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CDM

SARASOTA BAY
NATIONAL ESTUARY PROGRAM

POINT/NON-POINT SOURCE POLLUTION LOADING ASSESSMENT PHASE I

JANUARY 10, 1992

Camp Dresser & McKee

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1.0 INTRODUCTION

1.1 BACKGROUND OF THE SARASOTA BAY NATIONAL ESTUARY PROGRAM

Sarasota Bay was identified in Section 317 of the Water Quality Act of 1987 as an estuary to be given priority consideration for inclusion in the National Estuary Program (NEP). As a result, Governor Bob Martinez nominated Sarasota Bay to the NEP, in a May 19, 1987 letter to EPA Administrator Lee Thomas. According to the Act, documentation was required to support the nomination. This documentation would evaluate the need for a management conference, likelihood of program success, and need to protect water quality beyond existing controls.

In 1987, the EPA established a cooperative agreement with Mote Marine Laboratory to gather data regarding environmental status, trends and problems in Sarasota Bay. These data were to be used as the documentation to support the Bay's nomination to the NEP. The report developed by Mote was presented at a workshop of federal, state and local government representatives on March 17, 1988. Through the workshop, additional information on Sarasota Bay was obtained.

The Florida Department of Environmental Regulation (FDER) used the Mote report as the basis for the completion of the Governor's nomination document. The supporting documentation was submitted on May 31, 1988 to the EPA Office of Marine and Estuary Protection. After EPA's evaluation, the Bay was designated as a member of the NEP on July 18, 1988.

In May of 1989, the Sarasota Bay NEP released a Request for Proposal (RFP) for work related to the preservation, restoration and enhancement of the Bay. The RFP included the following areas:

- Baywide Segmentation and Mapping
- Wetland Habitat Assessment
- Estuarine Bottom Habitat Assessment
- Regional Beach/Inlet Management
- Impacts of Sea Level Rise
- Fishery Resource Assessment
- Shellfish Contamination Assessment
- Point and Nonpoint Pollution Loading Assessment, Calibration, Verification, and Projections
- Resource Access and Use Assessment
- Data Management

The information gathered in these areas will lead to the development of a comprehensive conservation and management plan.

1.2 PURPOSE AND SCOPE OF POINT AND NONPOINT POLLUTION LOADING ANALYSIS

CDM was selected to conduct the analysis of point and nonpoint source loadings to Sarasota Bay. Basically, the objective of the analysis is to quantify the loadings of nutrients and metals to the Bay, to identify the areas that are contributing the largest share of the total load, and to analyze alternative measures for reducing the loadings.

For purposes of this study, assessment of pollutant loadings was restricted to total nitrogen, total phosphorus, lead and zinc. Sources of loadings evaluated include baseflow, storm event runoff, atmospheric, and point source loadings. While it is fully recognized that there are other contaminating substances entering Sarasota Bay through a variety of other sources, these parameters were chosen as surrogates for major non-point and point source loadings. These parameters represent contaminants which are well characterized in the literature, and for which documented relationships with land-use exist. As such, this

study does not attempt to characterize all pollutant loadings, nor all sources of pollution, but rather focuses on the major loadings delivered to Sarasota Bay.

The analysis is divided into three distinct phases. In Phase 1, existing data are used to estimate current loading levels. Phase 2 is designed to collect field measurements or other data required to improve the estimates developed in Phase 1. Analysis of future loadings, based on projected changes in population, land use, and other factors, is performed in Phase 3. Evaluation of alternative management programs is also part of Phase 3.

This report documents the results generated in Phase 1. This phase includes the estimation of existing point and nonpoint source loadings. Even though future loading estimates are part of the Phase 3 analysis, preliminary estimates of future loadings also are included here in Phase 1.

1.3 ORGANIZATION OF REPORT

Chapter 2 summarizes the study area characteristics that are pertinent to the analysis of point and nonpoint sources loadings. The methodology used to develop loading estimates is presented in Chapter 3. Chapter 4 documents the modeling of water quality constituents in the tidal tributaries of the major watersheds. The estimated loadings for existing and future land uses are presented in Chapter 5 and 6, respectively. Chapter 7 evaluates and summarizes the results presented in Chapters 5 and 6. The references used in the study are listed in Chapter 8.

2.0 STUDY AREA CHARACTERISTICS

2.1 INTRODUCTION

This chapter describes the NEP study area characteristics that are essential to the pollutant loading analyses. These characteristics include watershed boundaries, existing and future land use, soil classifications , water quality, and sources of pollution.

2.2 WATERSHED DELINEATION

The Sarasota Bay NEP study area is shown in Figure 2-1. The area extends to the north as far as Anna Maria Island and Perico Island, and to the south as far as Casey Key. The watersheds in the study drain not only to Sarasota Bay itself, but to several smaller bays to the south including Roberts Bay, Little Sarasota Bay, Dryman Bay, and Blackburn Bay. In this report, the term "Sarasota Bay" will include all of the bays listed above.

Delineation of the total study area draining to Sarasota Bay, and delineation of major watersheds within the study area, was done on 1" = 2000' USGS quadrangle maps. These maps were combined in a mosaic to create one large map which was used as a project work map for the study. In some cases, additional information was required to delineate watershed boundaries due to the lack of topography. Previous studies (CDM, 1987; Briley and Wild, 1984) were used to check the delineation and to provide guidance where map topography was lacking.

Table 2-1 lists the watersheds that were defined in the delineation process. In addition, the table shows the drainage area and jurisdiction or jurisdictions in which each watershed is located. In all, the study area contains approximately 150 square miles of land area, plus 52 square miles of water surface.

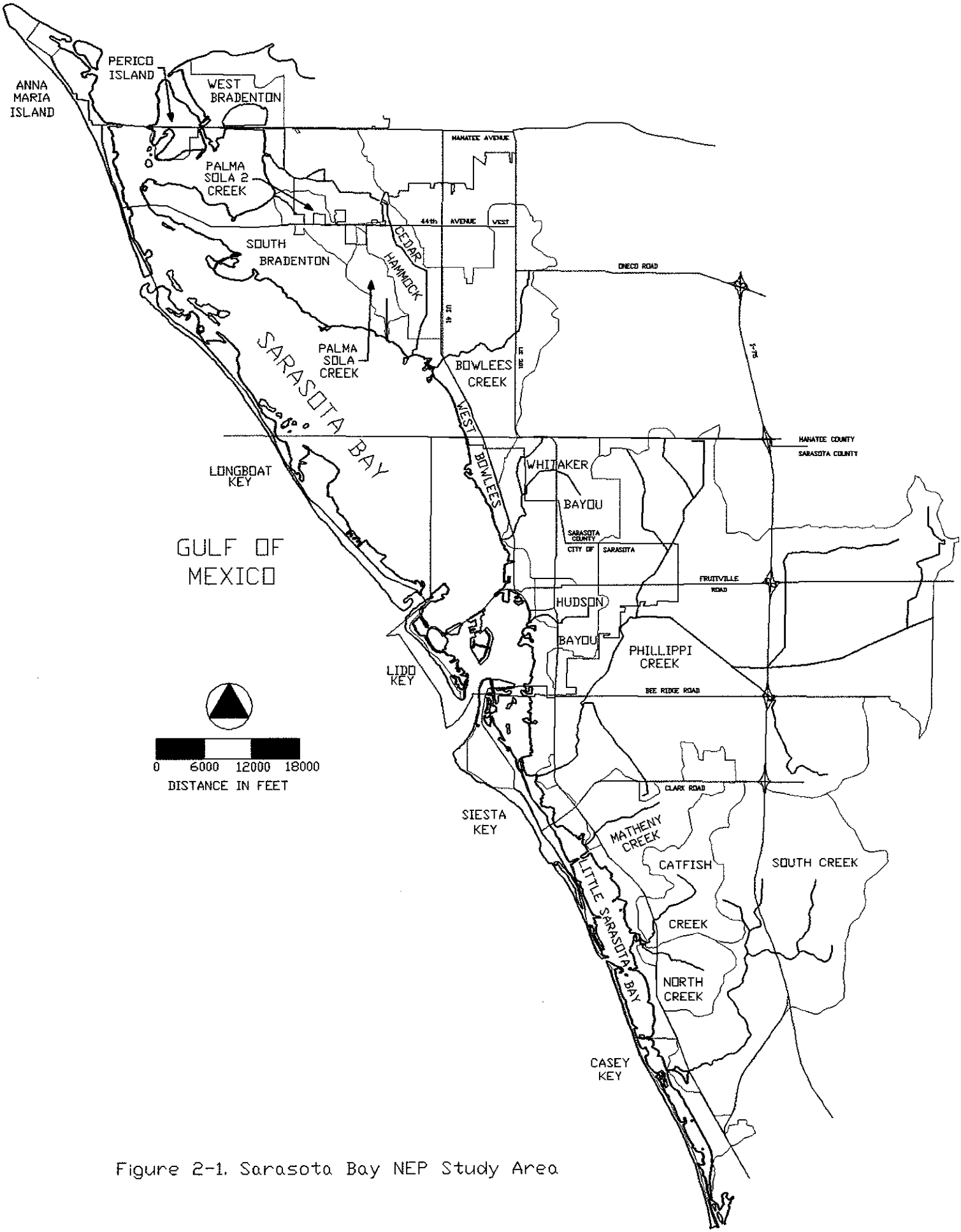

Figure 2-1. Sarasota Bay NEP Study Area

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TABLE 2-1

WATERSHEDS IN SARASOTA BAY NEP STUDY AREA

Watershed	Drainage area (Acres)	Jurisdiction(s)
Phillippi Creek	36,417	City of Sarasota Sarasota County Manatee County
Hudson Bayou	1,595	City of Sarasota
Bowlees Creek	6,489	City of Sarasota Sarasota County Manatee County
West Bowlees	1,559	City of Sarasota Sarasota County Manatee County
Whitaker Bayou	5,015	City of Sarasota Sarasota County
Direct to Bay	4,241	City of Sarasota Sarasota County
Matheny Creek	3,800	Sarasota County
Catfish Creek	3,360	Sarasota County
North Creek	1,920	Sarasota County
South Creek	12,995	Sarasota County
Palma Sola Creek	900	Manatee County
Palma Sola 2	1,120	Manatee County
West Bradenton	4,395	Manatee County
South Bradenton	4,635	Manatee County
Cedar Hammock	1,930	Manatee County
Siesta Key	1,385	Barrier Islands
Anna Maria Island	919	Barrier Islands
Perico Island	860	Barrier Islands
Longboat Key	1,697	Barrier Islands
Other Islands	900	Barrier Islands

2.3 EXISTING LAND USE

Existing land use was established in the study area based on Real Estate Data Inc. (REDI) maps. These maps include aerial photographs and corresponding zoning maps. From the aerials, developed and undeveloped areas were identified. The type of development in urban areas was determined based on the zoning maps.

The study area was classified according to the following land uses:

- Cropland
- Forested Uplands
- Rangeland/Woodlands
- Open/Recreation
- Wetland
- Citrus
- Low Density Single Family Residential
- Medium Density Single Family Residential
- High Density Single Family Residential
- Multi-Family Building
- Mobile Home
- Commercial/Services
- Institutional
- Industrial
- Transportation
- Waterbody
- Sewage Treatment and Power Plants

Table 2-2 summarizes the assumed directly connected impervious area (DCIA) established for each urban land use category. The DCIA value is important because it determines the amount of surface runoff that is generated by precipitation. The values in the table were selected based on literature values and previous CDM studies. For urban land use, industrial and commercial areas tend to have the highest percentage of impervious area. In residential areas, the DCIA value increases with the density of the development (i.e., number of dwellings per acre).

TABLE 2-2
IMPERVIOUS COVER FOR URBAN LAND USE CATEGORIES

Land Use	Directly Connected Impervious Area (%)
Low Density Single Family Residential	20
Medium Density Single Family Residential	30
High Density Single Family Residential	40
Multi-family Building	50
Mobile Home	60
Commercial/Services	85
Extractive	70
Institutional	40
Industrial	70
Transportation	90
STP and Power Plants	40

Table 2-3 presents the existing land use by jurisdiction for the study area. As shown in the table, Sarasota County has the largest contributory area to the Bay, accounting for 65 percent of the total land area. The City of Sarasota, Manatee County, and the barrier islands make up 8, 21 and 6 percent of the total land area, respectively.

In the study area, slightly more than half of the land area consists of urban development (residential, commercial, industrial and institutional land uses), and the rest is rural. Of the urban development, about 81 percent is residential, primarily medium density and high density. For the rural areas, about 18 percent is either cropland or citrus, and the rest is primarily rangeland/woodlands, open/recreation and forested uplands.

The following sections discuss land use distributions for each jurisdiction.

2.3.1 SARASOTA COUNTY

The existing land use distribution for Sarasota County, broken down by watershed, is presented in Table 2-4. The values in the table indicate that Phillippi Creek accounts for over half of the total drainage area in the County. South Creek accounts for about 21 percent of the total area, and the remaining watersheds each account for 6 percent or less of the total area.

In the County, approximately 42 percent of the land area consists of urban development and the remaining 58 percent is rural. The urban development is most prevalent in the land areas closest to the Bay (i.e., the western sections of each watershed), and rural areas are typically located in the eastern sections of each watershed. Of the urban development, about 87 percent is residential, primarily split between low, medium and high density single family residential. For the rural areas, about 17 percent is either cropland or citrus, and the rest is primarily rangeland/woodlands or open/recreation.

TABLE 2-3

EXISTING LAND USE BY JURISDICTION IN
SARASOTA BAY NEP STUDY AREA

Land Use	AREA (Acres)				
	City of Sarasota	Sarasota County	Manatee County	Barrier Islands	Total
Cropland	0	3,756	1,912	130	5,798
Forested Uplands	168	673	1,052	44	1,937
Rangeland/Woodlands	126	15,544	1,253	19	16,942
Open/Recreation	650	11,688	2,222	1,373	15,933
Wetland	0	1,449	415	403	2,267
Citrus	4	2,278	209	0	2,491
Low Density Single Family Residential	368	7,375	292	388	8,423
Medium Density Single Family Residential	1,320	6,827	2,012	1,641	11,800
High Density Single Family Residential	2,164	5,163	3,422	741	11,490
Multi-family Building	946	1,983	2,677	754	6,360
Mobile Home	0	1,065	862	37	1,964
Commercial/Services	926	1,485	654	169	3,234
Institutional	529	647	365	0	1,541
Industrial	521	1,106	1,989	40	3,656
Transportation	17	203	633	15	868
Waterbody	75	1,028	228	2	1,333
Sewage Treatment and Power Plants	30	30	30	5	95
Total	7,844	62,301	20,226	5,761	96,132

TABLE 2-4

EXISTING LAND USE BY WATERSHED IN SARASOTA BAY NEP STUDY AREA - SARASOTA COUNTY

Land Use	AREA (Acres)									
	Total	Phillippi Creek	Matheny Creek	Catfish Creek	North Creek	South Creek	Bowlees Creek	West Bowlees	Whitaker Bayou	Direct to Bay
Cropland	3,756	3,612	0	0	48	65	0	0	31	0
Forested Uplands	673	570	15	20	20	0	0	0	29	19
Rangeland/Woodlands	15,544	5,304	675	2,202	728	6,410	7	0	29	189
Open/Recreation	11,688	5,353	444	171	655	4,502	7	0	499	57
Wetland	1,449	436	14	199	57	565	0	0	3	175
Citrus	2,278	1,938	104	50	10	120	0	0	4	52
Low Density Single Family Residential	7,375	4,770	145	227	191	636	0	0	578	828
Medium Density Single Family Residential	6,827	4,997	114	257	70	133	0	38	291	927
High Density Single Family Residential	5,163	3,685	1,176	0	0	140	0	0	80	82
Multi-family Building	1,983	896	307	73	5	109	0	0	317	276
Mobile Home	1,065	423	30	42	35	80	0	0	314	141
Commercial/Services	1,486	588	435	30	35	30	0	13	105	250
Institutional	647	496	0	20	0	75	7	0	21	28
Industrial	1,106	542	221	0	25	10	0	0	308	0
Transportation	203	65	0	0	0	0	135	0	2	0
Waterbody	1,028	542	120	69	41	120	4	0	98	34
Sewage Treatment and Power Plants	30	30	0	0	0	0	0	0	0	0
Total	62,301	34,247	3,800	3,360	1,920	12,995	160	51	2,710	3,058

2.3.2 MANATEE COUNTY

The existing land use distribution for the watersheds in Manatee County is presented in Table 2-5. The largest watersheds in the County include Bowlees Creek, South Bradenton, and West Bradenton. These three watersheds account for 75 percent of the total drainage area in the County.

In Manatee County, about 64 percent of the land area consists of urban development and the other 36 percent is rural. Generally, the areas immediately south and west of the City of Bradenton are undeveloped, whereas the remaining areas are developed. Roughly 72 percent of the urban area is residential, primarily divided between medium and high density single family and multi-family building. In the rural areas, about 29 percent is either cropland or citrus, and the remaining 71 percent is typically either rangeland/woodlands or open/recreation.

2.3.3 CITY OF SARASOTA

Table 2-6 presents the existing land use distribution for the watersheds in the City of Sarasota. The largest watersheds in the City include Whitaker Bayou, Phillippi Creek and Hudson Bayou. These watersheds account for 75 percent of the City drainage area. In addition, another 15 percent drains directly to Sarasota Bay.

In the City, 87 percent of the land area consists of urban development and the other 13 percent is rural. Most of the rural area is located in the far eastern part of the City, and the majority of the rural area actually consists of golf course and park land that will not be urbanized in the future. Residential development accounts for 70 percent of the total urban land use, and it is primarily split between medium density and high density single family residential and multi-family building.

TABLE 2-5

EXISTING LAND USE BY WATERSHED IN SARASOTA BAY NEP STUDY AREA - MANATEE COUNTY

Land Use	AREA (Acres)								
	Total	Phillippi Creek	Palma Sola 2	Bowlees Creek	West Bradenton	Cedar Hammock	West Bowlees	Palma Sola Creek	South Bradenton
Cropland	1,912	0	0	16	160	0	0	250	1,486
Forested Uplands	1,052	0	65	32	180	15	0	135	625
Rangeland/Woodlands	1,253	87	45	345	160	30	41	20	525
Open/Recreation	2,222	0	385	365	720	10	77	55	610
Wetland	415	0	0	0	305	0	0	0	110
Citrus	209	0	0	204	5	0	0	0	0
Low Density Single Family Residential	292	63	0	24	125	80	0	0	0
Medium Density Single Family Residential	2,012	0	0	958	280	120	319	20	315
High Density Single Family Residential	3,422	0	295	621	1,540	400	246	35	285
Multi-family Building	2,677	0	180	481	550	865	41	310	250
Mobile Home	862	0	70	461	20	80	101	0	130
Commercial/Services	654	0	0	294	145	105	25	0	85
Institutional	365	0	0	95	80	115	0	75	0
Industrial	1,989	0	80	1,663	80	95	31	0	40
Transportation	633	0	0	633	0	0	0	0	0
Waterbody	228	0	0	24	45	15	0	0	144
Sewage Treatment and Power Plants	30	0	0	0	0	0	0	0	30
Total	20,226	150	1,120	6,215	4,395	1,930	881	900	4,635

TABLE 2-6

EXISTING LAND USE BY WATERSHED IN SARASOTA BAY NEP STUDY AREA - CITY OF SARASOTA

Land Use	AREA (Acres)						
	Total	Phillippi Creek	Hudson Bayou	Bowlees Creek	West Bowlees	Whitaker Bayou	Direct to Bay
Cropland	0	0	0	0	0	0	0
Forested Uplands	168	38	0	9	0	111	10
Rangeland/Woodlands	126	27	0	35	6	57	0
Open/Recreation	650	370	65	0	59	104	52
Wetland	0	0	0	0	0	0	0
Citrus	4	4	0	0	0	0	0
Low Density Single Family Residential	368	55	0	0	77	197	39
Medium Density Single Family Residential	1,320	356	150	3	210	117	484
High Density Single Family Residential	2,164	574	635	1	170	555	229
Multi-family Building	946	306	240	25	5	370	0
Mobile Home	0	0	0	0	0	0	0
Commercial/Services	926	99	305	19	46	178	279
Institutional	529	113	180	19	54	124	39
Industrial	521	38	20	0	0	433	30
Transportation	17	0	0	0	0	2	15
Waterbody	75	39	0	3	0	27	6
Sewage Treatment and Power Plants	30	0	0	0	0	30	0
Total	7,844	2,020	1,595	114	627	2,305	1,183

2.3.4 BARRIER ISLANDS

The existing land use distribution for the barrier islands draining to Sarasota Bay is presented in Table 2-7. Siesta Key, Anna Maria Island, Perico Island and Longboat Key are the major land areas contributing to the Bay. A group of smaller islands, including Lido Key, St. Armands Key, Coon Key, Bird Key, Otter Key and Casey Key, was combined under the category of "Other Islands".

For the barrier islands, 66 percent of the land area consists of urban development and the other 34 percent is rural. Most of the rural area is located on Longboat Key and Perico Island, whereas Siesta Key and Anna Maria Island are predominantly urbanized. Of the urban area, 94 percent is residential. Medium density single family makes up almost half of the residential area, and the rest is split primarily between low and high density single family residential and multi-family building. Cropland and citrus account for only 7 percent of the total rural area on the islands. Over 70 percent of the rural area is open/recreation.

2.4 FUTURE LAND USE

Even though the focus of Phase 1 is determination of existing loads to Sarasota Bay, preliminary projections of future loadings were developed to get a preliminary estimate of the incremental increases in loadings that are expected due to future development. Consequently, future land use data were developed as part of the analysis. Two future land use scenarios were developed: 5-year future and a buildout future.

The 5-year future land use was developed based on the Developments of Regional Impact (DRI) data provided by Sarasota and Manatee Counties. The DRI information was screened to determine which projects were located in the Sarasota Bay study area. The appropriate projects were located on the existing land use maps to determine the watershed in which the development would occur, and the type of land that would be

TABLE 2-7

EXISTING LAND USE BY WATERSHED IN SARASOTA BAY NEP STUDY AREA - BARRIER ISLANDS

Land Use	AREA(Acres)					
	Total	Siesta Key	Anna Maria Island	Perico Island	Longboat Key	Other Islands
Cropland	130	0	0	130	0	0
Forested Uplands	44	0	0	0	38	6
Rangeland/Woodlands	19	0	0	0	0	19
Open/Recreation	1,373	45	172	330	689	137
Wetland	403	48	0	290	8	57
Citrus	0	0	0	0	0	0
Low Density Single Family Residential	388	199	0	0	34	155
Medium Density Single Family Residential	1,641	788	0	0	459	394
High Density Single Family Residential	741	10	621	15	95	0
Multi-family Building	754	243	55	80	311	65
Mobile Home	37	0	12	0	25	0
Commercial/Services	169	42	59	0	38	30
Institutional	0	0	0	0	0	0
Industrial	40	5	0	15	0	20
Transportation	15	0	0	0	0	15
Waterbody	2	0	0	0	0	2
Sewage Treatment and Power Plants	5	5	0	0	0	0
Total	5,761	1,385	919	860	1,697	900

converted to urbanized area. Because some of the DRI projects are already underway and some are not due to be completed 5 years from now, the increase in urban area during the 5-year planning horizon was estimated to reflect the amount of development expected to occur between 1991 and 1996. For example, a DRI with a scheduled construction start date of 1991 and buildout date of 2001 would be assumed 50 percent complete in the 5-year planning horizon.

The Comprehensive Plans for Manatee and Sarasota Counties were used to develop the buildout future land use scenario. Development of rural areas in the two counties was evaluated by locating rural areas on the existing land use maps, and consulting the comprehensive plans to determine the future land use.

For both scenarios, the City of Sarasota and the barrier islands were not included in the analysis. The City of Sarasota is approaching build-out, and future development will be limited. The barrier islands were excluded because they represent only 6 percent of the land area in the study, and because comprehensive plans for the island communities were not available when the analysis was conducted.

2.4.1 5-YEAR FUTURE

After screening the DRI data for Sarasota and Manatee Counties, the following developments were included in the 5-year future land use analysis:

- Palmer Ranch, Increments I-V, in Catfish and Matheny Creek Watersheds, of Sarasota County
- Gateway Development, in Phillippi Creek Watershed, of Sarasota County
- Sawgrass Hollow Development, in Phillippi Creek Watershed, of Sarasota County

Based on information in the DRI reports and the existing land use maps, the development of 1,686 acres of rural land was projected. Note that all of these developments are in Sarasota County.

The 5-year future land use for Sarasota County is presented in Table 2-8. Overall, 248 acres of open/residential, 1,350 acres of rangeland/woodlands and 88 acres of citrus are developed to create 1,319 acres of medium density single family residential, 120 acres of industrial, 20 acres of institutional and 227 acres of commercial area. In addition, 87 acres are shifted from low density to medium density residential to account for increased densities in developments which were only partly developed under existing land use conditions.

2.4.2 BUILDOUT FUTURE

Tables 2-9 and 2-10 present the buildout future land use distributions for Sarasota and Manatee Counties, respectively. Between the two counties, almost 31,000 acres of undeveloped land are converted to urban uses in going from the existing to the buildout future scenario. Of the 31,000 acres, about 85 percent is developed into residential land use, and the remaining 15 percent is primarily converted to commercial or industrial use.

The Comprehensive Plans for Manatee and Sarasota Counties do not specify the planning horizon that is represented by the buildout scenario. However, by comparing the 23,000 acres of development for Sarasota County in the buildout scenario to the 1,686 acres of development in the 5-year scenario, the buildout scenario is estimated to represent a planning horizon of roughly 68 years (23,000 acres divided by 1,686 acres, times 5 years). This estimate involves two assumptions. One is that the current rate of development is representative of the long-term rate, and the other is that the 5-year estimate of land development is accurate. While the 5-year estimate is believed to be accurate, it may be less than the overall long-term rate of development due to the weakness of the economy at this time.

TABLE 2-8

FIVE - YEAR FUTURE LAND USE BY WATERSHED IN THE SARASOTA BAY NEP STUDY AREA - SARASOTA COUNTY

Land Use	AREA (Acres)									
	Total	Phillippi Creek	Matheny Creek	Catfish Creek	North Creek	South Creek	Bowlees Creek	West Bowlees Creek	Whitaker Bayou	Direct to Bay
Cropland	3,756	3,612	0	0	48	65	0	0	31	0
Forested Uplands	673	570	15	20	20	0	0	0	29	19
Rangeland/Woodlands	14,194	5,114	403	1,314	728	6,410	7	0	29	189
Open/Recreation	11,439	5,118	430	171	655	4,502	7	0	499	57
Wetland	1,449	436	14	199	57	565	0	0	3	175
Citrus	2,190	1,850	104	50	10	120	0	0	4	52
Low Density Single Family Residential	7,288	4,770	121	164	191	636	0	0	578	828
Medium Density Single Family Residential	8,233	5,408	304	1,062	70	133	0	38	291	927
High Density Single Family Residential	5,163	3,685	1,176	0	0	140	0	0	80	82
Multi-family Building	1,983	896	307	73	5	109	0	0	317	276
Mobile Home	1,065	423	30	42	35	80	0	0	314	141
Commercial/Services	1,712	689	435	156	35	30	0	13	105	250
Institutional	667	496	0	40	0	75	7	0	21	28
Industrial	1,226	542	341	0	25	10	0	0	308	0
Transportation	203	65	0	0	0	0	135	0	2	0
Waterbody	1,028	542	120	69	41	120	4	0	98	34
Sewage Treatment and Power Plants	30	30	0	0	0	0	0	0	0	0
Total	62,301	34,247	3,800	3,360	1,920	12,995	160	51	2,710	3,058

TABLE 2-9

BUILDOUT FUTURE LAND USE BY WATERSHED IN THE SARASOTA BAY NEP STUDY AREA - SARASOTA COUNTY

Land Use	AREA (Acres)									
	Total	Phillippi Creek	Matheny Creek	Catfish Creek	North Creek	South Creek	Bowlees Creek	West Bowlees Creek	Whitaker Bayou	Direct to Bay
Cropland	1,695	1,655	0	0	9	0	0	0	31	0
Forested Uplands	33	6	5	20	0	0	0	0	2	0
Rangeland/Woodlands	3,582	1,167	90	64	0	2,249	0	0	2	10
Open/Recreation	5,221	677	21	65	0	4,382	0	0	49	27
Wetland	1,449	436	14	199	57	565	0	0	3	175
Citrus	369	353	0	0	0	12	0	0	4	0
Low Density Single Family Residential	12,738	7,763	145	227	339	2,868	0	0	578	818
Medium Density Single Family Residential	22,114	13,448	729	2,285	1,364	2,355	14	38	725	1,156
High Density Single Family Residential	5,163	3,685	1,176	0	0	140	0	0	80	82
Multi-family Building	1,983	896	307	73	5	109	0	0	317	276
Mobile Home	1,065	423	30	42	35	80	0	0	314	141
Commercial/Services	1,775	765	455	51	45	30	0	13	105	311
Institutional	667	496	0	40	0	75	7	0	21	28
Industrial	3,186	1,840	708	225	25	10	0	0	378	0
Transportation	203	65	0	0	0	0	135	0	2	0
Waterbody	1,028	542	120	69	41	120	4	0	98	34
Sewage Treatment and Power Plants	30	30	0	0	0	0	0	0	0	0
Total	62,301	34,247	3,800	3,360	1,920	12,995	160	51	2,710	3,058

TABLE 2-10

BUILDOUT FUTURE LAND USE BY WATERSHED IN THE SARASOTA BAY NEP STUDY AREA - MANATEE COUNTY

Land Use	AREA (Acres)								
	Total	Phillippi Creek	Palma Sola 2	Bowlees Creek	West Bradenton	Cedar Hammock	West Bowlees Creek	Palma Sola Creek	South Bradenton
Cropland	0	0	0	0	0	0	0	0	0
Forested Uplands	39	0	0	0	21	15	0	3	0
Rangeland/Woodlands	88	0	20	0	18	30	0	20	0
Open/Recreation	325	0	0	0	315	10	0	0	0
Wetland	415	0	0	0	305	0	0	0	110
Citrus	93	0	0	88	5	0	0	0	0
Low Density Single Family Residential	685	63	0	24	518	80	0	0	0
Medium Density Single Family Residential	4,132	0	108	1,151	658	120	437	20	1,638
High Density Single Family Residential	5,650	0	495	713	1,579	400	246	417	1,800
Multi-family Building	3,240	0	315	616	555	865	41	365	483
Mobile Home	862	0	70	461	20	80	101	0	130
Commercial/Services	824	87	32	294	196	105	25	0	85
Institutional	365	0	0	95	80	115	0	75	0
Industrial	2,452	0	80	2,116	80	95	31	0	50
Transportation	633	0	0	633	0	0	0	0	0
Waterbody	228	0	0	24	45	15	0	0	144
Sewage Treatment and Power Plants	195	0	0	0	0	0	0	0	195
Total	20,226	150	1,120	6,215	4,395	1,930	881	900	4,635

With the exception of the West Bradenton watershed in Manatee County and the Philippi and South Creek watersheds in Sarasota County, all of the watersheds are almost completely developed in the buildout scenario. The West Bradenton watershed includes area near Perico Island that is planned for conservation purposes. Both the Philippi and South Creek watersheds include area east of I-75 that is designated as rural land use in the Sarasota County Comprehensive Plan.

2.5 SOILS CHARACTERISTICS

The soils characteristics for the study area were determined using the Soils Conservation Service Soil Surveys for Manatee and Sarasota Counties. The SCS hydrologic soils groups (A, B, C, and D) indicate the relative infiltration characteristics of a soil after prolonged wetting. In the SCS system, an 'A' soil is the most well-drained and a 'D' soil is the most poorly-drained.

Review of the soils data indicated that most of the area is characterized by B/D soils. In the Manatee County part of the study area, three soils associations make up most of the total area. These are the Eau Gallie-Floridana, Wabasso-Bradenton-Eau Gallie, and Delray-Floridana associations. The soil types in these associations are classified as B/D by SCS. For Sarasota County, the major soil types shown on the soil survey maps were Eau Gallie and Myakka fine sands, and Pineda fine sand. Each of these soils is classified as B/D by SCS. Based on these data, the entire study area was considered to be B/D soils for this analysis.

2.6 WATER QUALITY CHARACTERISTICS

Based on reports from the Florida Department of Environmental Regulation (FDER, 1990; FDER, 1987), Sarasota Bay is generally characterized as having "fair" water quality, and its tributaries are characterized as having "poor" to "fair" water quality. The classifications were established by analyzing water quality data in EPA's Storage and

Retrieval System (STORET), as well as USGS data. The monitoring data were transformed by FDER into Water Quality Indices (WQI) and Trophic State Indexes (TSI) for tributaries and various areas of the Bay.

Tributaries with "fair" water quality ratings include Phillippi Creek, Matheny Creek and Catfish Creek. Whitaker Bayou has a "poor" water quality rating. In most cases, elevated nutrient levels are the reason for the poor to fair ratings. The elevated nutrient levels are usually attributed to urban runoff and wastewater treatment plant effluent.

Several studies (Heyl and Dixon, 1987; CDM, 1990) have explored the trends in Sarasota Bay water quality since the mid-1960s. These studies have identified a downward trend in salinity and nutrient concentrations over time. Rainfall patterns, changes in agricultural land use, changes in point source loadings and other factors were considered as reasons for the identified trends.

The changes in land use appear to be one plausible reason for declining salinity and nutrients in the Bay. The transformation of certain types of agricultural land to urban residential land use results in increased surface runoff, which in turn results in more freshwater dilution in the Bay. In addition, a previous local study (CDM, 1987) for the Braden River projected a decrease in nutrients as agricultural land was converted to low density residential use. It should be noted that the study also projected an increase in heavy metals loading as a result of urbanization. Unfortunately, water quality trends for metals in Sarasota Bay could not be assessed due to a lack of monitoring data.

Recent improvements in wastewater treatment and disposal should continue to improve water quality in the Bay. The City of Sarasota Wastewater Treatment Plant (WWTP), which discharges to Whitaker Bayou, has recently upgraded treatment from secondary to advanced waste treatment (AWT). In addition, the quantity of effluent discharged to Whitaker Bayou has been reduced through a recently implemented reuse irrigation system. Manatee County has developed a deep-well injection system to accept excess effluent

from the WWTP with the largest flow in the Sarasota Bay study area, and has improved its reuse irrigation system.

2.7 SOURCES OF POLLUTION

In this study, five different sources of pollution to Sarasota Bay have been considered. They include the following:

- Surface runoff
- Baseflow
- Point source discharges
- Septic tanks
- Rainfall

A brief summary of each pollution source is presented below.

2.7.1 SURFACE RUNOFF

During a rainfall event, the volume of rainfall that cannot infiltrate into the soil becomes surface runoff which enters numerous tributaries and ultimately is transported to Sarasota Bay. En route to the tributaries, the surface runoff picks up pollutants that have accumulated on the land surface. Examples of such pollutants include nutrients such as nitrogen and phosphorus, which are applied to lawn areas for fertilization, and metals such as lead and zinc, which are deposited on streets by automobiles.

Because 60 percent of the study area is currently characterized by improved land uses (e.g., agricultural, residential, industrial, commercial), it is likely that surface runoff is a significant contribution to the total pollution loading to the Bay. Cropland, citrus, commercial, industrial, and the more dense residential land uses can be expected to contribute high concentrations of nitrogen and phosphorus to tributaries. With the exception of cropland and citrus, these same land uses will also contribute relatively high metals concentrations.

2.7.2 BASEFLOW

The baseflow loading accounts for pollution conveyed by groundwater. The fraction of total watershed loading that is due to baseflow becomes smaller as the watershed develops, because more of the rainfall is converted to surface runoff and less infiltrates into the soil. The concentration of pollutants in the groundwater is based on the natural composition of the soil.

2.7.3 POINT SOURCE DISCHARGES

Point source discharges in the study area include wastewater treatment plants (WWTPs) that discharge treated wastewater from municipal and industrial sources. Municipal sources account for almost all of the total point source discharge.

Anna Maria Island, Longboat Key and the portion of Manatee County within the study area are all served by the Southwest Regional WWTP. The plant currently has an average daily flow rate of 12.8 million gallons per day (mgd). The effluent is used for irrigation purposes, primarily at the Manatee Fruit Company site and several golf courses. In addition, effluent can also be discharged into a deep well injection system during wet weather conditions. In effect, no effluent is directly discharged to surface waters.

The City of Sarasota and some areas in Sarasota County are served by the City of Sarasota WWTP. In 1990, the average discharge from the plant was 6.9 mgd. The plant has recently been upgraded from secondary treatment to AWT. Disposal of the effluent consists of irrigation on pasture land and golf course property with intermittent surface water discharge. Loadings to Sarasota Bay from discharge to Whitaker Bayou have decreased considerably since these improvements were implemented. Additional reuse sites, which will further reduce loadings from this point source, are planned.

Siesta Key and parts of Sarasota County are served by a number of small package plants and privately-owned wastewater treatment utilities. The total flow for these plants is approximately 7.4 mgd. Some of these facilities achieve AWT standards. Most of the facilities discharge via irrigation, drain fields, and percolation ponds, though several of the larger plants discharge directly to surface water.

2.7.4 SEPTIC TANKS

Septic tanks (also referred to as onsite disposal systems) are used in some cases to treat waste from individual homes, multi-family buildings, and commercial and industrial areas. Basically, a septic tank achieves primary treatment (i.e., settling) in an anaerobic environment, and discharges the effluent to a drainfield. Presumably, further pollutant transformation and removal occurs as the effluent percolates downward through the drainfield to the water table. Further dilution and removal is expected to occur as the effluent mixes with and moves along with the groundwater flow.

Table 2-11 shows septic tank coverage information for the Sarasota Bay NEP study area. Septic tanks are used throughout the Sarasota County mainland and in the barrier islands. For Casey Key, all of the residential development (157 acres) is served by septic tanks. In Sarasota County, the percentage of land use served by septic tanks depends on the type of land use. For residential land use, about 58 percent of the low and medium single family residential land use is served by septic tanks, whereas the percent served for high density single family residential, multi-family building and mobile homes are estimated to be 38, 13, and 3 respectively. The percent served for commercial, industrial and institutional land uses are estimated to be 21, 23, and 9, respectively.

The pollutants of concern from septic tanks are total nitrogen and, to a lesser extent, total phosphorus. Both total nitrogen and total phosphorus are discharged at high concentrations from a septic tank. Typical effluent concentrations are 40 to 80 mg/L for

TABLE 2-11

SEPTIC TANK COVERAGE FOR SARASOTA BAY NEP STUDY AREA

Land Use	Manatee County		City of Sarasota		Barrier Islands		Sarasota County		Total	
	Area Served by Septic Tanks (acres)	Percent of Total Area	Area Served by Septic Tanks (acres)	Percent of Total Area	Area Served by Septic Tanks (acres)	Percent of Total Area	Area Served by Septic Tanks (acres)	Percent of Total Area	Area Served by Septic Tanks (acres)	Percent of Total Area
Low Density Single Family Residential	0	0%	0	0%	155	40%	4272	58%	4427	53%
Medium Density Single Family Residential	0	0%	0	0%	0	0%	3897	57%	3897	33%
High Density Single Family Residential	0	0%	0	0%	0	0%	1963	38%	1963	17%
Multi-family Building	0	0%	0	0%	0	0%	252	13%	252	4%
Mobile Home	0	0%	0	0%	0	0%	34	3%	34	2%
Commercial/Services	0	0%	0	0%	0	0%	311	21%	311	10%
Institutional	0	0%	0	0%	0	0%	59	9%	59	4%
Industrial	0	0%	0	0%	0	0%	252	23%	252	7%

NOTES:

1. Septic tank areas in Sarasota County estimated based on mapping provided by County staff.

2. Small number of septic tanks are still active in Manatee County and the City of Sarasota, but were excluded from the analysis.

total N and about 15 mg/L for total P, as compared to 3 mg/L total N and 1 mg/L total P for AWT. In most instances, soil is effective in removing total P, such that 90 percent or more is retained in the soil through adsorption. For total N, however, much of the mass in the effluent reaches the water table, with ammonia nitrogen being converted to nitrate nitrogen under aerobic conditions in the soil. Nitrate nitrogen is known to be very mobile in groundwater and can have serious health effects if drinking water concentrations are too high.

2.7.5 RAINFALL

Loadings to Sarasota Bay also are contributed by rainfall on the Bay surface. Considering that the water surface is about 52 square miles (34 percent of the total drainage area to the Bay), rainfall could have a significant impact on pollution loading. Precipitation totals for the study area are discussed in Section 3.2, and rainfall quality is discussed in Section 3.6.

3.0 METHODOLOGY FOR POLLUTION LOADING PROJECTIONS

3.1 INTRODUCTION

This section presents the methodology and assumptions used to estimate pollution loadings to Sarasota Bay. The discussion includes the relationship between rainfall and streamflow, and the selection of nonpoint pollution loading factors. Data regarding quantity and quality of point sources, septic tanks and rainfall are also presented.

3.2 RAINFALL/RUNOFF RELATIONSHIPS

The annual loadings for surface runoff and baseflow are based upon the streamflow from the watershed, mean pollutant concentrations of the surface runoff and baseflow, and the distribution of streamflow between surface runoff and baseflow. To calculate annual streamflow volumes for the study area, long-term monitoring data from USGS gages and local raingages were analyzed. In addition to analyzing average annual conditions, rainfall and streamflow volumes for the wet season (June - September) and the dry season (October - May) that comprise the average annual conditions were also determined. Finally, the data were also analyzed to establish a wet year and a dry year scenario.

3.2.1 RAINFALL AND STREAMFLOW DATA

Table 3-1 shows rainfall data for two long-term gages in the vicinity of the study area. The average year totals for the Bradenton and Myakka gages were determined by averaging the annual totals over the entire period of record. Similarly, the wet season and dry season volumes were calculated by averaging the total rainfall during each season over the period of record. The wet year and dry year values were established by ranking the annual rainfall totals from lowest to highest, selecting the 10th percentile value as the dry year total and the 90th percentile value as the wet year total.

TABLE 3-1

PRECIPITATION DATA FOR GAGES IN
SARASOTA BAY NEP STUDY AREA

PRECIPITATION (INCHES)	
BRADENTON GAGE (104 YEARS OF RECORD)	
AVERAGE YEAR	54.6
- WET SEASON	33.7
- DRY SEASON	20.9
WET YEAR	69.7
DRY YEAR	41.7
MYAKKA GAGE (44 YEARS OF RECORD)	
AVERAGE YEAR	54.3
- WET SEASON	32.5
- DRY SEASON	21.8
WET YEAR	69.6
DRY YEAR	40.4
BRADENTON GAGE (44 YEARS OF RECORD)	
AVERAGE YEAR	53.3
- WET SEASON	31.8
- DRY SEASON	21.5
WET YEAR	69.7
DRY YEAR	42.6

The values generated for the Bradenton gage were selected for the runoff analysis. As shown in Table 3-1, the results for the same 44 years of record at the Bradenton and Myakka gages were comparable. Because the rainfall values for the two gages are similar, it is appropriate to use the values for the gage with the longest period of record. Thus, an average annual rainfall total of 54.6 inches was assumed for the study area. Of the 54.6 inches, 33.7 inches (62 percent) occurs during the months of June through September, and the remaining 20.9 inches (38 percent) occurs during the other eight months. The annual values for a wet year and a dry year are 69.7 and 41.7 inches, respectively. These values are 28 percent higher and 24 percent lower than the average annual rainfall total.

Streamflow data for two USGS gages in the vicinity of the study area are presented in Table 3-2. For the Lake Manatee and Myakka River gages, streamflow values for average annual, wet season, dry season, wet year and dry year scenarios were established in the same manner as the rainfall values.

Because the two gages had comparable periods of record, the streamflow values used in the runoff analysis were the average of the values for the two gages. As shown in Table 3-2, the average annual streamflow volume is 14.8 inches, with 9.9 inches (67 percent) occurring during the wet season and 4.9 inches occurring during the dry season. The wet year and dry year streamflow values are 22.9 and 7.6 inches, respectively. Both values vary by roughly 50 percent from the average annual value.

3.2.2 PERVIOUS AREA RUNOFF

The streamflow volume due to surface runoff from pervious areas was estimated by assigning a runoff coefficient. The runoff coefficient was multiplied by the rainfall volume to calculate the surface runoff volume from pervious areas. A single value was established to estimate the average annual runoff, given the average rainfall total.

TABLE 3-2

STREAMFLOW DATA FOR GAGES IN
SARASOTA BAY NEP STUDY AREA

STREAMFLOW (INCHES)	
LAKE MANATEE GAGE (50 YEARS OF RECORD)	
AVERAGE YEAR	15.0
- WET SEASON	10.3
- DRY SEASON	4.7
WET YEAR	22.6
DRY YEAR	9.0
MYAKKA GAGE (50 YEARS OF RECORD)	
AVERAGE YEAR	14.5
- WET SEASON	9.5
- DRY SEASON	5.0
WET YEAR	23.2
DRY YEAR	6.1
AVERAGE OF LAKE MANATEE AND MYAKKA GAGES	
AVERAGE YEAR	14.8
- WET SEASON	9.9
- DRY SEASON	4.9
WET YEAR	22.9
DRY YEAR	7.6

An average annual runoff coefficient of 0.15 was established for pervious areas. In this analysis, the runoff coefficient of 0.15 combined with an annual rainfall total of 54.6 inches results in an annual runoff of 8.2 inches. By subtracting the 8.2 inches from average annual streamflow volume of 14.8 inches, an annual groundwater baseflow volume of 6.6 inches is calculated. Thus, based on a runoff coefficient of 0.15, about 15 percent of rainfall becomes surface runoff, 12 percent contributes to stream baseflow, and the remaining 73 percent (39.8 inches) is lost via evapotranspiration.

3.2.3 IMPERVIOUS AREA RUNOFF

The streamflow volume due to surface runoff from impervious areas was also determined using runoff coefficients. For all impervious area, a runoff coefficient of 0.95 was assumed.

3.2.4 BASEFLOW

The baseflow volume at the USGS gages was calculated as the difference between streamflow volume and surface runoff, with gage drainage areas assumed to be rural (i.e., pervious). For undeveloped areas, baseflow was calculated to contribute about 45 percent of the streamflow.

For individual watersheds in the study area, the baseflow volume was reduced as a direct function of the percentage of urban impervious area. For example, if the drainage area was 50 percent impervious due to residential and commercial development, then the baseflow volume was reduced by 50 percent. Thus, the percentage of streamflow due to baseflow diminishes as development occurs in the watershed. However, it is not only because baseflow diminishes, but also because surface runoff increases.

3.3 NONPOINT POLLUTION LOADING FACTORS

For both surface runoff and baseflow, the pollution loadings were calculated by multiplying the flow volume by an appropriate pollutant concentration. In the case of surface runoff, event mean concentration (EMC) data developed through studies such as EPA's Nationwide Urban Runoff Program (NURP) were used to characterize runoff concentrations. For baseflow, local ambient monitoring data were used to develop the concentrations.

3.3.1 SURFACE RUNOFF

Since the completion of EPA's Nationwide Runoff Program (NURP) in the early 1980's (USEPA, 1983), there is a general consensus in the field of nonpoint pollution management that local monitoring studies of single land use watersheds are no longer required to characterize urban nonpoint pollution loadings for management studies. In place of an expensive local monitoring program, available literature values for nonpoint pollution loading factors can be used to formulate the watershed management plan. In addition to the transferability evaluations in the EPA NURP study, this approach has worked out well in previous watershed management studies where mixed land use monitoring data were available for comparison.

In the Sarasota Bay NEP study, pollutant loading analyses were limited to the constituents for which considerable loading data are reported in the literature. The following four pollutants were included: total phosphorus (total P), total nitrogen (total N), lead, and zinc. Total P and total N are included because they may be responsible for adverse eutrophication impacts. Lead and zinc are heavy metals which typically exhibit higher nonpoint pollution loadings than other metals found in urban runoff, and therefore, transferable loading factors are available in the literature. These heavy metals may be viewed as surrogates for a wide range of toxicants that have been identified in previous field monitoring studies of urban runoff pollution (USEPA, 1983).

The EMC values to estimate surface runoff loadings are presented in Table 3-3. Again, the values are based primarily on data from the EPA NURP study, although values for land uses such as cropland (which tend to vary substantially from one location to another) are also based on local data. These same values have been applied successfully in several other studies in the State of Florida (CDM, 1990).

For nutrients (total N and total P), the EMC values are highest for cropland, citrus, and low and medium density single family residential land uses. This is due to fertilization of the cropland and the lawns of the residential areas. Commercial, industrial and unimproved areas have the lowest EMC values for nutrients, less than half as large as the agricultural and residential values.

It should be noted, however, that the pollutant loading depends on the EMC value and the volume of surface runoff for a particular land use. Because commercial and industrial land uses have a much greater percentage of impervious area than residential land use, they tend to produce greater loadings in terms of lbs/ac/year, even though they are characterized by lower EMC values. For example, the average annual surface runoff loads for commercial and medium density single family residential land uses are relatively similar (1.6 lb/ac/yr for commercial and 2.1 lb/ac/yr for residential) for total P, even though the EMC is much higher for the residential area. The loadings for total N are 12.3 and 10.1 lb/ac/yr for commercial and medium density residential land uses, respectively. Thus, EMC values alone cannot be used to determine the relative loading impacts of different land uses.

For lead and zinc, Table 3-3 shows that unimproved and agricultural land uses have EMCs of zero, whereas residential, commercial, industrial and other urban land uses are shown to generate loadings of metals. The EMC values increase as the percent imperviousness of the land use increases. Because more impervious areas will also generate more runoff, the loadings from commercial and industrial areas will be substantially higher than the loadings from the residential areas.

TABLE 3-3

EVENT MEAN CONCENTRATION VALUES
FOR SARASOTA BAY NEP STUDY

Land Use	Event Mean Concentration Values in mg/l			
	Total Phosphorus	Total Nitrogen	Total Lead	Total Zinc
Cropland	1.13	3.74	0.000	0.000
Forested Uplands	0.16	1.02	0.000	0.000
Rangeland/Woodlands	0.16	1.02	0.000	0.000
Open/Recreation	0.16	1.02	0.000	0.000
Wetland	0.03	0.25	0.000	0.000
Citrus	0.41	0.92	0.000	0.000
Low Density Single Family Residential	0.39	1.87	0.049	0.054
Medium Density Single Family Residential	0.39	1.87	0.049	0.054
High Density Single Family Residential	0.33	1.65	0.076	0.060
Multi-family Building	0.33	1.65	0.076	0.060
Mobile Home	0.33	1.65	0.076	0.060
Commercial/Services	0.15	1.18	0.235	0.120
Institutional	0.15	1.18	0.235	0.120
Industrial	0.15	1.18	0.235	0.120
Transportation	0.15	1.18	0.235	0.120
Waterbody	0.15	0.82	0.006	0.146
STP and Power Plants	0.15	1.18	0.235	0.120

3.3.2 BASEFLOW

Baseflow loadings, like surface runoff loadings, were calculated by determining the flow volume and the flow concentration. Based on analysis of existing water quality data, the following values were selected for baseflow concentrations:

- Total P: 0.30 mg/L
- Total N: 1.00 mg/L
- Lead: 0.003 mg/L
- Zinc: 0.05 mg/L

The total N and total P values were selected after analyzing concentration-frequency curves for several STORET stations. It was assumed that the median concentrations for these stations were representative of dry weather conditions where baseflow was predominant, and that the stations were located in areas where dry weather flows are not affected by point source discharges or septic tank impacts. Unfortunately, the same stations did not include metals data. The values shown above for metals were selected based on a limited number of STORET values for raw water monitoring at various water treatment plants in and around the study area.

A summary of available STORET data is presented in Appendix A.

3.4 POINT SOURCE LOADINGS

Table 3-4 lists the point source discharges included in the loading analysis. These represent all of the discharges located in the study area that have a daily average flow rate exceeding 0.1 mgd. Together, these plants account for over 95 percent of the total point source discharge in the study area. In all, the total discharge from these treatment plants is roughly 27 mgd.

Data shown in the table include the watershed, average flow, level of treatment and method(s) of disposal. In Sarasota County and the City of Sarasota, discharges occur in

TABLE 3-4

POINT SOURCE DISCHARGES IN SARASOTA BAY NEP STUDY AREA

Discharge	Watershed	Average Flow (mgd)	Level of Treatment	Disposal Method(s)
Southwest Regional WWTP - Manatee County	South Bradenton	12.80	Secondary	Irrigation Deep well injection
Southeastern-Bent Tree	Phillippi Creek	0.26	Secondary	Percolation ponds Irrigation
Atlantic Utilities	Phillippi Creek	0.77	Secondary	Irrigation
Dolomite - Fruitville	Phillippi Creek	0.14	Secondary	Percolation ponds
Florida Cities - Southgate	Phillippi Creek	1.10	AWT	Percolation ponds Surface water
Kensington Park Utilities - 27th St.	Phillippi Creek	0.09	Secondary	Percolation ponds Irrigation
Meadowood Utilities	Phillippi Creek	0.47	Secondary	Percolation ponds Irrigation
Tamaron Utility Authority	Phillippi Creek	0.11	Secondary	Percolation ponds Irrigation
Camelot	Phillippi Creek	0.10	Secondary	Percolation ponds
Sorrento	Matheny Creek	0.25	Secondary	Percolation ponds
Central County Utilities	Matheny Creek	0.31	Secondary	Percolation ponds
Florida Cities - Gulf Gate	Matheny Creek	1.37	AWT	Surface water
Sarasota City WWTP	Whitaker Bayou	6.90	AWT	Irrigation Surface water
Dolomite - Tri Par	Whitaker Bayou	0.23	Secondary	Percolation ponds Irrigation
Kensington Park Util.- Monica Pkwy.	Whitaker Bayou	0.36	Secondary	Percolation ponds Irrigation
Siesta Key Utilities	Siesta Key	1.82	AWT	Surface water
Southbay Utilities	Direct to Bay	0.13	Secondary	Drainfields

the Phillippi Creek, Matheny Creek and Whitaker Bayou watersheds. Disposal methods include a combination of irrigation, percolation ponds, and surface water discharge. Manatee County, Anna Maria Island and Longboat Key are served by the Southwest Regional WWTP, which disposes of effluent through irrigation and deep well injection. Siesta Key is served by Siesta Key Utilities, which disposes of effluent via surface water discharge.

To estimate the point source pollution loadings, a number of assumptions were made. Assumptions regarding effluent quality (i.e., concentrations of pollutants in the effluent) were made based on limited monitoring data supplemented by literature values. For disposal methods other than surface water discharge, the fraction of effluent load reaching Bay tributaries was assumed.

The effluent concentrations assumed for the point source analysis are presented below:

• Secondary treatment:	Total N = 20 mg/L
	Total P = 4 mg/L
	Lead = 25 ug/L
	Zinc = 100 ug/L
• Advanced waste treatment:	Total N = 3 mg/l
	Total P = 1 mg/L
	Lead = 25 ug/L
	Zinc = 100 ug/L

Nutrient values for secondary treatment were established based on monthly operating report (MOR) data from several of the Sarasota County dischargers, and the nutrient values for AWT were based on the typical standards included in NPDES permits. The reviewed data did not include any lead or zinc concentrations, so these values are strictly based on literature data. The values are in the mid-range of concentrations that may be expected, based on effluent data from 12 California WWTPs that use effluent for

irrigation (Lewis, 1985) as well as typical influent concentration and removal efficiency data developed in an EPA study of priority pollutants in publicly owned treatment works (EPA, 1982).

For land disposal of wastewater, the fraction of the mass load reaching Bay tributaries depends upon the type of disposal. It was assumed that no load would reach the Bay for deep well injection. For percolation ponds and drainfields, a removal rate of 90 percent was assumed for all pollutants. A previous CDM study (CDM, 1985) found that the 90 percent value was appropriate for retention and exfiltration best management practices (BMPs). A slightly higher removal rate of 95 percent was assumed for irrigation practices, with the higher efficiency attributed to plant uptake.

Based on the assumptions above, the point source loadings shown in Table 3-5 were developed for existing conditions. The flow rates represent only the surface water discharges plus a fraction of the discharge to percolation ponds and drainfield. This fraction was set equal to 0.27, which is the ratio of streamflow to precipitation. The concentrations of nutrients and metals were established such that the product of flow and concentration was equal to the combined mass of pollutant from surface water and percolation pond/drainfield discharges. Surface discharges for annual, wet season and dry season are constant for all watersheds except Whitaker Bayou, which receives discharge from the City of Sarasota. The City of Sarasota discharge of 3.30 mgd represents a projected discharge of 7 mgd for a total of 172 days during 1991, based on a mid-year estimate (CDM, 1991). Of the 172 days, 75 are during the wet season (June through September) and 97 are during the dry season (October through May). Consequently, the average flow rates during the wet and dry season are 4.30 and 2.79 mgd, respectively. The remaining 0.17 mgd attributed to Whitaker Bayou comes from two small package plants. For the South Bradenton watershed, the flow value of 2.08 mgd represents 27 percent of 7.7 mgd attributed to irrigation. Recent data indicate that about 60 percent of the SWWWTP effluent is used for irrigation, and the remaining 40 percent is discharged via deep well injection.

TABLE 3-5

POINT SOURCE FLOWS AND CONCENTRATIONS FOR EXISTING CONDITIONS

WATERSHED	DISCHARGE (mgd)			CONCENTRATION (mg/L)			
	ANNUAL	WET SEASON	DRY SEASON	TOTAL P	TOTAL N	LEAD	ZINC
Phillippi Creek	1.63	1.63	1.63	1.03	3.78	0.015	0.076
Matheny Creek	1.52	1.52	1.52	1.05	3.44	0.019	0.094
Whitaker Bayou	3.47	4.47	2.96	1.02	3.20	0.019	0.097
Direct to Bay	0.04	0.04	0.04	1.48	7.38	0.007	0.037
Siesta Key	1.82	1.82	1.82	1.00	3.00	0.020	0.100
South Bradenton	2.08	2.08	2.08	0.74	3.69	0.004	0.018

Point source flows for the 5-year future scenario were estimated using available data. In Manatee County, linear interpolation was used to estimate a 5-year flow rate of 14.1 mgd, given the existing rate of 12.8 mgd and the 20-year projected rate of 18 mgd. In addition, it was estimated that 9.8 mgd out of the 14.1 mgd would be used for irrigation. For the other localities, the total flow rate was estimated by evaluating changes in residential land use. The total number of dwelling units in the localities for the existing and 5-year scenarios was calculated by assigning densities (dwellings per acre) to each residential land use. The ratio of future to existing dwelling units was then multiplied by the existing total point source flow rate in order to estimate the 5-year total flow rate. Based on this method, a value of 15.9 mgd was calculated.

The 5-year future point source flow rate was then distributed between the City of Sarasota plant and the other existing utilities and package plants. The City was assigned a flow rate of 9.0 mgd, based on available flow projections. The remaining 6.9 mgd was equivalent to the sum of the existing discharges in the Phillippi Creek, Matheny Creek, Direct to Bay and Siesta Key watersheds. Consequently, the 5-year future surface water discharge values for facilities other than the City of Sarasota WWTP were set equal to the existing discharge values.

The same methodology was used to estimate the buildout future total point source flow rate in Sarasota County and the City of Sarasota. As a result, a total flow of 23.0 mgd was estimated. The City of Sarasota was assigned a flow rate of 13.0 mgd, the current design capacity of the plant. The remaining 10.0 mgd was divided between utilities and package plants, with the increase in flow applied mainly to the Manatee and Phillippi Creek watersheds. The relative proportions of disposal via surface discharge, percolation ponds, drainfields, and irrigation were consistent with existing conditions. For Manatee County, the 20-year estimates of 18 mgd (16 mgd irrigation and 2 mgd deep well injection) were used for the buildout scenario.

Table 3-6 presents the point source loading data for the 5-year future scenario. The value of 1.61 mgd for the City of Sarasota WWTP is based on a flow of 9.0 mgd discharging to surface water for a total of 59 days per year plus package plant discharge of 0.17 mgd. The 59 days of discharge is consistent with an NPDES permit that is currently being sought by the City WWTP. The Southwest WWTP discharge of 2.66 mgd reflects 27 percent of the 9.8 mgd attributed to irrigation. The other surface water discharge rates are equal to the rates for existing conditions.

The point source data for the buildout future scenario are presented in Table 3-7. The value of 2.10 mgd for the City of Sarasota WWTP reflects a 13 mgd surface water discharge for a total of 59 days per year. In the other watersheds, the surface water discharges are higher than the 5-year future discharges. Future package plants and utilities are assumed to operate similarly to existing facilities. In other words, discharge is distributed between surface waters, percolation ponds, draifields, and irrigation.

3.5 SEPTIC TANK LOADINGS

Some of the existing developments in Sarasota County are serviced by septic tanks. The Sarasota County Health Department estimates that there are approximately 45,000 septic tanks within the County, and the majority of these are probably within the NEP study area. On Casey Key, all of the residential area is served by septic tanks, and the number of permitted tanks is 330.

The assessment of septic tank loadings included a literature review designed to better quantify the impacts of failing and working septic tanks. Previous CDM studies have focused on the impacts of failing septic tanks. Reasons for septic tank failure include high water table, structural failure, and direct connection between septic tank and receiving water. These failing septic tanks are expected to discharge high concentrations of

TABLE 3-6

POINT SOURCE FLOWS AND CONCENTRATIONS FOR FIVE-YEAR FUTURE CONDITIONS

WATERSHED	DISCHARGE(mgd)			CONCENTRATION (mg/L)			
	ANNUAL	WET SEASON	DRY SEASON	TOTAL P	TOTAL N	LEAD	ZINC
Phillippi Creek	1.63	1.63	1.63	1.03	3.78	0.015	0.076
Matheny Creek	1.52	1.52	1.52	1.05	3.44	0.019	0.094
Whitaker Bayou	1.61	2.19	1.33	1.05	3.43	0.019	0.094
Direct to Bay	0.04	0.04	0.04	1.48	7.38	0.007	0.037
Siesta Key	1.82	1.82	1.82	1.00	3.00	0.020	0.100
South Bradenton	2.66	2.66	2.66	0.74	3.69	0.004	0.018

TABLE 3-7

POINT SOURCE FLOWS AND CONCENTRATIONS FOR BUILDOUT FUTURE CONDITIONS

WATERSHED	DISCHARGE (mgd)			CONCENTRATION (mg/L)			
	ANNUAL	WET SEASON	DRY SEASON	TOTAL P	TOTAL N	LEAD	ZINC
Phillippi Creek	2.62	2.62	2.62	1.03	3.78	0.015	0.076
Matheny Creek	2.45	2.45	2.45	1.05	3.44	0.019	0.094
Whitaker Bayou	2.10	2.94	1.68	1.00	3.00	0.020	0.100
Direct to Bay	0.04	0.04	0.04	1.48	7.38	0.007	0.037
Siesta Key	1.82	1.82	1.82	1.00	3.00	0.020	0.100
South Bradenton	4.34	4.34	4.34	0.74	3.69	0.004	0.018

nutrients. For working septic tanks, a methodology was established to estimate pollutant loadings based on of the literature review. Appendix B contain a technical memorandum summarizing the findings of the literature review.

The septic tank evaluation conducted for purposes of this study was limited to the contaminants identified in section 1.2; namely total nitrogen, total phosphorus, lead and zinc. The evaluation focused on relative (to other sources evaluated) loading contribution from on-site disposal systems. As such, human health issues (such as proximity to drinking water sources, bacterial and viral issues) of septic systems were not explicitly evaluated.

3.5.1 FAILING SEPTIC TANKS

Nutrient concentrations for failing septic tanks were developed from a review of septic tank leachate monitoring studies. The typical concentrations established based on the literature values are as follows:

- Total N 30 mg/L
- Total P 2 mg/L

Generally, these values are in the range of groundwater concentrations measured at or near septic tank discharges. The values reflect pollutant removal within the soil of roughly 50 percent for total N and 90 percent for total P, based on average effluent concentrations cited in the literature.

Nutrient loadings for specific land uses were calculated by multiplying the concentrations by a flow rate. The flow rate for a particular land use depended upon the number of residents per acre, and the per capita flow rate.

Table 3-8 shows the septic tank flow rates developed for various land uses. For all land uses, a per capita flow rate of 75 gallons per day was established. This value is at the

TABLE 3-8

SEPTIC TANKS FLOW RATES FOR VARIOUS LAND USES

Land Use	Dwelling Units Per Acre	Persons Per Dwelling unit	Per Capita Wastewater Flow Rate (gal/day/person)	Flow Rate (gal/acre/day)
LDSF Residential	1	2	75	150
MDSF Residential	4.5	2	75	675
HDSF Residential	7.5	2	75	1125
Multi-family Bldg	9	2	75	1350
Mobile Home	9	2	75	1350
Commercial/Services	-	-	-	1350
Institutional	-	-	-	1350
Industrial	-	-	-	1350

high end of the range of flow rates documented in the literature, and reflects local water use data. For the residential areas, values of dwelling units per acre were determined based on the descriptions of various land uses in the Sarasota County Comprehensive Plan and densities observed in aerial photographs. Each dwelling unit is assumed to have 2.0 people, based on household size estimates for Sarasota and Charlotte Counties and the City of North Port as cited in the City of North Port Comprehensive Plan. This value is somewhat lower than the national average, because some of the population is seasonal and because the population distribution is weighted more heavily toward retired persons who would tend to have a smaller household size. For commercial and industrial areas, the flow values were assumed equal to the highest residential value.

A final consideration in the loading analysis for failing septic tanks is the failure rate - that is, what percentage of the septic tanks are failing. These data were established based on permitting data from the Sarasota County Health Department. The Health Department requires a permit for repair or replacement of septic tanks. During the period 1980 through 1990, an average of 740 repairs per year was recorded. Based on the estimate of 45,000 septic tanks in the County, the annual repair rate is 1.6 percent. Recognizing that failure may occur for a number of years before repair is initiated, the failure rate at any time is likely to be higher than 1.6 percent. In previous studies, the annual failure rate has been multiplied by a factor of 5, which implies that septic systems on average fail for 5 years before repairs are made. For Sarasota County, the resulting failure rate is 8 percent. This value compared favorably with the results of a septic tank survey conducted in Jacksonville, FL by the Department of Health and Rehabilitative Services. In the study, an inspection of more than 800 sites revealed about 90 violations, or a failure rate of 12 percent. Failure calculations also were done specifically for Casey Key, which had a higher annual repair rate. The failure rate established for Casey Key was 20 percent.

3.5.2 WORKING SEPTIC TANKS

Based on the literature review of septic tanks, a methodology for assessing impacts of working septic tanks was developed. The methodology uses data such as surficial aquifer transmissivity, recharge volume, typical distances from septic tanks to receiving waters, and pollutant decay rates to determine how much of the total N and total P discharged from septic tanks will reach the Bay tributaries. A detailed description of the calculations is provided in a technical memorandum developed in Phase 2 of the Sarasota Bay NEP study (see Appendix B). An overview of the methodology is presented below.

The methodology is based on equations developed by Dupuit (Todd, 1985) to define baseflow to a stream. In the septic tank analysis, the baseflow was set equal to the recharge rate, which was defined as the sum of natural baseflow calculated during the hydrologic analysis plus drainfield flow contributed by septic tanks. It was assumed that the recharge to the surficial aquifer occurred uniformly between the stream and the most distant recharge point. By inspection of USGS quadrangle maps, the typical maximum recharge distance (i.e., typical maximum distance to a perennial stream) was set equal to 3,000 feet. Thus, at any distance from the stream, the flow could be calculated. Furthermore, by establishing typical values of aquifer thickness, transmissivity and porosity, the velocity at any distance from the stream could also be determined. These calculations were performed at 10-foot increments to establish cumulative travel times from the septic tank to the receiving stream as a function of distance. By applying a first order decay coefficient uniformly between the minimum distance and the maximum distance between septic tank and receiving stream, an overall delivery ratio was established. The minimum distance was set at 75 feet, which is the DER requirement for septic tank implementation, and the maximum distance was set at 3000 feet, the maximum recharge distance.

Initially, the first order decay rate was established based on work done by Ostendorf (1986). Ostendorf developed a model to simulate total N, chloride, boron and methylene

blue active substances (MBAS) downgradient from the Otis Air Force Base in Massachusetts. The base has discharged an average flow of 0.53 mgd since 1941. Samples were taken at various distances downgradient from the infiltration beds in order to test the model's predictive ability. Chloride, a conservative substance, was simulated first to test the model accuracy. Results showed a very good agreement between predicted and measured concentrations. When total N and MBAS were modeled as conservative substances, the model overpredicted the concentrations. Consequently, first order decay rates were established for these constituents. For total N, a rate of 1.69 X 10^{-9}/second was established. At this rate, the total N concentration would be reduced by 5 percent after a travel time of 1 year, 41 percent after 10 years, and 93 percent after 50 years.

Other parameter values used in the septic tank analysis are presented in Table 3-9. Values for aquifer thickness, porosity and conductivity were based on review of the soil survey for Sarasota County and a Southwest Florida Water Management District report on groundwater resource availability in Sarasota County (SWFWMD, 1988). In addition, the minimum travel distance of 75 feet was based on septic tank regulations, and the maximum distance of 3,000 feet was based on inspection of USGS maps.

To evaluate the methodology and the first-order decay rate, the septic tank analysis results were applied to the drainage areas of two STORET stations in the Phillippi Creek watershed. These include the Main A Canal at Palmers Boulevard Bridge (Station 24010630) and Phillippi Creek at Bahia Vista Street Bridge (Station 24010625). The Palmers Boulevard station has a drainage area of about 8 square miles, which consists primarily of cropland, rangeland, and low and medium density single family residential land uses. 89 percent of the low density and 66 percent of the medium density residential areas are served by septic tanks, and there are no substantial point source loads. The Bahia Vista Street station has a drainage area of 44 square miles, comprised mainly of cropland, rangelands, open space, and low and medium density residential land uses. 53 percent of the low density, 41 percent of the medium density, and 37 percent of the high

TABLE 3-9

PARAMETERS FOR ANALYSIS OF WORKING SEPTIC TANKS

Parameter	Value	Source
Aquifer Conductivity	8.0 in/hr	SWFWMD, 1988
Aquifer Thickness	60.0 ft	SWFWMD, 1988
Porosity	0.3	SWFWMD, 1988
Minimum Travel Length	75 ft	FDER
Maximum Travel Length	3000 ft	USGS maps

density residential areas are served by septic tanks. Unlike the Palmers Boulevard station, the water quality at Bahia Vista Street has been impacted by the Atlantic Utilities and Kensington Park Utilities point sources, which had been directly discharging secondary effluent to Phillippi Creek during the STORET period of record. It is possible that other smaller point sources may have also been discharging directly, rather than through percolation ponds and irrigation, during the period of record.

The results of the analysis indicated that nitrogen concentrations were oversimulated when the low first-order decay rate was used. At the Palmers Boulevard station, the average annual total N concentration was oversimulated by 49 percent. The oversimulation of total N at the Bahia Vista Street station was only 11 percent, but sensitivity analyses indicated that significantly higher first-order decay rates would still result in reasonable total N predictions. Consequently, higher decay rates (which would result in a lower delivery ratio) were investigated.

After analyzing various first order decay rates, a conservative value of 0.00055/day was established. The value was selected such that the observed and simulated total N concentrations at the Bahia Vista Street station matched. When the same value was used for the Palmer Street station, the simulated total N concentration exceeded the observed concentration by about 20 percent. This may indicate that the analysis methodology is better suited for stations with larger drainage areas like the Bahia Vista Street station. It is also possible that the septic tank loading is conservatively high, and that additional point source loadings (rather than septic tank loading) are responsible for the high total N concentrations at the Bahia Vista Bridge station.

Figure 3-1 shows total N concentration of septic tank effluent as a function of distance from the receiving water, based on the conservative first order decay rate of 0.00055/day. As shown in the figure, most of the total N is predicted to reach the receiving water at a distance of 75 feet. AWT conditions (total N = 3 mg/L) are not met unless the distance

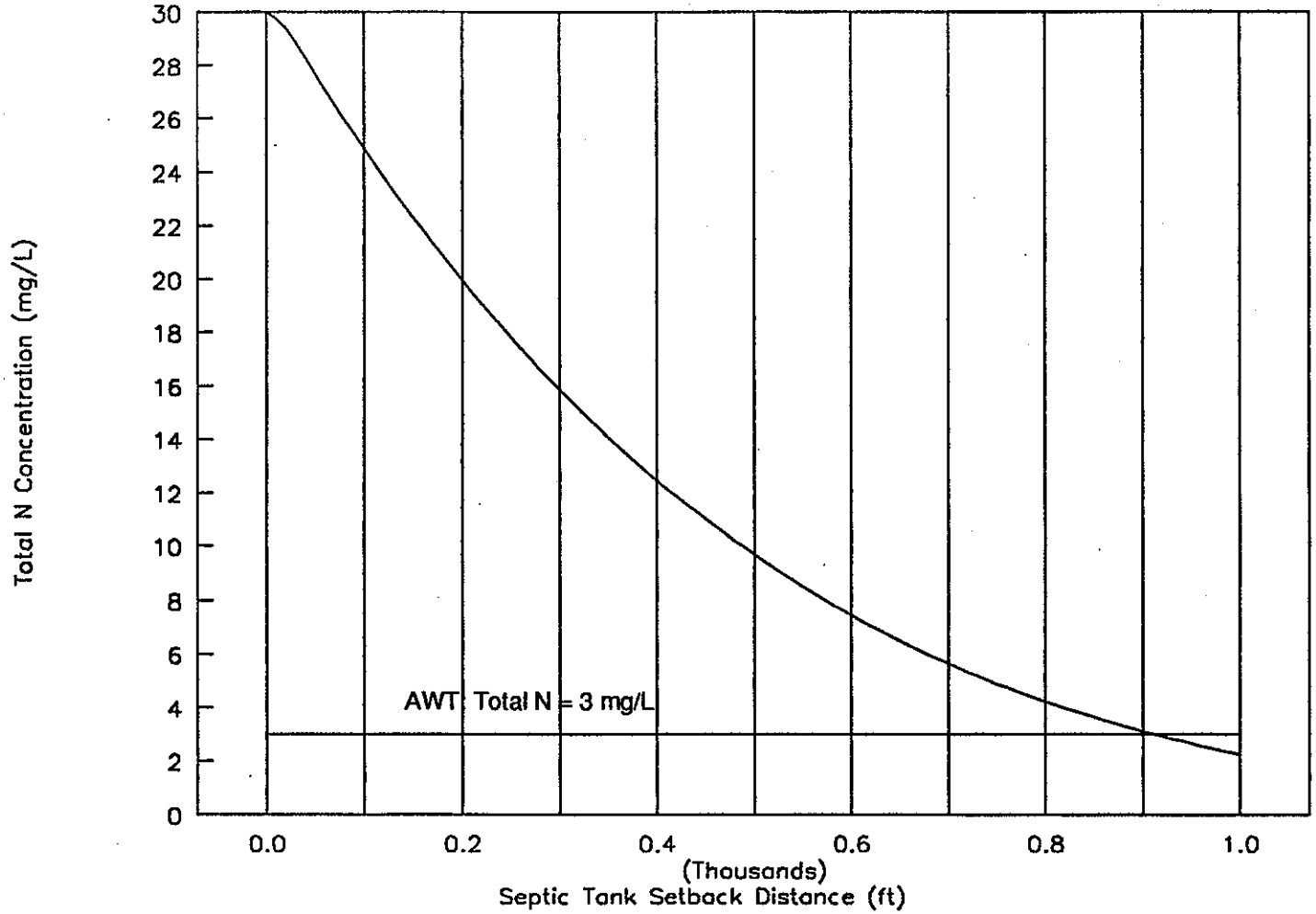

Figure 3-1. Septic Tank Total N Concentration at Various Distances from Receiving Water.

from the septic tank to the receiving water is almost 1000 feet. Consequently, a setback distance in excess of 75 feet would appear to be appropriate for water quality protection in the study area.

3.6 RAINFALL LOADINGS

In order to account for rainfall loadings on the Bay water surface, concentrations representing rainfall loadings were included in the analysis. The Bay surface area is about 52 square miles. For the average annual precipitation, the rainfall total of 54.6 inches per year spread over the Bay surface results in an equivalent flow rate of 135 mgd.

The pollutant concentrations selected for rainfall were based on monitoring data from the Tampa Bay NURP study (Priede-Sedgwick, Inc., 1982). The values are listed below:

- Total N 0.82 mg/L
- Total P 0.15 mg/L
- Lead 6 ug/L
- Zinc 146 ug/L

The nitrogen concentrations from the Tampa Bay NURP Study are consistent with other local data, based on a review of other Tampa Bay loading studies and of rainfall monitoring data from Pinellas County. Unfortunately, the studies and monitoring data did not include concentrations for total P, lead or zinc.

For the average rainfall year, the calculated rainfall loads in lb/yr are 337,400 for total N, 61,700 for total P, 2,500 for lead, and 60,100 for zinc. The significance of these loads with respect to the other sources discussed previously in this section will be evaluated in subsequent sections of this report.

4.0 LOADING TRANSPORT TO BAY

The surface runoff pollutant loadings described in Section 3.3 represent estimates of loadings which have been discharged into a storm sewer, swale or stream channel. However, it is possible that the loading to these conveyance systems (particularly stream channels) will be reduced enroute to the Bay by processes such as settling. Because many of the watersheds are relatively small, and storm flows will typically result in turbulent stream conditions, significant load reductions are not likely to occur in the free-flowing sections of the Bay tributaries. On the other hand, some removal may occur in the tidal portions of the tributaries, where flows may tend to be more quiescent.

Computer modeling using the EPA's WASP4 model (EPA, 1990) was conducted to evaluate the potential for pollution removal within the major tidal tributaries. The following tributaries were included in the analyses:

- Phillippi Creek
- Whitaker Bayou
- Hudson Bayou
- Bowlees Creek
- Cedar Hammock

The watersheds of these tributaries account for 55 percent of the total land area, and 64 percent of the total improved (e.g., urban and agricultural) land area. Most of the remaining improved area drains directly to the Bay instead of discharging to a major tributary.

The analysis focused strictly on the removal of suspended pollutants by means of settling. Thus, dissolved pollutants were assumed to exhibit 100 percent delivery to the Bay. Settling of suspended pollutants was influenced by the assumed settling rate, water depth, and tidal flushing effects.

4.1 MODEL DESCRIPTION

The Water Quality Analysis Simulation Program -4 (WASP4) consists of two separate subprograms - the hydrodynamics program DYNHYD5 and the water quality program WASP4. DYNHYD5 solves the one - dimensional equations of continuity and momentum in order to calculate water surface elevations, velocities and flow rates at various points within the modeling system. WASP4 solves the conservation of mass equation in order to calculate pollutant concentrations within the system.

Both programs use the "link-node" method of simulation. The water body is represented in the model as a series of storage points (nodes) interconnected with a series of channels (links). For each time step during the simulation, the model solves the equation of momentum for each link to calculate flow between connected nodes, and solves the equation of continuity to determine water surface elevations at each node. Water quality constituents are transported between nodes by the flows in each link. In addition, loads may be added to each node via point sources or nonpoint sources. For each node, the mass balance equation is solved to calculate the mass of pollutant, and this value is divided by the node volume (a function of the node water surface elevation) to determine the pollutant concentration.

Figures 4-1 through 4-5 show the model segmentation developed for each major tributary. The model segmentation was designed to extend upstream from the mouth to most distant extent of tidal influence. Segments in individual systems were sized according to recommendations in the WASP4 User's Manual (EPA, 1990). Generally, it is best to segment the system so that the water volumes are roughly the same. This guideline allows larger time steps and results in greater numerical accuracy.

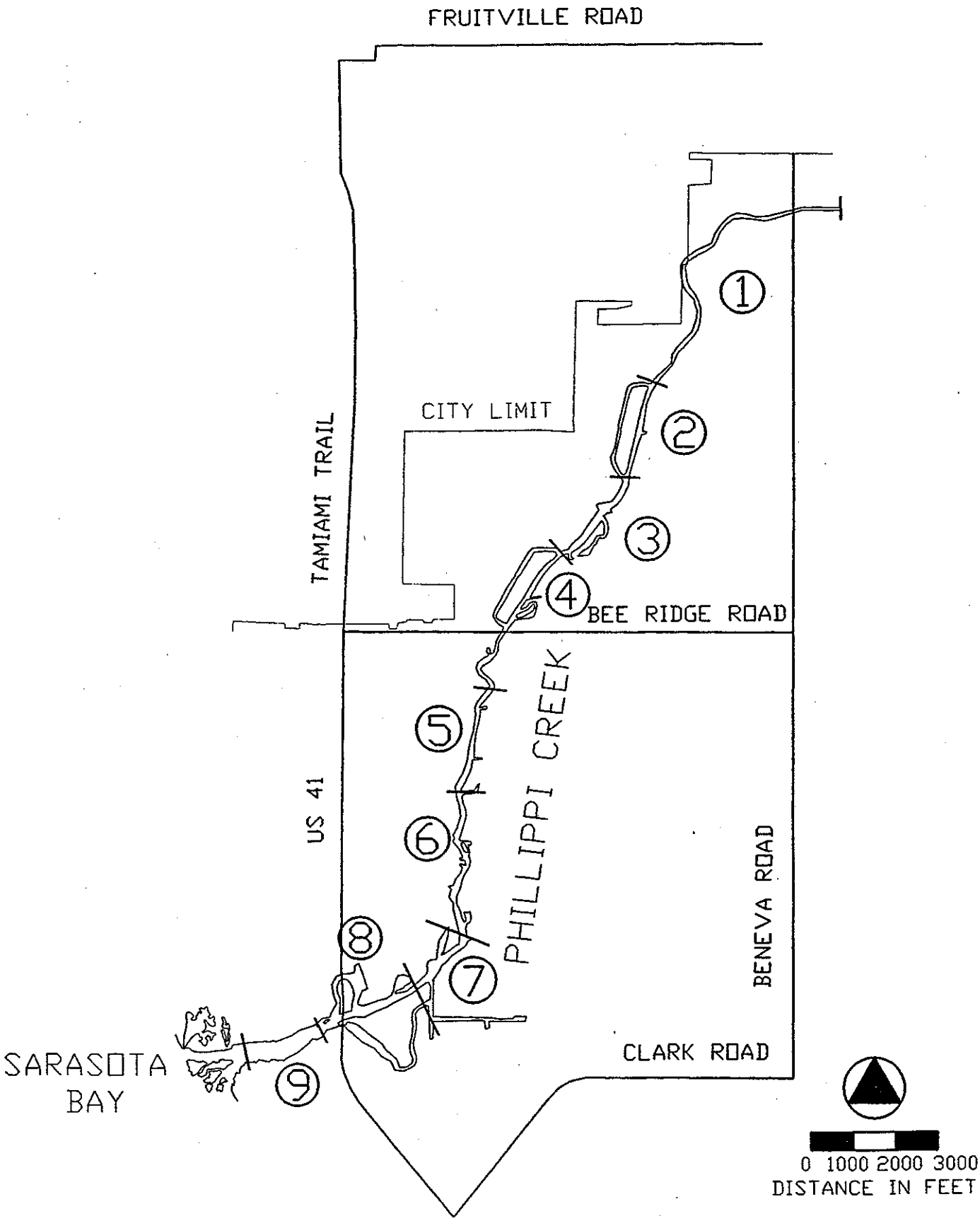

Figure 4-1. WASP4 Model Segmentation for Phillippi Creek.

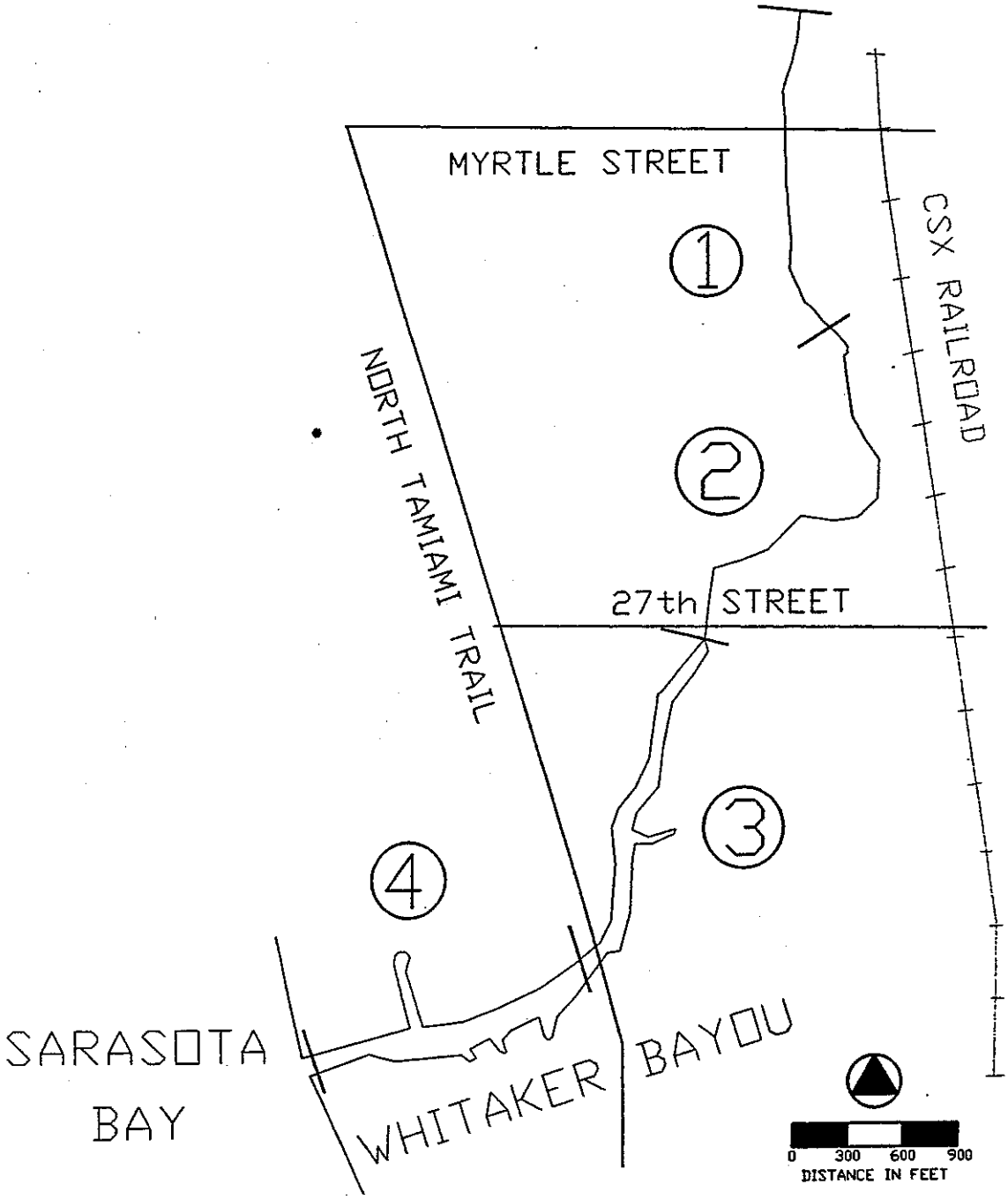

Figure 4-2. WASP4 Model Segmentation for Whitaker Bayou.

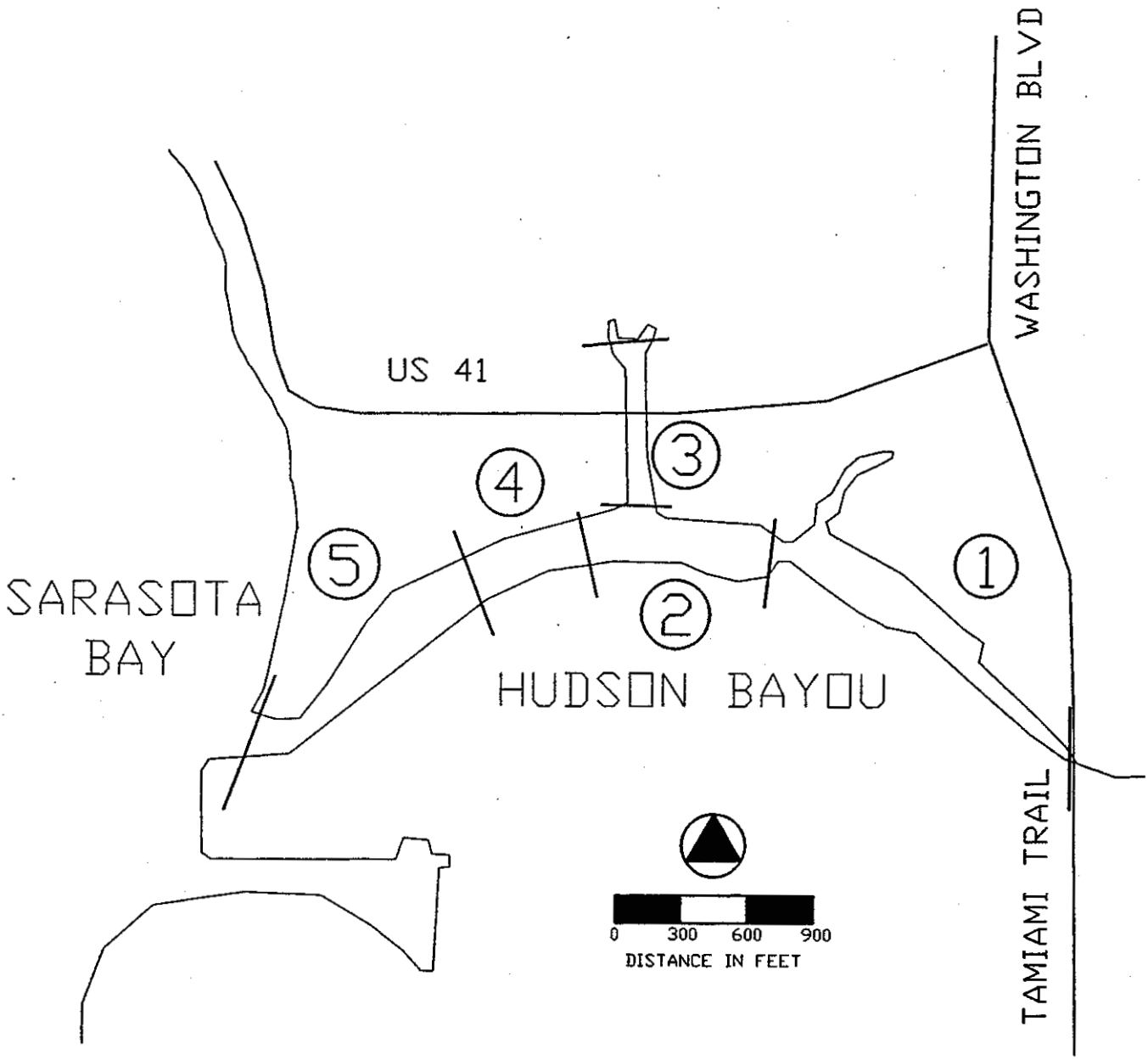

Figure 4-3. WASP4 Model Segmentation for Hudson Bayou.

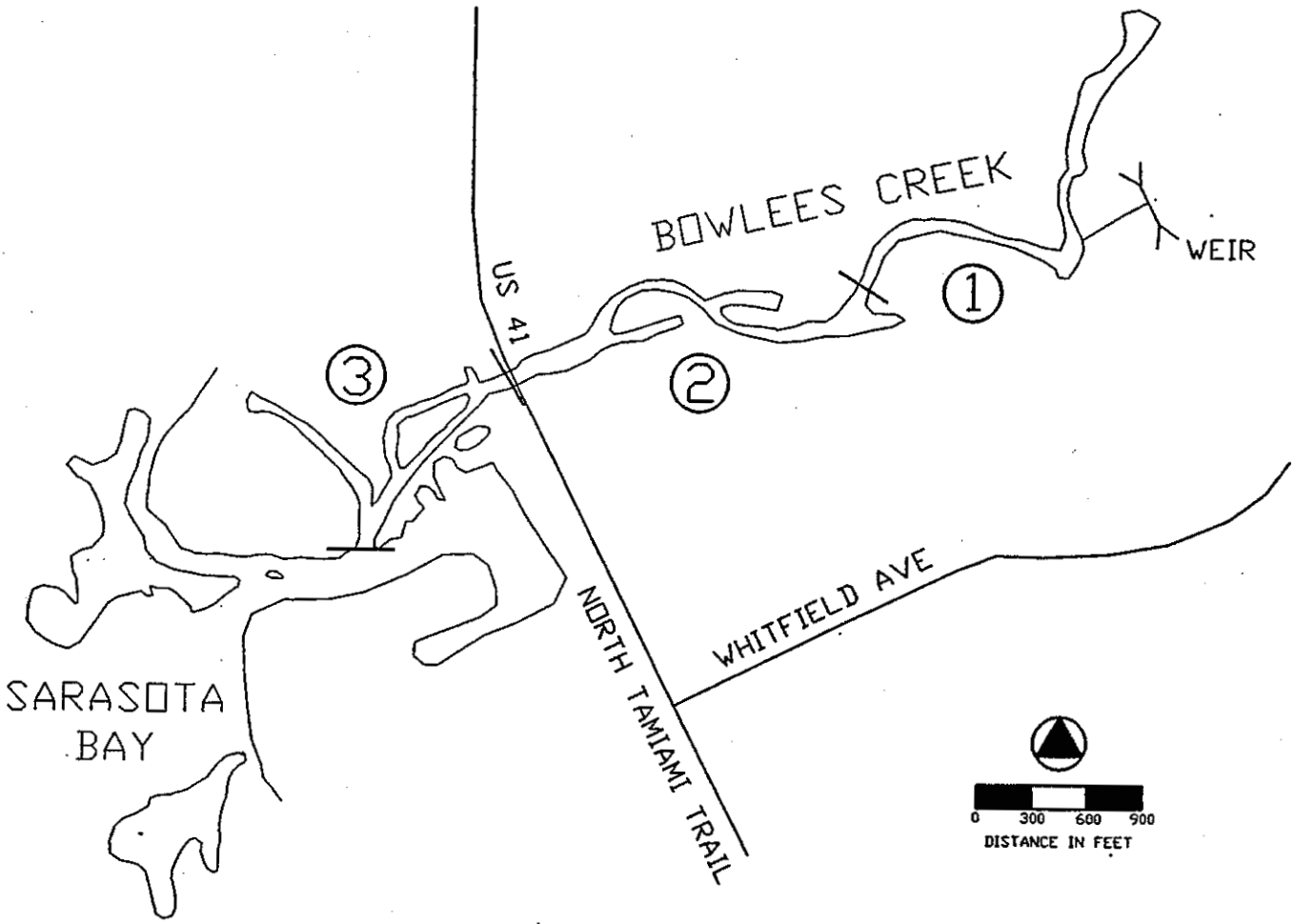

Figure 4-4. WASP4 Model Segmentation for Bowlees Creek.

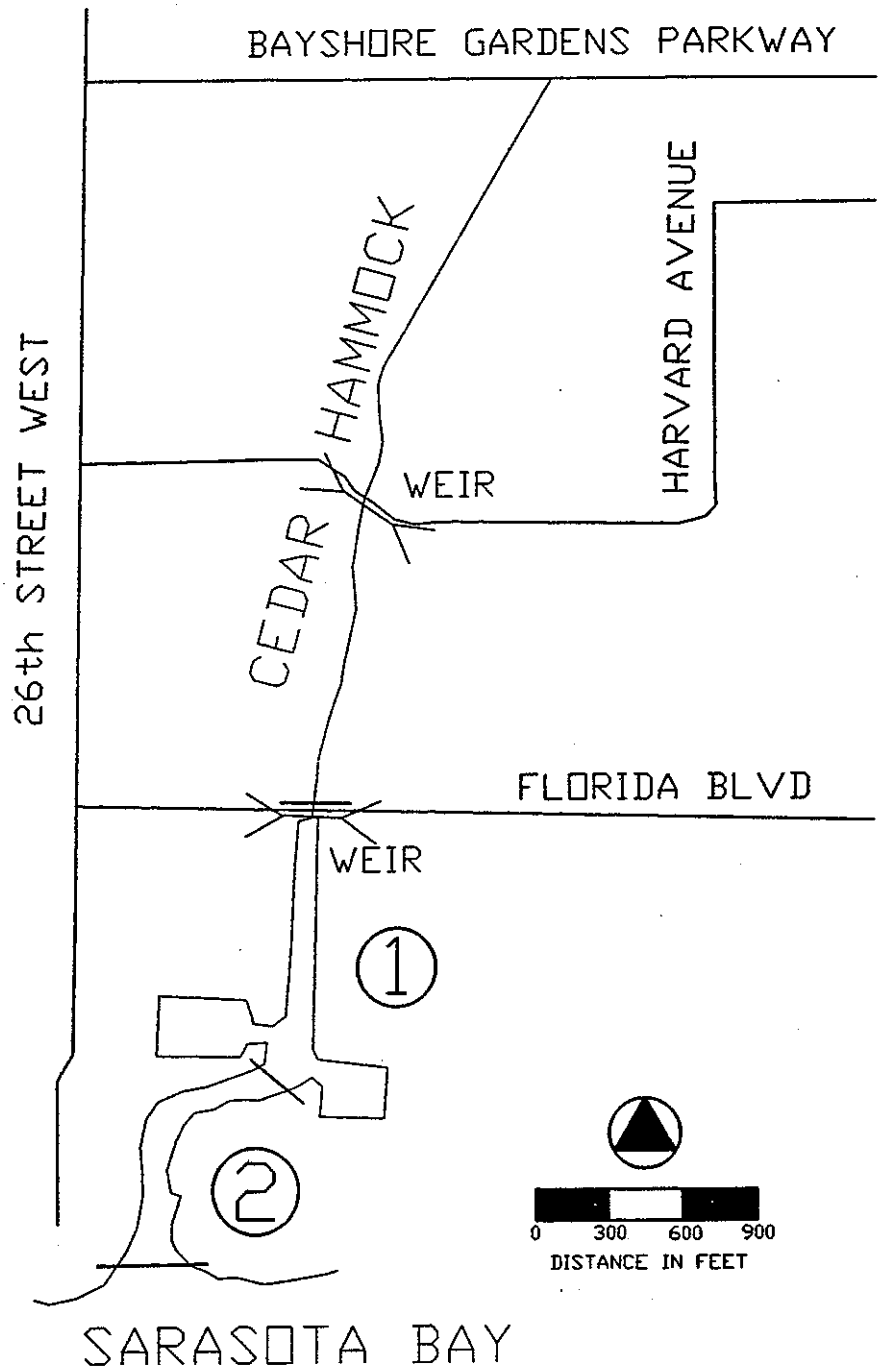

Figure 4-5. WASP4 Model Segmentation for Cedar Hammock.

4.2 MODEL PARAMETERS

In modeling the Bay tributaries a number of parameters were evaluated. These included tidal influence, channel geometry, suspended pollutant settling rate and surface runoff loadings and flows. The evaluation of these parameters is discussed below.

4.2.1 TIDAL INFLUENCE

One of the major forcing functions in each of the tributaries is the inflow and outflow of the tide. In the model, a lunar semidiurnal tide was specified, with a period of 12.5 hours. Key values that were established are the water elevation at mean tide, and the mean tidal range.

Based on data from the 1991 Tide Tables, the selected parameter values for tidal effects were 1.0 ft National Geodetic Vertical Datum (NGVD) as the mean tide elevation, and 2.0 feet as the mean tidal range. The mean water elevation is consistent with a review of Phillippi Creek cross-sectional data developed for the Sarasota County Stormwater Master Plan report (CDM, 1987). The value of 1.0 ft NGVD was the mid-range of water elevations measured at the cross-sections in the tidal part of the creek.

4.2.2 TRIBUTARY FLOWS AND LOADINGS

The other major forcing function in each tributary is the flow and associated surface runoff pollutant loading from the watershed. Generally, because runoff from the large majority of the drainage area enters the stream above the first model segment, the total flow and load was assigned to the first segment. The exception was Hudson Bayou, where 60 percent of the flow and load was assigned to Segment 1 and 40 percent was assigned to Segment 3, based on drainage area to each segment.

The loadings and flows were simulated as steady input values, calculated from the average annual results generated by the spreadsheet model. Streamflow values, calculated by the model in terms of inches per year over the drainage area, were converted to a steady inflow in units of cubic meters per second. Similarly, the annual loading values in pounds per year were converted to a steady loading in kilograms per day.

Sensitivity runs were conducted to determine whether wet year, dry year, and seasonal flows and loadings would generate substantially different results then the average year flows and loadings. Results showed that the delivery ratios (the percentage of surface runoff loading that reaches the Bay) were not substantially different for any of these cases. Consequently, the delivery ratios determined for average annual conditions were used for all rainfall scenarios.

4.2.3 TRIBUTARY GEOMETRIES

The depth, width, length and cross-sectional geometries of the tributaries were established based on existing data. Bowlees Creek and Phillippi Creek were the tributaries having the most detailed data. Cross-sections were developed for Phillippi Creek as part of the Sarasota County Stormwater Master Plan (CDM, 1987), and Bowlees Creek had previously been modeled using the U.S. Corps of Engineers HEC-2 model. Data for the other tributaries were developed based on USGS quadrangle maps, NOAA nautical charts and Florida Department of Transportation bridge records and field inspections.

The cross-sectional data were used to develop HEC-2 datasets for each tributary, and these datasets were used to develop the input data required by the WASP4 model. For each tributary, the HEC-2 model was run at the average stream flow and mean tidal height, producing values of depth, volume and surface area. This output was used to specify the depth, volume and surface area of each of the segments in the WASP4 model.

4.2.4 POLLUTANT SETTLING PARAMETERS

The WASP4 model was run for each tributary assuming that settling of suspended pollutants was the only pollutant removal process. Two key factors in determining how much removal will occur are the pollutant settling rate, and the fraction of total pollutant that is in the suspended form.

A settling rate of 1.0 foot per day was selected based on a review of the literature. A review of previous modeling studies indicated that calculated settling velocities for suspended solids in quiescent waters have ranged from 0.1 to 5.0 meters per day (Delos et al, 1983). In studies of the Flint River (Richardson et al, 1983) and the Deep River (Metcalfe et al, 1984), calibrated settling rates ranged from 0.2 to 0.65 meters per day (0.7 to 2.1 feet per day). In contrast, literature settling rates for phytoplankton range from 0.0 to 30.0 meters per day, with most in the rage of 0.02 to 0.6 meters per day (EPA, 1985). Consequently, a settling rate of 1.0 feet per day (0.30 meters per day) is in the mid-range of typical settling values.

Sensitivity runs were conducted to determine the effect of increasing or decreasing the settling rate. The analysis evaluated settling rates of 0.5 and 1.5 feet per day, which represent a 50 percent variation from the selected rate of 1.0 feet per day. Results indicated that the change in delivery ratio ranged from 2 to 20 percent, and was generally less than 10 percent. Thus, it appears that the delivery ratio results are not sensitive to these changes in the settling rate.

The settling rate was applied to the suspended fraction of each pollutant, which was also established based on a literature review. The selected values for the constituents analyzed in the study area, based on typical values for urbanized areas, are as follows:

- Total N 25% suspended
- Total P 40% suspended

- Lead 90% suspended
- Zinc 40% suspended

These values are typical of monitoring data from the NURP study. Based on these values lead is the pollutant that will exhibit the highest degree of settling in the tributaries, and total N will exhibit the lowest degree of settling.

4.3 MODELING PROCEDURE

The data described in Section 4.2 were used in the WASP4 model to determine the delivery ratio for each of the major tributaries. The model was run for a simulation period of 30 days, with a repeated semi-diurnal tide and constant streamflow and pollutant loading, to establish steady-state conditions (i.e., concentrations did not vary from one day to the next). The WASP4 model output included a mass balance file that summarized the outflow of pollutant from the tributary. The pollutant outflow was compared to the constant loading to establish the delivery ratio for each pollutant.

A slightly different procedure was used for Cedar Hammock, due to the presence of two sediment traps in the non-tidal part of the tributary. Figure 4-2 shows the location of these traps at Florida Boulevard and Harvard Avenue. The areas upstream of the traps could not be modeled within the WASP4 framework. City records regarding sediment accumulation in these traps suggest that substantial pollutant removal may be occurring there, unlike salinity barriers or other minor structures that are unlikely to promote significant settling.

The pollutant reduction due to the sediment traps was estimated in a spreadsheet. Based on the average flow rate and the weir length and elevation, the water elevation behind each weir was determined. Cross-sectional data from a survey of the area were entered into a HEC-2 model dataset to determine water depth, volume and surface area. Using

these data along with the values for settling rate and suspended fraction of pollutant, removal due to settling was calculated.

To run the WASP4 model for Cedar Hammock the pollutant parameters were adjusted to account for the settling in the sediment traps. The average pollutant loading was reduced to reflect the settling. In addition, the suspended fraction of each pollutant had to be changed, because the suspended fraction to the Bay was lower than the suspended fraction to the sediment traps. For example, if a 100 pound per day load to the sediment traps contains 40 pounds of suspended pollutant (i.e., suspended fraction is 40 percent), and 20 pounds per days of suspended pollutant are removed in the sediment traps, then 20 pounds per day of suspended pollutant remains in the 80 pounds per day of pollutant reaching the Bay, resulting in a suspended fraction of 25 percent, rather than 40 percent.

4.4 MODEL RESULTS

The delivery ratios developed for each tidal tributary are presented in Table 4-1. As one would expect, the delivery ratios are highest for total N, which had the lowest suspended fraction, and lowest for lead, which had the highest suspended fraction. Bowlees Creek, Hudson Bayou and Whitaker Bayou exhibit little reduction in loadings to the Bay, with delivery ratios of over 90 percent for all pollutants. Phillippi Creek provided 30 percent removal of lead in the tributary, but delivery of zinc, total N and total P are still in the neighborhood of 90 percent. Cedar Hammock exhibits the most pollutant removal, chiefly because of the sediment traps in the non-tidal tributary.

As presented in Chapter 5.0, these delivery ratios were applied to the surface runoff loads for the major tributaries. For the areas draining directly to the Bay, and for the other tributaries that were not modeled, 100 percent delivery was assumed. The ratios were not applied to point source discharges, septic tank discharges, baseflow and rainfall, because the pollutants for these type of discharges are expected to be primarily in the dissolved form.

TABLE 4-1

DELIVERY RATIOS FOR MAJOR TIDAL TRIBUTARIES

Tributary	Delivery Ratio (%)			
	Total P	Total N	Lead	Zinc
Phillippi Creek	87	93	71	87
Whitaker Bayou	97	100	92	97
Hudson Bayou	92	96	82	92
Bowlees Creek	96	99	89	96
Cedar Hammock	82	90	58	82

5.0 POLLUTION LOADING PROJECTIONS FOR EXISTING LAND USE CONDITIONS

The data presented in the previous chapters were used as input to a spreadsheet model which calculated pollutant loadings to Sarasota Bay for existing land use conditions. The results were analyzed in a number of ways. Total loadings to the Bay were analyzed to determine the relative impacts of surface runoff, point sources, septic tanks, baseflow and rainfall. In addition, the loadings attributed to each of the study area jurisdictions, and each of the watersheds in the study area were calculated. For the average annual rainfall, the percentage of the total loading occurring in the wet and dry seasons was also established. Finally, the analysis considered the loadings for a wet year and a dry year, comparing the loadings with those of an average year.

5.1 AVERAGE ANNUAL LOADING RESULTS

5.1.1 LOADINGS BY WATERSHED

Table 5-1 presents the average annual loading results by watershed for existing land use conditions. The results include the impacts of surface runoff, baseflow, septic tanks, point source discharges and rainfall. Values in the table include total area, total runoff, and loading data for total P, total N, lead and zinc. The loading data include the total mass in pounds, the unit load in pounds per acre, and the flow-weighted concentration in milligrams per liter. The last line in the table represents the values for the entire study area, including the land areas and the Bay water surface.

For total P, the watersheds that exhibit the highest total loadings, unit loadings and concentrations include Phillippi Creek, Whitaker Bayou, South Bradenton and Siesta Key. Phillippi Creek, South Bradenton and Whitaker Bayou account for 40 percent of the total P load to the Bay. Though the total load from Siesta Key is not nearly as high as for

TABLE 5-1

AVERAGE ANNUAL LOADINGS BY WATERSHED
FOR EXISTING LAND USE CONDITIONS

WATERSHED	AREA	TOTAL RUNOFF	TOTAL P			TOTAL N			LEAD			ZINC		
	(ac)	(in)	(lb)	(lb/ac)	(mg/l)	(lb)	(lb/ac)	(mg/l)	(lb)	(lb/ac)	(mg/l)	(lb)	(lb/ac)	(mg/l)
PHILLIPPI CREEK	36,417	25.24	70,710	1.94	0.34	374,730	10.29	1.80	9,080	0.25	0.044	10,240	0.28	0.049
PALMA SOLA 2	1,120	25.12	1,780	1.59	0.28	8,790	7.85	1.38	430	0.38	0.067	350	0.31	0.055
BOWLEES CREEK	6,489	33.61	11,350	1.75	0.23	65,280	10.06	1.32	7,350	1.13	0.149	4,410	0.68	0.089
WEST BRADENTON	4,395	28.94	7,680	1.75	0.27	37,240	8.47	1.29	1,700	0.39	0.059	1,510	0.34	0.052
CEDAR HAMMOCK	1,930	32.35	4,170	2.16	0.29	21,080	10.92	1.49	1,320	0.68	0.093	990	0.51	0.070
WEST BOWLEES	1,559	28.01	3,080	1.98	0.31	15,050	9.65	1.52	760	0.49	0.077	630	0.40	0.064
PALMA SOLA	900	23.47	1,810	2.01	0.38	7,800	8.67	1.63	280	0.31	0.058	250	0.28	0.052
SOUTH BRADENTON	4,635	27.87	12,920	2.79	0.44	57,420	12.39	1.96	790	0.17	0.027	1,200	0.26	0.041
WHITAKER BAYOU	5,015	40.71	20,400	4.07	0.44	90,320	18.01	1.95	3,750	0.75	0.081	3,660	0.73	0.079
MATHENY CREEK	3,800	35.96	11,790	3.10	0.38	58,630	15.43	1.89	2,370	0.62	0.077	2,230	0.59	0.072
CATFISH CREEK	3,360	21.73	3,710	1.10	0.22	19,010	5.66	1.15	280	0.08	0.017	580	0.17	0.035
NORTH CREEK	1,920	20.60	2,160	1.13	0.24	11,180	5.82	1.25	230	0.12	0.026	350	0.18	0.039
SOUTH CREEK	12,995	18.79	11,870	0.91	0.21	55,670	4.28	1.01	580	0.04	0.010	1,560	0.12	0.028
HUDSON BAYOU	1,595	32.58	3,090	1.94	0.26	16,650	10.44	1.41	1,460	0.92	0.124	940	0.59	0.080
SIESTA KEY	1,385	45.94	8,410	6.07	0.58	30,240	21.83	2.10	580	0.42	0.040	1,030	0.74	0.071
ANNA MARIA	919	28.32	1,740	1.89	0.29	8,660	9.42	1.47	450	0.49	0.076	360	0.39	0.061
PERICO	860	33.12	1,090	1.27	0.17	4,900	5.70	0.76	80	0.09	0.012	110	0.13	0.017
LONGBOAT KEY	1697	23.62	2,730	1.61	0.30	13,000	7.66	1.43	440	0.26	0.048	450	0.27	0.050
OTHER ISLANDS	900	27.94	1,640	1.82	0.29	8,360	9.29	1.47	310	0.34	0.054	290	0.32	0.051
DIRECT TO BAY	4,241	31.85	8,850	2.09	0.29	51,430	12.13	1.68	2,340	0.55	0.076	1,880	0.44	0.061
BAY SURFACE	33,280	54.60	61,730	1.85	0.15	337,460	10.14	0.82	2,470	0.07	0.006	60,080	1.81	0.146
TOTAL	129,412	34.26	252,710	2.13	0.30	1,292,900	10.20	1.47	37,050	0.41	0.058	93,100	0.45	0.060

Note: Loading totals do not include pollutant settling in tidal tributaries. See text for discussion of settling in tributaries.

Phillippi Creek and Whitaker Bayou, the unit loading and concentration from the watershed is higher than any other watershed. Surface water discharge of point sources is the major reason for high total P concentrations in the Siesta Key watershed.

The same four watersheds, along with Matheny Creek and the areas in western Sarasota County that drain directly to the Bay, also have high loading and concentration values for total N. About 36 percent of the total N loading to the Bay comes from Phillippi Creek and Whitaker Bayou. Surface water discharge of point sources is the major reason for high total N concentrations in the Matheny Creek and Siesta Key watersheds.

Phillippi Creek, Bowlees Creek and Whitaker Bayou are the largest loading sources for lead. These three watersheds account for 54 percent of the total Bay loading. Surface runoff is the major source of lead in Bowlees Creek, whereas a combination of surface runoff and point source discharge are the major contributors in Phillippi Creek and Whitaker Bayou. Relatively high lead concentrations were calculated for Hudson Bayou and Cedar Hammock. This can be attributed to surface runoff in these two watersheds.

Other than rainfall, which accounts for 65 percent of the zinc loading to the Bay, major zinc loadings are attributed to Phillippi Creek, Bowlees Creek and Whitaker Bayou. The high zinc concentration in the rainfall, which was assumed based on Tampa Bay NURP data, is responsible for the large rainfall loading. Surface runoff and point source discharge are the major factors in Phillippi Creek and Whitaker Bayou, and surface runoff is the major factor in Hudson Bayou.

The values in Table 5-1 do not include the effects of pollutant settling in the tidal tributaries. Pollutant settling was assumed to apply only to the loading from surface runoff. When the delivery ratios presented in Table 4-1 were applied to the tributaries, the reduction in surface runoff loadings was only 6 percent for total P and zinc, 3 percent for total N, and 13 percent for lead. When considering the total loading from all sources,

the loading reductions due to settling were 3 percent for total P, 12 percent for lead, and 2 percent for total N and zinc.

5.1.2 LOADINGS BY SOURCE

Overall loading statistics as a function of pollution source are presented in Table 5-2. The sources included in the table are surface runoff, baseflow, septic tanks, point sources, and rainfall. The total runoff and loadings of total P, total N, lead and zinc are presented, as is the percentage of the total loading attributed to each source. Generally, the results indicate that surface runoff and rainfall are the two largest sources of pollutant loadings to the Bay. Together, these two sources account for 71 percent of the total P, 73 percent of the total N, 98 percent of the lead and 91 percent of the zinc loadings. Surface runoff is the major source of total P, total N and lead, while rainfall is the major source of zinc.

These are several reasons why these two sources dominate the total loadings. One is that the two sources account for 84 percent of the total flow that reaches the Bay. Another is that the remaining 16 percent of the total runoff is primarily attributed to baseflow, which has rather low pollutant concentrations.

Septic tanks and point source discharges contribute a relatively small percentage of total loadings. The values in the table show that the combined loadings of septic tanks and point sources are 16 to 18 percent of the total loadings for the nutrients, and 1 to 3 percent for the metals. Point source loadings are limited by the implementation of AWT standards at wastewater treatment plants, along with a shift from surface water discharge to land application of wastewater. Septic tank loadings are limited by the relatively low failure rate of 8 percent. In addition, as a result of the substantial travel time from septic tanks to the Bay and its tributaries, a relatively small fraction of septic tank effluent loading reaches the Bay.

TABLE 5-2

AVERAGE ANNUAL LOADINGS BY SOURCE
FOR EXISTING LAND USE CONDITIONS

SOURCE	RUNOFF (in)	% OF TOTAL	AVERAGE YEAR POLLUTANT LOADING							
			TOTAL P (lb)	% OF TOTAL	TOTAL N (lb)	% OF TOTAL	LEAD (lb)	% OF TOTAL	ZINC (lb)	% OF TOTAL
SURFACE	14.58	42.6%	117,830	46.6%	609,990	47.2%	33,790	91.2%	24,890	26.7%
BASEFLOW	3.84	11.2%	33,810	13.4%	112,700	8.7%	300	0.8%	5,620	6.0%
SEPTIC	0.70	2.0%	8,230	3.3%	123,520	9.6%	0	0.0%	0	0.0%
POINT SOURCE	1.10	3.2%	31,110	12.3%	109,230	8.4%	490	1.3%	2,510	2.7%
RAINFALL	14.04	41.0%	61,730	24.4%	337,460	26.1%	2,470	6.7%	60,080	64.5%
TOTAL	34.26		252,710		1,292,900		37,050		93,100	

Note: Loading totals do not include pollutant settling in tidal tributaries. See text for discussion of settling in tributaries.

The values in Table 5-2 do not include the effects of pollutant settling in the tidal tributaries. When the delivery ratios presented in Table 4-1 were applied to the tidal tributaries to assess the impact on the source distribution percentage, the results were only slightly different than the results generated without considering the delivery ratios. The percentage of loading due to surface runoff changed by 2 percentage points or less, and the percentages for the other sources changed by no more than 1 percentage point. Thus, the relative distribution of the sources remained essentially the same, with surface runoff, baseflow and rainfall providing the highest percentages of the total pollutant loadings.

5.1.3 LOADINGS BY JURISDICTION

Loading totals were also calculated by jurisdiction, and these totals are presented in Table 5-3. The jurisdiction list includes Sarasota County, Manatee County, the City of Sarasota, the Barrier Islands, and the Bay Water Surface. The Barrier Islands were initially included in a separate group because it was speculated that rainfall totals for the barrier islands could be significantly different than mainland rainfall totals. However, a statistical analysis of rainfall data indicated that the barrier island and inland rainfall data were very similar (See Appendix C). For each jurisdiction, the table lists the area, the runoff volume, and loadings of total P, total N, lead and zinc. The percentage of the total runoff and loadings attributed to each jurisdiction are also included.

Table 5-3 shows that the largest areas generally produce the highest percentage of runoff volume and pollutant loading. Sarasota County is the largest jurisdiction, comprising 49 percent of the total land and water surface area. The Bay Surface is next largest at 26 percent, followed by Manatee County at 16 percent. Together, these three jurisdictions account for 89 percent of the total runoff, and 78 to 92 percent of the pollutants listed in the table.

For total P and total N, Sarasota County accounts for about 44 percent of the loading to the Bay, and Manatee County and the Bay surface account for another 40 to 42 percent.

TABLE 5-3

AVERAGE ANNUAL LOADINGS BY JURISDICTION
FOR EXISTING LAND USE CONDITIONS

JURISDICTION	AREA (ac)	RUNOFF (in)	% OF TOTAL	AVERAGE YEAR POLLUTANT LOADING							
				Total P (lb)	% OF TOTAL	Total N (lb)	% OF TOTAL	LEAD (lb)	% OF TOTAL	ZINC (lb)	% OF TOTAL
SARASOTA CO.	62,301	11.94	34.8%	108,900	43.1%	575,960	44.5%	14,720	39.7%	16,790	18.0%
SARASOTA CITY	7,844	2.20	6.4%	25,230	10.0%	109,970	8.5%	6,170	16.7%	5,170	5.6%
MANATEE CO.	20,226	4.66	13.6%	41,240	16.3%	204,350	15.8%	11,830	31.9%	8,820	9.5%
ISLANDS	5,761	1.42	4.1%	15,610	6.2%	65,160	5.0%	1,860	5.0%	2,240	2.4%
BAY SURFACE	33,280	14.04	41.0%	61,730	24.4%	337,460	26.1%	2,470	6.7%	60,080	64.5%
TOTAL	129,412	34.26		252,710		1,292,900		37,050		93,100	

Note: Loading totals do not include pollutant settling in tidal tributaries. See text for discussion of settling in tributaries.

Sources of nutrients in Sarasota County include surface runoff, baseflow, septic tanks and point sources. Of these, surface runoff is the major contributor. Surface runoff is also the key factor for Manatee County. Loading to the Bay surface occurs through rainfall.

In comparison to nutrients, the values for lead indicate a higher percentage contribution from the City of Sarasota and Manatee County. This is primarily due to the surface runoff from the highly developed areas within the City and parts of the County. In contrast, rainfall has a much lower relative contribution due to the low lead concentration assumed, based on Tampa NURP data.

Due to the high concentration of zinc in rainfall (based on the Tampa NURP study), the Bay surface loading accounts for 65 percent of the zinc loading to the Bay. As with lead, the zinc loadings from the City of Sarasota and Manatee County tend to be more significant with respect to the loading from Sarasota County, due to urban surface runoff.

For all of the pollutants, the islands are responsible for 7 percent or less of the total loadings. The relative contribution of nutrients is higher than the relative contribution of metals for the islands. This can be attributed to the somewhat higher rate of septic tank failure assumed for Casey Key (20 percent compared to 8 percent for other watersheds), and the surface water discharge from Siesta Key, in addition to surface runoff and baseflow loadings.

The values in Table 5-3 do not include the effects of pollutant settling in the tidal tributaries. When the delivery ratios presented in Table 4-1 were applied to the tidal tributaries to assess the impact on the loading distribution between jurisdictions, the results were only slightly different than the results generated without considering the delivery ratios. The relative percentages of loading attributed to the various jurisdictions did not change by more than 1 percentage point.

5.2 WET SEASON AND DRY SEASON RESULTS

Separate analyses were conducted to evaluate loadings during the wet season (June through September) and the dry season (October through May) of an average year. The results were used to determine how the total annual load was distributed between the two seasons. In addition, the results for each season were compared to the annual results to identify changes in loading distributions by source and by jurisdiction.

Tables 5-4 through 5-7 present the results of the seasonal loading analysis. Loadings by watershed for the wet season and dry season are listed in Tables 5-4 and 5-5, respectively. Table 5-6 includes loading values by pollutant source for both the wet and the dry season. Loading values by jurisdiction for both seasons are shown in Table 5-7.

Based on the data in Tables 5-4 and 5-5, about 60 percent of the annual loading occurs during the wet season, and 40 percent occurs during the dry season, for all four of the analyzed pollutants. Because surface runoff and rainfall are major load contributors, one would expect that the loading distribution would reflect the precipitation distribution between wet and dry season. As shown previously in Table 3-1, 20.9 inches of rain was established for the dry season and 33.9 inches of rain was established for the wet season. This results in a rainfall distribution of 38 percent in the dry season and 62 percent in the wet season, which is almost identical to the loading distribution. The runoff distribution is also very similar, with 62 percent of the runoff attributed to the wet season and 38 percent of the runoff attributed to the dry season.

A review of the values in Table 5-6 indicates that the distributions of loadings between the various pollutant sources during the wet and dry season are very similar to the average annual distribution. The largest changes occur for point sources loadings. Unlike the other sources of pollution, point sources and septic tanks actually have a greater total flow volume during the 8-month dry season than during the 4-month wet season.

TABLE 5-4

WET SEASON LOADINGS BY WATERSHED
FOR EXISTING LAND USE CONDITIONS

WATERSHED	AREA	TOTAL RUNOFF	TOTAL P			TOTAL N			LEAD			ZINC		
	(ac)	(in)	(lb)	(lb/ac)	(mg/l)	(lb)	(lb/ac)	(mg/l)	(lb)	(lb/ac)	(mg/l)	(lb)	(lb/ac)	(mg/l)
PHILLIPPI CREEK	36,417	15.53	43,040	1.18	0.34	220,830	6.06	1.72	5,590	0.15	0.044	6480	0.18	0.051
PALMA SOLA 2	1,120	16.06	1,140	1.02	0.28	5,570	4.97	1.37	270	0.24	0.066	220	0.20	0.054
BOWLEES CREEK	6,489	21.12	7,150	1.10	0.23	40,860	6.30	1.32	4,540	0.70	0.146	2740	0.42	0.088
WEST BRADENTON	4,395	18.41	4,900	1.11	0.27	23,520	5.35	1.28	1,060	0.24	0.058	950	0.22	0.052
CEDAR HAMMOCK	1,930	20.38	2,620	1.36	0.29	13,210	6.84	1.48	820	0.42	0.092	630	0.33	0.071
WEST BOWLEES	1,559	17.79	1,950	1.25	0.31	9,480	6.08	1.51	470	0.30	0.075	390	0.25	0.062
PALMA SOLA	900	15.08	1,140	1.27	0.37	4,940	5.49	1.61	180	0.20	0.059	160	0.18	0.052
SOUTH BRADENTON	4,635	16.16	6,870	1.48	0.40	29,500	6.36	1.74	480	0.10	0.028	750	0.16	0.044
WHITAKER BAYOU	5,015	23.52	10,710	2.14	0.40	48,980	9.77	1.83	2,280	0.45	0.085	2090	0.42	0.078
MATHENY CREEK	3,800	20.63	5,960	1.57	0.34	30,910	8.13	1.74	1,440	0.38	0.081	1280	0.34	0.072
CATFISH CREEK	3,360	13.98	2,450	0.73	0.23	11,990	3.57	1.13	180	0.05	0.017	380	0.11	0.036
NORTH CREEK	1,920	13.26	1,420	0.74	0.25	7,040	3.67	1.22	140	0.07	0.024	240	0.13	0.042
SOUTH CREEK	12,995	12.32	7,980	0.61	0.22	36,440	2.80	1.00	360	0.03	0.010	1070	0.08	0.029
HUDSON BAYOU	1,595	20.51	1,940	1.22	0.26	10,420	6.53	1.41	900	0.56	0.121	590	0.37	0.080
SIESTA KEY	1,385	23.89	3,680	2.66	0.49	14,120	10.19	1.88	330	0.24	0.044	490	0.35	0.065
ANNA MARIA	919	17.97	1,120	1.22	0.30	5,450	5.93	1.46	280	0.30	0.075	230	0.25	0.061
PERICO	860	21.16	700	0.81	0.17	3,170	3.69	0.77	50	0.06	0.012	70	0.08	0.017
LONGBOAT KEY	1,697	15.17	1,750	1.03	0.30	8,270	4.87	1.42	260	0.15	0.045	280	0.16	0.048
OTHER ISLANDS	900	17.71	1,030	1.14	0.29	5,150	5.72	1.43	190	0.21	0.053	190	0.21	0.053
DIRECT TO BAY	4,241	19.61	5,450	1.29	0.29	30,790	7.26	1.63	1,450	0.34	0.077	1,190	0.28	0.063
BAY SURFACE	33,280	33.70	38,100	1.14	0.15	208,290	6.26	0.82	1,520	0.05	0.006	37,090	1.11	0.146
TOTAL	129,412	21.12	151,100	1.24	0.29	768,930	5.99	1.42	22,790	0.25	0.058	57,510	0.28	0.060

Note: Loading totals do not include pollutant settling in tidal tributaries. See text for discussion of settling in tributaries.

TABLE 5-5

DRY SEASON LOADINGS BY WATERSHED
FOR EXISTING LAND USE CONDITIONS

WATERSHED	AREA	TOTAL RUNOFF	TOTAL P			TOTAL N			LEAD			ZINC		
	(ac)	(in)	(lb)	(lb/ac)	(mg/l)	(lb)	(lb/ac)	(mg/l)	(lb)	(lb/ac)	(mg/l)	(lb)	(lb/ac)	(mg/l)
PHILLIPPI CREEK	36,417	9.71	27,670	0.76	0.35	153,900	4.23	1.92	3,490	0.10	0.044	3,770	0.10	0.047
PALMA SOLA 2	1,120	9.06	650	0.58	0.28	3,210	2.87	1.40	170	0.15	0.074	130	0.12	0.057
BOWLEES CREEK	6,489	12.48	4,130	0.64	0.23	24,440	3.77	1.33	2,810	0.43	0.153	1,650	0.25	0.090
WEST BRADENTON	4,395	10.52	2,780	0.63	0.27	13,690	3.11	1.31	650	0.15	0.062	550	0.13	0.052
CEDAR HAMMOCK	1,930	11.97	1,530	0.79	0.29	7,890	4.09	1.51	510	0.26	0.097	370	0.19	0.071
WEST BOWLEES	1,559	10.22	1,120	0.72	0.31	5,580	3.58	1.54	300	0.19	0.083	230	0.15	0.064
PALMA SOLA	900	8.39	660	0.73	0.39	2,870	3.19	1.68	110	0.12	0.064	90	0.10	0.053
SOUTH BRADENTON	4,635	11.71	6,060	1.31	0.49	27,940	6.03	2.27	310	0.07	0.025	460	0.10	0.037
WHITAKER BAYOU	5,015	17.20	9,690	1.93	0.50	41,280	8.23	2.11	1,460	0.29	0.075	1,570	0.31	0.080
MATHENY CREEK	3,800	15.33	5,820	1.53	0.44	27,710	7.29	2.10	930	0.24	0.070	950	0.25	0.072
CATFISH CREEK	3,360	7.75	1,290	0.38	0.22	7,010	2.09	1.19	100	0.03	0.017	190	0.06	0.032
NORTH CREEK	1,920	7.34	730	0.38	0.23	4,150	2.16	1.30	80	0.04	0.025	120	0.06	0.038
SOUTH CREEK	12,995	6.46	3,900	0.30	0.20	19,250	1.48	1.01	220	0.02	0.012	480	0.04	0.025
HUDSON BAYOU	1,595	12.07	1,150	0.72	0.26	6,220	3.90	1.43	560	0.35	0.128	360	0.23	0.082
SIESTA KEY	1,385	22.05	4,740	3.42	0.68	16,100	11.62	2.33	250	0.18	0.036	550	0.40	0.079
ANNA MARIA	919	10.35	640	0.70	0.30	3,210	3.49	1.49	170	0.18	0.079	130	0.14	0.060
PERICO	860	11.96	380	0.44	0.16	1,730	2.01	0.74	30	0.03	0.013	40	0.05	0.017
LONGBOAT KEY	1,697	8.45	970	0.57	0.30	4,760	2.80	1.46	160	0.09	0.049	160	0.09	0.049
OTHER ISLANDS	900	10.23	610	0.68	0.29	3,200	3.56	1.53	120	0.13	0.058	100	0.11	0.048
DIRECT TO BAY	4,241	12.24	3,350	0.79	0.28	20,630	4.86	1.75	900	0.21	0.077	700	0.17	0.060
BAY SURFACE	33,280	20.90	23,630	0.71	0.15	129,170	3.88	0.82	950	0.03	0.006	23,000	0.69	0.146
TOTAL	129,412	13.14	101,500	0.89	0.32	523,940	4.20	1.53	14,280	0.16	0.059	35,600	0.18	0.060

Note: Loading totals do not include pollutant settling in tidal tributaries. See text for discussion of settling in tributaries.

TABLE 5-6

WET SEASON AND DRY SEASON LOADINGS BY SOURCE
FOR EXISTING LAND USE CONDITIONS

SOURCE	RUNOFF (in)	% OF TOTAL	WET SEASON POLLUTANT LOADING TOTAL P (lb)	% OF TOTAL	TOTAL N (lb)	% OF TOTAL	LEAD (lb)	% OF TOTAL	ZINC (lb)	% OF TOTAL
SURFACE	9.00	42.6%	72,640	48.1%	376,520	49.0%	20,880	91.6%	15,360	26.7%
BASEFLOW	2.82	13.4%	24,790	16.4%	82,600	10.7%	200	0.9%	4,110	7.1%
SEPTIC	0.23	1.1%	4,120	2.7%	61,740	8.0%	0	0.0%	0	0.0%
POINT SOURCE	0.40	1.9%	11,450	7.6%	39,780	5.2%	190	0.8%	950	1.7%
RAINFALL	8.67	41.1%	38,100	25.2%	208,290	27.1%	1,520	6.7%	37,090	64.5%
TOTAL	21.12		151,100		768,930		22,790		57,510	

SOURCE	RUNOFF (in)	% OF TOTAL	DRY SEASON POLLUTANT LOADING TOTAL P (lb)	% OF TOTAL	TOTAL N (lb)	% OF TOTAL	LEAD (lb)	% OF TOTAL	ZINC (lb)	% OF TOTAL
SURFACE	5.58	42.5%	45,050	44.4%	233,420	44.6%	12,970	90.8%	9,520	26.7%
BASEFLOW	1.03	7.8%	9,030	8.9%	30,090	5.7%	50	0.4%	1,510	4.2%
SEPTIC	0.47	3.6%	4,130	4.1%	61,820	11.8%	0	0.0%	0	0.0%
POINT SOURCE	0.69	5.3%	19,660	19.4%	69,440	13.3%	310	2.2%	1,570	4.4%
RAINFALL	5.37	40.9%	23,630	23.3%	129,170	24.7%	950	6.7%	23,000	64.6%
TOTAL	13.14		101,500		523,940		14,280		35,600	

Note: Loading totals do not include pollutant settling in tidal tributaries. See text for discussion of settling in tributaries.

TABLE 5-7

WET SEASON AND DRY SEASON LOADINGS BY JURISDICTION
FOR EXISTING LAND USE CONDITIONS

JURISDICTION	AREA (ac)	RUNOFF (in)	% OF TOTAL	WET SEASON POLLUTANT LOADING Total P (lb)	% OF TOTAL	Total N (lb)	% OF TOTAL	LEAD (lb)	% OF TOTAL	ZINC (lb)	% OF TOTAL
SARASOTA CO.	62,301	7.39	35.0%	66,080	43.7%	340,160	44.2%	9,070	39.8%	10,600	18.4%
SARASOTA CITY	7,844	1.32	6.3%	13,790	9.1%	62,460	8.1%	3,760	16.5%	3,030	5.3%
MANATEE CO.	20,226	2.90	13.7%	24,850	16.4%	121,860	15.8%	7,330	32.2%	5,530	9.6%
ISLANDS	5,761	0.85	4.0%	8,280	5.5%	36,160	4.7%	1,110	4.9%	1,260	2.2%
BAY SURFACE	33,280	8.67	41.0%	38,100	25.2%	208,290	27.1%	1,520	6.7%	37,090	64.5%
TOTAL	129,412	21.12		151,100		768,930		22,790		57,510	

JURISDICTION	AREA (ac)	RUNOFF (in)	% OF TOTAL	DRY SEASON POLLUTANT LOADING Total P (lb)	% OF TOTAL	Total N (lb)	% OF TOTAL	LEAD (lb)	% OF TOTAL	ZINC (lb)	% OF TOTAL
SARASOTA CO.	62,301	4.55	34.6%	42,760	42.1%	235,840	45.0%	5,660	39.6%	6,190	17.4%
SARASOTA CITY	7,844	0.88	6.7%	11,360	11.2%	47,440	9.1%	2,390	16.7%	2,140	6.0%
MANATEE CO.	20,226	1.77	13.4%	16,410	16.2%	82,490	15.7%	4,550	31.9%	3,290	9.2%
ISLANDS	5,761	0.57	4.3%	7,340	7.2%	29,000	5.5%	730	5.1%	980	2.8%
BAY SURFACE	33,280	5.37	40.9%	23,630	23.3%	129,170	24.7%	950	6.7%	23,000	64.6%
TOTAL	129,412	13.14		101,500		523,940		14,280		35,600	

Note: Loading totals do not include pollutant settling in tidal tributaries. See text for discussion of settling in tributaries.

Consequently, the percentage of the total loading due to point sources is substantially higher during the dry season, and lower during the wet season. Even during the dry season, however, the point source loadings for total P, total N and zinc are less than the loadings due to surface runoff or rainfall.

A comparison between Tables 5-3 and 5-7 reveals that there is little difference in the distribution of runoff and loadings between the various jurisdictions during the wet season, dry season and average year. In almost all cases, the change in the distribution values were less than one percentage point. The values for the wet season tended to be more similar to the average annual values than were the dry season values.

The values in Tables 5-4 through 5-7 do not include the effects of pollutant settling in the tidal tributaries. As discussed in Section 5.1, the application of the delivery ratios determined for the tributaries did not produce substantial changes in total loadings or the distribution of loadings between sources or jurisdictions.

5.3 WET YEAR AND DRY YEAR RESULTS

Analyses were also conducted to evaluate loadings during a wet year and a dry year. As discussed in Section 3.2, the 10th percentile and 90th percentile value for annual precipitation and annual streamflow were used to represent the wet and dry years. Results were used to determine the changes in total loadings to the Bay, and to assess changes in load distribution by source and by jurisdiction.

Tables 5-8 through 5-11 present the results of the wet and dry year loading analyses. Loadings by watershed for the wet year and the dry year are listed in Tables 5-8 and 5-9, respectively. Table 5-10 includes loading values by pollutant source for both the wet and the dry year. Loading values by jurisdiction for both wet and dry years are shown in Table 5-11.

TABLE 5-8

WET YEAR LOADINGS BY WATERSHED
FOR EXISTING LAND USE CONDITIONS

WATERSHED	AREA	TOTAL RUNOFF	TOTAL P			TOTAL N			LEAD			ZINC		
	(ac)	(in)	(lb)	(lb/ac)	(mg/l)	(lb)	(lb/ac)	(mg/l)	(lb)	(lb/ac)	(mg/l)	(lb)	(lb/ac)	(mg/l)
PHILLIPPI CREEK	36,417	34.86	95,410	2.62	0.33	476,100	13.07	1.65	11,650	0.32	0.040	14,340	0.39	0.050
PALMA SOLA 2	1,120	34.98	2,490	2.22	0.28	11,960	10.68	1.35	560	0.50	0.063	490	0.44	0.055
BOWLEES CREEK	6,489	44.90	15,370	2.37	0.23	86,300	13.30	1.31	9,400	1.45	0.142	5,780	0.89	0.088
WEST BRADENTON	4,395	39.83	10,660	2.43	0.27	50,380	11.46	1.27	2,190	0.50	0.055	2,070	0.47	0.052
CEDAR HAMMOCK	1,930	43.45	5,600	2.90	0.29	27,870	14.44	1.47	1,700	0.88	0.089	1,320	0.68	0.069
WEST BOWLEES	1,559	38.37	4,190	2.69	0.31	20,170	12.94	1.49	980	0.63	0.072	850	0.55	0.063
PALMA SOLA	900	33.05	2,480	2.76	0.37	10,580	11.76	1.57	370	0.41	0.055	350	0.39	0.052
SOUTH BRADENTON	4,635	37.46	16,330	3.52	0.41	70,550	15.22	1.79	1,000	0.22	0.025	1,690	0.36	0.043
WHITAKER BAYOU	5,015	51.52	23,740	4.73	0.41	106,190	21.18	1.81	4,750	0.95	0.081	4,530	0.90	0.077
MATHENY CREEK	3,800	46.57	14,230	3.74	0.35	69,880	18.39	1.74	3,000	0.79	0.075	2,840	0.75	0.071
CATFISH CREEK	3,360	31.34	5,550	1.65	0.23	26,470	7.88	1.11	380	0.11	0.016	870	0.26	0.036
NORTH CREEK	1,920	29.87	3,210	1.67	0.25	15,460	8.05	1.19	290	0.15	0.022	530	0.28	0.041
SOUTH CREEK	12,995	27.85	18,550	1.43	0.23	82,220	6.33	1.00	770	0.06	0.009	2,560	0.20	0.031
HUDSON BAYOU	1,595	43.68	4,170	2.61	0.26	22,020	13.81	1.39	1,880	1.18	0.119	1,250	0.78	0.079
SIESTA KEY	1,385	56.49	9,470	6.84	0.53	34,850	25.16	1.97	720	0.52	0.041	1,200	0.87	0.068
ANNA MARIA	919	38.71	2,410	2.62	0.30	11,600	12.62	1.44	580	0.63	0.072	490	0.53	0.061
PERICO	860	46.02	1,620	1.88	0.18	6,990	8.13	0.78	110	0.13	0.012	180	0.21	0.020
LONGBOAT KEY	1,697	33.25	3,840	2.26	0.30	17,800	10.49	1.39	550	0.32	0.043	630	0.37	0.049
OTHER ISLANDS	900	38.53	2,260	2.51	0.29	11,090	12.32	1.41	400	0.44	0.051	400	0.44	0.051
DIRECT TO BAY	4,241	42.75	11,780	2.78	0.29	65,070	15.34	1.58	2,990	0.71	0.073	2,510	0.59	0.061
BAY SURFACE	33,280	69.70	78,800	2.37	0.15	430,790	12.94	0.82	3,150	0.09	0.006	76,700	2.30	0.146
TOTAL	129,412	45.57	332,160	2.79	0.30	1,654,340	13.12	1.41	47,420	0.52	0.055	121,580	0.60	0.060

Note: Loading totals do not include pollutant settling in tidal tributaries. See text for discussion of settling in tributaries.

TABLE 5-9

DRY YEAR LOADINGS BY WATERSHED
FOR EXISTING LAND USE CONDITIONS

WATERSHED	AREA	TOTAL RUNOFF	TOTAL P			TOTAL N			LEAD			ZINC		
	(ac)	(in)	(lb)	(lb/ac)	(mg/l)	(lb)	(lb/ac)	(mg/l)	(lb)	(lb/ac)	(mg/l)	(lb)	(lb/ac)	(mg/l)
PHILLIPPI CREEK	36,417	16.79	49,050	1.35	0.35	286,180	7.86	2.07	6,880	0.19	0.050	6,650	0.18	0.048
PALMA SOLA 2	1,120	16.49	1,150	1.03	0.27	6,030	5.38	1.44	330	0.29	0.079	230	0.21	0.055
BOWLEES CREEK	6,489	23.81	7,840	1.21	0.22	47,130	7.26	1.35	5,610	0.86	0.160	3,230	0.50	0.092
WEST BRADENTON	4,395	19.43	5,040	1.15	0.26	25,760	5.86	1.33	1,290	0.29	0.067	1,020	0.23	0.053
CEDAR HAMMOCK	1,930	22.72	2,910	1.51	0.29	15,260	7.91	1.54	1,010	0.52	0.102	720	0.37	0.072
WEST BOWLEES	1,559	18.98	2,090	1.34	0.31	10,650	6.83	1.59	580	0.37	0.087	440	0.28	0.066
PALMA SOLA	900	15.06	1,180	1.31	0.38	5,380	5.98	1.75	220	0.24	0.072	160	0.18	0.052
SOUTH BRADENTON	4,635	19.43	9,960	2.15	0.49	45,940	9.91	2.25	590	0.13	0.029	770	0.17	0.038
WHITAKER BAYOU	5,015	31.31	17,480	3.49	0.49	76,520	15.26	2.15	2,900	0.58	0.082	2,900	0.58	0.082
MATHENY CREEK	3,800	26.71	9,660	2.54	0.42	48,820	12.85	2.12	1,820	0.48	0.079	1,700	0.45	0.074
CATFISH CREEK	3,360	13.25	2,090	0.62	0.21	12,410	3.69	1.23	210	0.06	0.021	310	0.09	0.031
NORTH CREEK	1,920	12.42	1,230	0.64	0.23	7,390	3.85	1.37	160	0.08	0.030	200	0.10	0.037
SOUTH CREEK	12,995	10.77	5,920	0.46	0.19	32,170	2.48	1.01	410	0.03	0.013	660	0.05	0.021
HUDSON BAYOU	1,595	22.95	2,160	1.35	0.26	12,010	7.53	1.45	1,120	0.70	0.135	680	0.43	0.082
SIESTA KEY	1,385	36.74	7,500	5.42	0.65	26,230	18.94	2.27	470	0.34	0.041	870	0.63	0.075
ANNA MARIA	919	19.27	1,180	1.28	0.29	6,130	6.67	1.53	350	0.38	0.087	250	0.27	0.062
PERICO	860	21.83	630	0.73	0.15	3,080	3.58	0.72	60	0.07	0.014	50	0.06	0.012
LONGBOAT KEY	1,697	15.18	1,750	1.03	0.30	8,850	5.22	1.52	320	0.19	0.055	280	0.16	0.048
OTHER ISLANDS	900	18.68	1,100	1.22	0.29	6,000	6.67	1.57	240	0.27	0.063	200	0.22	0.052
DIRECT TO BAY	4,241	22.35	6,280	1.48	0.29	39,640	9.35	1.85	1,780	0.42	0.083	1,320	0.31	0.061
BAY SURFACE	33,280	41.70	47,150	1.42	0.15	257,730	7.74	0.82	1,890	0.06	0.006	45,890	1.38	0.146
TOTAL	129,412	24.44	183,350	1.56	0.31	979,310	7.66	1.57	28,240	0.31	0.064	68,530	0.33	0.060

TABLE 5-10

WET YEAR AND DRY YEAR LOADINGS BY SOURCE
FOR EXISTING LAND USE CONDITIONS

SOURCE	RUNOFF (in)	% OF TOTAL	WET YEAR POLLUTANT LOADING TOTAL P (lb)	% OF TOTAL	TOTAL N (lb)	% OF TOTAL	LEAD (lb)	% OF TOTAL	ZINC (lb)	% OF TOTAL
SURFACE	18.62	40.9%	150,380	45.3%	778,600	47.1%	43,140	91.0%	31,750	26.1%
BASEFLOW	7.23	15.9%	63,640	19.2%	212,200	12.8%	640	1.3%	10,620	8.7%
SEPTIC	0.70	1.5%	8,230	2.5%	123,520	7.5%	0	0.0%	0	0.0%
POINT SOURCE	1.10	2.4%	31,110	9.4%	109,230	6.6%	490	1.0%	2,510	2.1%
RAINFALL	17.92	39.3%	78,800	23.7%	430,790	26.0%	3,150	6.6%	76,700	63.1%
TOTAL	45.57		332,160		1,654,340		47,420		121,580	

SOURCE	RUNOFF (in)	% OF TOTAL	DRY YEAR POLLUTANT LOADING TOTAL P (lb)	% OF TOTAL	TOTAL N (lb)	% OF TOTAL	LEAD (lb)	% OF TOTAL	ZINC (lb)	% OF TOTAL
SURFACE	11.14	45.6%	89,990	49.1%	465,910	47.6%	25,820	91.4%	18,980	27.7%
BASEFLOW	0.78	3.2%	6,870	3.7%	22,920	2.3%	40	0.1%	1,150	1.7%
SEPTIC	0.70	2.9%	8,230	4.5%	123,520	12.6%	0	0.0%	0	0.0%
POINT SOURCE	1.10	4.5%	31,110	17.0%	109,230	11.2%	490	1.7%	2,510	3.7%
RAINFALL	10.72	43.9%	47,150	25.7%	257,730	26.3%	1,890	6.7%	45,890	67.0%
TOTAL	24.44		183,350		979,310		28,240		68,530	

Note: Loading totals do not include pollutant settling in tidal tributaries. See text for discussion of settling in tributaries.

TABLE 5-11

WET YEAR AND DRY YEAR LOADINGS BY JURISDICTION
FOR EXISTING LAND USE CONDITIONS

JURISDICTION	AREA (ac)	RUNOFF (in)	% OF TOTAL	WET YEAR POLLUTANT LOADING Total P (lb)	% OF TOTAL	Total N (lb)	% OF TOTAL	LEAD (lb)	% OF TOTAL	ZINC (lb)	% OF TOTAL
SARASOTA CO.	62,301	16.59	36.4%	148,220	44.6%	739,160	44.7%	18,890	39.8%	23,570	19.4%
SARASOTA CITY	7,844	2.86	6.3%	30,440	9.2%	135,280	8.2%	7,840	16.5%	6,540	5.4%
MANATEE CO.	20,226	6.31	13.9%	55,100	16.6%	266,780	16.1%	15,180	32.0%	11,870	9.8%
ISLANDS	5,761	1.89	4.1%	19,600	5.9%	82,330	5.0%	2,360	5.0%	2,900	2.4%
BAY SURFACE	33,280	17.92	39.3%	78,800	23.7%	430,790	26.0%	3,150	6.6%	76,700	63.1%
TOTAL	129,412	45.57		332,160		1,654,340		47,420		121,580	

JURISDICTION	AREA (ac)	RUNOFF (in)	% OF TOTAL	DRY YEAR POLLUTANT LOADING Total P (lb)	% OF TOTAL	Total N (lb)	% OF TOTAL	LEAD (lb)	% OF TOTAL	ZINC (lb)	% OF TOTAL
SARASOTA CO.	62,301	7.86	32.1%	74,270	40.5%	433,080	44.2%	11,140	39.4%	10,810	15.8%
SARASOTA CITY	7,844	1.63	6.7%	20,630	11.3%	88,060	9.0%	4,750	16.8%	3,980	5.8%
MANATEE CO.	20,226	3.22	13.2%	29,140	15.9%	150,150	15.3%	9,020	31.9%	6,200	9.0%
ISLANDS	5,761	1.00	4.1%	12,160	6.6%	50,290	5.1%	1,440	5.1%	1,650	2.4%
BAY SURFACE	33,280	10.72	43.9%	47,150	25.7%	257,730	26.3%	1,890	6.7%	45,890	67.0%
TOTAL	129,412	24.44		183,350		979,310		28,240		68,530	

Note: Loading totals do not include pollutant settling in tidal tributaries. See text for discussion of settling in tributaries.

Based on a comparison with the average year loadings, the values in Tables 5-8 and 5-9 show that loadings for all pollutants will be 28 to 31 percent higher during the wet year, and 24 to 27 percent lower during the dry year. These values correspond closely to the differences in rainfall and runoff values between the wet year, dry year, and average year. During the wet year, rainfall was calculated to be 28 percent higher than average, and the runoff total shown in Table 5-8 is 31 percent higher than the average year. For the dry year, rainfall was calculated to be 24 percent lower than average, and the runoff total shown in Table 5-9 is 29 percent lower than the average year. The results presented in Table 5-10 indicate that the wet year and dry year load distributions by source are very similar to the average year distribution. The largest change occurs for point source discharges, because the total loading is assumed to be the same regardless of the annual precipitation volume. Thus, the percentage of loadings due to point sources are noticeably higher during the dry year and lower during the wet year. Even during the dry year, however, the point source loadings for total P, total N and zinc are less than the loadings due to surface runoff and rainfall.

A comparison between Tables 5-3 and 5-11 reveals that there is little difference in the distribution of runoff and loadings among the wet, dry and average years. For virtually all jurisdictions and pollutants, the change in the distribution values were less than one percentage point. Values for the wet year tended to be more similar to the average year than were the dry year values.

The values in Tables 5-8 though 5-11 do not include the effects of pollutant settling in the tidal tributaries. As discussed in Section 5.1, the application of the delivery ratios determined for the tributaries did not produce substantial changes in total loadings or the distribution of loadings between sources or jurisdictions.

5.4 SUMMARY

The results from the analysis of existing loads indicates that, as one would expect, the largest runoff volumes and pollutant loadings are generated within the largest watersheds. However, small but highly urbanized watersheds can also contribute substantial loads from surface water runoff and point sources. Overall, surface runoff and rainfall account for the majority of the pollutant loading, to the Bay. Point sources and septic tanks combined account for 16 to 18 percent of the total nutrient loadings and 1 to 3 percent of the metals loadings, and baseflow provides an even lower percentage of the total loading.

Analyses of wet and dry seasons, and wet and dry years, revealed that the distribution of loadings between jurisdictions and between sources of pollution remain relatively similar to the average year distributions. Point source loadings tend to be more prominent during dry periods, but are still lower than surface runoff and rainfall loadings.

6.0 POLLUTION LOADING PROJECTIONS FOR FUTURE LAND USE CONDITIONS

Preliminary loading estimates were also developed for two future land use scenarios. The scenarios included the five-year future and the buildout future land uses. The methods used to develop these land use scenarios were presented in Section 2.4 of this report.

The results of the future land use analyses are presented in this section. Similar to the existing land use analysis, results are presented for average annual, wet and dry season, and wet and dry year rainfall conditions. Tables are presented which quantify loadings by watershed, by source and by jurisdiction. The values are compared to the existing land use results to identify local and Bay-wide changes.

6.1 FIVE-YEAR FUTURE LAND USE

Tables 6-1 through 6-11 present the loading results for the five-year future land use analysis. The results for the average annual rainfall condition are shown in Tables 6-1 through 6-3. Wet season and dry season results are listed in Tables 6-4 through 6-7, and wet year and dry year results are presented in Tables 6-8 through 6-11.

Table 6-1 shows the average annual loadings by watershed. A comparison of Tables 5-1 (existing land use conditions) and 6-1 reveals a small decrease in overall total P loadings, and a small increase in total N and metals loadings. The projected shift in point sources from surface water discharge to land application accounts for reductions in pollutants, particularly nutrients, in point source loadings. This reduction is offset by an increase in surface runoff loadings due to new development. Phillippi Creek and Whitaker Bayou are still the major contributors of all four pollutants, and Bowlees Creek is a major contributor of metals loadings.

TABLE 6-1

AVERAGE ANNUAL LOADINGS BY WATERSHED
FOR FIVE - YEAR FUTURE LAND USE CONDITIONS

WATERSHED	AREA	TOTAL RUNOFF	TOTAL P			TOTAL N			LEAD			ZINC		
	(ac)	(in)	(lb)	(lb/ac)	(mg/l)	(lb)	(lb/ac)	(mg/l)	(lb)	(lb/ac)	(mg/l)	(lb)	(lb/ac)	(mg/l)
PHILLIPPI CREEK	36,417	25.45	71,360	1.96	0.34	378,670	10.40	1.80	9,420	0.26	0.045	10,460	0.29	0.050
PALMA SOLA 2	1,120	25.12	1,780	1.59	0.28	8,790	7.85	1.38	430	0.38	0.067	350	0.31	0.055
BOWLEES CREEK	6,489	33.61	11,350	1.75	0.23	65,280	10.06	1.32	7,350	1.13	0.149	4,410	0.68	0.089
WEST BRADENTON	4,395	28.94	7,680	1.75	0.27	37,240	8.47	1.29	1,700	0.39	0.059	1,510	0.34	0.052
CEDAR HAMMOCK	1,930	32.35	4,170	2.16	0.29	21,080	10.92	1.49	1,320	0.68	0.093	990	0.51	0.070
WEST BOWLEES	1,559	28.01	3,080	1.98	0.31	15,050	9.65	1.52	760	0.49	0.077	630	0.40	0.064
PALMA SOLA	900	23.47	1,810	2.01	0.38	7,800	8.67	1.63	280	0.31	0.058	250	0.28	0.052
SOUTH BRADENTON	4,635	29.55	14,230	3.07	0.46	63,940	13.80	2.06	800	0.17	0.026	1,230	0.27	0.040
WHITAKER BAYOU	5,015	35.76	14,800	2.95	0.36	73,410	14.64	1.81	3,640	0.73	0.090	3,100	0.62	0.076
MATHENY CREEK	3,800	37.25	12,110	3.19	0.38	60,620	15.95	1.89	2,660	0.70	0.083	2,390	0.63	0.074
CATFISH CREEK	3,360	25.42	4,920	1.46	0.25	25,250	7.51	1.30	790	0.24	0.041	920	0.27	0.048
NORTH CREEK	1,920	20.60	2,160	1.13	0.24	11,180	5.82	1.25	230	0.12	0.026	350	0.18	0.039
SOUTH CREEK	12,995	18.79	11,870	0.91	0.21	55,670	4.28	1.01	580	0.04	0.010	1,560	0.12	0.028
HUDSON BAYOU	1,595	32.58	3,090	1.94	0.26	16,650	10.44	1.41	1,460	0.92	0.124	940	0.59	0.080
SIESTA KEY	1,385	45.94	8,410	6.07	0.58	30,240	21.83	2.10	580	0.42	0.040	1,030	0.74	0.071
ANNA MARIA	919	28.32	1,740	1.89	0.29	8,660	9.42	1.47	450	0.49	0.076	360	0.39	0.061
PERICO	860	33.12	1,090	1.27	0.17	4,900	5.70	0.76	80	0.09	0.012	110	0.13	0.017
LONGBOAT KEY	1,697	23.62	2,730	1.61	0.30	13,000	7.66	1.43	440	0.26	0.048	450	0.27	0.050
OTHER ISLANDS	900	27.94	1,640	1.82	0.29	8,360	9.29	1.47	310	0.34	0.054	290	0.32	0.051
DIRECT TO BAY	4,241	31.85	8,850	2.09	0.29	51,430	12.13	1.68	2,340	0.55	0.076	1,880	0.44	0.061
BAY SURFACE	33,280	54.60	61,730	1.85	0.15	337,460	10.14	0.82	2,470	0.07	0.006	60,080	1.81	0.146
TOTAL	129,412	34.32	250,600	2.12	0.30	1,294,680	10.22	1.47	38,090	0.42	0.060	93,290	0.46	0.061

Note: Loading totals do not include pollutant settling in tidal tributaries. See text for discussion of settling in tributaries.

TABLE 6-2

AVERAGE ANNUAL LOADINGS BY SOURCE
FOR FIVE - YEAR FUTURE LAND USE CONDITIONS

SOURCE	RUNOFF (in)	% OF TOTAL	AVERAGE YEAR POLLUTANT LOADING							
			TOTAL P (lb)	% OF TOTAL	TOTAL N (lb)	% OF TOTAL	LEAD (lb)	% OF TOTAL	ZINC (lb)	% OF TOTAL
SURFACE	14.81	43.1%	120,300	48.0%	622,830	48.1%	34,930	91.7%	25,660	27.5%
BASEFLOW	3.81	11.1%	33,490	13.4%	111,660	8.6%	300	0.8%	5,570	6.0%
SEPTIC	0.70	2.0%	8,260	3.3%	123,890	9.6%	0	0.0%	0	0.0%
POINT SOURCE	0.96	2.8%	26,820	10.7%	98,840	7.6%	390	1.0%	1,980	2.1%
RAINFALL	14.04	40.9%	61,730	24.6%	337,460	26.1%	2,470	6.5%	60,080	64.4%
TOTAL	34.32		250,600		1,294,680		38,090		93,290	

Note: Loading totals do not include pollutant settling in tidal tributaries. See text for discussion of settling in tributaries.

TABLE 6-3

AVERAGE ANNUAL LOADINGS BY JURISDICTION
FOR FIVE - YEAR FUTURE LAND USE CONDITIONS

JURISDICTION	AREA (ac)	RUNOFF (in)	% OF TOTAL	AVERAGE YEAR POLLUTANT LOADING							
				Total P (lb)	% OF TOTAL	Total N (lb)	% OF TOTAL	LEAD (lb)	% OF TOTAL	ZINC (lb)	% OF TOTAL
SARASOTA CO.	62,301	12.13	35.3%	111,080	44.3%	588,130	45.4%	15,860	41.6%	17,510	18.8%
SARASOTA CITY	7,844	2.01	5.9%	19,630	7.8%	93,060	7.2%	6,060	15.9%	4,610	4.9%
MANATEE CO.	20,226	4.72	13.8%	42,550	17.0%	210,870	16.3%	11,840	31.1%	8,850	9.5%
ISLANDS	5,761	1.42	4.1%	15,610	6.2%	65,160	5.0%	1,860	4.9%	2,240	2.4%
BAY SURFACE	33,280	14.04	40.9%	61,730	24.6%	337,460	26.1%	2,470	6.5%	60,080	64.4%
TOTAL	129,412	34.32		250,600		1,294,680		38,090		93,290	

Note: Loading totals do not include pollutant settling in tidal tributaries. See text for discussion of settling in tributaries.

TABLE 6-4

WET SEASON LOADINGS BY WATERSHED
FOR FIVE-YEAR LAND USE CONDITIONS

WATERSHED	AREA	TOTAL RUNOFF	TOTAL P			TOTAL N			LEAD			ZINC		
	(ac)	(in)	(lb)	(lb/ac)	(mg/l)	(lb)	(lb/ac)	(mg/l)	(lb)	(lb/ac)	(mg/l)	(lb)	(lb/ac)	(mg/l)
PHILLIPPI CREEK	36,417	15.66	43,450	1.19	0.34	223,160	6.13	1.73	5,810	0.16	0.045	6,610	0.18	0.051
PALMA SOLA 2	1,120	16.06	1,140	1.02	0.28	5,570	4.97	1.37	270	0.24	0.066	220	0.20	0.054
BOWLEES CREEK	6,489	21.12	7,150	1.10	0.23	40,860	6.30	1.32	4,540	0.70	0.146	2,740	0.42	0.088
WEST BRADENTON	4,395	18.41	4,900	1.11	0.27	23,520	5.35	1.28	1,060	0.24	0.058	950	0.22	0.052
CEDAR HAMMOCK	1,930	20.38	2,620	1.36	0.29	13,210	6.84	1.48	820	0.42	0.092	630	0.33	0.071
WEST BOWLEES	1,559	17.79	1,950	1.25	0.31	9,480	6.08	1.51	470	0.30	0.075	390	0.25	0.062
PALMA SOLA	900	15.08	1,140	1.27	0.37	4,940	5.49	1.61	180	0.20	0.059	160	0.18	0.052
SOUTH BRADENTON	4,635	16.74	7,320	1.58	0.42	31,740	6.85	1.81	480	0.10	0.027	760	0.16	0.043
WHITAKER BAYOU	5,015	21.48	8,420	1.68	0.34	42,090	8.39	1.72	2,230	0.44	0.091	1,860	0.37	0.076
MATHENY CREEK	3,800	21.40	6,150	1.62	0.33	32,130	8.46	1.74	1,620	0.43	0.088	1,370	0.36	0.074
CATFISH CREEK	3,360	16.18	3,150	0.94	0.26	15,790	4.70	1.28	490	0.15	0.040	590	0.18	0.048
NORTH CREEK	1,920	13.26	1,420	0.74	0.25	7,040	3.67	1.22	140	0.07	0.024	240	0.13	0.042
SOUTH CREEK	12,995	12.32	7,980	0.61	0.22	36,440	2.80	1.00	360	0.03	0.010	1,070	0.08	0.029
HUDSON BAYOU	1,595	20.51	1,940	1.22	0.26	10,420	6.53	1.41	900	0.56	0.121	590	0.37	0.080
SIESTA KEY	1,385	23.89	3,680	2.66	0.49	14,120	10.19	1.88	330	0.24	0.044	490	0.35	0.065
ANNA MARIA	919	17.97	1,120	1.22	0.30	5,450	5.93	1.46	280	0.30	0.075	230	0.25	0.061
PERICO	860	21.16	700	0.81	0.17	3,170	3.69	0.77	50	0.06	0.012	70	0.08	0.017
LONGBOAT KEY	1,697	15.17	1,750	1.03	0.30	8,270	4.87	1.42	260	0.15	0.045	280	0.16	0.048
OTHER ISLANDS	900	17.71	1,030	1.14	0.29	5,150	5.72	1.43	190	0.21	0.053	190	0.21	0.053
DIRECT TO BAY	4,241	19.61	5,450	1.29	0.29	30,790	7.26	1.63	1,450	0.34	0.077	1,190	0.28	0.063
BAY SURFACE	33,280	33.70	38,100	1.14	0.15	208,290	6.26	0.82	1,520	0.05	0.006	37,090	1.11	0.146
TOTAL	129,412	21.17	150,560	1.24	0.29	771,630	6.02	1.42	23,450	0.26	0.060	57,720	0.28	0.061

Note: Loading totals do not include pollutant settling in tidal tributaries. See text for discussion of settling in tributaries.

TABLE 6-5

DRY SEASON LOADINGS BY WATERSHED
FOR FIVE-YEAR LAND USE CONDITIONS

WATERSHED	AREA	TOTAL RUNOFF	TOTAL P			TOTAL N			LEAD			ZINC		
	(ac)	(in)	(lb)	(lb/ac)	(mg/l)	(lb)	(lb/ac)	(mg/l)	(lb)	(lb/ac)	(mg/l)	(lb)	(lb/ac)	(mg/l)
PHILLIPPI CREEK	36,417	9.80	27,930	0.77	0.35	155,470	4.27	1.92	3,620	0.10	0.045	3,860	0.11	0.048
PALMA SOLA 2	1,120	9.06	650	0.58	0.28	3,210	2.87	1.40	170	0.15	0.074	130	0.12	0.057
BOWLEES CREEK	6,489	12.48	4,130	0.64	0.23	24,440	3.77	1.33	2,810	0.43	0.153	1,650	0.25	0.090
WEST BRADENTON	4,395	10.52	2,780	0.63	0.27	13,690	3.11	1.31	650	0.15	0.062	550	0.13	0.052
CEDAR HAMMOCK	1,930	11.97	1,530	0.79	0.29	7,890	4.09	1.51	510	0.26	0.097	370	0.19	0.071
WEST BOWLEES	1,559	10.22	1,120	0.72	0.31	5,580	3.58	1.54	300	0.19	0.083	230	0.15	0.064
PALMA SOLA	900	8.39	660	0.73	0.39	2,870	3.19	1.68	110	0.12	0.064	90	0.10	0.053
SOUTH BRADENTON	4,635	12.81	6,920	1.49	0.51	32,220	6.95	2.39	310	0.07	0.023	480	0.10	0.036
WHITAKER BAYOU	5,015	14.28	6,380	1.27	0.39	31,260	6.23	1.93	1,400	0.28	0.086	1,240	0.25	0.076
MATHENY CREEK	3,800	15.85	5,960	1.57	0.44	28,480	7.49	2.09	1,040	0.27	0.076	1,020	0.27	0.075
CATFISH CREEK	3,360	9.24	1,760	0.52	0.25	9,460	2.82	1.34	300	0.09	0.043	330	0.10	0.047
NORTH CREEK	1,920	7.34	730	0.38	0.23	4,150	2.16	1.30	80	0.04	0.025	120	0.06	0.038
SOUTH CREEK	12,995	6.46	3,900	0.30	0.20	19,250	1.48	1.01	220	0.02	0.012	480	0.04	0.025
HUDSON BAYOU	1,595	12.07	1,150	0.72	0.26	6,220	3.90	1.43	560	0.35	0.128	360	0.23	0.082
SIESTA KEY	1,385	22.05	4,740	3.42	0.68	16,100	11.62	2.33	250	0.18	0.036	550	0.40	0.079
ANNA MARIA	919	10.35	640	0.70	0.30	3,210	3.49	1.49	170	0.18	0.079	130	0.14	0.060
PERICO	860	11.96	380	0.44	0.16	1,730	2.01	0.74	30	0.03	0.013	40	0.05	0.017
LONGBOAT KEY	1,697	8.45	970	0.57	0.30	4,760	2.80	1.46	160	0.09	0.049	160	0.09	0.049
OTHER ISLANDS	900	10.23	610	0.68	0.29	3,200	3.56	1.53	120	0.13	0.058	100	0.11	0.048
DIRECT TO BAY	4,241	12.24	3,350	0.79	0.28	20,630	4.86	1.75	900	0.21	0.077	700	0.17	0.060
BAY SURFACE	33,280	20.90	23,630	0.71	0.15	129,170	3.88	0.82	950	0.03	0.006	23,000	0.69	0.146
TOTAL	129,412	13.15	99,920	0.88	0.31	522,990	4.20	1.54	14,660	0.16	0.061	35,590	0.18	0.061

Note: Loading totals do not include pollutant settling in tidal tributaries. See text for discussion of settling in tributaries.

TABLE 6-6

WET SEASON AND DRY SEASON LOADINGS BY SOURCE
FOR FIVE - YEAR FUTURE LAND USE CONDITIONS

SOURCE	RUNOFF (in)	% OF TOTAL	WET SEASON POLLUTANT LOADING TOTAL P (lb)	% OF TOTAL	TOTAL N (lb)	% OF TOTAL	LEAD (lb)	% OF TOTAL	ZINC (lb)	% OF TOTAL
SURFACE	9.14	43.2%	74,170	49.3%	384,470	49.8%	21,590	92.1%	15,830	27.4%
BASEFLOW	2.79	13.2%	24,550	16.3%	81,840	10.6%	200	0.9%	4,070	7.1%
SEPTIC	0.23	1.1%	4130	2.7%	61,900	8.0%	0	0.0%	0	0.0%
POINT SOURCE	0.34	1.6%	9,610	6.4%	35,130	4.6%	140	0.6%	730	1.3%
RAINFALL	8.67	40.9%	38,100	25.3%	208,290	27.0%	1,520	6.5%	37,090	64.3%
TOTAL	21.17		150,560		771,630		23,450		57,720	

SOURCE	RUNOFF (in)	% OF TOTAL	DRY SEASON POLLUTANT LOADING TOTAL P (lb)	% OF TOTAL	TOTAL N (lb)	% OF TOTAL	LEAD (lb)	% OF TOTAL	ZINC (lb)	% OF TOTAL
SURFACE	5.67	43.1%	46,000	46.0%	238,330	45.6%	13,410	91.5%	9,820	27.6%
BASEFLOW	1.02	7.7%	8,940	8.9%	29,810	5.7%	50	0.3%	1,510	4.2%
SEPTIC	0.47	3.6%	4,140	4.1%	61,980	11.9%	0	0.0%	0	0.0%
POINT SOURCE	0.62	4.7%	17,210	17.2%	63,700	12.2%	250	1.7%	1,260	3.5%
RAINFALL	5.37	40.9%	23,630	23.6%	129,170	24.7%	950	6.5%	23,000	64.6%
TOTAL	13.15		99,920		522,990		14,660		35,590	

Note: Loading totals do not include pollutant settling in tidal tributaries. See text for discussion of settling in tributaries.

TABLE 6-7

WET SEASON AND DRY SEASON LOADINGS BY JURISDICTION
FOR FIVE - YEAR FUTURE LAND USE CONDITIONS

JURISDICTION	AREA (ac)	RUNOFF (in)	% OF TOTAL	WET SEASON POLLUTANT LOADING Total P (lb)	% OF TOTAL	Total N (lb)	% OF TOTAL	LEAD (lb)	% OF TOTAL	ZINC (lb)	% OF TOTAL
SARASOTA CO.	62,301	7.50	35.4%	67,380	44.8%	347,510	45.0%	9,780	41.7%	11,030	19.1%
SARASOTA CITY	7,844	1.24	5.9%	11,500	7.6%	55,570	7.2%	3,710	15.8%	2,800	4.9%
MANATEE CO.	20,226	2.92	13.8%	25,300	16.8%	124,100	16.1%	7,330	31.3%	5,540	9.6%
ISLANDS	5,761	0.85	4.0%	8,280	5.5%	36,160	4.7%	1,110	4.7%	1,260	2.2%
BAY SURFACE	33,280	8.67	40.9%	38,100	25.3%	208,290	27.0%	1,520	6.5%	37,090	64.3%
TOTAL	129,412	21.17		150,560		771,630		23,450		57,720	

JURISDICTION	AREA (ac)	RUNOFF (in)	% OF TOTAL	DRY SEASON POLLUTANT LOADING Total P (lb)	% OF TOTAL	Total N (lb)	% OF TOTAL	LEAD (lb)	% OF TOTAL	ZINC (lb)	% OF TOTAL
SARASOTA CO.	62,301	4.63	35.2%	43,630	43.7%	240,630	46.0%	6,100	41.6%	6,490	18.2%
SARASOTA CITY	7,844	0.77	5.8%	8,050	8.1%	37,420	7.2%	2,330	15.9%	1,810	5.1%
MANATEE CO.	20,226	1.80	13.7%	17,270	17.3%	86,770	16.6%	4,550	31.0%	3,310	9.3%
ISLANDS	5,761	0.57	4.3%	7,340	7.3%	29,000	5.5%	730	5.0%	980	2.8%
BAY SURFACE	33,280	5.37	40.9%	23,630	23.6%	129,170	24.7%	950	6.5%	23,000	64.6%
TOTAL	129,412	13.15		99,920		522,990		14,660		35,590	

Note: Loading totals do not include pollutant settling in tidal tributaries. See text for discussion of settling in tributaries.

TABLE 6-8

WET YEAR LOADINGS BY WATERSHED
FOR FIVE - YEAR FUTURE LAND USE CONDITIONS

WATERSHED	AREA	TOTAL RUNOFF	TOTAL P			TOTAL N			LEAD			ZINC		
	(ac)	(in)	(lb)	(lb/ac)	(mg/l)	(lb)	(lb/ac)	(mg/l)	(lb)	(lb/ac)	(mg/l)	(lb)	(lb/ac)	(mg/l)
PHILLIPPI CREEK	36,417	35.11	96,170	2.64	0.33	480,850	13.20	1.66	12,090	0.33	0.042	14,610	0.40	0.050
PALMA SOLA 2	1,120	34.98	2,490	2.22	0.28	11,960	10.68	1.35	560	0.50	0.063	490	0.44	0.055
BOWLEES CREEK	6,489	44.90	15,370	2.37	0.23	86,300	13.30	1.31	9,400	1.45	0.142	5,780	0.89	0.088
WEST BRADENTON	4,395	39.83	10,660	2.43	0.27	50,380	11.46	1.27	2,190	0.50	0.055	2,070	0.47	0.052
CEDAR HAMMOCK	1,930	43.45	5,600	2.90	0.29	27,870	14.44	1.47	1,700	0.88	0.089	1,320	0.68	0.069
WEST BOWLEES	1,559	38.37	4,190	2.69	0.31	20,170	12.94	1.49	980	0.63	0.072	850	0.55	0.063
PALMA SOLA	900	33.05	2,480	2.76	0.37	10,580	11.76	1.57	370	0.41	0.055	350	0.39	0.052
SOUTH BRADENTON	4,635	39.15	17,640	3.81	0.43	77,070	16.63	1.87	1,010	0.22	0.025	1,720	0.37	0.042
WHITAKER BAYOU	5,015	46.57	18,140	3.62	0.34	89,280	17.80	1.69	4,640	0.93	0.088	3,970	0.79	0.075
MATHENY CREEK	3,800	48.08	14,600	3.84	0.35	72,320	19.03	1.75	3,370	0.89	0.081	3,040	0.80	0.073
CATFISH CREEK	3,360	35.64	6,990	2.08	0.26	34,110	10.15	1.26	1,020	0.30	0.038	1,290	0.38	0.048
NORTH CREEK	1,920	29.87	3,210	1.67	0.25	15,460	8.05	1.19	290	0.15	0.022	530	0.28	0.041
SOUTH CREEK	12,995	27.85	18,550	1.43	0.23	82,220	6.33	1.00	770	0.06	0.009	2,560	0.20	0.031
HUDSON BAYOU	1,595	43.68	4,170	2.61	0.26	22,020	13.81	1.39	1,880	1.18	0.119	1,250	0.78	0.079
SIESTA KEY	1,385	56.49	9,470	6.84	0.53	34,850	25.16	1.97	720	0.52	0.041	1,200	0.87	0.068
ANNA MARIA	919	38.71	2,410	2.62	0.30	11,600	12.62	1.44	580	0.63	0.072	490	0.53	0.061
PERICO	860	46.02	1,620	1.88	0.18	6,990	8.13	0.78	110	0.13	0.012	180	0.21	0.020
LONGBOAT KEY	1,697	33.25	3,840	2.26	0.30	17,800	10.49	1.39	550	0.32	0.043	630	0.37	0.049
OTHER ISLANDS	900	38.53	2,260	2.51	0.29	11,090	12.32	1.41	400	0.44	0.051	400	0.44	0.051
DIRECT TO BAY	4,241	42.75	11,780	2.78	0.29	65,070	15.34	1.58	2,990	0.71	0.073	2,510	0.59	0.061
BAY SURFACE	33,280	69.70	78,800	2.37	0.15	430,790	12.94	0.82	3,150	0.09	0.006	76,700	2.30	0.146
TOTAL	129,412	45.66	330,440	2.78	0.30	1,658,780	13.17	1.41	48,770	0.54	0.057	121,940	0.61	0.061

Note: Loading totals do not include pollutant settling in tidal tributaries. See text for discussion of settling in tributaries.

TABLE 6-9

DRY YEAR LOADINGS BY WATERSHED
FOR FIVE - YEAR FUTURE LAND USE CONDITIONS

WATERSHED	AREA	TOTAL RUNOFF	TOTAL P			TOTAL N			LEAD			ZINC		
	(ac)	(in)	(lb)	(lb/ac)	(mg/l)	(lb)	(lb/ac)	(mg/l)	(lb)	(lb/ac)	(mg/l)	(lb)	(lb/ac)	(mg/l)
PHILLIPPI CREEK	36,417	16.98	49,590	1.36	0.35	289,440	7.95	2.07	7,140	0.20	0.051	6,830	0.19	0.049
PALMA SOLA 2	1,120	16.49	1,150	1.03	0.27	6,030	5.38	1.44	330	0.29	0.079	230	0.21	0.055
BOWLEES CREEK	6,489	23.81	7,840	1.21	0.22	47,130	7.26	1.35	5,610	0.86	0.160	3,230	0.50	0.092
WEST BRADENTON	4,395	19.43	5,040	1.15	0.26	25,760	5.86	1.33	1,290	0.29	0.067	1,020	0.23	0.053
CEDAR HAMMOCK	1,930	22.72	2,910	1.51	0.29	15,260	7.91	1.54	1,010	0.52	0.102	720	0.37	0.072
WEST BOWLEES	1,559	18.98	2,090	1.34	0.31	10,650	6.83	1.59	580	0.37	0.087	440	0.28	0.066
PALMA SOLA	900	15.06	1,180	1.31	0.38	5,380	5.98	1.75	220	0.24	0.072	160	0.18	0.052
SOUTH BRADENTON	4,635	21.11	11,270	2.43	0.51	52,460	11.32	2.37	600	0.13	0.027	800	0.17	0.036
WHITAKER BAYOU	5,015	26.35	11,880	2.37	0.40	59,610	11.89	1.99	2,790	0.56	0.093	2,340	0.47	0.078
MATHENY CREEK	3,800	27.83	9,940	2.62	0.41	50,440	13.27	2.10	2,040	0.54	0.085	1,830	0.48	0.076
CATFISH CREEK	3,360	16.45	3,100	0.92	0.25	17,490	5.21	1.40	600	0.18	0.048	580	0.17	0.046
NORTH CREEK	1,920	12.42	1,230	0.64	0.23	7,390	3.85	1.37	160	0.08	0.030	200	0.10	0.037
SOUTH CREEK	12,995	10.77	5,920	0.46	0.19	32,170	2.48	1.01	410	0.03	0.013	660	0.05	0.021
HUDSON BAYOU	1,595	22.95	2,160	1.35	0.26	12,010	7.53	1.45	1,120	0.70	0.135	680	0.43	0.082
SIESTA KEY	1,385	36.74	7,500	5.42	0.65	26,230	18.94	2.27	470	0.34	0.041	870	0.63	0.075
ANNA MARIA	919	19.27	1,180	1.28	0.29	6,130	6.67	1.53	350	0.38	0.087	250	0.27	0.062
PERICO	860	21.83	630	0.73	0.15	3,080	3.58	0.72	60	0.07	0.014	50	0.06	0.012
LONGBOAT KEY	1,697	15.18	1,750	1.03	0.30	8,850	5.22	1.52	320	0.19	0.055	280	0.16	0.048
OTHER ISLANDS	900	18.68	1,100	1.22	0.29	6,000	6.67	1.57	240	0.27	0.063	200	0.22	0.052
DIRECT TO BAY	4,241	22.35	6,280	1.48	0.29	39,640	9.35	1.85	1,780	0.42	0.083	1,320	0.31	0.061
BAY SURFACE	33,280	41.70	47,150	1.42	0.15	257,730	7.74	0.82	1,890	0.06	0.006	45,890	1.38	0.146
TOTAL	129,412	24.48	180,890	1.54	0.31	978,880	7.66	1.57	29,010	0.32	0.066	68,580	0.33	0.061

Note: Loading totals do not include pollutant settling in tidal tributaries. See text for discussion of settling in tributaries.

TABLE 6-10

WET YEAR AND DRY YEAR LOADINGS BY SOURCE
FOR FIVE - YEAR FUTURE LAND USE CONDITIONS

SOURCE	RUNOFF (in)	% OF TOTAL	WET YEAR POLLUTANT LOADING TOTAL P (lb)	% OF TOTAL	TOTAL N (lb)	% OF TOTAL	LEAD (lb)	% OF TOTAL	ZINC (lb)	% OF TOTAL
SURFACE	18.91	41.4%	153,500	46.5%	795,000	47.9%	44,600	91.4%	32,740	26.8%
BASEFLOW	7.17	15.7%	63,060	19.1%	210,260	12.7%	630	1.3%	10,520	8.6%
SEPTIC	0.70	1.5%	8,260	2.5%	123,890	7.5%	0	0.0%	0	0.0%
POINT SOURCE	0.96	2.1%	26,820	8.1%	98,840	6.0%	390	0.8%	1,980	1.6%
RAINFALL	17.92	39.3%	78,800	23.8%	430,790	26.0%	3,150	6.5%	76,700	62.9%
TOTAL	45.66		330,440		1,658,780		48,770		121,940	

SOURCE	RUNOFF (in)	% OF TOTAL	DRY YEAR POLLUTANT LOADING TOTAL P (lb)	% OF TOTAL	TOTAL N (lb)	% OF TOTAL	LEAD (lb)	% OF TOTAL	ZINC (lb)	% OF TOTAL
SURFACE	11.31	46.2%	91,860	50.8%	475,710	48.6%	26,690	92.0%	19,570	28.5%
BASEFLOW	0.77	3.2%	6,800	3.8%	22,710	2.3%	40	0.1%	1,140	1.7%
SEPTIC	0.70	2.9%	8,260	4.6%	123,890	12.7%	0	0.0%	0	0.0%
POINT SOURCE	0.96	3.9%	26,820	14.8%	98,840	10.1%	390	1.3%	1,980	2.9%
RAINFALL	10.72	43.8%	47,150	26.1%	257,730	26.3%	1,890	6.5%	45,890	66.9%
TOTAL	24.48		180,890		978,880		29,010		68,580	

Note: Loading totals do not include pollutant settling in tidal tributaries. See text for discussion of settling in tributaries.

TABLE 6-11

WET YEAR AND DRY YEAR LOADINGS BY JURISDICTION
FOR FIVE - YEAR FUTURE LAND USE CONDITIONS

JURISDICTION	AREA (ac)	RUNOFF (in)	% OF TOTAL	WET YEAR POLLUTANT LOADING Total P (lb)	% OF TOTAL	Total N (lb)	% OF TOTAL	LEAD (lb)	% OF TOTAL	ZINC (lb)	% OF TOTAL
SARASOTA CO.	62,301	16.81	36.8%	150,790	45.6%	753,990	45.5%	20,340	41.7%	24,460	20.1%
SARASOTA CITY	7,844	2.66	5.8%	24,840	7.5%	118,370	7.1%	7,730	15.8%	5,980	4.9%
MANATEE CO.	20,226	6.37	14.0%	56,410	17.1%	273,300	16.5%	15,190	31.1%	11,900	9.8%
ISLANDS	5,761	1.89	4.1%	19,600	5.9%	82,330	5.0%	2,360	4.8%	2,900	2.4%
BAY SURFACE	33,280	17.92	39.3%	78,800	23.8%	430,790	26.0%	3,150	6.5%	76,700	62.9%
TOTAL	129,412	45.66		330,440		1,658,780		48,770		121,940	

JURISDICTION	AREA (ac)	RUNOFF (in)	% OF TOTAL	DRY YEAR POLLUTANT LOADING Total P (lb)	% OF TOTAL	Total N (lb)	% OF TOTAL	LEAD (lb)	% OF TOTAL	ZINC (lb)	% OF TOTAL
SARASOTA CO.	62,301	8.02	32.8%	76,100	42.1%	443,040	45.3%	12,010	41.4%	11,390	16.6%
SARASOTA CITY	7,844	1.44	5.9%	15,030	8.3%	71,150	7.3%	4,640	16.0%	3,420	5.0%
MANATEE CO.	20,226	3.28	13.4%	30,450	16.8%	156,670	16.0%	9,030	31.1%	6,230	9.1%
ISLANDS	5,761	1.00	4.1%	12,160	6.7%	50,290	5.1%	1,440	5.0%	1,650	2.4%
BAY SURFACE	33,280	10.72	43.8%	47,150	26.1%	257,730	26.3%	1,890	6.5%	45,890	66.9%
TOTAL	129,412	24.48		180,890		978,880		29,010		68,580	

Note: Loading totals do not include pollutant settling in tidal tributaries. See text for discussion of settling in tributaries.

The average annual loadings by source are presented in Table 6-2. The results for the five-year future land use are similar to the results for the existing land use. The total runoff for the study area increased slightly, from 34.26 to 34.32 inches per year. The percentage of the total runoff due to surface runoff increased slightly (from 42.6% to 43.1%), while the percentages for the other sources were the same or slightly lower. For pollution loadings, the percentage of total loading due to point sources decreased noticeably, whereas the nonpoint source percentage exhibited the largest increase. Again, a decrease in the amount of pollution due to point sources is projected based on a shift from surface water discharge to land application. Increases in nonpoint source loadings are due to future development. Baseflow loadings decrease slightly, because new development results in less groundwater recharge and a corresponding reduction in baseflow quantity. Septic tank and rainfall loadings are assumed to be the same as for existing conditions. Surface runoff is still the major source of total N, total P and lead, whereas rainfall is the major source of zinc.

Table 6-3 lists the average annual loadings by jurisdiction. A comparison to the results for the existing land use condition (see Table 5-3) shows an increase in loadings for Sarasota County and Manatee County, a decrease in loadings for the City of Sarasota, and the same loadings for the Barrier Islands. No changes were projected for the Barrier Islands during the 5-year planning horizon because no DRIs were identified in the study area, and the load to the Bay surface due to rainfall was not expected to change. In Sarasota County, the new development and corresponding increase in surface runoff is the reason for the loading increases. Transition from surface water discharge to land application for the City of Sarasota wastewater treatment plant is the reason for the reduced loadings from the City. In Manatee County, increased wastewater flows account for the loading increases. Similar to existing conditions, the jurisdictions of Sarasota County, Manatee County and the Bay Surface together account for 90 percent of the total runoff and 79 to 93 percent of the pollutants analyzed.

The wet season and dry season results for the five-year future land use scenario, as presented in Tables 6-4 through 6-7, show the same trends that were identified in the analysis for existing land use conditions. Based on the data in Tables 6-4 and 6-5, about 60 percent of the annual loading occurs during the wet season, and 40 percent occurs during the dry season, for runoff, nutrients and metals. Surface runoff and rainfall are the major loading sources for all of the pollutants, as shown in Table 6-6. Surface runoff tends to provide a larger percentage of loading during the wet season than during the dry season, whereas point sources and septic tanks provide a larger percentage of the total loading during the dry season than during the wet season. However, the total contribution due to point sources and septic tanks is less than contributions due to surface runoff and rainfall. In Table 6-7, the distributions of runoff and loadings by jurisdiction for the wet and the dry seasons are only slightly different than the distributions for the average annual loadings, shown in Table 6-3.

Tables 6-8 through 6-11 present the five-year future land use scenario results for the wet year and dry year analysis. In comparison with the average annual five-year future loadings, the values in Tables 6-8 and 6-9 show that loadings for all pollutants will be 28 to 32 percent higher during the wet year, and 24 to 28 percent lower during the dry year. Results in Table 6-10 indicate that the wet year and dry year load distribution by source are similar to the distribution for the average rainfall year. Similarly, the results in Table 6-11 indicate that the wet year and dry year distributions by jurisdiction are virtually the same as for the average rainfall year.

The values in Tables 6-1 through 6-11 do not include the effects of pollutant settling in the tidal tributaries. As discussed in Section 5.1, the application of the delivery ratios established for the tidal tributaries did not produce substantial changes in total loadings or the distribution of loadings between sources or jurisdictions. The reduction in surface loadings due to the delivery ratios was only 6 percent for total P and zinc, 3 percent for total N and 13 percent for lead. When considering the loadings from all sources, the loading reductions due to settling were 3 percent for total P, 12 percent for lead, and 1

percent for total N and zinc. With regard to source distribution, the percentage of total loading due to surface runoff changed by 2 percentage points or less, and the percentages for the other sources changed by no more than 1 percentage point. Distribution by jurisdiction remained essentially unchanged, with differences always less than 1 percentage point.

6.2 BUILDOUT FUTURE LAND USE

Tables 6-12 through 6-22 present the loading results for the buildout future land use analysis. The buildout future land use includes development in all areas identified in the Comprehensive Plans for Manatee and Sarasota Counties. The results for the average annual rainfall condition are shown in Tables 6-12 through 6-14. Wet season and dry season results are listed in Tables 6-15 through 6-18, and wet year and dry year results are presented in Tables 6-19 through 6-22.

Table 6-12 shows the average annual loading results by watershed. A comparison of Tables 5-1 (existing land use conditions) and 6-12 show an overall increase from existing loadings for all pollutants. The increase in loading for total P, total N and zinc ranges from 10 to 15 percent, whereas the increase for lead is 35 percent. The percent increase in loadings for zinc and the nutrients is relatively small because of the substantial loadings attributed to rainfall and baseflow. Lead, on the other hand, has very low concentrations in baseflow and rainfall but moderate to high values in runoff from urbanized areas. Consequently, projected increases in urban area result in a substantially larger annual loading of lead from the study area.

In some cases, watersheds that had minor impacts under existing land use conditions have a substantially larger contribution in the buildout future scenario. For total P, Phillippi Creek and South Bradenton are still the largest watershed contributors, but the loading from South Creek has increased 46 percent, such that the total loading from South Creek is greater than the Whitaker Bayou loading. The Phillippi Creek, South Bradenton, South

TABLE 6-12

AVERAGE ANNUAL LOADINGS BY WATERSHED
FOR BUILDOUT FUTURE LAND USE CONDITIONS

WATERSHED	AREA	TOTAL RUNOFF	TOTAL P			TOTAL N			LEAD			ZINC		
	(ac)	(in)	(lb)	(lb/ac)	(mg/l)	(lb)	(lb/ac)	(mg/l)	(lb)	(lb/ac)	(mg/l)	(lb)	(lb/ac)	(mg/l)
PHILLIPPI CREEK	36,417	29.80	85,840	2.36	0.35	458,250	12.58	1.86	14,990	0.41	0.061	14,670	0.40	0.060
PALMA SOLA 2	1,120	31.79	2,480	2.21	0.31	12,330	11.01	1.53	690	0.62	0.086	540	0.48	0.067
BOWLEES CREEK	6,489	36.31	12,240	1.89	0.23	71,700	11.05	1.34	8,450	1.30	0.158	4,990	0.77	0.093
WEST BRADENTON	4,395	30.99	8,440	1.92	0.27	41,550	9.45	1.35	2,010	0.46	0.065	1,750	0.40	0.057
CEDAR HAMMOCK	1,930	32.35	4,170	2.16	0.29	21,080	10.92	1.49	1,320	0.68	0.093	990	0.51	0.070
WEST BOWLEES	1,559	28.82	3,260	2.09	0.32	15,830	10.16	1.55	790	0.51	0.078	660	0.42	0.065
PALMA SOLA	900	30.68	1,970	2.19	0.31	9,610	10.68	1.54	480	0.53	0.077	390	0.43	0.062
SOUTH BRADENTON	4,635	43.66	19,710	4.25	0.43	96,980	20.92	2.11	2,160	0.47	0.047	2,330	0.50	0.051
WHITAKER BAYOU	5,014	38.36	16,710	3.33	0.38	79,190	15.79	1.82	3,930	0.78	0.090	3,450	0.69	0.079
MATHENY CREEK	3,800	44.41	15,960	4.20	0.42	76,170	20.04	1.99	3,620	0.95	0.095	3,140	0.83	0.082
CATFISH CREEK	3,360	30.17	6,790	2.02	0.30	34,330	10.22	1.49	1,300	0.39	0.057	1,330	0.40	0.058
NORTH CREEK	1,920	28.47	4,110	2.14	0.33	20,230	10.54	1.63	590	0.31	0.048	700	0.36	0.057
SOUTH CREEK	12,995	21.83	17,340	1.33	0.27	81,160	6.25	1.26	1,520	0.12	0.024	2,520	0.19	0.039
HUDSON BAYOU	1,595	32.58	3,090	1.94	0.26	16,650	10.44	1.41	1,460	0.92	0.124	940	0.59	0.080
SIESTA KEY	1,385	45.94	8,410	6.07	0.58	30,240	21.83	2.10	580	0.42	0.040	1,030	0.74	0.071
ANNA MARIA	919	28.32	1,740	1.89	0.29	8,660	9.42	1.47	450	0.49	0.076	360	0.39	0.061
PERICO	860	33.12	1,090	1.27	0.17	4,900	5.70	0.76	80	0.09	0.012	110	0.13	0.017
LONGBOAT KEY	1,697	23.62	2,730	1.61	0.30	13,000	7.66	1.43	440	0.26	0.048	450	0.27	0.050
OTHER ISLANDS	900	27.94	1,640	1.82	0.29	8,360	9.29	1.47	310	0.34	0.054	290	0.32	0.051
DIRECT TO BAY	4,241	32.86	9,210	2.17	0.29	53,460	12.61	1.69	2,540	0.60	0.080	2,000	0.47	0.063
BAY SURFACE	33,280	54.60	61,730	1.85	0.15	337,460	10.14	0.82	2,470	0.07	0.006	60,080	1.81	0.146
TOTAL	129,412	37.26	288,660	2.42	0.31	1,491,140	11.75	1.53	50,180	0.51	0.068	102,720	0.53	0.066

Note: Loading totals do not include pollutant settling in tidal tributaries. See text for discussion of settling in tributaries.

TABLE 6-13

AVERAGE ANNUAL LOADINGS BY SOURCE
FOR BUILDOUT FUTURE LAND USE CONDITIONS

SOURCE	RUNOFF (in)	% OF TOTAL	AVERAGE YEAR POLLUTANT LOADING							
			TOTAL P (lb)	% OF TOTAL	TOTAL N (lb)	% OF TOTAL	LEAD (lb)	% OF TOTAL	ZINC (lb)	% OF TOTAL
SURFACE	17.79	47.7%	151,340	52.4%	790,360	53.0%	46,900	93.5%	34,990	34.1%
BASEFLOW	3.34	9.0%	29,380	10.2%	98,030	6.6%	260	0.5%	4,910	4.8%
SEPTIC	0.70	1.9%	8,270	2.9%	124,060	8.3%	0	0.0%	0	0.0%
POINT SOURCE	1.39	3.7%	37,940	13.1%	141,230	9.5%	550	1.1%	2,740	2.7%
RAINFALL	14.04	37.7%	61,730	21.4%	337,460	22.6%	2,470	4.9%	60,080	58.5%
TOTAL	37.26		288,660		1,491,140		50,180		102,720	

Note: Loading totals do not include pollutant settling in tidal tributaries. See text for discussion of settling in tributaries.

TABLE 6-14

AVERAGE ANNUAL LOADINGS BY JURISDICTION
FOR BUILDOUT FUTURE LAND USE CONDITIONS

JURISDICTION	AREA (ac)	RUNOFF (in)	% OF TOTAL	AVERAGE YEAR POLLUTANT LOADING							
				Total P (lb)	% OF TOTAL	Total N (lb)	% OF TOTAL	LEAD (lb)	% OF TOTAL	ZINC (lb)	% OF TOTAL
SARASOTA CO.	62,301	14.17	38.0%	139,670	48.4%	731,660	49.1%	24,440	48.7%	24,380	23.7%
SARASOTA CITY	7,844	2.06	5.5%	20,880	7.2%	95,430	6.4%	6,100	12.2%	4,790	4.7%
MANATEE CO.	20,226	5.57	14.9%	50,770	17.6%	261,430	17.5%	15,310	30.5%	11,230	10.9%
ISLANDS	5,761	1.42	3.8%	15,610	5.4%	65,160	4.4%	1,860	3.7%	2,240	2.2%
BAY SURFACE	33,280	14.04	37.7%	61,730	21.4%	337,460	22.6%	2,470	4.9%	60,080	58.5%
TOTAL	129,412	37.26		288,660		1,491,140		50,180		102,720	

Note: Loading totals do not include pollutant settling in tidal tributaries. See text for discussion of settling in tributaries.

TABLE 6-15

WET SEASON LOADINGS BY WATERSHED
FOR BUILDOUT FUTURE LAND USE CONDITIONS

WATERSHED	AREA	TOTAL RUNOFF	TOTAL P			TOTAL N			LEAD			ZINC		
	(ac)	(in)	(lb)	(lb/ac)	(mg/l)	(lb)	(lb/ac)	(mg/l)	(lb)	(lb/ac)	(mg/l)	(lb)	(lb/ac)	(mg/l)
PHILLIPPI CREEK	36,417	18.15	51,290	1.41	0.34	268,370	7.37	1.79	9,230	0.25	0.062	9,090	0.25	0.061
PALMA SOLA 2	1,120	20.04	1,570	1.40	0.31	7,710	6.88	1.52	430	0.38	0.085	330	0.29	0.065
BOWLEES CREEK	6,489	22.74	7,670	1.18	0.23	44,740	6.89	1.34	5,210	0.80	0.156	3,100	0.48	0.093
WEST BRADENTON	4,395	19.63	5,350	1.22	0.27	26,160	5.95	1.34	1,240	0.28	0.063	1,100	0.25	0.056
CEDAR HAMMOCK	1,930	20.38	2,620	1.36	0.29	13,210	6.84	1.48	820	0.42	0.092	630	0.33	0.071
WEST BOWLEES	1,559	18.27	2,050	1.32	0.32	9,950	6.38	1.54	490	0.31	0.076	410	0.26	0.064
PALMA SOLA	900	19.37	1,230	1.37	0.31	6,020	6.69	1.52	300	0.33	0.076	250	0.28	0.063
SOUTH BRADENTON	4,635	23.86	9,550	2.06	0.38	46,570	10.05	1.86	1,320	0.28	0.053	1,390	0.30	0.055
WHITAKER BAYOU	5,014	22.89	9,430	1.88	0.36	45,390	9.05	1.75	2,410	0.48	0.093	2,060	0.41	0.079
MATHENY CREEK	3,800	24.80	7,660	2.02	0.36	38,900	10.24	1.82	2,200	0.58	0.103	1,760	0.46	0.082
CATFISH CREEK	3,360	19.01	4,280	1.27	0.30	21,310	6.34	1.47	810	0.24	0.056	840	0.25	0.058
NORTH CREEK	1,920	17.96	2,590	1.35	0.33	12,550	6.54	1.61	350	0.18	0.045	440	0.23	0.056
SOUTH CREEK	12,995	14.13	11,310	0.87	0.27	51,940	4.00	1.25	950	0.07	0.023	1,650	0.13	0.040
HUDSON BAYOU	1,595	20.51	1,940	1.22	0.26	10,420	6.53	1.41	900	0.56	0.121	590	0.37	0.080
SIESTA KEY	1,385	23.89	3,680	2.66	0.49	14,120	10.19	1.88	330	0.24	0.044	490	0.35	0.065
ANNA MARIA	919	17.97	1,120	1.22	0.30	5,450	5.93	1.46	280	0.30	0.075	230	0.25	0.061
PERICO	860	21.16	700	0.81	0.17	3,170	3.69	0.77	50	0.06	0.012	70	0.08	0.017
LONGBOAT KEY	1,697	15.17	1,750	1.03	0.30	8,270	4.87	1.42	260	0.15	0.045	280	0.16	0.048
OTHER ISLANDS	900	17.71	1,030	1.14	0.29	5,150	5.72	1.43	190	0.21	0.053	190	0.21	0.053
DIRECT TO BAY	4,241	20.21	5,670	1.34	0.29	32,020	7.55	1.65	1,570	0.37	0.081	1,260	0.30	0.065
BAY SURFACE	33,280	33.70	38,100	1.14	0.15	208,290	6.26	0.82	1,520	0.05	0.006	37,090	1.11	0.146
TOTAL	129,412	22.82	170,590	1.39	0.30	879,710	6.86	1.48	30,860	0.31	0.067	63,250	0.32	0.066

Note: Loading totals do not include pollutant settling in tidal tributaries. See text for discussion of settling in tributaries.

TABLE 6-16

DRY SEASON LOADINGS BY WATERSHED
FOR BUILDOUT FUTURE LAND USE CONDITIONS

WATERSHED	AREA	TOTAL RUNOFF	TOTAL P			TOTAL N			LEAD			ZINC		
	(ac)	(in)	(lb)	(lb/ac)	(mg/l)	(lb)	(lb/ac)	(mg/l)	(lb)	(lb/ac)	(mg/l)	(lb)	(lb/ac)	(mg/l)
PHILLIPPI CREEK	36,417	11.65	34,560	0.95	0.36	189,840	5.21	1.98	5,770	0.16	0.060	5,570	0.15	0.058
PALMA SOLA 2	1,120	11.75	910	0.81	0.31	4,610	4.12	1.55	270	0.24	0.090	200	0.18	0.067
BOWLEES CREEK	6,489	13.57	4,510	0.69	0.23	26,990	4.16	1.35	3,230	0.50	0.162	1,880	0.29	0.094
WEST BRADENTON	4,395	11.35	3,090	0.70	0.27	15,390	3.50	1.36	770	0.18	0.068	650	0.15	0.057
CEDAR HAMMOCK	1,930	11.97	1,530	0.79	0.29	7,890	4.09	1.51	510	0.26	0.097	370	0.19	0.071
WEST BOWLEES	1,559	10.55	1,180	0.76	0.32	5,880	3.77	1.58	310	0.20	0.083	250	0.16	0.067
PALMA SOLA	900	11.31	720	0.80	0.31	3,600	4.00	1.56	180	0.20	0.078	150	0.17	0.065
SOUTH BRADENTON	4,635	19.79	10,180	2.20	0.49	50,440	10.88	2.43	830	0.18	0.040	930	0.20	0.045
WHITAKER BAYOU	5,014	15.47	7,280	1.45	0.41	33,750	6.73	1.92	1,520	0.30	0.086	1,390	0.28	0.079
MATHENY CREEK	3,800	19.61	8,290	2.18	0.49	37,290	9.81	2.21	1,420	0.37	0.084	1,390	0.37	0.082
CATFISH CREEK	3,360	11.16	2,490	0.74	0.29	13,020	3.88	1.53	500	0.15	0.059	490	0.15	0.058
NORTH CREEK	1,920	10.51	1,500	0.78	0.33	7,680	4.00	1.68	220	0.11	0.048	260	0.14	0.057
SOUTH CREEK	12,995	7.70	6,050	0.47	0.27	29,230	2.25	1.29	570	0.04	0.025	860	0.07	0.038
HUDSON BAYOU	1,595	12.07	1,150	0.72	0.26	6,220	3.90	1.43	560	0.35	0.128	360	0.23	0.082
SIESTA KEY	1,385	22.05	4,740	3.42	0.68	16,100	11.62	2.33	250	0.18	0.036	550	0.40	0.079
ANNA MARIA	919	10.35	640	0.70	0.30	3,210	3.49	1.49	170	0.18	0.079	130	0.14	0.060
PERICO	860	11.96	380	0.44	0.16	1,730	2.01	0.74	30	0.03	0.013	40	0.05	0.017
LONGBOAT KEY	1,697	8.45	970	0.57	0.30	4,760	2.80	1.46	160	0.09	0.049	160	0.09	0.049
OTHER ISLANDS	900	10.23	610	0.68	0.29	3,200	3.56	1.53	120	0.13	0.058	100	0.11	0.048
DIRECT TO BAY	4,241	12.65	3,480	0.82	0.29	21,430	5.05	1.76	970	0.23	0.080	740	0.17	0.061
BAY SURFACE	33,280	20.90	23,630	0.71	0.15	129,170	3.88	0.82	950	0.03	0.006	23,000	0.69	0.146
TOTAL	129,412	14.44	117,890	1.02	0.32	611,430	4.89	1.60	19,310	0.20	0.068	39,470	0.21	0.066

Note: Loading totals do not include pollutant settling in tidal tributaries. See text for discussion of settling in tributaries.

TABLE 6-17

WET SEASON AND DRY SEASON LOADINGS BY SOURCE
FOR BUILDOUT FUTURE LAND USE CONDITIONS

SOURCE	RUNOFF (in)	% OF TOTAL	WET SEASON POLLUTANT LOADING TOTAL P (lb)	% OF TOTAL	TOTAL N (lb)	% OF TOTAL	LEAD (lb)	% OF TOTAL	ZINC (lb)	% OF TOTAL
SURFACE	10.98	48.1%	93,290	54.7%	487,860	55.5%	28,950	93.8%	21,580	34.1%
BASEFLOW	2.45	10.7%	21,550	12.6%	71,860	8.2%	180	0.6%	3,580	5.7%
SEPTIC	0.23	1.0%	4,130	2.4%	61,990	7.0%	0	0.0%	0	0.0%
POINT SOURCE	0.49	2.2%	13,520	7.9%	49,710	5.7%	210	0.7%	1,000	1.6%
RAINFALL	8.67	38.0%	38,100	22.3%	208,290	23.7%	1,520	4.9%	37,090	58.6%
TOTAL	22.82		170,590		879,710		30,860		63,250	

SOURCE	RUNOFF (in)	% OF TOTAL	DRY SEASON POLLUTANT LOADING TOTAL P (lb)	% OF TOTAL	TOTAL N (lb)	% OF TOTAL	LEAD (lb)	% OF TOTAL	ZINC (lb)	% OF TOTAL
SURFACE	6.81	47.2%	57,880	49.1%	302,480	49.5%	17,980	93.1%	13,390	33.9%
BASEFLOW	0.89	6.2%	7,830	6.6%	26,170	4.3%	40	0.2%	1,330	3.4%
SEPTIC	0.47	3.2%	4,140	3.5%	62,070	10.2%	0	0.0%	0	0.0%
POINT SOURCE	0.90	6.2%	24,410	20.7%	91,540	15.0%	340	1.8%	1,750	4.4%
RAINFALL	5.37	37.2%	23,630	20.0%	129,170	21.1%	950	4.9%	23,000	58.3%
TOTAL	14.44		117,890		611,430		19,310		39,470	

Note: Loading totals do not include pollutant settling in tidal tributaries. See text for discussion of settling in tributaries.

TABLE 6-18

WET SEASON AND DRY SEASON LOADINGS BY JURISDICTION
FOR BUILDOUT FUTURE LAND USE CONDITIONS

JURISDICTION	AREA (ac)	RUNOFF (in)	% OF TOTAL	WET SEASON POLLUTANT LOADING Total P (lb)	% OF TOTAL	Total N (lb)	% OF TOTAL	LEAD (lb)	% OF TOTAL	ZINC (lb)	% OF TOTAL
SARASOTA CO.	62,301	8.67	38.0%	82,960	48.6%	428,910	48.8%	15,050	48.8%	15,060	23.8%
SARASOTA CITY	7,844	1.27	5.6%	12,120	7.1%	56,800	6.5%	3,730	12.1%	2,890	4.6%
MANATEE CO.	20,226	3.38	14.8%	29,130	17.1%	149,550	17.0%	9,450	30.6%	6,950	11.0%
ISLANDS	5,761	0.85	3.7%	8,280	4.9%	36,160	4.1%	1,110	3.6%	1,260	2.0%
BAY SURFACE	33,280	8.67	38.0%	38,100	22.3%	208,290	23.7%	1,520	4.9%	37,090	58.6%
TOTAL	129,412	22.82		170,590		879,710		30,860		63,250	

JURISDICTION	AREA (ac)	RUNOFF (in)	% OF TOTAL	DRY SEASON POLLUTANT LOADING Total P (lb)	% OF TOTAL	Total N (lb)	% OF TOTAL	LEAD (lb)	% OF TOTAL	ZINC (lb)	% OF TOTAL
SARASOTA CO.	62,301	5.51	38.1%	56,620	48.0%	302,740	49.5%	9,410	48.7%	9,310	23.6%
SARASOTA CITY	7,844	0.79	5.5%	8,680	7.4%	38,570	6.3%	2,350	12.2%	1,900	4.8%
MANATEE CO.	20,226	2.19	15.2%	21,620	18.3%	111,950	18.3%	5,870	30.4%	4,280	10.8%
ISLANDS	5,761	0.57	4.0%	7,340	6.2%	29,000	4.7%	730	3.8%	980	2.5%
BAY SURFACE	33,280	5.37	37.2%	23,630	20.0%	129,170	21.1%	950	4.9%	23,000	58.3%
TOTAL	129,412	14.44		117,890		611,430		19,310		39,470	

Note: Loading totals do not include pollutant settling in tidal tributaries. See text for discussion of settling in tributaries.

TABLE 6-19

WET YEAR LOADINGS BY WATERSHED
FOR BUILDOUT FUTURE LAND USE CONDITIONS

WATERSHED	AREA	TOTAL RUNOFF	TOTAL P			TOTAL N			LEAD			ZINC		
	(ac)	(in)	(lb)	(lb/ac)	(mg/l)	(lb)	(lb/ac)	(mg/l)	(lb)	(lb/ac)	(mg/l)	(lb)	(lb/ac)	(mg/l)
PHILLIPPI CREEK	36,417	40.11	112,720	3.10	0.34	575,660	15.81	1.74	19,170	0.53	0.058	19,720	0.54	0.060
PALMA SOLA 2	1,120	42.75	3,310	2.96	0.31	16,280	14.54	1.50	890	0.79	0.082	710	0.63	0.065
BOWLEES CREEK	6,489	48.06	16,380	2.52	0.23	94,030	14.49	1.33	10,780	1.66	0.153	6,490	1.00	0.092
WEST BRADENTON	4,395	42.22	11,600	2.64	0.28	55,660	12.66	1.32	2,570	0.58	0.061	2,360	0.54	0.056
CEDAR HAMMOCK	1,930	43.45	5,600	2.90	0.29	27,870	14.44	1.47	1,700	0.88	0.089	1,320	0.68	0.069
WEST BOWLEES	1,559	39.31	4,390	2.82	0.32	21,120	13.55	1.52	1,010	0.65	0.073	880	0.56	0.063
PALMA SOLA	900	41.46	2,650	2.94	0.31	12,740	14.16	1.51	610	0.68	0.072	520	0.58	0.061
SOUTH BRADENTON	4,635	54.77	23,260	5.02	0.40	112,950	24.37	1.96	2,750	0.59	0.048	3,030	0.65	0.053
WHITAKER BAYOU	5,014	49.38	20,200	4.03	0.36	95,860	19.12	1.71	4,980	0.99	0.089	4,360	0.87	0.078
MATHENY CREEK	3,800	55.88	18,560	4.88	0.39	89,100	23.45	1.85	4,580	1.21	0.095	3,920	1.03	0.081
CATFISH CREEK	3,360	41.18	9,260	2.76	0.30	45,310	13.49	1.44	1,670	0.50	0.053	1,790	0.53	0.057
NORTH CREEK	1,920	39.03	5,590	2.91	0.33	26,630	13.87	1.57	740	0.39	0.044	960	0.50	0.057
SOUTH CREEK	12,995	31.39	25,240	1.94	0.27	113,670	8.75	1.23	1,970	0.15	0.021	3,730	0.29	0.040
HUDSON BAYOU	1,595	43.68	4,170	2.61	0.26	22,020	13.81	1.39	1,880	1.18	0.119	1,250	0.78	0.079
SIESTA KEY	1,385	56.49	9,470	6.84	0.53	34,850	25.16	1.97	720	0.52	0.041	1,200	0.87	0.068
ANNA MARIA	919	38.71	2,410	2.62	0.30	11,600	12.62	1.44	580	0.63	0.072	490	0.53	0.061
PERICO	860	46.02	1,620	1.88	0.18	6,990	8.13	0.78	110	0.13	0.012	180	0.21	0.020
LONGBOAT KEY	1,697	33.25	3,840	2.26	0.30	17,800	10.49	1.39	550	0.32	0.043	630	0.37	0.049
OTHER ISLANDS	900	38.53	2,260	2.51	0.29	11,090	12.32	1.41	400	0.44	0.051	400	0.44	0.051
DIRECT TO BAY	4,241	43.93	12,210	2.88	0.29	67,510	15.92	1.60	3,250	0.77	0.077	2,670	0.63	0.063
BAY SURFACE	33,280	69.70	78,800	2.37	0.15	430,790	12.94	0.82	3,150	0.09	0.006	76,700	2.30	0.146
TOTAL	129,412	49.02	373,540	3.11	0.31	1,889,530	14.96	1.47	64,060	0.65	0.065	133,310	0.69	0.065

Note: Loading totals do not include pollutant settling in tidal tributaries. See text for discussion of settling in tributaries.

TABLE 6-20

DRY YEAR LOADINGS BY WATERSHED
FOR BUILDOUT FUTURE LAND USE CONDITIONS

WATERSHED	AREA	TOTAL RUNOFF	TOTAL P			TOTAL N			LEAD			ZINC		
	(ac)	(in)	(lb)	(lb/ac)	(mg/l)	(lb)	(lb/ac)	(mg/l)	(lb)	(lb/ac)	(mg/l)	(lb)	(lb/ac)	(mg/l)
PHILLIPPI CREEK	36,417	20.79	62,430	1.71	0.36	356,290	9.78	2.08	11,410	0.31	0.066	10,270	0.28	0.060
PALMA SOLA 2	1,120	22.27	1,750	1.56	0.31	8,910	7.96	1.58	530	0.47	0.094	380	0.34	0.067
BOWLEES CREEK	6,489	26.15	8,620	1.33	0.22	52,430	8.08	1.36	6,450	0.99	0.168	3,700	0.57	0.096
WEST BRADENTON	4,395	21.21	5,710	1.30	0.27	29,270	6.66	1.39	1,530	0.35	0.072	1,210	0.28	0.057
CEDAR HAMMOCK	1,930	22.72	2,910	1.51	0.29	15,260	7.91	1.54	1,010	0.52	0.102	720	0.37	0.072
WEST BOWLEES	1,559	19.68	2,230	1.43	0.32	11,270	7.23	1.62	600	0.38	0.086	460	0.30	0.066
PALMA SOLA	900	21.31	1,370	1.52	0.32	6,910	7.68	1.59	370	0.41	0.085	280	0.31	0.064
SOUTH BRADENTON	4,635	33.98	16,640	3.59	0.47	83,160	17.94	2.33	1,650	0.36	0.046	1,710	0.37	0.048
WHITAKER BAYOU	5,014	28.84	13,680	2.73	0.42	64,840	12.93	1.98	3,040	0.61	0.093	2,660	0.53	0.081
MATHENY CREEK	3,800	34.47	13,700	3.61	0.46	64,980	17.10	2.19	2,790	0.73	0.094	2,480	0.65	0.084
CATFISH CREEK	3,360	20.58	4,640	1.38	0.30	24,800	7.38	1.58	990	0.29	0.063	910	0.27	0.058
NORTH CREEK	1,920	19.24	2,830	1.47	0.34	14,640	7.63	1.75	440	0.23	0.053	480	0.25	0.057
SOUTH CREEK	12,995	13.41	10,390	0.80	0.26	52,660	4.05	1.33	1,130	0.09	0.029	1,450	0.11	0.037
HUDSON BAYOU	1,595	22.95	2,160	1.35	0.26	12,010	7.53	1.45	1,120	0.70	0.135	680	0.43	0.082
SIESTA KEY	1,385	36.74	7,500	5.42	0.65	26,230	18.94	2.27	470	0.34	0.041	870	0.63	0.075
ANNA MARIA	919	19.27	1,180	1.28	0.29	6,130	6.67	1.53	350	0.38	0.087	250	0.27	0.062
PERICO	860	21.83	630	0.73	0.15	3,080	3.58	0.72	60	0.07	0.014	50	0.06	0.012
LONGBOAT KEY	1,697	15.18	1,750	1.03	0.30	8,850	5.22	1.52	320	0.19	0.055	280	0.16	0.048
OTHER ISLANDS	900	18.68	1,100	1.22	0.29	6,000	6.67	1.57	240	0.27	0.063	200	0.22	0.052
DIRECT TO BAY	4,241	23.23	6,600	1.56	0.30	41,280	9.73	1.85	1,940	0.46	0.087	1,420	0.33	0.064
BAY SURFACE	33,280	41.70	47,150	1.42	0.15	257,730	7.74	0.82	1,890	0.06	0.006	45,890	1.38	0.146
TOTAL	129,412	27.08	214,970	1.81	0.32	1,146,730	8.97	1.62	38,330	0.39	0.073	76,350	0.39	0.066

Note: Loading totals do not include pollutant settling in tidal tributaries. See text for discussion of settling in tributaries.

TABLE 6-21

WET YEAR AND DRY YEAR LOADINGS BY SOURCE
FOR BUILDOUT FUTURE LAND USE CONDITIONS

SOURCE	RUNOFF (in)	% OF TOTAL	WET YEAR POLLUTANT LOADING TOTAL P (lb)	% OF TOTAL	TOTAL N (lb)	% OF TOTAL	LEAD (lb)	% OF TOTAL	ZINC (lb)	% OF TOTAL
SURFACE	22.71	46.3%	193,150	51.7%	1,008,890	53.4%	59,830	93.4%	44,660	33.5%
BASEFLOW	6.29	12.8%	55,380	14.8%	184,560	9.8%	530	0.8%	9,210	6.9%
SEPTIC	0.70	1.4%	8,270	2.2%	124,060	6.6%	0	0.0%	0	0.0%
POINT SOURCE	1.39	2.8%	37,940	10.2%	141,230	7.5%	550	0.9%	2,740	2.1%
RAINFALL	17.92	36.6%	78,800	21.1%	430,790	22.8%	3,150	4.9%	76,700	57.5%
TOTAL	49.02		373,540		1,889,530		64,060		133,310	

SOURCE	RUNOFF (in)	% OF TOTAL	DRY YEAR POLLUTANT LOADING TOTAL P (lb)	% OF TOTAL	TOTAL N (lb)	% OF TOTAL	LEAD (lb)	% OF TOTAL	ZINC (lb)	% OF TOTAL
SURFACE	13.59	50.2%	115,620	54.8%	603,760	52.7%	35,860	93.6%	26,720	35.0%
BASEFLOW	0.68	2.5%	5,990	2.8%	19,950	1.7%	30	0.1%	1,000	1.3%
SEPTIC	0.70	2.6%	4,140	2.0%	124,060	10.8%	0	0.0%	0	0.0%
POINT SOURCE	1.39	5.1%	37,940	18.0%	141,230	12.3%	550	1.4%	2,740	3.6%
RAINFALL	10.72	39.6%	47,150	22.4%	257,730	22.5%	1,890	4.9%	45,890	60.1%
TOTAL	27.08		210,840		1,146,730		38,330		76,350	

Note: Loading totals do not include pollutant settling in tidal tributaries. See text for discussion of settling in tributaries.

TABLE 6-22

WET YEAR AND DRY YEAR LOADINGS BY JURISDICTION
FOR BUILDOUT FUTURE LAND USE CONDITIONS

JURISDICTION	AREA (ac)	RUNOFF (in)	% OF TOTAL	WET YEAR POLLUTANT LOADING Total P (lb)	% OF TOTAL	Total N (lb)	% OF TOTAL	LEAD (lb)	% OF TOTAL	ZINC (lb)	% OF TOTAL
SARASOTA CO.	62,301	19.15	39.1%	183,840	49.2%	925,240	49.0%	31,230	48.8%	32,790	24.6%
SARASOTA CITY	7,844	2.72	5.5%	26,090	7.0%	120,740	6.4%	7,770	12.1%	6,160	4.6%
MANATEE CO.	20,226	7.33	15.0%	65,210	17.5%	330,430	17.5%	19,550	30.5%	14,760	11.1%
ISLANDS	5,761	1.89	3.9%	19,600	5.2%	82,330	4.4%	2,360	3.7%	2,900	2.2%
BAY SURFACE	33,280	17.92	36.6%	78,800	21.1%	430,790	22.8%	3,150	4.9%	76,700	57.5%
TOTAL	129,412	49.02		373,540		1,889,530		64,060		133,310	

JURISDICTION	AREA (ac)	RUNOFF (in)	% OF TOTAL	DRY YEAR POLLUTANT LOADING Total P (lb)	% OF TOTAL	Total N (lb)	% OF TOTAL	LEAD (lb)	% OF TOTAL	ZINC (lb)	% OF TOTAL
SARASOTA CO.	62,301	9.82	36.3%	101,110	47.0%	563,320	49.1%	18,610	48.6%	17,040	22.3%
SARASOTA CITY	7,844	1.50	5.5%	16,290	7.6%	73,600	6.4%	4,700	12.3%	3,610	4.7%
MANATEE CO.	20,226	4.04	14.9%	38,260	17.8%	201,790	17.6%	11,690	30.5%	8,160	10.7%
ISLANDS	5,761	1.00	3.7%	12,160	5.7%	50,290	4.4%	1,440	3.8%	1,650	2.2%
BAY SURFACE	33,280	10.72	39.6%	47,150	21.9%	257,730	22.5%	1,890	4.9%	45,890	60.1%
TOTAL	129,412	27.08		214,970		1,146,730		38,330		76,350	

Note: Loading totals do not include pollutant settling in tidal tributaries. See text for discussion of settling in tributaries.

Creek and Whitaker Bayou watersheds are also the largest contributors of total N in the study area. Phillippi Creek, Whitaker Bayou and Bowlees Creek are still the major contributors of lead and zinc loadings. Like South Creek, Matheny Creek also exhibits substantial loading increases, such that the loading from Matheny Creek is comparable to the Whitaker Bayou loadings for all of the analyzed pollutants.

The average annual loadings by source are presented in Table 6-13. A comparison of Tables 5-2 and 6-13 shows that the total study area flow increased from 34.26 inches to 37.26 inches. Surface runoff is the major factor, increasing from 14.58 inches to 17.79 inches. Point source flows also increase, whereas baseflow is lower, and septic tank and rainfall flows are the same. As expected, the increase in surface runoff also generates increased surface runoff loadings, with increases ranging from 28 percent for total P to 41 percent for zinc. The increase in surface runoff due to urban development also results in a decrease in baseflow quantity, so baseflow loading is less for the buildout scenario. Point source loading is greater than existing conditions for the buildout scenario, due to the increase in wastewater flows generated by the buildout population. Rainfall and septic tank loadings are assumed to be the same for the existing and buildout scenarios, the latter because all future development was assumed to be sewered rather than served by septic tanks. Overall, the major sources of nutrients and metals are surface runoff and rainfall.

Table 6-14 lists the average annual loadings by jurisdiction. A comparison of these results with the results for the existing land use condition (see Table 5-3) shows an increase in loadings for Sarasota and Manatee Counties, a decrease in loadings for the City of Sarasota, and the same loadings for the Barrier Islands and the Bay Surface. Future land use changes for the islands were not considered because comprehensive planning documents were not available. In Sarasota County, loading increases ranged from 27 percent for total N to 66 percent for lead, primarily due to surface runoff. In Manatee County, future urbanization accounted for loading increases ranging from 23 percent for total P to 29 percent for lead. Reductions in City of Sarasota loadings ranged from 1 percent for lead to 17 percent for total P, due to transition from surface water

discharge to land application of wastewater. Because most of the future development is in Sarasota County, the relative percentage of total loading contributed by Sarasota County increased, whereas the percentage contributed by each of the other jurisdictions typically either decreased or remained the same.

The wet season and dry season results for the buildout future land use scenario, as presented in Tables 6-15 through 6-18, show trends similar to those identified in the analysis of existing land use conditions. Based on the data in Tables 6-15 and 6-16, about 60 percent of the annual loading occurs during the wet season, and 40 percent occurs during the dry season, for runoff, nutrients and metals. Surface runoff and rainfall are the major loading sources for all of the pollutants, as shown in Table 6-17. Surface runoff tends to provide a larger percentage of loading during the wet season than during the dry season, whereas point sources and septic tanks provide a larger percentage of the total load during the dry season than during the wet season. In fact, the combination of point source and septic tank nutrient loadings actually exceed the rainfall nutrient loadings during the dry season. In Table 6-18, the distributions of runoff and loadings by jurisdiction for the wet and dry seasons are only slightly different than the distributions for the average annual loadings, shown in Table 6-14.

Tables 6-19 through 6-22 present the buildout future land use scenario results for the wet year and dry year analysis. In comparison with the average year loadings, the values in Tables 6-19 and 6-20 show that loadings for all pollutants are 27 to 30 percent higher during the wet year and 23 to 26 percent lower during the dry year. Results in Table 6-21 indicate that the wet year and dry year loading distributions by source are essentially the same as the distribution for the average rainfall year. Similarly, the results in Table 6-22 indicate that the wet year and dry year distributions by jurisdiction are virtually the same as for the average rainfall year.

The values in Tables 6-12 through 6-22 do not include the effects of pollutant settling in the tidal tributaries. As discussed in Section 5.1, the application of the delivery ratios

established for the tidal tributaries did not produce substantial changes in total loadings or the distribution of loadings between sources or jurisdictions. The reduction in surface loadings due to the delivery ratios was only 6 percent for total P and zinc, 3 percent for total N and 13 percent for lead. When considering the loadings from all sources, the loading reductions due to settling were 3 percent for total P, 12 percent for lead, and 1 percent for total N and zinc. With regard to source distribution, the percentage of total loading due to surface runoff changed by 2 percentage points or less, and the percentages for the other sources changed by no more than 1 percentage point. Distribution by jurisdiction remained essentially unchanged, with differences always less than 1 percentage point.

7.0 SUMMARY

In Phase I of the Sarasota Bay National Estuary Program Point and Nonpoint Source Loading Assessment, existing data were used to quantify the loadings of nutrients and metals to Sarasota Bay. Loadings were estimated for three different land use scenarios: existing, five-year future and buildout future. The three scenarios were investigated to establish current loading trends and to project how these trends may change in the future.

The results of the analysis for the average rainfall year are presented graphically in Figures 7-1 through 7-10. Figures 7-1 through 7-5 are stacked bar graphs which show the distribution of average annual loadings between the watersheds that comprise the study area. Results are presented for total runoff, total P, total N, lead and zinc. In Figures 7-6 through 7-10, the bar graphs show the distribution by source for the same five constituents. In all of the figures, values are presented for all three land use scenarios.

Figures 7-1 through 7-5 show that the Phillippi Creek, Whitaker Bayou, Bowlees Creek and South Creek watersheds account for over half of the runoff and total loadings to the Bay, excluding rainfall. Phillippi Creek and Whitaker Bayou contribute a large percentage of the total loadings for both the nutrients and the metals. In contrast, Bowlees Creek has a greater relative impact on metals loadings than on nutrient loadings, and South Creek has a greater relative impact on nutrient loadings than on metals loadings. This is because Bowlees Creek is highly industrialized relative to the other watersheds, whereas South Creek is primarily rural.

The figures also show that five-year future loadings will be similar to existing loadings, but that the buildout future loadings will be considerably higher. The results show a very small increase in total runoff volume, a small <u>decrease</u> in total P loadings, and a small <u>increase</u> in total N and metals loadings for the five-year scenario. Loading increases due to increased urbanization are offset by loading reductions due to changes in wastewater disposal methods.

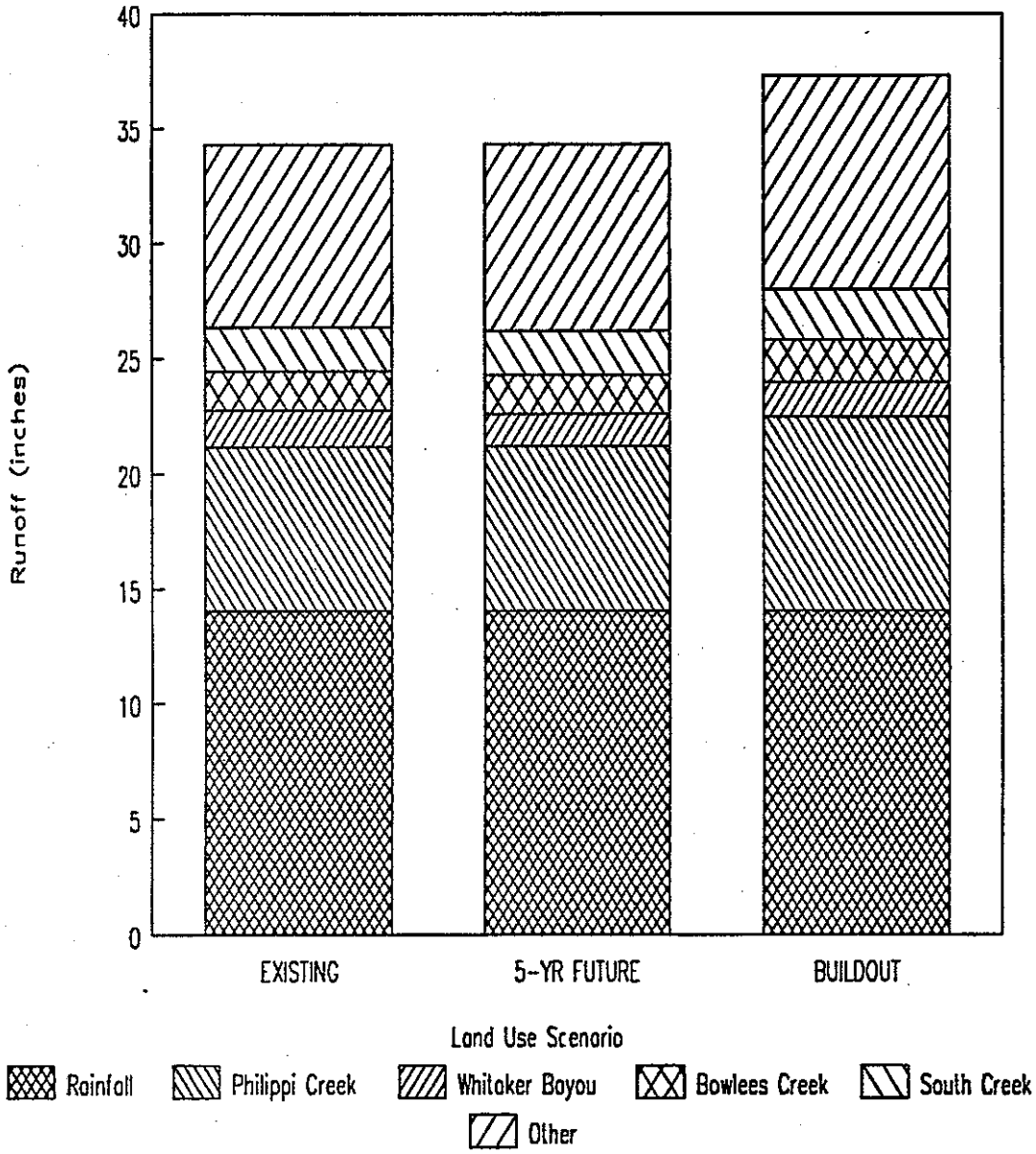

Figure 7-1. Flow Distribution by Watershed in Sarasota Bay NEP Study Area.

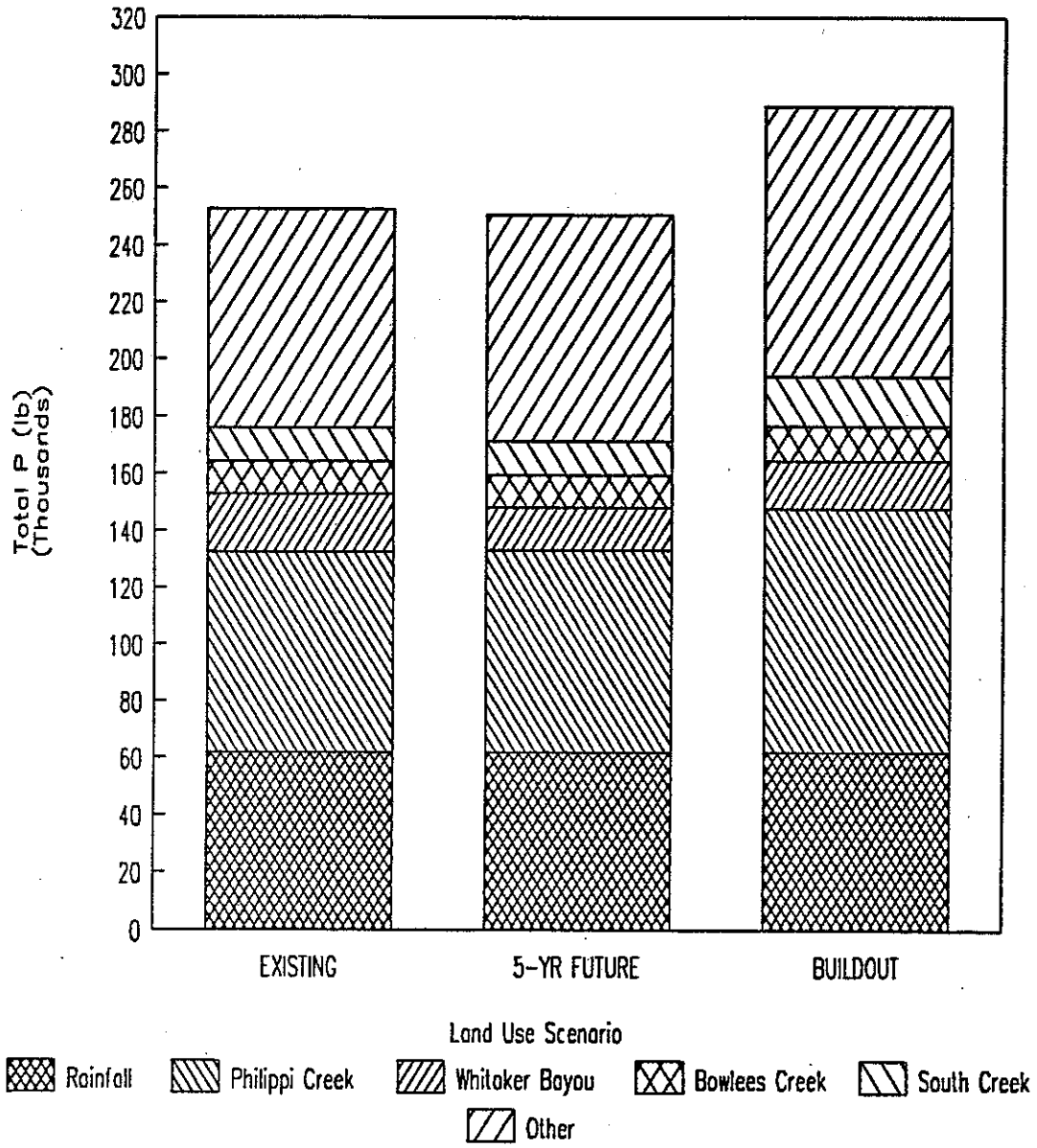

Figure 7-2. Total P Distribution by Watershed in Sarasota Bay NEP Study Area.

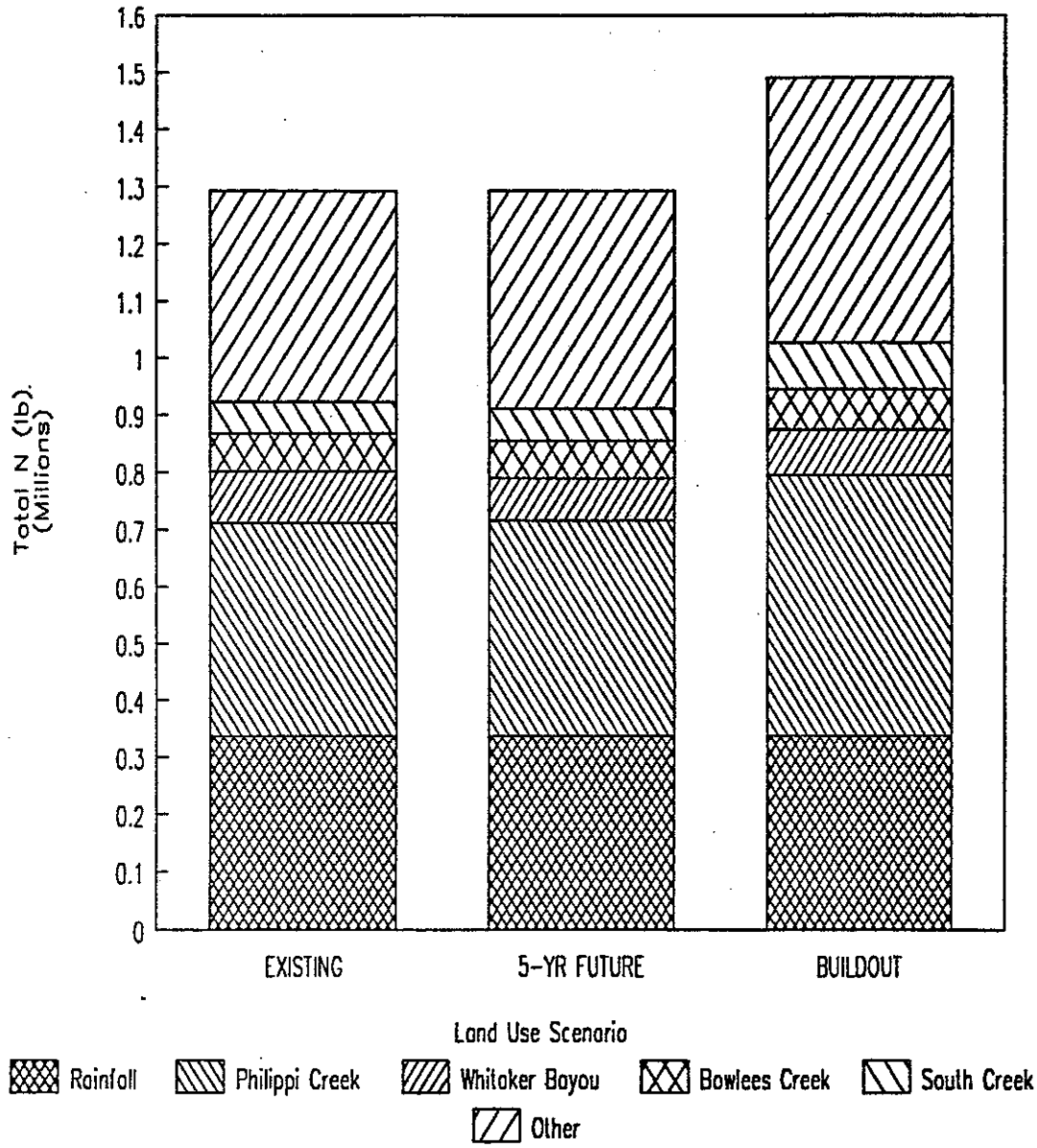

Figure 7-3. Total N Distribution by Watershed in Sarasota Bay NEP Study Area.

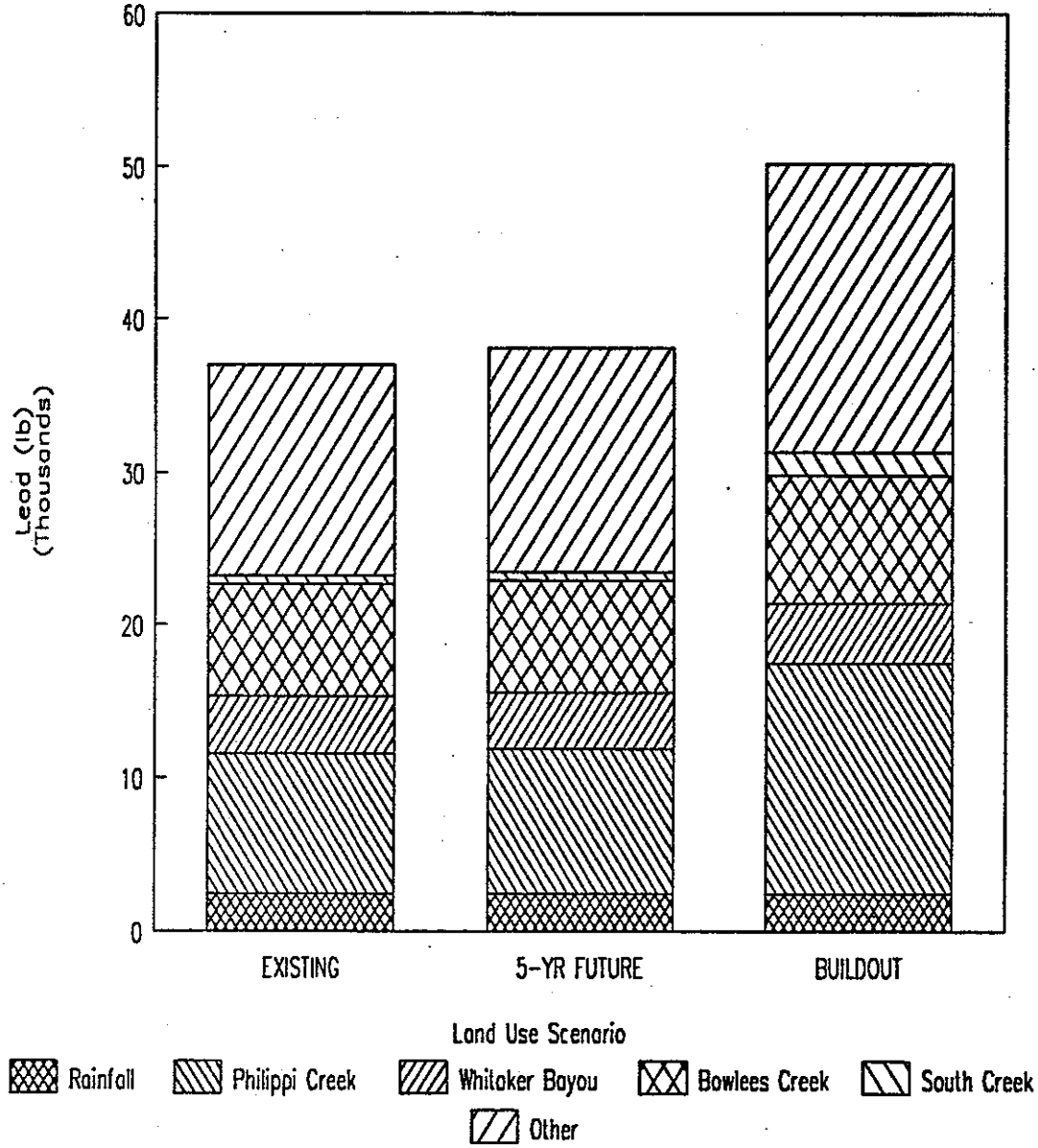

Figure 7-4. Lead Distribution by Watershed in Sarasota Bay NEP Study Area.

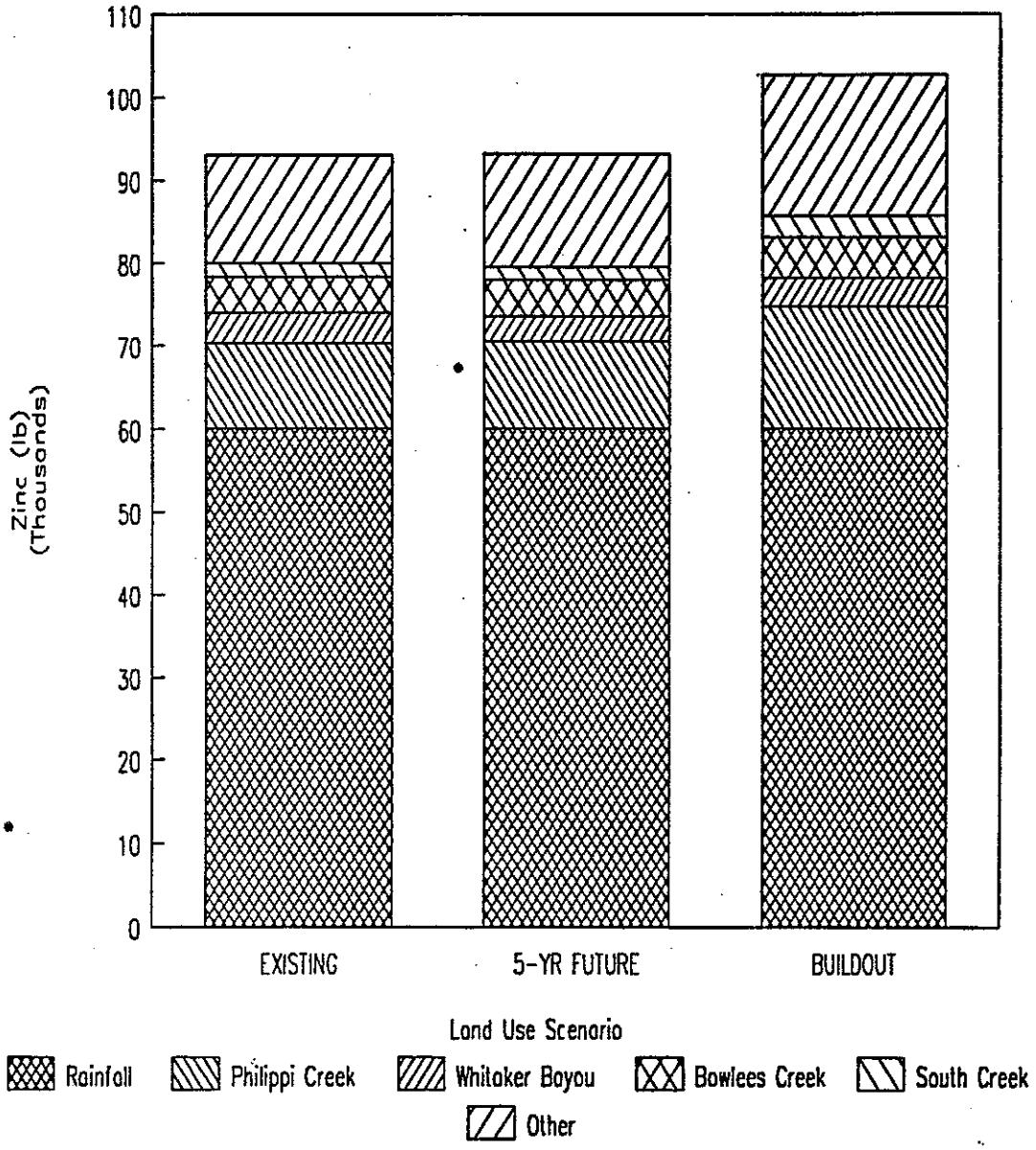

Figure 7-5. Zinc Distribution by Watershed in Sarasota Bay NEP Study Area.

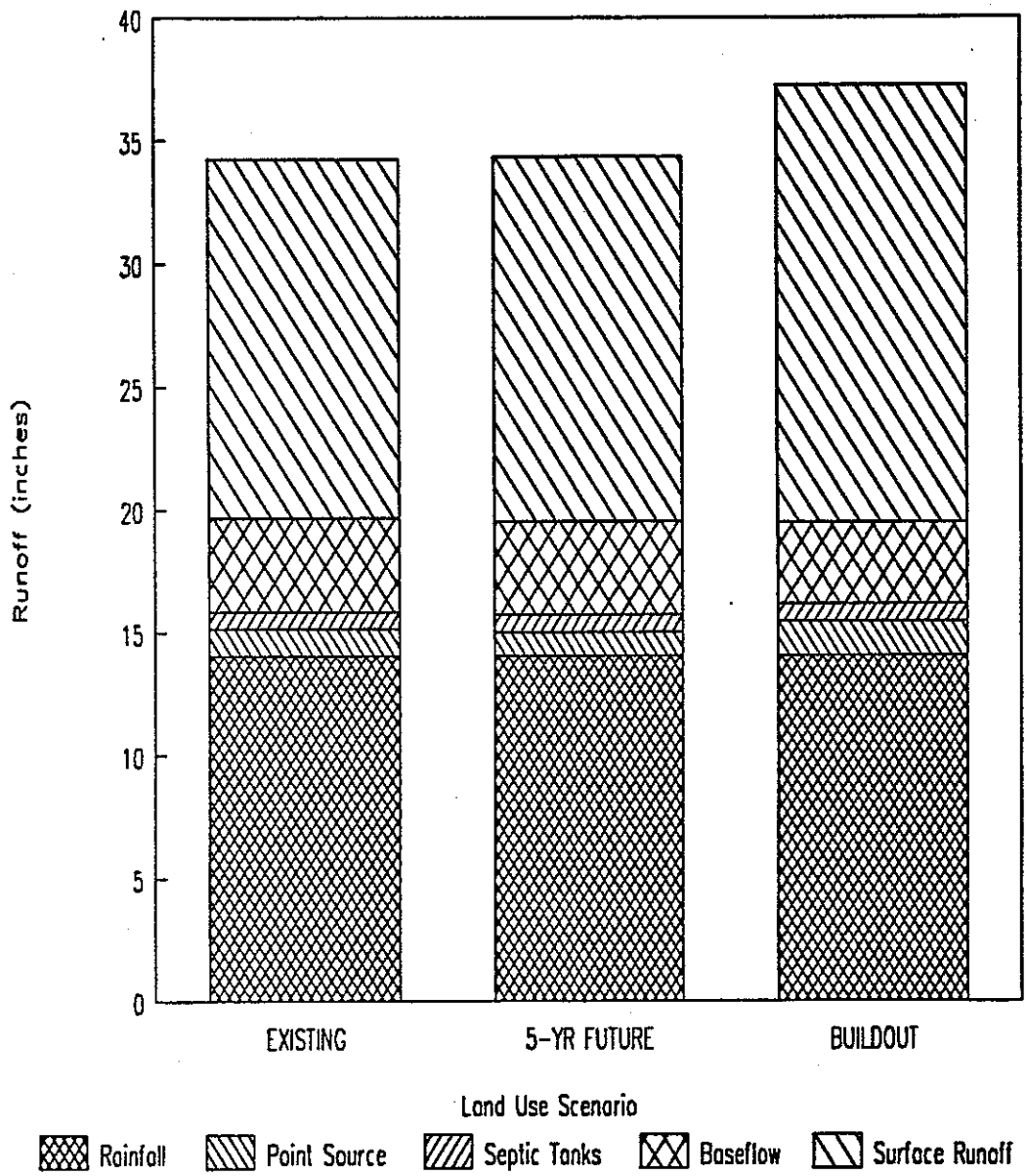

Figure 7-6. Flow Distribution by Source in Sarasota Bay NEP Study Area.

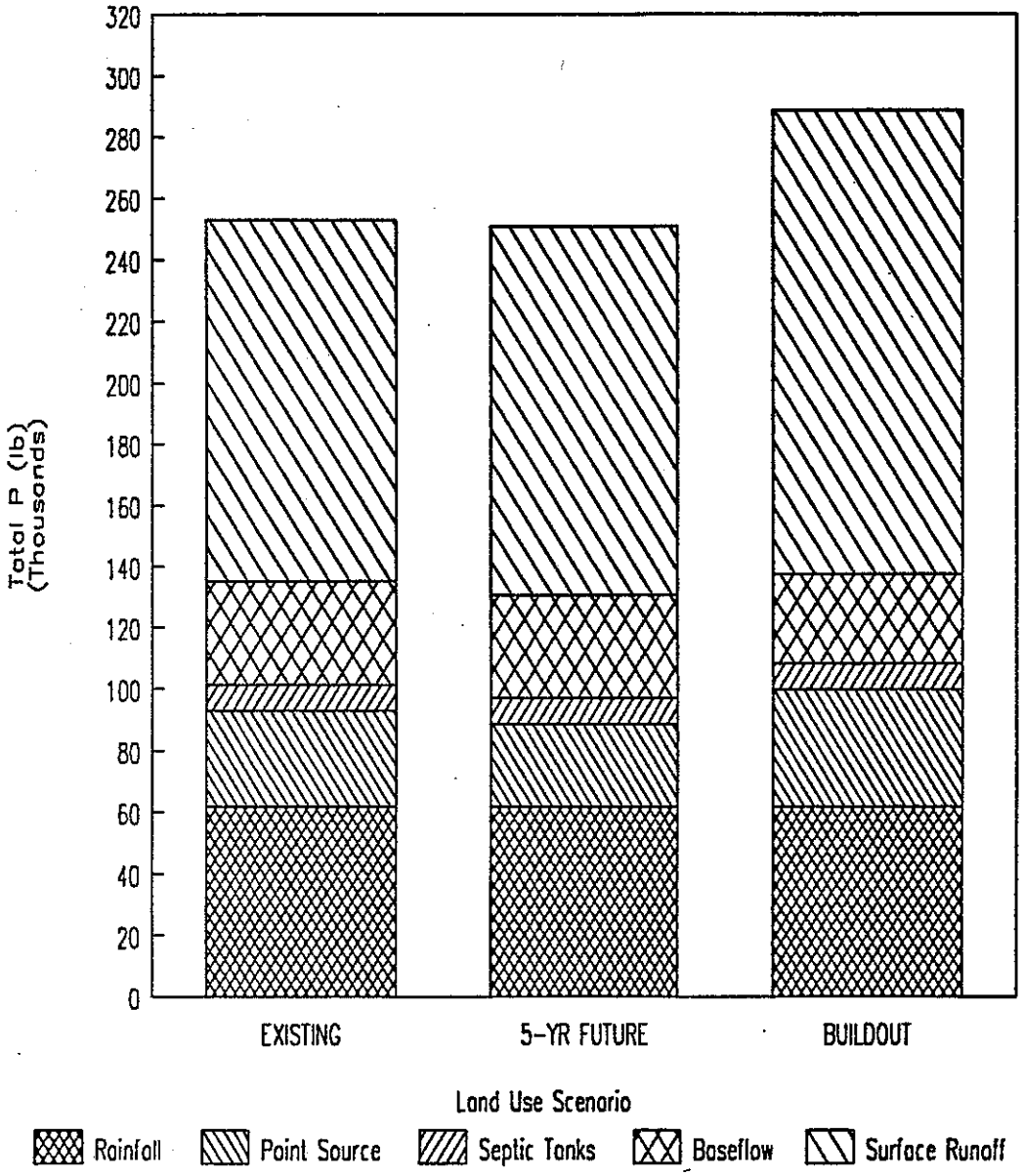

Figure 7-7. Total P Distribution by Source in Sarasota Bay NEP Study Area.

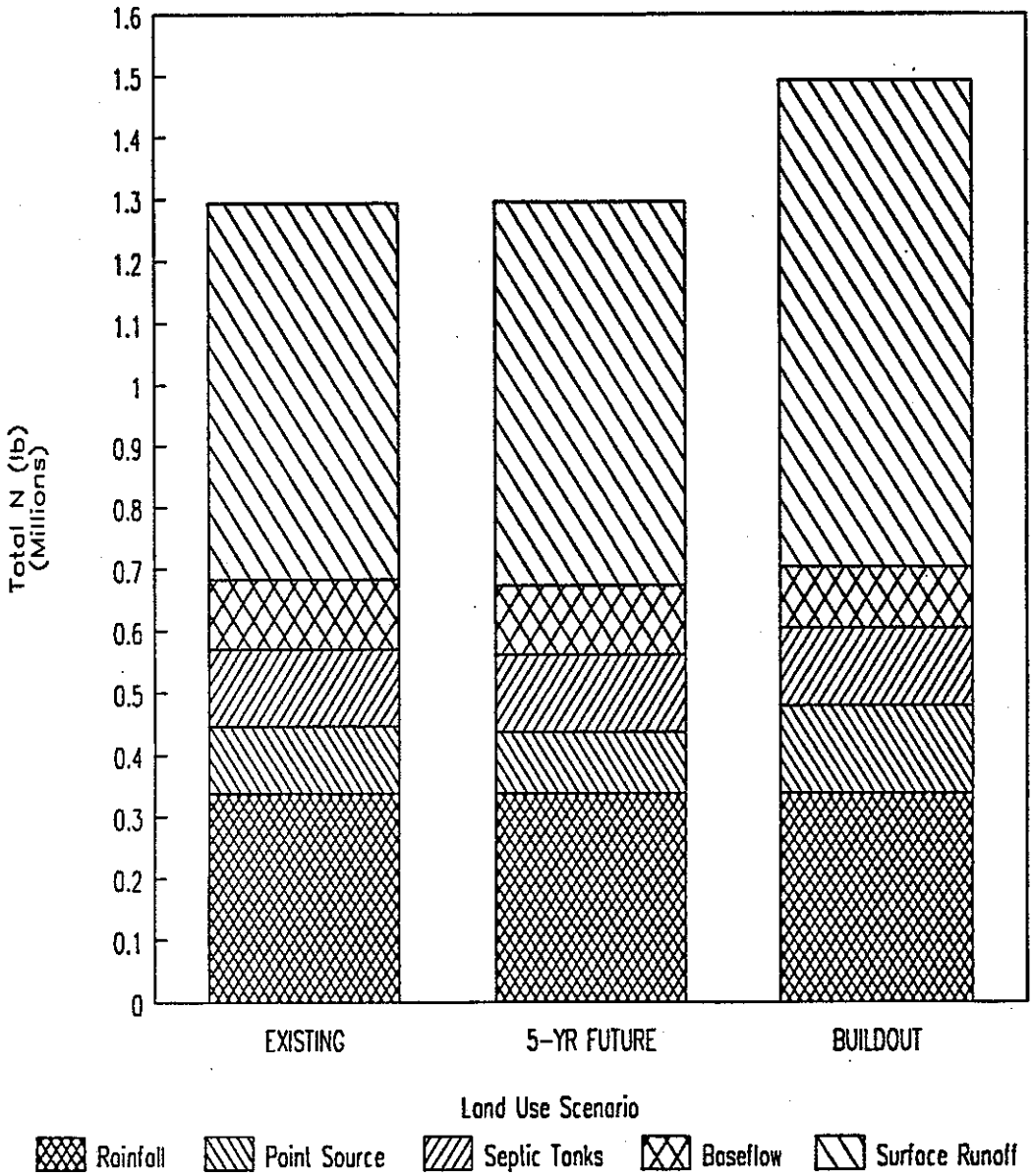

Figure 7-8. Total N Distribution by Source in Sarasota Bay NEP Study Area.

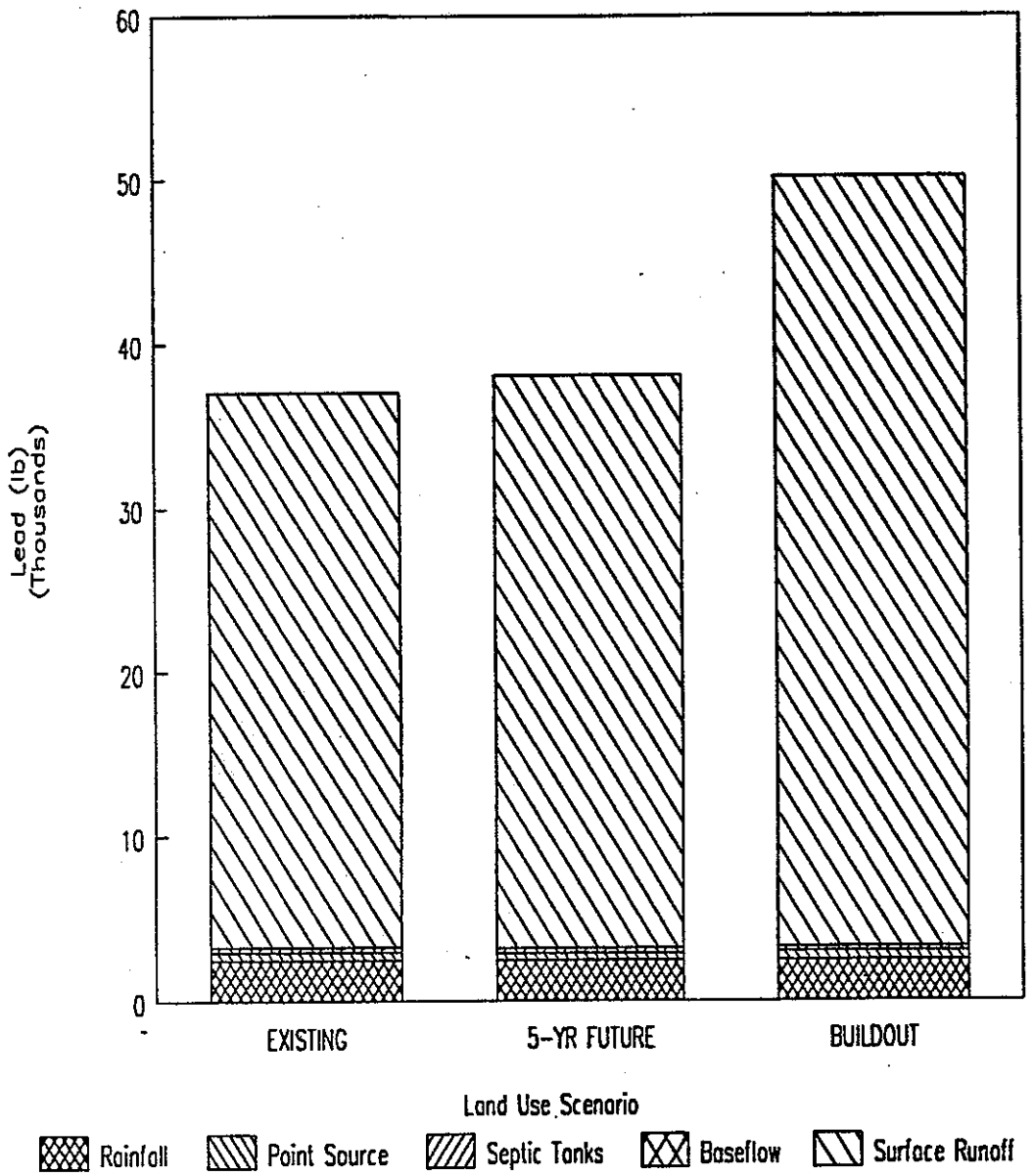

Figure 7-9. Lead Distribution by Source in Sarasota Bay NEP Study Area.

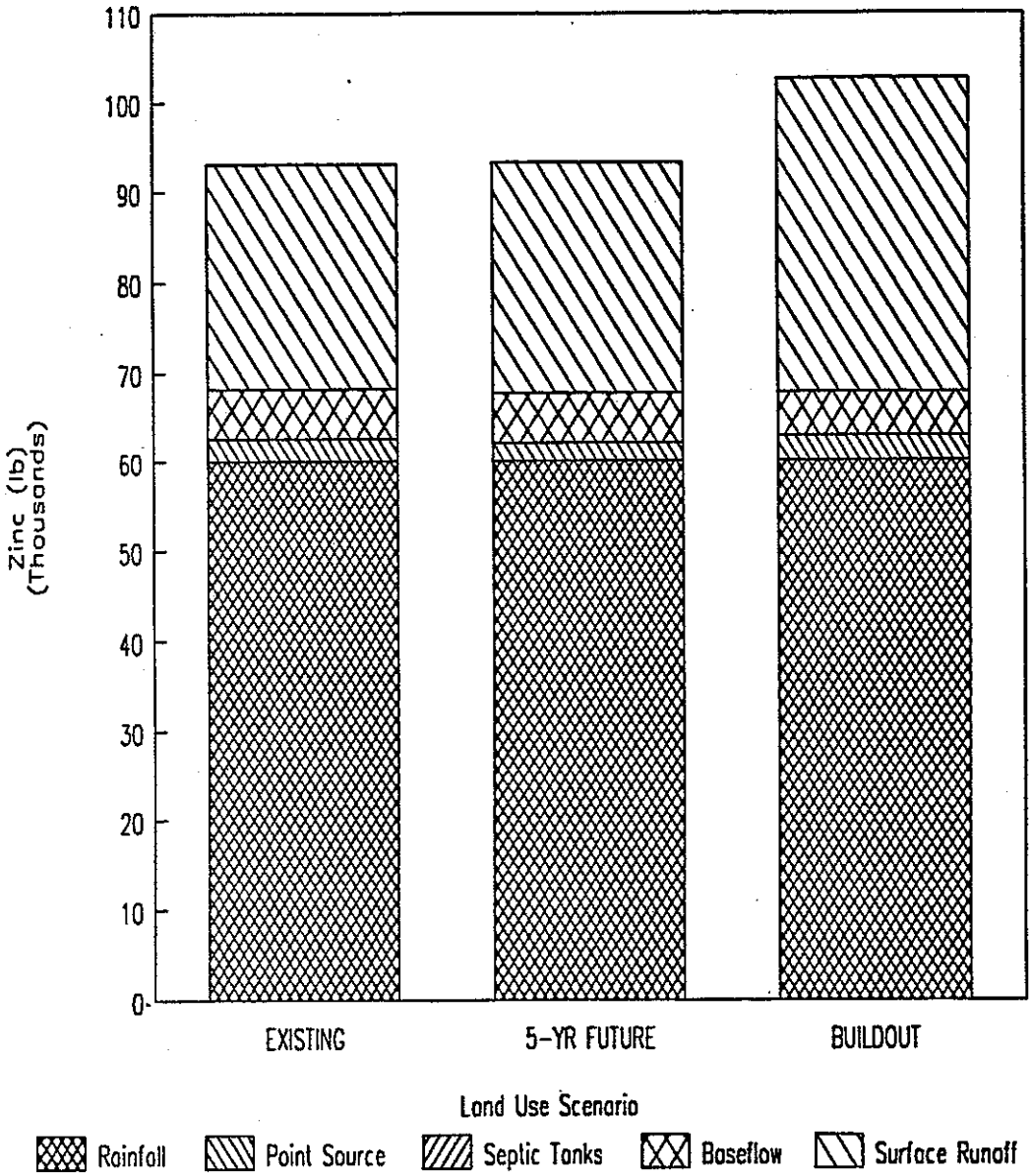

Figure 7-10. Zinc Distribution by Source in Sarasota Bay NEP Study Area.

For the buildout scenario, however, loadings are higher for all constituents. The figures generally show increased loadings for all of the watersheds, due to impacts of increasing urbanization.

Figures 7-6 through 7-10 indicate that surface runoff and rainfall are currently the most important factors in determining total loadings to the Bay. The two major sources account for 84 percent of the total runoff, and 71 to 98 percent of the nutrient and metal loadings. Of the two sources, surface runoff is the largest source of total P, total N and lead, whereas rainfall is the largest source of zinc.

As shown in the figures, point sources and septic tanks are less significant than surface runoff and rainfall. Point source loadings are relatively low because most of the treatment facilities achieve Advanced Wastewater Treatment (AWT) standards. Most of the facilities also discharge via land application (irrigation, percolation ponds, drainfields) which removes much or all of the effluent pollutant load via plant uptake or soil removal mechanisms. Septic tank loadings are not a major contributor for several reasons. One is that Sarasota County and Casey Key are the only parts of the study area in which septic tanks are in use. In addition, the failure rate of septic tanks in Sarasota County is believed to be low, based on repair permit data from the County Health Department. Finally, because of the low hydraulic conductivity and hydraulic gradients in the surficial aquifer, the travel time from any septic tank to the Bay or one of its tributaries is probably on the order of months or years. With some pollutant removal occurring as the waste travels through the aquifer, it is likely that most of the septic tank effluent loading does not reach the Bay. However, the septic tank loadings may result in localized water quality impacts, particularly in areas of high septic tank densities, relatively steep hydraulic gradients, and relatively short travel distances from the septic tanks to the receiving waters.

A comparison of existing and future distributions indicates that surface runoff will have an increasing impact on Bay loadings, while the impact of other sources will decrease or remain the same. With increased urban development, more surface runoff is generated and less

recharge occurs, resulting in lower baseflow quantities. Because new development is typically served by collection systems rather than septic tanks, the septic tank loading is not expected to increase in the future. Wastewater quantities will increase in the future as the population increases, but the combination of AWT effluent quality and land application of the effluent results in a relatively low contribution to Bay loading. Rainfall loadings are assumed to be constant.

The estimates presented here will be used as input to Phase 3 of the Sarasota Bay NEP Point and Nonpoint Source Loading Assessment. In Phase 3, alternative management strategies for control of Bay loadings will be identified and evaluated. These strategies may include nonstructural controls (e.g., land use controls), structural stormwater controls (e.g., wet detention basins, infiltration basins) and point source controls (e.g., increased use of effluent for irrigation). Both the water quality benefits and the costs of alternative strategies will be assessed. Based on the analysis, selected management strategies will be recommended.

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APPENDIX A

STORET WATER QUALITY DATA FOR TRIBUTARIES TO SARASOTA BAY

WHITAKER BAYOU AT TRI-PAR DR - BRK

YEAR	MONTH	DAY	STATION	TOTAL N (MG/L)	TOTAL P (MG/L)
75	1	27	24010558		0.170
77	11	15	24010558	0.63	0.298
78	1	17	24010558		0.234
78	3	27	24010558		0.325
80	4	28	24010558	1.22	0.609
80	9	15	24010558	1.66	0.762
80	10	13	24010558		1.092
81	2	2	24010558	1.07	0.398
81	6	15	24010558	1.32	0.944
82	1	5	24010558	1.01	0.404
82	4	5	24010558	0.87	0.193
83	2	8	24010558	0.93	0.132
83	3	28	24010558	0.92	0.351
83	4	25	24010558	0.76	0.320
83	5	31	24010558	0.67	0.554
83	10	24	24010558	0.82	0.406
84	1	23	24010558	0.82	0.188
84	2	27	24010558	0.91	0.226
84	4	2	24010558	0.69	0.307
84	7	9	24010558		
84	11	26	24010558		
85	1	21	24010558	0.73	0.300
85	3	25	24010558	0.80	0.445
85	8	20	24010558	0.82	
85	10	28	24010558		0.551
85	11	18	24010558	1.25	0.354
86	1	6	24010558	0.69	0.353
86	3	31	24010558	1.54	0.386
86	6	16	24010558		
87	1	20	24010558	0.82	0.425
87	3	23	24010558	0.63	0.431
87	6	8	24010558	0.66	0.282
87	9	22	24010558	0.86	0.444
88	1	4	24010558	0.94	0.246
88	5	2	24010558	0.98	0.378
88	9	26	24010558	1.51	0.729
88	11	14	24010558	0.98	0.318
89	1	17	24010558	0.80	0.456
89	4	24	24010558	0.80	0.480

WHITAKER BAYOU ON 27TH STREET

YEAR	MONTH	DAY	STATION	TOTAL N (MG/L)	TOTAL P (MG/L)
75	1	27	24010553		1.300
75	1	27	24010553		1.300
77	11	15	24010553	5.77	1.328
78	1	17	24010553	3.08	0.865
78	3	27	24010553	3.21	1.358
80	4	28	24010553	6.13	1.023
80	9	15	24010553	2.39	0.737
80	10	13	24010553		1.768
81	2	2	24010553	5.68	1.295
81	6	15	24010553	3.30	1.466
82	1	5	24010553	5.25	1.387
82	4	5	24010553	3.42	0.764
83	2	8	24010553	1.88	0.323
83	3	28	24010553	1.46	0.559
83	4	25	24010553	4.50	0.776
83	5	31	24010553	2.20	0.895
83	10	24	24010553	1.70	1.118
84	1	23	24010553	2.73	
84	2	27	24010553	5.09	1.230
84	4	2	24010553	6.35	1.330
84	7	9	24010553		
84	11	26	24010553		
85	1	21	24010553	5.64	1.722
85	3	25	24010553	6.56	1.982
85	8	20	24010553	3.03	
85	10	28	24010553	2.93	1.062
85	11	18	24010553	7.00	1.850
86	1	6	24010553	5.83	1.492
86	3	31	24010553	2.02	1.736
86	6	16	24010553	3.40	1.810
86	12	1	24010553	1.65	0.517
87	1	20	24010553	2.10	1.139
87	3	23	24010553	1.99	1.371
87	6	8	24010553	1.06	0.867
87	9	22	24010553	1.83	0.706
88	1	4	24010553	1.78	0.389
88	5	2	24010553	1.52	0.358
88	9	26	24010553	1.86	0.394
88	11	14	24010553	1.58	0.358
89	1	17	24010553	2.30	0.595
89	4	24	24010553	2.18	0.960

PHILLIPPI CREEK AT FRUITVILLE ROAD

YEAR	MONTH	DAY	STATION	TOTAL N (MG/L)	TOTAL P (MG/L)
75	1	10	24010626		
77	11	1	24010626	5.20	1.662
77	12	6	24010626	4.38	1.634
78	2	7	24010626	4.03	1.177
78	4	11	24010626	4.54	1.733
79	10	9	24010626		0.900
80	3	10	24010626	5.79	
80	12	1	24010626		
81	5	18	24010626	9.04	1.861
81	9	8	24010626	1.22	0.551
82	3	1	24010626	7.34	1.007
82	6	7	24010626	4.36	1.656
82	10	5	24010626	1.63	0.561
83	1	18	24010626	6.28	0.400
83	3	7	24010626	1.14	0.520
83	5	16	24010626	5.97	0.847
83	7	18	24010626	3.64	0.513
83	9	27	24010626		
84	1	3	24010626	2.59	0.591
84	3	5	24010626	3.48	0.555
84	4	9	24010626	4.81	0.673
84	8	27	24010626		
84	10	15	24010626		
85	1	14	24010626	8.64	
85	3	18	24010626	6.51	2.071
85	5	20	24010626	9.71	1.509
85	8	12	24010626	2.72	
86	1	20	24010626	10.54	
86	4	21	24010626	7.10	1.535
86	7	28	24010626	1.14	0.393
86	10	20	24010626	2.04	0.696
87	1	26	24010626	2.09	0.569
87	3	2	24010626	3.68	1.002
87	8	24	24010626	4.22	0.821
87	11	2	24010626	3.30	1.298
88	5	31	24010626	4.31	1.539
88	7	26	24010626	1.73	0.728
88	10	17	24010626	1.36	0.460
88	11	29	24010626	1.18	0.462
88	12	27	24010626	0.99	0.401
89	2	27	24010626	1.00	0.307
89	5	22	24010626	0.69	0.542

PHILLIPPI CREEK AT 17TH STREET BRIDGE

YEAR	MONTH	DAY	STATION	TOTAL N (MG/L)	TOTAL P (MG/L)
75	1	10	24010627		
77	11	1	24010627	0.79	0.468
77	12	6	24010627	1.01	0.511
78	2	7	24010627		0.438
78	4	11	24010627		0.498
79	1	24	24010627	1.44	0.585
79	3	5	24010627	0.59	0.532
79	4	24	24010627	0.53	1.193
79	10	9	24010627		0.579
80	1	21	24010627	1.97	0.985
80	3	10	24010627	2.13	0.420
80	12	1	24010627		
81	5	18	24010627	1.29	0.428
81	9	8	24010627	1.01	0.451
82	3	1	24010627	1.25	0.549
82	6	7	24010627	1.15	0.791
82	10	5	24010627	1.40	0.357
83	1	18	24010627	1.53	0.208
83	3	7	24010627	3.29	0.750
83	5	16	24010627	0.74	1.426
83	7	18	24010627	0.83	0.402
83	9	27	24010627		
84	1	3	24010627	1.15	0.306
84	3	5	24010627	1.00	0.329
84	4	9	24010627	1.30	0.416
84	8	27	24010627		
84	10	15	24010627		
85	1	14	24010627	0.83	0.353
85	3	18	24010627	0.65	0.418
85	5	20	24010627	0.74	0.290
85	8	12	24010627	1.01	0.350
86	1	20	24010627	1.23	0.270
86	4	21	24010627	1.11	0.672
86	7	28	24010627	0.96	0.432
86	10	20	24010627	0.95	0.445
87	1	26	24010627	1.33	0.427
87	3	2	24010627	1.16	0.681
87	8	24	24010627	3.19	0.450
87	11	2	24010627	0.96	0.440
88	2	16	24010627	0.96	0.279
88	5	31	24010627	0.56	0.480
88	7	26	24010627	1.13	0.413
88	10	17	24010627	1.11	0.420
88	11	29	24010627	1.22	0.362
88	12	27	24010627	1.05	0.421
89	2	27	24010627	0.94	0.348
89	5	22	24010627	0.82	0.659

PHILLIPPI CREEK AT 17TH ST WEST BRIDGE

YEAR	MONTH	DAY	STATION	TOTAL N (MG/L)	TOTAL P (MG/L)
79	10	1	24010670	1.88	0.976
80	1	21	24010670	9.71	
80	3	10	24010670	8.55	
83	1	3	24010670		1.101
84	3	5	24010670	8.34	0.945
84	4	9	24010670	7.67	1.187
84	8	27	24010670		
84	10	15	24010670		
85	1	14	24010670	16.32	1.568
85	3	18	24010670	18.59	3.664
85	5	20	24010670		1.489
85	8	12	24010670	13.14	
86	1	20	24010670	19.23	
86	4	21	24010670	12.82	1.920
86	7	28	24010670	0.88	0.845
86	10	20	24010670	3.06	1.161
87	1	26	24010670	3.57	0.874
87	3	2	24010670	6.64	1.783
87	8	24	24010670	2.56	1.447
87	11	2	24010670	5.61	5.969
88	2	16	24010670	3.30	0.716
88	7	26	24010670	2.20	1.299
88	10	17	24010670	0.93	0.661
88	11	29	24010670	0.91	0.603
88	12	27	24010670	0.80	0.562
89	2	27	24010670	1.31	0.613
89	5	22	24010670	0.81	0.794

CLARKS LAKE DRAINAGE AT WILKINSON ROAD

YEAR	MONTH	DAY	STATION	TOTAL N (MG/L)	TOTAL P (MG/L)
77	10	25	24010642	1.01	0.415
79	9	24	24010642	1.00	0.414
80	1	21	24010642	3.35	0.606
80	3	10	24010642	2.70	
80	12	1	24010642		
81	9	8	24010642	1.13	0.451
82	3	1	24010642	1.40	0.349
82	6	7	24010642	1.85	0.617
82	10	5	24010642	2.38	0.485
83	1	18	24010642	1.50	0.256
83	3	7	24010642	2.13	0.358
83	5	16	24010642	0.82	0.492
83	7	18	24010642	0.93	0.718
83	9	27	24010642		
84	1	3	24010642	1.59	0.265
84	3	5	24010642	1.36	0.267
84	4	9	24010642	1.84	0.297
84	8	27	24010642		
84	10	15	24010642		
85	1	14	24010642	0.69	0.235
85	3	18	24010642	1.28	0.438
85	5	20	24010642	1.29	1.276
85	8	12	24010642	1.10	0.214
86	1	20	24010642	1.18	
86	4	21	24010642	0.76	0.423
86	7	28	24010642	1.26	0.413
86	10	20	24010642	1.16	0.232
87	1	26	24010642	1.39	0.305
87	3	2	24010642	1.56	0.441
87	8	24	24010642	1.46	0.450
87	11	2	24010642	1.54	0.398
88	2	16	24010642	1.39	0.199
88	5	31	24010642	0.81	0.440
88	7	26	24010642	0.95	0.433
88	10	17	24010642	1.34	0.280
88	11	29	24010642	1.28	0.321
88	12	27	24010642	1.32	0.421
89	2	27	24010642	1.38	0.286
89	5	22	24010642	1.09	0.736

MAIN A CNL AT CATTLEMANS ROAD BRIDGE

YEAR	MONTH	DAY	STATION	TOTAL N (MG/L)	TOTAL P (MG/L)
74	11	19	24010629		0.150
78	1	24	24010629	1.31	0.328
78	4	4	24010629		0.310
79	10	1	24010629	2.04	0.965
80	1	21	24010629	2.86	0.606
80	3	10	24010629	1.53	0.210
80	12	1	24010629		
81	5	18	24010629	1.79	0.553
81	9	8	24010629	1.52	1.027
82	3	1	24010629	1.46	0.458
82	6	7	24010629	1.65	0.791
82	10	5	24010629	1.62	0.602
83	1	18	24010629	0.87	0.250
83	3	7	24010629	1.12	0.177
83	5	16	24010629	0.81	0.323
83	7	18	24010629	0.95	1.273
83	9	27	24010629		
84	1	3	24010629	1.59	0.286
84	3	5	24010629	1.15	0.185
84	4	9	24010629	1.39	0.297
84	8	27	24010629		
84	10	15	24010629		
85	1	14	24010629	1.29	0.510
85	3	18	24010629	2.72	0.817
85	5	20	24010629	0.67	
85	8	12	24010629	1.52	
86	7	28	24010629	2.37	
86	10	20	24010629	1.30	0.619
87	1	26	24010629	2.43	0.529
87	3	2	24010629	2.29	1.022
87	8	24	24010629	1.72	0.469
87	11	2	24010629	1.49	0.628
88	2	16	24010629	1.57	0.358
88	5	31	24010629	0.67	0.820
88	7	26	24010629	1.04	0.787
88	10	17	24010629	1.20	0.240
88	11	29	24010629	1.42	0.562
88	12	27	24010629	1.33	0.341
89	2	27	24010629	0.89	0.307
89	5	22	24010629	2.71	0.446

PHILLIPPI CREEK AT BAHIA VISTA STREET BRIDGE

YEAR	MONTH	DAY	STATION	TOTAL N (MG/L)	TOTAL P (MG/L)
75	1	10	24010625		
77	11	1	24010625	2.62	1.041
77	12	6	24010625	2.73	1.109
78	2	7	24010625	2.18	0.492
78	4	11	24010625	2.78	1.520
79	1	24	24010625	2.37	
79	3	5	24010625	1.70	0.772
79	4	24	24010625	2.20	1.888
79	9	24	24010625	0.91	0.695
80	3	10	24010625	2.88	0.420
80	12	1	24010625		
81	5	18	24010625	5.03	2.188
82	3	1	24010625	3.73	1.111
82	6	7	24010625	2.57	1.114
82	10	5	24010625	1.89	0.642
83	1	18	24010625	4.38	0.944
83	3	7	24010625	2.57	0.583
83	5	16	24010625	3.47	1.174
83	7	18	24010625	1.76	0.985
83	9	27	24010625		
84	1	3	24010625	2.43	0.653
84	3	5	24010625	2.52	0.637
84	4	9	24010625	2.84	0.673
84	8	27	24010625		
84	10	15	24010625		
85	1	14	24010625	4.70	
85	3	18	24010625	2.93	1.215
85	5	20	24010625	5.07	1.857
85	8	12	24010625	1.53	
86	1	20	24010625	5.94	
86	4	21	24010625	4.60	
86	7	28	24010625	1.42	0.413
86	10	20	24010625	2.36	0.754
87	1	26	24010625	2.16	0.590
87	3	2	24010625	3.55	1.002
87	8	24	24010625	2.39	0.704
87	11	2	24010625	2.77	0.942
88	2	16	24010625	2.06	0.537
88	5	31	24010625	2.63	1.099
88	7	26	24010625	2.62	0.846
88	10	17	24010625	3.23	0.801
88	11	29	24010625	2.77	0.663
88	12	27	24010625	3.16	0.822
89	2	27	24010625	4.84	1.472
89	5	22	24010625	6.19	1.646

MAIN A CNL AT BAHIA VISTA ST BRIDGE

YEAR	MONTH	DAY	STATION	TOTAL N (MG/L)	TOTAL P (MG/L)
75	1	10	24010628		
79	1	24	24010628	1.87	
79	3	5	24010628	1.51	0.632
79	4	24	24010628	0.94	0.691
79	9	24	24010628	0.29	0.705
80	1	21	24010628	3.95	1.061
80	1	21	24010628	4.41	1.061
80	3	10	24010628	2.65	0.420
80	3	10	24010628	2.54	0.420
80	12	1	24010628		
81	5	18	24010628	5.03	3.043
82	1	18	24010628	2.14	0.761
82	3	1	24010628	2.96	1.385
82	6	7	24010628	2.00	0.894
82	10	5	24010628	1.84	0.702
83	3	7	24010628	2.39	0.832
83	5	16	24010628	3.28	1.040
83	7	18	24010628	1.18	2.874
83	9	27	24010628		
84	1	3	24010628	2.01	0.367
84	3	5	24010628	2.73	
84	4	9	24010628	1.95	0.435
84	8	27	24010628		
84	10	15	24010628		
85	1	14	24010628	3.55	1.293
85	3	18	24010628	3.08	1.374
85	5	20	24010628	5.89	1.934
85	8	12	24010628	1.10	
86	1	20	24010628	4.89	
86	4	21	24010628	9.61	
86	7	28	24010628	1.70	
86	10	20	24010628	2.12	0.948
87	1	26	24010628	2.34	0.569
87	3	2	24010628	4.76	1.282
87	8	24	24010628	2.48	0.704
87	11	2	24010628	2.33	0.754
88	2	16	24010628	2.13	0.438
88	5	31	24010628	4.93	1.959
88	7	26	24010628	2.24	0.866
88	10	17	24010628	2.26	0.380
88	11	29	24010628	3.22	0.723
88	12	27	24010628	2.11	0.421
89	2	27	24010628	2.77	0.532
89	5	22	24010628	5.15	1.937

PHILLIPPI CREEK AT SARASOTA, FL

YEAR	MONTH	DAY	STATION	TOTAL N (MG/L)	TOTAL P (MG/L)
68	5	14	2299800		2.500
70	6	11	2299800		1.000
70	10	6	2299800		0.880
71	4	21	2299800		2.600
71	10	13	2299800		0.350
72	4	27	2299800		1.600
74	5	2	2299800	3.04	2.400
74	10	15	2299800		0.700
75	4	14	2299800		3.200
75	10	20	2299800		0.510
76	6	1	2299800	3.09	0.940
76	9	16	2299800	1.50	0.430
77	5	2	2299800	3.10	1.160
77	10	12	2299800	1.70	0.750
78	5	8	2299800		

MAIN A CNL AT PALMERS BLVD BRIDGE

YEAR	MONTH	DAY	STATION	TOTAL N (MG/L)	TOTAL P (MG/L)
74	11	19	24010630		0.160
77	11	1	24010630	0.88	0.194
77	12	6	24010630	1.90	0.527
78	1	24	24010630	1.33	0.270
78	4	4	24010630		0.417
79	1	24	24010630	0.95	1.652
79	3	5	24010630	1.99	0.681
79	4	24	24010630	0.54	0.658
79	10	1	24010630	1.61	0.886
80	1	21	24010630	2.51	0.606
80	3	10	24010630	3.05	
80	12	1	24010630		
81	5	18	24010630	0.75	0.252
81	9	8	24010630	1.46	0.877
82	3	1	24010630	1.51	0.291
82	6	7	24010630	1.56	0.820
83	1	18	24010630	1.03	0.148
83	3	7	24010630	1.28	0.225
83	5	16	24010630	0.89	0.209
83	7	18	24010630	1.28	0.965
83	9	27	24010630		
84	1	3	24010630	1.61	0.224
84	3	5	24010630	1.50	
84	4	9	24010630	1.29	
84	8	27	24010630		
84	10	15	24010630		
85	1	14	24010630	0.69	0.137
85	3	18	24010630		0.697
85	5	20	24010630	0.57	0.058
85	8	12	24010630	1.72	0.389
86	1	20	24010630	0.84	
86	4	21	24010630	0.74	0.384
86	7	28	24010630	1.10	
86	10	20	24010630	1.42	0.155
87	1	26	24010630	3.07	0.285
87	3	2	24010630	1.52	0.461
87	8	24	24010630	1.73	0.391
87	11	2	24010630	1.12	0.251
88	2	16	24010630	4.35	0.318
88	5	31	24010630	0.69	0.240
88	7	26	24010630	1.07	0.472
88	10	17	24010630	2.27	0.160
88	11	29	24010630	1.60	0.362
88	12	27	24010630	1.06	0.140
89	2	27	24010630	0.48	0.061
89	5	22	24010630	4.10	0.484

APPENDIX B

TECHNICAL MEMORANDUM ON SEPTIC TANK LITERATURE REVIEW AND ANALYSIS

M E M O R A N D U M

TO: Mike Heyl, CDM/Sarasota

FROM: Rich Wagner, CDM/Annandale

SUBJECT: Literature Review of Septic Tank Loadings

DATE: January 27, 1992

INTRODUCTION

CDM conducted a literature review to evaluate the pollutant loadings contributed by septic tank systems. Data gathered as part of this review include septic tank wastewater flow rates and effluent characteristics, pollutant removal mechanisms and efficiencies in drainfields, and delivery of loadings to surface waters. These data were used to assess the pollution impacts of septic tanks in the Sarasota Bay NEP study area.

LITERATURE SEARCH

Sources of information were obtained through a computerized literature review in conjunction with manual research of sources based on previous work. The initial computer search was conducted through the United States Geological Survey (USGS) on-line library system. Key words such as "septic tank","onsite disposal system", and "groundwater contamination" were used to identify potential sources of data in technical journals, textbooks, and conference proceedings. In addition, sources were identified by examining the literature review that is published annually by the Journal of the Water Pollution Control Federation (WPCF). The review includes a segment devoted specifically to on-site alternatives for treatment and disposal.

After the USGS and WPCF listings had been reviewed, specific journal articles, reports and conference proceedings were obtained. These sources were reviewed to provide data for the septic tank loading assessment. In addition, the sources included other references that were reviewed in order to identify other apparent data sources, which were then obtained and reviewed.

In all, over 50 articles and reports were reviewed as part of the septic tank loading evaluation. Those that were used in the evaluation are identified in the bibliography of this memorandum.

DEFINITION OF LOADING PARAMETERS

The data found during the literature was used to define a number of loading parameters for the analysis. These parameters include the following:

- Typical effluent flow rate (gal/capita/day)
- Typical effluent water quality characteristics (e.g., concentrations of various pollutants)
- Typical removal processes and efficiencies that characterize effluent percolation through the soil
- Processes occurring after the effluent reaches the groundwater and is ultimately transported to surface waters

Of these parameters, effluent quantity and quality were documented in many studies. Removal processes during percolation are also well-documented, and efficiencies are listed or can be estimated by analysis of monitoring data in the literature. Unfortunately, processes occuring between the drainfields and surface waters and estimation of surface water loadings due to septic tanks are not well-documented. However, several articles have considered the far-field impacts of septic tank loadings, and these were used to develop a methodology for estimating septic tank impacts for Sarasota Bay.

Effluent Flow Rate

Table 1 presents a listing of effluent flow rates in gallons/capita/day (gpcd) that were either measured or assumed by various authors. Typically, the values range between 40 and 80 gpcd. Local water usage data for the study area indicate that the per capita wastewater flow rate for the study area is expected to be about 75 gpcd, which is at the high end of the identified range. Based on the local data, a value of 75 gpcd was selected as a typical flow rate for septic tank systems in the study area.

Effluent Quality

Water quality characteristics for septic tank effluent are presented in Table 2. These values were either measured or assumed by various authors. The table focuses on total nitrogen (total N) and total phosphorus (total P), because nutrient impacts are typically the major concern for septic tanks. For each source, the table indicates the number of samples and the average concentration for total N and total P.

As shown in Table 2, both the concentration and the range of concentrations for total N is larger than for total P. Total N values in the literature ranged from 40 to 130 mg/L, with most of the values in the 40 to 80 mg/L range. For the purposes of this study, a mid-range value of 60 mg/L was selected for the total N effluent concentration. In contrast, the total P effluent concentratins ranged from 4 to 16 mg/L. A number of the observations fall between 13 and 16 mg/L, so a value of 15 mg/L was

selected for the purposes of this study.

Removal Processes and Efficiencies in Unsaturated Zone

In the case of total P, the main removal process in the unsaturated soil zone between the septic tank and the water table is adsorption. Many articles have concluded that most or virtually all of the total P in the effluent will be captured in the drainfield, such that adverse water quality impacts on groundwater or surface waters are unlikely. Several articles have indicated that pollution due to total P may ultimately occur when the adsorptive capacity of the soil is exceeded, but this would require a substantial, long-term discharge.

Removal of total N is not as complete nor as simple as that of total P. Of the total N, typically about 20 percent is in the organic form, and the remaining 80 percent is present as ammonia nitrogen. The organic nitrogen is likely to be removed during effluent percolation via filtration. The ammonia nitrogen, on the other hand, will primarily remain in solution rather than being removed through adsorption. In most cases, the ammonia nitrogen is completely converted to nitrate nitrogen in the drainfield, if aerobic conditions are present. Nitrate nitrogen is very mobile in solution, and very little nitrate removal would be expected in the drainfield under aerobic conditions. If part of the drainfield is anaerobic, however, and a sufficient carbon source is present, denitrification may occur, converting nitrate nitrogen to nitrogen gas. This would reduce the amount of nitrogen entering the groundwater and, ultimately, surface waters.

Based on the literature data, it is difficult to precisely quantify the removal of total N and total P between the septic tank and the water table. In some cases, nutrient concentrations are reported in the soil near the septic tank, but the septic tank effluent concentrations are not specified. In other cases, a removal percentage is defined without specifying the effluent and soil concentrations. Also, the removal efficiency may vary at a particular site depending upon the conditions at the time of the monitoring.

After a review of the data, it was assumed that the concentrations of total N and total P after percolation to the water table are 30 mg/L and 2 mg/L, respectively. Given the assumed total N effluent concentration of 60 mg/L, the water table concentration of 30 mg/L presumes that 50 percent of the total N is removed as the effluent percolates through the soil. This concentration and percent removal are consistent with the results presented by Andreoli et al. (1980), Walker et al.(1973a), Ellis (1983), and Cogger et al. (1988). For total P, an assumed water table concentration of 2 mg/L implies a removal of about 90 percent during the effluent

percolation, based on the assumed effluent concentration of 15 mg/L. Numerous studies, such as Jones and Lee (1979), Gilliam and Patmont (1983), Reneau et al. (1989) and Sawhney and Starr (1977) have concluded that 90 percent or more of the total P remains in the soil. Thus, both of these assumed values are reasonable with respect to findings of other studies.

Surface Water Impacts

Though most of the focus in the literature has been on effluent quality and groundwater concentration in the immediate vicinity of individual septic tanks, several studies have analyzed the potential extent of large-scale septic tank impacts on groundwater quality and surface water quality. Surface water studies typically used monitoring data to identify areas with septic tank loadings, and to quantify the loadings, whereas groundwater studies typically developed a modeling framework to assess loadings. Several of the modeling studies are described below.

Bauman and Schafer (1984) have developed a method of estimating groundwater impacts for nitrogen based on a mass balance approach. The approach requires an evaluation of the water budget and the nitrogen budget within the surficial aquifer. Water budget and nitrogen budget components include groundwater flow, natural recharge and septic system effluent. By determining the volume of water from each source and defining a nitrogen concentration for each source, the concentration of the combined sources can be calculated. Groundwater flow is calculated by determining aquifer thickness, width, hydraulic conductivity and hydraulic gradient, and groundwater concentration is based on local monitoring data. Similarly, recharge volume and concentration is determined from local data, and septic tank data are estimated based on population density and typical effluent characteristics.

A transport model for pollutants in the water table aquifer has been developed by Anderson et al (1987) as part of the Florida Onsite Disposal System (OSDS) project. The model is more complex than that of Bauman and Schafer, simulating transport as a steady, one-dimensional flow field with three-dimensional dispersion, retardation, and first-order decay. Though more complex, required data for this model are similar to those required for the mass balance model, including septic tank flows and loadings, as well as aquifer hydraulic conductivity and hydraulic gradient. Dispersivity factors are also required to quantify the dispersion of the effluent down gradient of the source.

A third approach to modeling surficial aquifers affected by septic tank effluent was presented by Ostendorf (1986). This model simulates the near field mixing and routing of effluent and groundwater as a linear reservoir, and simulates far field pollutant concentrations based on a first order decay rate. As with the other models, the essential data include effluent flow,

effluent water quality characteristics, and aquifer characteristics (e.g., hydraulic conductivity, hydraulic gradient, thickness).

The Ostendorf model was applied at the Otis Air Force Base in Massachusetts, which has discharged an average effluent flow rate of 0.53 mgd to its drainfields since 1941. Concentrations of chloride, boron, total N and methylene blue active substances (MBAS) were measured in the groundwater at various distances downgradient of the drainfields. Using the input data described above, the model was tested first for chloride, a conservative constituent, to determine if the model transport simulation was accurate. The results showed an excellent agreement between predicted and measured concentrations downgradient of the drainfields. Then, the model was applied for the other constituents, including the calibration of total N and MBAS by the evaluation of a first order decay rate.

After reviewing these modeling approaches, a methodology for estimating septic loads that reach receiving waters was developed. The methodology uses some of the components of these models. The development of the methodology is discussed in the next section.

MODELING METHODOLOGY

Calculation of septic tank loadings to surface waters is performed within the NPS spreadsheet model. The existing model already includes a method for calculating loads due to failing septic tanks. As part of the Sarasota Bay NEP Study, the model has been modified to include the calculation of loads due to septic tanks that are not failing. The calculation method for both failing and working septic tanks are presented below.

Failing Septic Tanks

Nutrient concentrations for failing septic tanks were established based on the literature review. It was assumed that the concentrations for a failing septic tank are equivalent to the concentrations established for the effluent at the water table. These were as follows:

- Total N 30 mg/L
- Total P 2 mg/L

The values reflect pollutant removal within the soil of roughly 50 percent for total N and 90 percent for total P.

Nutrient loadings for specific land uses were calculated by multiplying the concentrations by a flow rate. The flow rate for a particular land use depended upon the number of residents per acre, and the per capita flow rate.

Table 3 shows the septic tank flow rates developed for various land uses. For all land uses, a per capita flow rate of 75 gallons per day was established. For the residential areas, values of dwelling units per acre were determined based on the descriptions of various land uses in the Sarasota County Comprehensive Plan and densities observed in aerial photographs. Each dwelling unit is assumed to have 2.0 people, based on household size estimates for Sarasota and Charlotte Counties and the City of North Port, as cited in the City of North Port Comprehensive Plan. This value is somewhat lower than the national average, because some of the population is seasonal and because the population distribution is weighted more heavily toward retired persons who would tend to have a smaller household size. For commercial and industrial areas, the flow values were assumed equal to the highest residential value. The literature indicates that commercial and industrial flows can vary widely, but it was assumed that any large industrial or commercial wastewater source would be served by sewers.

A final consideration in the loading analysis for failing septic tanks is the failure rate - that is, what percentage of the tanks are failing. These data were established based on permitting data from the Sarasota County Health Department. The Health Department requires a permit for repair or replacement of septic tanks. During the period 1980 through 1990, an average of 740 repairs per year was recorded. Based on the estimate of 45,000 septic tanks in the County, the annual repair rate is 1.6 percent. Recognizing that failure may occur for a number of years before repairs are initiated, the failure rate at any time is likely to be higher than 1.6 percent. In previous studies, the annual failure rate has been multiplied by a factor of 5, which implies that septic systems on average fail for 5 years before repairs are made. For Sarasota County, the resulting failure rate is 8 percent. This value compares favorably with the results of a septic tank survey conducted in Jacksonville, FL by the Department of Health and Rehabilitative Services. In the study, an inspection of more than 800 sites revealed about 90 violations, or a failure rate of 12 percent. Failure calculations also were done specifically for Casey Key, which had a higher annual repair rate. The failure rate established for Casey Key was 20 percent.

Working Septic Tanks

The surface water loading due to effluent from working septic tanks is calculated based on the modeling frameworks that were found in the literature (Bauman and Schafer, 1984; Ostendorf, 1986). The model assumes that a load of total N and total P enters the surficial aquifer below the septic tank after percolating through the unsaturated soil zone. The load then travels along with the surficial aquifer flow, subject to a first order decay rate that reduces the mass over time. The load that is left when the surficial aquifer reaches a permanent water body is assumed to discharge to the water body.

Figure 1 shows the theoretical basis of the septic tank analysis. It is assumed that recharge of the surficial aquifer occurs at a constant rate (W). Under steady flow conditions, this recharge rate is equivalent to the discharge rate in the receiving stream, assuming no leakage to the lower aquifer layers. By determining factors such as the length (L), the aquifer thickness at the receiving stream (h_a), and the hydraulic conductivity of the aquifer, groundwater flow equations can be used to calculate the water table height and flow velocity at various distances from the receiving stream. The velocity values can then be used to determine travel times to the receiving stream. The travel time, combined with the first order decay rate, determines the fraction of septic tank loading that reaches the receiving stream.

Equations developed by Dupuit (Todd, 1985) were used to perform the groundwater flow and velocity calculations. These equations have been used in models such as DRAINMOD to simulate subsurface water movement into drain tubes or ditches. One of the basic equations used in the analysis is

(1) $$q_x = Wx$$

where

x = distance from the point of maximum water table elevation (ft)

q_x = groundwater flow per unit of stream length (ft^2/day)

W = groundwater recharge (ft/day)

In the septic tank analysis, the value of W was calculated as the sum of the natural recharge determined by the hydrologic analysis plus the flow contributed by septic tanks. For the areas with septic tanks, an average value of 7 inches/year (0.0016 ft/day) was calculated. Using equation (1), the flow rate at any distance from the point of maximum water table elevation can be calculated. The other basic equation is

(2) $$h_x^2 = h_a^2 + (W/K)(L^2 - x^2)$$

where

h_x = water table height at distance x from maximum water table elevation (ft)

h_a = water table height at receiving stream (ft)

K = hydraulic conductivity of aquifer (ft/day)

L = distance from point of maximum water table elevation to centerline of stream (ft)

This equation can be used to calculate water table height at any point between the stream and the location of the maximum water table elevation. These two equations were used to develop a third equation, that determines the velocity at various distances from the receiving stream. The equation is as follows:

(3) $V_x = (q_x)/(P \times h_x)$

where

V_x = velocity at distance x from location of maximum water table elevation (ft/day)

P = porosity of surficial aquifer

Velocity is an important parameter in the analysis because it influences the travel time from the septic tank to the surface water, which in turn affects the extent of pollutant decay en route to the surface water.

The aquifer values established for the Sarasota Bay study area are presented in Table 4. The values represent an average of the data obtained at a number of monitoring sites in the vicinity of the study area. Values for aquifer thickness (h_a), porosity (P) and conductivity (K) are based on review of the Soil Survey for Sarasota County and a Southwest Florida Water Management District (SWFWMD) report on groundwater availability in Sarasota County (SWFWMD, 1988). The maximum distance value (L) of 3,000 feet was selected based on inspection of USGS quadrangle sheets covering the study area, and the recharge value of 7 inches/year was based on the hydrologic simulation.

Travel times at distances up to 1000 feet from the receiving stream are shown in Figure 2. The cumulative travel times shown in the figure were developed in a spreadsheet which generates values at points established at 10 foot increments, from 0 to 3000 feet from the stream. At each point, the spreadsheet calculates the velocity, and then determines the travel time across the 10-foot distance between that point and the previous point. By summing travel times from consecutive 10-foot intervals, cumulative travel times are also calculated. Thus, at any point between 0 and 3000 feet from the stream, the total travel time to the stream is determined. Figure 2 shows that the travel distance in one year ranges from 60 to 110 feet, with higher velocities in the areas closest to the stream. These travel times translate into velocities of 0.16 to 0.30 feet per day.

Assuming a first order decay rate, the reduction in pollutant mass as a function of travel time is determined by the following equation:

(4) $$f = 1-e^{-kt}$$

where

f = fraction of pollutant removed after time t

k = first order decay coefficient (1/days)

t = time since the effluent entered the surficial aquifer (days)

This equation was also included in the spreadsheet to determine the pollutant reduction associated with each 10-foot increment. In this way, the fraction of pollutant delivered at various distances from the stream were determined. In addition, an overall average delivery ratio was established by averaging the delivery ratios at each 10-foot increment.

APPLICATION OF MODEL

The methodology presented above was incorporated into a spreadsheet model that calculates pollutant loadings from surface runoff, baseflow and point sources as well as septic tank loadings. This model was used to estimate loadings at two water quality stations located on Phillippi Creek. In estimating septic tank loadings, initial model runs were conducted assuming the first order decay rate of 0.00015/day that was established in the Ostendorf study. The results indicated a very high delivery of working septic tank loadings to the receiving streams, which could not be verified by analysis of stream water quality monitoring data in the study area. Subsequently, the first order decay rate was adjusted upward so that the loadings were more consistent with observed instream water quality. Once an appropriate decay rate was established, the model was applied to each watershed in the study area to determine the relative significance of septic tank loadings.

Comparison of Observed and Simulated Instream Water Quality

The methodology and first-order decay rate were evaluated by comparing observed and simulated water quality data at two monitoring stations in the Phillippi Creek watershed. The STORET stations used in the analysis were the Main A Canal at Palmers Boulevard Bridge (Station 24010630) and Phillippi Creek at Bahia Vista Street Bridge (Station 24010625). The Palmers Boulevard Bridge station has a drainage area of about 8 square miles, which consists primarily of cropland, rangeland, and low and medium density single family residential land uses. 89 percent of the low

density and 66 percent of the medium density residential areas are served by septic tanks, and there are no substantial point source loads. The Bahia Vista Street station has a drainage area of 44 square miles, comprised mainly of cropland, rangeland, open space, and low and medium density residential land uses. 53 percent of the low density, 41 percent of the medium density and 37 percent of the high density residential areas are served by septic tanks. Unlike the Palmers Boulevard station, the water quality at the Bahia Vista Street station has been impacted by the Atlantic Utilities and Kensington Park Utilities point sources, which had been directly discharging secondary effluent to Phillippi Creek during the STORET period of record. It is possible that other smaller point sources may also have been discharging directly, rather than through percolation ponds and irrigation, during the period of record.

The results of the water quality analyses for the two monitoring stations are presented in Table 5. The table includes results for three different first-order decay rates, which are as follows:

- The initial Ostendorf decay rate of 0.00015/day
- Decay rate of 0.00170/day based on assumed removal via percolation ponds and irrigation
- Decay rate of 0.00055/day based on calibration of Bahia Vista Street station loadings

For each decay rate, the results include the overall percent delivery from septic tanks, and a comparison of observed and simulated instream concentrations on an annual and seasonal basis. The overall percent delivery includes the impacts of both failing and working septic tanks, and reflects the fraction of nitrogen loading that is transported from the drainfield to the receiving water. The methodology used to determine the simulated and observed instream concentrations are described below.

The simulated instream concentrations were determined by calculating loadings from septic tanks, surface runoff, point sources and baseflow for an <u>average</u> rainfall year, divided into a wet season (June through September) and a dry season (October through May). The calculations were conducted by using a spreadsheet model developed by CDM, which has been applied in a number of water quality studies in Florida and other states. The model uses long-term precipitation and streamflow data, along with runoff coefficients for pervious and impervious area, to determine the relationship between rainfall, surface runoff and baseflow. Loadings associated with surface runoff are calculated by using event mean concentration (EMC) values. The EMC represents the flow-weighted concentration of pollutant in surface runoff during a typical storm event. Distinct EMC values are specified for different types of land use (e.g., residential, commercial,

agricultural). Baseflow loadings are calculated assuming a constant baseflow concentration. Point source loadings are included by specifying wastewater flows and concentrations, and septic tank loadings are calculated using the newly developed methodology described in this memorandum. The results of the modeling include total loading (e.g., pounds of nitrogen) and the total runoff depth (e.g., inches of flow distributed over the drainage area) for the modeling period. Given these output values and the size of the drainage area, a flow-weighted instream concentration can be calculated.

Because the simulated results include a flow-weighted instream concentration, the monitoring data were also analyzed to provide flow-weighted instream concentrations. The concentration data were sorted by month, and an average concentration was calculated for each month. Monthly flows were estimated using the same long-term streamflow records used in the spreadsheet model, and the percentage of annual flow attributed to each month was established. Using this information, a flow-weighted concentration was developed on an annual and a seasonal basis.

As shown in Table 5, nitrogen concentrations are substantially oversimulated when the Ostendorf decay rate was used. At the Palmers Boulevard station, the average annual total N concentration was oversimulated by 49 percent, and both wet season and dry season concentrations were oversimulated by more than 40 percent. The oversimulation at the Bahia Vista Street station was only 11 percent for the annual average analysis, but was 23 percent for the wet season analysis. Sensitivity analyses indicated that higher first-order decay rates would still result in reasonable total N predictions at the Bahia Vista Street station, while improving the predictions at the Palmers Boulevard station. Consequently, higher decay rates (which would result in a lower delivery ratio) were investigated.

Using a decay rate of 0.00170/day produces results that appear to be more reasonable that those developed using the Ostendorf rate. Based on the typical surficial aquifer velocity, this decay rate translates into 20 percent delivery (i.e., 80 percent removal) for sources at a distance of 300 feet from the receiving water. Together with the previous assumption of 50 percent total N removal in the unsaturated soil above the water table, the overall delivery is reduced to 10 percent. This value is consistent with the 90 percent removal value assumed for percolation ponds, which in many cases are located only a few hundred feet from receiving waters.

The simulation results indicate an oversimulation of total N at the Palmers Boulevard station and an undersimulation of total N at the Bahia Vista Street station for the annual average analysis. However, both sets of simulated results are within 20 percent of the observed values. Given the uncertainty associated with the monitoring data and the calculation of the surface runoff, baseflow

and point source loads, these results appear to be reasonable. The largest discrepancy between simulated and observed values occurs in the dry season analysis for the Bahia Vista Street station. During the dry season, the loading due to surface runoff is less significant, whereas point sources and septic tanks account for a greater percentage of the overall loading. Thus, one possible explanation of the total N undersimulation is that the point source loading during the monitoring period was underestimated. As mentioned earlier, two relatively large plants were discharging directly to Phillippi Creek, and it is possible that some of the smaller plants were also discharging directly to the creek at that time. In addition, the Florida South Gate plant discharges directly to the creek downstream of the Bahia Vista Street station, and some of that loading may influence the water quality at the station due to dispersion and tidal transport. Alternatively, the undersimulation may indicate that the loading due to septic tanks has been underestimated.

A third set of results was generated in which the decay rate was established such that the simulated and observed total N concentration at the Bahia Vista Street station matched for the average annual simulation. Through a calibration process, a decay rate value of 0.00055/day was established. The corresponding overall delivery from the drainfield to the receiving water is 20 percent, which is one-half of the delivery ratio calculated using the Ostendorf decay rate and twice the delivery ratio calculated using the decay rate of 0.00170/day.

The results show that there is good agreement between simulated and observed values at the Bahia Vista Street station, but that total N is oversimulated at the Palmers Boulevard station. As discussed above, the annual average simulated results match the observed values because that was the basis of the decay rate calibration. The results from the seasonal analyses for the Bahia Vista Street station show simulated total N concentrations that are somewhat higher than observed values during the wet season, and somewhat lower than observed values during the dry season. However, in both cases the difference between simulated and observed values is less than 20 percent. Given the uncertainty associated with the monitoring data and the calculation of the surface runoff, baseflow and point source loads, these results appear to be reasonable. For the Palmers Boulevard station, there is an oversimulation of total N for the annual and seasonal analyses. In all cases, the simulated loads are about 20 percent higher than the observed loads.

Due to the uncertainty in estimating loads and measuring instream concentrations, it is impossible to determine the loading due to septic tanks with any certainty. The results using the Ostendorf decay rate appear to generate excessive total N loadings from septic tanks. The results based on the other two decay rates both appear to give a reasonable estimate of septic tank loadings. The

rate of 0.00170/day seems reasonable for the annual and seasonal analyses, with the percent difference between simulated and observed total N concentrations ranging from +14 to -20. In comparison, the results for the decay rate of 0.00055/day show percent differences ranging from +26 to -16. The overall septic tank delivery ratio for the two alternative decay rates are 10 percent and 20 percent, respectively. Thus, based on the analysis described above, a delivery ratio of 10 to 20 percent is assumed to be representative for septic tank loadings in the study area.

In the final calculation of study area loadings, the more conservative delivery ratio value of 20 percent was selected. Because the relatively high delivery ratio was selected, it is likely that the impacts of septic tank loadings will not be underestimated, and in fact may be overestimated.

Average Annual Loadings for Study Area Watersheds

The average annual loading results for the watersheds in the study area are shown in Table 6. Because nutrients are the major concern for septic tanks, total P and total N results are included in the table. The results are shown separately for those watersheds that do have septic tanks, whereas the watersheds without septic tanks have been combined into one category. For each watershed, the table lists the total loading in pounds attributed to septic tanks, the total loading from all sources, and the percentage of the total loading attributable to septic tanks. The total loading includes septic tanks plus surface runoff, baseflow, point sources, and precipitation falling directly onto the Bay surface.

The results presented in Table 6 indicate that septic tanks account for only a small fraction of the total study area loadings, but that the impact of septic tanks varies between watersheds. Overall, septic tanks account for 3.3 percent of the total P loading and 9.6 percent of the total N loading to the Bay. For total P, the septic tank contribution is less than the contribution of any of the other four pollution sources (surface runoff, baseflow, point sources and rainfall). For total N, the septic tank contribution is less than that of surface runoff and rainfall, but is slightly higher than the contribution due to point sources or baseflow. Watersheds that have a relatively high percentage of septic tank contribution include Phillippi Creek, Matheny Creek and the areas along the west coast that drain directly to the Bay. Phillippi Creek alone accounts for 71 percent of the septic tank loading for total N.

SUMMARY

CDM conducted a literature review to evaluate the pollutant loadings contributed by septic tank systems. Data gathered as part of this review included septic tank wastewater flow rates and

effluent characteristics, pollutant removal mechanisms and efficiencies in drainfields, and delivery of loadings to surface waters. Methods for estimating pollution loadings due to working and failing septic tanks were developed, based on previous studies and the literature review. When these methods were applied to the Sarasota Bay study area, the results indicated that the septic tank loadings may have significant local water quality impacts, but do not appear to be a major factor in total pollution loadings to the Bay.

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TABLE 1

FLOW RATES FOR SEPTIC TANK EFFLUENT

Reference	Flow Rate (gal/capita/day)
Waller et al., 1987	75
Sawnhey and Starr, 1977	50
Cogger and Carlile, 1984	50
Starr and Sawhney, 1979	50
Alhaggar et al., 1989	36-47
Andreoli et al., 1979	60
Piluk and Hao, 1989	66
Reneau et al., 1989	45
Brandes, 1978	41-45
Reddy and Dunn, 1984	40-80

TABLE 2

NUTRIENT CONCENTRATIONS IN SEPTIC TANK EFFLUENT

Reference	Total N		Total P	
	n	(mg/l)	n	(mg/l)
Waller et al., 1987	5	39	5	4.1
Walker et al., 1973	N/A	80	N/A	N/A
Whelan and Titmanis, 1981	N/A	100	N/A	15
Gilliam and Patmont, 1983	N/A	N/A	54	15
Alhaggar et al., 1989	356	73	357	7.9-14
Andreoli et al., 1979	N/A	61.3	N/A	N/A
Piluk and Hao, 1989	N/A	69.4	N/A	8.3
USEPA, 1978	N/A	45	N/A	13
Reneau et al., 1989	N/A	40-80	N/A	16
Cogger et al., 1988	32	28	32	6.2

Notes:

1. n = number of samples
2. N/A = not available

TABLE 3

SEPTIC TANKS FLOW RATES FOR VARIOUS LAND USES

Land Use	Dwelling Units Per Acre	Persons Per Dwelling unit	Per Capita Wastewater Flow Rate (gal/day/person)	Flow Rate (gal/acre/day)
LDSF Residential	1	2	75	150
MDSF Residential	4.5	2	75	675
HDSF Residential	7.5	2	75	1125
Multi-family Bldg	9	2	75	1350
Mobile Home	9	2	75	1350
Commercial/Services	-	-	-	1350
Institutional	-	-	-	1350
Industrial	-	-	-	1350

TABLE 4

PARAMETERS FOR ANALYSIS OF WORKING SEPTIC TANKS

Parameter	Value	Source
Aquifer Conductivity	8.0 in/hr	SWFWMD, 1988
Aquifer Thickness	60.0 ft	SWFWMD, 1988
Porosity	0.3	SWFWMD, 1988
Minimum Travel Length	75 ft	FDER
Maximum Travel Length	3000 ft	USGS maps

TABLE 5
SIMULATED AND OBSERVED TOTAL N DATA
PALMERS BOULEVARD AND BAHIA VISTA STREET STATIONS

FIRST-ORDER DECAY RATE (1/day)	OVERALL PERCENT DELIVERY	MONITORING STATION	SIMULATION PERIOD	TOTAL N (MG/L)		
				OBSERVED	SIMULATED	% DIFF.
0.00015	40	Palmers Boulevard	Annual	1.55	2.31	49%
			Wet Season	1.49	2.22	49%
			Dry Season	1.69	2.47	46%
		Bahia Vista Street	Annual	2.09	2.33	11%
			Wet Season	1.67	2.05	23%
			Dry Season	3.00	2.79	-7%
0.00170	10	Palmers Boulevard	Annual	1.55	1.76	14%
			Wet Season	1.49	1.69	13%
			Dry Season	1.69	1.87	11%
		Bahia Vista Street	Annual	2.09	1.95	-7%
			Wet Season	1.67	1.69	1%
			Dry Season	3.00	2.40	-20%
0.00055	20	Palmers Boulevard	Annual	1.55	1.94	25%
			Wet Season	1.49	1.87	26%
			Dry Season	1.69	2.07	22%
		Bahia Vista Street	Annual	2.09	2.08	-0%
			Wet Season	1.67	1.81	8%
			Dry Season	3.00	2.53	-16%

TABLE 6
AVERAGE ANNUAL LOADINGS FOR STUDY AREA WATERSHEDS
EXISTING LAND USE CONDITIONS

WATERSHED	AREA (acres)	TOTAL P			TOTAL N		
		SEPTIC TANK LOADING (lb/yr)	TOTAL LOADING (lb/yr)	% OF TOTAL	SEPTIC TANK LOADING (lb/yr)	TOTAL LOADING (lb/yr)	% OF TOTAL
Phillippi Creek	36,417	5,850	70,710	8.3%	87,750	374,730	23.4%
Whitaker Bayou	5,015	620	20,400	3.0%	9,270	90,320	10.3%
Matheny Creek	3,800	690	11,790	5.9%	10,380	58,630	17.7%
Catfish Creek	3,360	150	3,710	4.0%	2,310	19,010	12.2%
North Creek	1,920	100	2,160	4.6%	1,540	11,180	13.8%
South Creek	12,995	70	11,870	0.6%	1,030	55,670	1.9%
Barrier Islands	5,761	50	15,610	0.3%	680	65,160	1.0%
Direct to Bay	4,241	700	8,850	7.9%	10,560	51,430	20.5%
Watersheds without Septic Tanks	22,623	0	45,880	0.0%	0	229,310	0.0%
Bay Surface (Rainfall Loading)	33,280	0	61,730	0.0%	0	337,460	0.0%
TOTAL	129,412	8,230	252,710	3.3%	123,520	1,292,900	9.6%

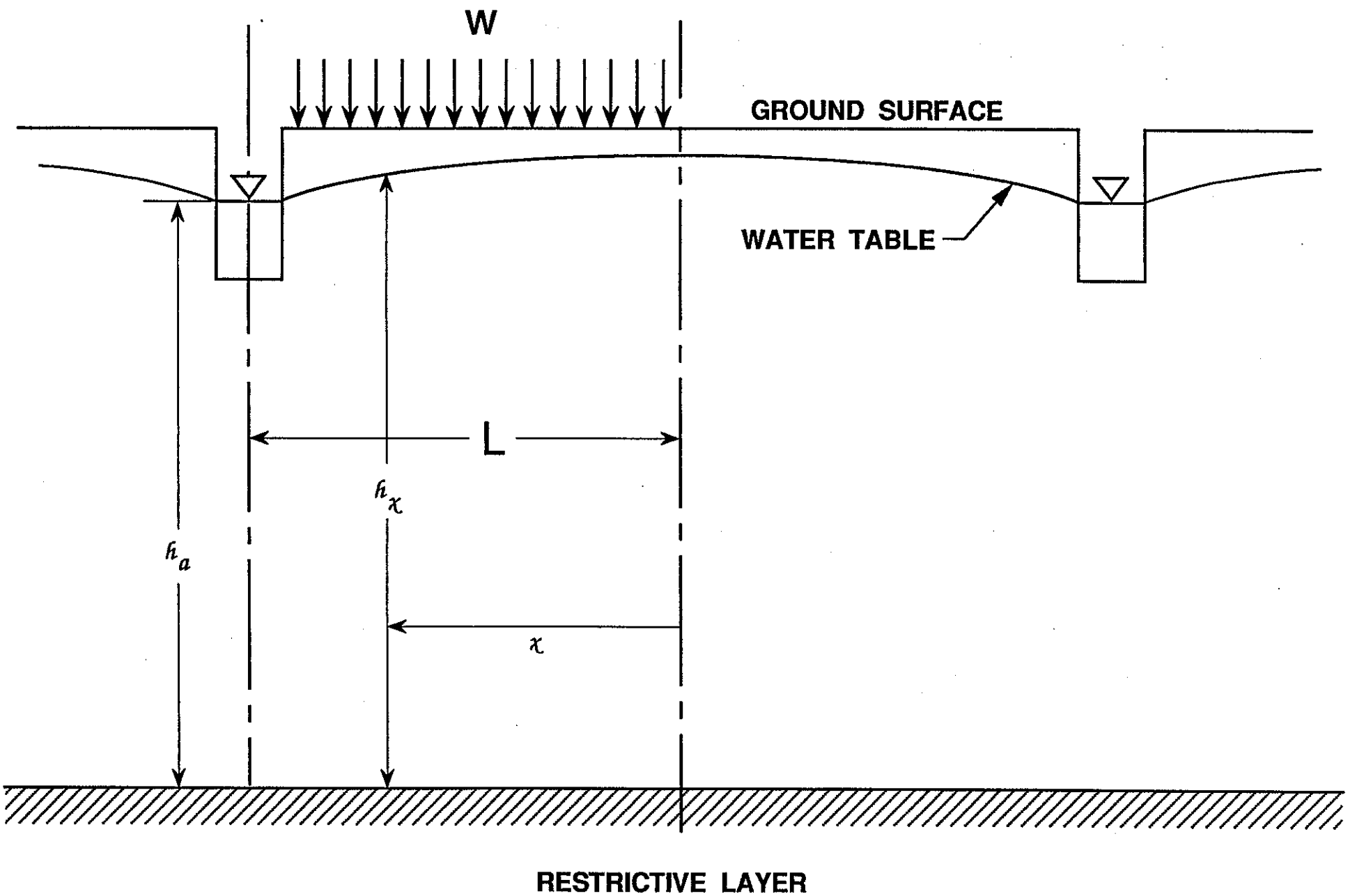

Figure 1. Surficial Aquifer Flow to Receiving Stream

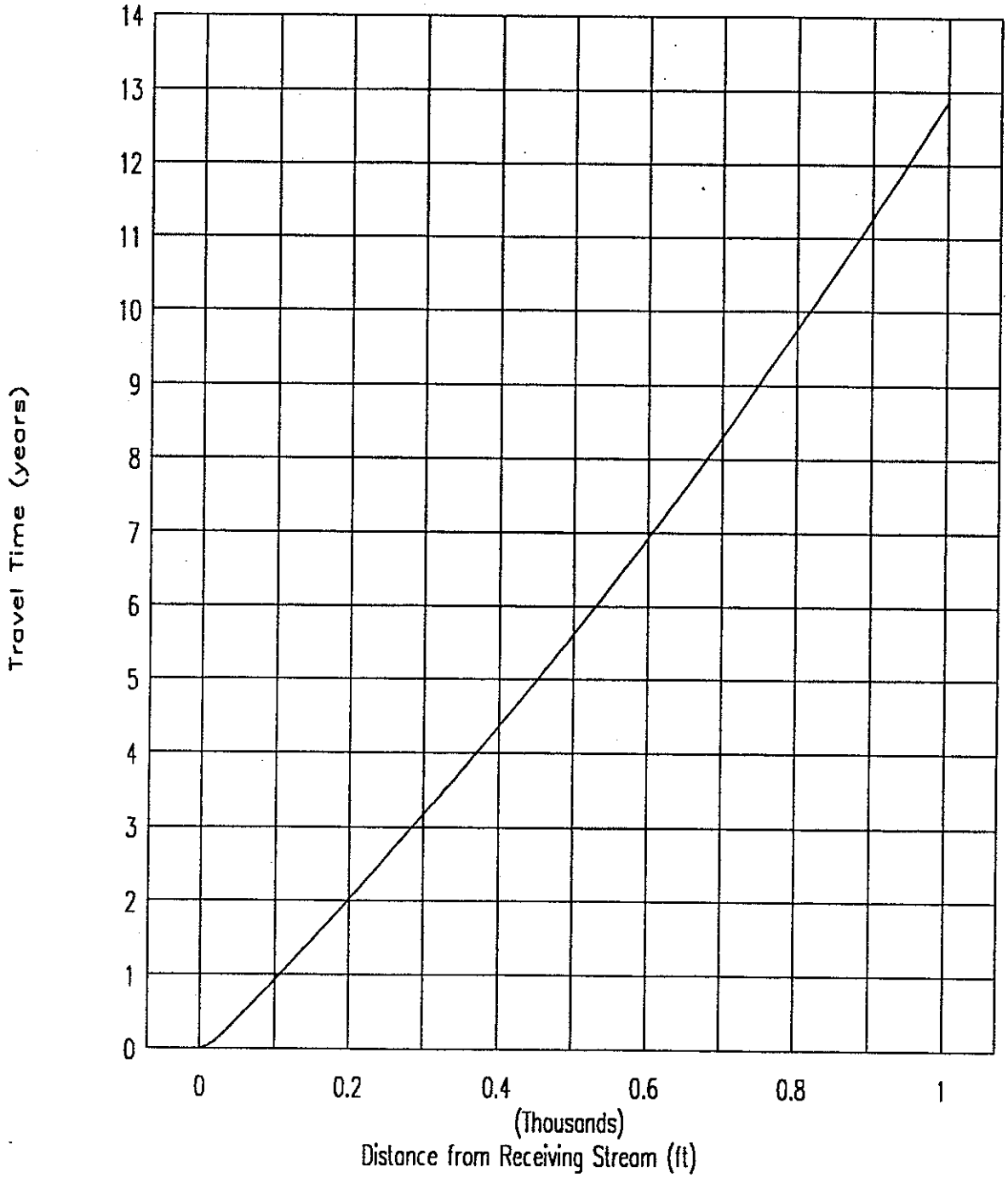

Figure 2. Travel Time from Septic Tank to Receiving Water.

APPENDIX C

STATISTICAL ANALYSIS OF BARRIER ISLAND AND MAINLAND RAINFALL DATA

APPENDIX C
STATISTICAL ANALYSIS OF BARRIER ISLAND AND MAINLAND RAINFALL DATA

The climate in the Sarasota Bay National Estuary Program study area is subtropical, with a mean daily temperature of about 78 degrees. The weather is influenced by latitude, low elevation, wind patterns and proximity to the Gulf of Mexico and to Sarasota Bay. Average annual rainfall for the study area is about 54 inches, with approximately 60 percent of the total precipitation falling during the summer months of June through September. The summer rainfall patterns typically consist of short duration, intense convective thunderstorms occurring in the late afternoon. Rainfall in the winter months is generally associated with cold fronts moving across the region. Compared to summer rainfall events, winter rainfall events usually have a longer duration and lower intensity.

Typically, continuous monthly rainfall totals in excess of 25-30 years period of record are used in estimating annual, or seasonal non-point source pollutant loadings. Of the local rain gage data available, data from only one station (Bradenton ESE) meets the criteria, although except for a 15 month gap in record keeping, the Myakka River rainfall record meets the duration criteria. The Bradenton station is located in the upper northeastern portion of the study area. It was felt that use of this gage alone was insufficient to represent the rainfall over the entire study area, and the Myakka gage record was extrapolated to provide gage data in the southern portion of the study area.

There are two rain gages within the Myakka River State Park. The Myakka River NWS (National Weather Station # 6065-04) rainfall record is lacking three consecutive months in 1966, and all of 1967. In order to obtain a long-term rainfall record in the southern portion of the NEP study area, the 1966 rainfall records for the two stations for the nine months were compared, and deemed sufficiently close to allow substitution of the missing three months in the NWS station.

Except for 1967, the Bradenton ESE and Myakka NWS station data were averaged for each month of the period of record, and annual totals derived. The Bradenton ESE rainfall totals were used for the year of 1967.

The question of dissimilar distribution, and rainfall totals between the seaward barrier islands and the inland rainfall totals was investigated. Monthly, and annual rainfall totals from several local rain gages, including three stations located on barrier islands were compiled and statistically compared with four inland gages and one composite rainfall record. Rainfall totals were obtained as hard copy from the South West Florida Water Management District for the following stations :

Station Name	Approximate Location
Sarasota Bradenton	Airport
Cutter	South Longboat Key (barrier island)
Siesta Key	North Siesta Key (barrier island)
Tallevast	US 301 North of Airport

Rainfall data for City Island was obtained from Mote Marine Laboratory as daily digital data, and was totalled by month and year. Myakka River State Park was obtained as daily totals from National Climatic Data Center (NOAA) in digital form from 1957-1985, and totalled by month and year. This data was supplemented with climatological bulletins published by National Climatic Data Center (NCDC). Bradenton ESE (NWS station 0945-04) rainfall totals were also taken from climatological bulletins. Data prior to 1981 were taken from microfiche of earlier bulletins.

Arithmetic averages of monthly totals (except as previously noted) were derived from the Myakka NWS and Bradenton ESE stations, and are designated as BRAdenton-MYaKka (BRAMYK).

The descriptive statistics of each rainfall record are given below in Box 1. In accordance with USEPA (EPA-600/4-82-029) guidelines, all stations except Tallevast and Bradenton appear to be normally distributed (coefficient of skewness < 0.7). These two stations were deleted from further parametric evaluation and subjected to non-parametric tests.

Box 1

	years	df	mean	s.d.	var.	skew	kurt.
CITY ISL.	9	8	48.20	10.20	104.05	0.6361	2.987
MYAKKA	46	45	55.70	11.56	133.65	0.2009	2.238
CUTTER	10	9	50.14	11.04	121.98	0.2345	2.026
SARBRA	10	9	49.52	9.40	88.41	-0.5432	2.692
SIESTA	12	11	49.31	8.78	77.12	0.3334	2.721
TALLY	39	38	58.04	15.25	232.64	**0.8702**	4.479
BRADENTON	51	50	54.54	11.30	127.76	**0.7224**	4.314
BRAD+MYAK	46	45	55.48	7.95	63.28	0.4167	2.299

Prior to using parametric means tests (Student's 't' test), the equality of variance must be established. The 'F' ratio was used to determine if the variance of the station pairs were statistically similar. The results, given in Box 2, indicate that the following station pairs had statistically different variances (two-tailed significance < = 0.05): Myakka/Tallevast, Siesta/Tallevast, Bradenton/Tallevast, BRAMYK/Tallevast, BRAMYK/Bradenton and BRAMYK/Myakka. Non-parametric tests were conducted for these station pairs.

Box 2

Stations Compared	F	df/df	two-tailed signif.
City Isl vs. Myakka	1.2845	45/8	0.3764
City Isl vs. Cutter	1.1723	9/8	0.4166
City Isl vs. SarBra	1.1769	8/9	0.4036
City Isl vs. Siesta	1.3492	8/11	0.3151
City Isl vs. Tally	2.2358	38/8	0.1154
City Isl vs. Bradenton	1.2279	50/8	0.4066
City Isl vs. BRAMYK	1.6443	8/45	0.1392
Myakka vs. Cutter	1.0957	45/9	0.4771
Myakka vs. SarBra	1.5117	45/9	0.2614
Myakka vs. Siesta	1.7330	45/11	0.1629
Myakka vs. Tally	1.7407	38/45	**0.0376**
Myakka vs. Bradenton	1.0461	45/50	0.4366
Myakka vs. BRAMYK	2.1120	45/45	**0.0068**
Cutter vs. SarBra	1.3797	9/19	0.2642
Cutter vs. Siesta	1.5817	9/11	0.2335
Cutter vs. Tally	1.9072	38/9	0.1524
Cutter vs. Bradenton	1.0474	50/9	0.5123
Cutter vs. BRAMYK	1.9276	9/45	0.0720
SarBra vs. Siesta	1.1464	9/11	0.4085
SarBra vs. Tally	2.6314	38/9	0.0625
SarBra vs. Bradenton	1.4451	50/9	0.2873
SarBra vs. BRAMYK	1.3971	9/45	0.2180
Siesta vs. Tally	3.0166	38/11	**0.0267**
Siesta vs. Bradenton	1.6566	50/11	0.1833
Siesta vs. BRAMYK	1.2187	11/45	0.3028
Tally vs. Bradenton	1.8209	38/50	**0.0236**
Tally vs. BRAMYK	3.6764	38/45	**0.0000**
Bradenton vs. BRAMYK	2.0190	50/45	**0.0091**

Station pairs consisting of normally distributed data and equivalent variances were then evaluated for statistical similarity of annual means, without pairing of occurrence. The null hypothesis evaluated was that there is no difference in the annual mean rainfall totals. The results are given in the top half of Box 3, and indicate that twelve pairs were statistically equivalent at, or above the 0.05 significance level, and two pairs were not equivalent at the 0.05 level.

Next, the station pairs were subjected to a 't' test of paired annual means. The results are illustrated in the bottom half of the previous box. Station pairs with significance levels less than 0.05 are considered statistically different. Eight were found to be different, and six pairs were found to be statistically equivalent at the 0.05 significance level.

For station pairs that could not be evaluated with parametric techniques due to non-normality, or unequal variances, a Mann-Whitney test of similarity was employed. The results for annual, unpaired rainfall totals are given in the lower portion of Box 3. The results indicate that none of

the annual mean comparisons excluded from parametric testing were significantly different (at the 0.05 significance level).

Box 3

two-sided significance level: unpaired t-test of annual means

		1	2	3	4	5	6	7	8
paired	1		0.0568	0.6956	0.7745	0.7970	*|<non-normal>|*		0.0566
	2	**0.0255**		0.1620	0.0787	**0.0417**	*|<non-normal>|*		*(F-test)*
't'	3	0.2735	**0.0012**		0.8930	0.8490	*|<non-normal>|*		0.1631
test	4	0.6794	**0.0062**	0.6408		0.9581	*|<non-normal>|*		0.0740
(two-	5	0.4841	**0.0086**	0.1767	0.9225		*|<non-normal>|*		**0.0345**
sided)	6	*|<---------- non-normal----------|*						*(..)*	*(F-test)*
	7	*|<---------- non-normal----------|*							*(F-test)*
	8	**0.0021**	*(F-test)*	**0.0012**	**0.0020**	**0.0032**	*(F-test)*	*(F-test)*	

Non-Parametric;two-sided significance level: Mann- Whitney test

	1	2	3	4	5	6	7	8
1						0.0684	0.1086	
2						0.6753	0.5463	0.9906
3						0.1538	0.2973	
4						0.1467	0.3252	
5						0.0637	0.1132	
6							0.2509	0.7276
7								0.4902

Mann - Whitney Comparison for non-normal stations, or unequal variances.

1 = City Island, 2 = Myakka, 3 = Cutter, 4 = Sarasota Bradenton AOP
5 = Siesta, 6 = Tallevast, 7 = Bradenton ESE, 8 = (Bradenton+Myakka)/2

Italics type indicates either non-normal distributions based on the coefficient of skewness, or unequal variances as determined by the F'test. **Bold** faced type are significance levels <= 0.05.

The monthly totals were compared using a linear least squares regression. The regression test, by definition, is a 'paired' comparison. The following illustration (Box 4) indicates that there is no significant difference in the seasonal distribution of any station pair, suggesting that monthly variation between stations is consistent. In other words, when the monthly rainfall at one station is higher, it is likely to be relatively higher at all stations, although the magnitude of increase may vary between stations. In essence, the 'wet season' occurs at all stations during the same time of the year. All pairs were significant at P < = 0.0000, although it should be noted that station pairs including Tallevast and Bradenton are not normally distributed and thus may not be accurately represented by a least squares evaluation based on a normal distribution assumption.

Box 4

r^2 of linear regression (monthly totals)

	1	2	3	4	5	6	7	8
1	--------	0.7444	0.8831	0.8466	0.8574	0.7691	0.5900	0.7317
2		--------	0.7331	0.8029	0.7584	0.7461	0.7513	0.9322
3			--------	0.8582	0.8815	0.7881	0.8269	0.8089
4				--------	0.8744	0.9478	0.8969	0.8870
5					--------	0.8350	0.8491	0.8387
6						--------	0.8668	0.8451
7							--------	0.9350
8								--------

(Note : Significance of all Comparisons < = 0.0000)

The results of the statistical evaluations indicate the following points:

1) The wet and dry seasons occur synchronously at all stations evaluated.

2) Taken as pairs of annual rainfall totals, there are significant differences among the stations evaluated. When the station locations are considered, the differences appear to be related to distance from the coast. For example, the results from the Myakka (and BRAMYK, which includes the Myakka results) were statistically different from the coastal stations, but not from the other inland stations. Station pairs exhibiting differences in paired annual means include the following:

Myakka and a) Cutter, b) Sarasota-Bradenton, c) Siesta, d) City Island.
BRAMYK and a) Cutter, b) Sarasota-Bradenton, c) Siesta, d) City Island.

3) When evaluated as unpaired annual totals, the number of significant differences were minimal, with the Siesta Key annual rainfall differing from both the Myakka results and the BRAMYK results.

For the present annual NPS loading evaluation, 'when' an annual rainfall total occurs is immaterial, and the unpaired comparisons are more appropriate than the paired comparisons. Considering the relatively short (10-12 years) period of the coastal stations, use of the longer records of the inland stations is appropriate.