Assessing the Densities and Potential Water Quality Impacts
Of Septic Tank Systems in the Peace and Myakka River Basins

Prepared by
Charlotte Harbor Environmental Center, Inc
And Water Resources and Issues

For
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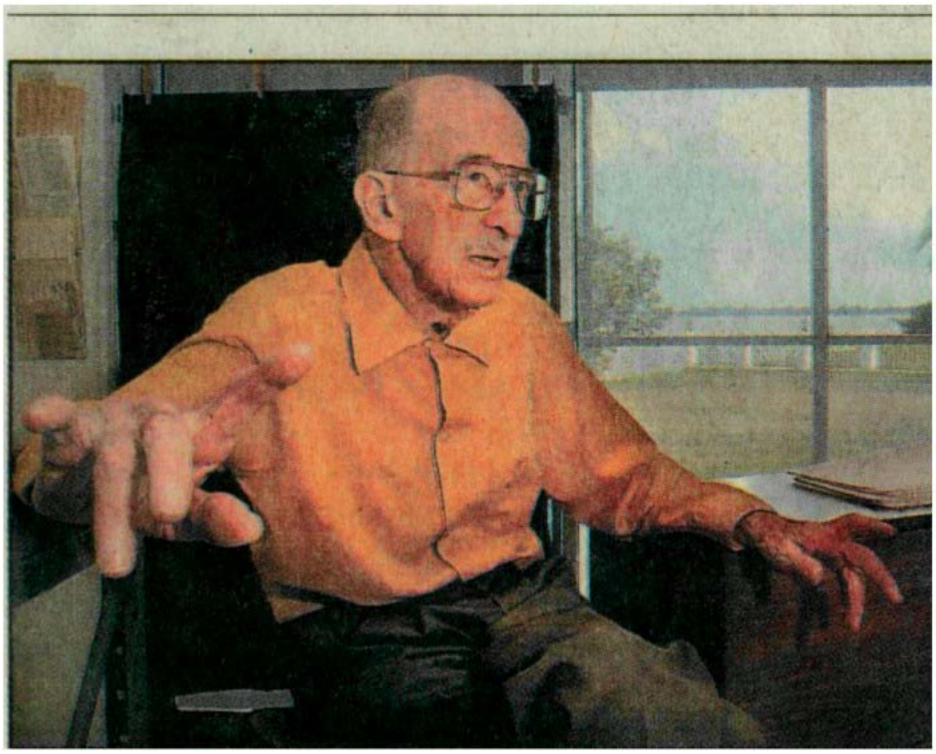

Photograph by : Jonathan Fredin, photographer for "The Charlotte Sun".

In Remembrance of Mr. James R.E. Smith

The authors of this report would like to acknowledge the contributions of Mr. James R.E. Smith, an active member of the Charlotte Harbor National Estuary Program, who passed away on November 14th 2002. Mr. Smith, who felt strongly about the need for an OSTDS study in the Peace and Myakka watersheds contributed financially to this project.

Though Mr. Smith is no longer with us, his legacy continues through the projects and partnerships he promoted. We hope that Mr. Smith's hard work and dedication to the area's resources will continue to be realized as we progress into the future.

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Assessing the Densities and Potential Water Quality Impacts of Septic Tank Systems in the Peace and Myakka River Basins.

1.0 INTRODUCTION

On Site Disposal Systems (OSDS), otherwise known as septic tank systems, are common methods of wastewater disposal in Florida. An estimated 26 percent (1990 Census Bureau) of all homes in Florida are served by OSDS. This number rises to 42 percent for the combined Peace and Myakka basins, serving an estimated 335,000-414,000 residents. OSDS do not provide the same level of treatment afforded by centralized wastewater treatment facilities (WWTF). Consequently, there is concern over the impact of OSDS on water quality of the Peace and Myakka basins.

While there are a number of technological advances for onsite treatment and disposal systems (OSTDS) available today, onsite wastewater systems in various forms have been in use in the United State since the mid-1800s (Knowles, 1998. EPA, 1997) with technological improvements advancing from cesspools, to simple outhouses, to septic tanks. Septic tanks as we know them appeared in the late 1800s and are generally considered OSDS as there is little treatment provided other than primary settling. The most commonly installed system today can be traced to an 1874 technology (Grant, 2003) whose primary function was to minimize human contact with wastewater by keeping the wastewater underground. Discharge into subsurface gravel lined-pits became common practice during the middle of the 20th century (Kreissl, 2000). Some authors refer to the combination of a septic tank and the drainfield/infiltration galley (Subsurface Wastewater Infiltration System, or SWIS) as an onsite wastewater treatment system (OSWS). While the tank does provide primary treatment (settling), any water quality treatment that occurred was ancillary to the primary purpose of avoiding contact and protecting human health. For purposes of this report, the terms OSTDS and septic systems will be used synonymously to represent the holding/settling septic tank and the associated drainfield/infiltration bed.

In 2002, the Charlotte Harbor Environmental Center, Inc. (CHEC) entered into a contract with the Charlotte Harbor National Estuary Program (CHNEP) to assess the densities and potential water quality impacts of OSTDS within the Peace and Myakka basins (**Figure 1**). The completed project includes the following:

- Estimation of the OSTDS densities in the Peace and Myakka watersheds.
- Identification of potential health and environmental 'hot spots' resulting from the placement of OSTDS within the watersheds.
- Estimation of annual nitrogen and phosphorus loads resulting from OSTDS.
- Estimation of hydraulic load resulting from OSTDS.
- Description of a cost-effective monitoring program to further assess the water quality and pathogenic impacts of OSTDS within the watershed.

This report documents the development of the database and methodologies used to identify areas of concern based on the densities, estimated loadings and the siting of OSTDS within the watersheds. OSTDS loading estimates were derived from the calculation algorithms used in the MANAGE (Method for Assessment, Nutrient-Loading, And Geographic Evaluation) watershed model developed by the University of Rhode Island Cooperative Extension Service (URI, 2002). Identification of OSTDS 'hot spots' were also based on the protocols utilized in MANAGE.

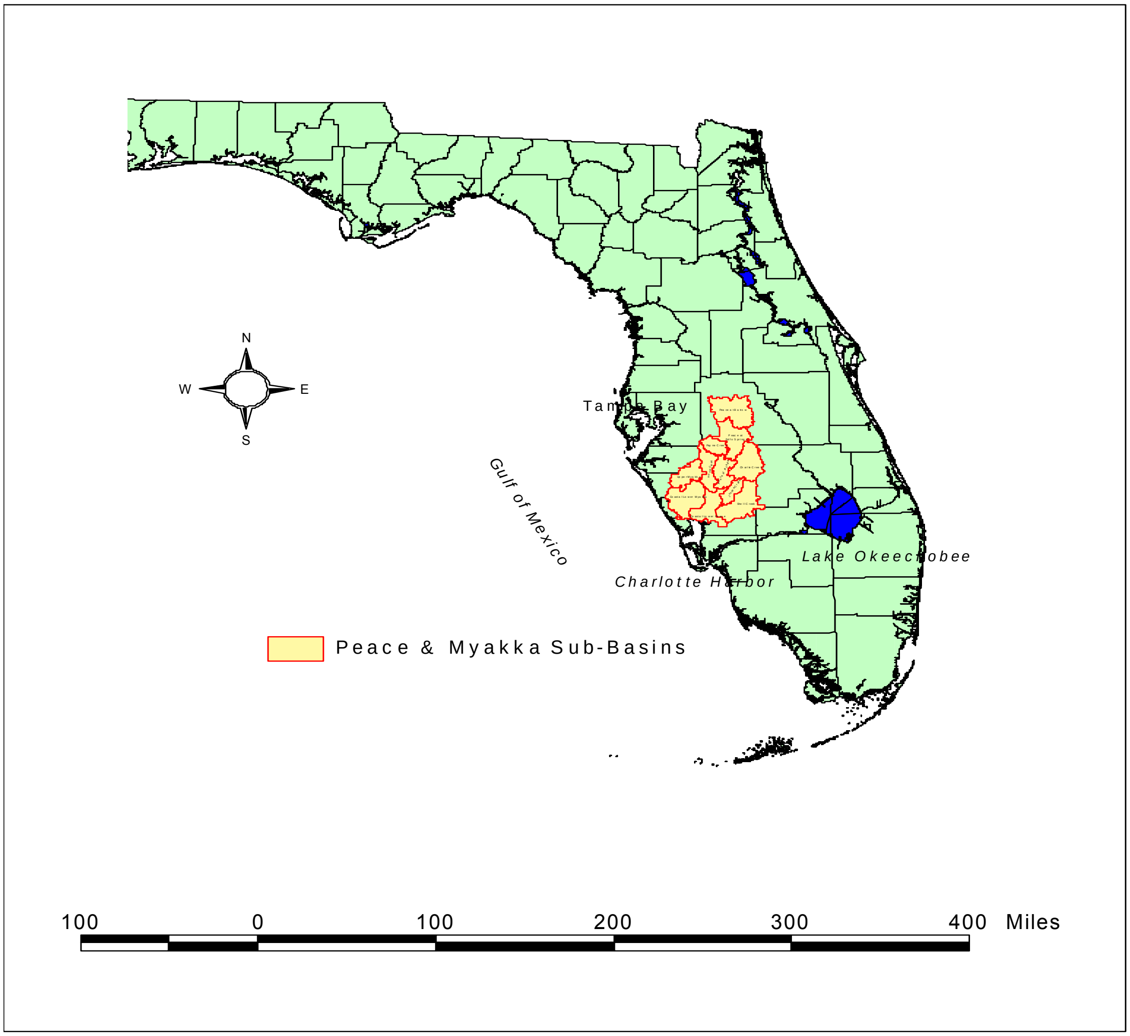


Figure 1
Peace and Myakka Watersheds

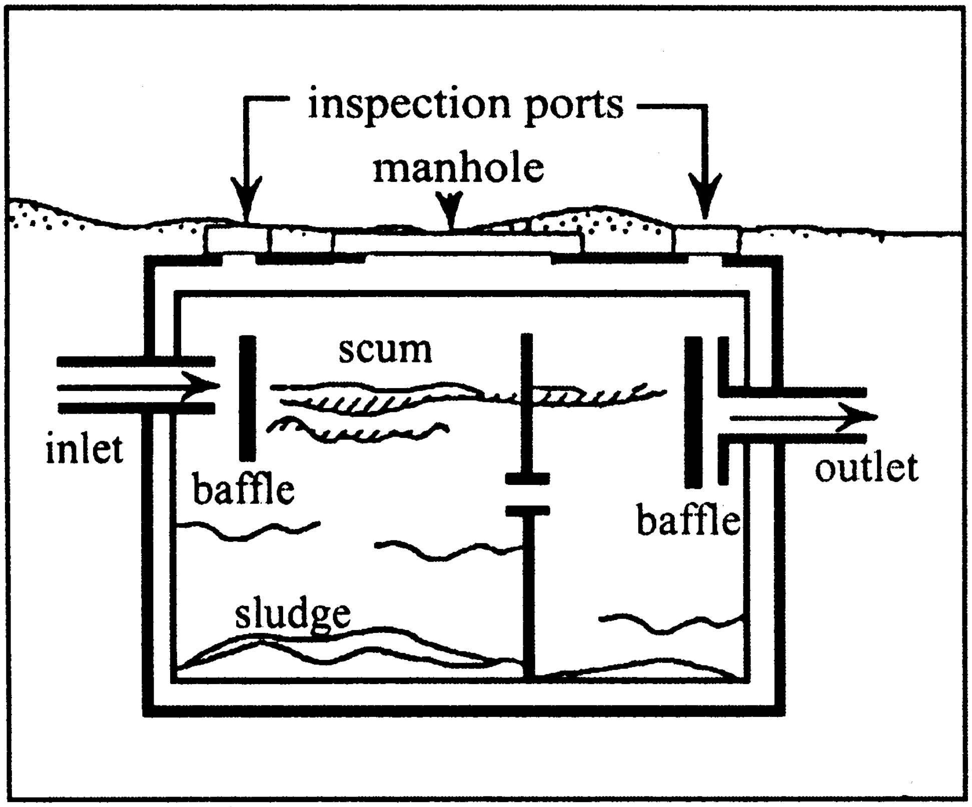
Several watershed loading models include wastewater and OSTDS loadings. Most notably, CDM's Watershed Management Model (WMM) includes a septic routine and was widely used to comply with the municipal stormwater NPDES permitting requirements. Neither model addresses all aspects of septic loading, but the MANAGE Model includes loading estimates from 'working' OSTDS which is absent in the CDM model. Furthermore, the MANAGE model is well described in the most recent EPA guidance of OSTDS systems. (EPA, 2002). For these reasons, MANAGE was selected as the preferred tool for the present project.

The typical residential OSTDS consists of an approximately 1,000-2,000 gallon (EPA, 1999) concrete, or fiberglass buried tank that contains a series of baffles that drains into an absorption field (**Figure 2**). The structural life expectancy is on the order of 12-20 years (Maryland Task Force, 1999). Within the tank, bacterial action breaks down organic material and undigestable solids settle to the bottom to form sludge. Tanks must be of sufficient size to allow sufficient residence time for bacterial action to occur. Grease, foam and lighter particles float to the top and form a layer of scum. An exit pipe is fitted with a baffle to keep both the sludge and the scum from flowing out of the tank as these substances can clog soil pores in the drainfield. These substances must be pumped out periodically and most sources recommend pumpage at 3-5 year intervals.

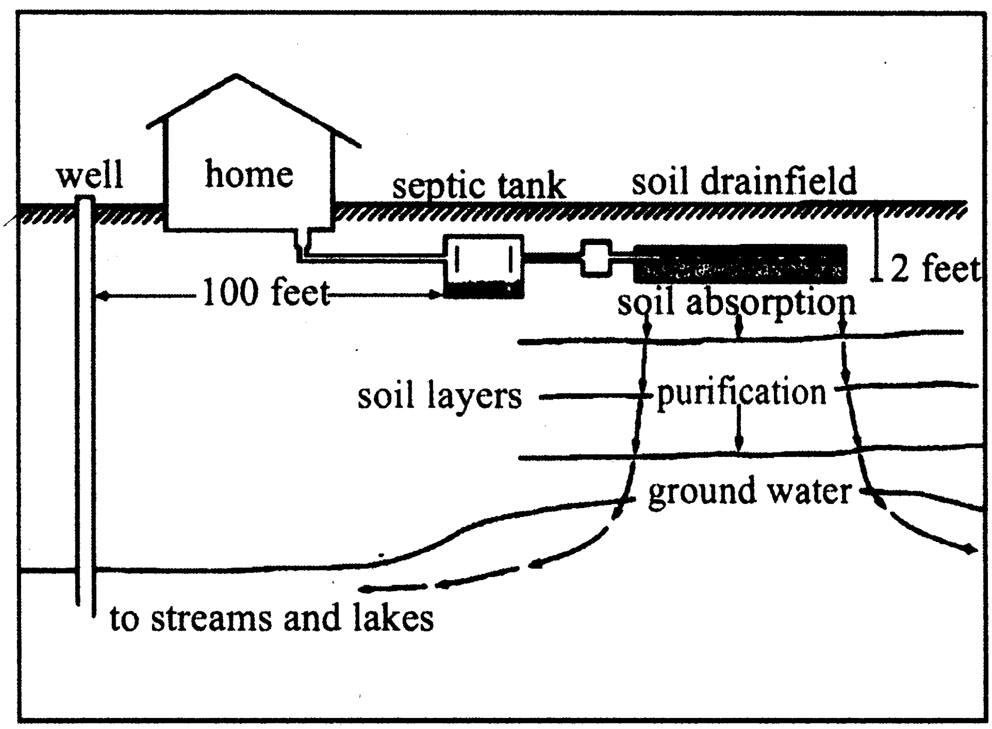
Next, the effluent flows into a distribution box or header pipe constructed below grade and covered with soil. There the wastewater is spread evenly into porous pipes arranged in an absorption field. Typically, two, or more porous pipes are used to direct the flow into parallel trenches 1.5 – 2 feet wide by 1.5 –2 feet deep. The trenches are filled with gravel and are usually covered with 1- 2 feet of soil. Sometimes a single gravel filled bed is used and filter fabric is used to minimize initial clogging with soil particles. The soil beneath the absorption fields must be porous so that air and wastewater can move through it and contact with one another. The unsaturated zone under the gravel bed should never be less than two feet to seasonal high water table (SHWT). Considering the thickness of the gravel bed, the soil layer above the gravel bed and the requisite unsaturated zone below the absorption field, SHWT should be greater than about 3.5- 6 feet below land surface. The distribution box and gravel bed are known as a drainfield, or a SWIS.

OSTDS contribute pollution through two pathways. In a properly working OSTDS, the effluent remains below land surface and infiltrates to the surficial groundwater where it mixes with existing groundwater. Effluent plumes then move downgradient with the surficial aquifer. If the surficial aquifer intersects a stream, lake or other depression in the land the effluent and surficial water will exit as baseflow. Nutrients and pathogens are attenuated by movement vertically and horizontally through the soil.

In cases where the drainfield is plugged, vertical infiltration rate is insufficient because of poor siting or installation, or where the surficial aquifer rises to the land surface, septic effluent may rise to land surface. OSTDS that fail in this manner provide a surface pathway, as the effluent becomes surface runoff. When a system fails, toilets will flush either slowly or not at all and often sewage backs up into the home. If the condition is temporary, or minor the homeowner may ignore the warning signs for several years.



Two Compartment Septic Tank – Courtesy of National Small Flows Clearing



Wastewater Treatment and Disposal – Courtesy of North Carolina Extension

Figure 2
Septic System (OSDS)

Although the definition of 'failure' varies, national failure rates average 19 percent (EPA, 2002) and range from a high of 50-70 percent (Minnesota) to low of 0.4 percent (Wyoming), with Florida reported as 1-2 percent. It is unclear if this number represents the total number of failures at any time, or the annual number of repair permits issued. In EPA's guidance manual *Forecasting Onsite Soil Absorption System Failure Rates* Hudson, (1986) acknowledged that many failures go unreported. Modeling guidelines developed (CDM, 1998) for EPA's Rouge River demonstration project suggest homeowners ignore signs of failure for 5 years before completing repairs, resulting in a range of 5-10 percent failures for Florida. This value is consistent with a Department of Health study conducted in Jacksonville where site inspections were conducted at 800 facilities and found an 11 percent failure rate.

2.0 DATA SOURCES

2.1 OSTDS Usage / Residential Characteristics

The 1990 US Census collected data on household wastewater disposal. This information is available on a census block group level only (**Figure 3**) as the number of households in an area on central service, septic tanks or other. The 1990 GIS coverages were obtained from Florida State (FSU, 2002). During the 2000 census, this information was not collected by the Bureau. Address-specific information is not available for the 1990 census. Using ArcView©, the percentage of septic usage at the block group level was applied to each urban land use parcel within the block. However, the 2000 census results[1] were used to determine the average number of residents per household as shown in **Table 1**.

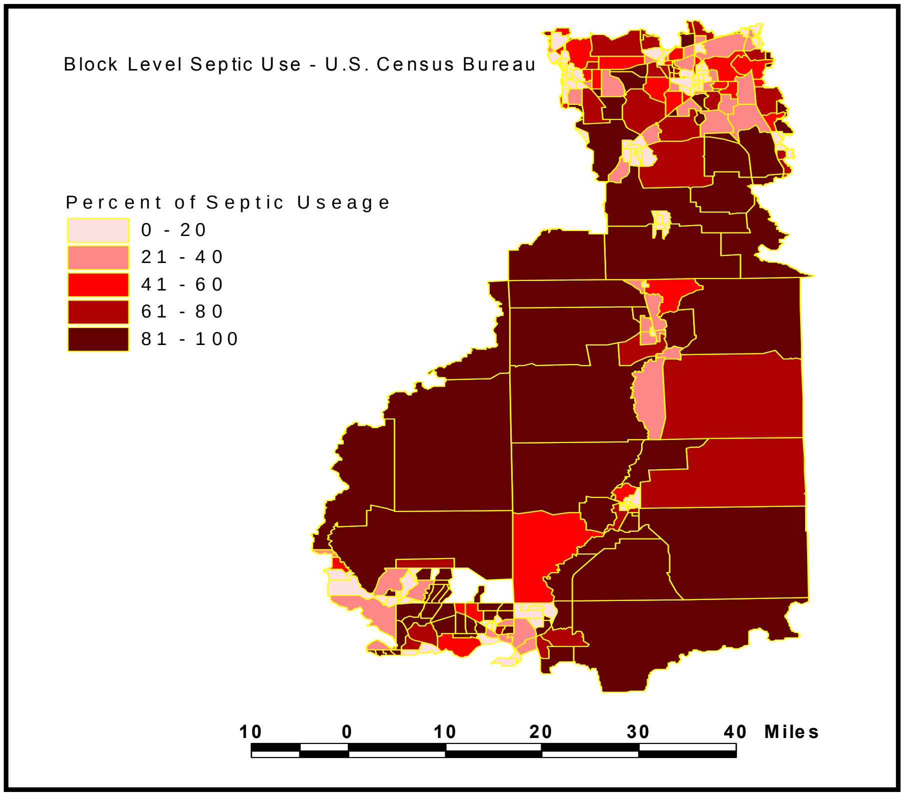


Figure 3
Septic Tank Usage

Table 1
Average Residents by Household (2000)

County	Average Residents per Household
Charlotte	2.18
Sarasota	2.13
Polk	2.52
DeSoto	2.70
Hardee	3.06
Manatee	2.29

[1] (http://quickfacts.census.gov/qfd/states/12000.html)

2.2 Centralized Wastewater Service

Centralized wastewater service is available for some of the study area. The location of domestic wastewater treatment facilities (WWTF) is available through FDEP's (FDEP, 2003) website and is shown in **Figure 4**. The extent of the actual service areas associated with each WWTF is not as well defined or as accessible. Franchise limits are available in GIS format for Sarasota, and Charlotte counties and in AutoCAD© for Polk County. However, actual service within those limits is not guaranteed and is currently unavailable. Manatee County does not provide wastewater service to those portions of the County within the Peace/Myakka study area, and neither DeSoto nor Hardee County have wastewater service areas available in GIS format. Unfortunately, even knowledge of the true service area boundaries is insufficient to determine the extent of centralized service. For example, in Sarasota County (CDM, 2000) it was found that even within the same residential block connection to centralized service could range from 0 to 100 percent with a franchised service area. Thus, while central sewer may be available within an area, there is no guarantee that there are customers as many residents have chosen to remain on OSTDS. Furthermore, several of the private franchises in Sarasota County declined to provide a list of customer addresses. Similar responses are expected throughout the study area.

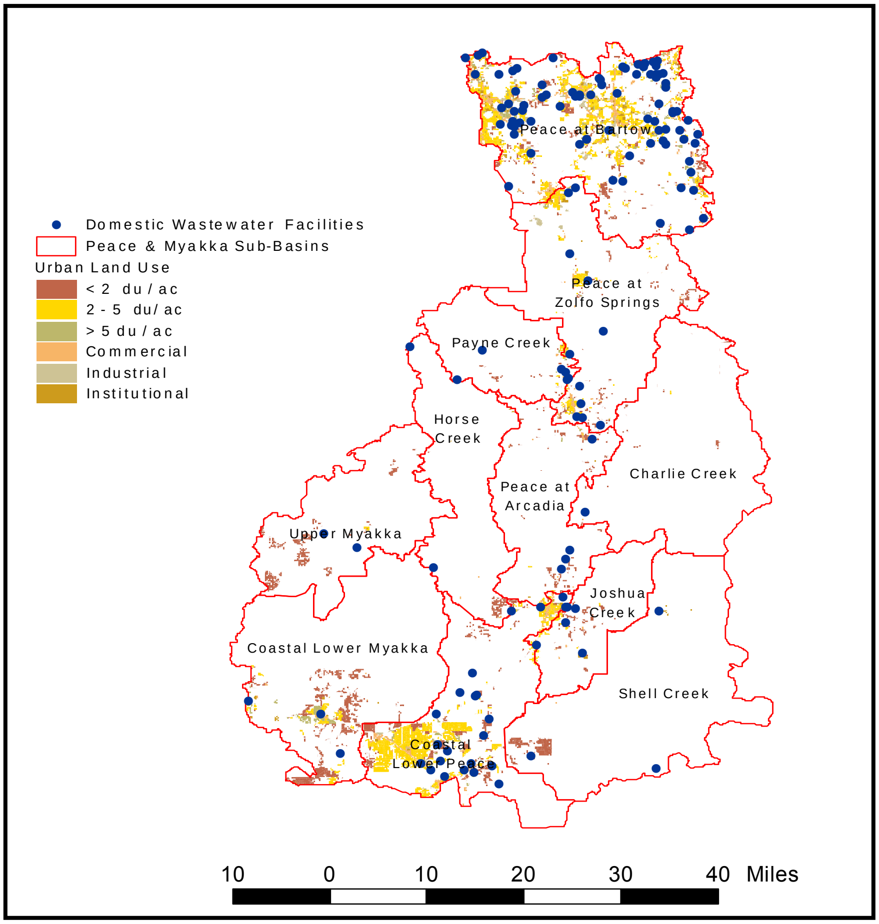


Figure 4
Urban Land Use and Location of WWTFs

While detailed information is not presently available, it should be noted that Charlotte County is very near to completing several projects that will provide valuable information about OSTDS locations and maintenance needs. The County, through an EPA grant has completed digitizing site information for approximately 30,000 OSTDS permits issued by the County. In addition, the County has just completed digitizing the location of wastewater infrastructure and both databases will soon be available as GIS coverages.

2.3 Land use

Land use is available from the Southwest Florida Water Management District[2] (SWFWMD) for 1995 and 1999, while the Florida Department of Environmental Protection (FDEP) distributes[3] land use for 1989 and 1995. The Peace and Myakka watersheds are located on the southwest coast of Florida and are the primary inflows the Charlotte Harbor. The Peace is the larger watershed consisting of 2,350 mi^2 of mostly agricultural or pastoral land use. The Myakka watershed is 600 mi^2 and is also dominated by agricultural/pastoral and use. Based on 1995 SWFWMD land use coverages defined by the Florida Land use and Cover Classification System (FLUCCS), there is only a small fraction of urbanized land use with wastewater disposal needs as shown in Figure 4 and **Table 2**.

Table 2
Urban Land use in Peace and Myakka River Basins

Land use (FLUCCS)	Peace (mi^2)	Myakka (mi^2)
Low Density Residential (1100)	42.1	20.5
Medium Density Residential (1200)	77.0	3.5
High Density Residential (1300)	12.3	2.5
Commercial and Services (1400)	20.4	0.4
Institutional (1700)	6.0	0.6
Industrial- Non-Extractive (1500)	6.6	0.1
Total: mi^2 (percent watershed)	164.4 (7 %)	27.6 (5 %)

The percentage of OSTDS use obtained from the census bureau was then applied to the urban land used to obtain the area served by OSTDS. The results are given in **Table 3** and indicate that the OSTDS coverage averages 3.6 percent across the study area.

Table 3
OSTDS Service Area in Peace and Myakka River Basins

Land use (FLUCCS)	Peace (mi^2)	Myakka (mi^2)
Low Density Residential (1100)	32.1	16.8
Medium Density Residential (1200)	36.0	1.1
High Density Residential (1300)	4.8	0.2
Commercial and Services (1400)	7.9	0.1
Institutional (1700)	2.5	0.1
Industrial- Non-Extractive (1500)	3.3	0.0
Total: mi^2 (percent watershed)	86.6 (4 %)	18.3 (3 %)

[2] (http://www.swfwmd.state.fl.us/data/gis/shape_search.htm)
[3] (http://www.dep.state.fl.us/gis/datadir.asp)

2.4 Soil Characteristics

Soil types and classifications were obtained from the FDEP site. Soils are classified according to their hydrologic conditions (infiltration and seasonal water table elevations) according to a standardized scale with type 'A' soils exhibiting the highest infiltration (**Table 4**) and deepest SHWT. Soils assigned to the hydrologic soil group (HSG) 'D' are the wettest soils with the least infiltration capacity. Soil scientists have defined hybrid (e.g. B/D) groups which exhibit native characteristics of the soil group in the denominator, but when artificial drainage is provided exhibit characteristics of the drier group identified in the numerator. OSTDS performance is enhanced when the drainfield is constructed in the drier 'A' and 'B' type of soils.

Table 4

Group A	Highly permeable (low runoff) primarily sands and gravel
Group B	Well Drained (low to moderate runoff)
Group C	Moderately Drained (moderate to high runoff) fine textured
Group D	Poorly Drained (high runoff) clay
Groups A/D, B/D	Soils that exhibit different characteristics under developed and undeveloped conditions

The National Resource Conservation Service (NRCS, formerly the Soil Conservation Service, SCS) publishes soil surveys by county. The Charlotte County Comprehensive Plan (2003) states:

> *Since most of the naturally occurring soils in Charlotte County are classified by the U.S. Soil Conservation Service as "severe" for septic tank use (US SCS, 1984), the use of septic tanks to treat domestic sewage in some the more densely populated areas of Charlotte County must be questioned.*

This statement is appropriate for all of the study area as many of the soil groups found in Charlotte are common throughout the study area. Two measures of soil characteristics published by the NRCS are the minimum depth of SHWT and the maximum depth of SHWT. These represent the average for a given soil group and may not apply at every location where the soil group occurs. Nevertheless, the reported numbers are a good representation of the soil group as a whole. The area-weighted minimum and maximum averages for the urban soils evaluated as part of this study are 1.8 feet below land surface and 2.8 feet below land surface. Fifteen soil series represent 76 percent (**Table 5**) of the urban area in the study area. Of those, twelve (54 percent of total urban land use in study area) are described as 'severe' by the NRCS when classifying the soil series for suitability as a septic tank absorption field. NRCS descriptions include 'ponding', 'percs slowly', 'poor filter', and ' severe limitations due to wetness and high water table'.

Table 5
Predominant Soil Series in Study Area

Soil Series	Percent Urban	Absorption Field Limits	Soil Series	Percent Urban	Absorption Field Limits
Candler	10.0	Slight	Immokalee	5.1	Severe
Smyrna	8.8	Severe	Urban Land	3.6	Severe
Tavares	7.6	Moderate	Sparr	2.8	Severe
EauGallie	6.3	Severe	Zolfo	2.5	Severe
Pomona	5.9	Severe	Fort Meade	4.5	(Unknown)
Myakka	5.6	Severe	Adamsville	2.5	Severe
Matlacha	5.5	Severe	Wabasso	2.4	Severe
Oldsmar	5.3	Severe	Total	76.0	

Within the urban land uses of the present study area, 0.6 percent of the soils were designated A/D. For evaluation, these soils were grouped with those classified ‘A’. In a like manner group B soils (0.4 percent of urban soils represented) were grouped with ‘B/D’ soils and ‘C/D’ soils (0.1 percent) were grouped with ‘C’ soils. The distribution of urban soil groups by basin is given in **Table 6**, while a more detailed accounting which includes the urban land use is given in Appendix A.

Table 6
Urban Hydrologic Soil Group Acreage by Sub-Basin

	A, A/D	B, B/D	C, C/D	D, Water
Coastal Lower Peace	437.3	14,786.4	2,107.3	826.4
Peace @ Arcadia	128.4	1,453.1	317.9	244.5
Peace @ Zolfo Springs	1,031.9	1,799.5	980.3	199.0
Peace @ Bartow	10,814.8	6,192.5	4,169.3	822.4
Horse Creek	1.0	1,192.8	73.3	53.6
Payne Creek	35.7	364.0	295.6	48.5
Charlie Creek	70.9	398.8	59.0	17.3
Joshua Creek	20.6	1,821.0	257.1	268.4
Shell Creek	268.4	2,578.5	43.9	172.0
Peace Basin Total	**25,349.6**	**58,594.7**	**16,563.5**	**5,132.2**
Percent Peace Basin	**24%**	**55%**	**16%**	**5%**
Coastal Lower Myakka	444.9	5,113.8	815.4	1,099.2
Upper Myakka	260.1	2,996.7	504.3	503.8
Myakka Basin Totals	**1,149.9**	**13,216.6**	**2,135.1**	**2,702.2**
Percent Myakka Basin	**6%**	**69%**	**11%**	**14%**

2.5 Dwelling Unit Densities

The FLUCCS residential land use assignments are based on the density of dwelling units (du) illustrated. The Peace/Myakka watersheds are largely rural and an attempt was made to define a representative low-density value by making fixed assumptions about the density of the other two residential classes. From these assumptions, an estimate of the total population was developed and

FLUCCS Definitions	
Low density	< 2 du/acre
Medium density	2-5 du/acre
High Density	> 5 du/acre

compared with the total population reported by the Census bureau. DeSoto and Hardee counties were chosen because each lies entirely in the study area. The combined 1995 population of the two counties was estimated by the US Census bureau as 46,409 residents. The combined acres of medium density land use as reported by SWFWMD were multiplied by a mean density of 3.5 du/acre and the appropriate number of residents per du (2.70 for DeSoto and 3.06 for Hardee) to estimate the fraction of the population living in medium density dwellings. A minimum qualifying value of 5.1 du/acre was chosen for high-density land uses and a similar estimate prepared. The sum of the population in these two land uses is 66,296, a value that exceeds the total population of the combined counties without accounting for the low-density land use. Reducing the medium density to 0.2 du/acre (the minimum specified by the FLUCCS medium density residential code) results in a low density of 0.15 du/acre. However, a half-acre medium density lot appears to be inconsistent with the Peace/Myakka watersheds where quarter acre residential lots prevail. Vincent (undated) reports. . *several hundred thousand-quarter acre lots. .* in Port Charlotte alone. The discrepancy could not be resolved and two density assignments were analyzed as shown in **Table 7**. The lower values are based on the minimum FLUCCS densities that will result in agreement with the census estimates. The higher values are considered typical and representative of the area.

Table 7
Peace/ Myakka Dwelling Unit Densities

Land use	FLUCCS	DU/ Acre (Low FLUCCS)	DU/ Acre (Normal for Area)
Low Density Residential	1100	0.15	1.0
Medium Density Residential	1200	2.0	3.5
High Density Residential	1300	5.1	7.5
Commercial and Services (1)	1400	2.0	3.5
Institutional (1)	1700	2.0	3.5
Industrial- Non-Extractive (1)	1500	2.0	3.5

(1) Based on assumptions of MANAGE Model.

2.6 Waste Loading

Septic flow rates were obtained from a study (Mayer et al., 1999) of the indoor water use at 1,188 homes as summarized by EPA (2002). The mean daily per capita use was 69.3 gallons. Mass loadings were obtained as the mid-range of values reported by EPA (ibid) as 9.2 pounds/person/year of total nitrogen and 1.2 pounds/person/year for total phosphorus. It should be noted that the total phosphorus value reflects recent sampling data characteristic of today's reduced phosphorus detergents.

2.7 Soil Attenuation

After passing through the settling tank, OSTDS flows are directed to a sub-surface drainfield. The fluid then percolates through the soil until it meets surficial ground water or an aquiclude. During the percolation, the leachate undergoes biochemical transformations and interactions with the soil that reduces the overall pollution loading.

Initially, most nitrogen is in the reduced form of ammonia that is not very mobile. As the leachate migrates downward, ammonia is converted to nitrate that is very mobile. Under certain conditions, de- nitrification can also occur which converts the nitrate to nitrogen gas that is lost to the atmosphere. Phosphate is primarily reduced through interaction and binding with the soil. Phosphorus is strongly attenuated during passage from the drainfield.

Soil removal rates were taken from Anderson et al. (1994) as reported by EPA (2002). The vertical removal rate was taken as the average concentration measured at 0.6 meter and 1.2 meter below the drainfield (n $\simeq$ 35), compared to the effluent concentration. This value was determined to be 59 percent removal for total nitrogen and 97.5 percent removal for total phosphorus. For comparison, 50 percent and 90 percent respectively were used to evaluate Sarasota Bay watershed (CDM, 1991) while Coastal Environmental (1995) used a value of 80 percent soil attenuation for TN and 90 percent for TP.

2.8 Septic Failure Rates / Surface Delivery Ratio

Septic failure rates as a function of hydrologic soil group were taken from MANAGE. The default values used in MANAGE are as follows: Soil Group A or B; 10 percent septic failure rate, Group C; 30 percent failure, Group D; 50 percent failure rate. While these values may seem intuitively high, no other guidance or literature values could be identified. On the other hand, an area-weighted failure rate of 15.4 percent was calculated from the distribution of urban land soils in the study area. (e.g. 79 percent A, A/D, B or B/D; 15 percent C or C/D and 6 percent as D or water.) The area-weighted failure rate is reasonably close to estimates previously described.

MANAGE assigns different delivery ratios to receiving waters for the pooled effluent that surfaces because of OSTDS failure. For lots located within a 150-foot riparian zone adjacent to a waterbody, MANAGE assumes that 100 percent of the nitrogen and phosphorus loading will be delivered to the receiving water. For OSTDS sited more than 150 feet from a surface water body, MANAGE assumes that 50 percent of the phosphorus and 80 percent of the nitrogen is delivered to the water body. In the present study, insufficient detail exists in the census data to identify specific residences on OSTDS and therefore the distance to the nearest water body could not be determined. Therefore, it was assumed that all lots were located outside the 150-foot riparian zone and the default delivery ratios were used. **Figure 5** illustrates the nitrogen losses assigned for working and failed septic tanks. **Table 8** summarizes the constants used in the MANAGE evaluation.

Table 8
Rate/Constants Used

	A or B	C	D
Failure Rate	**10%**	**30%**	**50%**
	TN	**TP**	
Individual Waste (lbs/year)	**9.2**	**1.2**	
Delivery Ratio, Lots ≥ 150 feet	**80%**	**50%**	
Vertical Delivery	**41%**	**2.5%**	
Horizontal Delivery	**10%**		

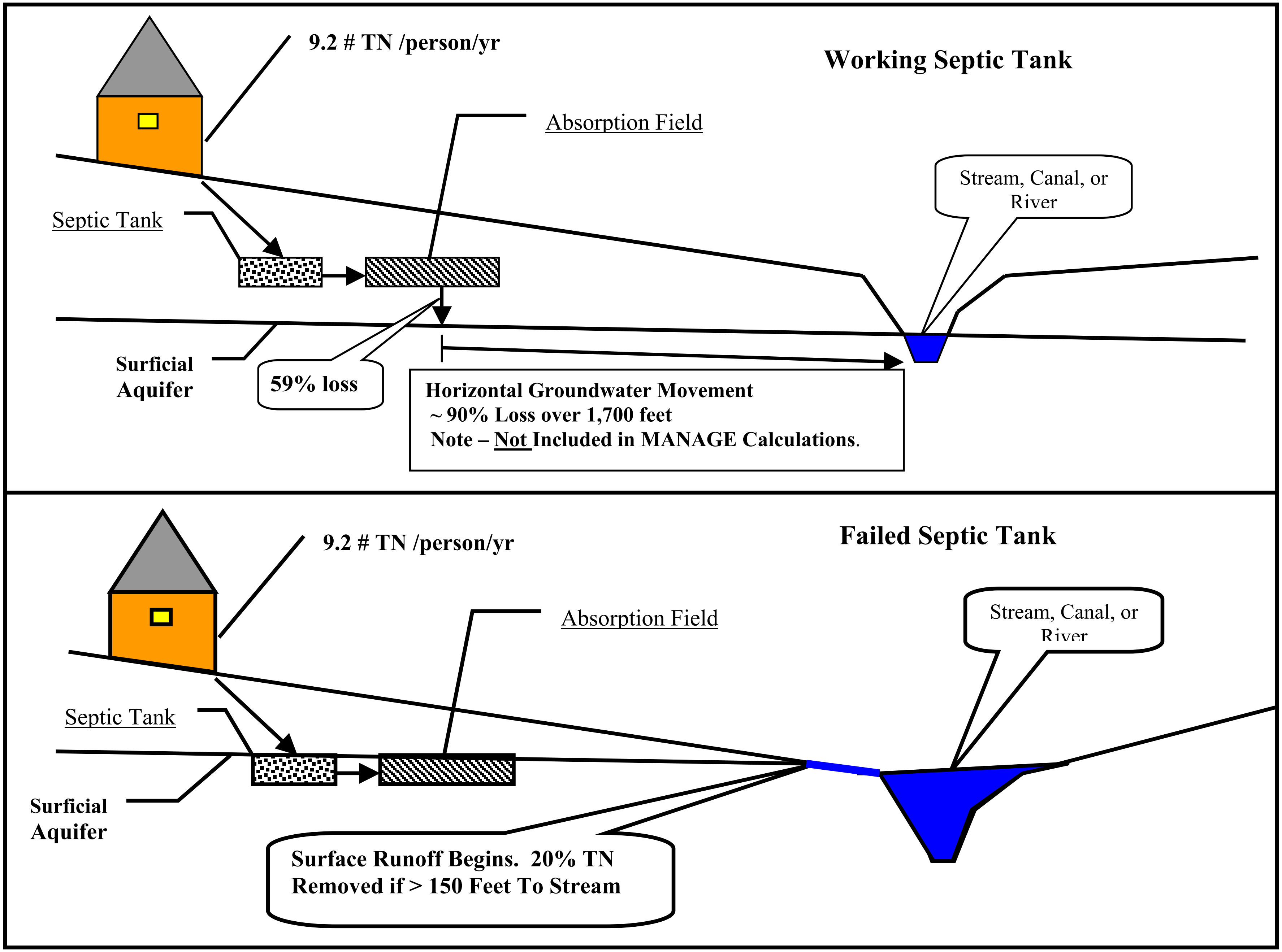


Figure 5
Nitrogen Losses for Working and Failed Septic Tanks

2.9 Missing Data

As is the case in most GIS studies of this nature, there are spatial areas of missing data. **Figure 6** illustrates the gap in coverage for soils, land use and septic tank coverage. Taken in perspective, the missing soils account for 0.1 percent of the study area while the missing land use represents 1.9 percent of the study area. Missing septic coverage is 3.8 percent of the study area.

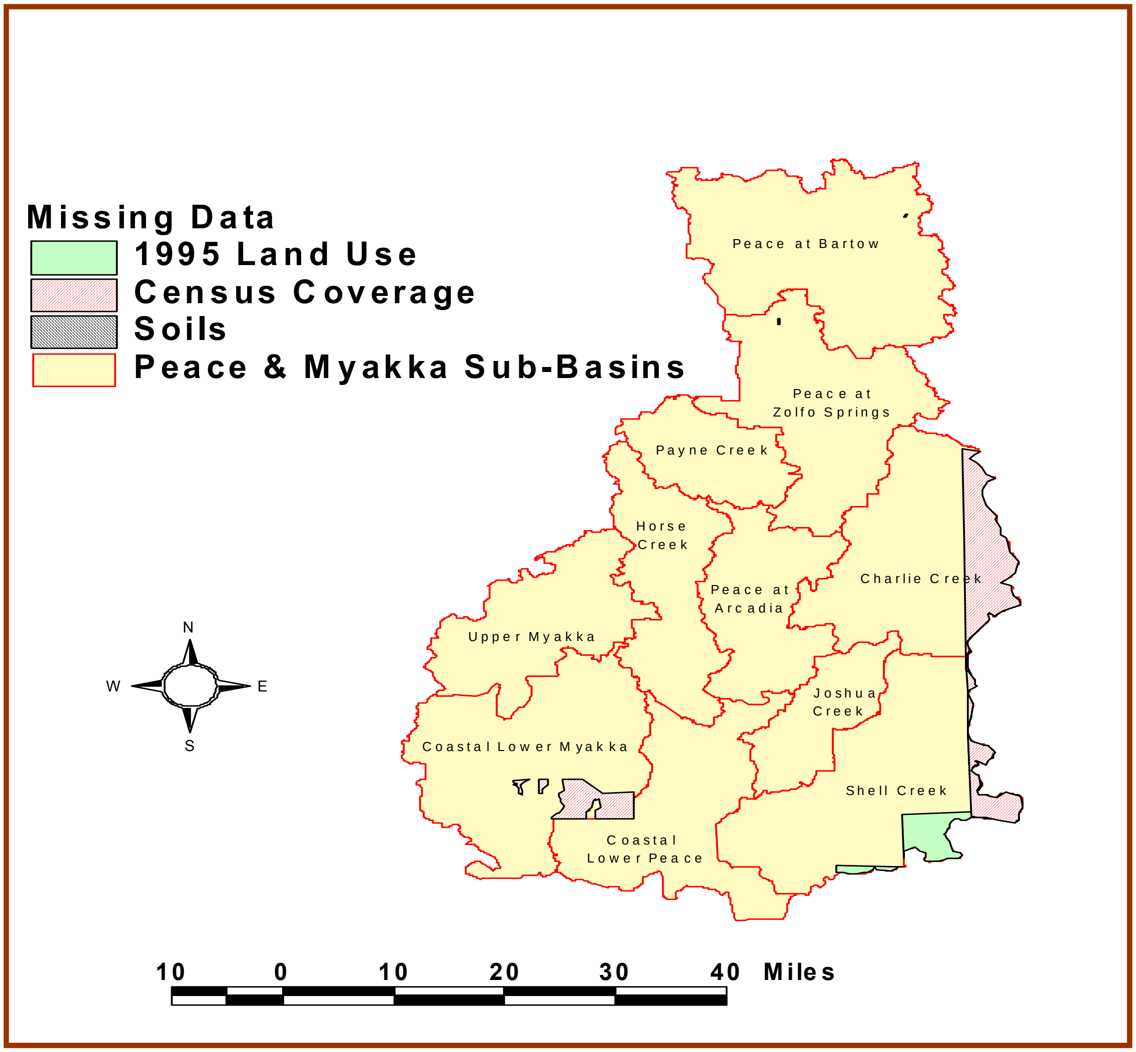


Figure 6
Missing Data

3.0 LOAD ESTIMATION

The estimation of loads is straightforward for both groundwater and surface waters. Initially population is estimated as follows:

Population of Land use = (Land use Acres) X (Dwelling Units / Land use Acre)
X (# Residents/Dwelling Unit.
The population of each land use is determined and summed to provide a study area population.

Mass loading of nitrogen and phosphorus is determined as follows:
Annual pounds of nitrogen waste = population X 9.2 lbs/person/yr
Annual pounds of phosphorus waste = population X 1.2 lbs/person/yr.

Surface loading resulting from failed OSTDS is calculated next as follows:
Surface Load = Total Nitrogen X Failure Factor X Delivery Ratio ; (0.8 for TN)
Surface P Load = Total Phosphorus X Failure Factor X Delivery Ratio ; (0.5 for TP)

Potential groundwater load is calculated as the Total Load minus the Surface Load[4]. The remainder is used to determine the groundwater contribution as follows:
GW Total Nitrogen Load = (Total Load – Surface Load) * 0.41 * 0.1
GW Total Phosphorus Load = (Total Load – Surface Load) * 0.025

It should be noted that the MANAGE estimate of groundwater loading does not reflect attenuation resulting from horizontal movement that can be very significant depending on the distance of horizontal movement. For example in Port Charlotte CDM (1994) calculated that 90 percent of the nitrogen that reaches the surficial aquifer is removed within 1,700 feet of horizontal movement with the surficial water. In order to more accurately estimate the groundwater loadings, the MANAGE estimates were multiplied by 0.1 to reflect a 90% attenuation due to horizontal travel.

[4] As coded, MANAGE does not make this distinction and calculates both the groundwater and surface loading from the source loading resulting in a 'double counting' which can result in a total pollutant loading which exceeds the source loading.

4.0 RESULTS

4.1 Loading Estimates

Table 9 provides the resulting pollution loads for each sub-basin using the higher dwelling unit densities assumed appropriate for the study area. **Table 10** is similar, but is based on the lower dwelling unit densities identified in Table 7. Total nitrogen loadings range from 305,000 - 600,000 pounds per year. Phosphorus loads are estimated to range from 25,000 to 49,000 pounds per year depending upon the dwelling unit density chosen for evaluation. **Figures 7** and **8** illustrate the normalized septic loading for the higher dwelling unit densities. It should be noted that the results portrayed in Figures 7 and 8 are normalized for acres of septic use only and do not reflect a spatial average of septic and non-septic use within the area. The figures reflect the impact of the high density of OSTDS in Charlotte County, particularly around Port Charlotte. Canal water quality in this region was studied by Ardaman & Associates and Mote Marine Laboratory (Ardaman, 1995) and found to consistently exceed Florida's water quality criteria.

4.2 Regional Comparison

Data presented by Coastal Environmental (Coastal, 1995. Appendix 4) indicates that loading from OSTDS constituted fourteen percent of the Peace and thirty-two percent of the Myakka watershed nitrogen load. The Coastal estimates were based on an inventory of homes within 2,000 feet of a waterbody and reflect only the groundwater loading from properly functioning systems. The Coastal estimate assumed that the OSTDS loads would be attenuated by 80 percent once the contaminants reached the surficial aquifer and before reaching a receiving waterbody. Coastal estimated that 30,349 septic tanks were located within 2,000 feet of a water body in 1992 producing a nitrogen loading at the receiving water of 4.7 lbs/OSTDS/yr.

Using the combined Peace/Myakka watershed TN from non-OSTDS sources reported by Coastal (2.9 E6 lb/yr) and the present OSTDS loading estimates the contribution ranges from 11 to 21 percent of the overall nitrogen load. This compares favorably a 22 percent contribution derived from Coastal's data. The current phosphorus loading estimates range from 3 to 6 percent of all sources using non-OSTDS sources reported by Coastal.

CDM (1992) estimated that three percent of the total nitrogen and 10 percent of the total phosphorus generated in the Sarasota Bay watershed was the result of failed OSTDS. Estimates for the Indian River Lagoon (Coastlines, 2000) put the OSTDS contribution of nitrogen at 12 percent of the total load. At the other extreme is Buttermilk Bay, Massachusetts where the OSTDS contribution is estimated at 74 percent of the total nitrogen budget (EPA, 2002).

The wide range of estimates is largely the result of whether the investigators considered both functional and failed OSTDS and within those categories, it is the result of different assumptions used by various investigators. For example, the Buttermilk Bay calculation is based on source generation only and does not consider reductions that occur within the OSTDS/SWIS or in the groundwater migration. MANAGE accounts for both failed and

Table 9a.
OSDS Loadings for Typical Dwelling Unit/Acre Assumptions

Basin	Total Urban Acres	OSDS Acres	Number of OSDS	Average OSDS Density (# / acre)	Annual Flow (Mg/yr)	TN Surface lbs/yr	TP Surface lbs/yr
Upper Myakka	4,355	4,265	4,563	1.07	252	12,191	994
Coastal Lower Myakka	13,338	7,479	10,095	1.35	550	29,037	2,367
Charlie Creek	645	547	885	1.62	67	2,666	217
Coastal Lower Peace	30,940	18,157	51,803	2.85	2,977	125,664	10,244
Horse Creek	1,416	1,321	1,822	1.38	128	5,115	417
Joshua Creek	2,851	2,367	5,658	2.39	387	18,968	1,546
Payne Creek	1,136	746	1,935	2.60	148	9,195	750
Peace at Arcadia	3,060	2,147	3,732	1.74	270	14,095	1,149
Peace at Bartow	52,557	23,016	75,205	3.27	4,797	204,125	16,641
Peace at Zolfo Springs	9,317	4,082	9,575	2.35	664	34,260	2,793
Shell Creek	3,315	3,063	4,218	1.38	244	10,454	852

Basin	TN Groundwater lb/yr	TP Groundwater lb/yr	Flow Mg/acre[1]/yr	TN Surface lb/acre/yr	TP Surface lb/acre/yr	TN Groundwater lb/acre/yr	TP Groundwater lb/acre/yr
Upper Myakka	3,249	273	0.06	2.86	0.23	0.76	0.06
Coastal Lower Myakka	6,986	591	0.07	3.88	0.32	0.93	0.08
Charlie Creek	894	74	0.12	4.88	0.40	1.64	0.14
Coastal Lower Peace	39,214	3,272	0.16	6.92	0.56	2.16	0.18
Horse Creek	1,697	141	0.10	3.87	0.32	1.28	0.11
Joshua Creek	4,985	420	0.16	8.01	0.65	2.11	0.18
Payne Creek	1,823	156	0.20	12.33	1.01	2.44	0.21
Peace at Arcadia	3,449	292	0.13	6.57	0.54	1.61	0.14
Peace at Bartow	59,542	4,985	0.21	8.87	0.72	2.59	0.22
Peace at Zolfo Springs	8,262	699	0.16	8.39	0.68	2.02	0.17

Table 9b.
OSDS Loadings for Typical Dwelling Unit/Acre Assumptions

County (Within Watershed)	Total Urban Acres	OSDS Acres	Number of OSDS	Average OSDS Density (# / acre)	Annual Flow (Mg/yr)	TN Surface lbs/yr	TP Surface lbs/yr
Charlotte	32,559	21,253	50,387	2.37	2,780	114,524	9,336
DeSoto	11,637	8,215	18,973	2.31	1,297	61,768	5,035
Hardee	6,776	4,002	8,600	2.15	666	36,335	2,962
Manatee	1,141	1,084	1,381	1.27	80	3,205	261
Polk	58,529	25,540	81,079	3.17	5,172	222,441	18,134
Sarasota	12,289	7,095	9,071	1.28	489	27,498	2,242
Watershed Total	122,931	67,189	169,491	2.52	10,484	465,771	37,970

County (Within Watershed)	TN Groundwater lb/yr	TP Groundwater lb/yr	Flow Mg/acre(1)/yr	TN Surface lb/acre/yr	TP Surface lb/acre/yr	TN Groundwater lb/acre/yr	TP Groundwater lb/acre/yr
Charlotte	36,738	3,062	0.13	5.4	0.44	1.7	0.14
DeSoto	16,790	1,411	0.16	7.5	0.61	2.0	0.17
Hardee	8,425	714	0.17	9.1	0.74	2.1	0.18
Manatee	1,062	88	0.07	3.0	0.24	1.0	0.08
Polk	64,143	5,374	0.20	8.7	0.71	2.5	0.21
Sarasota	6,147	523	0.07	3.9	0.32	0.9	0.07
	(1) Note- All "per acre" basis refer to OSDS acres.						
Watershed Total	133,304	11,172	0.16	6.9	0.57	2.0	0.17

Table 10a.
OSDS Loadings for Low Dwelling Unit/Acre Assumptions

Basin	Total Urban Acres	OSDS Acres	Number of OSDS	Average OSDS Density (# / acre)	Annual Flow (Mg/yr)	TN Surface lbs/yr	TP Surface lbs/yr
Upper Myakka	4,355	4,265	819	0.19	46	2,060	168
Coastal Lower Myakka	13,338	7,479	3,007	0.40	163	8,746	713
Charlie Creek	645	547	331	0.61	25	1,013	83
Coastal Lower Peace	30,940	18,157	27,644	1.52	1,588	67,574	5,509
Horse Creek	1,416	1,321	559	0.42	40	1,759	143
Joshua Creek	2,851	2,367	2,790	1.18	191	9,389	765
Payne Creek	1,136	746	999	1.34	76	4,840	395
Peace at Arcadia	3,060	2,147	1,494	0.70	108	5,786	472
Peace at Bartow	52,557	23,016	42,301	1.84	2,698	114,980	9,373
Peace at Zolfo Springs	9,317	4,082	4,670	1.14	324	17,259	1,407
Shell Creek	3,315	3,063	1,299	0.42	78	3,925	320

Basin	TN Groundwater lb/yr	TP Groundwater lb/yr	Flow Mg/acre(1)/yr	TN Surface lb/acre/yr	TP Surface lb/acre/yr	TN Groundwater lb/acre/yr	TP Groundwater lb/acre/yr
Upper Myakka	596	50	0.01	0.48	0.04	0.14	0.01
Coastal Lower Myakka	2,068	175	0.02	1.17	0.10	0.28	0.02
Charlie Creek	335	28	0.05	1.85	0.15	0.61	0.05
Coastal Lower Peace	20,890	1,744	0.09	3.72	0.30	1.15	0.10
Horse Creek	526	44	0.03	1.33	0.11	0.40	0.03
Joshua Creek	2,456	207	0.08	3.97	0.32	1.04	0.09
Payne Creek	936	80	0.10	6.49	0.53	1.26	0.11
Peace at Arcadia	1,370	116	0.05	2.70	0.22	0.64	0.05
Peace at Bartow	33,413	2,798	0.12	5.00	0.41	1.45	0.12
Peace at Zolfo Springs	3,988	338	0.08	4.23	0.34	0.98	0.08
Shell Creek	1,000	84	0.03	1.28	0.10	0.33	0.03
	(1) Note- All "per acre" basis refer to OSDS acres.						

Table10b.
OSDS Loadings for Low Dwelling Unit/Acre Assumptions

County (Within Watershed)	Total Urban Acres	OSDS Acres	Number of OSDS	Average OSDS Density (# / acre)	Annual Flow (Mg/yr)	TN Surface lbs/yr	TP Surface lbs/yr
Charlotte	32,559	21,253	24,707	1.16	1,363	57,578	4,694
DeSoto	11,637	8,215	9,196	1.12	628	29,831	2,432
Hardee	6,776	4,002	4,003	1.00	310	17,872	1,457
Manatee	1,141	1,084	373	0.34	22	801	65
Polk	58,529	25,540	45,155	1.77	2,880	124,147	10,121
Sarasota	12,289	7,095	2,477	0.35	134	7,100	579
Watershed Total	122,931	67,189	85,912	1.28	5,337	237,329	19,348
County (Within Watershed)	TN Groundwater lb/yr	TP Groundwater lb/yr	Flow Mg/acre(1)/yr	TN Surface lb/acre/yr	TP Surface lb/acre/yr	TN Groundwater lb/acre/yr	TP Groundwater lb/acre/yr
Charlotte	17,956	1,498	0.06	2.71	0.22	0.84	0.07
DeSoto	8,143	684	0.08	3.63	0.30	0.99	0.08
Hardee	3,883	331	0.08	4.47	0.36	0.97	0.08
Manatee	290	24	0.02	0.74	0.06	0.27	0.02
Polk	35,617	2,985	0.11	4.86	0.40	1.39	0.12
Sarasota	1,691	143	0.02	1.00	0.08	0.24	0.02
	(1) Note- All "per acre" basis refer to OSDS acres.						
Watershed Total	67,580	5,665	0.08	3.53	0.29	1.01	0.08

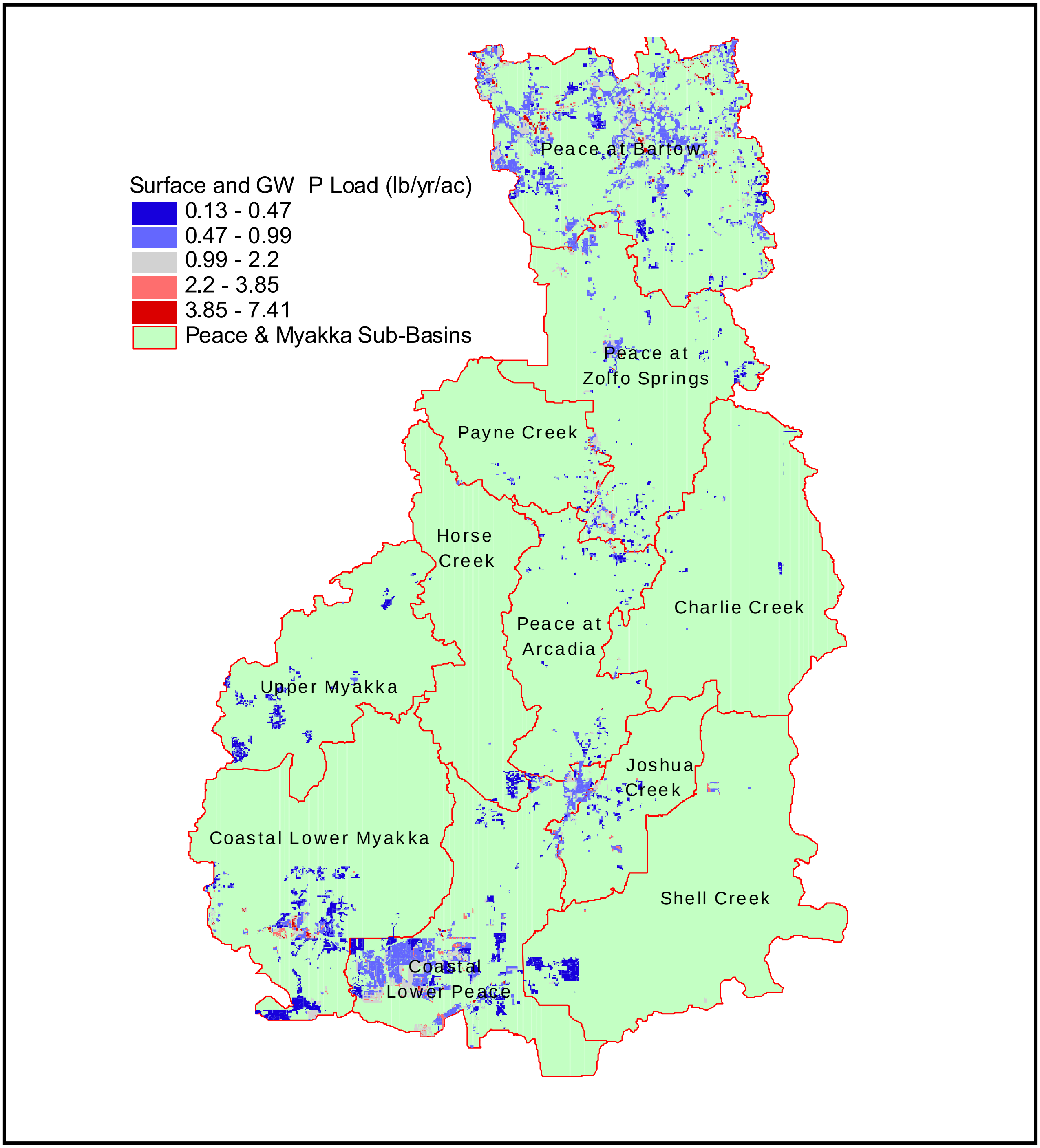


Figure 7
Phosphorus Loading (Surface and Groundwater) , lbs/acre/yr.
Note – Normalized for OSDS acreage. See Text

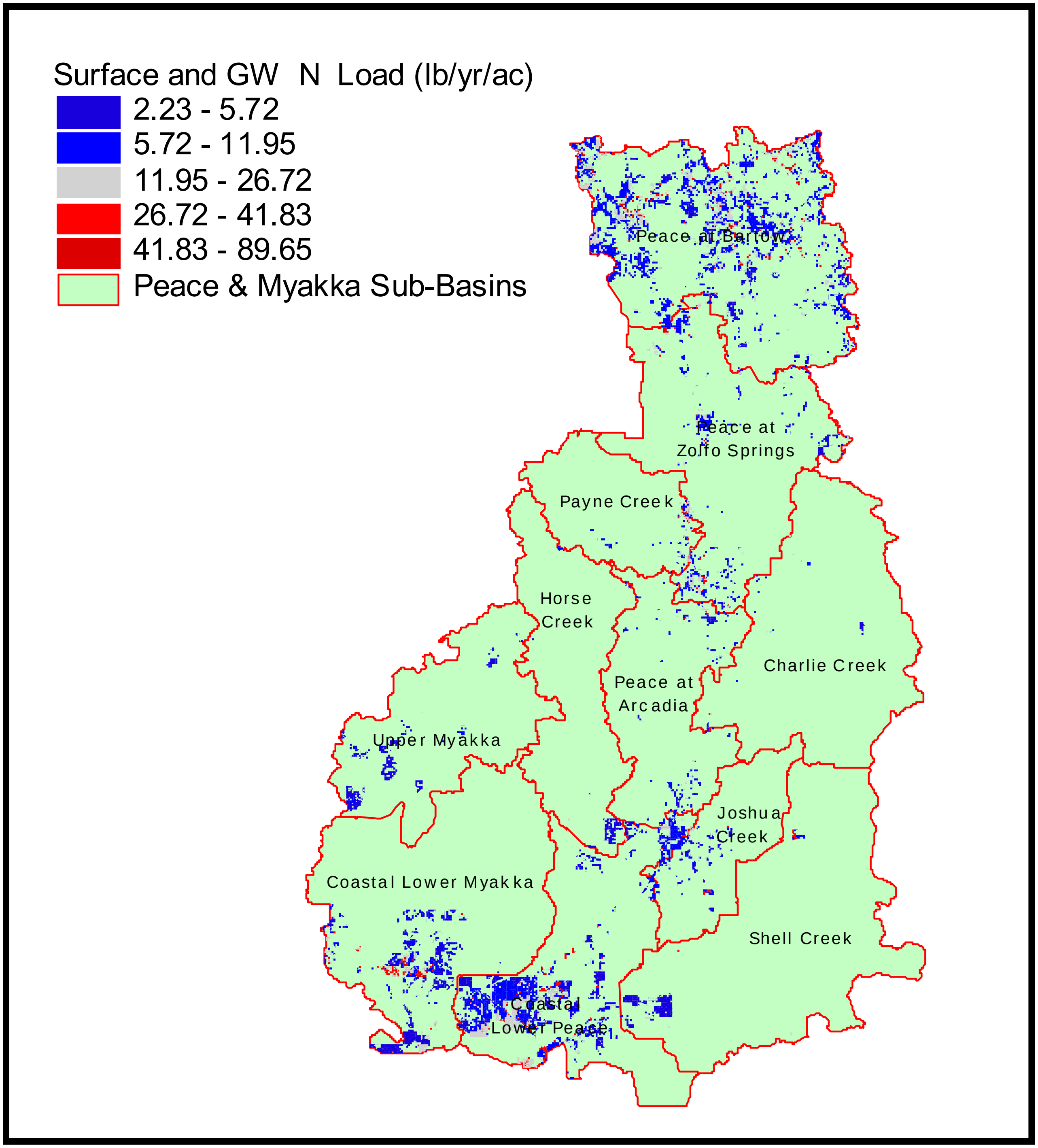


Figure 8
Nitrogen Loading (Surface and Groundwater) , lbs/acre/yr.
Note – Normalized for OSDS acreage. See Text

vertical soil attenuation in the SWIS from properly functioning OSTDS, but does not account for attenuation during lateral groundwater migration.

4.3 Identification of OSTDS 'Hot Spots'

The hotspot analysis protocol of MANAGE model was used to identify potential high-risk pollution source areas in the Peace and Myakka sub-basins. This analysis uses GIS techniques to combine high-intensity land use with high-risk soil and known OSTDS densities for a rapid screening of potential OSTDS impacts to surface and ground water quality.

Hotspot analysis maps were created using ArcGIS 8.3© and the following data layers which were also used to develop the loading estimates:

- 1990 U.S. Census Data – Census data was received from the U.S. Census Bureau and was used to establish septic tank density within the project area. Septic information, categorized by Block Group, was derived from individuals responding to the 1990 long form. Based on the total number of individuals responding in each Block Group a percent septic density was determined. This information was then joined to a U.S. Census Block Group shapefile and is further described in Section 2.1.
- 1995 Land use obtained from the Southwest Florida Water Management District (SWFWMD as a shapefile based on Florida Department of Transportation (FDOT) Level II FLUCCS as described in Section 2.3.
- HSG and water table depths information were obtained from the National Resource Conservation Service (NRCS) county soil report as a GIS shapefile. Hydrologic soil groups are described in Section 2.4.
- Nutrient Loading – Loading information was generated by the model MANAGE during the nutrient analysis part of this project and described in Section 4.1.
- Probability Septic (Charlotte County) – 2002 Septic density information was obtained from Charlotte County's GIS department as a GIS point shapefile. This ongoing GIS project identifies septic locations by combining property appraiser information and wastewater treatment service area information. All properties with structures not serviced by wastewater treatment are assumed to be serviced by OSTDS and identified with a point.
- OSTDS New (State Health – Sarasota County) – 2002 OSTDS information was obtained from Sarasota County's GIS as a point shapefile. This project is an ongoing Sarasota County Health Department project which uses information obtained from permit applications to determine OSTDS locations.

The ‘hotspot’ identification is based on the premise that higher intensity urban land uses are more likely to produce pollutants than less intense land uses, and that higher intensity urban land uses using OSTDS are more likely to produce pollutants than comparable land uses levels utilizing centralized sewer treatment for wastewater management. The highest potential for OSTDS generated pollutants may be visualized by overlaying 1995 land use with 1990 septic information. Next high-infiltration areas and runoff-generating soils using soil permeability and water table depth were identified. Mapping soil permeability helps to establish water and pollutant movement. High-infiltration soils are more likely to move water and pollutants via groundwater whereas poorly drained soils are more likely to lead to water and pollutant movement via surface runoff. Finally, urban land uses with seasonally high water table soils were mapped as a hotspot indication for stormwater runoff and septic system failure.

The project area was divided into four geographic regions to aid in visual interpretation. The upper Peace region includes the Peace at Bartow, Payne Creek, and Peace at Zolfo sub-basins. The middle Peace region includes the Horse Creek, Peace at Arcadia, and Charlie Creek sub-basins. The lower Peace region includes the Coastal Lower Peace, Joshua Creek, and Shell Creek sub-basins. And finally, the Myakka region includes the Upper Myakka and Coastal Lower Myakka sub-basins. Results for each geographic region are summarized below. Graphic results are included as **Appendices C-F**.

<u>4.3.1 Upper Peace Region</u>

The upper Peace region includes the Peace at Bartow, Payne Creek, and Peace at Zolfo sub-basins.

- Peace at Bartow – This sub-basin has the largest spatial coverage and highest intensity of urban land use types in the upper Peace region with all urban land use types present. The highest concentrations of urban land uses occur within and directly adjacent to incorporated communities and along major roadways.

  Septic densities in the Peace at Bartow sub-basin range from 0-100 percent at the Block Group level. Septic densities are lowest in incorporated areas where municipal wastewater treatment facilities are available. Wastewater treatment is also available at the county level for several geographic regions including a large area between Lake Hancock and Winter Haven, and an area between Lake Hancock and Hillsborough County south of Lakeland. Smaller areas serviced by county wastewater treatment facilities throughout the sub-basin include an area south of Frostproof, an area west of Lake Pierce, and an area south of Dundee.

  Potential hotspots for OSTDS generated pollutants include the urban areas in and around Lakeland not serviced by wastewater treatment facilities, the urban area along Business U.S. 98 between Lakeland and Auburndale, and the urban areas outside of municipal waste waster service, in and around Winter Haven and the Chain of Lakes region.

  Soils in the Peace at Bartow sub-basin tend to be excessively permeable to well drained, a hotspot indication for groundwater transport of OSTDS generated pollutants. Seasonally high water table soils (0-3.5 ft) occur at a lower frequency in this sub-basin when compared to other sub-basins in the project area. Previously noted hotspot areas occurring on seasonally high water table soils include the urban areas around Lakeland not serviced by wastewater treatment facilities and the urban area along U.S.B. 98 between Lakeland and Auburndale. As a result, these areas are at higher risk for stormwater runoff and septic system failure.

Nutrient loads to surface and ground waters in the Peace at Bartow sub-basin from septic tanks are highest in the area west of Lakeland at U.S.B 98, but are also elevated in the other identified and unidentified potential hotspot areas.

- Peace at Zolfo – Urban land use in this sub-basin is concentrated around four incorporated communities running north/south along U.S. 17.

  Septic density range from 0-100 percent at the Block Group level and is lowest in incorporated areas where municipal wastewater treatment is available. Hotspots in this sub-basin are found in and around incorporated areas following U.S. 17 north and south.

  Soils in the Peace at Zolfo sub-basin range from excessively permeable to poorly drained in the northwest half of the sub-basin, and from well drained to moderately drained in the eastern and southern half of the sub-basin. As such, pollutant loads to both surface and ground waters are likely.

  Seasonally high water table soils (0-3.5 ft) in this sub-basin cover much of the eastern and southern half of the sub-basin and follow the general pattern of hydrologic soil type in the northwest half of the sub-basin with high water table soils occurring primarily on poorly drained soils. Previously mentioned potential hotspots in this sub-basin do not occur on seasonally high water table soils, with the exception of the urban area located outside of incorporated Wauchula at the southern end of the sub-basin. This area outside of Wauchula presents a greater risk of stormwater runoff and septic system failure.

  Nutrient loads to surface and ground waters from septic systems in the Peace at Zolfo sub-basin are highest in and around the incorporated cities and U.S. 17 running between them.

- Payne Creek – Minimal urban land use occurs in the Payne Creek sub-basin. The highest intensity land use is found in and around Bowling Green, which straddles the Payne Creek and Peace at Zolfo sub-basins.

  Septic density in the Payne Creek sub-basin ranges from 9-100 percent at the Block Group level and is lowest along the eastern edge of the sub-basin from Bowling Green south along U.S. 17. No hotspots were noted in this sub-basin.

Soils in the Payne Creek sub-basin range from excessively permeable to poorly drained in the northern half of the sub-basin and from well drained to moderately drained in the southern half of the sub-basin. Seasonally high water table soils (0-3.5 ft.) follow the pattern of hydrologic soil type with high water table soils occurring in all areas of the sub-basin except those areas with excessively permeable soils.

Minimal nutrient loading from septic systems occur in this sub-basin. Nutrient loads that do occur are highest around Bowling Green and along U.S. 17 located on the eastern edge of the sub-basin.

<u>4.3.2 Middle Peace Region</u>

The middle Peace region includes the Horse Creek, Peace at Arcadia, and Charlie Creek sub-basins.

- Horse Creek – Urban land use in the Horse Creek sub-basin is confined to the southern tip of the sub-basin where minimal low intensity residential land use is present.

  Septic density ranges from 59-100 percent at the Block Group level. No hotspots were identified in this sub-basin, as very minimal urban land use is present.

  Soils in the Horse Creek sub-basin are primarily well drained although moderately and poorly drained soils are also present. Seasonally high water table soils (0-3.5 ft.) cover the majority of this sub-basin.

  Minimal nutrient loading from septic systems occur in this sub-basin.

- Peace at Arcadia – Urban land use in the Peace at Arcadia sub-basin occurs primarily at the very north and south of the sub-basin. At the north, low-intensity residential land use is found around incorporated Zolfo Springs. In the south, low to moderate intensity land use is found in and north of incorporated Arcadia, which straddles the Peace at Arcadia and Coastal Lower Peace sub-basins.

  Septic density ranges from 12-100 percent at the Block Group level with the lowest septic density occurring within the incorporated areas. No hotspots were identified in this sub-basin although continued growth in urban landuse should be monitored along U.S. 17 north of Arcadia.

  Soils in the Peace at Arcadia sub-basin are primarily well drained with poorly drained soils occurring along the Peace River. Seasonally high water table soils cover most of this sub-basin.

  Minimal nutrient loading from septic systems occur in this sub-basin. Nutrient loads that do occur are highest at the southern end along U.S. 17 north of Arcadia.

- Charlie Creek – Minimal low intensity urban land use occurs in the Charlie Creek sub-basin, although is should be noted that land use data was not available for a small area located at the southeastern edge of the basin.

  Septic density ranges from 28-100 percent at the Block Group level. It should also be noted that septic density information was not available for the portion of this sub-basin falling inside Highlands County. No hotspots were identified in this sub-basin because of the lack of urban land use.

  Soils in the Charlie Creek sub-basin are primarily well drained with highly permeable soils occurring along the eastern edge of the sub-basin and poorly drained soils occurring along Charlie Creek. Seasonally high water table soils cover the majority of this sub-basin.

  Minimal nutrient loading from septic systems occur in this sub-basin.

<u>4.2.3 Lower Peace Region</u>

The lower Peace region includes the Coastal Lower Peace, Joshua Creek, and Shell Creek sub-basins.

- Coastal Lower Peace – Urban land use occurs at all levels in the Coastal Lower Peace sub-basin with the largest intensity and spatial coverage occurring in the unincorporated area of Port Charlotte. Moderate to low intensity urban land use is also present in incorporated Punta Gorda and Arcadia, and along U.S. 17 that runs between these two cities.

  Septic densities range from 0-100 percent at the Block Group level. The lowest septic densities occur within incorporated Punta Gorda and Arcadia. Septic densities are also low east of I-75 in Port Charlotte in a sub-division known as Deep Creek and within several Block Groups east and west of U.S. 41 in Port Charlotte that are provided wastewater treatment through county facilities.

  Potential hotspots for OSTDS generated pollutants include all of Port Charlotte and the urban area along U.S. 17 between Punta Gorda and Arcadia.

  Additional and more current OSTDS information is available for the portions of this sub-basin falling within Charlotte and Sarasota counties. This information supports the hotspot determinations made above, and particularly that of the heavily populated areas of Port Charlotte.

  Soils within the Coastal Lower Peace sub-basin include all hydrologic groups. Well drained soils dominate much of this sub-basin with poorly drained, moderately drain and occasionally excessively permeable soils occurring along the Peace River and its tributaries. Poorly drained soils increase in prevalence in the northern (Desoto County) portion of the sub-basin. Seasonally high water table soils (0-3.5 ft.) cover much of this sub-basin, increasing the risk of stormwater runoff and septic system failure in the urban areas where they occur.

Nutrient loads to surface and ground waters from septic tanks in the Coastal Lower Peace sub-basin are potentially highest in the Port Charlotte area, but are also elevated in the other potential hotspot areas previously identified.

- Joshua Creek – Low to moderate intensity urban land use occurs sporadically in the southern half of this sub-basin, with the majority of urban land use radiating out from Arcadia to the north and south of Joshua Creek, primarily along U.S. 17, S.R. 31, and S.R. 70.

  Septic densities range from 79 to 97 percent at the Block Group level. Potential Hotspots in this sub-basin includes the moderate intensity land use areas along U.S. 17 and S.R. 31.

  Soils in the Joshua Creek sub-basin are primarily well drained with moderately drained soils occurring along Joshua Creek and poorly drained soils scattered throughout the sub-basin. Seasonally high water table soils (0-3.5 ft.) cover much of this sub-basin, increasing the risk of stormwater runoff and septic system failure in the urban areas where they occur.

  Nutrient loads to surface and ground waters from septic tanks in the Joshua Creek sub-basin are highest along S.R. 31 and the small stretch of U.S. 17 that runs through the sub-basin.

- Shell Creek – Minimal urban land use occurs in this sub-basin, and consists of low intensity residential concentrated around Shell Creek at the western edge of the sub-basin. It should be noted however that land use data was not available for the areas of this sub-basin occurring in Highlands and Glades counties.

  Septic density ranges from 66-94 percent at the Block Group level. No hotspots were identified in this sub-basin, as very minimal urban land use is present at this time. As urban landuse increases along the southwestern edge of the sub-basin potential hotspots may arise.

  Soils in the Shell Creek sub-basin are primarily well drained with excessively permeable soils occurring along Shell Creek and poorly drained soils scattered throughout the sub-basin, mostly east of S.R. 31. It should be noted that soil data was not available for the small area of this sub-basin occurring in Glades County.

  Seasonally high water table soils (0-3.5 ft.) occur throughout most of this sub-basin; however, they are generally absent in the area of shell creek where excessively permeable soils and urban land use occurs. This decreases the risk for stormwater runoff and septic system failure.

Minimal nutrient loading from septic systems occur in this sub-basin. Nutrient loads that do occur are highest at the eastern edge of the sub-basin where low-density urban land use is present.

4.3.4 Myakka Region

The Myakka region includes the Upper Myakka and Coastal Lower Myakka sub-basins.

- Upper Myakka – Urban land use in the Upper Myakka sub-basin occurs at both a low density and frequency.

  Septic densities range from 95-100 percent at the Block Group level. No hotspots were identified in this sub-basin due to the lack of urban land use. As urban landuse increases along the western edge of the sub-basin near upper and lower Myakka Lakes, potential hotspots may arise.

  Soils in the Upper Myakka sub-basin are primarily well drained with the other major hydrologic groups occurring throughout the sub-basin. Seasonally high water table soils cover the majority of this sub-basin.

  Minimal nutrient loading from septic systems occur in this sub-basin. Nutrient loads that do occur are highest in Myakka City located in the center of the sub-basin.

- Coastal Lower Myakka – All urban land use types occur in the Coastal Lower Myakka sub-basin with the highest intensity urban land uses concentrated around North Port and to a lesser degree around Golf Cove located on the west side of the Myakka River and El Jobean on the eastern side of the Myakka River, both located at the southern end of the sub-basin.

  Septic densities range from 1-100 percent at the Block Group level with the highest septic densities occurring in the northern half of the sub-basin where urban land use is lacking. Other high-density septic areas include the low-density land use areas of Golf Cove and North Port. North Port, Golf Cove, and El Jobean are all potential hotspots in this sub-basin. It should be noted that septic density information for several Block Groups in the North Port area was unavailable.

  Additional and more current OSTDS information is available for the portions of this sub-basin falling within Charlotte and Sarasota counties. This information supports the hotspot determinations made above.

  Soils in the Coastal Lower Myakka are primarily well drained with scattered poorly drained soils. Excessively permeable soils are located between U.S. 41 and S.R. 776, an area of minimal urban land use. Seasonally high water table soils cover most of this sub-basin including the hotspot urban land use areas identified above. These hotspot areas are therefore at greater risk for stormwater runoff and septic system failure.

Nutrient loads to surface and ground waters from septic systems are highest in the North Port area, north and south of U.S. 41 Nutrient loads are also elevated in the other identified potential hotspot areas.

5.0 MONITORING PROGRAM ELEMENTS

The suitability of soils in the Peace/Myakka watersheds for OSTDS use has been reported earlier in this report along with estimates of density and potential loading. High densities of OSTDS and installation in unsuitable soils significantly increase the probability of eutrophication in the receiving water and contamination with bacteria or viruses. However, monitoring those effects is complicated by the fact that the nutrient and biological pollution is not esoteric to human sewage. While several tracers that are unique to human waste have been proposed, each has limitations and separating the anthropogenic effects from other sources may require a suite of tests and adoption of a 'weight of evidence' approach. The remainder of this section is devoted to discussing tracers and techniques that can be used to determine the source of diffuse contamination. The list is not intended to be exhaustive, but rather to describe a range of popular techniques.

5.1 Tracer Background

Tracers can be broadly categorized into biological and chemical signatures of anthropogenic wastewater. To be useful, a tracer should involve a relatively inexpensive analysis and be a test commonly available through environmental labs. OSTDS are potential sources of high nutrients and fecal coliform counts and in the case of failing systems, one would expect to find both impacts in the receiving water. Nitrogen would be in the reduced form of ammonia and nitrite/nitrate would typically be low to non-detectable. In the case of functioning OSTDS, the degree of treatment and the pathway connecting the source and receiving water can drastically affect the quality. For example, the plume from a properly functioning OSTDS will contain high concentrations of nitrite/nitrate, but relatively low concentrations of phosphorus and low to non-existent coliform counts. Phosphorus forms complexes and is absorbed by minerals in the soil and the mechanical filtration of the biomat and soil effectively removes bacteria (but not viruses)

5.1.1 Biological Tracers

Fecal coliform are abundant in the gut of warm-blooded animals and for this reason, high concentrations are found in human sewage. However, there are numerous other non-human sources of fecal coliform in urbanized watersheds and the occurrence of high fecal counts does not prove the presence of domestic waste. Examples of non-human sources include waterfowl, pets, livestock (including small hobby farms), rats, raccoons, pigeons, gulls, beaver, and other urban wildlife commonly found along urban and suburban creeks in southwest Florida. Many animals produce a far greater number of counts daily in fecal matter than do humans and it should be noted that animal feces will also increase the nutrient concentrations. **Table 10** compares the daily discharge rate of fecal coliform for humans and typical urban/domestic animals. Genetic studies (Alderiso et al., 1996; Trial et al., 1993) indicated that 95 percent of fecal coliform in stormwater was from non-human sources. Two studies (Bannerman et al, 1993. Steuer et al., 1997) indicated that residential lawns, driveways and streets are the major source of bacteria in stormwater runoff. Curiously, both studies also indicated that end-of-pipe concentrations were an order of magnitude higher than the runoff source. One possible explanation of this is that the stormwater conveyance system itself was a major source. Studies by Burton et al. (1987) and Marino and Gannon (1991) have confirmed that fecal coliform bacteria can both survive and reproduce in the highly organic sediments frequently found in stormwater ditches and retention ponds. During a runoff event, the sediments are disturbed by the flow, releasing coliform bacteria.

Table 10
Daily Discharge of Fecal Coliform
(Counts/day)

Waterfowl	3.97E+09
Dog	3.34E+09
Duck	2.25E+09
Human	2.07E+09
Cow	1.61E+09
Cat	5.38E+08
Rat	5.81E+06

The mean concentration in urban runoff greatly exceeds Florida's 'not to exceed' fecal Coliform standard of 800 counts/100 ml. Pitt (1998) reported a mean count of 20,000 MPN/100ml using the results of the Nationwide Urban Runoff Program (NURP) completed in the 1980's by the United States Environmental Protection Agency (EPA) (1983). Under the NURP, more than 2,220 storm events were monitored at 28 urban locations across the U.S. Pitt (1998) reported on 25 studies conducted since the NURP evaluation and reported a mean coliform concentration of 20,000 MPN/100ml. The Center for Wetland Protection (Schueler, 1999) evaluated 34 recent urban monitoring programs and reported a geometric mean of 15,000 MPN/100ml.

Human sources may include sanitary sewer overflows (SSOs), illicit connections, septic systems, landfills, marinas, pumpout facilities and inadequately treated direct discharges. Recent evidence also indicates that fecal coliform can survive and even multiply in the sediments after runoff events. Surcharged stream conveyance systems that cause streambed erosion may actually re-suspend colonies deposited during previous events.

From a management perspective, even a minor amount of urbanization will produce non-point sources of coliform sufficient to cause exceedances of the 200 MPN/100ml national water quality standard adopted by EPA. Even in the absence of illicit connections or wastewater leaks, the typical urban stormwater values are two orders of magnitude greater than the national standard. Thus, fecal coliform alone is a poor indicator of OSTDS impact.

Traditionally, the ratio of fecal coliform (FC) to fecal streptococci (FS) has been used to assess whether the source is likely to be human or animal. However, the 18^{th} Edition of Standard Methods (APHA, 1992) is unclear about the use of the FC/FS ratio. In one method (Method 9213 D) the ratio is advocated while elsewhere in the same edition (Method 9230 A) the methodology is rejected. Generally, water resources managers are abandoning use of this ratio. Feachem (1975) reports that the ratio is constantly changing with time due to differing rates of die-off between the two bacterial groups. If the source is human, the ratio will start out high and decrease with time. In contrast, a non-human source begins with a low ratio, which increases with time. As a result, the test is only valid if taken within 24 hours following deposition of feces. If the travel time is known, then the source is known *a priori*. Even though the test is readily available and inexpensive ($55 estimated), the FC/FS ratio is not recommended.

It should be noted that fecal coliform are an imperfect indicator of sewage, but is used as a surrogate for other pathogenic agents in wastewater because it is easy to measure. The fecal coliform indicator used to measure water quality is also flawed because of the non-fecal souces of at least one member of the fecal coliform group. For example, the *Klebsiella* species have been observed in cotton mill wastewater and in sugar beet wastes in the absence of fecal contamination (EPA, 1986). Since 1986 EPA has recommended the use of Enterococci as the preferred organism for identifying wastewater contamination. Despite these recommendations, over ninety percent of the states still rely on fecal coliform. (Schuler, 1999)

More definitive source identification can be obtained by matching the genetic code of coliform bacteria found in receiving waters. Coliform bacteria are filtered from the suspect water source and incubated (Coastlines, 1998). A DNA pattern is obtained from ribosomal RNA of each isolate and compared to the DNA patterns of various sources. Large libraries of isolates have been developed for the scat of urban animals (pets, raccoons, beaver, migrating fowl etc.) and marine mammals. The similarity of the DNA patterns is used to assess the likelihood and variety of the source.

To some extent, the patterns remain consistent from region to region for a given source. Therefore, within limitations it is possible to use the DNA ribotype of a raccoon isolate from Florida to suggest a source of raccoon coliform in waters elsewhere. Once the candidate sources have been short-listed, local specimens can be collected and used to refine the testing. The cost of incubating coliform and preparing an RNA fingerprint from a local source is about $150 per coliform. For a typical urban evaluation, approximately 200-400 coliform cells are isolated, incubated and their RNA mapped. Cost of a typical program is $30,000 – 60,000. Only a handful of research laboratories are capable of providing this type of analysis.

Another technique that relies on development of a library is known as antibiotic resistance analysis (ARA) or multiple antibiotic resistance (MAR) that compares bacterial response (*fecal streptococcus* or *E. coli*) to a standard suite of antibiotics. The method is based on the premise that humans are exposed to a different set of antibiotics than are cattle, poultry, domestic animals and wild animals (no exposure). A database, or library of known antibiotic resistance patterns for target sources is developed first as shown in Table 10. Most investigators test each isolate with eight of more antibiotics and 30-70 antibiotic/concentrations. The results are subjected to a statistical technique (discriminant analysis) to generate predictive equations that are then used to classify the resistance patterns of unknown isolates by source (Haywood, 1999). For example, the test results can identify the probability that an unknown bacterial sample collected from a stream was from a raccoon, squirrel, bovine or human source. Classification accuracy is typically 50-90 percent (Harwood, 2003. BST, 2000.) with a good local library. In the example case illustrated, 94.9 percent of the bird isolates, 72 percent of the cow, 94.8 percent of the dog isolates etc. were correctly identified. The average rate of correct classifications indicates the overall accuracy of the database, which in this case is 83 percent. Collection of source material and development of the library can run from

Table 11
Example ARA Database Illustrating Percent Correct Identification of Known Sources.

Source	Bird	Cow	Dog	Human	Pig	Total
Bird (# Samples)	258	10	1	1	2	272
(Percent Correct)	94.85	3.68	0.37	0.37	0.74	100.00
Cow (# Samples)	6	219	17	25	37	307
(Percent Correct)	1.97	72.04	5.59	8.22	12.17	100.00
Dog (# Samples)	3	9	273	0	3	288
(Percent Correct)	1.04	3.13	94.79	0.00	1.04	100.00
Human (# Samples)	21	15	23	246	12	317
(Percent Correct)	6.62	4.73	7.26	77.60	3.79	100.00
Pig (# Samples)	4	55	2	20	252	333
(Percent Correct)	1.20	16.52	0.60	6.01	75.66	100.00
Total (# Samples)	292	308	316	292	306	1514
(Percent Correct)	19.29	20.34	20.57	19.29	20.21	100.00

$6,000 to $15,000 but once established the actual cost of analyzing unknown samples is on the order of $200.

Enteric viruses and pathogens have also been used as direct evidence of contamination with sanitary wastewater. Organisms such as coliphage and bacteroides that reproduce only in bacteria found in the human digestive system can be used as definitive tracers. However, only specialized laboratories can provide analysis of enteric viruses, and thus costs are difficult to estimate. A recent investigation of enteric viruses by Dr. Joan Rose in Chassahowitzka (a spring-fed river) was completed for $60,000 (Leary, 2001).

5.1.2 Chemical Tracers

Nutrient concentrations may be indicative of OSTDS impacts, but as previously discussed, there are numerous sources of elevated nutrient concentrations. Other constituents that are found in wastewater provide better evidence of anthropogenic sources.

Surfactants are widely used in both domestic and industrial detergents and are commonly measured as Methylene-Blue Active Substances (MBAS). However, the MBAS test is not specific to the Linear Alkylbenzesulfonates (LAS), which is the predominant class of anionic surfactants. In studies of the Mississippi River (Barber et al., 1995, interference from naturally occurring MBAS substances (e.g. humic acids) resulted in poor correlation between MBAS and direct measurement of LAS. Thus, direct testing for LAS is preferred over the more common MBAS measurement of surfactants. LAS degrades easily under aerobic conditions and can be measured in either aqueous or sediment samples. Results of the Mississippi River studies indicate aqueous concentrations ranging from 0.00005 to 0.01 mg/l and sediment concentrations ranging from 0.1 to 1 mg/kg downstream of major urban centers.

Surfactants are present in domestic wastewater in the range of 1-20 mg/l (Standard Methods, 18th Edition. APHA, 1992). Analysis of MBAS is a commonly measured water quality parameter and is a useful tracer in the absence of naturally occurring interferences. Direct measurement of LAS is a more complex analysis requiring infrared spectroscopy or gas chromatographic techniques and is not a common analysis for commercial environmental laboratories. As with all of the non-specific tracers, the presence of LAS is not confirmatory for domestic sources alone, but can be expected to increase with proximity to either a domestic or industrial wastewater source.

Coprostanol is a fecal sterol that exists in human and animal wastes. It exists as a series of chemical isomers. The ratio of certain isomers is relatively specific for humans. Because of coprostanol's affinity for particulates, coprostanol measurements are typically performed on sediments. Coprostanol is more persistent in sediments than LAS. Sediment concentrations in excess of 0.1 mg/kg and containing the specific mix of isomers indicate human sewage contamination. Coprostanol is not commonly analyzed by commercial environmental laboratories, although several universities and research organizations do conduct this test.

Caffeine is naturally present in coffee, and is an additive in many soft drinks and food products, which makes caffeine a fairly specific tracer of domestic wastewater. Concentrations in municipal wastewater range from 20-300 ug/l. A study done by USGS (McCorquodale, 1997) on the Mississippi River found the highest concentrations near metropolitan areas. However, unless sophisticated analytical techniques are employed, caffeine levels must be in high concentrations before they are detectable, and Sargane (1999) reports that a dilution of more than 200:1 will typically result in non-detectable concentrations for most laboratories. On the other hand, the USGS (NWQL, 1997) has modified the standard GC/MS technique developed for priority pollutants to achieve a method detection limit of 0.02 ug/l and FIU (Gardinali, 2002) has developed a methodology that achieves a limit of detection of 4 ppt (0.004 ug/l) that extends the value of caffeine as a tracer. The USGS estimates the cost per analysis at these low-levels to be approximately $200/sample (Gardinali, 2002 and R. Seiler, personal communication). It should be noted that while caffeine is a very good indicator of wastewater discharge, there are data (San Diego DEH, undated. BST, 2003) that caffeine has the potential to degrade in soil and thus for working septic tanks the levels may fall below detection limits prior to reaching the receiving water. For purposes of the present evaluation, this may limit the value of this potential tracer to the location of failing septic tanks.

EDTA (ethylene diamine tetra-acetic acid) is widely used in domestic and industrial applications to solublize metals. Uses include bleaching agents in domestic laundry soaps, and prevention of boiler scale in industry. It is also an additive to many food products. Like LAS and other non-specific tracers, its presence is suggestive of anthropogenic sources, but cannot differentiate sanitary wastewater from other types of sources.

Fluoride may be a useful tracer when ambient levels are low. The American Dental Association recommends a concentration range of 0.7-1.2 mg/l in potable water for dental health and many communities add fluoride to potable water. Where potable water is fluoridated and where ambient fluoride concentrations are low, the presence of elevated fluoride values may be used to assist in identifying waters of anthropogenic origin. However, it should be noted that fluoride levels would also be elevated in grey water, car wash water and other non-sanitary sources. Fluoride is an inexpensive analysis commonly provided by commercial laboratories

Although the ratio varies regionally, the ratio of ammonia to potassium was found to be a useful tracer in Birmingham, Alabama (Lalor, 1993). The mean ratio in sanitary wastewater (1.7) and septic tank effluent (5.2) were two orders of magnitude greater than ambient, potable water, car wash water and radiator flush water ratios. Both ammonia and potassium are inexpensive analyses commonly provided by environmental laboratories.

Brightening agents used in laundry products have also been used as tracers for the detection of failing septic systems. These compounds fluoresce under ultraviolet light and can be detected in the field with a portable fluorometer. There is no EPA approved methodology for the analysis of brighteners, and commercial environmental laboratories do not commonly provide this test. Once the equipment has been purchased (Estimated cost of $12,000 for a Turner AU-10 field fluorometer with appropriate filters[5].), there is no additional per/sample cost for chemicals, as the technique is instrumental in nature. It has the added advantage that it can be conducted in the field providing immediate results if a field fluorometer is available. In practice, a flow-through cell is used with the field fluorometer to obtain a continuous sampling.

[5] http://www.turnerdesigns.com/t2/esci/esci.html

Field fluorometry has been used successfully in Texas (TAMU, 1999. Humphry et al. 1998) and in Indiana (Grant, 1998) to identify OSTDS plumes in receiving waters. For best results, it is necessary to establish an ambient background fluorescence in each waterbody and sampling should be conducted early in the morning before brighteners decay in sunlight. The technique offers a cost-effective screening tool that can isolate areas of probable impact. In a study of 18 lakes in Indiana, Grant (ibid) used a flow-through fluorometer to identify shoreline areas for conventional coliform and phosphorus sampling. The instrument-aided results indicated a statistically significant ($p<0.0019$) increase in both phosphorus concentrations and Coliform counts. The phosphorus concentrations were 2-10 times higher in waters with high fluorescent when compared to shoreline samples with indicated low fluorescence. A typical fluorescents graph illustrates the technique. Controls were an undeveloped lake and a lake served by central sewer, neither showing positive fluorometry results. By contrast, all of the lakes served by OSTDS tested positive for septic plumes discharging into the near-shore areas of the lake. It should be noted that all of the septic systems were dye-tested for straight pipe discharge and/or surface failure prior to the study.

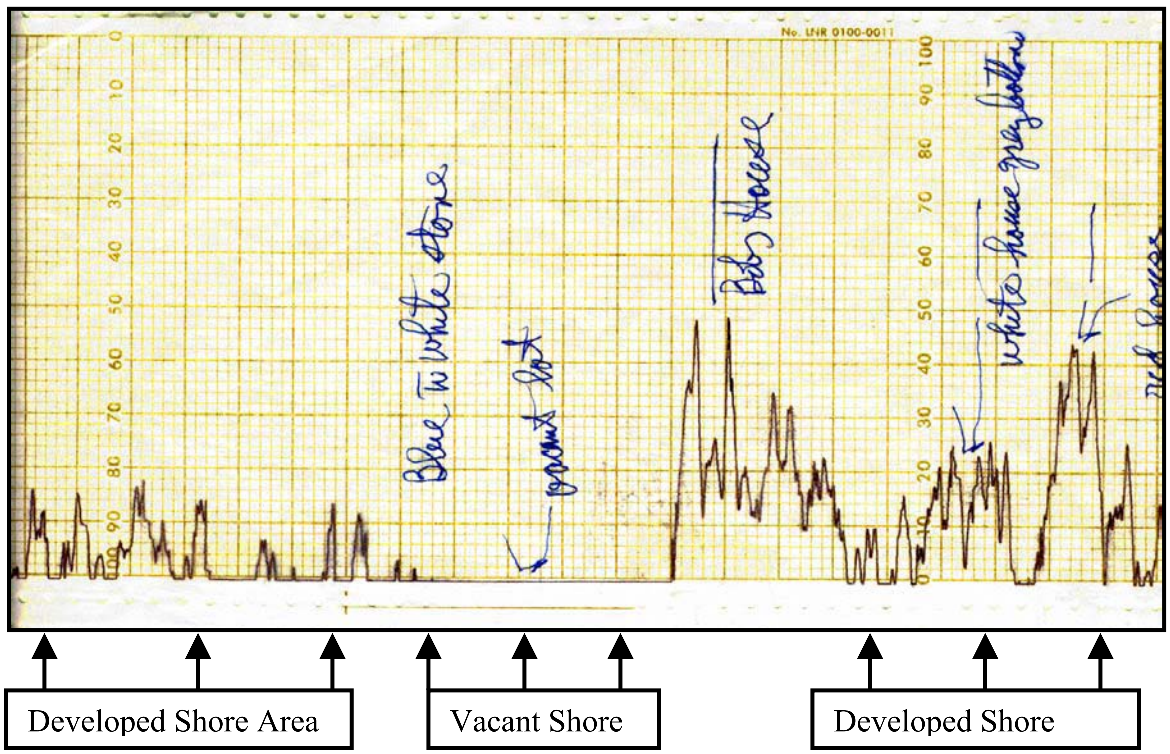


Figure 10
Leachate Detector Survey of Near-Shore Area of Developed Lake with Septic Systems..
(Reprinted with permission)

A less expensive sampling variant involves placement of absorbent cotton pads in areas of suspected OSTDS impacts. The pads are left in place for one week and then recovered. A simple black-light (UV lamp) is then used to detect the presence of brighteners absorbed onto the pads. An Optical Brightener Handbook describing the technique is available from the Merrimack Planning Commission (Sargent and Castonguay, 1998)

Although not widely used, the enrichment of isotope ratios of nitrogen (N^{15}/N^{16}) and of oxygen (O^{18}/O^{16}) over a standard ratio have been used (Aravena et al. 1993) to characterize the source water. As nitrogen passes through trophic levels, the ratio of heavier isotopes changes. It is possible to differentiate between "new" atmospheric nitrogen and nitrogen from fertilizer, or nitrogen from wastewater sources. Since Florida has no naturally occurring source of nitrate, King (2000) reports that the N^{14}/N^{15} ratios in nitrate can indicate whether the origin was organic or inorganic. Oxygen and hydrogen have also been used. However, few laboratories can analyze for these stable isotopes.

Fluorescent dyes, such as rhodamine or fluorosine (uranine) are frequently used to detect failing septic tanks. The dye is flushed through the toilet. If the absorbtion field is not working, the dye may appear in seepage puddles. After a period of time (hours to days), it may appear in nearby groundwater or in downgradient receiving waters. Uranine retention in soil approximates the renovation properties of soil. Rhodamine WT is nontoxic, easy to measure and approved for use by EPA (Turner Designs, Undated) but it readily absorbs to clay particles in the soil, and as such it is not as effective at verifying malfunctions (Robillard et al. Undated). It can be detected in wastewater systems *in-situ* using a field fluorometer at levels of approximately 100 parts per trillion (0.1 ug/l). As an alternative and similar to the use of cotton with brighteners, charcoal packets can be placed at suspected discharge points and retrieved 7-14 days later.

Increasingly researchers are promoting a multi-parameter approach. King (2000) promoted the use of isotopes, caffeine, and enterococci bacteria as a 'smoking gun' to detect OSTDS impacts and Hagedon (BST, 2003) recommends a "toolbox" approach. The National Park Service (NPS) and the United States Geological Survey (USGS) began a monitoring program for those portions of the Chattahoochee National Recreation Area located within metropolitan Atlanta. One of the primary objectives of the program is to identify the sources of microbial contamination. The USGS is currently developing a standard protocol and a list of 46 parameters to be used in tracing the source of domestic and industrial wastewater. The draft list is included as **Appendix G**.

6.0 CONCLUSIONS AND RECOMMENDATIONS

With the exception of the availability of central wastewater service, the data available for the present evaluation is nearly 100 percent complete for soils, general OSTDS usage and land use. The extent of missing data ranged from 0.1 to 3.8 percent of the study area. If site location of OSTDS were available, the distance to a receiving waterbody could have been determined and the OSTDS loading estimates refined.

Urbanization is small fraction of the overall land use in the study area. The present estimate is 6.5 percent of the total area (~192 mi^2). The present estimate excludes extractive/mining that is defined as a FLUCCS coded urban area and has been included in previous estimates of urbanization in the watersheds. Of the remaining urban land uses that have wastewater disposal needs, approximately 55 percent (105 mi^2) utilize some form of on-site disposal. Approximately 4 percent of the total area is served by OSTDS.

The total population as reported by the U.S. Census bureau does not agree with an estimate derived from land use area, defined dwelling unit densities and the number of residents per dwelling unit. In order to match the Census bureau estimates, uncharacteristically low estimates of dwelling unit densities were required. As a result, two estimates of OSTDS loading were developed for a) dwelling unit densities typical of the area and b) lower densities required to match the published population.

The majority (>58 percent) of the urban soils in the watershed are unsuitable for OSTDS use because the SHWT will interfere with the drainfield. Based on the soil characteristics, 15 percent of the established OSTDS are believed to be showing signs of failure for all, or part of the year. Except as noted in the text, estimates of loading followed the algorithms found in the University of Rhode Island MANAGE model. Failing OSTDS are assumed to produce surface runoff of effluent, while functioning OSTDS are assumed to produce groundwater pollution. Inputs derived from Florida studies were used to the extent possible.

MANAGE does not consider the attenuation that results from horizontal groundwater migration of OSTDS loads. There is inconsistency among researchers on which pathways to simulate and which losses to include, making comparison between studies difficult. The present study adopted values developed through modeling for Port Charlotte. The adjusted current results are similar to previous estimates developed for the watershed. However, the assumptions of the attenuation model should be verified with field sampling of the surficial groundwater downgradient of the drainfield. A local study should be undertaken to monitor the decline of total nitrogen, ammonia, nitrate-nitrogen and total phosphorus in the plume.

The combination of unsuitable soils and high densities of OSTDS result in high predicted localized loadings. Hot spots have been identified and estimates of per acre loadings have been developed for these areas. Measured values in one predicted area indicated that the water quality chronically exceeded water quality standards for dissolved oxygen.

Despite the widespread use, fecal coliform monitoring is an insufficient tool for assessing OSTDS impacts because it is not specific to humans. A preferred approach using biological monitors is the use of ARA to define the source of bacterial contamination.

The recommended monitoring program consists of the following components:

- Rent a field fluorometer[6] and measure laundry brighteners to identify shorelines of OSTDS influence. Trial measurements should be conducted during the wet season to assure that naturally occurring humic and tannic substances will not interfere. If the procedure is successful, optionally purchase a field fluorometer for continued identification of impacted sites.

- Once impacted sites have been identified, complete a series of monitoring events at the impacted and non-impacted sites for commonly measured parameters (bacteria, conductivity, pH, N and P nutrient series, fluoride, potassium, MBAS or LAS). Complete a rigorous statistical comparison including step-wise regression, and discriminant analysis of the water quality data with the goal of identifying a commonly measured constituent, ratio of constituents or multiple constituents that could be used by others in the watershed for screening.

- Develop a local ARA database that can be used when needed to confirm the source of bacterial contamination.

In addition to the monitoring program, a pro-active management strategy at the local-government level is strongly recommended. The thrust of EPA's (EPA, 2003) recent guidelines for OSTDS stress the need to develop programs that will either promote (through education) or require (through ordinance) regular inspection and maintenance. Charlotte County's program to identify site locations is part of a larger program outlined in the county's comprehensive plan to develop a county-wide management plan. Within that context, the University of Florida is conducting a 3-year study of solids build-up in Charlotte County OSTDS. The results will be used to determine the pump-out frequency. Ultimately, the county's OSTDS management and maintenance program will require home-owners to have their systems inspected and pumped-out. Another requirement of the county's comprehensive plan is that the county complete a surface and groundwater monitoring program aimed at determining the impacts of wastewater activities. The combination of these elements (identification, management and monitoring) provides the mechanism for minimizing OSTDS impacts within the county. It is recommended that other local governments adopt similar programs. CHNEP could support these efforts through several mechanisms. In many cases, the only record of OSTDS location is through construction or repair permits which are often in paper form. CHNEP could provide financial, or coordinate volunteer assistance in converting the hardcopy records to digital media support. CHNEP could also assist in the direct support of monitoring programs.

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[6] Turner Instruments offers rental equipment at the rate of $1,462/2 weeks. Personal communication Rob Ellison. Director of Sales and Marketing.

One component of an OSTDS mangement program will be routine pump-out of the septic tanks. Once implemented, septic sludge disposal will likely increase. The overall OSTDS management program should include a component to develop a database for the monitoring and management of the sludge disposal. Suitable sites should be for spreading and disposal which are isolated, have low runoff potential and are sited away from surface water bodies. In the absence of sites suitable for land-spreading, a regional sludge drying and management facility should be evaluated.

It is also recommended that an OSTDS educational program be developed and disseminated. As a minimum, the program should include discussion of the following components:

- Proper siting and construction (new installations)
- Signs of failure
- Repair/Renovation options
- Inspection frequency
- Pump-out frequency
- Materials that should not be introduced
- Effect of garbage disposal
- Alternative technologies

The recommended action items are summarized in **Table 12**. In conclusion, the present OSTDS impacts in the Peace and Myakka watershed are limited to a few enclaves of urbanization. Taken in a watershed context, the loadings are small because of low degree of urbanization. While it is believed that most of the existing OSTDS were in compliance at the time of construction, it is probable that most do not comply with current standards.

Table 12
Recommended Action Items

1.	Initiate OSTDS Downgradient Plume Monitoring for Nutrients. Determine Appropriate Set-Backs from Waterbodies
2.	Develop Antibiotic Resistance Analysis Database of Local Sources
3.	Determine Feasibility of Using Optical Brightners to Identify OSTDS Impacts
4.	Conduct Expanded Conventional Monitoring, Using OB Techniques to Focus Efforts. Conduct Rigorous Statistical Evaluation of Results to Determine if Conventional Monitoring is Effective At Isolating Impacts/OSTDS Sources
5.	Develop Comprehensive OSTDS Management Plan, Including Sludge Management

If the use of OSTDS continues and as urbanization becomes more widespread, the cumulative impact may be detectable at the watershed level. However, the combination of inadequate soils and the current high densities of OSTDS can cause localize degradation of water quality and habitat. Identifying and quantifying those impacts requires application of several monitoring techniques that have been described. One sequence of activities has been proposed, which if successful would result in multi-parameter analysis tool that could be used throughout the watershed to further identify areas of OSTDS impacts. Pro-active management of those impacts will require a policy of proper site identification, homeowner education, regular inspection/maintenance of the facilities and a suitable means of managing the sludge.

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Appendix A.
Land use by Basin and Hydrologic Soils Group

	Land use	A, A/D	B, B/D	C, C/D	D, W
Coastal Lower Peace	< 2 du/acre, Residential	299.3	4,720.4	244.8	327.8
	2-5 du/acre, Residential	119.7	8,411.4	1,740.2	346.6
	> 5 du/acre, Residential	5.4	443.5	47.0	62.4
	Commercial Services	7.4	997.3	56.2	80.2
	Industrial		118.9		1.0
	Institutional	5.5	94.9	19.1	8.4
Peace @ Arcadia	< 2 du/acre, Residential	47.7	1,189.8	242.1	203.8
	2-5 du/acre, Residential	20.2	65.6	25.7	8.8
	> 5 du/acre, Residential	20.8	59.3	29.6	19.6
	Commercial Services		102.8	18.9	9.4
	Industrial	23.9	20.2		1.2
	Institutional	15.8	15.4	1.6	1.7
Peace @ Zolfo Springs	< 2 du/acre, Residential	316.0	1,288.7	334.0	100.5
	2-5 du/acre, Residential	404.1	248.3	328.9	29.4
	> 5 du/acre, Residential	26.5	13.5	42.4	14.7
	Commercial Services	152.4	230.0	115.5	37.4
	Industrial	89.9	12.0	76.8	13.5
	Institutional	43.0	7.0	82.7	3.5
Peace @ Bartow	< 2 du/acre, Residential	2,513.1	1,698.8	733.6	416.0
	2-5 du/acre, Residential	5,446.0	2,682.3	1,944.9	214.1
	> 5 du/acre, Residential	767.5	567.2	539.0	89.3
	Commercial Services	1,146.2	735.6	542.1	69.9
	Industrial	543.4	411.4	266.2	29.0
	Institutional	398.6	97.2	143.5	4.1
Horse Creek	< 2 du/acre, Residential	1.0	1,053.8	38.0	41.8
	2-5 du/acre, Residential				
	> 5 du/acre, Residential		8.3		
	Commercial Services		41.6	17.1	1.5
	Industrial		8.9		
	Institutional		80.2	18.2	10.3
Payne Creek	< 2 du/acre, Residential	24.8	192.0	153.5	23.4
	2-5 du/acre, Residential		66.4	85.5	5.3
	> 5 du/acre, Residential	4.4	24.1	40.2	8.8
	Commercial Services	6.5	18.7	16.4	4.4
	Industrial				
	Institutional		62.8		6.6
Charlie Creek	< 2 du/acre, Residential	47.4	336.0	41.7	17.3
	2-5 du/acre, Residential	19.2	16.8	8.6	
	> 5 du/acre, Residential		15.0	4.0	
	Commercial Services	4.3	31.0	1.2	
Charlie Creek	Industrial				

	Land use	A, A/D	B, B/D	C, C/D	D, W
	Institutional			3.5	
Joshua Creek	< 2 du/acre, Residential	8.0	918.8	153.4	96.2
	2-5 du/acre, Residential	8.0	604.0	83.9	60.3
	> 5 du/acre, Residential		75.0		3.7
	Commercial Services	4.6	101.9	19.8	16.6
	Industrial		5.9		3.2
	Institutional		115.4		88.4
Shell Creek	< 2 du/acre, Residential	268.4	2,354.4	43.9	73.1
	2-5 du/acre, Residential				
	> 5 du/acre, Residential		86.8		
	Commercial Services		2.4		6.0
	Industrial				
	Institutional		134.9		92.9

12,809.0	30,586.6	8,303.7	2,652.1
			54,351.4

Coastal Lower Myakka	1100	422.7	4,544.9	643.9	997.4
	1200	17.7	393.9	157.9	66.6
	1300		79.5	13.6	17.6
	1400	4.5	42.9		11.7
	1500		3.7		1.0
	1700		48.9		4.9
Upper Myakka	1100	258.9	2,888.6	494.6	503.8
	1200	1.2	78.5	6.6	
	1300				
	1400		21.9	3.1	
	1500				
	1700		7.7		

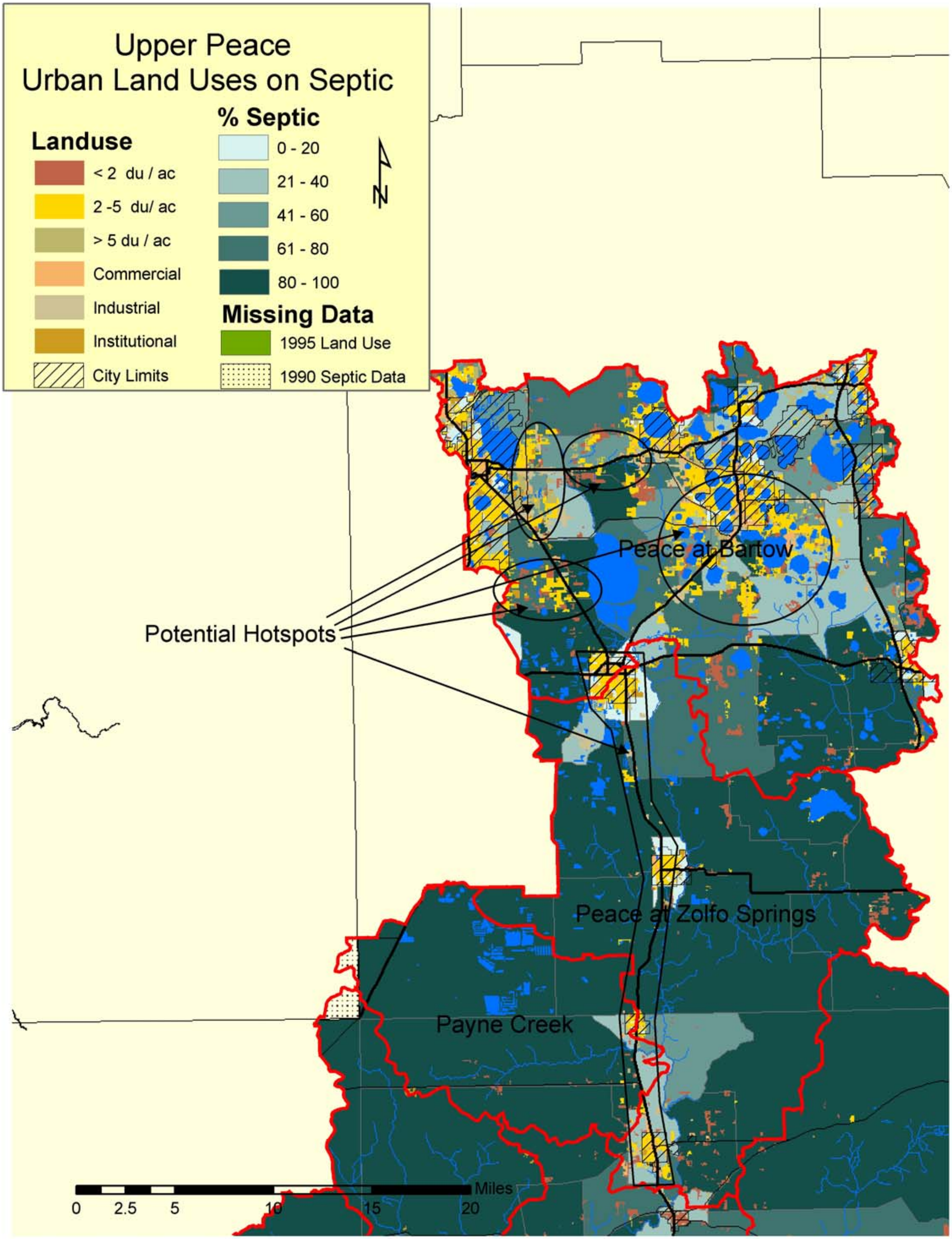
705.0	8,110.5	1,319.7	1,603.0

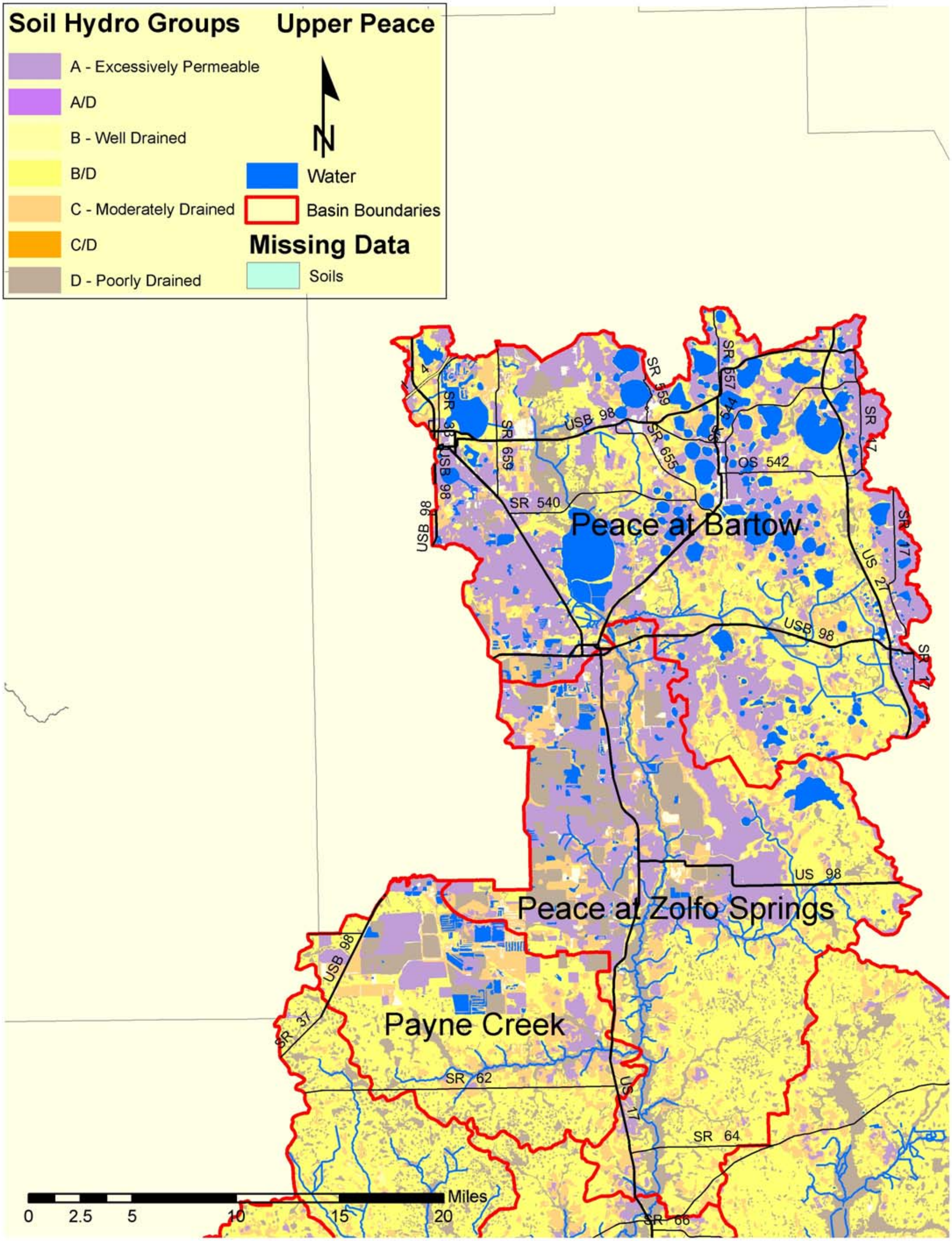
Appendix B
Land use by County and Hydrologic Soils Group

	Land use	A, A/D	B, B/D	C, C/D	D, W
Charlotte	< 2 du/acre, Residential	970.6	8,394.0	724.8	231.5
	2-5 du/acre, Residential	137.4	7,251.2	1,795.4	188.2
	> 5 du/acre, Residential	1.1	360.5	49.9	39.2
	Commercial Services	11.9	829.6	37.5	69.5
	Industrial		86.7		
	Institutional		46.9	18.5	8.3
Sarasota	< 2 du/acre, Residential	84.6	4,497.2	465.4	1,424.5
	2-5 du/acre, Residential		331.3	25.4	55.2
	> 5 du/acre, Residential		77.5	10.1	17.2
	Commercial Services		32.3		11.6
	Industrial		2.9		
	Institutional		48.9		4.9
Polk	< 2 du/acre, Residential	2,872.9	2,332.2	1,013.2	433.2
	2-5 du/acre, Residential	5,748.7	2,742.7	2,106.2	225.9
	> 5 du/acre, Residential	792.2	568.5	574.3	94.1
	Commercial Services	1,257.4	814.2	591.4	83.8
	Industrial	631.4	411.4	342.9	42.4
	Institutional	440.4	98.7	191.9	7.4
DeSoto	< 2 du/acre, Residential	64.9	3,485.4	419.0	497.2
	2-5 du/acre, Residential	28.2	1,890.1	186.9	238.0
	> 5 du/acre, Residential	4.3	303.0	7.3	31.6
	Commercial Services	20.2	377.1	63.2	36.7
	Industrial		47.9		3.9
	Institutional	15.7	309.8	1.8	183.1
Hardee	< 2 du/acre, Residential	35.9	1,889.7	329.5	187.7
	2-5 du/acre, Residential	84.6	273.7	261.8	23.6
	> 5 du/acre, Residential	6.2	62.7	74.1	34.7
	Commercial Services	57.3	251.1	95.5	35.5
	Industrial	25.8	32.0		1.3
	Institutional	6.8	152.8	56.4	17.1
Manatee	< 2 du/acre, Residential	177.7	587.9	171.7	27.1
	2-5 du/acre, Residential	1.2	78.5	6.6	
	> 5 du/acre, Residential				
	Commercial Services		22.0	3.1	
	Industrial				
	Institutional		7.7		
		13,477.4	38,698.1	9,623.8	4,254.4
				Grand Total (ac)	66,054

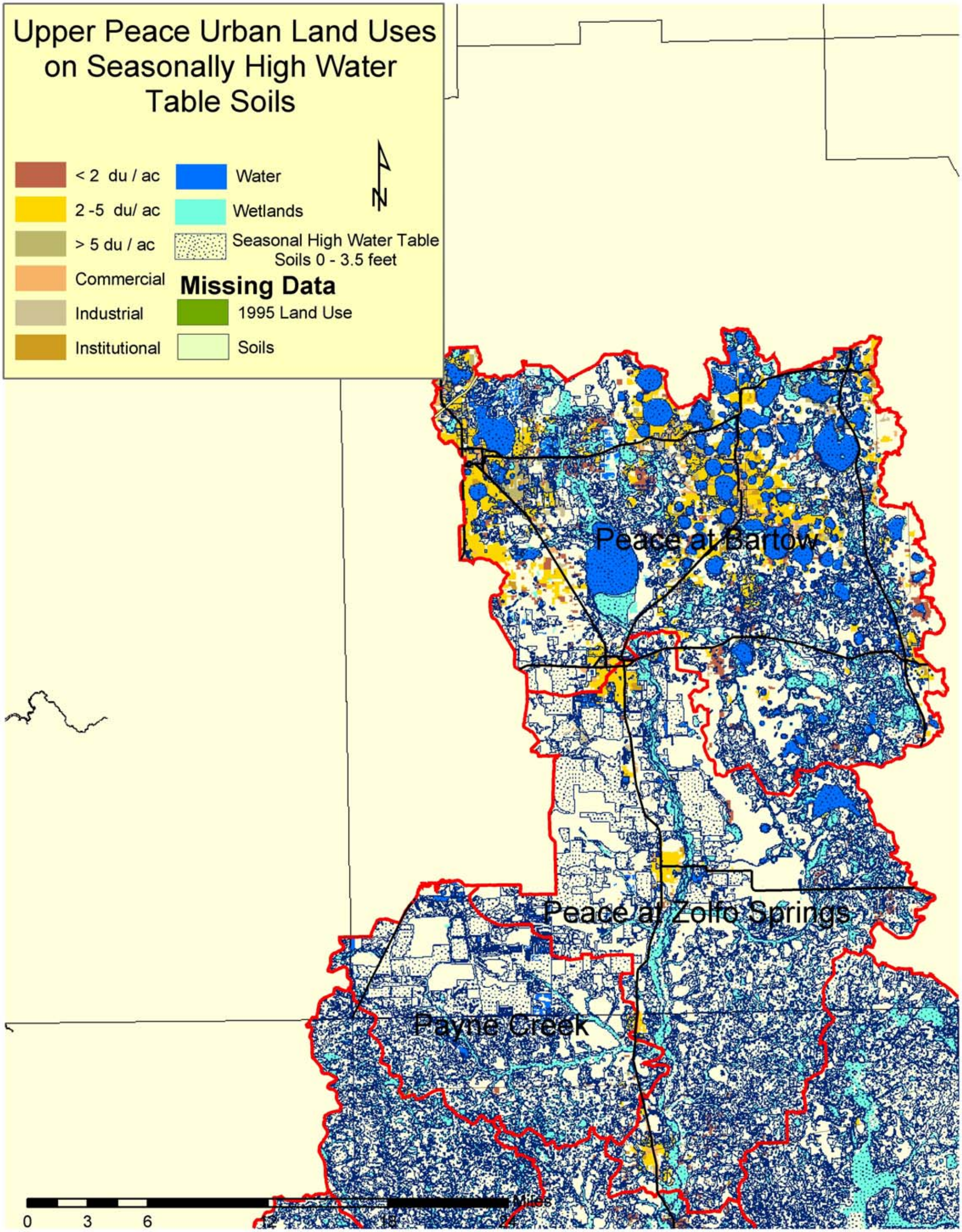
Appendix C

Upper Peace Region Hot-Spot Analysis

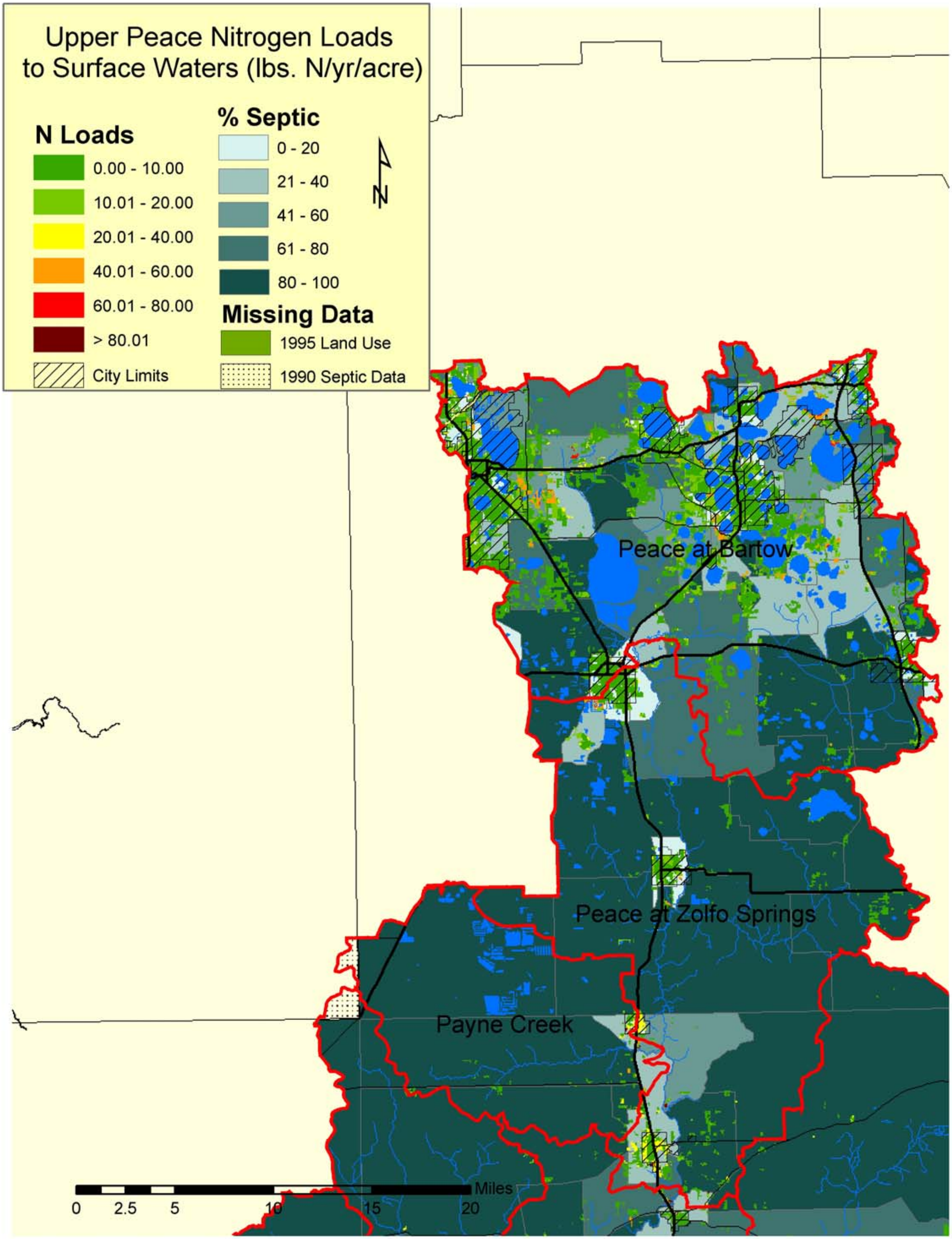

Upper Peace
Urban Land Uses on Septic
Landuse
< 2 du / ac
2 -5 du/ ac
> 5 du / ac
Commercial
Industrial
Institutional
City Limits
% Septic
0 - 20
21 - 40
41 - 60
61 - 80
80 - 100
Missing Data
1995 Land Use
1990 Septic Data
N
Peace at Bartow
Potential Hotspots
Peace at Zolfo Springs
Payne Creek
0
2.5
5
10
15
20
Miles



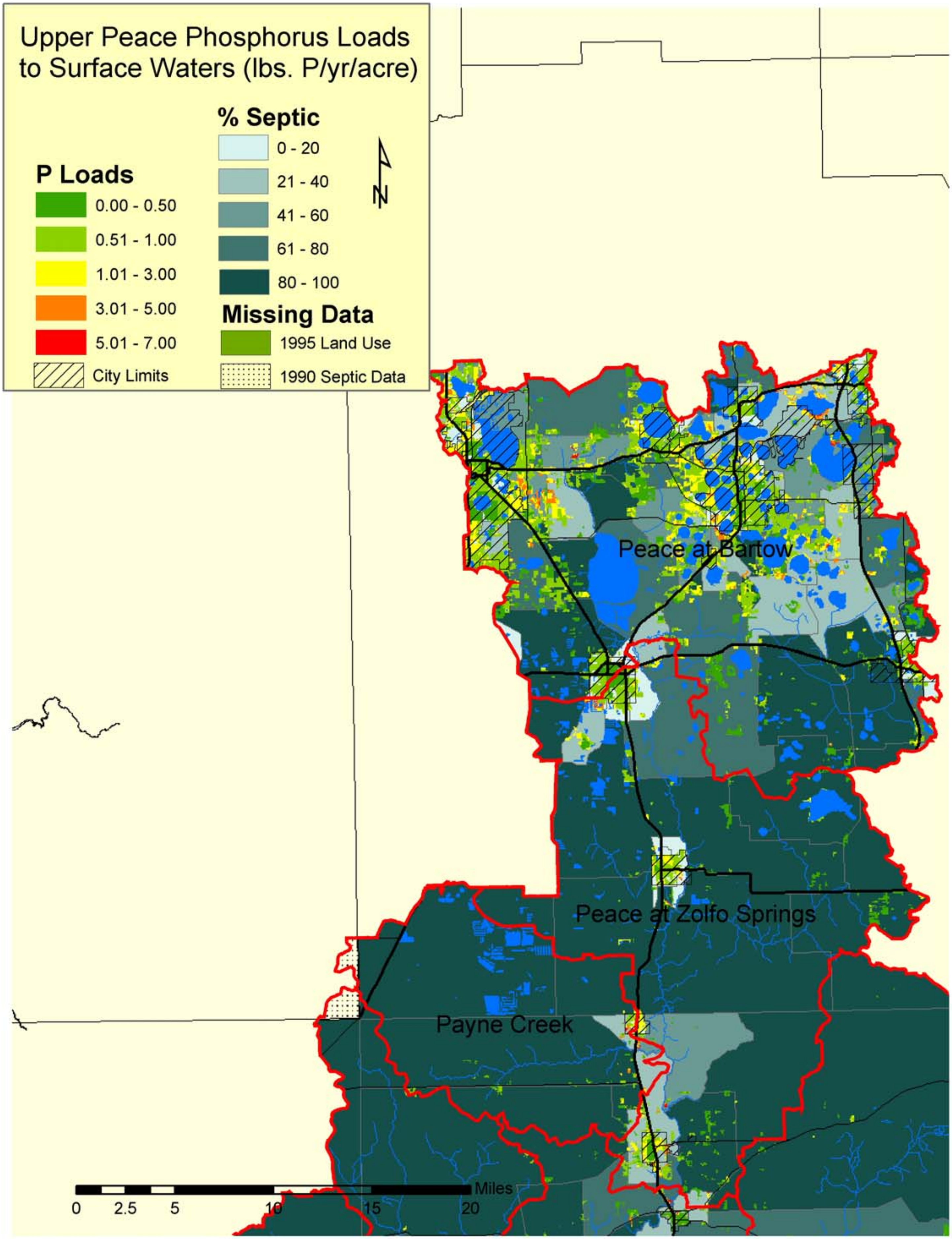
Soil Hydro Groups
Upper Peace
A - Excessively Permeable
A/D
B - Well Drained
B/D
C - Moderately Drained
C/D
D - Poorly Drained
N
Water
Basin Boundaries
Missing Data
Soils
Peace at Bartow
Peace at Zolfo Springs
Payne Creek
USB 98
SR 659
SR 540
SR 559
SR 655
SR 657
OS 542
SR 17
US 27
US 98
SR 37
SR 62
US 17
SR 64
SR 66
Miles
0
2.5
5
10
15
20

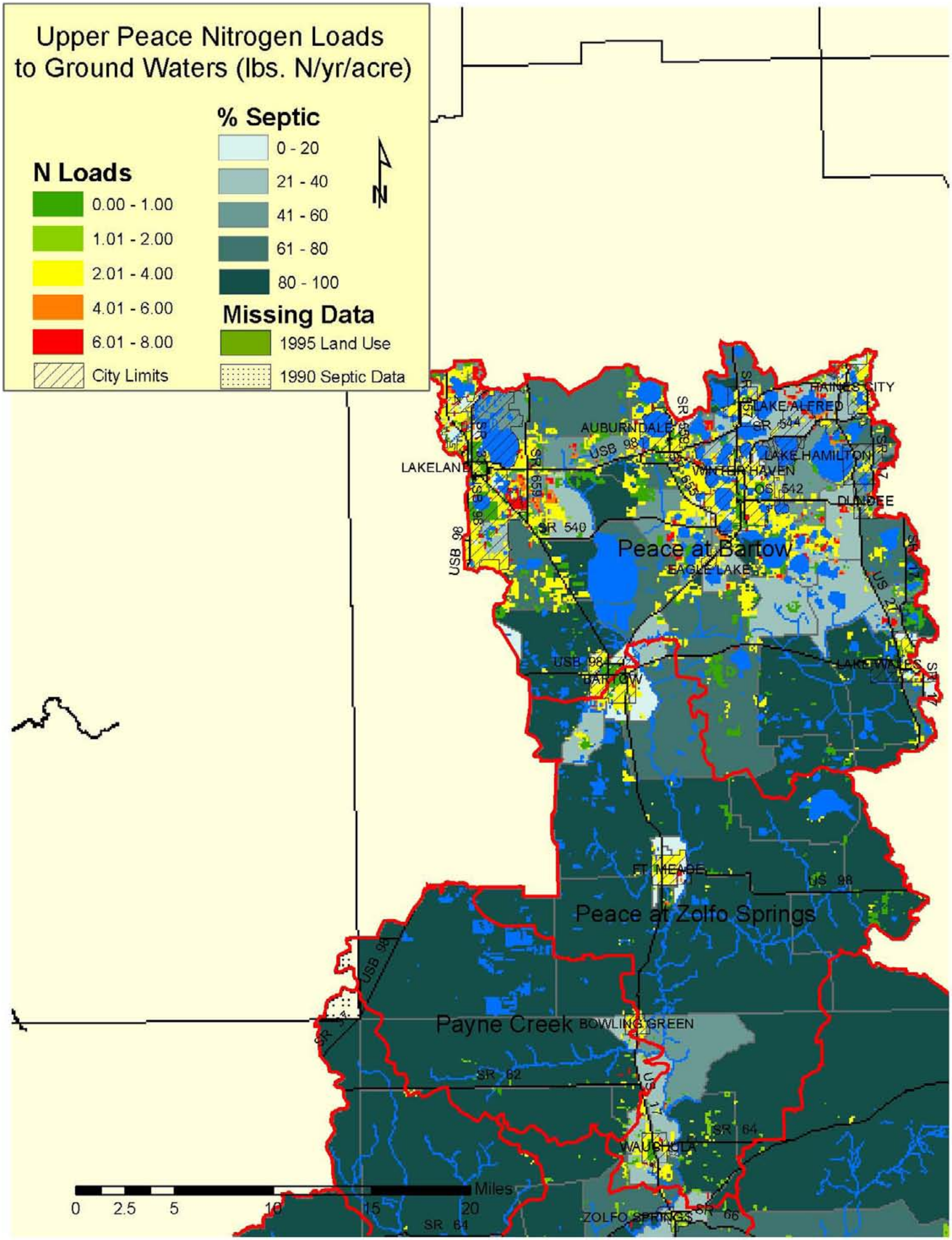


Upper Peace Urban Land Uses on Seasonally High Water Table Soils
< 2 du / ac
2 -5 du/ ac
> 5 du / ac
Commercial
Industrial
Institutional
Water
Wetlands
Seasonal High Water Table Soils 0 - 3.5 feet
Missing Data
1995 Land Use
Soils
Peace at Bartow
Peace at Zolfo Springs
Payne Creek
Miles
0
3
6
12
18
24

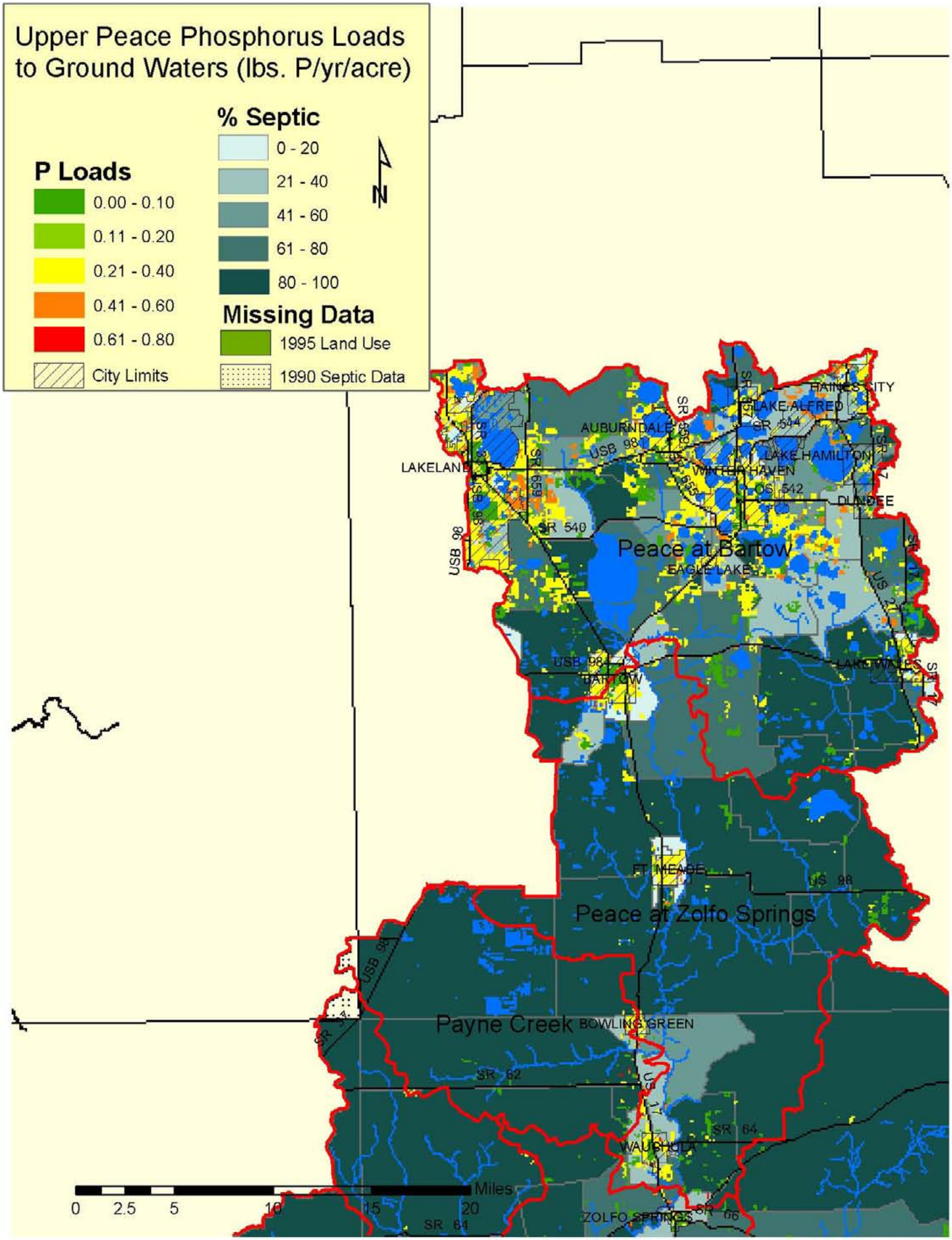


Upper Peace Nitrogen Loads
to Surface Waters (lbs. N/yr/acre)
N Loads
0.00 - 10.00
10.01 - 20.00
20.01 - 40.00
40.01 - 60.00
60.01 - 80.00
> 80.01
City Limits
% Septic
0 - 20
21 - 40
41 - 60
61 - 80
80 - 100
Missing Data
1995 Land Use
1990 Septic Data
N
Peace at Bartow
Peace at Zolfo Springs
Payne Creek
Miles
0
2.5
5
10
15
20


Upper Peace Phosphorus Loads to Surface Waters (lbs. P/yr/acre)
P Loads
0.00 - 0.50
0.51 - 1.00
1.01 - 3.00
3.01 - 5.00
5.01 - 7.00
City Limits
% Septic
0 - 20
21 - 40
41 - 60
61 - 80
80 - 100
Missing Data
1995 Land Use
1990 Septic Data
N
Peace at Bartow
Peace at Zolfo Springs
Payne Creek
0
2.5
5
10
15
20
Miles

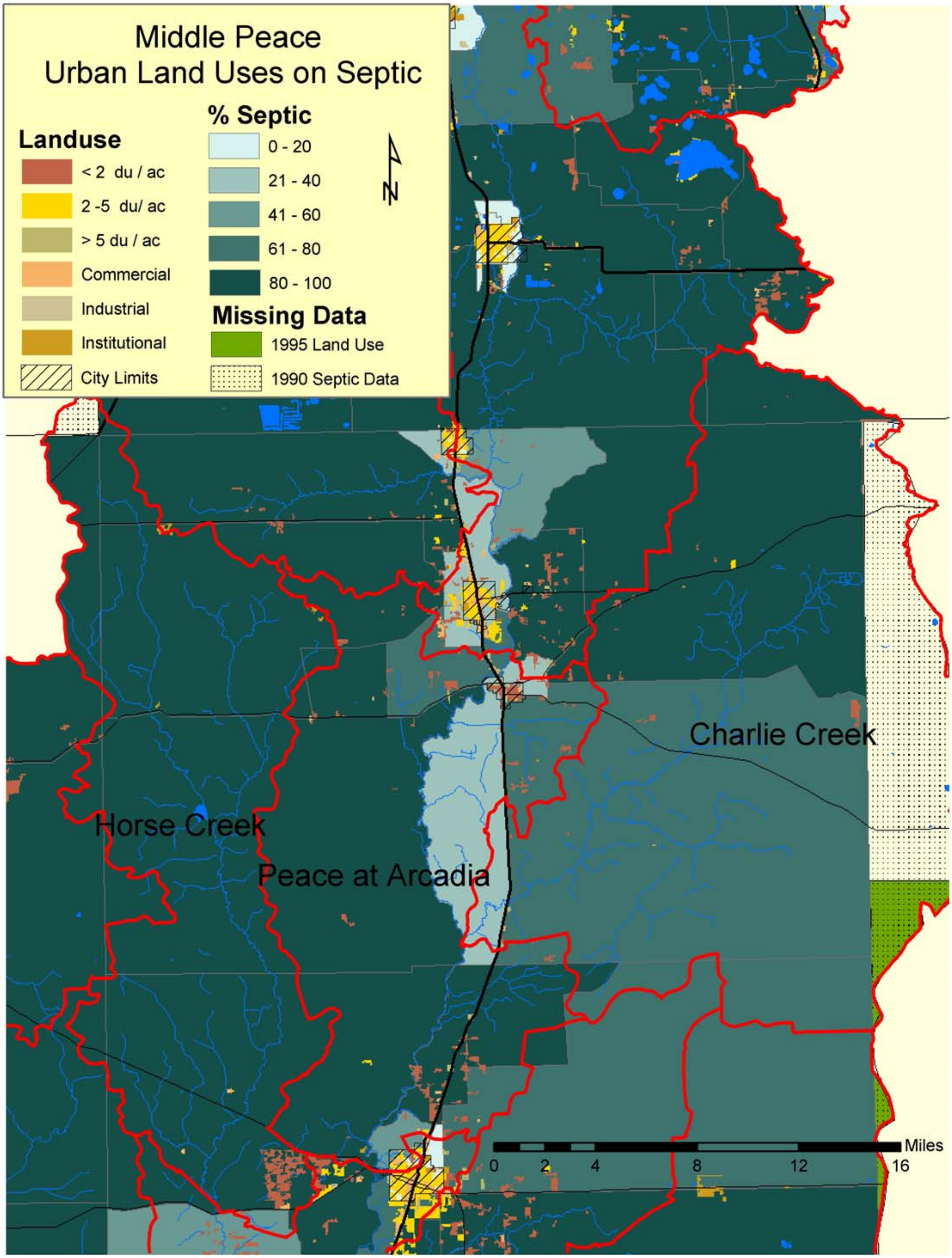


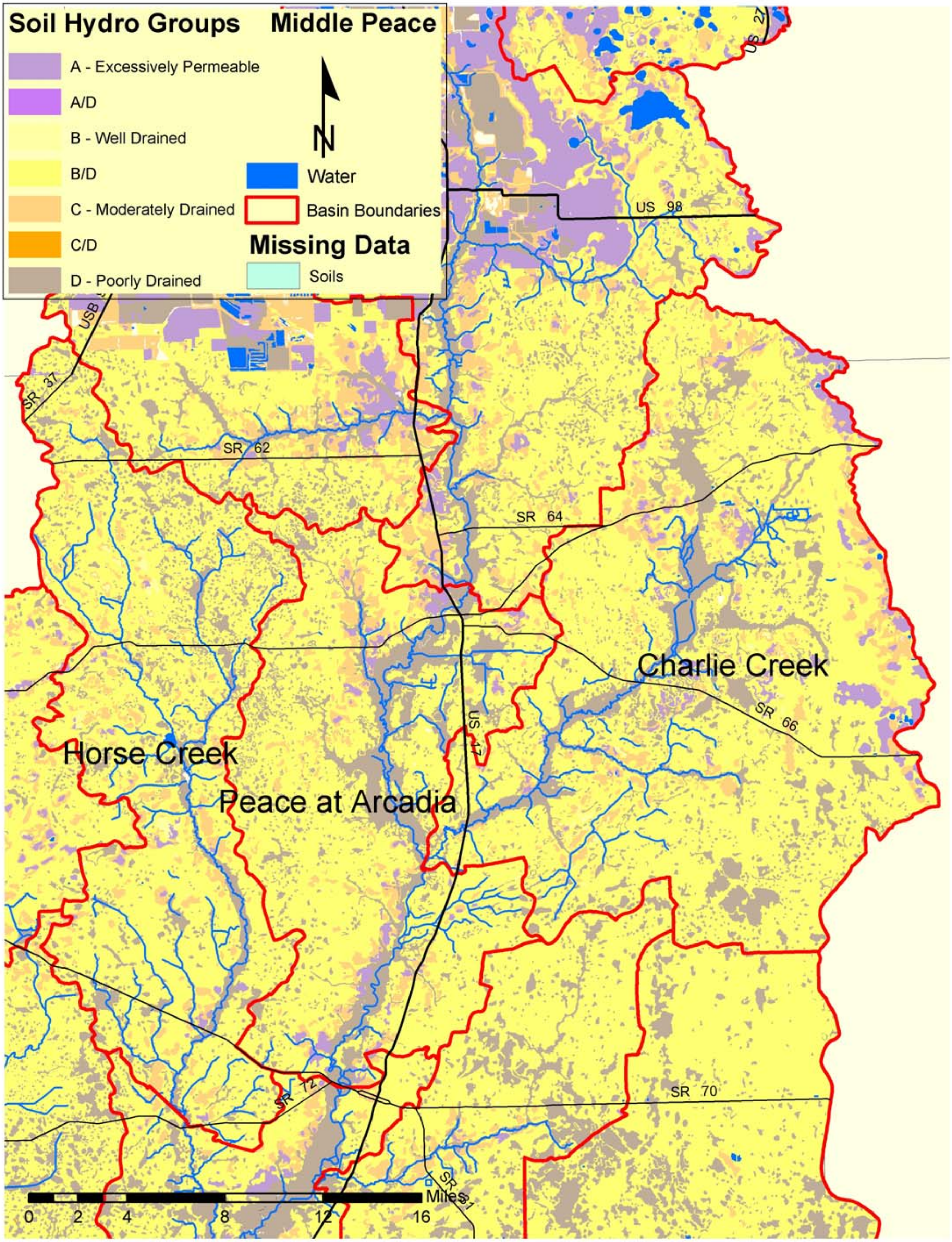
Upper Peace Nitrogen Loads to Ground Waters (lbs. N/yr/acre)
N Loads
0.00 - 1.00
1.01 - 2.00
2.01 - 4.00
4.01 - 6.00
6.01 - 8.00
City Limits
% Septic
0 - 20
21 - 40
41 - 60
61 - 80
80 - 100
Missing Data
1995 Land Use
1990 Septic Data
N
HAINES CITY
LAKE ALFRED
SR 544
AUBURNDALE
USB 98
LAKE HAMILTON
LAKELAND
WINTER HAVEN
DUNDEE
SR 540
Peace at Bartow
EAGLE LAKE
USB 98
BARTOW
LAKE WALES
FT. MEADE
US 98
Peace at Zolfo Springs
Payne Creek
BOWLING GREEN
SR 62
SR 64
WAUCHULA
ZOLFO SPRINGS
SR 66
SR 64
Miles
0
2.5
5
10
15
20


Upper Peace Phosphorus Loads to Ground Waters (lbs. P/yr/acre)
P Loads
0.00 - 0.10
0.11 - 0.20
0.21 - 0.40
0.41 - 0.60
0.61 - 0.80
City Limits
% Septic
0 - 20
21 - 40
41 - 60
61 - 80
80 - 100
Missing Data
1995 Land Use
1990 Septic Data
N
HAINES CITY
LAKE ALFRED
AUBURNDALE
LAKE HAMILTON
LAKELAND
WINTER HAVEN
DUNDEE
Peace at Bartow
EAGLE LAKE
BARTOW
LAKE WALES
FT. MEADE
Peace at Zolfo Springs
Payne Creek
BOWLING GREEN
WAUCHULA
ZOLFO SPRINGS
USB 98
SR 659
SR 540
SR 544
SR 655
OS 542
US 27
SR 17
US 98
SR 62
US 17
SR 64
SR 66
Miles
0
2.5
5
10
15
20

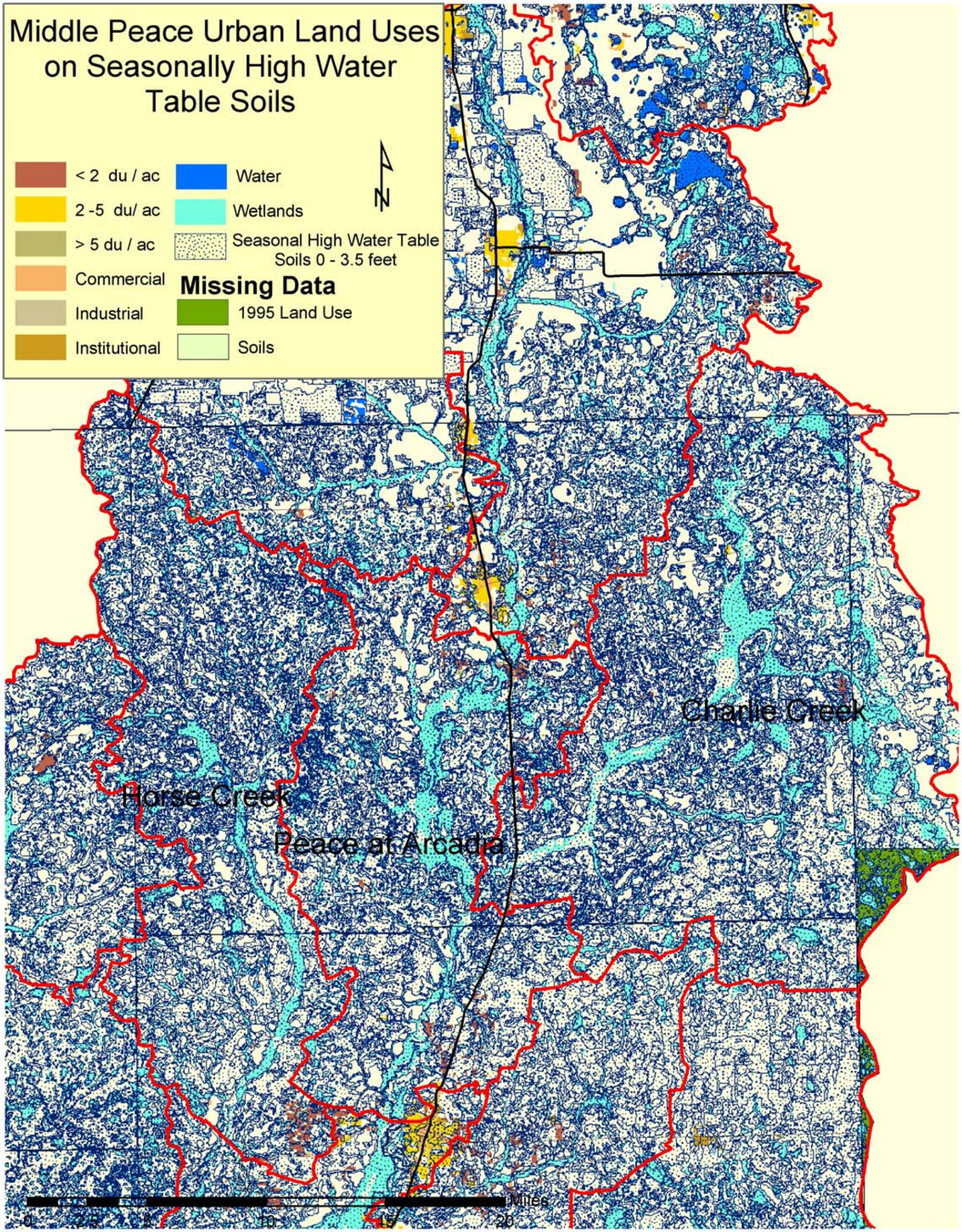
Appendix D

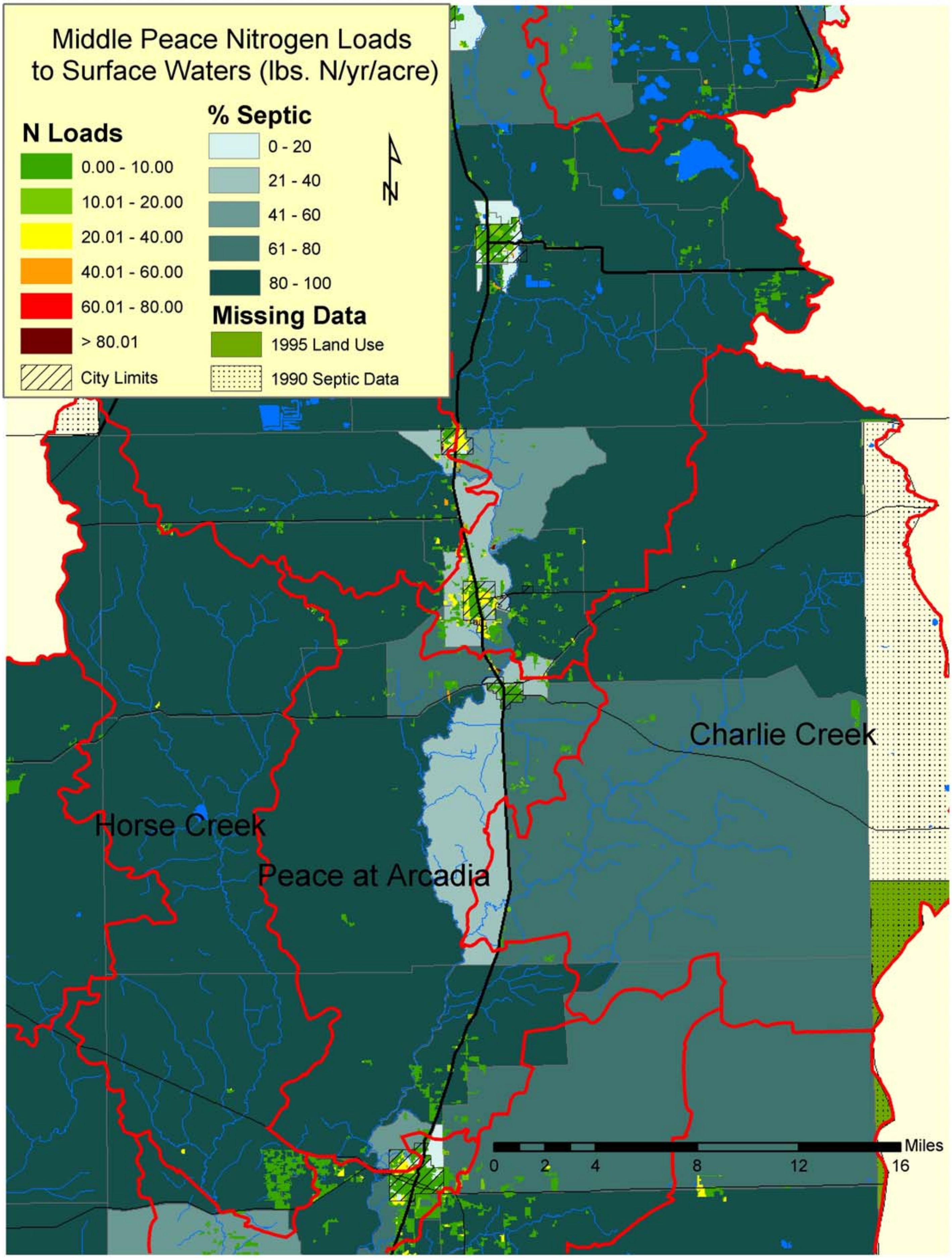
Middle Peace Region Hot-Spot Analysis

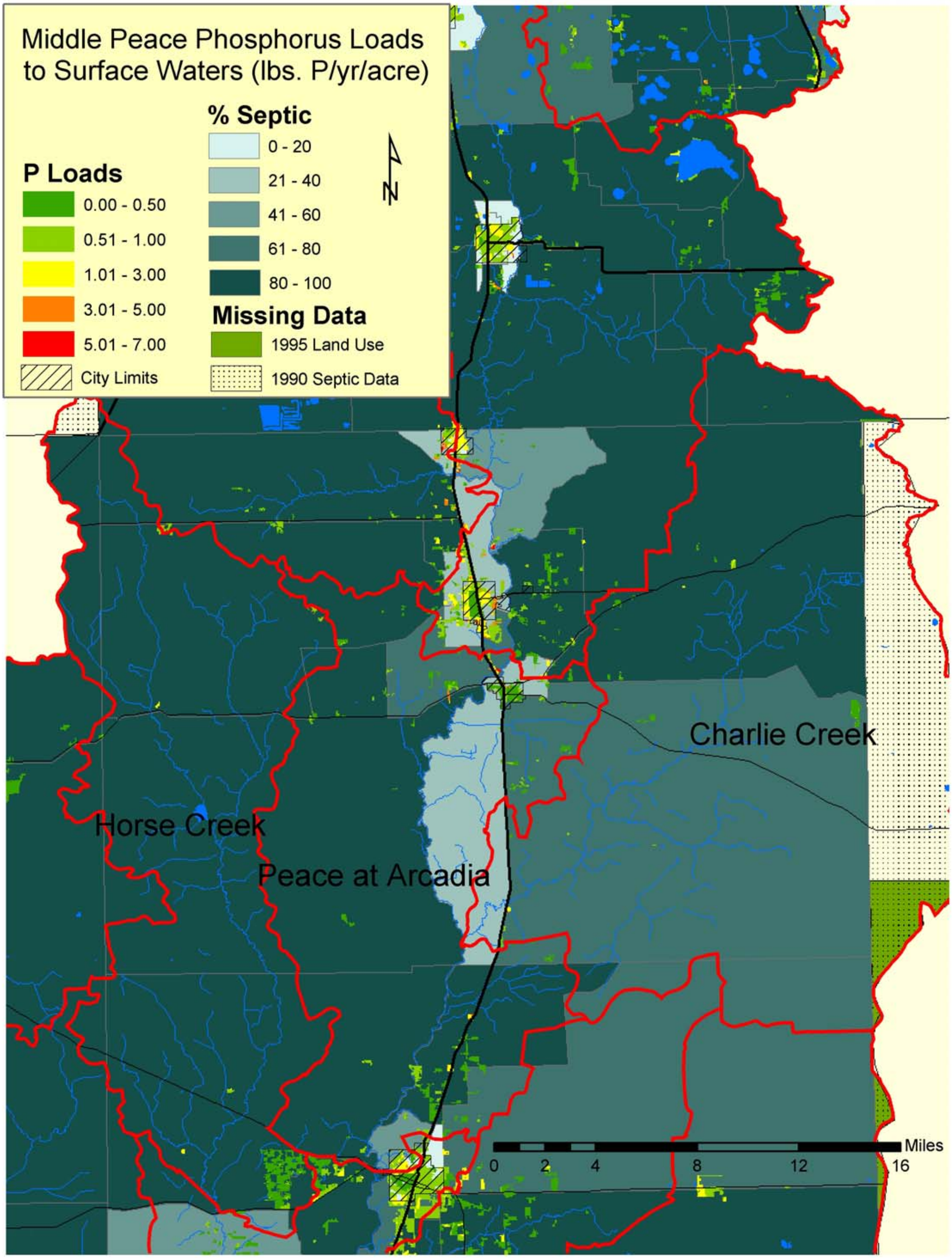

Middle Peace
Urban Land Uses on Septic
Landuse
< 2 du / ac
2 -5 du/ ac
> 5 du / ac
Commercial
Industrial
Institutional
City Limits
% Septic
0 - 20
21 - 40
41 - 60
61 - 80
80 - 100
Missing Data
1995 Land Use
1990 Septic Data
N
Charlie Creek
Horse Creek
Peace at Arcadia
0 2 4 8 12 16
Miles

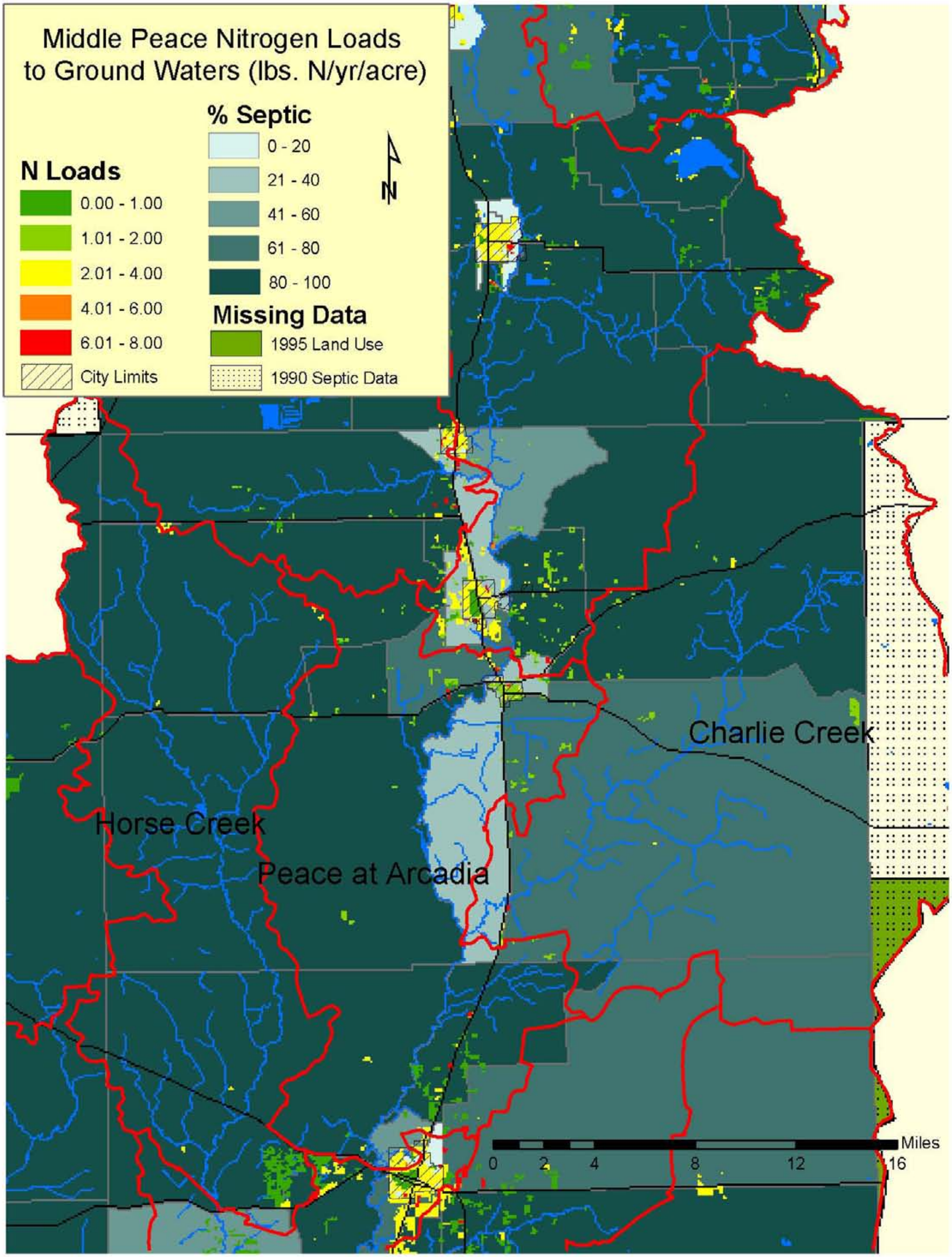


Soil Hydro Groups
Middle Peace
A - Excessively Permeable
A/D
B - Well Drained
B/D
C - Moderately Drained
C/D
D - Poorly Drained
N
Water
Basin Boundaries
Missing Data
Soils
US 27
US 98
SR 37
SR 62
SR 64
Charlie Creek
SR 66
US 17
Horse Creek
Peace at Arcadia
SR 72
SR 70
Miles
0 2 4 8 12 16

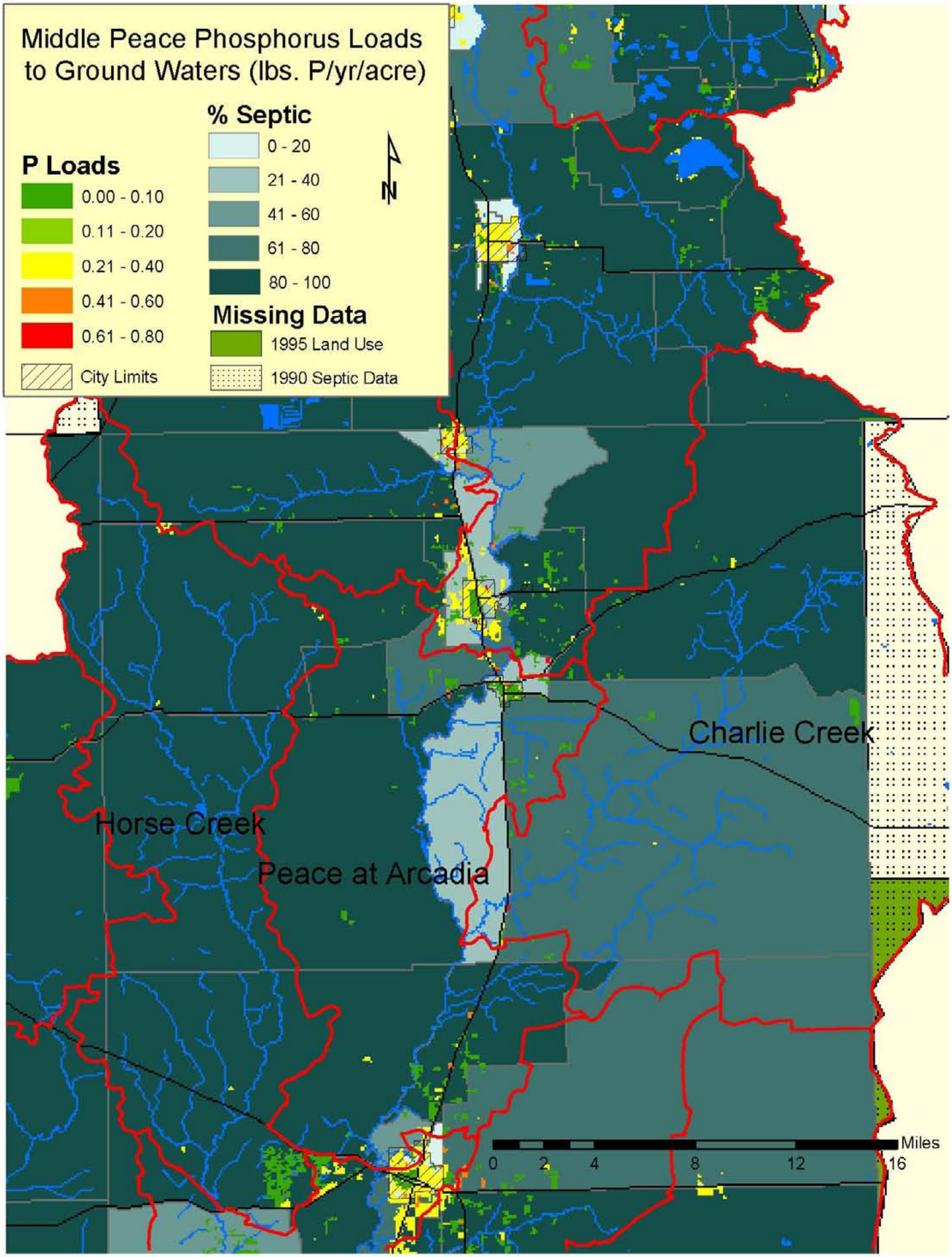

Middle Peace Urban Land Uses on Seasonally High Water Table Soils
< 2 du / ac
2 -5 du/ ac
> 5 du / ac
Commercial
Industrial
Institutional
Water
Wetlands
Seasonal High Water Table Soils 0 - 3.5 feet
Missing Data
1995 Land Use
Soils
N
Charlie Creek
Horse Creek
Peace at Arcadia
Miles
0
2.5
5
10
15
20


Middle Peace Nitrogen Loads to Surface Waters (lbs. N/yr/acre)
N Loads
0.00 - 10.00
10.01 - 20.00
20.01 - 40.00
40.01 - 60.00
60.01 - 80.00
> 80.01
City Limits
% Septic
0 - 20
21 - 40
41 - 60
61 - 80
80 - 100
Missing Data
1995 Land Use
1990 Septic Data
N
Charlie Creek
Horse Creek
Peace at Arcadia
Miles
0
2
4
8
12
16


Middle Peace Phosphorus Loads
to Surface Waters (lbs. P/yr/acre)
P Loads
0.00 - 0.50
0.51 - 1.00
1.01 - 3.00
3.01 - 5.00
5.01 - 7.00
City Limits
% Septic
0 - 20
21 - 40
41 - 60
61 - 80
80 - 100
Missing Data
1995 Land Use
1990 Septic Data
N
Charlie Creek
Horse Creek
Peace at Arcadia
0 2 4 8 12 16 Miles

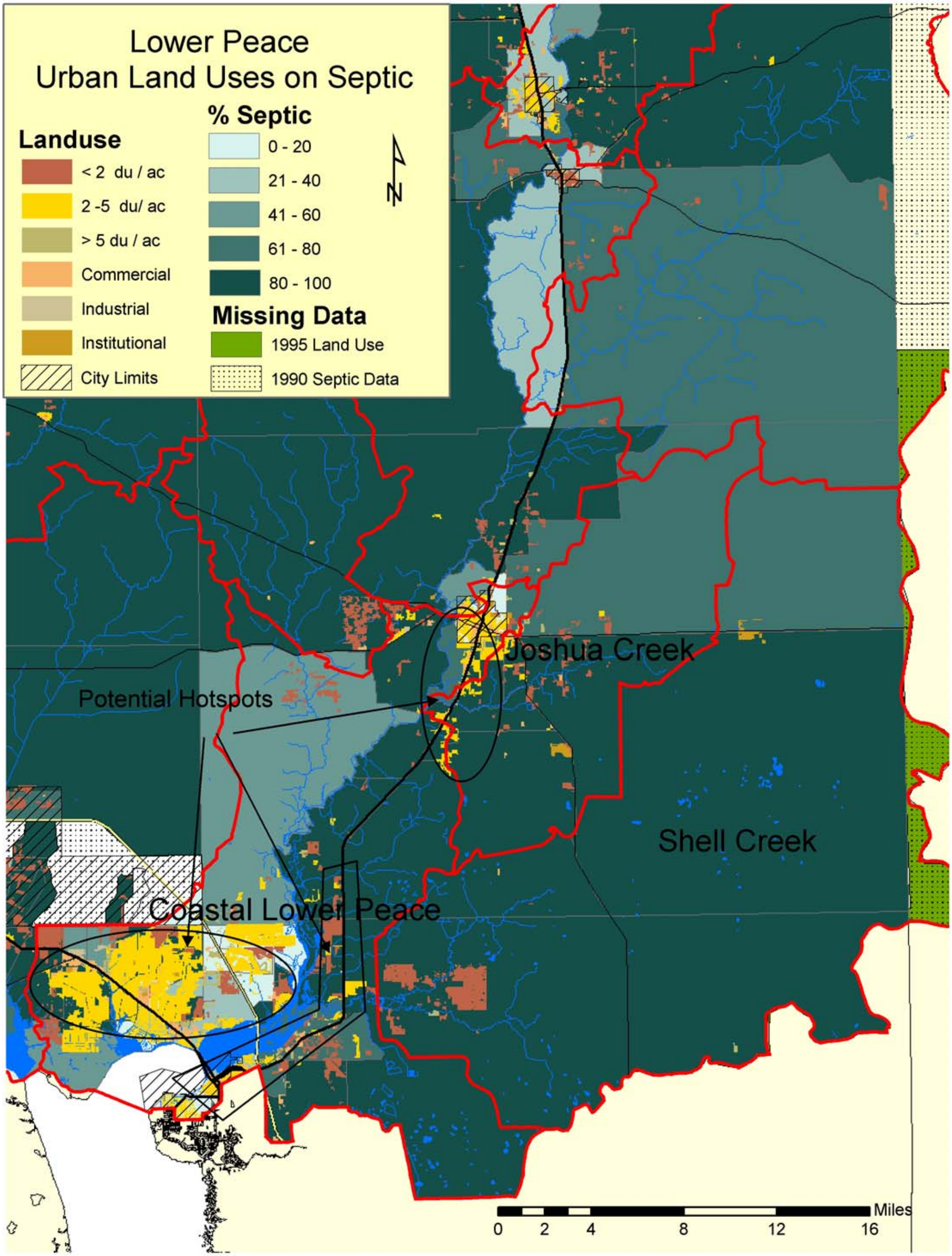


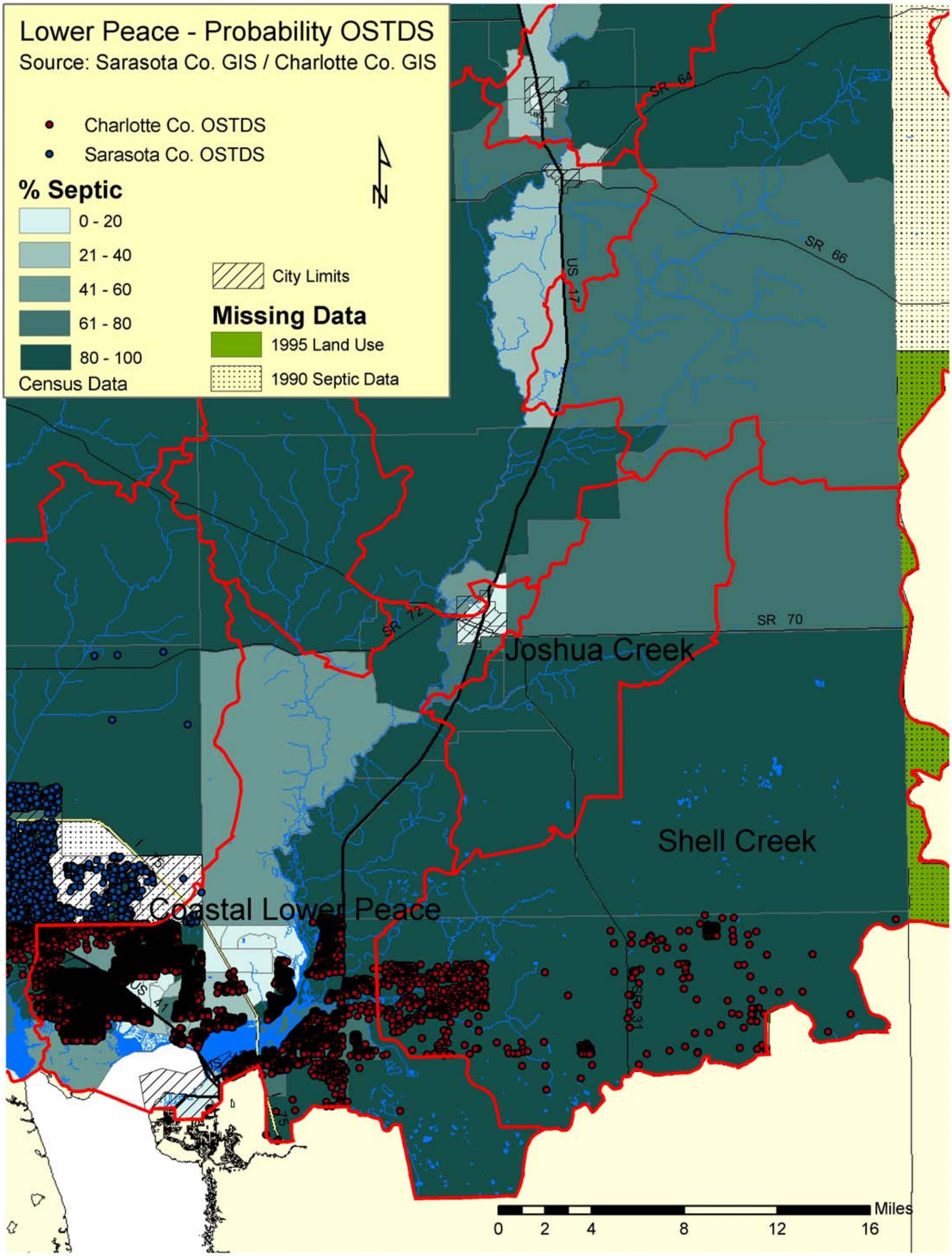
Middle Peace Nitrogen Loads to Ground Waters (lbs. N/yr/acre)
N Loads
0.00 - 1.00
1.01 - 2.00
2.01 - 4.00
4.01 - 6.00
6.01 - 8.00
City Limits
% Septic
0 - 20
21 - 40
41 - 60
61 - 80
80 - 100
Missing Data
1995 Land Use
1990 Septic Data
N
Charlie Creek
Horse Creek
Peace at Arcadia
Miles
0 2 4 8 12 16


Middle Peace Phosphorus Loads to Ground Waters (lbs. P/yr/acre)
P Loads
0.00 - 0.10
0.11 - 0.20
0.21 - 0.40
0.41 - 0.60
0.61 - 0.80
City Limits
% Septic
0 - 20
21 - 40
41 - 60
61 - 80
80 - 100
Missing Data
1995 Land Use
1990 Septic Data
N
Charlie Creek
Horse Creek
Peace at Arcadia
Miles
0
2
4
8
12
16

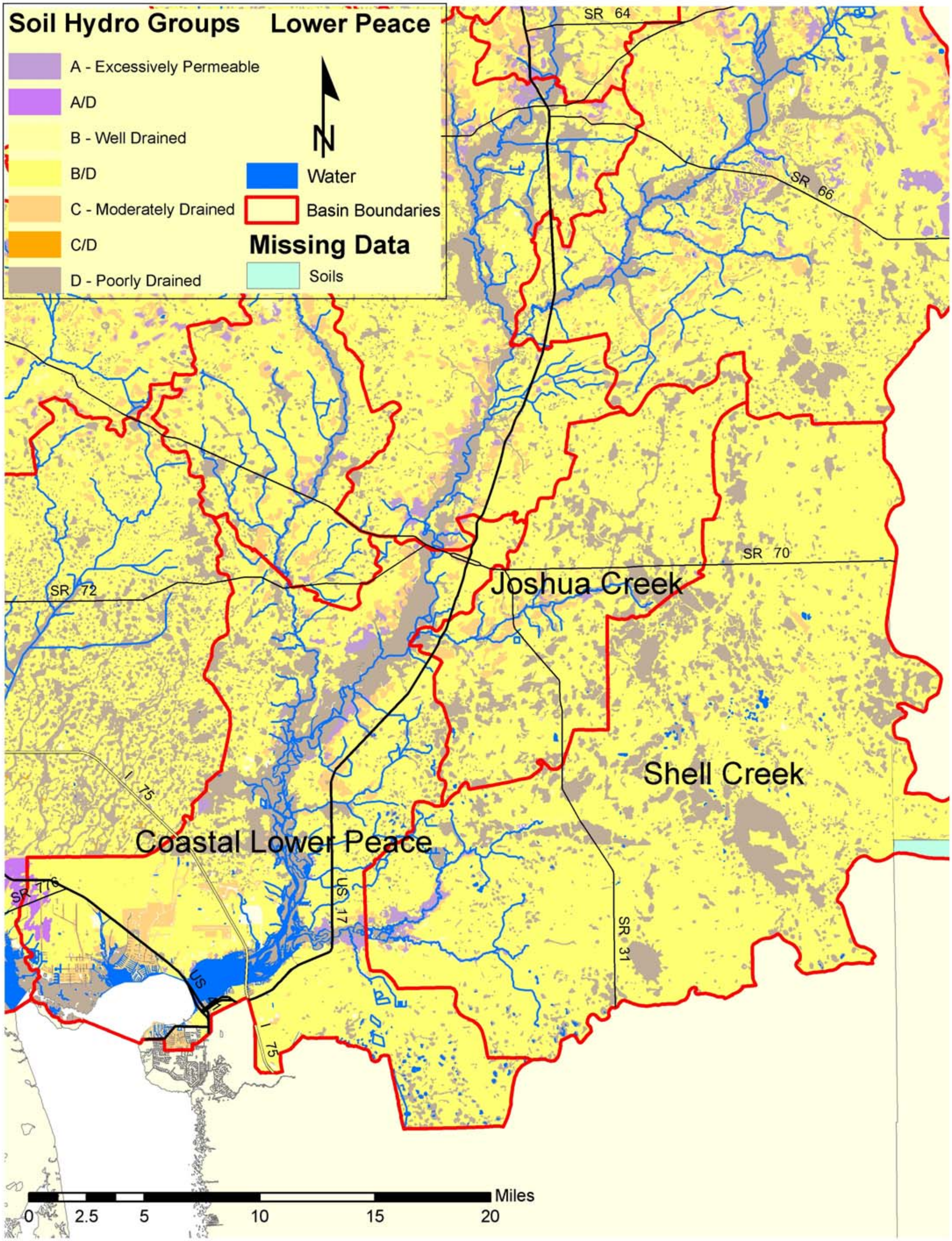
Appendix E

Lower Peace Region Hot-Spot Analysis

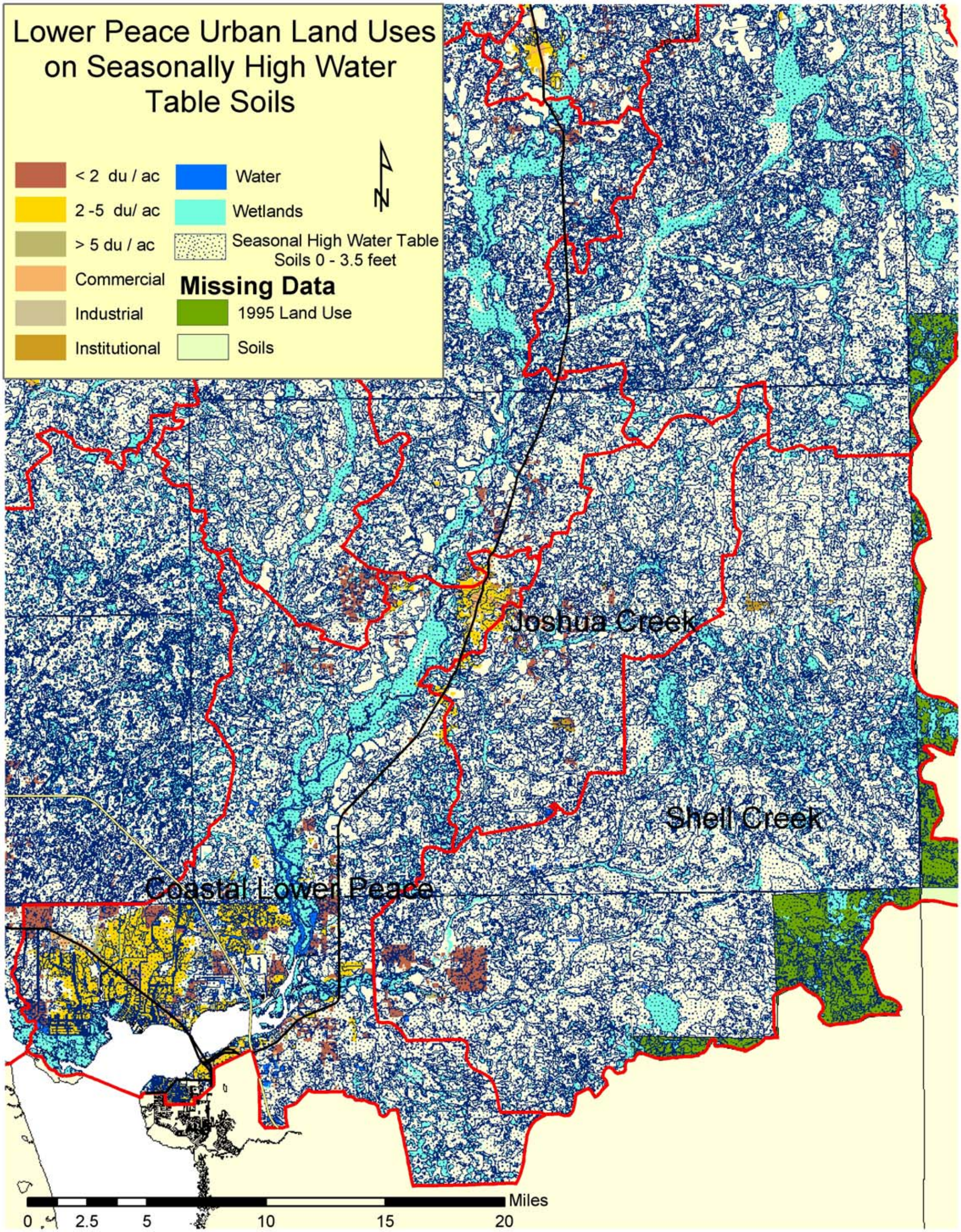

Lower Peace
Urban Land Uses on Septic
Landuse
< 2 du / ac
2 -5 du/ ac
> 5 du / ac
Commercial
Industrial
Institutional
City Limits
% Septic
0 - 20
21 - 40
41 - 60
61 - 80
80 - 100
Missing Data
1995 Land Use
1990 Septic Data
N
Joshua Creek
Potential Hotspots
Shell Creek
Coastal Lower Peace
0 2 4 8 12 16
Miles

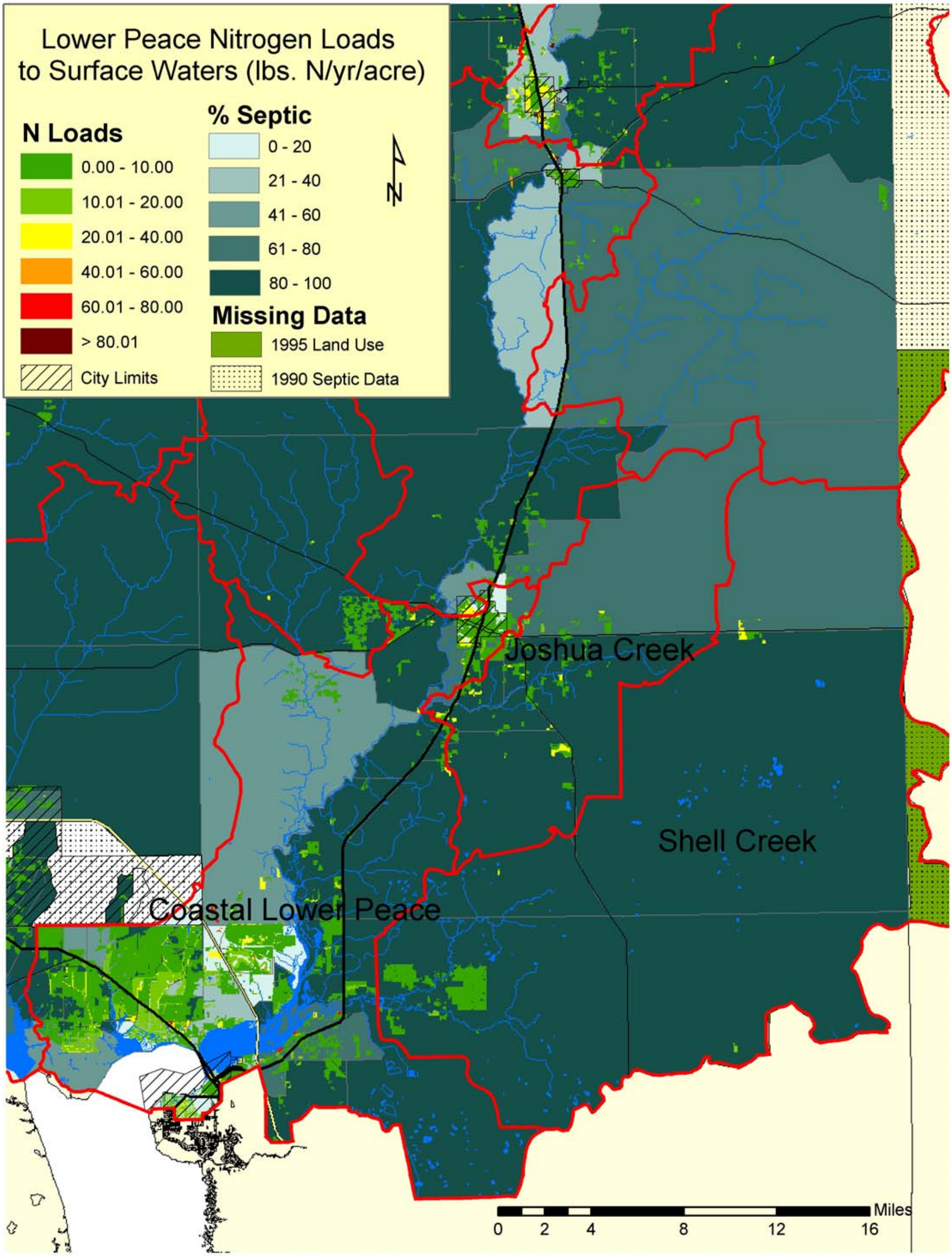


Lower Peace - Probability OSTDS
Source: Sarasota Co. GIS / Charlotte Co. GIS
Charlotte Co. OSTDS
Sarasota Co. OSTDS
% Septic
0 - 20
21 - 40
41 - 60
61 - 80
80 - 100
Census Data
City Limits
Missing Data
1995 Land Use
1990 Septic Data
N
SR 64
SR 66
US 17
SR 72
SR 70
Joshua Creek
Shell Creek
Coastal Lower Peace
US 41
SR 31
I 75
Miles
0
2
4
8
12
16

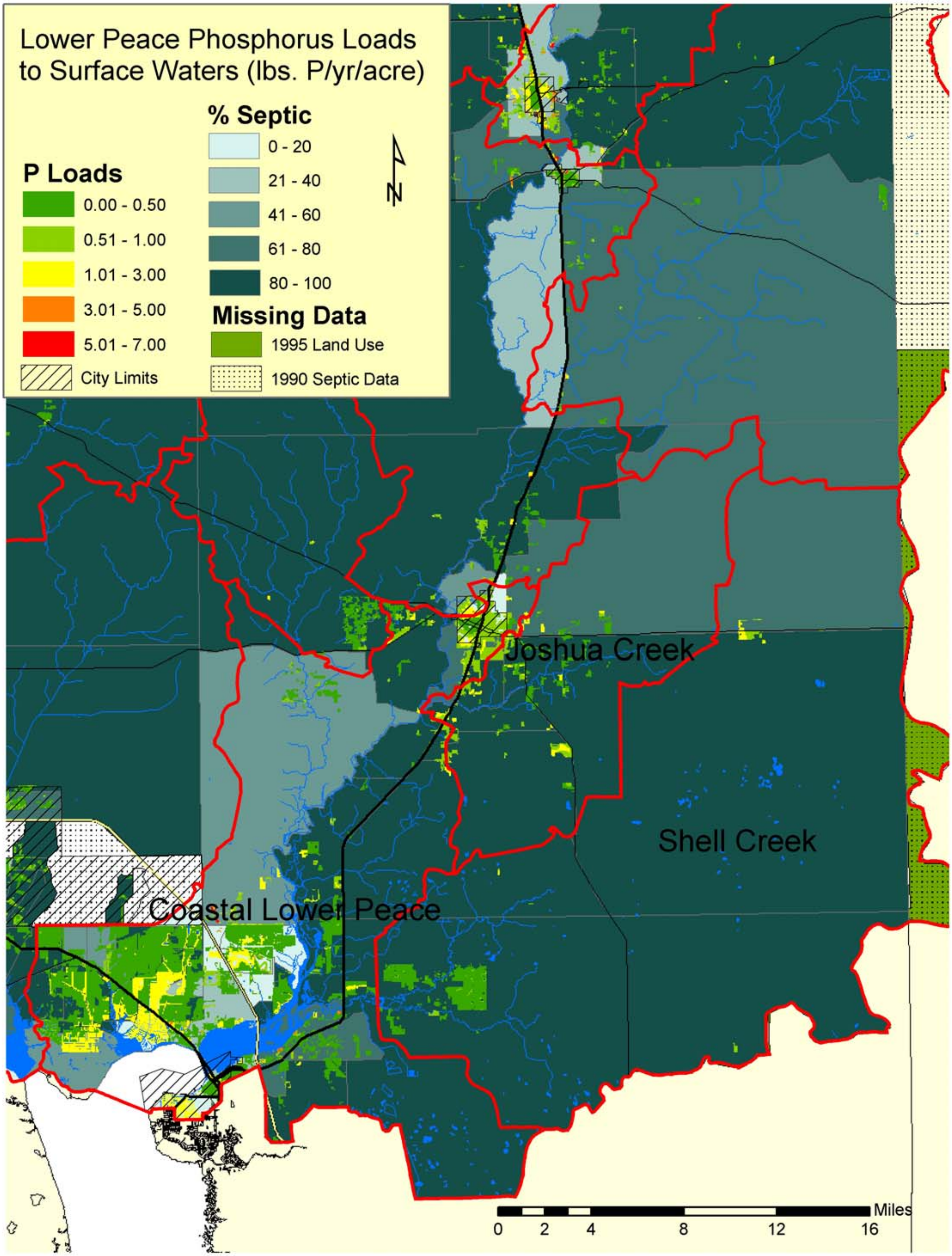


Soil Hydro Groups
Lower Peace
A - Excessively Permeable
A/D
B - Well Drained
B/D
C - Moderately Drained
C/D
D - Poorly Drained
Water
Basin Boundaries
Missing Data
Soils
N
SR 64
SR 66
SR 70
SR 72
SR 776
SR 31
US 17
US 41
I 75
Joshua Creek
Shell Creek
Coastal Lower Peace
Miles
0 2.5 5 10 15 20

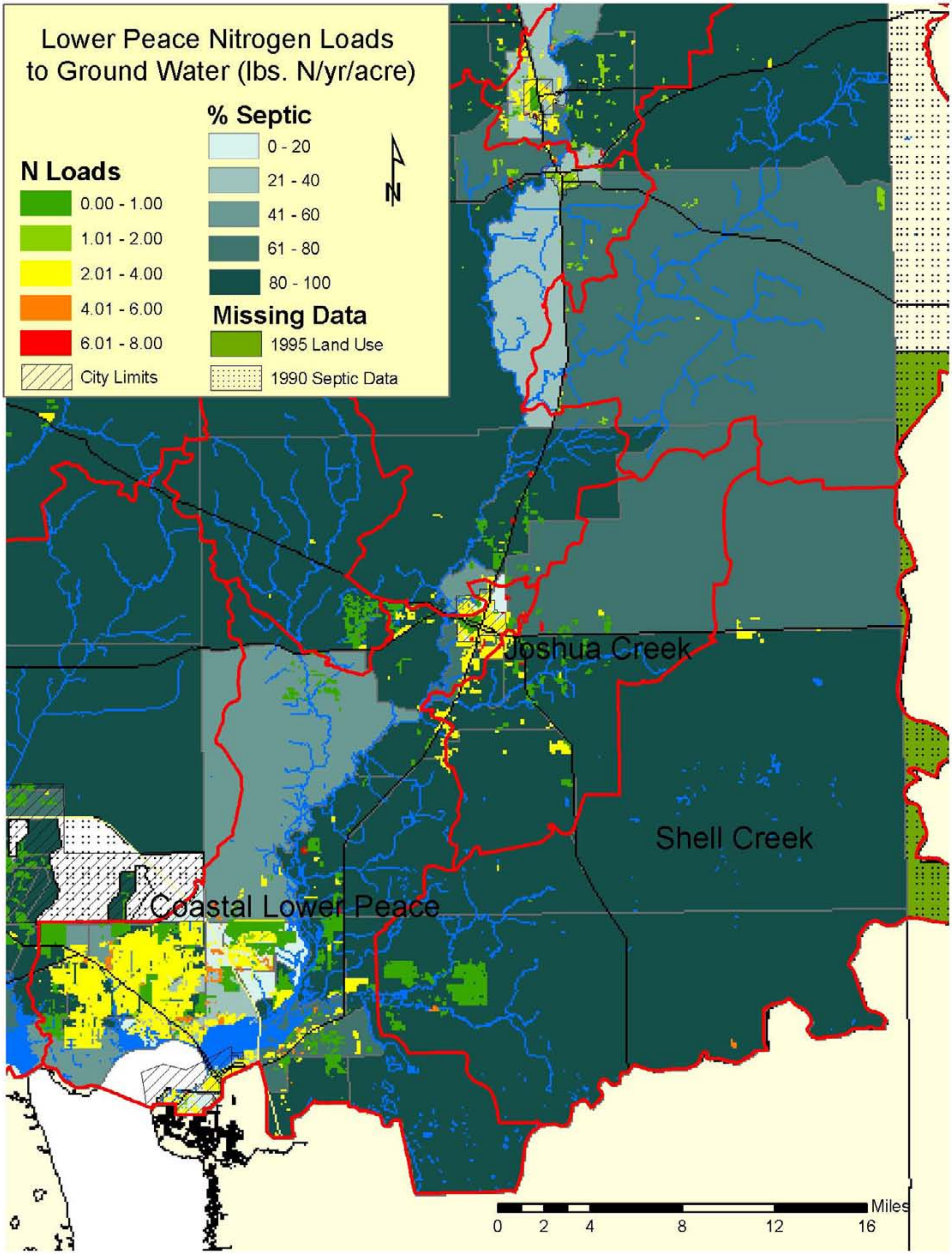

Lower Peace Urban Land Uses on Seasonally High Water Table Soils
< 2 du / ac
2 -5 du/ ac
> 5 du / ac
Commercial
Industrial
Institutional
Water
Wetlands
Seasonal High Water Table Soils 0 - 3.5 feet
Missing Data
1995 Land Use
Soils
N
Joshua Creek
Shell Creek
Coastal Lower Peace
Miles
0
2.5
5
10
15
20

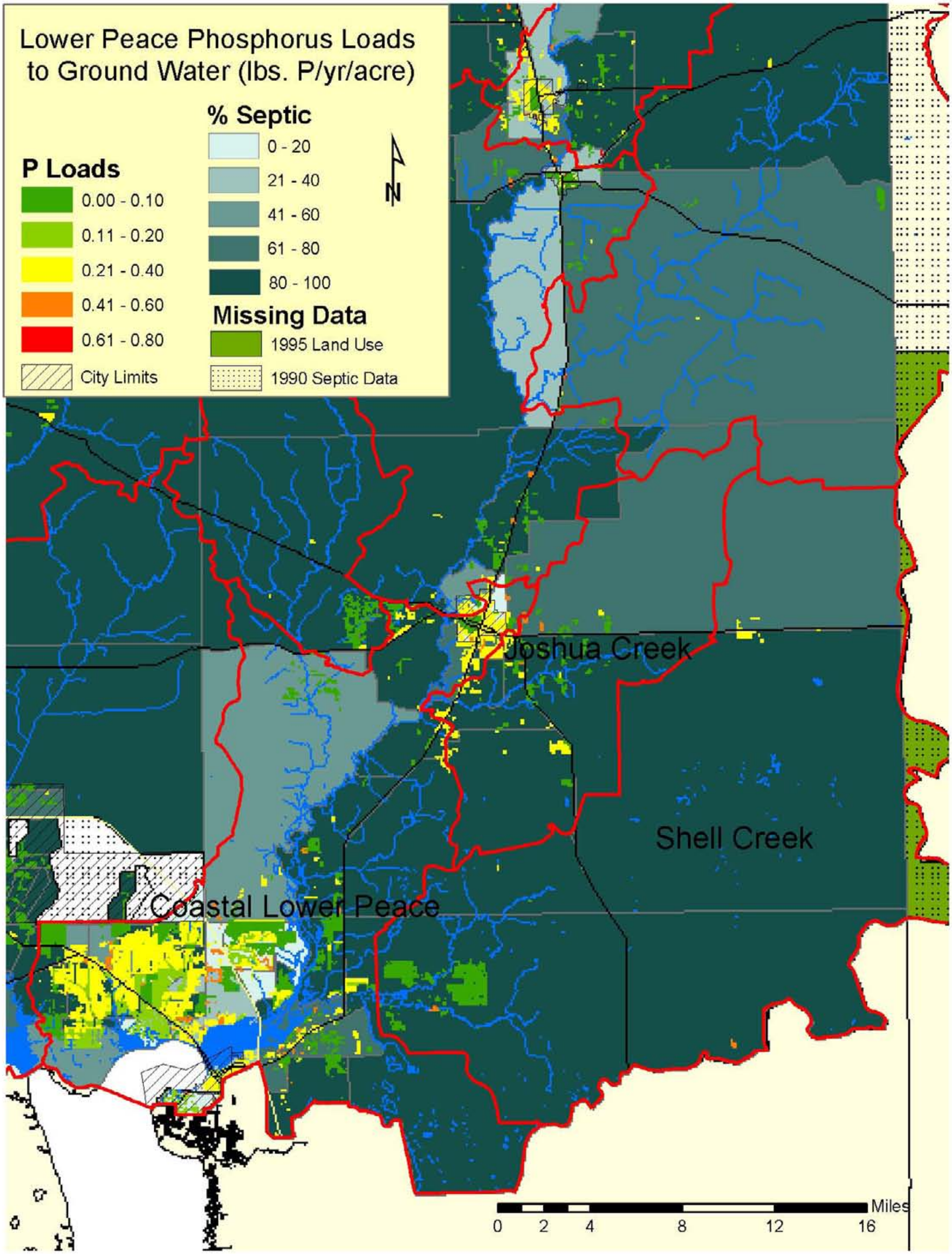


Lower Peace Nitrogen Loads
to Surface Waters (lbs. N/yr/acre)
N Loads
0.00 - 10.00
10.01 - 20.00
20.01 - 40.00
40.01 - 60.00
60.01 - 80.00
> 80.01
City Limits
% Septic
0 - 20
21 - 40
41 - 60
61 - 80
80 - 100
Missing Data
1995 Land Use
1990 Septic Data
N
Joshua Creek
Shell Creek
Coastal Lower Peace
Miles
0 2 4 8 12 16



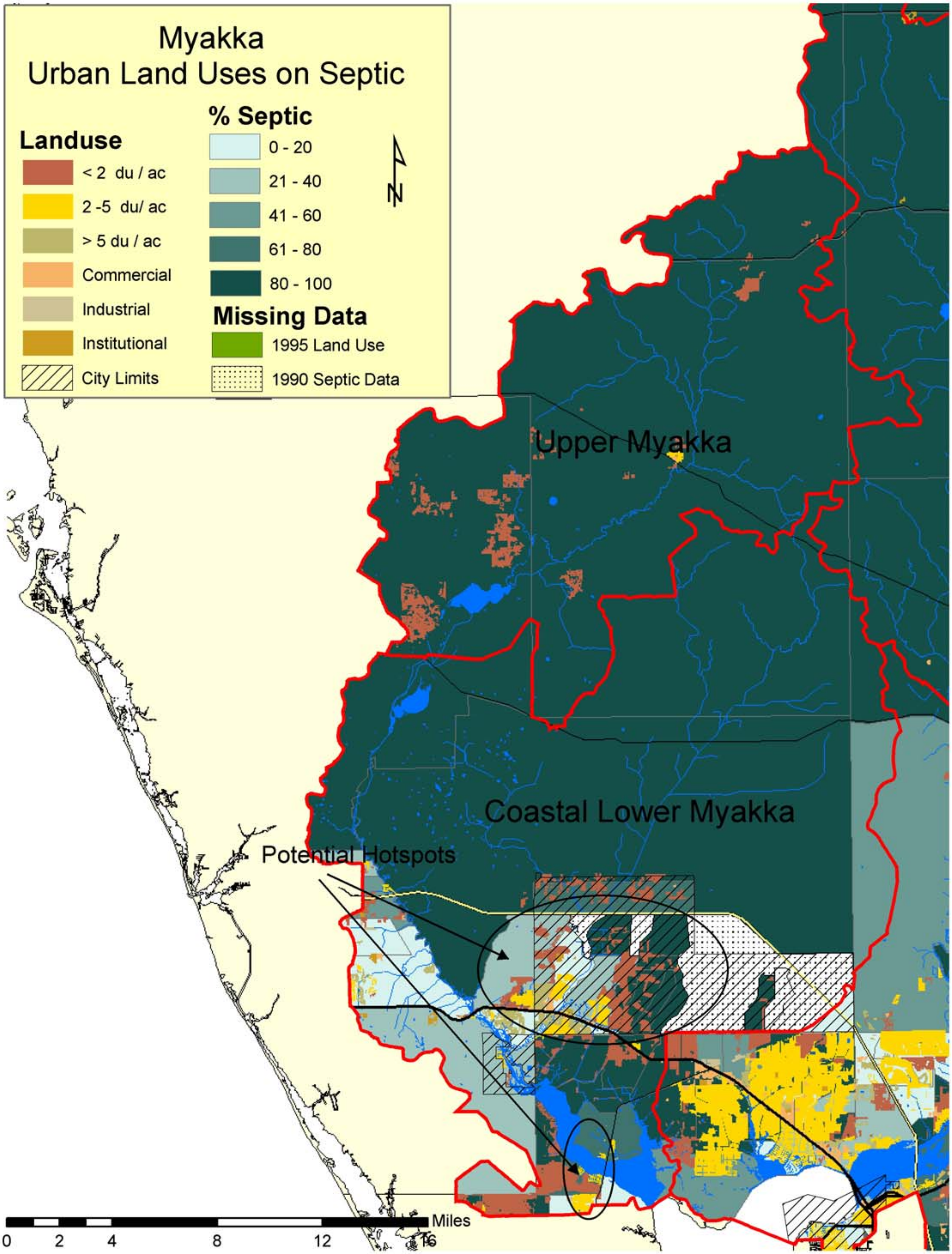
Lower Peace Phosphorus Loads to Surface Waters (lbs. P/yr/acre)
P Loads
0.00 - 0.50
0.51 - 1.00
1.01 - 3.00
3.01 - 5.00
5.01 - 7.00
City Limits
% Septic
0 - 20
21 - 40
41 - 60
61 - 80
80 - 100
Missing Data
1995 Land Use
1990 Septic Data
N
Joshua Creek
Shell Creek
Coastal Lower Peace
Miles
0
2
4
8
12
16

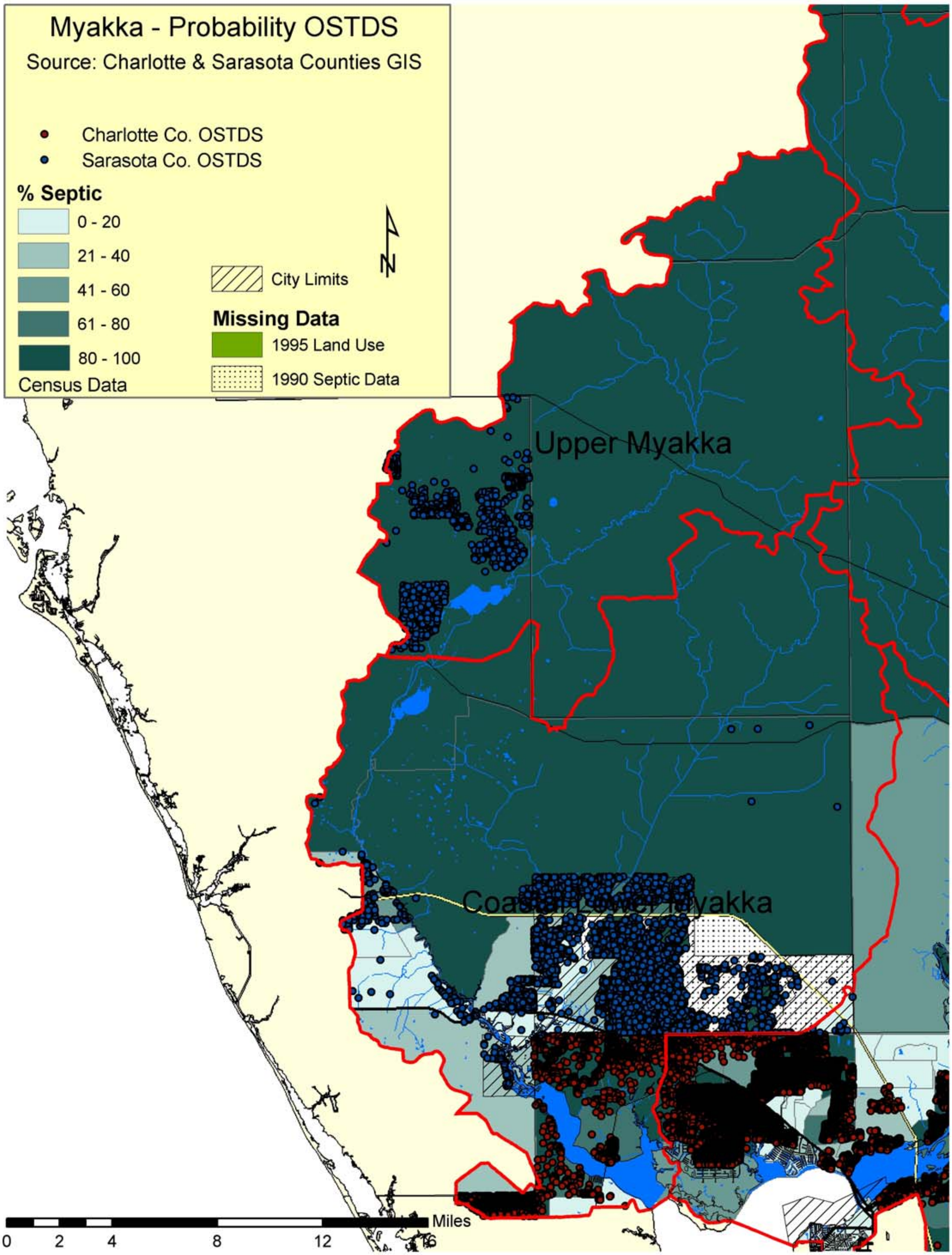

Lower Peace Nitrogen Loads
to Ground Water (lbs. N/yr/acre)
N Loads
0.00 - 1.00
1.01 - 2.00
2.01 - 4.00
4.01 - 6.00
6.01 - 8.00
City Limits
% Septic
0 - 20
21 - 40
41 - 60
61 - 80
80 - 100
Missing Data
1995 Land Use
1990 Septic Data
N
Joshua Creek
Shell Creek
Coastal Lower Peace
Miles
0
2
4
8
12
16


Lower Peace Phosphorus Loads to Ground Water (lbs. P/yr/acre)
P Loads
0.00 - 0.10
0.11 - 0.20
0.21 - 0.40
0.41 - 0.60
0.61 - 0.80
City Limits
% Septic
0 - 20
21 - 40
41 - 60
61 - 80
80 - 100
Missing Data
1995 Land Use
1990 Septic Data
N
Joshua Creek
Shell Creek
Coastal Lower Peace
0 2 4 8 12 16
Miles

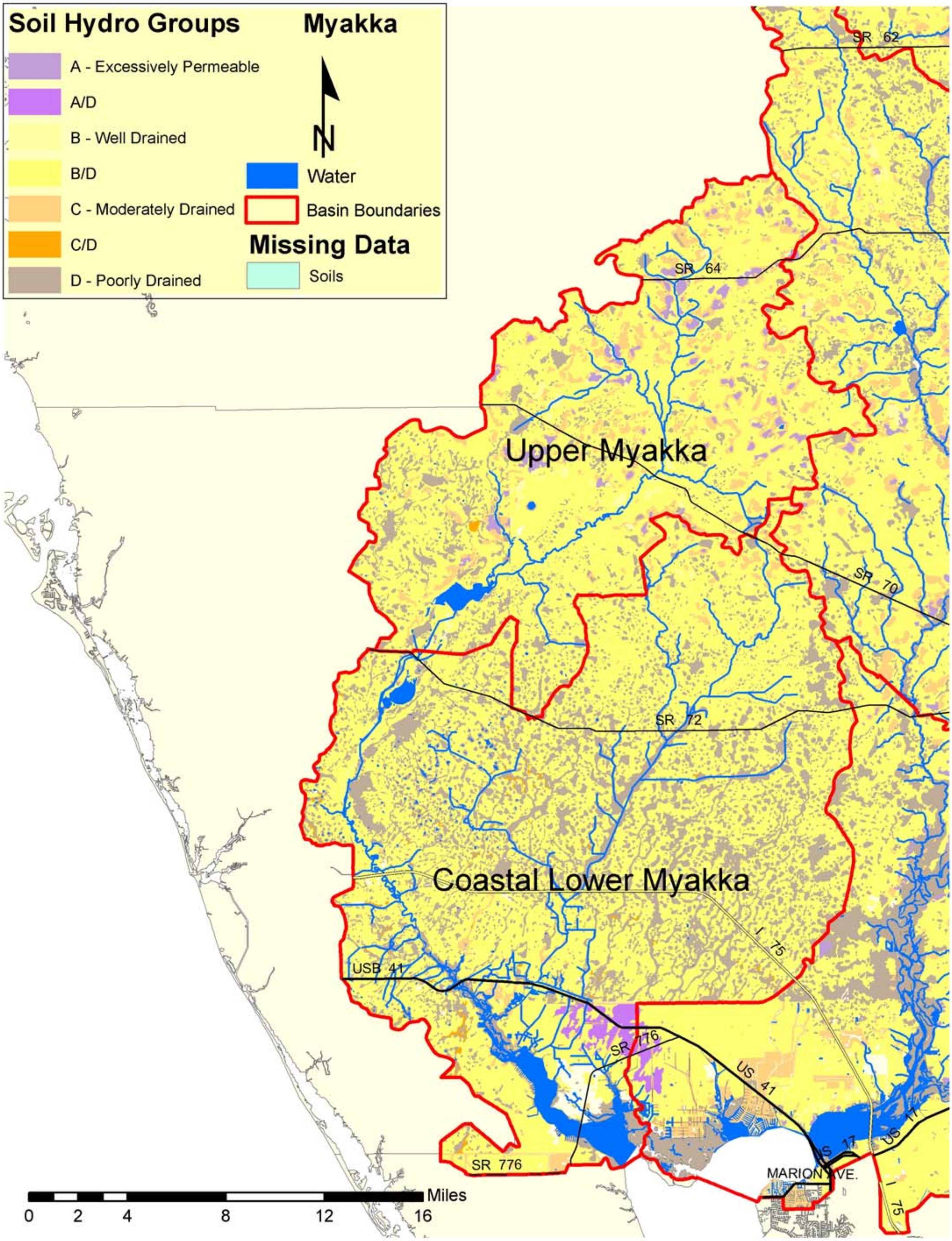
Appendix F

Myakka Region Hot-Spot Analysis

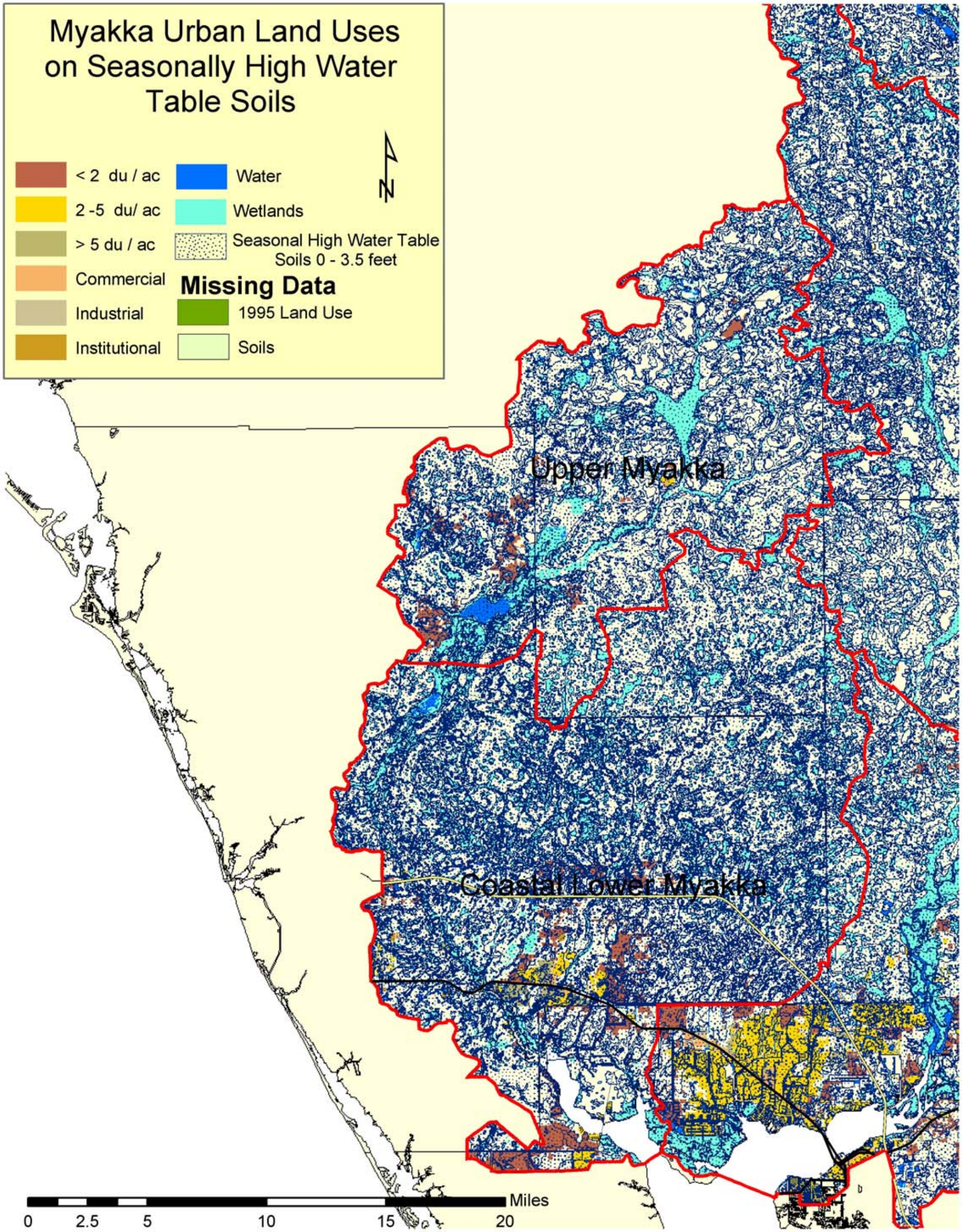

Myakka
Urban Land Uses on Septic
Landuse
< 2 du / ac
2 -5 du/ ac
> 5 du / ac
Commercial
Industrial
Institutional
City Limits
% Septic
0 - 20
21 - 40
41 - 60
61 - 80
80 - 100
Missing Data
1995 Land Use
1990 Septic Data
N
Upper Myakka
Coastal Lower Myakka
Potential Hotspots
Miles
0
2
4
8
12
16



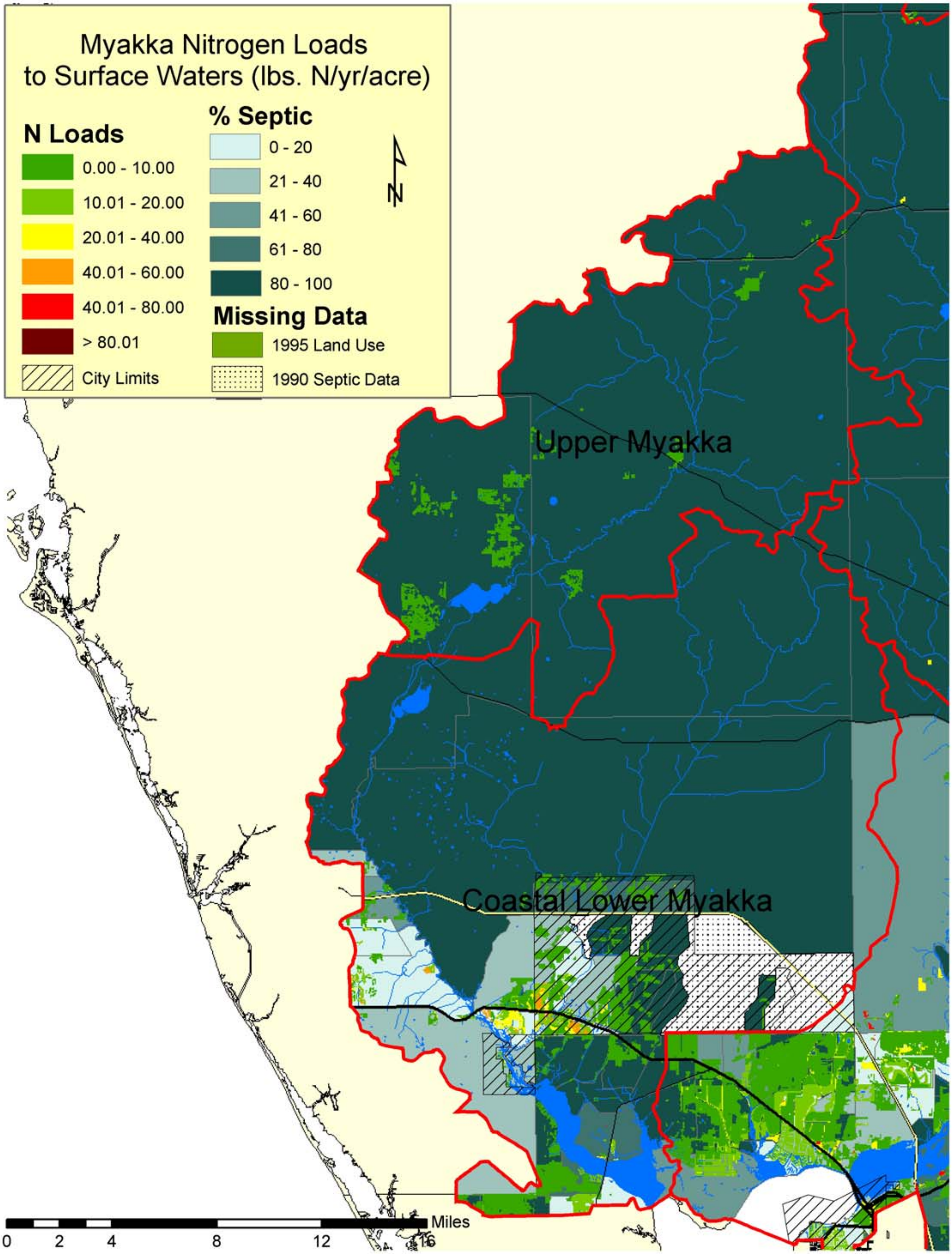
Myakka - Probability OSTDS
Source: Charlotte & Sarasota Counties GIS
Charlotte Co. OSTDS
Sarasota Co. OSTDS
% Septic
0 - 20
21 - 40
41 - 60
61 - 80
80 - 100
Census Data
City Limits
Missing Data
1995 Land Use
1990 Septic Data
N
Upper Myakka
Coastal Lower Myakka
Miles
0
2
4
8
12
16



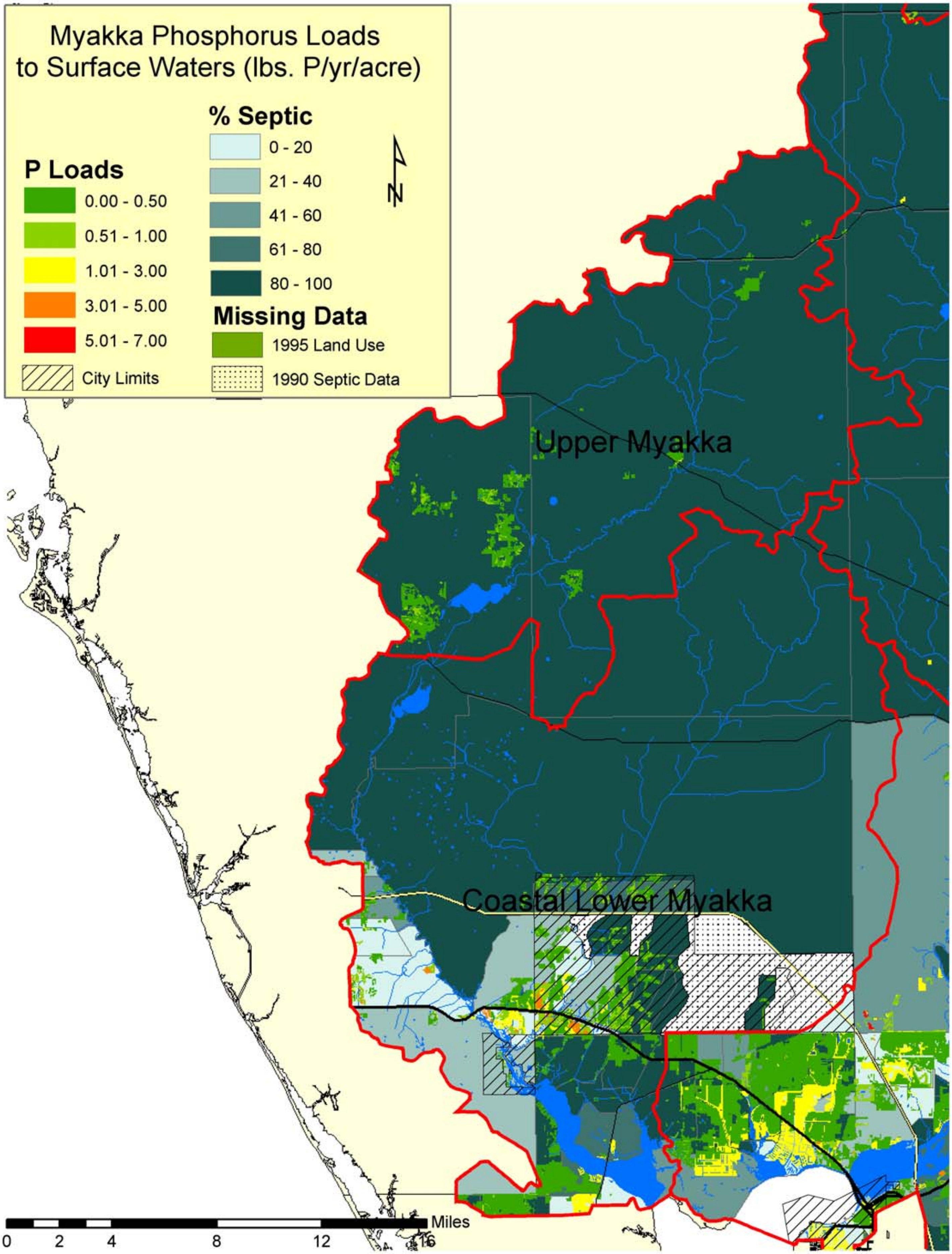
Soil Hydro Groups
Myakka
A - Excessively Permeable
A/D
B - Well Drained
B/D
C - Moderately Drained
C/D
D - Poorly Drained
N
Water
Basin Boundaries
Missing Data
Soils
SR 62
SR 64
Upper Myakka
SR 70
SR 72
Coastal Lower Myakka
I 75
USB 41
SR 776
US 41
US 17
MARION AVE.
SR 776
I 75
Miles
0
2
4
8
12
16



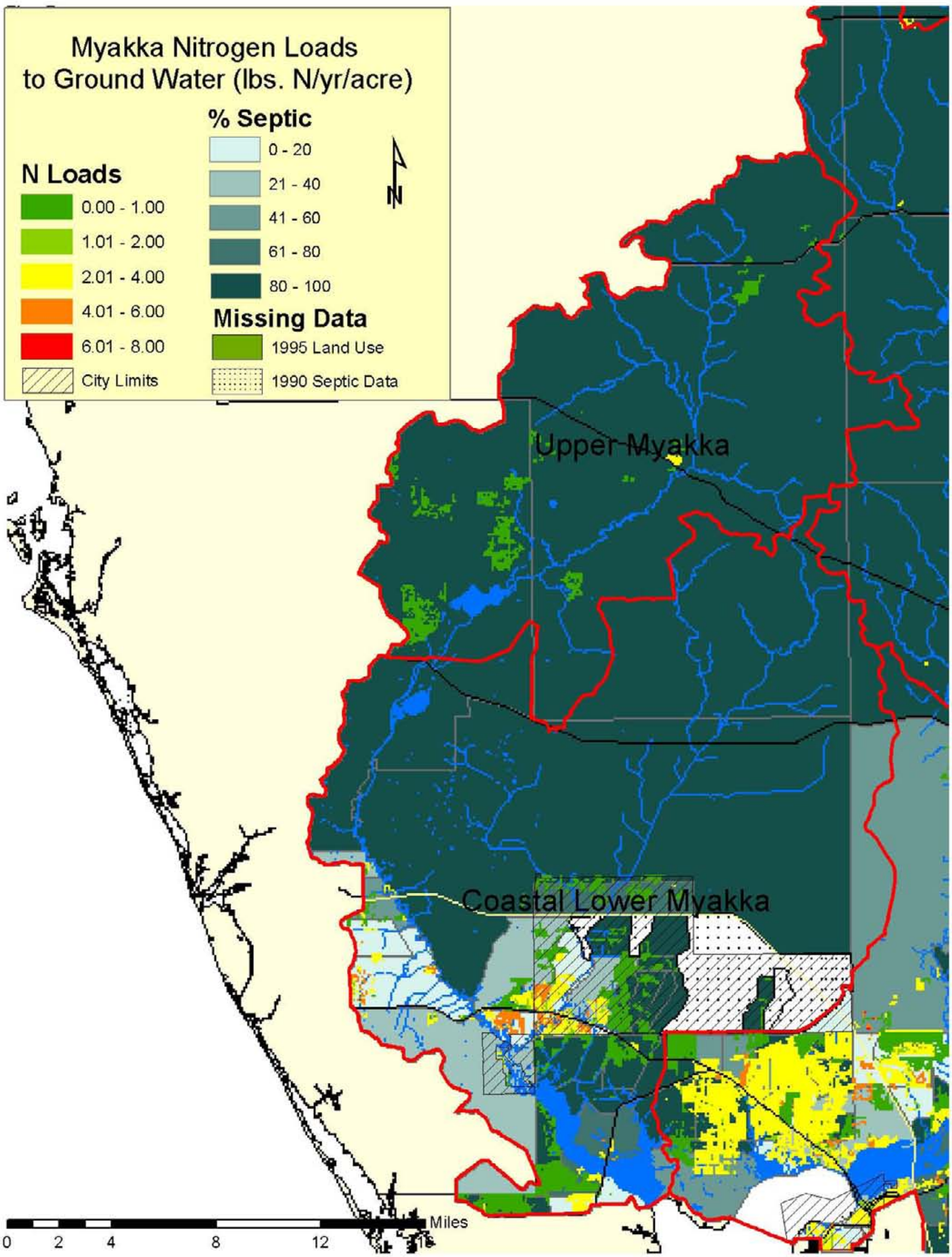
Myakka Urban Land Uses on Seasonally High Water Table Soils
< 2 du / ac
2 -5 du/ ac
> 5 du / ac
Commercial
Industrial
Institutional
Water
Wetlands
Seasonal High Water Table Soils 0 - 3.5 feet
Missing Data
1995 Land Use
Soils
Upper Myakka
Coastal Lower Myakka
Miles
0
2.5
5
10
15
20



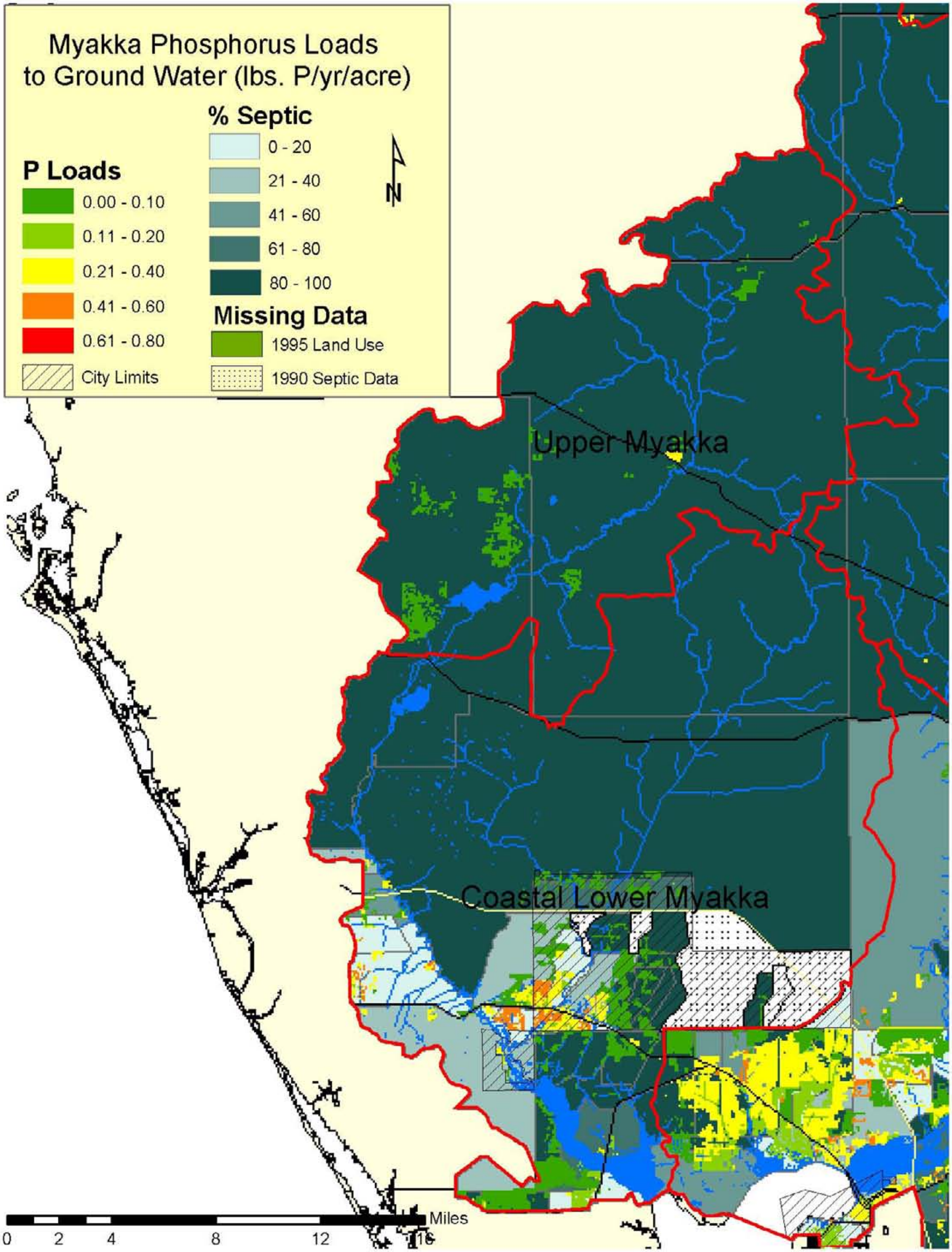
Myakka Nitrogen Loads
to Surface Waters (lbs. N/yr/acre)
N Loads
0.00 - 10.00
10.01 - 20.00
20.01 - 40.00
40.01 - 60.00
40.01 - 80.00
> 80.01
City Limits
% Septic
0 - 20
21 - 40
41 - 60
61 - 80
80 - 100
Missing Data
1995 Land Use
1990 Septic Data
N
Upper Myakka
Coastal Lower Myakka
Miles
0
2
4
8
12
16



Myakka Phosphorus Loads
to Surface Waters (lbs. P/yr/acre)
P Loads
0.00 - 0.50
0.51 - 1.00
1.01 - 3.00
3.01 - 5.00
5.01 - 7.00
City Limits
% Septic
0 - 20
21 - 40
41 - 60
61 - 80
80 - 100
Missing Data
1995 Land Use
1990 Septic Data
N
Upper Myakka
Coastal Lower Myakka
Miles
0
2
4
8
12
16



Myakka Nitrogen Loads
to Ground Water (lbs. N/yr/acre)
N Loads
0.00 - 1.00
1.01 - 2.00
2.01 - 4.00
4.01 - 6.00
6.01 - 8.00
City Limits
% Septic
0 - 20
21 - 40
41 - 60
61 - 80
80 - 100
Missing Data
1995 Land Use
1990 Septic Data
N
Upper Myakka
Coastal Lower Myakka
Miles
0 2 4 8 12 16



Myakka Phosphorus Loads
to Ground Water (lbs. P/yr/acre)
P Loads
0.00 - 0.10
0.11 - 0.20
0.21 - 0.40
0.41 - 0.60
0.61 - 0.80
City Limits
% Septic
0 - 20
21 - 40
41 - 60
61 - 80
80 - 100
Missing Data
1995 Land Use
1990 Septic Data
N
Upper Myakka
Coastal Lower Myakka
Miles
0
2
4
8
12
16

Appendix G
USGS Wastewater Tracer Suite

Compound	Class
	Wood Preservatives (1)
para-cresol	Wood preservative
	Solvents-degreaser/resins (2)
tetrachloroethylene	Solvent, degreaser
2(2-btxyethxy) ethyl acetate	Solvent for nitrocellulose resins
	Plasticizer, polymers or plastic manufacture (8)
bisphenol A	polymers: Used to manufacture
phthalic anhydride	plastics: Used to manufacture
ethanol,2-butoxy-,phosphate	Plasticizer
tributyl phosphate	Plasticizer
benzo(a)pyrene	Plasticizer
bis(2-ethyl hexyl) adipate	Plasticizer
triphenyl phosphate	Plasticizer
bis(2-ethylhexyl) phthalate	Plasticizer
	Pesticides (7)
carbaryl	Pesticide
diazinon	Pesticide
lindane	Pesticide
methyl parathion	Pesticide
cis-chlordane	Pesticide
dieldrin	Pesticide
chlorpyrifos	Pesticide
	PAH -Combustion Products (5)
naphthalene	PAH, fumigant
fluoranthene	PAH
pyrene	PAH
phenanthrene	PAH
anthracene	PAH
2,6-dimethylnaphthalene	
	Surfactants (5)
NPEO1-total	Nonionic detergent metabolite (anionic surfactant, endocrine disruptor, nano - 9 rings)
NPEO2-total	Nonionic detergent metabolite (anionic surfactant, endocrine disruptor, nano - 9 rings)
para-nonylphenol-total	Nonionic detergent metabolite
OPEO2	Anionic surfactant (endocrine disruptor, ocot - 8 rings)
OPEO1	Anionic surfactant (endocrine disruptor, ocot - 8 rings)
	Fumigants (3)
1,3-dichlorobenzene	Fumigant
1,4-dichlorobenzene	Fumigant
1,2-dichlorobenzene	Fumigant
	Fire Retardant (2)
tri(2-chloroethyl)phosphate	Fire retardant
tri(dichlorisopropyl)phosphate	Fire retardant
	Domestic Waste (7)
codeine	Analgesic
caffeine	Stimulant
17B-estradiol	Major estrogen metabolite
3B-coprostanol	Fecal indicator: carnivore
cholesterol	Fecal indicator
	Disinfectant (2)
phenol	Disinfectant: general
triclosan	Disinfectant, Antimicrobial
	Antioxidant (3)
2,6-di-t-p-benzoquinone	Antioxidant
2,6-di-t-butylphenol	Antioxidant
BHT	Antioxidant
	Flavor/Fragrance (2)
acetophenone	Fragrance

Appendix G
USGS Wastewater Tracer Suite

Compound	Class
	Wood Preservatives (1)
para-cresol	Wood preservative
	Solvents-degreaser/resins (2)
tetrachloroethylene	Solvent, degreaser
2(2-btxyethxy) ethyl acetate	Solvent for nitrocellulose resins
	Plasticizer, polymers or plastic manufacture (8)
bisphenol A	polymers: Used to manufacture
phthalic anhydride	plastics: Used to manufacture
ethanol,2-butoxy-,phosphate	Plasticizer
tributyl phosphate	Plasticizer
benzo(a)pyrene	Plasticizer
bis(2-ethyl hexyl) adipate	Plasticizer
triphenyl phosphate	Plasticizer
bis(2-ethylhexyl) phthalate	Plasticizer
	Pesticides (7)
carbaryl	Pesticide
diazinon	Pesticide
lindane	Pesticide
methyl parathion	Pesticide
cis-chlordane	Pesticide
dieldrin	Pesticide
chlorpyrifos	Pesticide
	PAH -Combustion Products (5)
naphthalene	PAH, fumigant
fluoranthene	PAH
pyrene	PAH
phenanthrene	PAH
anthracene	PAH
2,6-dimethylnaphthalene	
	Surfactants (5)
NPEO1-total	Nonionic detergent metabolite (anionic surfactant, endocrine disruptor, nano - 9 rings)
NPEO2-total	Nonionic detergent metabolite (anionic surfactant, endocrine disruptor, nano - 9 rings)
para-nonylphenol-total	Nonionic detergent metabolite
OPEO2	Anionic surfactant (endocrine disruptor, ocot - 8 rings)
OPEO1	Anionic surfactant (endocrine disruptor, ocot - 8 rings)
	Fumigants (3)
1,3-dichlorobenzene	Fumigant
1,4-dichlorobenzene	Fumigant
1,2-dichlorobenzene	Fumigant
	Fire Retardant (2)
tri(2-chloroethyl)phosphate	Fire retardant
tri(dichlorisopropyl)phosphate	Fire retardant
	Domestic Waste (7)
codeine	Analgesic
caffeine	Stimulant
17B-estradiol	Major estrogen metabolite
3B-coprostanol	Fecal indicator: carnivore
cholesterol	Fecal indicator
	Disinfectant (2)
phenol	Disinfectant: general
triclosan	Disinfectant, Antimicrobial
	Antioxidant (3)
2,6-di-t-p-benzoquinone	Antioxidant
2,6-di-t-butylphenol	Antioxidant
BHT	Antioxidant
	Flavor/Fragrance (2)
acetophenone	Fragrance