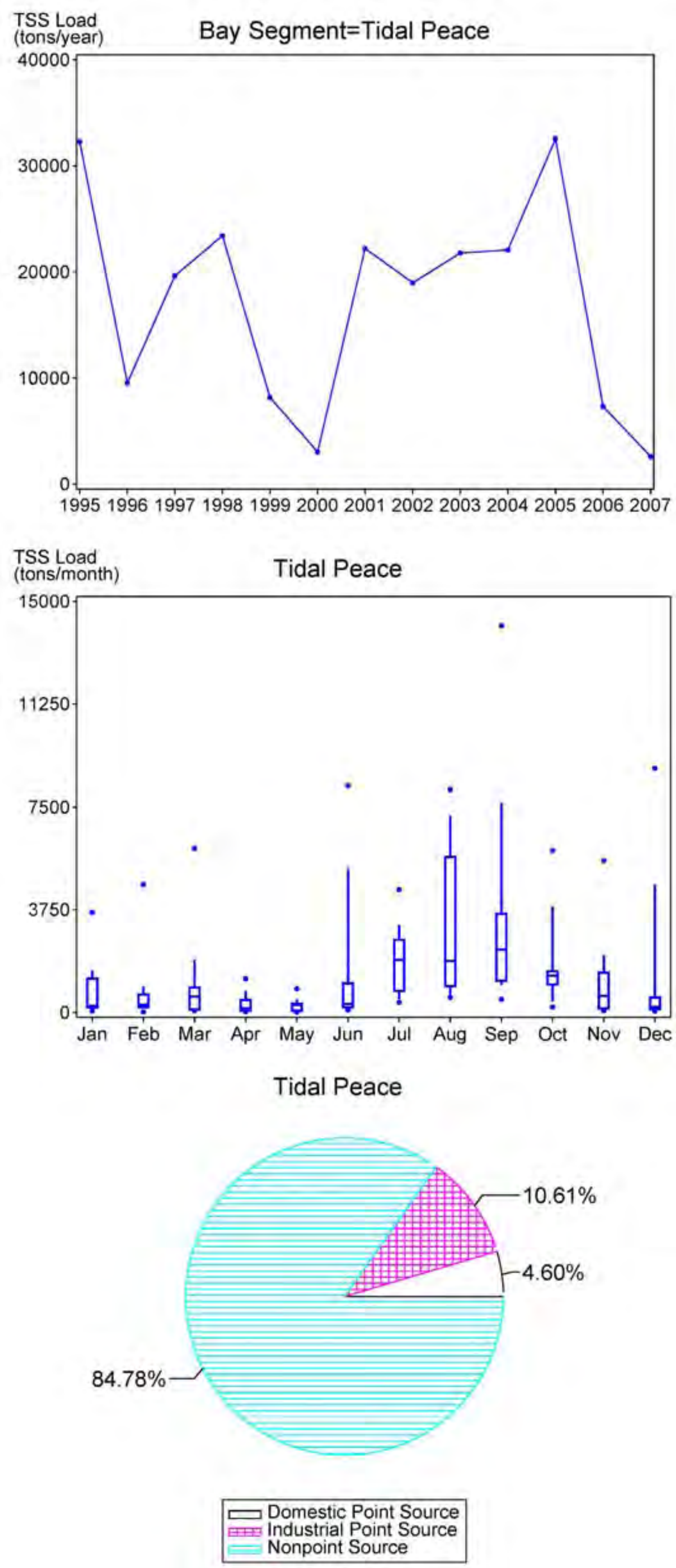

Figure 4-39. Tidal Peace River – TSS loads: annual, monthly, and by source.

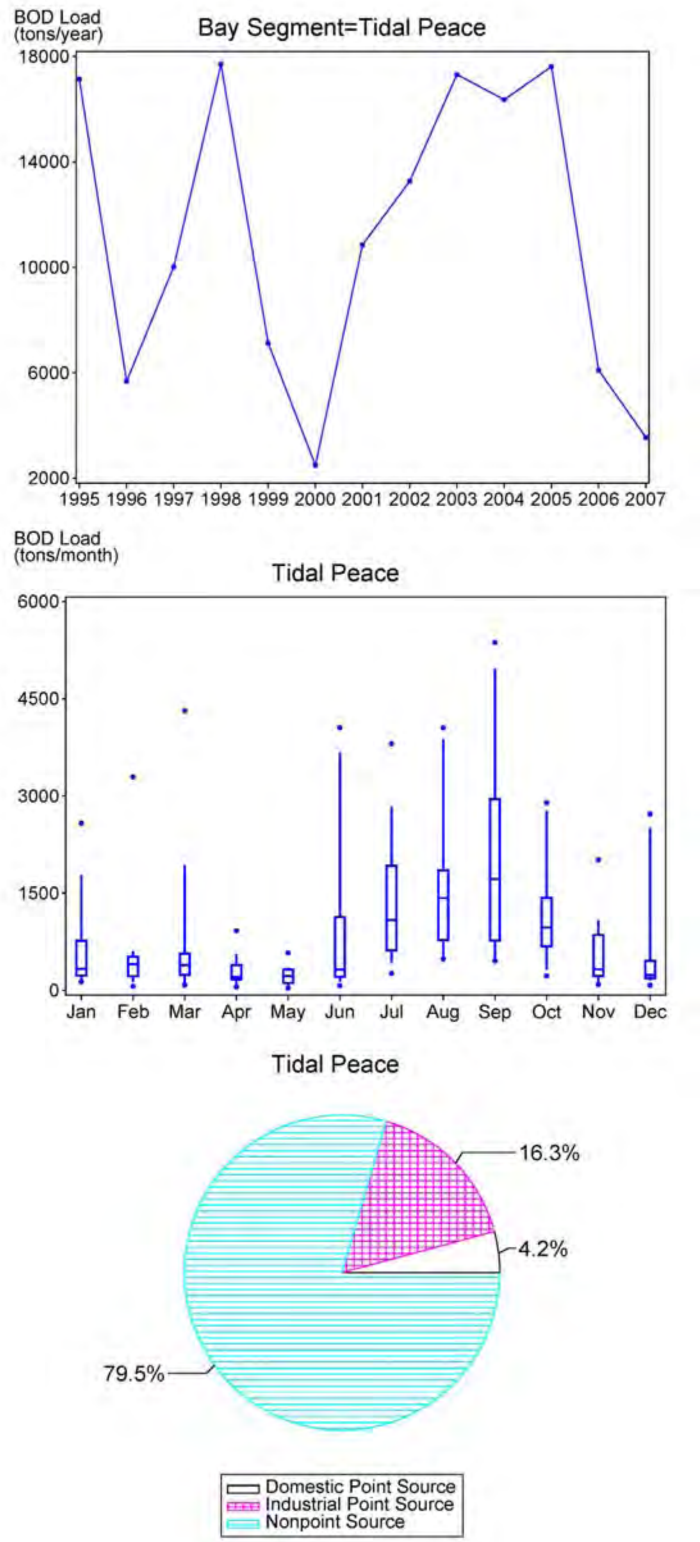

Figure 4-40. Tidal Peace River – BOD loads: annual, monthly, and by source.

4.2.10 Pine Island Sound

Figure 4-41 (top) shows annual TN total loads for Pine Island Sound for the period 1995 through 2007. Total loads range from 240 (1995) to 130 tons/year (1997). Loads were generally higher during years of higher rainfall, reflecting higher nonpoint source and atmospheric deposition inputs. For the period of data used, wetter years included 1995, 1997, 1998, 2003, and 2005. Dryer years included 1996, 2000, 2001, 2006, and 2007. Annual watershed loadings generally followed the same pattern as total loads.

Figure 4-41 (middle) shows average monthly TN total loads for the same period. Loads were higher during the June – September wet season, due to high nonpoint source runoff and/or atmospheric deposition. The wet season total loads average 26 tons/ month, and dry season loads average 7.2 tons/month. Figure 4-41 (bottom) shows the sources of TN total loads. The major contributor was atmospheric deposition (87%) (due to the relatively low watershed to estuary area ratio). Other sources included nonpoint source (12%) and septic tanks (<1%). There are no domestic or industrial point sources in this bay segment.

Figure 4-42 (top) shows annual TP total loads for Pine Island Sound for the period 1995 through 2007. Total loads range from 9.6 (1995) to 2.8 tons/year (2007). Figure 4-42 (middle) shows average monthly TP loads for the same period. The wet season loads average 1.0 tons/month, and dry season loads average 0.3 tons/month. Figure 4-42 (bottom) shows the sources of TP total loads. The major contributor was nonpoint source (57%). Other sources included atmospheric deposition (41%) and septic tanks (1.4%).

Figure 4-43 (top) shows annual TSS total loads for Pine Island Sound for the period 1995 through 2007. Total loads range from 410 (1995) to 52 tons/year (2007). Figure 4-43 (middle) shows average monthly TSS loads for the same period. The wet season loads average 38 tons/month, and dry season loads average 8.5 tons/month. Figure 4-43 (bottom) shows the sources of TSS total loads. The only contributor was nonpoint source.

Figure 4-44 (top) shows annual BOD total loads for Pine Island Sound for the period 1995 through 2007. Total loads range from 109 (1995) to 14 tons/year (2007). Figure 4-44 (middle) shows average monthly BOD loads for the same period. The wet season loads average 10 tons/month, and dry season loads average 2.3 tons/month. Figure 4-44 (bottom) shows the only source of BOD total loads nonpoint source.

It should be noted that the annual and monthly load figures have the same general shape for all parameters and segments. This is because most of the TN, TP, TSS, and BOD loadings are from nonpoint sources and are therefore determined in large from precipitation patterns. Thus, years with higher annual rainfall have higher total loadings than drier years, and wet season months (June through September) generally have higher loadings than dry season months. These patterns are generally consistent throughout the CNHEP area.

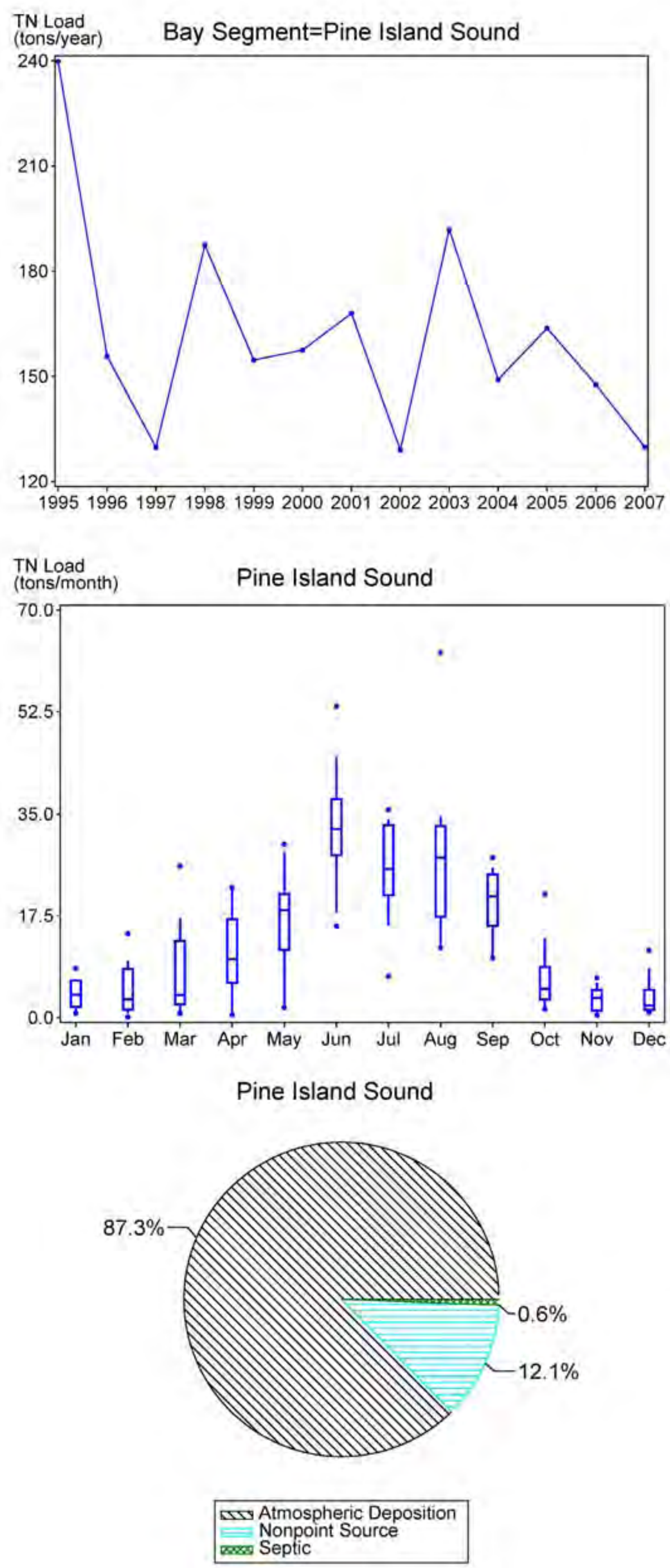

Figure 4-41. Pine Island Sound – TN loads: annual, monthly, and by source.

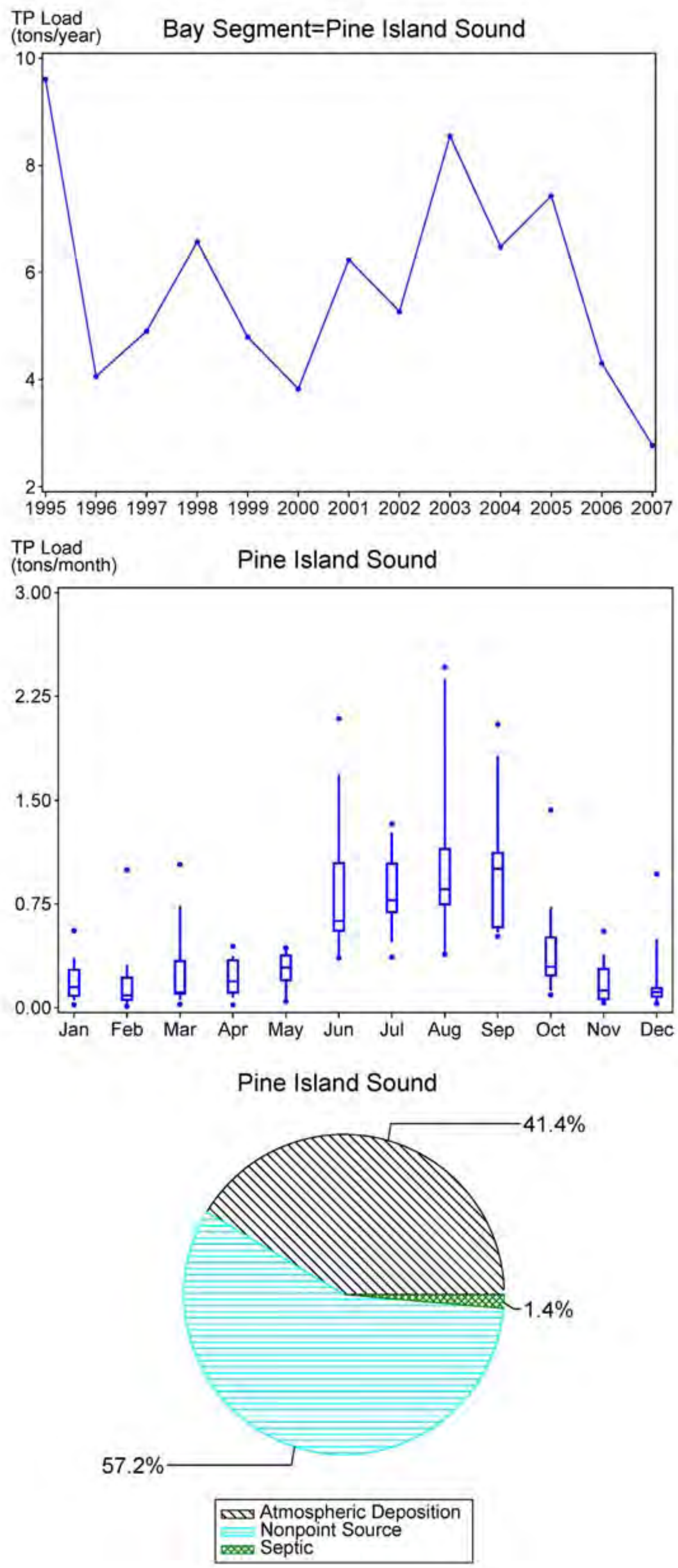

Figure 4-42. Pine Island Sound – TP loads: annual, monthly, and by source.

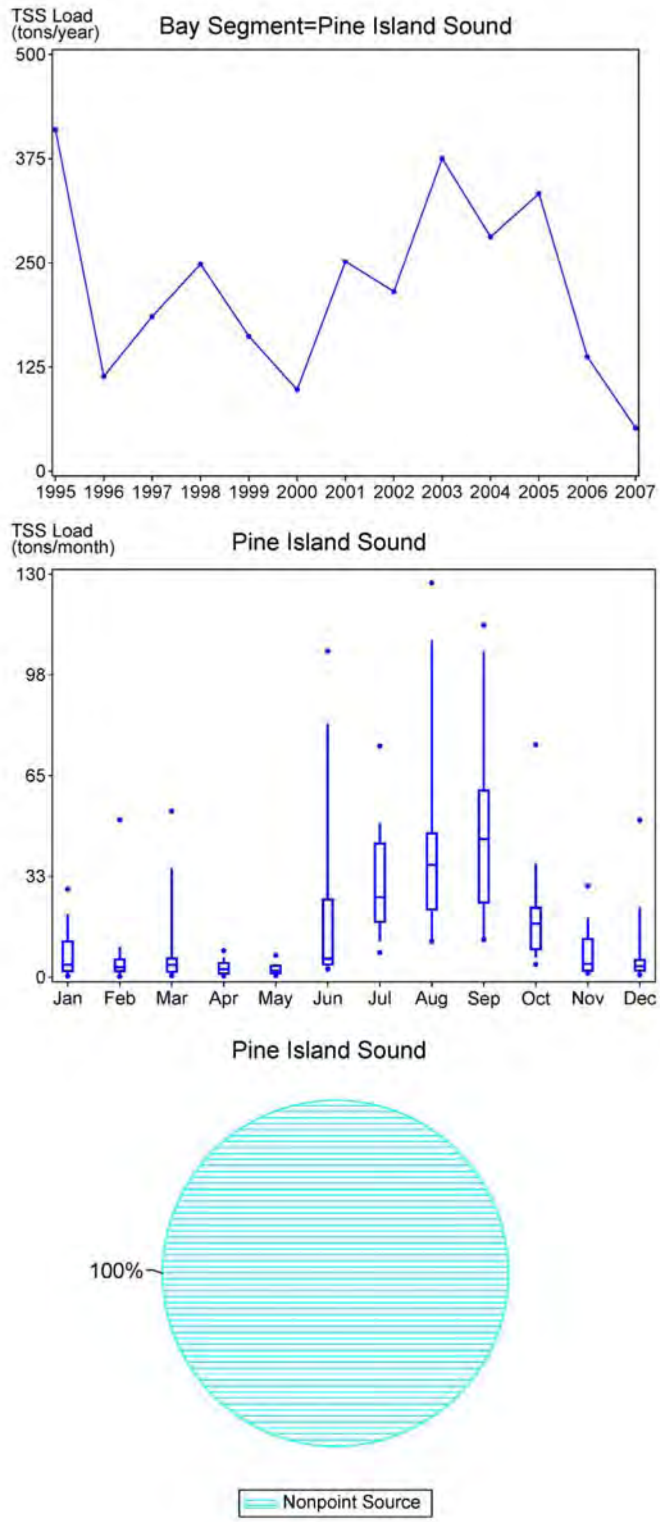

Figure 4-43. Pine Island Sound – TSS loads: annual, monthly, and by source.

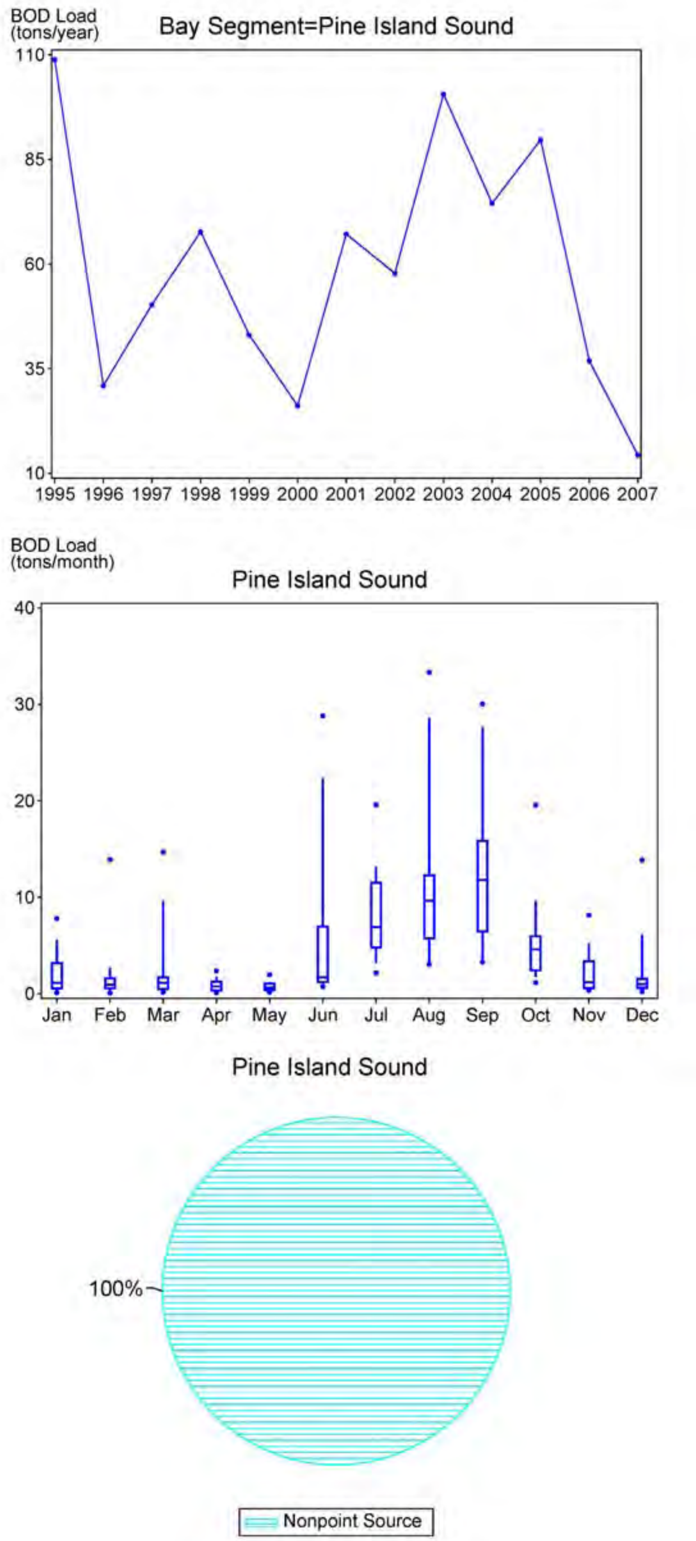

Figure 4-44. Pine Island Sound – BOD loads: annual, monthly, and by source.

4.2.11 Matlacha Pass

Figure 4-45 (top) shows annual TN total loads for Matlacha Pass for the period 1995 through 2007. Total loads range from 260 (1995) to 62 tons/year (2007). Loads were generally higher during years of higher rainfall, reflecting higher nonpoint source and atmospheric deposition inputs. For the period of data used, wetter years included 1995, 1997, 1998, 2003, and 2005. Dryer years included 1996, 2000, 2001, 2006, and 2007. Annual watershed loadings generally followed the same pattern as total loads.

Figure 4-45 (middle) shows average monthly TN total loads for the same period. Loads were higher during the June – September wet season, due to high nonpoint source runoff and/or atmospheric deposition. The wet season total loads average 27 tons/month, and dry season loads average 6.2 tons/month. Figure 4-45 (bottom) shows the sources of TN total loads. The major contributor was nonpoint sources (66%). Other sources included septic tanks (9.7%) and atmospheric deposition (24%). There is one domestic (City of Cape Coral – ROWTP) (<0.01%) and no industrial point source in this bay segment.

Figure 4-46 (top) shows annual TP total loads for Matlacha Pass for the period 1995 through 2007. Total loads range from 36 (1995) to 3.7 tons/year (2007). Figure 4-46 (middle) shows average monthly TP loads for the same period. The wet season loads average 3.1 tons/month, and dry season loads average 0.7 tons/month. Figure 4-46 (bottom) shows the sources of TP total loads. The major contributor was nonpoint source (89%). Other sources included septic tanks (7.1%) and atmospheric deposition (3.6%).

Figure 4-47 (top) shows annual TSS total loads for Matlacha Pass for the period 1995 through 2007. Total loads range from 2619 (1995) to 200 tons/year (2007). Figure 4-47 (middle) shows average monthly TSS loads for the same period. The wet season loads average 216 tons/month, and dry season loads average 45 tons/month. Figure 4-47 (middle) shows the sources of TSS total loads. The only contributor was nonpoint source.

Figure 4-48 (top) shows annual BOD total loads for Matlacha Pass for the period 1995 through 2007. Total loads range from 683 (1995) to 80 tons/year (2007). Figure 4-48 (middle) shows average monthly BOD loads for the same period. The wet season loads average 57 tons/month, and dry season loads average 12 tons/month. Figure 4-48 (bottom) shows the only source of BOD total loads, nonpoint sources.

It should be noted that the annual and monthly load figures have the same general shape for all parameters and segments. This is because most of the TN, TP, TSS, and BOD loadings are from nonpoint sources and are therefore determined in large from precipitation patterns. Thus, years with higher annual rainfall have higher total loadings than drier years, and wet season months (June through September) generally have higher loadings than dry season months. These patterns are generally consistent throughout the CNHEP area.

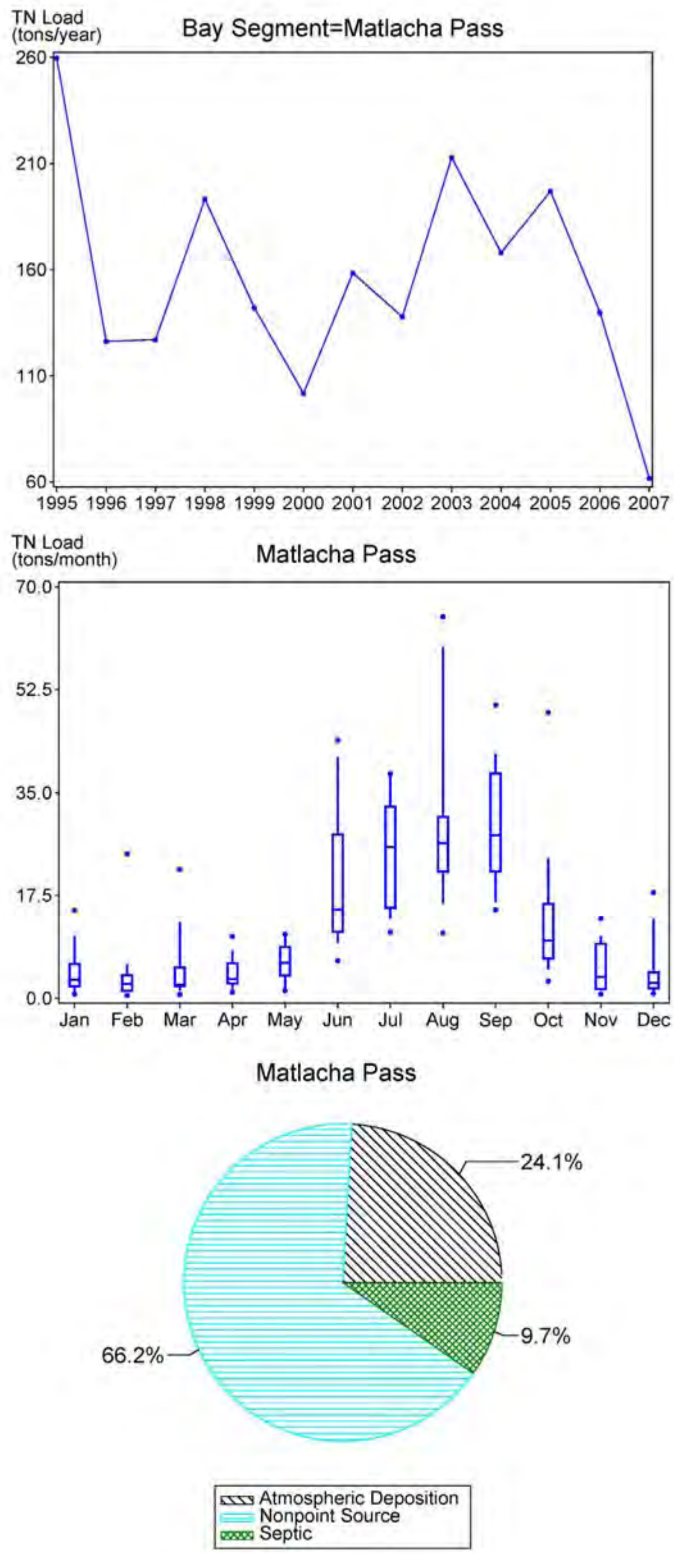

Figure 4-45. Matlacha Pass – TN loads: annual, monthly, and by source.

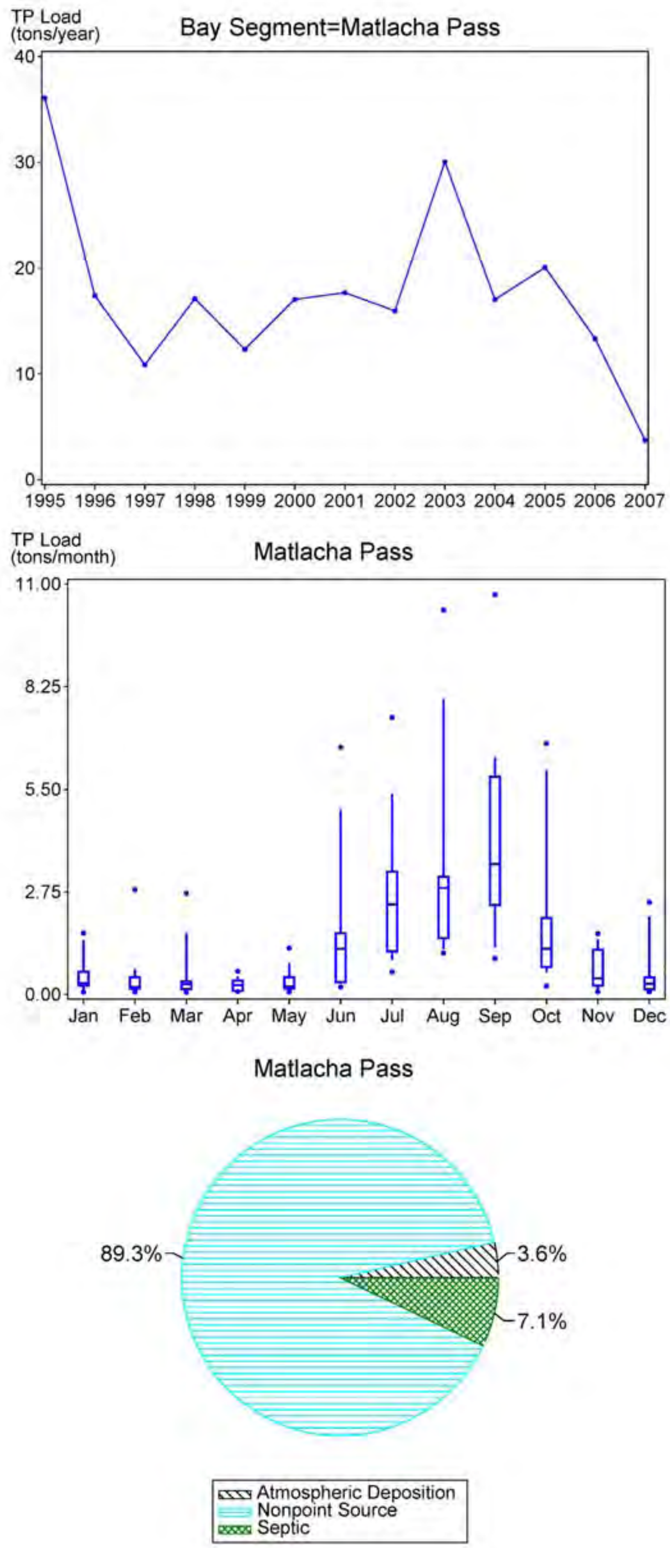

Figure 4-46. Matlacha Pass – TP loads: annual, monthly, and by source.

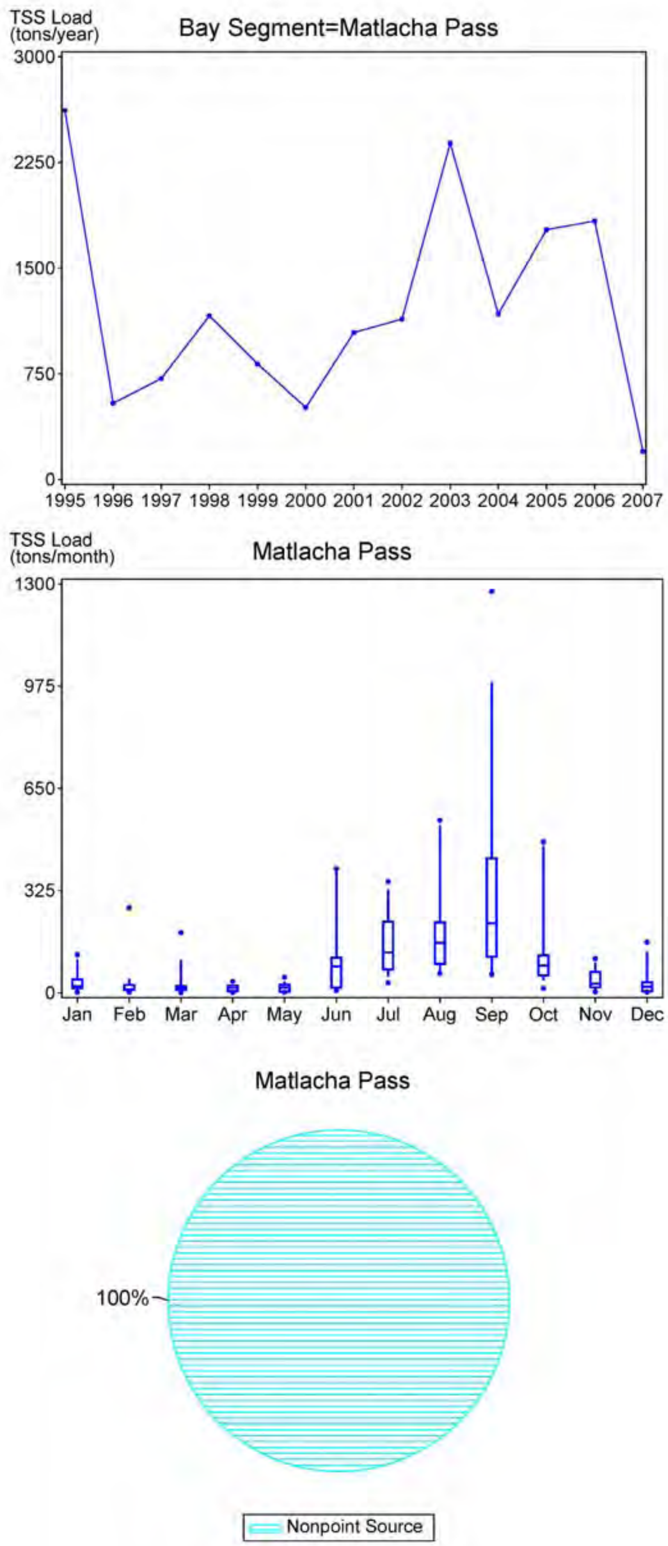

Figure 4-47. Matlacha Pass – TSS loads: annual, monthly, and by source.

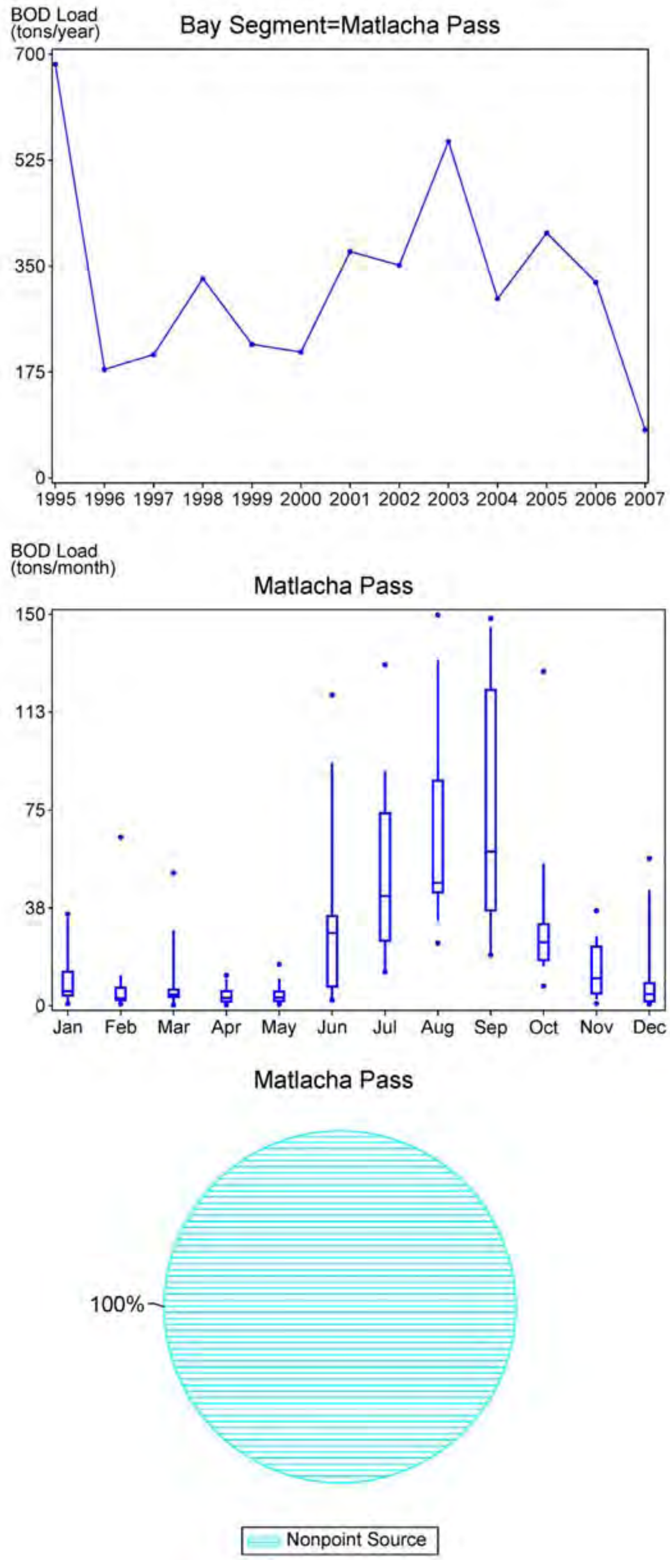

Figure 4-48. Matlacha Pass – BOD loads: annual, monthly, and by source.

4.2.12 San Carlos Bay

Figure 4-49 (top) shows annual TN total loads for San Carlos Bay for the period 1995 through 2007. Total loads range from 124 (1995) to 60 tons/year (2007). Loads were generally higher during years of higher rainfall, reflecting higher nonpoint source and atmospheric deposition inputs. For the period of data used, wetter years included 1995, 1997, 1998, 2003, and 2005. Dryer years included 1996, 2000, 2001, 2006, and 2007. Annual watershed loadings generally followed the same pattern as total loads.

Figure 4-49 (middle) shows average monthly TN total loads for the same period. Loads were higher during the June – September wet season, due to high nonpoint source runoff and/or atmospheric deposition. The wet season total loads average 13 tons/month, and dry season loads average 3.4 tons/month. Figure 4-49 (bottom) shows the sources of TN total loads. The major contributor was atmospheric deposition (75%) (due to the relatively low watershed to estuary area ratio). Other sources included nonpoint source (25%) and septic tanks (<1%). There are no domestic or industrial point sources in this bay segment.

Figure 4-50 (top) shows annual TP total loads for San Carlos Bay for the period 1995 through 2007. Total loads range from 7.4 (1995) to 1.9 tons/year (2007). Figure 4-50 (middle) shows average monthly TP loads for the same period. The wet season loads average 0.7 tons/month, and dry season loads average 0.2 tons/month. Figure 4-50 (bottom) shows the sources of TP total loads. The major contributor was nonpoint source (76%). Other sources included atmospheric deposition (24%) and septic tanks (<1%).

Figure 4-51 (top) shows annual TSS total loads for San Carlos Bay for the period 1995 through 2007. Total loads range from 502 (1995) to 87 tons/year (2007). Figure 4-51 (middle) shows average monthly TSS loads for the same period. The wet season loads average 45 tons/month, and dry season loads average 11 tons/month. Figure 4-51 (bottom) shows the sources of TSS total loads. The only contributor was nonpoint source.

Figure 4-52 (top) shows annual BOD total loads for San Carlos Bay for the period 1995 through 2007. Total loads range from 167 (1995) to 28 tons/year (2007). Figure 4-52 (middle) shows average monthly BOD loads for the same period. The wet season loads average 15 tons/month, and dry season loads average 3.6 tons/month. Figure 4-52 (bottom) shows the single source of BOD total loads, nonpoint source.

It should be noted that the annual and monthly load figures have the same general shape for all parameters and segments. This is because most of the TN, TP, TSS, and BOD loadings are from nonpoint sources and are therefore determined in large from precipitation patterns. Thus, years with higher annual rainfall have higher total loadings than drier years, and wet season months (June through September) generally have higher loadings than dry season months. These patterns are generally consistent throughout the CNHEP area.

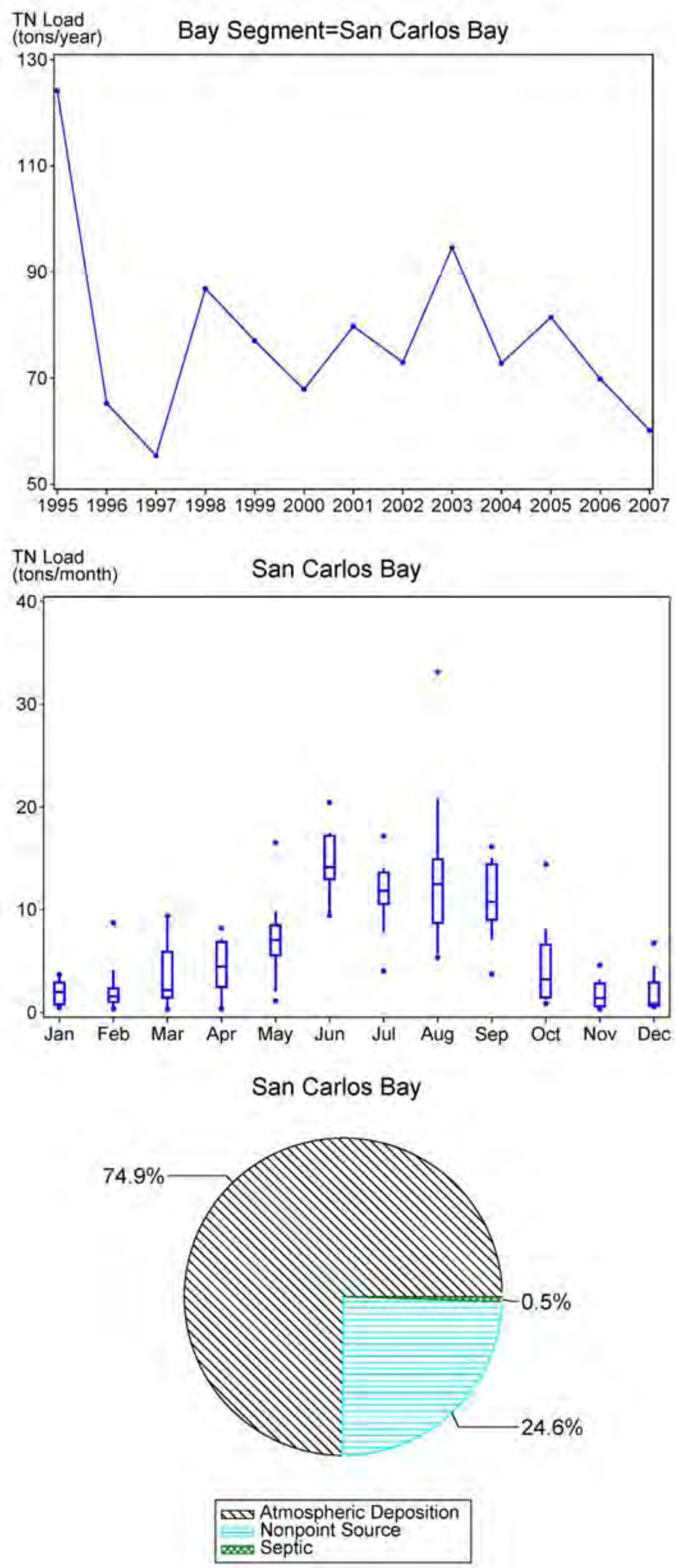

Figure 4-49. San Carlos Bay – TN loads: annual, monthly, and by source.

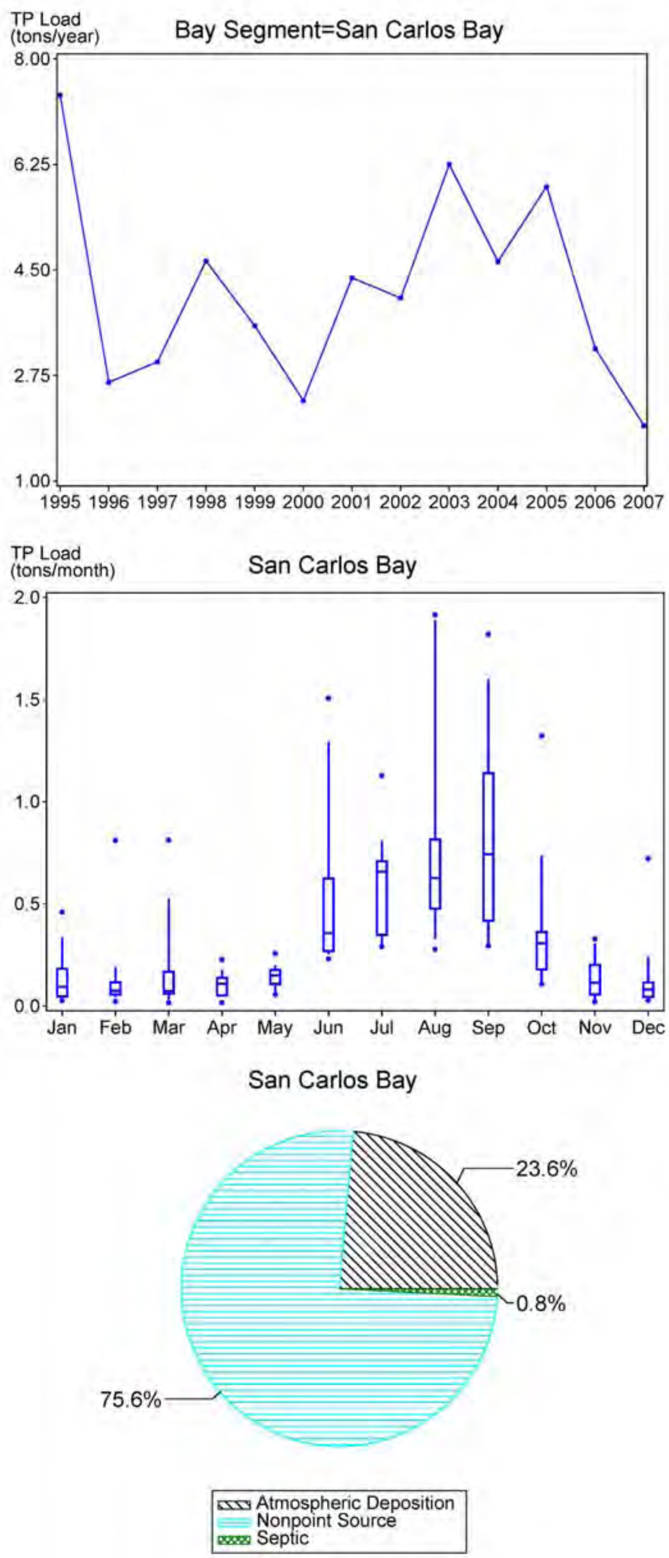

Figure 4-50. San Carlos Bay – TP loads: annual, monthly, and by source.

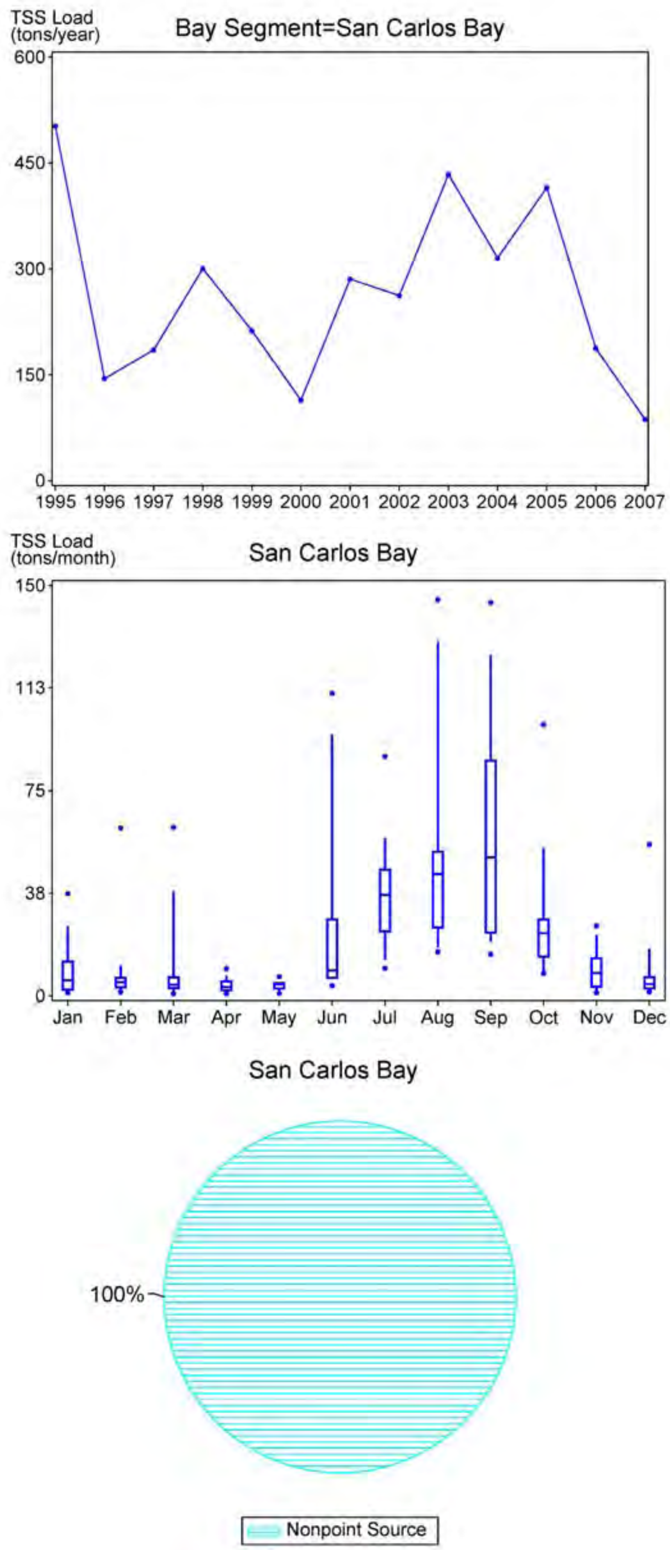

Figure 4-51. San Carlos Bay – TSS loads: annual, monthly, and by source.

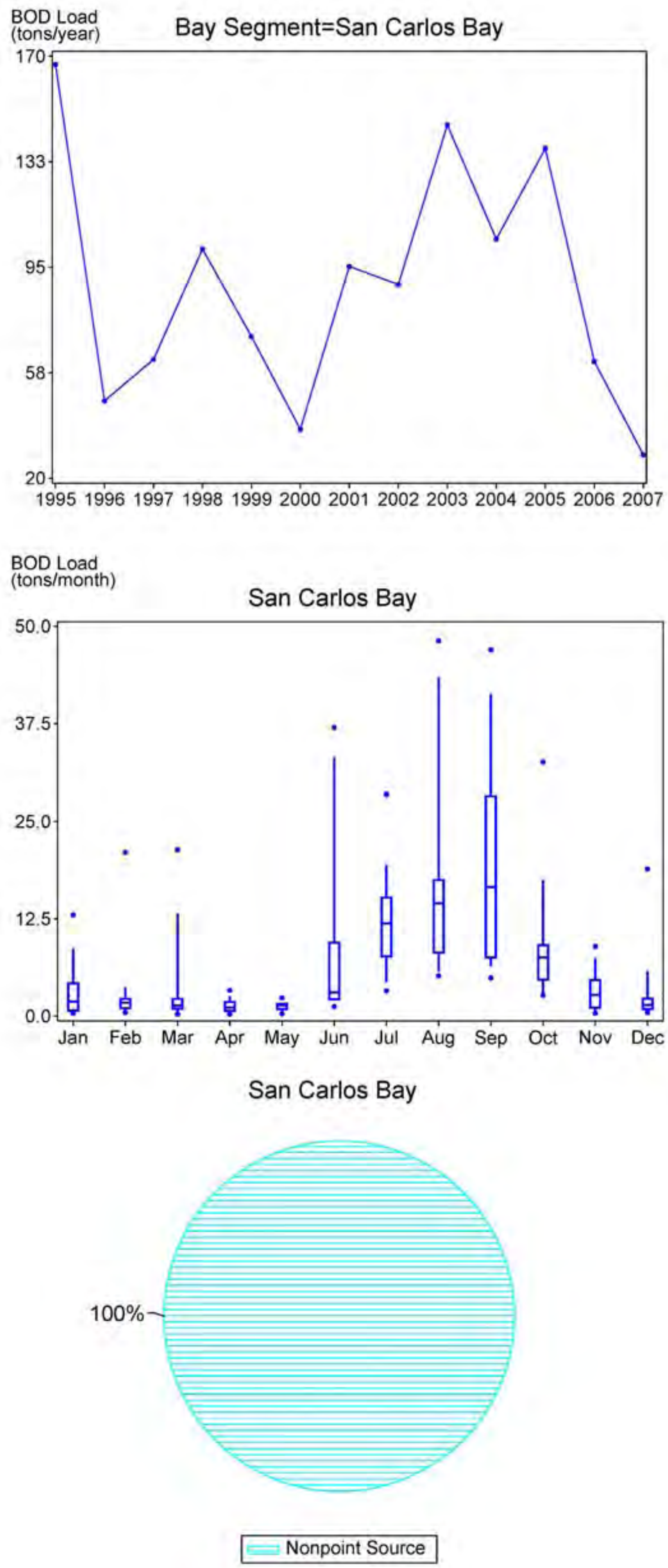

Figure 4-52. San Carlos Bay – BOD loads: annual, monthly, and by source.

4.2.13 Tidal Caloosahatchee River

Figure 4-53 (top) shows annual TN total loads for Tidal Caloosahatchee River for the period 1995 through 2007. Total loads range from 9863 (2005) to 450 tons/year (2007). Loads were generally higher during years of higher rainfall, reflecting higher nonpoint source and atmospheric deposition inputs. Wetter years included 1995, 1997, 1998, 2003, and 2005. Dryer years included 1996, 2000, 2001, 2006, and 2007. Annual watershed loadings generally followed the same pattern as total loads. Figure 4-53 (middle) shows average monthly TN total loads for the same period. Loads were higher during the June – September wet season, due to high nonpoint source runoff and/or atmospheric deposition. The wet season total loads average 557 tons/ month, and dry season loads average 233 tons/month. Figure4-53 (bottom) shows the sources of TN total loads. The major contributor was nonpoint source (97%). Other sources included atmospheric deposition (1.2%), septic tanks (<1%) and domestic point source (<1%). There are five domestic point sources and one industrial point source in this bay segment, as shown in Tables 3-6 and 3-7.

Figure 4-54 (top) shows annual TP total loads for Tidal Caloosahatchee River for the period 1995 through 2007. Total loads range from 957 (2005) to (61) 61 tons/year (2007). Figure 4-54 (middle) shows average monthly TP loads for the same period. The wet season loads average 62 tons/month, and dry season loads average 18 tons/month. Figure 4-54 (bottom) shows the sources of TP total loads. The major contributor was nonpoint source (99%). Other sources included atmospheric deposition (<1%), septic tanks (<%), and domestic point source (<1%).

Figure 4-55 (top) shows annual TSS total loads for Tidal Caloosahatchee River for the period 1995 through 2007. Total loads range from 67,405 (2005) to 2851 tons/year (2007). Figure 4-55 (middle) shows average monthly TSS loads for the same period. The wet season loads average 3148 tons/month, and dry season loads average 1224 tons/month. Figure 4-55 (bottom) shows the sources of TSS total loads. The only contributor was nonpoint source except for domestic point sources (<1%).

Figure 4-56 (top) shows annual BOD total loads for Tidal Caloosahatchee River for the period 1995 through 2007. Total loads range from 12,996 (2005) to 988 tons/year (2007). Figure 4-56 (middle) shows average monthly BOD loads for the same period. The wet season loads average 894 tons/month, and dry season loads average 349 tons/month. Figure 4-56 (bottom) shows the sources of BOD total loads. The major contributor is nonpoint source (99%). The other source is domestic point source (<1%).

It should be noted that the annual and monthly load figures have the same general shape for all parameters and segments. This is because most of the TN, TP, TSS, and BOD loadings are from nonpoint sources and are therefore determined in large from precipitation patterns. Thus, years with higher annual rainfall have higher total loadings than drier years, and wet season months (June through September) generally have higher loadings than dry season months. These patterns are generally consistent throughout the CNHEP area.

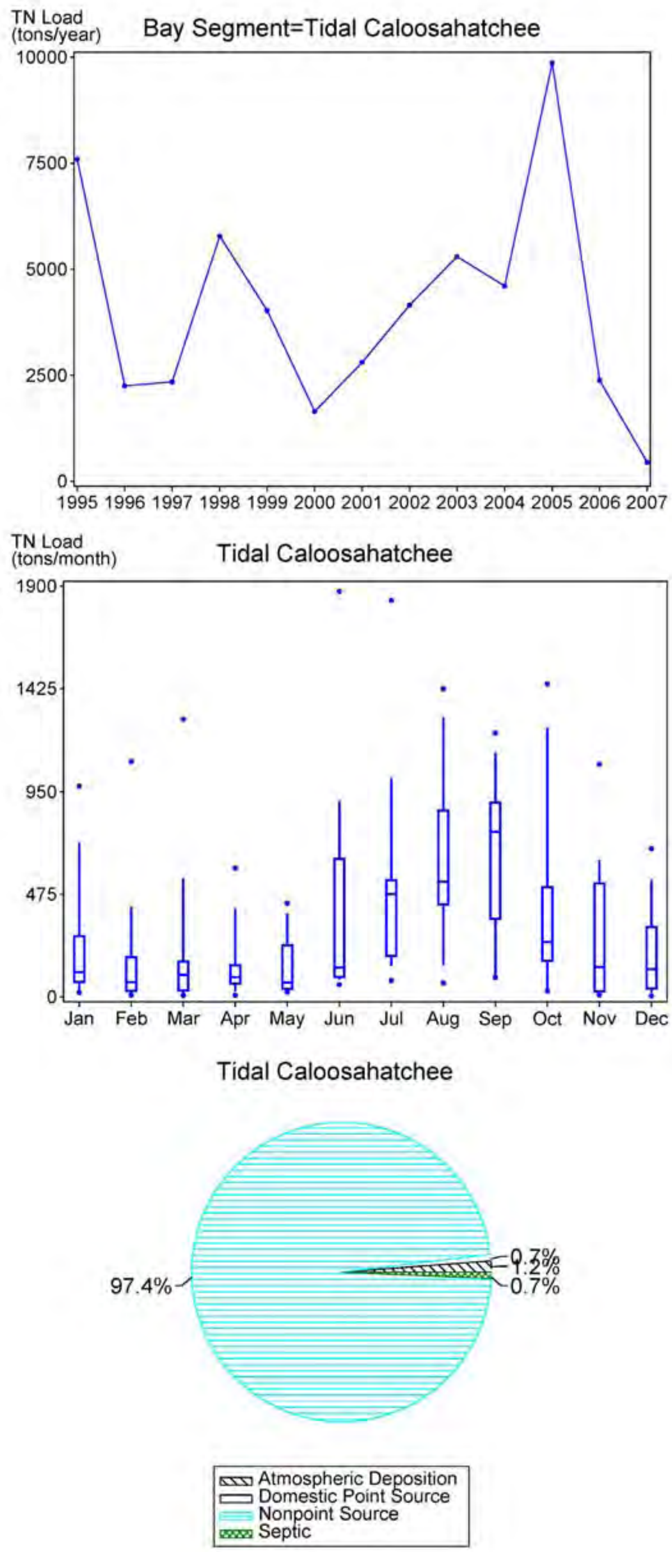

Figure 4-53. Tidal Caloosahatchee River – TN loads: annual, monthly and by source.

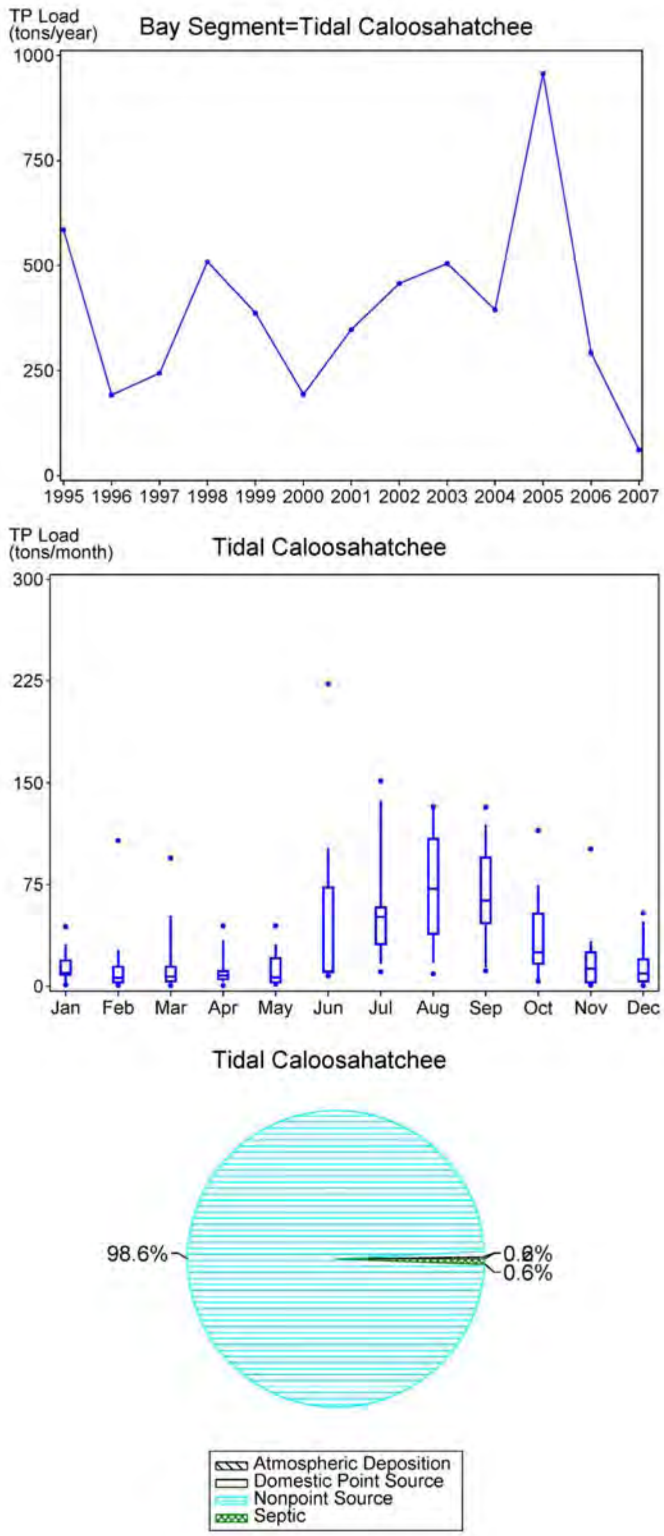

Figure 4-54. Tidal Caloosahatchee River – TP loads: annual, monthly, and by source.

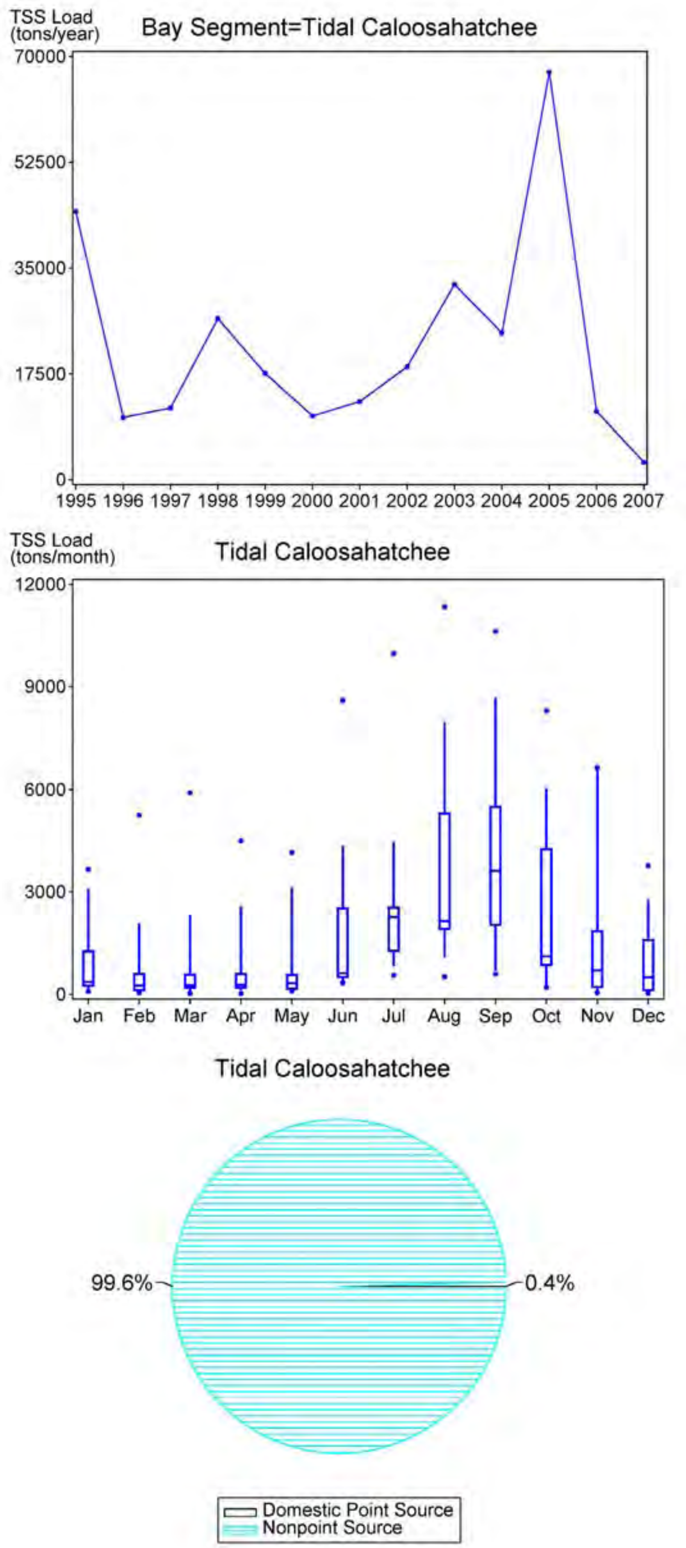

Figure 4-55. Tidal Caloosahatchee River – TSS loads: annual, monthly, and by source.

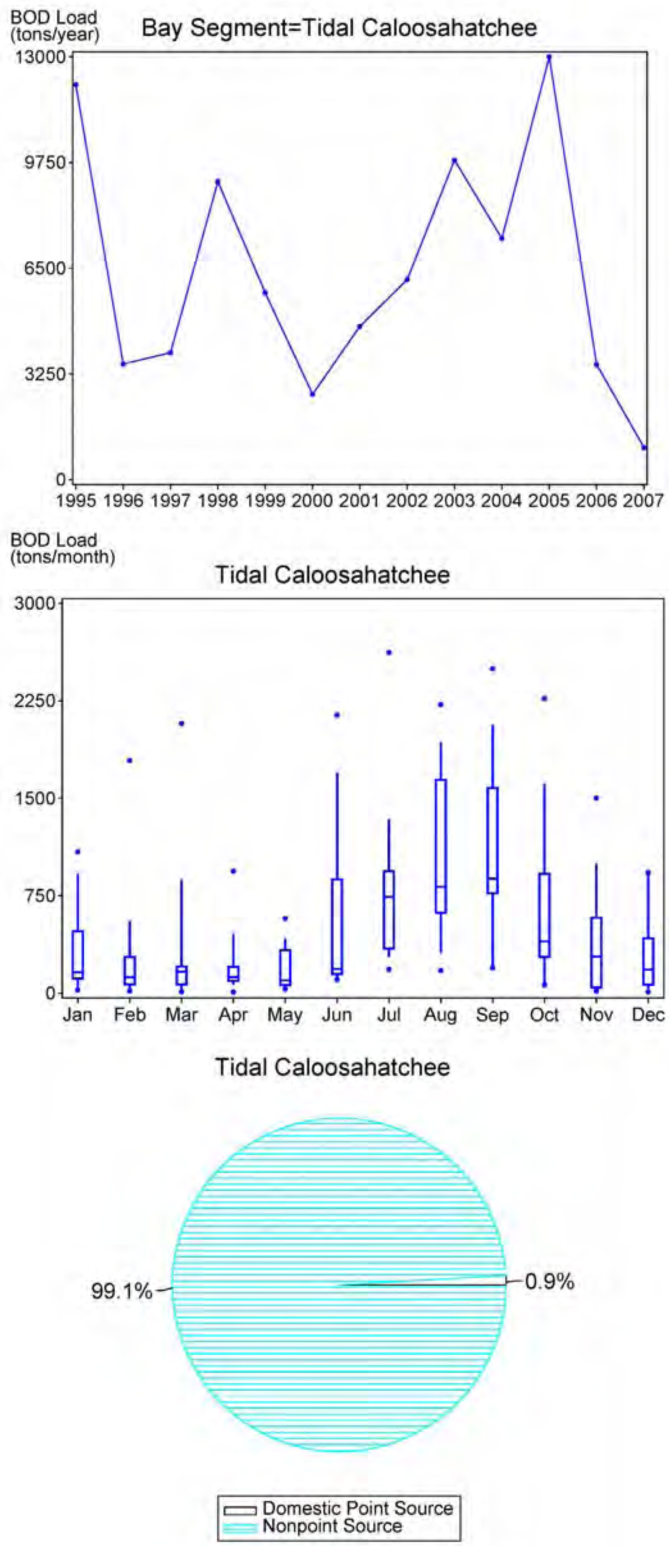

Figure 4-56. Tidal Caloosahatchee River – BOD loads: annual, monthly, and by source.

4.2.14 Estero Bay

Figure 4-57 (top) shows annual TN total loads for Estero Bay for the period 1995 through 2007. Total loads range from 845 (1995) to 186 tons/year (2007). Loads were generally higher during years of higher rainfall, reflecting higher nonpoint source and atmospheric deposition inputs. For the period of data used, wetter years included 1995, 1997, 1998, 2003, and 2005. Dryer years included 1996, 2000, 2001, 2006, and 2007. Annual watershed loadings generally followed the same pattern as total loads.

Figure 4-57 (middle) shows average monthly TN total loads for the same period. Loads were higher during the June – September wet season, due to high nonpoint source runoff and/or atmospheric deposition. The wet season total loads average 71 tons/month, and dry season loads average 19 tons/month. Figure 4-57 (bottom) shows the sources of TN total loads. The major contributor was nonpoint source (91%). Other sources included atmospheric deposition (7.3%), septic tanks (1.0%), and domestic point source (<1%). The City of Fort Myers Beach Sewage Treatment Plant is the only point source in this bay segment.

Figure 4-58 (top) shows annual TP total loads for Estero Bay for the period 1995 through 2007. Total loads range from 105 (1995) to 16 tons/year (2007). Figure 4-58 (middle) shows average monthly TP loads for the same period. The wet season loads average 9.1 tons/month, and dry season loads average 2.2 tons/month. Figure 4-58 (bottom) shows the sources of TP total loads. The major contributor was nonpoint source (98%). Other sources included atmospheric deposition, septic tanks, and domestic point sources, all less than 1%.

Figure 4-59 (top) shows annual TSS total loads for Estero Bay for the period 1995 through 2007. Total loads range from 9279 (1995) to 1473 tons/year (2007). Figure 4-59 (middle) shows average monthly TSS loads for the same period. The wet season loads average 645 tons/month, and dry season loads average 177 tons/month. Figure 4-59 (bottom) shows the sources of TSS total loads. The only significant contributor was nonpoint source.

Figure 4-60 (top) shows annual BOD total loads for Estero Bay for the period 1995 through 2007. Total loads range from 2548 (1995) to 469 tons/year (2007). Figure 4-60 (middle) shows average monthly BOD loads for the same period. The wet season loads average 205 tons/month, and dry season loads average 49 tons/month. Figure 4-60 (bottom) shows the only source of BOD total loads, nonpoint source.

It should be noted that the annual and monthly load figures have the same general shape for all parameters and segments. This is because most of the TN, TP, TSS, and BOD loadings are from nonpoint sources and are therefore determined in large from precipitation patterns. Thus, years with higher annual rainfall have higher total loadings than drier years, and wet season months (June through September) generally have higher loadings than dry season months. These patterns are generally consistent throughout the CNHEP area.

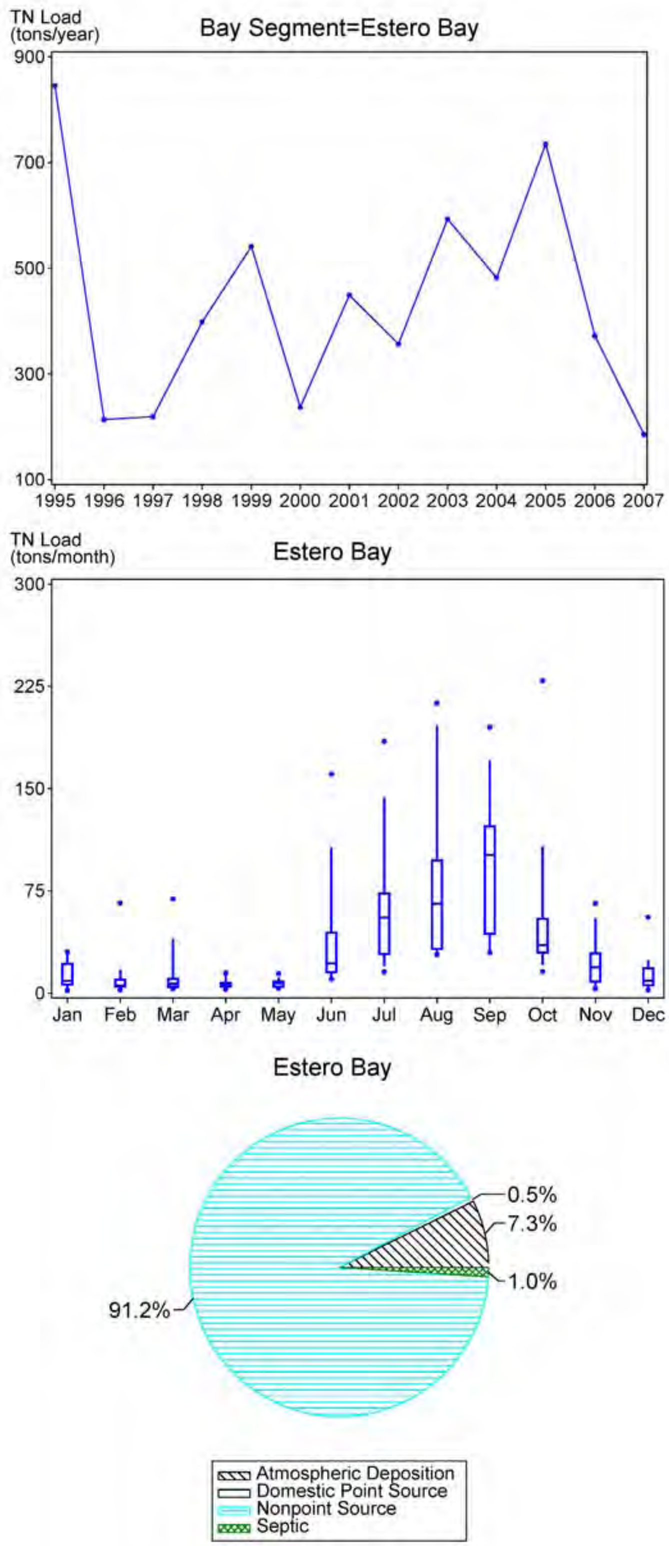

Figure 4-57. Estero Bay – TN loads: annual, monthly, and by source.

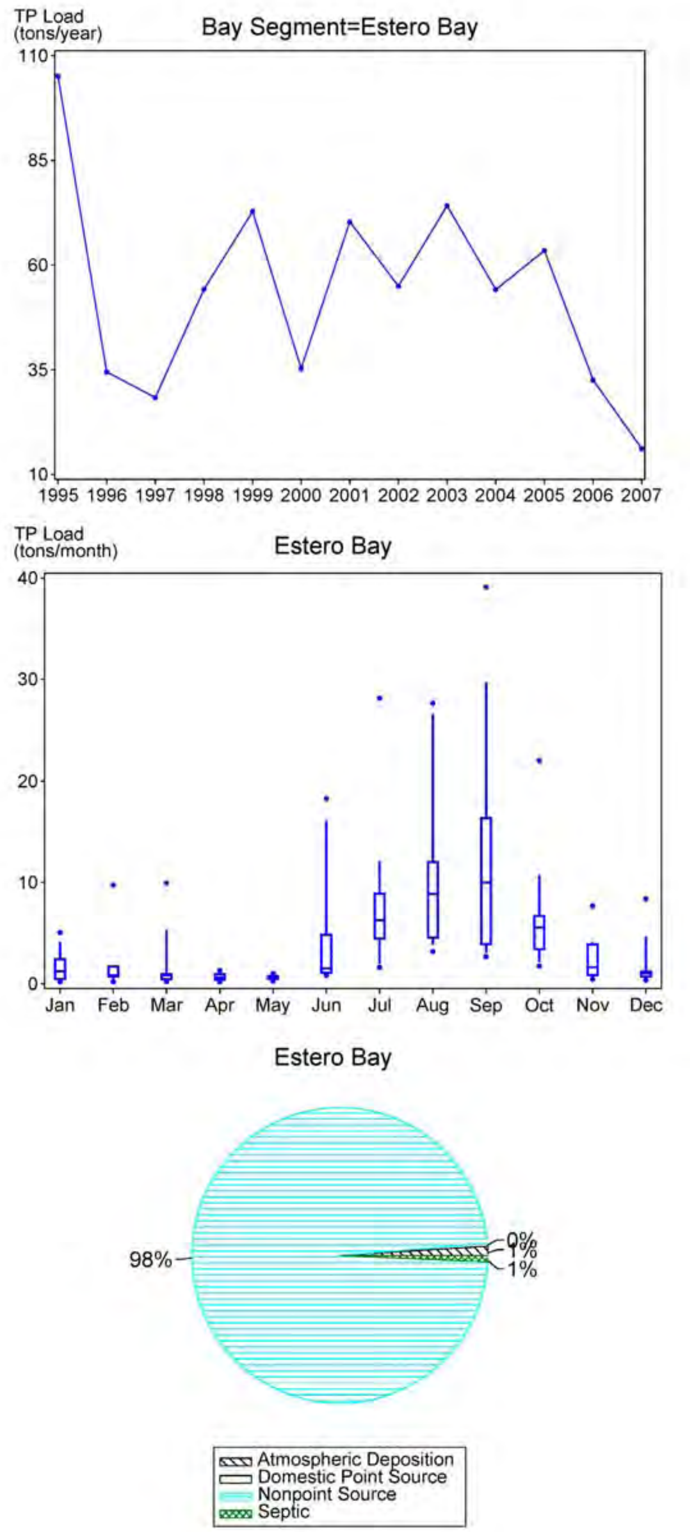

Figure 4-58. Estero Bay – TP loads: annual, monthly, and by source.

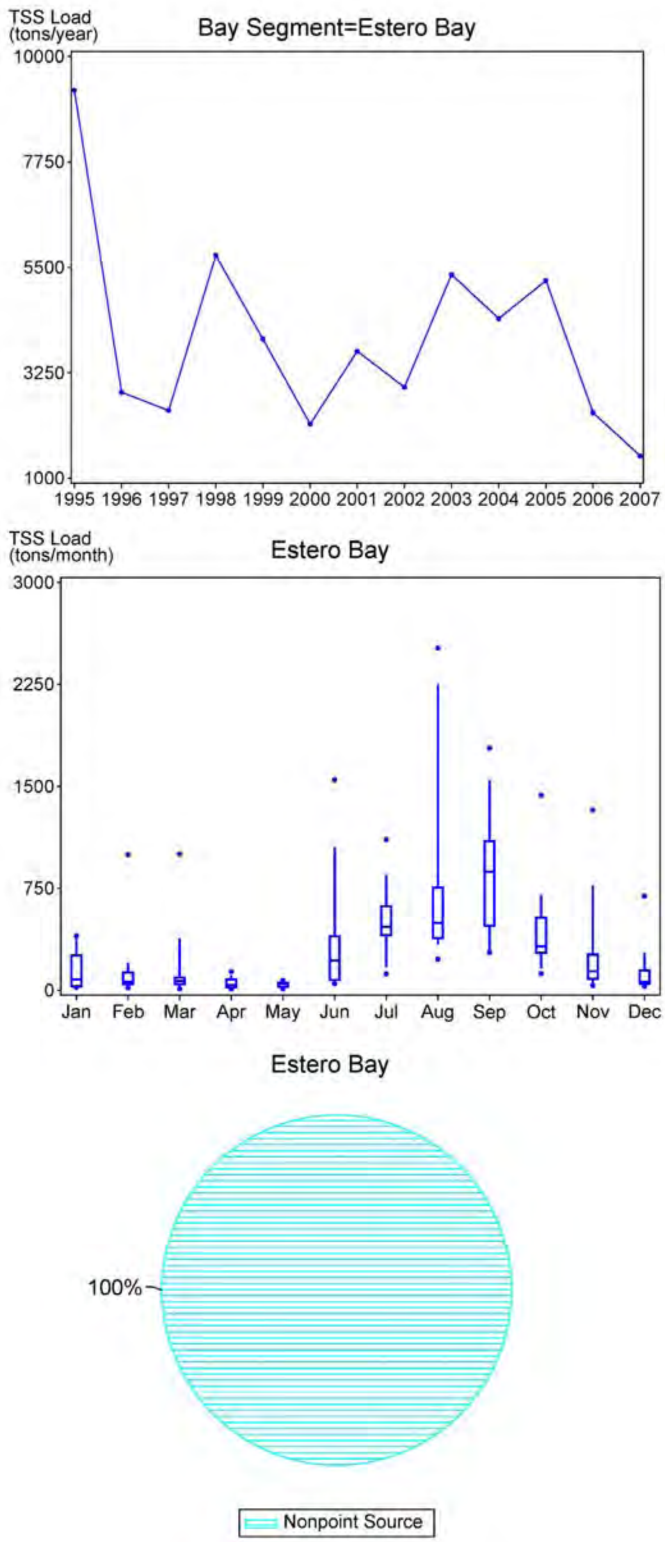

Figure 4-59. Estero Bay – TSS loads: annual, monthly, and by source.

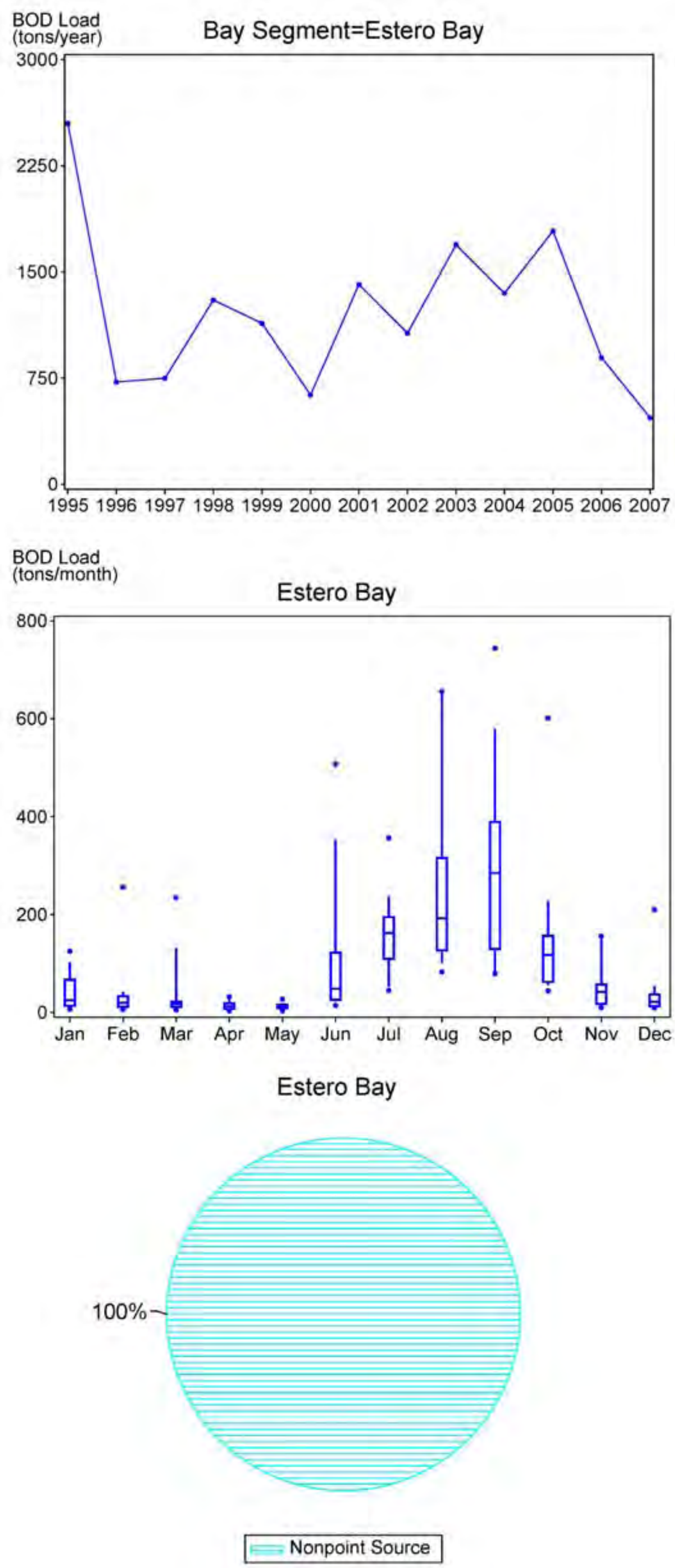

Figure 4-60. Estero Bay – BOD loads: annual, monthly, and by source.

4.3 Further Examination of Loadings

In this section various parameters relating to pollutant and hydrologic loads for watershed segments are examined and compared to identify temporal and spatial trends. Understanding how and why pollutant loadings vary is important for resource managers, especially with respect to the TMDL program and the emerging work on the development of numeric nutrient water quality criteria. Determining how watershed characteristics influence loading rates is an important step in controlling pollution, leading to the protection and enhancement of our surface water resources. Loading rates vary between segments based on segment size, land use, and pollutant source, as discussed below.

4.3.1 Pollutant Yield

A major challenge facing resource managers is to identify the relative importance of pollutant loads originating in watersheds of different sizes. Larger watersheds in general have larger loads, but it is often impractical to attempt to design treatment facilities to capture the large volumes of water associated with large watershed loadings. An alternative approach is to identify those watersheds with the most mass of pollutant in a given volume of water. More pollutant per volume of water means that less water has to be captured and treated to obtain the same load reduction as would be achieved by treating a larger volume of water from a watershed with less pollutant per water volume. Watersheds can be assessed in this manner by calculating the watershed's "yield."

The loading parameter yield, also known as the "unit area load", refers to the mass of a pollutant that a watershed generates per unit area for a given time period. A typical measure of yield is pounds per acre per year (lb/ac/yr). Using this metric, we can compare watershed segments with respect to how many pounds of TN, for example, a segment generates for each acre, on average, over a year. By estimating loads on a per-acre basis, the loading rates can be normalized, allowing segments of different sizes to be compared. Because the yield is insensitive to the size of the watershed segment, the relative contributions of large and small basins to be compared. Segments with larger yields can then be targeted to reduce the local loads.

Yields are most useful in assessing loading rates in basins with nonpoint source loads as the main source, as point and atmospheric sources can skew results. Yields are typically estimated using watershed, not total loads. As described above, the term "total load" refers to pollutant loadings from all sources including nonpoint, point (domestic and industrial), direct atmospheric deposition to the estuary, and septic tanks. The term "watershed load" refers to pollutant loading originating in the watershed but not the open water estuary, and thus does not include atmospheric deposition.

For these analyses pollutant loadings from the Tidal Caloosahatchee River were adjusted to remove inflows from Lake Okeechobee. Because hydrologic and pollutant loadings upstream of Structure S-79 in the Caloosahatchee River do not originate within the historical boundaries of the watershed, those loadings have been deleted from the segment loads. The TN annual average yields for the CHNEP watershed segments are shown in Figure 4-61. The larger riverine segments including Tidal Peace, Myakka, and Caloosahatchee Rivers, and Estero Bay all have intermediate yields close to 5 lb/ac/yr.

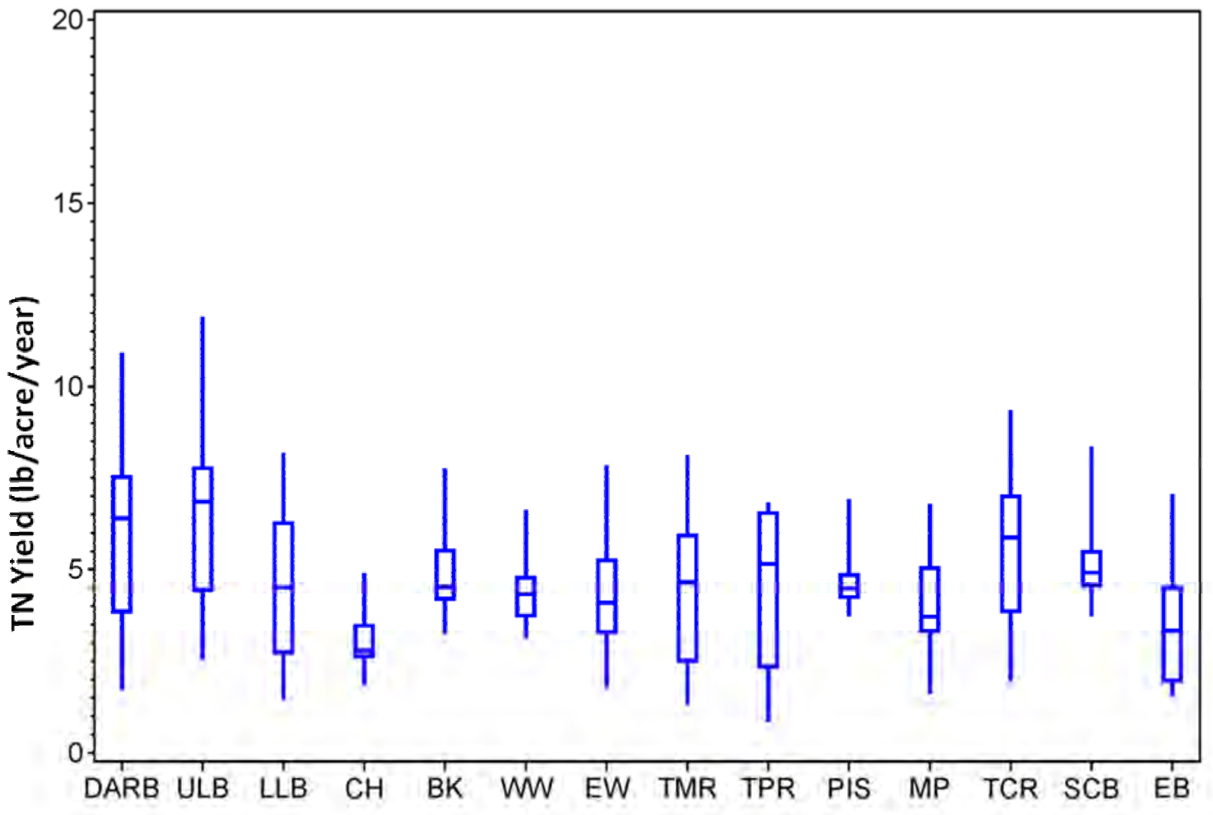

Figure 4-61. TN yield for CHNEP segments.

However, smaller segments (Dona and Roberts Bay and Upper and Lower Lemon Bay) show high yields. This demonstrates that segment size does not dictate yield values. The higher yields for the small segments (Dona and Roberts Bay and Upper Lemon Bay) may be attributable to the higher number of septic tanks close to coastal waters, as shown in Figure 3-7, and higher percentage of urban land use. The smallest yields are from the East and West Wall, and Cape Haze. These coastal segments all have low ratios of watershed to estuary.

To demonstrate the effect that inflows from Lake Okeechobee have on the Tidal Caloosahatchee River segment and the entire system, Figures 4-62 shows TN yields with the nutrient-rich inflows from S-79 on the Caloosahatchee River added in. As can be seen, the additional load dominates loadings from all watershed segments. The Lake Okeechobee load has not been included because that load cannot be controlled by local resource managers alone.

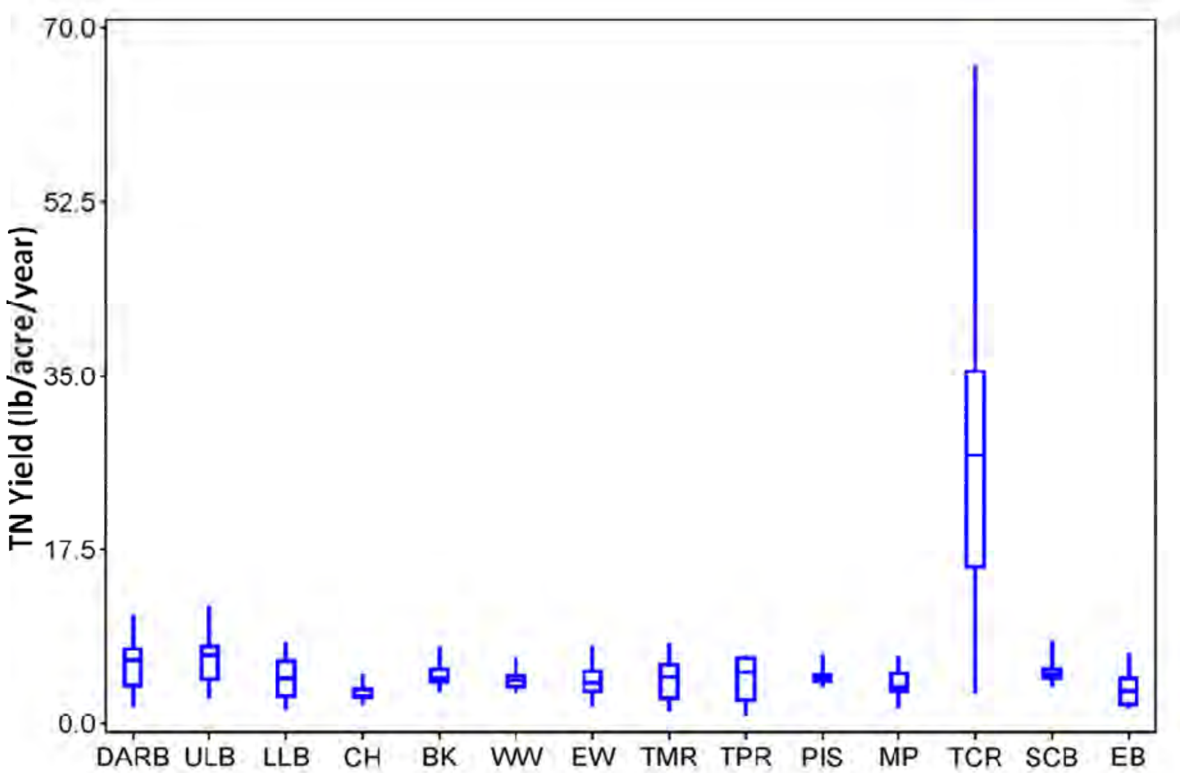

Figure 4-62. TN yield for CHNEP segments, (S-79 inputs included in Tidal Caloosahatchee River).

The TP yields for the segments (Figure 4-63) are somewhat lower than TN yields, with no yield higher than 2.0 lb/ac/yr. This is logical as TP concentrations are generally lower in surface waters than TN concentrations. However, the relative TP yields for both large (river segments) and small segments exhibit higher values. The Tidal Peace River has the highest TP yield, as expected considering the higher industrial discharges and background phosphorus levels. As with TN, coastal segments with low watershed to estuary ratios have the lowest TP yield.

4.3.2 Nutrient Load Delivery Ratio

An alternative to calculating a watershed yield is to examine the watershed nutrient load delivery ratio. This metric is a measure of the watershed nutrient load divided by the hydrologic load and is used to determine the mass of pollutant in a given volume of water (e.g., nonpoint source loading).

The magnitude of the ratio provides a good tool for relative spatial comparisons of loading intensities between segments. The ratio is calculated by dividing the watershed pollutant load (tons/month) by the watershed hydrologic load (million cubic meters/ month – Mm^3/month).

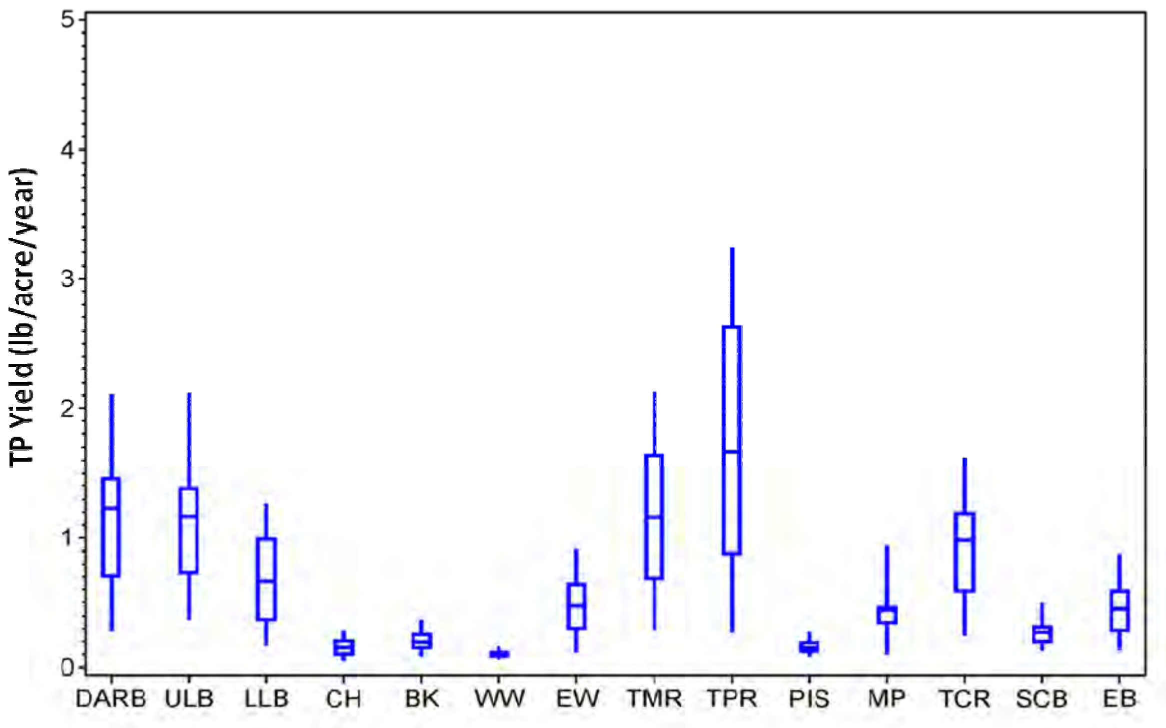

Figure 4-63. TP yield for CHNEP segments.

The ratio is a relative metric of the concentration of a pollutant in the loading – the higher the concentration the higher the ratio. As with yields, the delivery ratio is normalized to remove a direct influence of watershed segment size on the results. As shown in Figure 4-64, the mean segment TN delivery ratios range from between 0.5 to 0.6 (small coastal segments Cape Haze, Bokeelia, and the West Wall) to about 1.65 (Dona and Roberts Bay). The Tidal Myakka and Peace Rivers also have high delivery ratios. Generally, the segments that had a high TN yield also have a high TN delivery ratio. Larger segments include river systems Tidal Peace River, Tidal Myakka River, and Tidal Caloosahatchee River, as well as Pine Island Sound and Estero Bay. Smaller segments with high ratios include Dona and Roberts Bay and Upper and Lower Lemon Bay.

Higher ratios are attributed to nutrient loading sources that raise the concentrations of constituents such as septic tanks, point sources, and intensive urban development. Ratios are low for coastal segments Matlacha Pass, Cape Haze, Bokeelia, West Wall, Pine Island Sound, San Carlos Bay, and San Carlos Bay and indicate more undeveloped land or less intensive urban uses. TP delivery ratios generally have the same pattern as TN ratios (Figure 4-65). The two highest ratios are for the Tidal Peace River and Tidal Myakka River segments (larger segments), followed by Dona and Roberts Bay and Upper and Lower Lemon Bay (smaller segments). Of these the Tidal Peace River has by far the highest ratio due to industrial inputs and high background phosphorus levels.

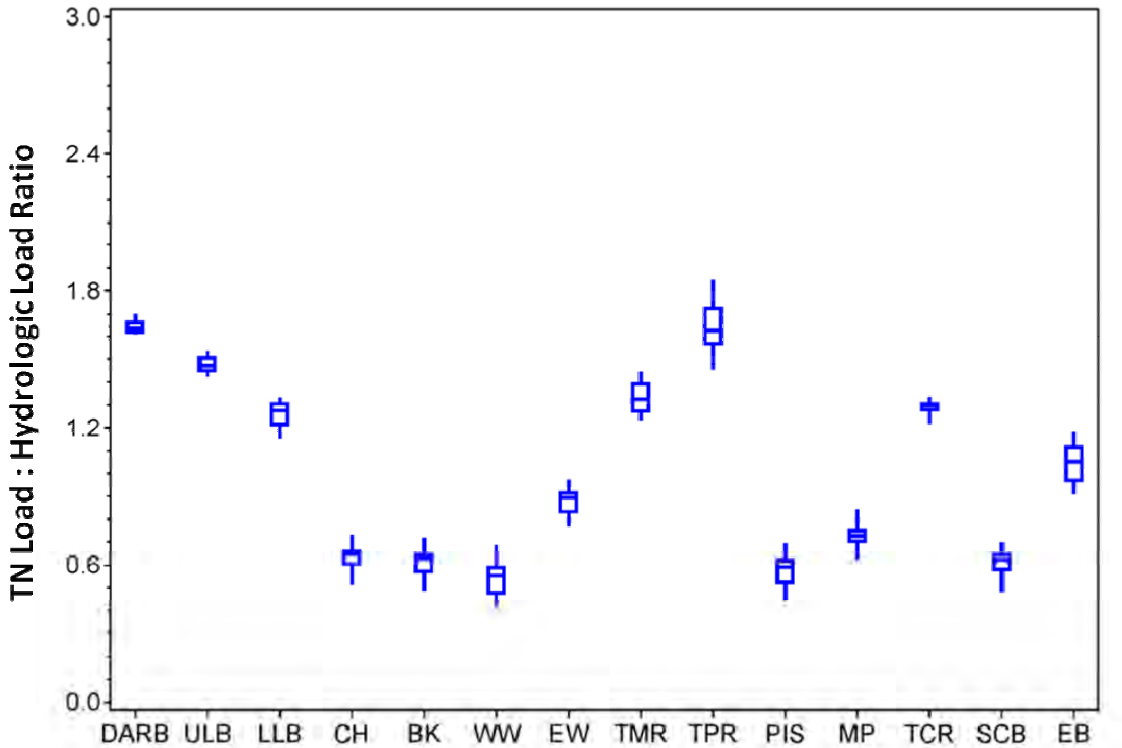

Figure 4-64. TN delivery ratio for CHNEP watershed segments.

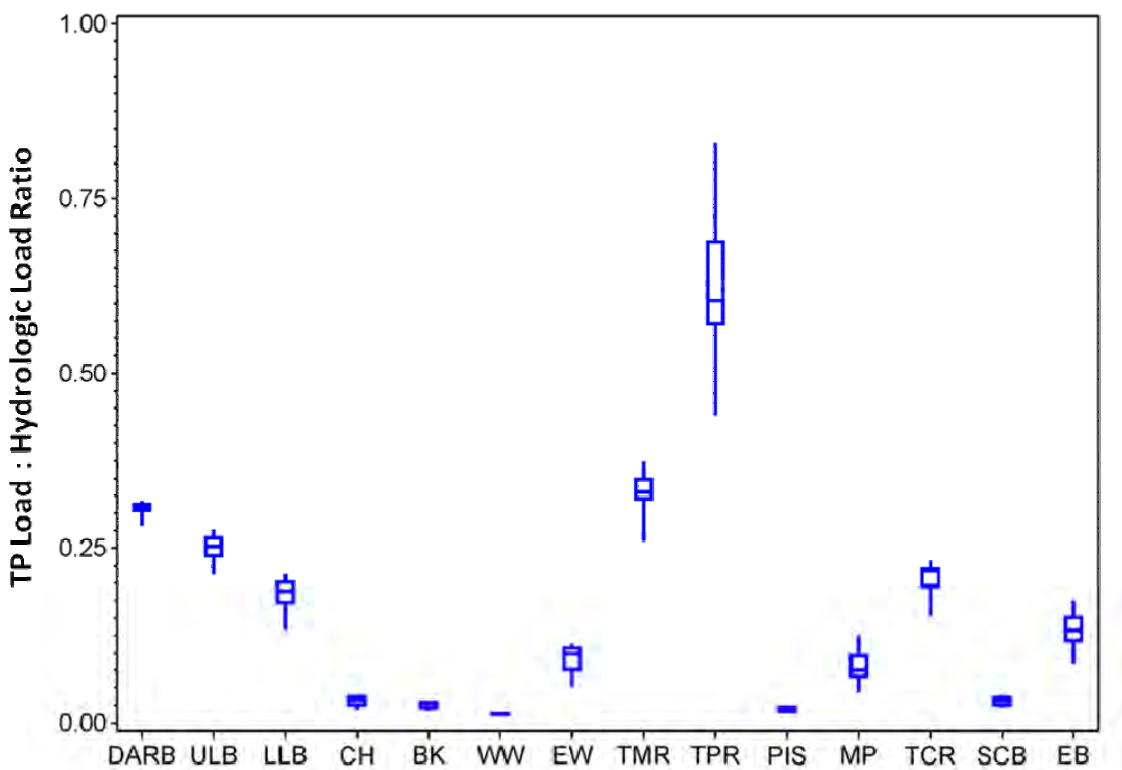

Figure 4-65. TP delivery ratio for CHNEP watershed segments.

4.3.3 Relationship of TN Delivery Ratio to Land Use/ Land Cover

As discussed above, the TN delivery ratio is greatly influenced by the relative proportion of different land uses within a segment watershed, as well as point source contributions. Low TN delivery ratios can be largely explained locally by the existence of less intensive urban development and more open land and open water/wetlands within in a segment watershed. Both these conditions contribute less TN load per acre by virtue of lower TN concentrations in nonpoint source, by the vegetative uptake of nutrients in a more natural setting, and by the on-site retention of stormwater and increased groundwater infiltration on land with less impervious surface (parking lots, roads, buildings, etc.). Likewise, higher TN delivery ratios can be expected in watersheds with more, and more intensive, urban land uses and fewer areas of open land and wetland/open water. More impervious surface results in more stormwater runoff and less on-site retention, and intensive urban land uses have been shown to generate higher concentrations of nutrients in runoff. Also fewer wetlands and open water bodies provide less opportunity for nutrient uptake and sequestering.

Given the relatively small contribution of TN loading from point sources within most of the Charlotte Harbor segments, it would be expected that segment TN delivery ratios would be significantly correlated with land use composition. Figure 4-66 shows the TN delivery ratio relative to the percent of a watershed segment covered by wetlands. The graphic clearly shows a decreasing trend ($r^2 = 0.81$) in TN delivery ratio as wetland coverage increases.

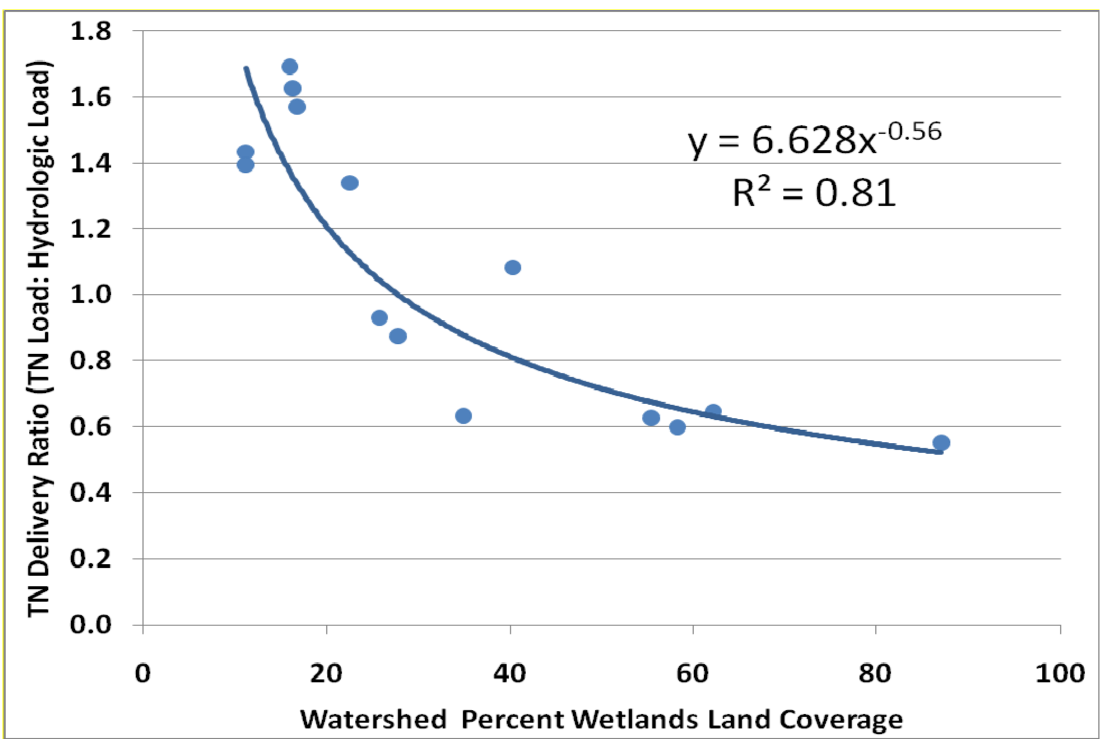

Figure 4-66. TN delivery ratio as a function of wetland coverage.

This trend strongly suggests that wetlands generate less nitrogen on a unit area basis, and/or that wetlands act as a nutrient sink and hold TN entering the wetland from upland sources. The trend provides strong evidence that the protection, creation, and enhancement of wetlands is a valid management tool for controlling nitrogen loading to the Charlotte Harbor estuary.

4.3.4 Nitrogen Delivery Ratio Compared to Estuary Area Ratio

The intensity of a pollutant loading compared to the relative size of the estuary and its watershed can greatly influence the potential for adverse impacts from nutrient inputs. Higher TN delivery ratios result in more pollutants entering a receiving water body per unit of inflow from the watershed. In large receiving water bodies higher loads and delivery ratios can be assimilated through dilution, chemical cycling, circulation, and dispersion with less pronounced effects. Smaller receiving water bodies have limited abilities to assimilate large loads and delivery ratios because of reduced water body volume and less ability to cycle pollutants. Figure 4-67 shows these comparisons for the 14 CHNEP segments.

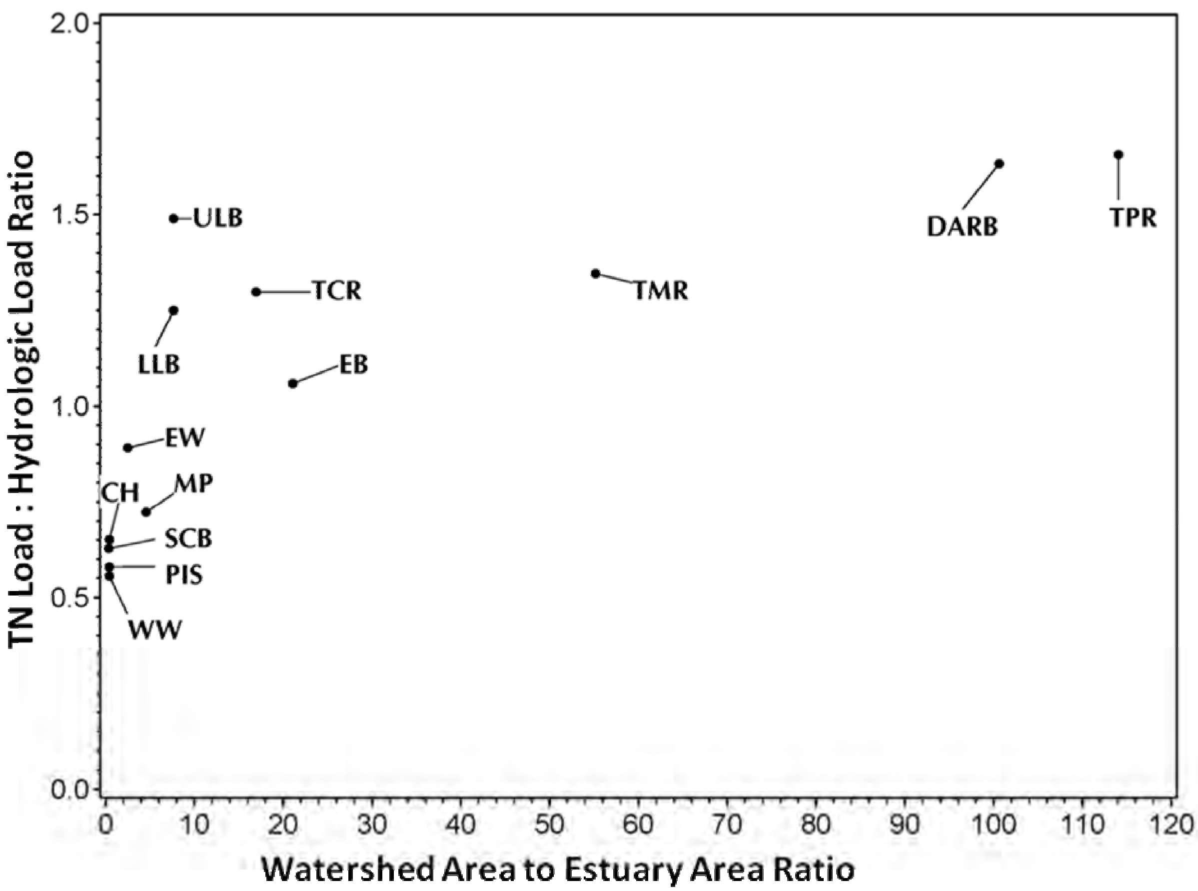

Figure 4-67. TN delivery ratio as a function of watershed to estuary ratio.

Therefore, comparing TN delivery ratios to the ratio of a watershed (land) to receiving water body (estuary) area can be used to predict the severity of the relative impact that TN loading can have on an estuary. The higher the delivery ratio and larger the land to water ratio is, the higher the potential for adverse impacts will be. The Tidal Peace River and Dona and Roberts Bay segments have the two largest watershed land:estuary water ratio, and also fairly high TN delivery ratios and thus could be most vulnerable to adverse impacts from poor water quality. Tidal Myakka River also has a high ratio. All the other segments have area ratios of 20 or less, with the lowest values seen for the coastal segments.

4.4 Findings and Conclusions of Loading Assessment

Bay segments of the CHNEP area were assessed for total and watershed loadings of TN, TP. TSS, and BOD. Inter-annual and seasonal patterns were identified, as were spatial differences between segment loadings. Significant findings include the following:

For the entire CHNEP area, annual loads for TN, TP, TSS, and BOD all varied by close to an order of magnitude during the period of record (1995 through 2007). Variability of all loads was closely tied to annual rainfall, with higher rainfall yielding higher loadings.

For the entire CHNEP area, monthly loads for TN, TP, TSS, and BOD were all higher during the wet summer season than during the dry winter. As with annual loads, higher rainfall resulted in higher loadings.

Nonpoint source loadings were by far the most significant source of pollutant inputs, and accounted for 70% of the TN load, 68 % of the TP load, 95 % of the TSS load, and 90% of the total BOD load in the CHNEP area. Other TN loads for the entire CHNEP area included industrial point sources (20%), atmospheric deposition (6.3%), domestic point sources (<1%), and septic tanks (2.4%).

For TP loads, nonpoint source contributed 68%, industrial had the next largest contribution (28.3%) much of which originated from the phosphate industry in the Peace River basin. Other sources included domestic point sources (1.9%), septic tanks (1%), and atmospheric deposition (<1%).

For TSS loads, sources other than nonpoint source included industrial point source (3.2%) and domestic point sources (1.6%). For BOD loads, sources other than nonpoint source included industrial point source (7.7%) and domestic point sources (2.3%).

TN loadings to bay segments were dominated in most cases by nonpoint sources. Exceptions included higher atmospheric deposition contributions in segments with high open water area to watershed area ratios (Cape Haze, Bokeelia, West Wall, Pine Island Sound, and San Carlos Bay), and higher septic tank loadings in Matlacha Pass that has a small watershed, small open water area, and a numerous septic tanks near the shoreline. The Tidal Peace River was unique in that 61% of its TN load originated from industrial point source, mainly through emergency discharges by mining facilities.

TP loadings to bay segments were dominated in most cases by nonpoint sources. As with TN, exceptions included higher atmospheric deposition contributions in segments with high open water area to watershed area ratios (Cape Haze, Bokeelia, West Wall, Pine Island Sound, and San Carlos Bay). The Tidal Peace River had 45% of its TP load originated from industrial point sources mainly through emergency discharges by mining facilities.

TSS loadings to bay segments were dominated in all cases by nonpoint sources, which contributed 95% or greater of the total load in all segments except Tidal Peace River, where industrial and domestic point sources combined for about 15% of the total.

BOD loadings to bay segments were dominated in all cases by nonpoint sources, which contributed 99% or greater of the total load in all segments except Tidal Peace River, where point sources contributed about 20% of the total load.

Land use and land cover has a significant influence on nutrient yields and delivery ratios. Whereas urban land uses generate higher volumes of runoff with higher pollutant concentrations, undeveloped land, especially wetlands, greatly attenuate pollutant outputs through nutrient uptake or sequestering in sediments, and by on-site retention of stormwater with enhanced groundwater infiltration.

The relative watershed area to estuary area ratio can influence the nutrient loading ratio for an estuary. The higher the loading ratio and the higher the watershed to estuary ratio, the greater the opportunity for degradation

The assessment of TN and TP yields indicated that most of the higher yields originated in both larger riverine segments including Tidal Peace, Myakka, and Caloosahatchee Rivers, and Estero Bay, and smaller segments (Dona and Roberts Bay and Upper and Lower Lemon Bay). The higher yields for the small segments (Dona and Roberts Bay and Upper and Lower Lemon Bay) may be attributable to the higher number of septic tanks close to coastal waters, and higher percentage of urban land use. This makes the smaller watersheds prime targets for siting Best Management Practices (BMPs) for pollutant removal.

Also, both large and small segments had high TN and TP delivery ratios. Tidal Peace River had the highest TP ratio, due to high industrial point source inputs.

Land use has a profound effect on delivery ratio. It was shown that the TN delivery ratio falls significantly with increasing percent wetland coverage of a watershed. This implies that wetlands do act as a filter to remove nutrients from surface waters.

5 ESTIMATING THE EFFECTS OF BEST MANAGEMENT PRACTICES

Best Management Practices (BMPs) are actions that are implemented in order to improve an ecosystem. The goal of BMPs as relates to this report is to reduce pollutant loadings from point and nonpoint sources. Load reductions can be achieved by reducing pollutant concentrations in the flow stream, and/or reducing the volume of water entering the receiving water. The CHNEP requires a method to estimate the potential effects of future changes to the watershed, including land use changes, and projects that are being proposed or implemented as part of on-going efforts to reduce loadings to Charlotte Harbor. The tool that is described in this section will allow the CHNEP to better predict the impact of future changes to the watershed. The tool will also allow direct comparison of proposed projects, which will assist managers in identifying the most cost effective method of achieving loading reductions.

The overall concept of the BMP calculator, as described below, is to set pollutant loading baseline conditions in an area (e.g., bay segment), to then provide an estimate of how much loadings would change from some proposed activity, and then taking the difference between the two loadings to assess the magnitude of change in loadings for that bay segment. The BMP calculator algorithm is shown in Figure 5-1.

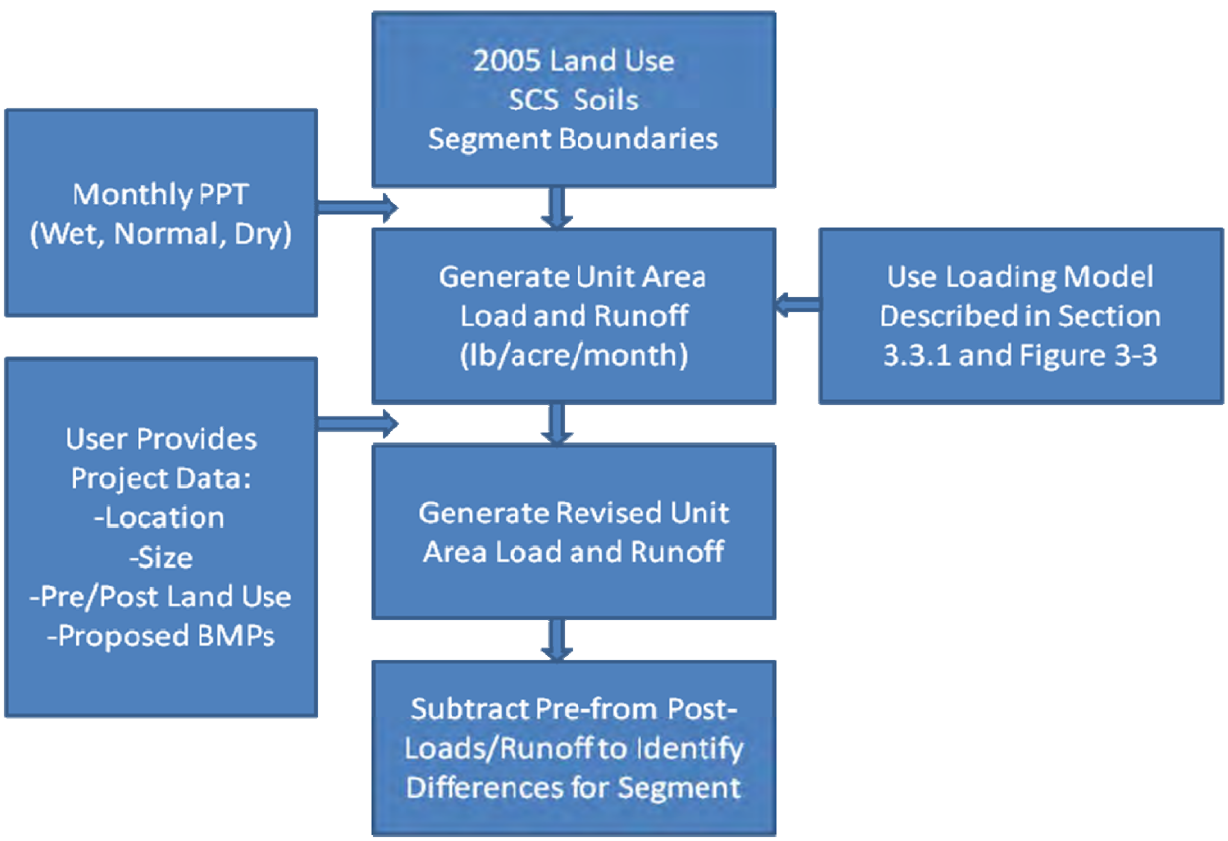

Figure 5-1. BMP Tool process.

5.1.1 Model Input

The model is driven by a data base of physio-hydro-chemical data that are specific to the Charlotte Harbor watershed. Model inputs include:

- land use,
- soils,
- watershed basin boundaries,
- monthly precipitation for wet, average, and dry years for each basin, developed from 1995 through 2007 data.
- USGS gaged streamflow data where available,
- land use specific runoff coefficients and event mean concentrations for TN, TP, TSS and BOD, and
- performance effectiveness (treatment efficiency) for a variety of BMPs.

5.1.2 Existing Condition Loadings

The first step in the use of the BMP calculator is to determine existing loadings. Loading estimates consist of hydrologic and pollutant components. The pollutant loadings are estimated by multiplying the hydrologic load (*e.g.,* cubic feet per second - cfs) times the concentration of the different pollutants in the water (*e.g.,* mg/L). The resultant load is expressed as a mass of pollutant over time (*e.g*., tons/year).

Hydrologic loads (streamflows) were estimated for both gaged and ungaged areas. The methods used are described in detail in Section 3.3.1. Methods proposed for use are very similar to those described in Janicki Environmental (2005). For gaged areas, point source inflows were subtracted from total streamflows reported by US Geological Service (USGS) using data from 1995 through 2007. The remainder of the flow was classified as streamflow originating from nonpoint source runoff and was apportioned to basins that are tributary to the gage, based on basin area and land use/soils.

Hydrologic loads in ungaged areas were estimated using an empirical model. The model was developed using measured flows from five gaged basins in the watershed, each of which was determined to be relatively unaffected by withdrawals, mining discharges, and/or agricultural irrigation. Monthly streamflow for the gaged basins was apportioned to each land use/soils grouping within the gaged basin and normalized to the rainfall that the basin received. By normalizing the runoff to the rainfall, antecedent conditions and seasonal variation in runoff was adequately accounted for. The end result of the empirical model was a database of unit area runoff values (*e.g*. cubic feet per month) specific to land use/soils and rainfall for each month between January 1995 and December 2007.

The database of monthly land use-specific values of runoff per unit area per inch of rainfall (cubic foot water/acre/inch rainfall) was then applied to the ungaged basins to predict nonpoint source runoff for each month of the 1995-2007 period. As with the gaged basins, land use/soils and monthly rainfall, specific to each ungaged basin, were used to estimate nonpoint source runoff. For the gaged basins, pollutant loads were estimated by multiplying hydrologic loads (cubic feet per month) by measured water quality data. In the instance where hydrologic loads were available but water quality data were not available, literature values of land use specific Event Mean Concentration (EMC) (mg/L) were used in place of measured water quality data. This process is described in detail above in Section 3.3.1.

For ungaged basins, pollutant loads were estimated by multiplying predicted hydrologic loads attributable to individual land uses by the literature values of land use specific EMCs (mg/L). The loads are expresses as a flux, such as tons per year.

5.1.3 Proposed Conditions

The next step in using the BMP calculator is to estimate the magnitude of change in loadings due to the proposed project. The user can utilize data embedded in the model for such items as BMP efficiency, etc. or site-specific data can be input. Necessary data include the following.

- Is the project an identified CHNEP Action Plan, or new activity?
- Describe the project location by governmental jurisdiction and CHNEP segment.
- Provide an anticipated schedule.
- Provide a total cost estimate, funding sources and/or cooperators.
- Summarize the project description or insert a Word file.

If applicable, user can also add the following quantitative information.

- What is the proposed habitat restoration acreage? (list current land use, target habitat, acres to be restored).
- What is the potential load reduction?

Information needed includes CHNEP segment, current land use, acres treated, treatment method, pollutants treated, current pollutant load, pollutant removal efficiency, final load reduction. The user can use values from embedded tables or input site-specific data. Once entered, the information can be edited within the program. Table 5-1 shows land uses included in the internal tables and the unit area loads used to estimate project loads (Janicki Environmental, Inc. 2008b).

After the user selects the area where the proposed project will be implemented, the model displays land use-specific loadings for dry, average, and wet conditions. The user then inputs the changes to the land use that will result from the proposed project. The proposed condition land use information replaces the existing conditions land use information and the model recalculates TN, TP, TSS, BOD, and hydrologic loads.

If BMPs that have quantified treatment efficiencies are to be integrated into the proposed project, constituent-specific treatment efficiencies can be entered into the model and the resulting loading reductions will be estimated. A list of BMPs will be accessible within the model, and will include those shown in Table 5-2 (Janicki Environmental, Inc., 2008b), and others as appropriate. Typical treatment efficiencies for the BMPs are also shown.

Table 5-1. Land Use and Covers and Unit Area Loads.

Land Use	TN LOAD (lb/acre/yr)	TP Load (lb/acre/yr)	TSS Load (lb/acre/yr)
Agricultural - Citrus	1.82	0.81	9.90
Agricultural - Feed Lot	46.46	8.96	117.91
Agricultural - Field and Row Crop	6.92	1.28	23.79
Agricultural – Nursery	1.65	0.73	8.95
Agricultural – Pasture	3.31	1.01	10.70
Barren	3.66	0.03	32.49
Commercial	7.29	1.05	309.61
Forested Freshwater Wetlands	3.72	2.57	44.30
Freshwater - Open Water	0.00	0.00	0.00
Industrial	5.84	0.95	335.13
Institutional/Transportation/Utilities	2.95	0.38	50.08
Medium Density Residential	4.15	0.63	67.56
Mining	2.80	0.36	118.62
Multifamily Residential	5.08	0.90	155.99
Non-forested Freshwater Wetlands	3.54	2.44	42.11
Rangeland	2.15	0.02	19.04
Saltwater Wetlands	0.00	0.00	0.00
Single Family Residential	2.48	0.41	23.38
Upland Forested	0.56	0.07	6.34

Table 5-2. Estimated Pollutant Removal Efficiency for Typical Water Quality BMPs.

Treatment Method	Treatment Efficiency (%)		
	TN	TP	TSS
Extended Detention Pond	30	60	48
Wet Pond	30	60	60
Constructed Wetland	25	35	75
Vegetated Swale	10	15	50
Vegetated Buffer Strip	35	45	50
Infiltration Basin	58	63	87
Exfiltration Trench	57	57	83
Wastewater Reuse	90	NA	NA
Baffle Box	30	25	70
Septic Tank Removal	10	10	10
Education Programs	10	10	10

NA – not available.

A proposed project may be new, or may be associated with an existing CHNEP Action Plan. A database of identified Action Plan projects within CHNEP will be developed for the BMP calculator. Information from the database will be available in summary form. Action Plans will be called up by name, or by a variety of pre-set search criteria, for example, Action Plans can be queried by Priority Issue and Bay Segment, by TN load reduction and Bay Segment, or by Habitat Restoration acreage and Bay Segment, among many other options.

The database will include the following information for each Action Plan project:

- Project title and description
- Location – by jurisdiction, bay segment and basin – interactive map will be included
- Schedule (planning, funding, construction, monitoring stage, etc.)
- Cost – annual and total cost, funding sources, cooperators, etc.)
- Habitat targets, if applicable
- Nonpoint source load reduction, if applicable
- Point source load reduction, if applicable (discharge type, pollutants, etc.)
- Log of activity concerning the Action Plan (additions, changes to project description or schedule, etc.)

If a project has not already been identified in an Action Plan the potential loading changes can be estimated using information in the model, or using other data. For nonpoint source loads, the user would enter the subbasin, acres, land use, treatment method, and treatment area. If an alternate load is to be used, that can be entered (lbs/yr) into the box. If an alternate treatment method or removal rate is to be used, enter that information. If there is documentation of the alternate information, embed the documentation into the database.

For point sources, the average discharge (millions of gallons/day), total nitrogen concentration (mg/L) in the discharge and the attenuation factor should be entered. Alternate data could be entered by the user with justification. If a project has a habitat restoration benefit, that information can be entered also. Table 5-3 shows restoration types applicable for the CHNEP area, although other types can be added.

5.1.4 Model Results

The pre- and post-project pollutant and hydrologic loadings are then compared. Post-project loadings with treatment minus pre-project loadings equals the change in loads for that area. Results of this analysis are then factored into segment-wide loadings. The model results can be used to determine allocations for TMDLs. It can also help identify the necessary level of treatment to offset increased loadings resulting from land use changes.

Table 5-3. Habitat Types for CHNEP Restoration Activities.	
Seagrass	Riparian Wetlands
Salt Barrens	Forested Uplands
Low Marsh	Coastal Uplands
Artificial Hardbottom	Mangrove Shoreline
Natural Hardbottom	Mangrove Island
Oyster Reef/Shell Bottom	Estuarine Water Column
Intertidal Mudflat	Forested Wetlands
Estuarine Beach	Submerged Mud Bottom
Isolated Freshwater Marsh	Submerged Sand Bottom
Oligohaline Marsh	Hardened Shoreline
High Marsh	Exotic Forests

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APPENDICES

APPENDIX A

Maps of Gaged and Ungaged Areas of Bay Segment Watersheds

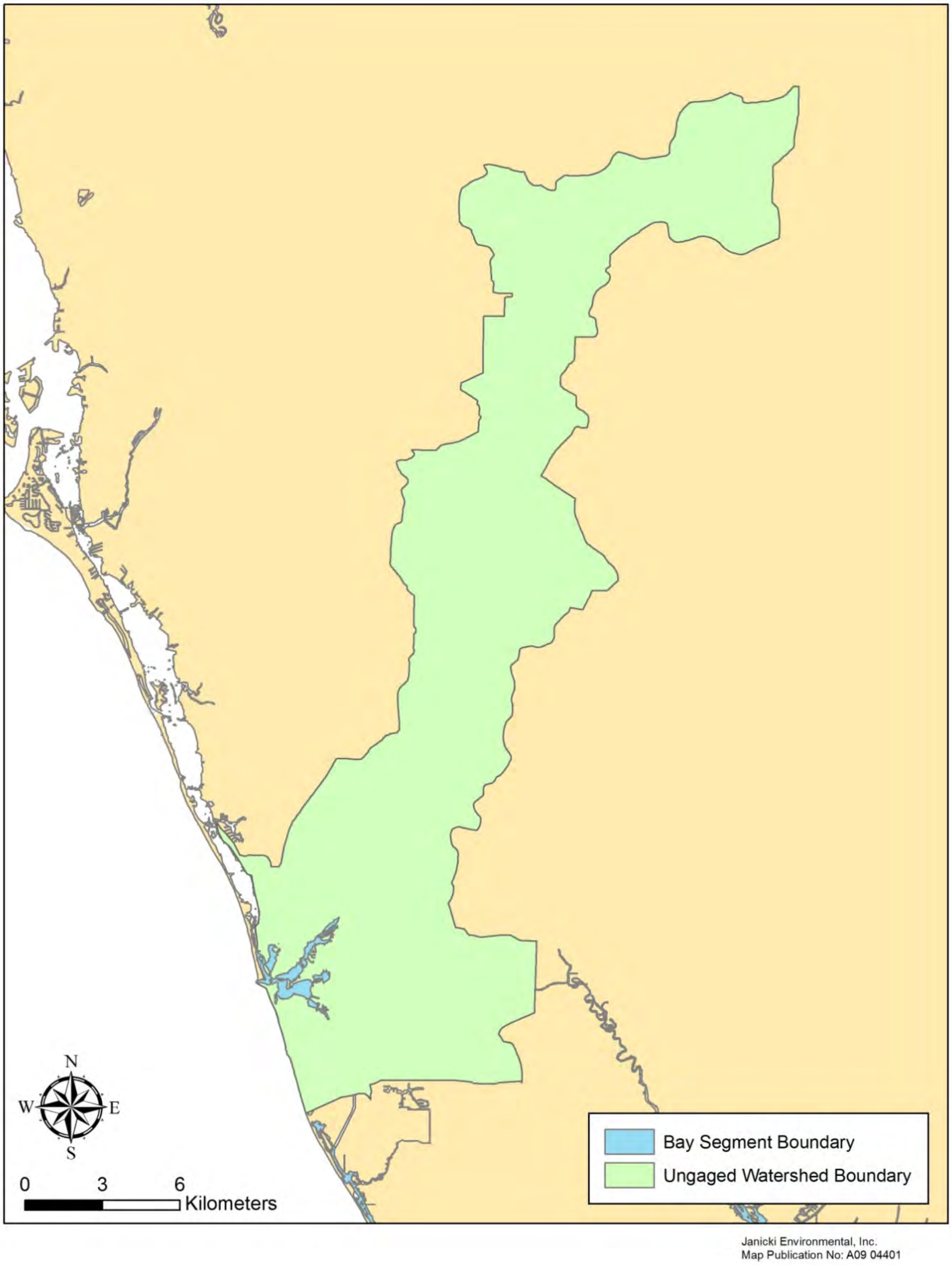


Figure A-1. Map showing ungaged watershed of Dona and Roberts Bay segment.

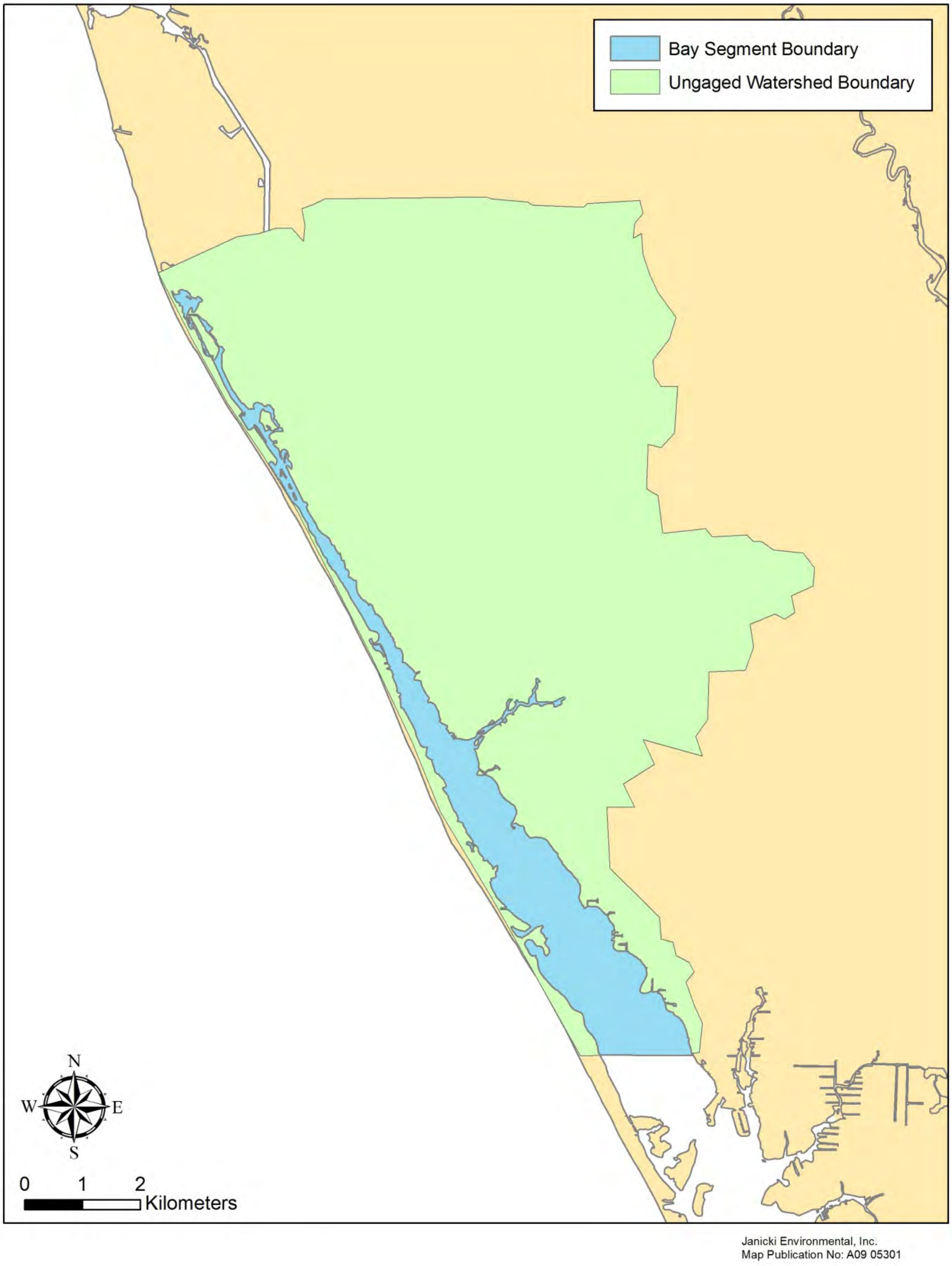
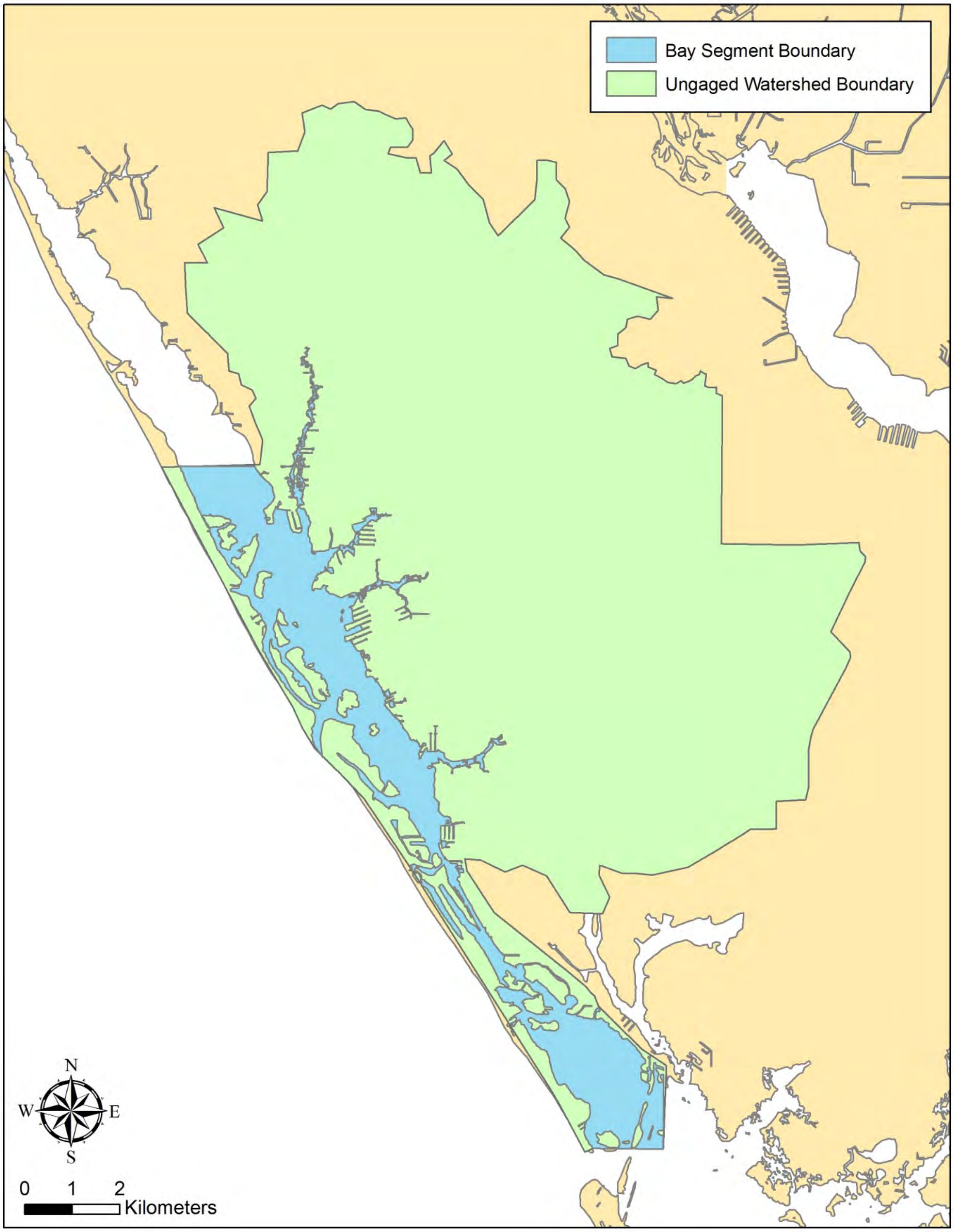
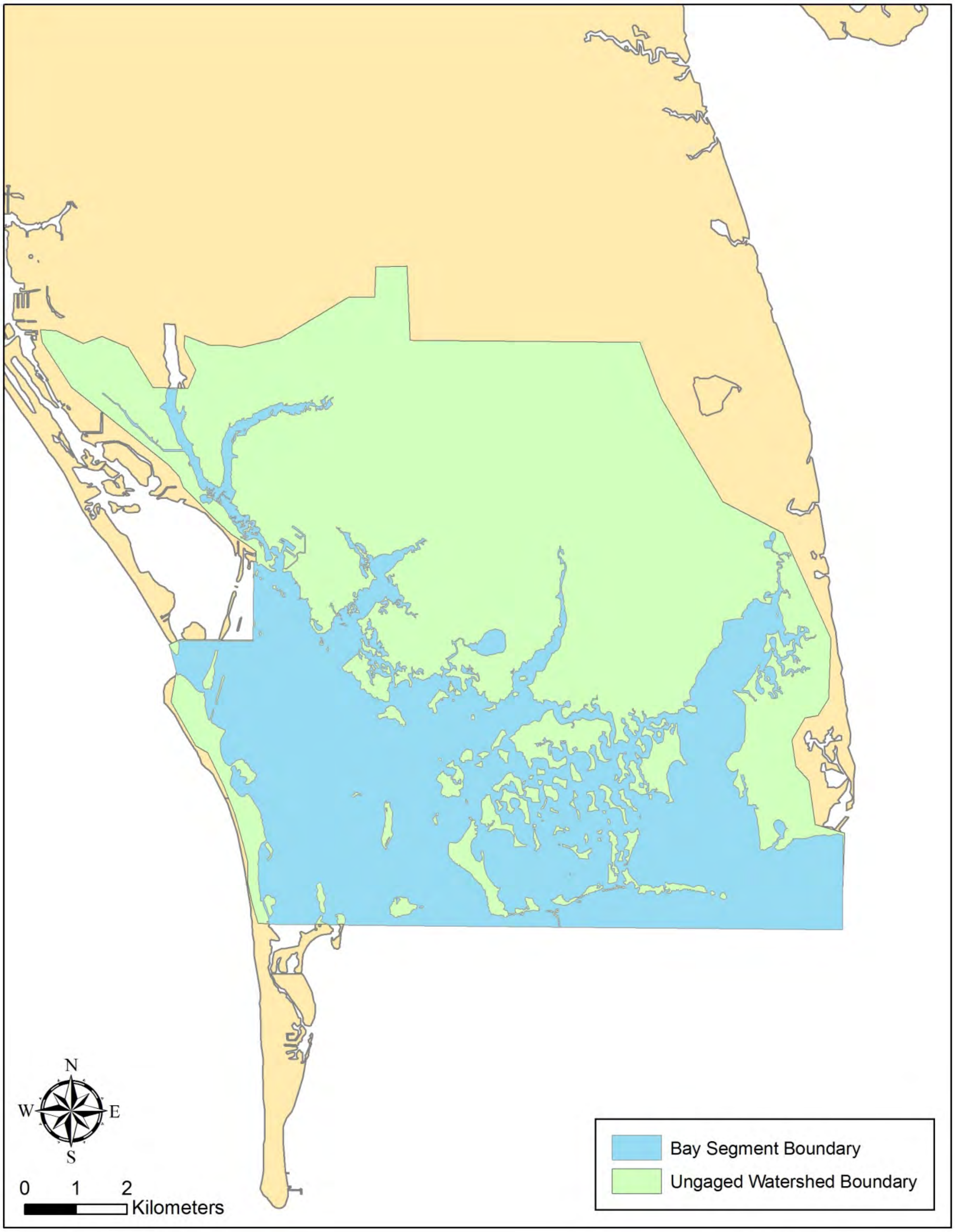


Figure A-2. Map showing ungaged watershed of Upper Lemon Bay segment.



Janicki Environmental, Inc.
Map Publication No: A09 04701

Figure A-3. Map showing ungaged watershed of Lower Lemon Bay segment.



Janicki Enviromental, Inc.
Map Publication No: A09 04301

Figure A-4. Map showing ungaged watershed of Cape Haze segment.

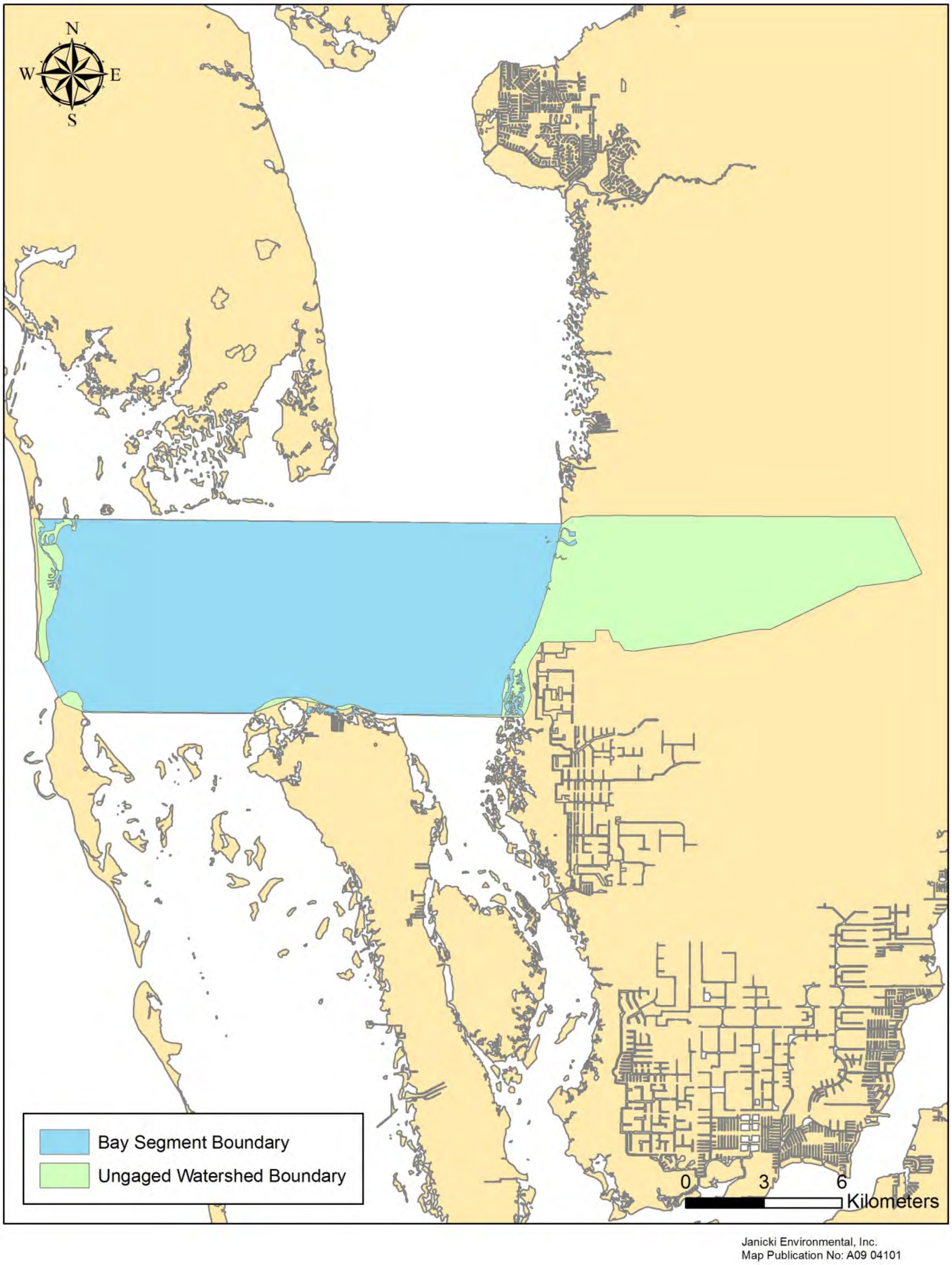
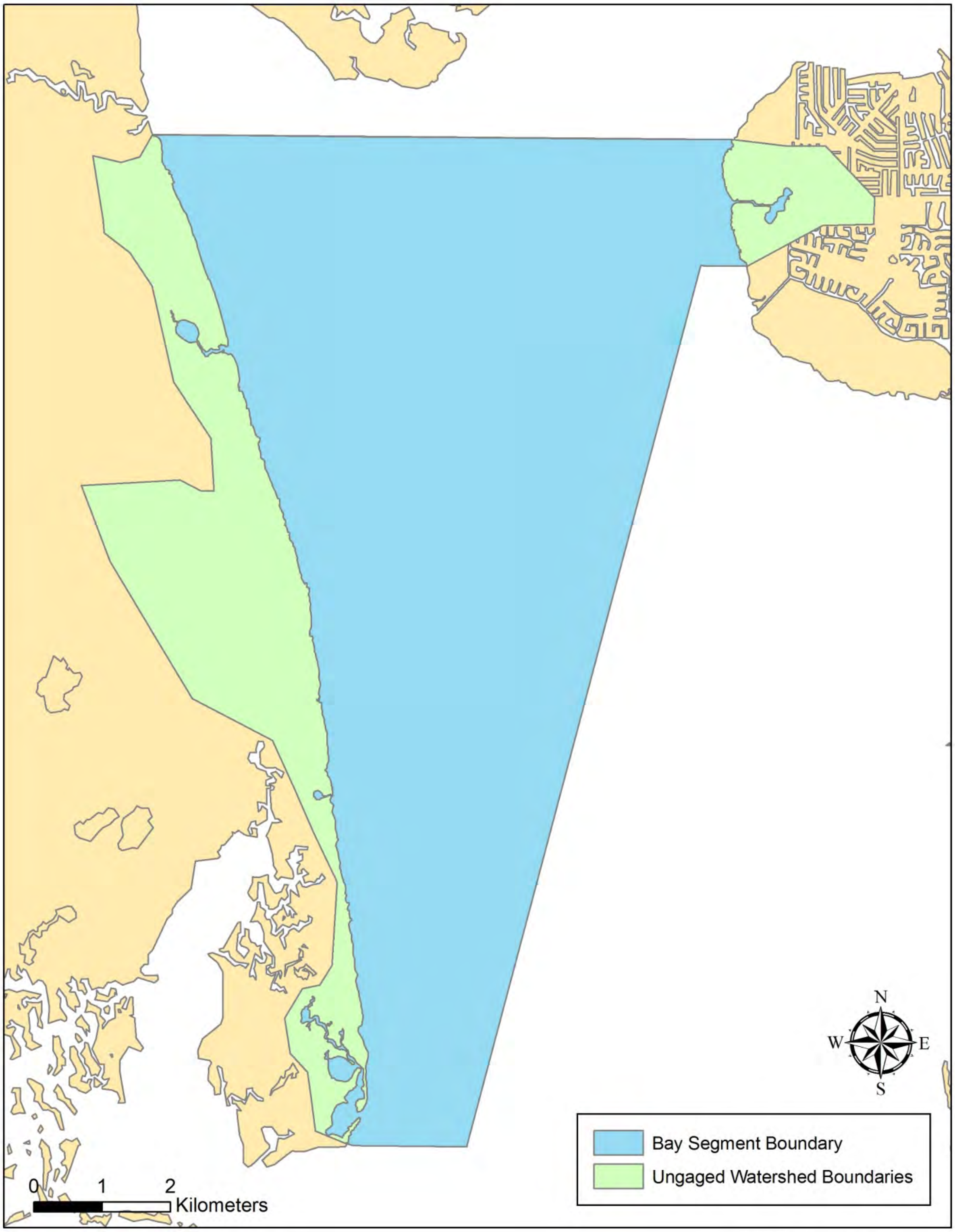
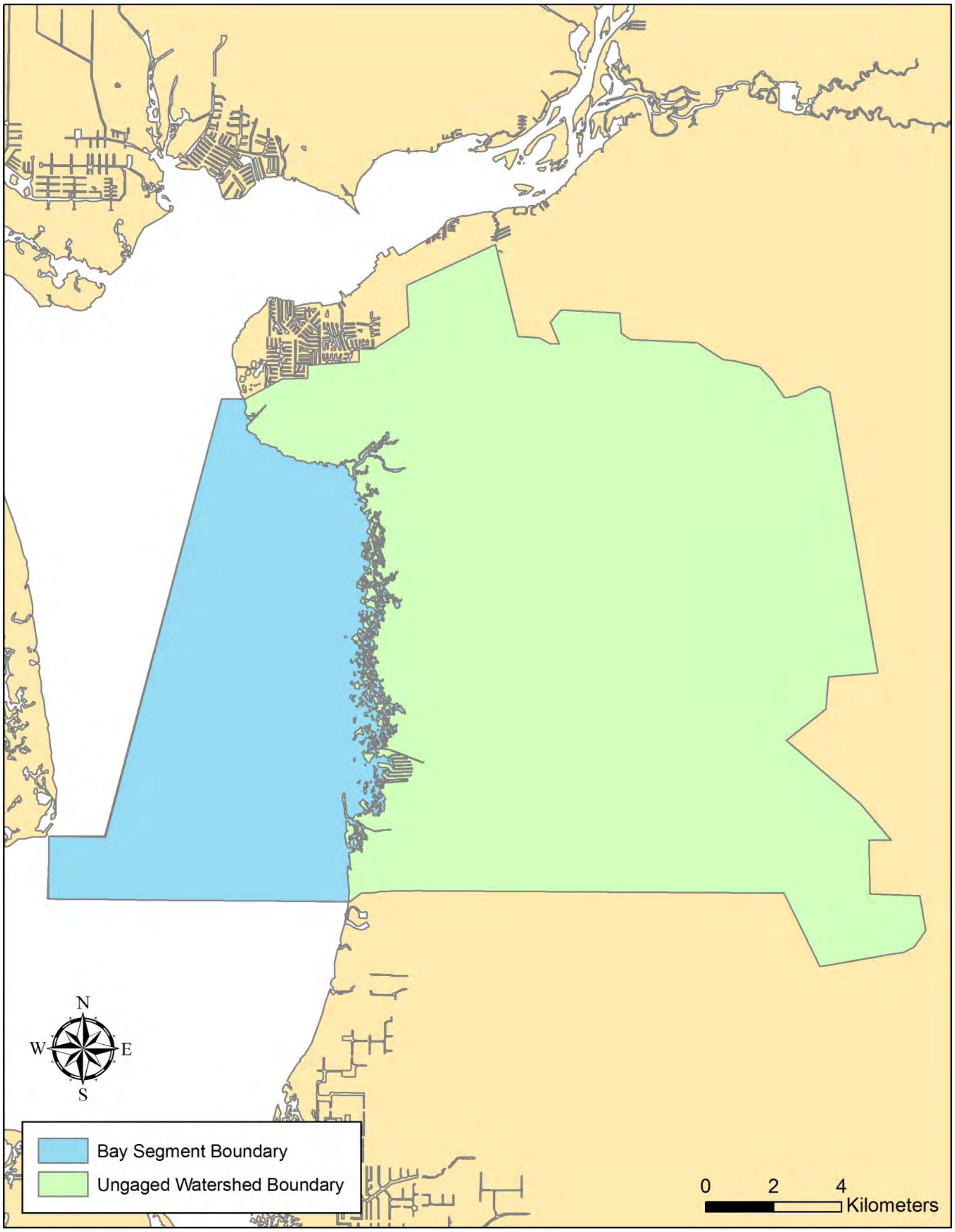


Figure A-5. Map showing ungaged watershed of Bokeelia segment.



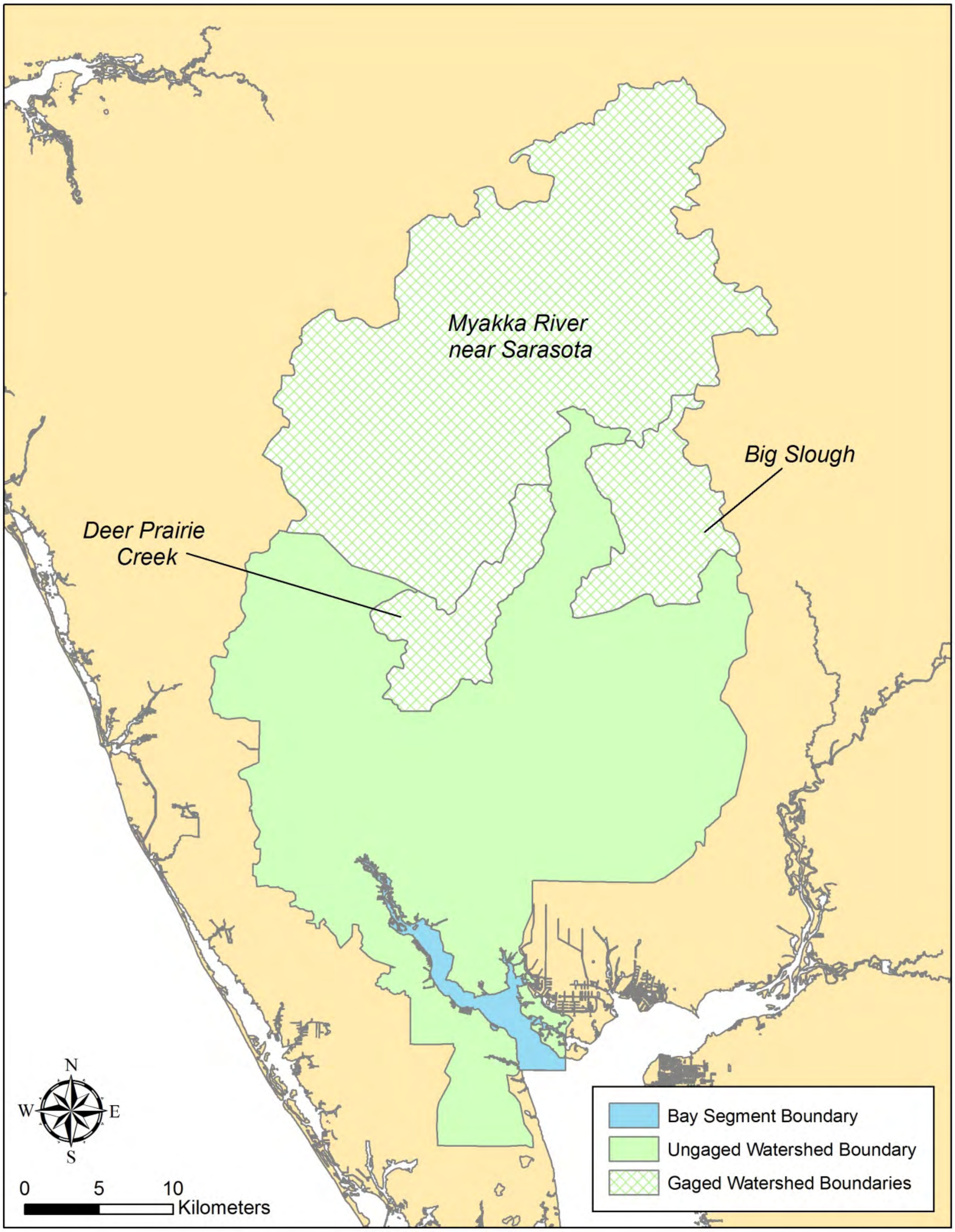
Janicki Environmental, Inc.
Map Publication No: A09 05401

Figure A-6. Map showing ungaged watershed of West Wall segment.



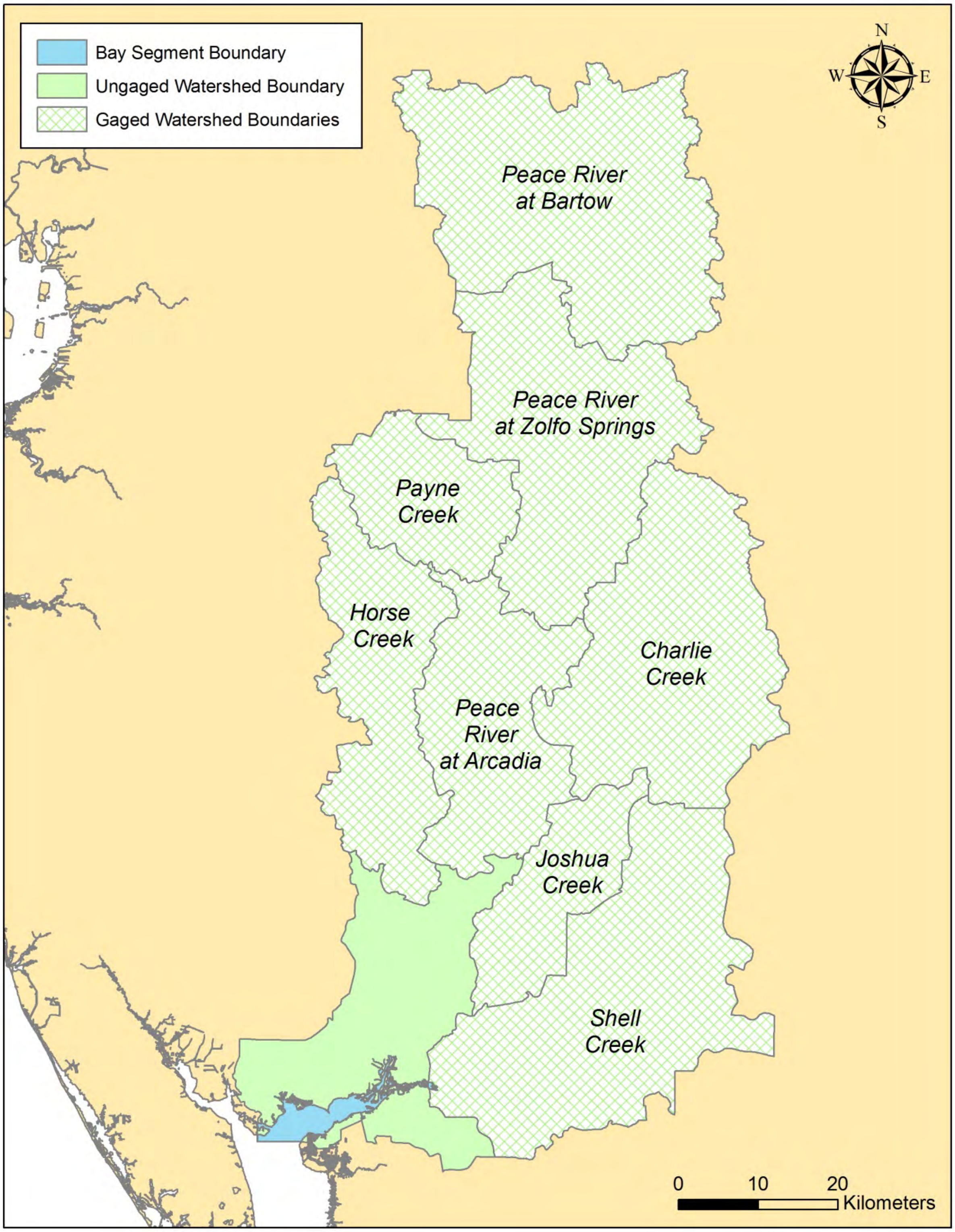
Janicki Environmental, Inc.
Map Publication No: A09 04501

Figure A-7. Map showing ungaged watershed of East Wall segment.



Janicki Environmental, Inc.
Map Publication No: A09 04901

Figure A-8. Map showing gaged and ungaged portions of watershed of Tidal Myakka segment.



Janicki Environmental, Inc.
Map Publication No: A09 05001

Figure A-9. Map showing gaged and ungaged portions of watershed of Tidal Peace segment.

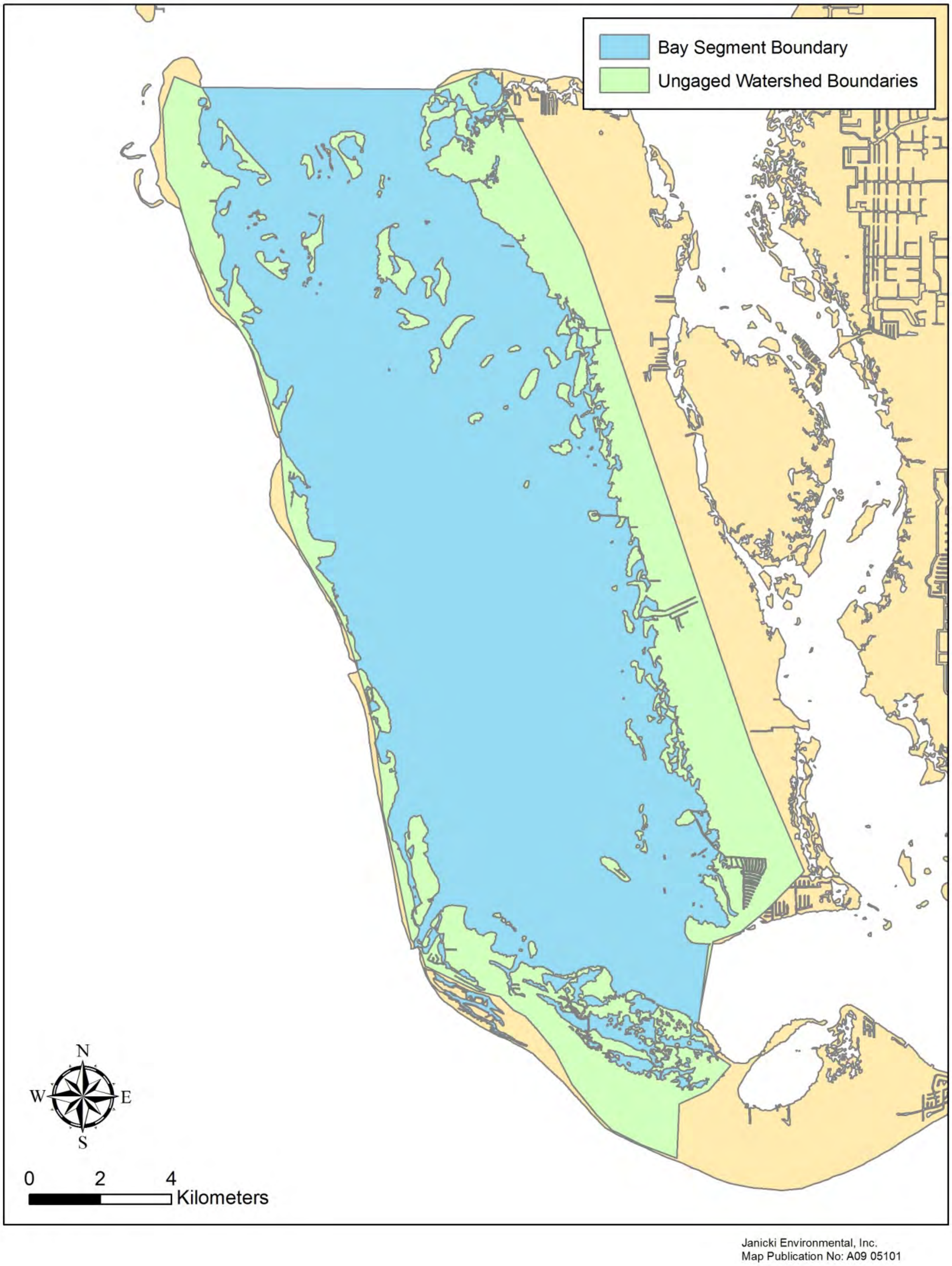


Figure A-10. Map showing ungaged watershed of Pine Island Sound segment.

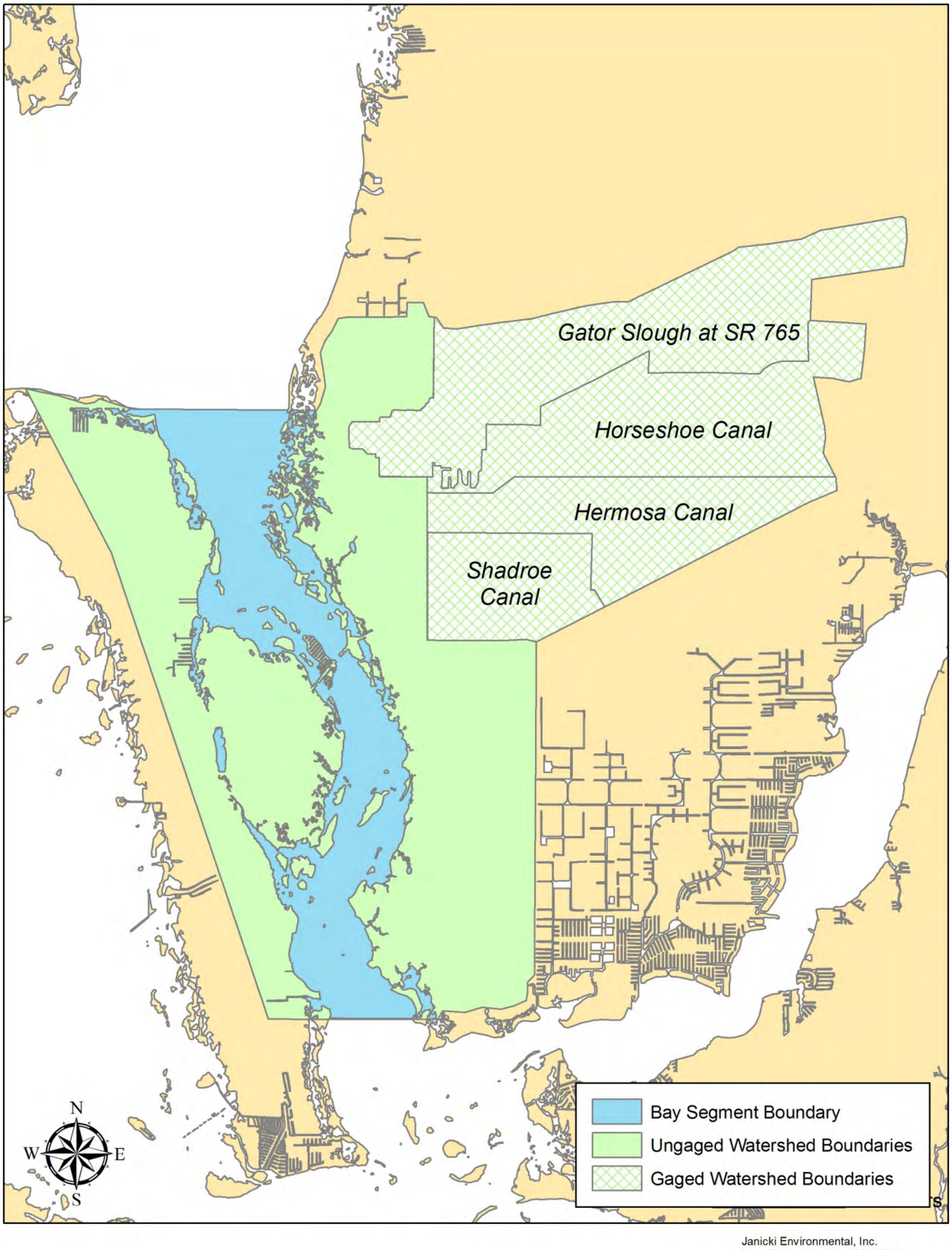
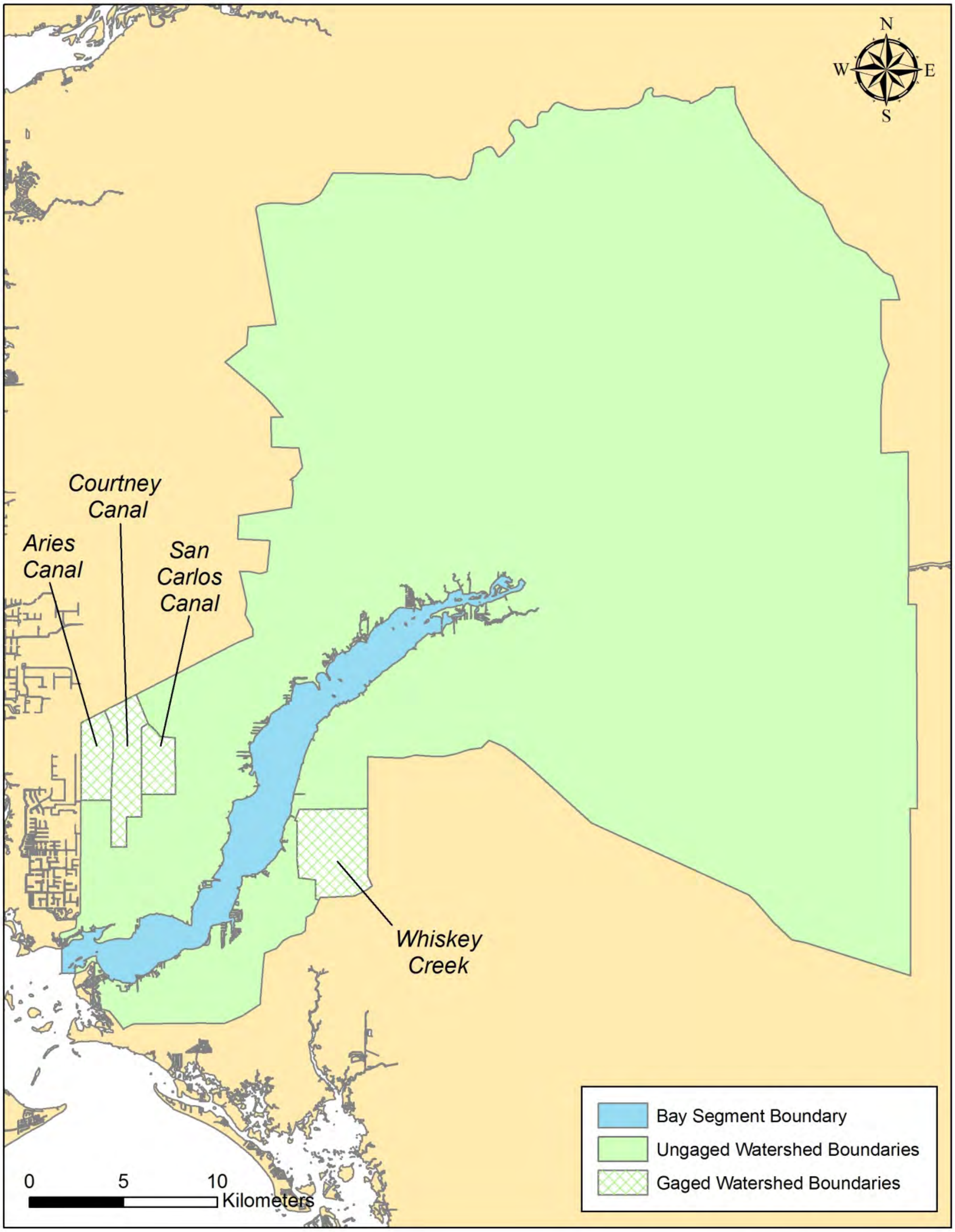
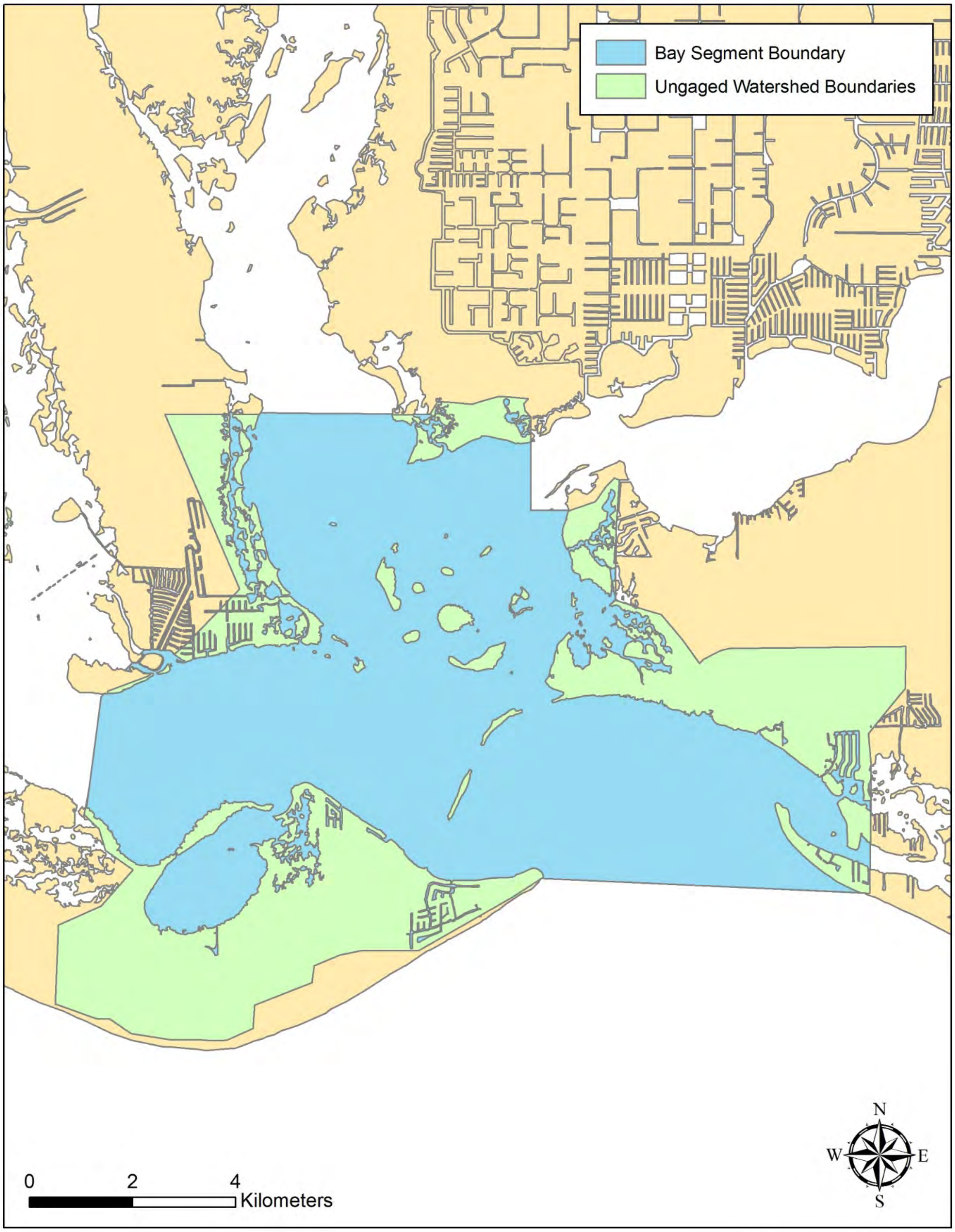


Figure A-11. Map showing gaged and ungaged portions of watershed of Matlacha Pass segment.



Janicki Environmental, Inc.
Map Publication No: A09 04201

Figure A-12. Map showing gaged and ungaged portions of watershed of Tidal Caloosahatchee River segment.



Janicki Environmental, Inc.
Map Publication No: A09 05201

Figure A-13. Map showing ungaged watershed of San Carlos Bay segment.

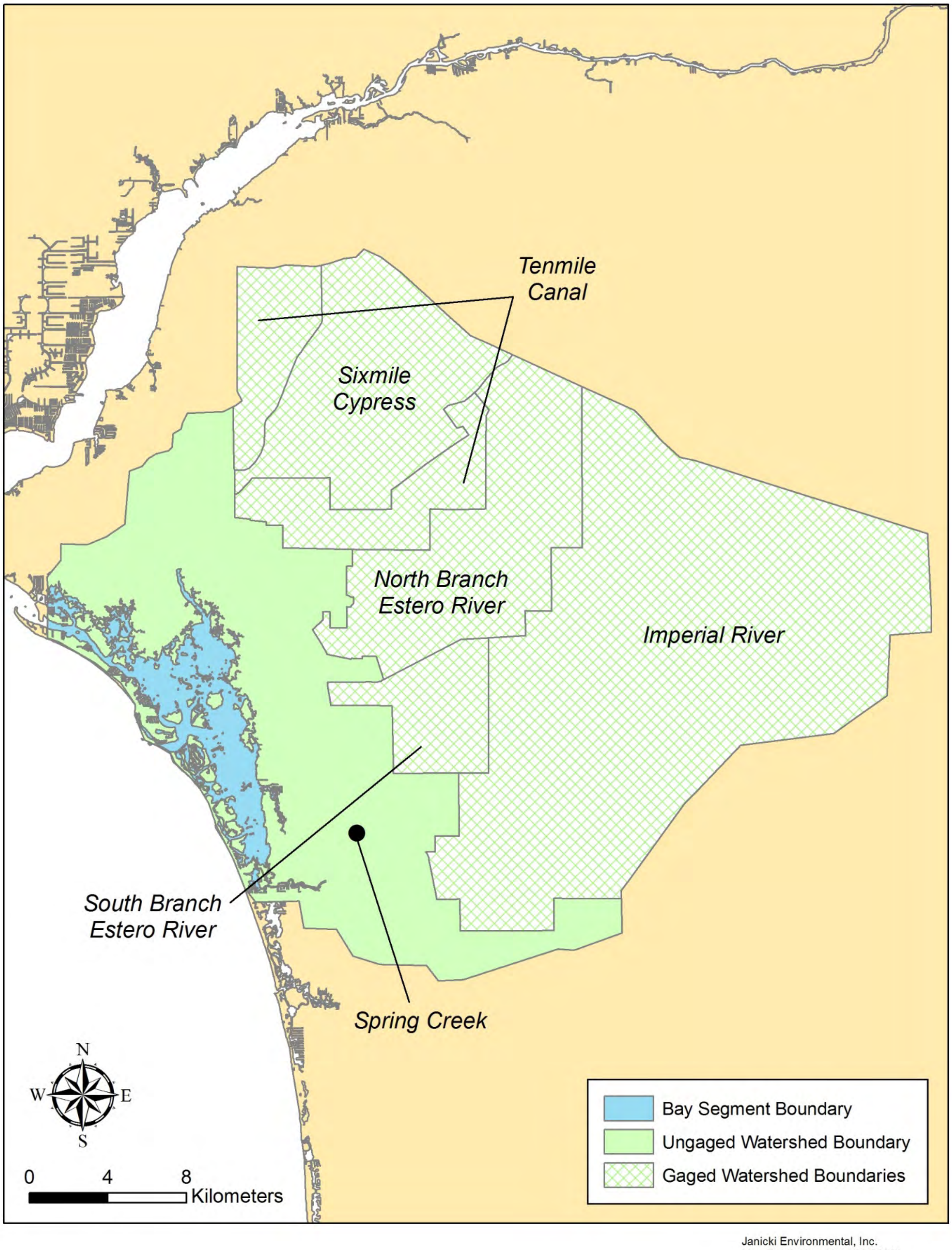


Figure A-14. Map showing gaged and ungaged portions of watershed of Estero Bay segment.

APPENDIX B

Aggregated Florida Land Use, Cover, and
Form Classification System Categories

URBAN LAND USE CATEGORIES

Coastal Land Use Code	LUCCS Code
1 - Low Density Residential	1100
2 - Medium Density Residential	1200
3 - High Density Residential	1300
4 – Commercial	1400
5 - Industrial	1500
7 - Institutional, Transportation, Utilities	1700 8100 8200 8300

AGRICULTURAL LAND USE CATEGORIES

Coastal Land Use Code	FLUCCS Code
6 - Mining	1600
11 - Groves	2200 2210 2220 2230
12 - Feedlots	2300
13 - Nursery	2400
14 - Row and Field Crops	2100 2140 2150 2440

UPLAND FORESTED LAND USE CATEGORIES

Coastal Land Use Categories	FLUCCS Code
8 - Range Lands	1480 1800 1900 2420 2600 3100 3200 3300
9 - Barren Lands	7100 7200 7300 7400
10 - Pasture	2110 2120 2130
15 - Upland Forests	4100 4110 4120 4200 4300 4340 4400

WATER AND WETLANDS LAND USE CATEGORIES

Coastal Land Use Categories	FLUCCS Code
16 - Freshwater	2500 2540 2550 5100 5200 5210 5220 5230 5240 5300 5310 5320 5330 5340 5500 5600 6440 6450
17 - Saltwater	5400 9113 9116 9121
18 - Forested Freshwater Wetlands	6100 6110 6150 6200 6210 6240 6300
19 - Saltwater Wetlands	6120 6420
20 - Non-forested Freshwater Wetlands	6400, 6410, 6411, 6430 6530
21 - Tidal Flats	6500, 6510 6520

APPENDIX C

Methods Used to Estimate Ungaged Flows

Description of Ungaged Flow Estimates

Objective

In order to estimate hydrologic and pollutant loadings from a watershed, hydrologic loads (flows) and pollutant concentrations are needed. As discussed in the main document, loadings from gaged basins are estimated by multiplying the flows from the gaged basin by pollutant concentrations when available. However, in ungaged basins, though water quality samples may be available, estimates of flow are not. Therefore, it was necessary to use modeling methods to estimate streamflow inputs from the portions of the watershed that are not gaged. The objective of this appendix is to summarize the methodology used to develop estimates of flows for the ungaged portions of the study area.

Methods

It was desired to use a relatively simple model that would produce acceptably accurate results using existing data, but that was flexible enough to be used over the entire watershed. Two models were evaluated to attempt to accurately estimate the flows from ungaged portions of the watershed. The models used land use, soils, rainfall, land use and soils specific runoff coefficients, and existing gaged flow data to predict streamflow. A description of data sources follows.

Rainfall data

To estimate total precipitation to each basin, an inverse distance-squared method was applied to data from 23 National Weather Service (NWS), 24 Southwest Florida Water Management District (SWFWMD), and 22 South Florida Water Management District (SFWMD) rainfall monitoring sites in or near the Charlotte Harbor National Estuary Program watershed. This method of estimating rainfall to a basin accounts for regional patterns while giving more emphasis to local conditions. Total monthly precipitation data were obtained from the long-term stations identified in Figure C-1. Total monthly precipitation values were estimated for the gaged and ungaged portions of each basin for the 1995-2007 period.

Land use/soils data

The SWFWMD 2007 land use and SFWMD 2005 land use were utilized for developing the 1995-2007 estimates of flows from ungaged areas. In addition, soils data were also obtained from SWFWMD and SFWMD for their respective portions of the watershed. Land use and soils data were intersected using Geographic Information System software (GIS) to obtain the surface areas comprised of different land use/soils combination for all basins. The land use/soils specific runoff coefficients were obtained from published literature, including references for the west-central and south Florida geographic area (Chow, 1964; USDA, 1975; Harper, 1991). A range of coefficient values for each land use was developed to account for seasonal changes in rainfall/runoff relationships, and for local soil conditions (Table 1).

Gaged flow data

Measured flows from five United States Geological Survey gages in the watershed, each of which is relatively unaffected by withdrawals, mining discharges, and/or agricultural irrigation were selected. These five gaged basins are presented in Figures C-2 through C - 5 and include the following:

- Charlie Creek (USGS 02296500),
- Horse Creek (USGS 02297310),
- Big Slough (USGS 02299410),
- 10 Mile Canal (USGS 02291673), and
- Whiskey Creek (USGS 02293230).

Models

As mentioned previously, special attention was paid to selecting gaged basins which were relatively unaffected by withdrawals, mining discharges, and/or agricultural irrigation. This is very important consideration in the Charlotte Harbor watershed. Although most of the ungaged areas have seen increases in urban land use classifications, these ungaged areas are typically not affected by withdrawals, mining activities, or agricultural activities.

The first model approach attempted was a linear regression model. A significant effort was made to develop statistically defensible relationships between gaged flows and rainfall and/or land use/soils. Variables used included numerous variations of rainfall and lagged rainfall, in an attempt to accurately account for antecedent conditions. Additionally, variables were introduced to attempt to account for the season variability in the flow data. However, statistically defensible relationships were not identified.

In an effort to better account for the seasonal and antecedent conditions that seem to be driving the systems, an approach was taken that is similar to the approach developed for disaggregation of loadings for the recent Tampa Bay Reasonable Assurance document (Tampa Bay Estuary Program and Janicki Environmental, Inc. 2009). This model used the same data sources that were used in the attempt to identify a linear regression model, including rainfall, land use/soils (and associate runoff coefficients), and gaged flows from the five basins discussed above.

The following steps were executed to estimate the runoff from the ungaged basins of the CHNEP watershed:

1. A time series of monthly unit area runoff values (cfs/square mile) was calculated for the five gaged basins (Charlie Creek, Horse Creek at

Arcadia, Big Slough, Whiskey Creek, and Ten Mile Canal) for the period 1995 to 2007.

2. The unit area runoff values for individual basins were then disaggregated by land use category (see Table C-1) using seasonally specific land use/soils runoff coefficients.

3. The land use specific unit area runoff values were then divided by the estimated rainfall for the basin producing a unit area runoff per rainfall for the land use categories.

4. The average unit area runoff per rainfall for the land use categories was then calculated across all five gaged basins.

5. The time series of unit area runoff per rainfall for the land use categories was then applied to the ungaged basins. Ungaged flows were estimated based on the land use and rainfall in the individual ungaged basins.

When used to predict flows from the gaged basins, the model was highly significant with an r^2 of 0.87. To verify that the model produced reasonable results for the ungaged basins, the unit area runoff versus annual rainfall was plotted for both gaged basins used to develop the model and the ungaged basins. As can be seen in Figure C-6, the results of the predictions for the ungaged basins are similar to the results of the gaged basins, during both be low or high rainfall conditions within the year.

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Table C-1. Runoff coefficients specific to land use, soils, and season.			
Coastal Land Use Classification and Land Use Type	Hydrologic Soil Group	Dry Season Runoff Coeff.	Wet Season Runoff Coeff.
1) Single Family Residential	A	0.15	0.25
	B	0.18	0.28
	C	0.21	0.31
	D	0.24	0.34
2) Medium Density Residential	A	0.25	0.35
	B	0.30	0.40
	C	0.35	0.45
	D	0.40	0.50
3) Multifamily Residential	A	0.35	0.50
	B	0.42	0.57
	C	0.50	0.65
	D	0.58	0.75
4) Commercial	A	0.70	0.79
	B	0.74	0.83
	C	0.78	0.97
	D	0.82	0.91
5) Industrial	A	0.65	0.75
	B	0.70	0.80
	C	0.75	0.85
	D	0.80	0.90
6) Mining	A	0.20	0.20
	B	0.30	0.30
	C	0.40	0.40
	D	0.50	0.50
7) Institutional, Transportation Utils.	A	0.40	0.50
	B	0.45	0.55
	C	0.50	0.60
	D	0.55	0.65
8) Range Lands	A	0.10	0.18
	B	0.14	0.22
	C	0.18	0.26
	D	0.22	0.30
9) Barren Lands	A	0.45	0.55
	B	0.50	0.60
	C	0.55	0.65
	D	0.60	0.70
10) Agricultural - Pasture	A	0.10	0.18
	B	0.14	0.22
	C	0.18	0.26
	D	0.22	0.30
11) Agricultural - Groves	A	0.20	0.26
	B	0.23	0.29
	C	0.26	0.32

	D	0.29	0.33

Table C-1. Runoff coefficients specific to land use, soils, and season. (continued)

Coastal Land Use Classification and Land Use Type	Hydrologic Soil Group	Dry Season Runoff Coeff.	Wet Season Runoff Coeff.
12) Agricultural - Feedlots	A	0.35	0.45
	B	0.40	0.50
	C	0.45	0.55
	D	0.50	0.60
13) Agricultural - Nursery	A	0.20	0.30
	B	0.25	0.35
	C	0.30	0.40
	D	0.35	0.45
14) Agricultural - Row and Field Crops	A	0.20	0.30
	B	0.25	0.35
	C	0.30	0.40
	D	0.35	0.45
15) Upland Forested	A	0.10	0.15
	B	0.13	0.18
	C	0.16	0.21
	D	0.19	0.24
16) Freshwater - Open Water	A	0.80	0.90
	B	0.80	0.90
	C	0.80	0.90
	D	0.80	0.90
17) Saltwater - Open Water	A	1.0	1.0
	B	1.0	1.0
	C	1.0	1.0
	D	1.0	1.0
18) Forested Freshwater Wetlands	A	0.50	.60
	B	0.55	0.65
	C	0.60	0.70
	D	0.65	0.75
19) Saltwater Wetlands	A	0.95	0.95
	B	0.95	0.95
	C	0.95	0.95
	D	0.95	0.95
20) Non-forested Freshwater Wetlands	A	0.45	0.55
	B	0.50	0.60
	C	0.55	0.65
	D	0.60	0.70
21) Tidal Flats	A	1.0	1.0
	B	1.0	1.0
	C	1.0	1.0
	D	1.0	1.0

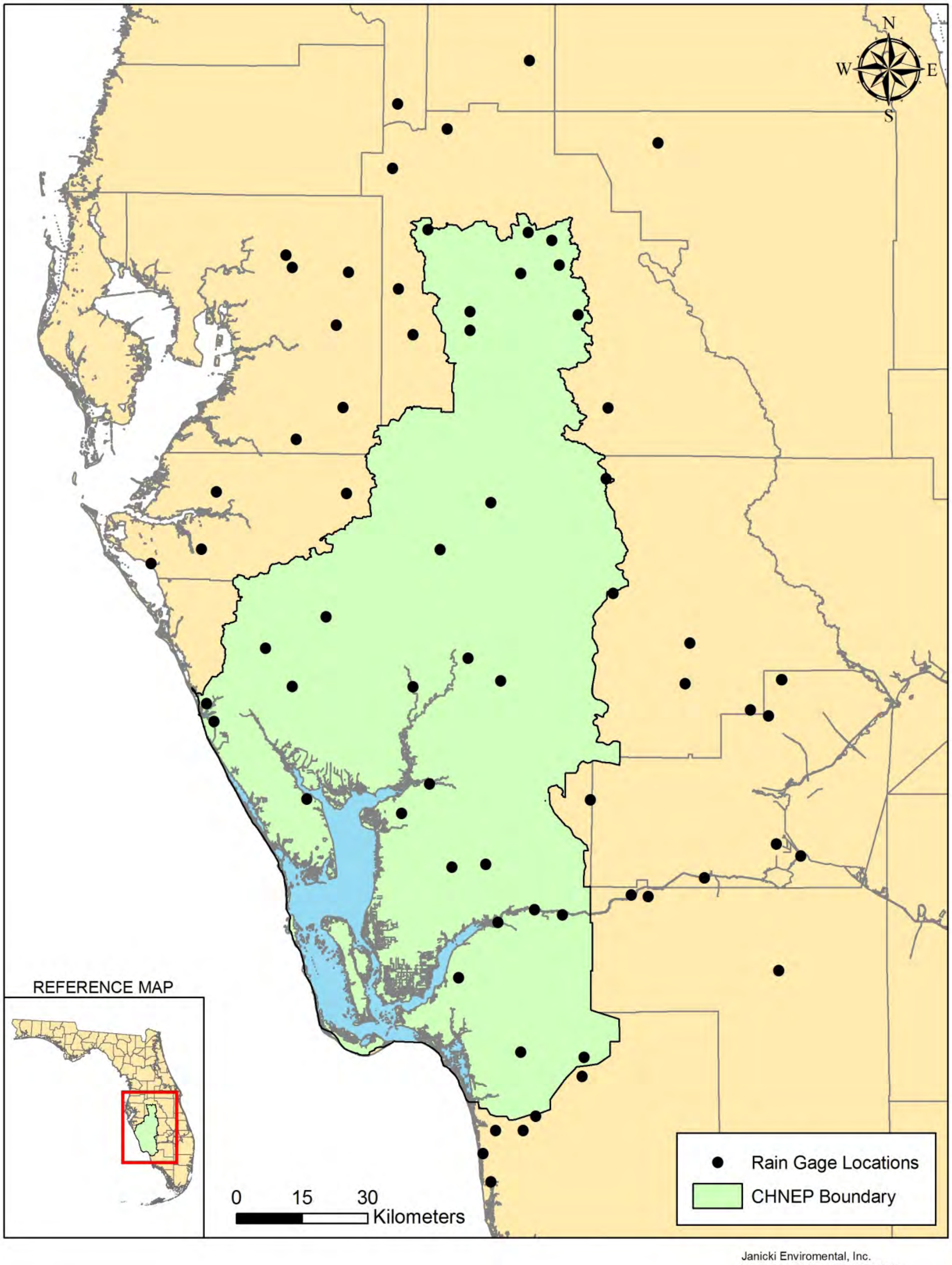

Figure C-1. Locations of long-term precipitation stations used for estimating rainfall to basins.

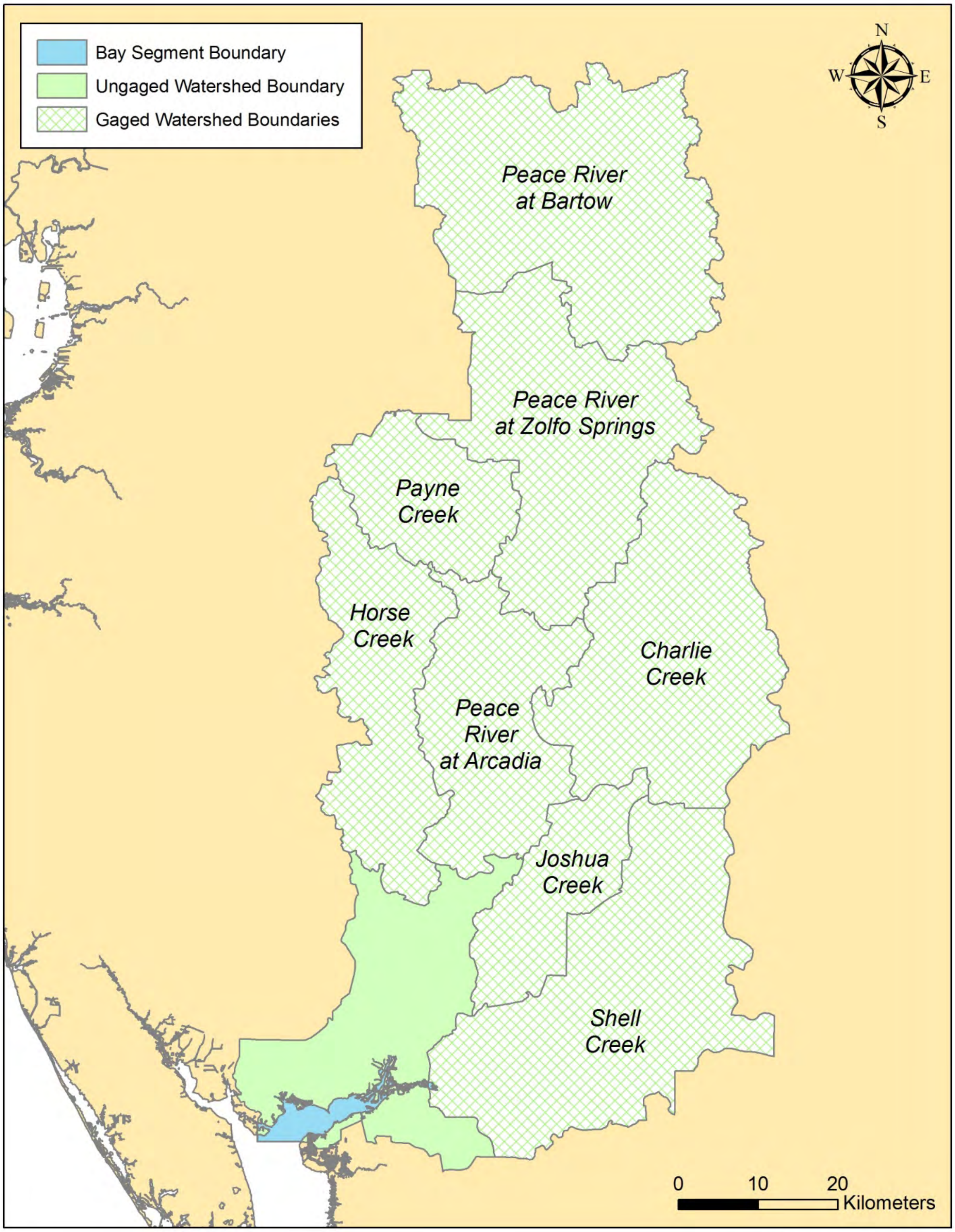

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Figure C-2. Locations of Charlie and Horse Creek basins.

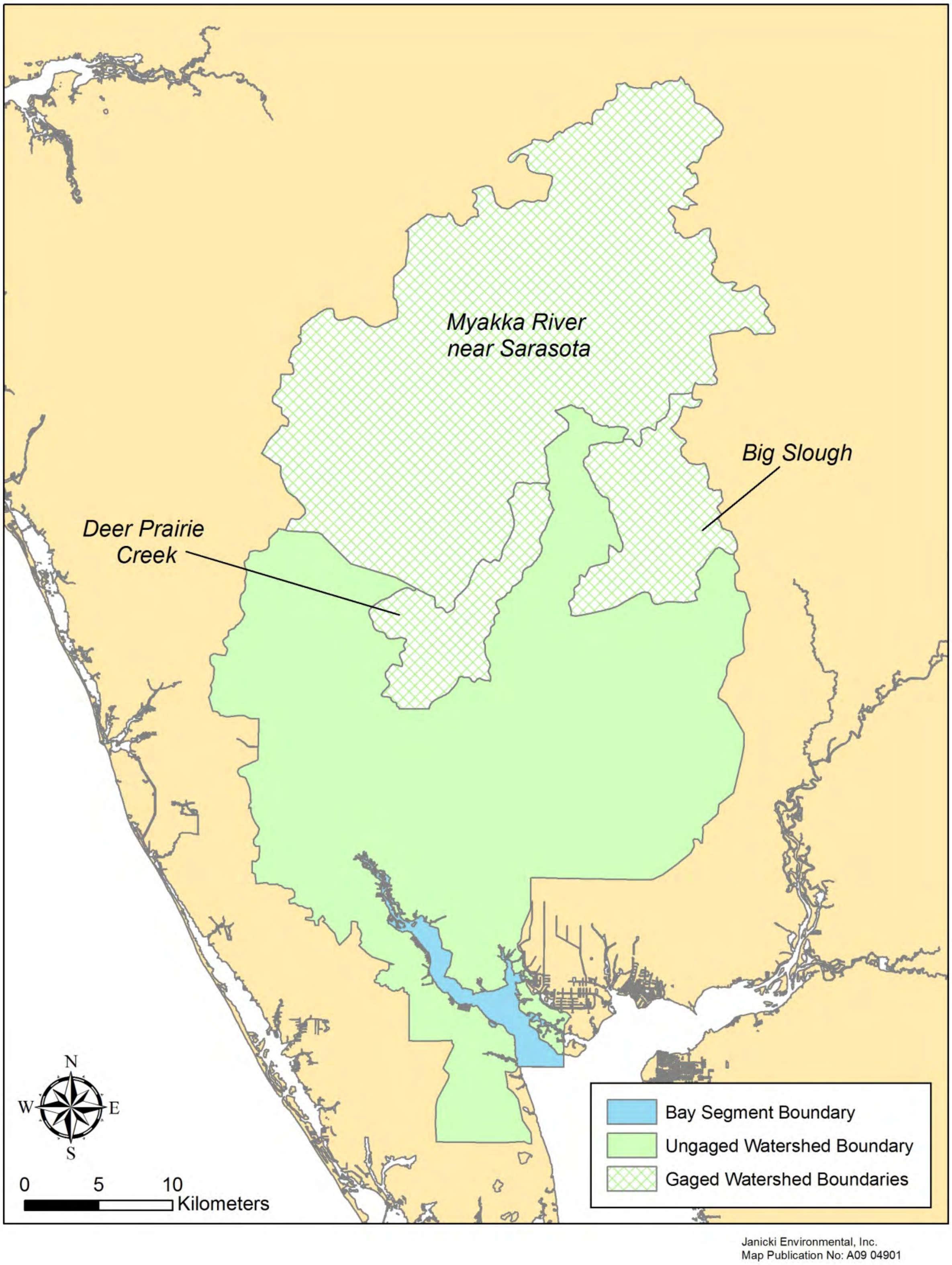
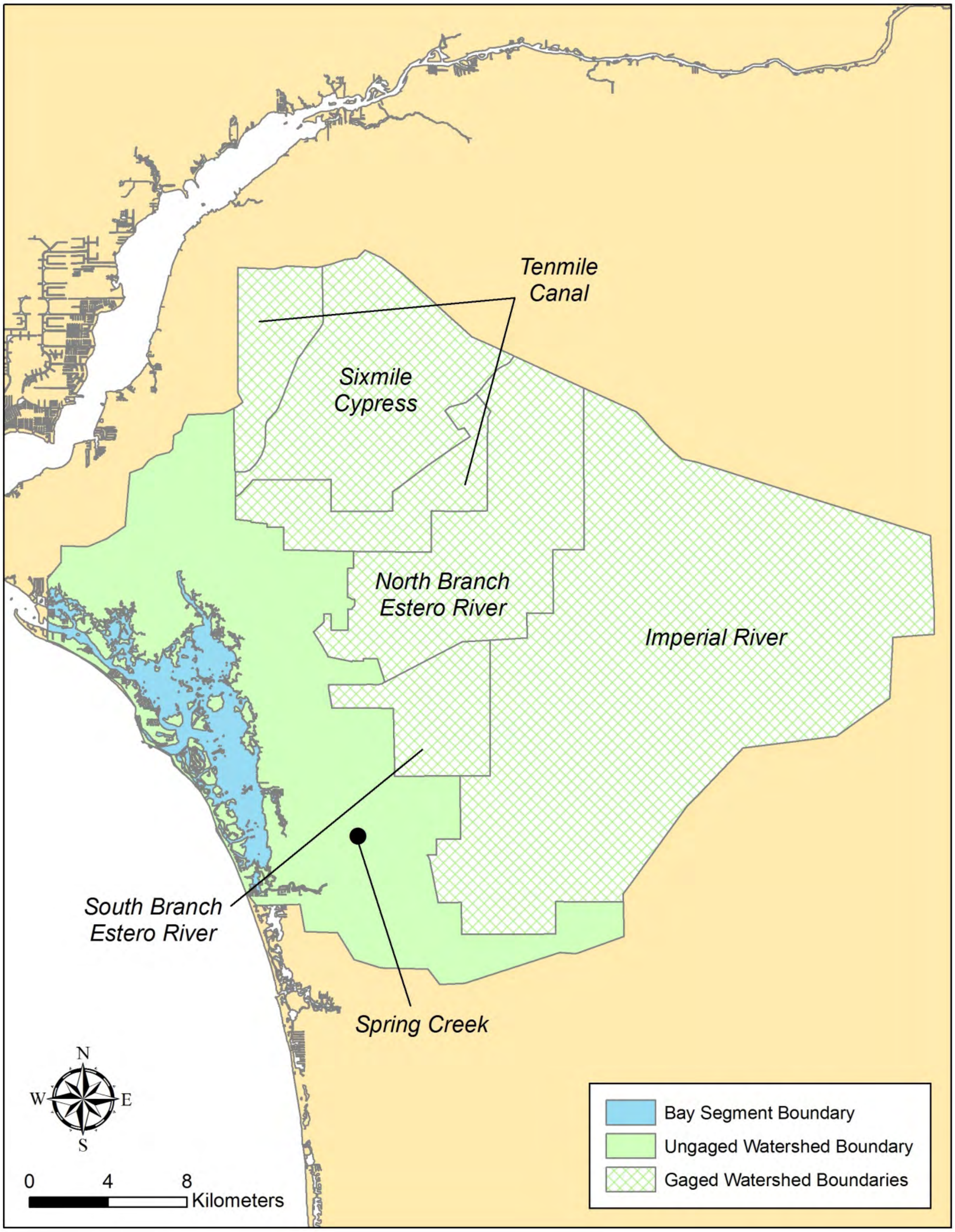


Figure C-3. Location of Big Slough basin.



Janicki Environmental, Inc.
Map Publication No: A09 04601

Figure C-4. Location of Ten Mile Canal basin.

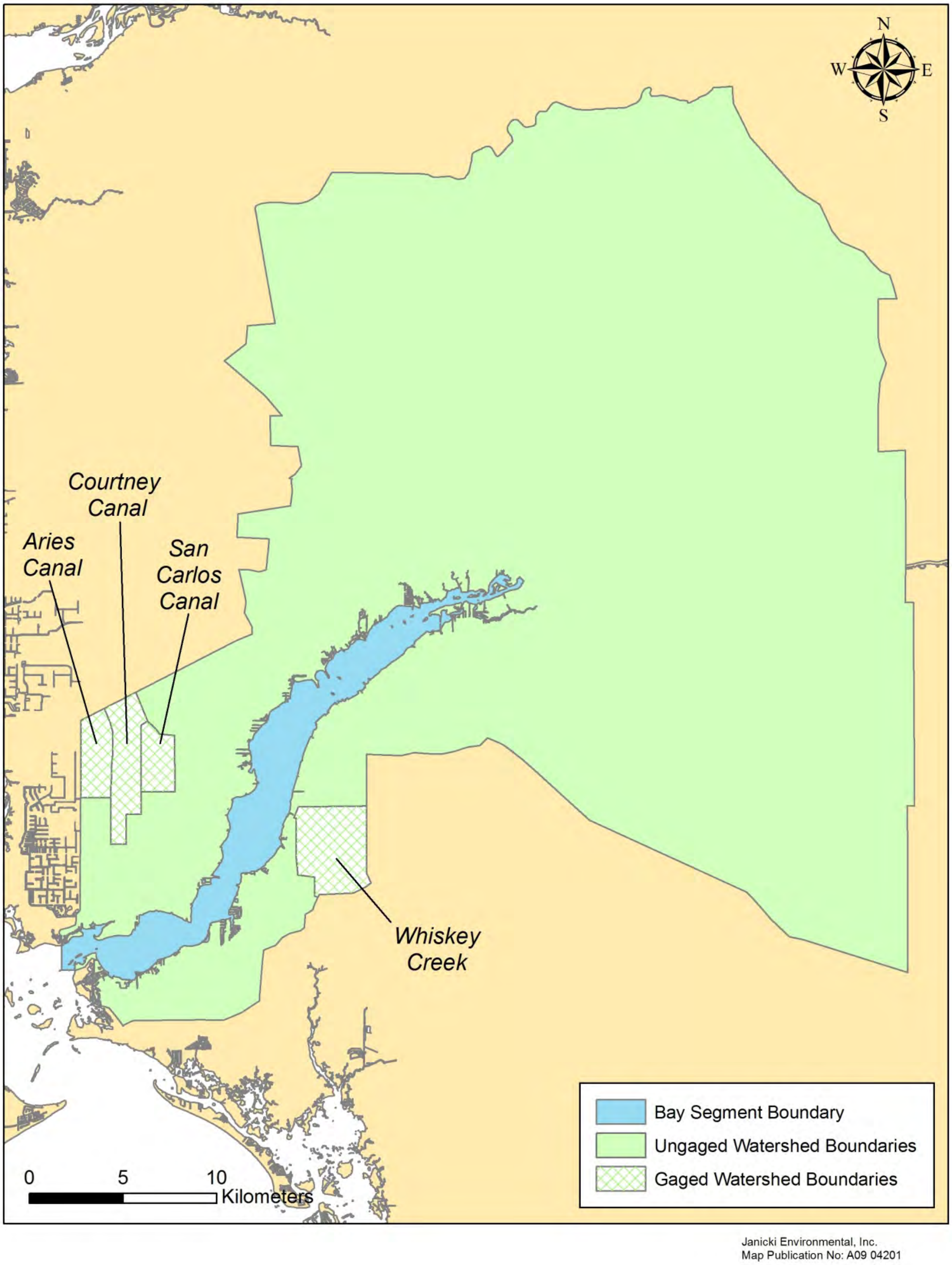


Figure C-5. Location of Whiskey Creek basin.

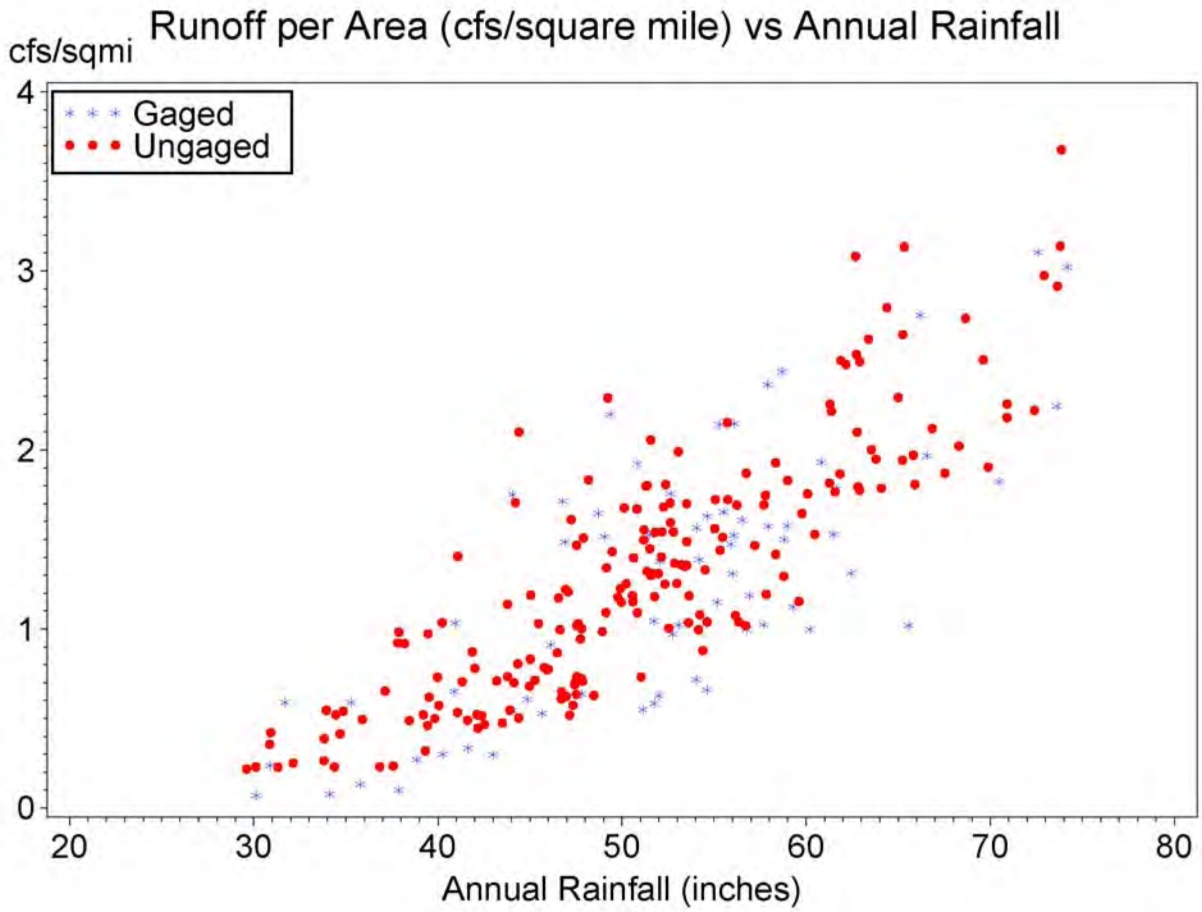


Figure C-6. Comparison of unit area runoff vs annual rainfall for ungaged predictions and gaged basins.

APPENDIX D

Land Use-specific Water Quality Event Mean Concentrations

Land Use-Specific Nonpoint Source Water Quality Event Mean Concentrations (EMC)

URBAN LAND USES						
Land Use Classification			Land Use-Specific Water Quality EMC			
Coastal Land Use Classification	Land Use Description	Reference	TN (mg/L)	TP (mg/L)	TSS (mg/L)	BOD (mg/L)
1 (LDR)	Low Density Single Family Residential (SFR)	(1)	2.31	0.40	33.0	-
		(1)	2.14	0.32	28.0	-
		(1)	0.605	0.073	7.2	-
		(1)	1.18	0.307	3.5	-
		(1)	3.0	0.45	-	-
		(1)	2.2	0.25	-	-
		(4)	1.87	0.39	-	-
		(8)	1.46	0.401	19.0	-
		(9)	1.56	0.27	20.8	-
		(10)	2.04	0.593	49.7	-
		(11)	2.88	0.72	56.8	-
		(13)	-	-	-	4.4
		min	0.605	0.073	3.5	-
		mean	1.93	0.380	27.3	4.4
		max	2.88	0.598	56.8	-
2 (MDR)	Medium Density (See notes)	mean	2.04	0.44	33.5	- 7.4 -
3 (HDR)	Multifamily Residential	(1)	1.61	0.33	53.0	-
		(1)	2.57	0.45	36.8	-
		(1)	4.68	0.72	95.6	-
		(1)	1.91	0.73	-	-
		(1)	1.02	0.033	67.6	-
		(1)	1.91	0.51	14.3	-
		(4)	1.65	0.33	-	-
		(8)	2.05	1.34	29.0	-
		(9)	2.04	0.282	10.7	-
		(10)	2.05	0.150	8.3	-
		(11)	2.00	0.56	41	-
		(13)	-	-	-	11.0
		min	1.02	0.033	8.3	-
		mean	2.14	0.49	39.6	11.0
		max	4.68	1.34	95.6	-

Coastal Land Use Classification	Land Use Description	Reference	TN (mg/L)	TP (mg/L)	TSS (mg/L)	BOD (mg/L)
4	Low Intensity Commercial	(1)	1.19	0.15	22.0	-
		(1)	1.10	0.10	45.0	-
	High Intensity Commercial	(1)	2.81	0.31	94.3	-
		(1)	3.53	0.82	-	-
		(1)	2.15	0.15	-	-
	Commercial (Office)	(8)	2.38	0.305	36.5	-
		(9)	1.08	0.495	50.6	-
		(10)	1.40	0.113	6.2	-
		(11)	1.05	0.145	13.8	-
	Commercial (Retail)	(8)	1.69	0.253	9.3	-
		(10)	1.28	0.177	14.5	-
		(11)	2.12	0.22	36.3	-
		(13)	-	-	-	17.2
	Combined Commercial	min	1.05	0.100	6.2	-
		mean	1.82	0.270	32.9	17.2
		max	3.53	0.495	94.3	-
5	Industrial	(1)	1.42	0.19	71.8	-
		(1)	1.42	0.31	102.0	-
		(4)	1.18	0.15	-	-
		(8)	2.28	0.332	18.2	-
		(9)	1.77	0.465	28.3	-
		(10)	1.92	0.490	84.3	-
		(11)	3.00	0.503	70.0	-
		(13)	-	-	-	9.6
6	Mining	(4)	1.18	0.15	35 (e)	-
		(13)	-	-	-	9.6
7	Institutional	(4)	1.18	0.15	35 (e)	-
		(13)	-	-	-	8.2

AGRICULTURAL LAND USES						
Land Use Classification			Land Use-Specific Water Quality Concentrations			
Coastal Land Use Classification	Land Use Description	Reference	TN (mg/L)	TP (mg/L)	TSS (mg/L)	BOD (mg/L)
10	Pasture	(1)	2.37	0.697	-	-
		(1)	2.48	0.27	8.6	-
		(2)	2.0	0.3	-	-
		(3)	3.0	0.25	-	-
		(4)	1.02	0.16	-	-
		(5)	5.1	3.2	-	-
		(13)	-	-	-	5.1
11	Grove	(7)	2.31	0.10	-	-
		(13)	-	-	-	2.55
					5.0 (e)	
11,13	Grove, Nursery	(4)	0.92	0.41	-	-
		(13)	-	-	-	2.55
					5.0 (e)	
12	Feed Lot	(3)	29.3	5.1	-	-
		(3)	3.74	1.13	-	-
		(5)	26.0	5.1	-	-
		(13)	-	-	-	5.1
					50.0 (e)	
14	Field Crop	(2)	2.5	0.25	-	-
		(3)	2.5	2.5	-	-
		(4)	3.75	1.13	-	-
		(13)	-	-	-	5.1
					10.0 (e)	
Mixed Agricultural						
10,11	Citrus+ Pasture	(1)	1.57	0.09	-	-
		(1)	1.33	0.09	4.6	-
		(1)	2.58	0.046	180	-
		(1)	2.68	0.562	-	-
		(1)	3.26	0.24	28.0	-
11,14	Citrus+ Row Crops	(6)	1.78	0.3	5.6	-

WATER/WETLAND AND FOREST/UNDEVELOPED LAND USES						
Land Use Classification			Land Use-Specific Water Quality Concentrations			
Coastal Land Use Classification	Land Use Description	Reference	TN (mg/L)	TP (mg/L)	TSS (mg/L)	BOD (mg/L)
8, 9	Open Space/ Non-forested	(1) (1) (1) (4) (13)	1.38 0.90 1.47 1.02 -	0.07 0.02 0.07 0.16 -	17.3 4.8 - - -	- - - - 1.45
15	Upland Forest	(2) (3) (4) (13)	0.1 0.2 1.02 -	0.007 0.007 0.16 -	- - - - 5.0 (e)	- - - 1.45
16,17	Open Water		NA	NA	NA	NA
18,20	Freshwater Wetland	(1) (1) (1) (1) (4) (13)	2.26 1.02 1.24 1.88 0.79 -	0.09 0.16 0.018 0.33 0.17 -	13.4 - 4.6 12.7 - -	- - - - - 4.63
17	Saltwater		NA	NA	NA	NA
19	Saltwater Wetlands		NA	NA	NA	NA
21	Tidal Flats		NA	NA	NA	NA

Notes:

- EMCs for CLUCCS code 2 (MDR) are an average of CLUCCS codes 1 (LDR) and 3 (HDR).
- EMCs for CLUCCS code 4 (Commercial) are an average of reported values for "low intensity" and "high intensity" commercial.
- Estimated (e) agricultural values were based on similar land uses data when no land use specific data were identified.
- Row crop data were often reported with other agricultural uses.
- Freshwater, saltwater and saltwater wetlands were assigned zero loads.

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APPENDIX E

Land Use-specific Seasonal Runoff Coefficients

Land Use-Specific Seasonal Runoff Coefficients

Coastal Land Use Classification and Land Use Type	Hydrologic Soil Group	Dry Season Runoff Coeff.	Wet Season Runoff Coeff.
1) Single Family Residential	A	0.15	0.25
	B	0.18	0.28
	C	0.21	0.31
	D	0.24	0.34
2) Medium Density Residential	A	0.25	0.35
	B	0.30	0.40
	C	0.35	0.45
	D	0.40	0.50
3) Multifamily Residential	A	0.35	0.50
	B	0.42	0.57
	C	0.50	0.65
	D	0.58	0.75
4) Commercial	A	0.70	0.79
	B	0.74	0.83
	C	0.78	0.97
	D	0.82	0.91
5) Industrial	A	0.65	0.75
	B	0.70	0.80
	C	0.75	0.85
	D	0.80	0.90

Land Use-Specific Seasonal Runoff Coefficients (cont.)

Land Use	Hydrologic Soil Group	Dry Season Runoff Coeff.	Wet Season Runoff Coeff.
6) Mining	A	0.20	0.20
	B	0.30	0.30
	C	0.40	0.40
	D	0.50	0.50
7) Institutional, Transportation Utils.	A	0.40	0.50
	B	0.45	0.55
	C	0.50	0.60
	D	0.55	0.65
8) Range Lands	A	0.10	0.18
	B	0.14	0.22
	C	0.18	0.26
	D	0.22	0.30
9) Barren Lands	A	0.45	0.55
	B	0.50	0.60
	C	0.55	0.65
	D	0.60	0.70
10) Agricultural - Pasture	A	0.10	0.18
	B	0.14	0.22
	C	0.18	0.26
	D	0.22	0.30

Land Use-Specific Seasonal Runoff Coefficients (cont.)

Land Use	Hydrologic Soil Group	Dry Season Runoff Coeff.	Wet Season Runoff Coeff.
11) Agricultural - Groves	A	0.20	0.26
	B	0.23	0.29
	C	0.26	0.32
	D	0.29	0.33
12) Agricultural - Feedlots	A	0.35	0.45
	B	0.40	0.50
	C	0.45	0.55
	D	0.50	0.60
13) Agricultural - Nursery	A	0.20	0.30
	B	0.25	0.35
	C	0.30	0.40
	D	0.35	0.45
14) Agricultural - Row and Field Crops	A	0.20	0.30
	B	0.25	0.35
	C	0.30	0.40
	D	0.35	0.45
15) Upland Forested	A	0.10	0.15
	B	0.13	0.18
	C	0.16	0.21
	D	0.19	0.24

Land Use-Specific Seasonal Runoff Coefficients (cont.)

Land Use	Hydrologic Soil Group	Dry Season Runoff Coeff.	Wet Season Runoff Coeff.
16) Freshwater - Open Water	A	0.80	0.90
	B	0.80	0.90
	C	0.80	0.90
	D	0.80	0.90
17) Saltwater - Open Water	A	1.0	1.0
	B	1.0	1.0
	C	1.0	1.0
	D	1.0	1.0
18) Forested Freshwater Wetlands	A	0.50	.60
	B	0.55	0.65
	C	0.60	0.70
	D	0.65	0.75
19) Saltwater Wetlands	A	0.95	0.95
	B	0.95	0.95
	C	0.95	0.95
	D	0.95	0.95
20) Non-forested Freshwater Wetlands	A	0.45	0.55
	B	0.50	0.60
	C	0.55	0.65
	D	0.60	0.70
21) Tidal Flats	A	1.0	1.0
	B	1.0	1.0
	C	1.0	1.0
	D	1.0	1.0