SECTION 2

BASIN CHARACTERISTICS

CITY OF COCOA BEACH, FLORIDA
STORMWATER MASTER PLAN

PARSONS ENGINEERING SCIENCE, INC.

OCTOBER 2001

SECTION 2
BASIN CHARACTERISTICS

2.1 LOCATION AND DESCRIPTION

As a barrier island in Brevard County, Cocoa Beach is surrounded by the Atlantic Ocean on the east, the Banana River on the west, the City of Cape Canaveral to the north, and Patrick Air Force Base (AFB) to the south. The City of Cocoa Beach is under the water resource jurisdiction of the St. Johns River Water Management District (SJRWMD) with the majority of its watershed draining to the northern portion of the Indian River Lagoon (IRL), specifically the Banana River. The SJRWMD has specific authority and responsibility for managing the northern part of the IRL, comprised of Volusia, Brevard, and Indian River counties, while the remaining sections of the IRL are controlled by the South Florida Water Management District (SFWMD).

2.2 TOPOGRAPHY

Throughout the City, elevations increase from west to east ranging from mean sea level at the lagoon side to a height of 10-15 feet at the crest of the beach dune ridges, and then back to mean sea level along the shoreline. The beach ridges are relict formations caused over time by the actions of wind and waves upon the shoreline. Provided as Figure 2-1 is a USGS quadrangle map of the area which shows general topographical information. More detailed topographical information (1' contour interval) was available for the project from the City's survey performed by Pine & Design, Inc. This survey data is reflected on the subbasin delineation maps provided as Exhibits A through I (discussed in Section 2.3).

2.3 BASIN DESCRIPTION

Within the limits of the watershed, a total of nine basins covering an area of approximately 2,196 acres were delineated, as shown on Figure 2-2, and assigned a letter from A through I. Wetlands and submerged areas within the Banana River were not included in the total areal coverage. This task was accomplished by referencing the following sources: the City survey completed by Pine Design, aerial photos provided by the City, FDOT roadway plans, City Stormwater Atlas maps, and field proofing, where necessary. Table 2-1 presents a breakdown of approximate drainage boundaries, acreage, and percentage of total watershed area for each basin.

The nine major basins (A through I) were further delineated into 889 individual subbasins ranging in size from 1 to 394 acres. The subbasins were delineated to a per-discharge point resolution and were essential in the preparation of the hydrological/hydraulic and water quality models. The majority of the City is serviced by a storm sewer system with curbside or ditch bottom inlets. To a lesser degree, a swale conveyance system and very little ditch and canal conveyance also transport the stormwater runoff to disposal. Private developments that are integrated with the City system or act independently were generally aggregated for simplicity. This detailed delineation was applied consistently to all areas served by the City system.

Impervious area are usually estimated from reference values associated with particular land uses, or manually estimated through review of aerial photographs and field inspection. This later is effective for small projects, but is considered too time intensive for the purposes of a Master Plan. The City's survey data was organized in a manner that allowed it to be easily imported into GIS. A GIS analysis was able to discretely partition typically impervious areas from other improvements to allow an accurate representation of the amount of impervious area present by land use.

Within the GIS, the impervious areas were obtained by converting specific CAD layers (roads, parking, buildings, etc...) from the City survey to GIS shape files as polygons. The combined total (connected and non-connected) impervious area for the City was intersected with the land use delineation to determine approximate total impervious areas by land use. The resulting areas were further refined to allow the approximate of DCIA percentages by land use by using estimated DCIA to total impervious ratios derived through review of reference material. Table 2-5 shows the amount of impervious area from each land use that was classified as DCIA. As expected, the more developed an area is (i.e. higher traffic volume, greater paved area) the more DCIA there will be.

Table 2-5
Summary of Impervious Area and DCIA by Land Use (Current Case)
With Derived Total Impervious Area and DCIA to Land Use Area Ratios

Land Use Classification	Total Impervious Area (FT^2)	Estimated DCIA (FT^2)	DCIA/Total Impervious Area Ratio	DCIA/Total Land Use Area* Ratio
Commercial - High Intensity	14,302,264	13,630,404	95%	73%
Commercial - Low Intensity	3,300,297	2,999,607	91%	42%
Residential - High Density	5,196,661	4,056,809	78%	40%
Residential - Medium Density	14,557,275	9,301,108	64%	27%
Residential - Low Density**	0	0	45%***	15%***
Recreational/Open Space	1,485,791	371,448	25%	2%
Transportation	2,355,232	2,355,232	100%	97%
Water	200	0	0%	0%
Wetland	15,524	0	0%	0%

* From Table 2-4 – Summary of Land Use by Basin Current Case
** There was no Residential - Low Density Land Use Area Delineated in the Current Case; This Land Use Classification Utilized in Section 4
*** Value determined through average of Residential-Medium Density & Recreational/Open Space

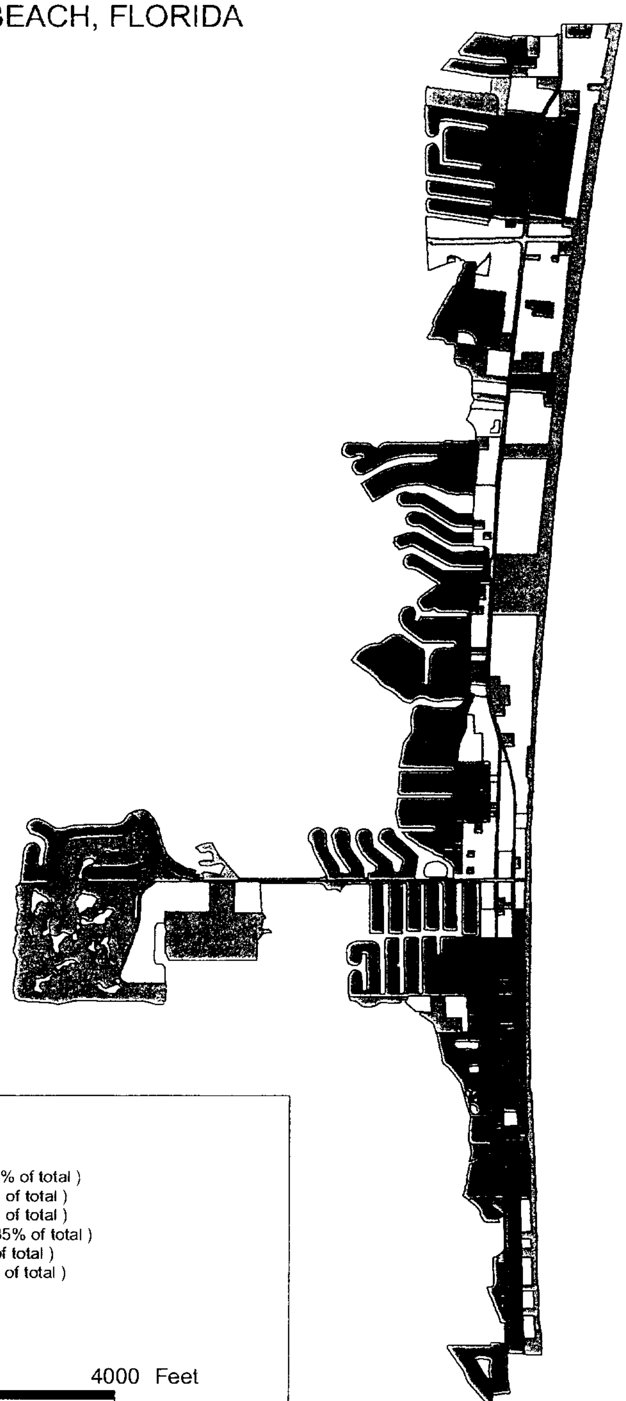
The total impervious area from GIS are shown on Figure 2.7. Table 2-6 presents the summary of DCIA by land use and basin for the current case. The majority of the DCIA runoff in the watershed comes from commercial high intensity (42%) and residential medium density (28%). Together these two categories also account for over half the land use. Overall, DCIA accounts for 736.5 acres of the total watershed area (33.5%).

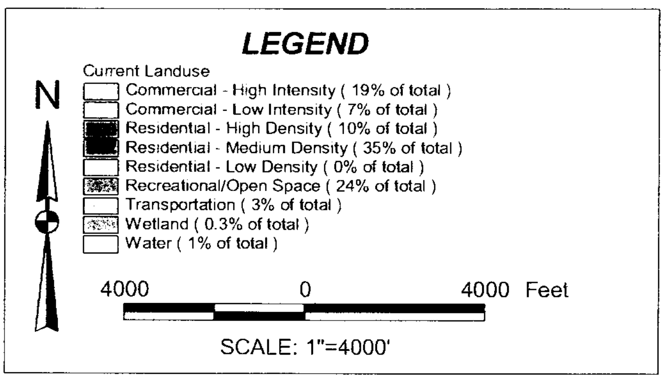
Table 2-4
Summary of Land Use by Basin - Current Case
Stormwater Master Plan
City of Cocoa Beach, Florida

Land Use	Basin Area (acres)									Total
	A	B	C	D	E	F	G	H	I	
Commercial - High Intensity	45.7	37.7	79.9	72.7	100.5	47.8	23.9	11.6	0.0	**419.8**
% of Land Use	11%	9%	19%	17%	24%	11%	6%	3%	0%	***19%***
Commercial - Low Intensity	14.2	0.2	2.0	20.7	13.7	31.5	19.9	4.5	55.7	**162.4**
% of Land Use	9%	0%	1%	13%	8%	19%	12%	3%	34%	***7%***
Recreational/Open Space	40.5	17.0	19.9	50.8	67.7	13.5	33.5	25.9	251.1	**519.9**
% of Land Use	8%	3%	4%	10%	13%	3%	6%	5%	48%	***24%***
Residential - High Density	9.5	0.7	35.8	15.8	24.7	21.5	52.5	53.5	12.9	**226.9**
% of Land Use	4%	0%	16%	7%	11%	9%	23%	24%	6%	***10%***
Residential - Medium Density	28.0	147.3	0.0	14.8	164.7	146.7	132.7	96.8	44.2	**775.2**
% of Land Use	4%	19%	0%	2%	21%	19%	17%	12%	6%	***35%***
Transportation	2.1	6.6	9.3	5.5	8.3	3.9	9.1	8.2	2.1	**55.1**
% of Land Use	4%	12%	17%	10%	15%	7%	17%	15%	4%	***3%***
Water	0.0	0.0	0.0	1.0	0.0	0.0	0.0	6.0	22.7	**29.7**
% of Land Use	0%	0%	0%	3%	0%	0%	0%	20%	76%	***1%***
Wetland	5.3	0.2	0.0	0.0	0.0	0.0	0.0	0.0	1.1	**6.6**
% of Land Use	80%	3%	0%	0%	0%	0%	0%	0%	17%	***0.3%***
Total	**145.3**	**209.7**	**146.9**	**181.3**	**379.6**	**264.9**	**271.6**	**206.5**	**389.8**	**2195.6**

FIGURE 2-6

CURRENT LAND USE
STORMWATER MASTER PLAN
CITY OF COCOA BEACH, FLORIDA





REFERENCE:

City of Cocoa Beach Land Use Maps,
Aerial Photograph Review,
Field Investigation

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dwelling unit/acre. These areas are represented by a moderate degree of impervious area.

5. ***Residential-High Density:*** Residential land use consisting of apartments and condominiums with greater than five dwelling units/acre. These areas are represented by a moderately high degree of impervious area.

6. ***Recreational/Open Space:*** Includes land that is used for recreational purposes or is undeveloped. Such areas include parks, golf courses, ranges, open spaces, and beach coastlines. These areas are represented by a very low degree of impervious area.

7. ***Transportation:*** Includes major transportation centers and roads, generally including airports, interstates, divided highways, and major multi-lane thoroughfares. Lands occupies by minor roadways such as arterial, collector, or local roads are assumed to be included within the general land through which they pass. These areas are represented by a high degree of impervious area.

8. ***Wetland:*** Natural areas covered by shallow waters that support various plant and animal species. These areas are represented by essentially no impervious area.

9. ***Water:*** Consists of open water bodies such as lakes, ponds, and rivers. These areas receive 100% of the rainfall that falls on them. They are often modeled as 100% impervious for the purposes of accounting for runoff volume as no infiltration is assumed to occur.

2.5.1 Current Land Use Case

The land use distribution for the current case is shown on Figure 2-6 and on Exhibit J. Table 2-4 presents the summary of land use by basin for the current condition for areas lying within the watershed boundary. The top three land uses resulting from this analysis are residential medium density (35%), recreational open space (24%), and commercial high intensity (19%). This reflects the urbanization of Cocoa Beach.

The directly connected impervious area (DCIA) is that portion of the total impervious area upon which stormwater runoff does not have the opportunity for infiltration through exposure to pervious areas on its course to the discharge point (catch basin, swale, canal, pond, etc.). This generally includes paved roads, parking lots, driveways, rooftops, etc. For example, parking lots generally generate runoff from the asphalt parking surfaces that flows over paved surfaces to a stormwater inlet. In this case the entire contributing parking area may be considered DCIA. Conversely, the portion of runoff falling on a rooftop from which discharges onto a yard or landscaped area where infiltration can occur does not constitute DCIA. The amount of DCIA in a watershed is impacted by the degree of urbanization; that is, as urbanization occurs, DCIA increases.

2.5 LAND USE AND IMPERVIOUS AREA

Land use coverage is a critical factor in determining stormwater runoff. A property's land use usually dictates the effective amount of pervious and impervious area that may be present, which is the most significant parameter affecting runoff volume. This is important in runoff quantity analysis, but also equally critical in pollutant loading estimation associated with stormwater runoff. Also, land use may indicate a probability of some type of internal stormwater management system, particularly within new developments.

A detailed assessment of the existing land use within the City of Cocoa Beach was performed for this Master Plan. It is important that the land use distribution developed for stormwater runoff analysis is generated to best reflect characteristics that directly effect runoff (i.e., impervious area). As such, land "zoning" maps are typically not directly applicable for this type of analysis without modification. The land use distribution developed for this project relied on several sources including City land use data, aerial photograph review, and field reconnaissance.

The land use analysis performed in this Master Plan was further complicated by the use of 1943 land use data in comparison with current data for the development of "provisional" stormwater pollutant reduction goals. This historical comparison was based on current SJRWMD methodology for pollutant assessment, and is described in detail in the Water Quality Assessment section of the Master Plan. The 1943 land use data used for this project was provide by the SJRWMD in GIS format.

The first step in land use analysis is to determine the land use classification to use that best reflect the basin characteristics. Often times available land use data is divided into many detailed classification and sub-classifications which may be important for development of municipal purposes but which unnecessarily complicate runoff analysis. Often times it is useful to combine land uses that are hydrologically similar. After review of the available data source, a land use classification to be used solely for the purposes of this Master Plan was developed to represent both the current and 1943 cases. The nine land use classifications are described as follows:

1. ***Commercial-High Intensity:*** Areas with high traffic volume moving in and out of the area all day. Such areas include regional malls, shopping centers, and downtown areas. These areas are represented by a high degree of impervious area.

2. ***Commercial-Low Intensity:*** Areas with moderate traffic volume where cars are parked for extensive hours during the day. Such areas include professional offices and schools. These areas are represented by a moderately high degree of impervious area.

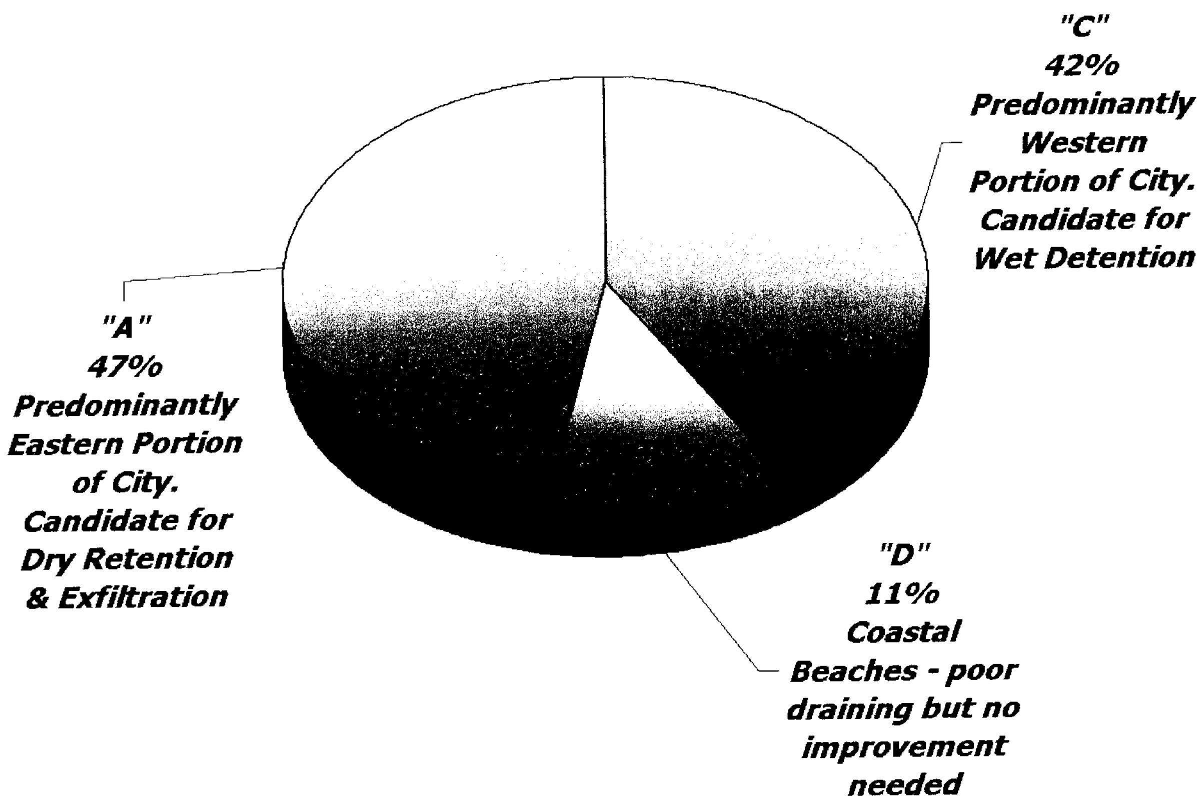
3. ***Residential-Low Density:*** Rural areas with less than one dwelling unit per acre, with lot sizes generally greater than one acre. These areas are represented by a small degree of impervious area.

4. ***Residential-Medium Density:*** Residential land use consisting of single-family homes with lot sizes less than one acre and dwelling densities greater than one

Hydrologic soil groups are commonly used in hydrologic analyses to estimate infiltration rates and soil moisture capacities. Runoff potential and infiltration rates are inversely related; as runoff increases, infiltration rates decrease. Therefore, soils classified as A have a low runoff potential with high infiltration rates, while C and D soils have a higher potential for runoff and lower infiltration values.

As seen in Figure 2-5, the watershed is predominantly composed of hydrologic soil groups A and C with 47% and 42% soil coverage, respectively. The well-drained sandy soils classified as type A are located predominantly on the eastern side of the City and consist of the following: Galveston-Urban Land Complex, Palm Beach Sand, and Urban Land. Urban land was classified as having a low runoff potential since it is predominantly surrounded by Palm Beach and Galveston soils–both classified as A. Found in the western portions of the City, the moderately well-drained Canaveral series were grouped as soil group C. The remaining 11% consisting of Coastal Beaches were grouped under hydrologic soil group D.

Figure 2-5
Soil Type Distribution by Hydrologic Soil Group



2.4 SOIL CHARACTERISTICS

Because Cocoa Beach is a barrier island bounded by the Atlantic Ocean and the Banana River, its predominant soil formation consists of a mixture of marine sands and shell fragments formed in marine sediments and reworked by wind and wave action. The remainder consists of low-lying wetland areas located along the edge of the Banana River and classified by the Natural Resources Conservation Service (NRCS) as tidal swamps composed of a mixture of sand, shell fragments, and organic soils. The percentage of tidal swamps has decreased with time as a result of urbanization. To promote development in the City, fill material from the Banana River consisting of sand and shells was dredged and deposited on portions of the tidal swamps area, leveled, and then smoothed.

According to the NRCS, there are seven different types of soils that occur in the Cocoa Beach watershed and are mapped in the 1974 Soil Survey of Brevard County. Figure 2-4 and Exhibit J show the various soil types found throughout each basin and was created by digitizing the soils in GIS software from the Brevard County Soil Survey using the City survey data as a base map reference.

A standard method of soil classification used for hydrologic modeling is the hydrologic soils group. Soils are grouped into four hydrologic soil groups ranging from A through D. Descriptions of these soil groups are:

- **Hydrologic Soil Group A (low runoff potential):** Soils that have high infiltration rates even when thoroughly wetted and a high rate of water transmission. Typical maximum infiltration rates of 8-10 in/hr when dry and 0.4-0.5 in/hr when saturated.
- **Hydrologic Soil Group B (moderately low runoff potential):** Soils that have moderate infiltration rates when thoroughly wetted and a moderate rate of water transmission. Typical maximum infiltration rates of 6-8 in/hr when dry and 0.25-0.4 in/hr when saturated.
- **Hydrologic Soil Group C (moderately high runoff potential):** Soils that have a slow infiltration rate when thoroughly wetted and a slow rate of water transmission. Typical maximum infiltration rates of 4-5 in/hr when dry and 0.15-0.25 in/hr when saturated.
- **Hydrologic Soil Group D (high runoff potential):** Soils having very slow infiltration rates when thoroughly wetted and a very slow rate of water transmission. Typical maximum infiltration rates of 1-3 in/hr when dry and 0.05-0.15 in/hr when saturated.

Soils within the Cocoa Beach basin were categorized according to this hydrologic soil group classification system, as defined by the NRCS. Three different soil groups describe the basin soils: A, C, and D. Table 2-3 lists the distribution of the hydrologic soil types within each individual basin.

Table 2-2
Subbasin Summary Description
Stormwater Master Plan
City of Cocoa Beach, Florida

			Subbasins with Surface Runoff to City Stormwater System			Subbasins with Surface Runoff Directly to Lagoon			Subbasins with Private Development Stormwater Systems			Subbasins with Surface Runoff Directly to Ocean		
Basin	Total Subbasins	Area (acres)	Total Subbasins	Area (acres)	% of Total Subbasin Area	Total Subbasins	Area (acres)	% of Total Subbasin Area	Total Subbasins	Area (acres)	% of Total Subbasin Area	Total Subbasins	Area (acres)	% of Total Subbasin Area
A	48	131	43	78	4%	2	32	1.5%	1	11	0%	2	10	0%
B	118	214	114	158	7%	2	35	1.6%	0	0	0%	2	19	1%
C	83	145	73	82	4%	6	25	1.1%	1	16	1%	3	25	1%
D	44	182	34	99	4%	7	41	1.9%	1	10	0%	2	31	1%
E	136	384	122	246	11%	8	61	2.8%	5	44	2%	1	33	1%
F	177	268	162	183	8%	13	75	3.4%	1	1	0%	1	9	0%
G	163	276	156	189	9%	6	70	3.2%	0	0	0%	1	17	1%
H	82	207	72	77	3%	7	93	4.2%	0	0	0%	3	37	2%
I	38	394	29	64	3%	9	330	15.0%	0	0	0%	0	0	0%
Totals	**889**	**2202**	**805**	**1176**	**53%**	**60**	**763**	**35%**	**9**	**82**	**4%**	**15**	**181**	**8%**

Table 2-1
Basin Summary Description

ID	Approximate Drainage Boundaries	Drainage Area (acres)	Drainage Area (mi^2)	% of Total Area
A	Young Avenue to Leon Lane	145	0.23	7
B	Leon Lane to SR 520	210	0.33	10
C	SR 520 to Flagler Lane	147	0.23	7
D	Flagler Lane to Banana River Boulevard	181	0.28	8
E	St. Croix Avenue to N. 4th Street	380	0.59	17
F	Cocoa Isles Blvd. to Minuteman Causeway	265	0.41	12
G	Minuteman Causeway to S. 6th Street	272	0.43	12
H	S. 6th Street to River Falls Drive	206	0.32	9
I	Minuteman peninsula including golf course, public works complex, and schools	390	0.61	18
Totals		**2,196**	**3.43**	**100**

Table 2-2 describes the major basins and related sub-basin characteristics within the City of Cocoa Beach. Stormwater runoff from the City is discharged directly to the Atlantic Ocean, Banana River, City stormwater systems, or private development systems without any positive outfall. The City's stormwater infrastructure handles 53% of all stormwater flows generated within the governmental boundaries of Cocoa Beach (See Figure 2-3).

Figure 2-3
Stormwater Discharge by Subbasins

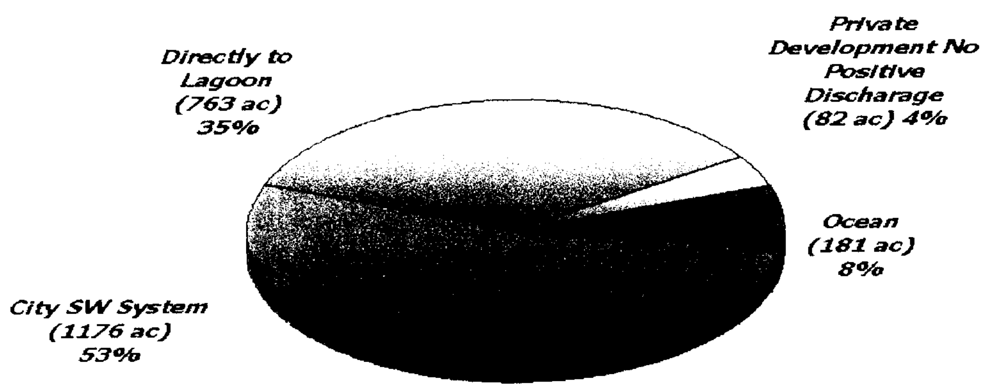


FIGURE 2-2

BASIN MAP
STORMWATER MASTER PLAN
CITY OF COCOA BEACH, FLORIDA

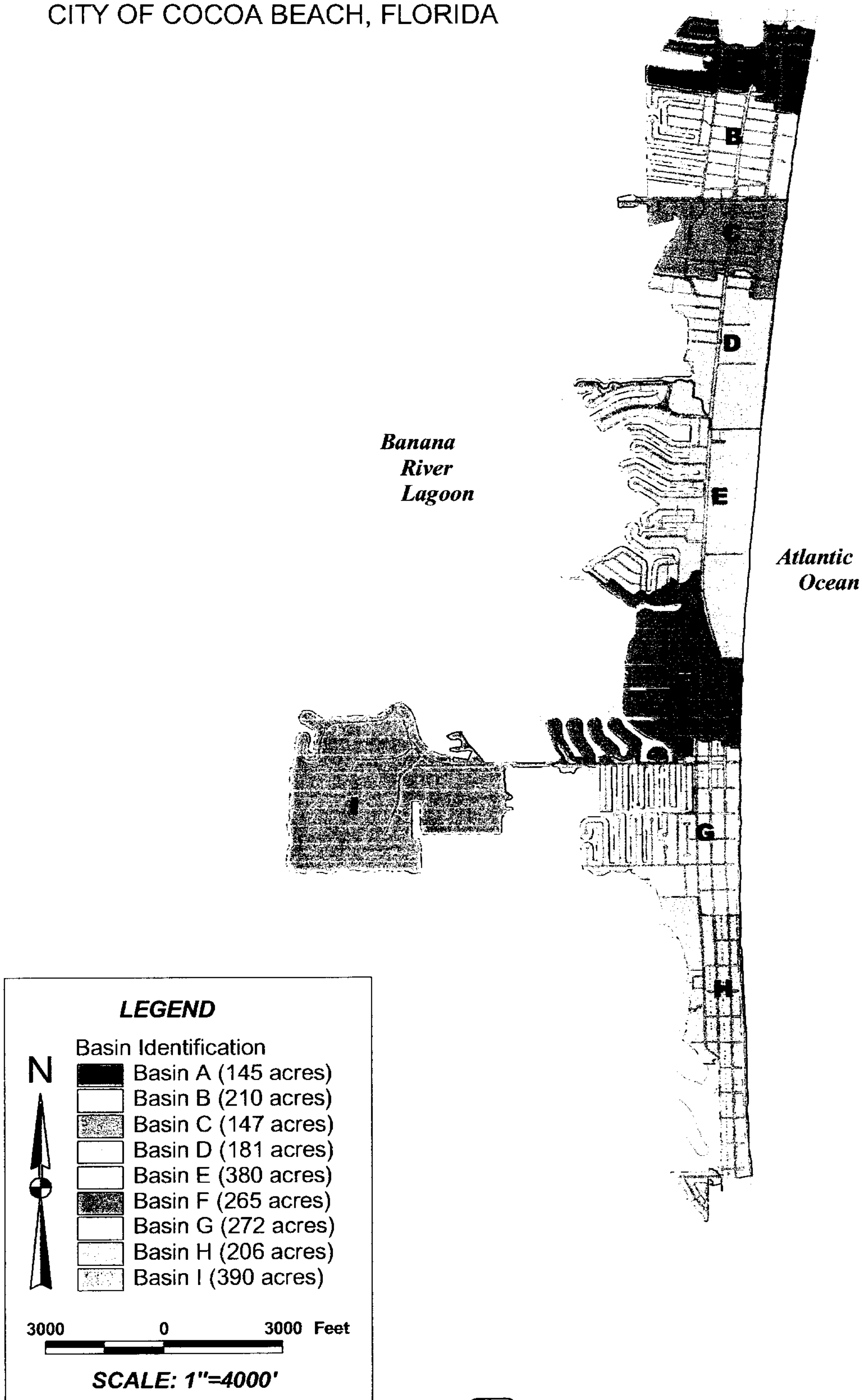


Table 2-6
Summary of DCIA by Land Use and Basin - Current Case
Stormwater Master Plan
City of Cocoa Beach, Florida

Land Use	Basin Area (acres)									Total
	A	B	C	D	E	F	G	H	I	
Commercial - High Intensity	33.6	27.7	58.7	53.4	73.8	35.1	17.6	8.5	0.0	**308.3**
% of Land Use	11%	9%	19%	17%	24%	11%	6%	3%	0%	***42%***
Commercial - Low Intensity	6.0	0.1	0.8	8.8	5.8	13.3	8.4	1.9	23.6	**68.6**
% of Land Use	9%	0%	1%	13%	8%	19%	12%	3%	34%	***9%***
Recreational/Open Space	0.7	0.3	0.3	0.8	1.1	0.2	0.5	0.4	4.1	**8.4**
% of Land Use	8%	3%	4%	10%	13%	3%	6%	5%	48%	***1%***
Residential - High Density	3.8	0.3	14.5	6.4	10.0	8.7	21.2	21.6	5.2	**91.6**
% of Land Use	4%	0%	16%	7%	11%	9%	23%	24%	6%	***12%***
Residential - Medium Density	7.4	39.2	0.0	3.9	43.8	39.0	35.3	25.8	11.8	**206.3**
% of Land Use	4%	19%	0%	2%	21%	19%	17%	12%	6%	***28%***
Transportation	2.1	6.4	9.0	5.3	8.0	3.8	8.8	7.9	2.0	**53.2**
% of Land Use	4%	12%	17%	10%	15%	7%	17%	15%	4%	***7%***
Water	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
% of Land Use	0%	0%	0%	0%	0%	0%	0%	0%	0%	***0%***
Wetland	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
% of Land Use	0%	0%	0%	0%	0%	0%	0%	0%	0%	***0%***
Total	**53.6**	**74.0**	**83.3**	**78.5**	**142.5**	**100.1**	**91.8**	**66.1**	**46.6**	**736.5**
% of Watershed Area	***7%***	***10%***	***11%***	***11%***	***19%***	***14%***	***12%***	***9%***	***6%***	***100%***

2.5.2 1943 Case

As discussed previously, the data source for this land use case was provided by the SJRWMD in GIS format for the entire IRL. This data was trimmed to the City limits then re-projected to match the coordinate system and measurement units of the City survey imported into GIS. The 1943 land use as derived from the SJRWMD GIS data is shown on Figure 2-7 and Exhibit J. The overall watershed boundary from the current land use case was overlaid for comparison. A comparison of the 1943 land use to the current is provided in Table 2-7. Using the same watershed boundary as in the current case, Table 2-8 presents the summary of land use by basin for the 1943 condition. The top two land uses resulting from this analysis are water (53%) and recreational open space (38%).

Table 2-7 – Comparison of Land Use Cases - 1943 Versus Current

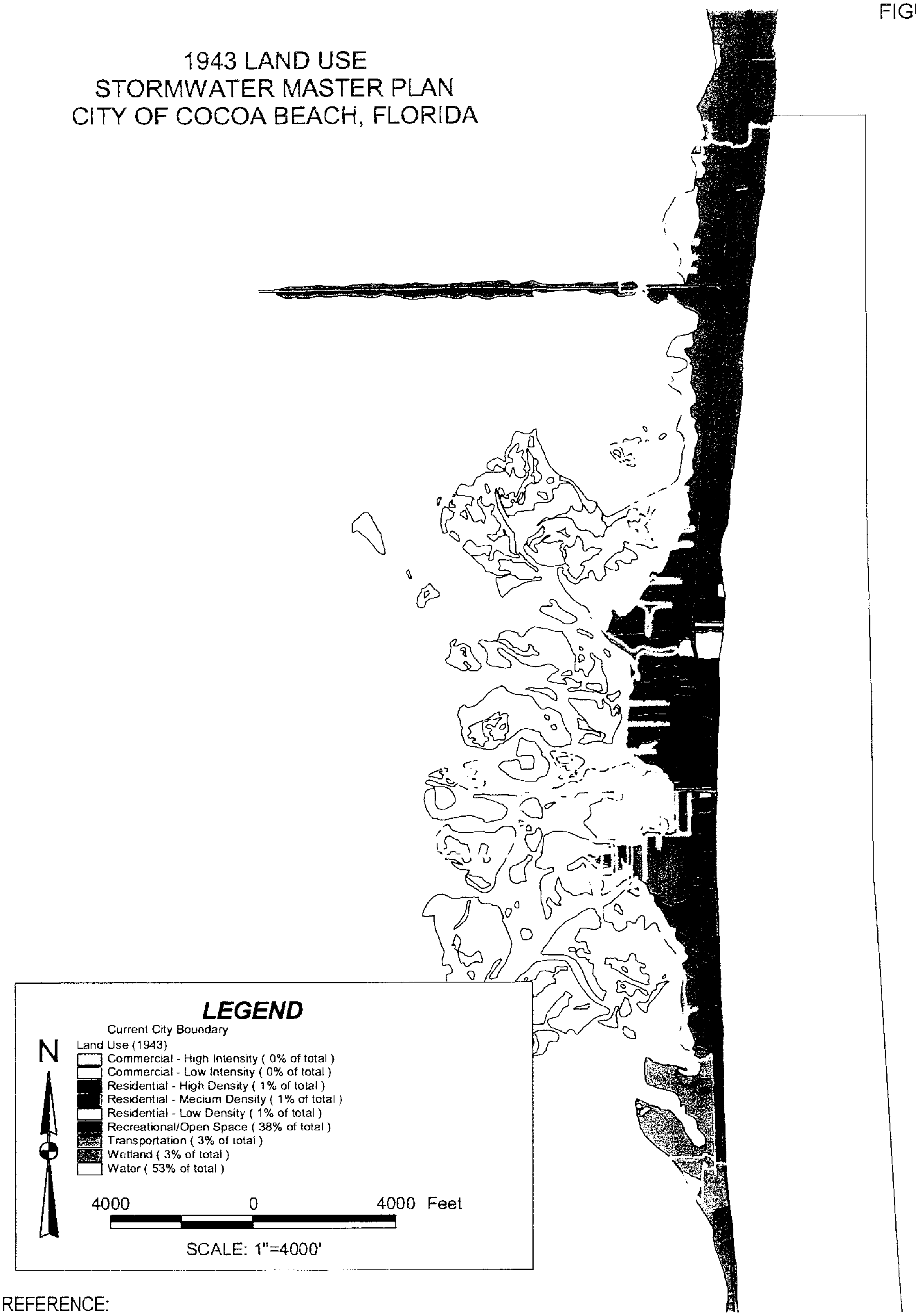
Land Use	1943	Current
Commercial - High Intensity	0%	19%
Commercial - Low Intensity	0%	7%
Recreational/Open Space	38%	24%
Residential - Low Density	1%	0%
Residential - Medium Density	1%	35%
Residential - High Density	1%	10%
Transportation	3%	3%
Water	53%	1%
Wetland	3%	0.3%
Total	**100%**	**100%**

Table 2.9 presents the summary of DCIA by land use and basin for the 1943 case, which was calculated based on the same estimated DCIA ratios developed for the current land use case. The majority of the DCIA runoff in the watershed originates from transportation (63%), while the remainder is from recreational/open space and residential dwellings. Overall, DCIA accounts for a small portion of the total watershed area (4.3%).

As seen in Table 2-8, water, wetlands, and recreational/open space primarily occupied the present watershed in 1943. The high percentage of water reflects the significant difference in land area between the current and 1943 land use cases. An increase in urban development has modified these land uses to allow room for commercial and residential growth. The calculated DCIA for the current conditions was eight times greater than in 1943. As expected, the more urbanized an area becomes (i.e., more paved areas and housing) the more DCIA there will be. Basin I did not exist in 1943; instead, the recreational/open space land use was dispersed throughout the entire City as opposed to currently limited to the golf course, beach areas, and city park locales. The wetlands in basins G and H were converted to primarily residential dwellings with commercial activity along zoned areas. As seen in the 1943 land use map, the Atlantic Ocean's shoreline appears to have been extended farther to the east. Overall, all nine basins have been significantly modified with development of the land toward the west.

FIGURE 2-8

1943 LAND USE
STORMWATER MASTER PLAN
CITY OF COCOA BEACH, FLORIDA



REFERENCE:

St. Johns River Water Management District
1943 Land Use Coverage

PARSONS ENGINEERING SCIENCE, INC.

Table 2-8
Summary of Land Use by Basin - 1943 Case
Stormwater Master Plan
City of Cocoa Beach, Florida

Land Use	Basin Area (acres)									Total
	A	B	C	D	E	F	G	H	I	
Recreational/Open Space	57.0	102.3	78.2	104.3	157.6	175.9	87.5	73.8	0.0	**836.8**
% of Land Use	7%	12%	9%	12%	19%	21%	10%	9%	0%	***38%***
Residential - Low Density	0.0	0.0	0.0	0.0	16.6	5.0	1.5	0.0	0.0	**23.1**
% of Land Use	0%	0%	0%	0%	72%	22%	7%	0%	0%	***1%***
Residential - Medium Density	0.0	0.0	0.0	0.0	0.0	6.8	13.3	0.0	0.0	**20.1**
% of Land Use	0%	0%	0%	0%	0%	34%	66%	0%	0%	***1%***
Residential - High Density	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.1	0.0	**16.1**
% of Land Use	0%	0%	0%	0%	0%	0%	0%	100%	0%	***1%***
Transportation	2.1	5.8	7.3	5.3	8.0	10.2	12.7	9.3	1.7	**62.2**
% of Land Use	3%	9%	12%	8%	13%	16%	20%	15%	3%	***3%***
Water	70.9	107.6	64.2	77.0	201.6	70.4	116.0	81.5	392.4	**1181.4**
% of Land Use	6%	9%	5%	7%	17%	6%	10%	7%	33%	***53%***
Wetland	1.1	0.0	0.0	0.0	0.0	0.0	45.0	26.2	0.0	**72.4**
% of Land Use	2%	0%	0%	0%	0%	0%	62%	36%	0%	***3%***
Total	**131.1**	**215.6**	**149.7**	**186.6**	**383.8**	**268.3**	**276.2**	**206.9**	**394.0**	**2212.2**

Table 2-9
Summary of DCIA by Land Use and Basin - 1943 Case
Stormwater Master Plan
City of Cocoa Beach, Florida

Land Use	Basin Area (acres)									Total
	A	B	C	D	E	F	G	H	I	
Recreational/Open Space	0.9	1.7	1.3	1.7	2.6	2.8	1.4	1.2	0.0	**13.6**
% of Land Use	7%	12%	9%	12%	19%	21%	10%	9%	0%	***14%***
Residential - Low Density	0.0	0.0	0.0	0.0	6.7	2.0	0.6	0.0	0.0	**9.3**
% of Land Use	0%	0%	0%	0%	72%	22%	7%	0%	0%	***10%***
Residential - Medium Density	0.0	0.0	0.0	0.0	0.0	1.8	3.5	0.0	0.0	**5.4**
% of Land Use	0%	0%	0%	0%	0%	34%	66%	0%	0%	***6%***
Residential - High Density	0	0	0	0	0	0	0	6.49	0	**6.5**
% of Land Use	0%	0%	0%	0%	0%	0%	0%	100%	0%	***7%***
Transportation	2.0	5.6	7.0	5.1	7.8	9.9	12.3	9.0	1.6	**60.3**
% of Land Use	3%	9%	12%	8%	13%	16%	20%	15%	3%	***63%***
Water	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
% of Land Use	0%	0%	0%	0%	0%	0%	0%	0%	0%	***0%***
Wetland	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
% of Land Use	0%	0%	0%	0%	0%	0%	0%	0%	0%	***0%***
Total	**3.0**	**7.2**	**8.3**	**6.8**	**17.0**	**16.6**	**17.9**	**16.7**	**1.6**	**95.0**
% of Watershed Area	***3%***	***8%***	***9%***	***7%***	***18%***	***17%***	***19%***	***18%***	***2%***	***100%***

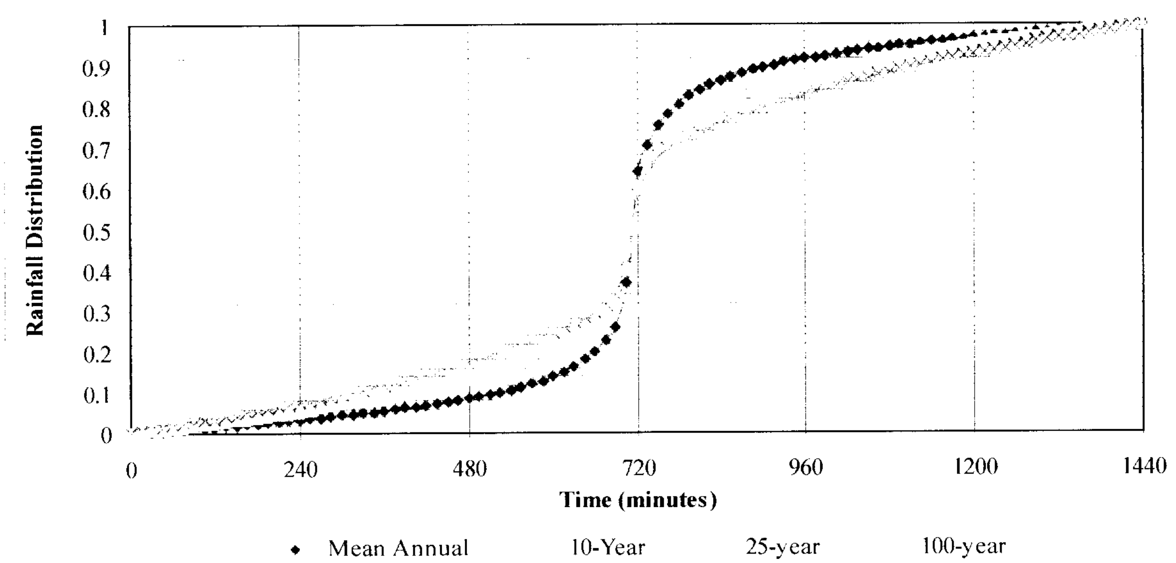
2.6 HYDROLOGIC ANALYSIS

2.6.1 Discrete Storm Event Precipitation Analysis

The flooding assessment model utilized in the Master Plan relies on discrete "design return period" storm event to assess the ability of the stormwater management system to perform to an acceptable level of service. Discrete unit hydrograph storm event distributions were used to analyze the likelihood of flooding throughout the watershed boundary. SJRWMD's technical publication titled "24-Hour Rainfall Distributions for Surface Water Basins within the St. Johns River Water Management District, Northeast Florida" was referenced to obtain 24-hour rainfall distributions for mean annual (2.5 years), 10-, 25-, and 100-year return periods for the Indian River Lagoon area. These distributions are shown on Figure 2-9. Note that the mean annual distribution data available in this reference were based on a district-wide distribution as opposed to Indian River Lagoon specific distributions provided for the 10, 25, and 100-year cases. Based on the SJRWMD reference, the following rainfall depths were determined for each return period as applicable to Cocoa Beach:

Return Period (years)	Rainfall Depth (inches)
2.5	5.00
10	7.65
25	9.50
100	13.0

Figure 2-9
24-Hour Rainfall Distributions for Modeled Return Period



2.6.2 Continuous Simulation Precipitation Analysis

The U.S. Weather Service of the National Oceanic and Atmospheric Administration (NOAA) maintains historical records of measured climatic data for various gage stations throughout the nation. To evaluate the precipitation that occurred near Cocoa Beach, hourly rainfall depths were obtained from the Melbourne Regional Airport's rain gage station, Cooperative Identification Station Number 85612, between January 1, 1990 and December 31, 1999. This station was selected because of its extensive and thorough historical rainfall data set along with its close proximity to Cocoa Beach – approximately 20 miles. Figure 2-10 depicts the daily rainfall for the 1900-1999 period, and Figure 2-11 presents the annual rainfall variability along with the mean precipitation. The daily precipitation occurring during this time frame is described in Figure 2-12.

For the continuous simulation analysis, it was assumed that the rainfall depths at the Melbourne Regional Airport station were representative of rainfall within the City of Cocoa Beach's watershed. The exact hourly rainfall depths observed at the Melbourne Regional Airport would not necessarily be the same, however, the magnitudes of rainfall depths and distribution of storm events observed at both locations should be on the same order. Because the objective of this Master Plan is to quantify design average annual runoff volumes, hourly rainfall at the Airport can be translated to the City. Any deviation existing over the average annual rainfall record between the two locations is well within the error associated with the model.

Historical rainfall records from 1939-1984 were reviewed to determine the average depth of precipitation. According to the SJRWMD's technical publication titled "Rainfall Analysis for Northeast Florida—Summary of Monthly and Annual Rainfall Data", during this time, an average rainfall of 48.34 inches occurred. The annual average amount of rain that fell (50.89 inches) during the 1990s, was found to be representative of the previous historical data set.

For the purpose of water quality modeling for the development of average annual pollutant loads, only the precipitation occurring between 1990 and 1993 was analyzed. The selection was based on the following criteria: a contiguous time frame that excluded years with abnormally high or low rainfall depths or intensive single event storms may tend to skew the data. Table 2-10 describes the monthly means with calculated deviations from the overall average. As seen in this table, the years 1990-1993 had the lowest deviations from the average as well as the least volume of rain falling with less than four inches measured. Although 1994 also had a low deviation from the average, it was not added on to this time frame since a large storm occurred at the end of the year.

Figure 2-10
24-Hour Rainfall Distributions for Modeled Return Period

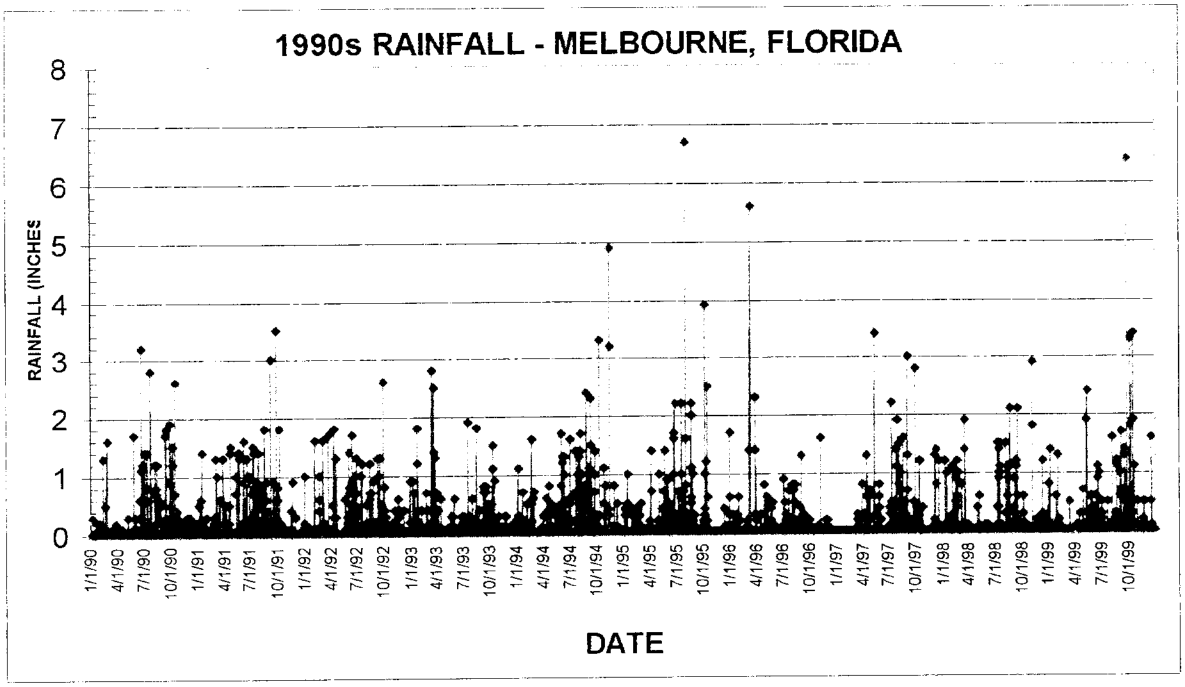
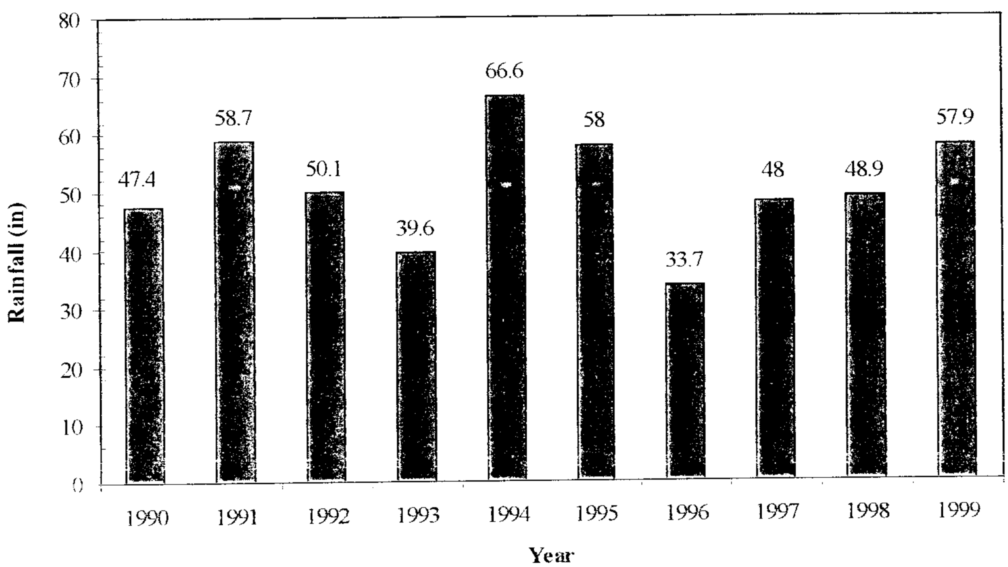


Figure 2-11
Annual Rainfall Depth Comparison – Melbourne Airport, Florida

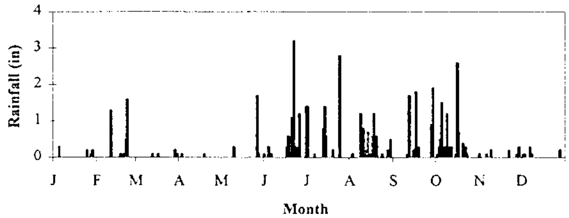


Mean Precipitation = 50.89 inches

Figure 2-12
1990s Annual Rainfall Summary By Year - Melbourne Airport, Florida
Stormwater Master Plan
City of Cocoa Beach, Florida

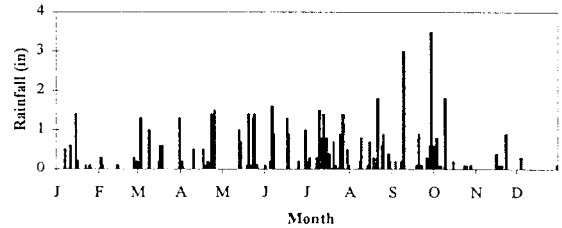
1990

1990 Daily Rainfall Data (47.4") for Melbourne Regional Airport Station (85612)



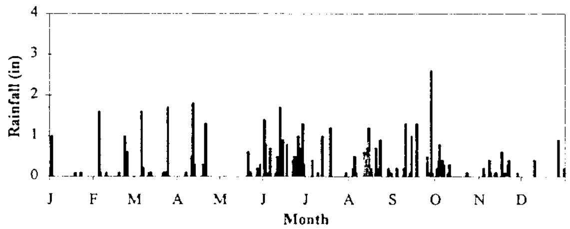
1991

1991 Daily Rainfall Data (58.7") for Melbourne Regional Airport Station (85612)



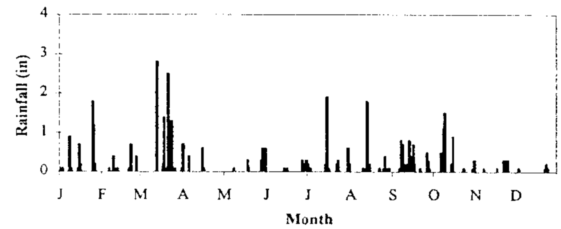
1992

1992 Daily Rainfall Data (50.1") for Melbourne Regional Airport Station (85612)



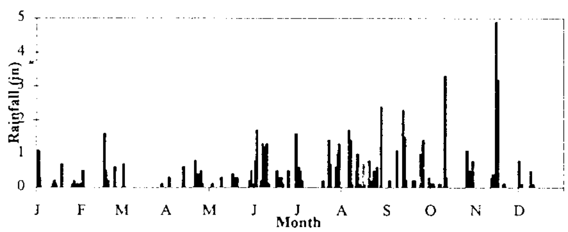
1993

1993 Daily Rainfall Data (39.6") for Melbourne Regional Airport Station (85612)



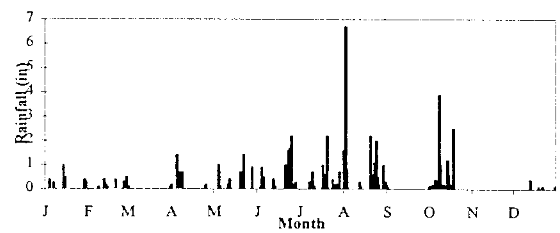
1994

1994 Daily Rainfall Data (66.6") for Melbourne Regional Airport Station (85612)



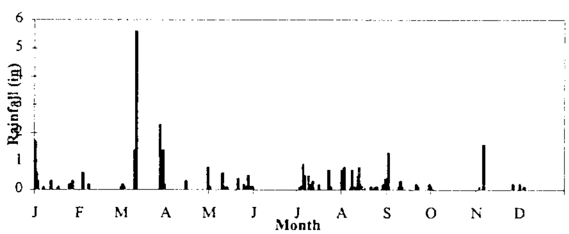
1995

1995 Daily Rainfall Data (58.0") for Melbourne Regional Airport Station (85612)



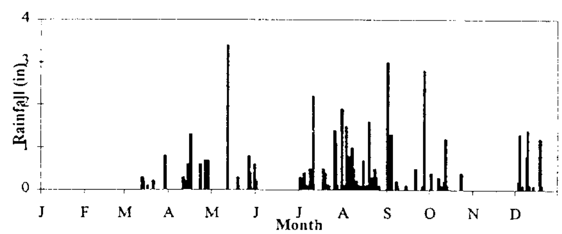
1996

1996 Daily Rainfall Data (33.7") for Melbourne Regional Airport Station (85612)



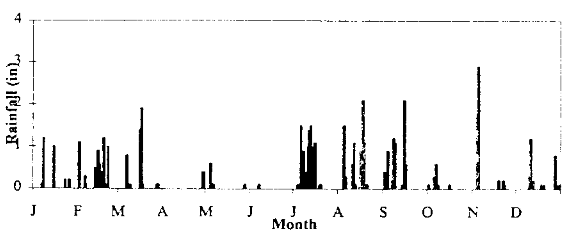
1997

1997 Daily Rainfall Data (48.0") for Melbourne Regional Airport Station (85612)



1998

1998 Daily Rainfall Data (48.9") for Melbourne Regional Airport Station (85612)



1999

1999 Daily Rainfall Data (57.9") for Melbourne Regional Airport Station (85612)

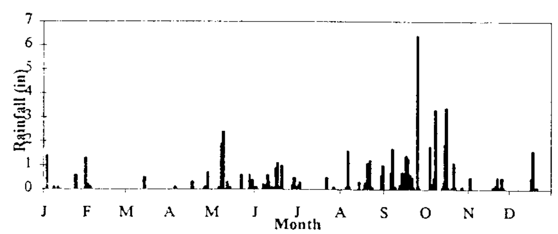


Figure Table 2-10
Average Monthly Rainfall and Deviation from 1990-1999 for Melbourne Regional Airport Station
Stormwater Master Plan
City of Cocoa Beach, Florida

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1990	0.8	3.6	0.5	0.2	2.1	7.3	8.7	6.4	7.1	8.9	1.0	0.8	**47.4**
diff from avg	1.8	1.3	3.2	2.3	1.3	2.0	2.3	1.5	0.0	3.4	1.4	0.8	*21.4*
1991	2.9	1.0	5.0	4.4	6.1	6.2	11.3	6.1	9.3	4.5	1.5	0.4	**58.7**
diff from avg	0.3	1.3	1.3	1.9	2.7	0.9	4.9	1.8	2.2	1.0	0.9	1.2	*20.4*
1992	1.4	3.9	4.0	4.3	1.4	12.4	2.8	5.9	7.4	2.6	2.5	1.5	**50.1**
diff from avg	1.2	1.6	0.3	1.8	2.0	7.1	3.6	2.0	0.3	2.9	0.1	0.1	*22.9*
1993	5.4	1.8	8.7	1.8	2.1	1.2	3.9	3.0	5.4	4.7	1.1	0.5	**39.6**
diff from avg	2.8	0.5	5.0	0.7	1.3	4.1	2.5	4.9	1.7	0.8	1.3	1.1	*26.7*
1994	3.0	3.5	0.8	2.7	2.2	11.1	6.7	10.2	9.1	6.8	9.0	1.5	**66.6**
diff from avg	0.4	1.2	2.9	0.2	1.2	5.8	0.3	2.3	2.0	1.3	6.6	0.1	*24.2*
1995	2.9	2.0	0.2	3.2	4.7	9.2	6.5	17.7	0.1	10.8	0.0	0.7	**58.0**
diff from avg	0.3	0.3	3.5	0.7	1.3	3.9	0.1	9.8	7.0	5.3	2.4	0.9	*35.6*
1996	3.8	0.8	11.6	1.1	2.4	0.0	3.7	5.3	2.7	0.1	1.9	0.3	**33.7**
diff from avg	1.2	1.5	7.9	1.4	1.0	5.3	2.7	2.6	4.4	5.4	0.5	1.3	*35.2*
1997	0.0	0.0	1.6	5.2	5.5	0.2	9.3	9.3	8.8	2.8	0.0	5.3	**48.0**
diff from avg	2.6	2.3	2.1	2.7	2.1	5.1	2.9	1.4	1.7	2.7	2.4	3.7	*31.9*
1998	2.7	6.1	4.5	0.8	0.8	0.1	9.5	8.2	6.9	1.2	5.2	2.9	**48.9**
diff from avg	0.1	3.8	0.8	1.7	2.6	5.2	3.1	0.3	0.2	4.3	2.8	1.3	*26.2*
1999	3.5	0.4	0.5	1.3	6.6	5.6	1.2	6.8	14.6	13.0	2.1	2.3	**57.9**
diff from avg	0.9	1.9	3.2	1.2	3.2	0.3	5.2	1.1	7.5	7.5	0.3	0.7	*32.9*
Total	**26.4**	**23.1**	**37.4**	**25**	**33.9**	**53.3**	**63.6**	**78.9**	**71.4**	**55.4**	**24.3**	**16.2**	**508.9**
Average	**2.6**	**2.3**	**3.7**	**2.5**	**3.4**	**5.3**	**6.4**	**7.9**	**7.1**	**5.5**	**2.4**	**1.6**	***50.9***

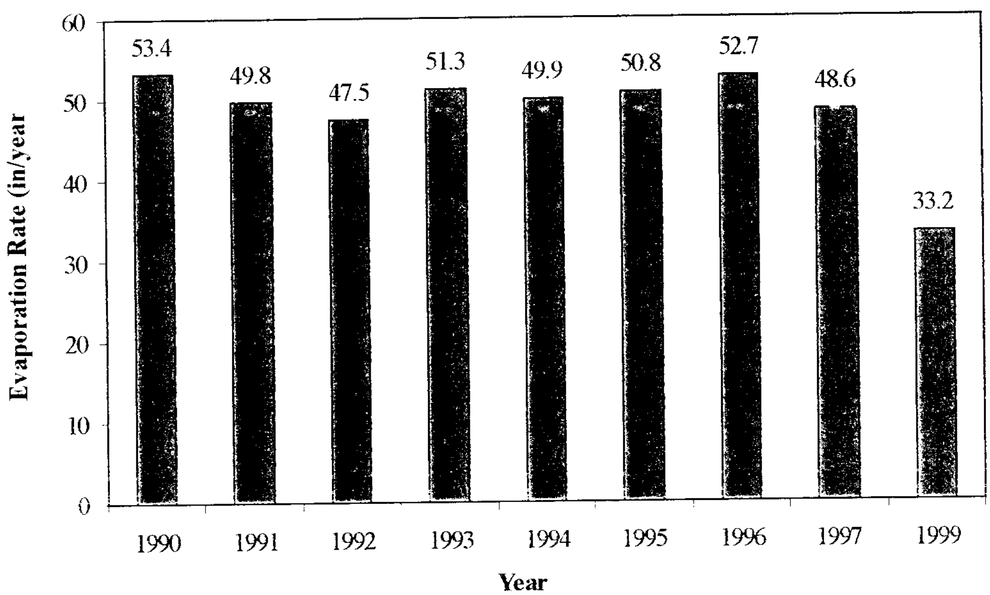
2.6.3 Evaporation Data

Evaporation, a water loss component of the hydrologic cycle, measures the net vapor transfer between the atmosphere and evaporating surfaces such as soils and surface water. It is a cooling process that removes heat from the surface by solar and advective energy (winds). Evaporation decreases the amount of water that can runoff or be available for storage; hence, it affects various parameters in the model such as: infiltration, depressional storage, open channels, and ponding.

Monthly pan evaporation depths were obtained from NOAA for the Vero Beach 4 W, Cooperative Identification Station Number 89219, between January 1, 1990 and December 31, 1999. This station was selected because of its extensive and thorough historical evaporation data set along with its proximity to Cocoa Beach – approximately 60 miles. For this analysis, it was assumed that the evaporation depths at Vero Beach were representative of evaporation within the watershed for the same reason as previously stated for rainfall. Figure 2-13 shows the annual evaporation rate for these ten years, while Table 2-11 shows the monthly evaporation rate.

For the two stations analyzed, the evaporation and rainfall average rates resulted in similar values, 48.6 inches and 50.9 inches, respectively. Therefore, during the past ten years in this area, the average volume of water that evaporated was a slightly bit less than the amount of water that precipitated.

Figure 2-13
Annual Evaporation Rates – Vero Beach, Florida



Mean Evaporation = 48.6 inches

Note: Data provided by NOAA for the year 1998 was incomplete and was omitted from this figure.

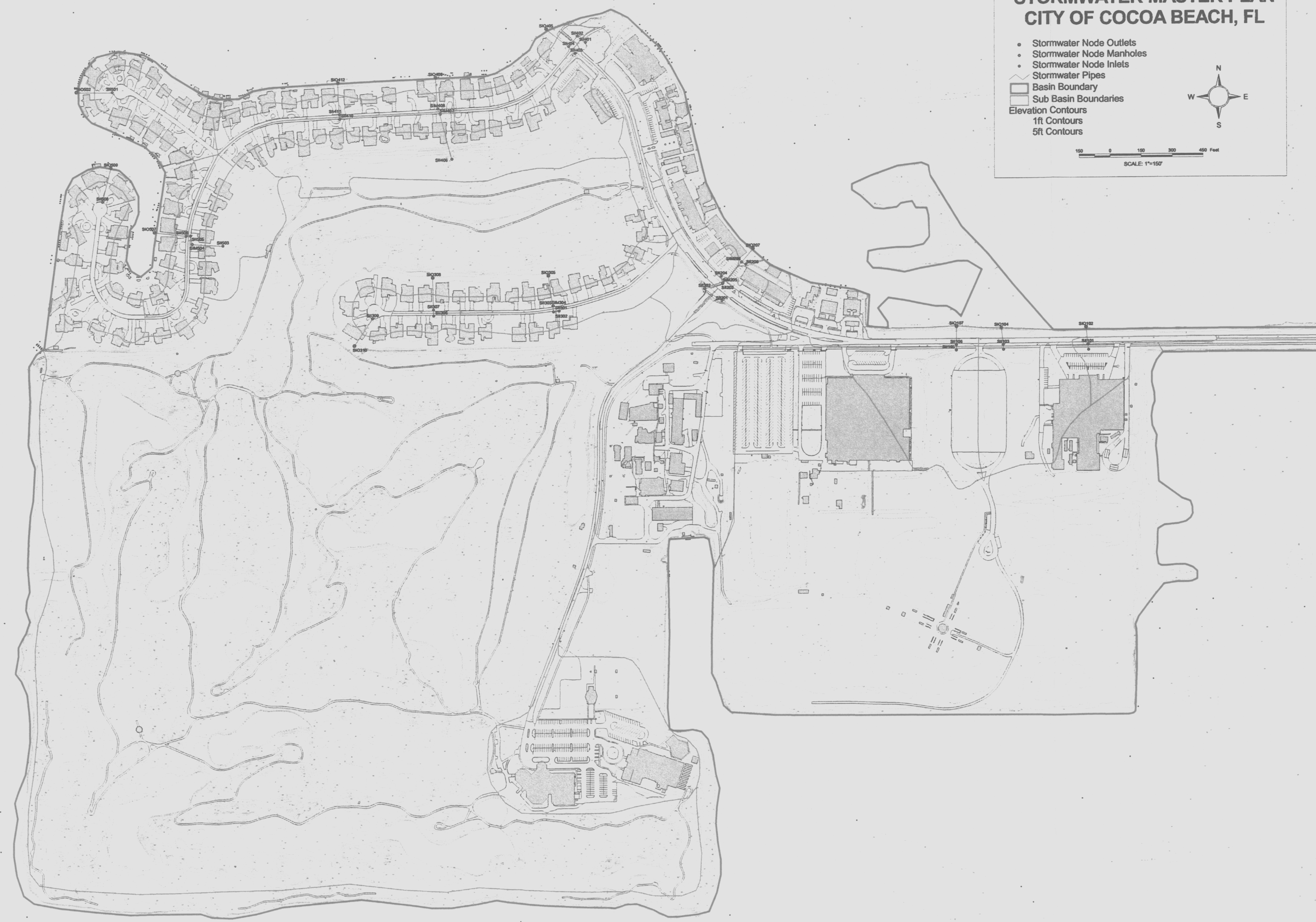
Figure Table 2-11
Summary of Evaporation Rates from 1990-1999 for Vero Beach, Florida
Stormwater Master Plan
City of Cocoa Beach, Florida

	Evaporation Rate (in/day)										
	Year										
Month	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	Average
Jan	0.007	0.007	0.006	0.005	0.004	0.005	0.008	0.006	--	0.004	0.006
Feb	0.009	0.009	0.007	0.008	0.009	0.010	0.009	0.009	--	0.007	0.008
Mar	0.013	0.013	0.010	0.010	0.013	0.012	0.014	0.010	--	0.010	0.012
Apr	0.015	0.016	0.014	0.015	0.014	0.013	0.013	0.012	--	0.011	0.014
May	0.015	0.016	0.014	0.018	0.015	0.018	0.016	0.016	--	0.011	0.015
Jun	0.016	0.016	0.014	0.017	0.013	0.014	0.015	0.018	--	0.009	0.015
Jul	0.014	0.012	0.017	0.013	0.015	0.016	0.015	0.014	--	0.011	0.014
Aug	0.016	0.013	0.012	0.016	0.013	0.014	0.014	0.013	--	0.009	0.013
Sep	0.014	0.012	0.012	0.012	0.013	0.012	0.014	0.014	--	0.010	0.013
Oct	0.012	0.010	0.011	0.011	0.010	0.011	0.009	0.009	0.010	0.009	0.010
Nov	0.010	0.007	0.007	0.009	0.011	0.008	0.009	0.005	0.005	--	0.008
Dec	0.005	0.006	0.006	0.006	0.008	0.007	0.007	0.007	0.005	0.006	0.006
in/month	0.15	0.14	0.13	0.14	0.14	0.14	0.14	0.13	0.02	0.10	0.13
in/year	53.4	49.8	47.5	51.3	49.9	50.8	52.7	48.6		33.2	49.0

-- Data not available from NOAA measuring station

EXHIBIT 2I

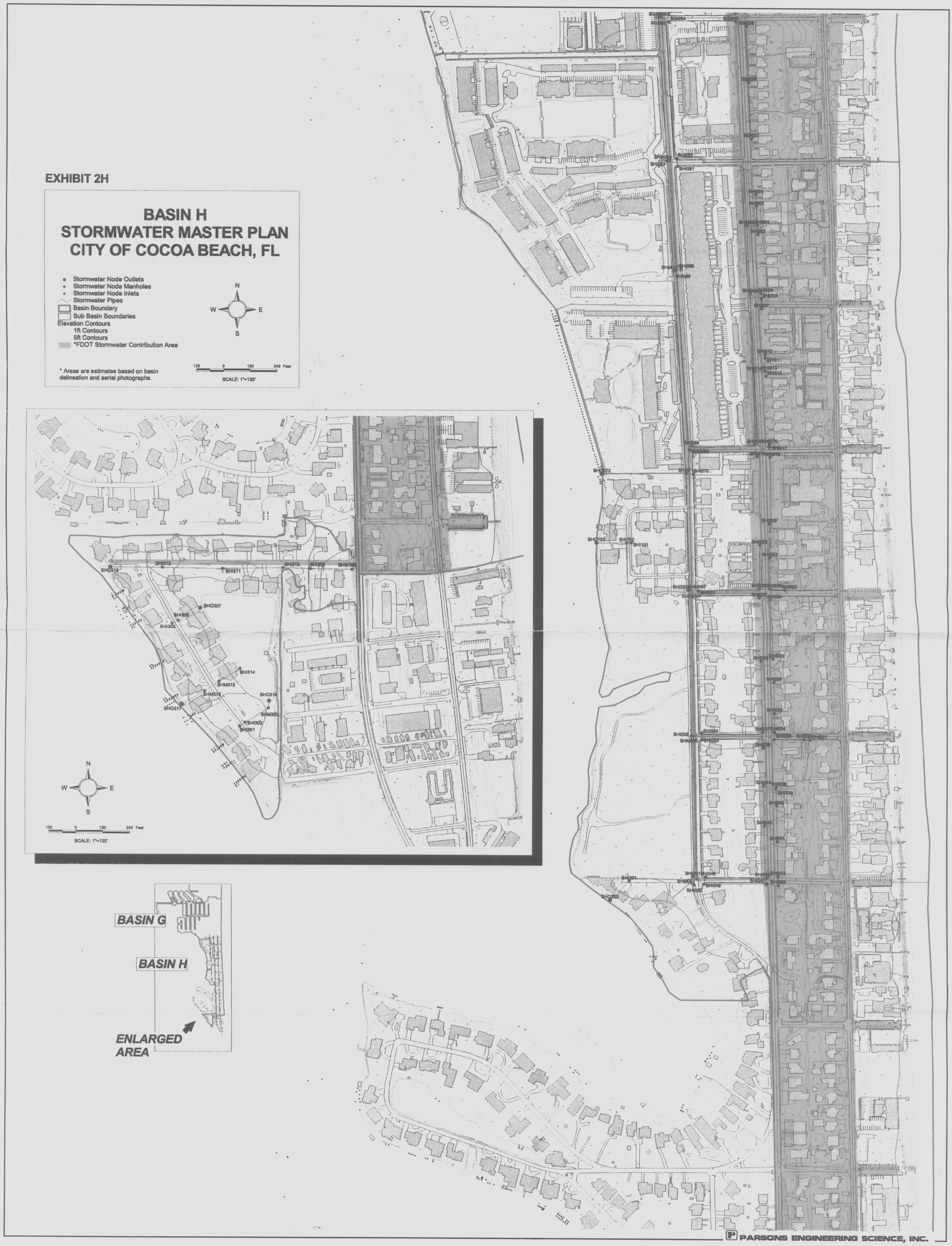
BASIN I
STORMWATER MASTER PLAN
CITY OF COCOA BEACH, FL



PARSONS ENGINEERING SCIENCE, INC.

EXHIBIT 2H

BASIN H STORMWATER MASTER PLAN CITY OF COCOA BEACH, FL



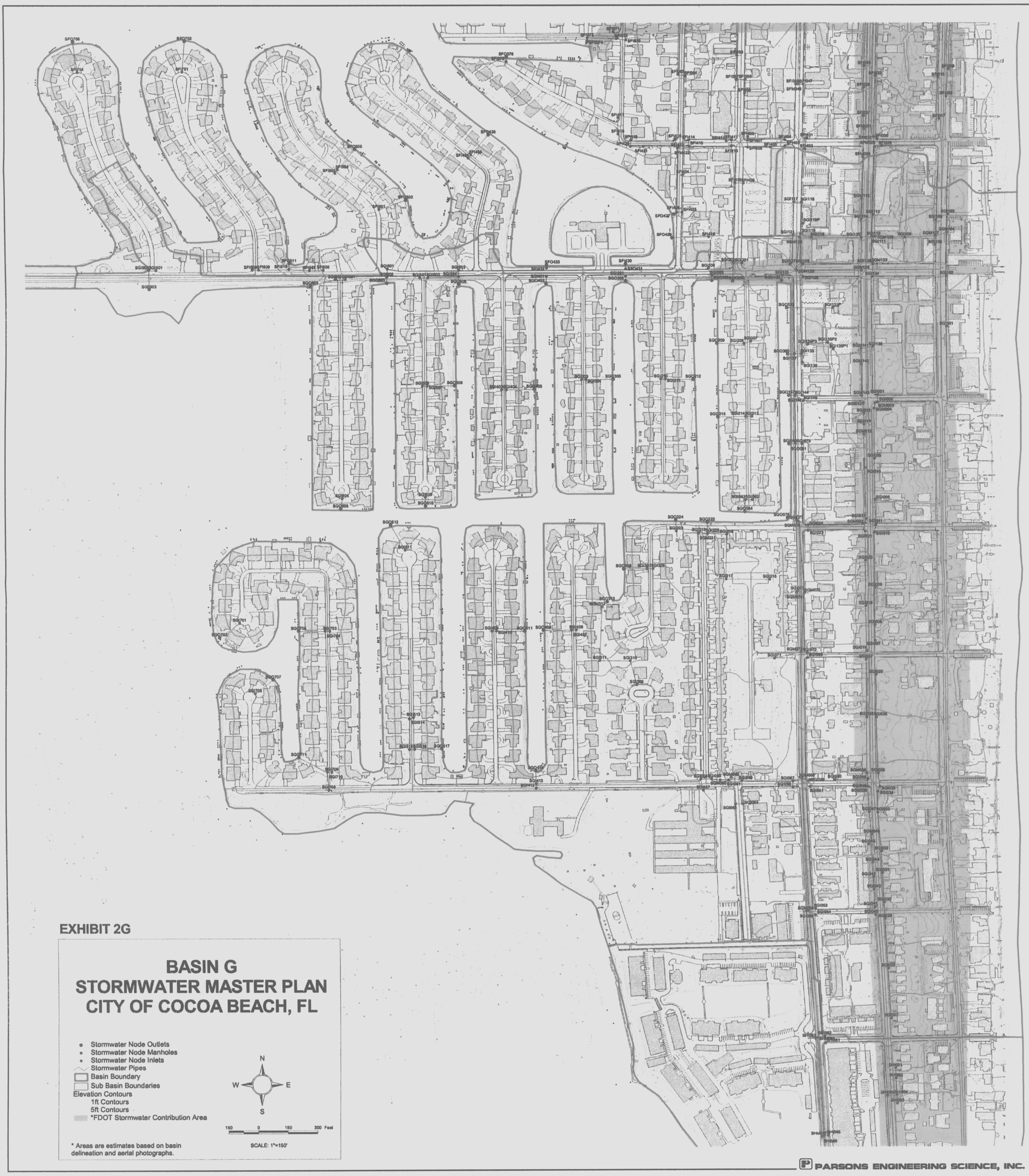
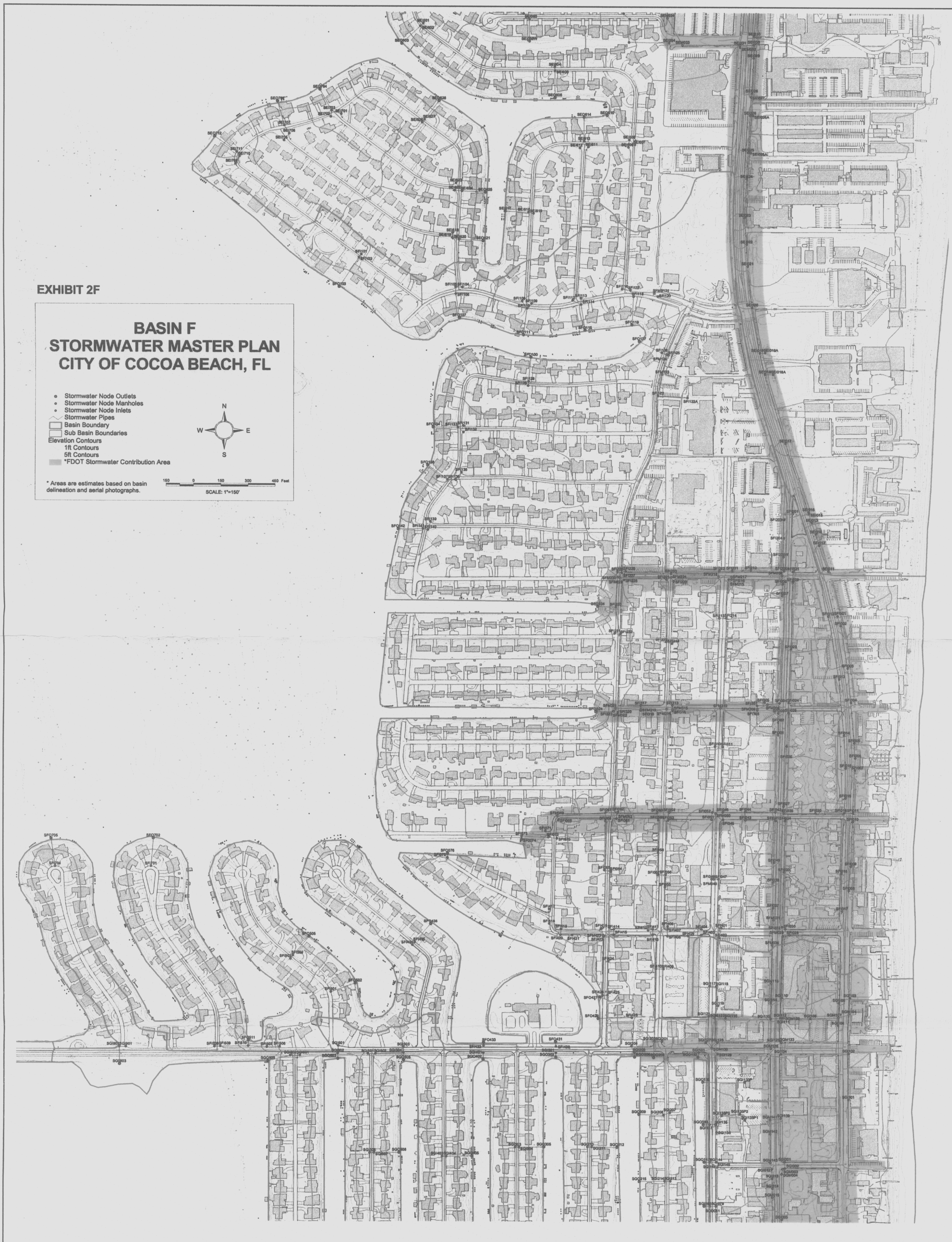


EXHIBIT 2G
BASIN G
STORMWATER MASTER PLAN
CITY OF COCOA BEACH, FL
Stormwater Node Outlets
Stormwater Node Manholes
Stormwater Node Inlets
Stormwater Pipes
Basin Boundary
Sub Basin Boundaries
Elevation Contours
1ft Contours
5ft Contours
*FDOT Stormwater Contribution Area
N
W
E
S
150
0
150
300 Feet
SCALE: 1"=150'
* Areas are estimates based on basin delineation and aerial photographs.
PARSONS ENGINEERING SCIENCE, INC.



PARSONS ENGINEERING SCIENCE, INC.

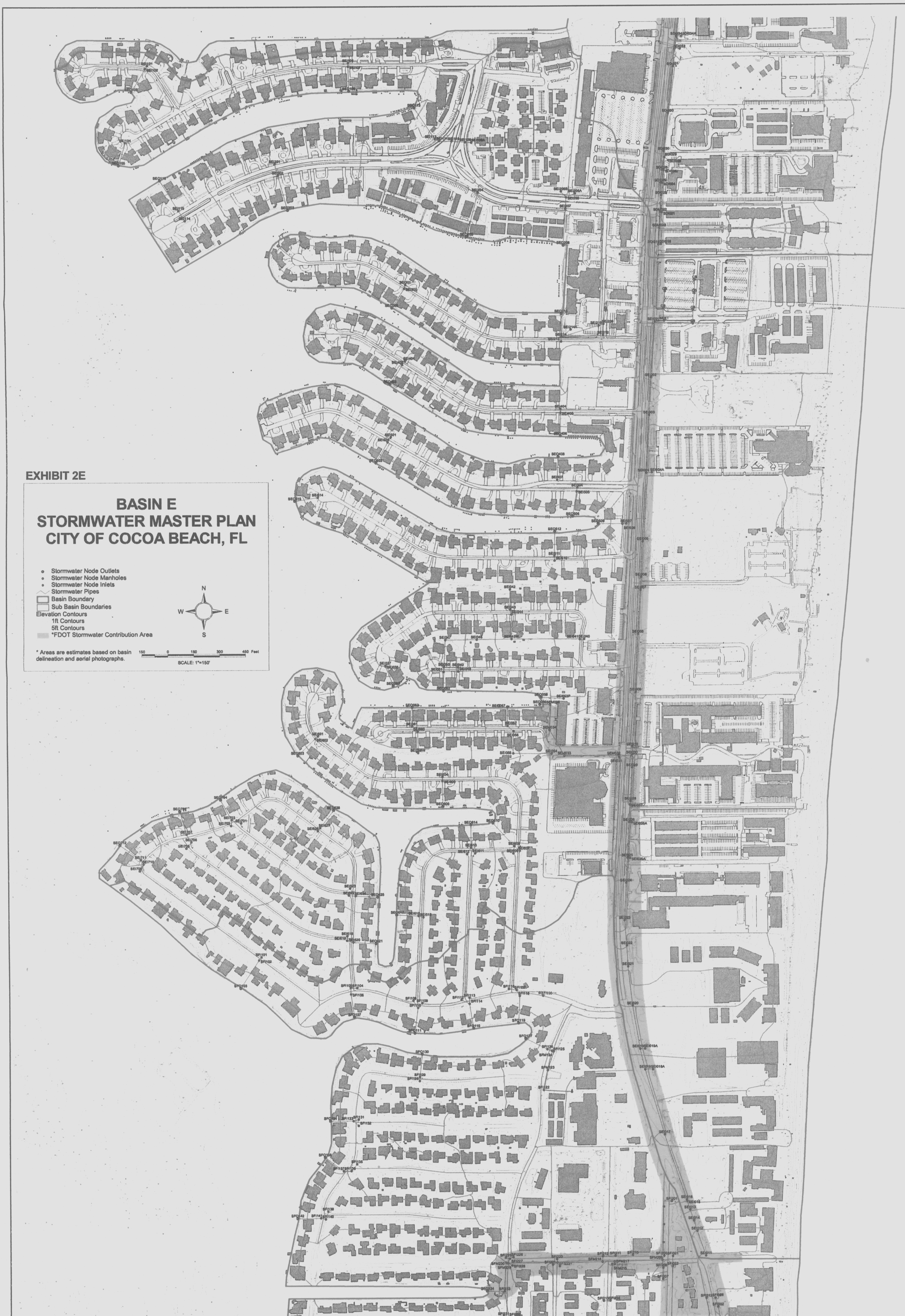


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EXHIBIT 2D
BASIN D
STORMWATER MASTER PLAN
CITY OF COCOA BEACH, FL
Stormwater Node Outlets
Stormwater Node Manholes
Stormwater Node Inlets
Stormwater Pipes
Basin Boundary
Sub Basin Boundaries
Elevation Contours
1ft Contours
5ft Contours
*FDOT Stormwater Contribution Area
N
E
S
W
SCALE: 1"=120'
* Areas are estimates based on basin delineation and aerial photographs.
PARSONS ENGINEERING SCIENCE, INC.

EXHIBIT 2C

BASIN C
STORMWATER MASTER PLAN
CITY OF COCOA BEACH, FL

- Stormwater Node Outlets
- Stormwater Node Manholes
- Stormwater Node Inlets
- Stormwater Pipes
- Basin Boundary
- Sub Basin Boundaries
- Elevation Contours
  - 1ft Contours
  - 5ft Contours
- *FDOT Stormwater Contribution Area

* Areas are estimates based on basin delineation and aerial photographs.

N E S W

100 0 100 200 300 Feet

SCALE: 1"=100'

PARSONS ENGINEERING SCIENCE, INC.

EXHIBIT 2B

BASIN B
STORMWATER MASTER PLAN
CITY OF COCOA BEACH, FL

- Stormwater Node Outlets
- Stormwater Node Manholes
- Stormwater Node Inlets
- Stormwater Pipes
- Basin Boundary
- Sub Basin Boundaries
- Elevation Contours
  - 1ft Contours
  - 5ft Contours
- *FDOT Stormwater Contribution Area

* Areas are estimates based on basin delineation and aerial photographs.

N, E, S, W

120 0 120 240 360 Feet

SCALE: 1"=120'

PARSONS ENGINEERING SCIENCE, INC.