Monroe County

Stormwater Management Master Plan

Prepared for Monroe County by

Camp Dresser & McKee, Inc.

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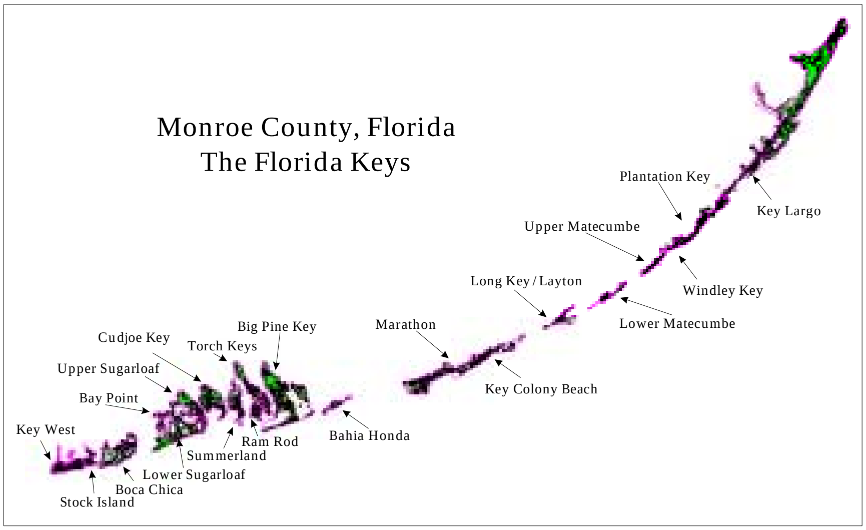
Monroe County
Stormwater Management Master Plan
Executive Summary



Introduction

Monroe County consists of approximately 1.2 million acres, the majority of which are submerged lands under state or federal jurisdiction. Excluding the mainland areas, Monroe County encompasses about 65,400 acres along the Florida Keys including the incorporated areas of Key West, Islamorada, Layton, Key Colony Beach and Marathon. The Florida Keys consist of 38 main keys connected to the mainland through Dade County along US Highway 1 (referred to as US 1).

Monroe County is required by their adopted Year 2010 Comprehensive Plan (Comp Plan) to prepare a Stormwater Management Master Plan (SMMP). The purposes of the SMMP are to assess the adequacy of existing systems, prioritize stormwater management needs for each island, identify regulations and policy needs, and develop a plan to finance the construction, operation and maintenance of required facilities. The geographic area of this project consists of the islands in the County (the Florida Keys), which are traversed by US 1. The figure above shows the study areas for the SMMP.

Several terms will be used to characterize the major areas of the Keys:

The Upper Keys begin with the Ragged Keys of Biscayne National Park to the north and run to Lower Matecumbe to the southwest.

The Middle Keys include the islands south and west of Lower Matecumbe to Marathon (Seven Mile Bridge).

The Lower Keys include Big Pine Key through Key West.

The Florida Keys

According to 1999 population data, the Upper Keys have the largest population at about 49,200. The Middle and Lower Keys have almost the same population at about 36,000 each. The largest stormwater study area population appears to be Key Largo, followed by Marathon. In 2010, the Upper Keys will still have the largest population at over 52,500, followed by the Lower Keys at about 39,100 and finally the Middle Keys at about 28,400. The largest study area populations are Key Largo and Marathon as in 1999.

The largest population growth for permanent residents between 1999 and 2010 is projected to be in Cudjoe Key at 15 percent over the 11 years, followed by Bay Point Key at 12.3 percent and Big Pine Key at 11.3 percent. Average population growth for permanent residents will be only 0.7 percent, due to incorporation. There is expected to be an overall loss of 3 percent in the seasonal population due to incorporation.

Due to their location, the Florida Keys possess unique conditions not found elsewhere in the United States. This has lead to the development of a variety of interconnected, tropical marine ecosystems. There are both climatic and biotic variations within the Keys that extend over one degree of latitude (~24.5 to 25.5 N) and almost three degrees of longitude (~80.2 to 82.9 W).

The designations of Upper, Middle and Lower Keys do have some natural constraints that affect the near shore marine and terrestrial environments. The Upper Keys form a fairly continuous barrier between the coastal waters of the mainland on the west and north sides of the Keys (Florida Bay, Barnes, Blackwater and Card Sounds, and Biscayne Bay; usually called "bayside") and those of Hawk Channel and the Straits of Florida on the east and south of the Keys ("Oceanside"). The Middle Keys have large passes that allow a considerable exchange of water. The Lower Keys have an intermediate tidal exchange from one side to the other. The waters to the north here are more properly considered Southwest Florida Shelf waters rather than part of Florida Bay because they are influenced by Florida Bay and the Gulf of Mexico.

Table ES-1 provides a breakdown of the acreage and percentage of land uses based on the existing database provided by Monroe County. About 75 percent of the land is categorized as Forest/Open, Urban/Open or Water/Wetland. The next highest land use is low density residential (9 percent). The rest of the land uses account for about 18 percent of the total land in Monroe County.

Table EX-2 shows the future land uses for Monroe County based on total build-out. About 72 percent of the future land use acreage is Forest/Open, Urban/Open and Water/Wetland. There will be increases in Medium and High Density Residential Land Uses. These increases change the nature of stormwater runoff from the Keys under future conditions.

Table ES-1 - Monroe County Existing Land Uses

Land Use	Lower Keys	Middle Keys	Upper Keys	Total	%
Forest Open	11,764	5,925	15,362	33,051	37.8%
Urban Open	457	923	336	1,717	2.0%
Agriculture/Pasture	5	33	3	41	0.0%
Low Density Resid.	1,688	3,700	2,370	7,758	8.9%
Medium Density Resid.	994	450	737	2,180	2.5%
High Density Resid.	264	390	290	945	1.1%
Commercial	815	1,538	675	3,028	3.5%
Industrial	54	55	69	178	0.2%
Water/Wetland	21,987	6,082	2,721	30,790	35.2%
FDOT Roads	702	566	370	1,637	1.9%
County Roads	1,206	325	889	2,421	2.8%
County Facility	2,914	636	96	3,646	4.2%
Total	42,849	20,623	23,919	87,390	

Table ES-2 - Monroe County Future Land Uses

Land Use	Lower Keys	Middle Keys	Upper Keys	Total	%
Forest Open	6,666	659	10,841	18,166	20.8%
Urban Open	6,374	4,718	4,116	15,209	17.4%
Agriculture/Pasture	13	9	3	26	0.0%
Low Density Resid.	1,883	1,955	1,114	4,952	5.7%
Medium Density Resid.	1,657	3,165	1,969	6,791	7.8%
High Density Resid.	437	569	858	1,863	2.1%
Commercial	1,120	1,404	952	3,476	4.0%
Industrial	106	27	0	133	0.2%
Water/Wetland	20,216	6,437	2,650	29,303	33.5%
FDOT Roads	665	617	386	1,669	1.9%
County Roads	1,077	337	866	2,280	2.6%
County Facility	2,636	725	164	3,525	4.0%
Total	42,851	20,623	23,919	87,392	

Over the last 40 years, especially in the last 10, the Florida Keys ecosystems have been of concern to governmental, scientific and public interests. With creation of the John Pennekamp Coral Reef State Park in 1960, the unique environment of the Keys was confirmed. Since that time, the deterioration of the near shore and reef environment has been well documented with the decline of corals, loss of grass beds, and increase in water pollution. While most studies have identified wastewater impacts as the major controllable source of pollutants affecting the environment, stormwater runoff has also been identified as a significant source. One of the purposes of the SMMP is therefore to identify a plan to reduce the stormwater runoff component of pollution within the Keys.

Goals and Objectives

Based on public input and the 2010 Comp Plan, the following is a list of recommended goals and objectives for the Monroe County Stormwater Management Master Plan:

Goal 1 - The SMMP will identify, prioritize and recommend remedial improvements for the significant water quality related problem areas within the unincorporated areas of the County.

Goal 2 - The SMMP will recommend actions that will reduce the sediment and nutrient loading of near shore waters resulting from runoff.

Goal 3 - The SMMP will review existing regulatory requirements for the control of new development related to flooding and water quality and will recommend improvements as needed. As a related issue, the SMMP will review existing enforcement activities and recommend changes necessary to improve the compliance of existing or new regulations.

Goal 4 - The SMMP will recommend activities related to the stormwater management of future growth that will be expected to result in no increase in sediment or nutrient loads to near shore waters.

Goal 5 - The SMMP will strive to use nonstructural and source controls to achieve a reduction in existing sediment and nutrient loads. When necessary, the SMMP will recommend structural controls associated with the publicly owned infrastructure.

Basics of Stormwater Management

When rainfall falls on soil or undeveloped land covered with vegetation, some of the rainfall penetrates into the ground (infiltration) until the soil is saturated. The remainder runs off the land into natural storage areas (wetlands and depressions), conveyances (small creeks and ditches) or near-shore waters. During large storms, the limited natural storage and conveyance system can back up causing the flooding of normally dry land.

Three major changes to runoff may occur with increased development in the Florida Keys. First, the amount and nature of the runoff can change. Development increases the amount of impervious area such as roofs, driveways, parking lots, etc., which in turn increases runoff volume. In the same manner, the runoff peak flow may get larger, the time of the peak from the start of the rainfall event may shorten and runoff induced velocities may increase. The overall effect is that increased development creates more runoff water in less time.

Secondly, increased urban development (both residential and commercial) can place houses and buildings in areas that naturally flood during certain times of the year. With increased runoff, the flooding increases and flood-prone areas are inundated for longer times. With residential or commercial structures now in places where flooding historically occurs, the increased runoff leads to potential citizen health and safety concerns.

Thirdly, urban development changes the nature and volume of pollutants carried by runoff. Runoff from development can carry man-induced pollutants such as sediments, fertilizers, detergents (from car washing, etc.), automotive fluids, metals, and pesticides.

The control of flooding caused by excess stormwater runoff is actually simple in concept yet difficult in practice. There are only two ways to control flooding: (1) increase the conveyance of stormwater away from the flooded area, (2) store the runoff permanently (retention) or temporarily (detention) until the conveyance can carry away the excess volume, and 3) a combination of storage and conveyance. Historically, the strategy of choice was to increase the conveyance capacity by widening channels and up-sizing culverts so that water flows to the near shore waters. Environmental regulations, such as the Florida Water Resources Act of 1972, began a shift toward water management with more focus on storage to attenuate and treat runoff.

With the increase in land and construction costs, municipalities have added source controls to address flooding. "Source controls" refers to a group of best management practices (BMPs) that control or reduce the problem at the source. Source controls related to flooding include methods to reduce runoff: minimization of impervious areas, land use controls, porous pavement requirements, water conservation measures (e.g., xeriscape), vegetated buffer strips, downspout diversion, etc. These BMPs attempt to reduce the runoff peak or volume so that historically sufficient conveyance and storage systems can accept the runoff. Unfortunately, these types of BMPs are generally not sufficient by themselves to return post-development runoff to pre-development levels. Nevertheless, source controls can reduce the costs for structural improvements downstream by decreasing the runoff and removing pollutants.

Developing land changes the type and quantity of pollution. Housing development increases fertilizer, pesticide and even household chemical pollutants. Commercial development can increase these and other more exotic pollutants. Of all the pollutant sources, however, the greatest is vehicular. Engines drop oil, grease, antifreeze and fuel. Automobiles yield metals such as selenium (tires), copper (brakes) and chromium into runoff. Engine emissions place pollutants (gaseous and particulate) into the atmosphere only to be pulled into raindrops and become part of runoff. Therefore, development not only increases the volume of runoff but also increases the type and severity of pollution carried by the runoff.

Similar to flood control, runoff quality can be controlled using source controls as well as structural improvements. Source controls reduce the amount of pollutants from getting into runoff in the first place. While source controls can be effective in reducing pollutants in runoff, a mixture of source controls and structural improvements to treat runoff may be needed to improve existing water quality problems and control future pollutant discharges.

Structural controls, on the other hand, provide constructed facilities that allow stormwater runoff to be physically, chemically and/or biologically treated. Physical treatment is generally for sediments and other particulates: runoff is allowed to slow down enough for gravity to settle sediment to the bottom of the facility (inlet baffle boxes, sediment sumps, and ditch-block weirs) or runoff is subjected to centrifugal forces to separate sediments from water (swirl concentrators). Chemicals can be added to runoff to increase the coagulation of pollutants and help the settling out of the resulting particulates. Biological treatment allows plants to uptake nutrients for growth thereby reducing the opportunity for the nuisance algae to grow.

Contrary to flood control, runoff quality should be treated during small-scale, frequent storm events. Studies of stormwater runoff have shown that a large portion of pollutant washes off of developed lands during the first flush of rain. This indicates that treatment of the first flush of rainfall will control most of the runoff-induced pollutant loading. Consequently, many governments that have stormwater quality ordinances define design criteria for stormwater treatment facilities based upon how much of the first inch or so of rainfall must be treated. For example, SFWMD requires the treatment of the equivalent runoff from the first 1.25 to 2.5 inches depending on the BMP type.

Concerns in the Florida Keys

Based on historical reports, staff input and public comments, there are two types of stormwater concerns in the Florida Keys: water quality and nuisance flooding. A survey of citizens present at recent public meetings on the SMMP ranked a number of stormwater-related issues from most important to least important:

Issue	Rank
Water Quality Protection/Improvement	1
Development Controls	2
Enforcement of Existing Regulations	3
Flooding	4
Costs	5
Operation & Maintenance	6
Recreational Opportunities	7

A list of stormwater problem areas was also identified and studied for potential improvements. The problem areas were ranked on the following criteria: flood severity, water quality benefits from improving the problem, expected growth of the study area, overall benefit to the county (i.e., does the problem area affect many citizens?), and historical priority assigned. Many of the problem areas were investigated and found to be on private property.

Existing Stormwater System

Given the nature of the Florida Keys and the problems encountered, the first issue to be addressed is related to the existing stormwater system. A review of permit files and existing studies was completed, and confirmed with field studies of stormwater systems. In all, only 254 structures were located, of which over two-thirds

contained stormwater quality treatment system and one-quarter contained wells. Through the Keys, the major stormwater system consisted of drainage systems along US 1, although many portions of this road had no stormwater controls at all. Ten residential areas were visited to review the types of stormwater controls that were present. Based on this survey, only 10 to 20 percent of residential areas in the Keys have stormwater systems of any type, even though many of the residential roads are paved. Not surprisingly, 40 percent of the residential areas visited had nuisance flooding concerns related to standing water (i.e., no structure flooding). Most of these areas have vegetated areas along or near the residential roads; however, it does not appear that they are designed to control stormwater.

Recommendations

In order to address the problems and concerns identified and to achieve the objectives of the SMMP, the following actions are recommended.

- *Monroe County should adopt a 95 percent treatment requirement and strictly enforce its application on new development and significant redevelopment.* The 95 percent treatment requirement means that new developments must remove 95 percent of the annual average load of pollutants from developed property. For the purposes of this plan, the 95 percent standard means 95 percent capture of the mean annual rainfall volume. Through modeling of stormwater pollutant loading for future growth, it has been shown that this requirement will achieve Goal 4 (no increase in future loads). The consequences of this requirement are two-fold. First, the County should review each new development to confirm that the 95 percent requirement is met and through construction inspection, confirm that the stormwater systems are being built according to the approved design. Second, the County should work with existing residential and commercial developments that plan to redevelop. Once reasonable stormwater retrofits are defined that meet the 95 percent rule, the County should allow redevelopment, as the redeveloped property will provide water quality benefits.

- *Monroe County should implement an operation and maintenance (O&M) program for public stormwater management systems and inspection of private systems.* The O&M program adopted by the County should include routine maintenance for critical stormwater systems as well as routine inspection of others. Furthermore, private stormwater systems should receive proper maintenance with annual certification by owners.

- *Monroe County or South Florida Water management District (SFWMD) should develop a stormwater well inventory.* Runoff from both public and private properties is discharged into drainage wells. Unfortunately, very little is known about the location, tributary area and land use draining to each well. While drainage wells provide significant stormwater flood relief, the benefits and impacts on water quality are not well documented because of the lack of information.

- *Monroe County and SFWMD should enforce existing regulations through inspection and as-built drawings.* The review of existing federal, state, regional and local stormwater regulations confirmed that there are sufficient regulatory controls defined today. However, field inspections confirmed that many of the permitted systems were not built according to the permit and/or are not being maintained. County and water management district inspectors should also be trained in sediment and erosion control.

- *Monroe County should pay special attention to marinas with respect to stormwater runoff.* Many of the stormwater quality problem areas identified in the Florida Keys were related to private marinas. Field inspections identified major problems that were related to runoff from material storage areas, unpaved areas, and lack of stormwater controls prior to discharge. The County should encourage the state to continue the Clean Marina Program, and marina retrofits should be reviewed on a case-by-case basis to meet the 95 percent rule.

- *Monroe County should encourage redevelopment and retrofit with reductions in impervious areas.* Many of the existing stormwater problems occur because development has increased the imperviousness of the area. Increased imperviousness changes the volume, timing, peak flow, and pollutant content of stormwater runoff. The County should offer incentives for the reduction of impervious areas using vegetated and landscaped swales, rain gardens, bio-filters, and pervious pavement.

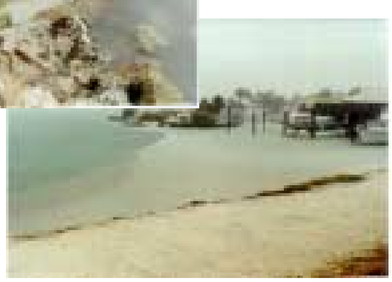
- *Monroe County should encourage the use of vegetated buffers and conservation measures.* As noted previously, the major problems encountered in the Florida Keys are due to the lack of stormwater controls prior to discharge. Simple, yet powerful, controls consist of vegetated buffers such as swales, rain gardens, bio-filters and bio-retention. Also, by conserving water through the use of runoff for residential irrigation reduces the volume of runoff and limits the pollutant loading discharged. Conservation measures such as cisterns, rain barrels and xeriscape are particularly effective.

- *Monroe County should require all vegetated systems such as swales, medians, etc., to be planted with native vegetation to minimize maintenance.* Planting of vegetated systems with native plants will maintain the beauty of the Florida Keys' natural environment as well

as minimize special maintenance. Public and private construction and development should be encouraged to use salt-tolerant plants near shoreline spray areas and other native plants away from the coast line.

- *With the support of federal, state, and regional governments, Monroe County should implement the recommended retrofit and rehabilitation projects to address existing problem areas.* Twenty-two retrofit and rehabilitation projects have been identified to address problem areas within Monroe County. The projects include improvements to be implemented by the Florida Department of Environmental Regulation (Heritage Bike Trail), Florida Department of Transportation (along US 1), Monroe County and Marathon. Three additional projects on private property have been considered as well: K-Mart in Marathon, Key Largo Trailer Village, and the Safe Harbor area on Stock Island. These represent example projects to illustrate the possible retrofit or rehabilitation of private property.

- *Where possible, FDOT should include stormwater controls as part of all Florida Keys projects, including bridge entrances and exits.* A review of existing designs and a field survey of FDOT systems showed that many areas have



limited stormwater quality controls. Many of the bridge entrances and exits, especially in the Upper Keys discharge uncontrolled stormwater that contain significant sediment loads. Since the FDOT stormwater system is the major (and in some study areas, the only) stormwater controls available, stormwater quality improvements will also result in improvements to near shore waters.

The SMMP provides a number of benefits related to the goals and objectives of the plan. First, the SMMP provides retrofit and rehabilitation projects for all of the identified public problem areas within the Keys. These projects will address both flooding and water quality improvements. Second, the implementation of the SMMP will also improve maintenance activities for existing and future stormwater management facilities. Third, the SMMP recommends a number of programs that will minimize the runoff pollutant loading to the near shore waters from future developments and eventually will reduce the loads from existing sources.

SMMP Costs and Funding

The costs to implement the SMMP fall into two categories: (1) capital costs for the construction of recommended improvements, and (2) ongoing costs for regulatory and maintenance related activities. Tables ES-3a (Monroe County) and 3b (Marathon) lists the retrofit and rehabilitation projects to be completed on public property in Monroe County and Marathon. An additional 12 projects are recommended for FDOT and FDEP (Heritage Bike Trails). These recommendations address all of the public problem areas identified historically and by the public related to stormwater runoff. Three private retrofit improvement projects are provided as examples of the effort needed for redevelopment of private property. The total cost for these projects is approximately $254,000 for unincorporated Monroe County and $196,200 for the City of Marathon. Funding for the Monroe County projects can be achieved through state and water management district grants and existing local infrastructure sales taxes.

For the FDOT and FDEP (Bike Trails), the SMMP recommends improvements on approximately 17.5 miles of the total 107-mile-long US 1 (Overseas Highway). Of the 107 miles, approximately 18.9 miles are bridges and 16.1 miles are in Key Largo (curb & gutter and swales). Thus, approximately 54.5 miles (75 percent) of US 1 are not addressed in this SMMP. Using the average cost per mile for the recommended FDOT/FDEP improvements, the projected cost for improvements to the 54.5 miles would be about $13.5 million, resulting in a total FDOT/FDEP rehabilitation cost of $18.5 million if all of US 1 were improved, excluding Key Largo.

For ongoing costs for Monroe County, it has been estimated that an additional $75,000 to $110,000 per year for the first three years and about $90,000 per year thereafter are needed to improve regulatory compliance and increase maintenance activities. These costs can be phased over a number of years to confirm the effectiveness of the programs.

Finally, related to costs, the 1992 "Water Quality Protection Program for the Florida Keys Natural Marine Sanctuary" report estimated a cost of over $530 to $680 million to retrofit all urban lands in the Sanctuary. Using the costs identified in this SMMP, total retrofit of urban land would cost about $465 million. However, this SMMP recommends that such retrofit to the 95 percent standard should occur as redevelopment is economically feasible.

Implementation of the SMMP

As with costs, implementation of the SMMP can be categorized by capital improvements and ongoing governmental improvements. For implementation of the capital improvements, Monroe County should coordinate efforts with other ongoing construction efforts such as FDOT's Five Year Plan and the Monroe County Sanitary Wastewater Management Plan. That is, improvements should coincide with other construction projects so local disturbances occur only once and construction costs are minimized.

For the overall plan, it is recommended that Monroe County implement the SMMP over the next four years. The suggested schedule for activities is provided in Figure ES-3. The schedule shows the responsibilities for each participating agency including Monroe County, city of Marathon, FDOT and FDEP. The overall program can be extended a few years depending on funding and construction coordination.

Table ES-3a - Summary of Retrofit and Rehabilitation Costs for Unincorporated County

Problem Area	Study Area	Estimated Cost
El Prado Circle on Coppitt Key	Big Coppitt	$89,700
Card Sound Road (SR 905A)	Key Largo	$89,700
Marathon Government Center	Marathon	$29,900
Burton Drive at US 1 in Tavernier	Key Largo	$11,300
Jo-Jean Way in Tavernier	Key Largo	$29,900
Veterans Park in Little Duck Key	Marathon	$3,500
	Total Estimated Costs	$254,000

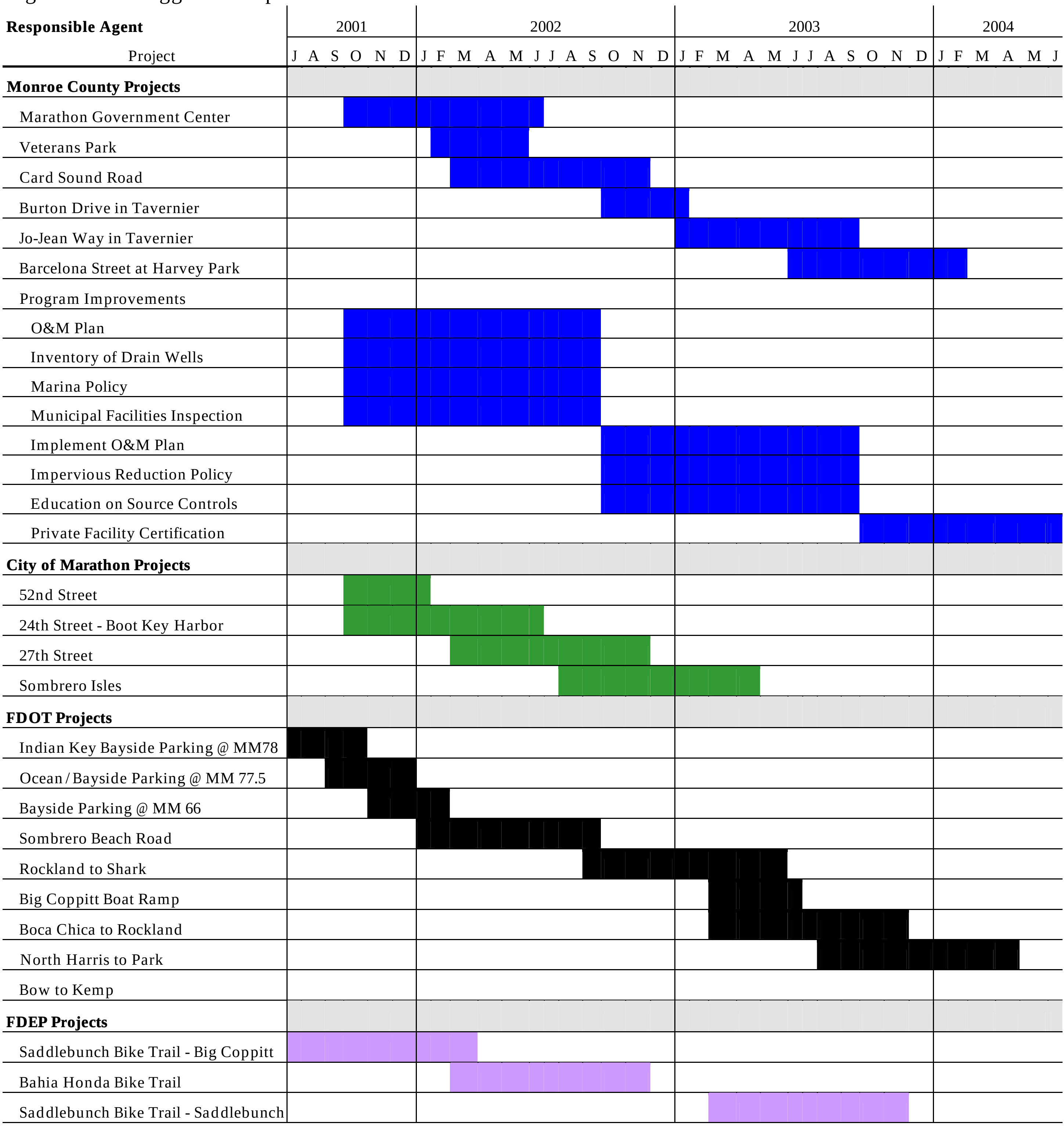
Table ES-3b - Summary of Retrofit and Rehabilitation Costs for City of Marathon

Problem Area	Study Area	Estimated Cost
27th Street	Marathon	$22,400
Sombrero Isles	Marathon	$147,900
24th Street	Marathon	$3,500
52nd Street (Palm Place) - Marathon	Marathon	$22,400
	Total Estimated Costs	$196,200

Table ES-3c - Summary of Retrofit and Rehabilitation Costs for FDOT and FDEP

Problem Area	Study Area	Estimated Cost
Indian Key Bayside Parking	Ram Rod Key	$2,100
Ocean / Bayside Parking at MM 77.5	Lower Matecumbe	$2,600
Bayside Parking at MM 66	Long Key	$16,900
Sombrero Beach Road	Marathon	$536,400
Rockland Channel to Shark Channel	Big Coppitt	$543,500
Big Coppitt Boat Ramp	Big Coppitt	$43,000
Boca Chica Channel to Rockland Channel	Boca Chica	$1,128,700
North Harris Channel to Park Channel	Lower Sugarloaf	$418,000
Bow Channel to Kemp Channel	Cudjoe Key	$1,045,100
Saddlebunch Bike Trail - Big Coppitt	Big Coppitt	$678,100
Bahia Honda Bike Trail	Bahia Honda	$912,000
Saddlebunch Bike Trail - Saddlebunch	Saddlebunch	$250,800
	Total Estimated Costs	$5,577,200

Figure ES-3 - Suggested Implementation Schedule for SMMP.



Section 1.0 Introduction

Monroe County, Florida, is required by their adopted Year 2010 Comprehensive Plan (Comp Plan) to prepare a Stormwater Management Master Plan (SMMP). The SMMP is to assess the adequacy of existing systems, prioritize stormwater management needs for each island, identify regulations and policy needs, and develop a plan to finance the construction, operation and maintenance of required facilities. The geographic area of this project consists of the islands (also referred to as the Florida Keys) in the County, which are traversed by US Highway 1, or are connected via a bridge to one of these islands.

The basic elements of the SMMP include Information/Data Gathering and Assessment; Objectives, Standards and Problem Areas; Management Strategies and Alternatives; Recommended Programs; and Public Interaction. The data collected and results of each of these efforts are documented in three volumes:

- Executive Summary of SMMP (to be prepared after Volumes 1 and 2 are completed)
- Volume 1 - Data Compilation and Assessment, along with Objectives.
- Volume 2 - Management Strategies and Alternatives, along with Recommended Programs and Implementation Plan.

The Public Interaction program has been enfolded into each of these reports.

The purpose of Section 2.0 of this report is to provide the collection and compilation of pertinent project data along with the assessment of the data relative to stormwater management within the Florida Keys. Pertinent data include the natural setting (e.g., weather, soils, land uses, near shore waters, population, etc.), pollutant sources, and existing stormwater management systems. Also included in this volume is a list of stormwater management methods currently used within Florida or United States for the control of flooding or stormwater related pollutants.

Section 3.0 of this volume discusses the objectives and goals of the SMMP. Problem areas are also identified and ranked from most important to least important using an objective-oriented ranking matrix.

It should be noted that this volume includes data collection within the incorporated areas (i.e., Marathon, Key West, Key Colony Beach, Layton and Islamorada). The rest of the SMMP does not include these incorporated areas except Marathon. Marathon became incorporated after the beginning of the SMMP process so that costs were included to cover problems within Marathon. However, these problem areas were separately ranked so that implementation by Marathon can occur independent of Monroe County.

Section 2.0
Data Compilation and Assessment

The purposes of this section are to compile pertinent data for the Monroe County Stormwater Management Master Plan (SMMP) and to assess the data collected relative to stormwater management within the Florida Keys. Information for this section was collected from federal, state, regional and local sources as described below (Subsection 2.1) and the need for additional data considered in Subsection 2.2. Also, to aid in the understanding of the stormwater runoff loading, estimates of pollutant loading from natural, background and urban sources were defined (Subsection 2.3). An inventory of existing stormwater facilities was developed including maps of facilities and fieldwork on selected structures and residential areas (Subsection 2.4). Subsection 2.5 provides a listing and assessment of regulatory requirements for federal, state, regional (water management district) and local governments. Finally, a list of available stormwater management and control mechanisms used in Florida and in United States is discussed in Subsection 2.6. Both structural and nonstructural stormwater controls are considered.

Monroe County consists of approximately 1.2 million acres, of which the majority are submerged lands under state or federal jurisdiction. Excluding the mainland areas, Monroe County amounts to about 65,400 acres along the Florida Keys including the incorporated areas of Key West, Islamorada, Layton, Key Colony Beach and the newly incorporated Marathon. The Florida Keys consist of 38 main keys connected to the mainland through Dade County along US 1. Provided in this chapter is a summary and analysis of available data as well as data specifically collected for the SMMP.

2.1 Existing Data Compilation

The first task for the Monroe County Stormwater Management Master Plan (SMMP) is the compilation of existing data related to the management of runoff within the Florida Keys. A significant amount of environmental data exists for the Florida Keys, some of which is pertinent to this SMMP. The goal of this section is to compile and assess the available data and describe the pertinent information.

In order to report the available data, the SMMP has adopted a standard set of study areas within the Florida Keys. Table 2.1-1 lists the study areas associated with the Planning Area Enumeration Districts (PAED's) and wastewater planning areas (from draft Monroe County Sanitary Wastewater Master Plan, March 2000) for reference.

Appendix A provides a list of governmental and private agencies contacted for the compilation of data. The list provides the agency and type of data provided. Appendix A also provides a list of the data provided by each agency, some of which are summarized below.

2.1.1 Population Statistics

Population information for the Florida Keys can be obtained from the "Unincorporated Monroe County Population Forecasts 1990-2015," produced by the Monroe County Planning Department. This report updates the Year 2010 Comprehensive Plan Technical Document. Table 2.1-2 provides the data summarized by Stormwater Planning Areas for 1999 and 2010 showing both resident and seasonal population data, and Table 2.1-3 shows the percent change in population from 1999 to 2010. It should be noted that the loss in population from the Middle Keys is due to the incorporation of Islamorada after the 1999 population estimate.

From these data, the 1999 population data shows that the Upper Keys has the largest population at about 49,200 with the Middle and Lower Keys having almost the same population at about 36,000. The largest stormwater study area population appears to be Key Largo Lower, followed by Marathon. In 2010, the Upper Keys will still have the largest population at over 52,500, followed by the Lower Keys at about 39,100 and then the Middle Keys at about 28,400. The largest study area populations are Key Largo Lower and Marathon as in 1999. However, it must be remembered that in the late 1999 election, Marathon voted for incorporation so that the population for this study area should be excluded in the actual 2010 population.

Related to population changes, the largest population growth for permanent residents is in Cudjoe Key at 15 percent over the 11 years, followed by Bay Point Key (12.3 percent) and Big Pine Key (11.3 percent). On the average the change in population growth was 0.7 in permanent residents, reflecting the incorporation issues. The largest population growth in seasonal population is for Toms Harbor Keys at over 25 percent followed by Key Largo Lower (South) at 14 percent and Cudjoe Key at 14

Table 2-1
Monroe County Stormwater Management Master Plan
Summary of Study Areas

Study Area	Name	PAED No. (1)	Wastewater Study Areas (2)
Lower Keys			
1	Key West		
2	Stock Island	1	1
3	Boca Chica Key	2	2
4	Bay Point Key	3	3
5	Lower Sugarloaf Key	3	4
6	Upper Sugarloaf Key	3	5
7	Cudjoe Key	4a	6
8	Summerland Key	4a	7
9	Ram Rod Key	4a	9
10	Torch Keys	4a	8, 10
11	Big Pine Key	5, 4b	11
12	Bahia Honda	6	12
Middle Keys			
13	Marathon	7, 9	13, 14
14	Key Colony Beach	8	13
15	Long Key	11	15
16	Layton	11	15
17	Lower Matecumbe Key	12a	16
18	Islamorada	13	17
19	Upper Matecumbe Key	13	17
20	Windley Key	12b	18
Upper Keys			
21	Key Largo Lower	14 to 20, 22	19 to 25
22	Key Largo Upper	21	26, 27

Notes: (1) Monroe County Year 2010 Comprehensive Plan, Technical Document, April 1993.
(2) Draft Monroe County Sanitary Wastewater Master Plan, Appendices (CH2MHill, March 2000).

Table 2-2
Monroe County Stormwater Management Master Plan
Summary of Population for Florida Keys

Study Area	Name	1999 Population			2010 Population		
		Perm	Season	Total	Perm	Season	Total
Lower Keys							
1	Key West (2)						
2	Stock Island	4,699	1,615	6,314	4,742	1,627	6,369
3	Boca Chica Key	3,344	1,691	5,035	3,451	1,728	5,179
4, 5, 6	Bay Point Key	2,168	1,913	4,081	2,434	1,988	4,422
	Lower Sugarloaf Key						
	Upper Sugarloaf Key						
7, 8, 9, 10	Cudjoe Key	4,939	4,268	9,207	5,679	4,830	10,509
	Summerland Key						
	Ram Rod Key						
	Torch Keys						
11	Big Pine Key	5,121	4,302	9,423	5,702	4,614	10,316
12	Bahia Honda	438	1,889	2,327	429	1,897	2,326
Middle Keys							
13	Marathon	10,482	9,942	20,424	10,702	10,172	20,874
14	Key Colony Beach	764	2,017	2,781	805	2,104	2,909
	Toms Harbor Keys	716	1,007	1,723	770	1,267	2,037
15, 16	Long Key	377	2,160	2,537	389	2,193	2,582
	Layton						
17	Lower Matecumbe Key	1,131	1,713	2,844	(3)	(3)	(3)
18, 19	Islamorada	1,292	3,374	4,666	(3)	(3)	(3)
	Upper Matecumbe Key						
20	Windley Key	153	929	1,082	(3)	(3)	(3)
Upper Keys							
21	Key Largo Lower (South)	20,869	22,823	43,692	21,705	25,144	46,849
22	Key Largo Upper	1,653	3,860	5,513	1,723	4,016	5,739
	Totals	58,146	63,503	121,649	58,531	61,580	120,111
	Lower	20,709	15,678	36,387	22,437	16,684	39,121
	Middle	14,915	21,142	36,057	12,666	15,736	28,402
	Upper	22,522	26,683	49,205	23,428	29,160	52,588

Note (1) Unincorporated Monroe County Population Forcasts 1990 - 2015; Planning Departr
(2) Not included since Key West is incorporated.
(3) Not included since Islamorada incorporated after 1999 population projection.

Table 2-3
Monroe County Stormwater Management Master Plan
Summary of Population for Florida Keys

Study Area	Name	1999 to 2000 Increase Perm	Season	Total
Lower Keys				
1	Key West (2)			
2	Stock Island	0.9%	0.7%	0.9%
3	Boca Chica Key	3.2%	2.2%	2.9%
4, 5, 6	Bay Point Key	12.3%	3.9%	8.4%
	Lower Sugarloaf Key			
	Upper Sugarloaf Key			
7, 8, 9, 10	Cudjoe Key	15.0%	13.2%	14.1%
	Summerland Key			
	Ram Rod Key			
	Torch Keys			
11	Big Pine Key	11.3%	7.3%	9.5%
12	Bahia Honda	-2.1%	0.4%	0.0%
Middle Keys				
13	Marathon	2.1%	2.3%	2.2%
14	Key Colony Beach	5.4%	4.3%	4.6%
	Toms Harbor Keys	7.5%	25.8%	18.2%
15, 16	Long Key	3.2%	1.5%	1.8%
	Layton			
17	Lower Matecumbe Key			
18, 19	Islamorada			
	Upper Matecumbe Key			
20	Windley Key			
Upper Keys				
21	Key Largo Lower (South)	4.0%	10.2%	7.2%
22	Key Largo Upper	4.2%	4.0%	4.1%
	Totals	0.7%	-3.0%	-1.3%
	Lower	8.3%	6.4%	7.5%
	Middle	-15.1%	-25.6%	-21.2%
	Upper	4.0%	9.3%	6.9%

percent. There is an overall loss of 3 percent in the seasonal population due to incorporation.

2.1.2 Near-shore Marine Information (by Mote Marine Lab[1])

Physical Environment

The location of the Florida Keys provides a unique suite of conditions in the United States and has lead to the development of a variety of interconnected, tropical marine ecosystems. There is both climatic and biotic variation within the Keys which extend over one degree of latitude (~24.5 to 25.5 N) and almost three degrees of longitude (~80.2 to 82.9 W). Several terms will be used to characterize the major areas of the Keys in the discussion that follows. The Upper Keys begin with the Ragged Keys of Biscayne National Park to the north and are generally demarcated at Upper Matecumbe (Teatable Key Channel) to the southwest. The Middle Keys encompass the islands south and west of Lower Matecumbe to Marathon (Seven Mile Bridge). The Lower Keys include Big Pine Key through Key West. Islands west of Key West to the Dry Tortugas will not be considered here as they are not included within the Monroe County SMMP project area.

Although somewhat arbitrary, these regional designations do have some natural constraints that affect the nearshore marine, and terrestrial, environments. The Upper Keys form a fairly continuous barrier between the coastal waters of the mainland on the west and north sides of the Keys (Florida Bay, Barnes, Blackwater and Card Sounds and Biscayne Bay; usually called "bayside") and those of Hawk Channel and the Straits of Florida on the east and south of the Keys ("oceanside"). The Middle Keys have large passes that allow considerable exchange of water. Both the Upper and Middle Keys have a similar surface geology known as Key Largo limestone (remnant Pleistocene reef). The Lower Keys are intermediate with respect to tidal exchange from one side to the other. The waters to the north here are more properly considered Southwest Florida Shelf waters rather than part of Florida Bay; they are influenced by Florida Bay and also by the Gulf of Mexico. The Lower Keys have a surface formation known as "Miami oolite" and this accounts for the very different orientation of the Lower Keys. This oolitic limestone has some important considerations for terrestrial biota but, other than general effects on water flow and wave energy, the actual limestone composition has little influence on marine environments.

Near Shore Waters

High temperatures and insulation during the summer lead to rapid evaporation rates. Shallow water bodies around the Keys with restricted exchange with deeper water can have salinities exceeding 40 parts per thousand (ppt), in some cases considerably higher. Salinity can quickly drop below 30 ppt during heavy rains. Florida Bay, immediately north of the Upper and Middle Keys, is also influenced by freshwater

[1] Erich Mueller, Ph.D., Director, Mote Marine Laboratory, Center for Tropical Research, 24244 Overseas Highway (US 1), Summerland Key, FL 33042.

flow from the Everglades and experiences even greater extremes; salinity may be as low as 2 ppt or as high as 70 ppt in very restricted bays. To a lesser extent, the southeastern Gulf of Mexico north of the Lower Keys, also experiences greater salinity fluctuations than offshore oceanic waters (which are typically 35-36 ppt). Similarly, the shallow waters around the Keys have a greater temperature range than found in offshore waters. Water temperatures peak in late summer and restricted waters around the Keys may exceed 35°C. Florida Bay temperatures have been recorded up to 40 °C.

The shallow waters around the Florida Keys are subject to other physical and chemical factors that influence the development of ecosystems and potential impacts upon them. The relatively low volume of water in these areas and proximity of the bottom means that benthic processes, both biotic (photosynthesis, respiration, decomposition) and abiotic (sediment resuspension, precipitation and dissolution) can have significant influence on the overlying water column. For example, oxygen can exhibit marked diurnal variations (high in late afternoon and low in early morning) because of the light-dependence of photosynthesis. As an abiotic example, turbidity in nearshore waters is much more variable than offshore because wind events and high tidal flow velocities can quickly resuspend fine material. Also, these waters are first to receive terrestrial inputs of sediment, nutrients and pollutants. Restricted embayments may experience extremes in a variety of parameters due to the low volume and long exchange times with more open waters. Thus, nearshore marine ecosystems of the Keys are characterized by variability relative to the oceanic conditions found not far offshore. Although biodiversity is often considered fairly high in the Florida Keys (relative to temperate climates), the shallowest areas that experience the greatest variability in physical conditions are occupied by species that tolerate such conditions leading to a relatively low biotic diversity.

The influence of water flow has been alluded to several times and has considerable influence on the structure, composition and vulnerability of marine ecosystems on several spatial scales. The Florida Keys lie at the interface between the Gulf of Mexico and the Florida Straits. Florida Bay is contiguous with the Gulf of Mexico and receives considerable influence from the Gulf along the Bay's western boundary. However, the very shallow waters of the Bay, relatively restricted exchange and terrestrial influence from the Everglades make this body of water distinct from the Gulf. At the largest scale, tropical Caribbean waters enter the Gulf of Mexico via the Yucatan Channel. Some of this water flows directly to the Atlantic Ocean through Straits of Florida (as the Florida Current) and can influence coastal waters of the Florida Keys. The Keys are also affected by waters leaving the Gulf of Mexico either directly through the Keys or after mixing back in with tropical oceanic waters in the Straits of Florida. Although initially of Caribbean origin, waters leaving the Gulf are affected to varying degrees by their residence time there. Numerous rivers empty into the Gulf, most notably the Mississippi, draining approximately 50% of the United States watershed. The 1993 flooding along the Mississippi River and its tributaries allowed satellite imagery to follow the turbid waters through the Gulf and along the Florida Keys.

The nearshore water of the Keys are primarily influenced by water from the Gulf of Mexico. This may be directly (primarily Lower Keys) or via passage through Florida Bay (primarily Middle Keys). There is net flow of surface and groundwater flow from the "bayside" to the "oceanside" of the Keys. Higher sea level has been observed in Florida Bay than in Hawk Channel thus providing a "head" that drives net water flow towards Hawk Channel. In general, net water transport within Hawk Channel is to the west with an offshore component. Because of this, water passing through the large passes of the Middle Keys flows west and south and has relatively little influence on oceanside waters of the Upper Keys. A few small channels allow Florida Bay waters into Hawk Channel in the Upper Keys so here there is more influence of the oceanic waters of the Florida Current. Periodically, oceanic waters from the Florida Current can influence lower portions of Hawk Channel depending upon offshore circulation patterns (gyres) and tides.

Water flow through the Keys is primarily tidally-driven with the underlying differential sea levels influencing the net transport. Wind events also affect such transport, particularly in winter when northerly winds enhance this net north to south movement and reduce sea levels, exposing shallow banks. The flow velocity in the channels is strongly influenced by tidal height differentials (greater during spring tides) as well as wind. Average and extreme flow velocities are important physical factors in determining the nature of marine sediment distribution and the associated benthic communities.

Nearshore Habitats of the Florida Keys

For the purposes of this document, discussion will be limited to marine habitats within 2 km of the islands of the Upper, Middle and Lower Florida Keys. Some studies have concluded that nutrients of terrestrial origin on the Keys reach as far as the reef tract 6-10 km offshore; however, a recent consensus (Kruczynski, 1999) of scientists concluded that good evidence for offshore transport of land-derived materials was on the order of several km and did not extend to the reef tract. This conclusion may change with future studies; however, the immediate concern is with impacts to nearshore communities. If stormwater and other anthropogenic input to these waters could be mitigated, then effects further downstream will also be reduced.

Natural shorelines of the Florida Keys are dominated by mangrove habitats. The upper portions of such systems are primarily terrestrial and composed of white mangroves (*Laguncularia racemosa*) and buttonwoods (*Conocarpus erecta*). The marine component of this transitional community includes the black mangrove (*Avicennia nitida*) and is dominated by the red mangrove (*Rhizophora mangle*). The latter is particularly important in stabilizing the shoreline and for providing a unique, shallow water habitat. The red mangrove is easily recognized by its complex aerial "prop" root system that can extend for several meters out into the water. These roots provide stability in areas prone to tropical storms and often characterized by shallow sediments underlain by rock. The prop roots serve as attachment points for algae and epifauna such as sponges, tunicates and hydroids. The roots also provide protection to a number mobile fauna including crabs, lobsters and fish. This is primarily habitat for many species but many others reside in this protective habitat only during larval or juvenile stages. Some species such as the gray (mangrove) snapper (*Lutjanus griseus*) and the Florida spiny lobster (*Panulirus argus*) become ecologically and, economically, important members of reef communities as adults. Thus, mangroves are considered to be a critical nursery habitat. The mangroves themselves, through production, loss and eventual decomposition of leaf material, contribute to the trophic structure of nearshore waters.

Other natural shoreline types are rocky, mud and sand. Rocky intertidal areas generally occur along fairly high-energy shores. The dissolution of limestone provides a topographically diverse habitat with varying degrees of aerial exposure. Tidal range is low in the Keys (~0.6 m) but several intertidal zones can be found along rocky shores. A number of species such as the Sally lightfoot crab (*Grapsus grapsus*) are found only here as well as representatives of more generally distributed marine species, including certain corals that are tolerant of the environmental conditions caused by exposure or periodic water confinement.

Natural sandy beaches are very rare in the Keys and are composed almost exclusively of biogenic calcium carbonate grains. The importance of such shorelines to the marine environment, which also applies to other shoreline types, includes the accumulation and decomposition of marine detritus, largely seagrasses and algae. These plant materials are broken down in "wrack lines" by amphipods and microorganisms. Nutrients are returned to the ocean by subsequent tides. Muddy shorelines are relatively uncommon and usually in association with mangroves. They occur in low wave energy environments and have a superficially low biodiversity. Fiddler crabs (*Uca* spp.) are usually the most obvious inhabitants, however, a rich diversity of infauna lies below the mud surface. The nature of muddy sediments in binding and retaining certain types of chemicals makes these organisms particularly susceptible to certain pollutants.

Moving into the nearshore waters proper, there are four primary habitat types: unconsolidated (mud or sand bottom), seagrasses, hard-bottom and patch reefs. Bank reefs are probably the most complex and certainly the most famous habitats of the Keys but occur further offshore than the scope of this review. The unconsolidated areas are relatively limited in extent and have received little research attention. The muddy types are found in relatively low energy channels and offshore within Hawk Channel. Various factors such as light penetration or instability prevents these areas from being colonized by seagrasses. As mentioned for muddy shorelines, the biodiversity of such areas is largely hidden beneath the surface. Around mangroves or in shallow channels with low current velocities can be found the upside-down jellyfish (*Cassiopeia* spp.). Some of the deeper areas of Hawk Channel are sparsely covered with several species of *Halophila*, a seagrass. Sandy bottoms are found in higher energy areas and are relatively thin over carbonate rock. The sand is largely composed of the disarticulated plates of *Halimeda*, a calcareous green algal genus represented by several species. Bottom dominated by such sediments has an "oatmeal" texture. Where only 1-2 cm thick, algae and sessile animals can attach to the underlying rock; these areas will be considered as hard-bottom and discussed later. Thicker sand deposits are relatively uncommon inshore. One place they are found is around patch reefs (discussed later) where they are referred to as sand "halos". Inhabitants include some of the larger infauna such as sea biscuits (*Meoma ventricosa* is most common), sea cucumbers and certain molluscs that may be visible on, or just below, the surface.

Most of the nearshore muddy or sandy bottoms are dominated by seagrasses. Seagrass communities are considered one of the most ecologically important marine habitats providing primary production, refuge and sediment consolidation. Worldwide, there are about four dozen species of seagrasses from two plant families. There are five or six species in the Keys. Three species are commonly:

- turtle grass (Thalassia testudinum),
- shoal grass (Halodule wrightii) and
- manatee grass (Syringodium filiforme).

The remaining 2 or 3 species (two are very similar) are members of the genus *Halophila* mentioned previously. Often a zonal pattern can be found as one proceeds out from a shoreline with shoal grass first encountered, followed by manatee grass and then turtle grass. The latter two species can form extensive meadows. North of Marathon is a particularly large meadow of manatee grass, acres of which were recently removed by a particularly large population explosion of the variegated sea urchin (*Lytechinus variegatus*). Turtle grass is by far the most common in the Keys and extensive beds are found in all nearshore waters. While virtually mono-specific meadows are common, the seagrass species may be mixed (particularly at boundary areas) or intermixed with a number of algal species including *Penicillus* spp. and *Halimeda* spp. Drift algae (mostly certain red algae) may be retained and continue to growth in seagrass beds as well. Drift algae have been found to be essential habitat for the Florida spiny lobster as it settles out of the water column, where its larval phases took place, and begins its benthic existence. There are a few corals found in some seagrass beds, particularly those with fairly low seagrass density. They include the ivory tube coral (*Cladocora arbuscula*), the finger coral (*Porites porites* forma *divaricata*) and the rose coral (*Manicina areolata*). The latter must first something hard to settle on, such as a shell or small rock, but eventually breaks off and remains unattached to the substrate. The pink-tipped anemone (*Condylactis gigantea*) and several other anemones are common inhabitants of many shallow seagrass beds.

Seagrasses have high rates of primary production and through both grazing and decomposition, contribute substantially to the trophic structure of coastal waters where they occur. Floating leaves also export some of this production to other ecosystems where they are degraded by microbial processes. Like mangroves, seagrass leaves provide a substrate for many epiphytic plants and animals, both attached and small mobile species. In addition to permanent residents, for which seagrasses provide both refuge and food resources, some species utilize nearby reef areas for protection at night and spend the day foraging in seagrass meadows (usually fish) or vice-versa (particularly certain sea urchins). As with mangrove areas, some species spend only their juvenile phases in seagrass meadows and move to other areas as adults. Seagrasses provide a transitional habitat for some species spending their earliest juvenile stages in the mangroves.

There is a habitat type that is somewhat transitional between seagrasses and hard-bottom, discussed below. These are "shoaling" or "shoal fringe" communities. They are shallow banks (< 1 m) that may fringe nearshore islands, particularly on the oceanside. There is a mixture of sand with finer sediments that supports low-moderate density seagrass beds and a variety of algae normally associated with seagrass areas. However, the major distinguishing characteristic of such areas is the abundance of the coralline ("coral-like") alga *Neogoniolithon strictum* and/or the finger coral. They provide a low-relief, but complex, microhabitat for a large variety of small species including crabs, shrimp, worms, echinoderms and molluscs. Virtually every animal phylum can be found in some of these communities.

Hard-bottom (sometimes called hardgrounds or live-bottom) occurs where rock substrate is exposed or covered by only a thin veneer of sand. One type of hardground is referred to as "algal/sponge flats" or just "sponge flats". Close to shore, sponges may be absent and the bottom dominated by a wide variety of sessile green, brown and red algae. The various species of *Halimeda*, also found in seagrass beds and on reefs, are the largest producers of sand in the Keys. Several species of *Caulerpa* are also common algae here. With just a little bit more depth and a good amount of tidal flow, the algal community is augmented by sponges including the large loggerhead sponge (*Spheciospongia vesparia*), vase sponge (*Ircinia campana*) and several species of commercially-valuable sponge. Sponges pump large volumes of water through them as they filter feed, thus helping to "clean" the water. They also provide habitat for many small invertebrates. The loggerhead sponges in particular provide important habitat for the Florida spiny lobster during certain growth phases as young adults. Drift algae can also be found in such areas and serve as settlement sites for post-juvenile lobster. Some small corals are also common on hardgrounds, particularly the "golf ball" corals (*Siderastrea radians, Favia fragum*) and the rose coral.

Where currents are moderate to strong and depth suitable, soft corals (octocorals) may be common. These areas are generally in tidal channels or in more exposed areas, both oceanside or bayside. Over a dozen species may be found in any one area and some may reach heights of 2 meters. Stony corals of a greater variety than found close to shore are also present, some of which are also found on reefs. Here they are usually small or grow laterally forming low colonies. The combination of octocorals, sponges and corals increases the habitat complexity providing habitat for an increasing number of species. A common fish of this habitat is the hogfish (*Lachnolaimus maximus*) as well as various snappers and grunts. Small to legal-sized lobster find occasional ledges and holes here. The commercially-valuable stone crab (*Menippe mercenaria*) also occupies burrows in octocoral hard-bottom.

The last habitat of the nearshore areas are the patch reefs. There are about a half dozen major types of reefs in the world, two of which are found in the Florida Keys. The bank reefs, the destination of most divers, lie along the edge of continental shelf beyond the scope of this discussion. Patch reefs occur both offshore (behind the bank reefs) and inshore. The inshore patch reefs, which will be discussed here, are somewhat different than those offshore, having a lower species diversity and lower relief due to the shallower water in which they form.

Isolated coral heads or small clumps can form on almost any exposed rocky substrate where there is adequate water flow. While providing a reef-like habitat, these are not considered a patch *per se*. Nevertheless, they are very common throughout nearshore waters and provide valuable habitat in areas where there are few areas of topographic relief. Where exposed substrate is more extensive and other conditions suitable, patch reefs can form. Typically these are along exposed coasts rather than in channels and are relatively uncommon in the Middle Keys where water flow from Florida Bay and the southeastern Gulf is less suitable for coral growth. Some form on the bayside, particularly north of the Lower Keys. These patch reefs are usually composed of isolated heads that grow up, much like a hard-bottom where the corals have grown taller. Coral species diversity is relatively low as reefs go because the variable water quality conditions. But these reefs also have some Gulf species, particularly fish such as spadefish (*Chaetodipterus faber*) and sheepshead (*Archosargus probatocephalus*), that are rare or absent on reefs of the oceanside.

Oceanside patch reefs are more extensive and massive with many corals growing together, often on one another. The relief of these reefs is usually limited by the water surface to 3-4 m. These are true reef communities with a high diversity of invertebrates and fish (though lower than offshore reefs). The bulk of the reef is usually formed by the mountainous star coral (*Montastraea annularis* complex) and other massive coral types including starlet corals (*Siderastraea siderastraea*) and brain corals. Notably absent from such reefs are the acroporids (staghorn - *Acropora cervicornis* and elkhorn - *A. palmata*) and species preferring greater depths. A typical feature of patch reefs is a sand halo. This appears to form from a combination of sand production on the reef and heavy grazing by sea urchins and fish that find refuge in the reef when not foraging. Beyond the halo, seagrass beds or octocoral-dominated hardbottom are common.

Most patch reefs are fairly small - up to 200 m across at most. However, this apparently is due to their age rather than their potential. Geologic evidence strongly indicates that the Keys themselves are largely the result of extensive patch reef formation during the Pleistocene Epoch. When examining the Key Largo limestone, the coral species composition is virtually identical to today's patch reefs. Although patch reefs do not have as many visitors or commercially-harvested species as the bank reefs offshore, they do contribute to both of these areas of human interest.

2.1.3 Land Uses

A major factor in the amount and quality of stormwater runoff is land use. Each land use has characteristic imperviousness and types of pollutants, based upon numerous studies around the country, especially the Nationwide Urban Runoff Program (NURP) concluded in 1983 and National Pollutant Elimination System (NPDES) municipal separate storm sewer system (MS4) programs (ongoing). Identifying both the existing and future land uses will improve the understanding of stormwater runoff in the Florida Keys.

Both existing and future land use data are available in digital format from a number of sources as found in Appendix A. Existing and future land use maps were available from the Monroe County Growth Management Division, FDOT and GTD Inc.

Existing Land Uses

Table 2.1-4 provide a summary of the acreage of the existing land uses for the unincorporated Monroe County as identified in the Year 2010 Comprehensive Plan (April 1993). The largest percentage of land is vacant (34.4 percent), followed closely by conservation (33.7 percent). Single family residential land uses account for 13.7 percent and all other land uses represent about 5 or less percent of the total. Of course, these land uses are not contiguous and are separated on each island. Table 2.1-5 lists the land uses identified by the Land Development Codes (Chapter 9.5, Article VII) that are consistent with the Comprehensive Plan.

Table 2.1-6 provides a breakdown of the acreage and percentage land uses based upon the GIS existing land use coverage provided by Monroe County. The land uses are summed for each SMMP study area. In summary, about 38 percent of the land is in the Forest/Open category. The second highest land use is water/wetland (35.2 percent) followed by low density residential at a little less than 9 percent.

Existing land use is depicted in maps provided in Appendix B at the end of this chapter.

Table 2-4
Monroe County Stormwater Management Master Plan
Summary of Year 2010 Comprehensive Plan Land Uses (1)

Land Use Type	Land Use Acreage Upper	Middle	Lower	Total	Percent of Total
Residential					
Single Family	3,391.0	2,037.0	2,950.9	8,378.9	13.7%
Mobile Homes	618.9	130.8	313.1	1,062.8	1.7%
Multifamily	391.6	220.9	25.2	637.7	1.0%
Mixed Residential	201.5	158.3	351.1	710.9	1.2%
Subtotal Residential	4,603.0	2,547.0	3,640.3	10,790.3	17.6%
Commercial					
General Commercial	462.1	276.6	255.4	994.1	1.6%
Commercial Fishing	10.7	84.6	151.8	247.1	0.4%
Tourist Commercial	421.1	460.5	147.3	1,028.9	1.7%
Subtotal Commercial	893.9	821.7	554.5	2,270.1	3.7%
Other					
Industrial	81.7	55.2	377.9	514.8	0.8%
Agricultural/Maricultural	0.0	41.9	0.0	41.9	0.1%
Education	65.8	31.7	8.9	106.4	0.2%
Institutional	46.2	37.3	32.8	116.3	0.2%
Public Bldgs/Grounds	11.3	32.6	16.9	60.8	0.1%
Public Facilities	36.1	446.2	56.8	539.1	0.9%
Military	0.0	0.0	3,288.7	3,288.7	5.4%
Historic	0.0	0.0	0.5	0.5	0.0%
Recreational	351.2	940.7	499.4	1,791.3	2.9%
Conservation	11,542.6	623.1	8,530.0	20,695.7	33.7%
Vacant	5,123.1	2,882.5	13,121.6	21,127.2	34.4%
Subtotal Other	17,258.0	5,091.2	25,933.5	48,282.7	78.7%
Total	22,754.9	8,459.9	30,128.3	61,343.1	100.0%

Note:
(1) Source is Monroe County Year 2010 Comprehensive Plan (April 15, 1993), Table 2.1, Page2-2.

Table 2-5
Monroe County Stormwater Management Master Plan
Summary of Land Use Districts (Chapter 9.5, Article VII)

District	Code	Description/Puprose
Urban Commercial	UC	High intensity commercial
Urban Residential	UR	High-density residential; vacation rental of detached dwellings, duplexes, and multifamily
Urban Residential Mobile Home	URM	Established MHP and subdivisions.
Urban Residential Mobile Home-Limited	URML-L	Established MHP and subdivisions; created to permit replacement below base flood level
Sub Urban Commercial	SC	To establish commercial uses to serve immediate planning area without use of US1
Sub Urban Residential	SR	To establish low- to medium-density residential; generally SFU
Sub Urban Residential (Limited)	SRL	To establish exclusive low- to medium-density residential
Sparsely Settled Residential	SS	Low-density residential with native/open character
Native Area	NA	To establish undisturbed areas except solid waste facilities; environmentally sensitive
Mainland Native Area	MN	To protect undeveloped and environmentally sensitive areas in mainland Florida
Offshore Island	OS	To establish areas not connected to US1; low-density residential and campgrounds
Improved Subdivision	IS	Legally vested residential development prior to adoption of chapter
Destination Resort	DR	To establish areas suitable for planned tourist centers
Recreational Vehicle	RV	To establish areas suitable for destination resours for RVs
Commercial Fishing Area	CFA	To establish uses essential to commercial fishing
Commercial Fishing Village	CFV	To establish areas of limited commercial fishing
Commercial Fishing Special	CFS	To establish areas of traditional commercial fishing
Mixed Use	MU	To establish areas of mixed uses for preservation representing character of Keys
Industrial	I	To establish areas for industrial, manufacturing, warehousing and distribution
Maritime Industries	MI	To establish areas for maritime uses; ship building, ship repair
Military Facilities	MF	To establish areas for military installations
Airport	AD	To prohibit residential, educational or others as hazardous due to airports
Park and Refuge	PR	To establish and protect parks, recreational areas and refuges
Conservation	CD	To provide areaas acquired for conservation or deed restrications for conservation

Table 2.1-6
Monroe County Stormwater Management Master Plan
Summary of Existing Land Use Acreage by Study Area

Study Area		Forest	Urban	Agric/	Residential					Water/	Roadways		Public	
No.	Description	Open	Open	Pasture	Low	Med	High	Comm	Indust	Wetland	FDOT	County	Facility	Total
Lower Keys														
1	Key West	7	39	0	809	851	257	528	0	464	36	36	563	3,589
2	Stock Island	146	0	0	235	80	7	159	32	291	48	57	338	1,392
3	Boca Chica Key	127	17	0	12	39	1	2	10	2,761	75	0	1,724	4,767
4	Bay Point Key	606		0	59	14	0	23	0	913	23	0	243	1,882
5	Lower Sugarloaf Key	1,576	0	0	19	0	0	5	0	2,368	89	117	1	4,175
6	Upper Sugarloaf Key	1,811	0	0	16	3	0	0	0	2,200	63	76	11	4,180
7	Cudjoe Key	1,847	2	0	25	2	0	2	2	4,477	58	141	26	6,583
8	Summerland Key	738	0	0	199	1	0	23	0	1,372	34	76	0	2,442
9	Ram Rod Key	708	0	5	151	0	0	28	0	541	0	61	2	1,496
10	Torch Keys	1,979	0	0	77	3	0	3	0	2,412	61	225	0	4,760
11	Big Pine Key	2,165	0	0	86	1	0	6	11	3,781	181	418	6	6,654
12	Bahia Honda	55	399	0	0	0	0	36	0	407	34	0	0	932
Middle Keys														
13	Marathon - Incorp	2,634	123	33	1,309	306	121	547	48	2,165	262	0	486	8,035
14	Key Colony Beach	175	0	0	298	0	26	11	5	0	18	1	0	533
15	Long Key	166	750	0	71	0	5	77	0	825	42	0	34	1,969
16	Layton	69	0	0	54	0	0	0	0	47	7	0	0	178
17	Lower Matecumbe Key	405	6	0	254	19	45	183	1	335	38	48	15	1,350
18	Islamorada	1,729	38	0	1,455	90	146	465	1	2,000	146	229	86	6,384
19	Upper Matecumbe Key	405	6	0	254	19	45	183	1	335	38	48	15	1,350
20	Windley Key	341	0	0	5	15	1	73	0	374	15	0	0	824
Upper Keys														
21,22	Key Largo	15,362	336	3	2,370	737	290	675	69	2,721	370	889	96	23,919
	Totals	33,051	1,717	41	7,758	2,180	945	3,028	178	30,790	1,637	2,421	3,646	87,390

Note: An "x" in the last column means that the values have been corrected for water/wetland land use overlaps.

Summary of Existing Land Use Percentage by Study Area

Study Area		Forest	Urban	Agric/	Residential					Water/	Roadways		Public	
No.	Description	Open	Open	Pasture	Low	Med	High	Comm	Indust	Wetland	FDOT	County	Facility	Total
Lower Keys														
1	Key West	0.2%	1.1%	0.0%	22.5%	23.7%	7.2%	14.7%	0.0%	12.9%	1.0%	1.0%	15.7%	100.0%
2	Stock Island	10.5%	0.0%	0.0%	16.9%	5.7%	0.5%	11.4%	2.3%	20.9%	3.5%	4.1%	24.3%	100.0%
3	Boca Chica Key	2.7%	0.3%	0.0%	0.2%	0.8%	0.0%	0.0%	0.2%	57.9%	1.6%	0.0%	36.2%	100.0%
4	Bay Point Key	32.2%	0.0%	0.0%	3.2%	0.8%	0.0%	1.2%	0.0%	48.5%	1.2%	0.0%	12.9%	100.0%
5	Lower Sugarloaf Key	37.7%	0.0%	0.0%	0.5%	0.0%	0.0%	0.1%	0.0%	56.7%	2.1%	2.8%	0.0%	100.0%
6	Upper Sugarloaf Key	43.3%	0.0%	0.0%	0.4%	0.1%	0.0%	0.0%	0.0%	52.6%	1.5%	1.8%	0.3%	100.0%
7	Cudjoe Key	28.1%	0.0%	0.0%	0.4%	0.0%	0.0%	0.0%	0.0%	68.0%	0.9%	2.1%	0.4%	100.0%
8	Summerland Key	30.2%	0.0%	0.0%	8.1%	0.0%	0.0%	0.9%	0.0%	56.2%	1.4%	3.1%	0.0%	100.0%
9	Ram Rod Key	47.3%	0.0%	0.4%	10.1%	0.0%	0.0%	1.9%	0.0%	36.2%	0.0%	4.1%	0.1%	100.0%
10	Torch Keys	41.6%	0.0%	0.0%	1.6%	0.1%	0.0%	0.1%	0.0%	50.7%	1.3%	4.7%	0.0%	100.0%
11	Big Pine Key	32.5%	0.0%	0.0%	1.3%	0.0%	0.0%	0.1%	0.2%	56.8%	2.7%	6.3%	0.1%	100.0%
12	Bahia Honda	5.9%	42.8%	0.0%	0.0%	0.0%	0.0%	3.9%	0.0%	43.7%	3.6%	0.0%	0.0%	100.0%
Middle Keys														
13	Marathon - Unincorp	32.8%	1.5%	0.4%	16.3%	3.8%	1.5%	6.8%	0.6%	26.9%	3.3%	0.0%	6.1%	100.0%
13a	Marathon - Incorp	32.8%	1.5%	0.4%	16.3%	3.8%	1.5%	6.8%	0.6%	26.9%	3.3%	0.0%	6.1%	100.0%
14	Key Colony Beach	32.8%	0.0%	0.0%	55.9%	0.0%	4.8%	2.0%	0.9%	0.0%	3.4%	0.2%	0.0%	100.0%
15	Long Key	8.4%	38.1%	0.0%	3.6%	0.0%	0.2%	3.9%	0.0%	41.9%	2.1%	0.0%	1.7%	100.0%
16	Layton	38.8%	0.0%	0.0%	30.4%	0.0%	0.0%	0.0%	0.0%	26.6%	4.1%	0.0%	0.1%	100.0%
17	Lower Matecumbe Key	30.0%	0.4%	0.0%	18.8%	1.4%	3.4%	13.5%	0.1%	24.8%	2.8%	3.6%	1.1%	100.0%
18	Islamorada	27.1%	0.6%	0.0%	22.8%	1.4%	2.3%	7.3%	0.0%	31.3%	2.3%	3.6%	1.3%	100.0%
19	Upper Matecumbe Key	30.0%	0.4%	0.0%	18.8%	1.4%	3.4%	13.5%	0.1%	24.8%	2.8%	3.6%	1.1%	100.0%
20	Windley Key	41.3%	0.0%	0.0%	0.5%	1.8%	0.2%	8.8%	0.0%	45.4%	1.8%	0.0%	0.0%	100.0%
Upper Keys														
21,22	Key Largo	64.2%	1.4%	0.0%	9.9%	3.1%	1.2%	2.8%	0.3%	11.4%	1.5%	3.7%	0.4%	100.0%
	Overall Average	37.8%	2.0%	0.0%	8.9%	2.5%	1.1%	3.5%	0.2%	35.2%	1.9%	2.8%	4.2%	100.0%

Future Land Uses

Future land use is shown in Table 2.1-7, based as above on the Monroe County GIS information. The land use acreages were prorated so that the total future land use acreages were equal to the total existing land acreage. Water/Wetland is the major land use at over 33 percent; however, this represents a drop of about 2 percent. The second largest future land use is Forest/Open at 20.8 percent, a decrease from the existing condition of 17 percent. This difference appears to be made up of a 15 percent increase in Urban Open land use and a 6 percent increase in medium density residential land use.

Future land use is depicted in maps provided in Appendix C at the end of this chapter.

Existing Habitat Mapping

As part of the assessment of the land use mapping, Environmental Consulting Systems Inc. (Susan Sprunt) reviewed the existing wetland digital mapping available from the County GIS (Appendix D). The purpose of this review was to consider the overall maps for habitat and biological accuracy. Based upon the scale of the maps, the majority of the maps correctly identified and labeled the wetland habitat within the Florida Keys. However, a site-specific review of the data would be required before the accuracy of the data relative to individual parcels could be assessed.

Land Uses Near Bridges

As noted previously, the major stormwater management system within the Florida Keys are contained along US 1 and other major roadways (see Appendix E). As a result extensive review of stormwater facilities along US 1 was completed including a field and pictorial assessment of the land use near the east- and west- bound bridge approaches. The tables, figures and photographs included in Appendices G and H provide the results of field work completed by Keith & Associates along US 1. The tables provide brief descriptions of the type of embankments exist for the approaches. The figures identify each of the 39 bridges considered, and the photographs show images of the approaches.

Table 2.1-8 summarizes the bridge approach information. The table lists the bridges, location, mile marker and percent of approach type. The percentage was defined by assigning each approach (4 in all for each bridge) 25 percent. For example, if two of the four approaches were grass, then 50 percent of the approach was assigned to the grass approach type. The tables show that most of the bridges (32 of 39) had some grass as part of the approach. Ten of the 39 had fully grassed approaches, the majority of them in the lower keys. Also, most of the bridge approaches also had some or all grass mixed with gravel. Only two contained swales to control sedimentation and one had "curb & gutter." This assessment indicates that only some

Table 2.1-7
Monroe County Stormwater Management Master Plan
Summary of Modeified [1] Future Land Use Acreage by Study Area

Study Area		Forest	Urban	Agric/	Residential					Water/	Roadways		Public	
No.	Description	Open	Open	Pasture	Low	Med	High	Comm	Indust	Wetland	FDOT	County	Facility	Total
Lower Keys														
1	Key West	7	39	0	815	857	259	531	0	468	36	36	540	3,589
2	Stock Island	0	106	0	22	195	135	307	80	370	61	72	43	1,392
3	Boca Chica Key	34	267	0	52	3	13	41	9	2,585	70	0	1,691	4,767 x
4	Bay Point Key	230	343	0	0	61	14	31	0	897	23	0	285	1,883
5	Lower Sugarloaf Key	1,292	1,098	0	99	27	0	28	0	1,494	56	74	6	4,175 x
6	Upper Sugarloaf Key	810	926	0	87	4	4	3	0	2,206	63	76	1	4,180 x
7	Cudjoe Key	1,277	555	0	72	29	5	18	15	4,367	57	137	50	6,583 x
8	Summerland Key	103	875	10	96	173	5	35	1	1,048	26	58	11	2,442
9	Ram Rod Key	0	529	3	159	200	0	27	0	518	0	58	2	1,496
10	Torch Keys	1,137	691	0	226	48	2	3	0	2,372	60	221	0	4,760 x
11	Big Pine Key	1,753	944	0	254	58	0	28	1	3,116	149	344	7	6,654 x
12	Bahia Honda	23	0	0	0	0	0	69	0	775	64	0	0	932
Middle Keys														
13	Marathon - Incorp	557	1,499	9	618	1,140	301	879	27	2,197	266	0	541	8,035
14	Key Colony Beach	0	51	0	192	63	64	35	0	97	30	1	0	533
15	Long Key	0	916	0	15	6	46	51	0	851	43	0	40	1,969
16	Layton	0	88	0	0	0	0	3	0	74	11	0	1	178
17	Lower Matecumbe Key	14	235	0	151	470	0	41	0	332	55	39	12	1,350
18	Islamorada	64	1,374	0	768	1,325	130	31	0	2,172	158	248	114	6,384
19	Upper Matecumbe Key	0	279	0	174	153	22	280	0	339	39	49	15	1,350
20	Windley Key	25	277	0	37	8	5	82	0	375	15	0	0	824
Upper Keys														
21,22	Key Largo	10,841	4,116	3	1,114	1,969	858	952	0	2,650	386	866	164	23,919
	Totals	18,166	15,209	26	4,952	6,791	1,863	3,476	133	29,303	1,669	2,280	3,525	87,392

Note: [1] Measured future land uses were prorated so that total future land use acreage was equal to total existing land use acreage.
A "x" in the last column means that values have been corrected for water/wetland overlaps.

Summary of Future Land Use Percentage by Study Area

Study Area		Forest	Urban	Agric/	Residential					Water/	Roadways		Public	
No.	Description	Open	Open	Pasture	Low	Med	High	Comm	Indust	Wetland	FDOT	County	Facility	Total
Lower Keys														
1	Key West	0.2%	1.1%	0.0%	22.7%	23.9%	7.2%	14.8%	0.0%	13.0%	1.0%	1.0%	15.0%	100.0%
2	Stock Island	0.0%	7.6%	0.0%	1.6%	14.0%	9.7%	22.1%	5.8%	26.6%	4.4%	5.2%	3.1%	100.0%
3	Boca Chica Key	0.7%	5.6%	0.0%	1.1%	0.1%	0.3%	0.9%	0.2%	54.2%	1.5%	0.0%	35.5%	100.0%
4	Bay Point Key	12.2%	18.2%	0.0%	0.0%	3.3%	0.7%	1.6%	0.0%	47.6%	1.2%	0.0%	15.1%	100.0%
5	Lower Sugarloaf Key	30.9%	26.3%	0.0%	2.4%	0.7%	0.0%	0.7%	0.0%	35.8%	1.3%	1.8%	0.1%	100.0%
6	Upper Sugarloaf Key	19.4%	22.2%	0.0%	2.1%	0.1%	0.1%	0.1%	0.0%	52.8%	1.5%	1.8%	0.0%	100.0%
7	Cudjoe Key	19.4%	8.4%	0.0%	1.1%	0.4%	0.1%	0.3%	0.2%	66.3%	0.9%	2.1%	0.8%	100.0%
8	Summerland Key	4.2%	35.9%	0.4%	3.9%	7.1%	0.2%	1.4%	0.0%	42.9%	1.1%	2.4%	0.5%	100.0%
9	Ram Rod Key	0.0%	35.4%	0.2%	10.6%	13.4%	0.0%	1.8%	0.0%	34.6%	0.0%	3.9%	0.1%	100.0%
10	Torch Keys	23.9%	14.5%	0.0%	4.7%	1.0%	0.0%	0.1%	0.0%	49.8%	1.3%	4.6%	0.0%	100.0%
11	Big Pine Key	26.3%	14.2%	0.0%	3.8%	0.9%	0.0%	0.4%	0.0%	46.8%	2.2%	5.2%	0.1%	100.0%
12	Bahia Honda	2.5%	0.0%	0.0%	0.0%	0.0%	0.0%	7.5%	0.0%	83.1%	6.9%	0.0%	0.0%	100.0%
Middle Keys														
13	Marathon - Unincorp	6.9%	18.7%	0.1%	7.7%	14.2%	3.7%	10.9%	0.3%	27.3%	3.3%	0.0%	6.7%	100.0%
13a	Marathon - Incorp	6.9%	18.7%	0.1%	7.7%	14.2%	3.7%	10.9%	0.3%	27.3%	3.3%	0.0%	6.7%	100.0%
14	Key Colony Beach	0.0%	9.5%	0.0%	36.0%	11.8%	12.0%	6.6%	0.0%	18.2%	5.7%	0.3%	0.0%	100.0%
15	Long Key	0.0%	46.5%	0.0%	0.8%	0.3%	2.4%	2.6%	0.0%	43.2%	2.2%	0.0%	2.1%	100.0%
16	Layton	0.0%	49.6%	0.0%	0.0%	0.0%	0.0%	1.9%	0.0%	41.5%	6.3%	0.0%	0.6%	100.0%
17	Lower Matecumbe Key	1.0%	17.4%	0.0%	11.2%	34.8%	0.0%	3.1%	0.0%	24.6%	4.1%	2.9%	0.9%	100.0%
18	Islamorada	1.0%	21.5%	0.0%	12.0%	20.8%	2.0%	0.5%	0.0%	34.0%	2.5%	3.9%	1.8%	100.0%
19	Upper Matecumbe Key	0.0%	20.7%	0.0%	12.9%	11.4%	1.7%	20.7%	0.0%	25.1%	2.9%	3.6%	1.1%	100.0%
20	Windley Key	3.1%	33.6%	0.0%	4.5%	0.9%	0.7%	10.0%	0.0%	45.5%	1.8%	0.0%	0.0%	100.0%
Upper Keys														
21,22,23	Key Largo	45.3%	17.2%	0.0%	4.7%	8.2%	3.6%	4.0%	0.0%	11.1%	1.6%	3.6%	0.7%	100.0%
	Totals	20.8%	17.4%	0.0%	5.7%	7.8%	2.1%	4.0%	0.2%	33.5%	1.9%	2.6%	4.0%	100.0%

Note: Data based upon a summary of GIS information provided by Monroe County.

Table 2-8
Monroe County Stormwater Management Master Plan
Summary of Bridge Approach Information

Bridge	Bridge Information			Approach						
No.	Channel/Creek	Location	MM	Grass	Grass/ Gravel	Swale	Rocks/ Gravel	Pave/ Grass	Grass/ Boulder	Curb & Gutter
1	Cow Key	Key West	4.0	50%	50%					
2	Boca Chica	Boca Chica Key	6.0	100%						
3	Rockland	Rockland Key	9.5	100%						
4	Shark	Shark Key	11.0	100%						
5	Saddlebunch No. 5	Saddlebunch Keys	12.5	100%						
6	Saddlebunch No. 4	Saddlebunch Keys	13.0	100%						
7	Saddlebunch No. 3	Saddlebunch Keys	14.0	100%						
8	Saddlebunch No.2	Saddlebunch Keys	14.5	100%						
9	Lower Sugarloaf	Sugarloaf Key	15.5	100%						
10	Harris	Sugarloaf Key	16.5	50%	50%					
11	Harris Gap	Park Key	17.6	50%	50%					
12	North Harris	Park Key	17.8	50%	50%					
13	Park	Park Key	18.6	50%	50%					
14	Bow	Cudjoe Key	20.0	50%	50%					
15	Kemp	Summerland Key	23.0	50%	50%					
16	Niles	Ramrod Key	25.5	50%	50%					
17	Torch Ramrod	Middle Torch Key	27.5	25%	50%	25%				
18	Torch Ramrod	Little Torch Key	28.0		100%					
19	South Pine	Big Pine Key	28.5	25%	50%	25%				
20	North Pine	Big Pine Key	29.0	25%	75%					
21	Spanish Harbor	Spanish Harbor Keys	33.0	25%	25%		50%			
22	Bahia Honda	Bahia Honda Key	35.0	100%						
23	Ohio Bahia Honda	Ohio Key	38.5		75%		25%			
24	Ohio Missouri	Missouri Key	39.0	50%	25%		25%			
25	Little Duck Missouri	Little Duck Key	39.5	50%	50%					
26	Seven Mile Bridge	Marathon	40.0	50%	50%					
27	Key Vaca Cut	Marathon	53.0	100%						
28	Tom's Harbor	Conch Key	60.5	50%					50%	
29	Tom's Harbor Cut	Conch Key	61.5		50%				50%	
30	Long Key Viaduct	Long Key	63.0		50%				50%	
31	Channel Five	Craig Key	71.0	25%				25%	50%	
32	Channel Two	Craig Key	72.5	25%	25%				50%	
33	Lignumvitae	Lower Matacumbe Key	77.5					75%	25%	
34	Indian Key	Lower Matacumbe Key	78.0	25%	25%			50%		
35	Teatable	Islamorada	79.0	25%	50%			25%		
36	Teatable Relief	Islamorada	79.5		50%			50%		
37	Whale Harbor	Islamorada	83.7	50%	25%		25%			
38	Snake Creek	Plantation Key	85.5	50%	25%			25%		
39	Tavernier	Plantation Key	91.0							100%
		Numbers		32	25	2	4	6	6	1

of the bridge approaches control nonpoint source discharges (especially sediment) to near shore waters with the use of grass or swales.

2.1.4 Existing Maps and Studies

An exhaustive research of existing information was completed to define the existing conditions relative to the stormwater management program. Numerous studies and documents were made available for the Florida Keys, many of which are pertinent to the SMMP. Appendix A contains a list of data collected with associated sources. Provided below is a brief summary of some of the pertinent studies.

Evaluation of Permitted Monroe County Stormwater Systems by Robin Dye (Monroe County Stormwater Project Manager)

This source is a stormwater file review by Robin Dye (Monroe County Stormwater Project Manager) of over 200 Monroe County commercial permits from projects reviewed by County Engineer David Koppel for compliance with the 1992 Stormwater Ordinance. The projects are filed by island, from Key West to Ocean Reef. Notes are provided for each project. An Excel © database was created including fields for application number, project name, location, permit approval, permit conditions, stormwater system type, and required South Florida Water Management District (SFWMD) or Florida Department of Environmental Protection (FDEP) permits. Also included in this source is a report on evaluation of over 52 permitted stormwater systems from SFWMD. An Excel © database with SFWMD permit information is also included. An example SFWMD Environmental Resource/Surface Water Management Permit Construction Completion/Certification form is provided. Field evaluation notes for each site visited are included.

Florida Keys Carrying Capacity Conceptual Framework Workshop, May 6-7, 1999 Meeting Notes: Final

The Meeting Notes from the Florida Keys Carrying Capacity Conceptual Framework Workshop document the main points and meeting progress that were offered during the meeting on May 6 through May 7, 1999. The notes highlight and summarize the key topics and issues that were discussed at the workshop. The first section provides an overall summary of the workshop, and the remaining sections summarize each of the agenda items as they occurred in the workshop. Selected attachments are provided in this document. The primary topics of discussion during this workshop included study origins, overview of study scope, workshop approach, presentations regarding carrying capacity, and development of guiding parameters to guide the technical workshops.

Florida Keys Carrying Capacity Study Ecosystems Workshop, July 7-8, 1999 Meeting Notes: Final

The Meeting Notes from the Florida Keys Carrying Capacity Study Ecosystems Workshop document the main points and meeting progress that were offered during the meeting on July 7 through July 8, 1999. The notes highlight and summarize the key topics and issues that were discussed at the workshop. The first section provides an overall summary of the workshop, and the remaining sections summarize each of the agenda items as they occurred in the workshop. Selected materials gathered during this workshop are provided as attachments in this document. The primary topics of discussion during this workshop included identification and definition of various ecosystems for the Florida Keys, discussion of selected elements of each ecosystem, development of units of measure for each ecosystem element, as well as recommendations of tasking for the Carrying Capacity Analysis Model (CCAM).

Florida Keys Carrying Capacity Study: Scope of Work

This document, prepared by the U.S. Army Corps of Engineers in September 1998, is a scope of work for conducting a Florida Keys Carrying Capacity Study. The scope of work was prepared in response to a request from the Florida Department of Community Affairs (DCA) under the Intergovernmental Cooperation Act. The carrying capacity analysis shall be designed to determine the ability of the Florida Keys ecosystem, and the various segments thereof, to withstand all impacts of additional land development activities. The carrying capacity analysis shall consider aesthetic, socioeconomic (including sustainable tourism), quality of life and community character issues, including the concentration of population, the amount of open space, diversity of habitats, and species richness.

Florida Keys Monitoring Study: Water Quality Assessment of Five Selected Pollutant Sources in Marathon, Florida Keys

Florida Keys Monitoring Study: Water Quality Assessment of Five Selected Pollutant Sources in Marathon, Florida Keys (South Florida Water Management District, July 1987) reports water quality impacts from boats and boating, seafood processing companies, commercial fishing, stormwater runoff, and wastewater treatment plants/septic system pollutant sources. A water quality monitoring plan is outlined. Twelve potential solutions and recommendations to improve water quality are presented. Of the twelve, recommendations for stormwater management include to create and implement guidelines for the elimination of direct stormwater discharges to surface waters (especially dead-end waterways).

Florida Keys National Marine Sanctuary

Florida Keys National Marine Sanctuary is an informational handout developed by the National Oceanic and Atmospheric Administration (NOAA) effective July 1, 1997. The handout is an overview of the Sanctuary plan. Ecological Reserves, Sanctuary Preservation Areas, Special Use Areas and Wildlife Management Areas are identified. Activities prohibited within the Ecological Reserve, Sanctuary Preservation Areas, and sanctuary-wide are noted.

Florida Keys National Marine Sanctuary Final Management Plan/Environmental Impact Statement: Volumes I, II and III

The *Final Management Plan/Environmental Impact Statement* (National Oceanic and Atmospheric Administration (NOAA, 1996) for the Florida Keys National Marine Sanctuary was developed as a result of the Florida Keys National Marine Sanctuary and Protection Act of 1990 designating the Florida Keys National Marine Sanctuary. The Act requires NOAA to develop a comprehensive management plan with implementing regulations to govern the overall management of the Sanctuary and to protect the Sanctuary resources and qualities for the enjoyment of present and future generations. Volume I contains the final comprehensive Management Plan and includes the discussion of the preferred alternative and socioeconomic analyses as well as 10 action plans composed of management strategies developed with substantial input from the public, local experts, and the Sanctuary Advisory Council to address management issues. The action plans provide an organized process for implementing management strategies, including a description of the activities required, institutions involved, staffing requirements, and an estimate of implementation cost. Volume II describes the process used to develop the draft management alternatives and includes environmental and socioeconomic impact analyses of the alternatives used in the draft management plan and environmental impact statement. Volume III consists of appendices, including the two acts that designate and implement the Sanctuary.

Monroe County Sanitary Wastewater Master Plan (Draft)

Monroe County Sanitary Wastewater Master Plan (March 2000 Draft) was mandated by the Monroe County Year 2010 Comprehensive Plan. The Master Plan was prepared by the Sanitary Wastewater Master Plan Team, comprised of CH2M HILL in association with Lindahl, Browning Ferrari & Hellstrom, Inc.; Continental Shelf Associates, Inc.; Hazen & Sawyer, P.C.; Katz, Kutter, Haigler, Alderman, Bryant and Yon, P.A.; and Ayres Associates under the direction of the Monroe County Department of Marine Resources. The objective of the Master Plan is to provide an equitable, ecologically sound, and economical implementation strategy for managing wastewater and improving the water quality in the Florida Keys. Existing wastewater facilities were investigated and a recommended Wastewater Management Plan is illustrated. Capital costs required to implement the Master Plan, a fiscal impact analysis, and finance recommendations are presented. The Master Plan also recommends Board of County Commissioners implementation actions.

Monroe County Stormwater Ordinance Manual of Stormwater Management Practices

This manual, prepared by the South Florida Regional Planning Council, is to accompany the Monroe County Stormwater Management Ordinance and is to be used in conjunction with the Monroe County Land Development Regulations. The manual details the requirements of a stormwater management plan as required as part of all building permit applications. The manual also provides methods of stormwater treatment and detail criteria for each individual type of treatment.

Monroe Stormwater Technical Advisory Committee Meeting Minutes and Miscellaneous Documents

The Monroe County Technical Advisory Committee is composed of representatives from local, state, and federal agencies for development of the statement of work, consultant selection and review and evaluation of the County's stormwater management master plan. This source is a collection of the Technical Advisory Committee meeting minutes from September 11, 1998 through March 15, 1999. Excerpts from selected memoranda and reports discussed at meetings are also included. In addition, included are copies of the memorandums discussing consultant submittals and presentations.

Water Quality Concerns in the Florida Keys: Sources and Solutions

Water Quality Concerns In the Florida Keys: Sources and Solutions is an informational brochure developed by the Florida Keys National Marine Sanctuary, the Florida Department of Environmental Protection (FDEP) and the U.S. Environmental Protection Agency (EPA). The Florida Keys natural resource, water quality threats to the ecosystem, and estimated nitrogen and phosphorus loadings by source are reported. The Water Quality Protection Program and the Florida Keys National Marine Sanctuary are also outlined. Identified solutions, on-going science/education projects, and sources of funding are summarized.

Water Quality Concerns in the Florida Keys: Sources, Effects, and Solutions

Water Quality Concerns in the Florida Keys: Sources, Effects, and Solutions (June 16, 1998) was developed by the Florida Keys National Marine Sanctuary Water Quality Protection Program. This document discusses the history, physical setting, water quality concerns, canals and confined waters, near shore waters, outer coral reefs, groundwater, and water quality effects on biological communities of the Florida Keys. Examples of areas with similar problems are also highlighted. Options for correcting water quality problems and the economics of clean water and natural resources are presented.

Water Quality Concerns in the Florida Keys: Sources, Effects, and Solutions

Water Quality Concerns In the Florida Keys: Sources, Effects, and Solutions (September, 1999) was prepared by William L. Kruczynski of the Florida Keys National Marine Sanctuary Water Quality Protection Program and issued by the U.S. Environmental Protection Agency (EPA, 904-R-99-005). This document discusses the history, physical setting, water quality concerns, canals and confined waters, near shore waters, outer coral reefs, groundwater, and water quality effects on biological communities of the Florida Keys. Examples of areas with similar problems are also highlighted. Options for correcting water quality problems and the economics of clean water and natural resources are presented.

Water Quality Protection Program Document for the Florida Keys National Marine Sanctuary

The Florida Keys National Marine Sanctuary was created as a result of the Florida Keys National Marine Sanctuary and Protection Act of 1990. The U.S. Environmental Protection Agency (EPA) and the State of Florida have been directed to develop a Water-Quality Protection Program for the Sanctuary. This Program was considered by the National Oceanic and Atmospheric Administration (NOAA) for inclusion into the comprehensive management plan to guide the use of the Sanctuary. The purpose of the Water-Quality Protection Program is to recommend priority corrective action and compliance schedules addressing point and nonpoint sources of pollution. *Water Quality Protection Program Document for the Florida Keys National Marine Sanctuary* (EPA, September 1996), prepared by Continental Shelf Associates, Inc., is a final Program Document developed from Phases I and II of the program. Findings from Phases I and II were used to develop the recommendations in the Program Document. The Program Document also includes changes made in response to public comments on NOAA's *Draft Management Plan/Environmental Impact Statement*. The Program Document presents recommendations for corrective actions, monitoring, research / special studies, and education / outreach.

Water Quality Protection Program for the Florida Keys National Marine Sanctuary: Phases I, II and III Reports

The Florida Keys National Marine Sanctuary was created as a result of the Florida Keys National Marine Sanctuary and Protection Act of 1990. The U.S. Environmental Protection Agency (EPA) and the State of Florida have been directed to develop a Water-Quality Protection Program for the Sanctuary. This Program was considered by the National Oceanic and Atmospheric Administration (NOAA) for inclusion into the comprehensive management plan to guide the use of the Sanctuary. The purpose of the Water-Quality Protection Program is to recommend priority corrective action and compliance schedules addressing point and nonpoint sources of pollution. *Water Quality Protection Program for the Florida Keys National Marine Sanctuary: Phase I* (EPA, July 1992), prepared by Continental Shelf Associates, Inc., involves a compilation and synthesis of information on the environment within the Florida Keys National Marine Sanctuary. This report includes water-quality, coral community, submerged and emergent aquatic vegetation, near shore and confined waters and spill and hazardous-material assessments. *Water Quality Protection Program for the Florida Keys National Marine Sanctuary: Phase II* (EPA, February 1993), prepared by Continental Shelf Associates, Inc., focuses on developing options for corrective action, developing a water quality monitoring program and associated research program, and developing a public education and outreach program. *Water Quality Protection Program for the Florida Keys National Marine Sanctuary: Phase III* (EPA, February 1995), prepared by Continental Shelf Associates, Inc., is an implementation plan covering monitoring and research, which can be implemented directly by EPA and the State of Florida in cooperation with NOAA.

City of Key Colony Beach Stormwater Management Master Plan (Stormwater Retrofit Project)

In response to an Objections, Recommendations, and Comments Report (ORC Report) for the City of Key Colony's Comprehensive Plan, the City consented to develop a stormwater management plan for eliminating untreated outfalls and to amend the City's Capital Improvement Schedule to provide necessary funding for the alternative disposal method that will eliminate stormwater discharge. *The City of Key Colony Beach Stormwater Management Master Plan (Stormwater Retrofit Project)* (Greiner, December 1993) provides a plan to retrofit the City's stormwater system for water quality improvements. Existing drainage plans, atlases, land-use maps, subdivision plats, ownership maps, topographic surveys, aerial photography, water quality data, drainage complaints, system maintenance records, permits, soils, tidal data, wastewater discharges, well logs and rainfall data were collected. The drainage system was inventoried and surveyed. The service life of the drainage system was estimated. A hydrologic and hydraulic model of both existing and future land use conditions was developed using the Advanced Interconnected Pond Routing Model (AdICPR). The drainage structures were evaluated on the basis of whether the structures can convey the stormwater runoff for the 5, 10, 25, and 100-year 72-hour duration storm events and a level of service of the system was established. Average annual pollutant loadings for existing and future land use conditions were evaluated for each subbasin. Stormwater improvement alternatives were selected from current Best Management Practices (BMP) for stormwater quality treatment using results of a decision matrix. The plan recommended implementation of the selected alternatives, development of a water quality monitoring program and development of operations and maintenance schedules.

Key Colony Beach Stormwater Management Master Plan Selection of Alternative Stormwater Treatment Methods: June 18, 1993 Public Meeting

In response to an Objections, Recommendations, and Comments Report (ORC Report) for the City of Key Colony's Comprehensive Plan, the City consented to develop a stormwater management plan for eliminating untreated outfalls and to amend the City's Capital Improvement Schedule to provide necessary funding for the alternative disposal method that will eliminate stormwater discharge. This document summarizes the public presentation by Greiner, Inc. at the City of Key Colony Beach City Hall on June 18, 1993. The meeting was held to discuss and select alternative stormwater treatment methods to retrofit the City's stormwater system. A decision matrix rating the stormwater treatment systems was presented. Preferred stormwater treatment methods for various areas within the City were selected.

Technical Memorandum Task E: City of Key Colony Beach Stormwater Management Master Plan (Stormwater Retrofit Project)

In response to an Objections, Recommendations, and Comments Report (ORC Report) for the City of Key Colony's Comprehensive Plan, the City consented to develop a stormwater management plan for eliminating untreated outfalls and to amend the City's Capital Improvement Schedule to provide necessary funding for the alternative disposal method that will eliminate stormwater discharge. *Technical Memorandum Task E: City of Key Colony Beach Stormwater Management Master Plan (Stormwater Retrofit Project)* (Greiner, Inc., July 1993) summarizes procedures and results associated with alternatives analysis and selection process. A process was developed to select alternatives for water quality improvements. Stormwater improvement alternatives were selected from current Best Management Practices (BMP) for stormwater quality treatment using results of a decision matrix. The decision matrix ranked versus criteria such as treatment efficiencies, economic and physical constraints, and social acceptance. The results of the decision matrices were used as a basis for selection of the final alternative for the design area within the City.

2.1.5 Rainfall and Temperature Data

Although lying north of the Tropic of Cancer, the Florida Keys are characterized by a tropical climate. Frost has never been observed in the Middle and Lower Keys and has been extremely rare in the Upper Keys. Like other tropical maritime areas, the climate pattern generally has a wet-dry seasonality. Because of the Key's location, the climate pattern is also influenced by temperate cold fronts and, occasionally, the associated low pressure systems. Increasing influence appears to be exerted by larger scale phenomena, particularly the El Niño / La Niña cycles.

The wet season runs from late spring through mid-late autumn. Local advective heating causes development of thunderstorms, often daily and typically in late afternoon. Rainfall during this period is augmented by tropical cyclone systems in various stages of development. Although the Florida Keys do not receive direct impact of tropical storms or hurricanes every year, it is not unusual to have considerable rainfall and moderate wind events associated with tropical systems that pass some distance away. Annual rainfall in Monroe County (approximately 40inches) is the lowest in Florida.

The dry, cool season, is marked by an alternation of cold fronts with periods of moderate-temperature trade winds from the southeast. The cold fronts bring some rain during this period but are most significant for periodically lowering temperatures and causing moderate wind events. Again, the shallow near shore waters experience the greatest fluctuation and may drop below 16°C near the Keys or below 10°C in parts of Florida Bay. The winter low temperatures are a major factor limiting the distribution of many tropical species. A number of species tolerant of the annual low temperatures along the Florida Straits cannot survive the more extreme lows that occur just 6-8 km away in the near shore waters of the Keys.

Rainfall data for the Florida Keys were obtained from the National Climactic Data Center (NCDC) and analyzed statistically. Table 2.1-9 lists the available rainfall data stations within the Florida Keys. Twenty-one stations are identified, the oldest of which is in Key West starting in January 1890. Of the 21 stations, 3 were chosen to represent the changes in rainfall patterns from the lower, middle and upper Keys. The data from Key West International Airport (48-year period of record, POR), Marathon Shores (26-year POR), and Tavernier (51-year POR) are summarized in Tables 2-10, 2-11 and 2-12, respectively, including rainfall, low and high temperatures.

Annual average precipitation is illustrated in Figure 2.1-1. It can be seen that the average rainfall for Key West and Marathon Shores is 39.7 inches while for Tavernier, it is 46.1 inches, almost 7 inches larger. While there are slight differences in average monthly values (< 0.5 inches) during the year, the difference in June among Key West, Marathon Shores and Tavernier appears to be the largest (~ 1.5 inches).

The average monthly low and high temperatures are also summarized in the Tables 2.1-10, 2.1-11 and 2.1-12. The data show that the three sites are similar over the year, with the average annual minimum temperature being 73, 70.6, and 73.7 degrees Centigrade (° C) for Key West AP, Marathon Shores and Tavernier, respectively. The average high temperatures are 82.7, 83.8, and 83.2 ° C, respectively. Low and high monthly average temperatures are illustrated in Figures 2.1-2 and 2.1-3, respectively.

2.1.6 Topographic Data and Hydrologic Units

To estimate the general behavior of stormwater runoff for each of the islands within the Florida Keys, topographic data from the Monroe County GIS datasets were used to identify general hydrologic units. In particular, the topographic data identified the portion of each island draining toward the Florida Straits (ocean side) and the portion draining toward Florida Bay (bay side). Unfortunately, the topographic data increment is 5 feet so that data were available only for the 0-, 5-, 10,-, 15-, and 20-foot contours. These data are graphically represented in Exhibit 5 located in Appendix F.

The figures show that the majority of the islands are not higher than 10 feet and only limited information can be gained by the contours. Therefore, based upon review of the data and on the lack of data for many islands, it is reasonable to represent US 1 as the topographic divide for each island. That is, lands to the bay side of US 1 drain mainly toward Florida Bay and lands to the ocean side of US 1 drain toward the Florida Straits. While this may seem obvious to long-time residents of the Florida Keys, the conclusion is partially supported by the available data. Also, the lack of data resolution means that detailed project specific survey information will be required for stormwater improvement projects.

Table 2-9
Monroe County Stormwater Management Master Plan
Rainfall Gages in Florida Keys [1]

Station Name	Location	Period of Record		COOP ID	Call Sign	Type
Big Pine Key	Big Pine Key	June 1, 1967	July 31, 1976	080747		
Big Pine Key Inn	Big Pine Key	April 1, 1950	December 31, 1955	080747		
Dry Tortugas	Dry Tortugas	June 1, 1950	May 1, 1966	082418		
Duck Key	Duck Key	June 1, 1982	Present	082441		
Flamingo	Flamingo	October 1, 1964	Present		2HY	COOP
Flamingo	Flamingo	May 1, 1958	August 31, 1966	083013		
Flamingo	Flamingo	January 1, 1951	Present			COOP
Flamingo Ranger Station	Flamingo	January 1, 1951	Present	083020		
Islamorada	Islamorada	December 1, 1998	Present	084320		
Islamorada 2 SW	Islamorada	July 1, 1965	September 30, 1966	084324		
Islamorada Station	Islamorada	October 1, 1972	Present		X84	CG
Key West	Key West	December 11, 1996	Present		KBYX	NEXRAD
Key West Boca Chiga Airport	Key West	November 3, 1942	June 30, 1953	084570		WBAS
Key West CAA	Key West	August 24, 1931	November 3, 1942			CAA
Key West CG	Key West	October 1, 1972	September 30, 1973			CG
Key West International Airport	Key West	July 1, 1957	Present	084570	EYW/KEYW	ASOS-NWS
Key West NAS	Key West	September 1, 1942	Present		NQX/KNQX	NAS U-ASOS
Key West WB City	Key West	January 1, 1890	December 31, 1974	084575		WBO
Lignumvitae Key		August 1, 1948	October 31, 1976	085035		
Marathon	Marathon	June 1, 1962	March 31, 1965			COOP
Marathon	Marathon	September 1, 1957	December 31, 1961			COOP
Marathon	Marathon	June 1, 1960	March 31, 1961			SAWR
Marathon Airport	Marathon	October 1, 1974	Present		MTH/KMTH	ASOS-FAA
Marathon Chamber of Commerce	Marathon	September 1, 1959	June 30, 1962	085348		
Marathon Fire Rescue	Marathon	January 27, 1997	Present	085345		
Marathon Radio WFFG	Marathon	June 1, 1962	May 31, 1967	085348		
Marathon Shores	Marathon Shores	April 1, 1957	June 30, 1969	085351		
Marathon Shores	Marathon Shores	June 1, 1969	July 1, 1976	085351		
Marathon Station	Marathon	October 1, 1972	Present		X88	CG
Marathon Vaca Key	Marathon	April 1, 1950	April 30, 1957	085351		
Tavernier	Tavernier	July 1, 1948	Present	088841		

Note: (1) From National Climactic Data Center (NCDC)

Figure 2-1
Monroe County Stormwater Management Master Plan
Summary of Rainfall Data

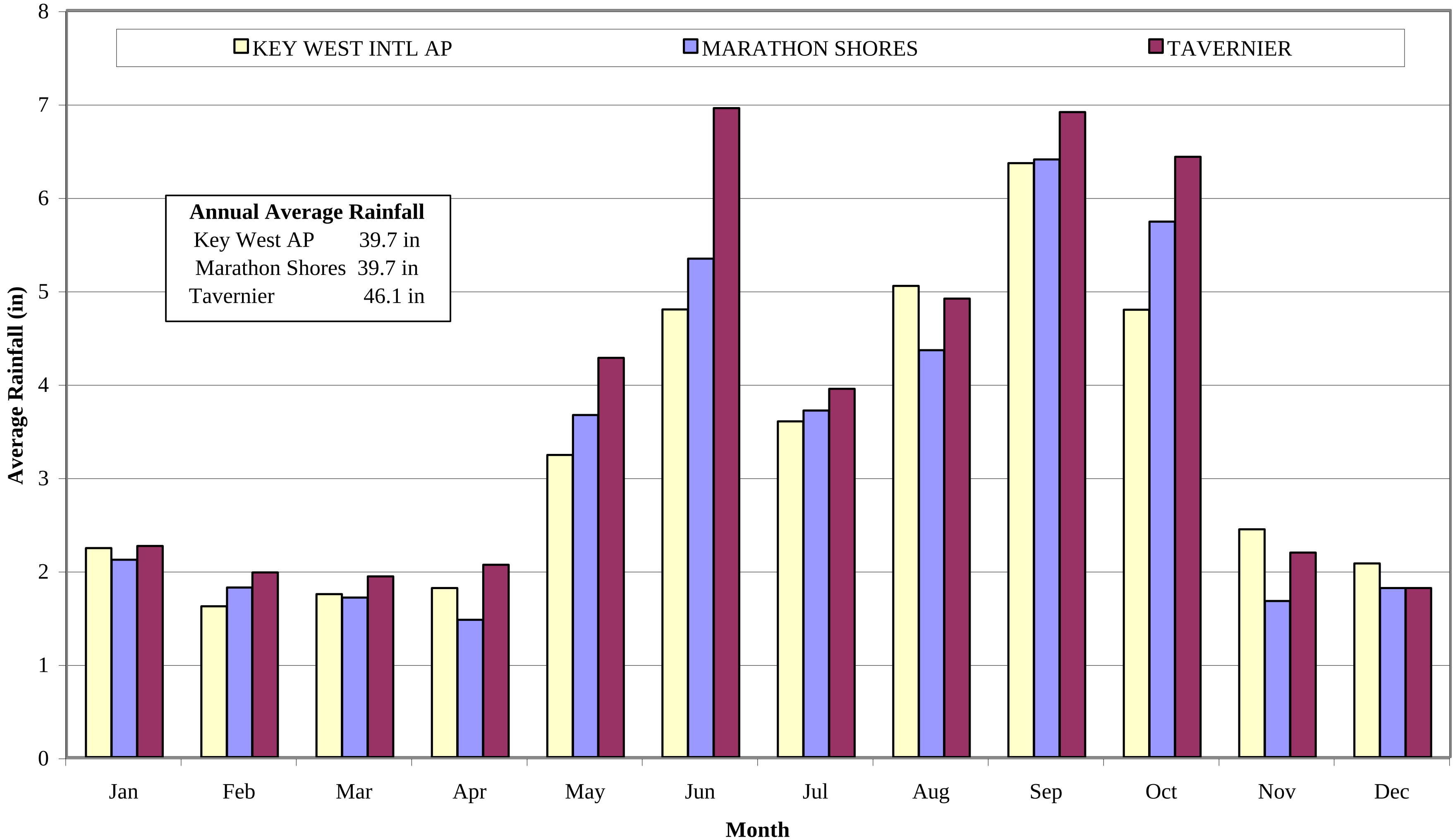


Table 2-10
Monroe County Stormwater Management Master Plan
Summary of Rainfall and Air Temperature Data - Key West International Airport

Station Name	KEY WEST INTL AP				
Station ID	4570	Latitude	24:33:00	Start Year	1948
State	FLORIDA	Longitude	081:45:00	End Year	1998
County	MONROE	Elevation	4	Num Years	48

Precipitation

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
# Days	1426	1299	1426	1380	1426	1380	1457	1457	1407	1457	1380	1426	16921
Avg Day	0.072	0.056	0.056	0.06	0.104	0.16	0.116	0.163	0.213	0.155	0.081	0.067	0.109
# Months	46	46	46	46	46	46	47	47	47	47	46	46	44
SDev Month	3.253	1.181	1.776	1.836	2.866	3.443	2.14	2.33	3.312	3.693	4.265	1.998	9.109
Min Month	0	0.06	0	0	0.34	0.33	0.44	2.23	1.7	0.74	0	0.07	19.99
Max Month	17.64	4.87	9.69	10.6	12.9	14.43	11.69	10.43	18.45	21.57	27.67	11.18	62.92
Avg Month	2.237	1.614	1.745	1.809	3.236	4.794	3.595	5.045	6.361	4.791	2.44	2.073	39.664
Skew Month	2.943	0.876	2.569	2.665	1.609	1.131	1.181	0.697	1.437	2.307	4.895	2.299	0.316
Kurt Month	11.989	3.192	10.269	12.002	4.745	3.395	5.326	2.065	5.513	9.875	26.8	9.925	3.033
M Min Year	1990	1959	1971	1959	1952	1994	1993	1991	1951	1972	1995	1981	1974
M Max Year	1983	1998	1987	1985	1960	1972	1970	1977	1963	1969	1980	1986	1969

Minimum Temperature

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
# Days	1425	1299	1426	1380	1418	1380	1457	1457	1406	1456	1373	1426	16903
Avg Day	64.994	65.539	68.758	72.112	75.723	78.343	79.482	79.179	78.272	75.498	71.265	66.612	73.053
# Months	46	46	46	46	46	46	47	47	47	47	46	46	44
SDev Month	3.408	3.502	2.575	2.383	1.442	1.195	1.299	0.802	0.917	1.293	2.288	2.857	0.94
Min Month	55.774	57.607	64.452	64.467	71.774	75.367	75.806	77.29	76.233	72.677	66.9	60.968	71.303
Max Month	72.903	72.821	73.032	76.467	78.742	80.633	82.581	80.742	80.2	78.097	76.533	72.387	74.8
Avg Month	64.995	65.589	68.758	72.112	75.719	78.343	79.482	79.179	78.276	75.5	71.259	66.612	72.978
Skew Month	-0.012	-0.067	-0.107	-0.742	-0.509	-0.203	-0.42	-0.24	-0.281	-0.099	-0.089	-0.031	0.279
Kurt Month	3.039	2.583	1.715	3.86	3.517	2.563	3.314	2.456	2.842	2.269	2.386	2.081	2.103
M Min Year	1981	1958	1960	1987	1992	1966	1950	1950	1950	1987	1962	1989	1951
M Max Year	1974	1959	1976	1982	1995	1981	1967	1969	1974	1959	1986	1971	1967

Table 2-10
Monroe County Stormwater Management Master Plan
Summary of Rainfall and Air Temperature Data - Key West International Airport

Station Name	KEY WEST INTL AP				
Station ID	4570	Latitude	24:33:00	Start Year	1948
State	FLORIDA	Longitude	081:45:00	End Year	1998
County	MONROE	Elevation	4	Num Years	48

Maximum Temperature

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
# Days	1417	1299	1426	1371	1426	1378	1451	1456	1396	1452	1380	1426	16878
Avg Day	74.935	75.727	78.652	81.777	85.208	87.964	89.395	89.564	88.194	84.584	80.049	76.115	82.746
# Months	46	46	46	46	46	46	47	47	47	47	46	46	44
SDev Month	2.911	3.067	2.251	1.703	1.287	1.412	1.055	1.098	1.065	1.3	2.001	2.343	0.948
Min Month	66.839	68.071	73.161	77.933	82.742	84.2	86.613	87.645	85.033	81.355	76.267	71.065	80.785
Max Month	80.455	81.357	82.355	85.133	88.323	90.267	91.258	92	90.733	87.129	84.667	80.516	84.516
Avg Month	74.97	75.72	78.652	81.79	85.208	87.962	89.39	89.564	88.193	84.578	80.049	76.115	82.662
Skew Month	-0.381	-0.292	-0.542	-0.072	0.186	-0.617	-0.291	0.265	-0.051	-0.048	0.072	-0.089	-0.184
Kurt Month	3.284	2.888	2.194	2.398	2.298	2.888	2.558	2.235	3.818	2.249	2.455	2.093	2.292
M Min Year	1981	1958	1969	1987	1970	1966	1984	1984	1984	1987	1962	1963	1966
M Max Year	1974	1949	1997	1982	1995	1994	1993	1990	1987	1960	1986	1978	1990

Table 2-11
Monroe County Stormwater Management Master Plan
Summary of Rainfall and Air Temperature Data - Marathon Shores

Station Name	MARATHON SHORES				
Station ID	5351	Latitude	24:44:00	Start Year	1950
State	FLORIDA	Longitude	081:03:00	End Year	1975
County	MONROE	Elevation	10	Num Years	26

Precipitation

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
# Days	682	621	620	660	712	674	682	738	657	702	689	682	8119
Avg Day	0.068	0.063	0.055	0.049	0.118	0.179	0.12	0.141	0.214	0.188	0.056	0.058	0.11
# Months	22	22	20	22	23	22	22	24	22	23	23	22	17
SDev Month	2.175	1.146	1.676	1.511	3.885	4.215	2.21	2.432	4.283	2.703	1.844	1.793	14.281
Min Month	0.09	0	0.01	0.03	0.16	0.18	0.31	1.44	0.22	1.49	0.09	0.25	22.21
Max Month	8.71	4.69	5.8	4.99	15.47	13.67	8.67	11.62	19.59	10.61	6.54	7.23	70.09
Avg Month	2.112	1.817	1.709	1.469	3.664	5.337	3.712	4.357	6.4	5.735	1.671	1.81	39.692
Skew Month	1.611	0.837	1.161	1.175	1.722	0.864	0.619	1.549	1.528	0.208	1.485	1.656	0.828
Kurt Month	4.577	2.988	2.714	2.8	4.64	2.206	2.602	4.606	4.857	1.649	3.341	4.549	2.212
M Min Year	1964	1955	1971	1968	1965	1950	1961	1975	1961	1962	1966	1956	1961
M Max Year	1958	1963	1967	1957	1968	1969	1952	1962	1959	1964	1954	1958	1959

Minimum Temperature

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
# Days	682	621	620	659	686	674	682	736	652	685	684	682	8063
Avg Day	62.965	63.666	66.885	70.304	73.039	75.594	76.918	77.37	75.739	72.66	67.935	63.776	70.682
# Months	22	22	20	22	22	22	22	24	22	22	23	22	17
SDev Month	2.707	3.567	2.16	1.655	1.075	1.612	2.011	1.589	1.854	2.797	3.106	3.351	1.393
Min Month	58.065	55.25	62.613	67.933	70.581	71.2	71.806	72.839	71.8	66	62.233	58.161	67.712
Max Month	70.032	71.286	70.742	73.267	74.806	77.433	79.484	81.4	78.967	78.565	73.067	71.71	72.523
Avg Month	62.965	63.769	66.885	70.303	73.015	75.572	76.918	77.403	75.74	72.605	67.937	63.776	70.576
Skew Month	0.633	-0.163	-0.395	0.284	-0.232	-1.078	-0.902	-0.366	-0.759	-0.253	-0.291	0.446	-0.557
Kurt Month	3.21	2.827	2.336	1.858	2.471	3.317	2.787	4.909	2.651	2.869	1.753	2.425	1.994
M Min Year	1958	1958	1969	1956	1951	1953	1953	1953	1953	1953	1956	1954	1953
M Max Year	1972	1959	1964	1970	1969	1950	1960	1975	1974	1975	1958	1971	1972

Maximum Temperature

Table 2-11

Monroe County Stormwater Management Master Plan

Summary of Rainfall and Air Temperature Data - Marathon Shores

Station Name	MARATHON SHORES												
Station ID	5351		Latitude		24:44:00		Start Year		1950				
State	FLORIDA		Longitude		081:03:00		End Year		1975				
County	MONROE		Elevation		10		Num Years		26				
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
# Days	682	621	620	659	683	670	682	737	652	693	684	682	8065
Avg Day	76.119	76.79	80.24	83.347	86.422	88.825	90.437	90.879	89.267	85.236	80.423	76.581	83.814
# Months	22	22	20	22	22	22	22	24	22	22	23	22	17
SDev Month	2.679	3.476	2.254	1.624	1.194	1.053	1.099	1.057	0.965	1.383	1.758	2.55	0.909
Min Month	69.419	66.179	74.677	79.967	83.194	86.933	87.645	88.839	87.4	82.226	77.067	72	81.222
Max Month	81.645	82.714	83.258	85.8	88.161	91.267	92.871	92.871	91.867	87.516	84.133	82.452	85.108
Avg Month	76.119	76.781	80.24	83.347	86.406	88.887	90.437	90.867	89.241	85.15	80.417	76.581	83.75
Skew Month	-0.27	-1.201	-1.074	-0.259	-0.723	0.743	-0.402	-0.055	0.603	-0.241	0.166	0.421	-1.247
Kurt Month	3.109	4.644	3.04	1.864	3.349	2.974	3.512	2.162	3.612	2.28	2.431	2.456	4.242
M Min Year	1958	1958	1958	1958	1958	1972	1974	1974	1956	1964	1962	1963	1958
M Max Year	1972	1959	1972	1970	1967	1950	1969	1952	1951	1971	1958	1971	1971

Table 2-12
Monroe County Stormwater Management Master Plan
Summary of Rainfall and Air Temperature Data - Tavernier

Station Name	TAVERNIER				
Station ID	8841	Latitude	25:00:00	Start Year	1948
State	FLORIDA	Longitude	080:31:00	End Year	1998
County	MONROE	Elevation	7	Num Years	51

Precipitation

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
# Days	1482	1316	1479	1499	1539	1369	1413	1494	1381	1510	1395	1473	17350
Avg Day	0.073	0.069	0.063	0.069	0.139	0.233	0.127	0.161	0.236	0.21	0.074	0.06	0.126
# Months	48	47	48	50	50	46	44	49	46	49	47	47	36
SDev Month	3.056	1.649	1.497	2.004	3.178	5.236	2.852	2.433	3.238	3.743	2.308	1.848	11.303
Min Month	0	0.11	0	0	0.19	0.34	0.47	0.52	1.98	0.71	0.03	0.05	24.41
Max Month	15.35	7.85	5.07	10.79	13.87	21.83	12.31	10.64	14.08	15.87	9.27	8.75	68.48
Avg Month	2.262	1.978	1.934	2.06	4.275	6.948	3.944	4.909	6.907	6.427	2.191	1.809	46.108
Skew Month	3.068	1.58	0.596	2.092	1.078	1.06	1.334	0.463	0.576	0.651	1.664	2.094	0.068
Kurt Month	11.202	5.465	2.135	8.337	3.763	3.117	3.973	2.513	2.264	2.549	4.621	6.93	2.301
M Min Year	1971	1995	1956	1987	1998	1950	1967	1972	1986	1974	1970	1968	1974
M Max Year	1983	1998	1995	1982	1968	1967	1949	1981	1960	1969	1982	1958	1969

Minimum Temperature

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
# Days	1477	1320	1479	1493	1532	1380	1424	1494	1400	1522	1399	1470	17390
Avg Day	63.46	63.888	67.278	70.471	73.908	76.53	78.037	78.05	76.865	73.668	69.348	64.973	71.403
# Months	47	47	48	50	49	46	45	47	47	49	46	48	35
SDev Month	4.061	3.818	2.394	2.021	1.437	1.34	0.972	0.934	1.326	1.694	2.808	3.225	1.095
Min Month	51.452	56.107	62.548	63.733	70.065	73.7	75.484	75.871	72.233	69.613	63.067	57.516	68.154
Max Month	71.968	72.857	70.968	74.833	77.194	80.733	80.032	79.71	80.033	77.5	75.4	70.935	73.695
Avg Month	63.431	64.009	67.254	70.488	73.889	76.53	78.049	78.018	76.868	73.701	69.357	64.956	71.207
Skew Month	-0.18	0.008	-0.362	-0.525	-0.283	0.219	-0.279	-0.072	-0.401	-0.102	0.052	-0.12	-0.407
Kurt Month	3.544	2.61	2.132	4.19	3.172	3.733	2.708	2.181	5.06	2.631	2.507	2.41	3.41
M Min Year	1981	1958	1969	1987	1982	1976	1955	1981	1981	1981	1962	1963	1981

Table 2-12
Monroe County Stormwater Management Master Plan
Summary of Rainfall and Air Temperature Data - Tavernier

Station Name	TAVERNIER												
Station ID	8841		Latitude		25:00:00		Start Year		1948				
State	FLORIDA		Longitude		080:31:00		End Year		1998				
County	MONROE		Elevation		7		Num Years		51				
M Max Year	1974	1959	1974	1991	1991	1998	1998	1972	1989	1998	1986	1971	1990
Maximum Temperature													
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
# Days	1478	1324	1479	1493	1534	1380	1419	1483	1390	1526	1399	1470	17375
Avg Day	76.038	77.09	79.953	82.869	85.938	88.151	89.911	90.072	88.466	84.952	80.622	77.11	83.439
# Months	47	47	48	50	49	46	45	47	46	49	46	48	35
SDev Month	2.334	2.798	2.138	1.77	1.549	1.849	1.792	1.45	1.526	1.646	2.085	2.266	1.195
Min Month	70.71	70.5	74.968	79.233	83.452	84.167	87.323	87.677	85.933	80.871	76.033	71.871	81.06
Max Month	80.871	83.643	84.742	86.467	89.097	92	93.387	93.097	92.167	88.323	85.9	83.258	86.249
Avg Month	76.019	77.073	79.935	82.874	85.918	88.151	89.914	90.013	88.45	84.939	80.616	77.096	83.17
Skew Month	0.036	0.002	-0.147	0.315	0.503	0.4	0.54	0.321	0.665	0.106	0.161	0.058	0.624
Kurt Month	2.364	2.721	3.053	2.327	2.15	2.445	1.904	2.181	2.405	2.5	2.713	3.133	2.909
M Min Year	1958	1958	1968	1966	1970	1966	1972	1996	1994	1996	1962	1963	1996
M Max Year	1989	1982	1982	1981	1981	1998	1982	1987	1982	1980	1986	1978	1982

Figure 2-2
Monroe County Stormwater Management Master Plan
Summary of Minimum Temperature Data

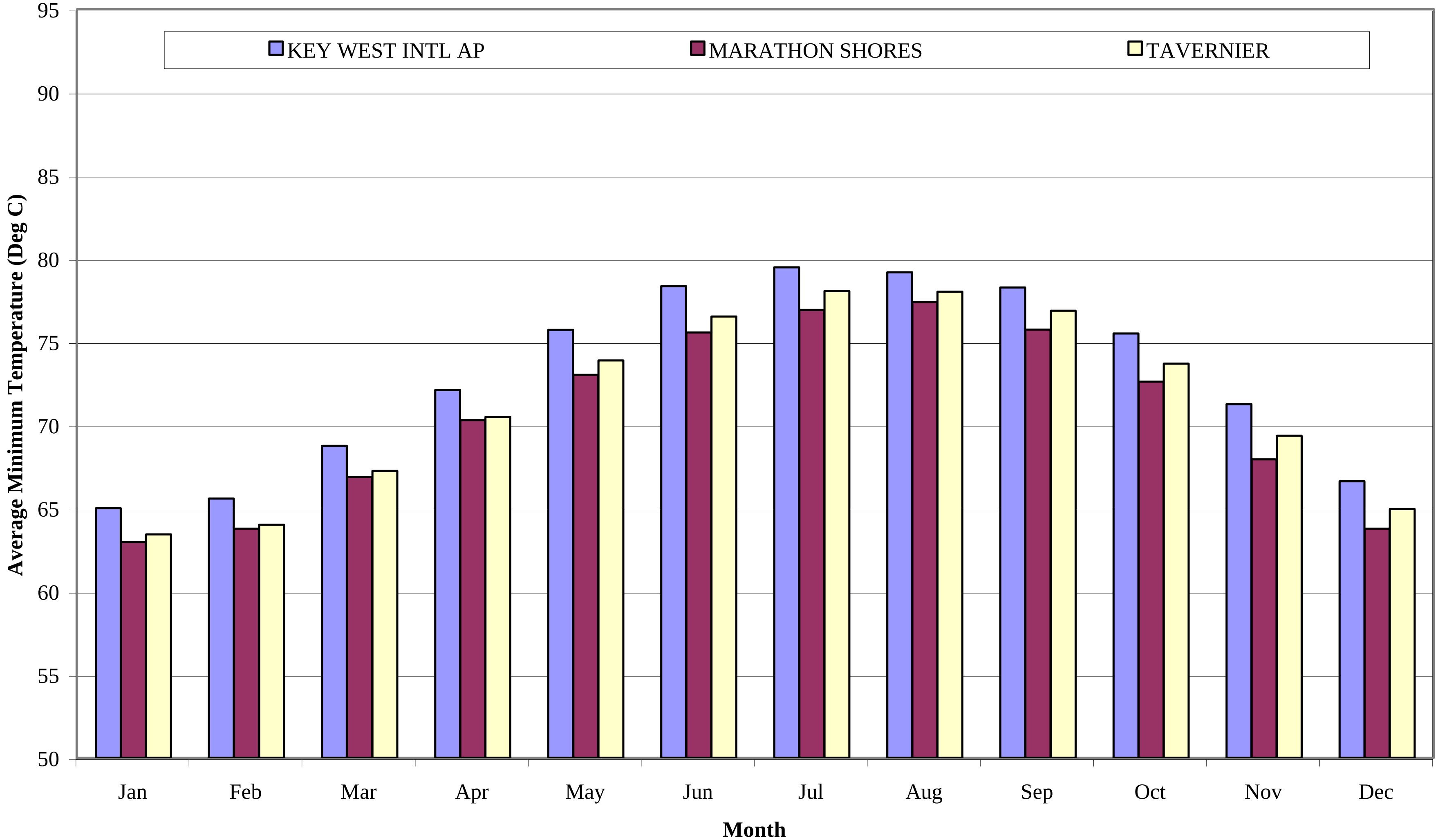
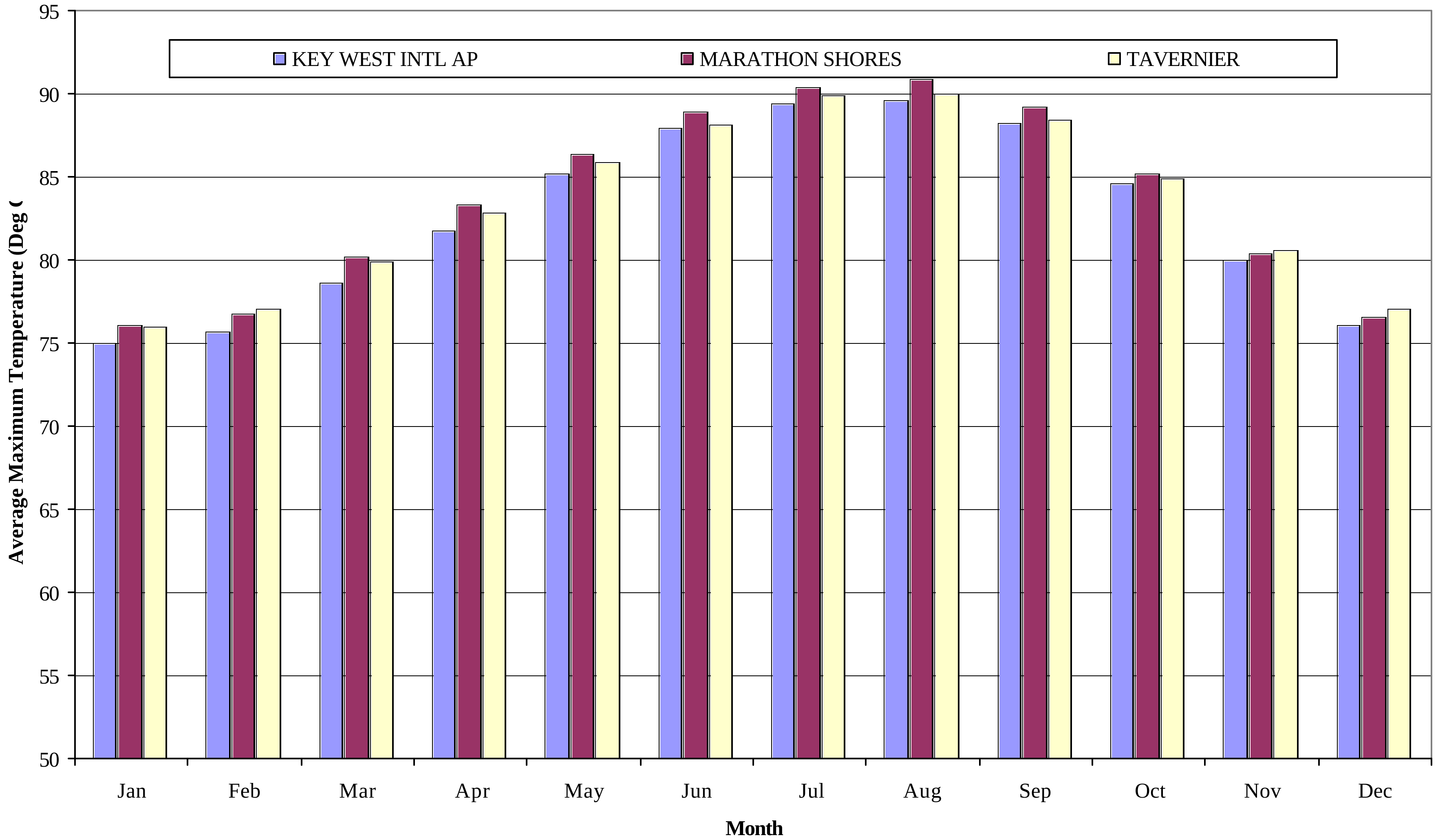


Figure 2-3
Monroe County Stormwater Management Master Plan
Summary of Maximum Temperature Data



2.1.7 Soils

As noted previously, the amount of runoff from a particular land use depends on many factors including intensity of rainfall, saturation of the soils prior to the rainfall, amount of impervious area relative to pervious area, and duration of rainfall, to name a few. For the pervious areas, a key factor is the type of soil. Some soils are highly permeable (e.g., sand) allowing for high amounts of infiltration and water storage within the soils, while other soils are almost impermeable (e.g., clays). Therefore, to understand the potential runoff patterns within the Florida Keys, soils data provided by South Dade Soil and Water Conservation District were assessed relative to permeability.

From data tables provided in the appendix, Table 2.1-13 summarizes the soils within the study areas for Monroe County. Soils Group A are highly permeable and Soils Group D have very low permeability. The table shows that neither Soils Group A nor Group C are found in the Keys. On the average, 79 percent of the study areas has a very slow infiltration rate (Group D) and only 21 percent has a moderate infiltration rate. Study areas that have soils with higher infiltration rates include Stock Island and Key Colony Beach, both with greater than 90 percent Group B soils. Study areas with 80 percent or greater Group D soils include Key West, Bay Point Key, Lower Sugarloaf Key, Upper Sugarloaf Key, Cudjoe Key, Torch Keys, Big Pine Key, Long Key, Upper Matecumbe Key, Windley Key, Key Largo Lower, and Key Largo Upper.

2.1.8 Problem Areas

Stormwater problems generally fall into two categories: flooding and water quality. Flooding problems can be severe (e.g., flooding of houses and other structures) or nuisance (flooding of yards and roads), and can be expressed as depth of flooding and duration. Based upon conversations with Monroe County staff including the County Engineer, the majority of flooding issues within the county are within the incorporated cities, in particular, Key West. County staff has not identified serious flooding problems (house and building flooding) for areas within the unincorporated county. Nuisance flooding (roadways) has been identified; these areas will be confirmed during the public meetings.

Stormwater quality issues have been identified by the Sanitary Wastewater Management Plan during the identification of "hotspots." These are discussed below.

Known Water Quality Problem Areas

Produced by the US Environmental Protection Agency Oceans and Coastal Protection Division (July, 1992), the report entitled, Water Quality Protection Program for the Florida Keys National Marine Sanctuary; Phase I Report, provides, among other things, a list of water quality "hot spots." These are areas where, based upon workshops and discussion groups, areas with known or suspected water quality

Table 2-13
Monroe County Stormwater Management Master Plan
Summary of Soils Data

Study Area	Description	Hydrologic Soils Group (1) A (ac)	A (%)	B (ac)	B (%)	C (ac)	C (%)	D (ac)	D (%)	Total (ac)
1	Key West	0	0%	389	12%	0	0%	2,852	88%	3,241
2	Stock Island	0	0%	856	93%	0	0%	64	7%	920
3	Boca Chica Key	0	0%	1,930	44%	0	0%	2,456	56%	4,386
4	Bay Point Key	0	0%	107	7%	0	0%	1,427	93%	1,535
5	Lower Sugarloaf Key	0	0%	0	0%	0	0%	2,797	100%	2,797
6	Upper Sugarloaf Key	0	0%	529	10%	0	0%	4,764	90%	5,293
7	Cudjoe Key	0	0%	586	18%	0	0%	2,668	82%	3,253
8	Summerland Key	0	0%	322	33%	0	0%	653	67%	974
9	Ram Rod Key	0	0%	325	34%	0	0%	632	66%	957
10	Torch Keys	0	0%	291	10%	0	0%	2,622	90%	2,913
11	Big Pine Key	0	0%	825	11%	0	0%	6,678	89%	7,503
12	Bahia Honda	0	0%	185	42%	0	0%	255	58%	440
13	Marathon	0	0%	3,261	61%	0	0%	2,085	39%	5,345
14	Key Colony Beach	0	0%	306	100%	0	0%	0	0%	306
15	Long Key	0	0%	202	19%	0	0%	861	81%	1,063
16	Layton	0	0%	40	60%	0	0%	26	40%	66
17	Lower Matecumbe Key	0	0%	424	47%	0	0%	478	53%	903
18	Islamorada	0	0%	1,319	30%	0	0%	3,077	70%	4,396
19	Upper Matecumbe Key	0	0%	96	10%	0	0%	863	90%	959
20	Windley Key	0	0%	81	17%	0	0%	398	83%	479
21	Key Largo Lower	0	0%	2,027	18%	0	0%	9,235	82%	11,262
22	Key Largo Upper	0	0%	858	7%	0	0%	11,404	93%	12,263
	Totals or Average	0	0%	14,960	21%	0	0%	56,296	79%	71,256

Notes:

(1) The hydrologic soils group identifies the propensity of the soil type to infiltrate rainfall.
Group A - soils having a high infiltration rate when thoroughly wet; generally sands.
Group B - soils having a moderate infiltration rate when thoroughly wet; generally course sands.
Group C - soils having a slow infiltration rate when thoroughly wet; generally fine texture.
Group D - soils having a very slow infiltration rate when thoroughly wet; generally clayey.

degradation. This report listed 84 "hot spots." According to a meeting summary (March 19, 1996) the "hot spots" were refined based upon newer information, leading to a list of 88 "hot spots." It should be noted that the majority of these is related to wastewater or septic tank influences and does not represent stormwater induced problem areas. In Technical Memorandum No. 4 by Lindahl, Browning, Ferrari & Hellstron, Inc. (Aug 16, 1999), the "hot spots" were assessed and ranked from high to low priority. Stormwater influences were identified as well. Finally, in July 1999, Monroe County produced "Water Quality 'Hotspots' in the Florida Keys: Evaluations for Stormwater Contributions. This report assessed the previously identified concerns, visited the areas in the field, and defined the most probable stormwater-influenced problem areas. Excluding the low priority sites, the high and medium priority problem areas are identified below.

High Priority

No.	Name
13	Campbell's Marina, Key Largo
41	Marathon Marina, Vaca Key
42	Boot Key Harbor drainage, Vaca Key
77	Alex's Junkyard, Stock Island
79	Oceanside Marina, Stock Island
80	Safe Harbor Area, Stock Island
83	Garrison Bight Marina, Key West
87	Key West Bight, Key West

Medium Priority

No.	Name
7	Key Largo Fishery Marina, Key Largo
20	Holiday Isle Resort, Windley Key
22	Lorelei, Upper Matecombe
27	Caloosa Cove Marina, Lower Matecombe
34	Coco Plum Causeway, Fat Deer Key
39	National Fish Market, Vaca Key
60	Summerland Key Seafood, Summerland
63	Venture Out Trailer Park, Cudjoe Key
78	Stock Island Lobster Co., Stock Island
85	Truman Annex Marina, Key West

Other areas identified in the report include:

- Key Largo Harbor Marina (Key Largo)
- Pipe at end of Jo Jean Way in Community Harbor (Tavernier)
- Commercial Fishing Area along Lake View Drive (Lower Matecombe)
- Anne's Beach (Lower Matecombe)

- 27th Street (Marathon)
- Veteran's Park (Little Duck Key)
- Winn Dixie Shopping Plaza (Big Pine Key)
- Key Haven (Raccoon Key)
- Old Town Trolley storage area (Stock Island)
- Coconut Grove residential area (Stock Island)

Additional problem areas may be identified during the fieldwork and by the public during the public meetings.

2.2 Data Needs

Section 2.1 above provides a compilation and assessment of existing information related to the Monroe County Stormwater Management Master Plan (SMMP). Added to these data and existing reports will be the information collected as part of the development of the SMMP by the Project Team, including Camp Dresser & McKee Inc., Keith & Associates Inc., Glen Boe & Associates, Environmental Consulting Systems Inc., Mote Marine Laboratories, Valerie Settles, Esq., and The Market Share Company. The additional information will include:

- Stormwater runoff pollutant loading estimates for each study area;
- Inventory and evaluation of existing stormwater management systems
- Assessment of existing regulatory programs;
- List and evaluation of available structural and nonstructural stormwater management techniques; and,
- Problem areas and priorities defined through the public meeting program.

This section considers the available information and new data generated as part of the SMMP and provides a list of data needed for the other elements of the SMMP of for the future refinement of the plan itself.

For the purposes of this section, data needs have been divided into two categories, water quantity (flooding) and water quality.

Water Quantity

During the initial public meetings, flooding problem areas were identified. In the unincorporated county, none of these problem areas involved the flooding of homes or building; however, at times, floodwaters covered roads and streets for a significant length of time. To adequately address these flood prone areas, additional stormwater-related data are needed. In particular, detailed studies of the problem areas (leading to engineering design documents) require precise topographic information. Elevation data available in the Florida Keys consist of the United States Geological Survey (USGS) 5-foot contour maps. These data are represented in Appendix F (Exhibit 5) of this document. For most of the island, no more than one contour line is shown since the island topography varies less than 10 feet. Therefore, topographic survey data are needed for select areas of the Florida Keys.

Topographic survey data can be derived by classical survey methods, digital survey techniques including Global Positioning System (GPS) information, and photogrammetry. The information must be gathered with resolution equal to, or better than, 1-foot intervals. To obtain topographic information, it is recommended that data should be gathered in phases. Initially, topographic information should be gathered in areas where stormwater retrofit or new projects are recommended. In subsequent phases, the county should work with the SFWMD and others to provide digital aerials with 1-foot topographic information included.

Survey information may also be required for stormwater facilities identified during the inventory of structures. As noted above, survey information should be gathered only in areas where recommended changes are defined. To augment these data, as built construction drawings should be required for public facilities.

Water Quality

Based upon the information collected to date, four areas of stormwater quality data have been identified for additional data collection: pollutant sources, BMP efficiencies and pollutant transport through the soil.

Stormwater Runoff Pollutant Sources. The Watershed Management Model (WMM) was used to estimate the average annual loading for twelve conventional, stormwater-related pollutants. The WMM uses event mean concentrations (EMCs) for various types of land uses within Monroe County including residential, commercial, institutional, and open lands. EMC data were derived from a significant volume of land use-specific sampling data, all of which were collected outside of the Florida Keys. While experience shows that the EMC data apply to the majority of the land uses in the Keys, there are a few land uses for which EMC data are not available: marinas, crab/lobster equipment storage areas, and highways (both local and state). While the WMM analysis to be provided as part of this SMMP should be sufficient to isolate potential pollutant problem areas and to complete the SMMP, more specific EMC data for the land uses listed above would help resolve specific sources to address potential retrofit projects.

BMP Efficiency. Numerous studies of the pollution reduction efficiencies for various types of Best Management Practices (BMPs) have been completed throughout United States. None have been completed in the Florida Keys. Therefore, the SMMP will be based upon sampling and literature data from BMPs from Florida but outside of the Keys. Since the weather, soils and land use conditions within Monroe County are different than even nearby parts of Florida, additional information on BMP efficiencies should be obtained through the sampling of existing or new stormwater facilities. These data will help validate the application of statewide BMP efficiency data to the Keys. Thus, the data would enhance the credibility of the SMMP implementation program.

Pollutant Transport. Once pollutants are picked up in runoff, there are two mechanisms to transport them to near shore water: direct and indirect discharges.

Direct discharges carry stormwater pollutants through the storm sewer system of swales, pipes, or detention ponds to discharge directly into near shore waters. Indirect discharges transport stormwater-related pollutants through shallow ground waters to near shore waters. While the characteristics of direct discharges can be adequately estimated and even measured, indirect discharges are less understood and quantifiable. For this reason, additional information should be gathered on the indirect discharge of pollutants. One way to do so would include the integrated modeling of surface, subsurface and near shore waters and pollutant transport. Not all study areas need to be considered in such a way: one or more of the study areas could be chosen (based on identified problem areas, for example) to be modeled using new, sophisticated numerical models. The model would be used to understand the relative magnitude of pollutant transport through the various media and the immediate fate of such pollutants in the near shore environment.

It should be noted that, while these data will help the implementation of the SMMP within the Florida Keys, none are necessary for the completion of the actual stormwater management plan itself. That is, sufficient data exist to day or will be generated as part of the SMMP scope of services to prepare the plan; however, additional data can refine the implementation of specific projects identified by the SMMP.

2.3 Pollution Load Targets and Analysis

To meet the objectives of the SMMP, it was necessary to identify and quantify the pollutants that may affect water quality. This section identifies stormwater-related pollutants that may affect water quality in the study area and describes application of the CDM Watershed Management Model (WMM) to estimate the pollutant loading from stormwater to waters within Monroe County. WMM was developed for FDEP and the USEPA NPDES program to evaluate point and nonpoint source pollution.

2.3.1 Pollutant Targets (by Mote Marine Lab [1])

2.3.1.1 Overview of Applicable Water Quality Standards

Virtually all water quality standards in the U.S. have been developed based on effects on humans or organisms of the temperate zone. There are a number of "standard" species used for eco-toxicological studies, generally to identify concentrations that are lethal to 50% of the population (LC_{50} values). Studies have also examined teratogenetic (i.e. those causing birth defects) and other sublethal effects but these are often not considered in establishing discharge standards. There are several considerations applicable to the Monroe County SMMP that have largely been ignored when establishing pollutant load targets and regulatory standards: 1) differential responses of subtropical/tropical organisms, 2) effects of chronic long-term exposure, and 3) the complex effects on ecosystem dynamics (i.e. changes in trophic structure, population displacement, changes in hydrology, etc.).

Although numerous materials of anthropogenic origin are discharged into near shore waters, this subsection considers four pollutant categories commonly associated with nonpoint discharges and most relevant to stormwater runoff: sediments/solids, oxygen demanding materials, nutrients, and metals. These pollutants, known to have broad deleterious effects on aquatic systems, have been targeted by the U.S. Environmental Protection Agency's National Pollutant Discharge Elimination System (NPDES). Provided below is a general overview of these NPDES pollutants and a literature review of their effects on organisms and ecosystems of the Florida Keys.

Most coastal waters of Monroe County are classified by the Florida Department of Environmental Protection as Class III; County waters within Everglades National Park are Class II (Rule 62-302, FAC, Surface Water Quality Standards). Waters of the Keys, except canals and certain point discharge locations, are also considered "Outstanding Florida Waters", which imposes a "no degradation" standard, and is primarily used for permitting purposes, rather than enforcement action. Thus, permitting of structural stormwater management devices may require addressing standards for pollutants in addition to those considered below.

[1] Erich Mueller, Ph.D., Director, Mote Marine Laboratory, Center for Tropical Research, 24244 Overseas Highway (US 1), Summerland Key, FL 33042.

Sediments [total suspended solids (TSS), total dissolved solids (TDS)]
Sediment from nonpoint sources is one the most common pollutants of surface waters (U.S. EPA 1996). Excessive sediment loads can directly impact benthic organisms, overwhelming their ability to shed sediment particles or interfering with feeding. Indirectly, sediment loading increases turbidity and reduces light penetration. The waters of the Florida Keys generally have very low turbidity, particularly offshore. Thus, communities with high light requirements, such as seagrass meadows and coral reefs, are present and are known to be sensitive to excessive turbidity. Many toxic pollutants including organic chemicals and heavy metals adsorb to sediment particles so that organisms near or in contact with the particles may be exposed to higher toxin concentrations than detected in bulk water samples. Toxic materials may also be re-mobilized into the water column under suitable environmental conditions, potentially causing problems long after adequate discharge controls are enacted.

The Florida Surface Water Quality Standards include two related parameters: "transparency" and "turbidity". The former standard for Class III waters is that transparency "shall not be reduced by more than 10% as compared to the natural background level." The turbidity standard is "≤ 29 NTU [nephelometric turbidity units] above natural background conditions." There are no surface water standards for TDS or TSS although there are criteria for wastewater discharge (Rule 62-600, FAC).

Oxygen Demand [biological oxygen demand (BOD), chemical oxygen demand (COD)]
These two parameters are essentially different ways of measuring the potential to reduce dissolved oxygen (DO) through macrobial respiration or chemical oxydation. The respiration potential is directly related to the amount of organic (carbon) compounds in the water. These standards are typically used for assessing effluent water streams (wastewater or stormwater). Organisms do not respond to oxygen demand directly but to the DO level that is influenced by oxygen demand and regenerative processes (photosynthesis and air-sea exchange).

Marine life in the water column and on the benthic surface generally requires well-oxygenated water to support respiration. Low DO can directly lead to mortality of fish, other invertebrates, and plants and, if chronic, cause major changes in the community structure. Sulfur-reducing bacteria thrive in low DO environments and produce hydrogen sulfide (H_2S) that is toxic to most organisms. In the tropics, DO is generally lower because of oxygen's inverse relationship with temperature. This, combined with generally higher respiration rates at elevated temperatures, means that tropical organisms have a lower margin for oxygen reduction (Johannes and Betzer, 1975) particularly in summer when temperatures are highest. The effects of low DO would also be primarily in areas with poor water circulation such as the numerous canal systems of the Florida Keys but low levels have also been documented in more open near shore areas of the Keys and Everglades National Park (Lapointe and Clark, 1990).

Canals dug substantially deeper than the surrounding waters often become stratified with persistently hypoxic (low oxygen) or anoxic (no oxygen) waters on the bottom. The addition of effluent with a high oxygen demand to waters of limited exchange would be expected to further depress DO levels and cause biotic shifts to a species tolerant of hypoxic or anaerobic conditions. Such species are generally considered “less desirable” to residents and users of these water bodies.

Nutrients [nitrogen - Total Kjeldahl (TKN) and Nitrate+Nitrite (NO_3^- +NO_2^-); phosphorous – Total (TP) and Dissolved (DP)]

Along with sediments, nutrients are considered the most common nonpoint source pollutants (U.S. EPA, 1996). Nutrients are essential materials for plant growth with nitrogen and phosphate considered two of the most important. They are the principal ingredients in fertilizers and thus a common constituent of stormwater runoff from agricultural and residential areas. Nutrients are also released by degradation of plant material. Total Nitrogen (TN) includes DIN, dissolved organic nitrogen (DON) and particulate nitrogen (N). Total Kjeldahl Nitrogen (TKN) is measured by a procedure (developed by Johan Kjeldahl) that measures organic nitrogen plus ammonia. In many studies, ammonia (NH_3 + NH_4^+) is often included with nitrate and nitrite as dissolved inorganic nitrogen (DIN); ammonia is readily assimilated by plants which can utilize nitrate as well. Total Phosphorous (TP) includes dissolved and particulate organic phosphorous as well as dissolved inorganic phosphate (DIP). DIP is composed of the various forms of phosphoric acid, H_3PO_4, which is often referred to in the literature as soluble reactive phosphorous (SRP). In seawater, the most abundant form is HPO_4^{2-} followed by PO_4^{3-}; it is the latter form that is most readily assimilated by plants.

In most marine systems, nitrogen availability is considered limiting to plant productivity. Thus, if concentrations of nitrogen are increased, plant growth is increased above that to which the ecosystem is generally adapted. In some waters, including some of those in the Keys, phosphate may be limiting due to the shallow waters and ability of carbonate sediments to bind phosphate (Jensen et al. 1998). The elevation of nutrient levels is generally described as “nutrification” but may lead to “eutrophication” whereby oxygen is depleted (described below) and major shifts to the ecosystem take place. This is most commonly observed in lakes but can occur in marine waters with limited circulation. The waters of the Florida Keys, like those throughout the tropics, are considered “oligotrophic”, that is having particularly low concentrations of nitrogen and phosphorous. Because the Keys marine ecosystems have developed under oligotrophic conditions, they are even more sensitive to nutrification than other Florida or temperate waters.

Excessive nutrient loading is often manifested by increases in phytoplankton abundance and may cause "blooms" with extremely high algal densities. The resulting increase in turbidity reduces light penetration and can have economic impacts by making the water unappealing for aquatic activities such as swimming and diving. Algal respiration at night can deplete DO and when these large numbers of algal cells die, microbial populations increase and can deplete DO throughout the diel cycle. Such a scenario produces classic eutrophication. "Harmful algal blooms" are caused by algal species, particularly certain dinoflagellates, that contain or secrete toxins. These toxins can cause massive fish kills and render filter feeders (e.g. oysters, clams etc.) unsuitable for human consumption. Elevated nutrients can also increase "nuisance" benthic and epiphytic plant growth. Higher growth or populations of such plants can result in overgrowth of sessile animals, such as corals, and seagrasses.

Heavy Metals [cadmium (Cd), copper (Cu), lead (Pb), zinc (Zn)]
Heavy metals are found in very low concentrations (typically nM levels) in seawater although there can be considerable differences across shelves (higher near shore) and with depth (higher in surface waters). Cadmium, copper, lead and zinc are most likely to be found in stormwater and are considered in this subsection. Copper and zinc are essential trace elements that are actively assimilated because they are necessary for certain enzymes; however, lead and cadmium are not utilized. Excessive metal concentrations are toxic to aquatic life and may bioaccumulate in tissues such that their toxicity is manifested at the higher trophic levels. Consumption of certain fish by humans can be a potentially toxic source of heavy metals. Sediments tend to bind metals, thus reducing concentrations in the overlying water; however, this may expose infauna to higher concentrations and, like organic toxins bound to sediment, may be remobilize under certain conditions. State standards for metals vary with water hardness and are different for fresh and marine waters.

2.3.1.2 Literature Review of Pollutant Effects

This review of pollution load targets has examined available literature relevant to the near shore area (within 2 km of the shoreline) of the Florida Keys. Both acute and chronic pollutant effects will be discussed as available along with information regarding changes to ecosystem structure that are not necessarily considered "toxic." In fact, there is very little information on specific pollutant load targets for specific organisms of this area. There is a fair body of information on environmental levels and effects, sometimes focused on an organism or biotic group, but often concerned with "ecosystem health" in general.

The format of each major pollutant category will address, as information is available, overall system effects and existing measurements, marine primary producers (including mangroves, seagrasses, benthic algae and phytoplankton), and benthic invertebrates and vertebrates. Invertebrates (most corals, certain cnidarians and some sponges) that harbor symbiotic algae act as functional autotrophs and will usually be discussed under primary producers except where the pollutant is reported to specifically to affect the host tissues.

Oxygen Demand

In the "Florida Keys Monitoring Study: 1984-1985", Heatwole (1987) conducted intensive monitoring, including BOD measurements, at five impacted (marina, seafood processing, stormwater drainage system, wastewater discharge, and residential canal) and two control sites in the Florida Keys. Significant elevation of BOD was found at four of the five impacted sites although the differences were relatively small (both control and impacted site values ranged ~0.1 to 1.2 mg/l). There was significant depletion of DO at all five impacted sites. The State water quality standard for minimum DO in Class III waters (4.0 mg/l; Rule 62-302, FAC.) was often violated at the impacted sites. These sites were all restricted in exchange with ambient waters but depressed DO values were also observed in the mixing areas indicating that water degradation in the impacted basins affected adjacent waters.

Mangroves are adapted to living in sediments with little or no oxygen. Unlike other organisms in the scope of this report, mangroves primarily extract oxygen from the air, thus, no lower limit for DO in waters around mangroves is anticipated or has been found in the literature.

In one of the few studies examining the BOD and coral growth rate, (Tomascik and Sander, 1985) found that BOD was a fairly strong indicator of *Montastraea annularis* growth rates. BOD values ranged from 0.71±0.41 mg/l at the least impacted site to 1.09±0.58 mg/l at the site most impacted, largely by wastewater effluent. This was attributed to general tendency towards eutrophication amongst the study sites as chlorophyll *a* concentrations and suspended particle matter were even stronger estimators of coral growth rates. DO did not vary between sites; however, the weekly sampling was at mid-day. As this was a correlative field study with multiple variables, no target thresholds could be established for BOD or any other water quality factors that were examined. Bell, et al. (Bell, Greenfield et al., 1989) state that corals "live near their critical tolerance levels for dissolved oxygen" and recommended that a BOD limit of 10% above ambient conditions be standard. A somewhat higher tolerance level of 19% over ambient levels has been suggested for the Great Barrier Reef (Hawker and Connell, 1992).

Suspended and Dissolved Solids

Controlled measurements of organism tolerance for these parameters are difficult, largely because creating well-defined levels of these parameters in the laboratory is difficult. Many correlative field studies have measured turbidity and its impacts on growth or distribution of various organisms, primarily plants and corals that are light dependent. In fact, elevated turbidity (or TSS) is one of the most common factors cited causing deleterious effects on seagrass populations (Longstaff and Dennison, 1999; Short and Wyllie-Echeverria, 1996), coral growth (Tomascik and Sander, 1985;

Hudson, Powell et al., 1989), and other invertebrates (Clark, 1994). In addition to inorganic materials, plankton populations, particularly phytoplankton contributes to measured turbidity values. Their concentrations are typically measured using chlorophyll *a* as a proxy and are generally considered to respond most directly to nutrient concentrations. Thus, reductions in nutrient loading would be expected to decrease turbidity and increase water transparency.

The "Florida Keys Monitoring Study: 1984-1985" found modal values of 0-2.9 NTU (Heatwole, 1987) across the seven sites. The study's typical maxima for impacted basins were in the 10-12 NTU range with the highest recorded value (33 NTU) at the ocean side control site due to wind-generated resuspension of fine sediments. Turbidity was significantly different at four of the five impact sites from the appropriate control sites; however, in three of those, the turbidity was lower in the protected basin. TSS values were also monitored and generally coincided with the turbidity measurements although there were no significant differences between any of the study sites. Typical values recorded were 4-15 mg/l with two maxima around 24 mg/l (one was an unexplained value at an impacted site and the other at a control site associated with a wind event). For the Great Barrier Reef, Connell and Hawker (1992) suggest an upper limit for suspended solids of 3.85 mg/l, an increase of 28% over ambient levels there.

Turbidities in Florida Bay have generally increased over the period 1991-1997 (Boyer et al., 1999) and these waters can affect near shore waters of the Upper and Middle Keys (Shinn et al., 1989; Forrester, 1996). The median value for the central Bay, which was highest, was 8.6 NTU. These authors have also been monitoring waters of the Florida Keys proper (but not within canals) and in 1999 found median turbidity values ranging from 0.295-1.100 NTUs. There was an inshore-offshore trend with decreasing turbidities at offshore stations which was documented in earlier reports from this group (Jones and Boyer, 1996; Jones and Boyer, 1997) but inshore water turbidity is still very low (median ~1 NTU). Although there are numerous subjective reports of decreasing water clarity in the Keys (Leeworthy and Wiley, 1996), there are no trends in the turbidity data for the Keys waters (Jones and Boyer, 1997).

Florida standards for turbidity (≤ 29 NTU over background) are not particularly relevant to waters of the Keys because of their general clarity. Although transient turbidities can exceed this value, persistent turbidity increases of much smaller values would be expected to have effects on Keys marine ecosystems. While it is difficult to assign specific values to various organisms because of the lack of literature, there is a good deal of baseline environmental data on which to base a "no degradation" standard.

Nutrients

Along with sediments, nutrient pollution is considered to be the major nonpoint pollutant in the U.S. (U.S. EPA, 2000). Many biologists feel that nutrification is <u>the</u>

most critical factor influencing near shore water quality and affecting seagrass and coral reef ecosystems. The consensus of scientists working in the Florida Keys is that nutrients from wastewater and stormwater has already substantially degraded near shore water quality (Kruczynski, FKNMS et al., 1999). The accumulating evidence is driving current efforts to improve wastewater treatment in the Florida Keys.

There have been a number of water quality studies in the Keys that have provided very detailed information about the various nitrogen and phosphorous species. Recent summaries of the literature and results are available (see Chiappone, 1996; Kruczynski et al., 1999) and annual reports by the ongoing Florida Keys Water Quality Monitoring Project provide the most up-to-date and comprehensive datasets (see Website at: http://serc.fiu.edu). Annual reports by Florida Baywatch, which includes many Keys sampling sites, are available from the Nature Conservancy Florida Keys Office. Below are values obtained in near shore waters and canal systems of the Florida Keys to support the Outstanding Florida Waters designation (FDER, 1985).

Nutrient Parameter	Ambient (mg/l)	Canals (mg/l)
ammonia ($NH_3 + NH_4^+$)	0.051 - 0.160	0.057 - 0.239
nitrate + nitrite ($NO_2^- + NO_3^-$)	0.000 - 0.027	0.002 - 0.054
TKN	0.128 - 0.693	0.196 - 1.150
TN (by calculation: TKN + $NO_2^- + NO_3^-$)	0.128 - 0.720	0.198 - 1.204
Total Phosphorus	0.001 - 0.054	0.005 - 0.083

Given that most canals do not contain what would be considered "healthy ecosystems" (Kruczynski et al., 1999), target concentrations to sustain a healthy environment should be lower than found in the canals and perhaps towards the lower end of the ambient concentrations as these values may already represent some degradation. However, the measured environmental values for TN and TP are well below the wastewater effluent standards that are only achievable today utilizing advanced technologies.

It would be an error to consider nutrient toxicity *per se* when considering effluent standards as toxic nutrient concentrations (where mortality occurs, growth rates depressed or other physiological parameters are adversely affected) are considerably higher than environmental concentrations. For example, in one of the more sensitive reef-building corals, 0.36 mg/l (20 µM) ammonium stimulated algal symbiont growth and increased host protein biomass (Muller-Parker et al., 1994). Reduction of symbiont growth did appear at 0.9 mg/l (50 µM) (Hoegh-Guldberg, 1994). Coral growth rates have been reported to be sensitive to phosphorous (Tomascik and Sander, 1985; Dubinsky and Stambler, 1996) and this has usually been ascribed to the "crystal poison" effect of phosphate on calcium carbonate precipitation (Simkiss, 1964). This hypothesis has never been adequately tested and direct effects of phosphate on corals are not known.

With respect to nutrients, proper ecosystem function should guide nutrient discharges but this is a complex end point and approaches need to be employed that are sensitive (Gray, 1992). The best-studied example of nutrification impacts (wastewater) on a coral reef is that of Kaneohe Bay, Hawaii (Smith et al., 1973). Nutrient discharges there effectively destroyed the reef and led to a dominance of the alga, *Dictyosphaeria cavernosa* (Smith et al., 1981). Several authors have utilized various arguments to set "threshold" limits for nutrients in reefal areas based on community effects. Bell (1992) suggests values of 0.1-0.2 µM for P-PO_4 (SRP) and 1.0 µM for DIN . Lapointe (1997) arrived at similar values (0.1 µM for SRP and 1.0 µM for DIN). A "fuzzy logic" model developed to predict coral community responses to elevated nutrients and sediment stress (Meesters et al., 1998), indicates that elevated DIN impacts are exacerbated by high suspended sediment loads. Based on an allowable 20% decrease in growth rates, arguably a satisfactory standard, Hawker and Connell (Hawker and Connell, 1992) suggest the following nutrient tolerance levels for the Great Barrier Reef (Australia): PO_4^{3-} - 0.25 µg/l (a 23% increase over ambient levels) and DIN - 1.96 µg/l (a 285% increase). They did not provide tolerances for TP or TN.

Declines in seagrass populations and productivity have been linked to anthropogenic nutrification (Lewis et al., 1985; Lapointe et al., 1994; for many more references, see Short and Wyllie-Echeverria, 1996). The nutrient impacts on seagrasses have usually been attributed to decreased water transparency (Short and Wyllie-Echeverria, 1996) due to phytoplankton blooms and high epiphyte loading (Lapointe et al., 1994) rather than direct toxicity of the nutrient (but see Tomasko et al., 1996). While seagrass communities may be slightly more tolerant of elevated nutrients than coral reefs, those of the Florida Keys are still adapted to low-nutrient levels and it would not be unreasonable to apply similar standards to both community types.

In developing any standards the following statement should be kept in mind, "…despite much research, our knowledge of the tolerance ranges and critical levels of nutrients for seagrass meadows and coral reefs is minimal" (Peters et al., 1997).

Heavy Metals

Heavy metals present difficulties in assessment of levels because of interactions with sediments, both deposited and suspended. Dissolved concentrations at any given time may provide underestimates of biological loadings. Nonetheless, criteria for these particularly toxic materials have been developed. The Florida standards for Class III marine waters are as follows (Rule 62-600, FAC):

Metal	Maximum Level (µg/l)
cadmium (Cd)	9.3
copper (Cu)	2.9
lead (Pb)	5.6
zinc (Zn)	86.0

A recent review of ecotoxicity in tropical marine systems (Peters et al., 1997) summarizes criteria (dissolved levels where specified) for these contaminants in other tropical jurisdictions. With respect to Cd, Florida has higher thresholds than Thailand (5.0 µg/l) or Australia (2.0 µg/l). Hawaii has the same numeric standard but qualifies this as a 24-hour average; up to 43.0 µg/l is allowed for a single measurement. Florida has the lowest limit for Cu of all jurisdictions presented which allow 5-50 µg/l. Florida also has conservative standards for Pb (others range from 5.0 to 140.0 µg/l). Zn standards are intermediate with others varying between 50.0 and 100.0 µg/l (again, Hawaii has the same numeric standard as Florida but specifies it as 24-hour average; up to 95.0 µg/l is allowed for a single measurement).

There are two main issues of concern with metals: toxicity to aquatic organisms and the potential hazard to humans consuming seafood in which metals have accumulated. With respect to toxicity, mangroves do not appear to be substantially affected by metals, however, metals are found in leaves and make their way into the food chain through detritus (Nye, 1990). This occurs with seagrasses as well (Peters et al., 1997), but direct toxicity has also been demonstrated(although few studies have examined seagrasses found in the Keys). In the temperate eelgrass (*Zostera marina*), the four metals of interest here had the following toxicity hierarchy: Cd>Cu>Zn>Pb (Lyngby and Brix, 1982). Chesher (1975) found that Cu reduced *Thalassia testudinum* photosynthesis by 50 percent at a concentration of 212 µg/l in 96-hour exposures. He found that other invertebrates, the tunicate *Ascidia nigra* and the echinoid *Lytechinus variegatus* had 50 percent mortalities in 96-hr at Cu levels of 102 and 155 µg/l, respectively. It should be noted that these concentrations were dilutions from desalinization plant effluent and not particularly relevant to stormwater discharge. Another study examining an Australian seagrass, *Halophila ovalis*, used photosynthetic performance to rapidly assess acute metal loads (Ralph and Burchett, 1998). This study found that Cu and Zn, which are essential elements, were more toxic than Cd and Pb which are not essential elements. Again, concentrations examined were very high and not suitable for establishing target loads.

Copper has been shown to be toxic to corals with 100 percent mortality in 24 hours of two Pacific species at concentrations of 1 mg/l (Howard and Brown, 1984). Substantial stress was also observed with 100-fold lower concentrations over 48 hours. A 96-hour, LC_{50} of 48 µg/l has been reported for the Pacific coral *Montipora verricosa* (Howard et al., 1986). Exposure of coral algal symbionts found that 40 µg/l Cu depressed cell division rates and that there was a synergistic effect with Zn (Goh and

Chou, 1997). Comparing Cu, Zn and Cd effects on fertilization success of a Pacific coral, Cu concentrations of 20 µg/l were found to be toxic while the other metals were not, even at much higher concentrations (Reichelt-Brushett and Harrison, 1999). Cu and Zn were both found to inhibit fertilization success in corals but the Zn effect was only seen at a concentration of 1 mg/l (Heyward, 1988).

Metal effects and accumulations have been recorded in several species of fish found in the Florida Keys including Zn in blue-striped grunts (see Peters et al., 1997) and grouper. Accumulations of Cd, Cu, Pb and Zn in Nassau grouper from the Bahamas and Gulf of Mexico were not found to be harmful to humans in 1973 (Taylor and Bright, 1973).

Most data on metal toxicity suggests that Cd and Cu are the most toxic. The prevalent use of Cu, including its use as an antifoulant, makes this metal of greatest practical concern. The following maximal concentrations (µg/l) have been suggested for reef areas: Cd (0.1), Cu (1.0), Pb(10.0) and Zn (20.0) (Hawker and Connell, 1992). Because metals are adsorbed into sediments and taken up by plants, it is not expected that they would occur at great distances from nonpoint discharges and that risk to reefs would be minimal. No similar target levels have been found for seagrass or other shallow habitats of the Florida Keys.

In summary, it appears that nutrients and sediments in stormwater can cause declines in seagrasses and coral reefs. For this reason, nutrients and sediments are highlighted in further studies provided below.

2.3.2 Nonpoint Source Pollution Loading Model

CDM's WMM was used to generate estimates of average annual pollutant loadings for existing and future land use conditions based upon local rainfall statistics. The model relies upon event mean concentration (EMC) factors for different land use categories to calculate pollution loadings. An EMC is the statistical average of a number of measurements of stormwater pollutant mass loading divided by the storm event volume. It is a representative, storm event pollutant concentration that many studies (e.g., NURP and NPDES MS4 permit applications) have shown to be similar for similar types of land uses. Because the model is relatively simple, it can be easily applied to screen the pollutant loading reductions that can be achieved by various best management practice (BMP) alternatives. A series of different BMP alternatives can be screened to identify BMP requirements that will adequately mitigate existing and projected long-term water quality problems within the watershed.

CDM WMM provides an annual point and nonpoint source pollutant load estimate for each hydrologic unit. EPA has tested 12 indicator pollutants for use in nonpoint source assessments: five-day biochemical oxygen demand (BOD5), chemical oxygen demand (COD), total suspended solids (TSS), total dissolved solids (TDS), total phosphorus (TP), dissolved phosphorus (DP), total Kjeldahl nitrogen (TKN), nitrate plus nitrite (NO23), lead (Pb), copper (Cu), zinc (Zn), and cadmium (Cd). It should be noted that total nitrogen is the sum of TKN and NO23.

The WMM was used to estimate relative nonpoint source loads from the study area. WMM uses a spreadsheet approach to estimate annual or seasonal nonpoint source loads from direct runoff based upon the event mean concentrations (EMCs) and runoff volumes. Data required for WMM include EMCs for each pollutant type, land use, runoff coefficients, and average annual precipitation. WMM can also address annual baseflow, and average baseflow pollutant concentrations, although these features are not used for the Monroe County SMMP. In its generic form, WMM includes the following features.

- WMM estimates annual runoff pollution loads and concentrations for nutrients (total phosphorus, dissolved phosphorus, ammonia plus organic nitrogen, nitrite and nitrate nitrogen), heavy metals (lead, copper, zinc, cadmium), and oxygen demanding substances (BOD and COD) and sediment (total suspended solids and total dissolved solids) based upon EMCs, land use, percent impervious, runoff coefficients, and annual rainfall;
- WMM estimates runoff pollution load reduction due to partial or full scale implementation of up to five types of BMPs;
- WMM applies a delivery ratio to account for reduction in runoff pollution load due to uptake or removal in stream courses (not applicable to Monroe County since travel times are short);
- WMM estimates annual pollution loads from stream baseflow (not applicable to Monroe County);
- WMM estimates point source loads for comparison with relative magnitude of nonpoint pollution loads (not used for the SMMP since point source loading estimated from previous studies); and
- WMM estimates pollution loads from failing septic tanks or onsite wastewater systems (estimated from previous studies rather than using WMM estimates).

Stormwater pollution control strategies that may be identified and evaluated using the WMM include:

- non-structural controls (e.g., land use controls, buffer zones, etc.); and,
- structural controls (e.g., onsite and regional detention basins, wet detention ponds, dry detention ponds, etc.).

The model provides a basis for planning level evaluations of the long-term (annual or seasonal) nonpoint pollution loads and the relative benefits of nonpoint pollution management strategies to reduce these loads. WMM can help the evaluation of alternative management strategies (combinations of non-structural and structural controls) to develop the stormwater management plan. The capabilities of the model are documented in the EPA document Compendium of Watershed-scale Management Models for TMDL Development (EPA 841-R-92-002).

The model first estimates the annual average runoff based upon imperviousness, impervious and pervious runoff coefficients, and the annual average rainfall. The total runoff, R_L, from a land use L is calculated as:

$$R_L = (c_i A_i + c_p A_p)\frac{I}{12}$$

or

$$R_L = A\left[c_p + (c_i - c_p)\frac{A_i}{A}\right]\frac{I}{12}$$

where

R_L =	runoff (ac-ft/yr);
c_i =	impervious runoff coefficient (generally between 0.85 and 1.0);
c_p =	pervious runoff coefficient (generally between 0.05 and 0.30);
A =	total area (A_i + A_p);
A_i =	impervious area (ac);
A_p =	pervious area (ac); and
I =	annual average rainfall (in/yr).

The total runoff from the watershed is the area-weighted sum of the runoff from all the land uses within the watershed.

The WMM converts the EMCs into nonpoint pollution loading factors (expressed as pounds/acre/year) based on the runoff volume for each land use within a watershed. Pollution loading factors vary by land use and the percent imperviousness associated with each land use. The pollution loading factor M_L is computed for each land use (L) using the following equation:

$$M_L = K * C_{EMC} * R_L$$

where:

M_L=	loading factor for land use L (pounds/acre/year);
C_{EMC} =	event mean concentration of runoff from land use L (mg/l);
R_L=	total average annual runoff from land use L (in/year); and,
K=	0.2266, a conversion constant (lb-l/mg-ac-in).

By multiplying the pollutant loading factor by the acreage in each land use and summing for all land uses, the total annual pollution load from a watershed can be computed. The WMM users guide is provided in Appendix I.

To apply CDM WMM to study areas within Monroe County, EMCs representative of this area as well as other local factors (point sources, septic tank influences, base flows, and land uses) were considered. Each of these factors is discussed below.

2.3.3 Selection of Event Mean Concentrations

The major sources of pollutants in a watershed are typically found in stormwater runoff from urban and agricultural areas, discharges from wastewater treatment and industrial facilities, and contributions from failed septic tanks. Stormwater runoff pollution and septic tank loadings usually are referred to as "nonpoint source" (NPS) or "nonpoint" pollution because the discharge is to receiving waters at dispersed points. A wastewater or industrial discharge is typically referred to as "point source" pollution because the discharge is released at a discrete point.

Urban nonpoint pollution has become a growing concern over the past 20 years as areas throughout the United States have identified the significant increase in nonpoint pollution discharges that occur when an area becomes urbanized. For example, compared to undeveloped land uses such as forest land, annual runoff pollution (in pounds/acre/year) from urban development is as much as 10 to 20 times greater for nutrients from fertilizers such as phosphorus, and as much as 10 to 50 times greater for toxic metals such as lead and copper. The SMMP targets the pollutants that are most frequently associated with stormwater, including:

Sediments
- Total Suspended Solids (TSS)
- Total Dissolved Solids (TDS)

Oxygen Demand
- Biochemical Oxygen Demand (BOD)
- Chemical Oxygen Demand (COD)

Nutrients
- Total Phosphorus (TP)
- Dissolved Phosphorus (DP)
- Total Kjeldahl Nitrogen (TKN)
- Nitrate+Nitrite (NO_3+NO_2)

Heavy Metals
- Lead (Pb)
- Copper (Cu)
- Zinc (Zn)
- Cadmium (Cd)

Estimates of the annual load of these pollutants are specified as part of the National Pollutant Discharge Elimination System (NPDES) stormwater permitting analysis.

The nonpoint pollution loading module of the WMM computes nonpoint pollution loads based on factors that relate local land use patterns, rainfall, and percent imperviousness in a watershed to "per acre" pollutant loadings. Nonpoint pollution loading factors (pounds/acre/year) for different land use categories are based upon annual runoff volumes and event mean concentrations (EMCs) for different pollutants. As noted previously, the EMC is a flow-weighted average concentration and is defined as the sum of individual measurements of stormwater pollution loads divided by the storm runoff volume. Selection of nonpoint pollution loading factors depends upon the availability and accuracy of local monitoring data, as well as the effective transfer of literature values for nonpoint pollution loading factors to a particular study area.

Over the past 15 years, nonpoint pollution monitoring studies throughout the United States have shown that "per acre" discharges of urban stormwater pollution (e.g., nutrients, metals, and BOD) are positively correlated to the amount of imperviousness in the land use (i.e., the more imperviousness, the greater the nonpoint pollution load). The studies have also indicated that the EMC is fairly consistent for a given land use type. These conclusions were confirmed in the recent NPDES wet weather sampling programs required by Phase 1 municipal separate storm sewer systems (MS4s) permit process.

Recommended annual nonpoint pollution loading factors for the urban land use categories in this plan (residential, commercial, and industrial) are based upon a detailed analysis of monitoring data collected under the EPA's NPDES Part 2 Stormwater Permit Application process between November 1990 and May 1993 in Florida. As part of the permit application process, representative stormwater outfalls were monitored in cities and counties throughout Florida with populations greater than 100,000. These "representative" outfalls typically discharged stormwater from tributary areas with predominantly residential, commercial, or industrial land uses. The outfalls were monitored and sampled during a minimum of three storm events. This analysis includes a total of 98 storm events that were monitored by certain cities and counties under the Florida stormwater NPDES permitting process. Previously, the EPA-sponsored Nationwide Urban Runoff Program (NURP) monitored stormwater pollution from urban areas in about 80 storm events in Tampa during 1978-1983.

Under the NPDES permitting process, flow-weighted composite samples were collected during storm events according to detailed sampling protocols prescribed by the EPA. Samples were analyzed for all of the pollutants targeted for the SMMP. Statistical analyses of available NPDES data were used to determine appropriate pollutant loading factors for watershed management applications.

Finally, related to EMCs for Monroe County, the land uses identified as Water/Wetland are often considered to be 100 percent impervious; that is, all of the rain that falls on water runs off on an annual basis. A more accurate practice is to take into account the infiltration and evapotranspiration in a water body that reduces the overall volume of water to be discharged. For the purposes of this assessment, it was assumed that 75 percent of the annual average rainfall was lost to evapotranspiration so that the imperviousness of the Water/Wetland land use was 25 percent. This value is consistent with wetland export coefficients measured in Central Florida. Also, it is normal practice consider that the runoff from the Water/Wetland land use to be entirely composed of the rainwater itself, so that the EMCs for this land use represent wetfall loadings. The EMCs for wetfall for this application were obtained from data collected during the NURP program and from wetfall sampling done for the Tampa Bay National Estuarine Program.

It should be noted that no such measurements are available from Monroe County. Monroe County was not part of the original NURP studies, nor was it subject to the NPDES Phase I program. As a result, there were not EMC data from Monroe County to use for this analysis. Therefore, it was necessary to use EMC data from other sources for the SMMP.

Based on these extensive data evaluations, **Table 2.3-1** presents the recommended EMCs and impervious percentages for Monroe County WMM. Listed with each pollutant group is the reference source for these recommended EMCs.

2.3.4 Rainfall

Rainfall data for the Florida Keys are considered in Section 2.1 (Existing Data Compilation). Twenty-one rainfall stations have been identified by the National Climatic Data Center (NCDC) with data collected since 1890. Of the three stations considered with long term data, the average annual rainfall for Key West and Marathon Shores was 39.7 inches and for Tavernier, 46.1 inches. The Comprehensive Plan estimates the annual rainfall to be 36 inches (Conservation and Coastal Management Element, page 3-1). For the purposes of this analysis, the weighted average of the NCDC data was used, resulting in an annual average rainfall of 42 inches.

Table 2.3-1
Monroe County Stormwater Management Master Plan - Nutrient Loading Estimates
Event Mean Concentrations (mg/l)

Land Use	DCIA(1)	BOD	COD	TSS	TDS	Source	TP	DP(2)	TKN	NO2+ NO3	Source	Pb	Cu	Zn	Cd	Source
Forest, Open, Park	1%	1	51	11	100	A,B	0.05	0.00	0.94	0.31	A	0.000	0.000	0.000	0.000	B
Agriculture, Golf Course	1%	4	51	55	100	A,B,E	0.34	0.23	1.74	0.58	E	0.000	0.000	0.000	0.000	B
Low Density Residential	10%	15	71	27	286	C	0.44	0.33	1.34	0.63	C	0.002	0.009	0.051	0.002	C
Medium Density Residential	30%	9	65	59	59	C,F	0.45	0.27	1.77	0.27	C	0.013	0.007	0.057	0.001	C
High Density Residential	50%	8	53	42	141	C	0.20	0.09	1.03	0.67	C	0.011	0.022	0.065	0.001	C
Commercial	90%	8	53	42	141	C	0.20	0.09	1.03	0.67	C	0.011	0.022	0.065	0.001	C
Industrial	70%	14	83	77	130	C	0.28	0.20	1.47	0.40	C	0.023	0.024	0.132	0.001	C
Urban Open	1%	1	51	11	100	A,B	0.05	0.00	0.94	0.31	A,D	0.000	0.000	0.000	0.000	A,D
Waterbodies & Watercourses	25%	4	6	6	12	D	0.08	0.04	0.79	0.59	D	0.011	0.007	0.030	0.001	D
FDOT Roadways	90%	11	99	121	189	C	0.40	0.15	1.51	0.34	C	0.039	0.022	0.189	0.002	C
County Roadways	90%	11	99	121	189	C	0.40	0.15	1.51	0.34	C	0.039	0.022	0.189	0.002	C
Public Facilities	90%	7	50	41	114	C	0.20	0.08	1.24	1.05	C	0.012	0.018	0.079	0.001	C

Notes:
(1) DCIA means Directly Connected Impervious Area, the portion of impervious area that directly connects to the stormwater management system.
(2) Ag/Golf Course DP estimated from TP as the DP/TP ratio of Forest, Open, Park.
Dissolved P concentration for Wetlands and Waterbodied/Watercoursed were estimated as 55 % of the Total P concentrations (Harper, 1992; Florida NPDES data 1992-1993).
(3) TKN and NO2+NO3 concentrations for non-urban land use categories were assumed to be 75 % and 25 % respectively of the TN concentrations (Florida NPDES data 1992-1993)
(4) Average values are derived from parametric statistics with a lognormal distribution. Concentrations reported below the detection limit were assumed to be 50 % of detection limit.

Sources:
A - "Estimation of Stormwater Loading Rate Parameters" Table 21. Harvey H. Harper, 1992.
B - Nationwide Urban Runoff Program (NURP), 1983.
C - NPDES Part II Stormwater Permit Applications for Sarasota County, Palm Beach County, Jacksonville, St. Petersburg, and Orlando. 1992-93.
D - Mean wetfall concentration - Tampa NURP Study.
E- Point and Nonpoint Source Loading Assessment. Phase II. Sarasota Bay National Estuary Program.
F- Unpublished CDM Data Compilation of 192 NPDES MS4 Permit Application Results (EMC used - Medium Density TDS only)

2.3.5 Baseflow Discharges

The CDM WMM allows for the consideration of baseflow. Baseflow is dry weather flow in a stream derived from shallow groundwater; in other words, it is flow in a stream that is independent of runoff. The purpose of the WMM application for the SMMP was to compare the stormwater loading to the wastewater loading and to identify high loading study areas for further consideration. Base flow was therefore not included in the calculations.

2.3.6 Point Source Discharges

Pollutant loadings from point source dischargers such as regional wastewater treatment facilities can be estimated to determine the relative contributions of point versus nonpoint pollution loadings. The draft Monroe County Sanitary Wastewater Management Plan (SWMP, March 2000) provided flow and nutrient data for comparison purposes. Rather than including point sources in WMM, the data from the draft SWMP were used directly and loading from the point sources and from WMM results are compared later in this section. **Table 2.3-2** summarizes data from the draft SWMP for most of the study areas considered for WMM.

2.3.7 Land Uses

For the land uses within Monroe County, a number of sources were used. Electronic data on existing and future land uses were obtained from a host of different agencies. Data was received from Monroe County, the South Florida Regional Planning Council (SFRPC), the Florida Keys National Marine Sanctuary, (FKNMS), the South Florida Water Management District (SFWMD), the City of Key Colony Beach (CKCB), the City of Key West (CKW), the City of Layton (CL), and the Florida Department of Community Affairs (FDCA). In order to maintain consistency with the Comprehensive plan, the majority of land use information utilized to calculate the land use areas by class was generated in digital format by Monroe County and manipulated using ArcView ™.

Using the Monroe County GIS land use data for both existing and future land use conditions, land use area calculations were performed for each study area. For each Monroe County land use category there is an associated area in acres for all the islands of interest (i.e., study area).

Prior to being able to calculate land use areas for use in WMM, it was necessary to reconcile the land use categories provided by Monroe County with the land use categories used in WMM. The following are the associations made between the default land use categories in WMM and the existing and future land use categories provided by Monroe County and used in the Comprehensive Plan:

Table 2.3-2
Monroe County Stormwater Management Master Plan
Summary of Wastewater Nutrient Loading (1)

Study Area	Name	Wastewater Study Areas (2)	Estimated Loading lb/d (3)		Estimated Sanitary Wastewater Flows (mgd)						
					On-Site Systems (4)					Treatment Plants	Total Sanitary
			Nitrogen	Phosphorus	ATU (5)	Septic	Sub-Std	Cesspool	Total		
Lower Keys											
1	Key West										
2	Stock Island	1	0.00	0.00	0.0012	0.1045	0.0044	0.0067	0.1168	0.3051	0.4219
3	Boca Chica Key	2	19.41	4.71	0.0044	0.2248	0.0105	0.0157	0.2554	0.1014	0.3568
4	Bay Point Key	3	10.93	2.66	0.0013	0.0322	0.0045	0.0067	0.0447	0.0041	0.0488
5	Lower Sugarloaf Key	4	12.99	3.24	0.0087	0.0957	0.0003	0.0005	0.1052	0.0140	0.1192
6	Upper Sugarloaf Key	5	4.74	1.16	0.0019	0.0298	0.0015	0.0022	0.0354	0.0279	0.0633
7	Cudjoe Key	6	16.60	4.10	0.0213	0.1042	0.0026	0.0039	0.1320	0.0500	0.1820
8	Summerland Key	7	11.23	2.79	0.0057	0.1056	0.0017	0.0025	0.1155	0.0020	0.1175
9	Ram Rod Key	9	9.78	2.43	0.0174	0.0455	0.0008	0.0013	0.0650	0.0020	0.0670
10	Torch Keys	8, 10	13.87	3.39	0.0027	0.0911	0.0045	0.0069	0.1052	0.0031	0.1083
11	Big Pine Key	11	54.63	13.22	0.0219	0.3042	0.0217	0.0325	0.3803	0.0550	0.4353
12	Bahia Honda	12	0.00	0.00	0.0000	0.0093	0.0000	0.0000	0.0093	0.0510	0.0603
Middle Keys											
13,14	Marathon (6)	13, 14	76.79	17.36	0.0073	0.5788	0.2093	0.3140	1.1094	0.5471	1.6565
15,16	Long Key / Layton	15	2.63	0.66	0.0002	0.0136	0.0004	0.0005	0.0147	0.0690	0.0837
17	Lower Matecumbe Key	16	14.81	3.65	0.0000	0.1471	0.0054	0.0082	0.1607	0.0170	0.1777
18,19	Islamorada, Upper Matecombe	17	1.78	0.43	0.0051	0.1829	0.0186	0.0278	0.2344	0.1280	0.3624
20	Windley Key	18	0.00	0.00	0.0000	0.0530	0.0037	0.0056	0.0623	0.0640	0.1263
Upper Keys											
21	Key Largo Lower	19 to 25	177.37	42.66	0.0106	1.5616	0.1165	0.1747	1.8634	0.5732	2.4366
22	Key Largo Upper	26, 27	7.17	14.37	0.0030	0.0561	0.0045	0.0067	0.0703	0.2521	0.3224
		Total	434.73	116.83	0.1127	3.7400	0.4109	0.6164	4.8800	2.2660	7.1460
		Total (lb/yr)	158,785	42,672							
		Total (mg/year)			41.2	1,366.0	150.1	225.1	1,782.4	827.7	2,610.1

Notes:
(1) From Technical Memorandum No. 4, for Monroe Co. Sanitary Wastewater Master Plan, Sept 1999, LBFH for CH2M Hill.
(2) From Appendix C, Exhibit C-1, Draft Monroe Co. Sanitary Wastewater Master Plan, March 2000, CH2M Hill.
(3) From Appendix B, Technical Memorandum No. 4, Sept 1999, LBFH for CH2M Hill.
(4) From Appendix C, Exhibit C-6, Draft Monroe Co. Sanitary Wastewater Master Plan, March 2000, CH2M Hill.
(5) ATU = Aerobic Treatment Unit.
(6) Marathon includes Key Colony Beach to compare to Sanitary Wastewater Master Plan.

Default Land Use Categories in WMM	Monroe County Existing Land Use Codes	Monroe County Future Land Use Codes
Forest/Open	Conservation, Vacant	Conservation
Urban Open	Recreation	Residential Conservation Recreation
Agricultural/Pasture	Agriculture	Agriculture
Low Density Residential	Single Family	Residential Low
Med. Density Residential	Multi-Family Mixed Residential	Residential Medium
High Density Residential	Multi-Family	Residential High
Commercial	General Commercial Commercial Fishing Tourist Commercial	Mixed Use / Commercial Mixed Use / Commercial Fishing
Industrial	Industrial	Industrial
Highways	Not included	Not included
Water/Wetlands	Not included	Not included

Highway, as a land use category, was not covered in the Monroe County GIS land use database. Additionally, in WMM the highway category was subdivided into two categories, state and county roads. The EMCs for the general highway category was applied to both the state and county road category. In order to calculate area of state roadway in each study area, roadway lengths were obtained from the FDOT GIS database. Monroe County databases were referenced to gain information on county roadways and roadway lengths and widths were compiled by Keith and Associates and presented to CDM in matrix form. Using standard roadway widths for state and county roads, area in acres by roadway type was calculated and incorporated into WMM as land use types. Also, highways were divided into FDOT and county so that the relative loadings could be separated.

Regarding the water/wetland land use category, acreage data by study area was obtained from GIS coverages provided to Keith & Associates from the Florida Marine Research Institute (FMRI). Wetland coverage information was subdivided into a broad range of types of wetland, however, for the purpose of running the WMM model, all wetland classes were summed into total wetland acreage by study area. Also, the water/wetland overage overlapped the County land use coverage (which did not have a separate water/wetland land use) so that for the final land use acreages, the overlap was subtracted from the County land uses.

Various land use types identified in the Monroe County GIS land use coverages for both existing and future conditions could not be directly associated to a specific WMM land use category. As a result, those areas not directly associated to a WMM category were classed as community facility land use type. The community facility land use category is comprised of several land use types as follows:

Default Land Use Categories in WMM	Monroe County Existing Land Use Codes	Monroe County Future Land Use Codes
Public Facility	Institutional Education Public Buildings Public Facilities Military Historical	Institutional Education Public Buildings Public Facilities Airport District Military

A new WMM land use category was created in order to evaluate the facility category and a set of EMCs assigned. The EMCs for institutional lands were used for public facility due to the similarity in land use type.

In some cases, while reviewing the GIS land use data for a particular area, a small percent of all study areas had land sections that had no land use code. Therefore, for each study area there is a land use category named “no code” which captures land sections not categorized in the database. These land uses were discussed with Monroe County staff and resolved prior to use in the WMM model.

Finally, after the land uses were determined from the GIS information and map data, tables of land use areas by land use types were created for existing and future land uses. Upon review of the preliminary tables, the total areas for the study areas for the existing land uses and the future land uses were not the same. For this reason, the future land use areas were prorated according to the existing total area defined by the GIS. In this way, the total area for each study area was the same in both the existing and future land use analyses. The resulting existing and future land use tables are provided in **Tables 2.3-3 and 2.3-4**, respectively.

There were a number of land uses identified as areas of potential stormwater pollution sources within the Florida Keys that require special consideration.

> *Marinas.* Marinas (a subset of commercial land use) are prevalent along the water bodies through the Keys. Activities within marinas may include boat repair, cleaning and storage, automobile parking, fish cleaning and processing, equipment storage and handling and fuel storage and handling. In some cases, discharge from these sites is directly to near shore waters without the benefit of any treatment such as oil/water separation or sediment control (settling). Unfortunately, although these land uses have been identified as a potential stormwater pollution source within the Florida Keys, no EMC database has been found to provide representative loading factors within Monroe County.

Table 2.3-3
Monroe County Stormwater Management Master Plan
Summary of Existing Land Use Acreage by Study Area

Study Area		Forest	Urban	Agric/	Residential					Water/	Roadways		Public	
No.	**Description**	**Open**	**Open**	**Pasture**	**Low**	**Med**	**High**	**Comm**	**Indust**	**Wetland**	**FDOT**	**County**	**Facility**	**Total**
Lower Keys														
1	Key West	7	39	0	809	851	257	528	0	464	36	36	563	3,589
2	Stock Island	146	0	0	235	80	7	159	32	291	48	57	338	1,392
3	Boca Chica Key	127	17	0	12	39	1	2	10	2,761	75	0	1,724	4,767
4	Bay Point Key	606		0	59	14	0	23	0	913	23	0	243	1,882
5	Lower Sugarloaf Key	1,576	0	0	19	0	0	5	0	2,368	89	117	1	4,175
6	Upper Sugarloaf Key	1,811	0	0	16	3	0	0	0	2,200	63	76	11	4,180
7	Cudjoe Key	1,847	2	0	25	2	0	2	2	4,477	58	141	26	6,583
8	Summerland Key	738	0	0	199	1	0	23	0	1,372	34	76	0	2,442
9	Ram Rod Key	708	0	5	151	0	0	28	0	541	0	61	2	1,496
10	Torch Keys	1,979	0	0	77	3	0	3	0	2,412	61	225	0	4,760
11	Big Pine Key	2,165	0	0	86	1	0	6	11	3,781	181	418	6	6,654
12	Bahia Honda	55	399	0	0	0	0	36	0	407	34	0	0	932
Middle Keys														
13	Marathon - Incorp	2,634	123	33	1,309	306	121	547	48	2,165	262	0	486	8,035
14	Key Colony Beach	175	0	0	298	0	26	11	5	0	18	1	0	533
15	Long Key	166	750	0	71	0	5	77	0	825	42	0	34	1,969
16	Layton	69	0	0	54	0	0	0	0	47	7	0	0	178
Islamorada														
17	Lower Matecumbe Key	405	6	0	254	19	45	183	1	335	38	48	15	1,350
18	Upper Matecumbe Key	2,134	44	0	1,709	109	192	648	1	2,336	184	277	100	7,734
19	Windley Key	341	0	0	5	15	1	73	0	374	15	0	0	824
20	Plantation Key	634	6	0	276	51	80	159	0	596	30	71	84	1,987
Upper Keys														
21,22	Key Largo	14,727	330	3	2,094	685	210	517	69	2,125	340	818	13	21,931
	Totals	33,051	1,717	41	7,758	2,180	945	3,028	178	30,790	1,637	2,421	3,646	87,390

Note: Data based upon a summary of GIS information provided by Monroe County.

Table 2.3-4
Monroe County Stormwater Management Master Plan
Summary of Future Land Use Acreage by Study Area (1)

Study Area		Forest	Urban	Agric/	Residential					Wet-	Roadways		Public	
No.	Description	Open	Open	Pasture	Low	Med	High	Comm	Indust	Land	FDOT	County	Facility	Total
Lower Keys														
1	Key West	7	39	0	815	857	259	531	0	468	36	36	540	3,589
2	Stock Island	0	106	0	22	195	135	307	80	370	61	72	43	1,392
3	Boca Chica Key	34	267	0	52	3	13	41	9	2,585	70	0	1,691	4,767
4	Bay Point Key	230	343	0	0	61	14	31	0	897	23	0	285	1,883
5	Lower Sugarloaf Key	1,292	1,098	0	99	27	0	28	0	1,494	56	74	6	4,175
6	Upper Sugarloaf Key	810	926	0	87	4	4	3	0	2,206	63	76	1	4,180
7	Cudjoe Key	1,277	555	0	72	29	5	18	15	4,367	57	137	50	6,583
8	Summerland Key	103	875	10	96	173	5	35	1	1,048	26	58	11	2,442
9	Ram Rod Key	0	529	3	159	200	0	27	0	518	0	58	2	1,496
10	Torch Keys	1,137	691	0	226	48	2	3	0	2,372	60	221	0	4,760
11	Big Pine Key	1,753	944	0	254	58	0	28	1	3,116	149	344	7	6,654
12	Bahia Honda	23	0	0	0	0	0	69	0	775	64	0	0	932
Middle Keys														
13	Marathon - Incorp	557	1,499	9	618	1,140	301	879	27	2,197	266	0	541	8,035
14	Key Colony Beach	0	51	0	192	63	64	35	0	97	30	1	0	533
15	Long Key	0	916	0	15	6	46	51	0	851	43	0	40	1,969
16	Layton	0	88	0	0	0	0	3	0	74	11	0	1	178
Islamorada														
17	Lower Matecumbe Key	14	235	0	151	470	0	41	0	332	55	39	12	1,350
18	Upper Matecumbe Key	64	1,653	0	942	1,478	152	311	0	2,511	197	297	129	7,734
19	Windley Key	25	277	0	37	8	5	82	0	375	15	0	0	824
20	Plantation Key	20	13	0	332	618	82	250	0	519	26	64	64	1,987
Upper Keys														
21,22	Key Largo	10,821	4,103	3	782	1,352	775	702	0	2,131	360	801	100	21,930
	Totals	18,166	15,209	26	4,952	6,791	1,863	3,476	133	29,303	1,669	2,278	3,525	87,390

Note: Original data based upon a summary of GIS information provided by Monroe County. Values prorated so that sum equal to the total area for each study area.

Equipment Storage. Likewise, numerous areas within the Keys are used for temporary storage of crab and lobster traps, and other such equipment. In some areas, the equipment is stored along road shoulders (generally near bridges) or within marinas. While these areas may contribute to the organic pollutant discharges within runoff, no EMC data are available.

Roads and Highways. As noted previously, the major stormwater management systems within the Florida Keys are associated with roads and highways. For this reason, state highways and county roads were specifically identified as land uses for the Monroe County WMM. EMC data for roads and highways are available and used for this application. The same EMCs were used for both state highways (US 1) and county roads; however, different BMPs will be applied as appropriate.

Thus, only one of the three special land uses had available EMCs for the WMM application in Monroe County (highways). The EMCs for the other two, marinas and equipment storage, can be measured by additional sampling during the implementation phase of the SMMP and if necessary, the WMM results can be refined.

2.3.8 Existing Best Management Practices

Finally, as discussed in more detail in Subsection 2.6, Stormwater Management Systems (Structural and Non-structural), the application of best management practices reduces the pollutants contained in runoff prior to discharge to near shore waters. Subsection 2.4, Existing System Inventory and Assessment, identifies that there are many stormwater systems in the Keys already. In particular, of the 254 structures inventoried, 167 were associated with water quality improvements, and of the 167 structures, the majority contained swales (122, or 73 percent). As part of the loading analysis, the potential benefits provided by existing stormwater management practices are included as part of this subsection.

Within the Florida Keys, the water management districts require permits for the alteration of natural drainage, known as Environmental Resource Permits (ERP). Among other activities, the ERP process regulates developments greater than 10 acres or 1 acre or more of construction by requiring BMPs to be constructed. In order to determine the percent of the studies areas that were benefited by existing BMPs, ERP permits issued in Monroe County were obtained from the South Florida Water Management District (WMD) as a GIS coverage. This coverage was overlaid on a base map, and the location and acreage for each permit (BMP) were assigned to one of the 22 study areas previously defined. The GIS coverage included the type of land use and area served by the BMP but did not include the type of BMP.

A total of 56 projects encompassing 1,951 acres were assigned as shown in **Table 2.3-5**. The WMD coverage included the land use served, but not the type of BMP

Table 2.3 - 5
Monroe County Stormwater Management Master Plan
Summary of Best Management Practices Using in WMM Simulations

Study Area	Acres	WMD LU Code	Initial WMM Assignment	WMD BMP Coverage	Final WMM Assignment	Existing LU WMM Acres	Existing LU % Existing Covered	
1	17.8	Airport Related Facility	Public Facility					
1	1.5	Airport Related Facility	Public Facility					
1	13.8	Institutional	Public Facility					
1	3.3	Institutional	Public Facility					
1	24.6	Institutional	Public Facility	61.0	Public Facility	563.0	10.8%	
1	3.4	Commercial	Commercial					
1	7.0	Commercial	Commercial					
1	7.7	Commercial	Commercial	18.1	Commercial	528.0	3.4%	
1	6.2	Residential	Medium Density Residential					
1	0.7	Residential	Medium Density Residential					
1	4.5	Residential	Medium Density Residential					
1	3.1	Residential	Medium Density Residential					
1	16.0	Residential	Medium Density Residential					
1	4.1	Residential	Medium Density Residential					
1	8.1	Residential	Medium Density Residential	42.7	Medium Density Resid.	851.0	5.0%	
2	26.1	Industrial	Industrial	26.1	Industrial	32.0	81.6%	
2	38.4	Recreational	Forest, Open, Park	38.4	Forest, Open, Park	146.0	26.3%	
2	22.0	Residential	Medium Density Residential	22.0	Medium Density Resid.	80.0	27.5%	
3	55.3	Residential	Medium Density Residential	55.3	Medium Density Resid.	233.0	23.7%	
6	10.3	Institutional	Public Facility	10.3	Public Facility	30.0	34.3%	
7	21.8	Highway	FDOT Roadways	21.8	FDOT Roadways	58.0	37.6%	
7	6.3	Residential	Medium Density Residential	6.3	Medium Density Resid.	71.0	8.9%	
8	8.9	Recreational	Forest, Open, Park	8.9	Forest, Open, Park	738.0	1.2%	
9	1.4	Highway	FDOT Roadways	1.4	Public Roads	61.0	2.3%	
11	288.7	Government	Public Facility	288.7	Public Facility	79.0	100.0%	[1]
12	2.2	Highway	FDOT Roadways					
12	2.6	Highway	FDOT Roadways	4.8	FDOT Roadways	34.0	14.1%	
13	62.0	Commercial	Commercial					
13	94.9	Commercial	Commercial					
13	10.4	Commercial	Commercial	167.3	Commercial	547.0	30.6%	
13	0.7	Highway	FDOT Roadways	0.7	FDOT Roadways	261.0	0.3%	
13	2.8	Industrial	Industrial	2.8	Industrial	48.0	5.8%	
13	16.4	Institutional	Public Facility					
13	0.8	Public	Public Facilities	17.2	Public Facilities	486.0	3.5%	[2]
13	23.6	Recreational	Forest, Open, Park	23.6	Forest, Open, Park	2,634.0	0.9%	
14	259.7	Residential	High Density	122.0	High Density	122.0	100.0%	
14		Residential	Medium Density	137.7	Medium Density	306.0	45.0%	
16	26.2	Industrial	Industrial	26.2	(Not Assigned)	0.0		[2]
17	18.0	Highway	FDOT Roadways	18.0	FDOT Roadways	38.0	47.4%	
17	5.9	Recreational	Forest, Open, Park	5.9	Forest, Open, Park	405.0	1.5%	
19	37.5	Institutional	Public Facility	37.5				
19	25.8	Commercial	Commercial	25.8	Commercial	183.0	14.1%	
19	18.6	Recreational	Forest, Open, Park					
19	2.2	Recreational	Forest, Open, Park	20.8	Forest, Open, Park	405.0	5.1%	
21	0.4	Commercial	Commercial	0.4	Commercial	675.0	0.1%	
22	78.0	Highway	FDOT Roadways					
22	126.0	Highway	FDOT Roadways	204.0	FDOT Roadways	370.0	55.1%	
22	0.7	Recreational	Forest, Open, Park					
22	4.1	Recreational	Forest, Open, Park					
22	39.9	Recreational	Forest, Open, Park	44.7	Forest, Open, Park	15,362.0	0.3%	
21	21.2	Institutional	Public Facility					
22	1.8	Office	Public Facility					
22	76.0	Government	Public Facilities	99.0	Public Facilities	99.0	100.0%	
21	20.7	Industrial	Industrial					
22	15.3	Industrial	Industrial	36.0	Industrial	69.0	52.2%	
22	102.7	Residential	Medium Density Residential					
22	253.0	Residential	Medium Density Residential	355.7	Medium Density Resid.	737.0	48.3%	

Notes: [1] Incomplete information; assigned 100%
[2] Not assigned as land use not identified.

constructed. Field notes compiled by Keith & Associates as part of the existing system inventory (Technical Memorandum 2) indicated that swale treatment is the predominant form of BMP, followed by exfiltration. For purposes of the present evaluation, swale treatment was assumed for all of the SFWMD permits.

It should be noted that for a more accurate evaluation of the benefits of existing BMPs, permit information should contain the following additional information: land use served, tributary area, and type of stormwater BMP. Until such information is available, loading estimates will be based upon BMP assumptions. Also, a significant number of drainage wells are located within the Florida Keys. Information regarding area drained will also improve the estimate of pollutant loading.

Based upon the information available, **Table 2.3-6** summarizes land uses covered by the BMPs identified by study area. For example, Table 2.3-6 indicates that for Boca Chica Key, 23.7 percent of the medium density residential land use acreage drains to a BMP (swale).

2.3.9 Pollutant Loading Results

Using the data defined in preceding subsections, WMM was used to simulate the annual average runoff pollutant loading for each of the study areas. In order to assess the model runs, the results are discussed by considering existing land uses, future land uses and finally, differences in runoff and loading between existing and future land use conditions. For existing conditions, detail is provided regarding sources of loading, separating out natural from urban loading. The type and magnitude of loading are similar for future loading and therefore are not repeated.

2.3.9.1 Existing Land Use Conditions

Table 2.3-7 shows the total and impervious areas for each study area along with the impervious percentage and estimated annual average runoff for the current land use conditions. **Figure 2.3-1** illustrates the differences in the total and impervious areas for the study areas. Key Largo has the largest total and impervious areas and Layton with the smallest total area. On the other hand, the largest percent impervious is Stock Island, followed by Key West and Boca Chica Key, all of which exhibit greater than 40 percent imperviousness. All other study areas have less than 30 percent imperviousness.

Table 2.3-7 also shows the estimated total stormwater runoff for the study areas, including all land uses. The largest runoff is from Key Largo, as expected because of the large total area and imperviousness. The second largest runoff amount is Incorporated Marathon, followed by Upper Matecumbe Key in Islamorada. **Figure 2.3-2** shows a summary of the sources of runoff for all of the study areas combined.

Table 2.3-6
Monroe County Stormwater Management Master Plan
Summary of BMP Coverages by Land Use - Swales Only [1]

Study Area No.	Study Area Description	Forest Open	Urban Open	Agric/ Pasture	Residential Low	Residential Med	Residential High	Comm	Indust	Water/ Wetland	Roadways FDOT	Roadways County	Public Facility
Lower Keys													
1	Key West					5.0%		3.4%					10.8%
2	Stock Island		26.3%			27.5%			81.6%				
3	Boca Chica Key					23.7%							
4	Bay Point Key												
5	Lower Sugarloaf Key												
6	Upper Sugarloaf Key												34.3%
7	Cudjoe Key					8.9%					37.6%		
8	Summerland Key		1.2%										
9	Ram Rod Key											2.3%	
10	Torch Keys												
11	Big Pine Key												100.0%
12	Bahia Honda										14.1%		
Middle Keys													
13	Marathon - Incorp		0.9%			45.0%	100.0%	30.6%	5.8%				3.5%
14	Key Colony Beach												
15	Long Key												
16	Layton												
17	Lower Matecumbe Key		1.5%								47.1%		
18	Islamorada												
19	Upper Matecumbe Key		5.1%					14.1%					
20	Windley Key												
Upper Keys													
21,22	Key Largo		30.0%			48.3%		0.1%	52.2%		55.1%		100.0%

Summary of BMP Efficiency by Parameter

Parameter:	BOD	COD	TDS	TSS	TKN	NO2+3	DP	TP	Cd	Cu	Pb	Zn
Efficiency	30%	30%	10%	80%	40%	40%	10%	40%	65%	50%	75%	50%

Note: (1) Percentages represent the percent of the land use acreage that drains to the BMP.

Table 2.3-7
Monroe County Stormwater Management Master Plan (SMMP)
Summary of Study Area Information
Existing Land Use Conditions

Study Area	Name	Total Area (ac)	DCIA (acres)	Percent DCIA	Total Runoff (ac-ft/yr)	Total Runoff (mgd)
Lower Keys						
1	Key West	3,589	1,514	42.2%	5,762	5.14
2	Stock Island	1,392	621	44.6%	2,334	2.08
3	Boca Chica Key	4,767	1,987	41.7%	7,581	6.76
4	Bay Point	1,882	453	24.1%	2,005	1.79
5	Lower Sugarloaf	4,175	792	19.0%	3,818	3.41
6	Upper Sugarloaf	4,180	695	16.6%	3,530	3.15
7	Cudjoe Key	6,583	1,332	20.2%	6,267	5.59
8	Summerland Key	2,442	486	19.9%	2,300	2.05
9	Ram Rod Key	1,496	235	15.7%	1,223	1.09
10	Torch Keys	4,760	881	18.5%	4,287	3.82
11	Big Pine Key	6,654	1,521	22.9%	6,853	6.11
12	Bahia Honda	932	167	18.0%	824	0.73
Middle Keys						
13	Incorp Marathon	8,035	1,940	24.1%	8,584	7.66
14	Key Colony Beach	533	74	13.8%	406	0.36
15	Long Key	1,969	350	17.8%	1,732	1.54
16	Layton	178	24	13.6%	134	0.12
Islamorada						
17	Lower Matecumbe Key	1,350	393	29.1%	1,641	1.46
18	Upper Matecumbe Key	7,734	1,963	25.4%	8,546	7.62
19	Windley Key	824	180	21.9%	824	0.74
20	Plantation Key	1,987	527	26.5%	2,264	2.02
Upper Keys						
21,22	Key Largo	21,931	2,691	12.3%	15,683	13.99
	Total or Average	87,390	18,827	21.5%	86,597	77.25

Figure 2.3-1

Monroe County Stormwater Management Master Plan

Comparison of Total and Impervious Areas for Study Areas - Sorted by Largest Total Areas

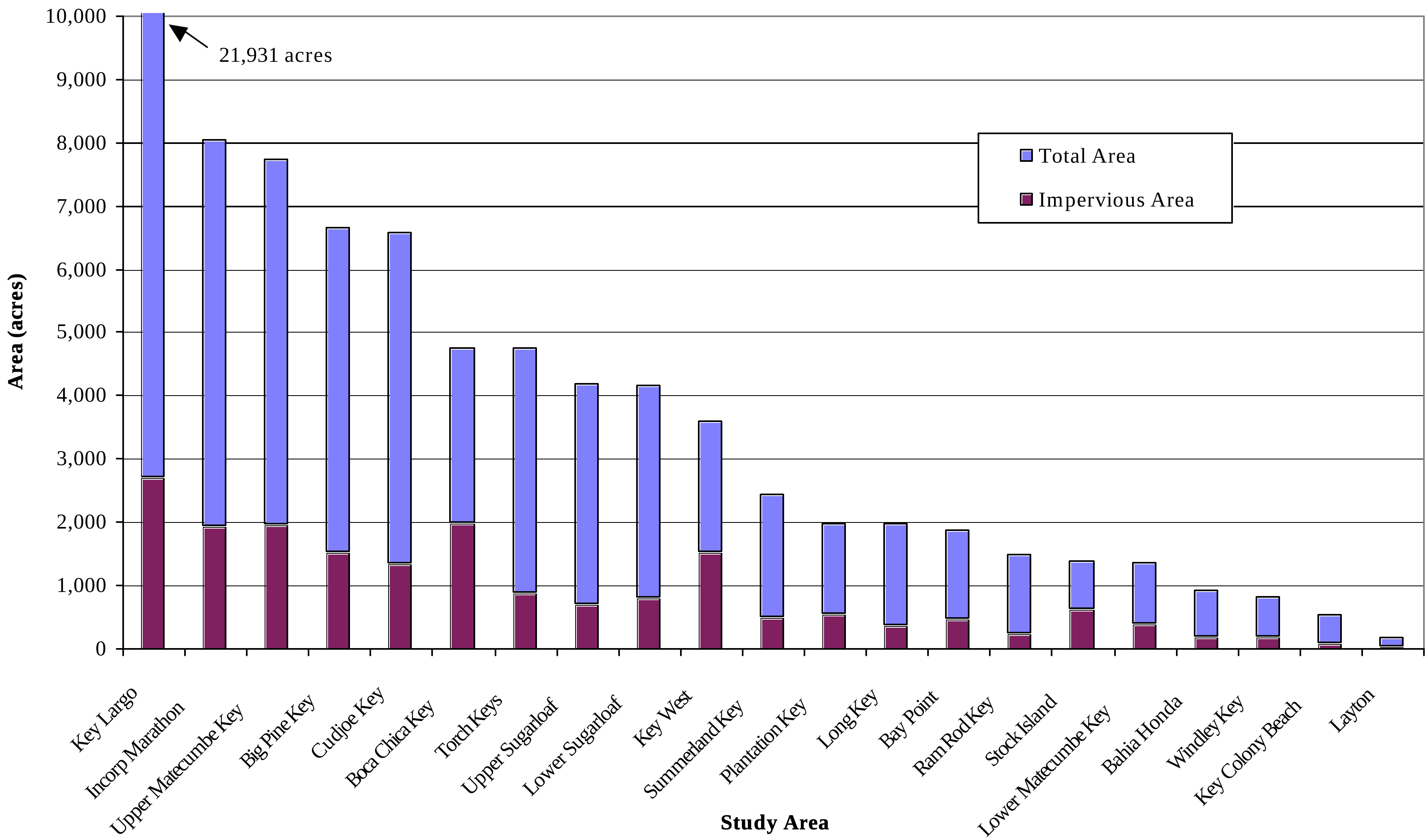
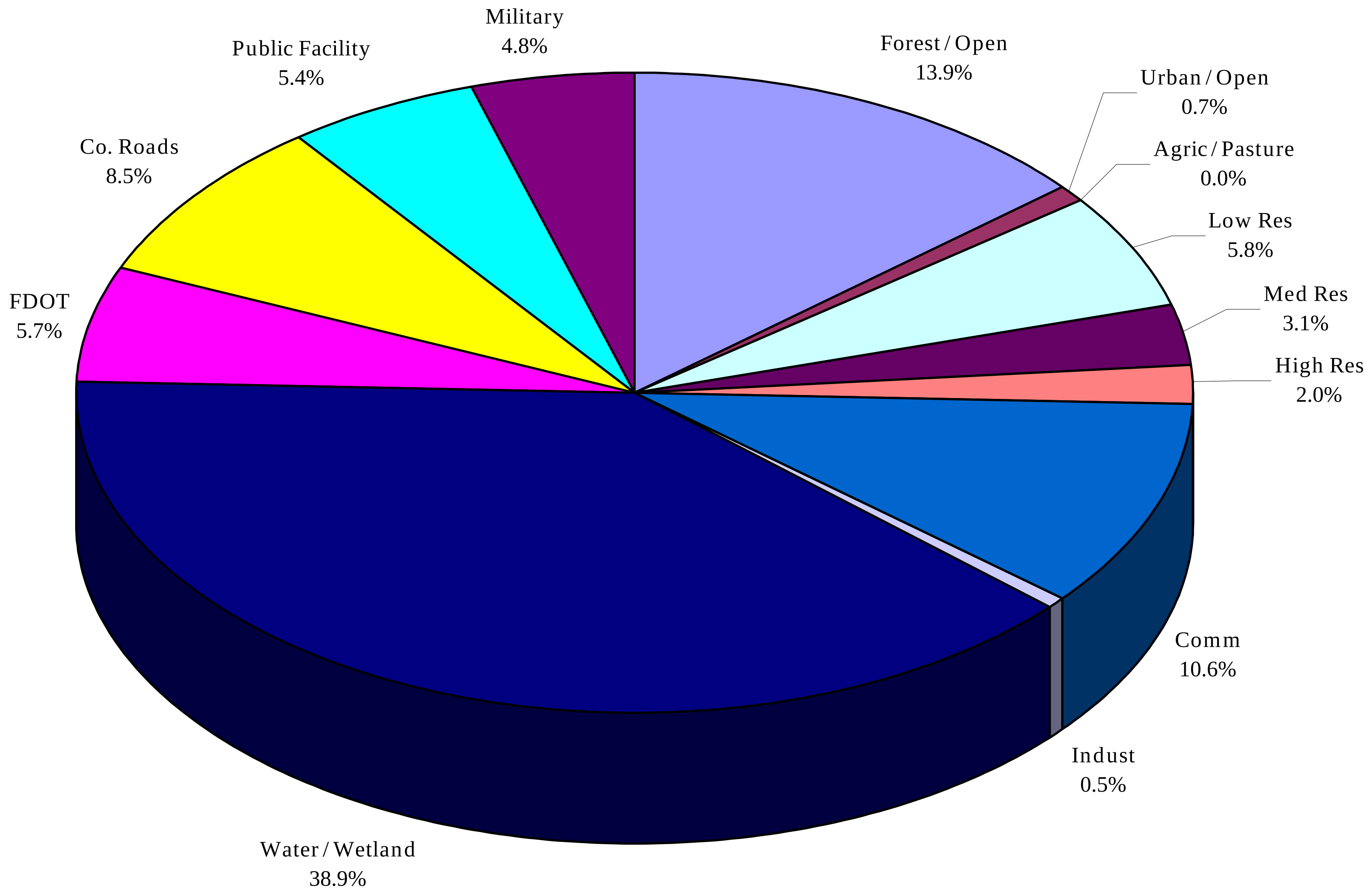


Figure 2.3 - 2
Monroe County Stormwater Management Master Plan
Summary of Sources of Runoff For All Study Areas



For this figure, the runoff from the Naval Air Station at Boca Chica Key was isolated from the Public Facilities land use. The figure shows that almost 40 percent of the runoff is derived from water and wetland land use (i.e., wetfall) with the next largest percentage being forest/open land uses at 14 percent. This means that over 50 percent of the runoff is derived from natural (undeveloped) sources.

Table 2.3-8 provides a summary of the pollutant loading estimates for the study areas for each of the 12 parameters categorized as oxygen demanding, sediment, nitrogen, phosphorus and metals. **Figures 2.3-3 through 2.3-14** illustrate the WMM loading results for all parameters and all islands. It should be noted that these loading results represent the total amount of pollutants carried by runoff including natural background, rainfall, wetland and urban sources. In this case the total loading mimics to a large degree the total land area of the study area and to a lesser degree the total imperviousness.

Table 2.3-9 provides a summary of the percent reduction in pollutant concentrations based upon the existing BMPs included as part of the WMM model. As noted previously, only limited data were available for BMPs; in fact, only data related to swales were sufficient enough to include in WMM. The inventory of existing stormwater systems indicates that there are a number of stormwater wells within the Florida Keys that would represent BMPs with a high percent efficiency to reduce pollutants. However, insufficient data are available to include the wells in the model. It is for this reason that Table 2.3-9 indicates such small pollutant removals.

Future Land Use Conditions. **Table 2.3-10** shows the total and impervious areas for each study area along with the impervious percentage and estimated annual average runoff for the future, built-out land use conditions. While the results are similar to the existing land use condition, there are some significant differences noted below.

Table 2.3-11 documents the differences between the existing and future land use conditions for impervious area, percent imperviousness and total runoff. Six of the 22 study areas show a decrease in impervious area, although one of them is insignificant (Key West with -0.2%). The largest decrease in impervious area will be Lower Sugarloaf with almost a 6 percent decease in imperviousness. Related to total runoff, reduction in imperviousness translates into reduced runoff volumes. For Lower Sugarloaf, the decrease in imperviousness will result in almost a 20 percent drop in runoff. Unfortunately, the rest of the study areas will exhibit an increase in impervious area, imperviousness and runoff. The highest increase is predicted to be Key Colony Beach, assuming no additional BMPs are implemented. **Figure 2.3-15** illustrates the changes in imperviousness and **Figure 2.3-16** shows the resulting changes in runoff volume.

Table 2.3-8

Monroe County Stormwater Management Master Plan

Summary of Pollutant Loading for Each Study Area (pounds per year)

Study Area		Oxygen Demand		Solids		Nitrogen		Phosphorus		Metals			
No.	**Description**	**BOD**	**COD**	**TDS**	**TSS**	**TKN**	**NO2+3**	**DP**	**TP**	**Cd**	**Cu**	**Pb**	**Zn**
Lower Keys													
1	Key West	128,817	830,517	1,920,355	652,738	19,076	10,157	2,186	4,071	17.2	532.7	178.9	1,025.2
2	Stock Island	50,147	339,592	791,257	288,418	7,466	4,480	710	1,467	7.3	151.4	90.2	503.6
3	Boca Chica Key	122,088	703,715	1,554,416	605,789	22,049	17,158	1,390	3,277	21.1	288.3	254.4	1,281.5
4	Bay Point Key	28,300	166,686	371,098	125,331	5,410	3,745	330	750	5.1	69.0	59.5	264.6
5	Lower Sugarloaf Key	49,260	294,707	577,386	267,502	9,688	5,271	551	1,344	10.5	90.6	144.2	536.6
6	Upper Sugarloaf Key	41,555	250,318	491,629	201,183	8,724	4,896	451	1,101	9.0	75.3	117.5	419.6
7	Cudjoe Key	74,772	344,495	686,475	291,253	14,931	9,187	810	1,847	16.7	135.5	207.8	711.2
8	Summerland Key	33,744	186,067	419,313	159,162	5,940	3,287	431	916	6.8	84.2	82.9	323.1
9	Ram Rod Key	18,550	126,703	294,498	94,543	3,298	1,673	250	530	3.4	51.4	40.1	171.4
10	Torch Keys	58,815	387,341	768,975	354,236	11,287	5,745	689	1,681	12.2	115.3	171.2	668.4
11	Big Pine Key	105,215	685,812	1,344,961	699,721	18,737	9,157	1,261	3,081	21.5	204.1	318.6	1,291.1
12	Bahia Honda	10,628	72,529	153,748	54,700	2,086	1,145	117	284	2.0	20.8	26.3	104.7
Middle Keys													
13	Marathon - Incorp	157,684	1,039,007	2,577,275	731,743	24,389	13,424	2,377	4,504	23.4	510.9	252.7	1,321.3
14	Key Colony Beach	11,939	75,709	231,693	46,540	1,372	596	222	354	1.6	56.2	10.3	74.6
15	Long Key	23,182	149,824	338,984	106,206	4,430	2,598	268	610	4.3	54.5	50.5	204.9
16	Layton	2,718	17,015	47,050	11,396	394	186	46	80	0.5	10.9	4.1	20.4
Islamorada													
17	Lower Matecumbe Key	33,613	225,706	571,746	175,031	4,780	2,500	474	954	5.0	105.8	56.4	297.5
18	Upper Matecumbe Key	173,395	1,120,102	2,851,339	893,879	24,933	12,766	2,554	5,003	27.4	571.0	306.2	1,537.3
19	Windley Key	11,588	72,237	161,428	54,126	2,110	1,229	134	303	2.0	28.2	24.4	99.6
20	Plantation Key	41,380	274,960	684,893	200,436	6,235	3,342	591	1,168	6.2	124.6	70.7	362.1
Upper Keys													
21,22	Key Largo	261,348	2,403,131	5,339,186	1,633,188	46,772	17,958	4,042	8,453	38.0	817.3	487.8	2,526.7
	Totals	1,438,738	9,766,170	22,177,705	7,647,119	244,106	130,500	19,885	41,780	241.1	4,097.8	2,954.7	13,745.3

Figure 2.3-3
Monroe County Stormwater Management Master Plan
Summary of Existing BOD Loadings from Each Study Area

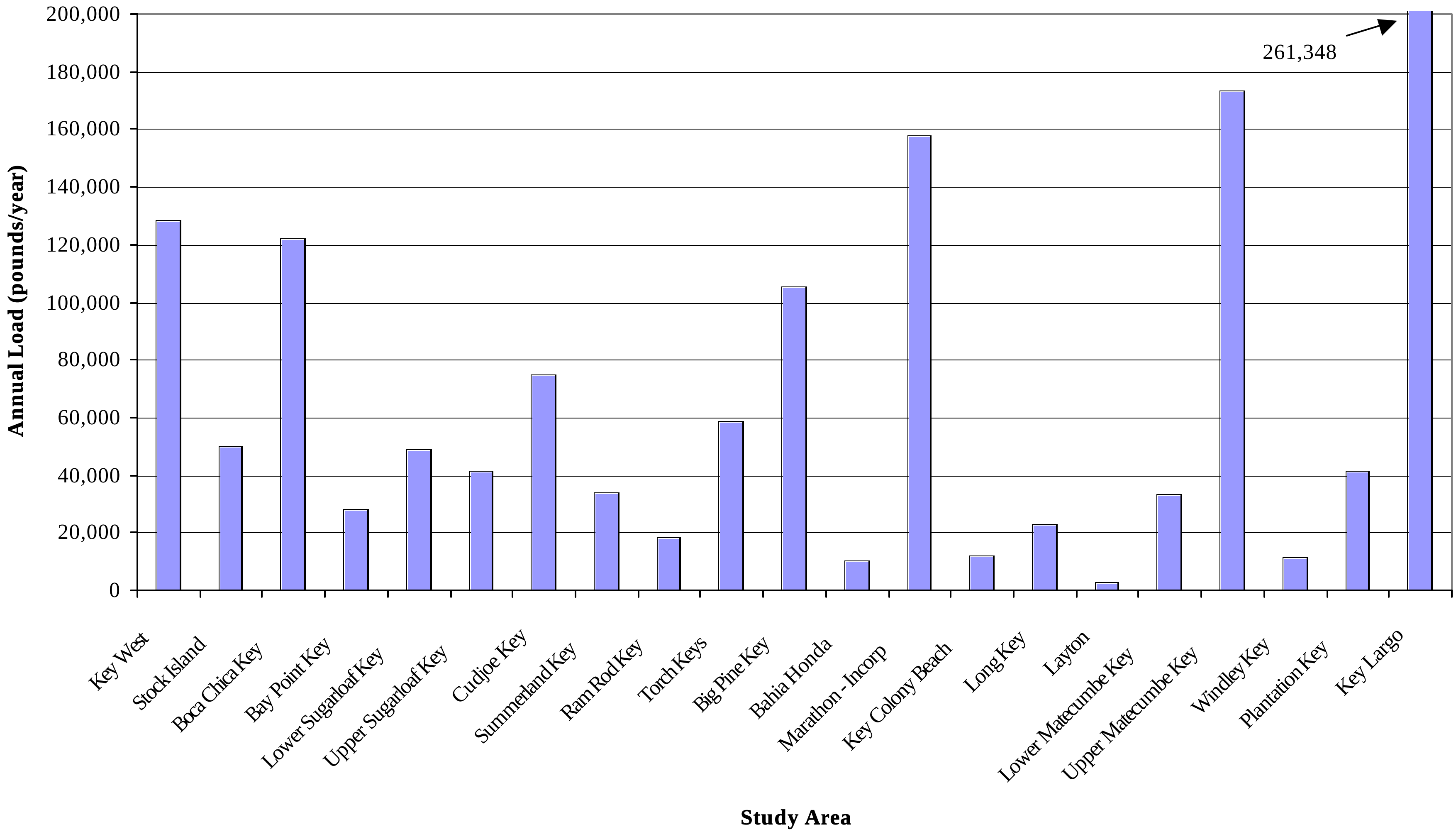


Figure 2.3-4
Monroe County Stormwater Management Master Plan
Summary of Existing COD Loadings from Each Study Area

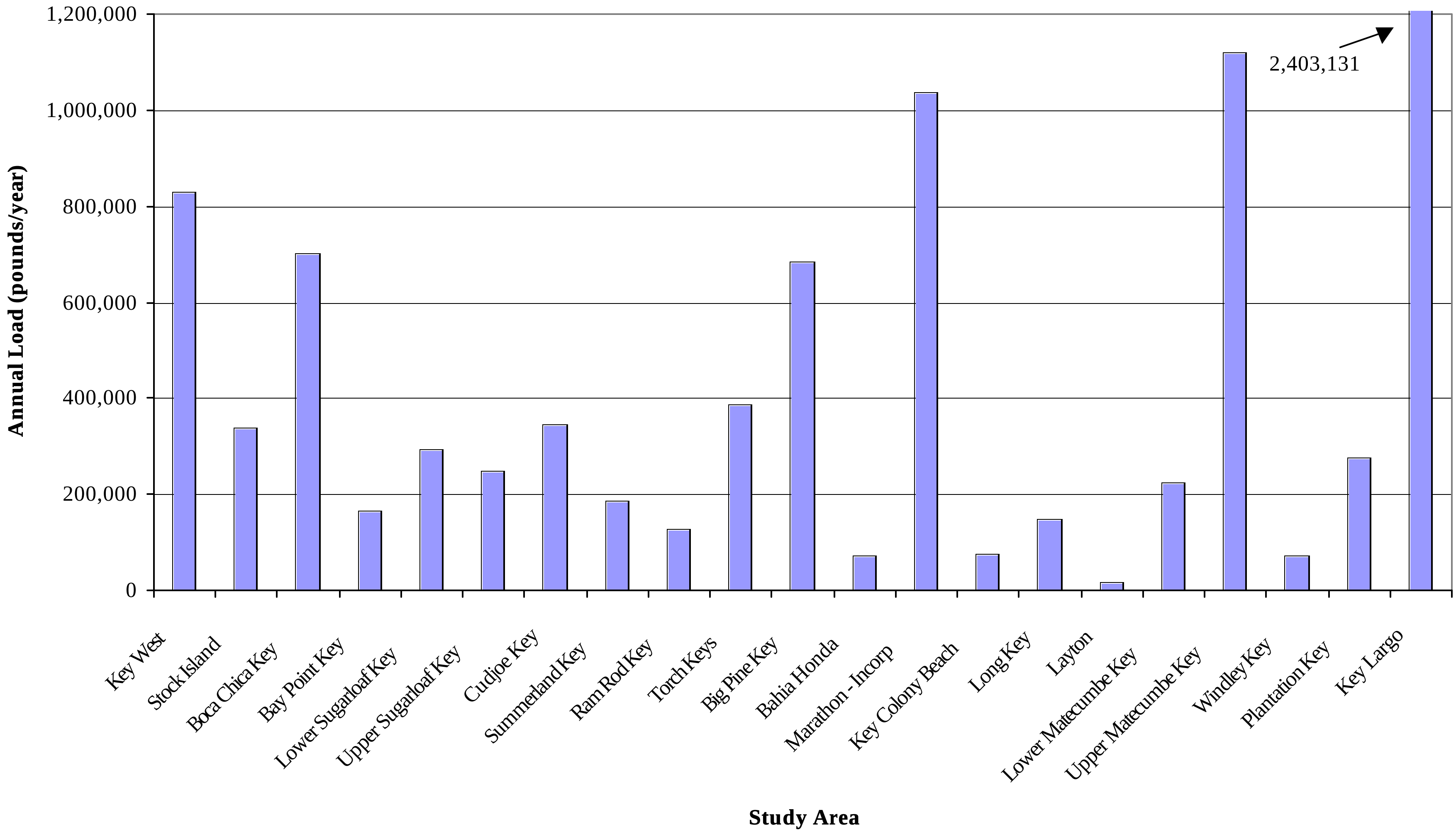
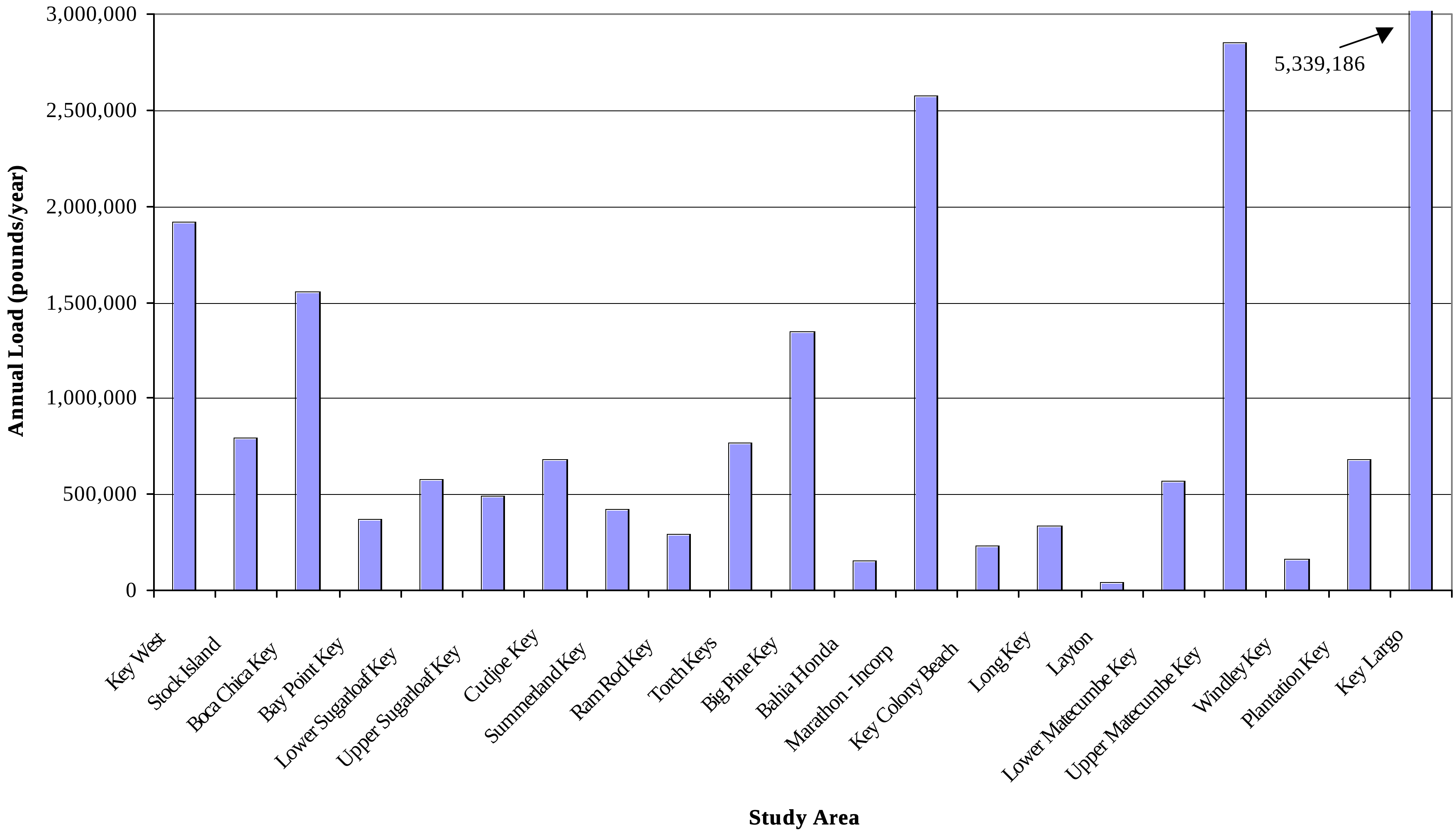
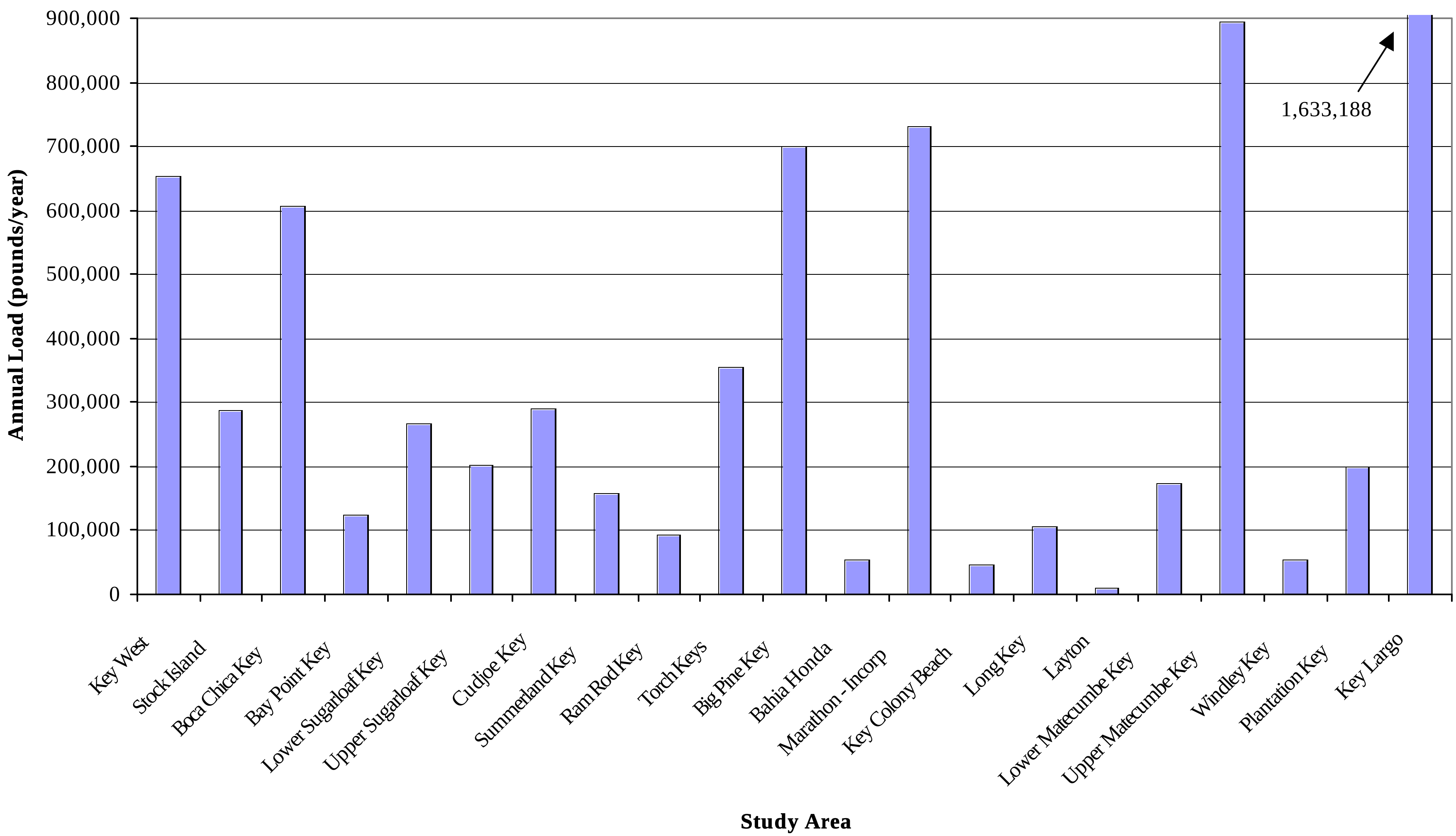


Figure 2.3-5
Monroe County Stormwater Management Master Plan
Summary of Existing TDS Loadings from Each Study Area



CDM Camp Dresser & McKee Inc.
S:\Monroe\Subsection 2.3\Table 2-8 - Existing Loading

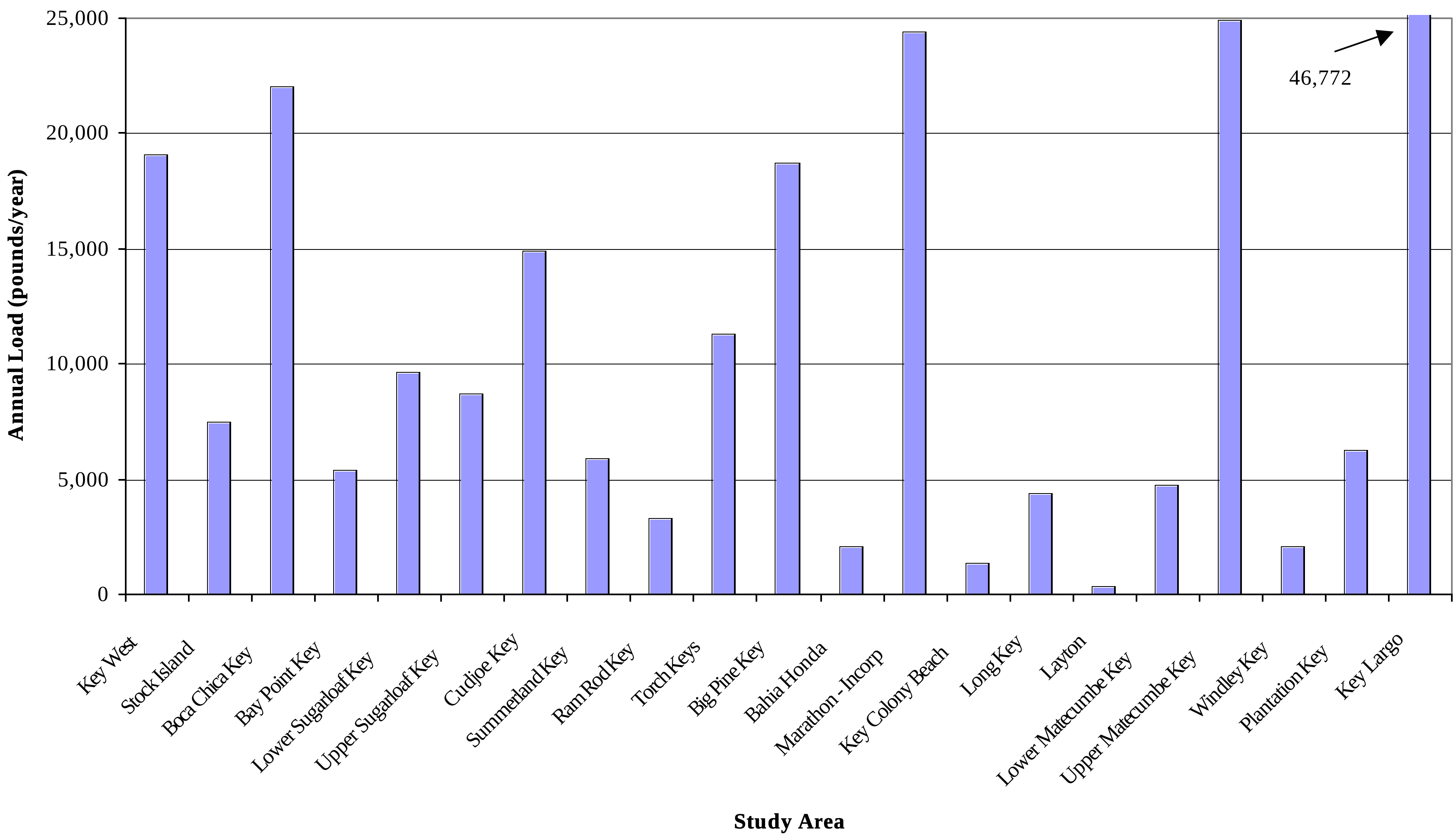
Figure 2.3-6
Monroe County Stormwater Management Master Plan
Summary of Existing TSS Loadings from Each Study Area



CDM Camp Dresser & McKee Inc.

S:\Monroe\Subsection 2.3\Table 2-8 - Existing Loading

Figure 2.3-7
Monroe County Stormwater Management Master Plan
Summary of Existing TKN Loadings from Each Study Area



CDM Camp Dresser & McKee Inc.
S:\Monroe\Subsection 2.3\Table 2-8 - Existing Loading

Figure 2.3-8
Monroe County Stormwater Management Master Plan
Summary of Existing Nitrate + Nitrite Nitrogen Loadings from Each Study Area

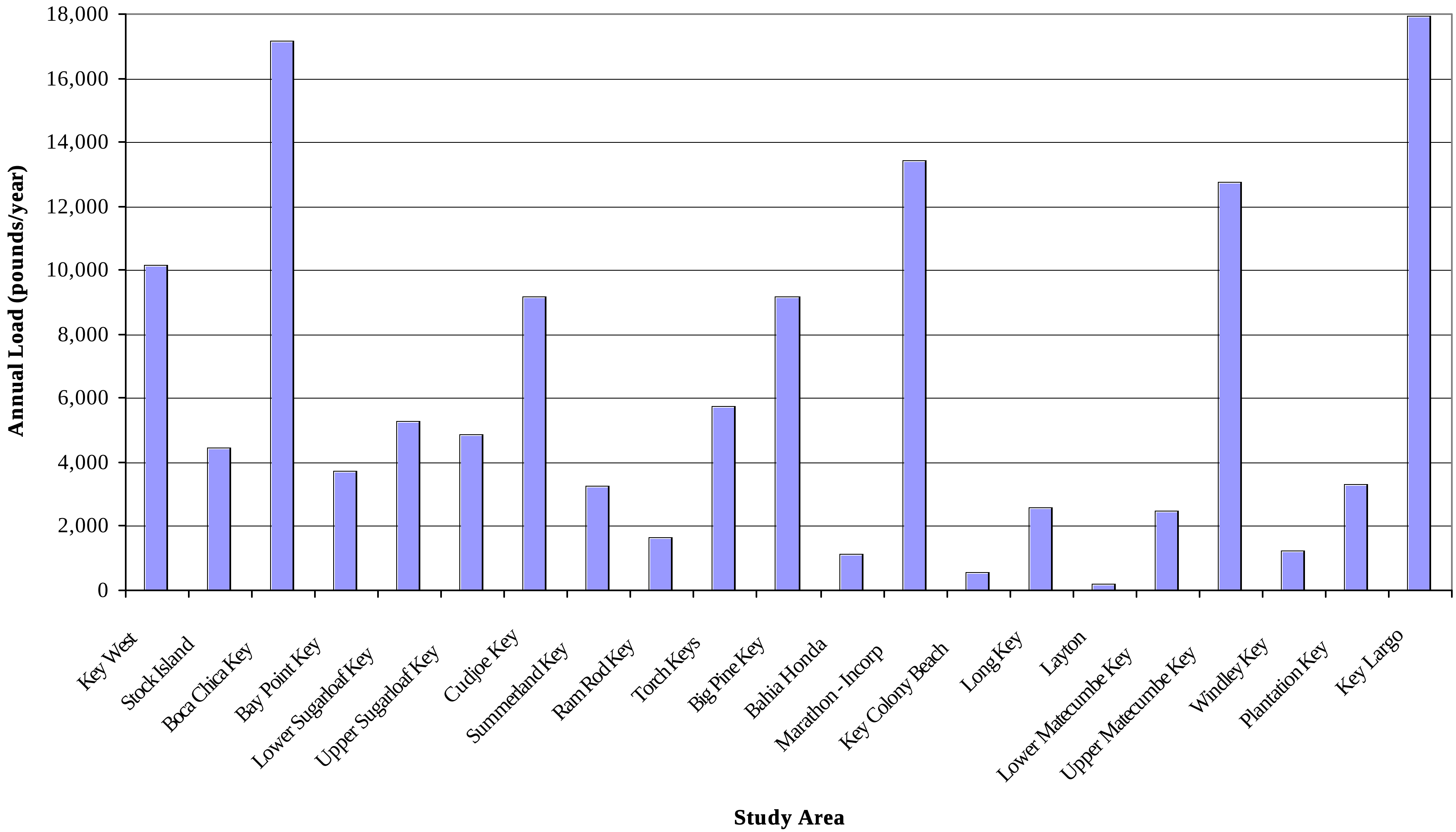


Figure 2.3-9
Monroe County Stormwater Management Master Plan
Summary of Existing Dissolved Phosphorus Loadings from Each Study Area

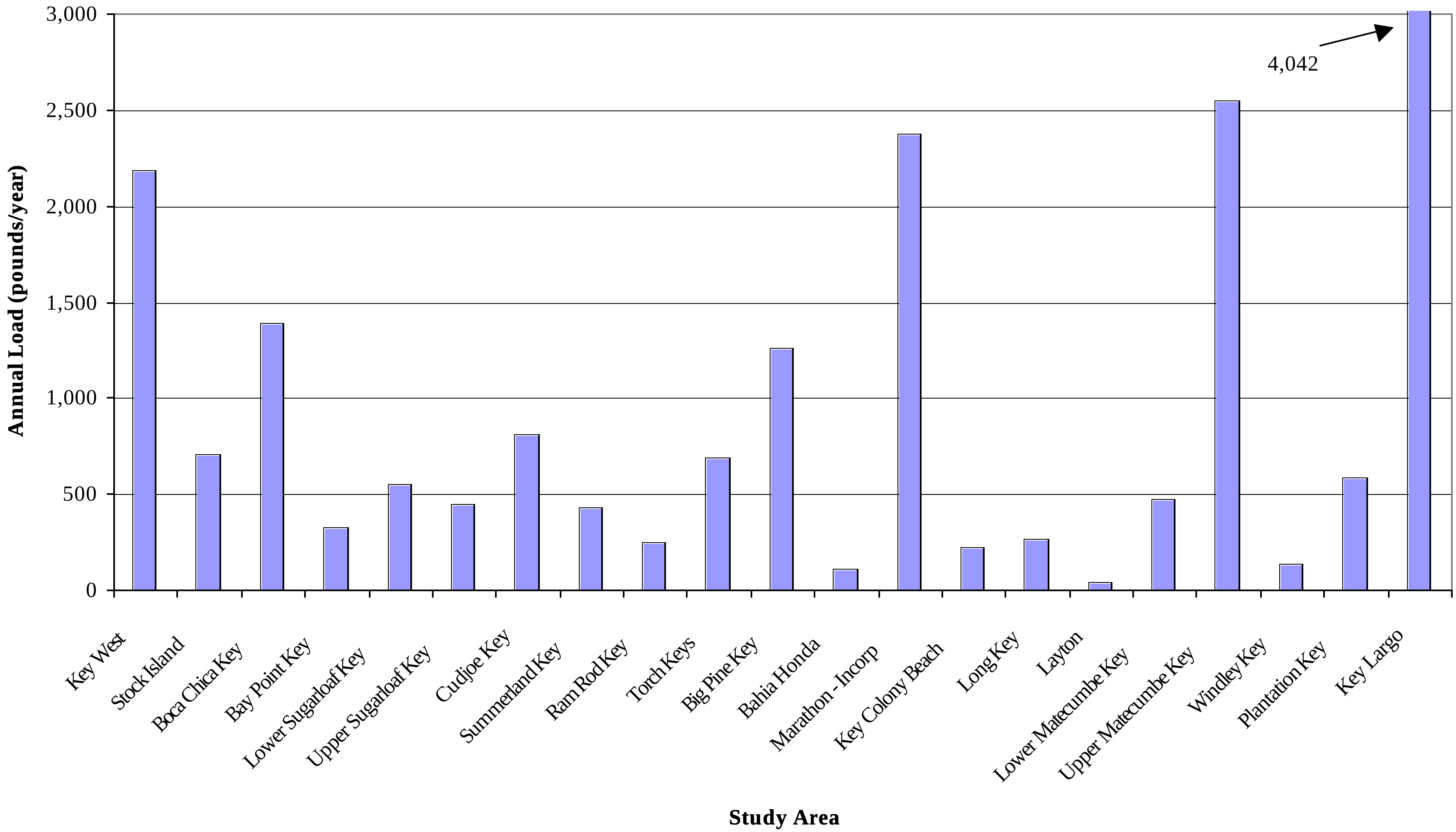


Figure 2.3-10
Monroe County Stormwater Management Master Plan
Summary of Existing Total Phosphorus Loadings from Each Study Area

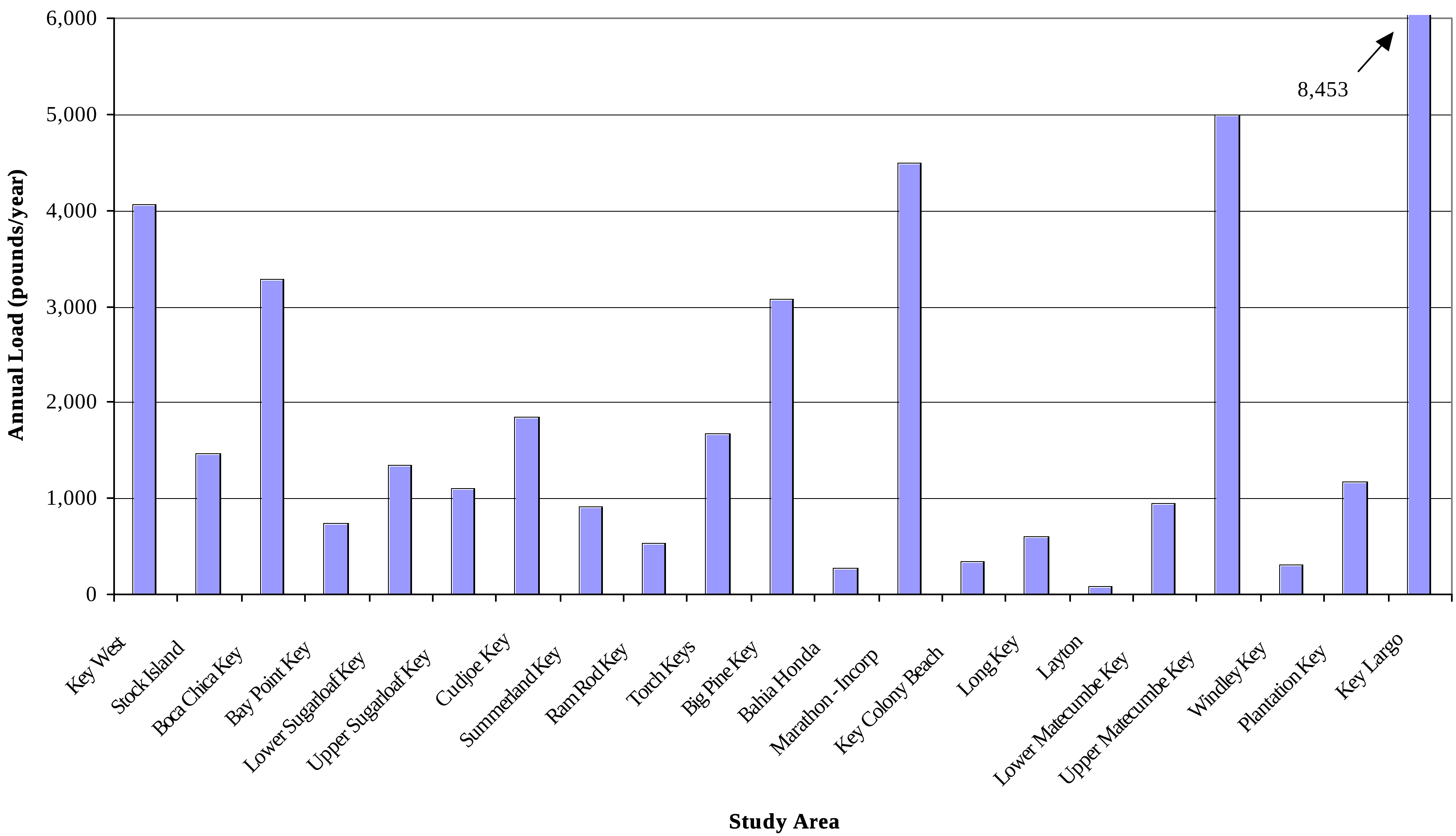


Figure 2.3-11
Monroe County Stormwater Management Master Plan
Summary of Existing Cadmium Loadings from Each Study Area

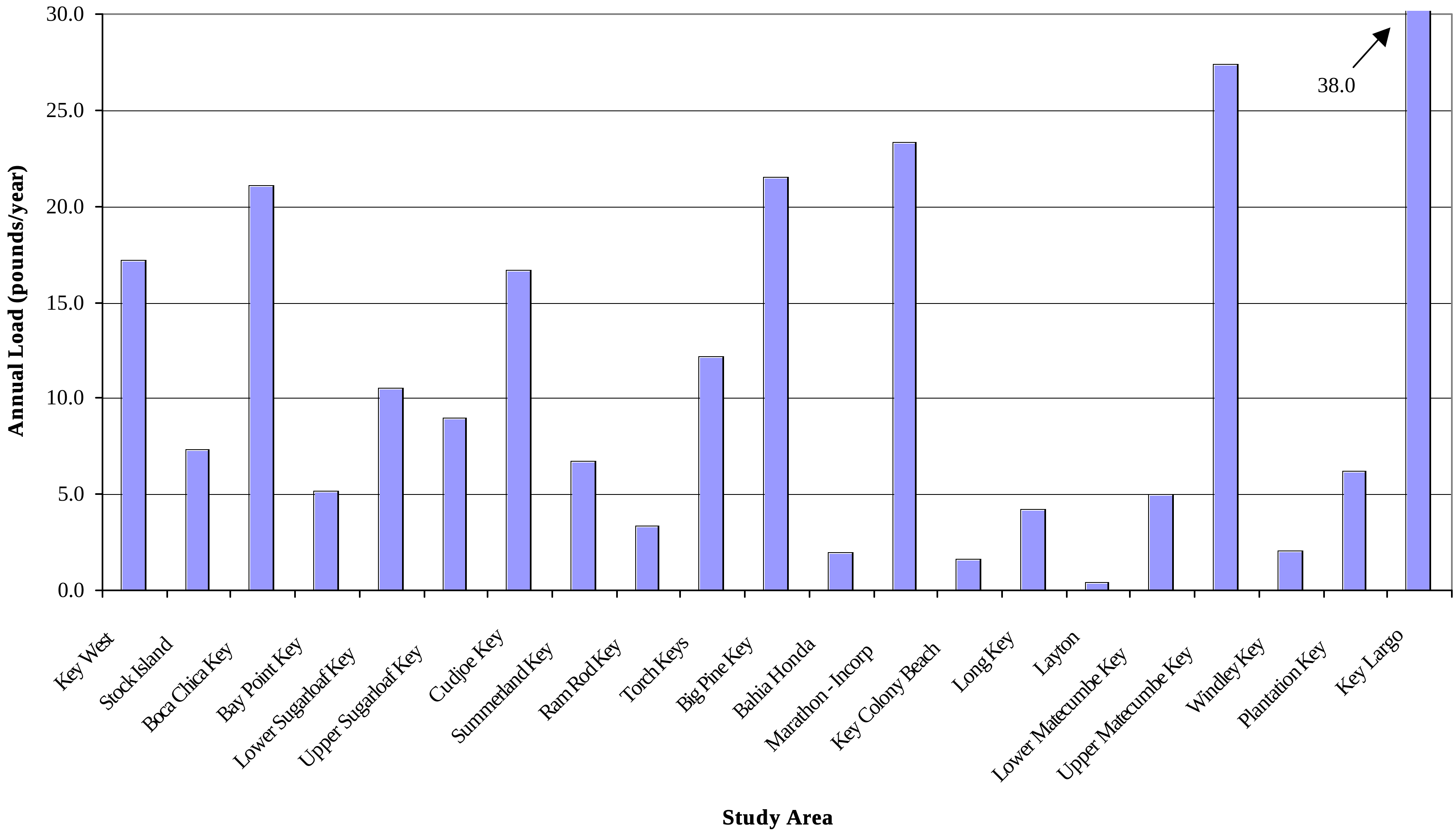


Figure 2.3-12
Monroe County Stormwater Management Master Plan
Summary of Existing Copper Loadings from Each Study Area

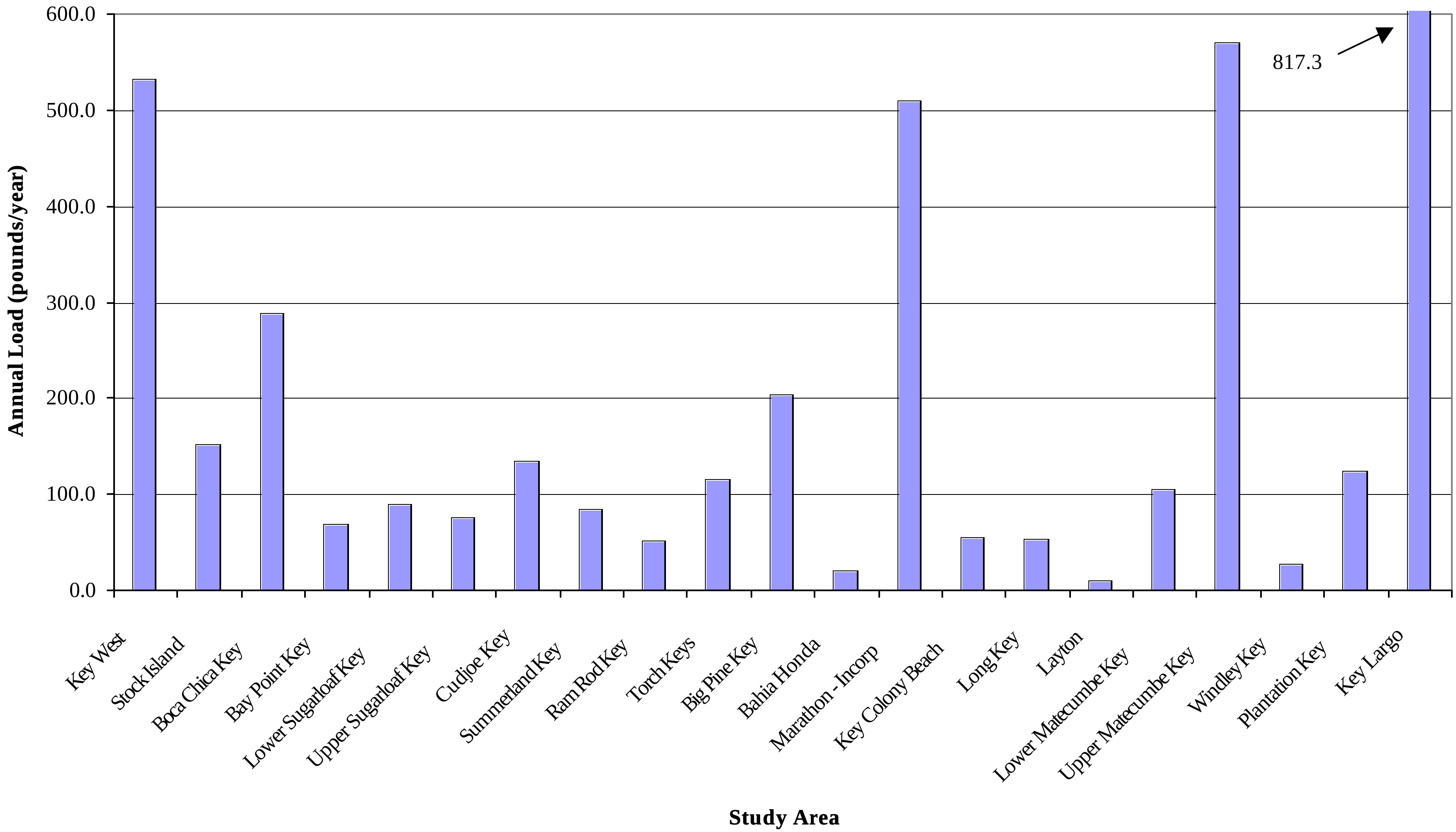
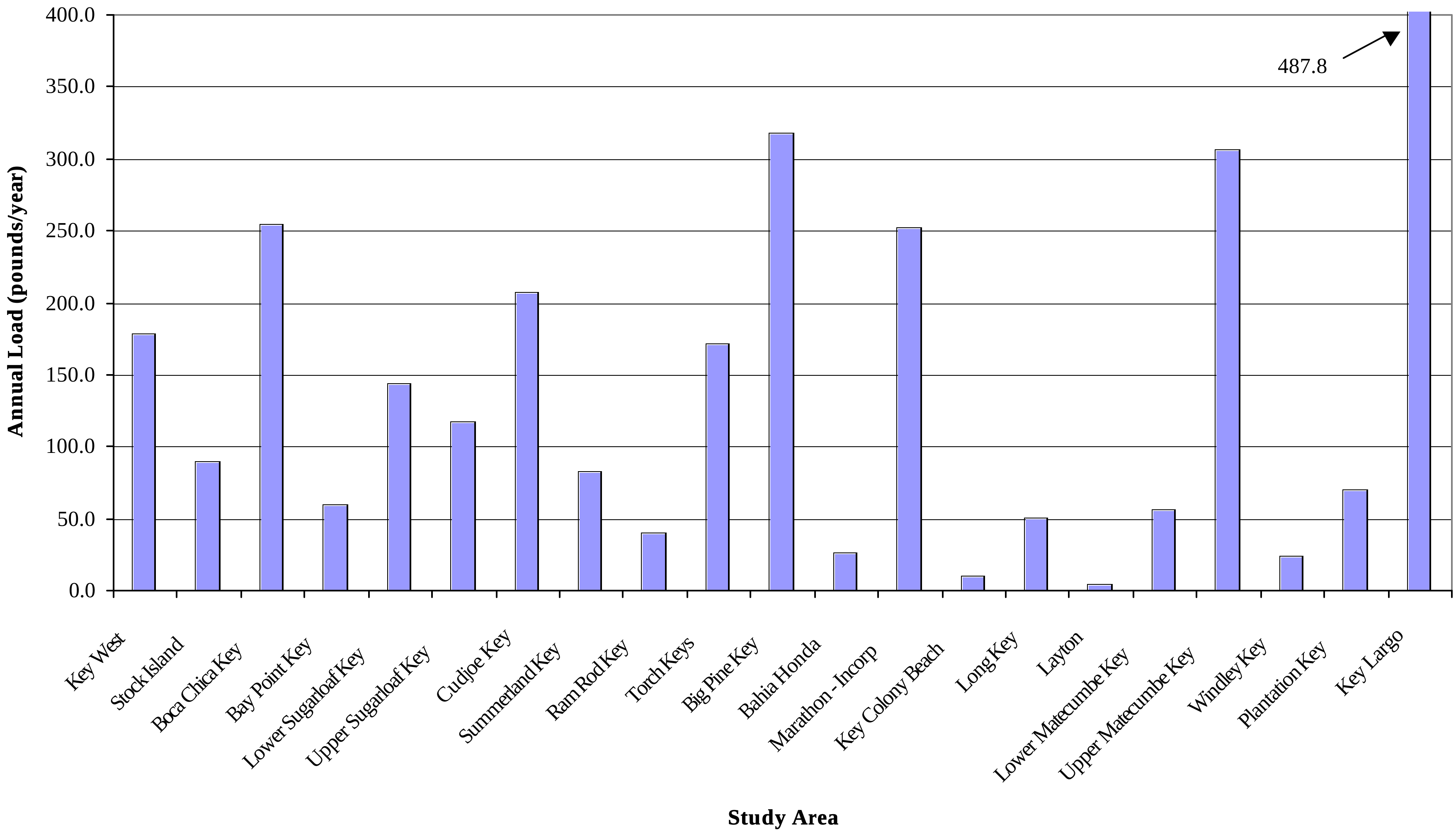
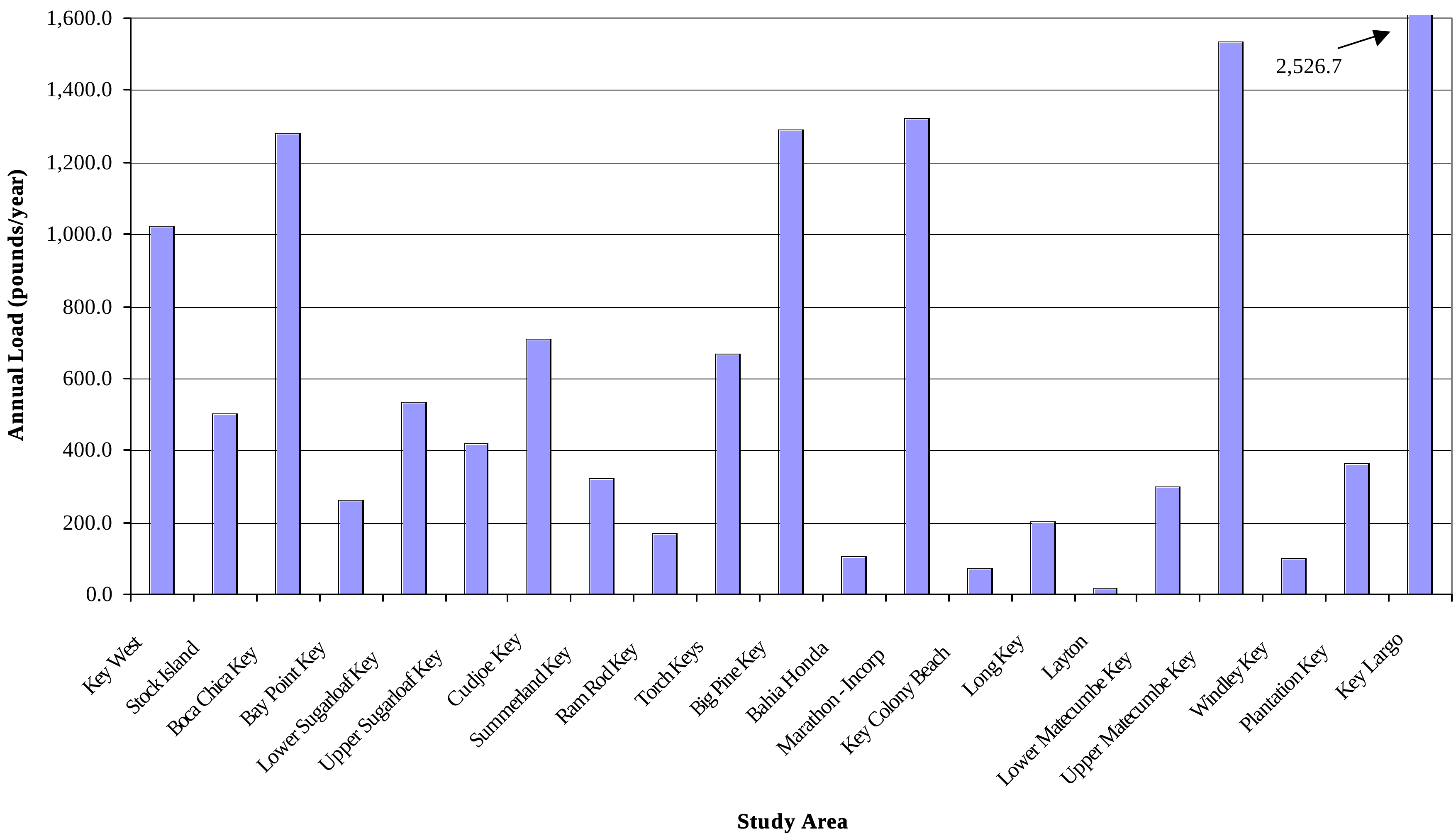


Figure 2.3-13
Monroe County Stormwater Management Master Plan
Summary of Existing Lead Loadings from Each Study Area



CDM Camp Dresser & McKee Inc.
S:\Monroe\Subsection 2.3\Table 2-8 - Existing Loading

Figure 2.3-14
Monroe County Stormwater Management Master Plan
Summary of Existing Zinc Loadings from Each Study Area



CDM Camp Dresser & McKee Inc.
S:\Monroe\Subsection 2.3\Table 2-8 - Existing Loading

Table 2.3-9
Monroe County Stormwater Management Master Plan
Summary of Existing Loading Reductions for Existing BMPs

Study Area		Oxygen Demand		Solids		Nitrogen		Phosphorus		Metals			
No.	Description	BOD	COD	TDS	TSS	TKN	NO2+3	DP	TP	Cd	Cu	Pb	Zn
Lower Keys													
1	Key West	1.2%	1.3%	0.4%	3.8%	1.9%	2.2%	0.4%	1.7%	2.6%	1.9%	3.5%	2.4%
2	Stock Island	1.8%	1.7%	0.3%	4.9%	2.0%	0.8%	0.8%	2.2%	2.2%	3.1%	4.1%	2.7%
3	Boca Chica Key	0.1%	0.1%	0.0%	0.2%	0.1%	0.0%	0.1%	0.2%	0.1%	0.4%	0.1%	0.1%
4	Bay Point Key	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
5	Lower Sugarloaf Key	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
6	Upper Sugarloaf Key	0.1%	0.2%	0.1%	0.4%	0.1%	0.2%	0.0%	0.2%	0.2%	0.3%	0.2%	0.2%
7	Cudjoe Key	0.8%	1.6%	0.5%	6.0%	0.7%	0.3%	0.3%	1.6%	1.4%	1.5%	2.5%	2.4%
8	Summerland Key	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
9	Ram Rod Key	0.2%	0.3%	0.1%	1.2%	0.2%	0.1%	0.1%	0.3%	0.4%	0.2%	0.8%	0.6%
10	Torch Keys	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
11	Big Pine Key	0.1%	0.1%	0.0%	0.2%	0.1%	0.2%	0.0%	0.1%	0.1%	0.2%	0.1%	0.1%
12	Bahia Honda	1.2%	1.6%	0.5%	6.9%	1.1%	0.5%	0.5%	2.2%	2.5%	2.1%	4.4%	3.5%
Middle Keys													
13	Marathon - Incorp	4.0%	4.1%	1.3%	12.8%	5.0%	4.7%	1.3%	5.6%	7.2%	7.7%	8.8%	6.3%
14	Key Colony Beach	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
15	Long Key	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
16	Layton	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Islamorada													
17	Lower Matecumbe Key	1.5%	1.9%	0.5%	8.2%	1.9%	0.8%	0.5%	2.5%	3.8%	1.5%	7.7%	4.7%
18	Upper Matecumbe Key	1.0%	1.1%	0.4%	2.8%	1.2%	1.6%	0.3%	1.2%	1.8%	1.4%	2.0%	1.6%
19	Windley Key	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
20	Plantation Key	4.4%	5.1%	1.4%	17.5%	6.7%	7.8%	1.5%	6.9%	9.4%	7.5%	13.8%	10.2%
Upper Keys													
21,22	Key Largo	3.6%	3.2%	0.8%	13.5%	4.2%	2.3%	1.5%	5.7%	7.8%	7.3%	12.5%	7.8%
	Totals	1.6%	1.8%	0.5%	5.9%	1.9%	1.4%	0.6%	2.5%	2.8%	3.4%	4.1%	3.0%

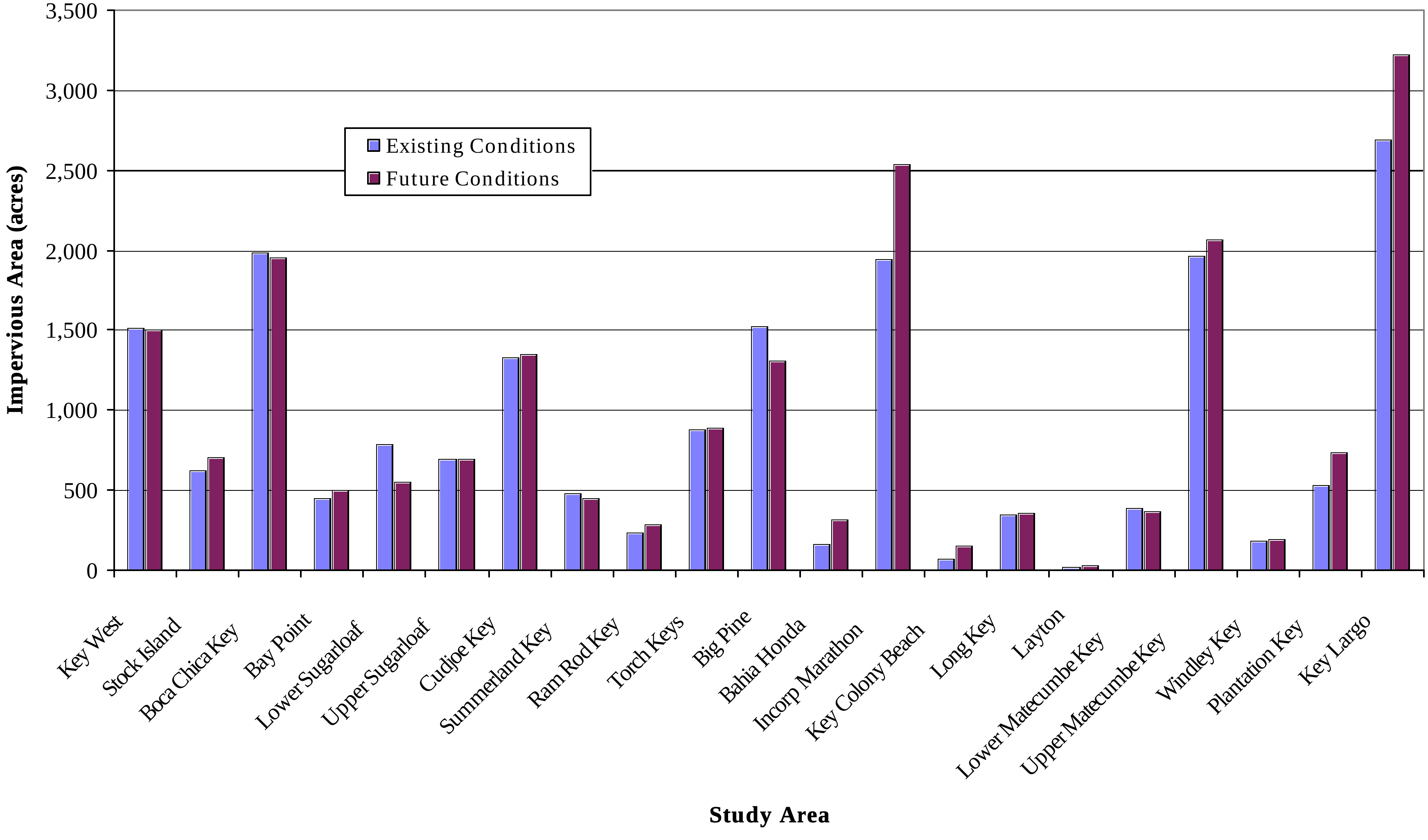
Table 2.3-10
Monroe County Stormwater Management Master Plan
Summary of Estimated Annual Averge Runoff Pollutant Loading
Future Land Use Conditions

Study Area	Name	Study Area (ac)	DCIA (acres)	Percent DCIA	Total Flow (ac-ft/yr)	Total Flow (mgd)
Lower Keys						
1	Key West	3,589	1,507	42.0%	5,740	5.12
2	Stock Island	1,392	704	50.5%	2,580	2.30
3	Boca Chica Key	4,767	1,951	40.9%	7,472	6.67
4	Bay Point	1,883	500	26.5%	2,146	1.91
5	Lower Sugarloaf	4,175	550	13.2%	3,097	2.76
6	Upper Sugarloaf	4,180	701	16.8%	3,548	3.16
7	Cudjoe Key	6,583	1,356	20.6%	6,337	5.65
8	Summerland Key	2,442	446	18.3%	2,183	1.95
9	Ram Rod Key	1,496	286	19.1%	1,374	1.23
10	Torch Keys	4,760	895	18.8%	4,329	3.86
11	Big Pine Key	6,654	1,309	19.7%	6,225	5.55
12	Bahia Honda	932	314	33.7%	1,260	1.12
Middle Keys						
13	Incorp Marathon	8,035	2,542	31.6%	10,375	9.26
14	Key Colony Beach	533	155	29.0%	647	0.58
15	Long Key	1,969	357	18.1%	1,751	1.56
16	Layton	178	33	18.5%	160	0.14
Islamorada						
17	Lower Matecumbe Key	1,350	371	27.5%	1,577	1.41
18	Upper Matecumbe Key	7,734	2,065	26.7%	8,849	7.89
19	Windley Key	824	191	23.2%	858	0.77
20	Plantation Key	1,987	740	37.2%	2,897	2.58
Upper Keys						
21,22	Key Largo	21,930	3,225	14.7%	17,271	15.41
	Total or Average	87,390	20,198	23.1%	90,676	80.89

Table 2.3-11
Monroe County Stormwater Management Master Plan
Summary of Estimated Annual Averge Runoff Pollutant Loading
Differences Between Existing and Future Land Uses

Study Area	Name	Study Area (ac)	DCIA Exist (acres)	DCIA Future (acres)	DCIA Delta (acres)	Percent DCIA Exist (%)	Percent DCIA Future (%)	Percent DCIA Delta (%)	Total Runoff Exist (mgd)	Total Runoff Future (mgd)	Total Runoff Delta (mgd)	Total Runoff Delta (%)
1	Key West	3,589	1,514	1,507	(7)	42.2%	42.0%	-0.2%	5.14	5.12	(0.02)	-0.4%
2	Stock Island	1,392	621	704	83	44.6%	50.5%	6.0%	2.08	2.30	0.22	10.6%
3	Boca Chica Key	4,767	1,987	1,951	(36)	41.7%	40.9%	-0.8%	6.76	6.67	(0.10)	-1.4%
4	Bay Point	1,882	453	500	47	24.1%	26.6%	2.5%	1.79	1.91	0.13	7.0%
5	Lower Sugarloaf	4,175	792	550	(242)	19.0%	13.2%	-5.8%	3.41	2.76	(0.64)	-18.9%
6	Upper Sugarloaf	4,180	695	701	6	16.6%	16.8%	0.1%	3.15	3.16	0.02	0.5%
7	Cudjoe Key	6,583	1,332	1,356	23	20.2%	20.6%	0.4%	5.59	5.65	0.06	1.1%
8	Summerland Key	2,442	486	446	(39)	19.9%	18.3%	-1.6%	2.05	1.95	(0.10)	-5.1%
9	Ram Rod Key	1,496	235	286	51	15.7%	19.1%	3.4%	1.09	1.23	0.13	12.3%
10	Torch Keys	4,760	881	895	14	18.5%	18.8%	0.3%	3.82	3.86	0.04	1.0%
11	Big Pine	6,654	1,521	1,309	(211)	22.9%	19.7%	-3.2%	6.11	5.55	(0.56)	-9.2%
12	Bahia Honda	932	167	314	147	18.0%	33.7%	15.8%	0.73	1.12	0.39	53.0%
13	Incorp Marathon	8,035	1,940	2,542	602	24.1%	31.6%	7.5%	7.66	9.26	1.60	20.9%
14	Key Colony Beach	533	74	155	81	13.8%	29.0%	15.2%	0.36	0.58	0.21	59.4%
15	Long Key	1,969	350	357	7	17.8%	18.1%	0.3%	1.54	1.56	0.02	1.1%
16	Layton	178	24	33	9	13.6%	18.5%	4.8%	0.12	0.14	0.02	19.0%
17	Lower Matecumbe Key	1,350	393	371	(21)	29.1%	27.5%	-1.6%	1.46	1.41	(0.06)	-3.9%
18	Upper Matecumbe Key	7,734	1,963	2,065	102	25.4%	26.7%	1.3%	7.62	7.89	0.27	3.5%
19	Windley Key	824	180	191	11	21.9%	23.2%	1.4%	0.74	0.77	0.03	4.1%
20	Plantation Key	1,987	527	740	213	26.5%	37.2%	10.7%	2.02	2.58	0.56	28.0%
21,22	Key Largo	21,931	2,691	3,225	534	12.3%	14.7%	2.4%	13.99	15.41	1.42	10.1%
	Total or Average	87,390	18,827	20,198	1,371	21.5%	23.1%	1.6%	77.25	80.89	3.64	4.7%

Figure 2.3-15
Monroe County Stormwater Management Master Plan
Comparison of Existing and Future Imperviousness



CDM Camp Dresser & McKee Inc.
S:\Monroe\Subsection 2.3\Table 2-7 - Runoff

Figure 2.3 - 16
Monroe County Stormwater Management Master Plan
Comparison of Future Loading Changes above Existing Loads

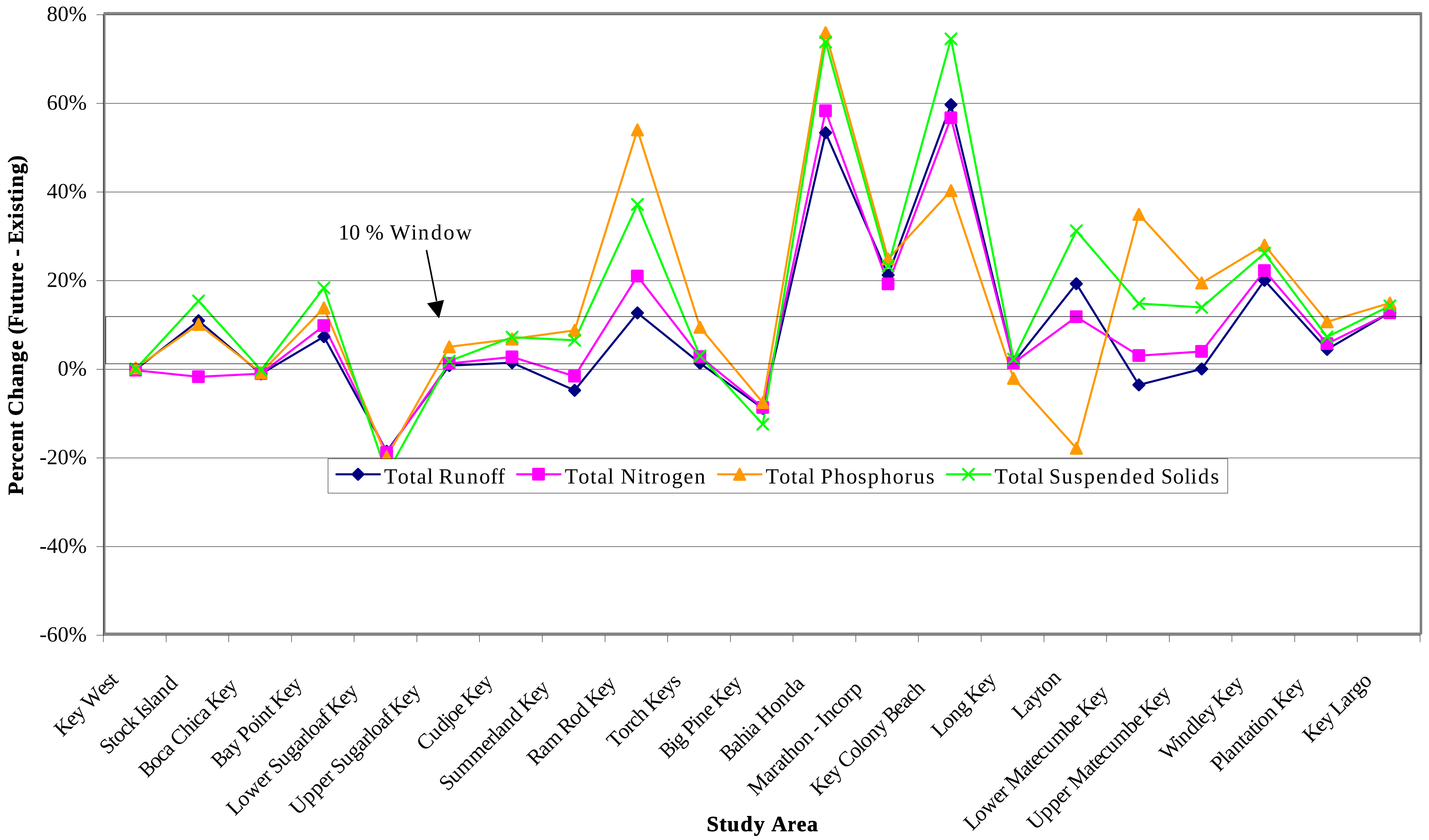


Table 2.3-12 provides a summary of the pollutant loading estimates for the study areas for each of the 12 parameters categorized as oxygen demanding substances, sediment, nitrogen, phosphorus and metals. **Table 2.3-13** shows the increase or decrease in pollutant loading due to the change in land uses from existing to future conditions. While some of the study areas will exhibit a decrease in pollutant loading under future conditions, in total, there will be an overall increase for each of the parameters modeled. To isolate these study areas, **Table 2.3-14** shows the percent change in runoff, total nitrogen, total phosphorus and total suspended solids (the target parameters). These differences are graphed in **Figure 2.3-17**. Given the fact that the results from the WMM modeling are not exact, a 10 percent window of accuracy is shown in Figure 2.3-17. Even allowing this window, the following study areas with future loading increases are identified:

Total Nitrogen	Ram Rod Key Bahia Honda Incorporated Marathon Key Colony Beach Layton Plantation Key
Total Phosphorus	Bay Point Key Ram Rod Key Bahia Honda Incorporated Marathon Key Colony Beach Lower Matecumbe Upper Matecumbe Plantation Key Key Largo
Total Suspended Solids	Stock Island Bay Point Key Ram Rod Key Bahia Honda Incorporated Marathon Key Colony Beach Layton Lower Matecumbe Upper Matecumbe Plantation Key Key Largo

Table 2.3-12
Monroe County Stormwater Management Master Plan
Summary of Future Pollutant Loading for Each Study Area (pounds per year)

Study Area		Oxygen Demand		Solids		Nitrogen		Phosphorus		Metals			
No.	Description	BOD	COD	TDS	TSS	TKN	NO2+3	DP	TP	Cd	Cu	Pb	Zn
Lower Keys													
1	Key West	128,579	828,145	1,914,712	650,974	19,008	10,055	2,189	4,067	17.2	533.6	178.3	1,019.6
2	Stock Island	55,805	379,356	826,919	331,904	7,879	3,819	803	1,610	7.6	158.3	105.1	546.7
3	Boca Chica Key	121,258	711,541	1,598,540	602,666	21,742	16,925	1,371	3,241	20.7	287.1	247.5	1,263.1
4	Bay Point Key	30,920	188,200	396,454	147,841	5,959	4,063	370	851	5.5	78.3	65.5	296.9
5	Lower Sugarloaf Key	37,478	285,958	584,798	203,467	8,038	4,053	445	1,074	7.3	82.6	95.1	367.5
6	Upper Sugarloaf Key	43,390	255,151	519,195	204,086	8,816	4,929	493	1,153	9.2	87.0	117.9	425.4
7	Cudjoe Key	78,614	372,627	753,222	311,302	15,347	9,357	886	1,967	16.9	154.2	209.6	737.1
8	Summerland Key	31,968	207,644	401,765	169,037	6,116	2,934	479	994	5.8	101.5	73.6	292.9
9	Ram Rod Key	24,059	159,405	314,120	129,337	4,245	1,754	429	814	4.0	98.7	47.2	203.9
10	Torch Keys	63,140	404,106	830,675	363,555	11,622	5,828	807	1,834	12.7	148.1	171.0	680.1
11	Big Pine Key	95,007	652,640	1,323,172	610,287	17,191	8,196	1,205	2,837	18.7	213.8	266.5	1,096.6
12	Bahia Honda	19,385	95,467	209,156	94,887	3,184	1,919	222	499	3.8	39.5	50.1	199.2
Middle Keys													
13	Marathon - Incorp	186,872	1,249,888	2,834,918	899,629	29,550	15,410	3,019	5,609	25.8	619.8	303.8	1,583.4
14	Key Colony Beach	15,922	100,182	252,813	81,069	2,125	953	274	496	2.3	66.4	23.5	126.9
15	Long Key	22,618	147,810	319,712	108,288	4,465	2,637	249	595	4.2	48.6	52.3	208.8
16	Layton	2,253	16,745	33,548	14,915	432	214	26	66	0.4	4.3	6.4	26.4
Islamorada													
17	Lower Matecumbe Key	33,607	233,207	406,351	200,386	5,673	1,805	706	1,283	4.8	165.6	60.8	288.9
18	Upper Matecumbe Key	137,169	915,380	1,716,962	828,783	23,101	8,853	2,557	4,868	22.0	587.4	281.4	1,268.6
19	Windley Key	40,690	274,220	640,604	229,265	5,940	2,891	611	1,226	5.9	138.0	71.5	365.3
20	Plantation Key	12,961	77,882	186,194	57,876	2,208	1,312	155	335	2.2	33.7	25.3	107.5
Upper Keys													
21,22	Key Largo	336,533	2,943,523	6,236,882	2,089,423	59,648	23,854	5,362	11,025	47.2	1,068.9	633.2	3,237.7
	Totals	1,518,228	10,499,076	22,300,714	8,328,978	262,290	131,761	22,659	46,445	244.3	4,715.5	3,085.6	14,342.5

Table 2.3-13

Monroe County Stormwater Management Master Plan

Summary of Increase or Decrease in Pollutant Loading for Each Study Area (pounds per year) [1]

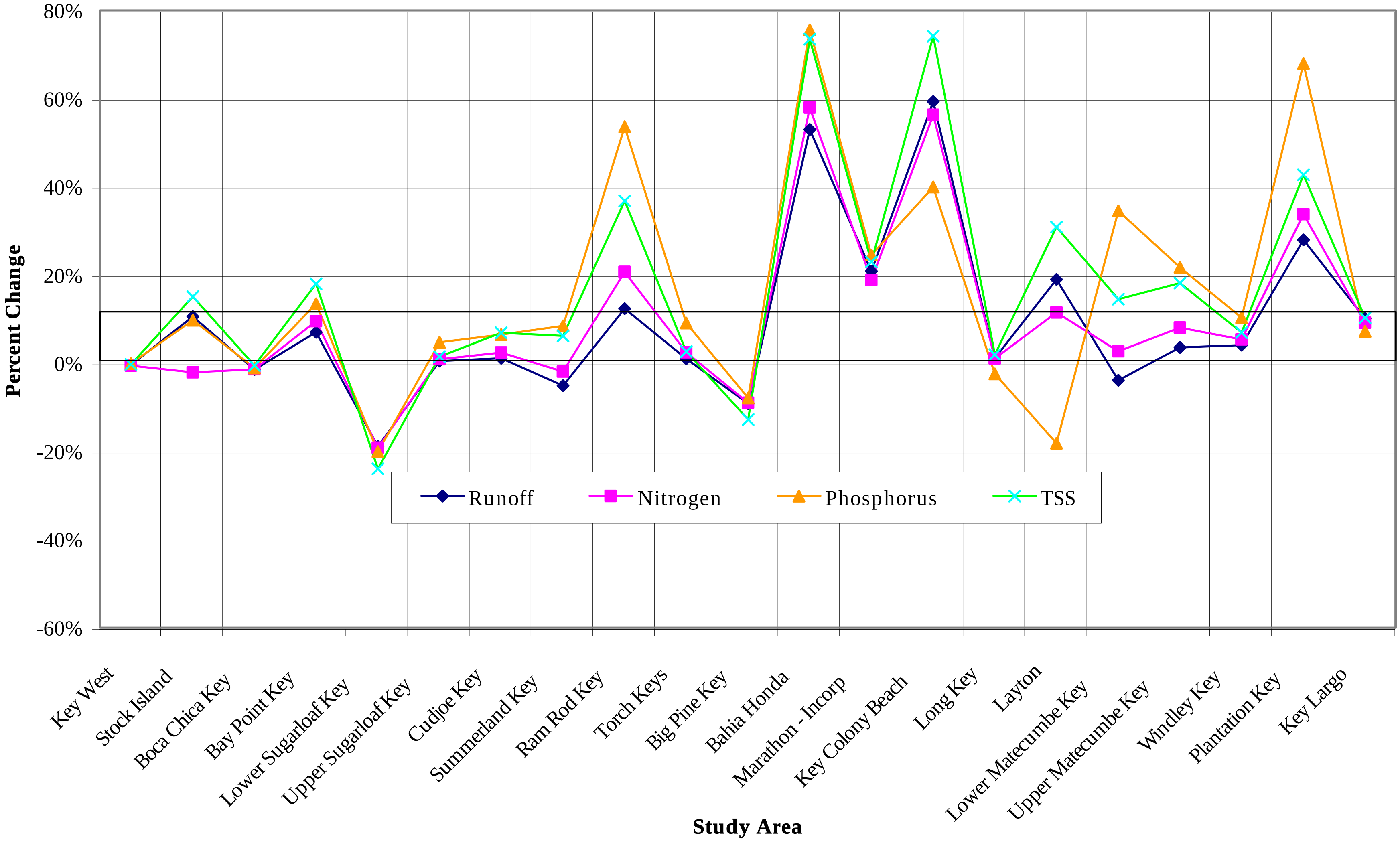
Study Area		Oxygen Demand		Solids		Nitrogen		Phosphorus		Metals			
No.	Description	BOD	COD	TDS	TSS	TKN	NO2+3	DP	TP	Cd	Cu	Pb	Zn
Lower Keys													
1	Key West	(238)	(2,372)	(5,643)	(1,764)	(67.8)	(102.1)	2.3	(3.5)	(0.04)	0.96	(0.62)	(5.59)
2	Stock Island	5,658	39,764	35,662	43,486	413.8	(660.7)	93.4	142.9	0.33	6.89	14.90	43.07
3	Boca Chica Key	(830)	7,826	44,125	(3,123)	(306.3)	(233.4)	(19.1)	(35.9)	(0.40)	(1.23)	(6.91)	(18.33)
4	Bay Point Key	2,622	21,595	25,516	22,528	550.4	319.1	40.3	101.2	0.31	9.27	6.02	32.34
5	Lower Sugarloaf Key	(11,782)	(8,748)	7,412	(64,036)	(1,650.1)	(1,218.2)	(106.7)	(270.0)	(3.25)	(8.02)	(49.08)	(169.09)
6	Upper Sugarloaf Key	1,836	4,833	27,566	2,903	91.7	33.3	42.0	52.1	0.26	11.63	0.43	5.81
7	Cudjoe Key	3,842	28,132	66,747	20,049	416.4	170.1	76.6	120.0	0.25	18.78	1.75	25.83
8	Summerland Key	(1,776)	21,577	(17,547)	9,875	176.1	(353.3)	47.9	77.3	(0.96)	17.30	(9.24)	(30.21)
9	Ram Rod Key	5,510	32,703	19,622	34,795	947.0	80.8	179.3	284.2	0.58	47.30	7.13	32.52
10	Torch Keys	4,325	16,765	61,701	9,319	335.5	82.9	117.8	152.9	0.49	32.76	(0.24)	11.70
11	Big Pine Key	(10,208)	(33,172)	(21,788)	(89,434)	(1,545.6)	(961.2)	(55.7)	(243.7)	(2.82)	9.79	(52.12)	(194.50)
12	Bahia Honda	8,756	22,937	55,408	40,187	1,098.2	774.3	105.2	215.0	1.82	18.75	23.75	94.48
Middle Keys													
13	Marathon - Incorp	29,188	210,881	257,643	167,886	5,161.8	1,985.8	642.0	1,104.9	2.45	108.93	51.08	262.06
14	Key Colony Beach	3,982	24,473	21,120	34,529	752.1	356.7	51.9	141.5	0.70	10.22	13.22	52.29
15	Long Key	(565)	(2,014)	(19,272)	2,082	35.6	38.6	(18.7)	(14.9)	(0.03)	(5.85)	1.87	3.94
16	Layton	(465)	(270)	(13,502)	3,519	38.4	28.2	(20.3)	(14.6)	(0.01)	(6.55)	2.34	6.02
Islamorada													
17	Lower Matecumbe Key	(6)	7,501	(165,395)	25,355	892.8	(695.0)	232.2	329.6	(0.21)	59.85	4.42	(8.60)
18	Upper Matecumbe Key	(3,929)	13,398	(570,453)	98,997	2,726.5	(1,594.7)	472.9	781.7	(0.67)	115.52	29.75	18.42
19	Windley Key	7,098	47,491	69,051	47,024	1,157.4	427.3	137.0	265.6	0.81	32.95	12.56	60.75
20	Plantation Key	1,374	5,645	24,766	3,749	97.1	83.2	20.8	31.4	0.19	5.51	0.87	7.86
Upper Keys													
21,22	Key Largo	33,805	265,432	212,803	255,800	6,641.3	2,555.1	728.4	1,404.0	2.98	127.02	74.64	348.89
	Totals	78,196	724,378	115,540	663,729	17,962.3	1,116.8	2,769.4	4,621.9	2.76	611.77	126.49	579.69

Note: 1 Negative number in red means that there will be a decrease in pollutant loading based upon the future land use conditions.

Table 2.3 - 14
Monroe County Stormwater Management Master Plan
Changes in Future Land Uses From Existing Land Uses (Future - Existing)
Percent Change in Runoff or Pollutant Loading above Existing Loads

Study Area	Total Runoff	Total Nitrogen	Total Phosphorus	TSS
1 Key West	0%	-1%	0%	0%
2 Stock Island	11%	-2%	10%	15%
3 Boca Chica Key	-1%	-1%	-1%	-1%
4 Bay Point Key	7%	9%	13%	18%
5 Lower Sugarloaf Key	-19%	-19%	-20%	-24%
6 Upper Sugarloaf Key	0%	1%	5%	1%
7 Cudjoe Key	1%	2%	6%	7%
8 Summerland Key	-5%	-2%	8%	6%
9 Ram Rod Key	12%	21%	54%	37%
10 Torch Keys	1%	2%	9%	3%
11 Big Pine Key	-9%	-9%	-8%	-13%
12 Bahia Honda	53%	58%	76%	73%
13 Marathon - Incorp	21%	19%	25%	23%
14 Key Colony Beach	59%	56%	40%	74%
15 Long Key	1%	1%	-2%	2%
16 Layton	19%	11%	-18%	31%
17 Lower Matecumbe Key	-4%	3%	35%	14%
18 Upper Matecumbe Key	0%	4%	19%	14%
19 Windley Key	20%	22%	28%	26%
20 Plantation Key	4%	5%	10%	7%
21,22 Key Largo	12%	12%	15%	14%
Total Change	5%	5%	11%	9%

Figure 2.3 - 17
Monroe County Stormwater Management Master Plan
Comparison of Future Loading Changes Above Existing Loading



2.3.10 Comparison of Nutrient Loading

2.3.10.1 Separation into Background, Wetfall, and Urban Loading

In order to discern the sources of the runoff, WMM was used to categorize runoff and loading into "natural", "wetfall", and "urban." For the purposes of this plan, "natural" sources will include the runoff and loading from the study areas with all of the land uses (except water/wetland) turned into forest/open land use. This would represent the loading if no urban development had occurred within the study area; i.e., predevelopment. "Wetfall" sources represent the load from rainfall falling on open water or wetlands. As noted previously, this load is represented by the runoff and loading from the wetland/water land use. Finally, the "urban" component of the runoff and loading will be calculated as the total load from WMM minus "natural" and "wetfall" loading. In essence, this represents the runoff and load increase caused by the urban developments.

Using these conventions, a summary of the sources of runoff is provided in **Table 2.3-15**. The table provides the urban, wetfall and natural runoff sorted by highest urban runoff value. As expected, Key Largo has the highest urban component of runoff (18.9 percent), followed by Key West (12.7 percent), Incorporated Marathon (12.6 percent) and Upper Matecumbe Key (12.5 percent). **Figure 2.3-18** illustrates the comparison of total and urban runoff.

Figures 2.3-19 through 23-23 show the land uses, nutrient load and TSS load segregated into sources. Figure 2.3-19 shows land uses. In this figure, the large public facility on Boca Chica Key is the military base and the low density residential peaks show for Incorporated Marathon, Upper Matecumbe Key and Key Largo. Runoff volumes are shown in Figure 2.3-20. As before, the military base on Boca Chica Key stands out, as do to a lesser degree, the cities. Total Nitrogen (Figure 2.3-21) and Total Phosphorus (Figure 2.3-22) show a similar pattern; however, the county road influence on Torch and Big Pine Keys indicates an increasing importance. Finally, Figure 2.3-23 shows the Total Suspended Solids loading for each study area. While the pattern of peaks at Boca Chica Key, the cities and Key Largo holds in this figure, the loading from county and FDOT roads is significant for a number study areas.

To compare the loading results to the pollutant loading target discussion, the loading was converted to event mean concentrations (load divided by runoff, EMC). **Table 2.3-16** provides the EMCs for each study area for each of the 12 parameters considered. EMCs were calculated for the "natural" condition loads and **Table 2.3-17** provides the difference in EMCs between the "natural" and total load. Thus, Table

Table 2.3-15
Monroe County Stormwater Management Master Plan
Summary of Runoff Sources (acre-ft/year) - Sorted By Largest Urban Runoff

Study Area		Urban		Wetfall		Natural		Total
No.	Description	Runoff	%	Runoff	%	Runoff	%	Runoff
21,22	Key Largo	7,236	40.3%	2,976	16.6%	7,734	43.1%	17,946
1	Key West	4,114	71.4%	508	8.8%	1,140	19.8%	5,762
13	Marathon - Incorp	4,074	47.5%	2,368	27.6%	2,142	25.0%	8,584
3	Boca Chica Key	3,829	50.5%	3,020	39.8%	732	9.7%	7,581
18	Islamorada	3,118	45.2%	2,188	31.7%	1,600	23.2%	6,906
11	Big Pine Key	1,669	24.4%	4,135	60.3%	1,048	15.3%	6,853
2	Stock Island	1,614	69.2%	318	13.6%	402	17.2%	2,334
19	Upper Matecumbe Key	904	55.1%	367	22.3%	370	22.6%	1,641
17	Lower Matecumbe Key	904	55.1%	367	22.3%	370	22.6%	1,641
10	Torch Keys	792	18.5%	2,638	61.5%	856	20.0%	4,287
4	Bay Point Key	653	32.6%	998	49.8%	354	17.6%	2,005
7	Cudjoe Key	602	9.6%	4,897	78.1%	768	12.3%	6,267
5	Lower Sugarloaf Key	569	14.9%	2,590	67.8%	659	17.3%	3,818
15	Long Key	412	23.8%	902	52.1%	418	24.1%	1,732
8	Summerland Key	409	17.8%	1,500	65.2%	390	17.0%	2,300
6	Upper Sugarloaf Key	401	11.4%	2,406	68.2%	723	20.5%	3,530
9	Ram Rod Key	283	23.1%	592	48.4%	348	28.5%	1,223
20	Windley Key	251	30.4%	410	49.7%	164	19.9%	824
14	Key Colony Beach	211	52.1%	0	0.0%	195	47.9%	406
12	Bahia Honda	187	22.7%	445	54.1%	191	23.2%	824
16	Layton	35	26.0%	52	38.6%	48	35.4%	134
	Totals	32,269	37.3%	33,676	38.9%	20,652	23.8%	86,597

Figure 2.3 - 18
Monroe County Stormwater Management Master Plan
Comparison of Total Land Uses and Urban Components - Sorted by Higher Percent Urban

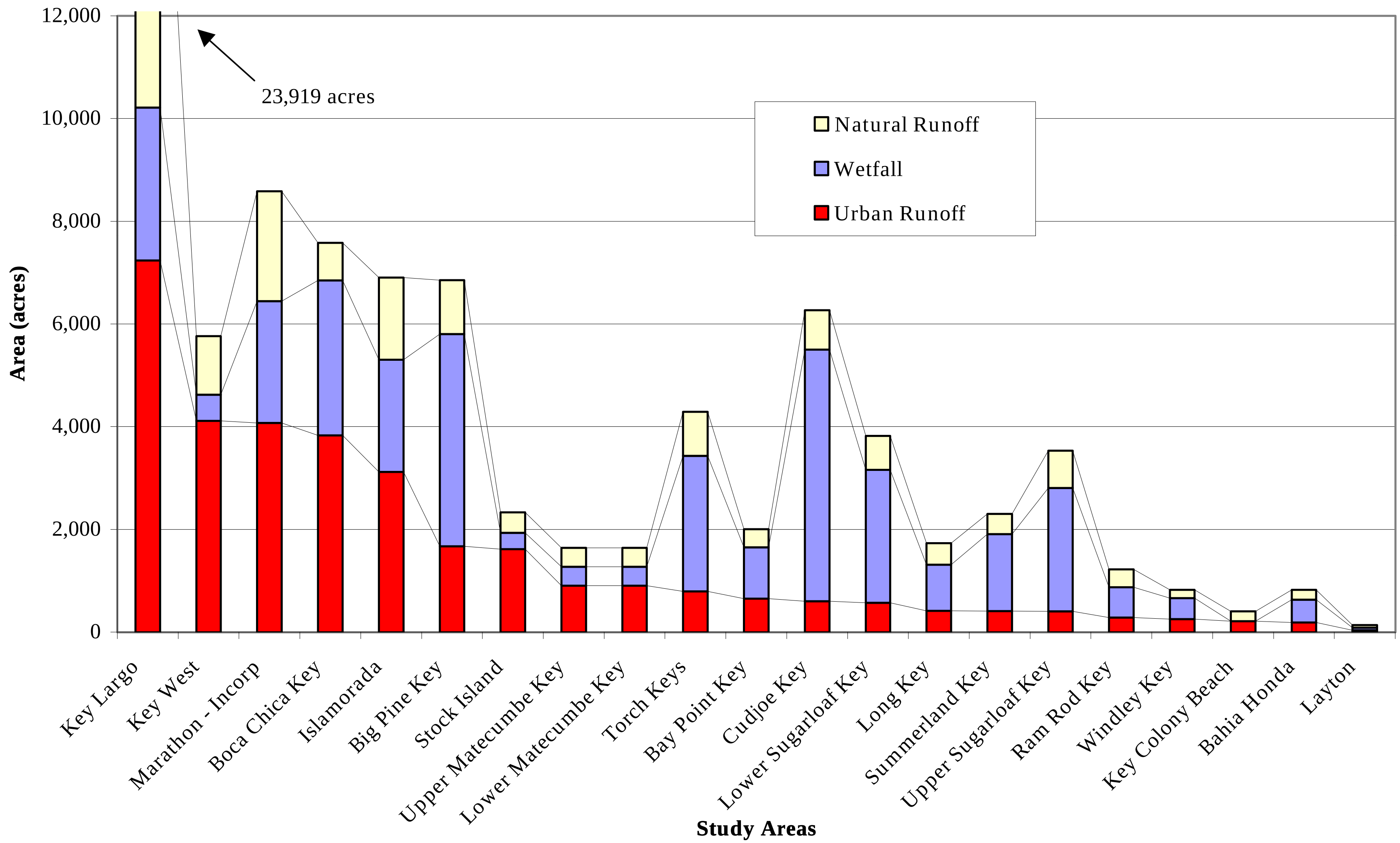


Figure 2.3 - 19
Monroe County Stormwater Management Master Plan
Summary of Urban Land Use Types

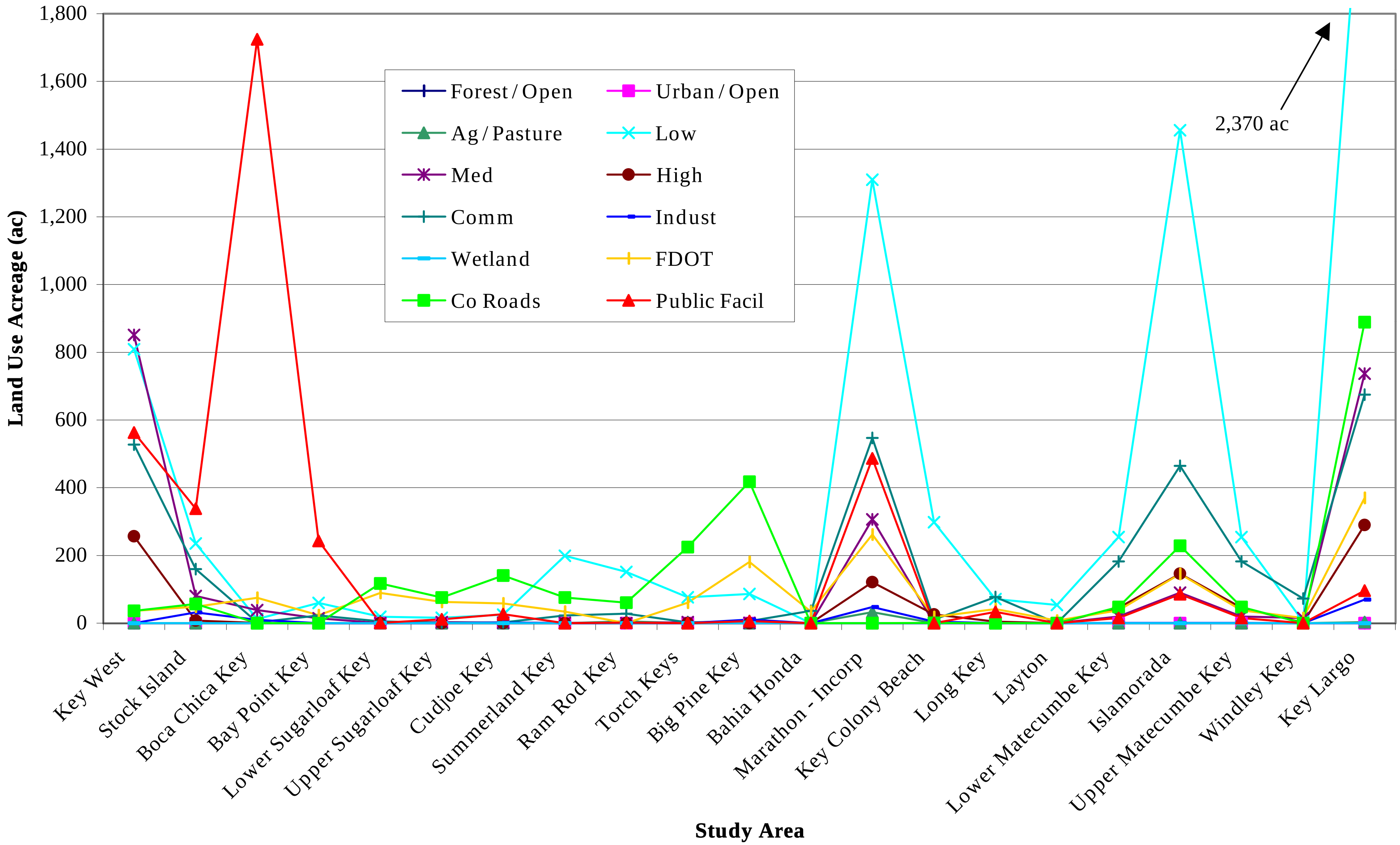


Figure 2.3 - 20
Monroe County Stormwater Management Master Plan
Sources of Stormwater Runoff for Existing Urban Land Uses - BMPs Applied

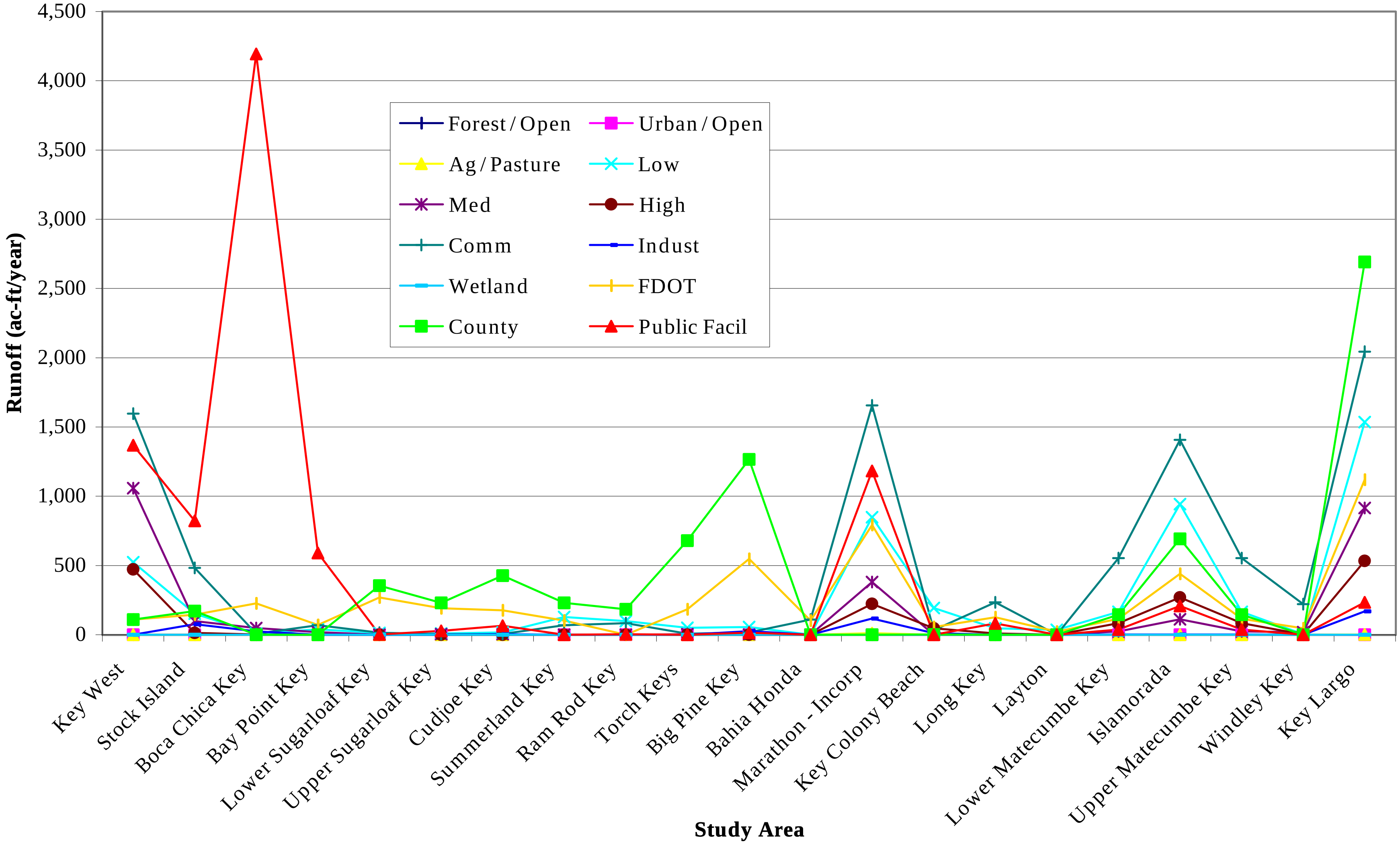


Table 2.3 - 21
Monroe County Stormwater Management Master Plan
Summary of Total Nitrogen Loading For Existing Urban Land Uses - BMPs Applied

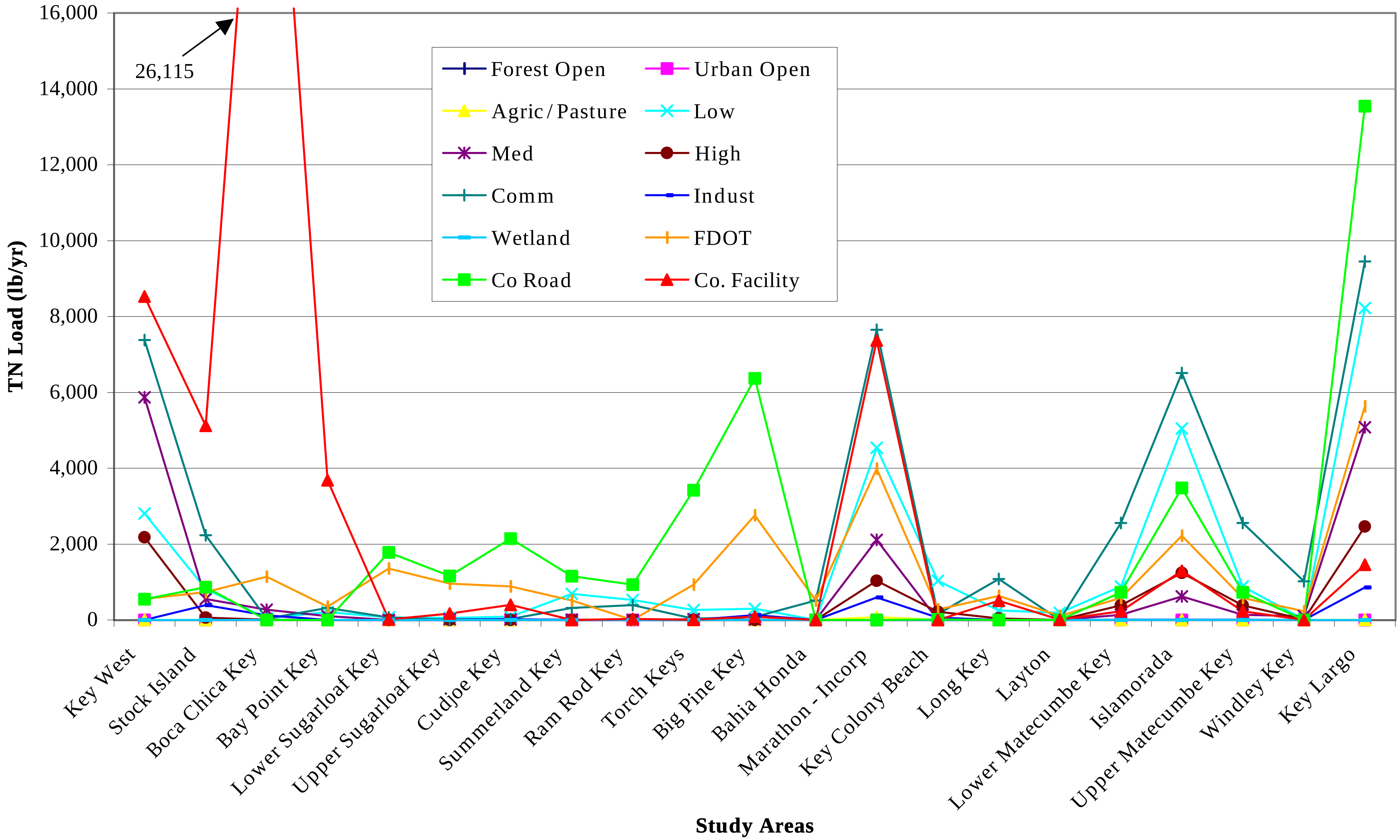


Figure 2.3 - 22
Monroe County Stormwater Management Master Plan
Summary of Total Phosphorus Loading for Existing Urban Land Uses - BMPs Applied

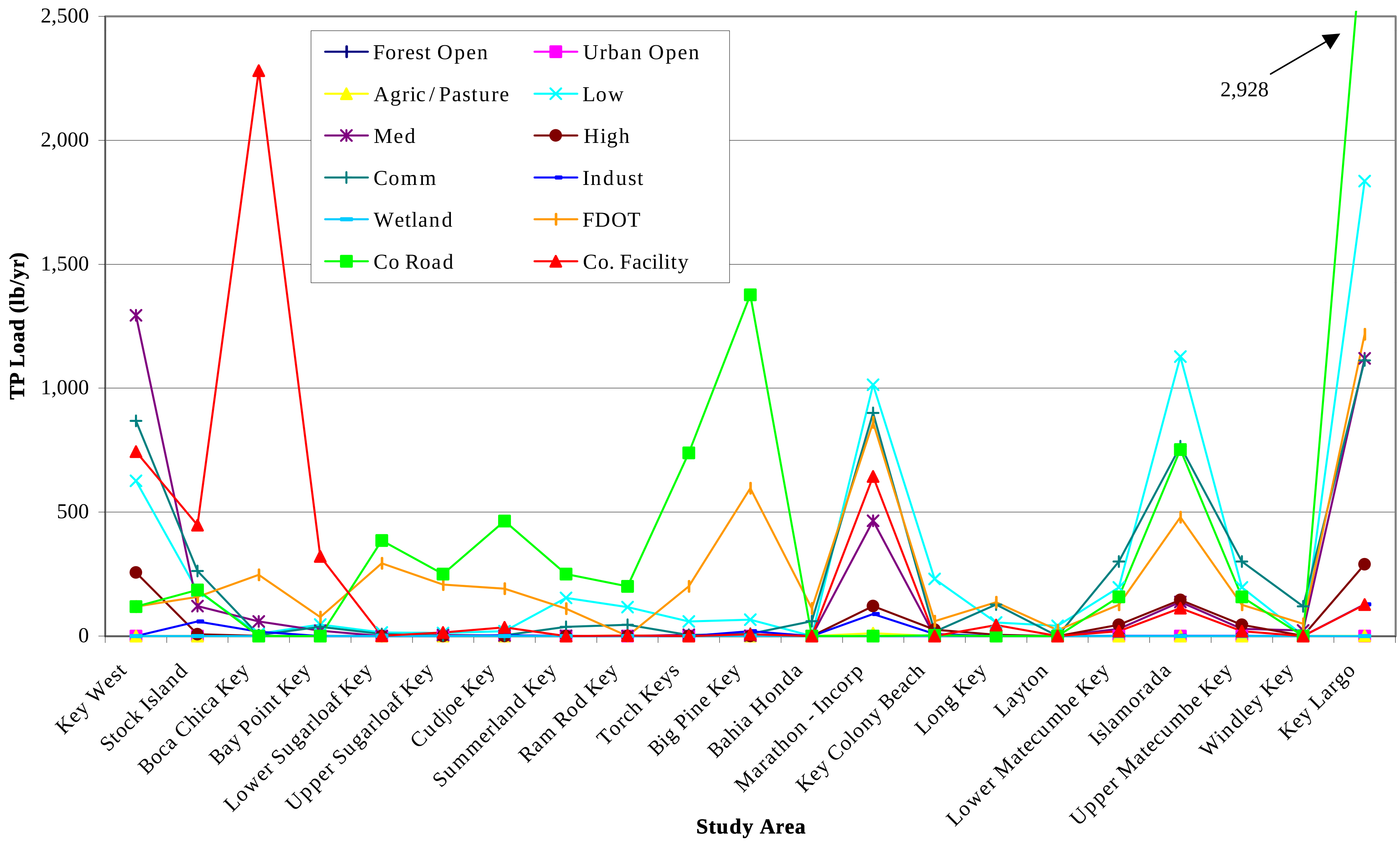


Figure 2.3 - 23
Monroe County Stormwater Management Master Plan
Summary of TSS Loading for Existing Urban Land Uses - BMPs Applied

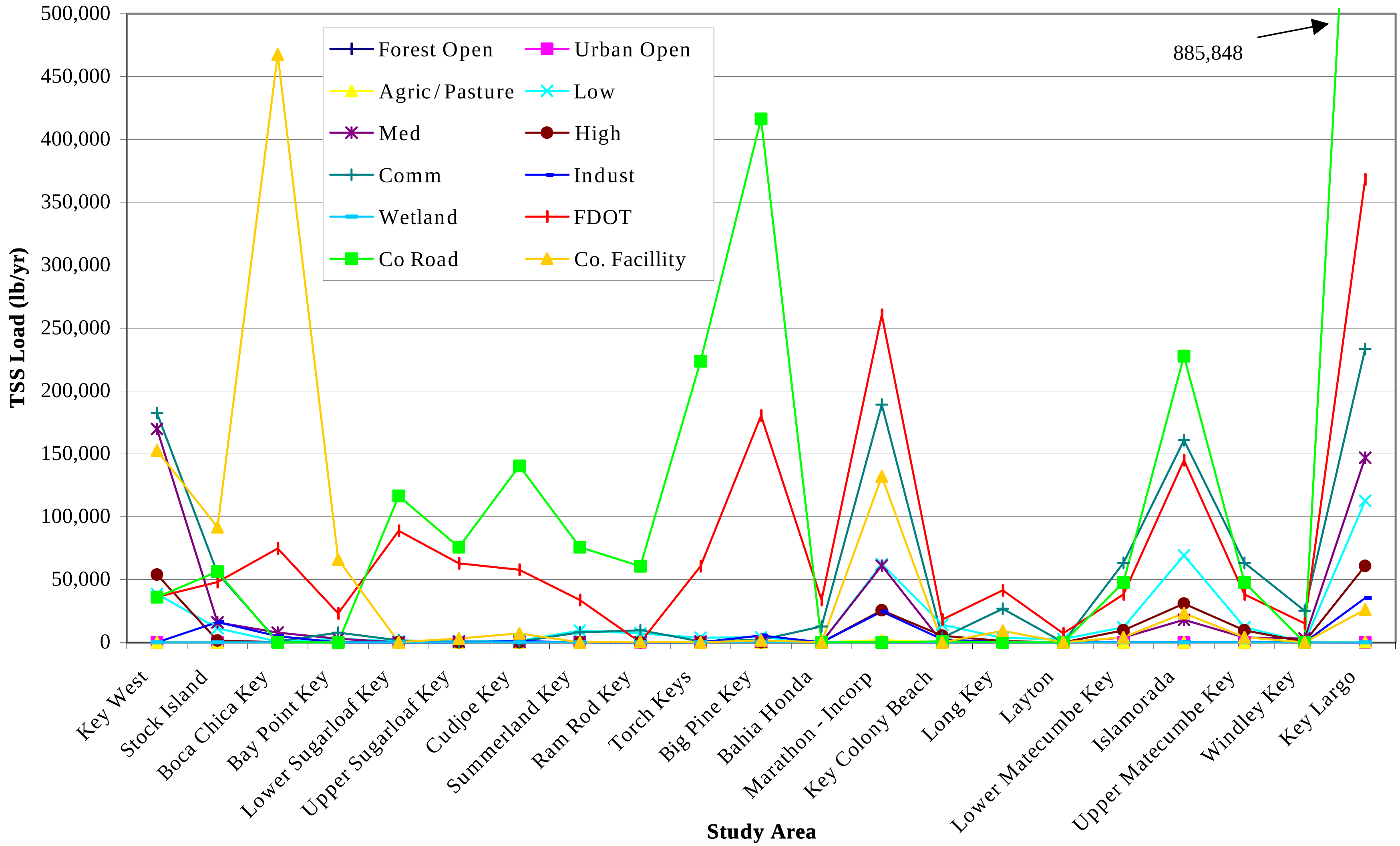


Table 2.3-16
Monroe County Stormwater Management Master Plan
Summary of Average Event Mean Concentrations for Each Study Area (mg/l) [1]

Study Area		Oxygen Demand		Solids		Nitrogen		Phosphorus		Metals			
No.	**Description**	**BOD**	**COD**	**TDS**	**TSS**	**TKN**	**NO2+3**	**DP**	**TP**	**Cd**	**Cu**	**Pb**	**Zn**
Lower Keys													
1	Key West	8.2	53	123	42	1.22	0.65	0.14	0.26	0.001	0.034	0.011	0.065
2	Stock Island	7.9	54	125	45	1.18	0.71	0.11	0.23	0.001	0.024	0.014	0.079
3	Boca Chica Key	5.9	34	75	29	1.07	0.83	0.07	0.16	0.001	0.014	0.012	0.062
4	Bay Point Key	5.2	31	68	23	0.99	0.69	0.06	0.14	0.001	0.013	0.011	0.048
5	Lower Sugarloaf Key	4.7	28	56	26	0.93	0.51	0.05	0.13	0.001	0.009	0.014	0.052
6	Upper Sugarloaf Key	4.3	26	51	21	0.91	0.51	0.05	0.11	0.001	0.008	0.012	0.044
7	Cudjoe Key	4.4	20	40	17	0.88	0.54	0.05	0.11	0.001	0.008	0.012	0.042
8	Summerland Key	5.4	30	67	25	0.95	0.53	0.07	0.15	0.001	0.013	0.013	0.052
9	Ram Rod Key	5.6	38	89	28	0.99	0.50	0.08	0.16	0.001	0.015	0.012	0.052
10	Torch Keys	5.0	33	66	30	0.97	0.49	0.06	0.14	0.001	0.010	0.015	0.057
11	Big Pine Key	5.6	37	72	38	1.01	0.49	0.07	0.17	0.001	0.011	0.017	0.069
12	Bahia Honda	4.7	32	69	24	0.93	0.51	0.05	0.13	0.001	0.009	0.012	0.047
Middle Keys													
13	Marathon - Incorp	6.8	45	110	31	1.04	0.58	0.10	0.19	0.001	0.022	0.011	0.057
14	Key Colony Beach	10.8	69	210	42	1.24	0.54	0.20	0.32	0.001	0.051	0.009	0.068
15	Long Key	4.9	32	72	23	0.94	0.55	0.06	0.13	0.001	0.012	0.011	0.044
16	Layton	7.4	47	129	31	1.08	0.51	0.13	0.22	0.001	0.030	0.011	0.056
Islamorada													
17	Lower Matecumbe Key	7.5	51	128	39	1.07	0.56	0.11	0.21	0.001	0.024	0.013	0.067
18	Upper Matecumbe Key	7.5	48	123	38	1.07	0.55	0.11	0.22	0.001	0.025	0.013	0.066
19	Windley Key	5.2	32	72	24	0.94	0.55	0.06	0.14	0.001	0.013	0.011	0.044
20	Plantation Key	6.7	45	111	33	1.01	0.54	0.10	0.19	0.001	0.020	0.011	0.059
Upper Keys													
21,22	Key Largo	6.1	56	125	38	1.10	0.42	0.09	0.20	0.001	0.019	0.011	0.059
	Average	6.1	41	94	32	1.04	0.55	0.08	0.18	0.001	0.017	0.013	0.058

Note: 1 Event Mean Concentration (EMC) is calculated as the load (lb / yr) divided by the runoff volume (ac-ft / year) with a conversion factor of 0.3677.

Table 2.3-17
Monroe County Stormwater Management Master Plan
Summary of Increase in Average Event Mean Concentrations for Each Study Area (mg/l) [1]

Study Area		Oxygen Demand		Solids		Nitrogen		Phosphorus		Metals			
No.	Description	BOD	COD	TDS	TSS	TKN	NO2+3	DP	TP	Cd	Cu	Pb	Zn
Lower Keys													
1	Key West	6.3	15.9	50	32	0.32	0.25	0.13	0.20	0.001	0.032	0.008	0.056
2	Stock Island	5.6	22.4	64	37	0.30	0.27	0.09	0.17	0.001	0.021	0.009	0.066
3	Boca Chica Key	2.5	19.4	46	22	0.25	0.30	0.04	0.08	0.000	0.008	0.003	0.038
4	Bay Point Key	2.0	12.8	33	16	0.16	0.17	0.03	0.07	0.000	0.007	0.003	0.026
5	Lower Sugarloaf Key	1.4	13.3	26	19	0.11	(0.03)	0.02	0.06	0.000	0.003	0.005	0.028
6	Upper Sugarloaf Key	1.0	9.7	19	14	0.08	(0.02)	0.02	0.04	0.000	0.002	0.004	0.021
7	Cudjoe Key	0.8	8.1	16	10	0.07	(0.01)	0.01	0.03	0.000	0.002	0.003	0.016
8	Summerland Key	2.0	14.5	37	18	0.13	(0.01)	0.04	0.07	0.000	0.008	0.005	0.028
9	Ram Rod Key	2.7	15.4	44	21	0.15	0.02	0.05	0.09	0.000	0.011	0.005	0.033
10	Torch Keys	1.8	16.2	32	23	0.14	(0.03)	0.03	0.07	0.000	0.005	0.006	0.035
11	Big Pine Key	2.3	21.7	42	31	0.19	(0.04)	0.04	0.09	0.000	0.005	0.008	0.045
12	Bahia Honda	1.6	12.9	30	17	0.10	0.01	0.02	0.06	0.000	0.004	0.004	0.026
Middle Keys													
13	Marathon - Incorp	4.2	17.1	57	23	0.18	0.12	0.08	0.13	0.000	0.018	0.005	0.041
14	Key Colony Beach	9.8	17.6	110	31	0.30	0.23	0.20	0.27	0.001	0.051	0.009	0.068
15	Long Key	1.9	11.6	32	15	0.10	0.05	0.03	0.06	0.000	0.007	0.003	0.023
16	Layton	4.9	19.1	75	23	0.22	0.05	0.11	0.15	0.001	0.026	0.005	0.040
Islamorada													
17	Lower Matecumbe Key	5.0	22.0	72	31	0.21	0.11	0.09	0.15	0.001	0.020	0.007	0.052
18	Upper Matecumbe Key	4.7	23.2	74	30	0.22	0.08	0.09	0.15	0.001	0.021	0.007	0.049
19	Windley Key	2.7	3.6	16	16	0.08	0.10	0.04	0.07	0.000	0.009	0.005	0.030
20	Plantation Key	3.6	25.8	74	25	0.18	0.03	0.07	0.12	0.000	0.015	0.004	0.037
Upper Keys													
	Key Largo	4.3	17.9	50	29	0.20	0.03	0.08	0.14	0.001	0.017	0.008	0.051
	Average	3.2	18.4	49	25	0.19	0.07	0.06	0.11	0.000	0.013	0.006	0.040

Note: 1 Event Mean Concentration (EMC) is calculated as the load (lb / yr) divided by the runoff volume (ac-ft / year) with a conversion factor of 0.3677.

2.3-17 represents the increase in runoff concentration due to urban loading. In loosely comparing these concentrations to the targets indicated in Subsection 2.3.1, it appears that to reduce the concentrations to values below the targets, minimal dilution (less than 10 to 1) would be required in the near shore, except in the cases of nitrate plus nitrite nitrogen and total phosphorus. For these parameters, dilutions of 20 to 50 times would be needed.

2.3.10.2 Stormwater Runoff versus Wastewater Loading

Table 2.3-18 combines the estimated wastewater loading data and the WMM urban stormwater loading estimates for comparison purposes. The sanitary wastewater information was obtained from the draft Monroe County Sanitary Wastewater Master Plan, SWMP (CH_2M-Hill, March 2000) and the study areas have been combined to compare the results directly. Key West data were not included in the SWMP, so that the Key West stormwater loadings have been excluded in this comparison.

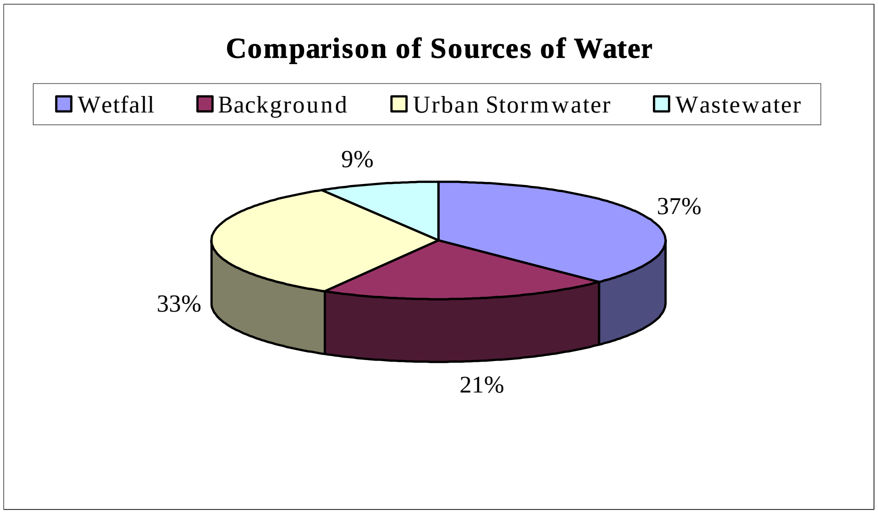
Finally, summarizing the segregated loading to the wastewater loads as defined by the Monroe County Wastewater Master Plan, Table 2.3-18 provides a comparison of the runoff or flow, total nitrogen and total phosphorus loading for wetfall, background (natural minus wetfall), urban stormwater and wastewater. The comparison is illustrated in **Figure 2.3-24**. For runoff volume or wastewater flows, urban runoff represents one-third of the total and wastewater represents less than 10 percent. For total nitrogen, urban stormwater and wastewater represent about a third each with natural (background plus wetfall) making up the final third. For total phosphorus, wastewater loading represents almost half of the load with urban stormwater and natural loading making up about a fourth each.

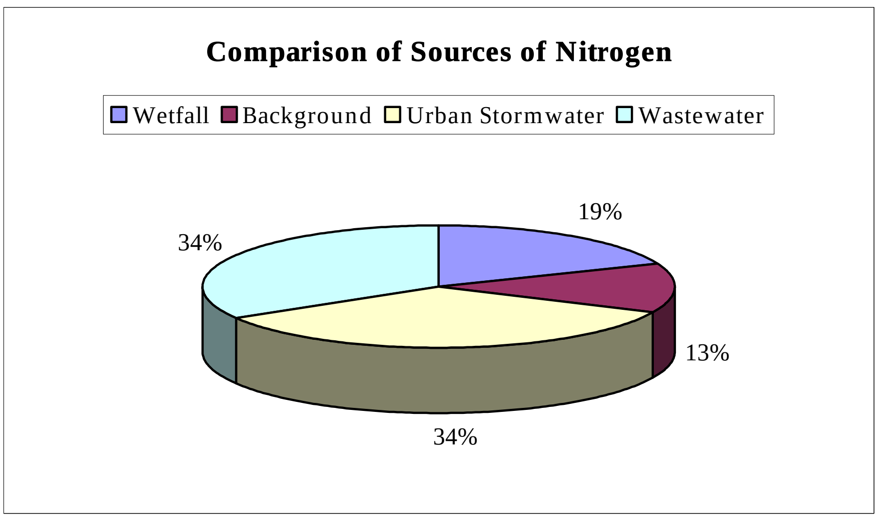
Table 2.3 - 18
Monroe County Stormwater Management Master Plan
Summary of Pollutant Loading Estimates [(1)]

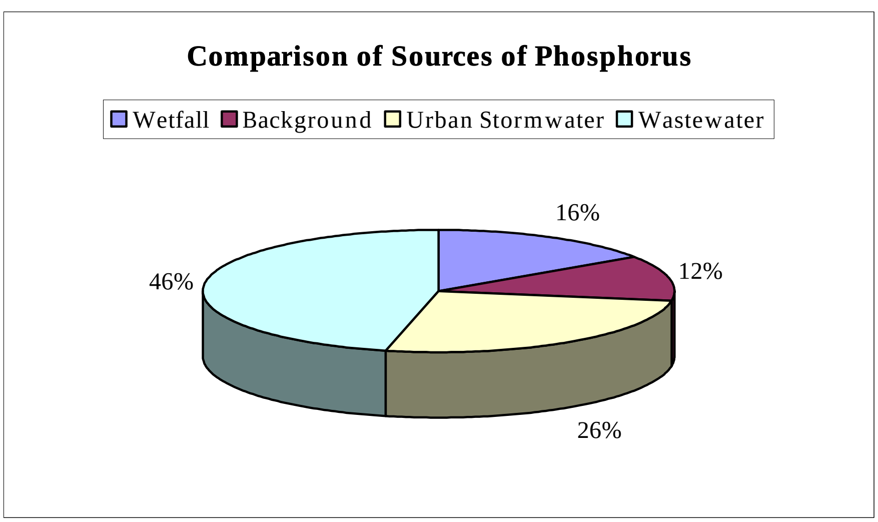
Source	Runoff or Flow (ac-ft/yr)	Runoff or Flow (mgd)	Runoff or Flow %	Total Nitrogen (lb/yr)	Total Nitrogen %	Total Phosphorus (lb/yr)	Total Phosphorus %
Wetfall [(2)]	33,168	29.59	37.5%	88,388	18.8%	14,431	15.7%
Background [(3)]	18,372	16.39	20.7%	61,947	13.2%	10,990	11.9%
Urban Stormwater [(4)]	29,295	26.13	33.1%	161,623	34.3%	24,005	26.1%
Wastewater	7,716	6.9	8.7%	158,785	33.7%	42,672	46.3%
Total	88,551	79.0		470,743		92,098	

Notes:
(1) Excludes Key West
(2) Wetfall is the estimated flow and loading from Water / Wetland Land Uses.
(3) Background (or Natural) is all land uses (other that Water / Wetland) converted to Forest / Open.
(4) Uban Stormwater is Existing Land Use Loading minus Natural Load.

Figure 2.3-24
Monroe County Stormwater Management Master Plan
Graphical Comparison of Water and Nutrient Loading Sources







2.4 Existing Systems Inventory and Assessment

To further understand the workings of the stormwater management system within Monroe County, an inventory of existing infrastructure was completed including mapping, identification of facilities, and field visits.

2.4.1 Inventory of Existing Systems

The inventory of existing public stormwater management facilities was completed by Keith & Associates. Provided in Appendix J, Technical Memorandum No. 2 includes inventory tables (Appendix 2 of Technical Memorandum No. 2) identifying public facilities, map location, source of data, study area, and pertinent features of the facilities. Each facility was described by drainage pipe sizes (there may be more than one pipe as part of the overall system inventoried), type of facility (exfiltration trench, inlet structures, swales/retention areas, wells, control structures, or oil/sand separators), and whether or not water quality improvements were provided.

Each of the facilities is also mapped in Appendix 1 of Technical Memorandum No. 2. The maps include the location of each facility with symbols to identify facilities with water quality improvements, systems with wells, and facilities specially visited in the field for evaluation (see Subsection 2.4.2 below). Also identified on the maps are areas located by citizens who attended one of the public meetings. These areas are noted as potential problem areas.

In all, 254 structures were located. Table 2.4-1 summarizes the structures by study areas. Since some of the structures, particularly along roadways, were within more than one study area, it is not possible to count the structures by study area. Of the structures found, 167 (66 percent) contained a water quality treatment system (infiltration trench or detention/retention pond). Only 4 oil/water separators were found. Also, 110 structures included inlets and 64 systems contained wells.

2.4.2 Residential Survey

As part of the SMMP, ten (10) residential subdivisions were visited as a representative sample of stormwater management for residential land uses in Monroe County. Appendix K provides documentation of the site visits. Subdivisions visited included:

- Cross Key Waterways
- Tropical Atlantic Shores
- Stratton Subdivision
- Tropical Bay Subdivision
- Bay Point Subdivision
- Pirates Cove
- Plantation Key Colony
- Eden Pines Subdivision
- Venture Out Resort
- Big Coppitt Key Area

Table 2.4-1
Monroe County Stormwater Management Master Plan
Summary of Stormwater Structure Inventory

No.	Study Area	Water Quality Benefits With	Water Quality Benefits Without	Water Quality Benefits Total
1	Key West	38	29	67
2	Stock Island	7	13	20
3	Boca Chica Key	6	8	14
4	Bay Point	1	3	4
5	Lower Sugarloaf	0	2	2
6	Upper Sugarloaf	3	4	7
7	Cudjoe Key	3	2	5
8	Summerland Key	4	0	4
9	Ram Rod Key	2	1	3
10	Torch Keys	2	1	3
11	Big Pine Key	6	9	15
12	Bahia Honda	0	3	3
13	Marathon - Unincorp	0	0	0
13a	Marathon - Incorp	25	24	49
14	Key Colony Beach	2	2	4
15	Long Key	0	1	1
16	Layton	0	1	1
17	Lower Matecumbe	0	3	3
18	Islamorada	1	1	2
19	Upper Matecumbe	0	6	6
20	Windley	11	25	36
21,22	Key Largo	1	4	5
	Totals	112	142	254

Table 2.4-2 summarizes the information collected during the qualitative visits. All of the subdivisions had paved roads; however, only one had curbs and gutter and none had swales. One subdivision appeared to have a discharge pipe and two appeared to have infiltration trenches (French drain). If this survey is representative of residential subdivisions within Monroe County, the it can be concluded that 10 to 20 percent of such subdivisions have any kind of stormwater management system at all, even though roads are paved. Also, most of the subdivisions have pea gravel (70 percent) which may contribute to sedimentation of near shore waters. Finally, residents within four of the ten subdivisions visited noted that flooding of streets had been observed.

2.4.3 General Geographic Information System Set Up

This section describes how the digital map coverages and tabular data need to be formatted for later inclusion into a geographic information system (GIS). The combination of spatial (digital map coverages) and attribute (tabular) data may be used at a later date to populate a Stormwater Management GIS for the County.

The result of Subtask I-C, Items 1 and 2 (the inventory of the stormwater systems) includes the locations of existing stormwater structures. This information includes x and y coordinate values for each structure. During the structure inventory process, a unique identifier would be assigned to each structure and stored with the x and y coordinate data. The identifier could consist of both alpha and numeric characters, and must be unique for each structure within the County. The coordinate values and unique identifier for each structure would be used to generate a digital map coverage, which would then represent the entire stormwater structure inventory within the County. Each structure within the digital map coverage would also store the feature's unique identifier.

Tabular data about each structure could include information such as the year installed, size, and material of each structure. In addition, the tabular data record for each structure would also include the unique identifier that was assigned to the structure during Items 1 and 2 of this Subtask. This tabular data could either be stored in a spreadsheet or a database table.

In the future, the digital map coverages and tabular data may be imported into a GIS. To do so, the digital map coverages would be imported to the GIS, creating the spatial component of the GIS. The tabular data would also be added to the GIS. The unique identifiers included in both the digital map coverages and the tabular data would be used to create the relationship between each structure in the digital map coverages and their associated attribute information in the tabular data files (spreadsheet or database table). After this relationship has been established within the GIS software, the full functionality of the GIS software should be available for use by the County, enabling capabilities such as analysis, report generation, and editing within the GIS environment.

Table 2-2
Monroe County Stormwater Management Master Plan
Stormwater Characteristics of Visited Residential Subdivisions

Area	Study Area	Mile Marker	Lot Coverage [1]	Characteristics: Paved Roads	Curbs & Gutters	Discharge Outlets	Swales	Ponds	Other	Comments
Upper Keys										
Cross Key Wateways	Key Largo	103.0	Pea & grass	Y	N	N	N	N	N	No anecdotal flooding [2]
Pirates Cove	Key Largo	98.5	Pea & grass	Y	N	N	N	N	N	No anecdotal flooding
Tropical Atlantic Shores	Key Largo	90.7	Pea & grass	Y	N	Y	N	N	Y [3]	
Plantation Key Colony	Key Largo	90.2	Grass	Y	N	N	N	N	N	
Stratton Subdivision	Upper Matecumb	82.0	Grass	Y	N	N	N	N	N	
Lower Keys										
Eden Pines Subdivision	Big Pine Key	30.2	Pea & grass	Y	N	N	N	N	N	No anecdotal flooding
Tropical Bay Subdivision	Big Pine Key	30.2	Pea & grass	Y	N	N	N	N	N	Flooding observed by residents
Venture Out Resort	Cudjoe Key	23.0	Paved	Y	Y	N	N	N	Y [3]	Flooding observed by residents
Bay Point Subdivision	Saddlebunch Key	15.0	Pea & grass	Y	N	N	N	N	N	Flooding observed by residents
Big Coppitt Residential Area	Boca Chica Key	11.0	Pea & grass	Y	N	N	N	N	N	Flooding observed by residents
	Total Number		Yes	10	1	1	0	0	2	
			No	0	9	9	10	10	8	

Notes:
(1) General coverage of residential lots in the subdivision.
(2) "No anecdotal flooding" means that a resident was interviewed and no flooding has been reported while the resident has been there.
(3) Believed to be French Drains.

2.5 Existing Regulatory Programs

The regulation of stormwater runoff within Monroe County is accomplished through federal, state, regional, and local legislative and governmental requirements. In order to define the regulatory and intergovernmental framework of the Monroe County Stormwater Management Master Plan, this section describes existing laws and regulations as they apply to the control of stormwater runoff with respect to flooding and water quality.

2.5.1 Federal Law and Regulations

Federal regulatory requirements are best understood by a description of the various agencies with jurisdiction over stormwater flooding and/or water quality. In particular, federal regulations are administered by the Environmental Protection Agency (USEPA), Army Corps of Engineers (USACOE), National Oceanic and Atmospheric Administration (NOAA) and US Fish and Wildlife Service. Federal laws and regulations are contained in the United States Code (USC) and Code of Federal Regulations (CFR), respectively, and sometimes refer to more than one federal agency. The federal government regulates sources of pollution via dozens federal laws, the most important of which for the purposes of this discussion are the National Environmental Policy Act (NEPA) and its amendments (42 USC §4321-4347) and the Clean Water Act (CWA) and its amendments (33 USC §1251 et seq.; that is, Title 33 of the US Code from §1251 to §1387).

2.5.1.1 National Environmental Policy Act (NEPA)

NEPA, originally adopted in 1969, provides the fundamental national policy of environmental protection. The specific purposes of NEPA include: "to declare a national policy which will encourage productive and enjoyable harmony between man and his environment, to promote efforts which will prevent or eliminate damage to the environment and biosphere and stimulate the health and welfare of man; to enrich the understanding of the ecological systems and natural resources important to the Nation; and to establish a Council on Environmental Quality" (CEQ). Congress directed that, "to the fullest extent possible", laws and regulations as well as agencies of the federal government will:

- Use a systematic approach integrating natural, social and environmental sciences in planning and decision making;
- Identify and develop methods with the CEQ to ensure that unquantified environmental benefits are considered with economic and technical ones;
- Consider environmental impacts, alternatives, short- and long-term impacts and resource commitments for legislation and governmental action significantly affecting the environment;

- Develop and study alternatives to actions related to unresolved conflicts related to resource uses;
- Make available to state and local governments as well as individuals environmental information; and,
- Use ecological information for planning and resource-oriented projects.

These provisions have been the foundation of most environmental activities since their adoption in 1969.

2.5.1.2 The Clean Water Act (CWA)

The Clean Water Act, a 1977 amendment to the Federal Water Pollution Control Act of 1972, provides the basis for USEPA regulatory authority, allowing them to set effluent standards for industries (technology-based) and water quality-based effluent limits where necessary to meet water quality standards. Fundamentally, the CWA states that it is unlawful to discharge to waters of the United States (navigable waters) unless the discharge is permitted under the National Pollutant Discharge Elimination System (NPDES) program. The purpose of the CWA is to restore and maintain the "chemical, physical and biological integrity of the Nation's waters" using the following goals and policies:

- Discharge of pollutants to navigable waters was to be eliminated by 1985;
- Protection and propagation of fish, shellfish and wildlife and provide for recreation was to be achieved as an interim goal by mid-1983;
- Elimination of the discharge of toxic pollutants in toxic amounts;
- Provide financial assistance to construct public facilities;
- Develop and implement "areawide waste treatment management planning processes;"
- Develop technology to eliminate discharges through major research and demonstration projects; and
- Develop and implement programs for the control of nonpoint sources.

The first and last goals led to the development of the NPDES program. Originally, USEPA regulated discharge to navigable waters by defining point sources as discharges though a pipe; e.g., wastewater treatment plant or industrial discharge. In the CWA amendments of 1987, point source was defined as discharges from a pipe or open but confined conveyance, opening the door for regulation of stormwater discharges.

§1312 of the CWA states that if the discharge of pollutants from a point source (or group of point sources) that provides technology-based treatment levels (e.g., secondary treatment for wastewater treatment plants) interferes with the attainment of designated uses, then water quality based effluent limits are required.

§1313 requires each state to submit water quality standards to the USEPA and to review these standards every three years, starting in October, 1972. These standards can be no less stringent than those adopted by the USEPA and become the basis for the determination of impairment. §1313(d)(1) requires that each state must identify and rank those waters for which minimum treatment is not sufficient to maintain the applicable water quality. From this list, each state must prepare total maximum daily loads (TMDLs). A TMDL is a determination of the maximum loading that a water body can assimilate accounting for point sources, nonpoint sources, natural background and a margin of safety to account for unknowns. "Such load shall be established at a level necessary to implement the applicable water quality standards with seasonal variations and a margin of safety…" The list of ranked water bodies is commonly referred to as the "303(d) Priority List" (based upon the CWA numbering system). The state of Florida is currently working on the latest update to its list. An update must be filed with the USEPA every even year.

§1315(b) requires each state to prepare a report to Congress starting in April, 1976 (and every other year thereafter), describing the water quality of all navigable waters within the state. The description must include an analysis of the degree to which the waters are attaining water quality standards. This report (referred to as the 305(b) Report using CWA numbering) is produced by FDEP in even numbered years.

§1329 provides for nonpoint source (NPS) management programs. Originally contained in Section 319 of the 1987 Amendments to the CWA, this section establishes a national program to control the discharge of pollution from nonpoint sources by requiring the preparation of a Nonpoint Source Management Program. The most recent FDEP update to Florida's NPS Management Program is dated November, 1999, wherein the FDEP defines a watershed management approach based upon a 5-phased program:

Phase	Program
1	Initial Basin Assessment
2	Coordinated Strategic Monitoring
3	Data Analysis and TMDL Development
4	Management Action Plan
5	Implementation

§1342 provides the regulatory authority for the NPDES permitting program and allows for the delegation of such permitting to each state. FDEP obtained delegation for the wastewater and industrial NPDES permits and is planning to obtain such authority for stormwater discharges in May of 2000. The NPDES permits are 5 years in duration and according to §1342(o), renewal permits can not be issued with conditions that are less stringent than the previous ones (anti-backsliding provision).

§1324(p) adds stormwater discharges to the NPDES program based upon population and significant contribution. Municipalities with populations of 100,000 or more are required to obtain an NPDES permit, as are stormwater discharges from specific industrial activities. Also included are discharges that are judged to contribute to a violation to a water quality standard. These discharges are referred to as the Phase 1 stormwater discharges. Recently, the USEPA promulgated regulations pertaining to stormwater discharges from municipalities with population under 100,000. These "small" municipalities are referred to as Phase 2 dischargers. The discharges are regulated to control the discharge of stormwater pollution to the "maximum extent practicable," a term not defined in law or regulation.

§1344 provides for dredge and fill activities within navigable waters, a program that is administered by the Corps of Engineers. The legislation allows for the delegation of this authority to the states.

§2317 states that an interim goal administered by the Corps of Engineers is "no overall net loss of the Nation's remaining wetlands base … and a long-term goal to increase the quality and quantity of the Nation's wetlands." The USCOE is to work with the USEPA and Fish and Wildlife Service to meet this long-term goal.

2.5.1.3 Code of Federal Regulations Title 40

Based upon the laws identified above, the USEPA has issued regulations codified in Title 40 of the Code of Federal Regulations, commonly referred to as 40 CFR. The most pertinent sections of 40CFR include those in Chapter I - Environmental Protection Agency. This chapter has 14 Subchapters (A through R) categorizing 799 parts. Subchapter D considers Water Programs, Parts 100 to 149, the most applicable of which are §122 (EPA Administered Permit Programs), §123 (State Program Requirements), §124 (Procedures for Decision-making), §130 (Water Quality Planning and Management) and §131 (Water Quality Standards). These regulations implement the requirements of the CWA described above.

2.5.2 State of Florida Statutes

State laws and regulations are best described through individual law or regulation, rather than by the administrating agency, since the laws or regulations may apply to multiple agencies. Regulatory agencies that are responsible for the environment include the Department of Environmental Protection (DEP), Department of Community Affairs (DCA), and Department of Transportation (DOT).

The statutes are organized into forty-seven Titles, depending on the subject matter, each of which is made up of one or more chapters. Table 2.5-1 lists the Titles and

Table 2-1
1999 Florida Statutes
Statute Titles with Associated Chapters

Title	Description		Chapters
I	Construction of Statutes		1-2
II	State Organization		6-8
III	Legislative Branch; Commissions		10-13
IV	Executive Branch		14-24
V	Judicial Branch		25-44
VI	Civil Practice & Procedure		45-88
VII	Evidence		90-92
VIII	Limitations		95
IX	Electors and Elections		97-107
X	Public Officers, Employees, & Records		110-122
XI	County Organization & Intergovernmental Relations		124-164
XII	Municipalities		165-185
XIII	Planning and Development		186-191
XIV	Taxation and Finance		192-221
XV	Homestead & Exemptions		222
XVI	Education		228-246
XVII	Military Affairs & Related Matters		250-252
XVIII	Public Lands & Properties		253-274
XIX	Public Business		279-290
XX	Veterans		292-296
XXI	Drainage		298
XXII	Ports & Harbors		308-315
XXIII	Motor Vehicles		316-325
XXIV	Vessels		326-328
XXV	Aviation		329-333
XXVI	Public Transportation		334-349
XXVII	Railroads & Other Regulated Utilities		350-368
XXVIII	Natural Resources; Conservation, Reclamation, & Use		369-380
XXIX	Public Health		381-408
XXX	Social Welfare		409-430
XXXI	Labor		435-452
XXXII	Regulation of Professions & Occupations		454-493
XXXIII	Regulation of Trade, Commerce, Investments, & Solicitations		494-560
XXXIV	Alcoholic Beverages & Tobacco		561-569
XXXV	Agriculture, Horticulture, & Animal Industry		570-604
XXXVI	Business Organizations		606-623
XXXVII	Insurance		624-651
XXXVIII	Banks & Banking		655-667
XXXIX	Commercial Relations		670-688
XL	Real & Personal Property		689-723
XLI	Statute of Frauds, Fraudulent Transfers & General Assignments		725-727
XLII	Estates & Trusts		731-738
XLIII	Domestic Relations		741-753
XLIV	Civil Rights		760-765
XLV	Torts		766-773
XLVI	Crimes		775-896
XLVII	Criminal Procedure & Corrections		900-985

chapter numbers for all of the 1999 Florida Statutes (F.S.). Only a few of the statutes are pertinent to the control of stormwater runoff; these are discussed in more detail below.

2.5.2.1 Chapter 125 - County Government

Chapter 125 F.S. defines the powers and duties of county government including the powers to:

- Prepare and enforce comprehensive plans for development;
- Establish and administer programs for drainage and to cooperate with governmental agencies in the development and operation of such programs;
- Establish municipal service taxing or benefit units within which drainage services may be provided from revenues derived from service charges, special assessments or taxes collected within the unit; and,
- Establish special districts to include both unincorporated and incorporated areas within which municipal services are provided funded by service charges, special assessments or taxes within the district.

The statute also considers tourist taxes, general obligation and revenue bonds, loans to public agencies, the purchase or privatization of water, sewer or wastewater reuse utilities, and the proposed purchase of real property.

2.5.2.2 Chapter 157 - Drainage by Counties

Chapter 157 F.S. allows counties to establish a "ditch, drain or canal" to control runoff in lands that are low, wet or submerged or liable to become submerged based upon the petition of the landowners through which the drainage structure is to pass. The commission can appoint a three-person committee to control the facility, supervise its construction and levy taxes for its construction and maintenance.

2.5.2.3 Chapter 163 - Local Government Comprehensive Planning Act

Chapter 163 F.S. is entitled "Intergovernmental Programs" and is comprised of six parts. Only those parts and sections that are pertinent to stormwater management are discussed below.

Part I - Florida Interlocal Cooperation Act of 1969 (subsection 163.01 to 163.07). This section allows governments to enter into agreements of cooperation on the basis of mutual advantage. Such a contract, known as an interlocal agreement, is a joint exercise of governmental power and provides for the purpose of the agreement, duration of agreement, definition of organization needed to administer the programs, manner of financial support including equitable allocation of costs, provision for funding of the programs, as well as a number of other administrative issues. An interlocal agreement, for example, can be entered into between the County and one or more cities for the purpose of stormwater management and control or funding of such activities.

Subsection 163.03 defines the powers and duties of the Secretary of the Department of Community Affairs, including the supervising and administering the Department of Community Affairs with respect to matters affecting community affairs and local governments; providing assistance in securing federal and state funds; administering emergency aid to stricken communities; and providing technical assistance to local government regarding development, redevelopment, planning and zoning, and transportation.

Subsection 163.07 considers the efficiency and accountability of local governmental services, helping local municipalities and counties deal with conflicts related to the delivery and financing of services. Counties and municipalities are authorized to develop a plan to provide efficient, accountable, and coordinated delivery of local governmental services and through resolution of each government, create a commission responsible for developing the plan and provide a timetable for execution of the plan. The plan itself must conform to all of the comprehensive plans within the cooperating governments.

Part II - Growth Policy Act (subsection 163.2511 to 163.2526). This act regulates the infill and redevelopment of urban cores as methods to reduce urban sprawl. A local government may identify an area as an urban infill and redevelopment area for the purposes of "targeting development, job creation, transportation, crime prevention, neighborhood revitalization and preservation, and land use incentives." The plan for redevelopment must be collaborative and based upon a neighborhood participation process. The Department of Community Affairs can offer regulatory and economic incentives to promote such a redevelopment area including an Urban Infill and Redevelopment Assistance Grant Program (§163.2523).

Subsections 163.3161 to 163.3217 comprise the Local Government Comprehensive Planning and Land Development Regulation Act. The purpose of this Act is to use and strengthen the role, processes and powers of local governments "in the establishment and implementation of comprehensive planning programs to guide and control future development." One of the intents of the Act is that the adopted comprehensive plans have legal status and no public or private developments can be permitted except in conformity with the Act.

Each local government is to prepare a comprehensive plan according to the provisions of the Act and submit the plan for approval to the state land-planning agency (DCA). A new municipality (i.e., incorporated after the adoption of the act) must establish a local planning agency within one year of incorporation and prepare and adopt a comprehensive plan within three years of incorporation. Until the new municipality has adopted such a plan, the county plan is controlling. If a new plan is not adopted in three years, the regional planning agency is to prepare the comprehensive plan. The comprehensive plan must include a public participation program during the adoption process.

The comprehensive plan, commonly referred to as the "comp plan," must be economically feasible and among other items, contain a 5-year capital improvement element for public facilities needed for the orderly development of the community. The plan must also contain the following elements: future land use plan; traffic circulation; general sanitary sewer, solid waste, **drainage**, potable water and natural groundwater aquifer recharge plan; conservation element (conservation, use, and protection of natural resources); recreation and open space plan; housing element; coastal management element; and intergovernmental cooperation program. Chapter 9J-5, Florida Administrative Code, entitled the Minimum Criteria for Review of Local Governmental Comprehensive Plans and Determination of Compliance of the Department of Community Affairs, is the regulatory counterpart of this Act. Subsection 163.3177 also states that it is the intent of the Legislature that " public facilities and services needed to support development shall be available concurrent with the impacts of such development."

Subsection 163.3178 covers the coastal management element of a comprehensive plan, restricting development activities that would damage coastal resources. This element must contain an analysis of the effects of existing drainage facilities and the impact of point and nonpoint source pollution on estuarine water quality.

Subsection 163.3180 defines the concurrency requirements of the Act. Concurrency refers to the requirement that the infrastructure (e.g., drainage, sewage treatment, and potable water) required to service the new growth is in place concurrent with the new development. In particular, drainage facilities (among others) must "be in place and available to serve new development no later than the issuance by the local government of a certificate of occupancy or its functional equivalent." The sufficiency of the drainage facilities is dependent on the local levels of service defined by the local government within the comp plan.

Within one year after the adoption of the comprehensive plan, the local government must adopt and enforce land development regulations to implement the comp plan elements. These regulations must, among other things, "regulate areas subject to seasonal and periodic flooding and provide for drainage and stormwater management" and "provide that public facilities and services meet or exceed the standards established in the capital improvements element" and are concurrent.

2.5.2.4 Chapter 187 - State Comprehensive Plan

Chapter 187, F.S., provides the State Comprehensive Plan required by Chapter 186, F.S. Section 187.201(8) lists specific goals and policies for water resources, with the goal to "maintain the functions of natural systems and the overall present level of surface and ground water quality." Also "Florida shall improve and restore the quality of waters not presently meeting water quality standards." Specific policies include:

- Encourage the development of strict floodplain management programs design to preserve hydrologically significant wetlands and natural features;
- Protect surface and ground water quality and quantity; and,
- Eliminate the discharge of inadequately treated stormwater runoff.

2.5.2.5 Chapter 373 - Florida Water Resources Act

Chapter 373, F.S., consists of six parts, the two pertinent parts of which are described below.

Part I - State Water Resources Plan. This part of the Florida Water Resources Act includes requirements for the setting of minimum flows and levels for water bodies based upon regional priorities, authorizes inter-agency agreements for water resource management, and authorizes the acquisition of property for water or water-related resource protection. For the minimum flows and levels, Subsection 373.042 requires each water management district to set minimum flows for all surface waters and minimum water levels for ground waters.

Part IV - Management and Storage of Surface Waters. Consisting of Subsections 373.403 to 373.461, F.S., this part provides:

- definitions pertinent to the management of surface waters;
- exemptions (including the authorization of general permits);
- mitigation banks and off-site regional mitigation;
- mitigation requirements for transportation projects proposed by DOT;
- additional criteria for activities in surface waters and wetlands (see below for more details);
- permit processing;
- wetland delineation methodologies and formal determinations;
- concurrent permit reviews;
- prohibitions, violations and penalties (see below for more details); and,

- the Surface Water Improvement and Management Act (see below for more details).

Section 373.414 , F.S., requires that, as part of the demonstration that an activity will not be harmful to water resources or inconsistent with district objectives, the governing board of the water management district or FDEP will require the applicant to provide "reasonable assurance that state water quality standards applicable to waters … will not be violated and reasonable assurance that such activity … is not contrary to the public interest. Furthermore, if the activity "significantly degrades or is within an Outstanding Florida Water", the applicant must provide reasonable assurance that "the proposed activity will be clearly in the public interest" (emphasis added). This section also provides specific criteria for FDEP or the water management districts to apply in consideration of this two-modal test of reasonable assurance, as well as criteria for the review of potential mitigation measures provided in case the applicant is unable to meet one or more of the reasonable assurance criteria.

Subsection 373.414(3) defines the legislative intent to provide for the use of certain wetlands as a natural means to manage stormwater and to incorporate such wetlands into a comprehensive stormwater management plan subject to ecological and resource management constraints.

A critical section within Part IV is §373.430 F.S. (Prohibitions, violation, penalty, and intent). It is a violation of Part IV to cause pollution so as to "harm or injure human health or welfare, animal, plant or aquatic life or property;" "fail to obtain any permit required … or violate or fail to comply with any rule, regulation, order or permit …;" and "knowingly make any false statement." The section provides for penalties for violation of Part IV and is the foundation of the environmental management regulatory programs implemented by the FDEP and water management districts.

Sections 373.451 to 373.4595 are together called the Surface Water Improvement and Management Act (or SWIM Act). The Legislature found that the water quality of many surface waters was degraded and natural systems altered to an extent detrimental to the right of the public to enjoy such waters. Further, it found that it is the duty of the state to enhance the environmental and scenic value of surface waters. Factors contributing to the decline include point and nonpoint source pollution and destruction of natural systems. The SWIM act required each water management district to prepare plans and implement programs for the improvement and management of surface waters. FDEP was also authorized to conduct statewide research to aid the understanding of impairment and restoration.

2.5.2.6 Chapter 376 - Pollutant Discharge Prevention and Removal

The first part of Chapter 376, F.S., is called the Pollutant Discharge Prevention and Control Act (§376.011 to §376.21). This Act controls the discharge of pollutants from vessels and terminal facilities to coastal waters of the state and defines the duties and powers of FDEP to implement the Act.

2.5.2.7 Chapter 380 - Land and Water Management

Chapter 380 F.S. provides for the management of land and water within the state of Florida. Part I of the statute is called "The Florida Environmental Land and Water Management Act of 1972," Part II is related to coastal planning and management and Part III considers the Florida Communities Trust. Only Part I is relevant to the Stormwater Management Master Plan.

Two elements of Part I relate to the Florida Keys. Section 380.051 provides a means of coordinated agency review for permits within the Florida Keys Area of Critical State Concern and authorizes interlocal agreements among state, regional and local agencies to coordinate development review. Section 380.0552 F.S., entitled the "Florida Keys Area Protection Act," defines the Florida Keys area as an area of critical state concern and requires the governor to appoint a resource planning and management committee to oversee the state's planning responsibilities within the Keys.

2.5.2.8 Chapter 381 - Public Health, General Provisions

Chapter 381, F.S., relates to Public Health and is mentioned here because it regulates onsite sewage treatment and disposal systems (§381.0065 to §381.0068, F.S.). While not specifically a matter for the Monroe County Stormwater Management Master Plan, stormwater has been related to the transport of pollutants from onsite sewage treatment systems. The Monroe County Sewage Management Master Plan, currently under development, provides a consideration of onsite sewage treatment systems.

2.5.2.9 Chapter 403 - Air and Water Pollution Control Act

Chapter 403, F.S., is the major statute related to the environmental management of the state, especially Part I - Pollution Control (Subsections §403.021 to §403.4132, F.S.). The legislative declaration (§403.021, F.S.) states that it is to be the public policy "to provide that no wastes be discharged into any waters of the state within first being given the degree of treatment necessary to protect the beneficial uses of such waters." To understand the provisions of this Act, a few definitions are pertinent:

Contaminant is defined as "any substance which is harmful to plant, animal or human life.

Pollution is defined as "the presence … of any substances, contaminants, noise, or manmade or man-induced impairment or air or waters or alteration of the chemical, physical, biological, or radiological integrity of air or water in quantities of levels which are or may be potentially harmful or injurious to human health or welfare, animal or plant life, or property or which unreasonably interfere with the enjoyment of life or property, including outdoor recreation unless authorized by applicable law."

Waters are defined as including "rivers, lakes, streams, springs, impoundments, wetlands, and all other waters or bodies of waters, including fresh, brackish, saline, tidal, surface, or underground waters. Waters owned entirely by one person other than the state are included only in regard to possible discharge on other property or water."

Wastes are defined as "sewage, industrial wastes, and all other liquid, gaseous, solid, radioactive, or other substances which may pollute or tend to pollute any waters of the state."

Stormwater management program is defined as "the institutional strategy for stormwater management including urban, agricultural and other stormwater."

Watershed is defined as "the land area which contributes to the flow of water into a receiving body of water."

Subsection 403.061, F.S., grants FDEP the power and duty to control and prohibit pollution of air and water, including the responsibility to develop and comprehensive program for the prevention, abatement and control of the pollution of the waters of the state. FDEP can group waters into classes related to the present and future "most beneficial uses" of the water. This section is implemented through the classification system provided in Chapter 62-302, Florida Administrative Code (see Section 2.5.3.7 below). This section also authorizes FDEP to establish water quality standards, including provision for reasonable mixing zones, except in Outstanding Florida Waters, and special standards for wetlands. To accomplish the implementation of pollution control programs, FDEP is authorized to establish a permitting system for the operation, construction, or expansion of pollution sources.

Subsection 403.0885, F.S., authorizes FDEP to establish a state National Pollutant Discharge Elimination System (NPDES) permitting program in accordance with Section 402 of the Clean Water Act (Public Law 92-500, as amended, 33 U.S.C. ss. 1251 et seq.) and to pay entirely for the program through permit fees. This allows the state to assume delegation of the NPDES permitting program from the U.S. Environmental Protection Agency.

2.5.2.10 Florida Watershed Restoration Act

During 1999, the Florida Legislature passed the Florida Watershed Restoration Act which creates a new Section 403.067 F.S. covering Total Maximum Daily Loads (TMDL). As noted in the discussion of the Clean Water Act (Subsection 2.5.1.2 above), a TMDL is the estimated total loading that a water body can assimilate accounting for point sources, nonpoint sources, natural background and a margin of safety to account for unknowns without exceeding water quality standards. Subsection 403.067(1) states that the TMDL process is "scientifically based" and is necessary to "fairly and equitably allocate pollution loads to both nonpoint and point sources." Further the allocation of load will include cost-effectiveness as a consideration and may be implemented through "non-regulatory and incentive-based programs." The first step in the TMDL process is to prepare a 303(d) Priority List (see Subsection 2.5.1.2 above) for which the TMDL calculation is to be completed according to a schedule. Based upon the list, FDEP is to prepare TMDL analyses and allocate the loading. The allocation process will be subject to a new rule scheduled to be adopted in 2000/2001. TMDLs can be based upon a Pollutant Load Reduction Goal (PLRG, see Subsection 2.5.3.3 below). Allocation of the TMDL will be pursuant to rule and will include consideration of existing treatment levels, different impacts by pollutant sources, the availability of treatment technology, economic and technical feasibility, cost-benefit analysis, reasonable schedules, and moderating provisions of the rules. The TMDLs will ultimately be adopted by administrative regulation.

2.5.3 State of Florida Regulations

Regulations are counterparts to the state statutes. These are contained mainly in Chapter 6 of the Florida Administrative Code (FAC). As in the case of the state statutes, descriptions of pertinent regulations are provided below. It should be noted that for the most part, the regulations are administered by FDEP, although the growth management regulations listed are managed by DCA.

2.5.3.1 Chapter 62-4 - Permits

Chapter 62-4 provides general regulations regarding the "issuance, denial, renewal, extension, transfer, modification, suspension and revocation of any permit" required by FDEP. The three parts of the Chapter include Part I - General, Part II - Specific Permits, and Part III - General Permits. The fundamental statement in the rule is contained in §62-4-030:

> "Any stationary installation which will reasonably be expected to be a source of pollution shall not be operated, maintained, constructed, expanded, or modified without the appropriate and valid permits issued by the Department, unless the source is exempted by Department rule. The Department may issue a permit only after it receives a reasonable assurance that the installation will not cause pollution in violation of any of the provisions of Chapter 403, F.S., or the rules promulgated thereunder."

The rest of the chapter deals with exemptions, procedures to obtain a permit, fees, special and general permits, and special provisions. The key phrases here are "exempted", and "reasonable assurance." Exemptions include structural changes that do not alter the "quality, nature, and quantity of … water contaminant … discharges or which will not cause pollution"; and existing or proposed installations which FDEP determines does not or will not discharge contaminants in sufficient quantity "as to contribute significantly to the pollution problems in the State."

Procedures for obtaining a permit from FDEP including processing time and fees are covered in §62-4.050. Fees for implementation of the FDEP regulatory and surveillance program are defined in §62-4.052. Also, typically FDEP issues permits with both general and specific permit conditions; the general permit requirements are listed in §62-4.160.

In Part II (Specific Permits; Requirements), three sections are of particular importance. The first set of requirement is listed in §62-4.242, entitled "Antidegradation Permitting Requirements, Outstanding Florida Waters; Outstanding National Resource Waters; Equitable Abatement."

> *Antidegradation*. This rule refers to the antidegradation policy defined in §62-302.300 and 62-302.700 discussed below. In particular, the policy states that FDEP may permit a discharge that will not reduce the receiving water quality below its classification if the degradation is "necessary or desirable under federal standards and under circumstances which are clearly in the public interest." §62-4.242 describes the factors that the department must consider in evaluating this two-pronged qualification, which is applicable to stormwater discharges as well as wastewater or industrial discharges to surface waters. The criteria to evaluate these two qualifications include: whether the project is important to and beneficial to public health, safety and welfare; whether the discharge will adversely affect the conservation of fish and wildlife and their habitat; whether the discharge will affect water-based recreation including fishing in the area; and whether the discharge is consistent with any SWIM Plan.
>
> *Outstanding Florida Waters.* §62.4-242(2) regulates discharges to Outstanding Florida Waters (OFW). Basically, FDEP may not issue a permit for a direct discharge to an OFW or which significantly degrades an OFW unless the discharge is clearly in the public interest and either a FDEP permit was issued prior to designation as an OFW or the existing ambient water quality will not be lowered outside an approved mixing zone. Similar, yet more stringent requirements apply to Outstanding National Resource Waters (ONRW).
>
> *Equitable Abatement.* A rarely used or quoted portion of the FAC [§62-4.242(4)] provides for the protection and enhancement of surfaces waters with quality artificially lowered below that necessary for their designated use. Under these circumstances, no permit to discharge pollutants can be issued unless "water quality standards once achieved would not be violated as a result of the proposed activity or discharge", the discharge is "necessary or desirable under federal standards and it is "clearly in the public interest." The rest of the rule considers the equitable allocation of allowable discharge under the circumstances to multiple discharges.

§62-4.243 provides exemptions to two types of artificial water bodies: artificial water bodies classified for agricultural supplies; and water bodies classified for navigation, utility and industrial use.

§62-4.244 describes FDEP regulations related to mixing zones. A mixing zone is an area adjacent to a point of discharge allowed to be degraded to minimum conditions [§62-3.051(1)] so as "to provide an opportunity for mixing and thereby reduce the cost of treatment." Specific restrictions on the applicability of mixing zones are listed.

2.5.3.2 Chapter 62-25 - Regulation of Stormwater Discharge

The state of Florida is one of less than 10 states in the United States that have adopted regulations for stormwater discharges. These regulations are contained in Section 62-25. This section states that "the discharge of untreated stormwater may reasonably be expected to be a source of pollution of waters of the state and is, therefore, subject to Department regulation." A new stormwater discharge facility is defined as a facility not in existence before February 1, 1982, or for which a permit was issued prior to this date, or an existing structure that has been modified. Other definitions are provided for detention, filtration, regional stormwater discharge facility, retention, stormwater management system, swale, and wetlands stormwater discharge facility. Also "stormwater" is defined as "the flow of water which results from, and which occurs immediately following, a rainfall event."

§62-25.025 provides design and performance standards for stormwater discharge facilities. Particular standards include:

- Retention and detention basins must provide treatment volume capacity again within 72 hours.
- Filtration system must have a safety factor of two or more unless otherwise proven.
- Swales must percolate 80 percent of the runoff from a 3-year, 1-hour design storm within 72 hours.
- Permanently wet retention and detention facilities must be fenced unless the side slopes are no steeper than 4 units vertical to 1 unit horizontal (4:1) out to 2 feet below the control elevation.
- Control of oil and grease is necessary in areas subject to such runoff.
- Facilities discharging to OFWs must include 50 percent more treatment than minimum requirements.

Exemptions to these rules include facilities for: one single family unit, duplex, triplex or quadruplex (if not part of a larger subdivision); single family residential project of less than 10 acres and less than 2 acres of impervious surface; facilities made up entirely of properly designed swales; facilities discharging to regional stormwater facilities; facilities for agricultural lands that are part of a Conservation Plan; and facilities for silvicultural lands.

§62-25.035 requires a general permit for the construction of four types of facilities:

- facilities that discharge to a permitted stormwater facility;
- facilities that provide retention or detention with filtration of the first inch of rainfall or for projects of less than 100 acres, treatment of the first 1/2 inch of runoff;
- modification or reconstruction of an existing government-operated facility "not intended to serve new development, and which will not increase pollution loading, or change points of discharge in a manner that would adversely affect the designate uses; or
- facilities that use a combination of stormwater management systems.

For the most part, these regulations are delegated to the water management district, and in the particular case of Monroe County, to the South Florida Water Management District through the Environmental Resource Permit process.

2.5.3.3 Chapter 62-40 - State Water Policy

The State Water Policy is intended "to provide water policy goals, objectives, and guidance for the development and review of programs, rules, and plans relating to water resources, as expressed in Chapters 187, 373, and 403, Florida Statutes." The chapter also explains and expands upon the various roles of state, regional, and local governments in the planning and implementation of the State Water Policy. While the chapter provides overall water program policy, the rule is not to be used as standards and criteria for individual permit review [§62-40.110(4)].

Part III of the chapter provides general policies related to water supply, water quality protection and management, flood protection and floodplain protection, natural systems protection and management, and management policies. Programs, rules and plans must seek to follow these policies if "economically and environmentally feasible, not contrary to the public interest and consistent with Florida law." A few pertinent policies are listed below:

- "Restore and protect the quality of ground and surface water by solving current problems and ensuring high quality treatment of stormwater and wastewater."

- "Encourage nonstructural solutions to water resource problems and give adequate consideration to nonstructural alternatives whenever structural works are proposed."

- "Manage the construction and operation of facilities which dam, divert, or otherwise alter the flow of surface waters to minimize damage from flooding, soil erosion or excessive drainage."

Part IV provides policies related to resource protection and management. §62-40.432 deals with surface water management and protection through policies for stormwater management programs. The major policies within this subsection are listed below.

- The primary goals for the state's stormwater management program include: maintain the pre-development characteristics of a site; reduce stream channel erosion, pollution and flooding; reduce stormwater pollution loading; encourage reuse; enhance groundwater recharge; maintain estuarine salinity regimes; and address stormwater management on a watershed scale.

- Watershed management plans are to be development the each water management district consistent within the SWIM and NPDES programs.

- In the development of an overall stormwater management program within the state, FDEP will be the lead agency responsible for the overall program goals, objectives and guidance. The water management districts are to administrate the stormwater management program through watershed specific goals, objectives and plans and the definition of watershed-specific pollution load reduction goals. Local governments implement stormwater management programs with the support of the state and water management district.

- §62-40.432(5) defines the minimum stormwater treatment performance standards for the state. When adopting rules pertaining to stormwater management , the state and water management districts must require that new stormwater facilities "achieve at least 80 percent reduction of the average annual load of pollutants that would cause or contribute to violations of state water quality standards." If the discharge is to OFW, the reduction increases to 95 percent of the annual average load.

- The water management districts must develop pollution load reduction goals (PLRGs) for older stormwater management systems (constructed prior to February 1982) and adopt them as part of a SWIM plan (see below) or other comprehensive water management plan. Pollution load reduction goals are "estimated numeric reductions in pollutant loadings needed to preserve or restore designated uses or receiving bodies of water and maintain water quality consistent with applicable state water quality standards." PLRGs are to be determined for SWIM waters first (by December 1994), then for waters identified by water management district priorities. PLRGs are part of the building blocks for watershed management, SWIM plans, and TMDLs. It should be noted that as of the beginning of 2000, no PLRGs have been set by SFWMD for the Florida Keys.

§62-40.450 notes that local governments have the primary responsibility for flood protection including land use control, development regulations, level of service definition and maintenance activities.

§62-40.520 requires each water management district to prepare a comprehensive water management plan known as the District Water Management Plan (DWMP). The plan must deal with water supply, flood protection, water quality management, and protection of natural systems. The most recent SFWMD plan is dated August 2, 1999 (see subsection 2.5.4 below).

2.5.3.4 Chapter 62-43 - Surface Water Improvement and Management Act

Enacted pursuant to the Surface Water Improvement and Management (SWIM) Act, §62-43 provides regulations for the development of priority lists, preparation and review of management plans, and distribution of SWIM Trust Funds. As a first step, each of the water management districts were to submit to FDEP a list of SWIM priority water bodies of regional or statewide significance that required restoration or protection. For each of the water bodies prioritized, the water management districts were to prepare restoration / protection plans for the review of FDEP, DCA, and other state agencies. FDEP would then distribute the SWIM Trust Funds to the approved plans. The funding of this program by the legislature has been limited and some of the water management districts have taken over the program. An Advisory List of SWIM Priority waters prepared by SFWMD contains 36 water bodies, with the Everglades National Park and Florida Bay 4th, and the Florida Keys 19th.

2.5.3.5 Chapter 62-112 - Project Certification Procedures

This short regulation has four sections, three of which were repealed in November 1996. The remaining section [§62-112.030] references project certification procedures for the coordinated agency review within the Florida Keys Area of Critical State Concern. In particular, it states that only applications received from D CA will be processed by FDEP for coordinated review.

2.5.3.6 Chapter 62-113 - Delegations

Chapter 62-113 lists all of the delegation agreements reached by FDEP related to the implementation of regulations. Agreements with particular pertinence include:

- Agreement #77-4: delegates to SFWMD permitting authority for construction or operation of facilities that discharges to waters of the State.

- Agreement #82-2: authorizes SFWMD to regulate water quality impacts of stormwater discharges.
- Agreement #84-15: delegates water quality certification for agricultural dredge and fill to SFWMD.
- Agreement #89-17: delegates MSSW permitting to SFWMD.
- Agreement #98-2: defines division of responsibilities relative to ERP program and wetland determinations.

2.5.3.7 Chapter 62-302 - Surface Water Quality Standards

Probably the most important regulation for the implementation of state statutes on pollution control is §62-302 FAC, since it provides the water quality standards for surface waters in the state. The water quality standards refer to the designated use classifications as well as the specific water quality criteria to achieve the designated use and the moderating provisions of mixing zones, zone of discharge, site specific alternative criteria, exemption and equitable allocation. The Findings section (§62-302.300) reiterates that "pollution which causes or contributes to new violations of water quality standards or to continuation of existing violation is harmful to the waters of this state and shall not be allowed." Subsection §62-302.300(17) defines the two-pronged test for permitting: "necessary and desirable under federal standards" and "under circumstances which are clearly in the public interest."

Water quality criteria are defined to achieve the present and future most beneficial uses of state waters. In Florida, the beneficial uses have been categorized as follows:

Class I	Potable Water Supplies
Class II	Shellfish Propagation and Harvesting
Class III	Recreation, Propagation and Maintenance of a Healthy, Well-Balanced Population of Fish and Wildlife
Class IV	Agricultural Water Supplies
Class V	Navigation, Utility and Industrial Use

Each of these classifications have specific water quality criteria assigned to them and are listed above generally in order of the degree of protection afforded in the regulation although Classes I, II and III share many criteria. Unless specifically identified by rule, all Florida waters are designated as Class III. Exceptions to this include secondary and tertiary canals wholly within agricultural areas and a list of waters provided in the rule. For Monroe County, waters from the Collier and Dade County lines southward to and including Florida Bay within the Everglades National

Park are defined as Class II. At a minimum, however, surface waters in the state must be free from components within discharges which cause nuisance settleables and floatables; produce color, odor taste or otherwise nuisance conditions; are acutely toxic; are present in concentrations that are carcinogenic, mutagenic or teratogenic; or pose a serious danger to public health, safety or welfare. These are known as the "Free Froms." Specific water quality criteria by designated use are provided in a table included in the rule as §62-302.530.

§62-302.700 lists waters that have a special designation of OFW, ONRW and otherwise. For Monroe County, the list includes the following areas:

- Outstanding Florida Waters
  - Dry Tortugas National Park
  - Everglades National Park
  - Crocodile Lake Wildlife Refuge
  - Great White Heron Wildlife Refuge
  - Key West Wildlife Refuge
  - National Key Deer Wildlife Refuge
  - Bahia Honda State Park
  - John Pennekamp Coral Reef State Park
  - Long Key State Recreation Area
  - Fort Zachary Taylor State Historic Site
  - Indian Key State Historic Site
  - Key Largo Hammock State Botanical Site
  - Lignumvitae Key State Botanical Site
  - Windley Key Fossil Reef State Geological Site
  - San Padro State Underwater Archaeological Preserve
  - Coupon Bright
  - Curry Hammock
  - North Key Largo Hammock
  - Port Bougainville
  - Biscayne Bay Aquatic Preserve (Cape Florida)
  - Biscayne Bay Aquatic Preserve (Card Sound)
  - Coupon Bright Aquatic Preserve
  - Lignumvitae Key Aquatic Preserve
  - Florida Keys (Special Waters) *
  - Big Cypress National Preserve
  - Key Largo Marine Sanctuary
  - Looe Key Marine Sanctuary
- Outstanding National Resource Waters
  - Biscayne National Park
  - Everglades National Park

* Note that a lengthy description of the boundaries of these special water is provided in §62-302.700(9)(i)13.

The last section in the surface water quality regulations is §62-302.800, Site Specific Alternative Criteria (SSAC). In the case of a water body that does not meet applicable water quality criteria due to natural background or "man-induced conditions which cannot be controlled or abated," an affected person or FDEP can petition to establish alternative water quality criteria. The regulations require a demonstration be made to the Department showing that the conditions are natural or not abatable and defining new criteria considering spatial, seasonal and diurnal variations.

2.5.3.8 Chapter 62-330 - Environmental Resource Permitting

The chapter adopts by reference the Environmental Resource Permitting (ERP) process from the water management districts, so that the state operates under a consistent set of permitting regulations. The correlation among the water management districts relative to specific regulations is described in the chapter.

2.5.3.9 Chapter 62-341 - Noticed General Environmental Resource Permits

§62-341 provides general permits for activities within the state that FDEP deems environmentally insignificant. Of particular interest to the SMMP for Monroe County is §62-341.443 that grants FDOT the ability to replace or modify bridges or their approaches with total dredge and filling of less than 0.5 acres. Channel clearing and shaping in wetlands and surface waters is also allowed when the combined total is less than 0.5 acres with the spoil material used on an upland site. §62-341.447 provides FDEP with a general permit to conduct minor highway construction during widening, replacement or maintenance of existing structures subject to excavation and deposition limitations.

2.5.3.10 Chapter 62-343 - Environmental Resource Permit Procedures

Similar to Chapter 62-341, this regulation provides for common regulatory authority for FDEP to implement the ERP process as well as the determination of the landward extent of wetland and surface waters.

2.5.3.11 Chapter 62-504 - State Revolving Loan Program for Stormwater Facilities

For a number of years, the state of Florida has operated a low-interest loan program for wastewater capital improvements. Recently, the state authorized that ten percent of the funds available for such loans were be potentially allocated to stormwater related projects. Chapter 62-504 regulates the low-interest loan (referred to as the State Revolving Loan) process. Loans can be procured for stormwater facilities related to collection, storage, retention, treatment or disposal of stormwater and residuals, land for stormwater facilities, construction and procurement, acquisition of stormwater facilities, and a list of other activities provided in §62-504.300. Access to the loans is obtained by submitting an application to FDEP and if granted, a loan agreement is negotiated with the Department.

Loans are distributed by FDEP based upon a priority list. Each year effective July 1, the priority list is adopted defining projects potentially fundable for the next fiscal year. Priority ranking is based upon a scoring system detailed in §62-504.650. A base score is assigned based upon reduction of a documented health hazard, reduction of coliforms discharged to surface or ground waters, compliance with total maximum daily load limitations, reduction of saltwater intrusion, compliance with NPDES MS4 permit conditions, and reduction in pollutant loadings. A multiplier to the base score is provided for discharges to special waters.

2.5.3.12 Chapter 62-520 - Ground Water Classes, Standards, and Exemptions

Chapter 62-520 FAC is the counterpart of ground water to the surface water rules in §62-302 FAC. In particular, §62-520 states that the "present and future most beneficial uses of all ground waters of the state have been designated by the Department by means of the classification system set forth in this chapter …" Subsection 62-520.400 defines the minimum standards for all ground waters (see "Free Froms" above). The classifications of ground waters are:

Class F-I — Potable water use; in a single source aquifer in §62-520.460 with TDS < 3000 mg/l and specifically reclassified as F-I.

Class G-I — Potable water use; in a single source aquifer with TDS < 3,000 mg/l .

Class G-II — Potable water use; with TDS < 10,000 mg/l; unless otherwise classified.

Class G-III — Non-potable water use; in unconfined aquifers with TDS ∃ 10,000 mg/l; or TDS 3,000 to 10,000 and either has been reclassified or exempted.

Class G-IV — Non-potable water use, in unconfined aquifers with TDS ∃ 10,000 mg/l

§62-520.420 provides standards for G-I and G-II ground waters. Both must meet primary and secondary drinking water standards (Rules 62-550.310 and 62-550.320, with exceptions). If the natural background concentrations exceed drinking water standards then the natural background concentrations become the prevailing standard. The standards do not apply within a permitted zone of discharge.

For G-III ground water, §62-520.430 states that only the minimum criteria (Free Froms) apply except in the case of an underground injection facility that has received an aquifer exemption. Class G-IV ground water standards are set on a case-by-case basis. Class F-I ground waters only apply in Flagler County.

Exemptions for installations discharging to Class G-I and G-II are considered in §62-520.500. Exemptions are possible only if granting the exemption is in the public interest and does not interfere with existing uses; compliance with the regulations is unnecessary to protect ground water supplies; the costs of compliance outweigh the benefits, a monitoring program is established; and public health, safety and welfare are not endangered. Existing discharges to Class G-II waters are exempt from the secondary drinking water standards unless FDEP determines that one or more standard is needed to protect a potable source; however, all installations discharging to Class G-II ground waters can not cause a violation of secondary drinking water standards at any water well outside the zone of discharge.

2.5.3.13 Chapter 62-522 - Ground Water Permitting and Monitoring Requirements

§62-522.300 states that no installation can directly or indirectly discharge to ground water any contaminant that causes a violation of water quality standards, except within a zone of discharge. No zone of discharge is allowed for wells or sinkholes that "allow direct contact with Glass G-I and G-II ground water", except in the cases of recharge using surface waters or inter-aquifer transfers. Also, no zone of discharge is allowed for discharges that pose an "imminent hazard" to the public.

For Class G-I, no zone of discharge is allowed (§62-522.400) except that "domestic effluent or reclaimed water and stormwater discharge sites authorized by Department permit or rule shall have zones of discharge extending no more than 100 feet from the site boundary " or property boundary, whichever is less. For Class G-II ground waters, the Department can establish a zone of discharge subject to certain provisions. §62-522.410(3)(c) states that stormwater facilities are not required to obtain a permit to establish a zone of discharge. The zone is 100 feet from the site or to the site boundary. Stormwater facilities are exempted from the ground water monitoring requirements

2.5.3.14 Chapter 62-528 - Underground Injection Control

The purpose of this chapter is to "protect the quality of the State's underground sources of drinking water and to prevent the degradation of the quality of other aquifers…" To this end, the rule establishes the State Underground Injection Control Program. Classification of wells include Class V, Group 6 stormwater wells used to drain stormwater runoff or for lake level control [§62-528.300(1)(e)6]. FDEP must identify and protect (except where exempted) "all aquifers or parts of aquifers" as an underground drinking water sources. An aquifer can be exempted after a public hearing.

Part B of Chapter 62-528 considers criteria and standards for Class V wells. These wells are for the injection of "non-hazardous fluids into or above formations that contain underground sources of drinking water." Exploratory well testing and well construction requirements are provided in §62-528.603 and §62-528.605, respectively. Monitoring is required of Group 6 (stormwater) wells by §62-528.615 and requirements for monitoring are to be included in the permit.

2.5.3.15 Chapter 9J-5 - Minimum Criteria for Review of Local Government Comprehensive Plans

For the management of growth pursuant to Chapter 163 F.S., Chapter 9J-5 FAC provides the minimum criteria, administered by the Department of Community Affairs (DCA), for the preparation, review and determination of compliance of comprehensive (comp) plans and plan amendments. Using the terminology of the chapter itself, the following divisions are included:

Rule	Description
9J-5.001	Purpose
9J-5.002	General guidelines for exercise of DCA authority
9J-5.003	Definitions
9J-5.004	Public participation procedures
9J-5.005	Format requirements, data requirements and other procedures
9J-5.0053	Minimum criteria for evaluation
9J-5.0055	Minimum criteria to ensure concurrency
9J-5.006 to 9J-5.019	Minimum criteria for comp plan elements
9J-5.022 to 9J-5.024	Establish standards procedures and criteria for review of required land development regulations

From Rule 9J-5.003, a number of definitions are pertinent to the SMMP. These are listed below so that, in the consideration of potential future regulations, new definitions or ordinances may be consistent with state requirements.

Drainage basin or *stormwater basin* is defined as the area topographically to contribute stormwater.

Drainage detention structure is defined as a structure "which collects and temporarily stores stormwater for the purpose of treatment…with the gradual release…"

Drainage facilities or *stormwater management facilities* are defined as "a system of man-made structures designed to collect, convey, hold, divert or discharge stormwater…"

Drainage retention structure is defined as a structure designed to collect and store stormwater without eventual release.

Floodplains are defined as areas inundated during a 100-year flood event or identified as Zone A or V on Flood Insurance Rate Maps (FIRM) or Flood Hazard Boundary Maps (FHBM).

Floodprone areas are defined as those within flood plains.

Level of service is defined as "an indicator of the extent or degree of service provided by, or proposed to be provided by, a facility-based upon and related to the operational characteristics of the facility. Level of service shall indicate the capacity per unit of demand for each public facility." This definition is important because it applies to all public facilities, not just transportation (see Subsection 2.5.3, Local Regulations, below).

Natural drainage features are defined as the naturally occurring features of land that accommodate stormwater flow such as river, lakes, floodplains and wetlands.

Natural drainage flow is defined as "the pattern of surface and storm water drainage through and from a particular site before the construction or installation of improvements or prior to regrading."

Nonpoint source pollution is defined as any source of water pollution that is not a point source.

Pollution is defined substantially as provided in Chapter 403 F.S.

Stormwater is defined as "the flow of water which results from a rainfall event."

Stormwater facilities are defined as drainage facilities that are part of a stormwater management system.

Stormwater management system is defined as "described in Rule 17-40.210(21)"; i.e., Rule 62-40.021(29), "a system which is designed and constructed or implemented to control stormwater…to prevent or reduce flooding, over-drainage, environmental degradation and water pollution or otherwise affect the quantity and quality of discharges from the system."

Rule 9J-5.0055 requires a concurrency management system whereby "public facilities and services needed to support development are available concurrent with the impacts of such development." In particular, local governments must adopt level of service standards for public facilities and services for a number of types of facilities and services including drainage. At a minimum, concurrency is satisfied for drainage if development orders or permits are issued subject to the condition that the necessary facilities and services are, or guaranteed to be, in place at the time of issuance [9J-5.0055((3)(a)].

Rule 9J-5.011 provides the regulations for the Sanitary Sewer, Solid Waste, Stormwater Management, Potable Water and Natural Groundwater Aquifer Recharge Element of the Comp Plan. This section requires the identification of: stormwater management facilities, existing and future capacity needs, major natural drainage features and existing regulations/programs to govern land uses and development. Goals, objectives and policies related to stormwater management are also to be provided including the setting of stormwater discharge water quality standards or stormwater management level of service standards.

Rule 9J-5.016 requires the definition of a capital improvements element that provides for the funding and construction or capital improvements needed for concurrency.

2.5.3.16 Chapter 14-86 - Drainage Connections

The last element of Florida regulations to be considered is Chapter 14 of the Florida Administrative Codes that relates to the Florida Department of Transportation. In particular, Chapter 14-86 addresses drainage connections to transportation facilities from adjacent properties. A "drainage connection" is "any structure, pipe, culvert, device, paved or unpaved area, swale, ditch, canal, or other feature whether natural or created which is … conveys stormwater runoff or other surface discharge from adjacent property to the Department's facility." To connect to an FDOT facility, a permit is required except in the following instances:

- Single family improvements not part of a larger common plan;
- Agricultural or silvicultural improvements regulated by FDEP or WMD that meet accepted drainage practices; and
- Other improvements for which the post-development impervious area is less than 40 percent, less than 5000 square feet of buildings and paved surfaces, no work is done in the FDOT right-of-way to alter drainage, and the property is located in an area with positive outlet.

All other connections require a permit. The permit applicant must provide assurances that the peak flow and volumes are provided for in an approved management plan as either allowed by regulation or such that the post-construction discharge rates are no more than the pre-construction rates. Also the applicant's discharge can not exceed a proportional share of the total facility capacity and meets all applicable water quality standards. Upon receipt of the permit, the drainage connection is not exempt from other state regulations. The permit can be revoked if the connection is not constructed according to the permit, emergency conditions exist, false or misleading information was provided in the permit application, or a notice of connection is not submitted to the Department in a timely manner after construction.

2.5.4 Water Management District Regulations

The South Florida Water Management District (SFWMD, known also as SoftMud) regulates and controls the management of public water within south Florida, including Monroe County.

2.5.4.1 Chapter 40E-1 - General and Procedural

Describing the basic permitting authority of the SFWMD, §40E-1 states that, unless exempt by statute or District rule, an Environmental Resource Permit (ERP) must be obtained for a number of activities including construction or modification of a surface water management system (e.g., stormwater facility, dam, impoundment, or reservoir). The ERP regulations are contained in §40E-4, §40E-40 and §40E-400. Conceptual ERP permits are authorized but do not allow the construction or operation of a facility. The ERP permit is accessed through application and reviewed according to the SFWMD manual "Basis of Review for Environmental Resource Permit Applications Within the South Florida Water Management District, August 1995."

2.5.4.2 Chapter 40E-4 - Environmental Resource Permits

Implemented pursuant to Part IV Chapter 373 F.S., this chapter for the Environmental Resource Permitting process. It is the policy of the District to regulate activities in wetlands or other surface waters and to control the management and storage of surface waters within the boundaries of the District. The operating principle is that "unless expressly exempt by law or rule, it is unlawful for any person to construct, alter, operate, maintain, remove or abandon and stormwater management system, dam, impoundment, reservoir, appurtenant work or works, or any combination thereof, including dredging and filling without first having obtained an environmental resource permit from the District" [§40E-4.041(1)]. This is done through individual ERP permits (§40E-4), standard general permits (§40E-40), and no-notice and noticed general permits (§40E-400). An individual permit is required for systems that serves a project of 100 acres or more, construction or alteration in 1 or more acres of wetlands or other surface waters, or the system includes more than 9 boat slips. To determine whether an activity may affect surface waters, an entity can petition the District for a formal determination of the landward extent of wetlands or surface waters. Exemptions include repair of existing pipes and culverts and limited maintenance, as well as a number of other activities not related to stormwater management. Conditions for issuance of an ERP permit are listed in § 40E-4.301 and 302.

2.5.4.3 Chapter 40E-40 - Environmental Resource Standard General Permits

Chapter 40E-40 requires standard general permits for "certain surface water management systems which have been determined not to be harmful to the water resources of the District and to be not inconsistent with the objectives of the District." The threshold limits for such permits are 1 acre or more for construction or alteration (including dredge and fill), 100 acres or more of project area, and more than 9 boat slips. This means that if a project exceeds any of the thresholds, an individual permit is required. §40E-40.042 authorizes a "Standard General Permit for Incidental Site Activities." These activities include upland land clearing; minimal earthwork; road subgrade construction; foundation construction; utility, fence, and construction trailer installation; and unconnected drainage facility construction. An application for the standard general permit is required and permit conditions include limitations on clearing and excavation within 50 and 200 feet, respectively, from the landward extent of wetlands or other surface waters.

2.5.4.4 Chapter 40E-400 - General Environmental Resource Permits

The last type of permitted activity includes general Environmental Resource Permits for activities that have "minimal adverse impacts to the water resources of the District." Certain minor surface water management activities can be implemented after notice to the District; others can be completed without notice.

2.5.4.5 Basis of Review for Environmental Resource Permit Applications

The last major element of the regulatory arena within SFWMD is the Basis of Review. The purpose of this regulation is to "identify the permit review criteria and information used by District staff when reviewing permit applications." Describing each element of the Basis of Review is beyond the scope of this document.

2.5.5 Local Regulations

Discussed below are ordinances pertaining to the control and regulation of stormwater or runoff for the County and each of the incorporated cities (Key West, Islamorada, Key Colony Beach and Layton). Also included is a discussion of the Monroe County Year 2010 Comprehensive Plan as it provides the foundation for this Stormwater Management Master Plan. It should be noted that at the time of the preparation of this section, Marathon had recently (November 1999) been voted to be incorporated. However, no ordinances related to stormwater were available.

2.5.5.1 Monroe County Land Development Regulations

The major ordinance that controls stormwater within Monroe County is Chapter 9.5, Land Development Regulations (LDR). This chapter of the Monroe County Code of Ordinances was enacted in May 1999 as Ordinance 21-1999. The pertinent sections of the code are listed in Table 2.5-2 that shows the Article, Division and Chapter or Section of the LDR along with the title. A brief description of the pertinent sections of the code is provided below.

Article I. The purpose of the LDR is to "establish the standards, regulations and procedures for review and approval of all proposed development of property … and to provide a development review process that will be comprehensive, consistent and efficient in the implementation of the goals, policies and standards of the comprehensive plan." Thus the two-fold purpose of the LDR is 1) to address proposed development, and 2) to control development within the scope of the comprehensive (comp) plan. This is done basically by the issuance of a development permit (Section 9.5-2), with some grandfathering exceptions.

A number of definitions are provided in Section 9.5-4 that are pertinent to the stormwater management program:

Table 2-2
Monroe County Stormwater Management Master Plan
Outline of County Land Development Code (Chapter 9.5)

Article	Division	Chapter / Section	Description
I	IN GENERAL		
I		9.5-1	Purpose
I		9.5-2	Applicability
I		9.5-3	Rules of Construction
I		9.5-4	Definitions
II	DECISION-MAKING AND ADMINISTRATIVE BODIES		
II		9.5-21	Board of County Commissioners
II		9.5-22	Planning Commission
II		9.5-23	Code Enforcement Board (Repealed)
II		9.5-24	Department of Planning
II		9.5-25	County Attorney
II		9.5-26	County Engineer
II		9.5-27	Hearing Officer
II		9.5-28	Qualified Biologist
III	DEVELOPMENT REVIEW		
III	1	GENERALLY	
III	1	9.5-41	Applicability
III	1	9.5-42	Application and fees
III	1	9.5-43	Preapplication Conference
III	1	9.5-44	Determination of comleteness and compliance, except SF
III	1	9.5-45	Notice
III	1	9.5-46	Hearing procedures for applications for development approval
III	1	9.5-47	Actions by decision-making persons and bodies
III	1	9.5-48	Successive applications
III	1	9.5-49	Suspension of development review proceedings
III	2	DEVELOPMENT AS OF RIGHT	
III	2	9.5-55	Development permitted as of right
III	3	CONDITIONAL USES	
III	3	9.5-61	Purpose
III	3	9.5-62	Authority
III	3	9.5-63	Authorized conditionqal uses
III	3	9.5-64	Initiation
III	3	9.5-65	Standards applicable to all conditional uses
III	3	9.5-66	Conditional use permits and bulk regulations
III	3	9.5-67	Conditions
III	3	9.5-68	Minor conditional uses
III	3	9.5-69	Major conditional uses
III	3	9.5-70	Final development plan subsequent to approval of conditional use permit
III	3	9.5-71	Recording of conditional uses
III	3	9.5-72	Development under an approved conditional use permit
III	3	9.5-73	Amendments to permits for conditional uses
III	3	9.5-74	Development(s) of regional impact
III	3	9.5-75	Developments of regional impact and development agreements
III	4	PLAT APPROVAL	

Note: Only sections of the Monroe County Code pertinent to the SMMP are represented in the table.

Monroe County Stormwater Management Master Plan
Outline of County Land Development Code (Chapter 9.5)

Article	Division	Chapter / Section	Description
III	4	9.5-81	Plat approval and recording required
III	4	9.5-82	General standards for plat approval
III	4	9.5-83	Preliminary plat approval
III	4	9.5-84	Final plat approval
III	4	9.5-85	Improvement guarantees
III	4	9.5-86	Preacceptance maintenance of public improvements
III	4	9.5-87	Damage and nuisance guarantee
III	4	9.5-88	Acceptance of public improvements
III	4	9.5-89	Limitations as to county maintenance
III	4	9.5-90	Maintenance of private improvements
III	4	9.5-91	Recording of final plat
III	4	9.5-92	Variances to required subdivision improvements
III	4	9.5-93	Vacation
III	4	9.5-94	Amendment of a recorded final plat
III	5	DEVELOPMENT AGREEMENT AUTHORIZATION	
III	5	9.5-101	Purpose and intent
III	5	9.5-102	Development agreement approval procedures
IV	BUILDING PERMITS		
IV	1	BUILDING PERMITS AND CERTIFICATES OF OCCUPANCY	
IV	1	9.5-111	Building permits required
IV	1	9.5-112	Certificate of compliance with development regulations required
IV	1	9.5-113	Review of building permit applications
IV	1	9.5-114	Posting of building permit
IV	1	9.5-115	Expiration of building permit
IV	1	9.5-115.1	Application fees
IV	1	9.5-116	Revocation of building permit
IV	1	9.5-117	Certificate of occupancy
IV	1	9.5-118	Revocation of certificate of occupancy
IV	1	9.5-119	Environmental restoration standards and agreements
IV	1	9.5-120	Dwelling unit allocation
IV	1	9.5-120.1	Definitions
IV	1	9.5-121	General provisions
IV	1	9.5-121.1	Residential dwelling unit allocations
IV	1	9.5-121.2	Residential dwelling unit allocation application procedures
IV	1	9.5-122	Residential dwelling unit allocation evaluation procedures
IV	1	9.5-122.1	Residential dwelling unit allocation evaluation criteria
IV	1	9.5-123	Appeals
IV	1	9.5-123.1	Conflict
IV	1	9.5-124	Severability
IV	2	SPECIAL PROCEDURES FOR FLOODPLAIN MANAGEMENT	
IV	2	9.5-125	Permit requirements
IV	2	9.5-126	Standards applicable to all conditional uses
IV	2	9.5-127	Variances
V	NONCONFORMITIES		
V		9.5-141	Purpose

Note: Only sections of the Monroe County Code pertinent to the SMMP are represented in the table.

Monroe County Stormwater Management Master Plan
Outline of County Land Development Code (Chapter 9.5)

Article	Division	Chapter / Section	Description
V		9.5-142	Registration
V		9.5-143	Nonconforming uses
V		9.5-144	Nonconforming structures
V		9.5-145	Nonconforming accessory uses and accessory structures
V		9.5-146	Nonconroming signs, parking, landscaping, lighting, access and buffer-yards
V		9.5-147	Nonconforming live-aboard vessels
VI	PROTECTION OF LANDOWNERS' RIGHTS		
VI	1	GENERALLY	
VI	1	9.5-161	Purpose
VI	2	BENEFICIAL USE	
VI	2	9.5-171	Beneficial use
VI	2	9.5-172	Procedures, standards and criteria for relief
VI	2	9.5-173	Relief under beneficial use
VI	2	9.5-174	Final determination by BOCC
VI	3	VESTED RIGHTS	
VI	3	9.5-181	Determination of vested rights
VI	3	9.5-182	Procedure for vested rights determinations
VI	3	9.5-183	Standards and criteria for vested rights
VI	3	9.5-184	Limitations on vested rights determinations
VII	LAND USE DISTRICTS		
VII	1	GENERALLY	
VII	1	9.5-201	General purpose
VII	1	9.5-202	Land use district established
VII	1	9.5-203	Purpose of the Urban Commerical District (UC)
VII	1	9.5-204	Purpose of the Urban Residential District (UR)
VII	1	9.5-205	Purpose of the Urban Residential Mobile Home District (URM)
VII	1	9.5-205.1	Purpose of the Urban Residential Mobile Home-Limited District (URML-L)
VII	1	9.5-206	Purpose of the Sub Urban Commercial District (SC)
VII	1	9.5-207	Purpose of the Sub Urban Residential District (SR)
VII	1	9.5-208	Purpose of the Sub Urban Residential District (Limited) (SRL)
VII	1	9.5-209	Purpose of the Sparsely Settled Residential District (SS)
VII	1	9.5-210	Purpose of the Native Area District (NA)
VII	1	9.5-211	Purpose of the Mainland Native District (MN)
VII	1	9.5-212	Purpose of the Offshre Island District (OS)
VII	1	9.5-213	Purpose of the Improved Subdivision District (IS)
VII	1	9.4-214	Purpose of the Destination Resort District (DR)
VII	1	9.5-215	Purpose of the Recreational Vehicle District (RV)
VII	1	9.5-216	Purpose of the Commercial Fishing Area District (CFA)
VII	1	9.5-217	Purpose of the Commercial Fishing Village District (CFV)
VII	1	9.5-218	Purpose of the Commercial Fishing Special District (CFS)
VII	1	9.5-219	Purpose of the Mixed Use District (MU)
VII	1	9.5-220	Purpose of the Industrial District (I)
VII	1	9.5-221	Purpose of the Maritime Industries District (MI)
VII	1	9.5-222	Purpose of the Military Facilities District (MF)
VII	1	9.5-223	Purpose of the Airport District (AD)

Note: Only sections of the Monroe County Code pertinent to the SMMP are represented in the table.

Monroe County Stormwater Management Master Plan
Outline of County Land Development Code (Chapter 9.5)

Article	Division	Chapter / Section	Description
VII	1	9.5-224	Purpose of the Park and Refuge District (PR)
VII	1	9.5-225	Purpose of the Conservation District (CD)
VII	1	9.5.226	Land use district map
VII	1	9.5-227	Existing conditions map
VII	2	PERMITTED USES	
VII	2	9.5-231	General
VII	2	9.5-232	Urban Commercial District
VII	2	9.5-233	Urban Residential District
VII	2	9.5-234	Urban Residential -Mobile Home District
VII	2	9.5-235	Sub Urban Commercial District
VII	2	9.5-235.1	URM-L District
VII	2	9.5-236	Sub Urban Residential District
VII	2	9.5-237	Sub Urban Residential District (Limited)
VII	2	9.5-238	Sparsely Settled Residential District
VII	2	9.5-239	Native Area District
VII	2	9.5-240	Mainland Native Area District
VII	2	9.5-241	Offshre Island District
VII	2	9.5-242	Improved Subdivision District
VII	2	9.5-242.5	Improved Subdivision District--Tourist Housing District
VII	2	9.5-243	Destination Resort District
VII	2	9.5-244	Recreational Vehicle District
VII	2	9.5-245	Commercial Fishing Area District (CFA)
VII	2	9.5-246	Commercial Fishing Village District
VII	2	9.5-247	Commercial Fising Special Districts
VII	2	9.5-248	Mixed Use District
VII	2	9.5-239	Industrial District
VII	2	9.5-250	Maritime Industries District
VII	2	9.5-251	Military Facilities District
VII	2	9.5-252	Airport Districts
VII	2	9.5-253	Park and Refuge District
VII	2	9.5-254	Conservation District
VII	2	9.5-255	Commercial Fishing Residential
VII	2	9.5-256	Aggregation of development
VII	3	LAND USE INTENSITIES	
VII	3	9.5-261	Land use intensities
VII	3	9.5-262	Maximum residential density and district open space
VII	3	9.5-263	Improved Subdivision and Commercial Fishing Village District densities
VII	3	9.5-264	Urban Residential Mobile Home District density
VII	3	9.5-265	Transferable development rights
VII	3	9.5-266	Affordable housing; employee housing
VII	3	9.5-267	Maximum hotel-motel, recreational vehicle and institutional residential densities
VII	3	9.5-268	Existing residential dwellings
VII	3	9.5-269	Maximum nonresidential land use intensities and district open space
VII	3	9.5-270	Comercial retail and multiple land use intensities and district open space
VII	4	BULK REGULATIONS	

Note: Only sections of the Monroe County Code pertinent to the SMMP are represented in the table.

Monroe County Stormwater Management Master Plan
Outline of County Land Development Code (Chapter 9.5)

Article	Division	Chapter / Section	Description
VII	4	9.5-281	Minimum yards
VII	4	9.5-282	Reserved
VII	4	9.5-283	Maximum height
VII	4	9.5-284	Additional requirements for residential dwellings
VII	4	9.5-285	Applicability of required yards to buffer-yards
VII	4	9.5-286	Shoreline setback
VII	4	9.5-287	Monuments
VII	4	9.5-288	Bulkheads, seawalls, riprap and fences
VII	5	DEVELOPMENT STANDARDS	
VII	5	9.5-291	General
VII	5	9.5-292	Adequate facilities and development review procedures
VII	5	9.5-293	Surface water management criteria
VII	5	9.5-293.1	Revision of surface water management criteria
VII	5	9.5-294	Wastewater treatment criteria
VII	5	9.5-295	General requirements for site improvements
VII	5	9.5-296	Streets
VII	5	9.5-297	Easements
VII	5	9.5-298	Blocks
VII	5	9.5-299	Lots
VII	5	9.5-300	Public sites and open spaces
VII	5	9.5-301	Monuments
VII	5	9.5-302	Curbs and gutters
VII	5	9.5-303	Sidewalks
VII	5	9.5-304	Installation of utilities and driveways
VII	5	9.5-305	Water supply and sanitary sewer service
VII	5	9.5-306	Street name signs
VII	5	9.5-307	Traffic-control signs
VII	5	9.5-308	Live-aboards
VII	5	9.5-309	Fences
VII	6	FLOODPLAIN MANAGEMENT STANDARDS	
VII	6	9.5-315	Purpose and intent
VII	6	9.5-316	General provisions
VII	6	9.5-317	Standards for issuance of building permits in areas of special flood hazard
VII	7	ENERGY AND WATER CONSERVATION STANDARDS	
VII	7	9.5-325	Purpose of energy and water conservation standards
VII	7	9.5-326	Energy conservation standards
VII	7	9.5-327	Potable water conservation standards
VII	8	ENVIRONMENTAL STANDARDS	
VII	8	9.5-335	Purpose of environmental performance standards
VII	8	9.5-336	Habitat analysis required
VII	8	9.5-337	Waiver of habitat analysis
VII	8	9.5-338	Habitat type analysis
VII	8	9.5-338.1	Habitat analysis objective
VII	8	9.5-338.2	Automatic high quality forst classification
VII	8	9.5-338.3	Habitat analysis definitions and approach

Note: Only sections of the Monroe County Code pertinent to the SMMP are represented in the table.

Monroe County Stormwater Management Master Plan
Outline of County Land Development Code (Chapter 9.5)

Article	Division	Chapter / Section	Description
VII	8	9.5-339	Habitat analysis for high hammocks
VII	8	9.5-340	Habitat analysis for low hammocks
VII	8	9.5-341	Habitat analysis for palm hammocks
VII	8	9.5-342	Habitat analysis for pinelands
VII	8	9.5-343	Open space requirements
VII	8	9.5-344	Transplantation plan
VII	8	9.5-345	Environmental design criteria
VII	9	PARKING AND LOADING STANDARDS	
VII	9	9.5-351	Off-street parking
VII	9	9.5-352	
VII	9	9.5-353	Restriction on use of parking and loading areas
VII	9	9.5-354	Configuration of parking and loading ingress and egres
VII	10	LANDSCAPING	
VII	10	9.5-361	Required landscaping
VII	10	9.5-362	Lanscaping standards
VII	10	9.5-363	Landscaping material
VII	10	9.5-364	Landscaping installation criteria
VII	10	9.5-365	Removal or major pruning
VII	10	9.5-366	Street trees
VII	10	9.5-367	Landscaping materials
VII	11	SCENIC CORRIDOR AND BUFFER YARDS	
VII	11	9.5-375	General
VII	11	9.5-376	Scenic Corridor
VII	11	9.5-377	District boundary buffers
VII	11	9.5-378	Required scenic corridor and major street buffers
VII	11	9.5-379	Buffer-yead standards
VII	11	9.5-380	Responsibility for district boundary buffer-yards
VII	11	9.5-381	Nonconforming buffers
IX	AREAS OF CRITICAL COUNTY CONCERN		
IX		9.5-471	Purpose
IX		9.5-472	Standards for designation of areas of critical county concern
IX		9.5-473	Procedures for designation
IX		9.5-473.1	Threshold designations
IX		9.5-474	Effect of designation of areas of critical county concern
IX		9.5-475	Development review in an area of critical county concern
IX		9.5-476	Development impact report
IX		9.5-477	North Key Largo Area of Critical County Concern
IX		9.5-478	Ohio Key Area of Critical County Concern
IX		9.5-479	Big Pine Key Area of Critical County Concern
IX		9.5-480	Holiday Isles Area of Critical County Concern (repealed) - Reserved
X	IMPACT FEES		
X		9.5-490	Impact fee procedures
X		9.5-490.1	Definitions
X		9.5-490.2	General provisions; applicability
X		9.5-490.3	Procedures for imposition, calculation and collection of impact fees

Note: Only sections of the Monroe County Code pertinent to the SMMP are represented in the table.

Monroe County Stormwater Management Master Plan
Outline of County Land Development Code (Chapter 9.5)

Article	Division	Chapter / Section	Description
X		9.5-490.4	Establishment of impact fee accounts; appropriation of impact fee funds; refunds
X		9.5-490.5	Appeals
X		9.5-491	Fair share transportion impact fee
X		9.5-492	Fair share community park impact fee
X		9.5-493	Fair share library impact fee
X		9.5-494	Fair share solid waste impact fee
X		9.5-495	Fair share police facilities impact fee
X		9.5-496	Affordable and employee housing fair share impact fee trust fund

Note: Only sections of the Monroe County Code pertinent to the SMMP are represented in the table.

Adverse impacts, stormwater management means "modifications … on ground or surface waters or wetlands, including quality, quantity, hydrodynamics, i.e., currents, flow patterns, surface area, species composition, living resources or usefulness which are or may be potentially harmful to human health and safety, to biological productivity or stability, or which interfere with the lawful enjoyment of life or property, including secondary, cumulative, and direct impacts."

Area of special flood hazard means lands that flood during the 100-year storm event (i.e., 1 percent chance).

Base flood means the 100-year flood event.

Best management practices, stormwater management means "those methods of stormwater management recognized by experts in the field as the most effective for treating or managing stormwater runoff."

Construction, stormwater management means any activity "which will result in the change in natural drainage patterns [on the property] and will require the creation of a new stormwater management system."

Control structure means a discharge structure that allows the controlled and gradual release of water.

Detention means "the delay of stormwater runoff prior to discharge to receiving waters."

Drainage means "the removal of water from an area to lower water level in that area."

Dry detention (retention) means "the delay (prevention) of stormwater runoff prior to (from) direct discharge into receiving waters in a structure with bottom elevation above the water elevation or control elevation." [Note that the definitions for detention and retention were sufficiently similar that for the purposes of this report, they were combined.]

Groundwater means "water beneath the surface of the ground.

Indirect discharge means the release of stormwater by means of a control structure such as a swale or sheet flow.

Level of service means a measure of describing "operational conditions within a traffic stream." It should be noted that normally level of service (LOS) applies to any infrastructure including stormwater and generally applies to the measure of the adequacy of infrastructure. For more on this subject, please see Chapter 3.0 of this report.

Natural water flow pattern means "the rate, volume and direction of surface water or groundwater flow occurring under natural (daily and seasonal) conditions before development."

Predevelopment condition for stormwater runoff means "topography, vegetation, rate, volume, direction and pollution load of surface water or groundwater flow existing immediately prior to development."

Stormwater management plan means the analysis describing how stormwater is to be controlled to meet the requirements of the LDR.

Stormwater management system means "the natural and constructed features of the property which are designed to treat, collect, convey, channel, hold, inhibit or divert the movement of surface waters." For the purposes of this SMMP, the term "stormwater management system" will include the structures that are owned and/or operated by the county to control stormwater quality and quantity. Chapter 403.031(16) provides a more general definition.

Stormwater runoff means that volume of rainfall that "does not percolate into the ground, nor evaporates, nor is intercepted before reaching the stormwater management system."

Swale means "a shallow constructed ditch with the bottom above the water table." This is a rather broad definition allowing for steep-sided ditches to be termed swales. A more restrictive definition is provided in §62-25.020(16) FAC that provides for gradually sloped sides and standing water after rain events within a vegetated depression. For the purposes of this report, the definition of "swale" provided by state regulations is adopted.

Watershed means "a catchment area which is otherwise draining to a watercourse or contributing to flow to a body of water."

Wet detention (retention) means "the delay (prevention) of stormwater runoff prior to (from) direct discharge into receiving waters in a structure with a bottom elevation below the water table or control elevation." As before, the definitions of "detention" and "retention" are combined.

Wet season water table means the groundwater level during the time of the year when the greatest amount of rainfall normally occurs.

There are a number of other definitions directly or indirectly related to stormwater management but were deemed less important to this SMMP than those listed above.

Article II. This article provides for the duties and responsibilities of the Board of County Commissioners (BOCC), Planning Commission, Department of Planning, County Attorney, County Engineer, Hearing Officer, and Qualified Biologist relative to the implementation and enforcement of the LDR. In particular, the BOCC controls the official land use development and existing conditions maps, amends the language of the LDR as needed, addresses variances to the LDR, and designates hearing officers. On the other hand, the Planning Commission is the local planning agency (relative to §163 F.S.) responsible for the comp plan, to consider applications for conditional use permits and plats, and to address appeals of administrative actions. Composed of five members, the Planning Commission is appointed by the mayor supported by the BOCC. The Department of Planning is to provide the planning functions within the county and provide technical support regarding development applications. The Department will consist of the following divisions: building, development review, capital improvement planning, environmental resources, lands use planning and code enforcement.

Article III. This article provides local regulations on the approval of new development. Development can be approved "as of right" when the uses are compatible with other land uses within a district and in conformity with the LDR; or conditionally, if the uses are generally compatible with other permitted land uses in the district but which require individual review and conditions. Plat approval is required for the division of land into 3 or more parcels.

Division 4 of this article also addresses the maintenance of public improvements. Until the improvement is accepted by the BOCC, the developer is responsible for maintenance with 10 percent of the construction cost as a maintenance bond. Dedication of public improvements occurs only after resolution by the BOCC, inspection by the county and assurance of design and construction in conformity to the LDR. It should be noted that the LDR does not obligate the county to accept maintenance unless the facility is in conformity with the LDR, nor to drain any land except that which is within public rights-of-way or easements. The maintenance of improvements on private lands is to be defined to the satisfaction of the director of planning.

Article IV. This article deals with building permits. In particular, Sections 9.5-111 and §9.5-112 require that no development can "occur except pursuant to a building permit" and a "certificate of compliance" with the LDR must be issued prior to issuance of the building permit. For the permitting of the development of additional dwelling units, Sections 9.5-120 to 9.5-124 deal with the allocation procedure to allow development commensurate with the service levels of the public facilities. The county is to review and monitor the rate of dwelling unit development in comparison to the public facilities and services built to serve the development. The regulation defines three areas where the Dwelling Unit Allocation process applies: Upper Keys (north of Fiesta Key), Middle Keys (Fiesta Key to Seven Mile Bridge), and Lower Keys (south of Seven Mile Bridge). Section 9.5-121.1 sets the annual residential dwelling unit as follows:

Subarea	Total	Market	Affordable
Upper Keys	99	79	20
Middle Keys	41	33	8
Lower Keys	115	92	23
Total	255	204	51

In this table, "affordable housing" is defined in Section 9.5-4. Basically, the Director of Planning accepts applications for dwelling unit allocation and if approved, subtracts the allocation from the allotment noted in the table. It should be noted that the annual allocation is further distributed quarterly by the LDR. The review of the applications is supported by a point system defined in Section 9.4-122.1 which assigns points for proper development consistent with the LDR, density reduction, affordable housing, habitat protection, protection of threatened and endangered species, water conservation, energy conservation, and structural integrity (protection from flood and wind damage).

The second division of Article IV includes the procedures for floodplain management. In particular, for building permits within areas of special flood hazard (i.e., within the 100-year floodplain), the building must be in compliance with the provision of Division 6 of Article VII (Floodplain Management Standards) considered in more detail later. Variances are allowed under exceptional hardship cases, subject to the approval of the BOCC.

Article VII. This article defines the land use districts acceptable within the county, consistent with natural resources and available public facilities. Table 2.5-3 provides a list of the land use districts, specific code for land use mapping and the general description and purpose. Section 9.5-226 requires the BOCC, with recommendation from the Planning Commission, to adopt an official land use map for the unincorporated county to help the review of development and redevelopment. Section 9.5-227 further requires the adoption of the existing conditions map which is the 1985 FDOT aerial photographs with habitat types identified. This map is to help determine the regulatory requirements for new development. Division 2 of this article describes in detail for each land use district the types of developments and structures authorized within the district, as well as the access requirements to U.S. 1 and recreational and open space requirements.

Division 5 of Article VII contains development standards. After February 28, 1988, development must be served by "adequate public facilities" for roads, solid waste, potable water, and schools. It should be noted that adequate stormwater management facilities are not required. Annually, the Director of Planning is to

Table 2.5-3
Monroe County Stormwater Management Master Plan
Summary of Land Use Districts (Chapter 9.5, Article VII)

District	Code	Description / Purpose
Urban Commercial	UC	High intensity commercial
Urban Residential	UR	High-density residential; vacation rental of detached dwellings, duplexes, and
Urban Residential Mobile Home	URM	Established MHP and subdivisions.
Urban Residential Mobile Home-	URML-L	Established MHP and subdivisions; created to permit replacement below base flood
Sub Urban Commercial	SC	To establish commercial uses to serve immediate planning area without use of US1
Sub Urban Residential	SR	To establish low- to medium-density residential; generally SFU
Sub Urban Residential (Limited)	SRL	To establish exclusive low- to medium-density residential
Sparsely Settled Residential	SS	Low-density residential with native / open character
Native Area	NA	To establish undisturbed areas except solid waste facilities; environmentally
Mainland Native Area	MN	To protect undeveloped and environmentally sensitive areas in mainland Florida
Offshore Island	OS	To establish areas not connected to US1; low-density residential and campgrounds
Improved Subdivision	IS	Legally vested residential development prior to adoption of chapter
Destination Resort	DR	To establish areas suitable for planned tourist centers
Recreational Vehicle	RV	To establish areas suitable for destination resours for RVs
Commercial Fishing Area	CFA	To establish uses essential to commercial fishing
Commercial Fishing Village	CFV	To establish areas of limited commercial fishing
Commercial Fishing Special	CFS	To establish areas of traditional commercial fishing
Mixed Use	MU	To establish areas of mixed uses for preservation representing character of Keys
Industrial	I	To establish areas for industrial, manufacturing, warehousing and distribution
Maritime Industries	MI	To establish areas for maritime uses; ship building, ship repair
Military Facilities	MF	To establish areas for military installations
Airport	AD	To prohibit residential, educational or others as hazardous due to airports
Park and Refuge	PR	To establish and protect parks, recreational areas and refuges
Conservation	CD	To provide areas acquired for conservation or deed restrictions for conservation

submit a report to the BOCC defining the capacity of the public facilities within each of three service areas (Upper Keys north of Whale Harbor Bridge; Middle Keys from Seven Mile Bridge to the Whale Harbor Bridge, and Lower Keys south of Seven Mile Bridge). The report must consider population and commercial growth and define inadequate facility capacity, if any. For areas of inadequate capacity, the county can not approve applications for development [Section 9.5-292(b)(5)b] unless the development does not decrease the capacity of the public system.

Section 9.5-293 provides guidelines and criteria for surface water management to minimize or eliminate adverse impacts to surface water, groundwater and other natural resources. Single family and duplex homes are to "observe best management practices" and have limited criteria to follow. A stormwater management plan is required by all development except for:

- maintenance work on existing mosquito control structures;
- maintenance, alteration or improvement of an existing structure, or placement of an new structure, that does not increase the design peak discharge rate, volume pollutant load of stormwater runoff, or impervious coverage;
- emergencies requiring immediate action to prevent material or public harm; and,
- single family or duplex homes on individual lots that are part of a subdivision provided an approved stormwater management system is in place.

Stormwater management plans are to be reviewed by staff regarding wetlands, pinelands, dunes/beach berms, hammocks, uplands, and rare or endangered plants and animals. Operation and maintenance of the stormwater management system is required. The systems will also be reviewed relative to surface water degradation as defined in state regulations, with a higher level of review for discharges to Outstanding Florida Waters. Particular standards are listed below:

- Off-site discharge is allowed at historical levels based upon natural site drainage patterns or as approved in previous SWFWMD permits;
- The stormwater management system is designed for the 24-hour, 25-year design storm event;
- The post-development conditions can not create a stormwater volume greater than the volume currently retained on-site.
- Discharges must meet state water quality standards as defined in §62-302, §62-25, and §62-40 FAC.

- Retention or detention is to be provided for the first inch of runoff or for 2.5 times the percent impervious coverage.

- Commercial or industrial developments must provide at leas 1/2 inch of dry detention or retention pretreatment.

- With some restrictions, systems with inlets within grassed areas are credited with up to 0.2 inch of wet detention for the contributing areas.

- Projects with over 40 percent imperviousness discharging to sensitive waters must provide 50 percent pretreatment of the total required. Sensitive waters are Class I, Class II, Outstanding Florida Waters, and canals connection these types.

Note that water surfaces are subtracted from the total site area.

The regulation also requires that a subdivision must have a stormwater management system installed by the permittee that collects and conveys runoff to the required retention/detention system with access points for individual lots. Specific design considerations are provided in Section 9.5-293(f)(3). Section 9.5-293(g) requires the building permit applicant to provide a stormwater management plan, sealed by a registered engineer, with sufficient information for evaluation of compliance with the LDR. The planning Department is to provide a manual and brochure describing stormwater management practices including the preparation of stormwater management plans, acceptable BMPs, environmentally sound practices for erosion and sediment control, and minimum specifications for stormwater management systems. The stormwater management system must also be adequately maintained and sufficient easement for inspection is also required [Section 9.5-293(j)]

Section 9.5-297 requires that a stormwater easement must be provided where a subdivision traverses "a watercourse, drainage way or channel" and maintenance easements of 15 feet are required along drainage channels. This is important since many counties in Florida are contending with inadequate easements for maintenance.

As noted above, Division 6 of Article VII contains the floodplain management standards. The intent of this division is to ensure that the county is eligible for, and receives, the benefits of the National Flood Insurance Program. By reference, the FEMA Flood Insurance Study and Wave Height Analysis for Monroe County (October 17, 1989) and revisions are adopted. In general, the regulations require new construction and substantial improvements (reconstruction of 50 percent or more of market value of existing structure) to minimize flood damage by using pilings or columns, flood resistant materials, and flood proofed utilities. Contracts for lots (and similar instruments) must contain the phrase "flood hazard warning" if the lots are within the 100-year floodplain. In cases where the base flood elevation is known, residential structures must be constructed with the base floor elevation above the base flood elevation and utilities protected from the base flood. Similar requirements are listed for non-residential structures.

Division 8 of Article VII provides environmental standards "for the conservation and protection of the environmental resources of the Florida Keys by ensuring that the functional integrity of natural areas is protected when land is developed." This is accomplished by requiring a habitat analysis for the development of lands classified as slash pineland or tropical hardwood hammock. The analysis is required to consider the distribution and quality of undisturbed lands within the parcel and rate the hardwood hammock and pineland relative to inherent character and integrity. Inherently high quality hammocks and pinelands are identified in the ordinance. The rating system is based upon tree size, soil depth, woody plant species diversity, threatened plants, invasive plant infestation, threatened/endangered animals, forest size, perimeter disturbance, wildlife habitat, and community connectivity. Section 9.5-343 of this division defines open space requirements within the County by listing the ratio of open space to total land for various types of habitat; development may not reduce the ratio. Section 9.5-345 provides elements for proper environmental design, including clustering development away from protected habitat, minimizing fill, protection of trees, and removal of invasive plants.

Article IX. This article defines areas within the county designated as Areas of Critical County Concern (ACCC). Such areas are defined by the BOCC when the area is "one of special environmental sensitivity, contains important historical or archaeological resources, is characterized by substantial capital improvement deficiencies, or provides significant redevelopment opportunities." Development within ACCC must prove that there the construction will not have an adverse impact on the features for which the ACCC was designated. If proven, the BOCC may conditionally approve the development. Areas of Critical County Concern listed in the regulation include North Key Largo, Ohio Key, and Big Pine Key.

Article X. Finally, Article X describes impact fees within Monroe County. Impact fees are fees imposed on a development to pay for the infrastructure improvements needed to accommodate the increase in capacity required by the development. In general, impact fees can only be spent within the area of growth in which the fee is collected and only for capital improvements for the infrastructure servicing the new development. The rule identifies impact fees for transportation, community parks, library, solid waste, police facilities, and affordable and employee housing.

2.5.5.2 Monroe County Comprehensive Growth Management Plan

The Year 2010 Comprehensive (Comp) Plan is divided into three volumes: Technical Document, Policy Document and Map Atlas. The 2010 Comp Plan was adopted by the Monroe County Board of County Commissioners on April 15, 1993, amended in January 1996, adopted by the DCA and Administrative Commission by July 1997. The Comp Plan was written pursuant to Chapters 163 and 380 F.S. and in addition to addressing other growth management and environmental issues, provides elements related to floodplain, drainage and runoff control. Each of the Elements that consider stormwater management is considered below.

Future Land Use Element (Chapter 2.0). Subsection 2.1.9 E. considers the availability of drainage facilities and services to address existing land uses. The section notes that "because of the low-lying topography, highly permeable soil conditions, proximity to the ocean and other receiving waters, and rural character of most of the county road network, most of the existing land uses in Monroe County are not served by stormwater management facilities." Section 2.4, Future Land Use Analysis, further states that "drainage… is not currently considered to be a carrying capacity constraint" because it was not possible at the time the Comp Plan was develop to quantify the impacts. Regarding floodplain, most of the Florida Keys are within the 100-year floodplain, with the exceptions of higher lands within Key Largo, Plantation Key, and Windley Key. The Permit Allocation System (see Land Development Code, LDC) as well as the LDC itself, limits growth within the 100-year floodplain. Subsection 2.4.5 (Economic and Fiscal Impacts of the Future Land Use Alternatives) states that the County is committed to prepare the Stormwater Master Plan that will help identify existing deficiencies and commits the County to manage growth according to regional SFWMD regulations. No costs are assigned for the Drainage Element.

Conservation and Coastal Management Element (Chapter 3.0). This chapter considers the environmental elements of the Comp Plan. Subsection 3.4 considers the soils within Monroe County. In general, there are 6 basic types: Beach, Marine Wetland, Tropical Hardwood Hammock, Slash Pineland, Freshwater Wetland, and Filled and Developed Land. The Monroe County Environmental Resources Department identified the following types of sites to be susceptible to excessive erosion: construction sites, existing development with inadequate stormwater management, active limestone mining sites, unstable dredged spoil disposal sites, beaches, and altered shorelines. Subsection 3.5.3 identifies known point and nonpoint source pollution problems. The point sources within the unincorporated County were wastewater related. Nonpoint sources included onsite wastewater disposal systems, abandoned or inactive landfills, live-aboard vessels, mosquito control pesticide use, and urban runoff, only the last of which is pertinent to this Stormwater Management Master Plan.

Drainage Element (Chapter 11.0). This element provides an assessment of the existing stormwater management conditions within the County related to grown management. Historically, drainage has been the sole concern of developers or property owners. Boat canals were used as the primary drainage facilities. On several Keys, the drainage facilities along US 1 are the primary stormwater management systems, even though much of US 1 has no drainage system at all. This chapter identifies five "needs" for stormwater management:

Stormwater Management Master Plan/Stormwater Utility. A facility-specific land use inventory along with an analysis of current and future stormwater needs should be completed. Associated with the assessment should be the consideration of how to finance the needed stormwater facilities.

- Revision of the Monroe County Code related to stormwater management. Section 9.5-293 should be revised to address stormwater controls for new development.
- Assessment of surface water quality. Additional data are required to understand the impacts of urbanization on local water quality.
- Inventory of facilities. An inventory of existing stormwater management systems (public and private) would help define the stormwater needs within Monroe County.

Subsection 11.7 describes the Sanitary Wastewater and Stormwater Management Master Plan. While described as a single plan, implementation of this subsection has split the plan into two: the Sanitary Wastewater Management Plan (SWMP) and Stormwater Management Master Plan (SMMP), the subject of this document. Considering on the SMMP, the purpose of the plan is "to identify and quantify potential sources of pollution due to...stormwater runoff and reduce the associated water quality degradation in the Florida Keys."

Subsection 11.8 identifies the Level of Service (LOS) standards for Monroe County. These are summarized as follows:

- Building floor elevations - 100-year, 3-day.
- Evacuation and emergency service routes - 100-year, 3-day.
- Arterial roads - 100-year, 3-day.
- Collector roads - 25-year, 3 day.
- Neighborhood roads - 5-year, 1 day.
- Urban sites - 5-year, 1-day.
- Rural sites - 3-year, 1-day.

As part of the LOS criteria, Subsection 11.8.1 states that off-site discharge rates are limited to predevelopment conditions. For water quality, the LOS criteria require development to "ensure that stormwater discharges will meet State water quality standards..." and identify the wet detention, dry detention and retention criteria required.

In support of both the Comp Plan and the Land Development Regulations, the County has issued the Layman's Brochure entitled, Guidelines for preparation of a site plan for single family and duplex lots in Monroe County. The brochure presents the public with information on reasons for controlling stormwater runoff (e.g., pollution minimization), how to prepare a site plan for a single family or duplex home and examples of stormwater best management practices for source controls. Recommendations include preservation of roadside swales, reduction of fill on the lot, flood protection measures, impervious surface minimization, water conservation and buffer zones.

2.5.5.3 Key West Land Development Regulations

The City of Key West regulates the development and re-development of land within the city through the Land Development Regulations (September 1997). The LDR divides twenty-one articles into five major chapters: General Administration, District and General Regulations, Performance Criteria, Administration of Development Plan Review and Subdivision, and Glossary. The stated purpose of the LDR is to assist the implementation of the city's comprehensive plan. The Key West Planning Board reviews the overall program (§1-2.4) and variances to the LDR are reviewed by the City Commission as the Board of Adjustment.

The LDR is implemented through the use of building permits (§1-2.3), an application for which must be accompanied by a development plan. It is through the review of the application that compliance with the LDR is confirmed. As a baseline, the LDR identifies the Future Land Use Map (FLUM) designations and zoning districts that are adopted as part of the LDR. The development of land within the city must be in conformance with the FLUM. FLUM Districts include:

- Conservation,
- Residential (low density residential, single family, medium density residential and high density residential),
- Commercial (limited, general and salt pond tourist),
- Mixed Use New Town (residential/office, planed redevelopment),
- Old Town Historic Preservation (historic residential/office, high density residential/commercial, medium density residential, planned development/redevelopment, neighborhood commercial, tourist commercial, public service, and high density residential), and
- Institutional (public services, and airport).

Each has a specific purpose as well as density and other characteristic restrictions (including open space and imperviousness limitations) identified in Article V. Section

2-5.9 also specifies through Table 2-5.9 specific impervious surface ratios (IPR) for each land use type (all are greater than 50 percent).

Section 2-7.15 in Article VII states that no work that may impact the 100-year floodplain or designated conservation area, or "redirects or/or increases or reduces off-site natural drainage or runoff" can be completed without and approved development plan. Also, borrow pits and mining activities are prohibited. The City Engineer reviews development plans for this purpose.

Chapter III (Articles IX to XVII) provides performance criteria including concurrency management, environmental management, and surface water protection. Section 3-9.8 provides the adopted levels of service (LOS) including drainage:

Drainage	a.	Post-development runoff can not exceed the predevelopment rate for the 25-year event, up to and including the 24-hour duration.
	b.	Facilities must be designed to achieve the standards defined in §62-25 FAC the treatment of the first inch of rainfall.
	c.	Facilities must be designed so as not to degrade water quality.

Section 3-11.2 requires an erosion and sediment control plan when the disturbance of land is required for development. Minimum measures include the minimization of runoff velocities, maximum protection of disturbed areas from runoff, and prevention or retention of sedimentation onsite.

Section 3-11.7 provides for floodplain protection. Development is to be outside of the 100-year floodplain unless otherwise authorized. If development does occur in the floodplain, compensatory mitigation is required providing for equivalent storage, 5 percent more open space, reduce imperviousness allowance and necessary stormwater facilities.

Article XII deals with Surface Water Management to implement the objectives of the Comprehensive Plan. The regulations are to complement those of FDEP and SFWMD and permits from both agencies are required as needed as well as those from the city. The article prohibits construction of a development project without first obtaining valid permits that include a stormwater management system. Impeding the functioning of a drainage system is likewise prohibited. Exemptions include agricultural systems, maintenance on mosquito control or impoundments, modifications to an existing structure resulting in a change of less than 500 square feet of impervious area, activities by the water management district, and activities related to emergencies. A Type A permit is required for all other activities. Criteria for the issuance of the permit include:

- The discharge must meet state water quality standards.
- The first inch of runoff or 2.5 inches times the imperviousness must be treated.
- Projects with greater than 40 percent impervious area discharging directly to sensitive waters must provide "dry detention or retention pretreatment equal to 50 percent of the total required." Water surfaces are subtracted from site areas for these calculations.
- A stormwater management system is required for properties subdivided for sale including a collection system and retention or detention prior to the outfall.
- Off-site discharges are limited to historical discharge amounts or limited by previous County or SFWMD actions.
- The stormwater management system must be designed for the 24-hour, 25-year design storm event. The 72-hour, 25-year event must also be considered.

The article also provides construction requirements for discharge structures, wet and dry detention / retention areas, impervious areas, inlets, etc.

Section 3-12.8 of Article XII considers development in a flood hazard zone. A Type B permit is required for such development and criteria for issuance include compensatory storage, mean and peak runoff velocities, pollution control, and elevations of structures.

Where appropriate, Section 3-12.12 allows the City Engineer to authorize the use of gravity injection wells for stormwater management. Criteria for use of such wells include use of a baffle box for sediment control as well as pretreatment using swales or ponds prior to the box, and 90- to 100-foot wells with the first 60 feet cased. The wells must first be approved by FDEP.

2.5.5.4 Islamorada Code of Ordinances

The city of Islamorada has adopted the Monroe County Code of Ordinances in their entirety.

2.5.5.5 Key Colony Beach Code of Ordinances

The Key Colony Beach Code of Ordinances is divided into Part I (Charter) and Part II (Code of Ordinances). Within Part II, Chapter 1 (General Provisions), Chapter 6 (Buildings) and Chapter 14 (Sewers and Sewage Disposal) contain pertinent references to the control of runoff.

Chapter 1 - General Provisions. Key Colony Beach regulates development and compliance with the Code through a code enforcement board, consisting of 7 members appointed by the city commission, and a special master also appointed by the commission. Violation of code may result in a fine, costs for reasonable repairs, and property lien.

Chapter 6 - Buildings. These regulations pertain to buildings, their construction and application for building permits. The regulations are administered by a building official and building inspector, appointed by the city commission. The building official is authorized to, among other responsibilities, "review plans and specifications for proposed construction and improvements," "approve and issue building permits," and "follow-up and make recommendations on citizen complaints on road, drainage, etc." A building permit is not required for cosmetic maintenance or for single-family or duplex residential structures, but is required for new or changed land uses and "construction, alteration or major structural repairs" for any building with cost exceeding $1,000. After construction, a professional engineer must certify that "the plans reflect that the lot drainage planned is such that water will be retained on site and otherwise conform to the drainage provisions of the Land Development Code, including the Level of Service Standard contained in Section 101-151(4)." Further a drainage and grading plan must be submitted to the building official showing proposed finished grades. During construction, the building official is to inspect the development at least once every 30 days. Furthermore, Section 6-13 requires that for the use of public rights-of-way, a permit is also required. For such a connection, "the flow of stormwater within drainage facilities will remain unimpeded" and "adequate measures will be taken to prevent pollution of water in the area from runoff…during the course of construction and restoration."

2.5.6 Regulatory Compliance

As a last step in the analysis of the existing regulatory environment, activities of the County in compliance with the regulations defined above were identified and assessed. Compliance activities considered were permit requirements, inspections, maintenance, staffing and effectiveness of program.

Permit Requirements

New development is permitted through the Building Department of the Growth Management Division. Unless exempted (see above), building permits are submitted to request new development or significant redevelopment. Appropriate permits from other agencies are required prior to submittal (e.g., Health Department and Electric Coop permits, and FDEP permits for docks). Building plans are required as part of the permit application; these plans are reviewed by the Building Department for residential and commercial construction and by the County Engineer for commercial development with impervious area greater than 200 square feet. For appropriate applications, the County Engineer reviews the stormwater management plans for the development (e.g., post-construction runoff peaks are predicted to be no more than the pre-construction ones). A building permit is then issued if the development is consistent with County regulations and building credits are available.

Inspection

During construction, the County provides numerous inspections including 10 or more times for single family home construction and 50 or more for multiple story buildings. These inspections provide confirmation that the construction is completed according to the approved plans. The inspection does not include review of the construction sediment and erosion control measures. However, the inspectors do consider whether or not the post-construction stormwater management facilities, if required, are constructed properly.

Maintenance Requirements

Most of the development plans reviewed by the Building Department are for residential construction that may include swales or retention ponds. Some include French Drains. Where appropriate, the County Engineer reviews the plans to confirm compliance with regulations. However, no assurances are required for the continued or proper maintenance of the stormwater facility constructed.

Staffing

Based upon the current development being reviewed, County staff believe that the staff resources available for review and inspection are adequate. Overloads occur during emergency conditions such as a hurricane. This assessment is based, of course, on the current moratorium on commercial development within the County. Should the moratorium be released or the development regulation be increased, staffing may need to be increased appropriately.

Training

Currently there is limited training offered to staff other than training on existing regulations. Additional training on construction sediment and erosion control is available from the Florida Department of Environmental Protection. It is recommended that this type of training should be offered to Building Department staff including inspectors.

Compliance Assessment

According to Building Department staff, voluntary compliance with the existing development requirements has improved over the last few years. Compliance improvements are generally attributed to public education on the building code.

2.6 Existing Stormwater Management Systems

In anticipation of the consideration of alternative management programs for the Stormwater Management Master Plan, a compendium of stormwater management alternatives was compiled from regional, state and national experience. Stormwater management includes structural and nonstructural controls to manage flooding induced by excessive runoff and water quality degradation due to runoff-borne pollutants. As a class, methods to control stormwater runoff are called Best Management Practices or BMPs. BMPs include techniques, approaches or constructed improvements that control runoff as its source (known as source controls or nonstructural controls) or that control runoff after it is collected (known as structural controls).

This subsection lists both structural and nonstructural controls (BMPs) that have been used in Florida and the United States. The intent of this subsection is to list BMPs reasonably applicable to Monroe County, providing information on benefits and limitations for their application. In Section 4.0 (Strategies and Solutions), the list of BMPs will be applied to problem areas within the County to define a management plan for stormwater pollution control and flood abatement. Table 2.6-1 lists the BMPs reviewed within this subsection.

The use of a specific BMP depends on the site conditions and objectives such as water quality protection, flood control, aquifer recharge, or volume control. In many cases, there are multiple goals or needs for a given project. Therefore, BMPs can be "mixed and matched" to develop a "treatment train." The treatment train concept maximizes the use of available site conditions from the point of runoff generation to the receiving water discharge in order to maximize water quantity (flood control), water quality (pollutant load reduction), aquifer recharge, and wetlands benefits. Figure 2.6-1 shows a schematic flowchart of the treatment train concept. The following comparative discussion of BMPs presents discussion on benefits and limitations of each BMP type.

2.6.1 Comparison of Structural BMPs

2.6.1.1 Wet Detention Ponds

Detention refers to the temporary storage of excess runoff onsite prior to gradual release after the peak of the storm inflow has passed. Runoff is held for a period of time and is slowly released to a natural or manmade watercourse, usually at a rate no greater than the pre-development peak discharge rate. For water quantity, detention facilities will not reduce the total volume of runoff, but will redistribute the rate of runoff over a longer period of time by providing temporary storage for the stormwater. Another objective of a wet detention facility is to remove pollutants produced from the tributary area.

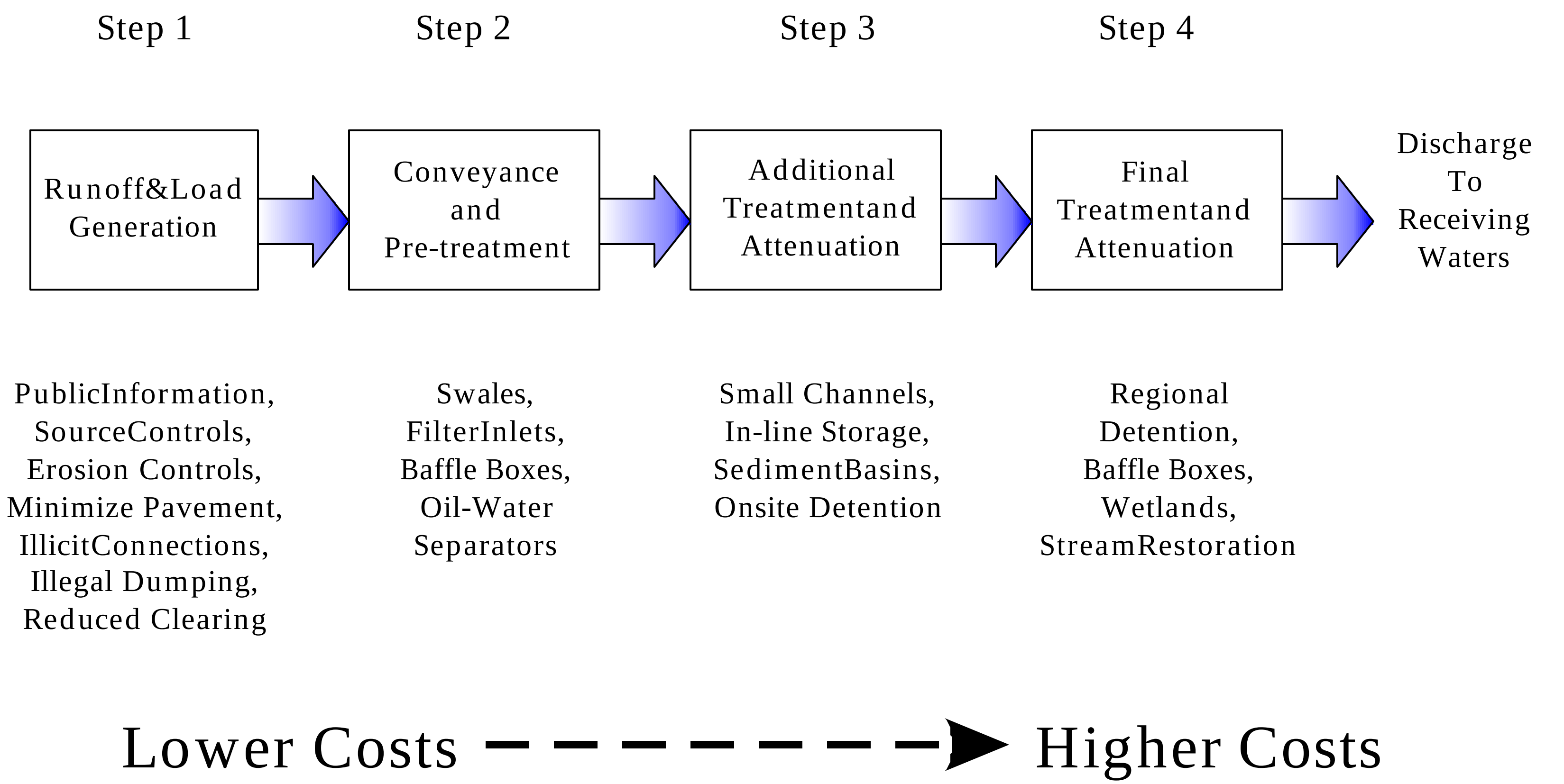
Table 2-1
Monroe County Stormwater Management Master Plan
List of Best Management Practices

Structural Stormwater Controls

- Dry detention ponds
- Wet detention ponds
- Exfiltration trenches
- Shallow grassed swales
- Retention basins
- Buffer strips
- Porous pavement
- Water quality inlets and baffle boxes
- Hydrodynamic separators
- Underdrains and stormwater filter systems
- Infiltration drainfield
- Dry Wells
- Modular treatment systems
- Stormwater wetlands
- Alum injection systems
- Aeration
- Level spreaders
- Oil/grease separators
- Recharge wells and bore holes with pretreatment

Nonstructural Stormwater Controls

- Land use planning
- Public information programs
- Stormwater management ordinance requirements
- Fertilizer application controls
- Pesticide use controls
- Control of gray water (Cisterns and Rainbarrels)
- Solid waste management
- Hazardous materials management
- Street sweeping
- Vehicle use reduction
- Directly connected impervious area (DCIA) minimization
- Low impact development
- Illicit connections (non-stormwater discharges) identification and removal
- Erosion and sediment control on construction sites
- Source control on construction sites
- Operation and maintenance



Notes:

1. DCIA is Directly Connected Impervious Area.
2. Recharge / Infiltration should be attained wherever possible.
3. Multi-step treatment maximizes removal of both suspended and dissolved pollutants.

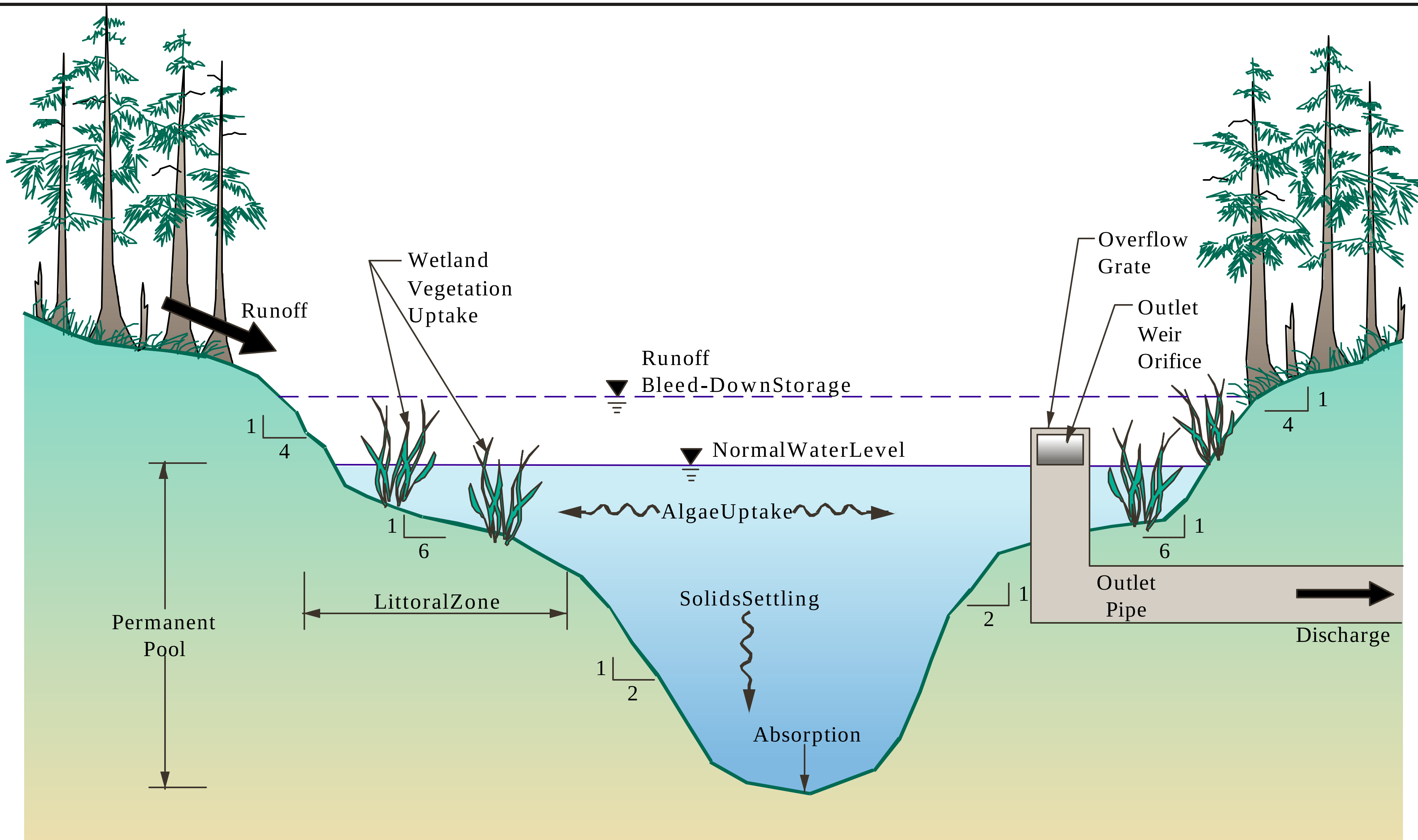
Figure 2.6-1
BEST MANAGEMENT PRACTICES
"Treatment Train" Concept
Monroe County
Stormwater Management Master Plan

A wet detention system includes a permanent pool of water, a shallow littoral zone with aquatic plants, and the capacity to provide detention for an extended time necessary for the treatment of a required volume of runoff. In wet detention ponds, pollutant removal occurs primarily within a permanent pool during the period of time between storm events. They are typically sized to provide at least a 2-week hydraulic residence time during the wet season. The primary mechanism for the removal of particulate forms of pollutants in wet detention ponds is sedimentation. Wet detention ponds can also achieve substantial reductions in soluble nutrients due to biological and physical/chemical processes within the permanent pool as illustrated on Figure 2.6-2. As may be seen, the facility consists of a permanent storage pool (i.e., section of the pond that holds water at all times), and for new developments or where site conditions allow, an overlying zone of temporary storage to accommodate the attenuation of peak flows. As illustrated on Figure 2.6-2, pollutant removal within the wet detention pond can be attributed to the following important pollutant removal processes that occur within the permanent pool:

- uptake of nutrients by algae and rooted aquatic plants;
- adsorption of nutrients and heavy metals onto bottom sediments;
- biological oxidation of organic materials; and
- sedimentation of suspended solids and attached pollutants.

Uptake by algae and rooted aquatic plants is probably the most important process for the removal of nutrients. Sedimentation and adsorption onto bottom sediments are probably the most important removal mechanisms for heavy metals. Absorption conditions at the bottom of the permanent pool will maximize the uptake of phosphorus and heavy metals by bottom sediments and minimize pollutant releases from the sediments into the water column. Since ponds that exhibit thermal stratification (i.e., separation of the permanent pool into an upper layer of high temperature and a lower layer of low temperature) are likely to exhibit anaerobic bottom waters during the summer months, relatively shallow (6 to 12 feet deep) permanent pools that maximize vertical mixing are preferable to relatively deep ponds. Water depth should be great enough to prohibit nuisance aquatic plant species in the open water portion of the pond (greater than six feet). A minimum depth of 6 to 12 inches should also be maintained in the littoral zone of the permanent pool to suppress mosquito breeding.

Wet detention BMPs offer other advantages that should be considered in BMP selection. Wet detention ponds are usually more visually appealing than dry ponds, particularly if there is desirable wetland vegetation around the perimeter of the permanent pool. When properly designed and constructed, wet detention ponds are



Notes:

1. Runoff is directed to the pond and detained for flood control and treatment by algae and vegetative uptake, solids settling, and adsorption.
2. The 1.0 to 2.5 inches of runoff is typically detained above a permanent pool (with a hydraulic residence time of 14 days) for treatment.
3. Storage recovery of first 1/2 inch of runoff is required in no less than 24 hours (SFWMD).

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Figure 2.6-2
TYPICAL WET DETENTION POND
Monroe County
Stormwater Management Master Plan

actually considered as property value amenities in many areas. Also, wet detention ponds offer the advantage that sediment and debris accumulate within the permanent pool. Since these accumulations are out-of-sight and well below the pond outlet, wet detention ponds tend to require less frequent cleanouts to maintain an attractive appearance and prevent clogging. Sediment forebay areas (or sumps) are recommended whenever possible.

If the contributing area is too small, storm runoff and dry weather inflows into the wet detention ponds may be too small to maintain a permanent pool during "dry" seasons. While excessive drawdown of the permanent pool does not pose a nonpoint pollution control problem, it may cause aesthetic problems.

While it can be argued that wet detention ponds can be designed to produce new wetland systems and that the additional water quality protection justifies potential wetlands impacts, extreme care and precautions must be exercised where stormwater treatment is provided through the use of existing wetlands. In these cases, the pond should be designed to re-establish wetland benefits to impacted wetlands and some swale pretreatment of pollutants should be provided.

Because wet detention ponds control flood peaks as well as treat stormwater quality, benefits of the wet detention pond include reduction of downstream flooding and of pollutant loading to receiving waters. Load reductions include both suspended and dissolved pollutants. These types of facilities also provide a wildlife habitat and generally increase nearby property values. Wet detention ponds can be located in areas of higher water tables and less permeable soils. The design of wet detention ponds can result in either off-line or on-line systems. On the other hand, wet detention ponds if not constructed properly can be a safety hazard and if not maintained, can exhibit nuisance problems such as algae, debris and mosquitoes. Sediment accumulated in the pond must also be periodically removed. Finally, wet detention ponds tend to be most beneficial when used as a regional facility thereby requiring significant vacant land.

Wet detention ponds are considered in England et al. (1999). Construction costs are reported to be about $90,000 per acre of pond.

2.6.1.2 Dry Detention Ponds

Dry detention ponds (sometimes referred to as extended dry detention ponds) combine the beneficial features of retention ponds (dry, grassed bottom) and wet detention ponds (flood waters detention and high pollutant removal efficiencies for settleable solids) in a hybrid design. However, they do not necessarily use certain valuable features of retention ponds (volume control and aquifer recharge) or wet detention ponds (high dissolved nutrient removal efficiencies) unless they are designed with some upstream retention prior to detention or they incorporate a small permanent pool, respectively.

Dry detention ponds increase detention times to provide treatment for the captured first-flush runoff to enhance solids settling and the removal of suspended pollutants. Extended detention facilities are drawn down through a control structure at a rate that is slow enough to achieve maximum pollutant removal by sedimentation. These types of detention ponds can be designed to achieve heavy metal loading reductions (e.g., 75 percent for lead and 40 percent for zinc) that are similar to wet detention ponds, since heavy metals in urban runoff tend to be primarily in suspended form. However, wet detention pond BMPs can achieve greater loading reductions for nutrients, which tend to appear primarily in dissolved form in urban runoff. Dry detention ponds require much less storage and cost less than wet detention ponds because they rely solely upon sedimentation processes without the expense of additional storage for the pool (i.e., portion of the pond that holds water at all times). However, in many retrofit cases, a certain fixed amount of open water area typically needs to be excavated to reduce flooding. Since this area needs to be at least six feet deep to discourage undesirable aquatic weeds, some wet detention will occur as an additional benefit. It should be noted that extended dry detention might be useful in areas where retrofit of BMPs is required. Dry detention is permittable for new development as approved by SFWMD. SFWMD allows a 25 percent reduction in treatment volume for dry detention compared to wet detention.

As with wet detention, dry detention ponds provide for the attenuation of peak rates of runoff and provide stormwater treatment. Suspended pollutants are removed most efficiently by dry detention and dissolved pollutants are removed. Sediment is stored in the pond itself since there is no permanent pool. Regular maintenance is required to remove sediments and debris. Dry detention ponds are always off-line.

Experience with dry detention ponds is reported in England et al. (1999). Construction costs are reported to be about $25,000 per acre of pond.

2.6.1.3 Exfiltration Trenches

An exfiltration trench is the onsite retention of stormwater accomplished through underground exfiltration. The trench can be off-line or on-line, with on-line volume requirements being greater than off-line. The subsurface retention facilities most commonly used are excavated trenches with perforated pipe backfilled with coarse graded aggregate. Stormwater runoff is collected for temporary storage and infiltration. Water is exfiltrated from the pipe and trench walls for groundwater recharge and treatment. The addition of the pipe increases the storage available in the system and helps promote infiltration by causing the runoff waters to be more effectively and evenly distributed over the entire length of the trench.

Exfiltration trenches are used to retain the "first flush" of stormwater runoff. This promotes pollutant load reductions to receiving waters, reduces the runoff volume and peak discharge rate from a site, filters suspended pollutants out of groundwater discharges, and promotes the recharge of groundwater.

Exfiltration trenches are practical in highly permeable soils (Hydrologic Group A) where the subsoil is sufficiently permeable to provide a reasonable rate of infiltration, and where the water table is sufficiently lower than the design depth of the facility to allow for recovery of the storage prior to the next storm event (generally required in 72 hours). It is frequently used for the disposal of runoff from roof drains, parking lots, and roadways. This practice is not recommended where runoff water contains high concentrations of suspended materials unless a presettling or filtering mechanism is provided. Likewise, grease and oil traps are also highly recommended prior to discharge to these systems. Providing sediment sumps in inlets or raising inlet tops above grade for pretreatment in swales will reduce sediment build-up in the trench. These precautions are primarily for maintenance since exfiltration systems are very susceptible to clogging and sediment build-up, which reduces their hydraulic efficiency and storage capacity to unacceptable levels. Figure 2.6-3 shows a profile view of a typical exfiltration trench.

Exfiltration trenches mimic the natural groundwater recharge capabilities of the site in areas where recharge is important. Due to the small size, exfiltration trenches can be easily fit into margins and other space-constrained sites including under pavement. For this reason, exfiltration can be used for retrofit where space is generally a problem. Exfiltration trenches also provide offline treatment for discharges into sensitive waters. However, exfiltration relies on the high permeability of the soils on the site, so such a trench is not recommended for clayey or highly erodible soils. Also because an exfiltration trench filters water, it has a relatively short life span and requires special maintenance to ensure proper operation.

2.6.1.4 Shallow Grassed Swales

Shallow grassed swales are natural or constructed shallow trenches shaped or gradually graded to required dimensions and established in suitable vegetation for the safe conveyance, storage, and treatment of runoff. A swale is defined by the SFWMD (see Chapter 40E-400) as a manmade trench that:

- Has a top width-to-depth ratio of the cross-section equal to or greater than 6:1, or side slopes equal to or greater than 3 feet horizontal to 1 foot vertical.
- Contains contiguous areas of standing or flowing water only following a rainfall event.

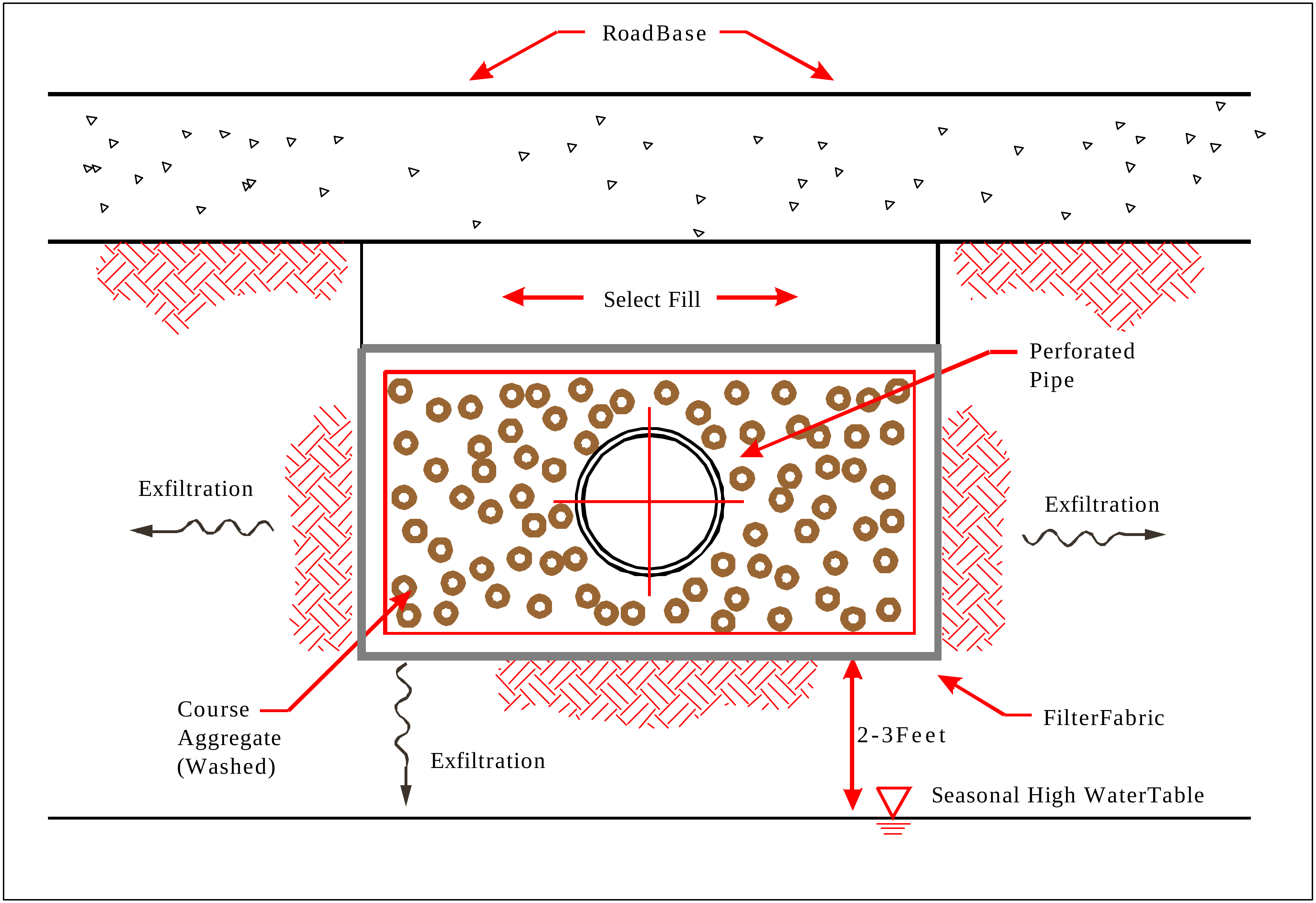

Figure 2.6-3
TYPICALEXFILTRATION TRENCH
Monroe County
StormwaterManagement Master Plan

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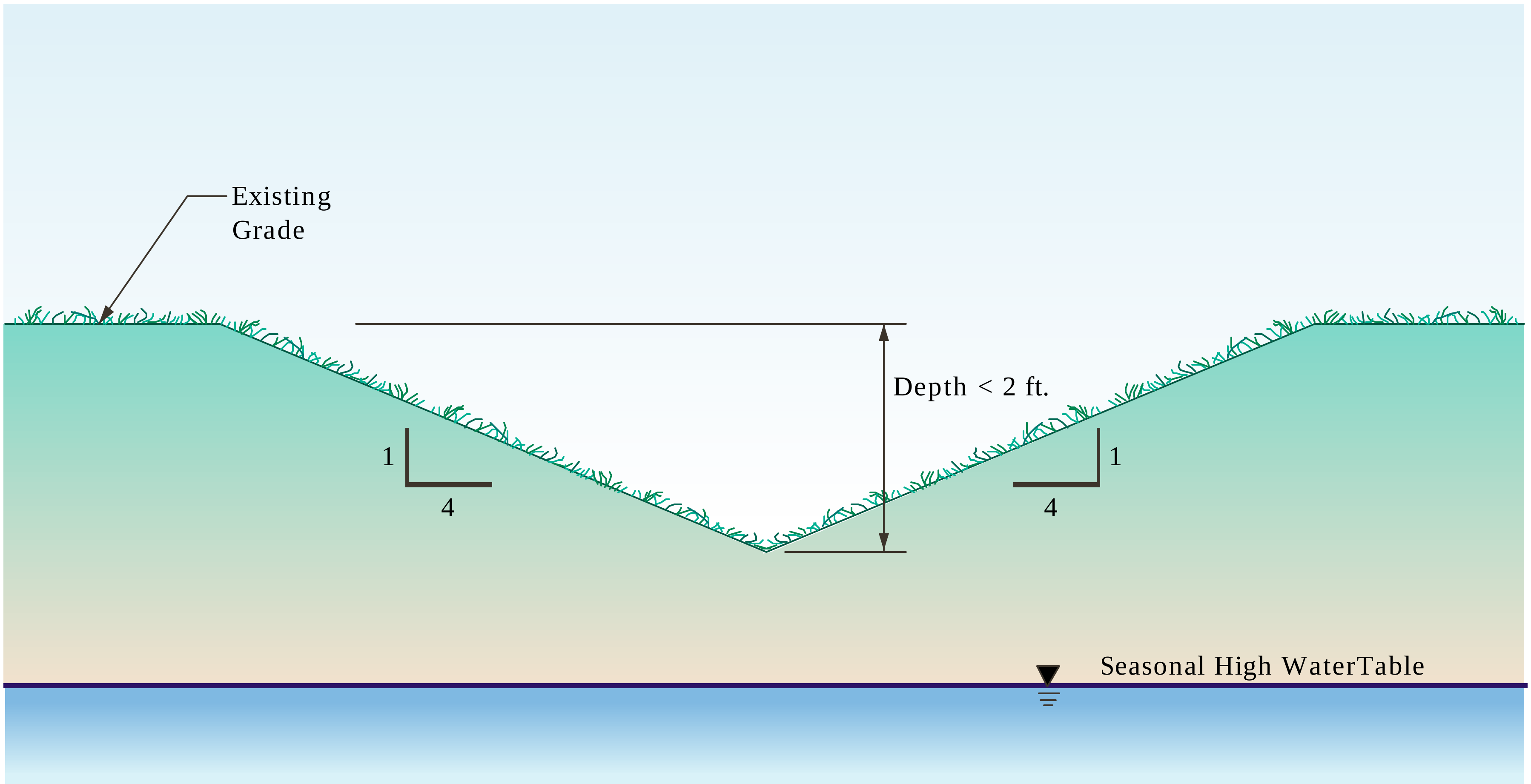
- Is planted with or has stabilized vegetation suitable for soil stabilization, stormwater treatment, and nutrient uptake.
- Is designed to take into account the soil errodability, soil percolation, slope length, and drainage area to prevent erosion and reduce the pollutant concentration of any discharge.

Swales are normally used for conveyance systems to transport runoff offsite or to a stormwater facility. They are best suited at sites with soils of moderate-to-high infiltration capacity (usually Hydrologic Groups A or B). With slight modification (e.g., check dams, raised inlets, or swale blocks), swales can be used to add retention storage, control erosion, provide aquifer recharge, and/or reduce the pollutant load from concentrated stormwater runoff in urban areas. They also may be used as pretreatment in the overall treatment train stormwater system. Implementation examples of swales include outlet channels from detention systems; stormwater collection and treatment along roadways or residential areas; and pretreatment to reduce stormwater pollutant loads before conveying stormwater or other management practices or offsite. Figure 2.6-4 shows an example of a typical swale and Figure 2.6-5 shows a typical check dam that can be used to modify a swale to provide limited retention/detention benefits.

Swales perform as infiltration BMPs in areas with permeable soils that are not restricted by a high water table. These controls can be very effective where suitable conditions exist (e.g., with Hydrologic Group A or B soils and a low water table; e.g., one to two feet below grade or lower), and these have the added benefit of increasing the recharge to the shallow water table. If swales are the only BMP used to provide water quality treatment, current Florida regulations (Chapter 62-25 FAC) require that swales be designed to percolate 80% of the runoff from a 3-year, 1-hour design storm within 72 hours (or 100% of the runoff from the 3-year, 1-hour design storm, depending on the receiving water body classification). Pretreatment uses for swales typically includes 0.25 to 0.5 inches of treatment.

Swales tend to be less expensive than curb and gutter and if constructed properly are hardly noticeable when shallow. Swales provide a measure of treatment and are best used as a preliminary part of a treatment train. A raised inlet or check dam can help increase the infiltration and reduce the runoff volume. Maintenance is minimal and can usually be performed by the adjacent landowner. As with exfiltration trenches, swales can be located in space-constrained sites as long as the soils are permeable. Without permeable soils, swales are simply conveyances. Swales can also be used as recessed and landscaped areas (green space). Swales must be designed properly (too deeply cut leads to a ditch-like system) and maintained regularly.



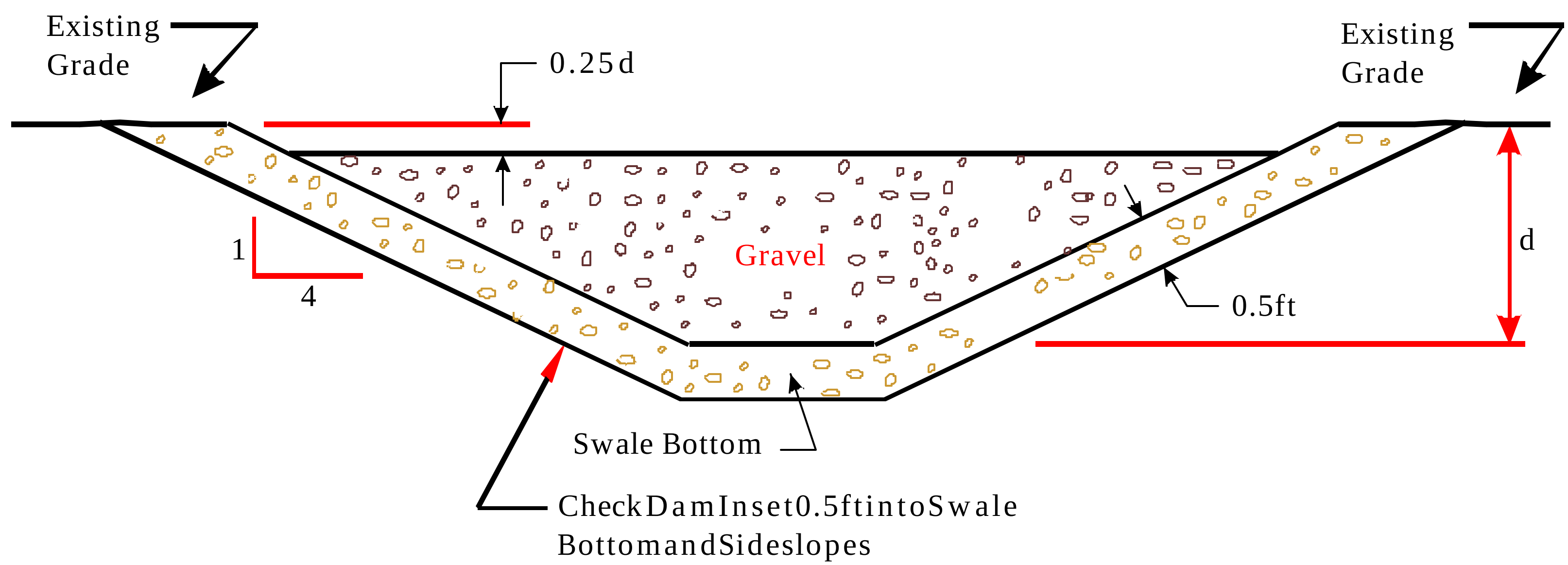
Notes:

1. Slopes shall be no steeper than 4 horizontal to 1 vertical and 6 horizontal to 1 vertical is preferred.
2. Swale invert shall be at least 1-2 feet above the seasonal high water table.
3. Swales shall be grassed and check dams placed as needed to control overflows and velocities.
4. Depths shall be no greater than 2 feet.

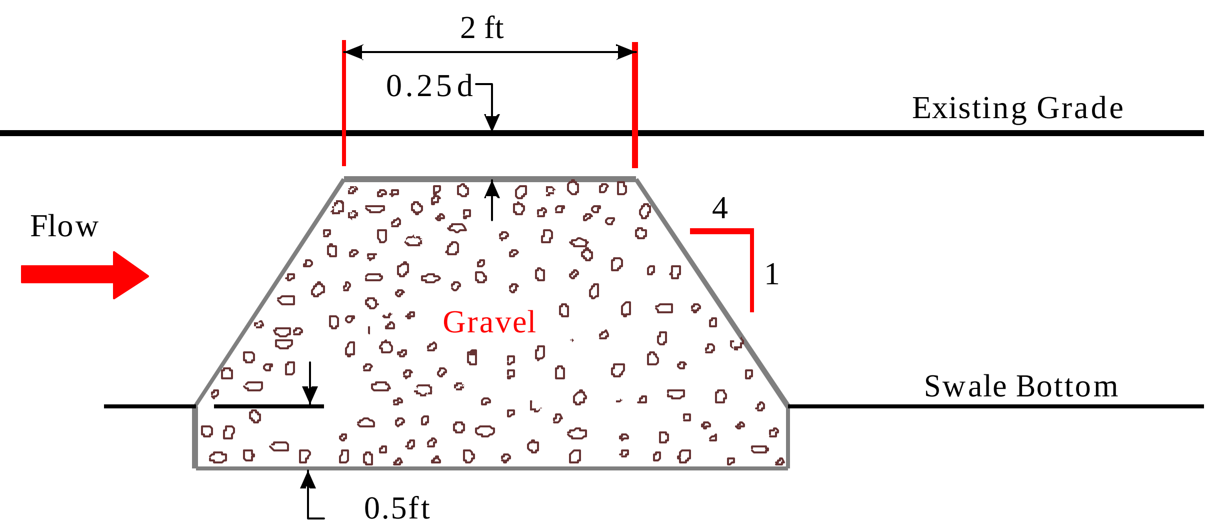
Source: CDM Technical Paper

CDM Camp Dresser & McKee

Figure 2.6-4
TYPICAL SHALLOW GRASSED SWALE
Monroe County
Stormwater Management Master Plan



SECTION



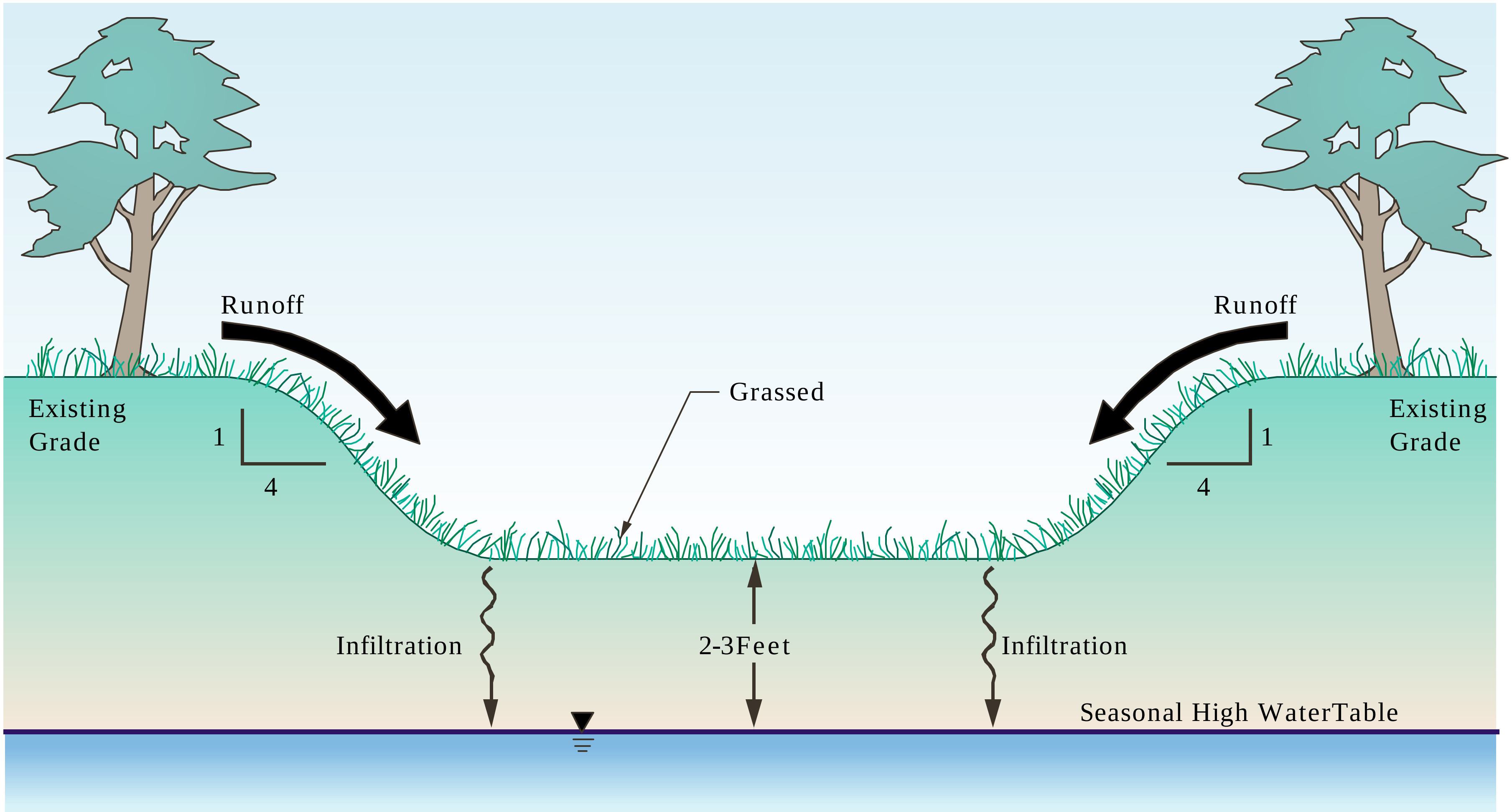
PROFILE

NOTES:

1. Place CheckDamsas needed to control overflows and velocities.

2. Gravel averageDia= 1.5to2.0in.

Figure 2.6-5
TYPICAL CHECKDAM
Monroe County
StormwaterManagement Master Plan



Notes:

1. Runoffisdirected tothepondandretainedwithoutoverflowordischargetodownstream.
2. Thefirsthalfinchofrunofforrunofffromthefirstinchofrainfallistypicallyretainedfortreatment.
3. Infiltrationandevapotranspirationprovideforrecovery of storage(72 hoursfortreatmentvolume,14daysforfloodcontrol volume)
4. Sideslopesshouldbenosteeperthan4horizontalto1vertical.

Source:CDMTechnicalPaper

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Figure2.6-6
TYPICALRETENTIONBASIN
MonroeCounty
StormwaterManagementMasterPlan

Swales can be used as part of landscaping. The swale can contain planted landscaping and be the collection point for runoff. The swale will treat runoff and help reduce conveyance requirements. Swales can also be used along roads prior to discharge to near shore waters.

2.6.1.5 Infiltration Basins and Retention Basins

A retention basin is an infiltration system designed to retain stormwater onsite, thus reducing pollution, recharging groundwater, and controlling flood waters. Typically, these basins have dry bottoms covered with native grasses. The site characteristics where retention basins function best are where soils are highly permeable and the seasonal high water table is situated well below the soil surface (at least 2 to 3 feet below pond bottom). These systems can be incorporated into multipurpose park areas when designed with very gradual slopes. Retention basins need to be inspected regularly to check for infiltration capacity. Figure 2.6-6 shows a profile view of a typical retention basin.

Infiltration controls are typically best suited for onsite applications (off-line from the primary stormwater management system) where the contributing area is limited to a single development site or subdivision (e.g., 1 to 50 acres). To be most effective, retention controls must be an integral part of the initial design and construction of a site. Retention BMPs may be suitable for use at individual urban redevelopment or retrofit sites within a watershed. SFWMD gives credit for a 50 percent reduction in treatment volume for retention compared to wet detention.

Bioretention is a BMP which utilizes soils and both woody and herbaceous plants to remove pollutants from stormwater runoff. The treatment area consists of a grass buffer strip, sand bed, ponding area, organic layer or mulch layer, planting soil, and plants. Runoff passes over a grass buffer strip which reduces velocity and filters particulates from the runoff. The sand bed also reduces the velocity, filters particulates, and conveys the runoff as sheet flow over the length of the bioretention area. The ponding area provides a temporary storage location for runoff prior to evaporation or infiltration. The maximum recommended ponding depth of the bioretention area is 6 inches. This depth provides for adequate storage and prevents water from standing for excessive periods of time. Some particulates not filtered out by the grass filter strip or the sand bed settle within the ponding area. The organic or mulch layer provides additional filtration of pollutants and an environment conducive to the growth of microorganisms, which degrade petroleum-based products and other organic material. In addition, the clay in the planting soil provides adsorption sites for hydrocarbons, heavy metals, nutrients, and other pollutants.

Bioretention is an ideal stormwater management BMP for median strips, parking lot islands, and swales. Construction of bioretention areas is best suited to sites where grading or excavation will occur in any case so that the bioretention area can be readily incorporated into the site plan without further environmental damage. Bioretention should be used in stabilized areas to minimize sediment loading in the treatment area. Sites with loamy sand soils are especially appropriate for bioretention because the excavated soil can be backfilled and used as the planting soil, thus eliminating cost. An unstable surrounding soil stratum and soils with a clay content greater than 25 percent may preclude the use of bioretention, as would a site with slopes greater than 20 percent or a site with mature trees that would be removed during construction of the BMP.

The application of retention BMPs should be considered on a case-by-case basis within the study area where soils and water table conditions are suitable. If located properly, retention can mimic the natural infiltration and recharge capabilities of a site as well as provide significant stormwater pollutant removal and attenuation of peak runoff rates. Retention ponds can provide temporary stormwater treatment facilities for construction sites to remove accumulated sediments from runoff. Retention ponds are also reasonably cost effective if suitable soils are present. As with similar BMPs, retention ponds require periodic maintenance including removal of debris, nuisance plant growth and sediment accumulated on the bottom of the pond.

In a summary of stormwater retrofit technology, England et al. (1999) considered on-line and off-line retention ponds. Construction costs for both on-line and off-line dry retention are reported as about $25,000 per acre of pond.

2.6.1.6 Buffer Strips

Buffer strips or filter strips, consisting of grass or other close-growing vegetation, are designed to accept overland flows of runoff. They are usually composed of dense vegetation such as high grasses, ground covers, or shrubs. Buffer strips are often combined with underlying stone layers to enhance infiltration. Buffer strips can be effective in slowing stormwater runoff rates and velocities, reducing downstream sediment loading by settling and physical entrapment. They can increase infiltration of stormwater and can provide some nutrient removal through uptake of plants. Buffer strips with berms or weirs are efficient for controlling roadway runoff discharges to sensitive surface waters.

Buffer strips are typically located between pollutant source areas and a downstream receiving water body. They also can be used as outlet or pretreatment devices for other stormwater control BMPs. A buffer strip is not a complete stormwater management system. Filter Strips need to be planted in combination with existing natural vegetation. Usually the minimum width for grassed filter area is 15 feet, while that of wooded areas is 35 feet. The ultimate size will depend on individual site since the width is based on a required detention. Buffer strips function best when they are level in the direction of stormwater flow toward the receiving water. This orientation creates proper sheet flow through the strip, increasing infiltration and filtering of sediments and other organic solids. To prevent erosion channel formation, a level spreader needs to be placed along the top edge of the filter strip.

2.6.1.7 Water Quality Inlets and Baffle Boxes

Water quality inlets are designed to prevent sediment, oil, and grease from entering storm drains and stormwater infiltration systems. Water quality inlets are typically installed at catch basins, and baffle boxes are typically installed further downstream in the storm sewer.

Two basic designs of baffle boxes are described by Schueler (WASHCOG, 1987): the Montgomery County design and the Rockville design.

- The Montgomery County design consists of a rectangular concrete box divided into three chambers where sediment, grit, and oil are separated from stormwater runoff as it passes through the chambers before exiting through an outlet to the storm drain system. The first chamber is designed for sediment trapping, and the second chamber is designed for oil separation. Each chamber contains a permanent pool and is accessible through manhole covers. The third chamber is for final settling.

- The Rockville design also consists of three chambers. However, runoff is allowed to exfiltrate into the subsoil through weep holes located at the bottom of the chambers. These holes prevent the formation of permanent pools and provide additional pollutant removal through exfiltration.

Baffle boxes, when used in conjunction with pretreatment measures such as street sweeping, may be the most feasible water quality control device in areas where the other more traditional measures may not be applicable due to various constraints. The design of a baffle box is identical to a primary clarifier with the addition of a skimmer for floatables. Target pollutant sizes are fine sands and larger size particles. There are limited percent pollutant removal data on these devices, but the quantity removed can be quantified when the boxed is cleaned of sediment and debris.

Precast oil/water separators are also available and can be installed on small commercial and industrial sites. The new coalescent plate separators are relatively efficient (50% to 80% removals are reported). These could be used for gas station and industrial area applications.

Water quality inlets are generally designed for sites of one acre or less. These inlets are typically used on commercial sites where high loads of sediments and oil are generated, such as gas stations, commercial stores, and small parking lots. Applications in residential areas are also becoming more frequent. Water quality inlets are typically designed to trap heavy sediments and/or oil and grease. Removal mechanisms are usually settling, filtration, and/or adsorption.

Maintenance requirements vary by device and application, but generally require a minimum of cleaning the chambers at least twice a year to remove pollutants. Frequent maintenance is essential for the effective removal of pollutants using these systems. The cleaning process from these devices includes pumping out the contents of each chamber into a tank truck. If the entire contents are pumped out as a slurry, they are then transferred to a sewage treatment system. If the runoff is separated from the sediments by onsite siphoning, the sediments can be trucked to a landfill for final disposal. These maintenance operations can be costly.

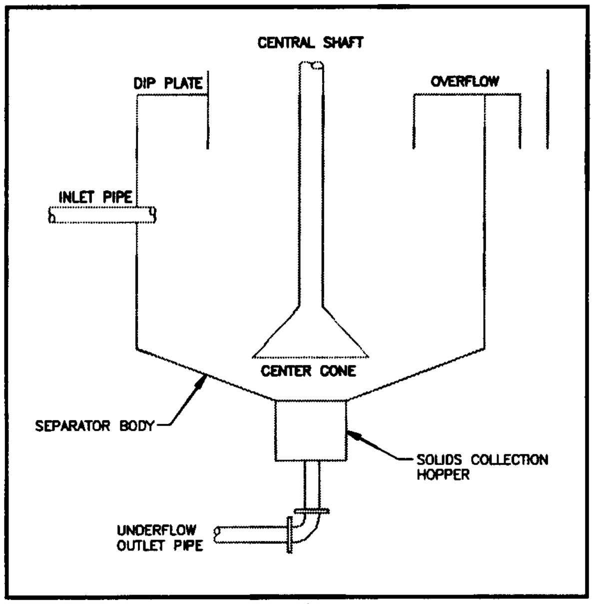
2.6.1.8 Hydrodynamic Separators

Hydrodynamic separators are flow-through structures with a settling or separation unit to remove sediments. The energy of the flowing water allows the sediments to efficiently separate so no outside power source is required. Depending on the type of unit, this separation may be by means of swirl action or indirect filtration. A generalized schematic of a unit is shown in Figure 2.6-7. Hydrodynamic separators are most effective where the materials to be removed from runoff are heavy particulates which can be settled or floatables which can be captured.

Vortechnics

The Vortechnics is a proprietary device that relies on the centrifugal forces of the water to help settle the sediments. Basically, storm sewer flow is diverted into the first chamber where the sediments are settled by the reduced velocity in that chamber and by the centrifugal force of the water as it swirls. The Vortechs system is divided into three chambers, the grit chamber, oil chamber and baffle wall, and flow control chamber. There are four phases to the operation of Vortechnics as described by its manufacturer. They are: initial wet weather phase, transition phase, full capacity phase, and storm subsidence phase/cleaning.

During a two-month storm event the water level begins to rise above the top of inlet pipe. This influent control feature reduces turbulence and avoids resuspension of pollutants. As the inflow increases above the controlled outflow rate, the tank fills and the floating contaminant layer accumulated from past storm rises. Swirling action increase at this second stage while sediment pile remains stable. When the high flow outlet approaches full discharge, storm drains are flowing at peak capacity.



Source: Fenner and Tyack, 1997.

Figure 2.6-7 Generalized Hydrodynamic Separator

The Vortechs system is designed to match the design storm flow and provide treatment throughout the range of storm events without bypassing. To accommodate very high flow rate, the system can be configured with a peak-flow bypass. At the final phase, treated runoff is decanted at a controlled rate, restoring the water level to a low dry-weather volume and revealing a pile of sediment. The low water level facilitates inspection and cleaning, and significantly reduces maintenance costs. The system's central baffle prevents transfer of floatables to the outlet during cleaning or during the next storm.

The removal efficiency as reported by the manufacturer is around 80 % for coarse material. To improve the removal efficiency of this unit, it is recommended that the unit be placed off-line.

Continuous Deflection System (CDS)

The mechanism by which the CDS technology separates and retains pollutants is by first diverting flow and associated pollutants in a storm sewer system away from the main flow stream of the pipe into a pollutant separation and containment chamber. The separation and containment chamber consists of a containment sump in the lower section of the unit and an upper separation chamber. Pollutants are removed with the removal of the sediments (> 50 micron) via a perforated plate allowing the filtered water to pass through to a return system and then to the outlet pipe. The water and associated pollutant contained within the separation chamber are kept in continuous motion by the energy generated by the incoming flow. This has the effect of preventing the separation plate from being blocked by the gross solids separated from the inflow. One of the benefits of the CDS unit is that it is always off-line.

Hydrodynamic separators can reduce sediments, floatables and oil and grease in runoff. Ideal for space limited areas, separators can be made available in a wide variety of sizes including small enough to fit through conventional manholes. Such units can also be used to polish (i.e., provide final treatment) to stormwater within a treatment train.

2.6.1.9 Porous Pavement

A porous pavement generally consists of a layer of porous or pervious concrete overlying an underground reservoir filled with stone aggregates. It is mainly designed to treat rainfall that falls on the pavement. After stormwater runoff infiltrates through the pavement, it is collected in reservoirs where it infiltrates into the subsoil. Porous pavements are typically used in the construction of parking lots as a built-in stormwater treatment device.

The design of a porous pavement can be modified to enable the system to accept runoff from surrounding areas and rooftops. This modification includes the installation of perforated inflow pipes to distribute the runoff throughout the stone reservoir. In addition, a pretreatment system is needed to remove trash, sediment, oil, and grease to prevent them from clogging the reservoirs. The FDEP has found these surfaces to be very effective in certain applications (Livingston, personal communication).

The cost-effectiveness of porous pavement can be estimated by determining the additional expenses incurred for constructing a parking lot with a porous pavement instead of conventional pavement, and by deducting the savings resulting from reduced land consumption and elimination of the need for additional BMPs. Porous pavements reduce stormwater volumes discharged to surface waters, thereby reducing pollutant loadings and increasing groundwater recharge. This is achieved by sorption, trapping, and straining, bacterial reduction, and groundwater diversion.

Porous pavements are not intended for the removal of coarse particulate pollutants; however, they are efficient in the removal of fine particulate pollutants. Estimates of cost-effectiveness can be made on a case-by-case basis only because of variables such as parking lot dimension, site size, amount of offsite runoff, and pretreatment requirements. In general, porous pavements are more cost-effective on sites between 3 acre and 10 acres in size.

The construction of a porous pavement system requires that rigorous construction practices be implemented. Adequate field testing and subgrade preparation is required before construction. Sediment control is needed before, during, and after construction. If regular maintenance is ignored, then the pores will clog and will not allow infiltration. Monthly (and possibly bimonthly) vacuuming may be required. Also, porous pavement does not stand up very well against heavy traffic loads.

Porous pavements are best suited for sites with the following features:

- Infiltration rates greater than 0.27 inch per hour.
- Soil with clay content less than 30 percent.
- Slope less than 5 percent.
- Minimum of 2- to 4-foot clearance between the bottom of the reservoir and the seasonally high water table.

2.6.1.10 Underdrains and Stormwater Filter Systems

These types of systems typically consist of a settling basin and a filter. The settling basin is essential to avoid rapid clogging of the filter. Treated water that passes through the filter bed is discharged through an underdrain. The biggest concern with this type of system is rapid clogging of the filter bed. This system also tends to work better offline so there is no continuous baseflow. This allows the system to dry out, which allows for the raking/removal of debris from the filter bed and promotes proper pollutant removal mechanisms.

Sand filters can be highly effective stormwater BMPs. They are intended primarily for water quality enhancement, providing very limited flow rate control. A typical sand filter system consists of two or three chambers or basins. The first is the sedimentation chamber where floatables and heavy sediments are removed. The second is the filtration chamber which removes additional pollutants by filtering the runoff through a sandbed. The third is the discharge chamber.

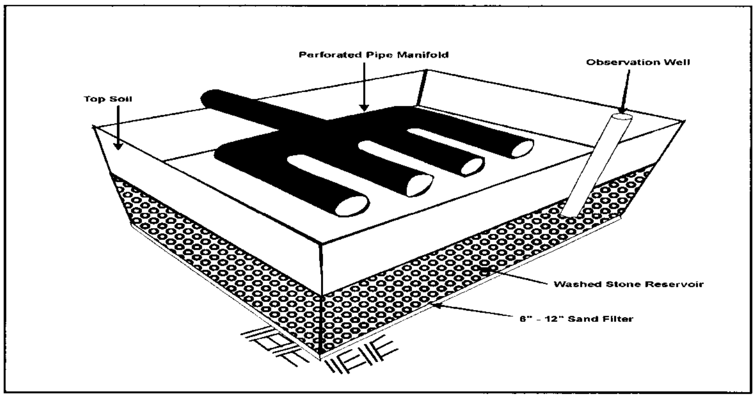
Sand filters can be used as alternatives for water quality inlets. They are more frequently used to treat runoff contaminated with oil and grease from drainage areas with heavy vehicle usage. They take up little space and can be used on highly developed sites and sites with steep slopes. In most cases, sand filters can be constructed with impermeable basin or chamber bottoms, which help collect, treat, and release runoff to a storm drainage system or directly to surface water with no contact between contaminated runoff and groundwater.

The primary differences among sand filter designs are location (above or below ground), the drainage area served, their filter surface areas, their land requirements, and the quantity of runoff they treat. Such facilities can remove sediments, BOD and coliform bacteria through filtration and since the filter media is periodically removed, the pollutants are permanently trapped. Land requirements are generally less than ponds or wetlands. On the other hand, total metals and nutrient removal is relatively low. Also, maintenance must be routinely completed to prevent filter clogging and even so, filter media replacement should occur every 3 to 5 years. Sand filters do not provide flood attenuation.

2.6.1.11 Infiltration Drainfield

Infiltration drainfields are systems designed to control runoff and prevent the contamination of water bodies by promoting infiltration of stormwater into subsoils. The system is usually composed of a pretreatment structure, a manifold system, and a drainfield. Runoff is first diverted through a pretreatment structure which removes coarse sediment, oils, and grease. The stormwater then enters the infiltration drainfield through a manifold system. This system consists of a perforated pipe which distributes the runoff evenly throughout the infiltration drainfield. An example of this system is shown in Figure 2.6-8.

The effectiveness of infiltration drainfields depends upon their design. When runoff enters the drainfield, 100 percent of the pollutants are prevented from entering surface water. Any water that bypasses the pretreatment system and drainfield will not be treated. Pollutant removal mechanisms include absorption and adsorption, straining, microbial decomposition in the soil below that drainfield, and trapping of sediment, grit, and oil in the pretreatment chamber. Drainfields have limited use in areas with sole-source aquifers. Also, maintenance costs can be high in areas of high sediment loads, which generally leads to a short life span. Drainfields must also have permeable soils and are therefore not suitable for clayey or silty soils. The soils within the drainfield must also have time to dry out otherwise clogging and anaerobic conditions can reduce the capacity of the system.



Source: Metropolitan Washington Council of Governments, 1987.

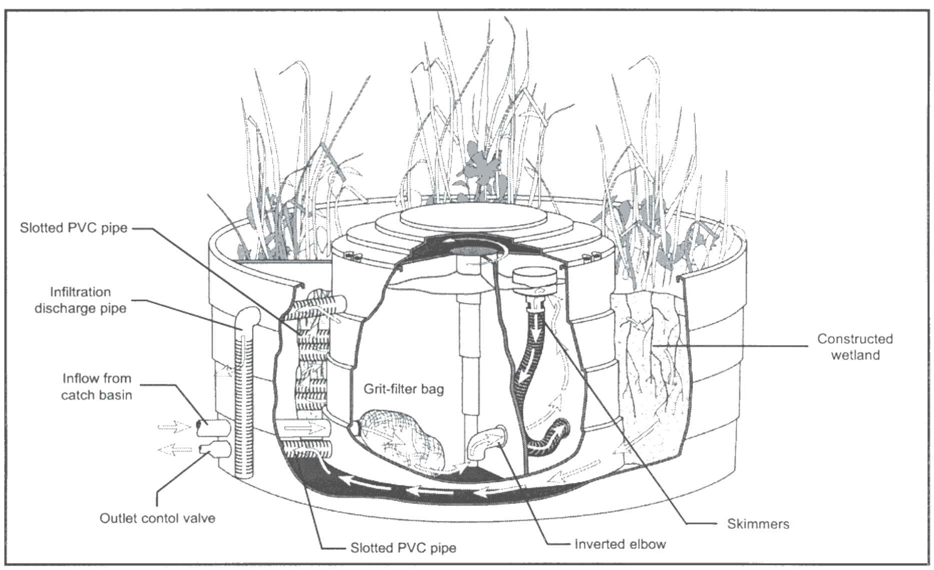
Figure 2.6-8 Typical Infiltration Drainfield Schematic

2.6.1.12 Dry Wells

Dry wells are small, excavated trenches backfilled with stone. Dry wells function as infiltration systems used to control runoff from building rooftops and need to be located close to the runoff source. Dry wells are capable of infiltrating the design storm event within 3 days from the beginning of the storm. these facilities must be sited away from slopes greater than 20 percent, particularly when the slope consists of fill materials over native ground. The overflow must be directed to downslope bioretention facilities, swales, or other management areas in a nonerosive fashion. Conveyance areas should be well vegetated and have slopes of less than 5 percent, or appropriately sized riprap should be used.

2.6.1.13 Modular Treatment Systems

One of the primary modular stormwater treatment systems currently on the market is the StormTreat™ System, or STS. The STS is a modular, 9.5-foot diameter recycled-polyethylene tank containing a series of sedimentation chambers and constructed wetlands. Figure 2.6-9 is a diagram of the STS. Influent is piped into the unit's sedimentation chambers where pollutants are removed through sedimentation and filtration. The sedimentation chambers are in the inner ring of the tank which has a diameter of nearly 5.5 feet. Stormwater is then conveyed from the sedimentation chambers to the outer ring containing the constructed wetland. Unlike most constructed wetlands systems, STS conveys the storm water directly into the subsurface of the wetland and through the root zone.



Source: StormTreat™ Systems, 1998.

Figure 2.6-9 Stormtreat™ System

Pollutants are then removed through filtration, adsorption, and biochemical reactions. These processes occur at higher rates within the root zone, making STS more efficient in pollutant removal. Stormwater is retained in the wetlands for five to ten days prior to discharge.

The STS design can be modified for areas with high groundwater levels or tidal influence. In areas with high groundwater, the discharge pipework can be modified so that runoff is discharged downgradient to an area with a lower water table. In tidally influenced areas, a check valve can be installed to prevent flow from re-entering the unit at its discharge point. This allows discharge to be released only during mid- to low-tide conditions.

Because of the size and configuration, a modular treatment system can be adaptable to a wide range of site constraints and drainage areas. This means that such a system may be useful in single site runoff treatment such as parking lots, airports, marinas and individual commercial, industrial or residential lots. The systems can remove hydrocarbons, nutrients, metals and suspended solids. However, this type of system is relatively new and has not been thoroughly tested in differing geographical areas.

2.6.1.14 Stormwater Wetlands

Wetlands improve the quality of stormwater runoff, and can also control runoff volume. They are one of the more reliable BMPs for removing pollutants and are adaptable to most locations. Wetlands remove pollutants from stormwater through physical, chemical, and biological processes. Chemical and physical assimilation mechanisms include sedimentation, adsorption, filtration, and volatilization. In general, wetlands remove pollutants about as effectively as do conventional pond systems.

Wetlands used for stormwater treatment can be incidental, natural, or constructed. Incidental wetlands are those that were created as a result of previous development or human activity. The use of natural wetlands for stormwater treatment is discouraged by many experts and/or public interest groups, and may not be an option in many areas.

Environmental benefits associated with stormwater wetlands include improvements in downstream water and habitat quality, enhancement of diverse vegetation and wildlife habitat in urban areas, and flood attenuation. Downstream water quality is improved by the partial removal of suspended solids, metals, nutrients, and organics from urban runoff. Habitat quality is also improved as reduced sediment loads are carried downstream and the erosion of stream banks associated with peak storm water flows is reduced. Wetlands can support a diverse wildlife population and can attenuate runoff and alleviate downstream flooding.

Stormwater wetlands can cause adverse environmental impacts upstream of the wetland, within the wetland itself, and downstream of the wetland. Possible adverse effects within the wetland itself are the potential for blocking fish passage, potential habitation by undesirable species, and potential groundwater contamination. A stormwater wetland can act as a heat sink, especially during the summer, and can discharge warmer waters to downstream water bodies. The increased temperatures can affect sensitive fish species and aquatic insects downstream. Wetlands may remove pollutants less effectively during the non-growing season and in localities with lower temperatures. Finally, because of the large land requirement for stormwater wetlands systems, their use may be precluded in urban settings and established communities.

2.6.1.15 Coagulant Injection Systems

Coagulant injection is a treatment process that uses coagulation to achieve a reduction in colloidal or fine suspended matter from stormwater. A number of chemicals have been used to provide coagulation including alum (aluminum sulfate), other aluminum-based coagulants, and a series of polymers (Superfloc, Polyfloc, Klaraid, etc.). The chemical is applied upstream of a treatment pond by means of an injection system. The pond must be designed to provide sufficient detention time to allow the chemical residual and coagulated particles to settle out to either a collection sump or pond bottom. Considerable experience with alum shows that as long as the pH is neutral (between 6 and 8) then the precipitates are stable and reside in the sediment.

There are both benefits and concerns when using a coagulant injection system. Benefits are significant reductions in solids (e.g., suspended solids, algae and bacteria), heavy metals and nutrients. Concerns are the added capital/operating costs and the chemical sludge that is accumulated over time. This can be very effective for colloidal solids that are difficult to settle through typical physical processes.

The majority of the historical experience for alum addition for the treatment of stormwater runoff is reported in Harper et al. (1997). Data from alum systems were collected from 1986 to 1995 and summarized in this article. Construction costs are reported to average $1,542 per acre treated with a range of $27 to $207 per acre treated per year for maintenance costs.

2.6.1.16 Aeration

Aeration is a mechanical means of increasing dissolved oxygen in a waterbody. Aeration can be done in several ways. The most common methods of aeration are diffusers, spray systems, and mechanical aerators which introduce oxygen to the waterbody. Aeration does have power costs associated with the operation of the mechanical equipment.

2.6.1.17 Level Spreaders

A level spreader is an outlet designed to convert concentrated runoff to sheet flow and disperse it uniformly across to prevent erosion. One type of level spreader is a shallow trench filled with crushed stone. The lower edge of the level spreader must be exactly level. Level spreaders can be used to convey sheet flow runoff from lawn areas within graded areas to bioretention facilities and transition areas. They can also be used to deliver runoff from parking lots and other impervious areas to infiltration areas. The receiving area of the outlet must be uniformly sloped and not susceptible to erosion. Particular care must be taken to construct the outlet lip completely level in a stable, undisturbed soil to avoid formation of channels. Erosion-resistant matting may be needed across the outlet lip.

2.6.1.18 Oil/Grease Separators

Oil and grease skimmers are a cost-effective method of prohibiting oil and grease from flowing onto receiving waterbodies. Oil and grease skimmers are easily installed and maintained. Skimmers should also be considered in the design phase of storage/treatment facilities such as the wet detention ponds. The SFWMD requires the use of skimmers or baffles at BMP outlets where oil and grease are expected (e.g., gasoline station) and where the upstream tributary has more than 50% of impervious surfaces. The skimmers are designed to retain the oils and greases at the surface of the retention/detention system to allow time for them to volatilize (evaporate) and biodegrade. They are also useful at gas stations and fuel storage areas.

Oil/grease separator BMP systems have been constructed where flow enters a treatment unit and is directed against an aluminum baffle. Floatables and trash are trapped against the baffle for easy removal. Upon entering the chamber, velocity slows, allowing grit, sludge, and oil particulate matter to settle to the sloping bottom. The stormwater is then directed upward through layers of absorbent media where oil and grease are removed via absorption onto the material. Coalescent plate separators use inclined plates to increase removal efficiencies.

Oil/grease separators are constructed to remove sediment and hydrocarbon loading s from parking lot and street runoff. As typically designed, oil/grease separators have limited storage capacities, but serve to separate some coarse sediment, oil/grease, and debris from urban runoff. Fine-grained particulate pollutants such as silt and clay, and associated trace metals and nutrients are less likely to be removed.

Oil/grease separators are compatible with the storm drain network, easy to access, and allow for pretreatment of runoff before it enters infiltration facilities. Disadvantages associated with oil/grease separators include limited pollutant removal capabilities, and difficulties in the disposal of accumulated sediments, which are sometimes classified as hazardous materials.

2.6.1.19 Recharge Wells and Bore Holes with Pretreatment

FDEP has allowed the use of shallow (Class V) injection wells for stormwater disposal (see Subsection 2.5, Existing Regulatory Systems). The use of boreholes for stormwater disposal should only be for stormwater pretreated by detention or other methods.

A typical borehole in the Florida Keys is an 8-inch diameter hole drilled to a depth of 60 to 90 feet and cased to a depth of 30 to 60 feet. Some large-diameter boreholes (24 to 30 inches) have been used in the Florida Keys for stormwater disposal.

2.6.2 Nonstructural BMPs

2.6.2.1 Land Use Planning

Land use planning and management presents an important opportunity to reduce/minimize pollutants in stormwater runoff and control flooding by using a comprehensive planning process to integrate County goals into the development and redevelopment process. Management measures may include modification or restrictions of certain land use activities. Greater restrictions may be warranted where development can affect impaired, threatened, or significant water bodies. Because increased pollutant loadings and flooding correspond to increase in impervious cover, land use planning can become an effective control measure.

2.6.2.2 Public Information Program

Public information and participation programs can provide a strategy for informing employees, the public, and businesses about the importance of protecting stormwater from improperly used, stored, and disposed pollutants. Many people do not realize that yard debris or trash thrown into ditches can worsen flooding and pollute surface waters. Municipal employees must be trained, especially those that work in departments not directly related to stormwater but whose actions affect stormwater. Residents must become aware that a variety of hazardous products are used in the home and that their improper use and disposal can pollute stormwater. Likewise, improper disposal of oils, antifreeze, paints, and solvents can end up in streams and lakes, poisoning fish and wildlife. If care is taken by individuals to properly dispose of yard debris, trash, and hazardous materials, many problems can be reduced in magnitude or avoided. Increased public awareness also facilitates public scrutiny of industrial and municipal activities and will likely increase public reporting of incidents. Businesses, particularly smaller ones that may not be regulated by Federal, State, or local regulations, must be informed of ways to reduce their potential to pollute stormwater.

Florida Clean Marina Program

FDEP has designed the Florida Clean Marina program to introduce citizens to simple, innovative BMPs for boatyards. Other participating organizations include the

University of Florida Sea Grant, Marine Industries Association (MIA) of Florida (including numerous local chapters), International Marine Institute, Marine Resource Council, Florida Marine Trades Association, Marina Operators Association of America, Marina Owner/Operators and Consultants. Guiding FDEPs actions are the principles of ecosystem management, foremost of which is that all things are connected. Ecosystem management takes a holistic approach to environmental protection, where air, water, land and living things are all considered together, not in isolation.

The Clean Marina program applies to boatyards that repair and convert recreational and small commercial vessels for Florida's waterways. U.S. shipyards are categorized as either first-tier or second-tier. This program addresses the second-tier that includes many small and medium-size businesses that construct and repair vessels smaller than 122 meters (383 feet).

The Clean Marina Program promotes hurricane preparations, petroleum control, boat cleaning, solid waste management, hazardous waste management, fish waste management and sewage management BMPs to prevent or reduce pollutant discharge.

Florida Yards and Neighborhoods Program

The Florida Yards & Neighborhoods Program were developed to address serious problems of pollution and disappearing habitats by enlisting citizens in the battle to save the natural environment. The program provides special educational and outreach activities directed at the community to help residents reduce pollution and enhance their environment by improving home and landscape management.

2.6.2.3 Stormwater Management Ordinance Requirements

The adopted Monroe County Stormwater Management Ordinance Section 9.5-293 of the Land Development Regulations establishes guidelines for the safe management and disposal of stormwater runoff from developed areas. The ordinance is applicable to all developments, and requires that all applications for building permits must contain a stormwater management plan. Subsection 2.5 of this report presents existing regulatory systems.

2.6.2.4 Fertilizer Application Control

Fertilizer application control is a voluntary control mechanism by citizens who use fertilizer as part of their landscaping activities. Fertilizer application controls are implemented through a public information program by making the public aware of the principals of environmental landscape maintenance and the problems associated with overuse of fertilizers. Overuse of fertilizers will cause excessive runoff of nutrients to surface waters thereby wasting money for the homeowner and potentially degrading the receiving water body. This is especially true during heavy rainfall periods that produce yard and neighborhood flooding. Information programs should also be extended to professional fertilizer users.

2.6.2.5 Pesticide Use Control

Pesticide use control is also a voluntary control by citizens who use pesticides as part of their housekeeping and lawn maintenance activities. Some pesticides are priority pollutants (e.g., Endrin, Lindane, and Silvex), which can be toxic. Overuse of these chemicals can cause excessive runoff to surface waters and entry into the food chain. Many professional applicators of pesticides are using approved pesticides in a safe and proper manner. An information program on pesticide use will help to reduce the amount of pesticides entering the stormwater system.

2.6.2.6 Cisterns and Rainbarrels

Cisterns are underground storage tanks used to manage water from the rooftops and impervious drainage areas. On-lot storage and possible reuse of collected stormwater saves potable water and thus may reduce water utility costs. Cisterns are applicable to residential, commercial, and industrial low-impact development sites. Larger cisterns are needed at commercial and industrial sites due to the size of rooftops and the amount of impervious drainage area. Individual cisterns can be located beneath each downspout, or storage volume can be provided in one common cistern. Cisterns need be located where it is easily accessible for maintenance.

Rain barrels are low-cost, effective, and easily maintainable retention devices practical in both residential and commercial/industrial site applications. Rain barrels first retain a predetermined volume of rooftop runoff and then an overflow pipe provides some detention beyond the retention capacity of the rain barrel. Like cisterns, rain barrels can also store runoff for reuse in irrigation. To be aesthetically acceptable, rain barrels can be incorporated into the lot's landscaping plans or patio or decking designs. Gutters and downspouts are used to convey water from rooftops to rain barrels. Filtration screens should be used ton gutters to prevent clogging of debris. Rain barrels should be designed so that complete draining of the system is possible. Rain barrels should also be equipped with a drain that has garden hose threading, suitable for connection to a drip irrigation system. An overflow adapter could be used to connect two or more barrels to divert surplus water away from foundations. An overflow outlet must be provided to bypass runoff from large storm events. Rain barrels must be designed with removable, child-resistant covers and mosquito screening on water entry holes. The size of the rain barrel will depend on the rooftop surface area that drains to the barrel and the amount of rainfall desired for retention storage.

2.6.2.7 Solid Waste Management

In some instances, problems can arise from trash and other debris flowing into, and obstructing, open channels, and culverts, and storm sewers. The public can be informed of the adverse impacts of littering and poor solid waste management. This can also include pet droppings and illegal dumping into storm drains, wooded areas, and ditches. Pet droppings can be a source of coliform bacteria and pathogens.

2.6.2.8 Hazardous Material Management

A BMP promoting efficient and safe housekeeping practices including storage, use, and cleanup when handling potentially harmful materials and the use of less harmful and safe alternative products may be implemented to reduce discharge of pollutants to storm water. Alternative products exist for such household items as fertilizers, pesticides, cleaning solutions, paint products, automotive products, and swimming pool chemicals. Municipal employees working with potentially harmful materials should be trained in good housekeeping practices and use of safer alternative products.

Implementation of this BMP will also involve coordination of public education efforts focusing on the benefits of good housekeeping practices and use of safer alternative products. The cost for this BMP is very minimal. Pubic awareness will promote a willingness to try alternatives and to modify old behaviors. One limitation for this BMP may be that alternative products may not always be available, suitable, or effective in every case.

The discharge of pollutants to storm water from material delivery and storage can be reduced and prevented by storing materials inside or under cover on paved surfaces, minimizing storage and handling of hazardous materials on-site, utilizing secondary containment, conducting regular inspections, and training employees and subcontractors. The key to this BMP is to design and maintain material storage areas that reduce exposure to storm water. Accurate and up-to-date inventories need to be kept of all stored materials. A supply of spill cleanup materials needs to be kept near the storage area and the employees need to be well-trained in proper material storage. The cost of this BMP will likely vary depending on the size of the facility and additional controls that are necessary. Storage sheds are also required to meet building and fire code specifications and this requirement may be this BMP's limitation.

Spill prevention should be part of a comprehensive BMP program to prevent runoff contamination. An important tool in preventing spills is a Spill Prevention Plan. A Spill Prevention Plan specifies materials handling procedures and storage requirements and identifies spill cleanup procedures for areas and processes in which spills may potentially occur. The plan standardizes process-operating procedures and employee training in an effort to minimize accidental pollutant releases that could contaminate stormwater runoff.

A Spill Prevention Plan is applicable to facilities that transport, transfer, and/or store hazardous materials, petroleum products, or fertilizers that can contaminate stormwater runoff. Most businesses and public agencies that generate hazardous water and/or produce transport, or store petroleum products are required by State and federal law to prepare spill control and cleanup plans. Existing plans should be reevaluated and revised to address stormwater management issues.

A Spill Prevention Plan reduces stormwater contamination and maintains the water quality of the receiving water. Spill Prevention Plans are often good ways of standardizing procedures and employee training to decrease the likelihood of spills. Some limitations associated with Spill Prevention Planning include a lack of employee motivation to implement the plan, commitment from senior management, and proper training in the areas of spill prevention, response, and cleanup of key individuals identified in the Spill Prevention Plan.

2.6.2.9 Street Sweeping

Street sweeping can be an effective method of improving street aesthetics in developed areas and, depending on the type of equipment used, can be an effective pretreatment method of water quality control. Special equipment vacuum or sweep debris and sediment accumulated from streets in urban environments. Curbs and gutters are required for street sweeping and it is common for such streets to be swept many times during the year. Sediment and debris are collected within the equipment and must be properly disposed. Recent developments in vacuum sweepers show increased removal efficiencies for smaller particles.

2.6.2.10 Vehicle Use Reduction

A BMP to reduce the discharge of pollutants to storm water from vehicle also exists. By highlighting the storm water impacts, promoting the benefits of alternative transportation on storm water, and integrating initiatives with existing or emerging regulations and programs, the amount of pollutant discharge to storm water may be reduced greatly. Integration of this BMP practice with other efforts by governmental agencies and businesses to reduce vehicle use and improve air quality can greatly enhance this BMP's applicability, effectiveness and efficiency by avoiding possible redundant and/or conflicting programs. Establishing trip reduction programs at major employers can be a great staring point. Support efforts to pass reasonable regulations at the State and local level aimed at reducing vehicle use and developing transit-oriented communities is very critical in achieving the full potential benefits of this BMP. Also the public needs to be led to associate that air pollution means water pollution and a public education program focusing on the water quality benefits of reduced vehicle use needs to be employed. Public participation in ride sharing programs can highly affect the success of this BMP.

There can be two possible limitations. Level of cooperation and integration between departments and programs may be challenging and the use of alternative transportation is highly dependent on its convenience and relative cost.

2.6.2.11 Directly Connected Impervious Area (DCIA) Minimization

Another nonstructural BMP option is to minimize the amount of directly connected impervious area (DCIA) on a site and to promote the use of green buffer zones around paved areas for infiltration. For example, roof runoff from structures can be directed to green buffer zones or shallow landscaped swales around houses. In addition, parking lots and driveways can be graded to landscaped/grassed areas or swales, reducing direct runoff to the storm drainage system. Also, commercial parking areas can be reduced by allowing parking lots to be sized for average use, not high attendance times (e.g., Christmas). Extra parking for such special occasions can be accommodated using pervious parking or other less permeable parking spaces.

2.6.2.12 Low Impact Development

Low impact development emphasizes environmental sensitive design development principles. Applying the principles together, planners, developers, and local officials can measurably reduce impervious cover, conserve natural areas, and reduce the impacts of stormwater from new development while at the same time enhancing both the natural environment and community well-being.

Listed below are some examples of low impact development ideas:

- Residential streets designed for the minimum required pavement width needed to support travel lanes, on-street parking, and emergency vehicle access.
- Reduction of residential street lengths by examining alternative street layouts.
- Minimization of the number of street cul-de-sacs and incorporate landscape areas to reduce their impervious cover.
- Where density, topography, soils and slope permit, vegetated open channels should be used in the street right-of-way to convey and treat runoff.
- Reduce excessive parking, minimize stall dimensions, encourage shared parking, and use pervious materials in spillover parking areas where possible.

- Provide stormwater treatment for parking lot runoff using bioretention areas, filter strips, and/or other practices that can be integrated into required landscaping areas and traffic islands.
- Advocate open space design development incorporating smaller lot sizes to minimize total impervious area, conserve natural areas, provide community recreational space, and promote watershed protection.
- Relaxation of setbacks to reduce overall lot imperviousness.
- Consider locating sidewalks on only one side of the street and providing common walkways linking pedestrian area.
- Promote alternative driveway surfaces and shared driveways to reduce overall lot imperviousness.
- Direct rooftop runoff to pervious areas.
- Clearing and grading of forested and native vegetation at a site should be limited to the minimum amount needed to build lots.
- Conserve trees and other vegetation at each site by planning additional vegetation, clustering tree areas, and promoting the use of native plants.

2.6.2.13 Illicit Connections (Non-Stormwater Discharges) Identification and Removal

In the 1987 Clean Water Act Amendments, three major goals were identified: to control pollution from municipal stormwater systems to the maximum extent practicable (MEP), to eliminate "illicit" discharges to storm sewers and to control the discharge of stormwater from industrial activities. These goals have generated the National Pollution Discharge Elimination System (NPDES) permitting programs for municipal storm sewer discharges to waters of the United States (see Subsection 2.5). For the second goal, "illicit" discharges are defined as those that are non-stormwater discharges to the storm sewer. Examples include laundromat wastewater, car washing water, restaurant wastes, etc. To achieve this goal, EPA has been encouraging municipalities to search for illicit connections and eliminate such discharges. The ongoing EPA NPDES illicit connection survey should be used to strengthen applicable codes and eliminate these connections which can cause plugs of toxic substances to enter surface waters. Aggressive inspection is a key component of this BMP program. Emphasis on cooperation and public outreach is also a critical to the effort to eliminate illicit discharges.

2.6.2.14 Erosion and Sediment Control on Construction Sites

Erosion and sediment control on construction sites provides for the protection of receiving waters from sediment loads. Proper erosion prevention and sediment flow controls during construction are listed below:

- Minimize needless clearing and grading using site planning, open space, buffer zones, and other protections.
- Protect waterways and stabilize drainageways.
- Phase construction to reduce soil exposure.
- Immediately cover, revegetate, and stabilize exposed soils with mulch or other means.
- Install controls to filter sediments, gravel filter weirs, including sediment fences, temporary berms, swales, exit controls, and inlet filters at the perimeter of the site and, on larger sites, throughout the site.
- Employ advanced sediment settling controls, such as well-designed and maintained basins.

The state of Florida has recently created a sediment and erosion control training process that provides education on proper sediment and erosion management of construction sites. Certification is also provided.

2.6.2.15 Source Controls on Construction Sites

Source control on construction sites can be accomplished with proper construction practices to prevent or reduce the discharge of pollutants from dewatering operations, paving operations and structure construction and painting. Contractor and employee training should be integrated with existing training programs to encourage appropriate material management, waste management and vehicle and equipment management to also prevent or reduce the discharge of pollutants.

2.6.2.16 Operation and Maintenance (O&M)

A recent survey by FDEP has reported that nearly 70 percent of existing treatment facilities in Florida are not properly maintained and therefore do not provide the intended pollutant removal effectiveness. Because of this, one of the most effective nonstructural BMPs is routine maintenance of existing treatment facilities. For publicly owned treatment facilities, routine maintenance and inspection should be performed. For privately owned facilities, maintenance is not typically performed by a municipality. There are several options that can be pursued by a municipality to help ensure that proper maintenance is being conducted. These options include a certification program initiated by a municipality that requires all approved subdivision ponds (private) to be recertified by the owner on a predetermined time interval. The recertification may be completed by a state certified / trained inspector or engineer. Enforcement of maintenance of privately owned facilities is one of the most difficult problems for privately owned facilities. Potential enforcement measures may include governmental intervention (after sufficient notification) where critical maintenance is completed by the government and the cost of the maintenance is billed to the owner or by other means as deemed necessary by the municipality. Another option would be to consider the assessment of fines.

Maintenance can be provided on a routine basis or as needed based upon inspection. Many governments provide a mixture of routine maintenance for critical facilities and inspection-based maintenance for less critical facilities. The following paragraphs highlight some important maintenance considerations for BMPs.

Mowing

The side slopes, embankments, emergency spillways, and other grassed areas of stormwater facilities must be periodically mowed to prohibit woody growth and control weeds. More frequent mowing may be required in residential areas by adjacent homeowners. Mowing usually constitutes the largest routine maintenance expense. The use of native or introduced grasses which are water-tolerant, pest-tolerant, and slow growing are recommended.

Debris and Litter Removal

Debris and litter accumulate near stormwater facility control structures and should be removed during regular mowing operations. Particular attention should be paid to floatable debris that can eventually clog the control structure or riser. Trash screens or racks can be strategically placed near inflow or outflow points to capture debris.

Erosion Control

Side slopes, emergency spillways, and embankments all may periodically suffer from slumping and erosion. This should not occur often if the soils are properly compacted and vegetated during construction. Regrading and revegetation may be required to correct any problems that develop.

Nuisance Control

Standing water or soggy conditions within a stormwater facility can create nuisance conditions for nearby residents. Odors, mosquitoes, weeds, and litter can all be potential problems in stormwater facilities. However, wetland plants established in wet detention ponds can harbor birds and predacious insects and fish that serve as a natural check on mosquitoes, and regular maintenance to remove debris and ensure control structure functionality will help control these potential problems.

Structural Repairs and Replacement
Eventually, the facility control structure will deteriorate and must be replaced. For ponds, these should be inspected at least once annually. In the case of exfiltration trenches and porous pavement, when the trench or pavement becomes clogged, part or all of the facility may need replacement.

2.6.3 BMP Removal Efficiencies

This subsection provides background discussion for the derivatives of pollutant removal efficiencies for a number of the BMPs considered above. Table 2.6-2 provides a summary of pollutant removal efficiencies found for stormwater facilities around the United States. However, Florida specific experience has been most recently documented in Harper (1995), the summary table from which is provided in Table 2.6-3.

2.6.3.1 Extended Dry Detention Ponds

Pollutant removal efficiencies for dry extended detention ponds are based on settling behavior of the particulate pollutants. Table 2.6-2 summarizes average pollutant removal efficiencies for dry extended detention ponds based on settling column data and field monitoring data. Settling column data from EPA National Urban Runoff Program (NURP) studies and from the Federal Highway Administration (FHWA) study were used to establish the removal efficiencies for TSS and metals (EPA, 1983b; FHWA, 1989). Removal efficiencies for the nutrients were determined from the results of two field monitoring studies of dry extended detention ponds in the metropolitan Washington, DC region (MWCOG, 1987). These efficiencies are applied to the percentage of total annual pollutant washoff captured for treatment in the extended dry detention pond BMP.

Dry detention systems without filtration were reviewed in Harper (1995). With a detention time of 1 to 3 days, the efficiencies for dry detention were as follows with the recommended efficiency in parenthesis:

- 10 to 20 percent for total nitrogen (15%),
- 10 to 40 percent for total phosphorus (25%),
- 60 to 80 percent for TSS (70%),
- 30 to 50 percent for BOD (40%),
- 20 to 50 percent for copper (35%),

Table 2.6-2
Monroe County Stormwater Management Master Plan
Pollutant Removal Efficiencies for Selected BMPs

	Extended Dry Detention	***Wet Detention[2]***	***Retention[3]***	***Swales[4]***	***Retention Swales with Wet Detention[5]***	***Bioretention[6]***	***Water Quality Inlets and Baffle Boxes[7]***	***Infiltration Drainfields[8]***	***Modular Treatment System (StormTreat™)[9]***	***Porous Pavement[10]***	***Sand Filters[11]***	***Stormwater Wetlands[12]***	***Alum Treatment[13]***
BOD5	30%	40%	90%	30%	76%	-	25%	-	-	-	70%	-	75%
COD	30%	40%	90%	30%	76%	-	25%	-	82%	-	-	-	-
TSS	90%	90%	90%	80%	96%	90%	85%	89%	99%	82-95%	70%	67%	90%
TDS	0%	40%	90%	10%	76%	-	0%	-	-	-	-	-	-
Total-P	30%	50%	90%	40%	80%	77%	25%	65%	90%	65%	33%	49%	90%
Dissolved-P	0%	70%	90%	10%	88%	-	0%	-	-	-	-	-	-
NO2+NO3	0%	30%	90%	40%	76%	-	15%	-	-	-	0%	-	-
TKN	20%	30%	90%	40%	72%	74%	0%	-	-	-	46%	-	-
Total-N	-	-	-	-	-	-	-	83%	77%	83%	21%	28%	50%
Cadmium	80%	80%	90%	65%	92%	-	75%	-	-	-	-	36%	-
Copper	60%	70%	90%	50%	88%	96%	55%	-	-	-	-	41%	80%
Lead	80%	80%	90%	75%	92%	96%	75%	-	77%	-	45%	62%	90%
Zinc	50%	50%	90%	50%	80%	96%	45%	-	90%	-	45%	45%	80%

NOTES:

1 Extended dry detention basin efficiencies assume that the storage capacity of the extended detention pool is adequately sized to achieve the design time for at least 80 percent of the annual runoff volume. For most areas of the United States, extended dry detention basin efficiencies assume a storage volume of at least 0.5 inches per impervious acre.

2 Wet detention basin efficiencies assume a permanent pool storage volume which achieves average hydraulic residence time of at least 2 weeks.

3 Retention removal rates assume that the retention BMP is adequately sized to capture at least 80 percent of the annual runoff volume from the BMP drainage area. For most areas of the United States, the required minimum storage capacity of the retention BMP will be in the range of 0.50 to 1.0 inch of runoff from the BMP drainage area, but the required minimum storage capacity should be determined for each location.

4 Source: *California Stormwater Best Management Practice Handbooks*, (CDM, et. al., 1993). These efficiencies are applied to the percentage of total annual pollutant washoff captured for treatment in the extended dry detention pond BMP.

5 This efficiency reflects removal efficiencies for series BMPs with 0.25 inches of retention swale pretreated upstream of a wet detention pond.

6 Source: *Stormwater Technology Fact Sheet – Bioretention*, (EPA, 1999). The design criteria for porous pavements are very similar to the design criteria of infiltration drainfields. The pollutant removal efficiencies are an estimate of porous pavement performance data.

7 Source: *City of Rockledge Stormwater Master Plan*, (CDM 1998). Based on 85% removal of the suspended fraction of each parameter.

8 Source: *Stormwater Technology Fact Sheet – Infiltration Drainfields*, (EPA, 1999).

9 Source: *Stormwater Technology Fact Sheet – Modular Treatment Systems*, (EPA, 1999). StormTreat™ Systems, Inc. installed in Kingston, MA.

10 Source: *Stormwater Technology Fact Sheet – Porous Pavement*, (EPA, 1999). Monitoring studies conducted in Rockville, MD, and Prince William, VA.

11 Source: *Stormwater Technology Fact Sheet – Sand Filters*, (EPA, 1999). Removal of Nitrite as Nitrogen (NO_2) was not reported.

12 Source: *Stormwater Technology Fact Sheet – Stormwater Wetlands*, (EPA, 1999). Average long-term pollutant removal rates for constructed wetlands, as a whole.

13 Source*: Pollutant Removal Techniques for Typical Stormwater Management Systems in Florida*, (Harper, 1998).

Table 2.6-3
Monroe County Stormwater Management Master Plan
Summary of BMP Treatment Efficiencies by Harper (1995) [1]

Type of System	Estimated Removal Efficiencies [2]						
	TN	TP	TSS	BOD	Cu	Pb	Zn
Dry Detention							
0.25-inch retention	60%	60%	60%	60%	60%	60%	60%
0.50-inch retention	80%	80%	80%	80%	80%	80%	80%
0.75-inch retention	90%	90%	90%	90%	90%	90%	90%
1.00-inch retention	95%	95%	95%	95%	95%	95%	95%
1.25-inch retention	98%	98%	98%	98%	98%	98%	98%
Offline retention / Detention	60%	85%	90%	80%	65%	75%	85%
Wet Retention	40%	50%	85%	40%	25%	50%	70%
Wet Detention	25%	65%	85%	55%	60%	75%	85%
Wet Detention w / Filtration	0%	60%	98%	99%	35%	70%	90%
Dry Detention	15%	25%	70%	40%	35%	60%	75%
Dry Detntion w / Filtration							
Type A or B Soils	0%	0%	75%	0%	65%	90%	25%
Type C or D Soils	0%	0%	60%	0%	45%	90%	10%
Alum Treatment	50%	90%	90%	75%	80%	90%	80%

Notes: (1) Harper, H.H., 1985. *Pollutant Removal Efficiencies for Typical Stormwater Management Systems in Florida*. In Proceedings of the 4th Biennial Stormwater Research Conference, SWFWMD, pp. 6-17.
(2) Percent of pollutant loading removed; for example, 60% means 60% of the load is removed and 40% of the polluant load remains.

- 40 to 80 percent for lead (60%), and
- 50 to 90 percent for zinc (70%).

2.6.3.2 Wet Detention Ponds

The EPA NURP study monitored several wet detention ponds serving small urban watersheds in different locations throughout the United States (EPA, 1983b). For wet detention ponds with significant average hydraulic residence times (e.g., 2 weeks or greater), average pollutant removal rates were on the order of 40 to 50 percent for total-P and 20 to 40 percent for total-N. For other pollutants which are removed primarily by sedimentation processes, the average removal rates were as follows: 80 to 90 percent for total suspended solids (TSS); 70 to 80 percent for lead; 40 to 50 percent for zinc; and 20 to 40 percent for BOD or chemical oxygen demand (COD).

Harper (1995) also considered wet detention since the most amount of research in Florida is with this type of system. One the average, wet detention was reported to have removal efficiencies of 20 to 30 percent for total nitrogen, 60 to 70 percent for total phosphorus and copper, and > 75 percent for TSS, lead and zinc. It was also reported that increasing the detention time from 7 to 14 days significantly increases the pollutant removal efficiencies. The addition of filtration was also considered concluding that over the long-term, filtration did not significantly add to the treatment efficiency.

To test the efficiency of detention facilities in the Keys, a simulation of the particulate capture rate was completed using the Storage, Treatment, Overflow, Runoff Model (STORM). Historical rainfall data from the Key West Airport were used to simulate the annual average percent capture within a detention facility. The treatment rate was based upon a 1-acre pond (i.e., the results are on a per acre basis) with a 72-hour discharge rate for the live (treatment) volume. Simulations were completed for residential (30 percent impervious), commercial (60 percent impervious) and pavement (100 percent impervious). Figure 2.6-10 illustrates the results of the model runs. The percent capture is shown on the vertical axis and treatment volume on the horizontal axis. Also shown are the minimum capture rates required by the State Water Policy (80 percent minimum and 95 percent for discharge to Outstanding Florida Waters). The figure shows that for 95 percent capture, 2 inches of treatment volume per acre are needed for commercial developments and 1 inch of treatment volume per acre is needed for residential.

2.6.3.3 Retention Basins

The design of retention systems is generally based on a specified diversion volume. Based on extensive field investigations and simulations using 20 years of rainfall data, average yearly pollutant removal efficiencies were estimated for fixed diversion volumes for onsite (small) watersheds, as presented in Table 2.6-2. The diversion depth is the depth of runoff water which must be stored and percolated from the total upstream tributary area that discharges to the retention pond (Florida Department of Environmental Regulation, 1988). Bioretention pollutant removal performance values were developed from studies conducted by the University of Maryland and Prince George County, Maryland DER (EPA, 1999).

A summary of efficiency information was compiled by Harper (1995) considering data collected in Florida. Dry retention was reported as providing a 95 percent removal of total phosphorus, total nitrogen, TSS, copper, lead and zinc when the treatment volume is 1 inch of runoff volume is retained. Wet retention reported to have 40, 50, 85, 40, 25, 50, and 68 percent removals, respectively for total nitrogen, total phosphorus, TSS, BOD, copper, lead and zinc. This difference is attributed to the slower recovery of treatment volume of wet retention and the resuspension and solubilization of particulate nutrients in the wet environment.

2.6.3.4 Shallow Grassed Swales

The removal efficiencies summarized in Table 2.6-2 for swales represent swales designed for infiltration and capture of 80 percent of the annual runoff volume. These efficiencies are based upon FHWA studies, NURP findings, CDM experience and research by Yousef and Wamehista. Finally, the pollutant removal rates for retention swale pretreated upstream of a wet detention pond are based on retaining the first 0.25 inches over the tributary area coupled with full wet detention treatment.

2.6.3.5 Porous Pavement

Porous pavement pollutant removal mechanisms include absorption, straining, and microbiological decomposition in the soil. An estimate of porous pavement pollutant removal efficiencies is summarized in Table 2.6-2. The estimates were developed by two long-term studies conducted in Rockville, Maryland and Prince William, Virginia (EPA, 1999).

2.6.3.6 Water Quality Inlets and Baffle Boxes

Two basic designs of baffle boxes were reviewed as described by Schueler (WASHCOG, 1987): the Montgomery County design and the Rockville design. Pollutant removal efficiencies are given in Table 2.6-2 based on 85% removal of the suspended fraction of each parameter.

2.6.3.7 Hydrodynamic Separators

Hydrodynamic separators are designed primarily for removable of floatable and gritty materials; they may have difficulty removing the less-settleable solids generally found in stormwater. The reported removal rates of sediments, floatables, and oil and grease differ depending on the vendor. Proper design and maintenance also affect the unit's performance.

2.6.3.8 Underdrains and Stormwater Filter Systems

Pollutant removal efficiencies for sand filter systems are shown in Table 2.6-2. The estimates are average values for various sand filters serving drainage areas of different sizes (EPA, 1999). No removal of nitrate was observed.

2.6.3.9 Infiltration Drainfields

Currently there is little monitoring data on the performance of infiltration drainfields. The design criteria for porous pavement are very similar to the design criteria of infiltration drainfields. An estimate of porous pavement pollutant removal efficiencies is given in Table 2.6-2.

2.6.3.10 Modular Treatment Systems

Runoff from a StormTreat™ System, or STS system installed in Kingston, Massachusetts was analyzed to assess pollutant removal efficiency (EPA, 1999). Thirty-three samples were collected over eight independent storm events during both the winter and summer conditions. The sampling results are given in Table 2.6-2.

2.6.3.11 Stormwater Wetlands

The pollutant removal effectiveness of shallow marsh and pond / wetland systems has been fairly well documented, while the amount of removal efficiency data for Extended Dry Detention wetlands is limited. Average long-term pollutant removal rates for constructed wetlands, as a whole are presented in Table 2.6-2 (EPA, 1999).

2.6.3.12 Coagulant Injection Systems

The removal efficiencies for alum injection systems summarized in Table 2.6-2 is based on information obtained in literature review. The mid-point of the range is given for comparison purposes (Harper, 1998).

2.6.4 BMP Implementation Considerations

In determining the best stormwater management facility or combination of facilities (treatment train), several factors such as the following need to be considered:

- Physical constraints or requirements of the site such as permeability of the soil, the location of the wet season high water table, and the amount of land available on the site to construct the facility.
- Permitability of the facility or facilities.
- Needed benefits to solve problems and guide future development in a given area.
- The benefits provided by the facility such as control of peak discharge for flood control, reduction in the total volume of discharge, groundwater recharge, erosion control, wetland management, reduction of pollutant loads to receiving waters, and/or optimized maintenance.
- Public acceptance of the BMP.
- Cost for implementation and/or long-term operation and maintenance costs of the facility or facilities.

Table 2.6-4 provides a list of requirements and benefits that can be used as a guide in the selection of a stormwater BMP type.

Table 2.6-4

Monroe County
Stormwater Management Master Plan
BMP Selection Features
Requirements Versus Benefits

Dry Detention Ponds	Wet Detention Ponds	Exfiltration Trenches	Shallow Grassed Swales	Retention Basins	Water Quality Inlets and Baffle Boxes
Requirements:					
Available Space (10-20% of tributary area)	Available Space (10-20% of tributary area) Water Table at or Near Pond Normal Pool Level Relatively Impermeable Soils	Water Table >2 Ft. Below Trench Bottom Highly Permeable Soils High Maintenance	Moderate to Limited Space Available Water Table >1-2 Ft. Below Swale Bottom Permeable Soils	Available Space (10-20% of Tributary Area) Water Table >2-3 Ft. Below Basin Bottom	Commitment to High Maintenance Pretreatment is Likely
Benefits:					
Peak Discharge Control Load Reduction for Suspended Pollutants Multi-Use Park Areas	Peak Discharge Control Pollutant Load Reduction for Dissolved and Suspended Pollutants Aesthetic Permanent Pool and Fountain Wildlife Habitat Multi-Use Park Areas	Aquifer Recharge Load Reduction for Dissolved and Suspended Pollutants Volume Discharge Control Fit into Limited Space	Peak Discharge Control Volume Discharge Control Aquifer Recharge Pollutant Load Reduction Off-line or On-line Pretreatment	Peak Discharge Control Volume Discharge Control Aquifer Recharge Pollutant Load Reduction Off-line or On-line Multi-Use Park Areas	Load Reduction for Suspended Pollutants and Potentially Oil, Grease and Floatables Fit into Limited Spaces

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Hydrodynamic Separators EPA 832-F-99-017
Flow Diversion EPA 832-F-99-014

Section 3
Objectives, Standards and Problem Areas

The purposes of this section are to identify the goals and objectives of the Monroe County Stormwater Management Master Plan, to identify the problem areas within the Florida Keys and to prioritize the problem areas to achieve the goals and objectives. The goals, objectives, problem areas and ranking are supported by information provided by Monroe County staff, the Monroe County Comprehensive (Comp) Plan and the public from multiple public meetings held in the Keys.

3.1 Goals and Objectives

As with all planning programs, the primary goal of the Monroe County SMMP is to protect public health, safety and welfare. Related to stormwater, this goal is accomplished by the prevention of significant flooding, the control of stormwater quality and protection of public waters through the minimization of stormwater pollution, and the maintenance and enhancement of the environmentally significant habitat related to stormwater management activities.

The Monroe County Year 2010 Comp Plan establishes the specific goals, policies and objectives for stormwater management and implements them through local ordinances. The regulatory component of the 2010 Comp Plan is considered in Subsection 2.5 (Existing Regulatory Programs), wherein a discussion of the Land Development Code (Chapter 9.5 of the Monroe County Code of Ordinances) is provided. The policy component of the 2010 Comp Plan is provided in the Policy Document. Of particular importance are Chapters 2.1 (Future Land Use), 2.2 (Conservation and Coastal Management), and 2.10 (Drainage). Pertinent elements of these chapters are discussed below.

3.1.1 Future Land Use

Chapter 2.1 of the Policy Document provides goal, objectives and policies for the management of future growth through land use controls. Provided below is a list of pertinent goals from this chapter.

> ***GOAL 101*** - *Monroe County shall manage future growth to enhance the quality of life, ensure the safety of County residents and visitors, and protect valuable natural resources.*

- To achieve this goal, the county will provide adequate public facilities to serve the development at the adopted levels of service (LOS). For drainage, the LOS is defined in Chapter 2.10.

- Future development will be regulated by requiring development and redevelopment to be consistent with the land uses adopted as the Future Land Use Map.

- Further controls on development have been instituted through the Residential and Non-residential Permit Allocation and Point Systems whereby positive points are allocated for beneficial elements of a development including environmental issues.

- Land development regulations are to be adopted that direct development away from areas of periodic flooding.

GOAL 102 *- Monroe County shall direct future growth to lands which are intrinsically most suitable for development and shall encourage conservation and protection of environmentally sensitive lands.*

- The Land Development Code should direct development to comply with environmental standards and design criteria to protect environmental resources.

- A water quality protection program is to be instituted with the support of EPA, DER, SFWMD and NOAA. In conjunction, the County is to start a permitting, inspection and enforcement program for stormwater runoff. The County will also implement programs for erosion and sediment control and pesticide contamination.

According to these goals, the management of future land uses will primarily protect three things: the quality of life in the Keys, the safety of citizens and visitors, and the natural resources. The second goal directs growth to suitable lands and promotes the conservation of environmentally sensitive lands.

3.1.2 Conservation and Coastal Management

Chapter 2.2 of the 2010 Comp Plan deals with conservation and the management of the coastal environment of the Florida Keys. Pertinent goals within Chapter 2.2 related to the SMMP are provided below.

GOAL 202 - *The environmental quality of Monroe County's estuaries, near shore waters (canals, harbors, bays, lakes and tidal streams,) and associated marine resources shall be maintained and, where possible, enhanced.*

- As noted previously, the County is to work with EPA, FDEP, SFWMD, and NOAA to develop a Water Quality Protection Program for the Florida Keys National Marine Sanctuary. Included will be studies to document pollutant loads, data to define relationships between water quality and sea grass and coral community declines, and other monitoring.

- This section also calls for the County to institute permitting, inspection and enforcement procedures to reduce pollutant discharges from multiple sources including on-site systems, wastewater treatment plants, moored vessels, marinas, seafood processing facilities, dredge & fill activities, and stormwater facilities.

GOAL 203 - *The health and integrity of living marine resources and marine habitat, including mangroves, sea grasses, coral reefs and fisheries, shall be protected and, where possible, enhanced.*

- Protection is offered by a 100 percent open space requirement for mangroves and the imposition of a 50-foot setback for development adjacent to marine resources.

- Studies are to be provided to consider the stresses on sea grasses and to map the location of existing beds. Similar studies will be completed for coral reefs.

GOAL 204 - *The health and integrity of Monroe County's marine and freshwater wetlands shall be protected and, where possible, enhanced.*

- A geographic information system (GIS) database of wetlands has been developed to identify protected wetlands.

- The setback provisions (see above) are also provided for wetlands.

- The County is to start a program to restore disturbed wetland by working with other governments, establishing a list of wetlands to be restored and providing for funding.

GOAL 205 - *The health and integrity of Monroe County's native upland vegetation shall be protected and, where possible, enhanced.*

- This goal is achieved through the Permit Allocation and Point System, the setback requirements, and adopted environmental design criteria.

GOAL 207 - *Monroe County shall protect and conserve existing wildlife and wildlife habitats.*

- To accomplish this goal, FEMA and the Fish & Wildlife Service jointly created maps identifying endangered species habitat. Developments located within areas of endangered species habitat are required to obtain special approval. Larger developments must prepare an Environmental Impact Assessment (EIA) including the survey of valuable wildlife and smaller developments must coordinate with the Fish & Wildlife Service.

GOAL 215 - *Monroe County shall provide the necessary services and infrastructure to support existing and new development proposed by the Future Land Use Element while limiting public expenditures which result in the loss of or adverse impacts to environmental resources in the Coastal Zone.*

- Infrastructure expenditures are to be consistent with a capital improvement program to support existing and future developments at the adopted LOS.

From these goals, there are five areas to be protected and, if possible, enhanced: estuaries and near shore waters, marine habitat, marine and freshwater wetlands, native upland vegetation, and wildlife and wildlife habitat. Furthermore, the County is to provide the services and infrastructure needed to support existing and new development (defined by Chapter 2.3 of the 2010 Comp Plan). For the purposes of this document, these five areas will be referred to as the Monroe County environmental resources. Thus, Goals 202 through 207 and 215 can be summarized relative to the SMMP as follows:

Monroe County will protect, and where possible, enhance the environmental resources within the county; and,

Monroe County will provide the services and infrastructure to support existing and future developments done in accordance with the 2010 Comp Plan and in accordance with the previously stated goal.

3.1.3 Drainage

The Drainage element of the Policy Document lists only one goal:

GOAL 1001 - *Monroe County shall provide a stormwater management system which protects real and personal properties, and which promotes and protects ground and near shore water quality.*

- The water quantity (flooding) LOS includes protection for the 100-year, 3-day design storm for residential, commercial and emergency shelters; protection for the 5-year, 1-day storm for evacuation routes and arterial, collector and neighborhood roads; and off-site discharge is limited to predevelopment levels.

- The water quality LOS state that project must be designed to meet the state water quality standards presumptively as follows:

- treatment of first inch of runoff or 2.5 times the imperviousness for wet detention;
- treatment of 75 percent of the above for dry detention;
- treatment of 50 percent of the dry detention volume for retention; and,
- 50 percent additional treatment is required when discharging to OFWs.

■ Replacement, expansion or increase in drainage facility capacity will require conformance to the new development requirements.

■ An inventory of existing County drainage facilities is to be completed (this is being done as part of the SMMP).

■ The County is to complete the Stormwater Management Master Plan to ensure that facilities attain the adopted LOS for existing and proposed lands. The study is to also estimate the pollutant loading from such facilities as well as their performance.

While stated in different terms, this goal is consistent with those of the Conservation and Coastal Management element since the "stormwater management system" includes services and infrastructure and the "ground and near shore water quality" is included in the environmental resources. The biggest addition is that the stormwater management system will protect real and personal property.

3.1.4 Public Goals and Issues

During the public meetings held in conjunction with the development of the SMMP, the public was asked to consider and rank stormwater management issues. The last category of public information included a list of seven stormwater management issues that were ranked by the attending public. The seven issues were flooding, maintenance of existing systems, development controls, recreational opportunities, water quality protection and improvement, enforcement of existing regulations, and construction costs. Each person who filled out the form numbered each from one to seven with the lowest number being most important. A summary of the results of this ranking is contained in Table 3.0-1.

The table shows that for these respondents, the highest priority is water quality protection and improvement, followed by development controls, enforcement of regulations, flooding, construction costs, maintenance and recreational opportunities. This ranking, that will be adjusted as other forms are included, will help prioritize potential stormwater management activities for the Florida Keys.

Table 3.0-1
Monroe County Stormwater Management Master Plan
Summary of Public Meeting Survey Results (1)

Issue	Rank:	Number of Attendees Selecting Rank 1	2	3	4	5	6	7	Weighted Score (2)	Priority
Water Quality Protection/Improvement		12	1	2	0	0	0	1	27	1
Development Controls		2	6	2	3	1	2	0	49	2
Enforcement of Regulations		0	7	1	4	0	1	2	53	3
Flooding		2	2	2	2	3	1	3	62	4
Construction Costs		0	1	5	4	1	2	2	64	5
Maintenance of Existing Systems		0	0	2	2	7	4	0	73	6
Recreational Opportunities		1	1	1	0	2	3	8	90	7
Respondents		17	18	15	15	14	13	16		

Notes:
(1) Based upon Public Meetings on May 1 and 2 in Marathon and Key Largo, respectively.
(2) Sum of number of respondents times rank, with lowest score representing highest priority.

3.1.5 SMMP Goals

Based upon the identified goals described heretofore from the 2010 Comp Plan and from public input, provided below is a list of recommended goals and objectives for the Monroe County Stormwater Management Master Plan.

Goal 1 - The SMMP will identify, prioritize and recommend remedial improvements for the significant water quality related problem areas within the unincorporated areas of the County.

Goal 2 - The SMMP will recommend actions that will reduce the sediment and nutrient loading of near shore waters resulting from runoff.

Goal 3 - The SMMP will review existing regulatory requirements for the control of new development related to flooding and water quality and will recommend improvements as needed. As a corollary issue, the SMMP well review existing enforcement activities and recommend necessary changes to improve the enforcement of existing or new regulations.

Goal 4 - The SMMP will recommend activities related to the stormwater management of future growth that will be expected to result in no increase in sediment or nutrient loads to near shore waters.

Goal 5 - To achieve a reduction in existing sediment and nutrient loads, the SMMP will strive to use nonstructural and source controls. When necessary, the SMMP will recommend structural controls associated with the publicly owned infrastructure.

3.2 Problem Area List

Stormwater problems generally fall into two categories: flooding and water quality. Flooding problems can be severe (e.g., flooding of houses and other structures) or nuisance (flooding of yards and roads), and can be expressed as depth of flooding and duration. Based upon conversations with Monroe County staff including the County Engineer, the majority of flooding issues within the county are within the incorporated cities, in particular, Key West. County staff has not identified serious flooding problems (house and building flooding) for areas within the unincorporated county. Nuisance flooding (roadways) has been identified; these areas will be confirmed during the public meetings.

Stormwater quality issues have been identified by the Sanitary Wastewater Management Plan during the identification of "hotspots." These are discussed below.

3.2.1 Known Water Quality Problem Areas

Produced by the US Environmental Protection Agency Oceans and Coastal Protection Division (July, 1992), the report entitled, Water Quality Protection Program for the Florida Keys National Marine Sanctuary; Phase I Report, provides, among other things, a list of water quality "hot spots." These are areas where, based upon workshops and discussion groups, areas with known or suspected water quality degradation. This report listed 84 "hot spots." According to a meeting summary (March 19, 1996) the "hot spots" were refined based upon newer information, leading to a list of 88 "hot spots." It should be noted that the majority of these is related to wastewater or septic tank influences and does not represent stormwater induced problem areas. In Technical Memorandum No. 4 by Lindahl, Browning, Ferrari & Hellstron, Inc. (Aug 16, 1999), the "hot spots" were assessed and ranked from high to low priority. Stormwater influences were identified as well. Finally, in July 1999, Monroe County produced "Water Quality 'Hotspots' in the Florida Keys: Evaluations for Stormwater Contributions. " This report assessed the previously identified concerns, visited the areas in the field, and defined the most probable stormwater-influenced problem areas. Excluding the low priority sites, the high and medium priority problem areas are identified below.

High Priority

No.	Name
13	Campbell's Marina, Key Largo (now Mangrove Marina)
41	Marathon Marina, Vaca Key
42	Boot Key Harbor drainage, Vaca Key
77	Alex's Junkyard, Stock Island
79	Oceanside Marina, Stock Island
80	Safe Harbor Area, Stock Island
83	Garrison Bight Marina, Key West
87	Key West Bight, Key West

Medium Priority

No.	Name
7	Key Largo Fishery Marina, Key Largo
20	Holiday Isle Resort, Windley Key
22	Lorelei, Upper Matecombe
27	Caloosa Cove Marina, Lower Matecombe
34	Coco Plum Causeway, Fat Deer Key
39	National Fish Market, Vaca Key
60	Summerland Key Seafood, Summerland
63	Venture Out Trailer Park, Cudjoe Key
78	Stock Island Lobster Co., Stock Island
85	Truman Annex Marina, Key West

Other areas identified in the report include:

- Key Largo Harbor Marina (Key Largo)
- Pipe at end of Jo Jean Way in Community Harbor (Tavernier)
- Commercial Fishing Area along Lake View Drive (Lower Matecombe)
- Anne's Beach (Lower Matecombe)
- 27th Street (Marathon)
- Veteran's Park (Little Duck Key)
- Winn Dixie Shopping Plaza (Big Pine Key)
- Key Haven (Raccoon Key)
- Old Town Trolley storage area (Stock Island)
- Coconut Grove residential area (Stock Island)

Additional problem areas were identified during the fieldwork and by the public during the public meetings.

3.2.2 Publicly Identified Problem Areas

Public meetings were held on May 1 and 2 and on November 20 and 21, 2000, to allow the public to identify additional problem areas besides those identified above. A series of maps showing the problem areas identified above was provided as part of the public meeting. Additional problem areas identified during the meeting are listed below.

- Sombrero Isles in Marathon - Flooding and Ponding
- Burton Drive & US 1 (Oceanside) in Tavernier - Flooding / Ponding
- Waldorf Plaza in Key Largo - Flooding / Ponding
- Key Largo Trailer Village in Key Largo - Flooding / Ponding
- US 1 (Oceanside) in Key Largo - Flooding / Ponding

The latter two identified problems were visited in the field as identified below.

3.2.3 Field Identified Problem Areas

As noted in Section 2.0, an inventory of stormwater facilities was prepared as part of the SMMP and fifteen facilities were visited in the field. The list of facilities visited is provided in Table 3.0-2. Also provided in Table 3.0-2 are sites which were considered for detailed review but based upon discussions with County staff, were not visited in the field. Detailed data collected for each visited facility are provided in Subsection 2.4 of this report.

Table 3.0-2
Monroe County Stormwater Management Master Plan
List of Stormwater Facilities for Detailed Investigation

	Characteristics (1)							
Area	Problem Area	Problem (2)	Permitted	Pond	Marina	S/D (3)	Public	Roadway
Safe Harbor	Y	WQ			Y			
Marathon Marina	Y	WQ					Y	
Anne's Beach	Y	WQ	Y				Y	
Key Largo Trailer Village	Y	F				Y	Y	Y
Card Island Sound (915A)	Y	WQ					Y	Y
Marathon Airport			Y	Y			Y	
Marathon Government Center	Y	F						
Tavenier Town Center	Y	F		Y				
US-1 at Cambells Marina	Y	F					Y	Y
K-Mart Marathon	Y	F	Y					
Big Pine Shopping Center	Y	F	Y					
Cudjoe Key Road			Y					Y
Sugarloaf Beach Road (939a)								Y
US-1 Long Key to Duck Key			Y					Y
DOT 5-yr Work Plan Project 1								Y
	10	10	6	2	1	1	6	7
Identified But Not Visited								
Venture Out Trailer Park	Y	WQ				Y	Y	Y
Sombrero Beach Road	Y	WQ					Y	Y
Marathon Seafood	Y	WQ			Y			
27th Street (Marathon)	Y	WQ					Y	Y
Harris Park/Barton Drive	Y	WQ					Y	Y
Tradewinds Shopping Center				Y				
Village of Hawk's Cay			Y	Y				
Long Beach Road (Big Pine)				Y				Y
Newport Village Housing						Y		
Big Copitt Key Roads						Y		Y
Tropical Bay S/D			Y			Y		
Bay Point/Bay Drive						Y		Y
Eden Pines S/D						Y		
DOT 5-yr Work Plan Project 2								Y
Key Haven			Y			Y		
Key Colony Beach Project			Y				Y	

Notes: (1) "Y" means that the site has this characteristic.
(2) Problems are identified as WQ for water quality and F for serious or nuisance flooding.
(3) "S/D" means residential subdivision.

3.3 Problem Area Ranking Process

3.3.1 Introduction

The purpose of Section 3.3 is to establish a prioritized stormwater capital improvement project list for Monroe County based on the problem areas identified in Section 3.2.

The problem areas in Section 3.2 were categorized as: (1) water quantity problem areas, and/or (2) water quality problem areas. Both water quantity and water quality problem areas were further classified as either a nuisance or serious problem. These terms are defined in the following text.

Water Quantity Problem Area

Nuisance Problem Area: Minor street flooding which causes inconvenience, traffic delays, and possibly the temporary blockage of secondary roads that are not essential for evacuation and/or emergency vehicle use. Backyard and front-yard flooding can be grouped under this category.

Serious Problem Area: An imminent threat to public safety and/or property including loss of human life, blockage of evacuation and/or emergency vehicle routes, and/or flooding of homes/buildings.

Water Quality Problem Area

Serious Problem Areas:

- Violation of Chapter 62-302, Florida Administrative Code (FAC) criteria unless a naturally occurring condition of non-compliance can be documented (e.g., wetland with low dissolved oxygen).
- Impairment of a unique environmental use (e.g., fishing, swimming, springs, threatened and/or endangered species habitat, other).
- The presence of toxic hazardous, or man-made inorganic or organic substances in sediments.

Nuisance Problem Areas: Nuisance problem areas are assumed to include some minor changes in color, turbidity, and/or odor that may be naturally occurring or just within the limits of Chapter 62-302, FAC criteria.

3.3.2 Development of Ranking Criteria

The preliminary ranking of stormwater problem areas was developed using an assessment criteria-screening matrix. The criteria used to rank the problem areas are:

Problem Area Severity

Priority

Expected Growth

County or Public Benefit

Water Quality Benefits

The typical evaluation for each problem area included assigning a value (0-10) to each criterion. These values are based on information collected during the investigation of these stormwater problem areas, and are intended only to assist in defining priorities. As more detailed information becomes available, these criteria should be reevaluated and priorities should be redefined accordingly. Values for each criterion are based on the following:

Problem Area Severity

The problem area severity is based upon whether the problem is considered nuisance or serious, with the nuisance problem areas with values ranging from 0 to 5 and serious problem areas with values ranging from 6 to 10.

Priority

The prioritization of identified problem areas was established by County staff and has been ranked as: high, medium or low (Section 3.2). A value of 0 would equate to a low priority, while a value of 5 represents a medium priority. A 10 represents a high priority.

Water Quality Enhancement Potential or Benefit

This criterion is related to the potential enhancement of water quality resulting from the remediation of the problem. A value of zero represents minimal or no potential water quality improvement. A value of 5 represents a moderate water quality improvement, while a 10 indicates a significant improvement potential.

County or Public Benefit

The public benefit criterion is related to the citizens most affected by the conceptual solution. A value of 0 means few citizens would be affected by the improvement while a value of 5 means many citizens would be affected. A 10 would represent that the most citizens would be affected.

Future Growth

In general, the higher the growth rate, the greater the urbanization that leads to flooding and pollution related problems. For this reason, the degree of future growth is added to the ranking with the highest growth assigned 10 points and lowest 0 points.

Criteria Weighting

Each of the criteria noted above have been assigned a "weight" that is based on the value of the criterion. That is, one criterion may be more important to the County than another. The weights assigned to each criterion were established after consultation with the County. The value assigned to each criterion is multiplied by the "weight" of the criterion and summed to determine the accumulative score for each problem area. The weights assigned to each criterion are as follows:

Criterion	Weight
Problem Area Severity	2.0
Priority	1.0
Water Quality Enhancement Potential	1.5
County or Public Benefit	1.0
Future Growth	2.0

The maximum total score is 75 points.

3.3.3 Problem Area Ranking Results

Applying the scoring protocol to the problem areas identified, Table 3.0-3 provides the resulting ranking matrix. At the onset of this project, Marathon was unincorporated and part of the SMMP program. During the execution of the SMMP, Marathon was incorporated. For this reason, the projects within Marathon were separated and ranked in Table 3.0-4.

The ranking shows that only a few problem areas received points for flooding severity and expected growth, which implies that the highest ranked problem areas are for existing urban development resulting in water quality issues. The first five problem areas are water quality related: Mangrove Marina, Alex's Junkyard, Safe Harbor Area, Winn Dixie Shopping Plaza, and Oceanside Marina. All of these are privately owned and are ranked high because of the county's perceived priorities and water quality benefits.

For incorporated Marathon, the highest ranked problem areas are Marathon Marina and Boot Key Harbor, both water quality related.

Finally, Table 3.0-3 indicates that US 1 represents the second highest ranking problem area based upon the ranking criteria. As noted previously, in many study areas, US 1 is the only stormwater management system available, so it is not surprising that it

Table 3.0-3
Monroe County Stormwater Management Master Plan
Problem Area Ranking Matrix

Unincorporated Monroe County

Problem Area	Public or Private	Issue [1]	Visited	Study Area	Flood Severity	Expected Growth	County Benefit	Priority	WQ Benefit	Total Score [2]	Rank
				Weight	1.0	0.5	1.0	1.0	2.0		
Mangrove (Campbell's) Marina	Private	WQ	Y	Key Largo	0	0	5	10	8	31.0	1
US 1	Public	WQ	Y	All	0	3	8	5	7	28.5	2
Alex's Junkyard	Private	WQ	N	Stock Island	0	0	6	10	5	26.0	3
Safe Harbor Area	Private	WQ	Y	Stock Island	0	0	6	10	5	26.0	3
Winn Dixie Shopping Plaza	Private	WQ	N	Big Pine Key	0	5	7	0	8	25.5	4
Oceanside Marina	Private	WQ	N	Stock Island	0	0	4	10	4	22.0	5
Venture Out Trailer Park	Private	F	N	Cudjoe Key	4	0	8	5	2	21.0	6
Summerland Key Seafood	Private	WQ	N	Summerland	0	0	4	5	6	21.0	6
Key Largo Fishery Marina	Private	WQ	N	Key Largo	0	0	3	5	5	18.0	7
Holiday Isle Resort	Private	WQ	N	Windley Key	0	0	3	5	5	18.0	7
Stock Island Lobster Co.	Private	WQ	N	Stock Island	0	0	4	5	4	17.0	8
Big Pine Shopping Center	Private	F	Y	Big Pine Key	5	5	2	0	2	13.5	9
US 1 (Oceanside)	Public	F	Y	Key Largo	2	0	3	0	4	13.0	10
Coconut Grove Residential Area	Private	WQ	N	Stock Island	0	0	4	0	4	12.0	11
Card Island Sound (915A)	Public	WQ	Y	Key Largo	0	2	3	0	4	12.0	11
Marathon Government Center	Public	F	Y	Marathon	3	1	4	0	2	11.5	12
Key Largo Trailer Village	Private	F	Y	Key Largo	4	0	2	0	2	10.0	13
Burton Drive & US 1	Public	F	Y	Key Largo	3	0	2	0	2	9.0	14
Tavernier Town Center	Private	F	Y	Key Largo	3	1	1	0	2	8.5	15
Waldorf Plaza	Private	F	Y	Key Largo	2	0	1	0	2	7.0	16
Key Largo Harbor Marina	Private	WQ	N	Key Largo	0	0	2	0	2	6.0	17
Jo Jean Way in Community Harbor	Public	WQ	N	Key Largo	0	0	2	0	2	6.0	17
Old Town Trolley Storage Area	Private	WQ	N	Stock Island	0	0	2	0	2	6.0	17

Note: 1: Issue for which the problem area was placed on the list: F - Flooding, WQ - Water Quality.
2: Total score is the sum of the individual scores times the associated weights.

Table 3.0-4
Monroe County Stormwater Management Master Plan
Problem Area Ranking Matrix

Incorporated Marathon					Flood Severity	Expected Growth	County Benefit	Priority	WQ Benefit		
	Public or			Weight	1.0	0.5	1.0	1.0	2.0	Total	
Problem Area	Private	Issue [1]	Visited	Study Area						Score [2]	Rank
Marathon Marina	Private	WQ	Y	Inc. Marathon	0	0	7	10	7	31.0	1
Boot Key Harbor Drainage	Public	WQ	N	Inc. Marathon	0	0	5	10	7	29.0	2
Coco Plum Causeway	Public	WQ	N	Inc. Marathon	0	0	4	5	5	19.0	3
National Fish Market	Private	WQ	N	Inc. Marathon	0	0	2	5	3	13.0	4
Marathon Seafood	Private	WQ	N	Inc. Marathon	0	0	2	5	3	13.0	4
27th Street	Public	WQ	N	Inc. Marathon	0	2	4	0	4	13.0	4
Veteran's Park	Public	WQ	N	Inc. Marathon	0	4	5	0	3	13.0	4
Sombrero Isles	Public	F	N	Inc. Marathon	8	0	3	0	1	13.0	4
K-Mart Store	Private	F	Y	Inc. Marathon	6	0	2	0	2	12.0	5
US-1 at Mangrove Marina	Public	F	Y	Inc. Marathon	4	1	3	0	2	11.5	6

Note: 1: Issue for which the problem area was placed on the list: F - Flooding, WQ - Water Quality.
2: Total score is the sum of the individual scores times the associated weights.

represent a high priority. In order to determine which part of US 1 represents the highest priorities, the sections of US 1 within each study area were considered relative to each of the ranking criteria. Assigning values to each criterion is discussed below:

- Flood Severity – whether flooding has been identified as a problem by staff of public. Actually, only one portion of US 1 in Key Largo has been identified as a flooding problem.

- Expected Growth – based upon Table 2.1-3, population growth from 1990 Census. The greater the change in growth the higher the score.

- County Benefit – based upon Table 2.1-2, existing population. The higher the existing population the higher the score.

- Priority – based upon Monroe County identified priorities. None of US 1 was identified in previous documents as a major priority.

- WQ Benefit – this used the WMM model results for TN, TP and TSS for each study area. The relative percentage of the FDOT road contribution to the total urban loading (see Subsection 2.3) was used. For example, in a few cases, the average percent loading exceeded 50 percent of the total urban load for the study area – these cases were assigned 10 points.

Table 3.0-5 shows the results of this ranking process. The highest four study areas are Key Largo (due to a large existing population and an identified flooding area), Bahia Honda and Layton (due to FDOT representing large percentages of the total urban load; >50%), and Big Pine Key (medium expected growth and percentage of urban load).

Table 3.0-5
Monroe County Stormwater Management Master Plan
Summary of Study Area Ranking for US 1

No.	US 1 by Study Area / Study Area	Flood Severity	Expected Growth [2]	County Benefit [3]	Priority [4]	WQ Benefit [5]	Total Score [1]	Rank
	Weight	1.0	0.5	1.0	1.0	2.0		
21,22	Key Largo	4	5	10	0	3	22.5	1
12	Bahia Honda	0	0	1	0	10	21.0	2
16	Layton	0	0	1	0	10	21.0	2
11	Big Pine Key	0	6	3	0	6	18.0	3
5	Lower Sugarloaf Key	0	0	1	0	8	17.0	4
6	Upper Sugarloaf Key	0	0	1	0	8	17.0	4
7	Cudjoe Key	0	8	3	0	5	17.0	4
13	Marathon - Incorp	0	4	5	0	5	17.0	4
15	Long Key	0	0	1	0	7	15.0	5
14	Key Colony Beach	0	4	1	0	5	13.0	6
20	Windley Key	0	0	1	0	5	11.0	7
4	Bay Point Key	0	5	2	0	3	10.5	8
8	Summerland Key	0	0	1	0	4	9.0	9
10	Torch Keys	0	0	1	0	4	9.0	9
3	Boca Chica Key	0	3	2	0	2	7.5	10
1	Key West	0	0	5	0	1	7.0	11
17	Lower Matecumbe Key	0	0	1	0	3	7.0	11
18	Islamorada	0	0	1	0	3	7.0	11
19	Upper Matecumbe Key	0	0	1	0	3	7.0	11
2	Stock Island	0	1	2	0	2	6.5	12
9	Ram Rod Key	0	0	1	0	0	1.0	13

Note 1: Total score is the sum of the individual scores times the associated weights.
2: Based upon Table 2.1-3.
3: Based upon existing population.
4: None of FDOT areas were defined has high, medium or low priority by staff.
5: Based upon average percent TN, TP, and TSS load for Urban Land Uses.

Section 4.0
Stormwater Management Strategies and Solutions

The purpose of this chapter is to consider alternative strategies and recommended improvements within Monroe County to achieve the goals and objectives defined in Chapter 3.0 (Objectives, Standards and Problem Areas). The goals of the SMMP are provided below:

Goal 1 - The SMMP will identify, prioritize and recommend remedial improvements for the significant water quality related problem areas within the unincorporated areas of the County.

- This is a requirement of the Monroe County Comprehensive 2010 Growth Management Plan.
- Sections 2.0 and 3.0 identified and prioritized problem areas within the County. Section 4.0 below identifies remedial improvements.
- Because the cities did not elect to participate in the SMMP, the plan will address improvements within the unincorporated County (including Marathon since it had not incorporated at the time the project started).

Goal 2 - The SMMP will recommend actions that will reduce the sediment and nutrient loading to near shore waters resulting from runoff.

- Sediments and nutrients from stormwater runoff contribute to the loss of grass beds and coral reefs by reducing incident light. Sediments cause turbidity (cloudiness) which blocks sunlight to grass beds and reefs. Nutrients allow the growth of algae that can also block sunlight.
- Sediment is a large contributor to nonpoint source pollution in Monroe County, as well as in the United States. Erosion is the principal source of sediment loading and occurs as a result of disturbances due to construction and alteration of natural hydrology.
- Nutrients in runoff come from fertilizers, surfactants, animal wastes and precipitation. Nutrients are either in dissolved (40 to 50 percent) or particulate (50 to 60 percent) form. Over time, particulate forms either settle to the bottom of a quiescent area or dissolve. Dissolved nutrients are generally more bio-available and are used by algae and other plants. To achieve significant reduction of nutrients, therefore, stormwater management must control both dissolved and particulate forms within stormwater runoff.

- The major sources of sediments include erosion and sedimentation from construction sites, erosion from unpaved roads, and non-vegetated road shoulders as well as yards and commercial areas.

- Other pollutants such as phosphorus, heavy metals and organic compounds are often bound or adsorbed onto suspended solids. The bioavailability of some pollutants is decreased when bound. Therefore, the control of sediments from stormwater sources will reduce suspended solids, some nutrients, and other compounds discharged to the near shore waters.

Goal 3 - The SMMP will review existing regulatory requirements for the control of new development related to flooding and water quality and will recommend improvements as needed. As a corollary issue, the SMMP will review existing enforcement activities and recommend necessary changes to improve the compliance with existing or new regulations.

- This is also a requirement of the Monroe County Comprehensive 2010 Growth Management Plan.

- Where the regulatory controls are sufficient, maintenance, inspection and enforcement are required.

- There are two important aspects of the SMMP to achieve successful water quality results: the retrofit of existing stormwater systems to improve or remediate existing problems, and the control of runoff from new development to avoid future problems. For the control of runoff from new development, the two methods generally applied to coastal communities are regulatory constraints (i.e., regulatory control of development) and post-development stormwater treatment. The latter can be expensive and land intensive. For successful regulatory controls, sufficient enforcement must be provided to ensure compliance and a combination of onsite and island-wide controls will be needed to provide a treatment train.

Goal 4 - The SMMP will recommend activities related to the stormwater management of future growth that will be expected to result in no increase in sediment or nutrient loads to near shore waters.

- Because near shore waters in Monroe County are designated as Outstanding Florida Waters, the presumptive stormwater treatment requirement by the State Water Policy is 95 percent treatment of the annual pollutant loading (generally as measured by suspended solids).

- Growth (also known as development) results in the increase of impervious area and / or the change in pollutant loading from a property. This results in the increase in stormwater runoff as well as pollutant loading carried by runoff.

- For most study areas (islands), major changes to future land uses are not expected to increase the pollutant loading of nutrients and sediments (see Subsection 2.3); however, some study areas are expected to exhibit increases. Stronger enforcement of the 95-percent rule should be implemented in these areas.

Goal 5 - To achieve a reduction in existing sediment and nutrient loads, the SMMP will strive to use nonstructural and source controls. When necessary, the SMMP will recommend structural controls associated with the publicly owned infrastructure.

- This means that the SMMP goals will be achieved with the use of both source controls and structural improvements. However, the primary focus will be source controls.

- While many of the stormwater problems encountered in the Keys were a result of the lack of stormwater facilities, a simple improvement is the use of vegetated swales and/or vegetated buffers before the runoff enters near shore waters. Use of vegetated systems will significantly reduce the discharge of both sediments and nutrients.

- Also, water conservation through the use of rain water for irrigation is also a general improvement to achieve this goal. Use of stormwater reduces the amount of runoff during rainfall events which in turn reduces the pollutant load.

These goals will be achieved by addressing the following issues: stormwater management retrofit projects (applicable to Goals 1 and 2), restoration and rehabilitation of permitted (regulated) systems (Goals 1, 2 and 3), future stormwater management needs (Goals 3 and 4), improvements to the existing regulatory programs (Goals 3 and 4), and alternative nonstructural recommendations (Goal 5).

It should be noted that the projects identified for retrofit and rehabilitation were derived from the problem area lists from Section 3.0 for the unincorporated Monroe County and Marathon. Retrofit projects are those for generally unregulated, existing developments while rehabilitation projects are for permitted or regulated developments. For clarity, these tables are reproduced here as Tables 4.0-1 and 4.0-2. A notable feature of the tables is that most of the problem areas listed are on private property, not the direct responsibility of Monroe County. For this reason, after discussion with Monroe County staff, example retrofit and rehabilitation projects were developed for three private problem areas: a commercial site, a marina and a residential area. These projects are intended to illustrate the improvements that can be made on these types of private property should the property redevelop. Actual retrofit or rehabilitation improvements should, however, be made on a case-by-case basis.

Table 4.0-1
Monroe County Stormwater Management Master Plan
Problem Area Ranking Matrix

Unincorporated Monroe County Problem Area	Public or Private	Issue [1]	Visited	Study Area	Flood Severity	Expected Growth	County Benefit	Priority	WQ Benefit	Total Score [2]	Rank
				Weight	1.0	0.5	1.0	1.0	2.0		
Mangrove (Campbell's) Marina	Private	WQ	Y	Key Largo	0	0	5	10	8	31.0	1
US 1	Public	WQ	Y	All	0	3	8	5	7	28.5	2
Alex's Junkyard	Private	WQ	N	Stock Island	0	0	6	10	5	26.0	3
Safe Harbor Area	Private	WQ	Y	Stock Island	0	0	6	10	5	26.0	3
Winn Dixie Shopping Plaza	Private	WQ	N	Big Pine Key	0	5	7	0	8	25.5	4
Oceanside Marina	Private	WQ	N	Stock Island	0	0	4	10	4	22.0	5
Venture Out Trailer Park	Private	F	N	Cudjoe Key	4	0	8	5	2	21.0	6
Summerland Key Seafood	Private	WQ	N	Summerland	0	0	4	5	6	21.0	6
Key Largo Fishery Marina	Private	WQ	N	Key Largo	0	0	3	5	5	18.0	7
Holiday Isle Resort	Private	WQ	N	Windley Key	0	0	3	5	5	18.0	7
Stock Island Lobster Co.	Private	WQ	N	Stock Island	0	0	4	5	4	17.0	8
US 1 (Oceanside)	Public	F	Y	Key Largo	2	0	3	0	4	13.0	10
Veteran's Park	Public	WQ	N	Bahia Honda	0	4	5	0	3	13.0	10
Coconut Grove Residential Area	Private	WQ	N	Stock Island	0	0	4	0	4	12.0	11
Card Sound Road (905A)	Public	WQ	Y	Key Largo	0	2	3	0	4	12.0	11
Marathon Government Center	Public	F	Y	Marathon	3	1	4	0	2	11.5	12
Key Largo Trailer Village	Private	F	Y	Key Largo	4	0	2	0	2	10.0	13
Burton Drive & US 1	Public	F	Y	Key Largo	3	0	2	0	2	9.0	14
Tavernier Town Center	Private	F	Y	Key Largo	3	1	1	0	2	8.5	15
Waldorf Plaza	Private	F	Y	Key Largo	2	0	1	0	2	7.0	16
Key Largo Harbor Marina	Private	WQ	N	Key Largo	0	0	2	0	2	6.0	17
Jo Jean Way in Community Harbor	Public	WQ	N	Key Largo	0	0	2	0	2	6.0	17
Old Town Trolley Storage Area	Private	WQ	N	Stock Island	0	0	2	0	2	6.0	17

Note: 1: Issue for which the problem area was placed on the list: F - Flooding, WQ - Water Quality.
2: Total score is the sum of the individual scores times the associated weights.

Table 4.0-2
Monroe County Stormwater Management Master Plan
Problem Area Ranking Matrix

Incorporated Marathon Problem Area	Public or Private	Issue [1]	Visited	Study Area	Flood Severity	Expected Growth	County Benefit	Priority	WQ Benefit	Total Score [2]	Rank
				Weight	1.0	0.5	1.0	1.0	2.0		
Marathon Marina/Seafood	Private	WQ	Y	Inc. Marathon	0	0	7	10	7	31.0	1
Boot Key Harbor Drainage	Public	WQ	N	Inc. Marathon	0	0	5	10	7	29.0	2
Coco Plum Causeway	Public	WQ	N	Inc. Marathon	0	0	4	5	5	19.0	3
National Fish Market	Private	WQ	N	Inc. Marathon	0	0	2	5	3	13.0	4
27th Street	Public	WQ	N	Inc. Marathon	0	2	4	0	4	13.0	4
Sombrero Isles	Public	F	N	Inc. Marathon	8	0	3	0	1	13.0	4
K-Mart Store	Private	F	Y	Inc. Marathon	6	0	2	0	2	12.0	5

Note: 1: Issue for which the problem area was placed on the list: F - Flooding, WQ - Water Quality.
2: Total score is the sum of the individual scores times the associated weights.

Each of the twenty-five projects were visited, photographs taken and conceptual improvements identified based upon the available engineering information. Estimated construction costs were also provided using a unit cost table prepared for Monroe County. The unit costs are listed in Table 4.0-3. As introduced originally in Subsection 2.6, each of the improvements was assessed as to the expected pollutant removal based upon the projected average annual volume of capture. Figure 4.0-1 repeats Figure 2.6-10 showing additional curves for various intermediate C values. The curves are plots of the various percent annual average volume capture versus treatment volume of the Retention, Detention or Vegetated Swale. The 95-percent capture is the target as noted above.

The points of coincidence (i.e., the points at which the 95% treatment line coincide with the capture curves) are plotted in Figure 4.0-2. The line through the points has the equation:

$$\text{Volume} = 3.1834C \quad (R^2 = 0.9987)$$

where volume is the live or treatment volume in inches and C is the runoff coefficient. This curve can be used for planning purposes.

For the retrofit and rehabilitation projects, a common element of the recommendations is the use of landscaped areas (swales, berms, and other systems) to achieve major improvements. As noted previously, controlling runoff through the use of vegetated buffers (landscaped swales) can be the single most beneficial BMP within the Florida Keys. However, the selection of this plant material must be carefully determined to ensure both the aesthetic value to the public, and survivability of the species. Many of the areas listed in the recommendations are in harsh environmental conditions (i.e. full sun, salt spray, and poor soil). Historically, the plant selection in these types of areas has been “sod” or grass. The grass usually dies and is replaced completely by herbaceous weeds and ultimately erodes and disappears. There are many native and naturalized species that would be suited for these types of conditions that will not require excessive maintenance; and in some cases actually decrease maintenance concerns. A list of recommended plant material is provided in Appendix 4.0-A. This list should not be considered as the “only” or the “best”, but simply a good basic reference. The majority of the species on the list are native to the area and have been categorized into sizes and salt tolerance to assist in the selection process. The list was created with the knowledge that the plantings would be established both in public and private areas, as well as a variety of environmental conditions. However, the basic assumptions of the growing conditions were as follows: (1). The plants would likely be in full sun, (2). The plants will not receive much care **after having been established** (i.e. fertilizer, water, etc.).

Table 4.0-3

Monroe County Stormwater Master Plan
Unit Cost Summary for Retrofit/Rehabilitation Project Cost Estimates

	Item	Units	Unit Cost (4)
1	Storm Sewer	Ft	Variable (5)
2	Storm Inlets	Each	$2,500
3a	Swales (1) - Commercial	Ft	$85
3b	Swales (2) - Residential, Roads	Ft	$25
3c	Swales (3) - Bike Trail	Ft	$12
4	Road/Driveway Repair	Sq Yd	$20
5	Excavation/Earthwork	Cu Yd	$12
6	Curb Replacements/Installation	Ft	$10
7	Exfiltration Trench	Ft	$250
8	Water Quality Treatment Unit (6)	Each	$15,000
9	Install/Repair Drain Well	Each	$5,000
10	Roof Drain Treatment Areas	Each	$1,500
11	Berm	Ft	$15
12	Porous Pavement	Sq Yd	$20

Notes:

(1) Swale costs include excavation, regrading, piping, sodding, driveway repair, and curb installation for swales on both sides of a roadway. This does not include land acquisition costs for swales not in existing rights-of-way.

(2) For residential areas and roadways (FDOT & County).

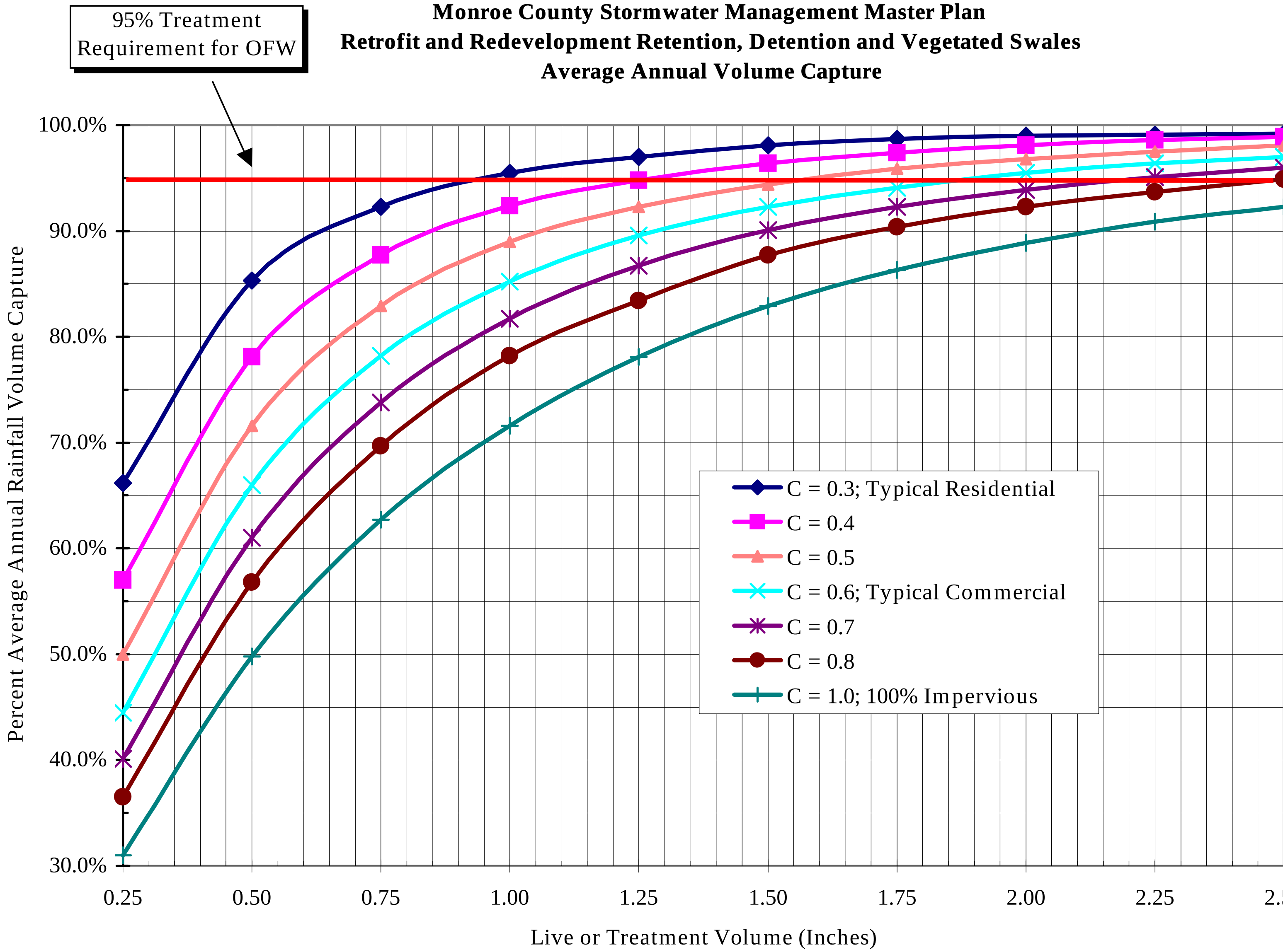
(3) For Bike Trail; cost reduced due to association with bike trail design.

(4) All costs are in 2001 dollars. Costs include only stormwater related infrastructure. Replacement or rehabilitation of non-stormwater infrastructure is not included.

(5) Generally between $2.00 and $3.25/foot/in diameter depending on pipe size.

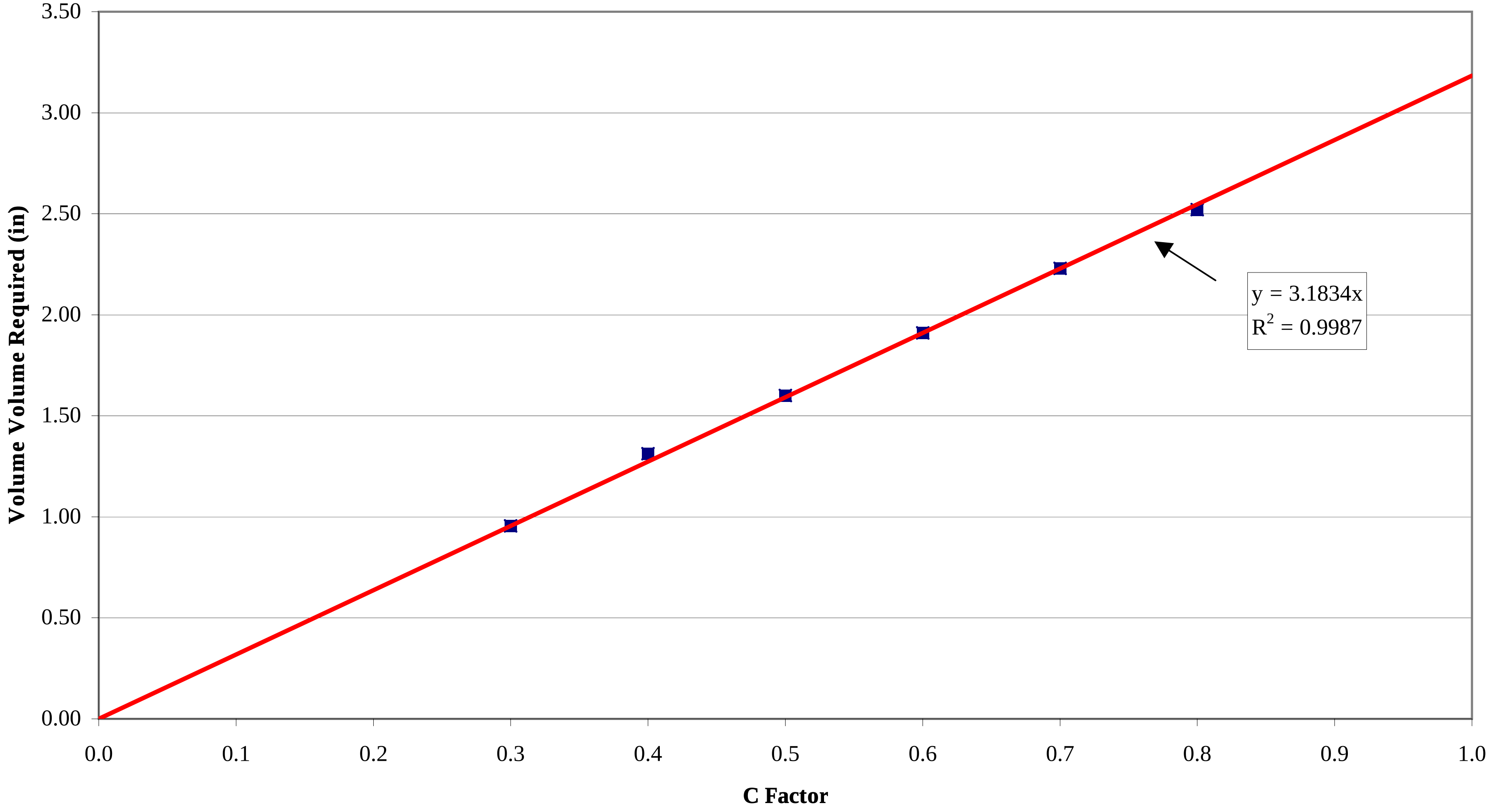
(6) Unit cost based upon sizing for tributary area of 10 acres or less.

Figure 4.0-1
Monroe County Stormwater Management Master Plan
Retrofit and Redevelopment Retention, Detention and Vegetated Swales
Average Annual Volume Capture



S:\MONROE\Fig 4-1 STORMcurve.XLS

Figure 4.0-2
Monroe County Stormwater Management Master Plan
95 Percent Capture Related to C Factor



4.1 Assessment of Stormwater Management Alternatives

In Section 2.6 (Existing Stormwater Management Systems), numerous alternative best management practices (BMPs) were considered including both structural improvements and sources controls. The alternative strategies discussed include BMPs that are particularly suited to the environment and conditions in the Florida Keys as well as those not particularly applicable to the Keys. Discussed below are various alternative strategies for stormwater management with particular emphasis on those to be used in the Monroe County Stormwater Management Master Plan.

4.1.1 Regional Versus Onsite Stormwater Management Systems

In general, there are two basic strategies for stormwater management improvements on a countywide scale: regional and onsite. The following discussion is provided for detention pond applications.

Onsite Approach. In the case of future urban development or retrofit of existing development, the onsite approach (also known as piecemeal approach to stormwater control) involves the delegation of responsibilities for BMP deployment to local land developers or the use by the County of BMPs serving small areas due to site constraints. Each developer is responsible for constructing a structural BMP at the development site to control nonpoint pollution loadings from the site. Onsite detention ponds typically have contributing areas of 20-50 acres. The local government is responsible for reviewing each structural BMP design to ensure conformance with specified design criteria, for inspecting the constructed facility to ensure conformance with the design, and for ensuring that a maintenance plan is implemented for the facility. The treatment facility usually consumes 15% of developable site based on research done in the State of Florida by CDM and others.

Regional Approach. The regional approach to stormwater control involves strategically locating regional structural BMPs to control nonpoint pollution loadings from multiple development projects. For ponds serving new development, the front-end costs for constructing the structural BMP are assumed by the developer and/or the local government that administers the regional BMP plan. BMP capital costs can then be recovered from upstream developers on a "pro-rata" basis as development occurs. Individual regional BMPs are phased in as development occurs rather than constructing all regional facilities at one time. Maintenance responsibility for regional structural BMPs can be assumed by the developer (or designee with certified maintenance bonds) or by the local government. For retrofit of existing development, regional BMPs may also be used to cost-effectively treat areas near the areas that cannot be cost-effectively treated. The regional approach can address concurrence for the entire watershed.

It is clear from this description that from a watershed point of view, regional stormwater management is preferred because of the following advantages: reduction of capital costs, reduction in total maintenance costs, greater reliability, greater opportunities to control multiple source pollutant loading, and the ability to provide multifunctional facilities. However, all of these advantages are predicated on a large-scale watershed, draining through a single site. The Florida Keys, to the contrary, consists of small tributary areas with minimum land slopes draining mostly to near shore waters. Thus, in the Keys, there are not many (if any at all) opportunities to locate regional facilities to which multiple areas drain. The system must operate on a piecemeal basis so the overall strategy must be piecemeal. For these reasons, the overall strategy of the Monroe County Stormwater Management Master Plan is to support smaller-scale, onsite stormwater systems.

4.1.2 BMP Alternatives

Table 2.6-1 in Subsection 2.6 lists 19 structural BMPs and 16 nonstructural source controls that are discussed in more detail within the subsection. Based upon the climate of the Florida Keys, the topography and soils of the islands, and stormwater management experience of engineers within the Keys, the following structural BMPs are recommended for application for all types of land development:

Buffer Strips	Porous Pavement	Water Quality Inlets
Baffle Boxes	Hydrodynamic Separators	Dry Wells w/Pretreatment
Modular Treatment	Stormwater Wetlands	Alum Injection
Aeration	Oil & Grease Separators	Vegetated Swales

Of this list, hydrodynamic separators, baffle boxes, modular systems and alum injection should probably be pilot tested prior to full-scale recommendation since there has been no experience with these BMPs within the Florida Keys.

For source controls all of the BMPs on the list are recommended except for street sweeping. While street sweeping can be effective in some urban environments, a curb and gutter road system is generally needed (non-vacuum system) and most of the Keys do not have such roads. Recommended source controls include:

Land Use Planning	Public Information	Ordinance Requirements
Cisterns/Rainbarrels	Vehicle Use Reduction	Impervious Reduction
Low Impact Development	Erosion/Sediment Control	Operation & Maintenance

More on these is contained in the detailed analysis below.

4.1.3 Bridges

Table 4.1-1 lists the islands along US1 within the Monroe County study area with the approximate lengths and bridges connecting them (lengths given to the nearest 0.1 mile). It can be seen that, of the 107 miles indicated, 18.9 miles (about 18 percent) of US1 are bridges of various lengths. As part of the Stormwater Management Master

Table 4.1-1
Monroe County Stormwater Management Master Plan
Summary of FDOT US1 Features by Mile Point

From	To	Description	Distance (mi) Island	Bridge
0.0	4.2	Key West	4.2	
4.2	4.3	Cow Key Bridge		0.1
4.3	6.2	Stock Island	1.9	
6.2	6.6	BocaChica Bridge		0.4
6.6	9.6	Boca Chica	3.0	
9.6	9.7	Rockland Channel Bridge		0.1
9.7	11.0	Big Coppitt	1.3	
11.0	11.1	Shark Key Bridge		0.1
11.1	12.5	Shark Key	1.4	
12.5	12.8	Saddlebunch No. 5 Bridge		0.3
12.8	13.2	Saddlebunch Keys	0.4	
13.2	13.3	Saddlebunch No. 4 Bridge		0.1
13.3	14.2	Saddlebunch Keys	0.9	
14.2	14.3	Saddlebunch No. 3 Bridge		0.1
14.3	14.5	Saddlebunch Keys	0.2	
14.5	14.6	Saddlebunch No. 2 Bridge		0.1
14.6	15.2	Saddlebunch Keys	0.6	
15.2	15.5	Lower Sugarloaf Channel Bridge		0.3
15.5	16.3	Lower Sugarloaf Keys	0.8	
16.3	16.5	Harris Channel Bridge		0.2
16.5	17.3	Lower Sugarloaf Keys	0.8	
17.3	17.4	Harris Gap Channel Bridge		0.1
17.4	17.6	Lower Sugarloaf Keys	0.2	
17.6	17.7	North Harris Channel Bridge		0.1
17.7	18.7	Park Key	1.0	
18.7	18.9	Park Channel Bridge		0.2
18.9	20.1	Upper Sugarloaf Key	1.2	
20.1	20.4	Bow Channel Bridge		0.3
20.4	23.4	Cudjoe Key	3.0	
23.4	23.7	Kemp Channel Bridge		0.3
23.7	25.2	Summerland Key	1.5	
25.2	26.0	Niles Channel Bridge		0.8
26.0	27.5	Ramrod Key	1.5	
27.5	27.6	Torch Ramrod Channel Bridge		0.1
27.6	27.9	Middle Torch Key	0.3	
27.9	28.0	Torch Channel Bridge		0.1
28.0	28.6	Little Torch Key	0.6	
28.6	28.9	South Pine Channel Bridge		0.3
28.9	29.3	Island	0.4	
29.3	29.5	North Pine Channel Bridge		0.2
29.5	33.0	Big Pine Key	3.5	
33.0	33.6	Spanish Harbor Channel Bridge		0.6

Note: Bridge distances given to the nearest 0.1 mile.

Table 4.1-1
Monroe County Stormwater Management Master Plan
Summary of FDOT US1 Features by Mile Point

From	To	Description	Distance (mi) Island	Bridge
33.6	35.3	Spanish Harbor Keys	1.7	
35.3	36.4	Bahia Honda Channel Bridge		1.1
36.4	38.3	Bahia Honda Key	1.9	
38.3	38.5	Ohio Bahia Honda Channel Bridge		0.2
38.5	39.0	Ohio Key	0.5	
39.0	39.2	Ohio Missouri Channel Bridge		0.2
39.2	39.5	Missouri Key	0.3	
39.5	39.6	Little Duck Missouri Channel Bridge		0.1
39.6	40.0	Little Duck Key	0.4	
40.0	47.0	Seven Mile Bridge		7.0
47.0	53.0	Vaca Key-Marathon	6.0	
53.0	53.2	Key Vaca Cut Bridge		0.2
53.2	60.5	Fat Deer Key/Crawl Key/Grassy Key-Marathon	7.3	
60.5	60.8	Toms Harbor Channel Bridge		0.3
60.8	61.5	Duck Key	0.7	
61.5	61.7	Toms Harbor Cut Bridge		0.2
61.7	63.0	Conch Keys	1.3	
63.0	65.4	Long Key Channel Bridge		2.4
65.4	70.9	Long Key	5.5	
70.9	71.9	Channel Five Bridge		1.0
71.9	72.8	Craig Key	0.9	
72.8	73.1	Channel Two Bridge		0.3
73.1	77.3	Lower Matecumbe Key	4.2	
77.3	77.4	Lignumvitae Channel Bridge		0.1
77.4	77.9	Island	0.5	
77.9	78.1	Indian Key Channel Bridge		0.2
78.1	79.0	Island	0.9	
79.0	79.2	Teatable Key Channel Bridge		0.2
79.2	79.3	Island	0.1	
79.3	79.4	Teatable Relief Bridge		0.1
79.4	83.7	Upper Matecumbe	4.3	
83.7	83.9	White Harbor Channel Bridge		0.2
83.9	85.5	Windley Key	1.6	
85.5	85.6	Snake Creek Bridge		0.1
85.6	90.8	Plantation Key	5.2	
90.8	90.9	Tavernier Creek Bridge		0.1
90.9	107.0	Tavernier/Rock Harbor/Newport/Key Largo	16.1	
		Totals	88.1	18.9

Note: Bridge distances given to the nearest 0.1 mile.

Plan, recommendations will be made (see below) on suggested retrofit and rehabilitation projects for US1, excluding along most of Key Largo, for approximately 17.5 miles. In order to address all of the potential sources of stormwater runoff, the contribution of the bridges was also considered.

Related to stormwater runoff, a bridge is 100 percent impervious and rain that falls on the bridge either runs off directly to the near shore waters under the bridge or flows down the bridge to the entrance or exit. The question, therefore, is whether or not runoff directly from the bridge can be treated efficiently and at a reasonable cost.

From 1993 to 1995, the U.S. Geological Survey conducted a study of the Bayside Bridge in Clearwater, Florida (Stoker, Y.E., "*Effectiveness of a stormwater collection and detention system for reducing constituent loads from bridge runoff in Pinellas County, Florida*", USGS Open File Report 96-484). For the Bayside Bridge, stormwater runoff was collected along the bridge through inlets, and carried to a land-based detention facility near the bridge entrance. This study concluded that, after monitoring 33 storm events, runoff quality varied with total runoff volume, antecedent dry period, and season. Many parameters, including sediments and nutrients, were inversely related to runoff volume. For treatment efficiency, suspended solid loads were reduced by 30 to 45 percent, inorganic nitrogen by 60 to 90 percent and most metals by 40 to 99 percent. However, TKN, alkalinity, pH and specific conductance, among others, had negative efficiencies (i.e., the outflow values were greater that the inflow).

This article points out the experience related to bridge BMPs: 1) runoff needs to be carried to the shore where it is treated, 2) regular maintenance is necessary, and 3) treatment efficiencies are highly variable, with some parameters actually increasing. While these results may not be encountered in the Florida Keys, bridge runoff control is not recommended on a large scale. However, it is suggested that bridge runoff treatment should be tried at one or more sites for a few years, with monitoring to confirm treatment efficiencies. Depending on the outcome, bridge runoff control could be implemented on selective bridges.

4.2 Alternatives for Stormwater Management Retrofit

As noted above, fifteen problem areas were selected for retrofit improvements. The selected areas are:

27th Street - Marathon
Sombrero Isles
Sombrero Beach Road FDOT
24th Street - Marathon
Saddle Bunch Bike Trail FDEP
Bahia Honda Bike Trail FDEP
US1 Rockland Channel to Shark Channel FDOT
US1 Big Coppitt Key Boat Ramp @ MM11 FDOT
US1 Boca Chica Channel to Rockland Channel FDOT
US1 Long Key @ MM66 FDOT
US1 Lower Matecumbe @ MM77 Bay and Ocean Sides FDOT
US1 North Harris Channel to Park Channel FDOT
US1 Bow Channel to Kemp Channel FDOT
US1 Indian Key Bay Side Parking @ MM78 FDOT
Safe Harbor (example - private marina retrofit)

The location of these areas is illustrated on Figure 4.2-1. Only one of the areas is on private property: Safe Harbor. All others are within the unincorporated Monroe County, City of Marathon or along FDOT right-of-way. Ten of the projects are within FDOT right-of-way, including the two Bike Trails (managed by FDEP).

Tables 4.2-1 and 4.2-2 show summaries of the conceptual retrofit projects for unincorporated Monroe County and City of Marathon, respectively. All of the public projects within the unincorporated County are along US 1 with two associated with the Heritage Bike Trail (managed by FDEP). The last project is an example private marina retrofit for Safe Harbor on Stock Island. As can be seen in the tables, most of the retrofits include simply the introduction of vegetated swales and some berms to slow or impede stormwater flows before discharge to near shore waters. Porous pavement is recommended for some of the FDOT projects to allow more infiltration rather than runoff.

Total estimated costs for these projects sum to about $5.15 million, of which $361,100 is for the Safe Harbor retrofit. It has been estimated that of the 107 miles of US 1, 18.9 miles are bridges and that Key Largo (with curb and gutter and swales existing along many parts of US 1) has about 16.1 miles of US 1. Therefore, the total miles of US 1 that could be improved is approximately 72 miles. Table 4.2-1 recommends improvements over 17.5 miles or about 25 percent of this figure, for a total cost of about $5.0 million. Thus, with an average retrofit cost of $284,400 / mile, the total cost to retrofit US 1 would be about $18.5 million [$5.0 million plus (72-17.5) miles times $284,400 / mile].

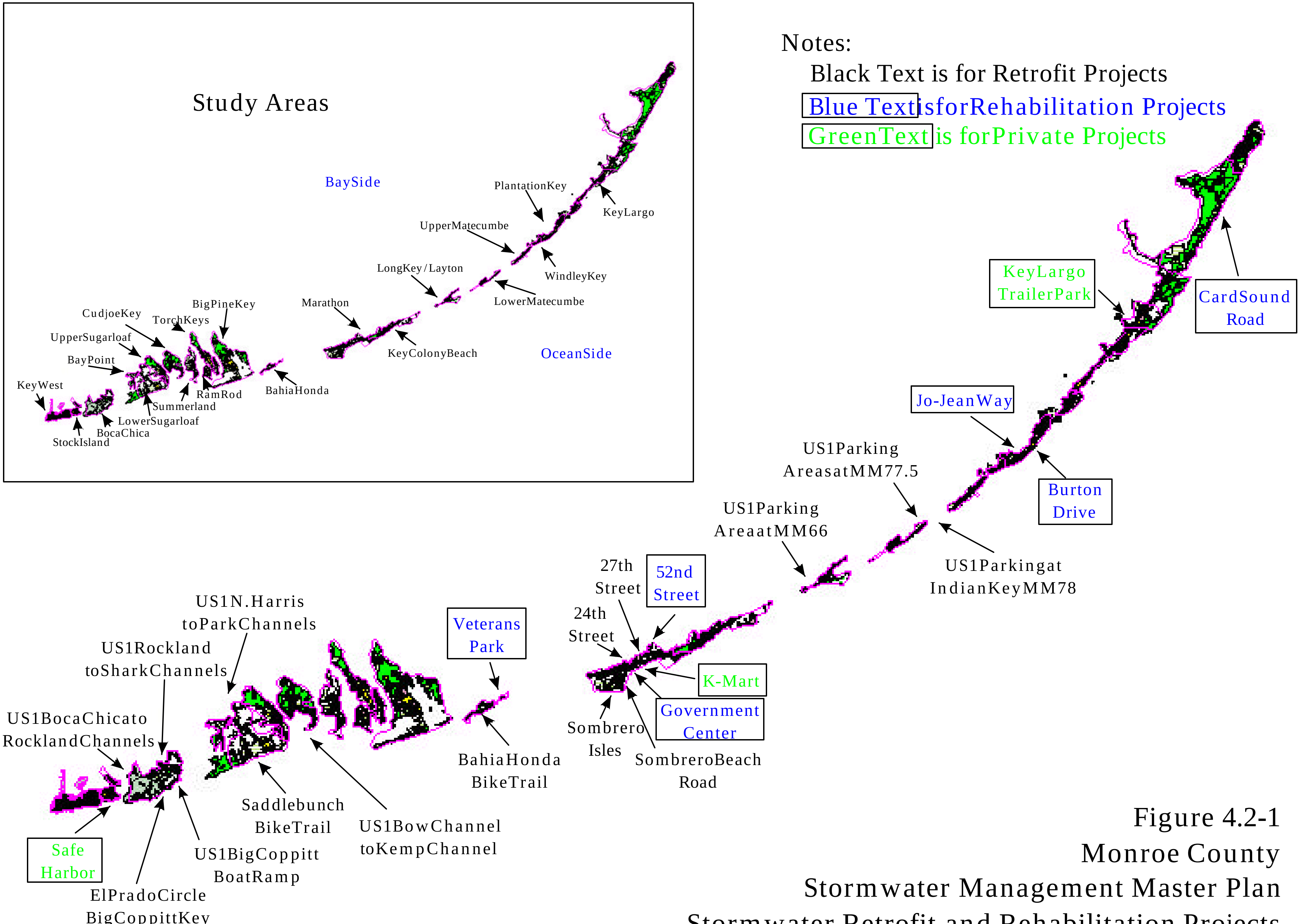


Figure 4.2-1
Monroe County
Stormwater Management Master Plan
Stormwater Retrofit and Rehabilitation Projects

Table 4.2-1

Monroe County Stormwater Management Master Plan

Summary of Retrofit Costs For Unincorporated Monroe County

Problem Area	Study Area	Rank	Description of Improvement	Estimated Cost
Saddlebunch Bike Trail - FDEP	Saddlebunch	2	Vegetated swales along one or both sides of road	$445,900
Bahia Honda Bike Trail - FDEP	Bahia Honda	2	Vegetated swales along both sides of road	$437,700
US1 Rockland Channel to Shark Channel	Big Coppitt	2	Vegetated swales along road, porous pavement	$543,500
US1 Big Coppitt Boat Ramp	Big Coppitt	2	Berm with vegetated swales	$43,000
US1 Boca Chica Channel to Rockland Channel	Boca Chica	2	Median to vegetated swale, swales along road, porous pavement	$1,128,700
US1 Bayside Parking Area at MM66	Long Key	2	Vegetated swale, regrading	$16,900
US1 Oceanside and Bayside Parking Areas at MM 77.5	Lower Matecumbe	2	Vegetated berm on both sides of road	$2,600
US1 North Harris Channel to Park Channel	Lower Sugarloaf	2	Vegetated swales along road, porous pavement	$418,000
US1 Bow Channel to East Side of Cudjoe Key	Cudjoe Key	2	Vegetated swales along road, porous pavement	$1,045,100
US1 Indian Key - Bayside Parking Area at MM 78	Lower Matcombe	2	Vegetated berm	$2,100
Safe Harbor (Example Private Marina)	Stock Island	3	General cleanup; source controls; vegetated swales	$361,100
			Total Retrofit	$4,444,600

Table 4.2-2

Monroe County Stormwater Management Master Plan

Summary of Retrofit Costs For City of Marathon

Problem Area	Study Area	Rank	Description of Improvement	Estimated Cost
Sombrero Beach Road FDOT	Marathon	2	Vegetated swales along both sides of road	$536,400
24th Street - Boot Key Harbor -- Marathon	Marathon	2	Berm to redirect runoff; Vegetated swale for treatment	$3,500
27th Street - Marathon	Marathon	4	Stormwater treatment device prior to discharge	$22,400
Sombrero Isles	Marathon	4	Recessed vegetated median; outfall to Sister Creek	$147,900
			Total Retrofit	$710,200

Appendix 4.0-B provides the detailed information collected for the fifteen retrofit projects. Included in the appendix are descriptions of the area, photographs of areas needing rehabilitation, conceptual sketches of the retrofit and an estimate of the construction costs.

4.3 Regulated Systems Rehabilitation

Based upon Table 3.0-1 and 3.0-2, ten problem areas that were already permitted but need rehabilitation were identified for consideration. One of the areas, Coco Plum Causeway, was itself public right-of-way, but the problems were private in nature, outside of County jurisdiction. For this reason, although visited in the field, this problem area was dropped. The areas addressed are listed below:

Card Sound Road (SR 905A)

Burton Drive @ US 1

Jo-Jean Way @ Community Harbor

Veterans Park in Little Duck Key

52nd Street - Marathon

Marathon Government Center

El Prado Cirole on Coppitt Key

Key Largo Trailer Park (example - private residential rehabilitation)

K-Mart Store - Marathon (example - private commercial rehabilitation)

Tables 4.3-1 and 4.3-2 show summaries of the estimated costs for the rehabilitation costs for the unincorporated Monroe County and city of Marathon, respectively. An example private residential rehabilitation is the Key Largo Trailer Village with a total cost of $120,500. An example of a commercial rehabilitation is K-Mart in Marathon with a total cost of $127,100. Excluding these private properties, the total cost for the County is $154,900 and for the city, $25,900.

As with the rehabilitation projects identified in Subsection 4.2, each of these was visited, pertinent features were photographed, and conceptual improvements identified. Appendix 4.0-C provides the collected data, conceptual designs and estimated construction costs.

Table 4.3-1

Monroe County Stormwater Management Master Plan

Summary of Rehabilitation Costs For Unincorporated Monroe County

Problem Area	Study Area		Description of Improvement	Estimated Cost
Veteran's Park in Little Duck Key	Bahia Honda	4	Vegetated berm and swale; xeriscape	$3,500
Card Sound Road (SR 905A)	Key Largo	11	Vegetated berms	$89,700
Marathon Government Center	Marathon	12	Clean catch basins, flush exfiltration, rehab wells, sediment control	$29,900
Key Largo Trailer Park (Example Private Residential)	Key Largo	13	Fill low areas, vegetated swales	$251,200
Burton Drive at US1 in Tavernier	Key Largo	14	Vegetated swales along Burton Drive and US1	$11,300
Jo-Jean Way in Tavernier	Key Largo	17	Baffle Box	$29,900
El Prado Circle on Coppitt Key	Big Coppitt	New	Exfiltraion trench plus catch basins	$89,700
			Total Rehabilitation	$505,200

Table 4.3-2

Monroe County Stormwater Management Master Plan

Summary of Rehabilitation Costs For City of Marathon

Problem Area	Study Area		Description of Improvement	Estimated Cost
52nd Street (Palm Place) - Boot Key Harbor - Marathon	Marathon	2	Stormwater treatment device prior to discharge	$22,400
K-Mart Store (Example Private Commercial)	Marathon	5	Recessed vegetated swales; drain well rehab; porous pavement	$509,100
			Total Rehabilitation	$531,500

4.4 Future Stormwater Management Needs

Although the County has identified that there will be limited growth within the Keys over the next 10 years, the pollutant loading analysis from Subsection 2.3 determined that a number of study areas will exhibit an increased loading due to land uses changes related to growth. Land use changes can increase loading by 1) increasing the runoff due to increases in impervious area; 2) increasing the characteristic pollutant concentration due to the type of land use; 3) changing the type of pollutants discharged due to the type of land use; 4) increasing the annual pollutant loading; and 5) changing the timing of the pollutant load delivery to receiving waters. Therefore, to control increases in pollutant loading for future growth, stormwater management activities include a treatment-train approach that provides for the control of runoff, source controls (to reduce pollutant loads from land uses) and post-development treatment. Options for source controls are discussed in detail in Subsection 2.6 in Volume 1 of the SMMP and recommendations for specific source controls for Monroe County are provided in Subsection 4.6 below. Alternatives to control runoff and for post-construction treatment for new development and significant redevelopment are considered in this section.

When dealing with future growth, there are a number of existing regulations that attempt to control the increase in future pollutant loading resulting from the development. As noted in Subsection 2.5 (Regulatory Environment), the State of Florida requires that stormwater facilities provide retention or detention with filtration of the first inch of rainfall or for projects of less than 100 acres, treatment of the first 1/2 inch of runoff. In the State Water Policy, 62-40.432(5) defines the minimum stormwater treatment performance standards for the state. The State and water management districts must require that new stormwater facilities "achieve at least 80 percent reduction of the average annual load of pollutants that would cause or contribute to violations of state water quality standards." If the discharge is to OFW, the reduction increases to 95 percent of the annual average load. Since the marine waters of the Florida Keys are OFW, the target is 95 percent reduction. The SFWMD presumptive criteria for Class III waters requires the treatment of the first inch of runoff from the tributary area or 2.5 inches of runoff over the impervious area, which ever is greater. Required for new development and significant redevelopment, each of these requirements attempt to reduce the increase in pollutant loading due to the development.

Similarly Section 9.5-293 of the Monroe County Land Development Regulation states that retention or detention is to be provided for the first inch of runoff or for 25 times the percent impervious coverage, and that for projects with over 40 percent impervious less discharging to OFWs must provide additional treatment. In these areas the WMD and County are consistent; the difference is in the minimum threshold at which the standards apply.

In Subsection 2.6, the efficiencies of alternative structural best management practices to control pollutant loading were considered. In particular, the efficiency of detention-like and retention facilities such as vegetated swales was tested for the Florida Keys. A simulation of the particulate capture rate was completed using the Storage, Treatment, Overflow, Runoff Model (STORM). Historical rainfall data from the Key West Airport were used to simulate the annual average percent capture within a detention / retention facility. The treatment rate was based upon a 1-acre system (i.e., the results are on a per acre basis) with a 72-hour discharge rate for the live (treatment) volume. Simulations were completed for residential (30 percent impervious), commercial (60 percent impervious) and pavement (100 percent impervious) as well as intermediate values. Figure 4.0-1 illustrates the results of the model runs. The percent capture is shown on the vertical axis and treatment volume on the horizontal axis. Also shown are the minimum capture rates required by the State Water Policy (95 percent for discharge to Outstanding Florida Waters). The figure shows that for 95 percent capture, about 2 inches of treatment volume per acre are needed for commercial developments and 1 inch of treatment volume per acre is needed for residential. This is consistent with the SFWMD presumptive criteria. These curves were used for the BMPs recommended below to identify the treatment efficiencies of the conceptual plans.

To confirm the value of the 95 percent treatment requirement, the CDM Watershed Management Model (WMM) was used to simulate the pollutant loading decreases that might occur if all new properties met the 95 percent treatment requirement. For this simulation, the future development to which the 95 percent treatment would apply was calculated as the difference between the future and existing urban land uses. The differences in urban land uses are shown in Table 4.4-1. It can be seen that the majority of the changes in land uses appear to be the change from Forest / Open to Urban / Open and the change from Low Density Residential and Water / Wetland to Medium Density Residential. Figures 4.4-1a, 4.4-1b and 4.4-1c shows the WMM results for the change in loading for TSS, TN and TP, respectively, as a result of future growth with the 95 percent treatment. It can be seen that the 95 percent controls will result in no study areas with load increases outside of the 10 percent window, while the uncontrolled loading shows many study areas with load increases above the 10 percent window. This confirms that the 95 percent controls will achieve the goal of no increases in pollutant loading for the future land uses.

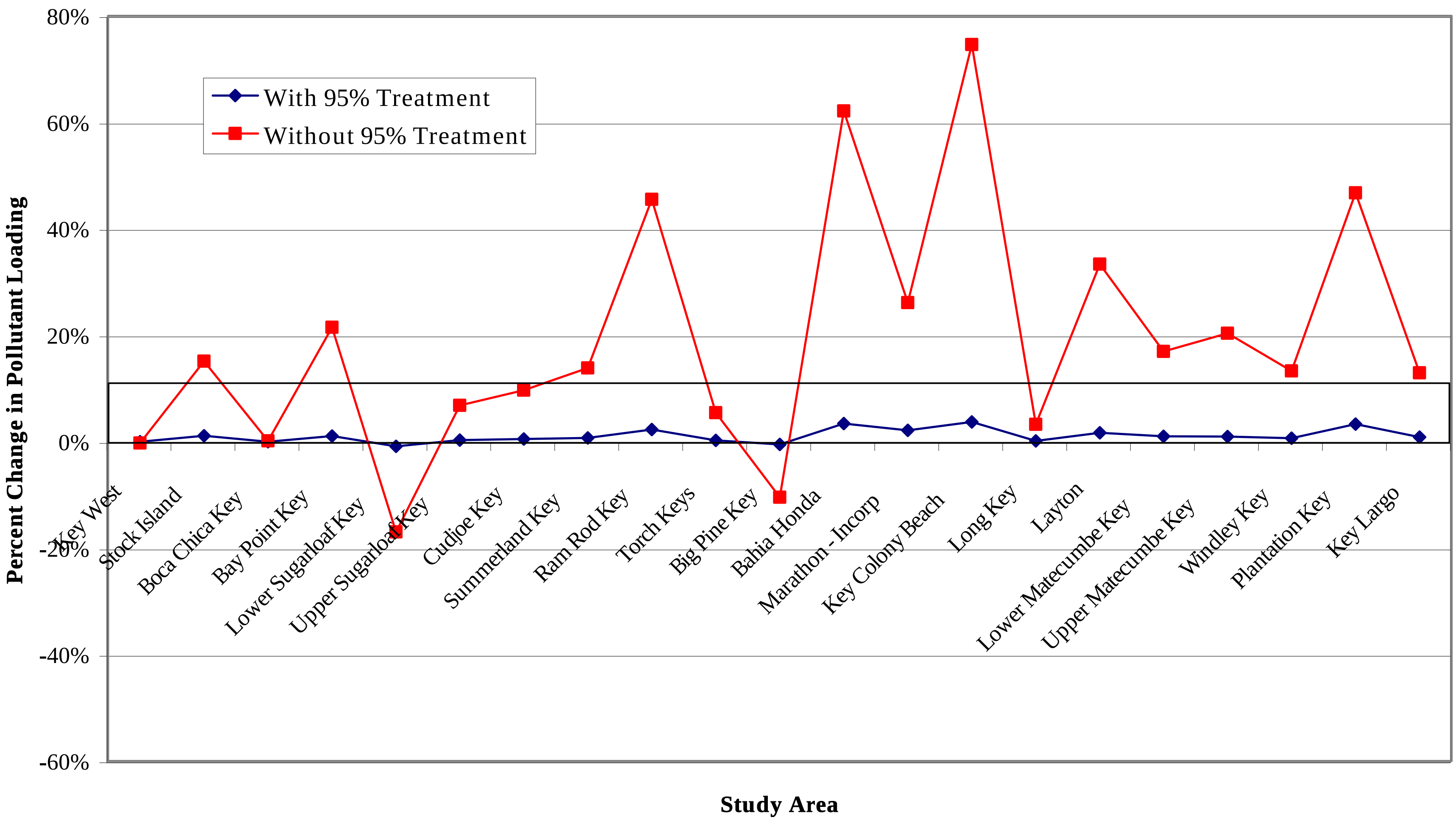
Finally, WMM was used to consider the potential effect on the pollutant loads to near shore waters if retrofit of all urban land uses was achieved. For the purposes of this simulation it was assumed that existing urban land uses (residential, commercial, industrial, and roads) were retrofit to 80% capture of the annual runoff. Figure 4.4-2 shows the WMM results for each parameter modeled. The figure indicates that for TSS, TN and TP, retrofit of existing urban land uses to 80% capture results in a 50%, 32% and 53% reduction, respectively, of pollutant loading.

Table 4.4-1
Monroe County Stormwater Management Master Plan
Summary of Difference in Use Acreage by Study Area (Future - Existing)

Study Area		Forest	Urban	Agric/	Residential					Water/	Roadways		Public	
No.	Description	Open	Open	Pasture	Low	Med	High	Comm	Indust	Wetland	FDOT	County	Facility	Total
Lower Keys														
1	Key West	0	0	0	6	6	2	4	0	3	0	0	(23)	(0)
2	Stock Island	(146)	106	0	(213)	115	128	148	49	80	13	15	(295)	0
3	Boca Chica Key	(92)	251	0	41	(36)	13	39	(1)	(176)	(5)	0	(33)	0
4	Bay Point Key	(377)	342	0	(59)	47	14	8	0	(16)	(0)	0	42	0
5	Lower Sugarloaf Key	(284)	1,098	0	80	27	0	23	0	(874)	(33)	(43)	5	0
6	Upper Sugarloaf Key	(1,001)	926	0	71	1	4	2	0	6	(0)	0	(10)	(0)
7	Cudjoe Key	(570)	553	0	47	27	5	16	13	(110)	(1)	(4)	24	(0)
8	Summerland Key	(635)	875	10	(103)	173	5	12	1	(323)	(8)	(18)	11	0
9	Ram Rod Key	(708)	529	(2)	7	200	0	(1)	0	(23)	0	(3)	(0)	0
10	Torch Keys	(842)	691	0	149	45	2	0	0	(40)	(1)	(4)	0	(0)
11	Big Pine Key	(412)	944	0	168	58	0	22	(10)	(665)	(32)	(74)	1	(0)
12	Bahia Honda	(32)	(399)	0	0	0	0	33	0	367	30	0	0	(0)
Middle Keys														
13	Marathon - Incorp	(2,078)	1,376	(24)	(691)	834	179	332	(21)	32	4	0	55	0
14	Key Colony Beach	(175)	51	0	(106)	63	38	24	(5)	97	12	1	0	(0)
15	Long Key	(166)	166	0	(56)	6	42	(26)	0	26	1	0	7	0
16	Layton	(69)	88	0	(54)	0	0	3	0	26	4	0	1	(0)
Islamorada														
17	Lower Matecumbe Key	(392)	229	0	(103)	450	(45)	(141)	(1)	(3)	17	(9)	(2)	(0)
18	Upper Matecumbe Key	(2,070)	1,609	0	(768)	1,369	(40)	(337)	(1)	176	13	20	29	0
19	Windley Key	(315)	277	0	32	(7)	4	10	0	0	0	0	0	0
20	Plantation Key	(615)	7	0	56	567	3	91	0	(77)	(3)	(8)	(20)	(0)
Upper Keys														
21,22	Key Largo	(3,906)	3,773	(0)	(1,312)	666	565	186	(69)	6	20	(17)	87	(2)
	Totals	(14,885)	13,490	(16)	(2,806)	4,611	919	448	(45)	(1,487)	32	(142)	(121)	(2)

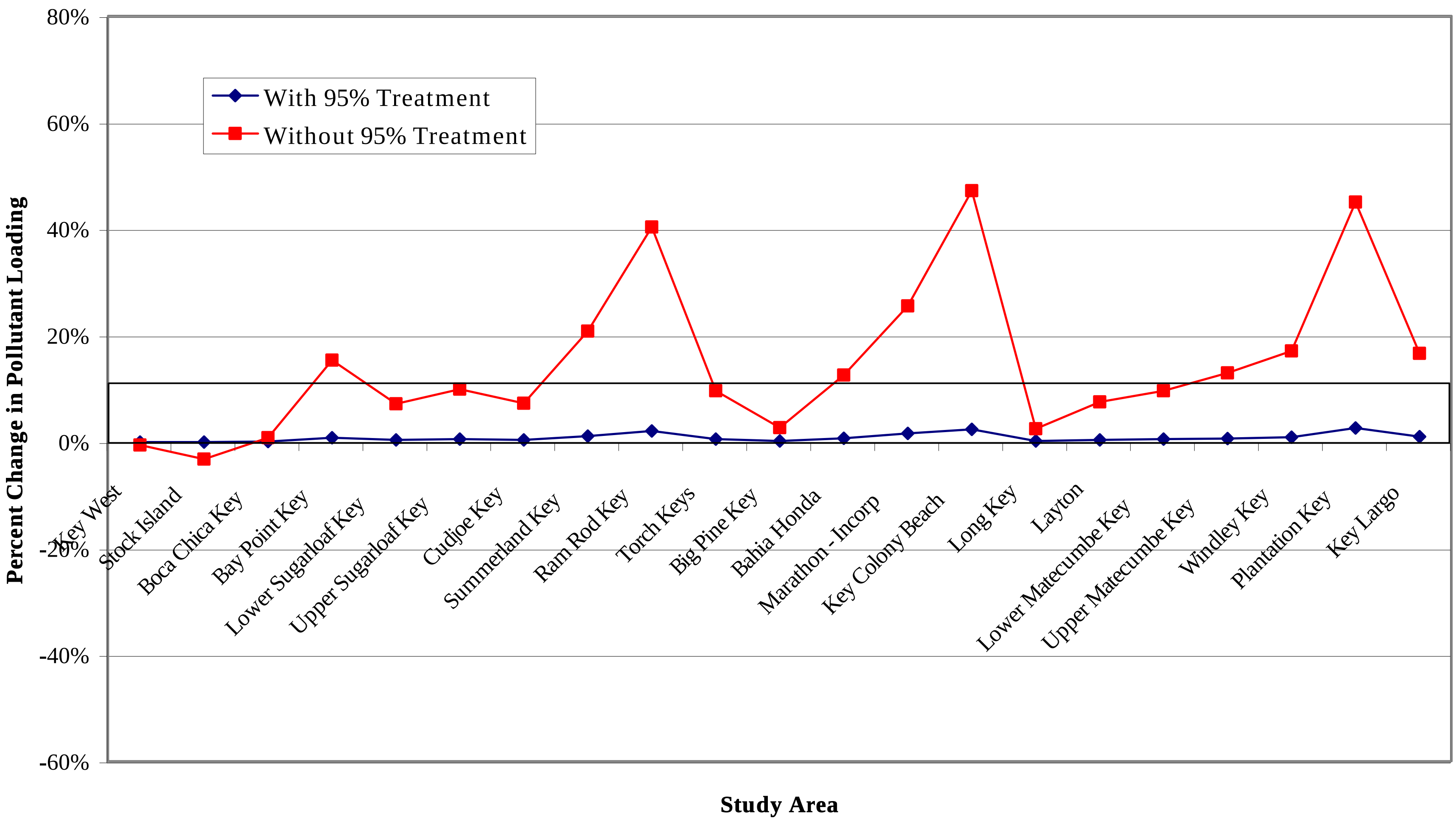
Note: This table consists of the difference in future and existing land uses.

Figure 4.4-1a
Monroe County Stormwater Management Master Plan
Future Loading Increases Showing the Benefit of
95% Treatment of All New Development For Total Suspended Solids



CDM Camp Dresser & McKee Inc.
S:\Monroe\Table 44-1 Change in Land Uses

Figure 4.4-1b
Monroe County Stormwater Management Master Plan
Summary of Future Loading Increases Showing the Benefit of 95% Treatment of All New Development For Total Nitrogen



CDM Camp Dresser & McKee Inc.
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Figure 4.4-1c
Monroe County Stormwater Management Master Plan
Summary of Future Loading Increases Showing the Benefit of
95% Treatment of All New Development For Total Phosphorus

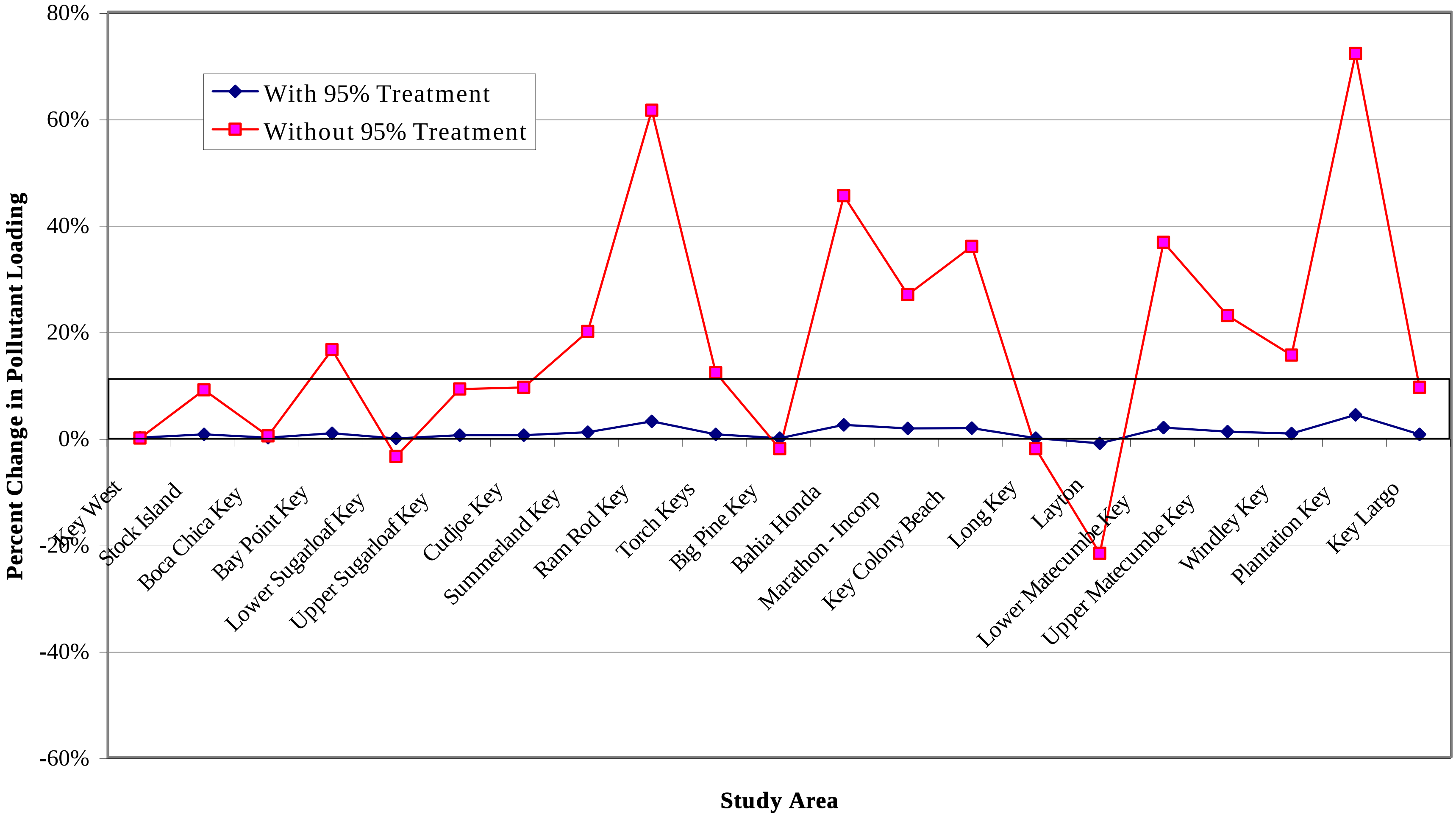
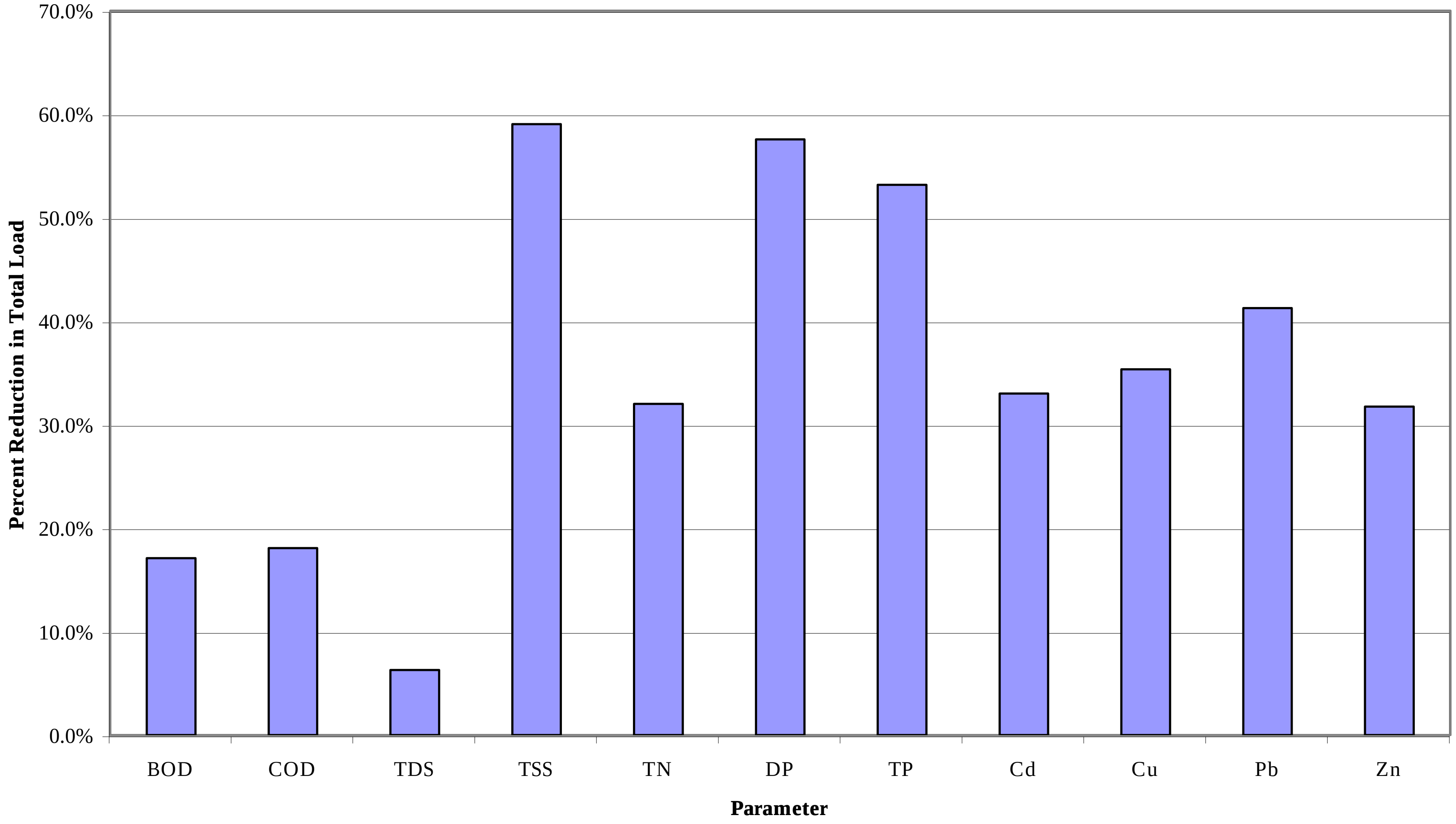


Figure 4.4-2
Monroe County Stormwater Management Master Plan
Retrofit to 80% Treatment for all Urban Land Uses



4.5 Regulatory Program Improvements

Upon review of the extensive stormwater regulatory requirements applicable within Monroe County, there appear to be sufficient regulatory controls to manage stormwater pollution from new development. Land use development controls are in place that limit encroachment on sensitive lands and require post-construction stormwater management in accordance with regional and state regulations. However, there are a number of issues related to the regulatory programs that need improvement including operation and maintenance, stormwater wells, enforcement of existing regulations, marinas, and reduction of imperviousness.

4.5.1 95-Percent Treatment Ordinance

Subsection 4.0 points out that Florida regulations require that for discharge to Outstanding Florida Waters, stormwater facilities must be "designed to achieve at least 95 percent reduction of the average annual load of pollutants that would cause or contribute to violations of state water quality standards…" (Rule 62-40, FAC). During the development of the SMMP, it has been shown that if new development achieves this treatment level, essentially no increase in nutrient or sediment loading would be experienced in the Keys. Also, it has been shown that if the developed, urbanized areas would achieve this goal, significant reductions in nutrient and sediment loading would occur. Therefore, the SMMP recommends that 95-percent treatment of annual average loads become the standard for stormwater discharges in Monroe County. Rule 62-40, FAC, already mandates this requirement for direct discharges to Outstanding Florida Waters in the Keys; however, it is not required for all waters in the Keys.

The SMMP recommends that Monroe County adopts a 95-percent treatment rule. There are a number of issues that must be addressed prior to adopting such a rule.

- As a minimum, direct discharge from new development to near shore waters must be required to meet the 95-percent rule. It is also recommended that direct discharges to canals and channels also be required to meet the 95-percent rule. Thus the requirement will be that all stormwater discharges from new development to waters in the Keys must meet the 95-percent treatment requirement.

- The SMMP also recommends that the 95-percent rule should apply to direct stormwater discharges from significant redevelopment.

- The final issue is how to deal with indirect discharges to near shore waters. For example, a commercial stormwater facility may discharge to a county-operated stormwater swale, which in turn discharges to a channel. Should the commercial discharge meet the 95-percent rule? To achieve the improvements recommended by this SMMP, the answer to this question should be yes. That is, even though the discharge is indirect, on-site treatment will, as part of a treatment train, improve the stormwater discharge to near shore waters. Nevertheless, since the effects of the 95-percent treatment of indirect discharges will be significantly less than for direct discharges, it is recommended that for indirect discharges, the 95-percent treatment policy should be a goal, not a requirement, with incentives for achieving the goal.

Based upon these conclusions, the SMMP recommends that 95-percent treatment should be required by new development and significant redevelopment for direct discharges to near shore waters. Indirect discharges should strive to achieve the 95-percent treatment goal and the ordinance should provide economic or regulatory incentives.

To adopt an ordinance requiring the 95-percent treatment, Monroe County must comply with it normal legal procedures, locating the regulations properly within the Land Development Codes and offering public hearings. To help in this process, ordinance language is offered below. Legal review is clearly required before adoption.

Definitions:

95-Percent Treatment. Minimum treatment level required for direct discharge to all coastal waters in Monroe County. Facilities providing live or treatment volume according to the equation below will be presumed to achieve 95-percent treatment:

Volume (inches) = 3.18 times Runoff Coefficient;

Where the Runoff Coefficient is the composite coefficient based upon both pervious and impervious areas. In the absence of site-specific information, the Runoff Coefficient is the sum of 0.95 times the impervious area and 0.1 times the pervious area, all divided by the total area.

Direct Discharge. Discharge from a stormwater facility or system directly to open waters of the state including canals and channels.

Indirect Discharge. Discharge from a stormwater facility or system to another stormwater facility or system including swales, ponds, exfiltration systems, drainage wells, vegetated buffer and wetland systems.

Significant Redevelopment. Reconstruction of 50 percent or more of the market value of the existing structures.

Regulations:

> Direct stormwater discharges from areas of new development or significant redevelopment shall be provided 95-Percent Treatment prior to direct discharge to coastal waters in Monroe County.
>
> Indirect stormwater discharges from areas of new development or significant redevelopment shall have the goal of providing 95-Percent Treatment prior to indirect discharge to coastal waters in Monroe County.

These definitions and regulations are intended to provide example text for potential adoption by Monroe County after legal review.

4.5.2 Operation & Maintenance

Currently, new development and significant redevelopment are required to provide treatment of stormwater runoff. Based upon the review of the efficiency curves illustrated in Subsection 4.4, the treatment required for such treatment facilities should be sufficient to achieve the objectives of the SMMP. However, such facilities continue to operate properly only if they are adequately maintained. Unfortunately, it appears that there are limited regulatory requirements for proper maintenance of stormwater facilities and no operational follow up to confirm that maintenance is being done. Therefore, it is recommended that, to confirm that maintenance will be provided to both public and private stormwater facilities, the following actions should be adopted:

- In order to obtain a development permit for non-residential properties and for larger residential developments subject to permitting (notwithstanding the other requirements of the County), the development must certify that the facility will receive proper maintenance. The design engineer can provide such certification.

- The County should develop a maintenance plan for County-owned or operated facilities. The plan should provide some routine maintenance for critical facilities augmented with routine inspection and as-needed maintenance for most facilities.

- Annually, the private development should document that maintenance has occurred through photographs and re-certification by the owner.

- The County should inspect private stormwater facilities every other year with half of the facilities completed each year. Failure to comply with maintenance agreements should result in code enforcement.

4.5.3 Stormwater Wells

Stormwater wells in the Florida Keys are used to dispose of excess runoff. While such wells decrease the volume of runoff (as well as the pollutant load and temperature of runoff) being discharged to near shore waters, wells tend to become clogged due to the amount of sediment and lack of maintenance. Also, the number, nature, tributary area, and other pertinent data for each well are not well documented. Therefore, it is recommended that the following actions should be adopted to deal with stormwater wells.

- A stormwater well database should be developed, identifying the owner, location, well characteristics, tributary area, land use, etc. The database should start with data on known wells within the Keys; however, the focus should be on new wells.

- In order to increase the operable life of existing and future wells, measures to reduce sediment loads into the well should be implemented. For most wells, this may simply be a vegetative buffer, landscaped swale or rain garden surrounding the well as illustrated in Figure 4.5-1. Such pre-treatment is relatively easy to install and maintain and therefore, relatively inexpensive to implement. The landscaped swale reduces the flow volume and pollutant load while using the runoff to irrigate and fertilize the vegetation.

4.5.4 Enforcement of Existing Regulations

As noted previously, it appears that there are sufficient regulations to control stormwater flooding and quality problems from new developments. However, based upon the field investigation of existing stormwater facilities, it appears that there is limited enforcement of permit conditions. That is, while there appears to be sufficient review of development plans to confirm compliance with Monroe County codes, there are developments that have not built stormwater facilities as permitted. That is, the permit information shows one type of facility design and the field inspection indicated another. Therefore, enforcement of County regulations should be improved. The following actions are recommended:

- The County should inspect developments during construction specifically for two features: does the construction site properly control runoff during construction and do the stormwater facilities being constructed match the permitted design.

- The development inspection form should be reviewed and potentially modified to account for inspection of stormwater facilities.

- The County should produce as-built drawings for County-constructed stormwater facilities and consider requiring as-built drawings with P.E certification for private developments that require permits.

- County inspectors should participate in the Florida Department of Environmental Regulation's Sediment and Erosion Control training program. This would ensure that inspectors are properly trained on runoff control during and after construction.

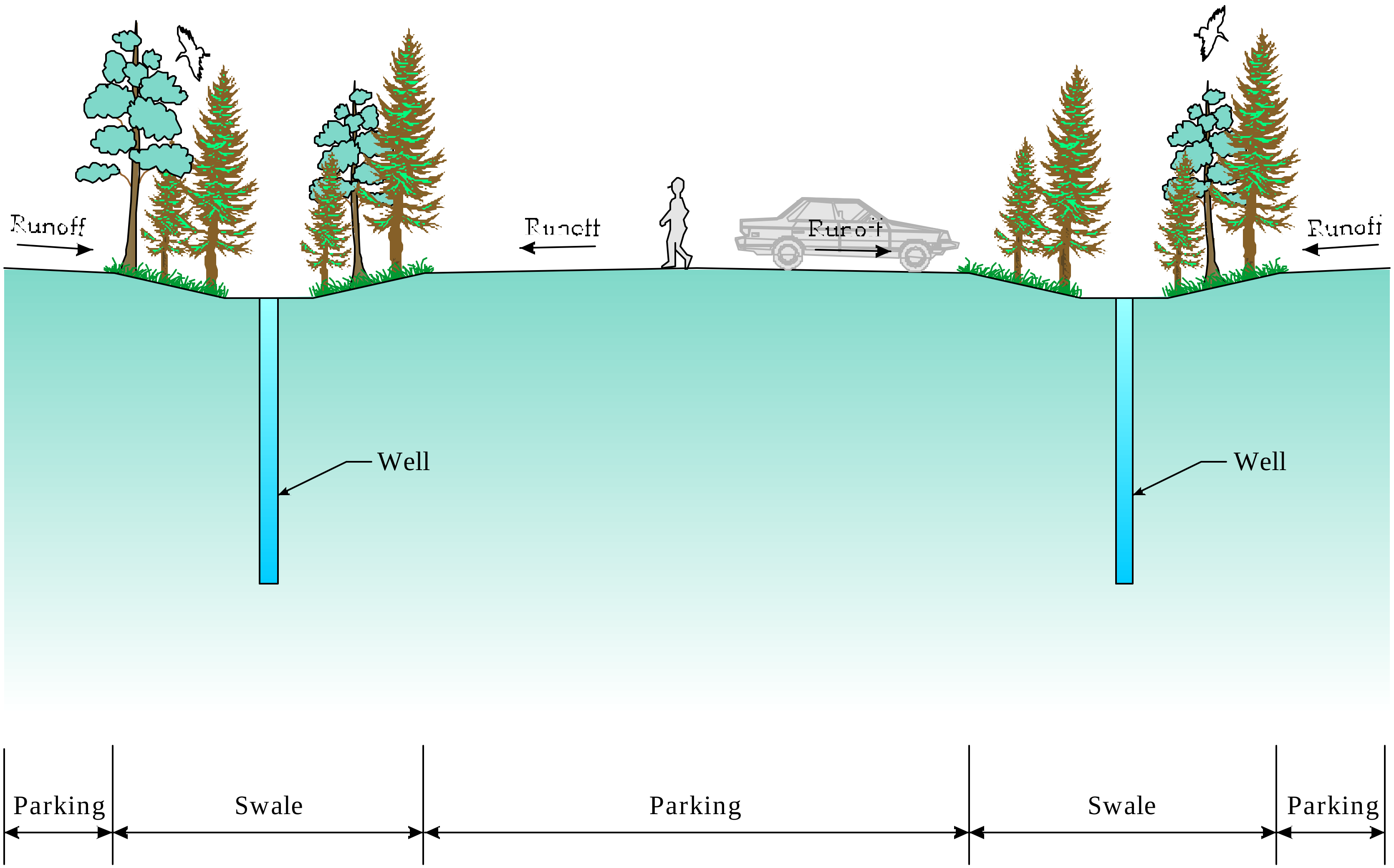


Figure4.5-1
MonroeCountyStormwaterManagementMasterPlan
LandscapedRetentionPretreatmentSwales
SectionView

CDM Camp Dresser & McKee Inc.

- After completion of the FDEP Sediment and Erosion Control training, the County or FDEP / SFWMD should offer the training to private construction site operators.

- As an option, the County can consider a stormwater facility operating permit that requires annual maintenance for compliance. Such a permit would require a more vigorous review of stormwater systems and their maintenance. However, the County would need to create the administrative and regulatory ability to enforce this option.

4.5.5 Marinas

A number of the problem areas identified by previous and current studies relate to marinas. While some of the marina-related problems identified heretofore are more associated with fueling and sanitary issues, some are related to uncontrolled stormwater runoff from material storage areas and unpaved areas. Field inspection of a few of the marinas confirmed that both problems (material storage and unpaved areas) appear to be the sources of stormwater runoff. For this reason, a marina was selected as a rehabilitation example as documented in Subsection 4.2. Other marinas are identified as problem areas and therefore, general recommendations are provided below.

- The County should continue to promote the Clean Marina Program and encourage retrofits through the ROGO (Rate of Growth Ordinance) credits. Also, by promoting marinas that have achieved the Florida Clean Marina status, Monroe County may provide an economic incentive.

- The Florida Clean Marina Program is a cooperative effort between the Florida Department of Environmental Protection and the Marine Industries Association of Florida (MIAF). A summary document related to the program is provided in Appendix 4.0-D.

- Marina retrofit should be considered on a case-by-case basis when the marina proposes to redevelop the property. Such redevelopment should be encouraged but only if proper stormwater management is provided to meet the 95 percent treatment requirement.

- In general, many of the stormwater problems encountered at marinas can be resolved using two fundamental practices: 1) unpaved marina areas should discharge to either baffle boxes, landscaped swales or other end-of-pipe technologies; and 2) stored material (scrap, motors, etc.) should be placed under a cover or roof to limit the exposure of the material to rainfall.

- The County can consider requesting FDEP to declare marinas in the Florida Keys designated facilities requiring coverage under the NPDES program. Florida has issued a general permit for the discharge of "industrial" stormwater to waters of the United States. Regulated industries include municipal facilities such as wastewater treatment facilities greater than 1 million gallons per day (mgd), landfills, and airports. However, FDEP can designate that the stormwater discharge from municipal and private facilities to need coverage under the general permit. Permit conditions include preparation of a stormwater pollution prevention plan and general housekeeping.

- Finally, if the programs identified above do not succeed in the improvement of marinas, the County may wish to implement a marina operating permit. An example ordinance from Miami-Dade is provided in Appendix 4.0-E.

4.5.6 Reduction of Imperviousness

To achieve Goals 2 through 5 listed above, one of the major elements of the SMMP is to reduce stormwater runoff from existing and future developments. As noted previously, this can be accomplished by source controls (reduction of the amount of runoff from property) or by post-development structural improvements (storage of runoff before discharge off-site). Of these two, the more cost-effective is the control of the source. Although discussed in more detail in Subsection 4.6 (Nonstructural Stormwater Management Recommendations), the implementation of such source controls can be accomplished through regulatory reduction of imperviousness or through the effective reduction by landscaped swales along roads, driveways and parking lots. The amount of impervious area is directly related to the volume of stormwater runoff. Reducing imperviousness reduces stormwater runoff.

It is recommended that the County offer incentives or otherwise encourage the reduction of imperviousness. It may be that this must be done on a case-by-case basis. However, one example of imperviousness reduction was considered in the Subsection 4.2 above related to rehabilitation: K-Mart in Marathon. At this site, a landscaped swale system has been considered to reduce flooding while providing retrofit treatment for the pollutant load. Also, currently the overflow parking area is paved even though it is used only during short windows of time around holidays. If such overflow parking areas were more pervious (e.g., pervious pavement, reinforced grass, etc.) then the total imperviousness and pollutant loading would be reduced. Incentives to reduce imperviousness could be offered or excess parking areas could be regulated to require pervious pavement.

4.5.7 Low Impact Design

For this SMMP, improvements are recommended that promote what has been termed "low impact design." Pioneered in Maryland, these design practices promote the same vegetative buffers, swales and bio-retention recommended in the SMMP. Therefore, it is recommended that the Monroe County Land Development Code should be reviewed to incorporate low impact design concepts. Similarly, the Florida Yards and Neighborhoods program should be considered as part of the landscape regulations.

4.6 Nonstructural Stormwater Management Recommendations

Nonstructural, or source, controls limit stormwater pollution at the source. In other words, source controls attempt to minimize the volume of runoff and control the potential sources of pollution from reaching the runoff in the first place. Numerous alternatives were identified in Subsection 2.6 (Existing Stormwater Management Systems). Provided below are recommendations for specific action within Monroe County.

4.6.1 Municipal Facilities

The County should control stormwater runoff and loading from county-owned or operated facilities. To do so, government facilities should be inspected specifically for the purpose of identifying areas of stormwater runoff concerns such as exposed materials storage, maintenance improvements, and uncontrolled erosion or sedimentation. Based upon the inspection, some facilities need to prepare a stormwater pollution reduction plan that documents actions needed to reduce stormwater pollution.

4.6.2 Maintenance

As discussed previously, proper operation and maintenance of stormwater facilities should be encouraged, starting with County-owned or operated facilities. Subsection 4.5.1 also discusses this nonstructural recommendation.

Subsections 4.2 and 4.3 recommend structural improvements to be implemented by Monroe County, Marathon and FDOT/FDEP. While these will improve the flooding and water quality conditions in the respective study areas, they must be properly maintained to continue to achieve expected benefits. Based on data from other parts of Florida regarding maintenance, the following unit costs were used to estimate the operation and maintenance (O&M) costs for the recommended improvements:

Swale	$1.00 per foot per year
Swale plus Porous Pavement	$1.50 per foot per year
Water Quality Unit O&M	$5,000 per year

Using the data from Appendix B and C, the total annual O&M costs are estimated to be $50,300 for Monroe County, $17,275 for Marathon and $183,300 for FDOT/FDEP for the improvements recommended. Table 4.6-1 shows the estimated costs for each project. For FDOT/FDEP, this represents approximately $6,700 per mile per year so that for the unaddressed 54.5 miles of US1 the total estimated O&M for FDOT would be $548,450 per year for all of US1 after improvements are made.

Table 4.6-1

Monroe County Stormwater Management Master Plan

Summary of Projected O& M Costs for Improvements

Problem Area	Study Area	Owner	Length (ft) Swale	Length (ft) Swale w/ Porous	WQ Unit	Estimated Costs
El Prado Circle on Coppitt Key	Big Coppitt	County			4	$20,000
Card Sound Road (SR 905A)	Key Largo	County			4	$20,000
Burton Drive at US1 in Tavernier	Key Largo	County	300			$300
Jo-Jean Way in Tavernier	Key Largo	County			1	$5,000
Marathon Government Center	Marathon	County			1	$5,000
Veterans Park in Little Duck Key	Marathon	County				$0
Subtotal Monroe County			300	0	10	$50,300
Bahia Honda Bike Trail - FDEP	Bahia Honda	FDOT	24,400			$24,400
US1 Rockland Channel to Shark Channel	Big Coppitt	FDOT		13,728		$20,592
US1 Big Coppitt Boat Ramp	Big Coppitt	FDOT	450			$450
US1 Boca Chica Channel to Rockland Channel	Boca Chica	FDOT		28,512		$42,768
US1 Bow Channel to East Side of Cudjoe Key	Cudjoe Key	FDOT		26,400		$39,600
US1 Bayside Parking Area at MM66	Long Key	FDOT	450			$450
US1 Oceanside and Bayside Parking Areas at MM 77.5	Lower Matecumbe	FDOT				$0
US1 North Harris Channel to Park Channel	Lower Sugarloaf	FDOT		10,560		$15,840
Sombrero Beach Road FDOT	Marathon	FDOT	14,350			$14,350
US1 Indian Key - Bayside Parking Area at MM 78	Ram Rod Key	FDOT				$0
Saddlebunch Bike Trail - FDEP	Saddlebunch	FDOT	24,850			$24,850
Subtotal for FDOT/FDEP			64,500	79,200	0	$183,300
24th Street - Boot Key Harbor -- Marathon	Marathon	Marathon	75			$75
27th Street - Marathon	Marathon	Marathon			1	$5,000
Sombrero Isles	Marathon	Marathon	2,200		1	$7,200
52nd Street (Palm Place) - Boot Key Harbor - Marathon	Marathon	Marathon			1	$5,000
Subtotal for Marathon			2,275	0	3	$17,275
Total O&M Costs			67,075	79,200	13	$250,875

Type of Facility	Unit Cost	
Swale	$1.00	per foot
Swale + Porous Pavement	$1.50	per foot
Water Quality Unit	$5,000	per unit

4.6.3 Land Use Controls

Through the County Land Development Regulation (LDR), land uses are regulated sufficiently regarding stormwater management. Two recommendations are offered:

- The use of freshwater wetlands for the treatment of stormwater runoff should be encouraged. Wetlands are natural treatment facilities and generally, wetlands need the water to survive. Many wetlands need to be rehydrated and stormwater is an excellent source of such water after treated by vegetated swale systems. It should be noted that sediment should be removed prior to discharge to the wetlands.

- The reduction of imperviousness of developed lands should be encouraged. See Subsection 4.5.5.

4.6.4 Vegetated Buffers

Based upon the field inspection of public and private systems in Monroe County, the major improvements can be achieved with the introduction of vegetated buffers and other similar stormwater systems such as vegetated swales, rain gardens, and bioretention. A rain garden is a type of bioretention area generally used in smaller, residential areas, although they can be used for commercial runoff control. It is essentially a landscaped, depressed area into which runoff flows such as the one shown below from Virginia. Stormwater pollutants are taken up by plants and filtered through the soil. Water is detained for only a short time (generally less than 48 hours).

Many areas of the Keys exhibit near shore pollution because stormwater flows unimpeded into such waters. By allowing stormwater to pass through vegetation prior to discharge (to near waters or even a drainage well), sediments are removed, which in turn reduces pollutants. This type of source control is useable for county roads, US 1, commercial and residential areas.

4.6.5 Cisterns, Rain Barrels and Other Conservation Measures

Another general statement is that if a practice is good for water conservation then it is also usually good for stormwater source controls. This statement applies to the use of cisterns, rain barrels, xeriscape and other conservation measures that reduce runoff or use runoff for limited water supply.

Also, where cisterns and/or rain barrels are used, the stored water should be used for irrigation purposes; thereby reducing the need for potable water for irrigation. Generally, a pump with a sediment filter can be used for the irrigation system.

The SMMP recommends that cisterns, rain barrels, Xeriscape and other water conservation measures related to stormwater should be supported by the County in two ways. First, it is suggested that the County work with the Florida Keys Aqueduct Authority to provide rate incentives for residential or commercial properties that use water conservation measures to reduce the use of potable water. For example, on a national average, about 30 percent of water use by residential customers is for outdoor uses (mostly landscape irrigation) according to Guidelines for Water Reuse (CDM, October 1994, EPA/625/R-92/004) and the average residential and public use is about 120 gallons per capita per day. Thus, on the average, up to 36 gal/cap/day is used for residential irrigation. If a customer reduces the use of potable water for irrigation by using stormwater from a cistern or rain barrel, this conservation measure could be encourage by a reduction in water rates. Second, The County may wish to provide a residential improvement fund for retrofits of residential properties with improvements related to conservation (e.g., Xeriscape or vegetated buffers). The fund could provide small grants to residential properties for improvements.

If these measures do not encourage conservation measures then the County may wish to adopt a conservation ordinance to require new developments to use Xeriscape and other such measures. However, such an ordinance requires additional inspection and enforcement and should be considered only as a last resort.

4.7 Evaluation Program

The final step in the overall strategy for the SMMP is to recommend methods to measure the success of the implementation of the SMMP. The purpose of this effort is to help the regulatory agencies to determine the effectiveness of the implemented program, to help the County decide whether or not limited public funds are being cost-effectively spent, and to show the benefits of the implemented SMMP to the public. Toward these ends, the following issues are pertinent.

4.7.1 Monitoring of Schedule

The schedule provided in the implementation program shows a number of milestones. These are events or completed actions of special importance. One method of monitoring for SMMP success is to monitor milestones completed versus schedule dates. If all milestones are achieved within the scheduled dates, then the SMMP is being implemented successfully.

4.7.2 Monitoring of Activities

A second method to monitor success is to document the activities completed as part of the SMMP. Two types of activities can be monitored: best management practices (BMPs) and capital improvements. In the case of BMPs, the following monitoring is recommended for each of the activities identified in Subsection 4.6.

- **Municipal Facilities.** In Subsection 4.6.1 it is recommended that the County municipal facilities should be inspected and pollution prevention plans prepared for each. The pollution prevention plan should have a list of activities to promote pollution control on the facility site. To monitor success, the County should annually inspect each municipal facility to document the completed activities related to the pollution prevention plan. Once completed, the annual inspections can document the maintenance of the onsite facilities.

- **Maintenance**. The County should document maintenance activities of county-owned or operated stormwater facilities such as drainage wells, swales, exfiltration trenches and the like. Maintenance activities such as mowing, litter control, repair, revegetation, sediment removal, etc., can be documented to show not only maintenance but also the effectiveness of the maintenance. For example, documenting the volume of litter removed indicates the volume of litter and trash eliminated from potential contamination of near shore waters.

- **Land Use Controls**. As noted in Subsection 4.6.3, the use of degraded wetlands or other habitat for stormwater management and the reduction of imperviousness are recommended. Wetlands can provide both attenuation and water quality treatment as long as they are not over-exposed to water or pollutants and the stormwater can rehydrate the wetland. Therefore, the success of land use controls can be measured by monitoring wetlands and imperviousness.

- **Vegetated Buffers**. The monitoring for the success of these types of BMPs is discussed below since most of the capital improvements suggested include vegetative buffers.

- **Conservation Measures**. The effectiveness of these types of BMPs is difficult to measure since their purpose is to reduce the volume of runoff generated by a particular parcel of land. However, with the use of xeriscape, vegetated buffers, rain gardens, cisterns and rain barrels, reduced volumes of sediment-laden stormwater should be experienced. Since such measure will likely be mostly residential in nature, citizen reporting of conservation measures taken and documentation of reduced sediment loads to the near shore waters can be extremely helpful in measuring success.

4.7.3 Monitoring of Capital Improvements

The success of the SMMP can be monitored related to stormwater improvements. A number of capital improvements are recommended in Subsections 4.2 and 4.3. Each of these was recommended to remediate an existing flooding or stormwater quality concern. The lack of flooding is a measure of success and is easily monitored through public reporting. To some degree, the public can also observe stormwater quality improvements. For example, if the public observed a sediment plume after rainfall previously and do not observe such a plume after the improvement, the project can be deemed successful. However, there are some more direct measures available. In particular, it is recommended that one or more of the capital improvements be monitored through sampling of the incoming stormwater and the outgoing treated water. Such monitoring should occur over more than one year to achieve a statistically significant dataset with paired stations (influent and effluent). The choice of the BMP monitored must be done with care because successful sampling is contingent upon controlled conditions (e.g., single points of water entry and exit).

4.7.4 Monitoring Near Shore Water Quality

Finally, monitoring the change in water quality of the near shore waters is another method to assess the success of the SMMP. Essentially, ambient water quality samples would be collected periodically and statistically assessed to determine trends. For the pertinent parameters of nutrients and sediments, ambient monitoring could show an increasing trend, which may imply that the SMMP is not successful, or a decreasing trend, implying that the SMMP is succeeding. However, as indicated in Volume 1, there are many sources of pollutants in the environment, not the least of which are wastewater sources. Ambient monitoring assesses the effects of the combination of sources, including natural ones. Also, to capture the effects of stormwater runoff, sampling must be taken during storm events. Experience has shown that this monitoring method is expensive, difficult to implement and generally inconclusive unless a significant number of samples are collected. For these reasons, the existing ambient monitoring should continue; however, if a trend is encountered showing water quality improvements, it should be interpreted that all of the environmental remedial actions (stormwater and wastewater) taken by the County and others are succeeding.

Section 5.0 Implementation Program

5.1 Implementation Plan

For the implementation plan, there are two elements to be considered: program (e.g., regulatory, management, etc.) improvements, and capital construction. Overall, given the nature of the recommended SMMP, the implementation plan has been prepared based upon a 3 to 5 year effort to complete the first portion of the plan.

The second element of the plan, or long-term plan, considers the implementation of the plan over a 20- to 30-year window of time. In essence, the long-term plan is to achieve 95-Percent Treatment for all urban developments, including residential, commercial, light industrial, military, and institutional properties, whether public or private. However, the SMMP does not recommend that this goal should be achieved in the short-term (i.e., within 5 years) due to the socio-economic impacts of such an ambitious venture. As part of the short-term plan, the 95-Percent Treatment rule is applied to new development and significant redevelopment. Over the long-term, it is expected that many of the public and private properties will seek redevelopment, which in turn, will trigger the 95-Percent Treatment requirement. In this manner, the 95-percent Treatment requirement will be achieve as economic reasons cause redevelopment.

It is possible for the County to accelerate this plan through funding support of private redevelopment. For example, the County could provide zero or low interest loans for redevelopment stipulating that the 95-Percent Treatment requirement must be achieved along with other environmental requirements. As another example, the County could periodically participate in a more regional (albeit small) stormwater retrofit that would by funding partially be the County and partially by the private redevelopment interests. These projects would have to be carefully selected to maximize the public pollutant reduction benefit.

5.1.1 Program Improvements

Implementation of the program elements is described below:

Operation & Maintenance. The O&M improvements for the County should be implemented over the next three years. The first element should be the requirement for maintenance certification in order to receive a building permit and annual re-certification of maintenance by the private development. The County should also prepare an O&M plan during the first year that identifies maintenance procedures for county-owned facilities, reporting protocols, and inspection frequencies. The plan should document the existing practices accomplished by the County. In the second year, the County should implement the program so that maintenance activities are fully documented showing the benefits of the O&M program. Inspection of private facilities should commence in the third year. Given the small number of private facilities permitted in the County, it is estimated that a single inspector could complete inspection on half of the facilities within a year. Based upon a $50,000 per year cost for an inspector salary and 100 percent overhead cost, this inspection program should cost about $100,000 per year to implement.

Also, as noted in Subsection 4.6.2, the O&M costs for the new capital improvements recommended by the SMMP are about $50,300, $17,300, and $183,300 for Monroe county, Marathon and FDOT, respectively.

Stormwater Wells. The recommended plan for drainage wells includes the development of an inventory documenting permit information as well as other data. Using existing information, the initial database is estimated to cost approximately $50,000 including GIS capabilities. The database would be updated as new wells were permitted or re-permitted. The preliminary stormwater well inventory can be developed in the next year.

Enforcement. To enforce the existing codes, the County staff already inspect construction sites frequently (see Subsection 2.5.2). However, the existing inspection includes only limited inspection of stormwater facilities. Therefore, to better enforce the stormwater regulations it is recommended that the County add more inspection and review of stormwater facilities during construction. To help this inspection an inspection form with sediment and erosion controls review should be developed and used. Inspection should consider stormwater controls for the construction as well as for the post-construction development.

Marinas. As noted previously, most of the marinas are private. The County should review each of the county-operated marinas and provide improvements where necessary. The retrofit/rehabilitation projects considered in Subsections 4.1 and 4.2 illustrate the types of improvements that can be implemented. The costs and improvements will be developed on a case-by-case basis. For private marinas, the County should continue to work with the owners to provide retrofits when redevelopment occurs.

Reduction of Imperviousness. The reduction of imperviousness is to be accomplished through incentives to private developers and as a standard practice for public developments. For the public developments, the County should adopt a policy of imperviousness reduction through design changes offering pervious pavement and more vegetated areas. For private developments, the County should develop standard incentives for impervious area reductions through regulatory changes.

Municipal Facilities. During the first year of implementation, the County should develop a database of municipal facilities within the Florida Keys and inspect each one relative to the management of stormwater runoff. Based upon the inspections, the County should prepare plans for each facility to improve stormwater management; these plans are called stormwater pollution prevention plans or SWPPPs. The SWPPPs should be implemented over the next two to three years. Estimated costs for the inspections are $25,000 and about $25,000 per year for improvements recommended by the inspections.

Vegetated Buffers and Conservation Measures. The SMMP recommends that vegetated buffers, swales, rain gardens, bioretention, cisterns, rain barrels, and other conservation measures should be used whenever possible for development, redevelopment, and rehabilitation of existing facilities. These practices can also be used in residential environments where interested public can volunteer to improve their property. To implement this program, it is recommended that the County obtain pamphlets and other public education documents to distribute to the citizens of the County to encourage volunteer vegetative retrofits and improvements.

Residential Retrofit. As noted in the introduction of Subsection 5.1, the 20- to 30-year long-term plan includes the eventual retrofit of urban properties including residential subdivisions. Residential redevelopment in the Keys appears to be dominated by single parcel improvements or infill rather then whole subdivision rehabilitation. Therefore, residential redevelopment to achieve the 95-Percent Treatment rule may be slow. If the County wishes to accelerate residential redevelopment, the SMMP suggests that the County should implement and residential rehabilitation program with the following elements:

- A list of potential residential redevelopment projects should be maintained, defining the location and potential cost of the retrofit. Projects would be done on a priority basis depending on age of subdivision and cost-benefit for example.

- Annually, the County could cooperatively or entirely fund a residential retrofit project, providing the 95-Treatment design for the entire subdivision. The residential property's portion of the cost and increased maintenance could be funding through a MSTU or MSBU assessment, reduced by County subsidy.

- Results of the subdivision retrofit projects should be advertised and promoted through public announcements. This may encourage other residential communities to participate in the program as well as document the success of the retrofits.

Retrofit Credits. Currently in Monroe County, the removal of a cesspit and replacement with a modern onsite wastewater treatment device will result in a development credit (needed for new development). As part of the SMMP, such a credit system was considered for stormwater management retrofits and the letter documenting the assessment is contained in Appendix 5.0-A. In summary, the nutrient reduction benefit resulting from a retrofit project depends on the size and nature of the drainage basin as well as the type of retrofit system. Thus, as a minimum, the administrative complexity and cost of a stormwater nutrient credit system would be significant. Also, in the case of the cesspit credit, removal of the cesspit and replacement with a new onsite system results in a significant net reduction in pollutant load. On the other hand, stormwater retrofit does not eliminate stormwater discharges and urban development increases discharges, so that the net gain from stormwater nutrient credits are not as clear as with the wastewater credit. For these reasons, while a stormwater nutrient credit is possible, the SMMP does not recommend implementation of such a credit.

5.1.2 Capital Improvements

An implementation plan for the SMMP has been developed based upon the agencies involved with incorporation of the FDOT 5-year Work Plan whenever possible. Figure 5.1-1 shows a possible schedule for implementation of the retrofit and rehabilitation projects recommended in Subsections 4.1 and 4.2. The figure shows the four major agencies involved in the projects: Monroe County, City of Marathon, Florida Department of Transportation and Florida Department of Environmental Regulation (for the Bike Trails). Since the fiscal years for each agency do not coincide, the projects for the County and City start in October (fiscal year is from October 1 to September 30) and for FDOT and FDEP, project start in July (fiscal year is from July 1 to June 30). The figure shows design (solid lines) and construction (striped lines) for all projects, generally not overlapping construction to allow equipment coordination. The exceptions to this rule are the small parking area excavation projects that can be designed and constructed in 3 to 4 months.

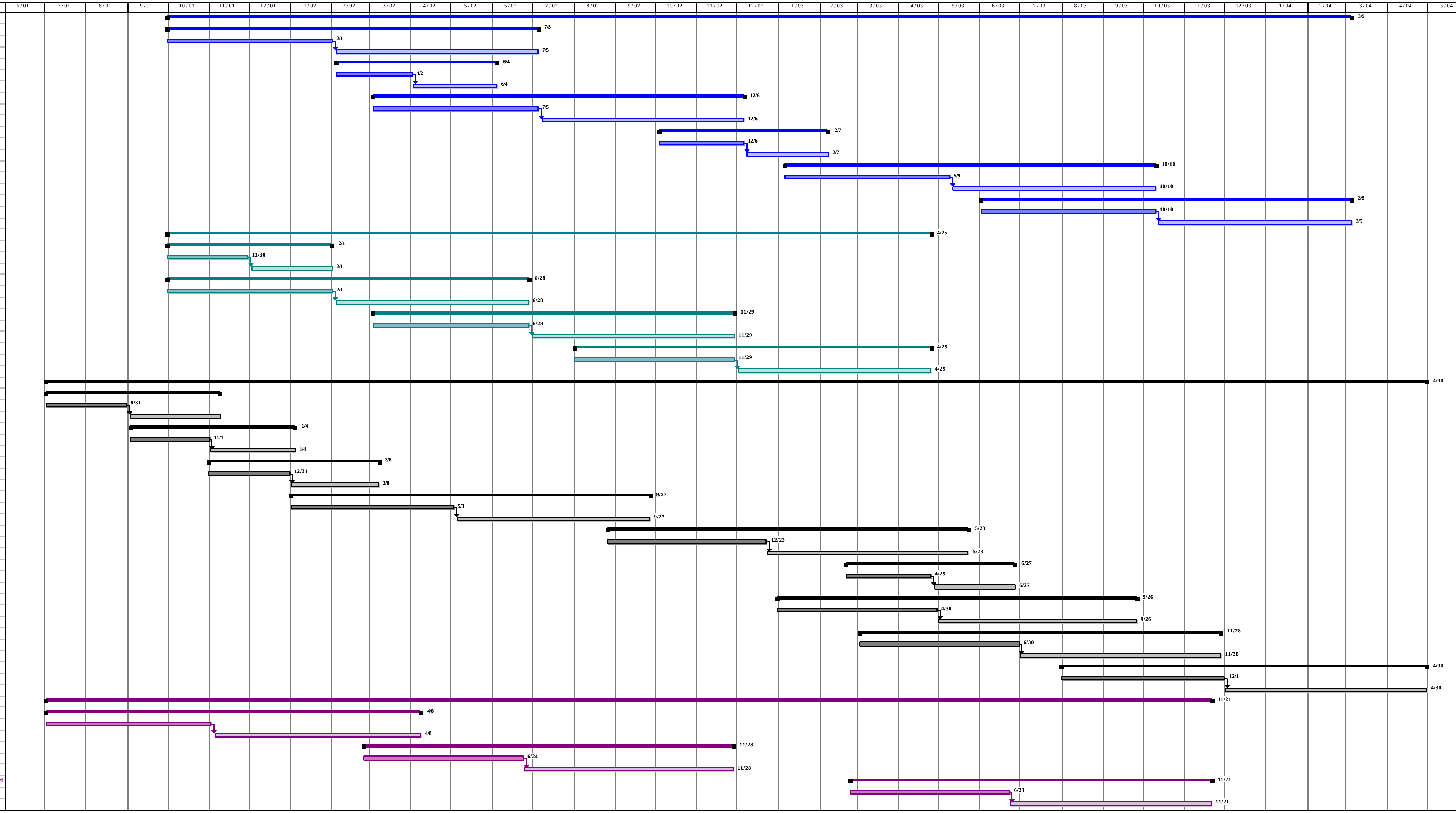
Using the estimated costs and the implementation schedule shown, Table 5.1-1 breaks the costs down into expenditures for each fiscal year. For the unincorporated County, project costs are about $80,000 to $90,000 per year. Projects can be completed within three years of implementation in FY 2002.

For the City of Marathon, costs are about $112,600 for the first year and $83,600 for the second, to complete the projects within two years. This can be spread out over a longer time; however, it is not recommended that this schedule be extended to more than 4 years.

FDOT costs are also spread out over three years with the first year at about $330,000, second year, about $1.53 million and third year, about $1.88 million. The projects are organized so that the US 1 retrofits coincide with the FDOT 5-year Work Plan to re-surface portions of US 1 during 2003. As noted in Subsection 4.2, the total FDOT improvement cost, excluding Sombrero Beach Road, has been estimated at $18.5 million, of which $3.7 million is part of this implementation plan. If FDOT expended approximately $2.0 million per year on US 1 retrofits and rehabilitation in a similar

Monroe County Stormwater Management Master Plan
Implementation Schedule

ID	Task Name
1	Monroe County Projects
2	Marathon Government Center
3	Design
4	Construction
5	Veterans Park
6	Design
7	Construction
8	Card Sound Road
9	Design
10	Constuction
11	Burton Drive in Tavernier
12	Design
13	Construction
14	Jo-Jean Way in Tavernier
15	Design
16	Construction
17	Barcelona Street at Harvey Park
18	Design
19	Construction
20	City of Marathon Projects
21	52nd Street
22	Design
23	Construction
24	24th Street - Boot Key Harbor
25	Design
26	Construction
27	27th Street
28	Design
29	Construction
30	Sombrero Isles
31	Design
32	Construction
33	FDOT Projects
34	Indian Key Bayside Parking @ MM 78
35	Design
36	Construction
37	Ocean & Bayside Parking @ MM 77.5
38	Design
39	Construction
40	Bayside Parking @ MM 66
41	Design
42	Construction
43	Sombrero Beach Road
44	Design
45	Construction
46	Rockland to Shark
47	Design
48	Construction
49	Big Coppitt Boat Ramp
50	Design
51	Construction
52	Boca Chica to Rockland
53	Design
54	Construction
55	North Harris to Park
56	Design
57	Construction
58	Bow to Kemp
59	Design
60	Construction
61	FDEP Projects
62	Saddlebunch Bike Trail - Big Coppitt
63	Design
64	Construction
65	Bahia Honda Bike Trail
66	Design
67	Construction
68	Saddlebunch Bike Trail - Saddlebuncl
69	Design
70	Construction



Task | Split | Progress | Milestone | Summary | Rolled Up Task | Rolled Up Split | Rolled Up Milestone | Rolled Up Progress | External Tasks | Project Summary

AB
Date: Thu 9/27/01

Figure 5.1-1
Suggested Implementation Schedule

Table 5.1-1
Monroe County Stormwater Management Master Plan
Summary of Implementation Costs

Project/Element [2]	Total Cost	Fiscal Year [1] FY02	FY03	FY04
Monroe County				
Marathon Government Center	$29,900			
Design		$4,485		
Construction		$25,415		
Card Sound Road	$89,700			
Design		$13,455		
Construction		$38,123	$38,123	
Burton Drive @ US1	$11,300			
Design			$1,695	
Construction			$9,605	
Jo-Jean Way in Tavernier	$29,900			
Design			$4,485	
Construction			$25,415	
El Prado Circle in Coppitt Key	$89,700			
Design				$13,455
Construction				$76,245
Veterans Park	$3,500			
Design		$525		
Construction		$2,975		
Total for Monroe County	$254,000	$84,978	$79,323	$89,700
City of Marathon				
24th Street - Boot Key Harbor	$3,500			
Design		$525		
Construction		$2,975		
27th Street	$22,400			
Design		$3,360		
Construction		$19,040		
Sombrero Isles	$147,900			
Design		$22,185		
Construction		$62,858	$62,858	
52nd Street - Boot Key Harbor	$22,400			
Design		$1,680	$1,680	
Construction			$19,040	
Total for City of Marathon	$196,200	$112,623	$83,578	$0

Notes: [1] Design costs are 15% and construction costs are 85% of total project costs.
[2] County and city fiscal years are from October to September; State fiscal years are from July to June.

Table 5.1-1 (continued)
Monroe County Stormwater Management Master Plan
Summary of Implementation Costs

Project/Element [2]	Total Cost	Fiscal Year [1] FY02	FY03	FY04
Florida Department Of Transportation				
Indian Key Bayside Parking	$2,100			
Design		$315		
Construction		$1,785		
Ocean/Bay Side Parking MM 77.5	$2,600			
Design		$390		
Construction		$2,210		
Bayside Parking MM 66	$16,900			
Design		$2,535		
Construction		$14,365		
Sombrero Beach Road	$536,400			
Design		$80,460		
Construction		$227,970	$227,970	
Rockland to Shark	$543,500			
Design			$81,525	
Construction			$461,975	
Big Coppitt Boat Ramp	$43,000			
Design			$6,450	
Construction			$36,550	
Boca Chica to Rockland	$1,128,700			
Design			$169,305	
Construction			$479,698	$479,698
North Harris to Park	$418,000			
Design			$62,700	
Construction				$355,300
Bow to Kemp	$1,045,100			
Design				$156,765
Construction				$888,335
Total for FDOT	$3,736,300	$330,030	$1,526,173	$1,880,098

Notes: [1] Design costs are 15% and construction costs are 85% of total project costs.
[2] County and city fiscal years are from October to September; State fiscal years are from July to June.

Table 5.1-1 (continued)
Monroe County Stormwater Management Master Plan
Summary of Implementation Costs

Project/Element [2]	Total Cost	Fiscal Year [1] FY02	FY03	FY04
Florida Department of Environmental Protection				
Saddlebunch Bike Trail - Big Coppitt	$678,100			
Design		$101,715		
Construction		$576,385		
Bahia Honda Bike Trail	$912,000			
Design		$136,800		
Construction			$775,200	
Saddlebunch Bike Trail - Saddlebunch	$250,800			
Design			$37,620	
Construction				$213,180
Total for FDEP	$1,840,900	$814,900	$812,820	$213,180

Notes: [1] Design costs are 15% and construction costs are 85% of total project costs.
[2] County and city fiscal years are from October to September; State fiscal years are from July to June.

fashion as shown in this plan, an additional 7 to 8 years would be needed to complete the rest of US 1.

Finally, in the 1992 "Water Quality Protection Program for the Florida Keys Natural Marine Sanctuary" (Phase II Report, USEPA), an estimate of the engineering costs for overall stormwater management options were offered in Table 3-7 of the report. Three options were offered:

- Option S1a – Retrofit "Hot Spots": Identify and retrofit hot spots. Eliminate stormwater runoff in areas handling toxic and hazardous materials. Install swales and detention facilities along limited sections of US1. Initial construction costs were estimated at about $80 million. Nutrient and sediment load reductions were estimated at 1 percent or less.

- Option S1b – Retrofit Hot Spots and Population Centers: Identify hot spots, and retrofit hot spots and population centers. Eliminate stormwater runoff in areas handling toxic and hazardous materials. Install swales and detention facilities along the majority (developed areas) of US1. Initial construction costs were estimated at about $370 million. Load reductions were estimated at 5 to 12 percent for nutrients and 20 to 50 percent for sediments.

- Option S1c – Retrofit Stormwater Facilities Throughout Sanctuary: Identify hot spots, and retrofit hot spots, population centers and other developed areas throughout the Sanctuary. Eliminate stormwater runoff in areas handling toxic and hazardous materials. Install swales and detention facilities along US1. Include ultimate disposal of stormwater via boreholes or deep wells for high-flow areas. Initial construction costs were estimated at about $530 and $680 million for boreholes and deep wells, respectively. Load reductions were estimated to be 20 to 50 percent for nutrients and 40 to 60 percent for sediments.

In comparison, the SMMP recommends the retrofit and rehabilitation of problem areas within the Keys (the problem area list includes the stormwater "hot spots" as well as newly identified problems); rehabilitation or retrofit of the majority of US1; and the economic-based retrofit of urbanized areas throughout the Keys. As noted above, the short-term (3 to 5 year window) construction costs for Monroe County, Marathon and FDOT/FDEP are about $6.0 million (see Table 5.1-1). For the long-term costs, the rehabilitation/retrofit costs identified in this plan were applied to total land uses within the Keys. That is, each of the retrofit/rehabilitation costs were used to estimate a retrofit cost per acre for the land use type. The results showed that the per-acre cost of retrofit for low, medium and high density residential properties were about $17,900, $9,400 and $4,100, respectively; $56,600 per acre for commercial and light industrial land uses; $23,200 per acre for roads and $7,200 per acre for public facilities. Using these unit costs and the total acreage of the land uses noted above, the estimated cost to retrofit 100 percent of urban areas (residential, commercial, industrial and institutional) within the

Keys is $465 million. As indicated in Figure 4.4-2, the pollutant removal expectations at stage when 80 percent of the urban areas are retrofit are about 30 to 35 percent for total nitrogen and 50 to 60 percent for total phosphorus. Sediment reductions are projected to be reduced by about 60 percent.

To compare the coasts of the SMMP to those of the Sanctuary program, a cost to retrofit 100 percent of Monroe County was estimated. First, based upon the improvements recommended in this SMMP, the cost of improvements per acre of specific land uses was estimated. These unit costs were applied to all of the existing urban land uses (low, medium and high density residential, commercial, industrial and roads). The estimated cost to retrofit all urban lands in the Keys would be $465 million, similar to the conclusions of the Water Quality Protection Program alternative S1c, although slightly less costly.

5.2 Implementation Schedule

The overall schedule for the implementation of the SMMP has been introduced in the previous section. The schedule can be summarized as follows with specific actions for each year of implementation, assuming that the first year is FY 2002 (October 1, 2001 to September 30, 2002).

FY 2002

- Preparation of County O&M Plan
- Inventory of Drainage Wells in Florida Keys
- Development of Private Facility Inspection Protocol
- Development of Marina Policy
- Develop Reduction of Imperviousness Policy
- Municipal Facilities Inspection and Preparation of SWPPPs
- First Year CIP Projects

FY 2003

- Implement O&M Policy
- Implement Private Facility Inspection
- Implement Reduction of Imperviousness Policy
- Implement First Year of Municipal Facilities SWPPPs
- Develop Public Education Plan For Volunteer Vegetative Retrofits
- Second Year CIP Projects

FY 2004

- Implement Private Facility O&M Certification Requirements
- Continue Municipal Facility SWPPPs Implementation
- Third Year CIP Projects

From the program and capital costs itemized above, the estimated costs for the County to complete the SMMP for the next four fiscal years are listed in Table 5.2-1.

Table 5.2-1
Monroe County Stormwater Management Master Plan
Summary of Implementation Costs

Fiscal Year	Program Costs	O& M Costs	CIP [1]	County Roads [1]	Total
2002	$200,000	$5,000	$85,000	$150,000	$440,000
2003	$125,000	$30,400	$79,300	$150,000	$384,700
2004	$125,000	$50,300	$89,700	$150,000	$415,000
2005	$125,000	$50,300	$0	$150,000	$325,300

Note: 1. Funding expected through existing Local Government Infrastructure Tax revenues along with WMD and/or FDEP grants.

According to Table 5.2-1, the County will need about $440,000 in FY 2002 reducing to $325,300 by FY 2005. Of these funding requirements, the majority will be for capital improvements; about $250,000 in the first years, dropping to $150,000 in the fourth year. At the end of the fourth year, program and O&M costs should stabilize at about $175,300 per year.

5.3 Implementation Responsibilities

The implementation plan has been prepared with various responsible agencies identified. For the programmatic improvements recommended in Subsection 5.1.1, Monroe County is the primary responsible agency, although inspection of permitted facilities can be shared with SFWMD. The capital improvements have been addressed with the implementing agency identified (County, City of Marathon, FDOT and FDEP). Specific responsibilities for the County are listed in Subsection 5.2 above. It is recommended that the pertinent agencies meet to define a reasonable implementation schedule for the completion of all elements of the SMMP. The schedule provided herein is based upon expenditures of about $80,000 per year for the County, $50,000 to $100,000 per year for Marathon, $1.5 to 2.0 million per year for FDOT and $800,000 for FDEP (Bike Trails). The schedule is also based upon the potential for overlapping construction crews within the Keys completing the retrofit and rehabilitation projects identified. Should any of these conditions change, a new schedule should be prepared. Identification of these conditions is best considered in coordination with the agencies involved.

5.4 Project Funding

Currently, Monroe County operates a $240 million budget using a number of funds. The General Fund accounts for all revenues except those placed in specific funds. Special revenue funds include Road & Bridges, Government Grants, Special Taxing Districts, and Environmental Restoration funds to name a few that pertain to public works and environmental issues. Capital Project Funds include the One Cent Sales Tax Capital Projects and Sales Tax Bond Capital Improvements (specifically earmarked for historically identified projects). Enterprise Funds for Monroe County include Card Sound Bridge, Airports and Solid Waste. Sources of funding are:

Property Taxes. This is revenue generated from taxes on property within Monroe County. Adopted for FY 2001, the millage for countywide services is 4.2181, generating about $42.1 million in property taxes.

Local Government Infrastructure Surtax. Generally referred to as the One-Percent Sales Tax, these taxes can be used for infrastructure purposes as well as land acquisition. The expected revenues from this source are estimated $12 million for FY 2001.

Constitutional Gas Tax. Collected and distributed by the state, this tax is two cents per gallon on fuel and is restricted for use on transportation. It is from these revenues that the Road & Bridges Fund is supported.

Local Option and Ninth-Cent Fuel Tax. Beyond the constitutional gas tax (2 cents) and County gas tax (1 cent), the County levies 6 additional cents on fuel taxes. These are generally restricted to transportation purposes.

Local Government Half-Cent Sales Tax. While these taxes are available for all countywide purposes, in FY 2000, these taxes have been used for tax relief of the general purpose municipal services taxing unit (MSTU) fund.

Charges for Services. The county currently charges fees for the following services: solid waste assessments and tipping fees, airport fees, and a number of clerk fees.

Based upon the magnitude of additional costs needed by Monroe County to implement the SMMP, it is recommended that existing sources be used, with augmentation of funding by regional and state grants or cooperative agreement funds. In particular, all of the recommended capital improvements are associated with county-operated roadways so that transportation or infrastructure taxes can be used. Since the Local Government Infrastructure Surtax has been readopted until 2018 and are projected to generate about $10 million or above in future years, the small capital costs identified in this SMMP can be paid for out of these funds with an insignificant affect on reduction of funding for other needed infrastructure needs.

According to Subsection 5.2, Monroe County will need approximately $390,000 in new funds for FY 2002, reducing to $275,000 by FY 2005. The majority of these costs are for capital improvements that can be funded through the existing Local Government Infrastructure Tax and SFWMD/FDEP grant funds. The rest of the costs (program and O&M) will require grants or other sources of funding. Assuming that some of the program costs can be funding through grants, the estimated ongoing funding requirement for program and O&M costs is about $150,000 per year. If this increase were funded by ad valorem taxes, this amounts to a 0.015 mill increase in the millage rate (based upon aggregate millage of 5.3339 with revenue of $53.25 million; Monroe County Fiscal Year 2001 Adopted Annual Operating & Capital Budget, page 100).

Other options for funding of the additional program and O&M needs include a non-ad valorem assessment and a user charge, both associated with a stormwater utility. For the non-ad valorem assessment, the Tax Collectors bill can be used according to Rule 197, FAC subject to the strict implementation requirements of this rule. The user charge would likely be associated with another utility fee such as that of the Florida Keys Aqueduct Authority. In both cases, the assessment or fee would have to be associated with the benefits or service received by the payer. In Florida, where about 100 stormwater assessments or fees have been implemented, the assessment or fee has generally been related to the amount of impervious area of a parcel of land (with credits for onsite stormwater treatment). Also in general, the annual revenues generated by such an assessment or fee would be about $10 per capita for each $12 per year ($1 per month) of assessment or fee. From Subsection 21, the 1999 unincorporated county population is about 45,200 (excluding Marathon); thus, a $12 per year assessment or $1 per month user fee would generate about $452,000 in revenue. Thus, a small assessment or user fee (on the order of $4 per year or $0.33 per month for the average residential property (would be sufficient to fund the identified program and O&M needs. On the other hand, implementing a stormwater assessment or user fee can be costly especially with each island in the Keys representing a different service area. The cost of implementation includes development of parcel-specific bills, billing administration, and collections.