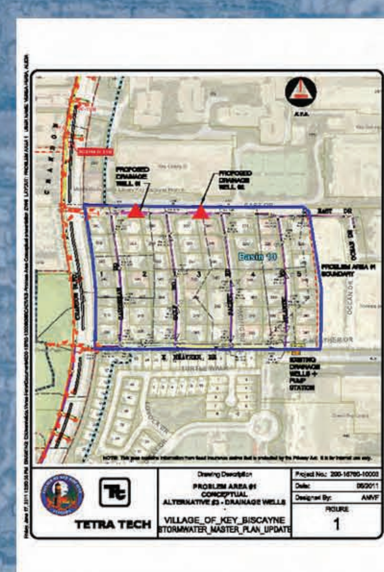
Stormwater Management Master Plan Update

Village of Key Biscayne

June 28, 2011



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VILLAGE OF KEY BISCAYNE
STORMWATER MASTER PLAN UPDATE

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Introduction

SECTION 1
INTRODUCTION

Tetra Tech was contracted by the Village of Key Biscayne (Village) on August 31, 2010 to prepare an update to the Village's Stormwater Management Master Plan (SWMMP). The previous SWMMP was completed in 1993.

This Stormwater Master Plan (SWMP) Update will:

- Improve and modernize the tools and methodologies used for planning and implementing stormwater improvements, as well as complying with regulatory requirements,
- Construct a hydraulic and hyrologic model for the purposes of this SWMP and future updates/addenda to this SWMP
- Identify the three highest priority areas
- Identify and evaluate alternatives
- Recommend improvements in the three highest priority areas
- Provide preliminary designs and costs for the recommended improvements
- Provide a funding snapshot for the recommended improvements

Tetra Tech collected detailed data on the stormwater system to create an electronic inventory of the current stormwater infrastructure, and utilized additional information to create a Geographic Information System (GIS) platform for the stormwater atlas. The GIS electronic format provides the Village the tool to continually update their system, as required, and view information in one location, unlike the previous paper copies of the stormwater atlas.

Once the inventory and stormwater atlas were brought up to current standards, they were utilized to construct a hydraulic and hydrologic (H&H) model to conduct evaluations related to this master plan. With the Village-wide H&H model, the Village will have a resource that can be used to analyze the next tier of problem areas that may exist within the existing drainage basins. The H&H model utilizes the same GIS platform created for the stormwater atlas, along with the electronic inventory. The H&H model was further developed to:

- Evaluate current existing conditions for various storm events to identify the deficiencies in the existing system;

- Analyze alternatives to alleviate flooding for the three (3) highest priority problem areas. For each problem area, Tetra Tech has provided up to three (3) alternatives solutions, and a recommendation to alleviate flooding; and
- Provide a tool which could be used for future addenda to this SWMP Update to identify projects to address lower priority areas after the highest priority projects have been implemented.

The final objective was to prepare preliminary designs and identify the related costs for each of the recommendations presented within this SWMP Update. These costs were coordinated with possible funding sources as well as the Stormwater Utility Rate Studied being prepared by others. Tetra Tech provided recommendations of the best benefit-to-cost assessment.

SECTION 2

Existing Conditions and Stormwater Management Systems

SECTION 2
EXISTING CONDITIONS AND STORMWATER MANAGEMENT SYSTEMS

2.1 EXISTING STUDY AREA

The project area encompasses the entire area within the Village municipal boundary, though the study area, for purposes of master plan recommendations, does not include the entire Village. The study area is described below, along with the characteristics that affect stormwater management planning. This stormwater master plan updates the previous master plan efforts by improving the utility atlas, including GIS mapping and running hydraulic/hydrologic models to determine the existing capacity of the system and defining the deficiencies by offering solution alternatives. **Figure 2.1** illustrates the limits of the Village.

2.1.1 Location

The Village of Key Biscayne is in Miami-Dade County, Florida. The Village is located in the center of an island (Key Biscayne), which is approximately 5.5 miles east of Downtown Miami. Access to the Village is by the Rickenbacker Causeway. The regional location of the Village is shown on **Figure 2.2**

The Village is approximately 850 acres bounded on the east by the Atlantic Ocean, the west by Biscayne Bay, the north by Crandon Park and the south by Bill Baggs State Park. The general location of the Village is shown on **Figure 2.3**.

2.1.2 Land Use

The existing land uses in the Village are shown on **Figure 2.4**. This figure indicates the Village is completely developed. Any change to future land use will be direct result from redevelopment. The study area is predominately single family homes, with an elementary school centrally located within the neighborhood and commercial development along Crandon Boulevard.

STUDY AREA MAP
STORMWATER MASTER PLAN UPDATE
VILLAGE OF KEY BISCAYNE, FLORIDA

Figure 2.1

Source: Miami- Dade GIS Data, Microsoft Virtual Earth

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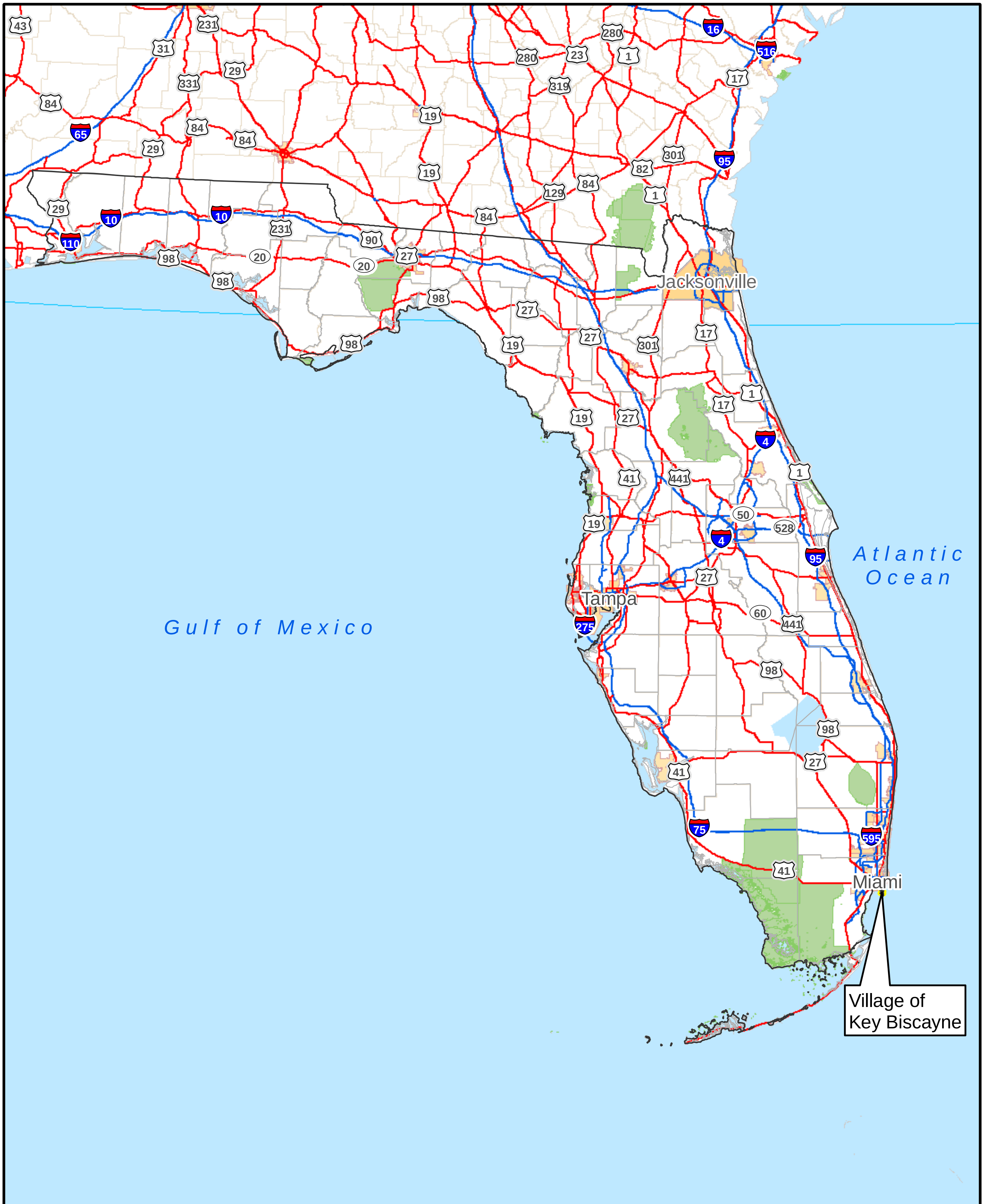

REGIONAL LOCATION MAP
STORMWATER MASTER PLAN UPDATE
VILLAGE OF KEY BISCAYNE, FLORIDA

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Figure 2.2

0 70 Miles

Source: Miami- Dade GIS Data,
Microsoft Virtual Earth

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GENERAL LOCATION MAP
STORMWATER MASTER PLAN UPDATE
VILLAGE OF KEY BISCAYNE, FLORIDA

Figure 2.3

Source: Miami- Dade GIS Data, Microsoft Virtual Earth

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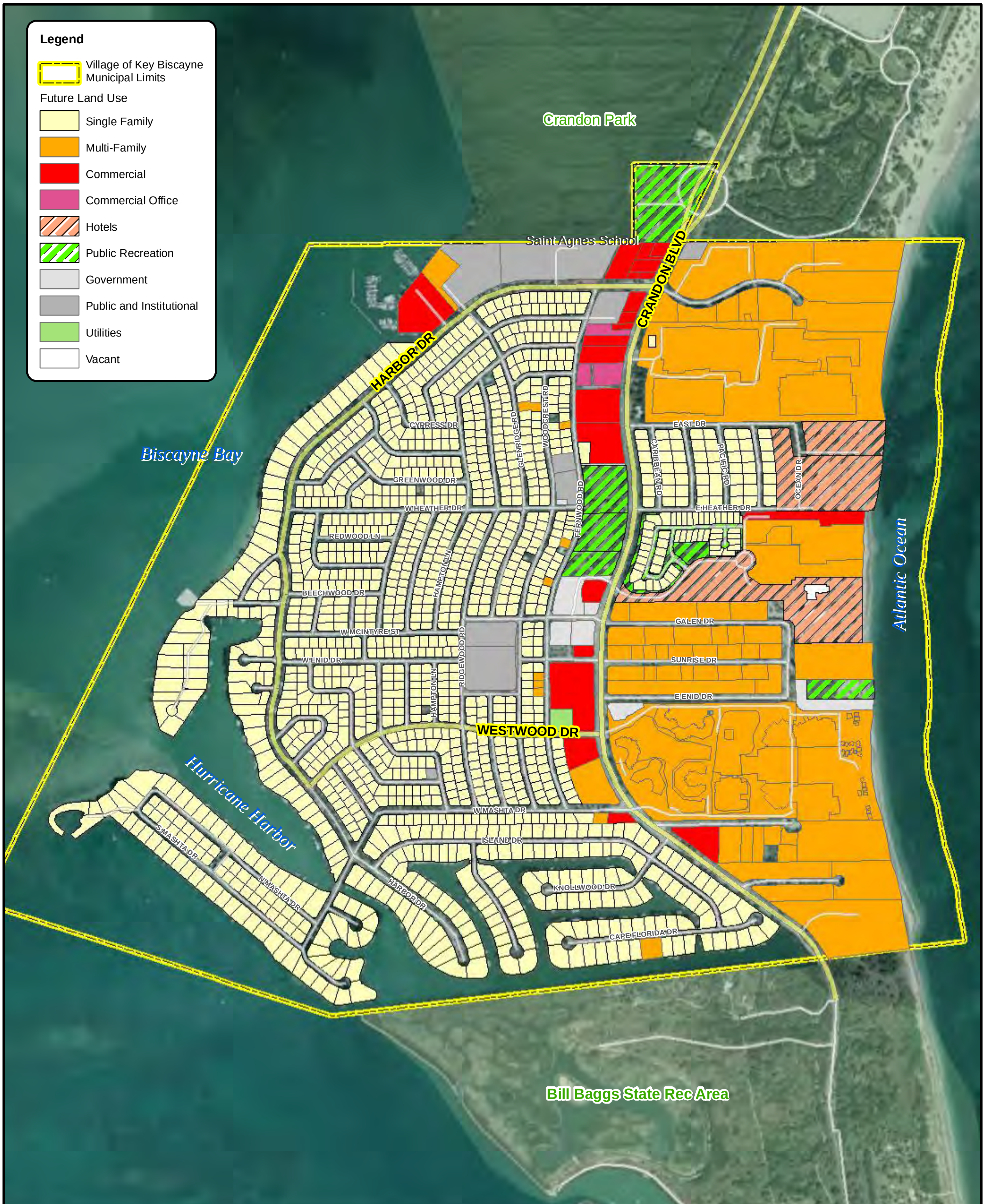

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FUTURE LAND USE MAP
STORMWATER MASTER PLAN UPDATE
VILLAGE OF KEY BISCAYNE, FLORIDA

Figure 2.4

0 1,200 Feet

Source: Miami- Dade GIS Data; Village of Key Biscayne Planning Data; Microsoft Virtual Earth

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The area east of Crandon Boulevard is a mixture of single family homes, hotels and high-rise residential development. This area has been fully developed since 1993; however some redevelopment is currently occurring, specifically where the Royal Sonesta Hotel was located.

It should be noted that examining the land use in the study area is for descriptive purposes only. This study pertains only to the land area encompassed by the public rights-of-way plus an additional 15 feet on either side. Land uses and the associated impervious/pervious characteristics outside of the study area were, therefore, not considered in the stormwater calculations and hydrologic/hydraulic modeling described in Section 3.

2.1.3 Topography

The public rights-of-way in the study area were previously surveyed by Williams, Hatfield & Stoner in 1997 and provided for the purposes of this Master Plan. This survey is included in **Appendix A**. In addition, LiDAR (light detection and ranging) data was obtained from the Miami-Dade County Department of Environmental Resources Management (DERM). General land contours were generated from the LiDAR data and are shown on **Figure 2.5**. The contours reflect the general slope of the roadways and low-lying areas. The raised house pads and landscape features were not considered in the contour modeling.

The datum referenced in the original survey for the Master Plan corresponded with the standards established by the National Geodetic Survey (NGS) and adopted by Miami-Dade County as per the National Geodetic Vertical Datum of 1929 (NGVD 29). For the purposes of this Master Plan update, the datum referenced will be the North American Vertical Datum of 1988 (NAVD 88) in accordance with Federal Emergency Management Agency (FEMA) requirements.

The topography on Key Biscayne is very flat. In general, the elevations of the roadways are approximately 3.5 to nearly 6 feet above mean sea level (msl). This is generally only 1.5 to 4 feet above the average high tide elevation

The low elevations are significant because the closer the outfall water elevation is to the land surface, the fewer options there are for stormwater management. The difference in elevation between water on the surface of the land and the outfall water elevation is referred to as "head".

VILLAGE OF KEY BISCAYNE FLORIDA

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LIDAR CONTOUR MAP
STORMWATER MASTER PLAN UPDATE
VILLAGE OF KEY BISCAYNE, FLORIDA

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Figure 2.5

0 1,200
Feet

Source: Miami- Dade GIS Data;
Miami-Dade LiDAR Data
Microsoft Virtual Earth

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This concept is central to stormwater management as it takes a certain difference in elevation, or head, to force water to drain or run off the land surface**.**

2.1.4 Water Table Characteristics

The elevation of the water table below the land surface is critical to stormwater management planning. The zone between the water table and the land surface is the area that can be used for soil storage of exfiltrated water and storage for retention/detention basins. The elevation of the water table also controls the available head to force storm water to drain into drainage wells.

The water table below Key Biscayne is completely influenced by tidal waters. The basis for future stormwater management planning in this study will use high tidal elevations in the bay as the tailwater condition for the Hydraulics and Hydrologic model.

2.1.5 Infiltration Rates

The soil infiltration rate, (the rate at which water will be absorbed by the ground), is very important for stormwater management planning. If water is absorbed quickly, there is less surface water runoff and more water can be removed from the land in a smaller amount of time. If water is absorbed slowly, there is more surface water runoff and larger amounts of land are necessary for stormwater retention purposes.

The soils on Key Biscayne are very silty, which means the soil particles are very small. These small particles do not allow water to soak into them very quickly. Water that does eventually infiltrate into the ground is stored in the soil above the water table until it is gradually drained. When the soil becomes saturated, infiltration is greatly reduced thus increasing the amount of surface water runoff from the remainder of the storm.

Existing geotechnical reports prepared by Langan Engineering and Environment Services, Inc., Florida Testing & Engineering, Inc., and Ardaman & Associates, which provided soil boring data and recent percolation tests, were reviewed to determine exfiltration rates. Exfiltration rate is the time it takes for water to be absorbed by the ground from a drainage pipe in a trench or well. The geotechnical test information is provided in **Appendix B**. This data shows that the silty soils in the Village occur as deep as 25 feet below ground and the percolation rate of the soil is only 0.0001 cubic feet per second (per square foot per foot of head), which is very slow.

2.1.6 Rainfall

The amount of rainfall affecting an area and the correlation between rain events and flooding is a good indicator of the amount of rain that the existing stormwater management system is designed to handle. The amount of rain in the storm that can be handled by the stormwater system is correlated to its probability of exceedance in years (i.e., one time in two years, one time in five years, etc). This storm is then referred to as the "design storm" or 'level of service" for which the stormwater system can be expected to function properly. A storm with greater amounts of rainfall than the design storm will generate more runoff than the stormwater management system is designed to remove and some flooding may result depending on the specific storm's intensity and duration.

Unfortunately, no rainfall data is available for Key Biscayne specifically. The closest rain gauge is located at Miami International Airport. South Florida Water Management District (SFWMD) standard rainfall and distribution curves for the various storms, as provided in **Appendix** C, therefore, were used to calculate the amount of runoff that should be anticipated by the future stormwater management systems in the study area.

2.1.7 Stormwater Management Regulations

Stormwater management regulations relating to both water quality (pollution) and water quantity (flooding) have become more stringent at all levels of government, Federal, State and County. Agencies regulating the quality of stormwater discharge include the Florida Department of Environmental Protection (FDEP), the South Florida Water Management District (SFWMD), and Miami-Dade County Department of Environmental Resource Management (DERM).

The two agencies that affect activities on Key Biscayne the most are the FDEP administering National Pollution Discharge Elimination System (NPDES) regulations and DERM with their water quality and water quantity standards for facility design.

Tetra Tech examined historical permits, on the South Florida Water Management Districts (SFWMD) online database, as well as the Miami-Dade Department of Environmental Resources Management (DERM) online database for past permits required for projects located within the Village of Key Biscayne. The permit conditions were reviewed to determine if there were any additional mitigation compliance and inspection requirements. Several historical permits were found for private development projects with greater than one acre of disturbed land. The private developments are mainly condominium residential units or hotels. These have independent systems that do not belong to the Village nor are connected to the drainage system within the public right-of-way. Therefore, no additional mitigation compliance and inspection requirements have been issued by permitting agencies affecting the Village.

2.1.7.1 National Pollution Discharge Elimination System (NPDES)

NPDES is an acronym for the National Pollutant Discharge Elimination System. The National Pollutant Discharge Elimination System (NPDES) is an Environmental Protection Agency (EPA) program designed to eliminate stormwater pollutant discharges to receiving waters of the United States. In 1987, the EPA was required under Section 402 (p) of the Clean Water Act (N40CFR Part 112.26) to establish final regulation governing stormwater discharge permit application requirements. The permit application contains capital improvement plans and storm water best management practices to be applied to improve the quality of stormwater discharge and identifies a dedicated funding source to pay for these improvements.

The permit requirements were broken into two phases, Phase I and Phase II. Phase I requirements went into effect in 1990 and were designed to cover large municipalities (population > 100,000), industrial activities, and construction sites that disturbed 5 acres or more. Phase I permitting was regulated by EPA. Phase II permit requirements went into effect in 1999. The Phase II program was designed to cover municipalities not regulated under the phase I program, and construction sites that disturb between 1 and 5 acres. In October of 2000, the EPA authorized the Florida Department of Environmental Protection (FDEP) to implement and maintain the NPDES permitting requirements in the State of Florida.

The Village of Key Biscayne is currently permitted under Phase I of the program through FDEP, for Municipal Separate Storm Sewer Systems as a co-permittee with Miami-Dade County under the EPA NPDES Permit No. FLS000003. The permit is an ongoing process that requires various action items to be performed in different permit years along with annual reporting of the implementation of these actions.

Tetra Tech assists the Village in maintaining compliance with the requirements of the NPDES permit by preparing the annual report for submittal to DERM and FDEP. All new construction must comply with DERM and NDPES requirements for retrofitting of existing systems to acceptable standards with regards to the quality of storm water discharged. The Village is in Year 7 of the Phase I permit. Due to litigation between the FDEP and EPA regarding language and implementation of additional activities, the FDEP had not been able to issue the renewal of the permit in the Year 4 Recertification. A compromise was reached by the agencies and the Draft Permit for Miami-Dade County was issued November 2010.

2.1.7.2 South Florida Water Management District (SFWMD)

Regulatory jurisdiction has been delegated to the Department of Environmental Resources Management in Miami-Dade County.

2.1.7.3 Miami-Dade County Department of Environmental Resources Management (DERM)

DERM adopted the SFWMD standards for stormwater management systems which must be complied with to be permitted. These regulations are described in **Appendix D** and the key aspects of these regulations that affect the drainage alternatives to be considered for the Village are summarized below.

<u>The Design Storm - Water Quality Requirements</u>

DERM has established design storm frequencies and flood limits for various street cross-sections. For two lane roads in residential and commercial areas, such as those in the study area, the street drainage system must be able to remove the runoff from a storm with a 5-year frequency. The use of the design storm was one of the critical elements in determining what type of drainage system was used in the study area in regard to the quantity of water that has been managed.

<u>Retention, Pretreatment - Water Quality Requirements</u>

DERM regulations state that where full on site retention cannot be provided, emergency overflow may be permitted if there are facilities in place that will provide retention for the first inch of runoff. Permits are required for emergency overflow into any water body in Miami-Dade County.

The purpose of providing retention and pretreatment for the first inch of runoff is that this first flush of water is most likely to contain the heaviest concentration of pollutants. Pretreatment of runoff must be provided prior to discharge into the seepage or other exfiltration facility.

This pretreatment is performed by a variety of methods such as swale retention or pollution control devices that serve as grease and oil separators as well as settling chambers. The Village has implemented the use of pollutant retardant drainage structures and exfiltration trenches for this purpose.

2.1.7.4 Florida Department of Environmental Protection (FDEP)

The Florida Department of Environmental Protection regulates underground injections through its Underground Injection Control (UIC) program, which consists of a team of geologists and engineers dedicated to protecting the State of Florida's underground sources of drinking water (USDW) while maintaining the lawful option of disposal of appropriately treated fluids via underground injection wells. A USDW is defined as an aquifer that contains a total dissolved solids concentration of less than 10,000 milligrams per liter. The UIC program also is dedicated to preventing degradation of the quality of other aquifers adjacent to the injection zone. Subsurface injection, the practice of emplacing fluids in a permeable underground aquifer by gravity flow or under pressure through an injection well, is one of a variety of wastewater disposal or reuse methods used in Florida. The five classes of injection wells:

- Class I - Wells used to inject hazardous waste (new hazardous waste wells were banned in 1983), nonhazardous waste, or municipal waste below the lowermost USDW.
- Class II - Wells used to inject fluids associated with the production of oil and natural gas or fluids used to enhance hydrocarbon recovery.
- Class III - Wells which inject fluids for extraction of minerals (none in Florida).
- Class IV - Wells or septic systems which are used to dispose of hazardous or radioactive wastes into or above a USDW. (Banned in Florida.)
- Class V - Wells not included in the other well classes which generally inject nonhazardous fluid into or above a USDW.

The class of injection well that is currently utilized by the Village of Key Biscayne is Class V. Class V wells are used for the storage or disposal of fluids into or above a USDW. The fluid injected must meet appropriate criteria as determined by the classification of the receiving aquifer. Common types of Class V wells include air conditioning return flow wells, swimming pool drainage wells, stormwater drainage wells, lake level control wells, domestic waste wells, and aquifer storage and recovery (ASR) wells. Drainage wells proposed as part of this stormwater master plan will be regulated by the FDEP under this program.

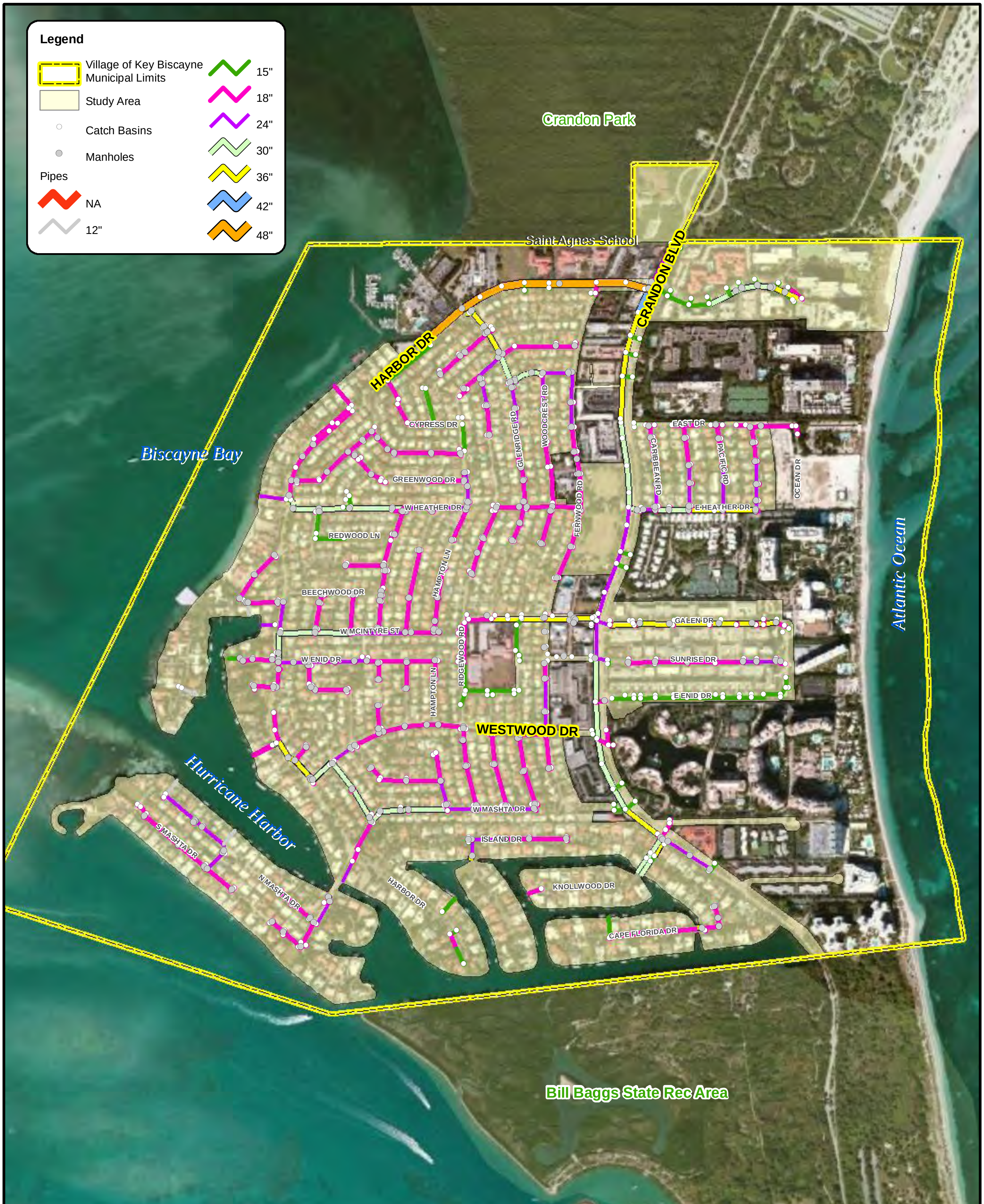
2.2 EXISTING STORMWATER MANAGEMENT SYSTEMS

The drainage systems currently in place in the Village are a combination of positive drainage systems and seepage systems. A positive drainage system refers to one in which water is transported directly from the land to a continuous outfall to the bay or ocean. A seepage system is one that utilizes the permeability of the soil for both retention (temporary storage) and cleansing of a portion of the stormwater. Once the soil is saturated in a seepage system, the remainder of the water to be drained becomes runoff and is transported by the positive drainage system to the outfall.

The information on the existing drainage system was gathered from various sources. These include:

- Field survey;
- Crandon Boulevard widening construction plans - FDOT Project Number 87052-3622;
- Miami-Dade County DERM Stormwater Monitoring and Evaluation Section;
- Recorded DERM outfall permits;
- Plans from C.AP. Engineering Consultants, Inc., Project #30E305.

The Village's existing stormwater collection system is shown on **Figure 2.6**. Figure 2.6 shows the general location of facilities and where no drainage infrastructure within the public right of way is in place. Additional details on the existing systems are described in the following subsections.



EXISTING STORMWATER SYSTEM MAP
STORMWATER MASTER PLAN UPDATE
VILLAGE OF KEY BISCAYNE, FLORIDA

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Source: Miami- Dade GIS Data
Microsoft Virtual Earth

Figure 2.6

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2.2.1 Existing Stormwater Management System Mapping

Understanding the existing facilities and their locations relative to flooding areas is essential. The following subsections describe the data collected and mapping procedures utilized.

2.2.1.1 Data Collection

Gathering data is an important element of the successful completion of a stormwater master plan update. Typically, documents are obtained from multiple sources. Tetra Tech compiled the following documentation for mapping purposes to prepare the H&H model in coordination with DERM, Miami-Dade County Public Works, Village Public Works Department, FEMA, and other consultants:

- Crandon Boulevard and Harbor Drive Improvements.
- Capital Improvement Projects (CIPs) and Repair and Replacement Projects (R&R) completed since 1997 through December 2008 which included Buttonwood, Glenridge & Woodcrest Drive Drainage Improvements, East Enid Drive Traffic Calming & Roadway Improvements, Holiday Colony Improvements which included the pump station for Ocean Lane Drive and improvements along Sunrise Drive.
- Letter of Map Revisions (LOMRs) filed in the vicinity of the Village that do not show up on current FEMA flood maps.
- LiDAR derived 1 ft topographic contours provided by Miami-Dade County
- 2009 FEMA DFIRM (Digital Flood Insurance Rate Map).
- Miami Dade Aerial Imagery (2007, 2010)
- Field investigation and surveyed information for Galen Drive; Knollwood Drive from Crandon Boulevard to Island Drive; and Harbor Drive from Crandon Boulevard to the Village Yacht Club as conducted 10/5/2010 through 10/7/2010.

The base map of the Village stormwater system was obtained from archived electronic computer aided drafting (CAD) files.

2.2.1.2 Mapping

A comprehensive map of all stormwater related datasets is needed to produce an effective stormwater master plan update. In its previous state, the Village's existing stormwater infrastructure was located in multiple CAD drawings with differing horizontal and vertical datums. Not only was it difficult to look at the most recent state of system as a whole, but it was impossible to look at the system in relation to existing datasets published in GIS by other entities. These other datasets include items such as USDA soils, land use classifications, FEMA flood maps, and topographic contours.

All of the Village's existing stormwater infrastructure that was previously in CAD format was organized and converted into a Geographic Information System (GIS) database. In general, the conversion from CAD to GIS is a four step process. First, a two dimensional spatial adjustment of the existing CAD datasets is performed. This places all the stormwater assets in the same 2-D plan view space. Secondly, the population of all pertinent attribute for stormwater infrastructure items are recorded within tables in the database. Attributes include parameters such as pipe diameter, length, material, invert elevations, asset ID, and flow direction. Third, a three dimensional adjustment of elevations into a common vertical datum is performed. In this case all elevations were adjusted to the North American Vertical Datum of 1988 (NAVD 88), as is required by FEMA. The majority of the elevations in the CAD based infrastructure were recorded the National Geodetic Vertical Datum of 1929 (NGVD 29) and were converted to NAVD88. Within the Village extents, on average, NAVD88 elevations are 1.56 ft lower than NGVD 29. Lastly, clean-up and analysis performed to identify areas where information is lacking or inadequate for stormwater modeling purposes. Survey may be required to fill in these areas and populated in the database. The GIS database is then used as the basis to perform the stormwater modeling and create spatial accurate maps throughout the report. While the GIS database contains stormwater infrastructure, there are other GIS based mapping assets utilized in the mapping process that include the following:

Mapping Assets:

- Existing Stormwater System (GIS Database)
    - Pipes
    - Catch Basin Location
    - Manhole Locations
    - Outfall Locations
    - Drainage Well Locations
    - Stormwater Pump Station Locations

- Historical Sub-basin Delineation
  - Updated Sub-basin Delineation
  - Exfiltration Trenches
  - Auger Wells
- Existing Floodplain Map and Atlas - (2009 FEMA DFIRM)
- Repetitive Loss Properties
- Existing and Localized Flooding Areas
- LiDAR Derived Topographic Contour Map - (Miami-Dade)
- Digital Elevation Model
- Future Land Use - (VKB)
- Impaired Water Bodies (FL DEP)
- USDA NRCS Soil Survey for Miami-Dade County
- Land Use /Land Cover (SFWMD 2005)

2.2.1.3 Drainage Basin Delineation

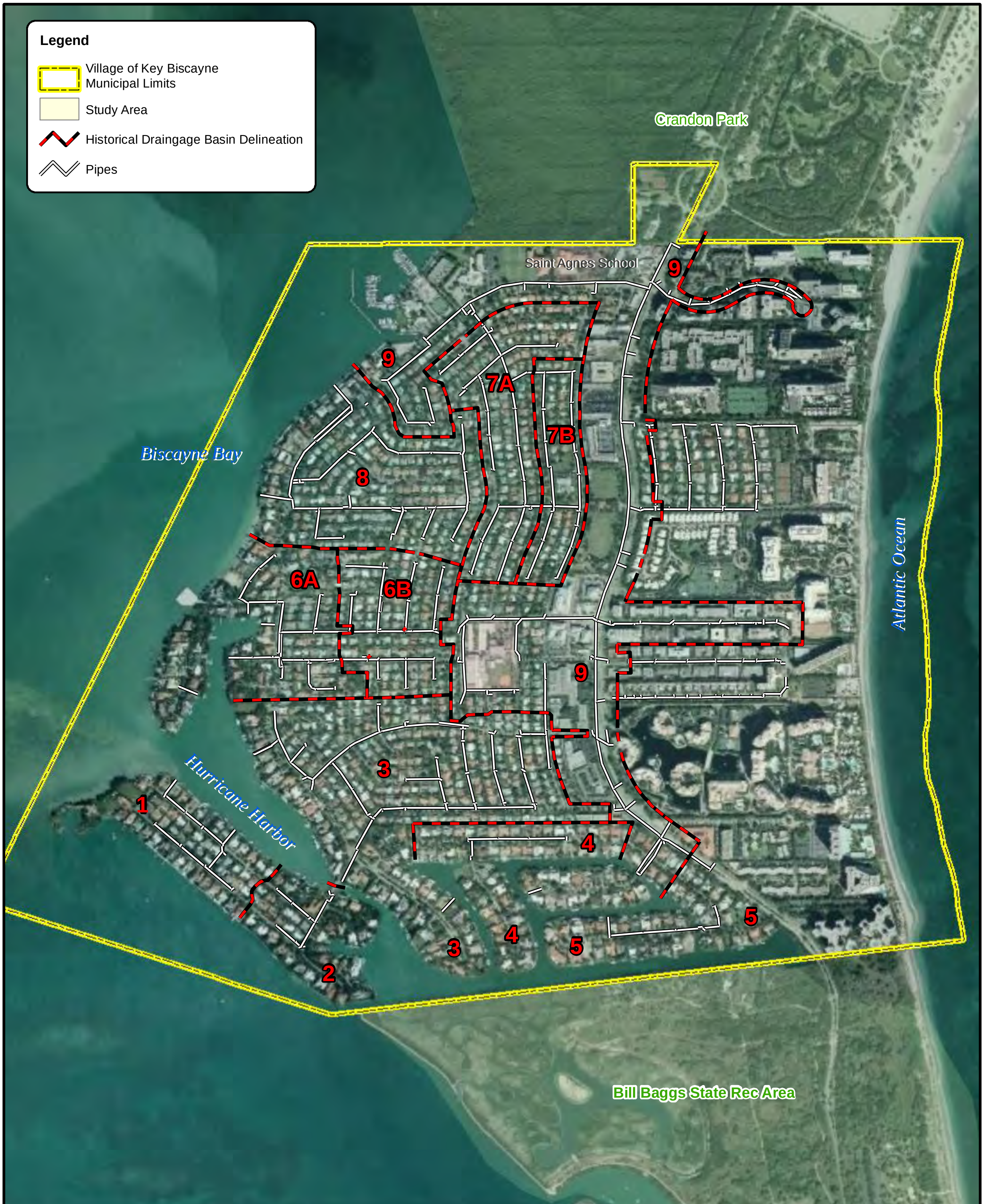
The Village was originally divided into nine drainage basins. Based on survey data, eight of the basins were developed into the existing stormwater collection system that are identified in **Figure 2.7.**

The pervious/impervious percentages were calculated for each drainage basin. Pervious area is not paved and provides an opportunity for some exfiltration. Impervious area is paved or otherwise modified from its natural condition in a manner that precludes exfiltration. This percentage, therefore, is very important when calculating the amount of water that must be retained (the first inch of runoff) to address water quality issues and entering the drainage system.

The characteristics of the existing drainage basins including their area (based on road right-of-way plus 15 feet on either side), percent impervious, and average storage volume of swales (assuming restoration in some areas), are listed in **Table 2.1**.

2.2.1.4 Summary

The existing facilities and their locations have been documented in the previous subsections. The overall system atlas is provided in **Appendix E** and the existing drainage structure inventory is included **Appendix F**.



VILLAGE OF KEY BISCAYNE FLORIDA

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HISTORICAL DRAINAGE BASIN DELINEATION
STORMWATER MASTER PLAN UPDATE
VILLAGE OF KEY BISCAYNE, FLORIDA

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Figure 2.7

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Feet

Source: Miami- Dade GIS Data
Microsoft Virtual Earth
VKB Stormwater Master Plan

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Table 2.1 – Existing Drainage Basin Characteristics

Basin Number	DRAINAGE AREA			SWALE STORAGE		
	Length (LF)	Width (LF)	Area (Acres)	Length (LF)	Area (SF)	Volume (CF)
1	3,100	80	5.7	5,450	1.87	10,219
2	1,900	80		3,750	1.87	
	700	100	5.1	900	2.87	9,619
3	3,050	80		6,400	1.87	
	920	100		1,450	2.87	
	3,000	130		5,900	4	
	5,700	80		11,400	1.87	
	1,750	100	31.2	2,600	4.7	72,931
4	3,050	80	5.6	5,600	1.87	10,500
5	2,400	80	4.4	4,750	1.87	8,906
6	10,300	80		20,600	1.87	
	1,350	130	22.9	2,400	4.75	50,025
7	13,000	80	23.9	26,200	1.87	49,125
8	7,700	80		15,200	1.87	
	1,700	130	19.2	3,300	4.7	44,175
TOTAL:			118.1		TOTAL:	255,500

The Village of Key Biscayne is a barrier island to the City of Miami located between the Atlantic Ocean on the east and the Biscayne Bay on the west. The original Stormwater Management Master Plan (SWMMP) isolated the drainage basins to a 30-foot-wide corridor along the public right-of-way and utilized roadway elevation surveys to approximate the basin divides. This SWMP Update divides the watersheds into subcatchments based on the elevation contours compiled from the Miami Dade County LiDAR, which represents the best available topographic data for this island. This delineation is more representative of the actual drainage throughout the Village. The watershed delineation was performed by the InfoSWMM 9.0 Subcatchment Manager Extension tool.

Most of the public infrastructure within the Village is located within the single family residential land use and some high rise residential land uses and discharges into the public system. Therefore, the modeling and CIP efforts are mainly concentrated within these land uses and exclude the commercial properties and the properties known to provide on-site storm water treatment. The same 1-foot contours from the Miami Dade County LiDAR were used to determine the local subcatchment delineations. The updated basins delineation is shown in

Figure 2.8 with the summary of characteristics included in **Table 2.2**, located at the end of this because of its length.

2.2.2 Positive Outfalls

There are 17 outfalls from individual drainage systems permitted by DERM in the Village. The outfalls range from 8" to 48" in size and were permitted and installed between 1969 and 1992. Many of the outfalls were constructed between residential lots, which limit access to them. It could not be determined, therefore, if all of these outfalls are open and functioning. Some may be silted over or otherwise inoperable. Positive outfall locations are shown in **Figure 2.9**.

2.2.3 Auger Wells

One primary component of the Village's original exfiltration (seepage) system was the 15-inch auger well installed to a depth of 10 feet and lined with gravel. Auger wells consisted of a catch basin atop a vertical perforated corrugated aluminum pipe with a depth of 10 feet. These wells were installed in many locations along the public rights-of-way throughout the Village. **Figure 2.10** shows a typical cross section of an auger well.

Once in an auger well, the water seeps through the holes in the pipe, filters through the gravel around the pipe (to help remove pollutants) and infiltrates into the soil around the well. Unfortunately, the soils in the Village at 10 feet of depth are very silty and thus the water infiltrates very slowly.

In addition, these wells are not connected by underground piping to any other parts of the drainage system. This minimizes the long term effectiveness of these wells because the water standing in the wells has no outlet, other than very slow exfiltration, so additional stormwater must either be accommodated by the positive drainage system or creates localized ponding on the land.

The Village is no longer utilizing auger wells and many have been decommissioned for the aforementioned reasons. Therefore, auger wells will not be considered in the hydraulic modeling or proposed as part of this master plan.

UPDATED DRAINAGE BASIN DELINEATION
STORMWATER MASTER PLAN UPDATE
VILLAGE OF KEY BISCAYNE, FLORIDA

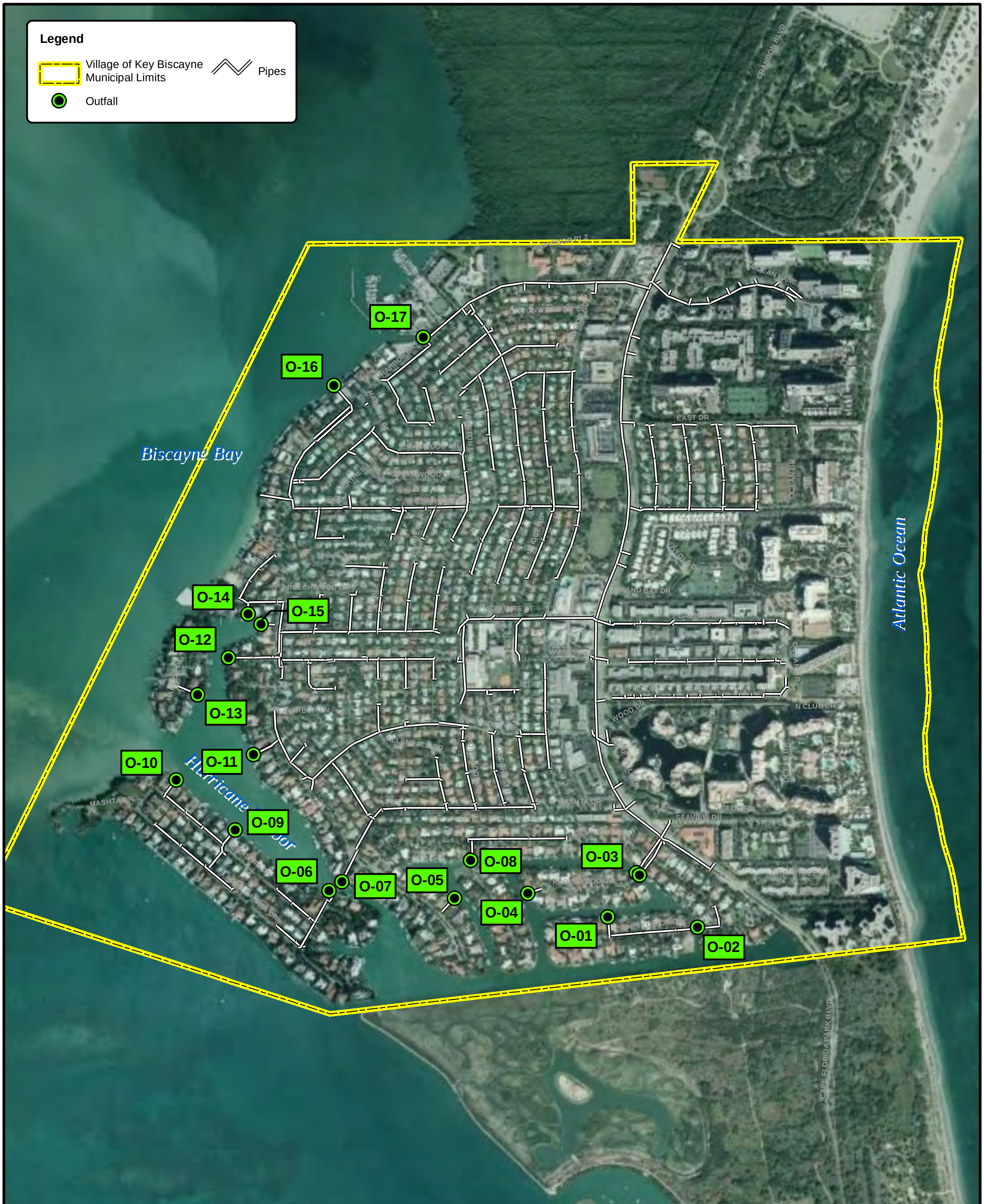
TETRA TECH

0 1,200 Feet

Source: Miami- Dade GIS Data
Microsoft Virtual Earth

Figure 2.8

File: P:\IER\15760\200-15760-10003\GIS\Maps\APF2.8.mxd
Printing Date: 03/23/2011
Drawn By: AMM

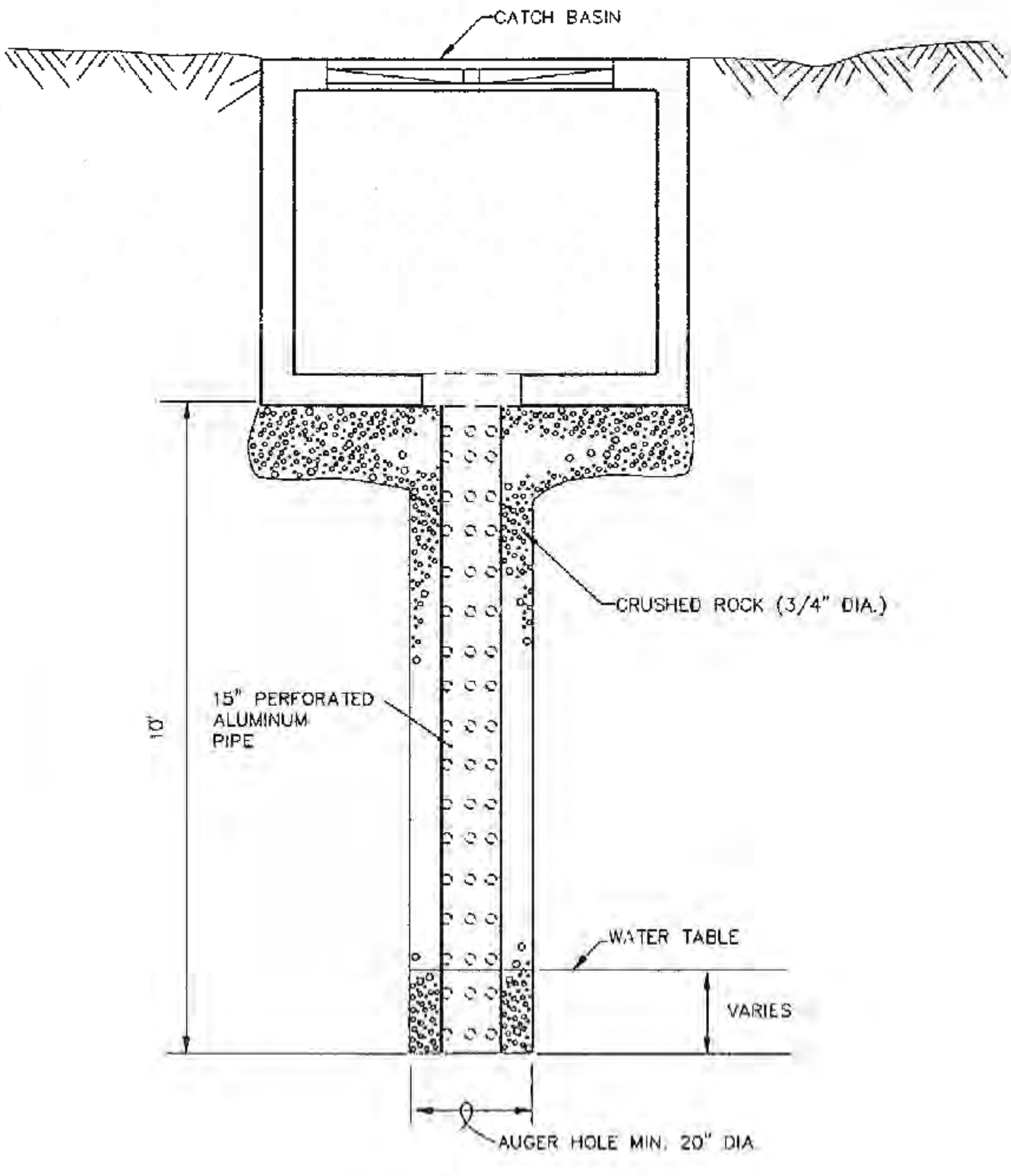


OUTFALL LOCATION MAP
STORMWATER MASTER PLAN UPDATE
VILLAGE OF KEY BISCAYNE, FLORIDA

Figure 2.9

Source: Miami- Dade GIS Data
Microsoft Virtual Earth

File: P:\IER\15760\200-15760-10003\GIS\Maps\APF2.9.mxd
Printing Date: 11/22/2010
Drawn By: AMM



CROSS SECTION

TETRA TECH	TYPICAL AUGER WELL STORMWATER MASTER PLAN UPDATE VILLAGE OF KEY BISCAYNE, FLORIDA	Figure 2.10	NOT TO SCALE Source: Miami- Dade GIS Data, Microsoft Virtual Earth File: P:\IER\15760\200-15760-10003\GIS\Maps\APF2.10.mxd Printing Date: 11/22/2010 Drawn By: AMM

2.2.4 Exfiltration Trenches

Exfiltration trenches have been installed in a small area by the Village Hall as indicated in **Figure 2.11**. An exfiltration trench is a perforated pipe laid in a trench 10 to 15 feet deep and surrounded by gravel and a filter material (see **Figure 2.12**). These drains function much like the auger wells with the primary difference being they are laid horizontally rather than vertically and have a greater surface area to facilitate exfiltration.

These exfiltration trenches or french drains provide some water storage in minor storm events but will be less productive during heavy and prolonged rainfalls. This is, again, due to the low permeability of the Village's soils at such shallow depths.

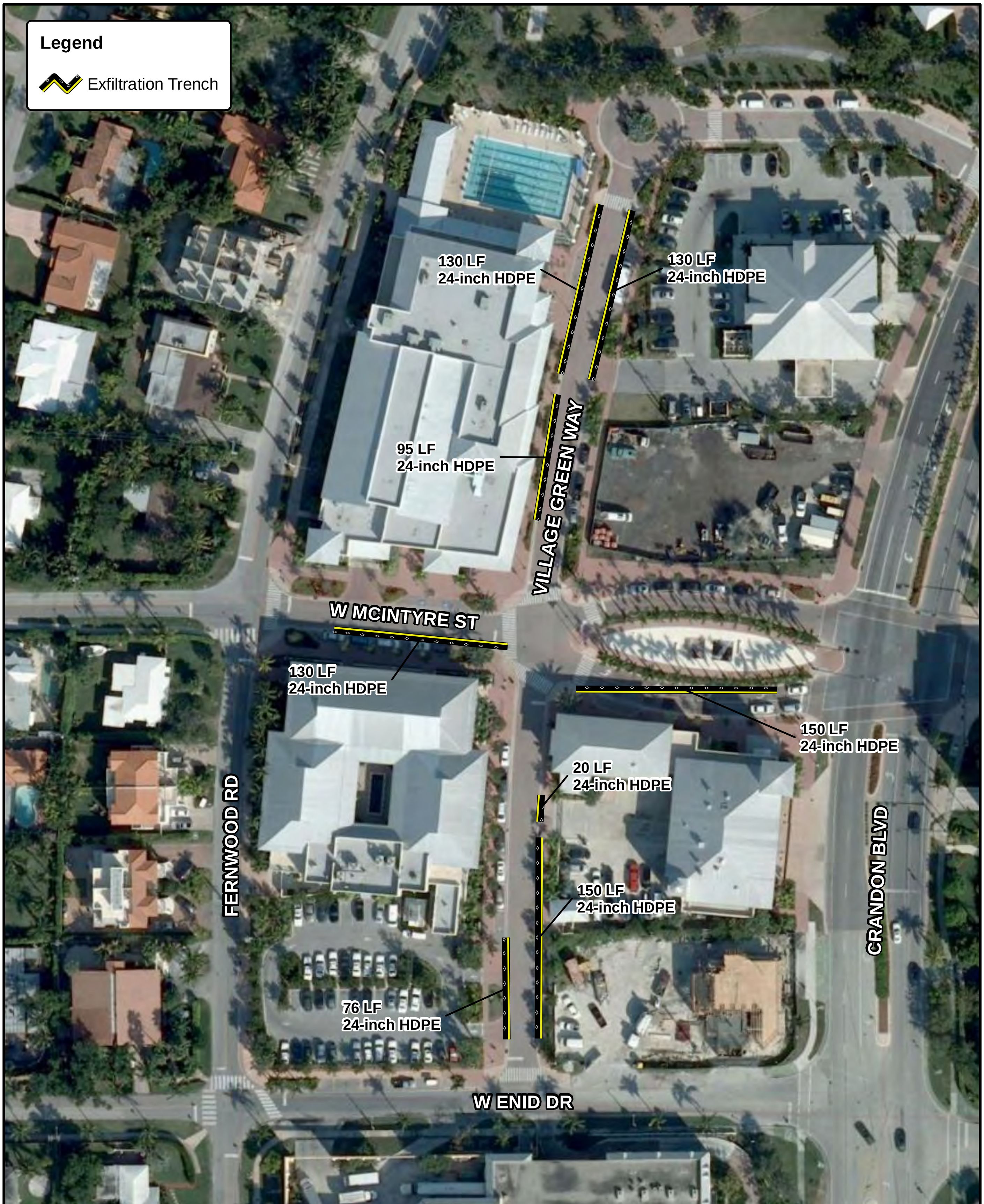
2.2.5 Stormwater Pump Stations and Injection Drainage Wells

The Village of Key Biscayne owns and operates two stormwater pump stations, which discharge to 28 injection drainage wells as part of their stormwater system.

The drainage wells function either by injection or by gravity. The existing stormwater drainage collection system connects to the deep injection wells throughout the Village as shown in **Figure 2.13**. The Village has routinely maintained and cleaned the system pipes and structures. The wells were in need of rehabilitation in order to function properly and efficiently.

In January 2010, a Village wide storm drainage well inspection report was conducted. All wells located throughout the Village were inspected. The results indicated that 27 wells were in need of rehabilitation. These 27 wells have been redeveloped to their original depths and tested with capacities of 800 gpm/ft of available head. Most of the wells are exceeding their intended capacities. The project was completed in September 2010 with a total cost of $293,080, which was funded in part by a matching grant from the SFWMD. The results of the latest performance tests as provided by Jaffer Well Drilling are provided in **Appendix G**.

Figure 2.14 displays the location of the two existing stormwater pump stations within the Village. These pump stations were also upgraded in 2010. Pump Station No. OL1 (PS OL1) is located



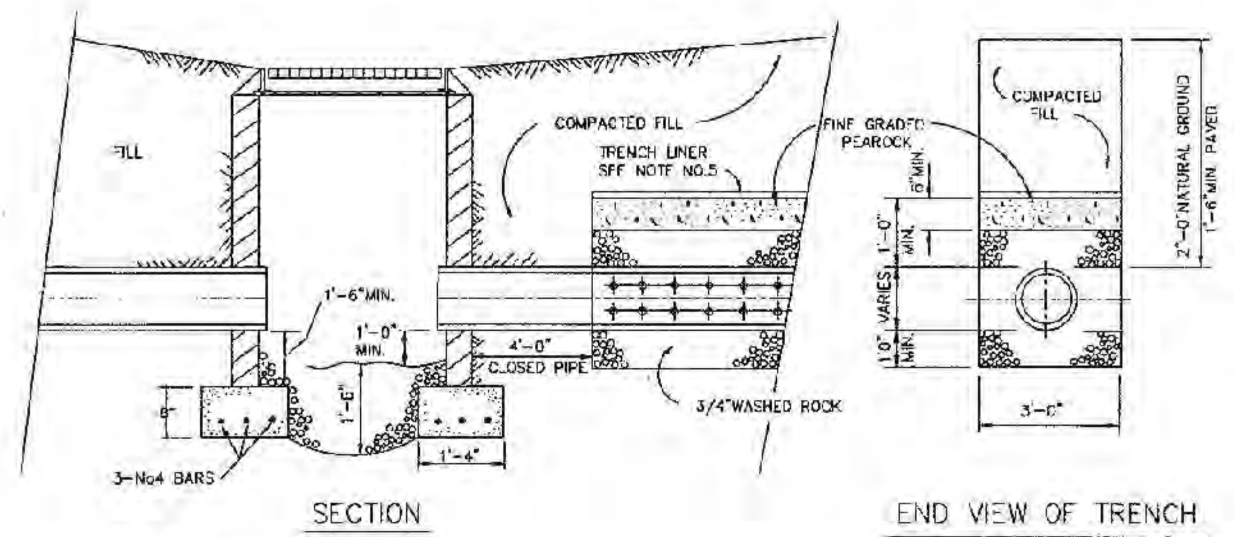
TETRA TECH

EXFILTRATION LOCATION MAP
STORMWATER MASTER PLAN UPDATE
VILLAGE OF KEY BISCAYNE, FLORIDA

Figure 2.11

Source: Miami- Dade GIS Data
Microsoft Virtual Earth

File: P:\IER\15760\200-15760-10003\GIS\Maps\APF2.11.mxd
Printing Date: 03/04/2010
Drawn By: AMM



NOTES

1. DRAIN FIELD MAY BE OF SLOTTED CONCRETE PIPE OR PERFORATED METAL PIPE.
2. PIPES SHALL TERMINATE 2 FEET FROM END OF TRENCH OR CONNECT TO ADDITIONAL CATCH BASINS AS REQUIRED.
3. COVER PIPE ENDS WITH NO. 10 GALVANIZED OR ALUMINUM SCREEN. OPENING SHALL BE NO LARGER THAN 1/2" x 1/2".
4. BALLAST ROCK SHALL BE FROM FRESH WATER WASHED FREE OF DELETERIOUS MATTER.
5. SIDES AND TOP OF TRENCH SHALL BE LINED WITH A PLASTIC BLANKET (GEOTEXTILE FABRIC) AND SHALL COMPLY WITH F.D.O.T. "STANDARD SPECIFICATIONS FOR ROAD AND BRIDGE CONSTRUCTION" AND SECTION 985, 1986 EDITION

EXFILTRATION TRENCH

TETRA TECH

TYPICAL TRENCH DRAIN
STORMWATER MASTER PLAN UPDATE
VILLAGE OF KEY BISCAYNE, FLORIDA

N

Figure 2.12

NOT TO SCALE

Source: Miami- Dade GIS Data, Microsoft Virtual Earth

File: P:\IER\15760\200-15760-10003\GIS\Maps\APF2.12.mxd
Printing Date: 11/22/2010
Drawn By: AMM

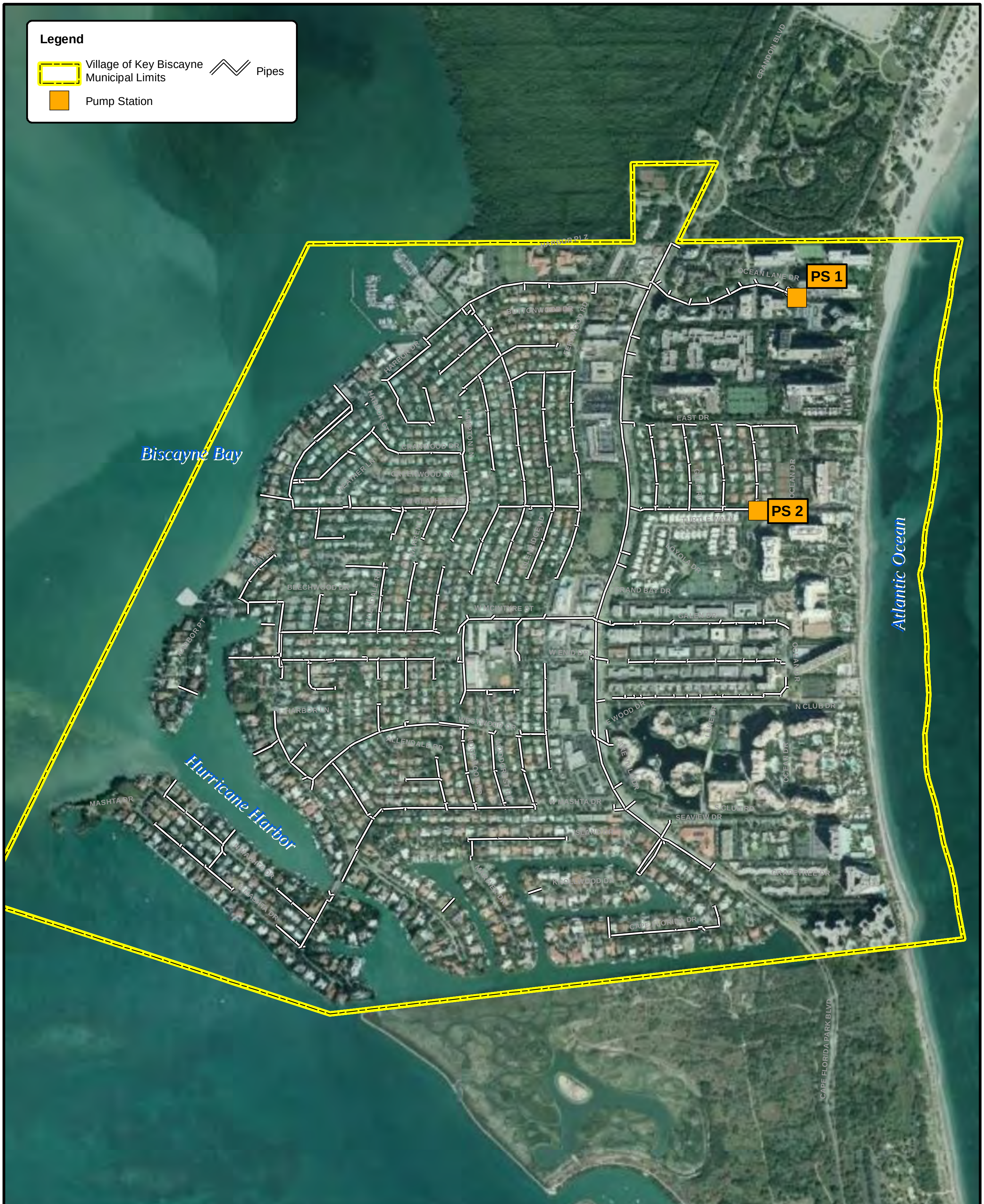
TETRA TECH

DRAINAGE WELL LOCATION MAP
STORMWATER MASTER PLAN UPDATE
VILLAGE OF KEY BISCAYNE, FLORIDA

Figure 2.13

Source: Miami- Dade GIS Data, Microsoft Virtual Earth

File: P:\IER\15760\200-15760-10003\GIS\Maps\APF2.13.mxd
Printing Date: 11/22/2010
Drawn By: AMM



PUMP STATION LOCATION MAP
STORMWATER MASTER PLAN UPDATE
VILLAGE OF KEY BISCAYNE, FLORIDA

0 1,200 Feet

Source: Miami- Dade GIS Data, Microsoft Virtual Earth

Figure 2.14

File: P:\IER\15760\200-15760-10003\GIS\Maps\APF2.14.mxd
Printing Date: 11/22/2010
Drawn By: AMM

at the east end of Ocean Lane Drive. The roadway drainage system receives overflow from the existing large condominium developments on each side of the road. The station's twin 4,000 gpm vertical propeller pumps had been in service since installation in 1995 and were in need of repair.

The upgrade project was completed in August 2010 and consisted of rehabilitating the existing pump station. This included the disassembling and restoration of the two pumps to their near-original condition. The top slab of the pump station was modified accordingly. Sand, silt and debris was removed out of the wet well. The total cost of $261,960.76 was shared between the Village and a matching grant from the SFWMD. Pump station details are provided in **Appendix H.**

The second pump station, Pump Station HC1 (HC1) at the east end of East Heather Drive is currently being rehabilitated as well.

2.2.6 The Crandon Boulevard System

The Crandon Boulevard system contains approximately 1.5 miles of 24-inch to 48-inch diameter drainage pipe, and two 48-inch diameter outfalls. The system was constructed in 1968-69 when Crandon Boulevard was widened to four lanes.

The system extends west along a segment of Harbor Drive, past Woodcrest Road to an outfall south of the Yacht Club. Drainage Improvements on Ocean Lane Drive, east of Crandon Boulevard, were later connected to the Crandon Boulevard system by Miami-Dade County. The drainage systems of the roadways surrounding Key Biscayne Elementary School are also connected into the Crandon Boulevard system, but are independent of the systems along the adjacent streets.

The drainage system was constructed by the Florida Department of Transportation (FDOT) and ownership was transferred to Miami-Dade County for operation and maintenance. Since the area currently served by the Crandon Boulevard drainage system is maintained by Miami-Dade County it was excluded from the original master plan.

Roadway improvements to Crandon Boulevard were designed by another consultant in 2006 and constructed in two phases completed in 2007. Along with the median beautification improvements, additional storm structures were included along the roadway and existing inlet grate elevations were adjusted.

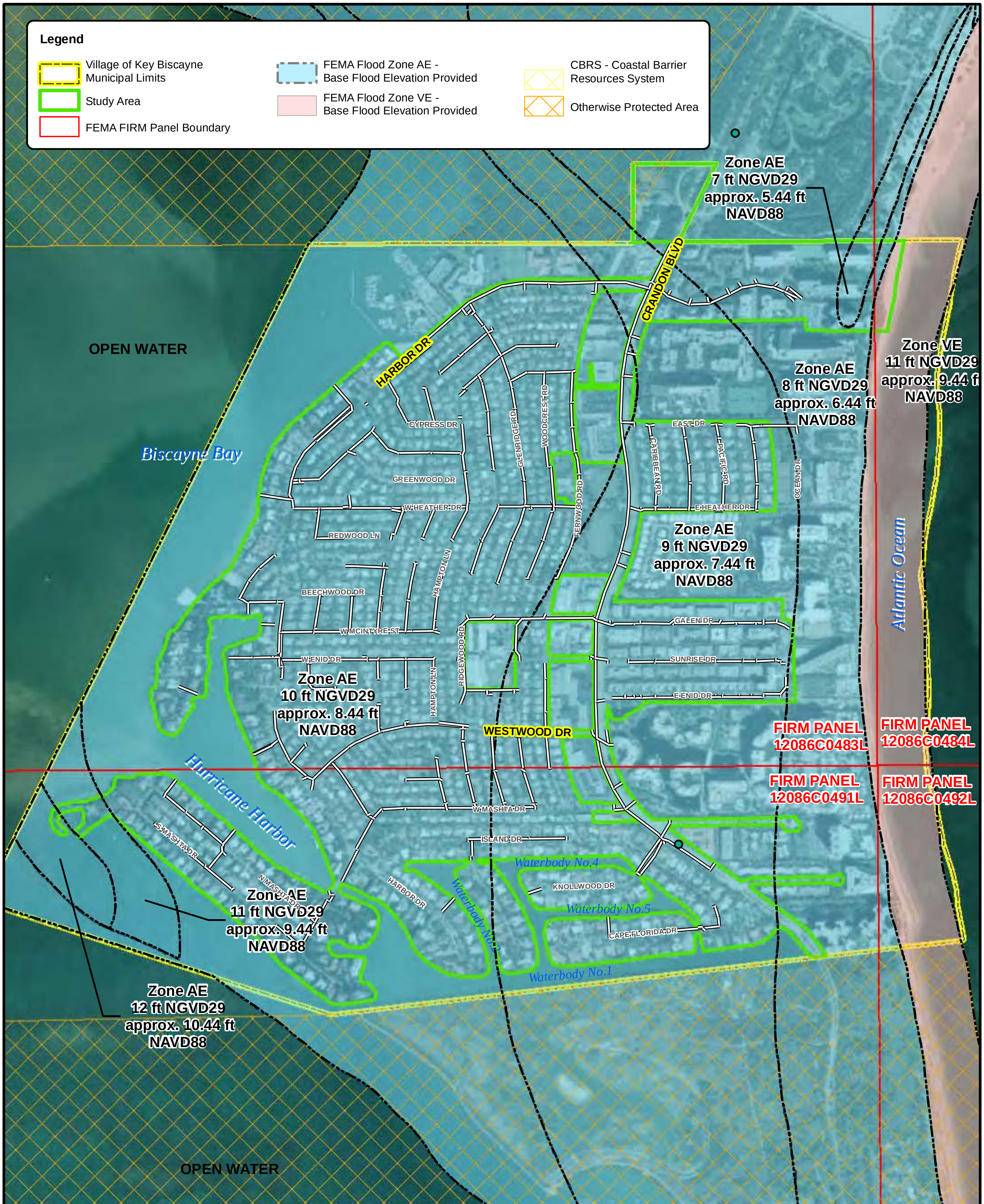
For the purposes of this update, the Crandon Boulevard system will be considered in the modeling since there are several points of connection with the existing drainage system at Eastwood Drive, East Heather Drive, Sunrise Drive and Ocean Lane Drive. As-builts files were received from Miami-Dade County Public Works Department on October 6, 2010.

2.3 EXISTING FLOODING AREAS

2.3.1 Introduction

Since the Village of Key Biscayne is located within a barrier island, the Village lies completely within a floodplain. This is one of the main contributing factors for the localized flooding and repetitive loss. FEMA provides Flood Insurance Rate Maps (FIRMs) to delineate both the special hazard areas and the insurance risk premium zones applicable to the community. The maps define the Base Flood Elevations (BFEs) as "the computed elevation to which floodwater is anticipated to rise during the base flood. The BFE is the regulatory requirement for the elevation or floodproofing of structures. The relationship between the BFE and a structure's elevation determines the flood insurance premium."

The FIRM map for the Village is separated into four panels as revised in September 11, 2009. The Community Identification number is 12086. **Figure 2.15** provides a compilation of the FIRM map panels. The Village lies within the VE and AE Zones which exhibit a one percent (1 %) or greater chance of flooding each year. Elevations are provided for Zones AE from 8 feet to 12 feet. The insurance premium for a structure is based on these zones and elevations due to the special flood hazard risk area.



FEMA FLOOD ZONE MAP
STORMWATER MASTER PLAN UPDATE
VILLAGE OF KEY BISCAYNE, FLORIDA

TETRA TECH

0 1,200
Feet

Source: Miami- Dade GIS Data
Microsoft Virtual Earth
FEMA 2009 DFIRM

Figure 2.15

File: P:\IER\15760\200-15760-10003\GIS\Maps\APF2.15.mxd
Printing Date: 11/22/2010
Drawn By: AMM

2.3.2 Localized Flooding Areas

The Village of Key Biscayne is known to have frequent localized flooding problems in recurrent areas. These areas are identified via logged complaints from the residents via email or phone calls and historical experience of Public Works personnel. **Figure 2.16** lists the location of documented flooding complaints. The causes of the flooding varies from rain events, where the intensity of rainfall is extreme for a short duration, to tidal events, where the high tide tail water flows into the drainage system and backflows through the structures onto the streets, or a combination of both. The topographic characteristics of specific roadways contribute as well. There are several low-lying, flat areas that do not drain efficiently.

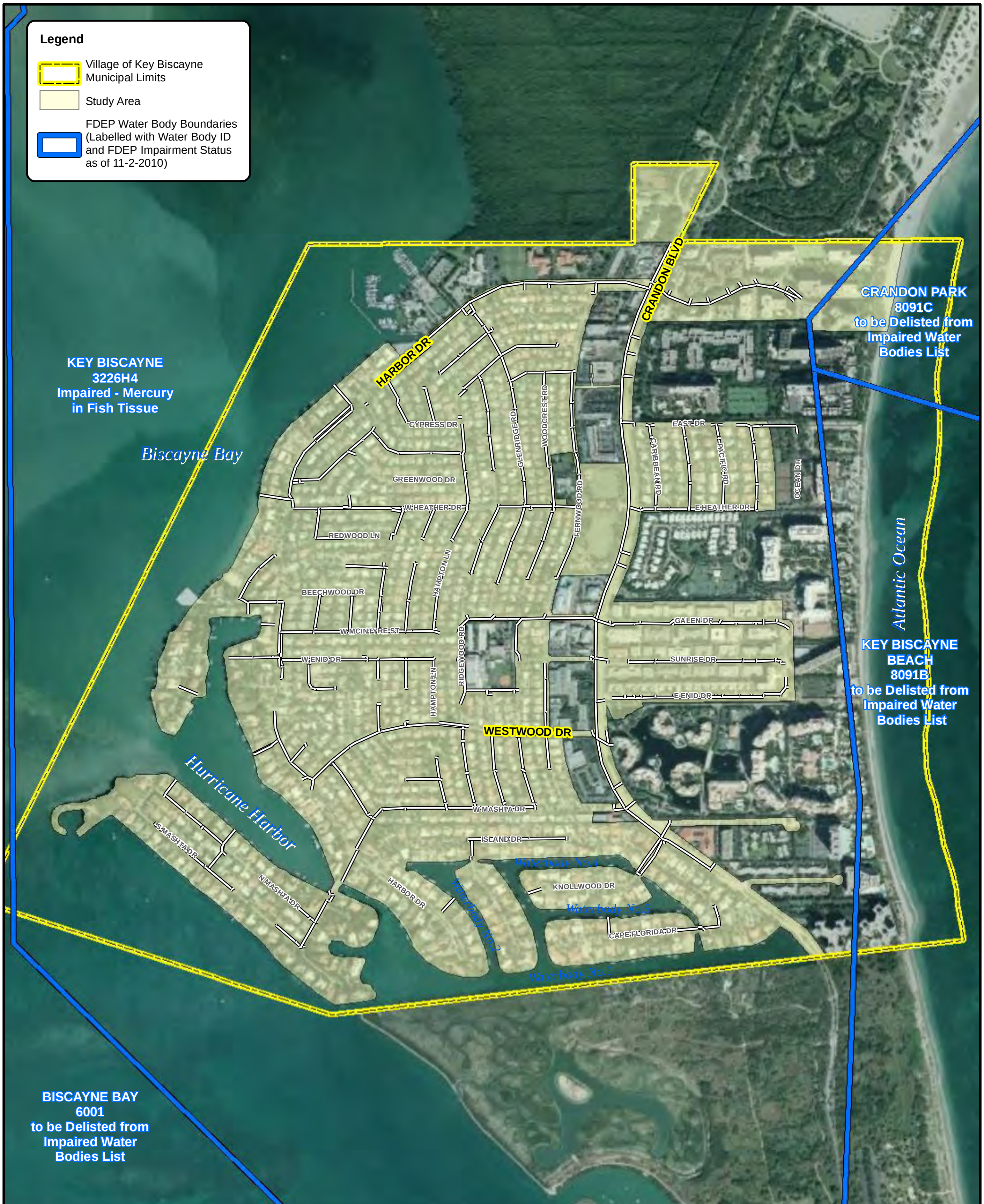
2.3.3 Repetitive Loss Properties

Repetitive loss properties are those properties for which two or more claims of more than $1,000 have been paid by the National Flood Insurance Program (NFIP) within any 10-year period as defined by FEMA in the Community Rating System (CRS) Coordinator's Manual. The Village is considered a Category C in the CRS in which more than 10 properties have been identified as repetitive loss. In 2008, FEMA provided a list of 28 properties. One of the activities involved with the Annual NFIP CRS Re-Certification process is the analysis of Repetitive Loss Areas (RLAs). The purpose of the analysis is to determine possible mitigation solutions to minimize the flood claims. Updates to the identified repetitive loss properties were submitted to FEMA October 1, 2010 for consideration. The updates were approved in February 2011. The findings of the analysis indicate the claims for 24 properties out of 28 listed in 2008 were related to hurricanes. Hurricanes are considered greater than 100-year events and therefore, the properties will be indicated as "mitigated" in future repetitive loss lists.

FIGURE 2.16

Village of Key Biscayne Flood/Puddle Complaint Log			Nov 2005 to April 2011	
	Date of e-mail complaint	**Action Taken Y/N**	**Description/Comments**	**Additional complaint(s) logged after action taken Y/N**
425 Allendale Road (corner with Heather Drive)	Nov-05	Y	drain covered with sod and mud - removed sod and mud on surface and pumped the catch basin	N
630 Allendale Road	Apr-10	Y	removed sediment in catch basin	N
400 Hampton Lane Drive	Apr-11	Y	removed sediment in catch basin	Y
400/500 Hampton Lane Drive block (524/525/400/401/415)	Jun-09	Y	removed sediment in catch basins	Y
255 Hampton Lane	Aug-08	N	Armando stated this drain is not connected to the drain system but he has a contractor reviewing the system to implement the required work. Armando found this work not feasible at approx $13,000	N
653 Hampton Lane	Jun-09	N	Resident states this never happened before - that the sewer project work caused this	
355 Harbor Lane	Jun-09	Y	removed sediment in catch basin	N
400/500 Warren Lane	T	Y	removed sediment in catch basin	N
690 Warren Lane	May-09	Y	removed sediment in catch basin	N
691 Warren Lane	T	Y	removed sediment in catch basin	N
320 Ridgewood Road	Jan-06	Y	swale lowered and regraded	N
355 Ridgewood Rd	Jun-05	Y	swale lowered and regraded	N
432 Ridgewood Road	Feb-06	N	regrading the street during the sewer project would have fixed existing puddle - water does not get to drain	
442 Ridgewood Road	T	N		
452/462 Ridgewood Road	Apr-10	N	additional catch basin added - solved for 452 but not for 462	Y
482 Ridgewood Road	T	N	Resident states this never happened before in front of his house - that the sewer project work caused this	
524 Ridgewood Road	Oct-08	Y	drain was excavated and linked underground to the stormwater system	N
165 Mc Intyre Road	T	U	adjacent to 524 ridgewwod - solution fixed both	N
9, 10, 14, 15 & 18 Harbor Point Drive	2007	Y	regrading of street after sewer project - benefited some - others got worse	Y
265 West Heather Drive	Nov-10	Y	re-profiled existing ashpalt to allow water to go to drain - homeowner did exfiltration work on private prop and adjusted driveway	N
315 West Heather Drive	May-10	Y	E & M added a catch basin	N
385 West Heather Drive	Jun-08	Y	Miguel Lopez added a catch basin	N
375 Harbor Drive	Jan-06	Y	removed sediment in catch basin	N
765 Myrtlewood lane	T	Y	coverted solid manhole cover to a graded cover at 701	N
701 Myrtlewood Lane	Jul-08	Y	coverted solid manhole cover to a graded cover	N
Palmwood Lane	Oct-08	N	related to 10 year storm - weather event 10/4/2008	N
corner of Satinwood and Beechwood	Oct-08	N	related to 10 year storm - weather event 10/4/2008	N
540 Sabal Palm Drive	May-08	Y	reprofiled street after the sewer project	N
530/526 Sabal Palm Drive	May-08	Y	reprofiled street after the sewer project	N
All of Ocean Lane Drive	Oct-08	N	related to 10 year storm - weather event 10/4/2008	N
300 Gulf Road	Oct-08	N	related to 10 year storm - weather event 10/4/2008	N
All Holiday Colony area	Oct-08	N	related to 10 year storm - weather event 10/4/2008	N
181 Cape Florida Drive	Aug-09	Y	resurfaced all of Cape Florida Drive	N
960 Harbor Drive	May-10	Y	Drainage project - Four catch basins added and one well	Y
475 Bay Lane	Nov-10	N	Resident states this never happened before - that the sewer project work caused this	

T = telephone call - failed to log date



IMPAIRED WATER BODIES MAP
STORMWATER MASTER PLAN UPDATE
VILLAGE OF KEY BISCAYNE, FLORIDA

TETRA TECH

Figure 2.17

0 — 1,200 Feet

Source: Miami- Dade GIS Data Microsoft Virtual Earth; FDEP Final Verified Lists for Group 4 Basins 11-2-2010

File: P:\IER\15760\200-15760-10003\GIS\Maps\APF2.17.mxd
Printing Date: 11/22/2010
Drawn By: AMM

2.4 WATER QUALITY

The FDEP prepares the Water Quality Assessment Report on a five- year cycle based on data monitored and collected by DERM. Biscayne Bay is part of the Southeast Coast Group 4 Basin. There are five (5) phases in each cycle. In September 2010, the FDEP completed its second cycle. Key Biscayne is directly connected to three (3) water bodies that have been identified with a Water Body Identification Number (WBID). These are delineated as shown in **Figure 2.17**. Per the First Water Quality Assessment results, Key Biscayne was found to have a high priority for Total Maximum Daily Load (TMDL) development for Mercury due to concentrations which exceed threshold limits. However FDEP recently noted a "flaw in the original analysis" and the water bodies are currently being delisted for these impairments. Currently the water bodies surrounding the Village of Key Biscayne have no impairments, although impairments may be added during future cycle's assessments. Updates on future assessments can be found on the FDEP website. A summary of the Key Biscayne FDEP Verified List of Impaired Waters - Group 4 (Cycle 2) Basins is provided in **Table 2.3**.

2.4.1 Total Maximum Daily Load (TMDL)

A TMDL is "the amount of a pollutant that can be accepted by a water body without causing an exceedance of water quality standards or interfering with the ability to use a water body for one or more of its designated uses". The allowable load is allocated to the various sources of the pollutant, such as stormwater discharge, which requires an NPDES permit, and nonpoint sources, which includes stormwater runoff from commercial and residential areas. Water bodies that do not meet water quality standards are identified as "impaired" for the particular pollutants of concern (i.e. nutrients, bacteria, mercury, etc.) and TMDLs are being developed, adopted and implemented for these to reduce pollutants and clean up the water body. Implementation strategies to improve water quality may include stormwater treatment plants, adoption of ordinances, retrofitting stormwater systems, and other BMPs.

Southeast Coast / Biscayne Bay (Group 4) - Verified List
Hydrologic Unit: Everglades

Table 2.3

OGC Case Number	Planning Unit	WBID	Water Segment	Waterbody Type	Waterbody Class[1]	1998 303(d) Parameters of Concern	Parameters Assessed Using the Impaired Waters Rule (IWR)	Concentration Causing Impairment[2]	Priority for TMDL Development[3]	Projected Year for TMDL Development[3]	Comments (# Exceedances/# Samples) PP=Planning Period VP=Verified Period[4]
06-0624	Biscayne Bay Intercoastal	3226H	ICCW DADE CO.	ESTUARY	3M		Fecal Coliform	>400 colonies/100 mL	Medium	2011	PP = 311 / 2525; VP = 218 / 1397
06-0625	Broward County	3271	POMPANO CANAL	STREAM	3F		Dissolved Oxygen	<5.0 mg/L	Medium	2011	PP = 8 / 18; VP = 11 / 28 Verified impaired and nutrients are found to be the causative pollutant based on chl a data.
06-0626	Broward County	3271	POMPANO CANAL	STREAM	3F	Nutrients	Nutrients (Chl a)	TN = 1.01 mg/L TP = 0.08 mg/L	High	2005	VP: Annual average Chl a values exceeded IWR threshold in 2000 (20.12 ug/L) and 2004 (20.67 ug/L). Data indicate that the WBID is co-limited (TN/TP median =12.122, standard deviation of 8.0617, range of 5.739 - 41.76, 18 observations).
06-0627	Broward County	3274	C-13 EAST/MIDDLE RIVER	ESTUARY	3M		Fecal Coliform	>400 colonies/100 mL	Medium	2011	PP = 19 / 168; VP = 39 / 205 Data based on updated Run 22 from 10-26-05.
06-0628	Broward County	3274	C-13 EAST/MIDDLE RIVER	ESTUARY	3M		Nutrients (Historic Chl a)	TN = 1.34 mg/L TP = 0.08 mg/L	Medium	2011	VP:The annual average Chl a values in the verified period exceeded the historical minimum (of 2.5 ug/L for the years 1992-1996) by more than 50% in 2001 (5.0825 ug/L), 2002 (9.5931 ug/l), 2003 (8.0321 ug/L) and 2004 (8.1306 ug/L). Data indicate that the WBID is co-limited (TN/TP median = 18.674, standard deviation of 15.003, range of 4.96 - 81.07, 71 observations). Data based on updated Run 22 from 10-26-05.
06-0629	Broward County	3226G4	LOS OLAS ISLES FINGER CANAL SYSTEM	ESTUARY	3M		Fecal Coliform	>400 colonies/100 mL	Medium	2011	PP = 199 / 563; VP = 20 / 74 Data based on updated Run 22 from 10-26-05.
06-0630	Broward County	3276A	NORTH FORK NEW RIVER	ESTUARY	3M		Dissolved Oxygen	<4.0mg/L	Medium	2011	PP = 28 / 86; VP = 28 / 83 Verified impaired and nutrients were found to be the causative pollutant. Data based on updated Run 22 from 10-26-05.
06-0631	Broward County	3276A	NORTH FORK NEW RIVER	ESTUARY	3M		Fecal Coliform	>400 colonies/100 mL	Medium	2011	PP = 147 / 265; VP = 45 / 104. Data based on updated Run 22 from 10-26-05.
06-0632	Broward County	3276A	NORTH FORK NEW RIVER	ESTUARY	3M		Nutrients (Chl a)	TN = 1.62 mg/L TP = 0.11 mg/L	Medium	2011	VP: Chl a values exceeded IWR threshold hold in 1998 (28.18 ug/L), 1999 (29.42 ug/L), 2000 (16.3 ug/L), 2001 (14.04 ug/L) and 2004 (26.27 ug/L). Data indicate that the WBID is co-limited (TN/TP median = 13.818, standard deviation of 8.7913, rangeof 5.609 - 62.0, 88 observations). Data based on updated Run 22 from 10-26-05.
06-0633	Broward County	3276A	NORTH FORK NEW RIVER	ESTUARY	3M		Total Coliform	>2400 colonies/100mL	Medium	2011	PP = 56 / 151; VP = 13 / 53 Data based on updated Run 22 from 10-26-05.
06-0634	Broward County	3277A	SOUTH NEW RIVER CANAL	ESTUARY	3M	Coliforms	Fecal Coliform	>400 colonies/100 mL	Low	2011	PP = 23 / 184; VP = 22 / 144 Data based on updated Run 22 from 10-26-05.

OGC Case Number	Planning Unit	WBID	Water Segment	Waterbody Type	Waterbody Class[1]	1998 303(d) Parameters of Concern	Parameters Assessed Using the Impaired Waters Rule (IWR)	Concentration Causing Impairment[2]	Priority for TMDL Development[3]	Projected Year for TMDL Development[3]	Comments (# Exceedances/# Samples) PP=Planning Period VP=Verified Period[4]
06-0636	Broward County	3277A	SOUTH NEW RIVER CANAL	ESTUARY	3M	Nutrients	Nutrients (Historic Chl a)	TN = 1.84 mg/L TP = 0.07 mg/L	Low	2011	VP: The annual average Chl a values in the verified period exceeded the historical minimum value (of 4.8 ug/L for the years 1995-1999) by more than 50% in 2003 (7.9892 ug/L) and 2004 (7.2405 ug/l). Data indicate that the WBID is co-limited (TN/TP median = 29.521, standard deviation of 50.263, range 7.337 - 247.9, 94 observations). Data based on updated Run 22 from 10-26-05.
06-0637	North Dade County	3283	SNAKE CREEK CANAL EAST	STREAM	3F		Fecal Coliform	>400 colonies/100 mL	Medium	2011	PP = 30 / 334; VP = 27 / 202
06-0638	North Dade County	3283	SNAKE CREEK CANAL EAST	STREAM	3F		Nutrients (Historic Chl a)	TP = 0.02 mg/L	Medium	2011	VP: The annual average Chl a values in the verified period exceeded the historical minimum value (of 2.0 ug/L for the years 1996-2000) by more than 50% in 2001 (3.13 ug/L) and 2002 (3.4136 ug/l). Data indicate that the WBID is phosphorous limited (TN/TP median = 95.509, standard deviation of 73.450, range, 1.238 - 405, 41 observations).
06-0639	North Dade County	3285	C-8/BISCAYNE CANAL	STREAM	3F	Coliforms	Fecal Coliform	>400 colonies/100 mL	Low	2011	PP = 129 / 342; VP = 105 / 255
06-0640	North Dade County	3285	C-8/BISCAYNE CANAL	STREAM	3F	Coliforms	Total Coliform	>2400 colonies/100mL	Low	2011	PP = 103 / 342; VP = 82 / 254
06-0641	North Dade County	3287	C-7/LITTLE RIVER	STREAM	3F	Coliforms	Fecal Coliform	>400 colonies/100 mL	Low	2011	PP = 62 / 226; VP = 45 / 148
06-0642	North Dade County	3287	C-7/LITTLE RIVER	STREAM	3F	Coliforms	Total Coliform	>2400 colonies/100mL	Low	2011	PP = 48 / 226; VP = 37 / 147
06-0643	North Dade County	3288	C-6/MIAMI RIVER	ESTUARY	3M		Copper	> 3.7 ug/L	Medium	2011	PP = 18 / 69; VP = 14 / 46
06-0644	North Dade County	3288	C-6/MIAMI RIVER	ESTUARY	3M	Coliforms	Fecal Coliform	>400 colonies/100 mL	Low	2011	PP = 253 / 631; VP = 202 / 434
06-0645	North Dade County	3288	C-6/MIAMI RIVER	ESTUARY	3M	Coliforms	Total Coliform	>2400 colonies/100mL	Low	2011	PP = 191 / 629; VP = 152 / 432
06-0646	North Dade County	3290	C-6/Miami Canal	ESTUARY	3F		Fecal Coliform	>400 colonies/100 mL	Medium	2011	PP = 27 / 167; VP = 33 / 149
06-0647	North Dade County	3292	CORAL GABLES CANAL	STREAM	3F		Fecal Coliform	>400 colonies/100 mL	Medium	2011	PP = 22 / 109; VP = 22 / 72
06-0648	North Dade County	3292	CORAL GABLES CANAL	STREAM	3F		Total Coliform	>2400 colonies/100mL	Medium	2011	PP = 13 / 110; VP = 13 / 72
06-0649	North Dade County	3226M2	UPPER ARCH CREEK	STREAM	3F		Fecal Coliform	>400 colonies/100 mL	Medium	2011	PP = 72 / 75; VP = 27 / 27
06-0650	North Dade County	3226M2	UPPER ARCH CREEK	STREAM	3F		Total Coliform	>2400 colonies/100mL	Medium	2011	PP = 57 / 75; VP = 24 / 27
06-0651	North Dade County	3288A	WAGNER CREEK	ESTUARY	3M		Dioxin	>7ppt	Medium	2011	Verified Impaired based fish advisory for Checkered Puffer, Striped Majarra and Yellow Fin Mojarra.
06-0652	North Dade County	3288A	WAGNER CREEK	ESTUARY	3M	Coliforms	Fecal Coliform	>400 colonies/100 mL	High	2005	PP = 198 / 223; VP = 139 / 157
06-0653	North Dade County	3288A	WAGNER CREEK	ESTUARY	3M	Coliforms	Total Coliform	>2400 colonies/100mL	High	2005	PP = 193 / 223; VP = 137 / 157

Southeast Coast / Biscayne Bay (Group 4) - Verified List
Hydrologic Unit: Everglades

Table 2.3

OGC Case Number	Planning Unit	WBID	Water Segment	Waterbody Type	Waterbody Class[1]	1998 303(d) Parameters of Concern	Parameters Assessed Using the Impaired Waters Rule (IWR)	Concentration Causing Impairment[2]	Priority for TMDL Development[3]	Projected Year for TMDL Development[3]	Comments (# Exceedances/# Samples) PP=Planning Period VP=Verified Period[4]
06-0654	North Dade County	3288B	C-6/LOWER MIAMI RIVER	ESTUARY	3M		Fecal Coliform	>400 colonies/100 mL	Medium	2011	PP = 38 / 74; VP = 16 / 26
06-0655	North Dade County	3288B	C-6/LOWER MIAMI RIVER	ESTUARY	3M		Total Coliform	>2400 colonies/100mL	Medium	2011	PP = 31 / 73; VP = 15 / 26
06-0656	South Dade County	3303	C-111 Canal	STREAM	3F		Nutrients (Historic Chl-a)	TP = 0.02 mg/L	Medium	2011	VP: The annual average Chl a values in the verified period exceeded the historical minimum value (of 2.2 ug/L for the years 1992-1996) by more than 50% in 2001 (5.0787 ug/l), 2002 (4.2198 ug/l) and 2004 (9.7538 ug/L). Data indicate that the WBID is phosphorous limited (TN/TP median = 95.273 with a standard deviation of 2079.4, range of 5.473 - 40670, 381 observations).
06-0657	Southeast Coast	8998	FLORIDA ATLANTIC COAST	COASTAL	3M		Mercury (in Fish Tissue)	Exceeds DOH threshold (>0.43 mg/kg)	Low	2012	Data verified to be within the last 7.5 years. 87 King Mackerel averaged 0.67 mg/Kg in 2002. WBIDs include: 3226 (G1-G4), 3226HB, **3226H**, 3226 (H1-H4), 6001, 6001 (A-C), 8088, 8089, 8090, 8091, 8091 (A-D), 8092, 8092 (A-D), 8093, 8093 (A-E), 8094, 8094 (A-F), 8095, 8095 (A-D).

[1] Florida's waterbody classifications are defined as: **1** - Potable water supplies, **2** - Shellfish propagation or harvesting, **3F** - Recreation, propagation, and maintenance of a healthy, well-balanced population of fish and wildlifein fresh water, **3M** - Recreation, propagation, and maintenance of a healthy, well-balanced population of fish and wildlife in marine water, **4** - Agricultural water supplies, **5** - Navigation, utility, and industrial use.

[2] The nutrient concentrations represent the 75th percentiles of data from the Verified Period. The target nutrient concentration used in the subsequent TMDL will be determined during the TMDL process.

[3] Priorities and schedule for TMDL development are only provided for waters in Category 5. Priorities set under the EPA Consent Decree were retained. Medium priority is used for newly listed waters identified under the IWR.

[4] Planning Period (PP) - 1/1/1993 to 12/31/2002; Verified Period (VP) - 1/1/1998 to 6/30/2005.

The Verified List is based on IWR Run 22

The threshold limits on pollutants in surface waters and associated water quality criteria table are summarized in **Table 2.4**, as per Florida Administrative Code Rule 62-302 provided in **Appendix D**. Storm water from Key Biscayne currently discharges to Water Body Identification (WBID) 3226H4, located to the west of Key Biscayne in the Biscayne Bay. The only impairment currently found in WBID 3226H4 is for mercury in fish tissues which has been a common impairment in water bodies throughout Florida. Adoption of a TMDL for mercury is currently being discussed by the FDEP; however this will likely be a statewide regulation mainly addressing atmospheric sources and is unlikely to impact storm water regulations.

Table 2.4 – Current Criteria Used for TMDL Development

PARAMETER*	CONCENTRATION THRESHOLD**
BOD	≥ 5.0 mg/L
DO	< 4.0 mg/L
Total Coliform	>2400 colonies/100mL
Fecal Coliform	>400 colonies/100 mL
TN	≥ 4.0 mg/L
TP	≥ 4.0 mg/L
Mercury (Based on fish samples)	DoH Threshold (> 0.3 mg/kg)
Dioxin	>7ppt
Iron	> 1.0 mg/L
Lead	> 8.5 ug/L
Conductance	> 1275 umhos/cm
Copper	≥ 3.7 µg/L

* Data taken from past TMDLs
** Thresholds for TMDL development may vary between water bodies

2.4.2 Statewide Rule

The purpose of the Statewide Unified Stormwater Rule (aka Statewide Rule) is to "protect surface waters from the effects of excessive nutrients in stormwater runoff". This will eliminate the inconsistencies between the stormwater rules used by each of the five Florida water management districts by establishing a standardized set of criteria. The FDEP in conjunction with the five water districts are collaborating in creating the statewide rule that will be implemented through the existing Environmental Resource Permit program.

The rule will require reduction of the amount of total phosphorus (TP) and total nitrogen (TN) in stormwater runoff for all new construction by implementing best management practice treatment options in series. The post-construction nutrient loads must be less than or equal to pre-construction nutrient loads.

2.4.3 Sampling Program

Miami-Dade County DERM manages an on-going county-wide surface water sampling program for Biscayne Bay and its watershed canals. The program was initiated in 1979, with less than 50 stations and has blossomed to include over 105 stations. The program conducts monthly surface water sampling for a variety of parameters including physical, chemical and microbiological characteristics.

Table 2.2 – Subcatchment Characteristics

Basin Number	Sub-Catchment ID	Acres
1	SUB-12084	4.00
	SUB-12088	3.50
	SUB-12162	2.78
	SUB-12164	2.22
	Subtotal Basin 1	12.50
2	SUB-12122	0.19
	SUB-12128	1.79
	SUB-12144	5.94
	SUB-12160	3.73
	Subtotal Basin 2	11.65
3	SUB-12060	2.07
	SUB-12062	1.41
	SUB-12068	1.34
	SUB-12072	6.42
	SUB-12086	4.32
	SUB-12100	3.48
	SUB-12112	2.63
	SUB-12142	5.11
	SUB-12150	2.18
	SUB-12152	3.52
	SUB-12154	5.91
	SUB-12158	1.85
	SUB-12168	2.10
	SUB-12170	0.59
	SUB-12172	1.13
	SUB-12174	2.62
	SUB-12176	1.71
	SUB-12180	2.43
	SUB-12182	1.14
	SUB-12184	0.55
	SUB-12186	1.68
	SUB-12188	2.83
	SUB-12190	2.07
	SUB-12192	2.76
	SUB-12196	1.66
	SUB-12202	2.84
	SUB-12204	1.39
	SUB-12206	2.89
	SUB-12208	1.19
	SUB-12210	2.01
	SUB-12442	0.44
	Subtotal Basin 3	74.27

Basin Number	Sub-Catchment ID	Acres
4	SUB-12166	1.49
	SUB-12200	1.66
	SUB-12450	1.16
	Subtotal Basin 4	4.31
6A	SUB-11978	2.70
	SUB-11994	1.78
	SUB-12004	1.65
	SUB-12010	1.46
	SUB-12016	2.74
	SUB-12024	2.10
	SUB-12052	3.12
	SUB-12198	1.81
	SUB-12226	1.72
	SUB-12228	1.82
	SUB-12230	0.66
	SUB-12232	0.66
	SUB-12234	1.17
	SUB-12246	1.15
	SUB-12248	1.19
	SUB-12250	1.96
	SUB-12438	4.07
	SUB-12448	1.91
	Subtotal Basin 6A	33.67
6B	SUB-11998	4.24
	SUB-12036	2.27
	SUB-12194	1.41
	SUB-12222	1.62
	SUB-12224	1.16
	SUB-12238	1.54
	SUB-12240	1.12
	SUB-12242	2.28
	SUB-12244	1.60
	SUB-12258	2.19
	SUB-12260	2.14
	SUB-12452	1.43
	Subtotal Basin 6B	23.0

Basin Number	Sub-Catchment ID	Acres
7A	SUB-11930	2.02
	SUB-11958	3.73
	SUB-11988	4.42
	SUB-11990	1.92
	SUB-12272	2.89
	SUB-12276	3.56
	SUB-12278	2.83
	SUB-12290	2.00
	SUB-12292	2.40
	SUB-12296	1.66
	SUB-12302	3.79
	SUB-12304	1.57
	SUB-12306	3.29
	SUB-12308	5.24
	SUB-12460	1.65
	Subtotal Basin 7A	42.96
7B	SUB-11954	1.51
	SUB-11968	2.27
	SUB-11984	2.31
	SUB-11986	2.35
	SUB-12280	3.82
	SUB-12284	2.23
	SUB-12286	2.17
	SUB-12288	4.01
	SUB-12300	3.45
	Subtotal Basin 7B	24.13

Basin Number	Sub-Catchment ID	Acres
8	SUB-11924	2.84
	SUB-11926	6.85
	SUB-11944	3.60
	SUB-11948	3.31
	SUB-11972	2.88
	SUB-12252	6.02
	SUB-12256	2.01
	SUB-12262	1.45
	SUB-12264	1.84
	SUB-12266	1.92
	SUB-12268	2.96
	SUB-12274	2.03
	SUB-12318	3.44
	SUB-12324	2.94
	SUB-12326	0.69
	SUB-12328	1.34
	SUB-12330	0.80
	SUB-12332	0.79
	SUB-12334	1.47
	SUB-12336	0.68
	Subtotal Basin 8	49.88

Basin Number	Sub-Catchment ID	Acres
9	SUB-11856	1.86
	SUB-11868	2.45
	SUB-11932	1.50
	SUB-11936	1.45
	SUB-11950	1.48
	SUB-11970	1.91
	SUB-12014	1.00
	SUB-12046	2.17
	SUB-12048	1.25
	SUB-12110	1.48
	SUB-12116	2.38
	SUB-12212	1.53
	SUB-12214	2.80
	SUB-12216	1.14
	SUB-12218	0.84
	SUB-12294	2.81
	SUB-12310	4.79
	SUB-12312	0.56
	SUB-12314	3.48
	SUB-12316	2.85
	SUB-12320	2.10
	SUB-12322	2.97
	SUB-12368	1.40
	SUB-12372	1.36
	SUB-12374	3.10
	SUB-12376	1.57
	SUB-12380	3.84
	SUB-12382	1.36
	SUB-12386	1.37
	SUB-12388	2.03
	SUB-12394	1.30
	SUB-12398	1.14
	SUB-12408	6.13
	SUB-12418	3.73
	SUB-12424	1.79
	SUB-12428	1.06
	SUB-12430	3.19
	SUB-12432	0.88
	SUB-12434	2.10
	SUB-12444	1.21
	SUB-12446	1.44
	SUB-12454	1.51
	SUB-12456	1.05
	SUB-12458	1.23
	Subtotal Basin 9	88.59
Outside	SUB-12044	2.27
	SUB-12132	3.06
	SUB-12136	2.48
	SUB-12138	1.97
	SUB-12340	2.22
	SUB-12344	1.76
	SUB-12346	1.83
	SUB-12348	2.42
	SUB-12350	2.35
	SUB-12352	2.78
	SUB-12354	3.24
	SUB-12356	1.85
	SUB-12358	1.41
	SUB-12362	0.32
	SUB-12364	0.39
	SUB-12366	0.45
	SUB-12396	3.56
	SUB-12400	0.79
	SUB-12402	2.97
	SUB-12404	2.01
	SUB-12410	1.62
	SUB-12414	2.70
	SUB-12420	1.48
	SUB-12422	1.68
	Subtotal Outside	47.60

SECTION 3

Hydrologic & Hydraulic Modeling

SECTION 3.0
HYDROLOGIC AND HYDRAULIC MODELING

3.1 OVERVIEW

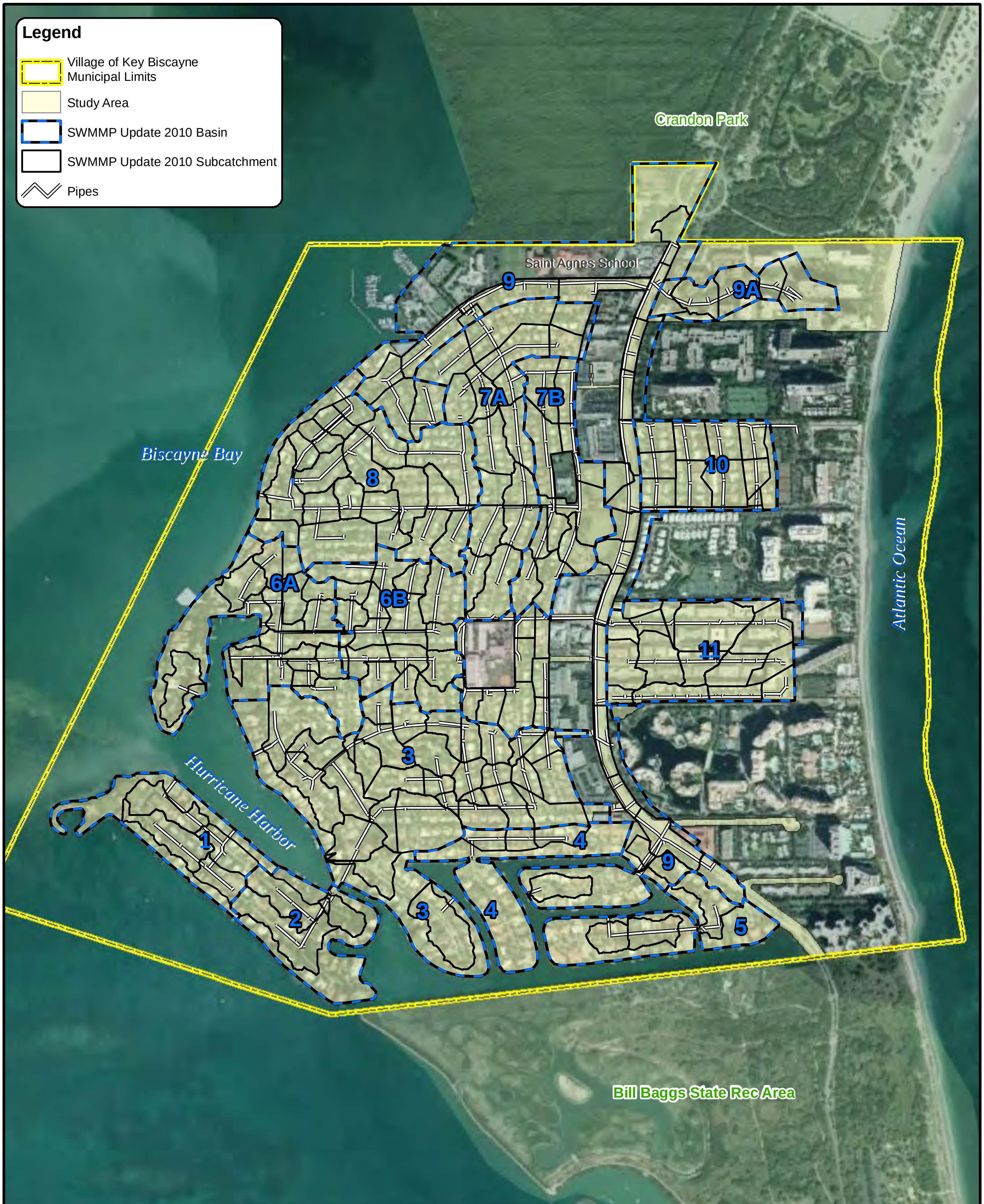
Following the data collection and mapping effort, Tetra Tech developed a Hydrologic and Hydraulic (H&H) model to represent the Village of Key Biscayne's existing stormwater infrastructure with the MWH Soft InfoSWMM 9.0 program. Using the Miami Dade County one-foot LiDAR contour data, the InfoSWMM software was used to delineate drainage basins and develop rainfall runoff for each drainage structure included in the model. The runoff was routed through the model components to illustrate problematic flooding areas. This model was developed as a planning tool to compare alternatives that alleviate flooding in targeted problem areas.

3.2 METHODOLOGY

The InfoSWMM 9.0 H&H model was used in the analysis. This model was derived from EPA's SWMM (Stormwater Management Model Version 5.0). InfoSWMM utilizes a dynamic wave solution to simulate runoff and flow routing through the system during a rainfall event. The model simulates such things as infiltration, runoff, hydraulic grade lines, pipe storage, weirs, pump stations, tidal fluctuations, and drainage wells. InfoSWMM is a powerful modeling platform that works within Arc-GIS allowing simplified editing and the ability to present illustrative results.

A model was developed from the GIS storm sewer database by manually compiling data obtained during the data gathering phase of this Stormwater Management Master Plan (SWMMP) Update. Storm sewer information was gathered from historic construction drawings and a field survey. Supplemental field survey was conducted in areas of the Village that did not have construction drawings showing information for existing stormwater infrastructure.

The 1993 Stormwater Master Plan created nine basins based on limited topography, obtained by field survey conducted at intervals of 100-feet along the existing roadways, and were estimated as the roadway width plus 15-feet on either side. Of these nine basins, eight were studied in the previous SWMMP. This SWMMP Update utilizes more accurate data and estimates the actual



UPDATED DRAINAGE BASIN DELINEATION
STORMWATER MASTER PLAN UPDATE
VILLAGE OF KEY BISCAYNE, FLORIDA

0 1,200 Feet

Source: Miami- Dade GIS Data
Microsoft Virtual Earth

Figure 3.1

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Drawn By: AMM

runoff from the entire Village that drains into the public infrastructure. The original 9 basins remain, one portion of basin 9 has been renamed basin 9A and two new basins, basin 10 and basin 11, have been added to the basin map as shown on Figure 2.8. These large drainage basins were delineated into smaller subcatchment drainage areas using the InfoSWMM software and the Miami-Dade LiDAR data. A total of 184 subcatchments were delineated, as shown on **Figure 3.1**.

Each of the subcatchments estimates runoff using the methodology published in Technical Release 55 (TR-55) "Urban Hydrology for Small Watersheds." This method estimates how much of the surface runoff in a subcatchment will infiltrate into the upper zone of the pervious area; impervious areas do not infiltrate. Estimates of impervious and pervious areas used in the model were chosen from typical values published in TR-55 based on the land use type from the SFWMD Florida Land Use, Land Cover Classification System (FLUCCS) map**.** Impervious areas include driveways, streets, parking areas, and roofs that are directly connected to the storm sewer system. Pervious areas include lawns, parks, and other grassy or wooded areas. To predict how much infiltration volume is available in the upper zone of the pervious area the soil type is used. Soil types developed by the National Cooperative Soil Survey (also known as the NRCS) were used to apply a Curve Number. Other watershed data used in the model include ground slope and the shape (width) of subcatchment areas. Slope and width were estimated from the LiDAR based on the specific characteristics of each individual subcatchment. Each subcatchment has a discharge outlet point for the rainfall excess, or runoff, not infiltrated into the soil. In the model these discharge outlet points are represented as nodes.

3.3 EXISTING CONDITIONS (2010) MODEL

3.3.1. Existing Conditions Model

The previous Stormwater Management Master Plan (SWMMP) for the Village was completed in September of 1993 and did not include provisions for a full scale model. This SWMMP Update includes a Village-wide H&H model to analyze the existing system for deficiencies that may exist. The purpose of an Existing Conditions Model is to assess the runoff, flows, storage, and hydraulic data within a storm sewer network to facilitate analysis of various alternatives within targeted problem areas.

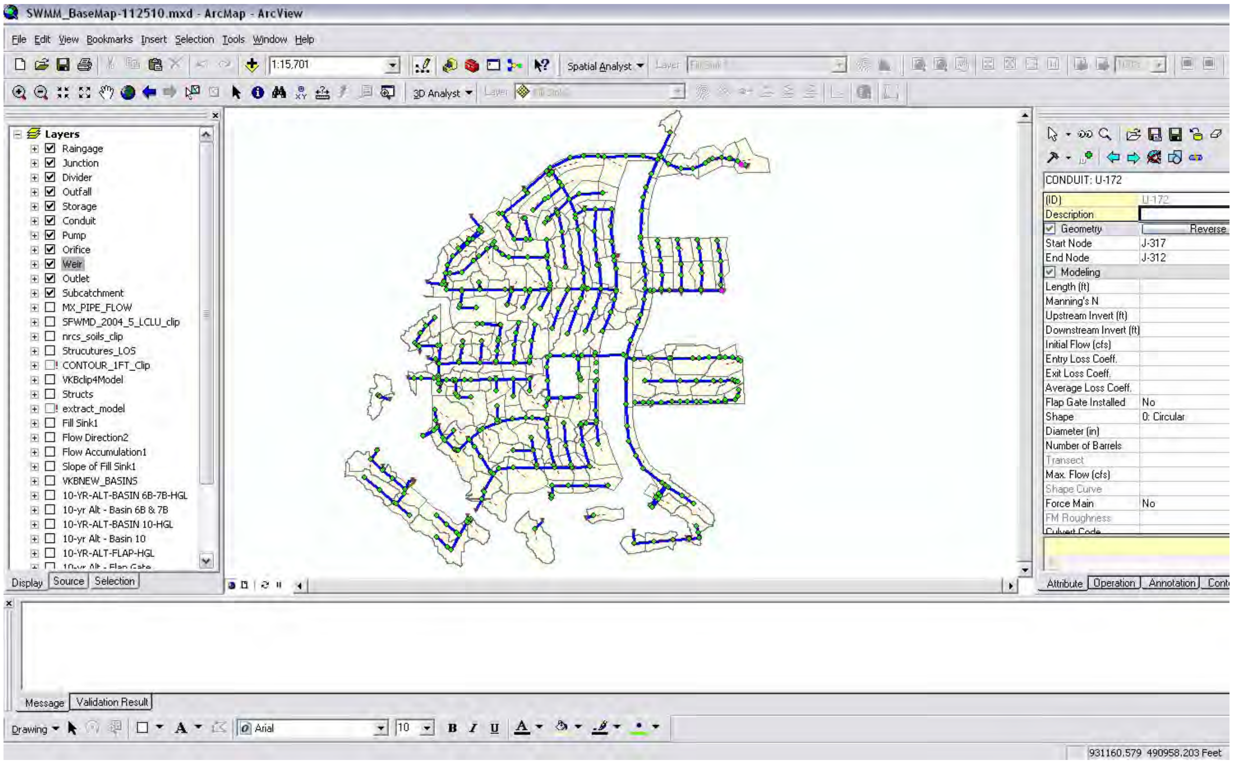
3.3.1.1 Physical Features

The parameters for the existing infrastructure are entered from the GIS Inventory, including inlets, pipes, outfalls, exfiltration trenches, drainage wells, weirs and pump stations. The Village has 277 manholes, 603 catch basins, and 874 storm sewer pipes included in the GIS Inventory. This storm sewer data was brought into the model using the GIS Gateway that converts the GIS Inventory of catch basins (the manholes are not included as they do not receive overland runoff) to junctions and the storm sewer pipes to conduit.

The model is composed of the following:

- a Rain gauge representing the hydrologic scenarios for the SFWMD predicted precipitation and length of storm;
- 184 subcatchments representing the land area that receives rainfall;
- 438 junctions representing the catch basins throughout the Village;
- 54 outfalls representing the outfalls to Biscayne Bay and the drainage wells;
- 441 conduits representing the storm pipes;
- 4 pumps representing the two pump stations;
- 13 weirs representing the weirs within the storm sewer system; and
- 31 outlets representing the flow into the drainage wells.

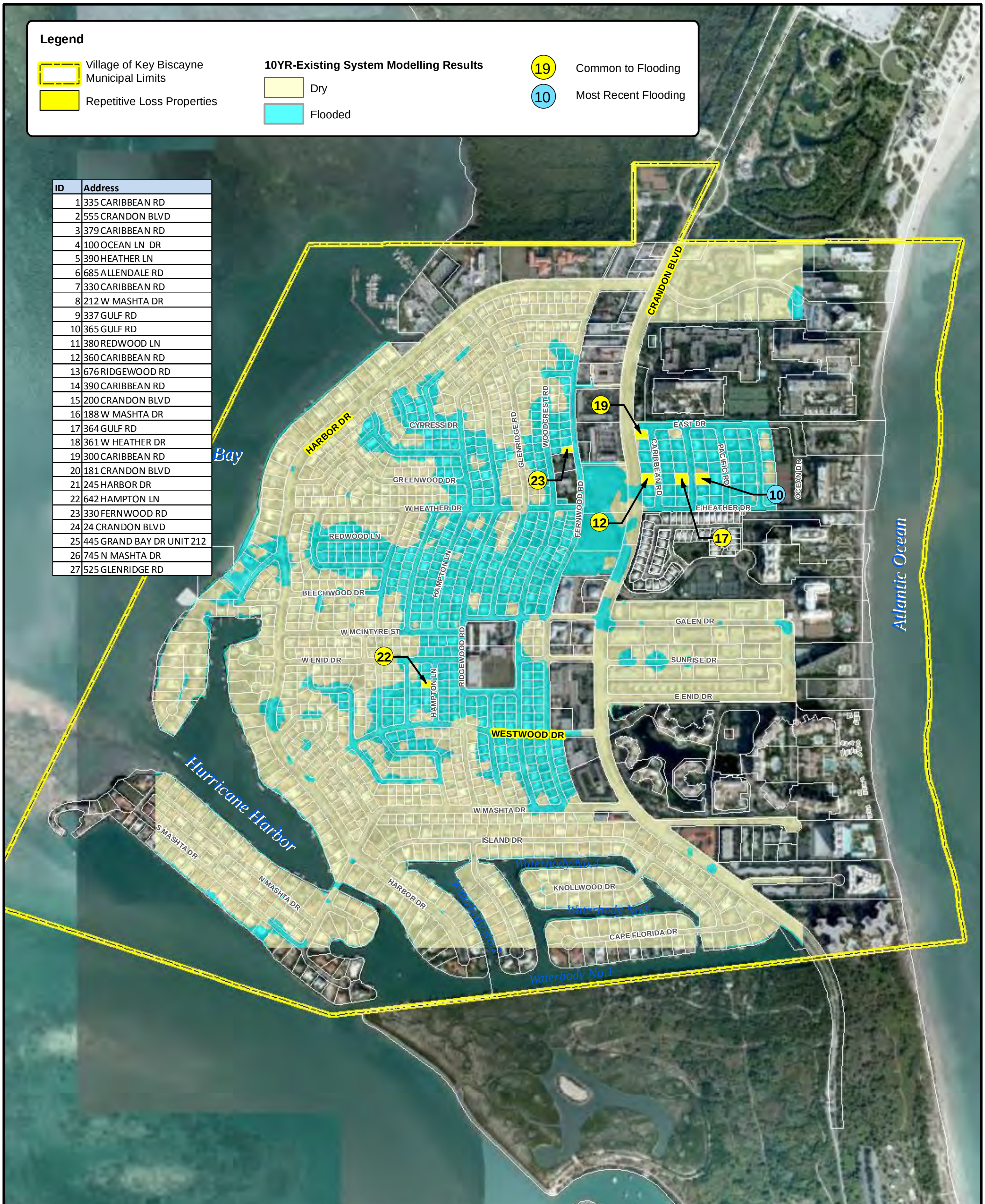
The model conduits range from 12-inches in diameter to 48-inches in diameter. The model increases in complexity with the increasing number of elements included in the model. Therefore, many of the duplicate catch basins were not included in the model. A duplicate catch basin location is where two or four catch basins exist to collect runoff from both sides of the road or an intersection; in these locations only one junction is depicted in the model. The junctions include the actual rim elevation of the catch basin and the bottom elevation of the structure. The conduit include the upstream and downstream pipe invert, if the invert is known. Since most, if not all, storm sewer pipes in the Village are submerged; Tetra Tech estimated invert elevations for some portions of the H&H model. The estimated storm sewer data should not affect the general results of this planning level model given the submerged condition of the existing stormsewer system. **Figure 3.2** shows the model junction-conduit diagram overlain on the basins/subcatchments. Below is a “snap shot” of the node and links in the InfoSWMM software environment.



There are 17 outfalls to Biscayne Bay within the Village, as shown on Figure 2.10. To simulate the boundary conditions for the outfalls to the Biscayne Bay, the mean tidal elevations were used from historical recordings of the S123-T tidal gauge, located approximately 9.8 miles southwest of Key Biscayne. The S123-T tide gauge is maintained by the South Florida Water Management District (SFWMD) in the National Geodetic Vertical Datum of 1929 (NGVD 29) and was converted to North American Vertical Datum of 1988 (NAVD 88) for this model. The modeled tide elevations range from 0.6-feet to -1.34-feet during a 72-hour period.

There are 13 weirs in the Village storm sewer infrastructure, located inside catch basins or manholes. Their primary function is to provide water quality treatment by detaining water in the system and directing it towards the drainage wells, eventually as the water elevation continues to rise it will exceed the elevation of the weir and allow the water to discharge into Biscayne Bay. The weirs are modeled as they exist in the system. Their geometry is trapezoidal in shape and the height and width was obtained from the original design drawings.

There are 28 drainage wells within the Village, as shown on Figure 2.13. Each of the drainage wells was designed to have a discharge capacity of 2400-gpm (5.35-cfs) at 2-foot of head. In a



ID	Address
1	335 CARIBBEAN RD
2	555 CRANDON BLVD
3	379 CARIBBEAN RD
4	100 OCEAN LN DR
5	390 HEATHER LN
6	685 ALLENDALE RD
7	330 CARIBBEAN RD
8	212 W MASHTA DR
9	337 GULF RD
10	365 GULF RD
11	380 REDWOOD LN
12	360 CARIBBEAN RD
13	676 RIDGEWOOD RD
14	390 CARIBBEAN RD
15	200 CRANDON BLVD
16	188 W MASHTA DR
17	364 GULF RD
18	361 W HEATHER DR
19	300 CARIBBEAN RD
20	181 CRANDON BLVD
21	245 HARBOR DR
22	642 HAMPTON LN
23	330 FERNWOOD RD
24	24 CRANDON BLVD
25	445 GRAND BAY DR UNIT 212
26	745 N MASHTA DR
27	525 GLENRIDGE RD

TETRA TECH

10 YEAR FLOODING PROPERTIES
EXISTING CONDITIONS
STORMWATER MASTER PLAN UPDATE
VILLAGE OF KEY BISCAYNE, FLORIDA

Figure 3.2

0 1,200 Feet

Source: Miami- Dade GIS Data
Microsoft Virtual Earth
FEMA RLP

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Printing Date: 11/22/2010
Drawn By: AMM

report completed by Jaffer Well Drilling dated July 21, 2010, the actual capacities of the 28 wells were tested. The existing drainage wells' actual performance testing values, performed by Jaffer Well Drilling, were represented within the H&H model as head verses flow rating curves. Several of the wells had a performance in excess of three times the design values, some as high as eight (8) times. As a factor of safety, the maximum value was set to three (3) times the design values. The remaining wells not tested by Jaffer Well Drilling utilize the design value, or 2400-gpm, within the model. The drainage wells located at the Fire Department, Police Department, and drainage well HC-1 are not modeled within the system because they are self contained drainage areas that are not included in the model.

There are two (2) pump stations in the Village, as shown on Figure 2.14. Both of the pump stations were designed under the "Holiday Colony, Ocean Lane, and Sunrise Drives Stormwater Improvement Plans" Project. Both pump stations utilize 16P Aurora 1160 propeller type pumps that pump large volumes of water in low head conditions. "Pump on" elevation for the lead pump is -0.5, and 0.5 for the lag pump. Pump station OL1 (PS OL1) was installed at the east end of Ocean Lane Drive. Each pump has a design capacity of 4,000-gpm. The pump station manifolds into a short forcemain system that discharges into drainage wells 3(w) and 4(e). Pump station HC1 (PS HC1) was installed at the east end of Holiday Colony. Each pump has a design capacity of 5,000-gpm. The pump station manifolds into a short forcemain system that discharges into drainage wells 1(w) and 2(e). These pump stations are included in the model with pump curves that pump at the design rate when turned on, 4,000-gpm per pump at PS OL1 and 5,000-gpm at PS HC1. The on and off elevations for the lead and lag pumps follow the original design elevations. The model calculates friction losses for the forcemains exiting the pump stations using the Hazen Williams equation, their actual lengths, and a C-Value of 120.

The horizontal datum referenced is State Plane Feet East North American Datum of 1983 (NAD 83). The vertical datum of the design data is based on the NGVD 29, and the field survey data is based on the NAVD 88. The datum conversion for this region of the state is minus 1.56-feet to adjust NGVD 29 to NAVD 88 according to the United States Department of the Army Corps of Engineers software CorpsCON, see **Appendix I**.

3.3.1.2 Precipitation

A design storm is a one that is equaled or exceeded, on average, once in a prescribed duration of time. Thus, a 10-year storm is equaled or exceeded, on average, once every 10 years. The design storm can also be expressed as a probability of occurring in any one year. Therefore, a 2-year storm has a 50 percent probability of being equaled or exceeded in a given year and a 5-year storm has a 20 percent probability.

At the time of the previous SWMMP the level of service standard for most residential roads was a 5-year/24-hour design storm. Since that time the Water Management Districts in the state of Florida have begun to require public infrastructure within the right of way to be sized or designed to safely convey a 10-year/72-hour design storm. Therefore, the results and figures depicted in this SWMMP Update will before the 10-year/72-hour design storm. In the Village a storm of this size yields approximately 9.5-inches of rainfall in 72-hours.

FEMA provides additional Community Rating Points for all communities that manage all storms up to and including the 100-year storm. Therefore for this SWMMP Update the design storms modeled are the mean-annual, 5-year, 10-year, 25-year, and 100-year/72-hour storm events as predicted by the SFWMD rainfall hyetograph shown in **Appendix J**. **Table 3.1** summarizes the total depth of rainfall associated with the various design storms.

Table 3.1 – Rainfall Depth per Storm Event

Storm Event	Rainfall (in)
Mean Annual	5.0
5-year/72-hour	8.2
10-year/72-hour	9.5
25-year/72-hour	10.9
100-year/72-hour	13.5

3.3.1.3 Controls

The control parameters within InfoSWMM make use of the EPA SWMM 5.0 engine for the Runoff Model, Infiltration Model, and Routing Model while allowing for ponding. Other control methods are utilized through user input rating curves for tidal fluctuation curves, pump curves, and outflow curves. These parameters provide guidance for the software to calculate the predicted flows, velocity, stages, and various other hydraulic data.

The surface runoff is estimated using the EPA SWMM Non-linear Reservoir method. This runoff is then applied to the Infiltration model and calculated based on the subcatchment curve number; the curve number was estimated based upon the land use and land cover maps. The remaining runoff, that does not infiltrate into the ground, is applied to the storm sewer network using a Dynamic Wave Routing Model with a four (4) second time step. The Dynamic Wave Routing model solves the continuity and momentum equations in a non-steady flow condition for the conduits and flow continuity equations for the nodes. This routing model takes much longer to calculate but yields the most accurate results.

The rating curves are user input controls that allow the model to apply known values from test data or design parameters. The rating curves for the tide are input as the average fluctuation in elevation from the SFWMD tide gauge and the model applies this as a tailwater boundary condition at the discharge locations on Biscayne Bay. The rating curves for the drainage wells control the flow through the outlet by applying the field tested parameters. The pump curves apply the design point flow values to the discharge pipe when the elevation within the wet well reaches the pump start elevation.

3.3.1.4 Calibration

Calibration compares the model results to observed results and adjusts the model parameters so that the model closely predicts any observed flood elevations that may be known. However, detailed calibration of storm sewer models involves gathering measurements such as flow rates, water surface elevations, and rainfall. These measurements require a large investment, which entails significant additional effort. Many communities find that the refinements that can be realized through calibration do not justify the investment. This is the approach chosen for this study. Calibration measurements can always be obtained at a later time if more refined results are ever desired by the Village.

For the purposes of this model, Tetra Tech reviewed the results of the existing conditions model to assess if the flood conditions were representative of known flooding problems in the Village. Hence, the existing conditions model was analyzed to determine if flooding in the area of repetitive loss properties is reasonable. The model shows flooding for many of the complaint flooding areas and most of the repetitive loss properties. The repetitive loss properties that do not flood within the model are properties that experienced flooding during known 100-year storm events (e.g. Hurricane Andrew and Hurricane Katrina) and would not be expected to flood during the 10-year design storm chosen for this SWMMP Update.

3.3.2 Existing Conditions Model Results

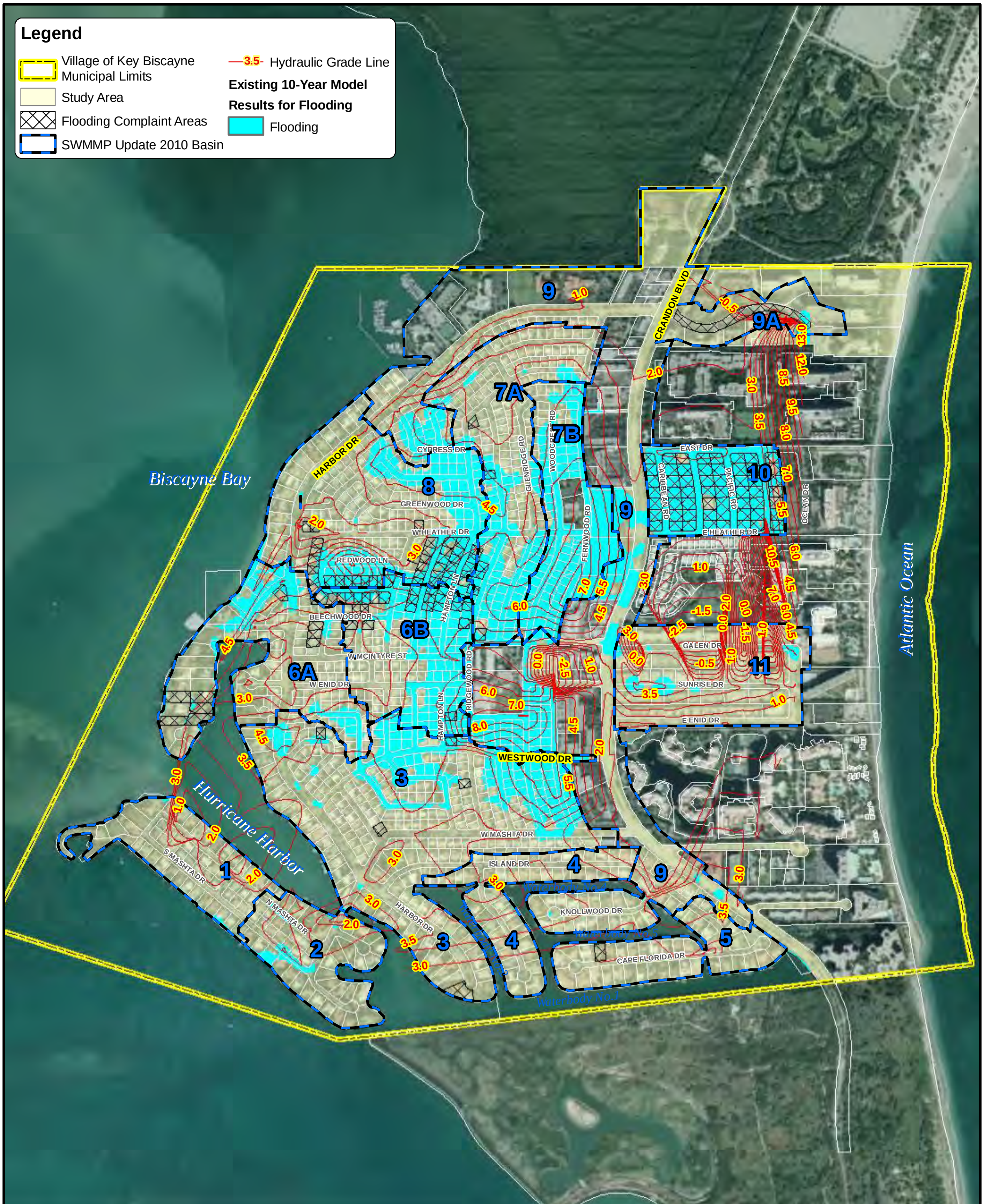
The modeling results illustrate that during major storm events, stormwater within the Village will fill the various shallow storage depressions, typically located on private property, and discharge into the public conveyance system. The water will continue flowing within the roadside swales into the storm sewer. As the water continues to fill the stormwater system, it will reach a point where the runoff enters the drainage wells. As the stage continues to rise in these drainage wells it reaches an elevation that allows the flow to overtop the weirs and discharge into the Biscayne Bay. During the more intense storms, the runoff for the system increases to a point where it overtaxes the conveyance capacity and eventually reaches an overloaded condition and flooding occurs. The conveyance capacity is very limited because the majority of the storm sewer pipes do not have any slope and rely on head pressure to move the water downstream. The model demonstrates that portions of the existing infrastructure lack enough positive head to adequately convey water downstream due to tidal tailwater interaction and insufficient conveyance capacity.

3.3.3 Existing Flooding Areas Defined by Model

Flooding problems in the Village of Key Biscayne, can be attributed to several causes, including floodplain encroachment, which accounts for the majority of the water quantity problems, high tailwater conditions caused by tidal fluctuations, and low topography. The level of service is the extent the stormwater system can be expected to adequately convey runoff. After the level of service has been exceeded, the stormwater system is overloaded and localized flooding can be expected.

Figure 3.3 illustrates the model results for a 10-year storm under existing conditions. The extents of flooding appear to be consistent with known flooding events in the Village. Basin 10, located east of Crandon Blvd, is an area of low topography surrounded by higher elevations creating a bowl effect for water to pond. The middle portion of the Village located on the west side of Crandon is also subject to a similar topographic phenomenon. This portion is much larger and encompasses portions of Basins 3, 6B, 7A, 7B, 8, and 9. There are several areas near outfalls to Biscayne Bay that are shown to flood during the design storm.

Table 3.2 summarizes the existing conditions models results indicating the relationship between the depth of flooding from the hydraulic grade line (HGL) and duration of flooding. Because of its length, the table appears at the end of Section 3. The depth of flooding indicated in the table is based on the HGL. The hydraulic grade line (HGL) is a graphic representation of the measure of flow energy from Bernoulli's equation. The line represents the total head available to fluid minus the velocity head and can be expressed as $HGL = p / \gamma + h$, where h is the elevation height and γ is the specific weight of water. This line is used as an aid during modeling of an existing storm drainage system by establishing the elevation to which water will rise when the system is operating under design conditions. Figure 3.3 graphically demonstrates the results provided in Table 3.2 with the hydraulic grade line elevations displayed for reference. From Figure 3.3 and Table 3.2, it is evident that the worse areas with the most flooding coincide with the three repetitive loss areas and known complaint areas. The three areas are defined in **Figure 3.4**. Alternatives for possible flooding solutions for these areas are provided in Section 4.



10-YEAR FLOODING PROPERTIES
STORMWATER MASTER PLAN UPDATE
VILLAGE OF KEY BISCAYNE, FLORIDA

TETRA TECH

Figure 3.3

0 1,200 Feet

Source: Miami- Dade GIS Data
Microsoft Virtual Earth
FEMA RLP

File: P:\IER\15760\200-15760-10003\GIS\Maps\APF3.3.mxd
Printing Date: 03/17/2011
Drawn By: AMM

0 1,200 Feet

Source: Miami- Dade GIS Data
Microsoft Virtual Earth
FEMA RLP

TETRA TECH

REPETITIVE LOSS AREAS
STORMWATER MASTER PLAN UPDATE
VILLAGE OF KEY BISCAYNE, FLORIDA

Figure 2.22

File: P:\IER\15760\200-15760-10003\GIS\Maps\APF2.22.mxd
Printing Date: 03/23/2011
Drawn By: AMM

TABLE 3.2 - Existing Conditions Model Results

Node	Storm Depth from HGL and Duration of Flooding							
	Mean Annual		5-year, 24-hour		10-Year, 72-hour		25-Year, 72 hour	
	Flooding Duration (Mins.)	Depth of Flooding from HGL (inches)	Flooding Duration (Mins.)	Depth of Flooding from HGL (inches)	Flooding Duration (Mins.)	Depth of Flooding from HGL (inches)	Flooding Duration (Mins.)	Depth of Flooding from HGL (inches)
J-102	0	-9.168	14.82	0	43.5	0	63.12	0
J-104	0	-9.432	0	-1.848	0	-1.668	26.46	0.84
J-106	0	-7.584	19.8	1.608	46.44	2.916	107.34	3.84
J-109	0	-14.088	0	-5.292	0	-3.216	29.7	1.044
J-11	0	-20.436	0	-7.092	0	-1.656	0	-1.656
J-110	0	-12.972	0	0	21	1.236	82.02	4.836
J-113	0	-21.132	0	-13.068	0	-11.952	7.38	1.008
J-114	0	-30.156	0	-23.064	0	-21	2.28	0.9
J-116	0	-31.98	0	-25.788	0	-23.832	0	-22.176
J-118	0	-31.548	0	-25.092	0	-23.052	0	-21.312
J-119	0.84	2.856	0.84	2.856	0.84	2.856	0.84	2.856
J-12	0	-20.268	0	-6.972	0	-1.632	0	-1.656
J-121	0	-21.744	0	-5.676	0	0	35.34	0.432
J-126	38.4	12.264	88.62	49.944	107.94	77.772	125.22	109.44
J-127	14.16	1.284	72.6	25.272	93.54	40.476	110.64	57.132
J-128	0	-0.168	68.64	21.492	90	34.788	107.4	49.236
J-129	0	-18.06	0	0.012	0.12	0.108	15.48	0.6
J-130	0.42	0.264	12.42	0.852	8.04	1.02	71.28	2.088
J-131	0.6	0.336	13.56	0.66	8.58	0.552	60.3	0.732
J-132	1.86	0.444	16.86	0.708	19.92	1.608	97.44	7.356
J-137	13.92	0.276	33.54	0.432	42.3	2.94	114.18	7.872
J-139	5.4	0	7.98	0	9.18	0	38.16	0
J-140	7.02	0.312	15.78	0.348	42.42	4.752	109.2	12.048
J-147	6	0.48	58.14	7.008	82.68	18.816	148.62	30.852
J-148	2.82	0.696	55.08	8.844	80.16	20.988	128.1	33.768
J-149	8.94	0.54	82.02	15.324	104.28	27.468	175.74	40.26
J-15	0	-13.596	1.86	0.084	27.84	6.912	37.92	8.304
J-152	5.52	0.504	66.06	9.816	88.38	22.26	153.48	35.448
J-153	6.84	0.66	68.16	8.928	89.1	21.348	160.5	34.572
J-155	7.08	0.552	72.12	10.116	95.16	22.524	166.68	35.772
J-156	8.16	0.468	80.4	12.6	102.54	24.972	178.68	38.256
J-158	2.58	0.516	59.4	11.628	83.52	23.964	138.06	37.26
J-160	1.26	0.264	52.08	9.828	77.1	21.756	118.02	34.632
J-161	0.9	0.276	16.32	0.756	10.08	0.552	86.16	2.892
J-162	0	0.024	3.06	0.456	3	0.54	26.76	0.66
J-163	1.56	0.312	16.8	0.636	21.9	2.904	103.2	9.18
J-164	0.36	0.156	17.22	0.732	9.3	0.888	92.94	3.324
J-165	0.48	0.216	17.58	0.972	9.48	0.912	88.98	1.932
J-166	0.36	0.072	17.64	0.708	9.42	0.816	95.82	3
J-167	0.6	0.132	15.06	0.9	8.34	0.9	75.18	0.936
J-168	0.54	0.312	15.78	0.756	8.22	0.732	76.14	0.864
J-169	1.44	0.624	23.16	0.756	12.48	0.624	94.32	1.248
J-170	2.16	0.42	24.72	0.612	15.48	0.54	103.26	0.78
J-174	5.82	0.624	79.92	18.24	98.52	30.168	174.6	43.044
J-175	8.7	0.48	86.58	15.264	107.04	27.192	193.86	40.08

TABLE 3.2 - Existing Conditions Model Results

Node	Storm Depth from HGL and Duration of Flooding							
	Mean Annual		5-year, 24-hour		10-Year, 72-hour		25-Year, 72 hour	
	Flooding Duration (Mins.)	Depth of Flooding from HGL (inches)	Flooding Duration (Mins.)	Depth of Flooding from HGL (inches)	Flooding Duration (Mins.)	Depth of Flooding from HGL (inches)	Flooding Duration (Mins.)	Depth of Flooding from HGL (inches)
J-176	3.18	0.936	52.8	6.012	78.06	15.588	138.42	25.98
J-179	1.14	0.936	51.3	9.348	76.8	18.192	124.98	27.828
J-18	0	-13.488	5.64	0.288	30.24	7.38	40.08	9.168
J-180	0	0	0	0	4.86	0.168	40.38	0.36
J-185	2.64	0.492	64.98	9.36	88.14	16.512	180.42	24.48
J-188	15.72	1.404	99.12	19.008	114.48	28.944	214.44	39.936
J-191	39.54	8.88	86.7	24.54	106.32	33.684	175.86	43.764
J-195	20.52	3.156	76.98	23.808	93.48	36.408	154.2	49.548
J-198	22.98	3.816	79.26	24.504	95.1	37.092	155.64	50.232
J-199	12.3	0.888	69.6	19.704	89.28	30.18	144.12	40.632
J-203	10.32	0.54	68.76	18.576	88.44	28.2	137.4	37.572
J-204	15.24	1.344	71.94	19.548	90.72	29.352	139.86	38.952
J-206	0	-3.132	54.48	11.58	75.78	17.844	128.34	23.232
J-208	0	-3.9	50.1	10.044	71.4	15.3	111.24	19.668
J-209	0	-1.8	59.34	14.016	77.88	22.224	133.26	30.252
J-212	0	-3.792	54.36	12.204	73.56	20.724	128.46	29.148
J-213	0.84	0	69.6	16.344	82.32	25.164	141.96	33.972
J-217	46.62	14.712	88.98	35.436	107.7	48.24	163.14	61.416
J-218	35.4	9.384	80.52	29.952	99.9	42.552	148.56	55.476
J-222	48.66	14.688	90.42	33.744	109.14	44.316	166.62	54.864
J-223	16.14	1.788	67.26	20.82	87.6	31.344	122.88	41.844
J-225	0	-3.408	54.9	13.176	76.8	21.432	122.58	29.22
J-226	0	-4.044	52.92	12.036	74.94	19.716	120.6	26.832
J-232	0	-7.824	37.62	6.252	61.32	11.304	108.48	15.396
J-233	0	-12.468	0	-0.12	40.68	1.584	56.82	2.448
J-235	0	-12.864	0	-0.96	36	0	51.96	0
J-238	0	-13.44	0	-0.564	10.38	0.768	25.86	1.26
J-24	0	-5.184	37.74	9.072	56.46	18.432	79.02	24.456
J-242	0	-10.512	12.18	1.476	37.98	5.004	100.56	6.168
J-244	0	-8.892	19.86	5.556	41.46	12.168	92.34	17.844
J-247	0	-16.956	0	-2.712	15.12	3.792	55.8	9.288
J-248	0	-10.548	8.04	0.852	27.9	4.416	62.82	6.264
J-249	0	-11.568	0	0	20.1	2.688	39.12	4.02
J-25	0	-5.616	36	8.592	55.26	17.952	74.52	23.976
J-253	18.42	3.504	67.2	23.112	83.88	36.816	95.04	51.192
J-254	14.04	2.208	62.46	21.516	80.16	34.848	92.58	48.792
J-256	6.84	0.444	57.6	19.68	75.84	32.64	88.98	46.272
J-259	0	-1.236	53.04	16.428	72.54	26.856	86.1	37.584
J-260	0	-16.92	1.86	0.072	38.82	4.608	48.12	10.176
J-261	0	-13.248	10.56	4.236	32.58	4.716	43.74	4.728
J-262	0	-23.796	0.3	0	0.72	0	0.36	0
J-266	0	-14.964	0	-0.996	0.54	0.024	10.5	2.004
J-267	0	-16.332	0	-2.688	0	-0.552	2.58	0.648
J-268	0	-16.272	0	-6.744	0	-4.896	0	-3.06
J-269	0	-16.5	0	-6.888	0	-4.98	0	-3.156
J-27	0	-4.8	40.5	9.684	58.86	18.984	89.52	25.008
J-271	0.84	1.152	0.84	1.152	0.84	1.152	0.84	1.152

TABLE 3.2 - Existing Conditions Model Results

Node	Storm Depth from HGL and Duration of Flooding							
	Mean Annual		5-year, 24-hour		10-Year, 72-hour		25-Year, 72 hour	
	Flooding Duration (Mins.)	Depth of Flooding from HGL (inches)	Flooding Duration (Mins.)	Depth of Flooding from HGL (inches)	Flooding Duration (Mins.)	Depth of Flooding from HGL (inches)	Flooding Duration (Mins.)	Depth of Flooding from HGL (inches)
J-275	0	-19.356	0	-10.176	0	-8.268	0	-6.456
J-278	0.12	0.288	0.12	0.288	0.12	0.288	0.12	0.288
J-280	0	0.048	0	0.048	0	0.048	0	0.048
J-281	0	-16.2	0	-8.424	0	-6.276	0	-4.488
J-282	0	-18.516	0	-10.032	0	-7.716	0	-5.724
J-283	0	-18.192	0	-9.672	0	-7.62	0	-5.76
J-284	0	-17.484	0	-8.94	0	-7.008	0	-5.184
J-285	0	-17.04	0	-7.908	0	-6.06	0.3	0.204
J-286	0	-13.212	0	-3.264	0	-1.56	16.62	0.528
J-288	0	-31.02	0	-22.284	0	-20.064	0	-18.06
J-290	0	-8.688	31.2	8.952	51.78	18.552	94.08	29.604
J-293	0	-11.052	23.28	3.996	44.46	10.992	71.1	18.96
J-295	0	-12.708	15.66	1.896	38.46	8.448	62.7	15.876
J-296	0	-9.768	25.62	4.32	46.44	10.26	74.94	16.992
J-297	0	-9.264	16.86	1.728	40.62	4.104	63.42	6.936
J-30	0	-4.776	39.18	8.292	57.96	16.536	89.04	21.876
J-300	0	-9.744	9.96	0.876	32.58	2.82	53.4	5.16
J-301	0	-10.584	0	-0.12	21.9	1.716	44.7	3.996
J-304	0	-8.748	19.26	1.788	41.52	3.3	72.18	5.376
J-305	0	-8.88	21.12	1.788	42.42	3.036	70.92	4.92
J-31	0	-3.72	41.7	8.724	60.06	16.392	91.56	21.42
J-310	0	-9.864	10.98	0.396	32.16	1.116	65.16	2.916
J-312	0	-9.756	15.84	0	37.32	0	51.12	0
J-314	0	-9	22.08	1.704	43.2	2.46	83.52	3.492
J-317	0	-2.94	41.64	11.52	59.16	18.456	106.14	26.004
J-321	0	-2.82	42.42	11.892	60.06	19.38	108.72	27.516
J-323	2.46	0.108	48.66	15.528	65.22	23.712	114.66	32.604
J-324	0	-0.708	46.62	15.288	63.9	24.36	114.42	34.224
J-327	0	-4.464	40.38	9.828	58.44	19.272	81.66	25.38
J-328	0	-3.78	43.68	11.388	60.54	21.228	92.22	27.78
J-33	0	-14.028	0	-6	0	-1.98	13.08	0
J-333	41.4	9.756	88.32	24	107.58	31.92	178.8	40.644
J-334	27.96	4.728	79.32	13.392	99.54	16.296	169.26	19.632
J-335	25.62	4.032	77.46	16.344	97.14	22.344	164.76	29.244
J-341	38.52	9.732	92.22	31.008	106.8	44.724	175.74	60.576
J-342	43.14	12.06	93.6	38.256	114	55.2	186.9	71.952
J-343	39.72	10.716	90.72	37.32	111.3	54.612	187.86	71.832
J-348	40.32	9.948	90.84	31.116	111.18	44.1	188.7	56.88
J-351	38.76	9.084	88.8	31.356	110.82	45.36	188.52	59.604
J-354	49.74	16.524	99.12	48.036	118.8	69.612	194.34	92.544
J-355	47.22	15.084	96.84	45.816	117.12	66.72	190.08	88.752
J-359	44.22	13.176	94.26	41.472	114.66	60.216	195.18	79.38
J-36	0	-6.012	22.98	1.812	44.7	5.76	58.08	7.932
J-362	0	-1.056	72.78	23.46	94.74	39.156	160.26	53.328
J-363	0	-1.908	70.8	21.684	93	36.852	158.22	49.92
J-364	0	-3.852	66.12	18.732	88.86	33.096	152.7	44.724
J-367	17.82	1.524	76.92	22.272	97.92	34.332	159.36	44.868

TABLE 3.2 - Existing Conditions Model Results

Node	Storm Depth from HGL and Duration of Flooding							
	Mean Annual		5-year, 24-hour		10-Year, 72-hour		25-Year, 72 hour	
	Flooding Duration (Mins.)	Depth of Flooding from HGL (inches)	Flooding Duration (Mins.)	Depth of Flooding from HGL (inches)	Flooding Duration (Mins.)	Depth of Flooding from HGL (inches)	Flooding Duration (Mins.)	Depth of Flooding from HGL (inches)
J-368	16.62	1.38	76.5	22.164	97.56	34.212	152.52	44.688
J-369	0	-7.848	51.54	10.32	75.3	19.8	133.68	24.888
J-374	0	-7.524	53.94	11.988	77.94	23.436	134.52	30.372
J-375	0	-9.06	45.72	8.28	70.2	17.028	127.08	20.64
J-380	0	-7.56	50.88	10.5	75.36	21.252	130.86	27.204
J-381	0	-10.356	42.06	7.14	67.08	16.488	123.12	20.364
J-384	0	-10.752	35.64	5.436	61.08	13.248	116.46	15.204
J-385	0	-21.516	0	-5.796	19.44	0	55.32	0
J-388	0	-13.968	0.78	0.012	40.32	6.3	99.72	7.224
J-389	0	-14.952	0	0	37.68	5.172	102.18	6.084
J-393	0	-14.244	0.06	0	38.16	5.34	102.36	6.324
J-396	0	-13.332	0	0	36.3	4.764	99.48	6.372
J-399	0	-16.776	0	-7.404	0	-5.196	36.24	0.792
J-40	21.6	3.216	66.66	10.404	89.34	16.392	138.18	23.52
J-402	0.78	0.516	27.24	7.884	54.12	19.056	117.6	28.584
J-405	0.72	0.828	8.28	0.828	39.3	8.712	101.94	13.332
J-407	0.12	0.312	0.12	0.312	31.8	4.644	86.52	5.88
J-409	0	-16.344	0	-1.968	29.34	3.612	65.52	3.996
J-410	0	-20.148	0	-5.88	0	-0.48	4.14	0.264
J-412	0	-19.404	0	-5.316	13.08	0	29.7	0
J-414	0	-9.54	25.02	5.616	50.58	12.084	103.02	14.364
J-415	0	-15.456	7.08	0.468	37.68	7.428	92.46	10.776
J-416	0	-18.216	0	-3.228	24.42	3.084	59.34	5.028
J-417	0	-22.86	0	-9.18	0	-3.204	35.82	2.184
J-42	112.08	28.32	174.6	46.092	211.38	57.252	287.16	69.096
J-421	0	-14.616	17.4	3.036	45	12.42	111.3	19.164
J-422	0	-15.876	16.5	2.784	44.64	12.936	110.7	20.88
J-423	0	-23.736	0	-11.088	0	-5.424	36.48	2.064
J-424	0	-15.504	0.18	0	34.98	7.2	102.6	12.648
J-427	0	-14.928	10.62	1.092	38.58	8.784	107.7	15.024
J-430	0	-16.752	14.4	2.292	40.98	11.844	110.1	21.492
J-431	0.3	0.096	56.4	12.792	85.32	25.428	142.44	40.164
J-432	0.6	0.18	62.94	15.048	90.36	27.516	173.64	42.06
J-433	0	-6.432	50.64	8.484	80.64	19.056	164.1	31.5
J-434	0	-7.692	43.92	6.312	75.54	16.776	155.1	29.076
J-435	0	0.048	28.44	2.412	65.16	12.456	147	24.3
J-436	0	-4.944	45.66	6.576	76.56	16.2	154.68	27.588
J-437	0	-0.768	57.84	11.016	86.52	20.544	177.54	31.836
J-438	0.12	0.012	18.3	0.912	58.14	8.544	149.58	17.952
J-439	0.12	0	0	0	49.38	6.096	126.36	15.444
J-440	0	-28.368	0	-28.728	0	-28.704	0.06	0.108
J-441	0	-37.788	0	-39.384	0	-39.372	0.54	0.204
J-444	0	8.808	0	16.968	0	20.556	0	22.824
J-445	0	-25.656	0	-16.584	0	-12.612	28.44	2.016
J-448	0	-23.184	0	-22.788	0	-20.964	0	-15.54
J-450	0	-21.108	0	-9.3	0	-4.044	47.4	2.832
J-454	0	-23.052	0	-21.528	0	-19.116	0	-5.112

TABLE 3.2 - Existing Conditions Model Results

Node	Storm Depth from HGL and Duration of Flooding							
	Mean Annual		5-year, 24-hour		10-Year, 72-hour		25-Year, 72 hour	
	Flooding Duration (Mins.)	Depth of Flooding from HGL (inches)	Flooding Duration (Mins.)	Depth of Flooding from HGL (inches)	Flooding Duration (Mins.)	Depth of Flooding from HGL (inches)	Flooding Duration (Mins.)	Depth of Flooding from HGL (inches)
J-455	0	-15.924	0	-13.068	0	-9.648	0.18	0.144
J-457	0	-24.768	0	-21.096	0	-18.564	0	-4.536
J-459	0	-34.404	0	-30.552	0	-27.696	0	-14.076
J-460	0	-17.004	0	-11.652	0	-9.192	2.04	1.248
J-463	0	-19.656	0	-14.196	0	-11.16	1.26	0.408
J-466	0	-31.488	0	-25.164	0	-21.984	0	-7.152
J-468	0	-29.52	0	-23.532	0	-20.364	0.48	1.764
J-47	0	-9.108	0	-11.712	0	-13.704	51.18	2.256
J-470	0	-22.392	0	-12.024	0	-17.16	0	-7.248
J-471	0	-36.684	0	-18.168	0	-24.936	0	-16.164
J-473	0	-17.34	0	-4.656	0	-9.252	0	-1.536
J-474	0	-24.312	0	-7.896	0	-13.56	0	-8.088
J-478	0	-16.008	0.06	0.024	0	-5.292	2.34	1.644
J-479	0	-13.416	0.18	0.084	0	-3.084	11.52	4.464
J-480	0	-19.524	0	-2.976	0	-7.656	0.9	0.12
J-481	0	-21.372	0	-1.824	0	0.024	33.96	3.852
J-482	0	-20.736	0	-3.456	0	0.012	44.04	6.108
J-484	0	-18.036	0	-0.264	0	-0.288	51.12	8.964
J-485	0	-18.444	0	-1.104	0	-0.408	50.94	8.82
J-486	0	-15.6	0.18	0.108	28.98	2.952	60.84	12.216
J-487	0	-19.284	0	-2.772	0	-0.132	54.42	9.204
J-489	0	-10.896	0	-2.412	30.24	2.916	65.82	12.312
J-491	0	-7.092	0	-0.42	44.22	7.128	76.08	16.536
J-492	0	-7.068	0	-5.82	29.64	2.292	82.74	11.676
J-493	0.06	0.048	0	-3.588	41.1	4.536	90.3	13.908
J-495	0.06	0.072	0	-8.496	0	-0.84	68.58	8.58
J-497	0.48	0.372	38.88	8.352	70.92	17.34	117	26.952
J-498	0.48	0.192	23.88	2.784	60.18	12.108	126.12	22.152
J-499	0.18	0.072	0.18	0.024	49.44	7.608	93.48	17.496
J-5	0	-20.436	0	-5.412	3.66	0.324	0.9	0.108
J-50	0	-13.8	0	-18.84	0	-20.292	35.64	2.724
J-500	0.06	0.288	22.56	2.712	59.04	11.844	99.78	21.648
J-505	0.24	0.156	40.62	8.508	73.2	17.64	113.88	27.444
J-508	0.18	0.24	0.12	0.18	47.88	6.9	87.54	16.692
J-51	0	-17.592	0	-18.864	0	-19.296	47.64	2.376
J-512	0.3	0.396	31.2	5.808	65.1	14.868	107.28	24.576
J-518	0.36	0.324	25.2	3.552	61.08	12.564	103.56	22.224
J-53	104.82	22.68	183.18	61.272	224.46	86.004	307.74	111.228
J-534	0	-11.88	0	-10.86	0	-9.564	13.32	7.8
J-537	0	-24.768	0	-23.1	0	-20.808	0.06	0.012
J-539	0	-25.848	0	-23.268	0	-20.268	0.48	0.984
J-54	127.86	28.104	202.44	66.696	242.76	91.428	405.42	116.652
J-541	0	-24.744	0	-17.316	0	-14.004	1.92	3.024
J-544	0.06	0.012	0	-3.372	0	-5.532	49.02	1.74
J-548	0	-26.82	0	-27.984	0	-26.136	0.06	0.192
J-550	0	-28.584	0	-29.856	0	-29.916	0	-27.636
J-553	0	-30.84	0	-21.528	0	-31.404	0	-21.108

TABLE 3.2 - Existing Conditions Model Results

Node	Storm Depth from HGL and Duration of Flooding							
	Mean Annual		5-year, 24-hour		10-Year, 72-hour		25-Year, 72 hour	
	Flooding Duration (Mins.)	Depth of Flooding from HGL (inches)	Flooding Duration (Mins.)	Depth of Flooding from HGL (inches)	Flooding Duration (Mins.)	Depth of Flooding from HGL (inches)	Flooding Duration (Mins.)	Depth of Flooding from HGL (inches)
J-554	0	-38.508	0	-29.112	0	-38.868	0	-37.02
J-555	0	-39	0	-36.552	0	-39.276	0	-36.576
J-557	0	-25.944	0	-24.672	0	-25.932	0	-24.78
J-558	0	-26.124	0	-25.068	0	-26.184	0	-25.164
J-559	0	-26.508	0	-6.228	0	-26.436	0	-24.048
J-560	0	-25.272	0	0.012	0	-25.284	0	-23.172
J-561	0	-9.744	0	-9.744	0	-9.744	0	-9.744
J-563	0	-13.848	13.86	1.872	34.32	10.368	33.3	9.576
J-565	0	-17.232	0	-2.1	23.52	4.152	5.52	4.248
J-566	0	-21.78	0	-3.168	12.96	0	0.36	0
J-567	0	-30.252	0	0	0	-3.408	0	-1.812
J-568	0	-21.792	0	0.012	0.78	0.144	0.96	0.792
J-569	0	-21.96	0	-5.22	0.06	0.972	0.24	2.508
J-570	0	-8.004	32.94	10.716	51.54	21.12	60.06	22.896
J-571	0	-15.9	23.4	8.736	45.54	24.732	55.74	30.528
J-572	0	-17.892	0	-16.344	0	-16.152	0	-15.924
J-575	0	-40.752	0	-40.74	0	-40.74	0	-40.74
J-576	0	-30.096	0	-29.808	0	-29.916	0	-28.128
J-577	0	-29.628	0	-29.616	0	-29.592	0	-29.568
J-578	0.06	0.108	0.06	0.108	0.06	0.108	0.06	0.108
J-58	140.4	29.568	209.04	67.116	246.3	91.236	484.74	115.68
J-581	0	-10.764	0	-10.764	0	-10.764	0	-10.764
J-585	30.66	0.672	38.04	1.128	25.44	7.944	106.08	24.504
J-588	6.24	0.708	12.96	1.296	0.78	0.096	71.58	1.26
J-59	124.74	25.224	200.34	61.224	241.32	84.348	403.68	107.604
J-591	0.66	0.372	0.6	0	0.18	0	0.6	0.18
J-596	3.72	0.792	9.3	0.768	0.18	0.024	73.2	0.84
J-598	0.24	0.072	10.74	2.064	31.38	13.044	112.2	26.136
J-6	0	-20.256	0	-5.784	2.82	0.264	0.78	0.276
J-60	124.86	24.984	200.34	60.756	241.26	83.796	389.64	106.908
J-601	0.06	0.06	0.24	0.06	17.1	3.972	100.92	13.836
J-602	0.12	0	0	-0.396	0.06	0	74.04	2.736
J-603	0	-26.484	0	-29.16	0	-27.048	0	-5.712
J-604	0	-15.156	0	-16.944	0	-16.908	13.38	0.384
J-606	0.18	0.252	0	0	0.06	0.072	38.94	1.236
J-607	0.12	0.168	0	0.06	0.06	0.252	39.66	1.152
J-609	0.06	0.192	0	-5.148	0	-2.244	55.44	1.932
J-61	118.02	23.928	195.18	59.64	237	82.644	354.9	105.708
J-611	0	-9.084	22.44	6.684	50.34	20.868	129.72	38.88
J-613	0	-8.88	0.24	0.024	33.66	9.096	115.74	22.44
J-615	0	-10.872	0.06	0	26.16	5.712	108.36	17.844
J-618	58.44	10.764	122.28	23.256	153.36	30.78	216.72	38.784
J-623	20.94	2.712	72	6.408	95.22	8.784	138.36	11.496
J-624	0.06	0.024	53.7	1.764	78.72	3.816	111.3	6.204
J-626	7.02	0	55.74	0	76.14	0	96.36	0
J-629	10.68	0.48	57.42	2.28	77.7	3.804	100.32	5.616
J-63	0	-3.108	60.84	5.556	82.62	8.616	100.56	11.916

TABLE 3.2 - Existing Conditions Model Results

Node	Storm Depth from HGL and Duration of Flooding							
	Mean Annual		5-year, 24-hour		10-Year, 72-hour		25-Year, 72 hour	
	Flooding Duration (Mins.)	Depth of Flooding from HGL (inches)	Flooding Duration (Mins.)	Depth of Flooding from HGL (inches)	Flooding Duration (Mins.)	Depth of Flooding from HGL (inches)	Flooding Duration (Mins.)	Depth of Flooding from HGL (inches)
J-632	23.52	3.744	68.64	9.264	91.26	13.848	140.34	19.284
J-633	9.06	0.972	48.18	2.7	63	2.988	84.6	3.492
J-637	19.8	3.9	61.92	5.808	79.98	6.552	116.1	7.5
J-64	0	-2.472	63.3	7.392	85.08	11.436	103.98	15.6
J-640	12.12	1.776	50.94	5.352	65.76	7.992	103.02	10.8
J-647	0	-11.304	0	-4.728	0	-1.368	31.08	1.272
J-650	0.06	0	36.24	0	52.62	0	63.06	0
J-653	1.86	0.156	52.02	6.348	62.94	10.812	105.3	16.212
J-654	6.78	0.264	55.56	9.096	65.4	14.868	105.3	21.768
J-657	0.6	0.204	21.6	1.608	32.82	4.488	62.4	7.944
J-659	0.12	0.036	0.3	0.204	4.26	0.12	21.6	0.228
J-663	2.46	1.032	12.06	0.924	39	3.108	46.26	2.88
J-665	1.2	1.452	10.8	0.948	32.16	4.476	48.54	4.104
J-666	0	-10.032	0	-0.204	26.64	3.996	20.76	3.48
J-67	19.56	2.316	76.68	22.536	97.74	34.656	162.36	46.188
J-670	0	-7.296	18.12	2.784	36.78	7.056	44.34	6.42
J-672	0.48	1.548	0.48	1.548	0.66	1.548	0.42	1.548
J-673	0.3	1.116	17.16	2.4	36	6.216	40.68	5.736
J-678	0	-7.38	20.88	4.344	42.3	8.784	60.66	8.556
J-682	0.54	0.216	0.42	0.216	0.42	0.216	0.66	0.216
J-684	0.36	0.396	0.24	0.396	0.24	0.396	0.42	0.396
J-686	0.06	0.048	0.06	0.048	0.06	0.048	0.06	0.048
J-687	0.06	0.096	0.06	0.096	0.06	0.096	0.06	0.096
J-691	0.18	3.012	0.18	3.012	0.18	3.012	0.18	3.012
J-692	0	-10.536	0	-10.536	0	-10.536	0	-10.536
J-693	0	-24.06	0	-24.06	0	-24.06	0	-24.06
J-697	0	-25.56	0	-25.128	0	-25.32	0	-25.332
J-7	0	-12.408	11.4	1.824	32.4	8.22	24.36	8.22
J-700	14.04	0.3	20.58	0.42	6.84	0.276	10.38	0.48
J-701	0	-19.356	0	-19.356	0	-19.356	0	-15.228
J-702	0	-23.064	0	-23.064	0	-23.064	0	-23.064
J-705	0.12	0.084	0.12	0.084	0.12	0.084	0.12	0.084
J-707	0.18	0.504	0.36	0.504	0.18	0.504	0.54	0.504
J-710	0.48	0.396	0.84	0.396	0.48	0.396	1.02	0.396
J-712	0	-18.564	19.62	4.5	41.46	17.556	56.1	34.08
J-714	0	-19.332	17.82	2.832	38.04	15.408	53.82	31.356
J-719	0	-23.964	6.12	0.732	22.26	3.204	40.62	15.744
J-72	0	-5.148	49.98	0	71.1	0	88.02	0
J-721	0	-31.236	0.42	0	0.48	0	0.54	0
J-725	0	-31.416	0	-9.768	0	-7.776	0	-5.736
J-728	0	-31.452	0	-15.024	0	-9.72	0	-7.548
J-73	0	-4.476	52.98	1.584	73.98	2.436	91.32	3.372
J-734	0	-31.764	0	-20.904	0	-16.176	0	-8.292
J-735	0	-28.428	0	-18.264	0	-13.08	0	-5.328
J-736	0	-32.088	0	-21.912	0	-16.86	0	-9.168
J-737	0	-31.968	0	-21.684	0	-16.788	0	-9.156
J-74	0	-5.1	37.5	0.936	57.48	2.196	77.22	3.144

TABLE 3.2 - Existing Conditions Model Results

Node	Storm Depth from HGL and Duration of Flooding							
	Mean Annual		5-year, 24-hour		10-Year, 72-hour		25-Year, 72 hour	
	Flooding Duration (Mins.)	Depth of Flooding from HGL (inches)	Flooding Duration (Mins.)	Depth of Flooding from HGL (inches)	Flooding Duration (Mins.)	Depth of Flooding from HGL (inches)	Flooding Duration (Mins.)	Depth of Flooding from HGL (inches)
J-740	70.2	8.22	153.48	37.188	193.74	55.86	327.42	73.524
J-741	0.06	0	81.3	19.284	123.6	32.928	240.96	46.2
J-744	9.54	1.956	66.48	18.756	96.72	27.996	200.64	37.812
J-745	9.72	2.04	66.96	18.876	97.44	28.104	197.28	37.908
J-748	0.06	0.144	58.44	15.108	88.62	24.3	176.7	34.056
J-749	0.12	0.06	56.04	14.292	86.64	23.448	175.08	33.168
J-750	0	0.036	22.98	2.712	61.08	11.844	132.72	21.54
J-751	0.12	0.012	55.26	13.608	86.16	22.824	198.72	32.58
J-752	0.54	0.012	65.46	17.112	95.16	26.52	213.18	36.444
J-753	0.66	0.024	63.96	16.932	93.78	26.364	197.04	36.336
J-754	9.54	0.324	67.02	18.024	96.54	27.492	235.62	37.5
J-755	3.48	0.6	7.92	1.38	0.36	0.072	55.92	2.016
J-757	2.04	0.276	2.64	0.168	0.42	0.072	66.18	3.264
J-760	92.4	18.588	157.02	36.084	188.52	47.004	239.28	58.584
J-761	0	-17.388	0	-8.076	0	-4.5	22.98	1.068
J-763	0	-29.628	0	-29.1	0	-27.852	0	-22.86
J-764	0	-13.104	12.18	2.388	32.58	8.352	22.38	8.232
J-766	0	-42.864	0	-36.576	0	-31.908	0	-26.988
J-768	0	-43.152	0	-37.32	0	-32.988	0	-28.524
J-769	0	-43.392	0	-37.956	0	-34.032	0	-29.928
J-77	31.98	6.432	81.84	18.372	101.76	24.276	165	30.804
J-771	0	-43.836	0	-39.204	0	-36.06	0	-32.892
J-772	0	-44.028	0	-39.54	0	-36.516	0	-33.516
J-774	0	-43.836	0	-39.264	0	-36.168	0	-32.916
J-776	0	-43.788	0	-39.12	0	-35.94	0	-32.58
J-778	0	-43.908	0	-39.444	0	-36.444	0	-33.432
J-780	0	-44.088	0	-39.708	0	-36.792	0	-33.9
J-782	0	-43.656	0	-38.676	0	-35.28	0	-31.764
J-784	0	-43.404	0	-37.956	0	-34.164	0	-30.192
J-786	0	-43.608	0	-38.508	0	-34.992	0	-31.188
J-788	0	-43.872	0	-39.252	0	-36.108	0	-32.7
J-790	0	-44.1	0	-39.876	0	-37.02	0	-34.044
J-792	0	-44.484	0	-40.656	0	-38.112	0	-35.616
J-793	0	-44.256	0	-40.26	0	-37.572	0	-34.908
J-795	0	-44.208	0	-40.152	0	-37.428	0	-34.692
J-799	0	-23.064	0	-5.484	0	-5.352	35.16	4.272
J-80	0	-0.312	64.86	12.54	85.32	19.236	132	26.64
J-800	0	-14.088	0	0.012	34.38	5.052	64.62	15.648
J-802	0	-12.744	0.06	0.012	39.48	6.564	69.66	17.208
J-806	0	-13.8	0	-0.828	37.86	6.252	67.08	16.848
J-809	0	-15.024	0	-2.424	35.88	5.64	65.22	16.248
J-810	0	-11.7	0.6	0.036	44.82	8.964	73.38	19.632
J-813	0	-11.412	6.66	0.3	45.84	9.828	74.28	20.904
J-816	0	-9.276	17.88	2.856	51.96	12.672	80.7	24.12
J-819	0	-9.456	15.78	2.544	49.98	12.816	80.46	24.804
J-82	0.96	0.828	45.42	6.468	71.7	15.06	120.18	24.444
J-822	0	-7.272	23.64	4.752	57.9	15.252	87.9	27.504

TABLE 3.2 - Existing Conditions Model Results

Node	Storm Depth from HGL and Duration of Flooding							
	Mean Annual		5-year, 24-hour		10-Year, 72-hour		25-Year, 72 hour	
	Flooding Duration (Mins.)	Depth of Flooding from HGL (inches)	Flooding Duration (Mins.)	Depth of Flooding from HGL (inches)	Flooding Duration (Mins.)	Depth of Flooding from HGL (inches)	Flooding Duration (Mins.)	Depth of Flooding from HGL (inches)
J-826	0	-4.944	26.4	5.832	59.52	15.876	114.36	27.696
J-829	0	-8.004	16.08	2.676	50.16	12.552	103.26	24.204
J-83	0.78	0.9	43.56	6.396	70.26	14.964	109.32	24.312
J-831	0	-8.976	13.56	1.752	49.08	11.34	91.8	22.644
J-836	0	-10.908	1.86	0	45.72	9.348	88.26	20.424
J-838	0	-6.72	23.04	5.496	56.7	16.224	84.12	28.704
J-84	0.78	0.228	44.46	6.624	70.98	15.336	113.82	24.84
J-841	0	-5.496	28.68	6.912	61.2	17.424	85.32	29.652
J-844	0	-5.364	30.6	7.272	60.54	17.34	84.84	29.064
J-848	0	-12.3	4.5	0.108	45.24	9.912	73.44	21.3
J-850	0	-20.736	0	-7.98	10.26	0.432	52.74	11.208
J-851	0	-17.28	0	-4.116	29.7	3.888	60.72	14.616
J-856	0	-23.136	0	-16.236	0	-7.884	0	2.916
J-860	0	-10.308	6.3	0.204	45.78	9.432	74.82	20.292
J-863	0	-8.22	11.82	0.804	48.54	10.056	77.7	21
J-865	0	-12.804	0	0	35.7	5.496	65.76	16.572
J-868	0	-5.988	1.32	0.144	44.52	7.704	74.52	18.948
J-87	1.44	0.48	52.62	6.732	76.68	12.204	150.06	18.24
J-870	0	-4.824	0.9	0.06	41.04	6.756	71.64	18.144
J-879	0	-124.836	0	-111.768	0	-89.784	0	-6.564
J-88	0.84	0.552	50.28	6.624	74.64	12.048	140.88	18.036
J-880	0	-89.208	0	-85.86	0	-82.416	0	-23.028
J-881	0	-87.36	0	-83.904	0	-80.4	0	-23.592
J-882	0	-54.648	0	-50.832	0	-47.064	6.78	6.372
J-883	0	-54.6	0	-50.664	0	-46.716	7.02	7.02
J-884	0	-54.588	0	-50.592	0	-46.56	3.24	13.176
J-888	94.26	19.332	158.94	37.296	190.26	48.6	236.46	60.6
J-889	93.66	19.212	158.4	37.86	190.02	49.764	253.98	62.4
J-891	86.76	17.46	152.52	37.248	183.96	50.268	237.6	64.092
J-892	92.46	19.08	157.56	38.88	188.94	51.9	245.28	65.724
J-894	100.74	23.256	165.3	43.056	196.74	56.088	258.84	69.948
J-896	106.56	24.876	170.64	44.676	205.92	57.732	273.42	71.592
J-899	60.36	9.12	129.48	29.628	161.46	43.308	225.3	57.864
J-902	1.2	0.144	52.92	12.9	83.7	21.936	196.5	31.572
J-903	0.06	0.084	21	2.352	60	11.364	121.26	20.988
J-905	0	-63.684	0	-63.684	0	-63.684	0	-63.684
J-910	0.24	0.948	0.24	0.948	0.24	0.948	0.24	0.948
J-912	0.36	0.528	0.36	0.528	0.36	0.528	0.36	0.528
J-917	0	-21.348	0	-21.348	0	-21.348	0	-21.348
J-918	0.24	1.944	0.24	1.944	0.24	1.944	0.24	1.944
J-920	0	0	0	0	0	0	0	0
J-930	0	-62.7	0	-62.7	0	-62.7	0	-62.7
J-933	0	-65.52	0	-65.52	0	-65.52	0	-65.52
J-934	94.92	19.428	159.96	39.24	192	52.308	257.64	66.18
J-951	0	-4.248	0	-4.248	0	-4.248	0	-4.248
J-953	0.06	0.288	0.06	0.288	0.06	0.288	0.06	0.288
J-954	0	-31.224	0	-30.564	0	-31.224	0	-26.688

TABLE 3.2 - Existing Conditions Model Results

Node	Storm Depth from HGL and Duration of Flooding							
	Mean Annual		5-year, 24-hour		10-Year, 72-hour		25-Year, 72 hour	
	Flooding Duration (Mins.)	Depth of Flooding from HGL (inches)	Flooding Duration (Mins.)	Depth of Flooding from HGL (inches)	Flooding Duration (Mins.)	Depth of Flooding from HGL (inches)	Flooding Duration (Mins.)	Depth of Flooding from HGL (inches)
J-958	0	-31.02	0	-24.576	0	-21.384	0.06	0.084
J-96	0.84	0.66	5.94	0.756	22.68	0.684	93.06	4.776
J-963	66.48	16.68	114.36	29.688	137.28	34.44	187.74	34.38
J-99	0	-2.688	0	-0.36	0.12	0.084	11.88	0.804
JCT-12	0	-78	0	-78	0	-78	0	-78
JCT-14	0	-72	0	-72	0	-72	0	-72
JCT-16	0	-78	0	-78	0	-78	0	-78
JCT-18	0	-78	0	-78	0	-78	0	-78
JCT-20	0	-66	0	-66	0	-66	0	-66
JCT-22	0	-66	0	-66	0	-66	0	-66
JCT-24	0	-17.184	0	-16.248	0	-15.18	2.52	7.2
JCT-26	0	-16.992	0	-17.148	0	-17.124	0	-16.956
JCT-28	0	-29.556	0	-28.392	0	-27.78	0	-21.492
JCT-30	118.32	19.716	192.48	29.544	210.6	33.528	356.1	33.096
JCT-32	0	-8.268	0	-8.184	0	-9.42	0	-2.328
JCT-36	0.36	120	0	120	0.66	120	0.06	120

SECTION 4

Alternatives Identification and Evaluation

SECTION 4
ALTERNATIVE ANALYSIS

4.1 Introduction

Due to the majority of the Village being located within the 100-year flood plain, and considering the infrastructure (roads and drainage systems) were not elevated above the flood plain, there are several areas at risk to flooding caused by a 10-year design storm event. The alternatives in this SWMMP Update seek to address the top three problem areas in the Village. In order to determine which areas are most prone to flooding during the design storm event, properties with historical flood claims for a 10-year storm or less were analyzed and compared with flooded areas within the model. Alternatives will first be identified and the three most feasible alternatives will be carried forward for analysis of the three (3) problem areas defined in Section 3, Figure 3.4, to alleviate flooding during the 10-year design storm event. The following sections summarize the possible alternatives and the analysis for the identified problem areas, but will not address all of the flooding within the Village at this time. Each problem area was analyzed by selecting the best alternative from a comparison of three, based on overall cost effectiveness.

4.2 Alternatives Identification

Numerous alternatives were identified to increase the LOS for the Village of Key Biscayne. The three alternatives which have the greatest likelihood to improve conveyance, protect existing structural features, and reduce the area and extent of inundation during a storm will be carried forward. Alternatives which were identified for consideration were:

- Retention/detention ponds
- Stormwater pumping stations
- Additional surface water discharges
- Increasing pipe sizes to increase flow capacity
- Exfiltration trenches
- Drainage wells
- Check valve/flap gates at existing outfalls

Retention/detention ponds allow the storage and/or the attenuation of stormwater runoff. While this is a common component of many stormwater systems in South Florida, the lack of currently available land and the high price of already-developed land in the Village make the implementation of this alternative very difficult. This alternative is therefore eliminated for further consideration.

Stormwater pumping stations are common to low-lying areas of South Florida similar to the Village. Currently, the Village owns and operates two pump stations, which discharge to injection drainage wells. The lack of available land to site a future pump station, along with the increased complexity of operating and maintaining an additional pump station therefore eliminate this alternative for further consideration.

The Village is generally surrounded by Biscayne Bay. Currently, the Village's stormwater system discharges to Biscayne Bay via 17 surface water outfalls. Normally, the availability of surface water for discharges of stormwater would be a feasible alternative. However, the regulatory requirements for constructing a new outfall, along with the regulatory requirements associated with the water quality of Biscayne Bay make the addition of any surface water outfalls less desirable. Therefore, this alternative is eliminated from further consideration.

Increasing pipe sizes of a stormwater conveyance system typically allows water to flow to the outfalls at a faster rate. However this is not the case for Village of Key Biscayne. Because the conveyance system is primarily flat with very little slope, the conveyance of stormwater through the outfall is more greatly influenced by the available head pressure rather than the slope and size of the system. Head pressure is the difference in water surface elevations between the stormwater flooding at street level and the water surface elevations at the outfall. Because of the likelihood of limited improvements due to this alternative, it has been eliminated from further consideration.

Exfiltration trenches are commonly used throughout South Florida because of the very porous nature of the limestone underlying much of the area. The existing stormwater system within the Village currently contains exfiltration trenches. Exfiltration trenches can be constructed within the public right of way and do not require dedicated land areas. For these reasons, exfiltration trenches will be considered for further evaluation.

The existing stormwater system within the Village currently contains 28 rehabilitated drainage wells. The existing drainage wells within the Village have historically performed extremely well. Installation of additional drainage wells within the problem areas would provide additional disposal for stormwater runoff that backs up onto roadways and private property. For these reasons, drainage wells will be considered for further evaluation.

Reducing the tidal influence on the surface water outfalls through the installation of check valves at the outfalls allows for the existing stormwater system to convey stormwater which backflows into the system from Biscayne Bay rather than store water,. Flap gates work by closing when the water elevation downstream is higher than the elevation upstream. The minimum downstream increase in depth above the upstream depth required to trigger closing the gate varies depending on the type of gate or valve used. The installation of these gates on the Village's outfalls could reduce the impact of high tide conditions for those periodic events that coincide with an inland storm event. The gates could help prevent the inflow of seawater into the conveyance system, thereby allowing stormwater runoff on the island to enter the stormsewer system instead of ponding on private property and public right of ways. The results from the model indicate that all ponding is not eliminated; however, the depth and duration of ponding are reduced. This alternative could potentially improve level of service for the storm inlets with rim elevations at or near the high tide elevation. When the tide is at the peak, water from Biscayne Bay has already backflowed into the stormwater system and, if a rainfall event coincides with high tide, the runoff cannot enter the inlets because of the backflow. For these reasons, check valves at outfall locations will be considered for further evaluation.

4.2.1 Problem Area No. 1 – Flooding Along East Drive

The first problem area studied in detail involves the flooding in the vicinity of East Drive. The storm sewer system along East Drive is connected to the systems on Caribbean Road, Gulf Road, Pacific Road and Atlantic Road. This system connects with Crandon Blvd to the West and pump station HC1 to the East. Much of this system has experienced repetitive flooding in the past including 10-year and 100-year storm events. This can mainly be attributed to the low elevations of this area as illustrated in Figure 2.4. LiDAR images show much of this area with grade elevations between just three (3) to four (4) feet above sea level. This low area is unable to produce a sufficient driving head into the Crandon Boulevard storm sewer system. In addition, the existing pump station is designed to the 5-year storm.

4.2.1.1 Problem Area No. 1 – Alternative 1 – Exfiltration Trenches

Tetra Tech conducted a desktop analysis of the approximate amount of exfiltration trenches that would be required to meet the 10-year/72-hour storm LOS. Approximately 90 linear feet of exfiltration trenches per acre are required to meet this LOS, based on the following:

- 80 percent imperviousness
- 2.0 feet depth to water table
- 28 ft/day hydraulic conductivity

Problem Area No. 1 has an approximate area of 22.6 acres. Approximately 2,000 linear feet exfiltration trenches are necessary for the 10–year/72-hour storm LOS. Construction of exfiltration trenches in the Village is extremely difficult due to the narrow rights of ways within the residential area, numerous underground utilities, unstable soils, and high groundwater elevations compared to the roadway elevations. In addition, installation of new sanitary sewer and replacement of aged water mains was completed in this area in 2009. The roadways were recently reconstructed and demolition/construction/disturbance of the same area would be highly undesirable.

4.2.1.2 Problem Area No. 1 – Alternative 2 – Installation of Check Valves/Flap Gates at Existing Outfalls

This alternative includes the installation of flap gates on all outfalls within the Village to reduce the tidal influence. The Village's stormwater drainage system is influenced by the tidal effects from Biscayne Bay due to low lying areas that are connected to storm pipe networks. Typically the tide fluctuates by as much as two feet (2') in six (6) hours. This is made evident by observing the rising and falling of stage levels within the drainage structures. As a result, the Village of Key Biscayne is prone to flooding during combinations of high tides and significant rainfall events.

For the 10-year storm, this alternative showed moderate improvements in flooded areas that are located closer to Biscayne Bay. While Problem Area No. 1 is connected to the outfalls via its connection to the Crandon Boulevard drainage system, most of the improvements were in the areas on the west side of the Village, as shown in **Figure 4.1** During the simulation, the flap gates were found to remain open for the majority of the storm duration. The tidal condition used in the model accounts for normal fluctuations over a three (3) day period as measured by the SFWMD. Therefore, the depth of water upstream from stormwater runoff would tend to be higher than the tidal elevations downstream. Hence, modeling this tidal condition did not indicate a significant benefit. Although the tidal conditions in this alternative did not get high enough to backflow into the Village, it did create a reduction in the flow capacity of the stormsewer systems. The high tide conditions reduce the driving head in the upstream stormsewer systems which reduce flow. This is a typical condition experienced in the Village's existing stormsewer system.

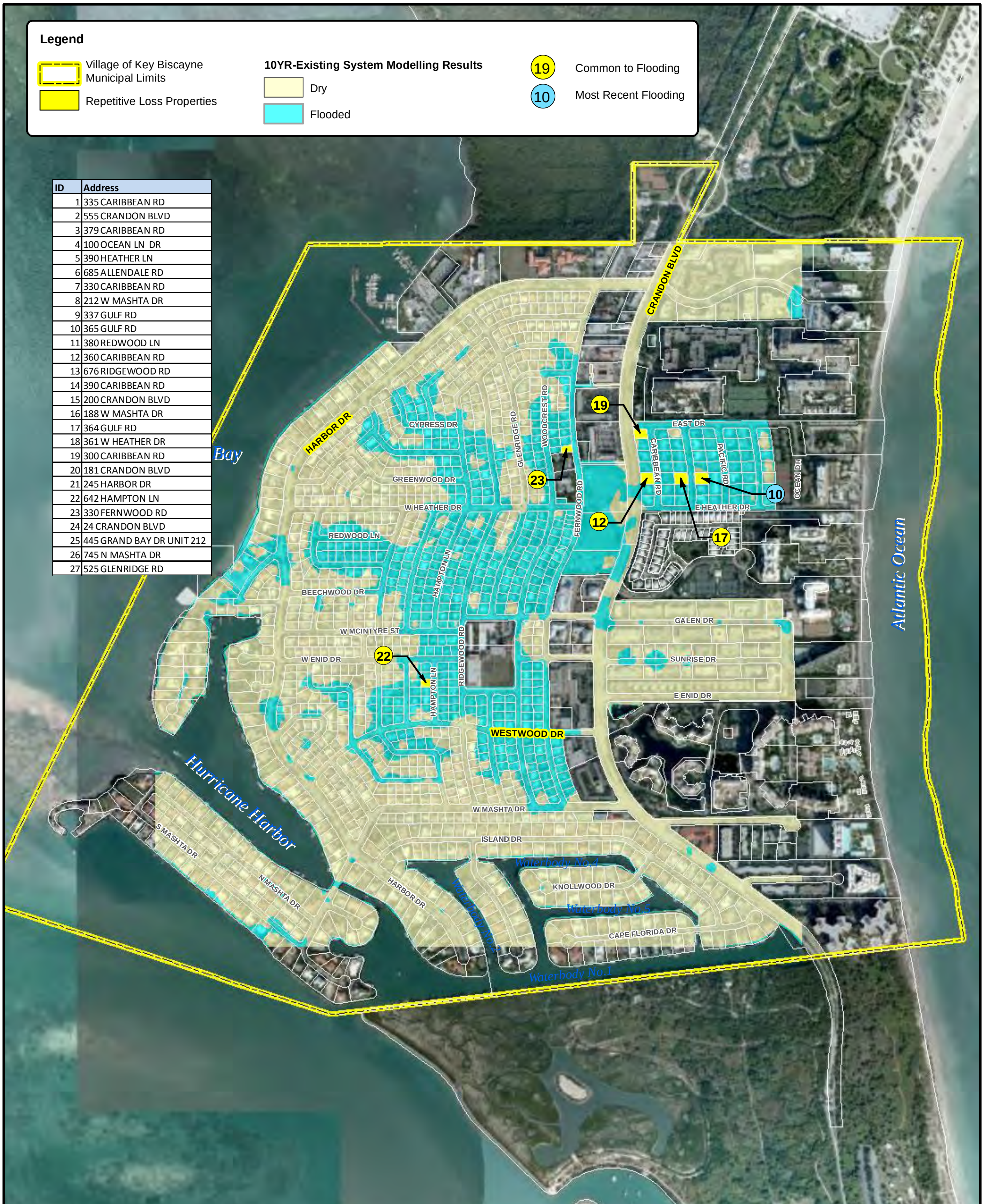
Where the flap gates are likely to be more effective is during abnormally high tidal conditions that periodically occur during rare sun and moon alignments. During such events, the tides are significantly higher, ranging between elevations 0.44 and 2.8 NGVD. This produces a larger head differential in the Bay that would close the flap gates for a longer period of time during a storm. This will effectively "hold back" sea water from entering and flooding the Village's stormsewer system. Such an event occurred in the Village on the October 3, 2008. If flap gates had been installed, there would have been less flooding during this event. **Table 4.1,** provided at the end of this section due to its length, indicates an estimate in the reduction in flooding that may have been achieved during this lunar event.

4.2.1.3 Problem Area No. 1 – Alternative 3 –Drainage Wells

Tetra Tech conducted a simulation for the installation of three (3) gravity drainage wells within Problem Area No. 1. The design capacity of 2,400-gpm, mentioned in Section 3, was used for each of the wells. The results from the model show a significant decrease in flooding for a 10-year storm event. The three proposed drainage wells are located along the intersections of East Heather Drive and Caribbean, Gulf and Pacific Roads. Almost all flooding in Problem Area No. 1 was eliminated in the model for the 10-year design storm. **Table 4.2** summarizes the improvements in depth of flooding. Refer to **Figure 4.1** for an illustration of the results for this area.

Table 4.2 – Problem Area No. 1 – Alternative 3 – Drainage Wells

Basin Number	Structure ID	Depth of Flood (ft) 10-Year Storm		Reduction in Depth of Flooding (ft)
		Existing Condition	New Wells	
9	J-484	2.98	1.84	1.14
9	J-485	2.97	1.84	1.12
9	J-799	2.99	1.82	1.18
9	J-800	3.06	1.77	1.29
9	J-802	3.09	1.82	1.27
Outside	J-806	3.06	1.72	1.34
Outside	J-809	3.06	1.66	1.40
Outside	J-810	3.09	1.70	1.39
Outside	J-813	3.26	1.96	1.30
Outside	J-816	3.40	2.18	1.22
Outside	J-819	3.61	2.49	1.12
Outside	J-822	3.71	2.65	1.07
9	J-826	3.66	2.69	0.98
Outside	J-829	3.59	2.57	1.02
Outside	J-831	3.44	2.49	0.95
Outside	J-836	3.32	2.20	1.12
Outside	J-838	3.69	2.53	1.17
Outside	J-841	3.59	2.38	1.22
Outside	J-844	3.39	2.09	1.30
Outside	J-848	3.27	1.93	1.34
Outside	J-850	3.04	1.62	1.42
Outside	J-851	3.01	1.58	1.43
Outside	J-856	2.84	1.47	1.38
Outside	J-860	2.88	1.54	1.33
Outside	J-863	2.93	1.64	1.29
Outside	J-865	3.00	1.77	1.23
Outside	J-868	3.08	1.94	1.14
Outside	J-870	3.15	2.08	1.07



ID	Address
1	335 CARIBBEAN RD
2	555 CRANDON BLVD
3	379 CARIBBEAN RD
4	100 OCEAN LN DR
5	390 HEATHER LN
6	685 ALLENDALE RD
7	330 CARIBBEAN RD
8	212 W MASHTA DR
9	337 GULF RD
10	365 GULF RD
11	380 REDWOOD LN
12	360 CARIBBEAN RD
13	676 RIDGEWOOD RD
14	390 CARIBBEAN RD
15	200 CRANDON BLVD
16	188 W MASHTA DR
17	364 GULF RD
18	361 W HEATHER DR
19	300 CARIBBEAN RD
20	181 CRANDON BLVD
21	245 HARBOR DR
22	642 HAMPTON LN
23	330 FERNWOOD RD
24	24 CRANDON BLVD
25	445 GRAND BAY DR UNIT 212
26	745 N MASHTA DR
27	525 GLENRIDGE RD

TETRA TECH

10 YEAR FLOODING PROPERTIES
EXISTING CONDITIONS
STORMWATER MASTER PLAN UPDATE
VILLAGE OF KEY BISCAYNE, FLORIDA

Figure 4.1

Source: Miami- Dade GIS Data
Microsoft Virtual Earth
FEMA RLP

File: P:\IER\15760\200-15760-10003\GIS\Maps\APF4.1.mxd
Printing Date: 11/22/2010
Drawn By: AMM

4.2.2 Problem Area No. 2 – Flooding Along Fernwood Road

The second problem area studied in detail involves the flooding in the vicinity of Fernwood Road. The storm sewer system in Problem Area 2 is located along Fernwood Road and branches to the West down West Heather Drive and Woodcrest Lane. The system has two drainage wells and an outfall to Biscayne Bay. LiDAR images show the properties along Fernwood Road to be located near a shallow depression with grade elevations approximately three feet above sea level. As a result, flooding is likely to occur first at this location.

4.2.2.1 Problem Area No. 2 – Alternative 1 – Exfiltration Trenches

Tetra Tech conducted a desktop analysis of the approximate amount of exfiltration trenches that would be required to meet the 10-year/72-hour storm LOS. Approximately 90 linear feet of exfiltration trenches per acre are required to meet this LOS, based on the following:

- 80 percent imperviousness
- 2.0 feet depth to water table
- 28 ft/day hydraulic conductivity

Problem Area No. 2 has an approximate area of 14 acres. Approximately 1,260 linear feet exfiltration trenches are necessary for the 10-year/72-hour storm LOS. Construction of exfiltration trenches in the Village is extremely difficult due to the narrow rights of ways, numerous underground utilities, unstable soils, and high groundwater elevations compared to the roadway elevations. In addition, installation of a new sanitary sewer and replacement of aged water mains was completed in this area in 2009. The roadways were recently reconstructed and demolition/construction/disturbance of the same area would be highly undesirable.

4.2.2.2 Problem Area No. 2 – Alternative 2 – Installation of Check Valves/Flap Gates at Existing Outfalls

As discussed in Section 4.2.1.2, an alternative was evaluated which included the installation of flap gates on all outfalls within the Village to reduce the tidal influence. The effects of this alternative were reviewed within Problem Area No. 2. For the 10-year storm, this alternative showed moderate improvements in flooded areas within Problem Area No. 2 and the results are furthered detailed in Section 4.2.1.2.

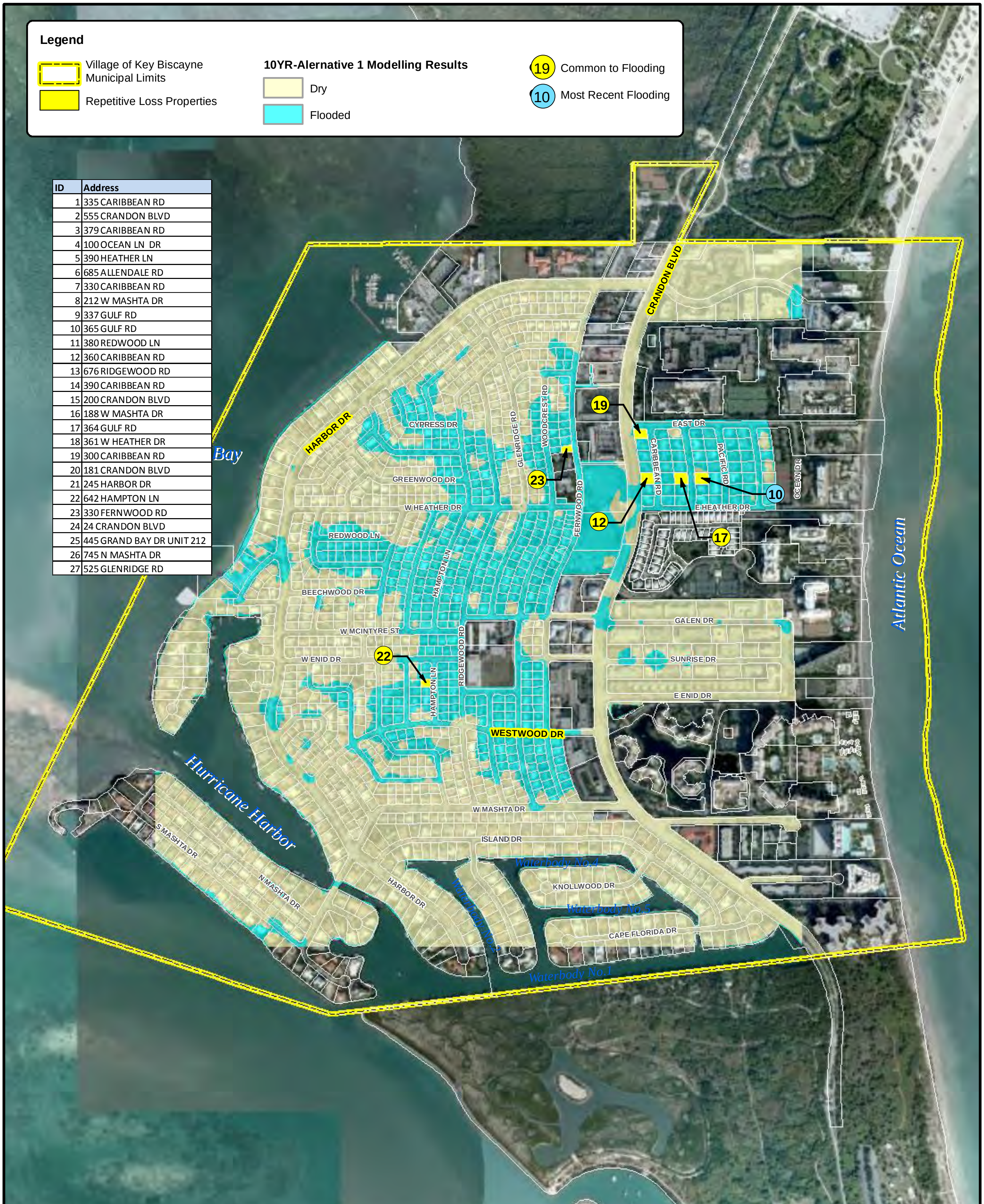
4.2.2.3 Problem Area No. 2 – Alternative 3 –Drainage Well

Tetra Tech conducted a simulation for the installation of one (1) gravity drainage well within Problem Area No. 2. The design capacity of 2,400-gpm, mentioned in Section 3, was used for the well. The results from the model show a significant decrease in flooding for a 10-year storm event. The proposed drainage well is located along the west side of Fernwood Road. Almost all flooding in Problem Area No. 2 was eliminated in the model for the 10-year design storm. **Table 4.3** summarizes the improvements in depth of flooding in this area and **Figure 4.2** provides an illustration of the extent of the improvements.

Table 4.3 – Problem Area No. 2 – Alternative 3 – Drainage Wells

Basin Number	Structure ID	Depth of Flood (ft) 10-Year Storm		Reduction in Depth of Flooding (ft)
		Existing Condition	New Wells	
7A	J-63	3.72	3.64	0.08
7A	J-73	3.20	3.20	0.00
7A	J-77	4.41	4.40	0.02
7A	J-80	4.60	4.58	0.02
7A	J-191	5.20	5.17	0.03
7A	J-333	4.90	4.88	0.02
7A	J-334	3.69	3.68	0.00
7A	J-335	4.42	4.41	0.01
7A	J-388	3.77	3.56	0.20
7A	J-389	3.77	3.56	0.21
7A	J-393	3.79	3.57	0.22
7A	J-396	3.79	3.57	0.22
7A	J-399	3.41	3.92	-0.51
7A	J-402	4.67	4.58	0.09
7A	J-405	3.92	3.87	0.05
7A	J-407	3.40	3.37	0.02
7A	J-410	3.25	3.31	-0.06
7A	J-414	3.49	3.43	0.05
7A	J-415	3.62	3.55	0.07

7A	J-416	3.45	3.40	0.05
7A	J-417	3.24	3.68	-0.44
7A	J-421	4.08	3.97	0.11
7A	J-422	4.27	4.15	0.12
7A	J-423	2.89	3.53	-0.64
7A	J-427	3.57	3.50	0.08
7A	J-430	4.13	4.04	0.09
7A	J-450	2.66	3.18	-0.52
7A	J-424	3.44	3.37	0.07
7A	J-409	3.27	3.25	0.02
7A	J-74	3.18	3.14	0.04
7A	J-64	3.95	3.83	0.12
7A	J-412	3.20	3.20	0.00
7A	J-385	4.00	4.00	0.00
7A	J-72	3.00	3.00	0.00
7B	J-67	5.83	5.37	0.46
7B	J-348	6.07	5.63	0.44
7B	J-351	6.34	5.92	0.42
7B	J-354	8.36	7.64	0.72
7B	J-355	8.17	7.43	0.74
7B	J-364	6.15	4.11	2.04
7B	J-367	5.70	5.27	0.43
7B	J-368	5.69	5.26	0.43
7B	J-369	4.84	4.43	0.41
7B	J-374	5.29	4.08	1.21
7B	J-375	4.61	4.20	0.41
7B	J-380	5.11	4.08	1.04
7B	J-381	4.71	4.01	0.71
7B	J-384	4.34	3.94	0.40
7B	J-342	7.04	6.15	0.89
7B	J-343	7.14	6.26	0.88
7B	J-359	7.56	6.74	0.82
7B	J-362	6.60	5.08	1.52
7B	J-363	6.41	4.61	1.80



ID	Address
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4	100 OCEAN LN DR
5	390 HEATHER LN
6	685 ALLENDALE RD
7	330 CARIBBEAN RD
8	212 W MASHTA DR
9	337 GULF RD
10	365 GULF RD
11	380 REDWOOD LN
12	360 CARIBBEAN RD
13	676 RIDGEWOOD RD
14	390 CARIBBEAN RD
15	200 CRANDON BLVD
16	188 W MASHTA DR
17	364 GULF RD
18	361 W HEATHER DR
19	300 CARIBBEAN RD
20	181 CRANDON BLVD
21	245 HARBOR DR
22	642 HAMPTON LN
23	330 FERNWOOD RD
24	24 CRANDON BLVD
25	445 GRAND BAY DR UNIT 212
26	745 N MASHTA DR
27	525 GLENRIDGE RD

VILLAGE OF KEY BISCAYNE FLORIDA

TETRA TECH

10 YEAR FLOODING PROPERTIES
ALTERNATIVE 1
STORMWATER MASTER PLAN UPDATE
VILLAGE OF KEY BISCAYNE, FLORIDA

N

Figure 4.2

0 — 1,200 Feet

Source: Miami- Dade GIS Data
Microsoft Virtual Earth
FEMA RLP

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Printing Date: 11/22/2010
Drawn By: AMM

4.2.3 Problem Area No. 3 - Flooding Along Hampton Road

The third problem area studied in detail involves the flooding in the vicinity of Hampton Road. The storm sewer system in Problem Area 3 is located along Hampton Road and runs westward along West Enid to two drainage wells and two outfalls to Biscayne Bay. Although the elevations in this area are not particularly low, it is located near the end of the drainage system which appears to have limited flow capacity.

4.2.3.1 Problem Area No. 3 – Alternative 1 – Exfiltration Trenches

Tetra Tech conducted a desktop analysis of the approximate amount of exfiltration trenches that would be required to meet the 10-year/72-hour storm LOS. Approximately 90 linear feet of exfiltration trenches per acre are required to meet this LOS, based on the following:

- 80 percent imperviousness
- 2.0 feet depth to water table
- 28 ft/day hydraulic conductivity

Problem Area No. 3 has an approximate area of 16 acres. Approximately 1,500 linear feet exfiltration trenches are necessary for the 10-year/72-hour storm LOS. Construction of exfiltration trenches in the Village is extremely difficult due to the narrow rights of ways, numerous underground utilities, unstable soils, and high groundwater elevations compared to the roadway elevations. In addition, installation of a new sanitary sewer and replacement of aged water mains was completed in this area in 2009. The roadways were recently reconstructed and demolition/construction/disturbance of the same area would be highly undesirable.

4.2.3.2 Problem Area No. 3 – Alternative 2 – Installation of Check Valves/Flap Gates at Existing Outfalls

As discussed in Section 4.2.1.2, an alternative was evaluated which included the installation of flap gates on all outfalls within the Village to reduce the tidal influence. The effects of this alternative were reviewed within Problem Area No. 3. For the 10-year storm, this alternative showed moderate improvements in flooded areas within Problem Area No. 3 and the results are furthered detailed in Section 4.2.1.2.

4.2.3.3 Problem Area No. 3 – Alternative –Drainage Well

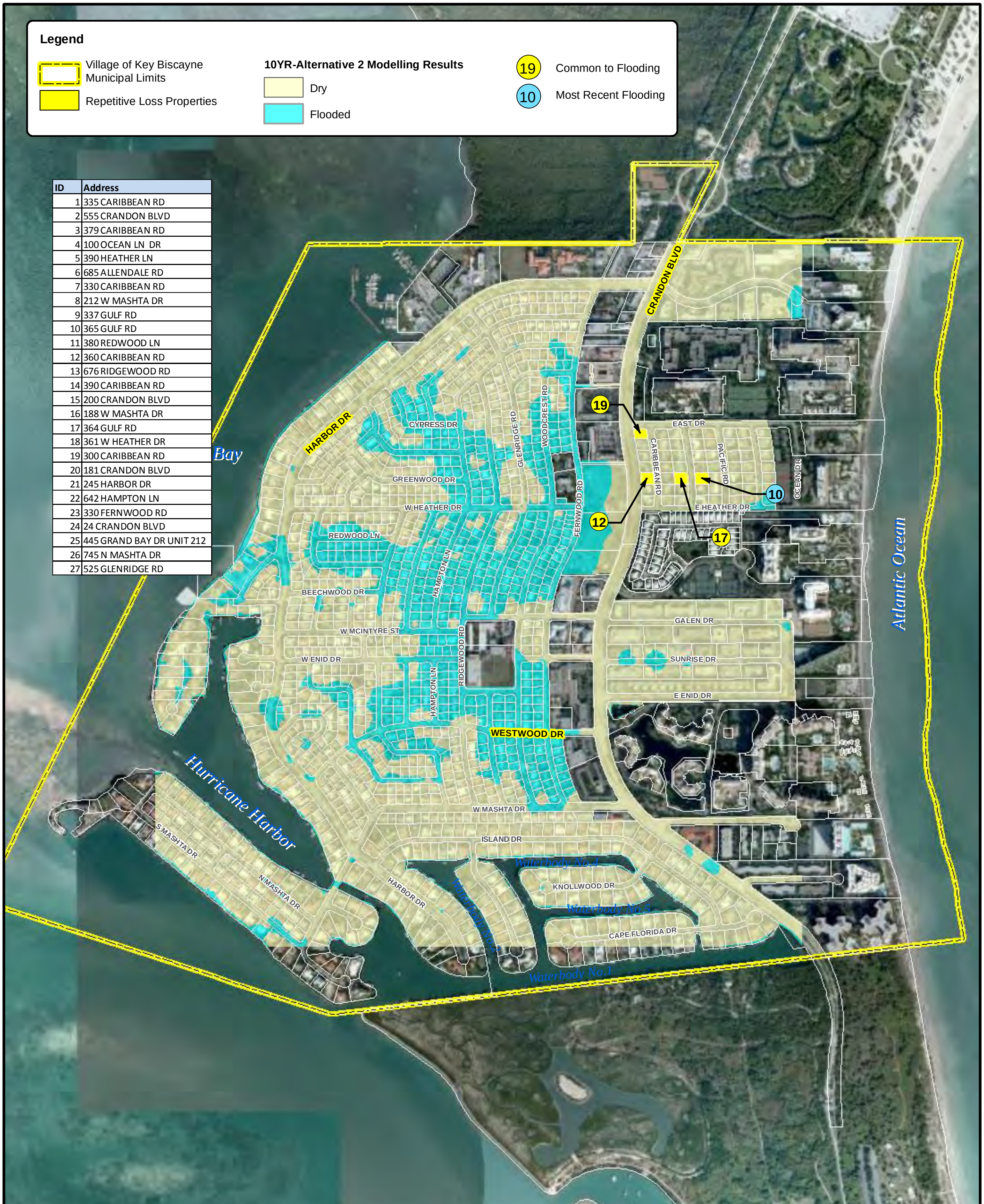
Tetra Tech conducted a simulation for the installation of one gravity drainage well within Problem Area No. 3. The design capacity of 2,400-gpm, mentioned in Section 3, was used for the well. The results from the model show a significant decrease in flooding for a 10-year storm event. The proposed drainage well is located along Hampton Road. Almost all flooding in Problem Area No. 3 was eliminated in the model for the 10-year design storm. **Table 4.4,** at the end of this section**,** summarizes the improvements in depth of flooding in this area and **Figure 4.3** provides an illustration of the extent of the improvements.

Table 4.4 – Problem Area No. 3 – Alternative 3 – Drainage Wells

Basin Number	Structure ID	Depth of Flood (ft) 10-Year Storm		Reduction in Depth of Flooding (ft)
		Existing Condition	New Wells	
3	J-5	3.03	3.02	0.01
3	J-6	3.02	3.03	0.00
3	J-7	3.03	3.03	0.00
3	J-12	2.86	2.87	0.00
3	J-15	3.22	3.22	0.00
3	J-18	3.29	3.28	0.00
3	J-24	3.98	3.97	0.00
3	J-25	3.98	3.97	0.00
3	J-27	3.97	3.97	0.00
3	J-30	3.77	3.77	0.00
3	J-31	3.66	3.65	0.00
3	J-36	2.84	2.84	0.00
3	J-40	4.03	4.03	0.00
3	J-42	5.89	5.89	0.00
3	J-764	3.04	3.05	-0.01
3	J-327	4.00	3.99	0.00
3	J-328	4.11	4.11	0.00
3	J-563	3.35	3.35	0.00
3	J-565	3.04	3.06	-0.02

3	J-568	3.01	3.01	0.00
3	J-569	3.08	3.15	-0.07
3	J-570	3.80	3.80	0.00
3	J-571	5.06	5.07	0.00
3	J-618	4.81	4.81	0.00
3	J-623	3.27	3.27	0.00
3	J-624	3.16	3.16	0.00
3	J-629	2.96	2.96	0.00
3	J-632	3.69	3.69	0.00
3	J-633	2.64	2.64	0.00
3	J-637	2.69	2.69	0.00
3	J-640	2.88	2.88	0.00
3	J-647	2.89	2.89	0.00
3	J-653	3.54	3.54	0.00
3	J-654	3.88	3.88	0.00
3	J-657	3.18	3.18	0.00
3	J-659	2.55	2.56	-0.01
3	J-663	2.80	2.80	0.00
3	J-665	2.81	2.82	0.00
3	J-666	2.82	2.82	0.00
3	J-670	2.83	2.83	0.00
3	J-672	3.13	3.13	0.00
3	J-673	2.56	2.56	0.00
3	J-678	2.87	2.87	0.00
3	J-760	5.81	5.81	0.00
3	J-888	5.93	5.93	0.00
3	J-891	6.43	6.43	0.00
3	J-892	6.43	6.43	0.00
3	J-912	4.04	4.04	0.00
3	J-963	2.87	2.87	0.00
3	J-899	6.61	6.61	0.00
3	J-889	6.10	6.10	0.00
3	JCT-30	2.79	2.79	0.00
3	J-566	3.00	3.00	0.00
3	J-11	2.86	2.87	0.00
3	J-626	2.60	2.60	0.00
3	J-650	2.50	2.50	0.00
3	J-33	2.84	2.83	0.00
3	J-567	3.72	2.90	0.82
6B	J-195	5.23	5.22	0.01
6B	J-198	5.23	5.22	0.01
6B	J-199	4.71	4.69	0.01

6B	J-203	4.49	4.48	0.01
6B	J-204	4.54	4.52	0.01
6B	J-206	3.68	3.67	0.01
6B	J-208	3.47	3.46	0.00
6B	J-209	4.14	4.13	0.01
6B	J-212	4.22	4.21	0.01
6B	J-213	4.29	4.28	0.01
6B	J-217	5.43	5.41	0.02
6B	J-218	5.38	5.36	0.02
6B	J-222	4.86	4.85	0.02
6B	J-223	4.85	4.84	0.02
6B	J-225	4.28	4.26	0.01
6B	J-226	4.13	4.12	0.01
6B	J-232	3.48	3.48	0.01
6B	J-233	2.77	2.77	0.00
6B	J-242	2.76	2.76	0.00
6B	J-310	2.58	2.58	0.01
6B	J-314	2.70	2.70	0.00
6B	J-317	4.08	2.66	1.42
6B	J-321	4.21	2.85	1.36
6B	J-323	4.37	2.45	1.91
6B	J-324	4.57	2.73	1.84
6B	J-235	2.60	2.60	0.00
6B	J-312	2.50	2.50	0.00



ID	Address
1	335 CARIBBEAN RD
2	555 CRANDON BLVD
3	379 CARIBBEAN RD
4	100 OCEAN LN DR
5	390 HEATHER LN
6	685 ALLENDALE RD
7	330 CARIBBEAN RD
8	212 W MASHTA DR
9	337 GULF RD
10	365 GULF RD
11	380 REDWOOD LN
12	360 CARIBBEAN RD
13	676 RIDGEWOOD RD
14	390 CARIBBEAN RD
15	200 CRANDON BLVD
16	188 W MASHTA DR
17	364 GULF RD
18	361 W HEATHER DR
19	300 CARIBBEAN RD
20	181 CRANDON BLVD
21	245 HARBOR DR
22	642 HAMPTON LN
23	330 FERNWOOD RD
24	24 CRANDON BLVD
25	445 GRAND BAY DR UNIT 212
26	745 N MASHTA DR
27	525 GLENRIDGE RD

TETRA TECH

10 YEAR FLOODING PROPERTIES
ALTERNATIVE 2
STORMWATER MASTER PLAN UPDATE
VILLAGE OF KEY BISCAYNE, FLORIDA

Figure 4.3

0 1,200 Feet

Source: Miami- Dade GIS Data
Microsoft Virtual Earth
FEMA RLP

File: P:\IER\15760\200-15760-10003\GIS\Maps\APF4.3.mxd
Printing Date: 11/22/2010
Drawn By: AMM

4.3 Alternatives Evaluation (Cost Comparison)

Planning level opinions of probable costs estimates were prepared for the three alternatives for each problem area and are included in **Appendix K**. Additional items related to the trench work were itemized and include surveying of existing utilities, maintenance of traffic, site restoration concrete, asphalt, and driveway removal/replacement. **Tables 4.5**, **4.6**, and **4.7** present a summary of these costs per problem area.

Table 4.5 - Problem Area #1 – Alternatives Cost Comparison

Alternative	Quantity	Unit	Cost Per Unit	Cost
Exfiltration Trenches	2,000	Feet	$105	$210,000
Flap Gates/Check Valves	17	Each	$10,000	$170,000
Drainage Wells	3	Each	$110,000	$330,000

Table 4.6 - Problem Area #2 – Alternatives Cost Comparison

Alternative	Quantity	Unit	Cost Per Unit	Cost
Exfiltration Trenches	1,260	Feet	$105	$132,300
Flap Gates/Check Valves	17	Each	$10,000	$170,000
Drainage Wells	1	Each	$110,000	$110,000

Table 4.7 - Problem Area #3 – Alternatives Cost Comparison

Alternative	Quantity	Unit	Cost Per Unit	Cost
Exfiltration Trenches	1,500	Feet	$105	$157,500
Flap Gates/Check Valves	17	Each	$10,000	$170,000
Drainage Wells	1	Each	$110,000	$110,000

Notes:

A value of 90 linear feet of exfiltration trench per acre of drainage basin was selected for the design. This is a typical value used for Floridian residential areas such as Key Biscayne. The value was also based on the low permeability of the soils in combination with a high percentage of impervious areas due to residential development in the Village.

A typical installation cost for an exfiltration trench in an average Floridian residential area from past projects has been $90 per linear foot. However due to the high density of development in the Village, in addition to limited right-of-way space to install the trenches, a value of $105 per linear foot was selected. This value takes into account potential locations that may come in close proximity to buildings, as well as potential conflicts with existing utilities such as water and sewer lines.

4.3.1 Problem Area #1

Capacity testing on existing drainage wells in the Village has shown to be very effective. The underlying soil characteristics tend to have high conductivity rates that allow moderate to high discharge of stormwater. Compared to other alternatives such as exfiltration systems, and surface pumps, and upsizing existing storm sewer pipe, drainage wells, in the Village, have the advantage of being more economical.

4.3.2 Problem Area #2

Capacity testing on existing drainage wells in the Village has shown to be very effective. The underlying soil characteristics tend to have high conductivity rates that allow moderate to high discharge of stormwater. Compared to other alternatives such as exfiltration systems, and surface pumps, and upsizing existing storm sewer pipe, drainage wells, in the Village, have the advantage of being more economical.

4.3.3 Problem Area #3

The flap gate installation at Outfall 17 will provide a benefit. Installing flap gates at each of the outfalls provides a marginal benefit during storms below the 10-year design storm.

4.4 Summary

Of the three alternatives evaluated for Problem Area No. 1, the flap gates/check valves alternative had the lowest estimated construction costs. The exfiltration trench alternative may be feasible; however, this alternative would create the most disturbance for within this area.

Considering the recent completion of the water and sewer construction project, the extensive excavations which would be required to install exfiltration trenches is not suggested. The modeling simulation of the flap gates/check valves alternatives showed little improvement within this problem area. The modeling simulation of the drainage well alternative showed much improvement within this problem area. The recommended alternative for Problem Area No. 1 is the drainage well alternative.

Of the three alternatives evaluated for Problem Area No. 2, the drainage wells alternative had the lowest estimated construction costs. The exfiltration trench alternative may be feasible; however, this alternative would create the most disturbance for within this area. Considering the recent completion of the water and sewer construction project, the extensive excavations which would be required to install exfiltration trenches is not suggested. The modeling simulation of the flap gates/check valves alternatives showed little improvement within this problem area. The modeling simulation of the drainage well alternative showed much improvement within this problem area. The recommended alternative for Problem Area No. 2 is the drainage well alternative.

Of the three alternatives evaluated for Problem Area No. 3, the drainage wells alternative had the lowest estimated construction costs. The exfiltration trench alternative may be feasible; however, this alternative would create the most disturbances within this area. Considering the recent completion of the water and sewer construction project, the extensive excavations which would be required to install exfiltration trenches is not suggested. The modeling simulation of the flap gates/check valves alternatives showed little improvement within this problem area. The modeling simulation of the drainage well alternative showed much improvement within this problem area. The recommended alternative for Problem Area No. 3 is the drainage well alternative.

SECTION 5

Recommended Plan

SECTION 5
RECOMMENDED PLAN

5.1 Recommended Alternatives Summary

As described at the end of Section 4, providing drainage wells is the recommended alternative for each of the three problem areas described in Section 3. A summary of the number of wells and costs for each problem area is provided in **Table 5.1** and a graphical comparison is provided in **Figure 5.1**.

TABLE 5.1 - SUMMARY OF RECOMMENDED ALTERNATIVE

Problem Area No.	Description of Area	Number of Drainage Wells	Construction Cost	Design & Other Costs	Total Amount
1	East Drive between Caribbean Rd, Gulf Rd & Pacific Rd	3	$ 623,595	$ 187,079	$ 810,674
2	Fernwood Rd & W Heather Dr	1	$ 238,665	$ 71,600	$ 310,265
3	Ridgewood Rd & W Enid Dr	1	$ 238,665	$ 71,600	$ 310,265

5.2 CIP Ranking and Implementation

5.2.1 Evaluation of Present Stormwater LOS Standard in Stormwater Master Plan

Tetra Tech conducted a brief review of the Code of the Village of Key Biscayne to learn currently applied Level of Service (LOS) standards for stormwater management infrastructure. Specific LOS requirements have not been developed within the Village’s code. For purposes of assigning LOS ratings to existing infrastructure, commonly applied performance standards used by various State agencies, and other local governments within Florida were applied.

Establishing LOS ratings to existing systems will help to facilitate prioritizing capital improvement projects and benefit the Village's effort to enforce concurrency management for stormwater infrastructure. LOS is included as one of the parameters in the prioritization guides listed in **Table 5.2** for the Village. In the course of further updates to the SMP, the Village may choose to assign LOS goals to existing stormwater systems by hierarchical importance to accomplishing its greater goals for water quality improvements in anticipation of mandates soon to be handed down from TMDL and EPA Numeric Nutrient regulations. This topic was discussed in further detail in Section 2.

The LOS for the Village's stormwater infrastructure has been established using the guidelines provided in **Table 5.3**. The results are tabulated in **Table 5.4**. The LOS guidelines recommended for the Village are provided below in **Table 5.2**. The Rating is separated into six (6) levels for three (3) categories. The levels range from A through F with A being the best rating. The categories include Primary Closed Conveyance Systems; Secondary Closed Conveyance Facilities and Miscellaneous Drainage Structures.

Primary Closed Conveyance Systems are intended for major conveyance, or flow, facilities that ultimately discharge into a receiving water body or outfall. These systems receive flow from secondary drainage systems. The term "closed" indicates underground conveyance through pipes or box culverts. Conversely, open systems are exposed at the ground surface and consist of swales and canals. Most of the stormwater conveyance systems in the Village are closed. A representative Primary Closed Conveyance System in the Village is along the Crandon Boulevard right of way. Crandon Boulevard is a Major Collector Road for the Village and is the only evacuation route. The Crandon Boulevard conveyance system is a collector of flow from the various secondary systems in nearby contributing drainage basins.

Secondary Closed Conveyance Systems collect drainage from minor (secondary) streets, alleys and side streets and discharge into primary systems. Secondary systems in the Village could be generally described as all other drainage structures beyond the Crandon Boulevard right of way. However, there are other areas in the Village that have closed conveyance systems that collect flow from residential and commercial areas that discharge into Biscayne Bay. These systems could be classified as primary conveyance systems if they are located in a right of way considered to be at least a minor collector.

5.2.2 Preliminary Evaluation of LOS in Investigated Areas

Using the LOS criteria in **Table 5.3** the Village's stormwater infrastructure was evaluated based on flood levels established in the H&H model. The results are summarized in **Table 5.4**.

5.2.3 Prioritization Methodology

In order to establish a method for prioritizing the Village's capital improvements projects, the guidelines below were created. These will help the Village assign numeric values to rank identified projects. The categories included for ranking include:

A. General Harm to Health, Safety and Welfare of the Public

B. Long standing problems

C. Beneficiary scope

D. Existing LOS Rating

Using the scoring guidelines in **Table 5.2** will facilitate the Village's effort to objectively rank capital improvement projects.

TABLE 5.2

RECOMMENDED PRIORITIZATION METHODOLOGY FOR RANKING CIP PROJECTS

A. GENERAL HARM TO HEALTH, SAFETY AND WELFARE OF PUBLIC	
Points Awarded	Description
0	No harm to the general public.
5	Flooding that causes inconvenience to property owner or public road-way, but does not threaten property damage, health, safety or welfare of public. Erosion causing some inconvenience.
10	Flooding of roads that prevents normal vehicle passage but does not impede the passage of emergency vehicles. Erosion, causing inconvenience and causing minor degradation of downstream water quality. Existing structure has likelihood to cause damage or harm to public. Potential for hydroplanning and other safety problem in large storm events.
15	Property flooding that impounds water/area enough for mosquito breeding, attracts other biotic nuisances, interferes with septic tank systems or otherwise adversely affects safety, health and welfare of residents. Erosion causing minor property damage or downstream water quality degradation. Existing structure does not meet Village or State standards for clear zone and has high likelihood for causing vehicular accidents or other public harm.
20	Major flooding of habitable structure. Property damage reported to insurance company or interior flooding. Erosion or stormwater causing major water quality degradation, property damage or public harm. Existing structure resulted in vehicular accidents. Flooding of roads causing significant hydroplanning during frequent rainfall events. Flooding that impede the safe passage of emergency vehicles and services.
25	Major flooding to multiple habitat structures or public property providing essential public services. Water quality may be degraded to levels of toxicity to plants, wildlife, or people due to stormwater discharges. Existing structure has caused accidents resulting in death.
B. LONG-STANDING PROBLEMS	
Points Awarded	Description
0	0-1 Years since first noted
1	1-2 Years since first noted
2	2-4 Years since first noted
3	4-8 Years since first noted
4	8-10 Years since first noted
5	Greater than 10 years
C. BENEFICIARY SCOPE	
Points Awarded	Number of ERUs[1] Directly Benefiting
0	0
1-4	1-3
5-8	4-10
9-12	10-20

13-16	20-50
17-19	50-100
20	>100
D. EXISTING LOS RATING(2)	
Points Awarded	Existing LOS Rating
0	A
5	B
10	C
15	D
20	E
25	F

Notes:

1. Equivalent residential unit (ERU) is one residential structure or a commercial use or business equal to a specified contributing area, in square feet, as calculated for a "typical" residential unit. The Village unit of measure for 1 ERU is 1083 SF of impervious area for commercial areas. A single-family dwelling unit is equivalent to 1.5 ERUs and a multi-family dwelling is 1.0 ERU per dwelling unit.

2. The guidelines for evaluating the Level of Service (LOS) provided by drainage facilities are outlined in Table 5.3 of this report. Where the guidelines do not adequately conform to a given situation, judgement shall be used to estimate the LOS in accordance with the relative service expectations indicated by Table 5.3.

TABLE 5.3

LOS GOALS EVALUATION CRITERIA FOR DRAINAGE FACILITIES

Description	LOS RATING					
	A	B	C	D	E	F
Collection/Conveyance Facilities						
Primary Closed Conveyance System[1]	HGL occurs below 12"of the gutter elevation for the 10-year design storm.	HGL occurs below 6" of the gutter elevation for the 10-year design storm.	HGL occurs at gutter elevation for the 10-year design storm	Half exterior travel lane not submerged or presence of significant inlet bypass during the 10-year design storm	Entire travel lane submerged to a depth not exceeding 1" at centerline during 10-year storm.	Entire travel lane submerged to a depth not exceeding 3" at centerline during 10-year storm.
Secondary Closed Conveyance Facilities[2]	HGL occurs below gutter elevation for the 10-year design storm	HGL occurs at or not exceeding 1" above the gutter for the 10-year design storm.	Half exterior travel lane not submerged or presence of significant inlet bypass during the 10-year storm	Entire travel lane submerged to a depth not exceeding 1" at centerline during 10-year storm.	Entire travel lane submerged to a depth not exceeding 6" at centerline during 10-year storm.	Entire travel lane submerged to a depth exceeding 6" at centerline during 10-year storm.
Miscellaneous drainage structures.	Structures constructed and performing in accordance with Village, FDOT or BMP standards or guidelines.	Structure is currently under-sized by less than 10%, needs minor repair, or requires minor maintenance, but would otherwise qualify for a LOS A.	Structure is currently under-sized by less than 25%, needs intermediate levels of repair, or requires intermediate levels of maintenance, but would otherwise qualify for a LOS A.	Structure is currently under-sized by less than 50%, needs significant repair, or requires significant maintenance, but would otherwise qualify for a LOS A.	Structure exist but is not constructed in accordance with Village, FDOT, or BMP standards or guidelines, is currently under-sized by more than 50%, level or needed repair or other condition that presents threat to public safety, health and welfare.	Structure absent where the function structure would serve is required (e.g. manhole junction, energy dissipator, etc.).

Notes:

1. Examples of primary closed conveyance facilities are similar to drainage pipes serving Major roadways such as Crandon Boulevard.
2. Examples of secondary closed conveyance facilities are similar to drainage pipes serving local and secondary roads in the Village.

Looking out for the health, safety and welfare of the public is a fundamental responsibility of government. A point system from zero to 25 is included to account for the severity of potential harm to the health, safety and welfare of a Village citizen resulting from a flooding problem. Selecting a value from this category involves some subjectivity. However, an attempt was made to make it as objective as possible. Consideration is also given to the length of time that a problem has been on file with the Village. The maximum point total of five (5) carries less weight than the other categories in the ranking methodology.

The beneficiary scope category is included to reward projects based on the number of residents that would benefit from a proposed project. The higher the number of beneficiaries, the higher the point total that could be obtained from this category. The total number of residents, for the purposes of this study, is based on the Village's standard unit of Equivalent Residential Units (ERUs) as established for the stormwater utility. One (1) ERU is one residential structure or a commercial use or business equal to 1,083 square feet, as calculated for a "typical" residential unit. A single-family dwelling unit is equivalent to 1.5 ERUs and a multi-family dwelling unit is 1.0 ERU per dwelling unit.

LOS is the next rating category. This is a completely objective rating based on the results of the H&H model for the 10 year/24 hour storm. A LOS has been established for each stormwater structure included in the model. The school, Village Hall, Community Center, Fire Department, the condominiums in Key Colony, Grand Bay, and The Ocean Club and three (3) commercial areas were extracted from the model due to their private self-contained stormwater management systems. To apply this category, the evaluator would only need to obtain the LOS determination for the structures within the problem area. A problem area with multiple structures will require a calculation of the average LOS. This can be accomplished by first assigning a point value to each of the LOS levels. For example,

A = 5, B = 4, C = 3, D = 2, E = 1, F = 0

Table 5.4 provides the comparison of the points per ranking item for each of the problem area options recommended. This indicates that Problem Area #1 should be constructed first in priority due to its overall impact.

TABLE 5.4 – CIP RANKING

	Problem Area #1	Problem Area #2	Problem Area #3
A. General Harm to Health, Safety and Welfare	5	4	4
B. Long-Standing Problems	5	5	5
C. Beneficiary Scope	5	5	5
D. Existing LOS Rating	2	1	1
TOTAL	17	15	15

5.3.4 CIP Schedule

Based on this ranking per the methodology presented in the previous section, this master plan recommends the following schedule in order to spread the probable construction costs over the next five years to minimize the impact on the overall Village CIP Budget. See **Figures 5.1, 5.2** and **5.3** for the graphic schedules per problem area. A summary of the schedule dates is provided below in **Table 5.5**.

TABLE 5.5 – RECOMMENDED SCHEDULE

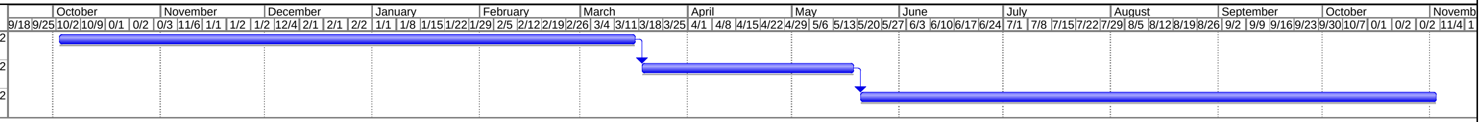
ACTIVITY	Days	Start Date	Finish Date
Problem Area #1 – Design & Permitting	120	Mon 10/3/11	Fri 3/16/12
Problem Area #1 - Bidding	45	Mon 3/19/12	Fri 5/1812
Problem Area #1 - Construction	120	Mon 5/21/12	Fri 11/2/12
Problem Area #2 – Design & Permitting	120	Mon 10/8/12	Fri 3/22/13
Problem Area #2 - Bidding	45	Mon 3/25/13	Fri 5/24/13
Problem Area #2 - Construction	120	Mon 5/27/13	Fri 11/8/13
Problem Area #3 – Design & Permitting	120	Mon 10/7/13	Fri 3/21/14
Problem Area #3 - Bidding	45	Mon 3/24/14	Fri 5/23/14
Problem Area #3 - Construction	120	Mon 5/26/14	Fri 11/17/14

5.4 Conceptual Designs

Figures 5.4, **5.5** and **5.6** illustrate a preliminary/conceptual design for the each of the recommended options for each corresponding problem area.

FIGURE 5.1 - STORMWATER SCHEDULE - PROBLEM AREA #1

ID	Task Name	Duration	Start	Finish
1	Problem Area #1 - Design & Perm	120 days	Mon 10/3/11	Fri 3/16/12
2	Problem Area #1 - Bidding	45 days	Mon 3/19/12	Fri 5/18/12
3	Problem Area #1 - Construction	120 days	Mon 5/21/12	Fri 11/2/12

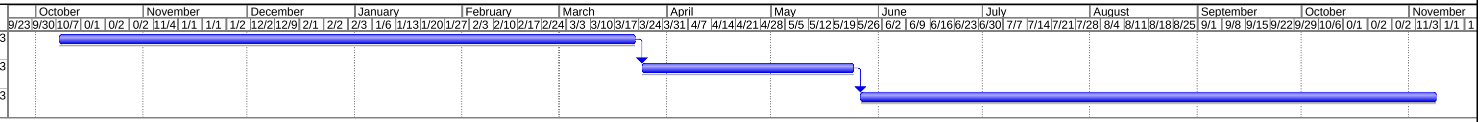


Project: Section 5-Schedule-Problem A
Date: Mon 6/27/11

Task | Split | Progress | Milestone | Summary | Project Summary | External Tasks | External Milestone | Deadline

FIGURE 5.2 - STORMWATER SCHEDULE - PROBLEM AREA #2

ID	Task Name	Duration	Start	Finish
1	Problem Area #2 - Design & Perm	120 days	Mon 10/8/12	Fri 3/22/13
2	Problem Area #2 - Bidding	45 days	Mon 3/25/13	Fri 5/24/13
3	Problem Area #2 - Construction	120 days	Mon 5/27/13	Fri 11/8/13

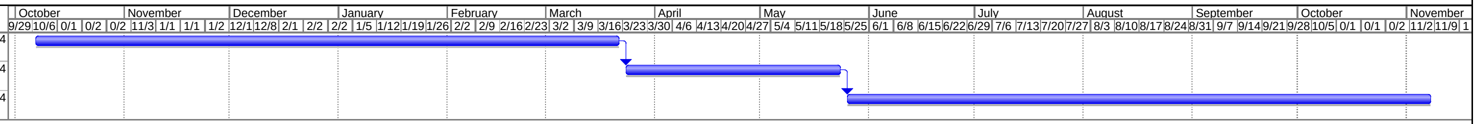


Project: Section 5-Schedule-Problem A
Date: Mon 6/27/11

Task | Split | Progress | Milestone | Summary | Project Summary | External Tasks | External Milestone | Deadline

FIGURE 5.3 - STORMWATER SCHEDULE - PROBLEM AREA #3

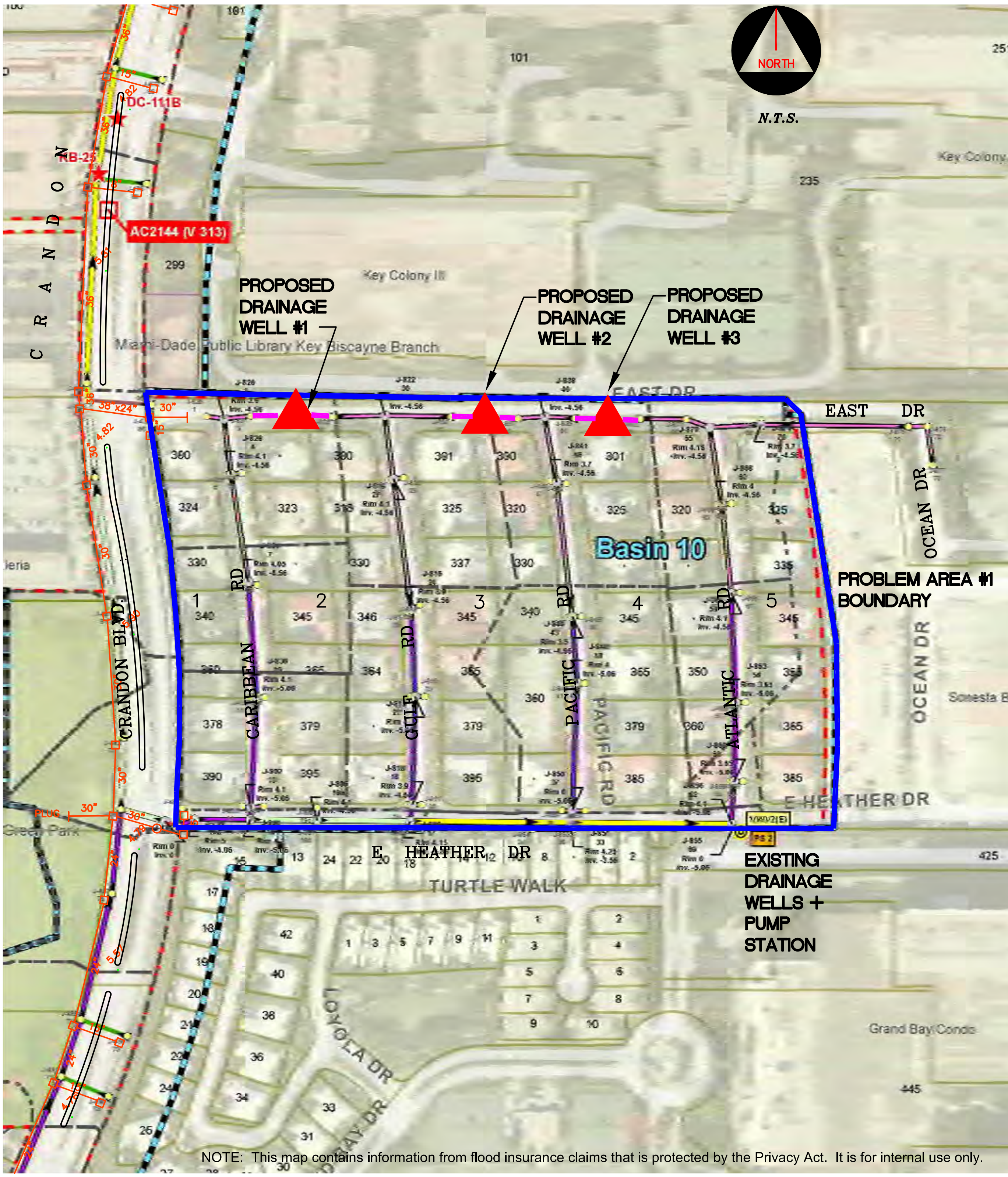
ID	Task Name	Duration	Start	Finish
1	Problem Area #3 - Design & Perm	120 days	Mon 10/7/13	Fri 3/21/14
2	Problem Area #3 - Bidding	45 days	Mon 3/24/14	Fri 5/23/14
3	Problem Area #3 - Construction	120 days	Mon 5/26/14	Fri 11/7/14



Project: Section 5-Schedule-Problem A
Date: Mon 6/27/11

Task | Progress | Summary | External Tasks | Deadline
Split | Milestone | Project Summary | External Milestone

Thursday, June 23, 2011 4:31:06 PM DRAWING: P:\15760 - VKB\200-15760-10003\GIS\CAD\VKB-Problem-Area-Conceptual-FINAL.DWG LAYOUT: PROBLEM AREA 1 USER NAME: VEREA-FERIA, ALICIA



NOTE: This map contains information from flood insurance claims that is protected by the Privacy Act. It is for internal use only.

TETRA TECH

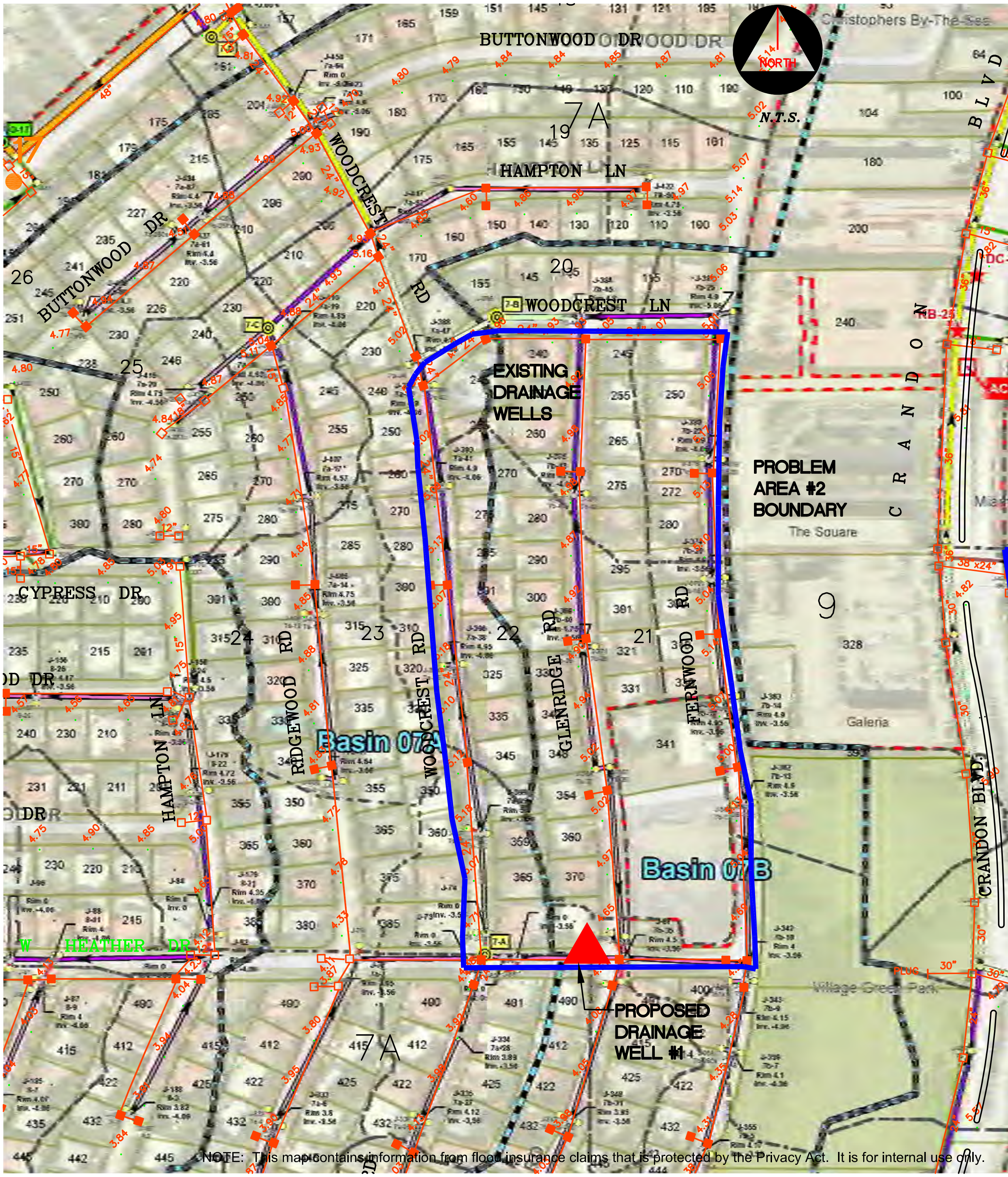
Drawing Description

PROBLEM AREA #1
CONCEPTUAL
ALTERNATIVE #3 - DRAINAGE WELLS

VILLAGE_OF_KEY_BISCAYNE
STORMWATER_MASTER_PLAN_UPDATE

Project No.:	200-15760-10003
Date:	05/2011
Designed By:	AMVF

FIGURE
5.4



Thursday, June 23, 2011 4:25:40 PM DRAWING: P:\15760 - VKB\200-15760-10003\GIS\CAD\VKB-Problem-Area-Conceptual-presentation.DWG LAYOUT: PROBLEM AREA 2 USER NAME: VEREA-FERIA, ALICIA

TETRA TECH

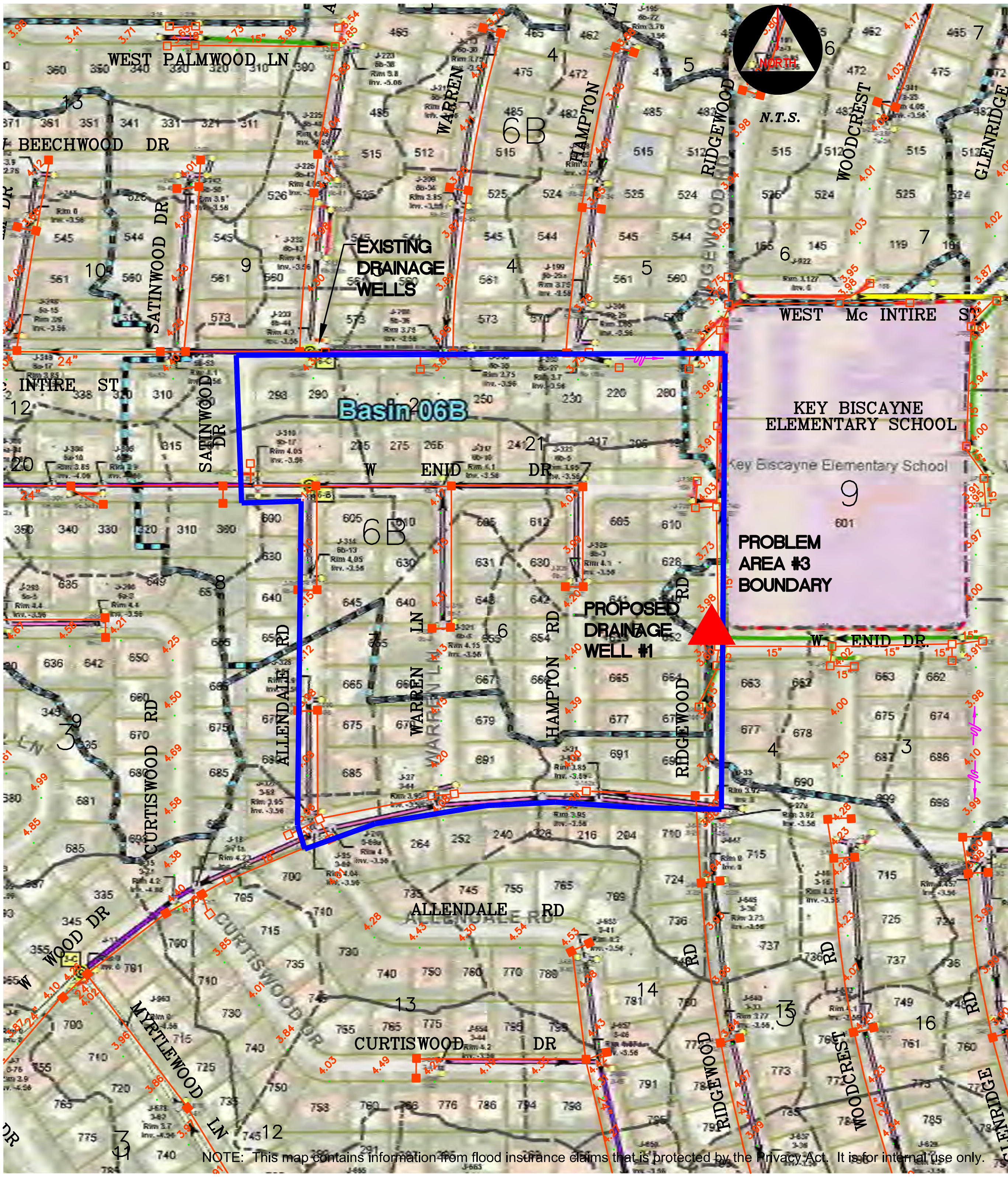
Drawing Description

PROBLEM AREA #2
CONCEPTUAL
ALTERNATIVE #3 - DRAINAGE WELLS

VILLAGE_OF_KEY_BISCAYNE
STORMWATER_MASTER_PLAN_UPDATE

Project No.:	200-15760-10003
Date:	05/2011
Designed By:	AMVF

FIGURE
5.5



NOTE: This map contains information from flood insurance claims that is protected by the Privacy Act. It is for internal use only.

TETRA TECH

Drawing Description

PROBLEM AREA #3
CONCEPTUAL
ALTERNATIVE #3 - DRAINAGE WELLS

VILLAGE_OF_KEY_BISCAYNE
STORMWATER_MASTER_PLAN_UPDATE

Project No.:	200-15760-10003
Date:	05/2011
Designed By:	AMVF

FIGURE
5.6

5.5 System Funding

In 1993 the Village created a stormwater utility to support the operations, maintenance and capital improvements of the stormwater system. Utility has continued to act as a partial funding source without a rate increase since its inception.

Concurrent with the preparation of this Master Plan Update, the Village commissioned Burton & Associates to conduct a stormwater rate study (see **Appendix L**). The purpose of this study is to evaluate the sufficiency of the utility rates to meet current and future needs and make recommendations of rate increases if necessary. In its evaluation of expenses the rate study considered the debt service from the Series 1999 bonds, the current operations and maintenance costs, projected additional operations and maintenance costs and additional pay-as-you-go capital improvements. However, the rate study does not include the impact of funding the CIP recommended in this Master Plan. The study concluded that the current rates do not meet the costs of the system and recommended a 78% increase in the stormwater fee as follows in **Table 5.6**:

TABLE 5.6 – RATE COMPARISON

Customer Class	Current Rate	Proposed Rate
Multi-family	$5.00	$8.90
Single-family	$7.50	$13.35

Since the recommended CIP is not anticipated to be funded by revenues from user rates, Tetra Tech recommends that the Village continue to aggressively pursue grant funding for qualified projects in the CIP. Grants are advantageous sources of funding as they do not have an impact of the Village stormwater rates. However, there is a certain amount of risk in securing grant funds as the amount of funding available varies from year to year and the number of applications for funding can be high. Historically the Village has had success in securing matching grants from South Florida Water Management District, however other grant programs are available for consideration including:

- Florida Department of Environmental Protection 319 Program
- FEMA Hazardous Mitigation Grant Program
- FEMA Pre-Disaster Mitigation Grants
- FEMA Flood Mitigation Assistance Grant
- FEMA Repetitive Flood Claim
- FEMA Severe Repetitive Loss Grant

5.6 Local Regulations Evaluation and Update

Local regulations were evaluated under a separate task in coordination with the Community Rating System (CRS) 5-year Re-certification activity. The findings of the re-certification review in May 2011 by the Insurance Services Office (ISO), on behalf of FEMA, require increased enforcement actions of the Village Ordinances in Section 10-21 and 10-61 related to substantial improvements and new construction in order to remain in compliance with CRS minimum requirements. Local regulation amendments may also be required due to the state and federal regulations related to the FDEP TMDL and TN/TP that are being finalized.

5.7 Monitoring Program

Village staff currently monitors rainfall and flooding events and to meet the requirements of the NPDES permit. The existing monitoring can be augmented with monitoring of five specific locations in the Village for the purposes of comparing the anticipated results depicted herein with actual field conditions to identify irregularities, damaged system, or areas where maintenance may be required. Rain/flooding gauges can be installed near five (5) suggested locations where repetitive flooding has occurred. The locations that should be monitored after rainfall/flooding events are:

- Galen Drive
- Ocean Lane Drive
- Beechwood Drive
- Hampton Lane – Between West Heather Drive & West McIntyre Street
- West Mashta Drive at Ridgewood Drive

5.8 Additional Recommendations

1. The Village's Stormwater Utility Rate was updated to compensate for only a portion of the added burden on the Village's Stormwater Management Plan from necessary capital projects, O&M and R&R. The Village's plan is also impacted by changes in the Village's customer base and new regulatory requirements such as the FDEP TMDL program. The Village should monitor the regulations and their anticipated impacts and pursue application

of grants to cover the remainder of the cost associated with recommended stormwater projects.

2. Biscayne Bay is listed as an impaired water body that receives flow from mainland Miami-Dade County and from the Village. Start planning for the arrival of TMDL requirements.
3. Public Works staff has been obtaining horizontal control of drainage infrastructure using GPS. At some point, this data should be imported into the Village's GPS database to update the comprehensive atlas completed as part of this study.
4. The Village has a growing list of permit compliance requirements. It would be prudent for the Village to development a tracking procedure to proactively notify the appropriate Public Works personnel of a pending deadline. There are commercial software programs available to assist the Village in this pursuit. Tetra Tech has a proprietary software called EnviroManager that is ideal for this application.
5. Investigate the ability of displaying Village GIS databases on the Google Earth platform. Advances in technology have made it possible to show the Village's stormwater infrastructure data from the Stormwater Atlas on Google Earth. Tetra Tech's GIS experts have done this for other communities we serve. This would make it easy for the public to have access to data chosen by the Village.
6. The Florida Department of Environmental Protection (FDEP) is scheduled to release a complete overhaul of state stormwater management requirements to account for post development loading of Total Nitrogen and Total Phosphorus. The Village should consider updating stormwater management requirements in the Land Development Code when regulations are finalized. In the mean time, the Village should monitor the regulations and their anticipated impacts.
7. Continue to actively pursue federal, state and local grants to support funding stormwater management, water quality and erosion control capital projects.
8. The Village should conduct additional evaluations meant to be an addendum to this SWMP update for areas that have recently become areas of concern. At a minimum, evaluations should be conducted in the following three (3) areas:
    a. Ocean Lane Drive Stormwater improvements – A performance and condition evaluation of the existing stormwater pump station and drainage wells.
    b. Galen Drive Stormwater improvements – A performance and condition evaluation of the existing stormwater system in this area due to recent flooding complaints.
    c. West Mashta Drive Stormwater improvements – A performance and condition evaluation of the existing stormwater system in the area by Ridgewood Drive due to repetitive flooding complaints.