UPDATE OF CYPRESS CREEK WATERSHED MANAGEMENT MASTERPLAN

Chapters 1 through 6

July 2011

Prepared for:

Hillsborough County Engineering Division
Department of Public Works
Stormwater Management Section

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This report submitted to the Hillsborough County Engineering Division Department of Public Works Stormwater Management Section, entitled: Update of Cypress Creek Watershed Management Masterplan has been prepared by or under the supervision of the undersigned:

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Table of Contents

Table of Contents (continued)

List of Figures

List of Figures (continued)

List of Tables

EXECUTIVE SUMMARY

Introduction

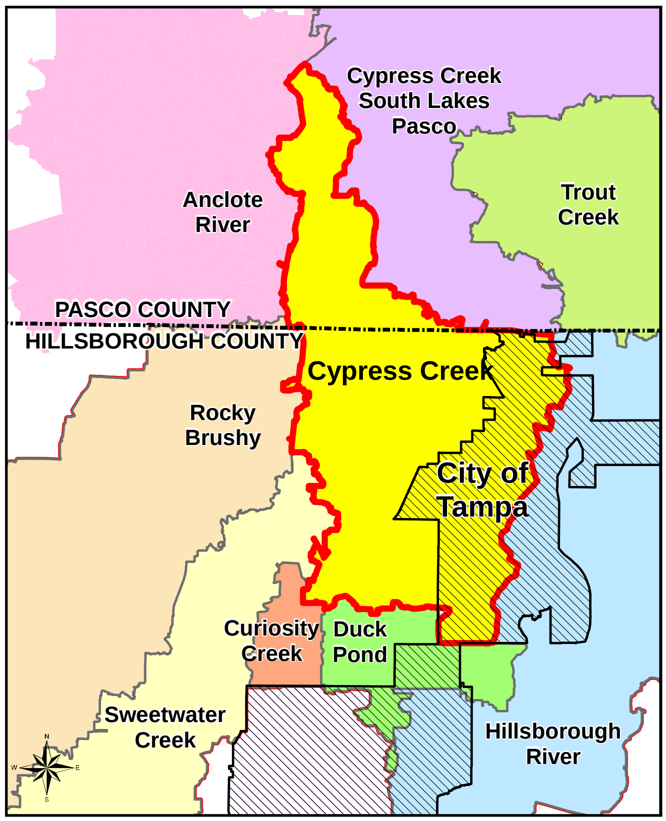
The Watershed Management Masterplan (WMMP) for the Hillsborough County portion of the Cypress Creek Watershed was completed in 2000 by URS Corporation Southern. The purpose of the study was to develop a computer simulation model and to analyze existing conditions to identify and propose alternatives to address flood control, water quality and natural system improvements. The Southwest Florida Water Management District (SWFWMD) subsequently conducted a model review to identify the improvements necessary to make the model consistent with the District's Guidelines and Specifications (G&S dated August 2002). The purpose of this project is to update the County's Cypress Creek model and use it for a feasibility assessment of water control structures and the associated conveyance/storage system for optimization of flood protection, natural systems, and water conservation functions. This assessment also included structure operations and maintenance recommendations, which is presented in a separate report prepared by Interflow Engineering, LLC as a subconsultant to Parsons.

The objective of project was to update the Hillsborough County SWMM model and floodplain mapping for the Cypress Creek Watershed with the focus on resolving inconsistencies between the current conditions within the watershed and the information used to develop the previous model update for the watershed. This watershed model update was based on 2007 land use, aerial photography and recent development within the watershed. The Cypress Creek Watershed model was updated with as-built information from improvements constructed in the watershed. Accordingly, the supporting GIS/database was updated to match the updated models. Based on the updated watershed model, the Cypress Creek Watershed Level of Service (LOS) was established. Only the portions of the WMMP pertaining to hydraulic & hydrologic modeling and LOS were revised and updated. Components pertaining to water quality and natural systems were not part of this project.

Significant improvements in the quality and quantity of available data have been made in the last ten years. Additionally, the use of ArcGIS to facilitate the organization and computation of these available data has increased the ability to more accurately predict model results on a more detailed level. These advances have warranted Hillsborough County, in cooperation with the Southwest Florida Water Management District (SWFWMD), to update the watershed models throughout the County. These model updates allow for the modernization of the FEMA floodplain maps, and County Capital Improvement Projects (CIP) and their corresponding project ranking.

Watershed Description

The Cypress Creek Watershed lies in the northern portion of Hillsborough County and in the southern portion of Pasco County. Overall, the Cypress Creek Watershed within Hillsborough County drains an area of approximately 33 square miles. It is roughly bound on its north side by Pasco County, to its east side by Bruce B. Downs Blvd. and I-75, and U.S. 41 on the west. Topography varies from a high of 74 feet NAVD in the northern portion of the watershed to a low of 20 feet NAVD at its junction with the Hillsborough River.



There is a portion of the watershed that exceeds 100 square miles and lies within the political boundaries of Pasco County that drains into Cypress Creek and flows into Hillsborough County near the I-75 and I-275 junction. The hydraulic characteristics of this very important area of the watershed is represented by boundary conditions developed from the Cypress and Trout Creek Model (CYPTRT) conducted by Pasco County and the SWFWMD. Approximately 5,000 acres of the chain of lakes known as Thirteen Mile Run, which lies primarily in Pasco County and drains into the Hillsborough County portion of Cypress Creek was explicitly modeled in this update by extracting the hydraulic data from the CYPTRT model.

The watershed has had a history of flooding problems. Flooding problems have occurred throughout the watershed, as especially during the 2004 hurricane season. Development, particularly residential, is rapidly moving northward into the rural portions of the watershed impacting runoff and drainage patterns.

Data Collection

The project included updating the model to the most current conditions using the best and latest available data. This included topographic, hydraulic and hydrologic data. The most significant dataset collected for this update was the digital elevation model (DEM) data and corresponding aerial photography. In previous watershed studies, the floodplain mapping was based primarily on SWFWMD topographic aerial hard copy maps. Hillsborough County has collected digital topography for all of the Cypress Creek Watershed. The datasets represent the topography of the watershed in 2005 whereas the previous mapping was based on older data. These digital data allow for more accurate and detailed mapping of the floodplain. Furthermore, the available 2007 aerial photography provides the ability to more clearly identify hydraulic features within the watershed where no other data is available to realize their existence and account for their function.

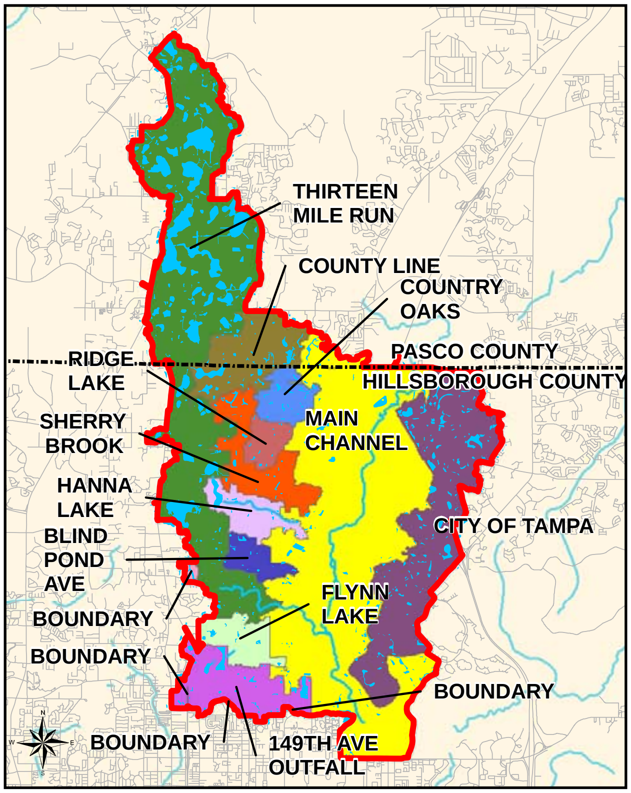
As part of this project, areas of new development and/or land use changes were updated in the model domain, which also included residential and commercial development. Data collected for hydraulic and hydrologic updates were collected primarily from the SWFWMD, but also collected from the FDOT. Every means possible was extended to collect and employ the most recent and current data for the updated model compilation.

Model Development and Flood Plain Mapping

Watershed Hydrologic and Hydraulic Model Development

An important aspect of the watershed masterplan is the proper representation of the hydrologic and hydraulic processes throughout the watershed that define flooding conditions. A good understanding of these watershed processes is necessary to determine the most effective means of controlling flooding and protecting public safety and environmental resources. This understanding comes from the compilation of a large amount of data that describe the physical attributes of the watershed and its stormwater management infrastructure, including: topographic and aerial mapping; land use conditions; soil types; land slope and cover; dimensions and elevations of culverts, bridges, pipes, weirs, and control structures; channel and floodplain cross sections and roughness coefficients; and storage relationships for ponds, lakes, wetlands and depressions. These data are needed to develop a computer model of the watershed.

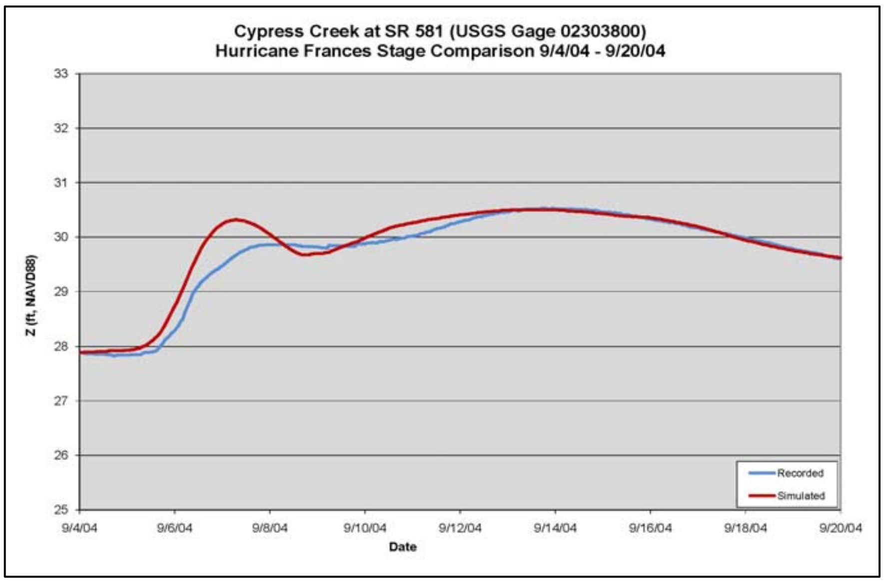
Although this project is a model update, none of the existing model framework could be used. The previous model was rather course and based on older and more limited data. As mentioned previously, new standards for watershed modeling have been employed by the SWFWMD in their cooperative projects, referred to as the SWFWMD Guidelines and Specifications (G&S) for watershed management programs. These standards are much more rigorous than past standards and dictate that storage areas > 1 acre and > 2 feet in depth be explicitly modeled. Other standards exist in this documentation, but this particular standard dictates the intricate detail needed to compile a watershed management plan model. To meet these detailed modeling standards, Parsons had to use a variety of data sources, including; existing model data, collected permits and plans, the County stormwater inventory, new survey performed by the County, Parsons' field measurements and County-provided DEM data.



For the Cypress Creek Watershed Management Masterplan update (just as in previous studies), the Hillsborough County version of the EPA SWMM model (HCSWMM) was used. The County has developed this program as a standard for all watershed management plans within Hillsborough County. The Cypress Creek Watershed was divided into the following eleven major subwatersheds, as shown: Cypress Creek Main Channel, County Line Drainage System, Country Oaks, Ridge Lake, Sherry Brook, Hanna Lake, Blind Pond Avenue, Thirteen Mile Run, Flynn Lake, 149th Avenue, and the City of Tampa. To provide the level of detail that was deemed necessary to accurately define and properly analyze the primary drainage facilities within the Cypress Creek Watershed for this update, the subbasin discretization was increased from 121 (in the previous study) to 683 subbasins. Each of these subbasins was described by its land use and soil type distribution using an electronic Geographic Information System (GIS) database. This GIS geodatabase was also used as a tool to store and retrieve all watershed information gathered and generated over the course of the watershed study and to deliver spatial data used in model development.

The hydraulic model (HCSWMM) of the Cypress Creek Watershed consists of a network of open channel segments, culverts, bridges, storm sewers, weirs, lakes, ponds, and wetlands that comprise the primary drainage system within the watershed. HCSWMM uses a conduit-junction concept to idealize the prototype drainage system. A junction is a discrete location in the drainage system, while conduits are the connections between junctions that convey water through the system. The entire network of junctions and conduits forms the hydraulic model network and serves as the computational framework for HCSWMM. The updated Cypress Creek watershed hydraulic model is quite comprehensive. It now comprises a total of 820 junctions (increased from 167 junctions) and 1644 linkages in its structure (increased from 296 linkages), including 569 closed conduits and open channels and 1075 weirs.

The Cypress Creek Watershed hydrologic and hydraulic model was tested through a rigorous process of calibration and verification to ensure that the model was properly representing the flooding conditions throughout the watershed. Model calibration refers to the adjustment of model parameters within reasonable limitations so that the model results (i.e., streamflow and water elevations) are in reasonable agreement with a set of measured data. The model is calibrated/verified with two different storm events that represent different volumes, intensities, and distributions. The model verification process tests the calibration by comparing resulting stage, flow, and volume information to data measured or recorded at established gaging stations for a set of comparable independent events without any model adjustments. The Cypress Creek Watershed hydrologic/ hydraulic model was calibrated to the 2004 Hurricane Frances storm event and verified to the March 10-12, 2010 historical storm event. Model results for these events were compared to the flows, volumes, and water elevations recorded in Cypress Creek at Bruce B. Downs (S.R. 581) and to recorded lake stages. The model was deemed successful in its emulation of the observed conditions.



Flooding Level of Service Deficiencies and Problem Identification

Upon completion of the development and re-calibration of the hydrologic and hydraulic model of the updated Cypress Creek Watershed, the next step of the flooding conditions analysis was to apply the model(s) to assess the performance of the basin-wide drainage facilities for a given set of design storm events. Results of these simulations were then analyzed with respect to Hillsborough County's adopted flooding level of service (LOS) criteria to identify locations within the watershed where the LOS criteria are not being met. These were correlated to known flooding problem areas which were identified during the recent 2004 flood event to prepare an assessment of the existing flooding conditions within the watershed.

The LOS definition that has been adopted by the County establishes the assigned LOS designation based primarily on the road crown elevation, and relates the existence of significant street, yard and/or structure flooding to the depth of flooding of the street. The numerical criteria that were adopted as a means of providing measurable depth definitions of "significant flooding" are listed in the following table. Note the addition of one new LOS designations, O, which were not included within the County Comprehensive Plan.

Flooding Level of Service	Hillsborough County Comprehensive Plan Definition	RBA Watershed Management Plan Definition
A	No significant street flooding. All lanes are drivable*	Street flooding is less than 3" above the crown of road
B	Minor street flooding. At least one lane drivable*	Street flooding is more than 3" above the crown of road, but less than 6"
C	Street flooding. Flooding depth above road crown is less than one foot.	Street flooding is more than 6" above the crown of road, but less than 12"
D	No limitation on flooding	Street flooding is more than 12" above the crown of road or flood elevation is greater than finished floor elevation
O	N/A	No structure and no street to compare with flood elevation

*The term drivable defined as less than or equal to three (3) inches of water above the crown of the road.

The Board of County Commissioners, in the Comprehensive Plan, promulgated the 25-year/24-hour/B flooding level of service as the target level of service for all watersheds within the county, including the Cypress Creek Watershed. Road crown elevations were compared with flood elevations generated by the model for the hypothetical 25-year/24-hour design storm event to determine the LOS provided. Those locations that do not attain the County's target level of service ('B' LOS) were identified as flooding level of service violations. In addition, the lowest structure elevation in each subbasin was compared with the flood elevations – any flooding of structures results in a 'D' LOS.

As stated previously, over 20 flood complaints were received by County staff in September 2004 following the Hurricane Frances storm event. The storm produced rainfall of 6 – 10 inches throughout the watershed. This flood complaints database included support information regarding the nature of the flooding and potential causes. These flood complaints were in good correlation with the floodplain and LOS evaluation.

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CHAPTER 1

INTRODUCTION

1.1 PURPOSE AND OBJECTIVES

Hillsborough County developed the watershed management masterplan and model for the Cypress Creek watershed in 2000. The Southwest Florida Water Management District (SWFWMD) conducted a model review to identify the improvements necessary to make the model consistent with the District's Guidelines and Specifications (G&S dated August 2002). The purpose of this project is to update the County's Cypress Creek model and use it for a feasibility assessment of water control structures and the associated conveyance/storage system for optimization of flood protection, natural systems, and water conservation functions. This assessment includes structure operations and maintenance recommendations.

To produce a rigorous model suitable for project purposes, the County's Cypress Creek watershed model and database was updated and where necessary merged with other models/databases. This update is very important and necessary for the County because Cypress Creek is one of the fastest developing areas. In addition, the SWFWMD conducted a model review that provided recommendations for updating the existing hydrologic and hydraulic (H&H) model. This project addresses the review comments in terms of digital data format, subbasin delineation, hydrologic and hydraulic data and parameter verification, storage verification, and model setup and stability. Except where noted, project development applies only to the Hillsborough County portion of the Cypress Creek watershed.

1.2 PROJECT LOCATION AND GENERAL DESCRIPTION

The Hillsborough County portion of the Cypress Creek watershed encompasses approximately 33 square miles, about 21,000 acres, in northern Hillsborough County. The total Cypress Creek Watershed including areas within Pasco and Hillsborough Counties is approximately 303 square miles. The Hillsborough County portion of the Cypress Creek drainage area is generally bordered by I-75 on the east, U.S. 41 on the west, Pasco County on the north, and Bruce B. Downs Blvd. (S.R. 581) on the south. The creek eventually flows to the Hillsborough River. The location of the Cypress Creek watershed is shown on Figure 1.2-1.

1.3 PREVIOUS STUDIES

The studies listed below were undertaken prior to this report, and have been used in the development of this report. A brief description of each report follows:

- In 2000, URS developed a Watershed Management plan of Cypress Creek for Hillsborough County. A modified version of SWMM software was used to compute peak discharge values and flood elevations within the Cypress Creek Watershed. The model was used to identify areas of concern. Alternatives were then proposed to address flood control and water quality and natural system improvements.

- In 2010, the SWFWMD and Pasco County cooperatively developed a detailed watershed model that covered a 170 square mile area of the Cypress Creek and Trout Creek watersheds lying within Pasco County.

1.4 REPORT STRUCTURE

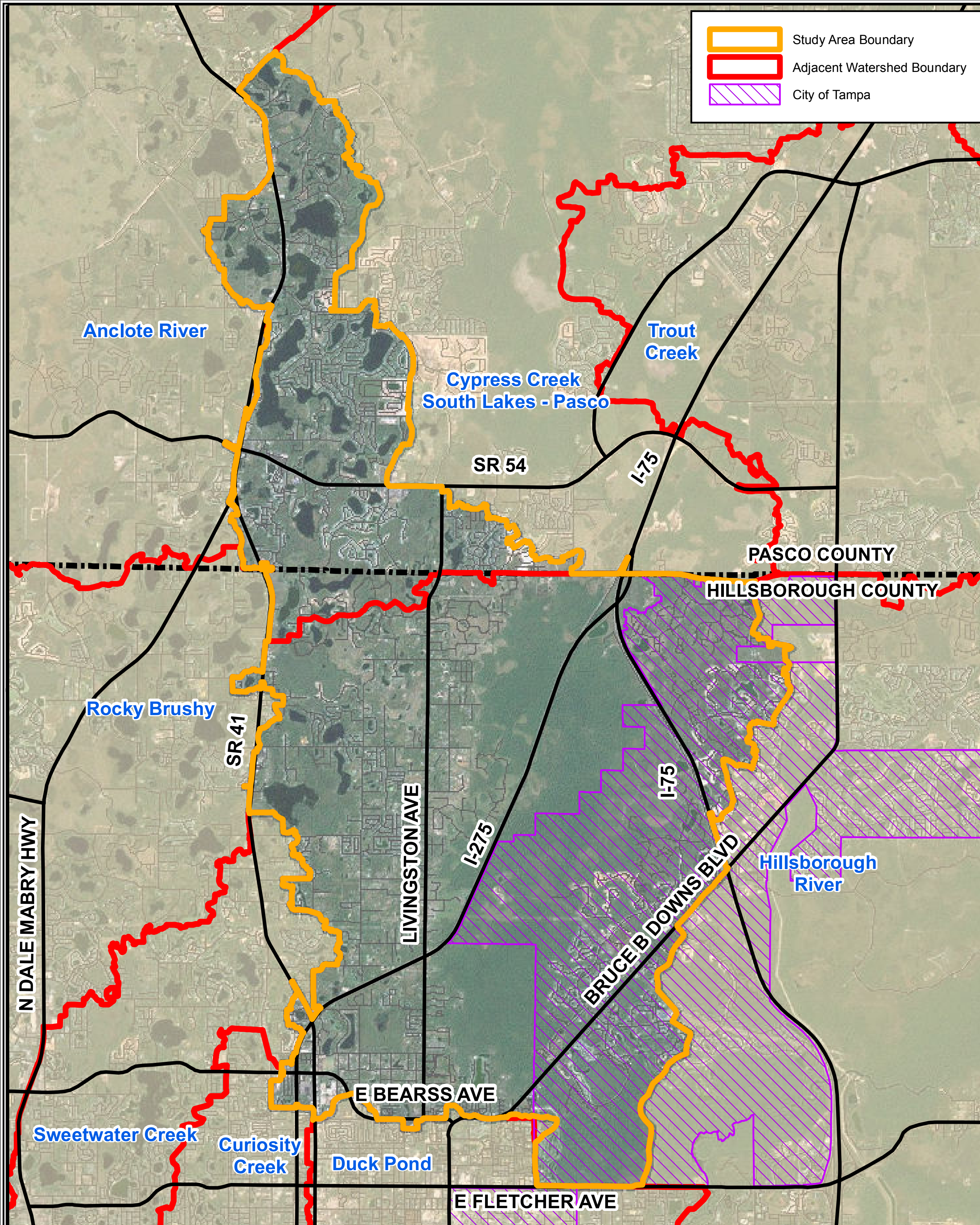
The update to the Cypress Watershed Management Masterplan includes new information relating to the model input data and results of the existing conditions model runs and revisions to the previous watershed management masterplan WMMP). This includes modifications and updates that are necessary to regenerate Chapters 1 through 6 of the 2000 WMMP document including text, tables, figures, maps, and GIS database. Land use changes that have occurred, as well as hydrologic/hydraulic model revisions, have been updated in the figures, tables, and model data files.

The report summarizes and documents results of the project and includes the following:

Executive Summary
Chapter 1 Introduction
Chapter 2 Watershed Description
Chapter 3 Major Conveyance Systems
Chapter 4 Hydrology/Hydraulic Model Methodology
Chapter 5 Model Development, Calibration and Verification
Chapter 6 Existing Conditions Flood Level of Service

The first two chapters provide an overview of the watershed, an introduction to the watershed management approach, and a description of the existing conditions within the watershed with respect to soils and hydrogeology, climate, hydrology, and land use. Chapter 3 provides a brief description of the major conveyance systems that are the subject of this plan.

Chapters 4, 5 and 6 are the most crucial to the update in that Chapter 4 describes in detail the methodology used to complete the hydrologic/hydraulic modeling; Chapter 5 provides the results of the model calibration/verification; and Chapter 6 describes in detail, the existing conditions results and level of service for the watershed.



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	Jul 08, 2011	Yoav Rappaport

Date of Photography:
Hillsborough County 2007

Figure 1.2-1

Study Area Map

Cypress Creek Watershed

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CHAPTER 2

WATERSHED DESCRIPTION

2.1 INTRODUCTION

This chapter describes the climate, physiography and hydrology, geology and hydrogeology, and soils and land use characteristics of the Cypress Creek watershed (CCW). This chapter provides a general description of the watershed and sets the stage for the more detailed existing conditions evaluations provided in the following sections.

The Cypress Creek Watershed drains an area of approximately 33 square miles or 21,000 acres in northern Hillsborough County. The Watershed is primarily suburban, and drains into the Hillsborough River. The basin is roughly bounded on its north side by the Pasco County, to its east side by I-75, along its south side by Bruce B. Downs Boulevard and on its west side by U.S. 41. Additionally, several major roads, including Livingston Avenue, Sunset Lane, Hanna Road, Debuel Road, Whitaker Road, and Sinclair Hills Road bisect the watershed.

2.2 CLIMATE

The climate of the area is humid subtropical, with an annual mean temperature of 72^{o}F. The average summer temperature is 81^{o}F and the average winter temperature is 62^{o}F with annual average precipitation of 47 inches. In a typical year, approximately 60% of the annual precipitation falls during the four-month rainy season that extends from June through September. Rainfall in this season comes primarily from convective afternoon and evening thunderstorms. Periods of extremely heavy precipitation associated with the passage of tropical low pressure systems and storms occur during summer and early fall in some years. Winter rainfalls is, historically, relatively light and is generally associated with the weak cold fronts that descend from the northern part of the country and travel south through the region. However, in late 1997 and early 1998, some of the largest rain events occurred in the winter months, and this is especially true in El Nino years.

Mean monthly temperatures range from a low of approximately 60^{o}F in January to a high of approximately 82^{o}F in August. Summer high temperatures typically reach 95^{o}F, with occasional highs greater than 100^{o}F. Annual low temperatures range from 25-30^{o}F, and occur following the passage of Arctic cold fronts. Winter temperatures rarely remain below freezing during daylight hours, and typically rise to 60-70^{o}F during periods between the passage of fronts.

According to the National Weather Service in Ruskin, humidity does not vary as seasonally as temperature and rainfall. The Service keeps daily records for 1 and 7 o'clock a.m. and 1 and 7 o'clock p.m.; the 7 a.m. time period generally records the highest humidity with the annual average at 88% with the 1 p.m. time period recording the lowest at an average of 58%.

Evapotranspiration rates vary and limited data are available for analysis. Estimates of 39 inches per year have been reported; however, Viessman, et al. (1977) reports the evapotranspiration to be closer to 48 inches per year. Lake evaporation data often quoted for use in Hillsborough County are those reported from Lake Alfred in Polk County, supplemented by scattered data available from the Lake Padgett weather station. Studies conducted by Tampa Bay Water estimate the lake evaporation rate to average approximately 56 inches per year in the study area.

2.3 SOILS

Soil distribution by type was developed based on Geographical Information Systems (GIS) coverages developed by SWFWMD. Much useful information, such as drainage classification, percent slope, water table depth, permeability, natural vegetation and potential uses for development and agriculture, can be obtained by consulting the SCS Manual for Hillsborough County for each particular soil type.

Generally, these soil types can be arranged into four groups based on their runoff-potential; A, B, C and D. The hydrologic groups are commonly used in watershed planning to estimate infiltration rates and moisture capacity. Soil properties that influence the minimum rate of infiltration obtained for a bare soil after prolonged wetting are: a) depth to seasonally high water table, b) intake rate and permeability, and c) depth to a layer or layers that slow or impede water movement. The major soil hydrologic groups are:

- Group A (low runoff potential) soils have high infiltration rates and a high rate of water transmission even when thoroughly wetted. They have typical infiltration rates of 10 in./hr. when dry and 0.50 in./hr. when saturated. Soil types found in the CCW that fall into this group include the Candler fine sands, Orsino fine sand, and the Tavares-Millhopper fine sands.

- Group B (moderately runoff potential) soils have moderate infiltration rates when thoroughly wetted and a moderate rate of water transmission. They have typical infiltration rates of 8 in./hr when dry and 0.40 in./hr when saturated.

- Group C (moderately high runoff potential) soils have low infiltration rates when thoroughly wetted and a low rate of water transmission. They have typical infiltration rates of 5 in./hr when dry and 0.25 in./hr when saturated. Soil types found in the CCW that fall into this group includes Seffner fine sand, and Zolfo fine sand.

- Group D (high runoff potential) soils have very slow infiltration rates when thoroughly wetted and a very low rate of water transmission. They have typical infiltration rates of 3 in./hr when dry and 0.10 in./hr when saturated. Soil types found in the CCW that fall within this group include Basinger, Holopaw and Samsula, Chobee muck.

- Dual classifications (e.g. A/D or B/D) can be assigned to soils that exhibit substantially different hydrologic characteristics during the wet and dry seasons. During the wet season, these soils become saturated throughout much of the soil column due to elevated water table conditions. Infiltration is thus impeded and the soils exhibit Group D infiltration and runoff rates. During the dry season when the water levels recede, infiltration rates increase and runoff rates decline to Group A or Group B levels. Soil types that fall within the B/D classification found within the CCW are Chobee loamy fine sand, Felda fine sand, Floridana fine sand, Immokalee fine sand, Malabar fine sand, Myakka fine sand, Myakka-Urban land complex, Ona fine sand, St. Johns fine sand, Wabasso-Urban land complex and Winder fine sand.

Figure 2.3-1 shows the spatial distribution of soil classifications for the Cypress Creek Watershed. Soils can also be classified as either hydric or non-hydric, which relates to whether the soils had wetland or upland origins, respectively. Those soils designated as hydric develop under anaerobic conditions in wetland areas and generally contain a large amount of organics, are poorly to very poorly drained or depressional in nature, and are associated with a high seasonal water table. Those soils, which are non-hydric, lack these characteristics and are associated with upland or transitional areas. Soil types with the hydric classification found within the CCW are Basinger, Holopaw and Samsula, Chobee loamy fine sand, Chobee muck, Eaton mucky sand, Felda fine sand, Floridana fine sand, Malabar fine sand, St. Johns fine sand and Winder fine sand. All of the other types would be considered non-hydric.

2.4 PHYSIOGRAPHY AND HYDROLOGY

The Cypress Creek Watershed lies within the Polk Upland physiographic unit as defined by White. This unit is part of the Central or Mid-Peninsular physiographic zone, one of three in Florida. This zone is characterized by discontinuous highlands formed by sub-parallel ridges that are separated by broad valleys. Land elevations in the CCW vary between a high of about 74 feet North American Vertical Datum (NAVD) in the northwestern portion of the watershed to a low of 20 feet NAVD at its outfall at the Hillsborough River. The general topographic relief for the watershed is shown on Figure 2.4-1. The watershed has twelve major outfalls. These include the Cypress Creek Main Channel, County Line Drainage System, Country Oaks System, Ridge Lake System, Sherry Brook System, Hanna Lake System, Blind Pond Avenue System, Thirteen Mile Run System, Flynn Lake System, Silver Lake System, 149th Street Outfall System, and Bruce B. Downs System. The County Line Drainage System outfalls north to Pasco County and then drains east to Cypress Creek and includes Hog Island and Hart Lake. The remainder of the outfalls discharges west to east to the Cypress Creek main channel floodplain. These systems carry the majority of the stormwater conveyance within the watershed.

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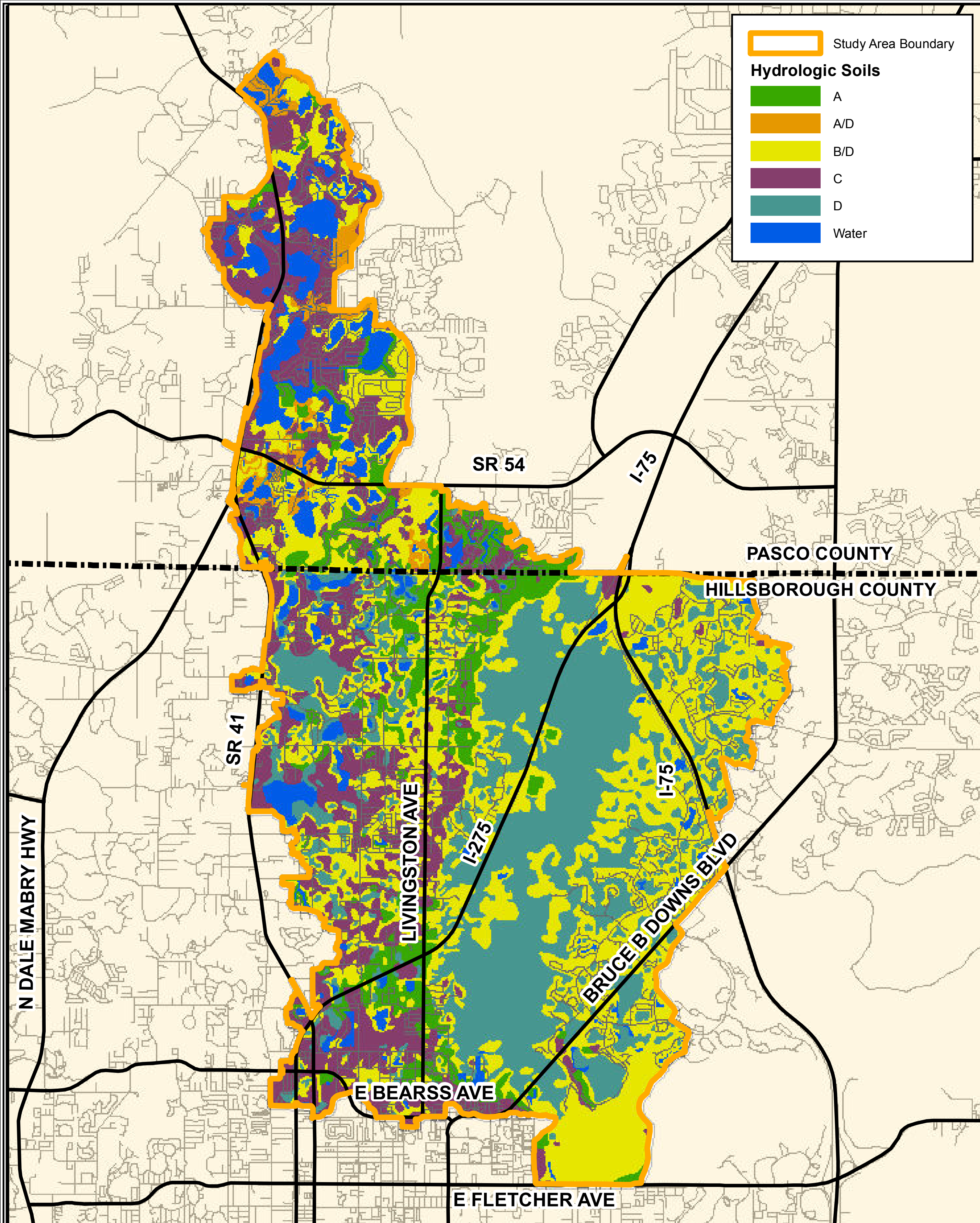

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Date of Photography:

Figure 2.3-1

Hydrologic Soil Group Classification Map

Cypress Creek Watershed

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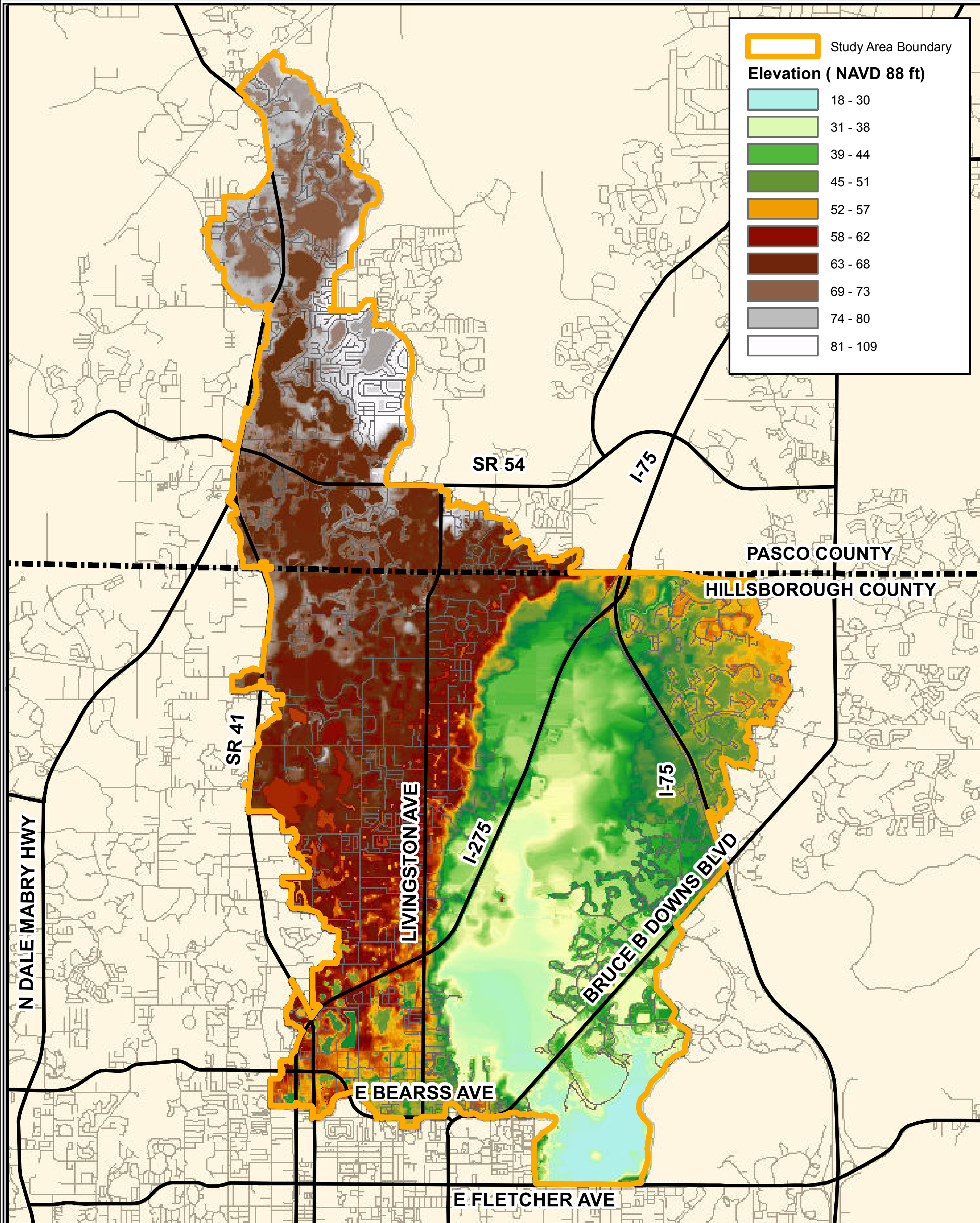

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					Cypress Creek Watershed

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There are many lakes, wetland areas and depressions located within the watershed. The numerous lakes and other depressional features in the area have been formed by sinkhole formation and other processes associated with the dissolution of the underlying limestone formations. Small lakes tend to be round, the most common expression of a sinkhole or solution feature. Larger lakes usually are formed by the coalescence of several or many solution features and do not express a characteristic shape.

Surface flows are generally from the west to the east or southeast toward the Cypress Creek Main channel. The Cypress Creek Main channel flows north to south from Pasco County to Hillsborough County. Hydrologically, surface flows originate for the most part through stormwater runoff with some influence from groundwater flows from lake seepage.

2.5 GEOLOGY AND HYDROGEOLOGY

The area is underlain by a thick sequence of sedimentary strata divided into an upper zone of unconsolidated sediments and lower zone of consolidated carbonate rock.
At land surface, undifferentiated sediments including silt, sand, and clay form surficial deposits which vary in thickness from less than 10 feet in coastal areas to over 100 feet in paleokarst depression or in sand ridges. Typical thickness of the surficial deposits varies from 20-to 50 feet. In low-lying areas near lakes and streams, thin layers of organic material mix with the surficial deposits. Pleistocene-aged silts and clays form the base of the undifferentiated sediments.

Underlying the unconsolidated material is a series of Tertiary-aged limestones and dolomites that form the carbonate platform of peninsular Florida. The sequence of carbonate rocks includes, in descending order, the following formations: Tampa Member of the Hawthorn Group, Suwannee Limestone, Ocala Group, Avon Park, Oldsmar, and Cedar Key Formations. A lithographic change from limestone and dolomite to a sequence of gypsiferous dolomite begins in the lower portion of the Avon Park Formation and continues into the Oldsmar and Cedar Key Formations. The top of this lithologic change marks the middle confining unit of the Floridan aquifer system. The middle confining unit is generally considered the base of the freshwater production zone of the Upper Floridan aquifer.

The Tampa Member of the Hawthorn Group is a tan-colored carbonate and sand mixture, which can contain variable amounts of clay. The Tampa Member can be fossiliferous and may also contain phosphate grains and chert. The Tampa Member ranges from 50 to 150 feet in thickness. The Suwannee Limestone consists of two rock types; the upper portion is a tan-colored, crystalline limestone containing prominent gastropod and pelecypod molds, and the lower portion is a cream-colored limestone containing foraminifers and pellets of micrite in a finely crystalline limestone matrix. The Suwannee Limestone varies from 150 to 300 feet in thickness.

The Ocala Group contains a series of limestones that are generally soft, friable, porous and fossiliferous. This unit is late Eocene in age and ranges in thickness from 90 to 300 feet. The Avon Park Formation comprises brown, highly fossiliferous, soft to well-indurated, chalky limestone and a gray to brown, very fine microcrystalline dolomite. The Avon Park Formation ranges from 300 to 500 feet in thickness.

The hydrogeologic flow system of the Tampa Bay region contains two distinct groundwater reservoirs: the unconfined surficial aquifer and the semi-confined Upper Floridan aquifer. The Upper Floridan aquifer is under water table conditions in areas where the clay confining layer is discontinuous or absent. Generalized geologic and hydrogeologic units of the Tampa Bay area are shown in Figure 2.5-1.

Surficial Aquifer

The surficial aquifer is comprised primarily of unconsolidated deposits of fine-grained sand with an average thickness of 30 feet. Due to the karst geology of the region, thickness of the sand is highly variable. The depth of the water table ranges from near land surface to several tens of feet below land surface. Water table elevation is primarily influenced by rainfall; annual highs in most years occur during the end of the wet season (in Sept.- Oct.), and annual lows occur near the end of the dry season (in May-June). The direction of groundwater flow varies locally and is significantly influenced by the topography of the land surface. The hydraulic gradient (change of elevation per unit length) in the area typically ranges from a few feet per mile to about ten feet per mile. The permeability of the surficial aquifer is generally low and water withdrawn from this aquifer is used most often for lawn irrigation and watering livestock. Surficial aquifer wells typically yield less than 20 gallons per minute.

Semi-Confining Zone

Below the surficial aquifer is a semi-confining unit comprised of clay, silt and sandy clay that somewhat retards the movement of water between the overlying surficial aquifer and the underlying Floridan Aquifer. The confining materials are comprised of blue-green to gray, plastic, sandy clay and clay. The upper portion of the Arcadia Formation (Hawthorn Group) typically forms the semi-confining layer.

Leakage from the surficial aquifer into the Floridan aquifer occurs by infiltration across the semi-confining layer or through fractures or secondary openings in the semi-confining unit caused by chemical dissolution of the underlying limestone. Due to the highly karstic nature of the geologic system, the clay semi-confining layer can be absent in one area but tens of feet thick a short distance away. These localized karst features, in which the clay semi-confining layer is breached or missing, significantly increases hydraulic connection between the two aquifers (Hancock and Smith 1996).

Figure 2.5-1 Generalized Geologic and Hydrogeologic Units of the Tampa Bay Area

SERIES	GEOLOGIC UNIT	GENERAL LITHOLOGY	HYDROGEOLOGIC UNIT	
UNDIFFERENTIATED	UNDIFFERENTIATED SAND AND CLAY	PREDOMINANTLY SAND WITH SOME INTERBEDDED CLAY, SHELL	SURFICIAL AQUIFER SYSTEM; INTERMEDIATE CONFINING UNIT	
MIOCENE	HAWTHORN GROUP PEACE RIVER FORMATION	INTERBEDDED SAND, CLAY, AND CARBONATE, ALL OF WHICH ARE VARIABLY PHOSPHATIC	INTERMEDIATE AQUIFER SYSTEM	
MIOCENE	ARCADIA FORMATION	SANDY AND CLAYEY LIMESTONE AND DOLOMITE WITH BEDS OF SAND AND CLAY, ALL OF WHICH ARE VARIABLY PHOSPHATIC	INTERMEDIATE AQUIFER SYSTEM	
MIOCENE	ARCADIA FORMATION – TAMPA MEMBER	SIMILAR TO ARCADIA FORMATION BUT WITH LESS DOLOMITE, SAND, CLAY AND PHOSPHATE	INTERMEDIATE AQUIFER SYSTEM / UPPER FLORIDAN AQUIFER SYSTEM	
OLIGOCENE	SUWANNEE LIMESTONE	LIMESTONE; SANDY LIMESTONE; FOSSILIFEROUS	UPPER FLORIDAN AQUIFER SYSTEM	FLORIDAN AQUIFER SYSTEM
EOCENE	OCALA LIMESTONE	CHALKY, FORAMINIFERAL LIMESTONE; DOLOMITIC NEAR BOTTOM	UPPER FLORIDAN AQUIFER SYSTEM	FLORIDAN AQUIFER SYSTEM
EOCENE	AVON PARK FORMATION	LIMESTONE AND CRYSTALLINE BROWN DOLOMITE; GYPSUM NODULES IN LOWER PART	UPPER FLORIDAN AQUIFER SYSTEM; MIDDLE CONFINING UNIT	FLORIDAN AQUIFER SYSTEM

MODIFIED FROM RYDER, 1985
AND CAMBELL & ARTHUR, 1993

Upper Floridan Aquifer

The Upper Floridan aquifer consists of a continuous series of carbonate units that include portions of the Tamar Member of the Hawthorn Group, Suwannee Limestone, Ocala Limestone and Avon Park Formation. Groundwater within the Upper Floridan aquifer is typically under artesian conditions within the project area.

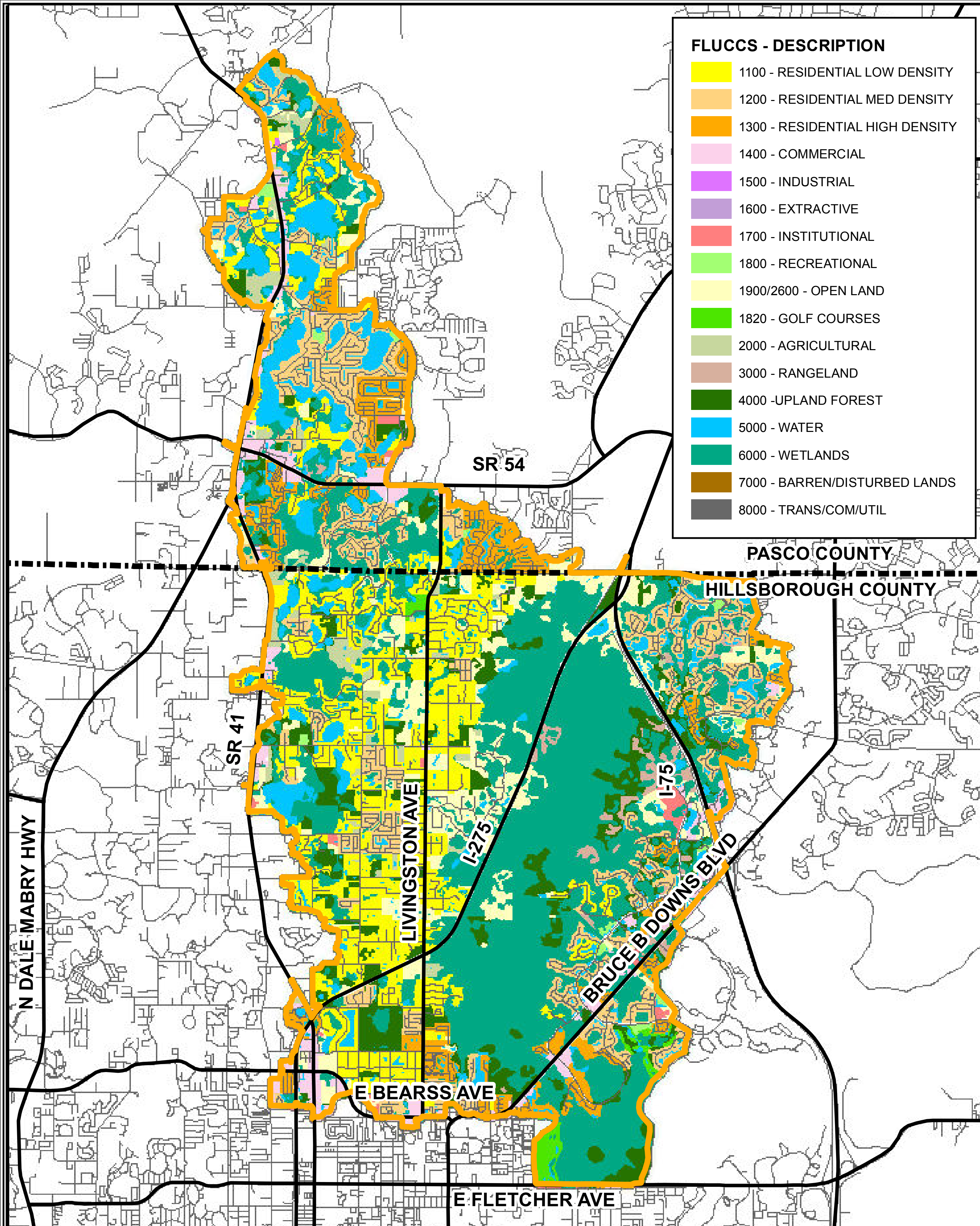
Near the base of the Avon Park Formation lies the middle confining unit of the Floridan aquifer, an evaporate sequence of very low permeability that is composed of gypsiferous dolomite and dolomitic limestone. The middle confining unit generally delineates the boundary between the freshwater Upper Floridan aquifer and the brine-saturated Lower Floridan aquifer. The evaporites function as a lower confining unit and retard vertical flow across the boundary. In general, the permeability of the Upper Floridan aquifer is moderate in the Tampa Member and Suwannee Limestone, low in the Ocala Limestone and very high in portions of the Avon Park Formation. The limestone and dolomite beds produce significant quantities of water due largely to numerous solution openings along bedding planes and fractures. The Ocala Limestone yields limited amounts of water and may be considered a semi-confining layer within the Upper Floridan aquifer. Overall, the Ocala Limestone tends to act as a semi-confining zone between the overlying Tampa/Suwannee Formations and the underlying Avon Park Formation. Transmissivity of the Avon Park Formation is very high due to the fractured nature of the dolomite zones.

Ground water flow in the Floridan aquifer originates as rainfall that percolates downward from the surficial aquifer. In areas where the Upper Floridan aquifer outcrops, this recharge can be direct. Recharge rates are generally higher in the northern portion of the County. Recharge can be highly variable throughout the area, however, due to karst ecology and induced leakage caused by ground-water withdrawals. The regional hydraulic gradient and direction of flow in the Upper Floridan aquifer is generally toward the south and west.

2.6 LAND USE

The Cypress Creek Watershed encompasses a wide variety of land uses. For modeling purposes, the Southwest Florida Water Management District's 2005 Land Use/Land Cover Map was updated using the 2007 aerials and is shown in Figure 2.6-1. There are several areas of Significant or Essential Upland Wildlife Habitat which exist within the watershed area which are associated with the Cypress Creek floodplain and other large lake and wetland areas. Residential areas are concentrated around many of the lakes with other subdivisions scattered throughout the western portion of the watershed. The majority of these residential areas tend to be older subdivisions with little or no stormwater treatment being provided.

Land use categorization is necessary to evaluate existing conditions and to plan future conditions. If land is developed without planning, conflicts can occur over infrastructure, utilities, open space, zoning and many other issues.



PARSONS
4925 Independence Pkwy
Suite 120
Tampa, FL 33634

Filename:	Map Date:	Prepared By:
	Jul 08, 2011	Yoav Rappaport

Date of Photography:

Figure 2.6-1

Watershed Existing (2007) Land Use Map

Cypress Creek Watershed

Path: J:\DATA\260464_Cypress_Creek_Update_HC\GIS\Maps\MXD\Final_Report\CC_Figures_Final.mxd

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The categorization of land uses can be accomplished in several ways, but the most popular and widely used method is the Florida Land Use, Cover, and Forms Classification System (FLUCCS) that was developed in the 1970s. This system describes and labels all developed and undeveloped land uses and covers in Florida into a simple numbering system. Table 2.6-1 includes a summary of the land use in the watershed.

Residential (1000-1300)

Residential land use is usually divided between low, medium, and high density residential, depending on the number of housing units per acre.

Commercial/Industrial (1400-1500)

For the purposes of this study, we have combined the commercial and industrial land uses, as these two land uses together. Commercial land uses include retail and wholesale sales and services such as shopping centers, offices, theaters, museums, camping facilities, gas stations and storage areas, and cemeteries.

Industrial land uses include manufacturing, assembly, or processing facilities, research and administrative centers, pulp and paper mills, oil refineries, and chemical plants

Institutional (1700)

The institutional land use includes educational, governmental, military and religious facilities and their associated parking lots and grounds.

Recreational (1800)

Recreational areas include parks, golf courses, swimming beaches, racetracks, marinas, community recreational facilities, historical sites, etc.

Open Land (1900)

This land use describes undeveloped urban land that exhibits no indication of what the future use may be. Often this land is in a transitional state and will eventually be developed, but until that future use is known the area is characterized as open or inactive.

Cropland and Pastureland (2100)

This land cover classification describes lands that are usually dominated by grasses, forbs, and shrubs, and are capable of being used as grazing land to raise cattle or sheep. These lands are usually in a semi-natural state and have not been graded, cultivated, irrigated, or fertilized. Usually the vegetation and hydrology are still somewhat intact.

Tree Crops (2200)

This land use describes lands that are used for growing trees for harvesting and includes orange groves and other row planted tree crops.

Nurseries and Vineyards (2400)

Nurseries and Vineyards include areas such, wine vineyards, plant nurseries or other lands that temporarily grow vegetative species specifically for transplanting to other locations.

Specialty Farms (2500)

This land use describes areas that are used for raising livestock, fish such as tropical fish farms or other lands with unique farming activities

Other Open Lands (2600)

Open lands other than the described areas included in the 1900 FLUCCS

Scrub and Brushlands (3000's)

This land use describes lands characterized by areas of dense growth of bushes, low trees and and/or shrubs.

Upland Forests (4000's)

The upland forests within the watershed include those areas with a tree canopy of greater than 10%, and with no other land use apparent, such as residential or recreational. Typical upland forests found in this region include pine flatwoods, xeric oak scrub, sand pine scrub, and upland mixed hardwood/conifer forests. The upland mixed hardwood/conifer forests are the dominant upland forest found in the watershed and usually former pine flatwoods or longleaf pine communities that have been logged out at one time. The pines have regenerated, but the hardwoods are usually co-dominant in the canopy due to the suppression of the natural fire cycle. This vegetation community type is important to the water quality and wildlife of the watershed in that they provide habitat and erosion protection.

Water Bodies (5000's)

The water body land use classification include ponds, reservoirs, lakes, streams springs and sloughs, and usually refer to open waters too deep to support emergent aquatic vegetation.

Wetland Forests (6100-6300)

The majority of the wetland forests are characterized as stream and lake swamps, also called bottomlands. The bottomlands are predominantly associated with the floodplain and its tributaries and are characterized by a canopy of oak, bay, hickory, maple and other hardwoods and a sparse understory of ferns and other shade-tolerant forb species.

TABLE 2.6-1 Land Use Types by Subwatershed in the Cypress Creek Watershed

Land Use	FLUCCS	Cypress Creek Main Channel (acres)	County Line Drainage System (acres)	Country Oaks System (acres)	Ridge Lake System (acres)	Sherry Brook System (acres)	Hanna Lake System (acres)	Blind Pond Avenue System (acres)	Thirteen Mile Run System (acres)	Flynn Lake Outfall System (acres)	149th Avenue Outfall System (acres)	City of Tampa Boundary (acres)	Total (acres)
Residential	1000-1300	1,167	565	330	166	581	370	287	3,155	289	727	1,220	8,856
Commercial/ Industrial	1400-1500	31	40	-	-	4	-	-	343	0	191	155	764
Institutional	1700	10	-	-	-	5	-	-	51	-	11	65	143
Recreational	1800	161	18	15	-	-	-	-	46	-	-	48	287
Open Land	1900	-	-	-	-	-	-	-	-	-	-	-	-
Cropland/ Pastureland	2100	29	1	7	0	51	-	5	250	0	-	8	351
Tree Crops	2200	2	3	9	-	13	4	3	67	-	4	-	105
Nurseries/ Vineyards	2400	4	-	-	-	-	-	-	5	-	-	-	9
Specialty Farms	2500	1	-	-	-	7	-	-	-	-	-	-	8
Other Open Lands	2600	782	91	60	122	152	88	21	397	27	92	315	2,148
Scrub and Brushlands	3000	154	-	-	-	-	-	-	9	-	-	126	290
Upland Forest	4000	840	47	25	20	63	73	39	438	159	69	246	2,020
Water Bodies	5000	167	121	26	9	36	43	14	1,318	18	95	279	2,127

TABLE 2.6-1 Land Use Types by Subwatershed in the Cypress Creek Watershed

Land Use	FLUCCS	Cypress Creek Main Channel (acres)	County Line Drainage System (acres)	Country Oaks System (acres)	Ridge Lake System (acres)	Sherry Brook System (acres)	Hanna Lake System (acres)	Blind Pond Avenue System (acres)	Thirteen Mile Run System (acres)	Flynn Lake Outfall System (acres)	149th Avenue Outfall System (acres)	City of Tampa Boundary (acres)	Total (acres)
Wetland Forest	**6100-6300**	5,079	122	3	1	40	35	18	816	7	0	991	7,111
Wetland Non-forested	**6400**	155	303	39	58	95	17	12	598	85	57	234	1,653
Non-vegetated Wetland	**6500**	4	1	3	-	-	0	0	1	-	4	-	14
Trans./ Utilities	**8000**	249	4				-		165	24	56	232	730
Total per Subwatershed		**8,837**	**1,316**	**517**	**377**	**1,047**	**631**	**400**	**7,660**	**609**	**1,305**	**3,920**	**26,618**

Tree Crops (2200)

This land use describes lands that are used for growing trees for harvesting and includes orange groves and other row planted tree crops.

Nurseries and Vineyards (2400)

Nurseries and Vineyards include areas such, wine vineyards, plant nurseries or other lands that temporarily grow vegetative species specifically for transplanting to other locations.

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This land use describes areas that are used for raising livestock, fish such as tropical fish farms or other lands with unique farming activities

Other Open Lands (2600)

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Scrub and Brushlands (3000's)

This land use describes lands characterized by areas of dense growth of bushes, low trees and and/or shrubs.

Upland Forests (4000's)

The upland forests within the watershed include those areas with a tree canopy of greater than 10%, and with no other land use apparent, such as residential or recreational. Typical upland forests found in this region include pine flatwoods, xeric oak scrub, sand pine scrub, and upland mixed hardwood/conifer forests. The upland mixed hardwood/conifer forests are the dominant upland forest found in the watershed and usually former pine flatwoods or longleaf pine communities that have been logged out at one time. The pines have regenerated, but the hardwoods are usually co-dominant in the canopy due to the suppression of the natural fire cycle. This vegetation community type is important to the water quality and wildlife of the watershed in that they provide habitat and erosion protection.

Water Bodies (5000's)

The water body land use classification include ponds, reservoirs, lakes, streams springs and sloughs, and usually refer to open waters too deep to support emergent aquatic vegetation.

Wetland Forests (6100-6300)

The majority of the wetland forests are characterized as stream and lake swamps, also called bottomlands. The bottomlands are predominantly associated with the floodplain and its tributaries and are characterized by a canopy of oak, bay, hickory, maple and other hardwoods and a sparse understory of ferns and other shade-tolerant forb species.

Wetland Non-Forested (6400)

This land cover classification is used to describe vegetated wetlands with no tree cover and predominantly herbaceous vegetation. This land cover includes freshwater marshes, wet prairies, saltwater marshes, floating aquatic macrophytes, and the emergent aquatic vegetation found on the littoral shelf areas of open water bodies.

Intermittent Ponds (6530)

This land use generally refers to design dry detention ponds

Barren Lands (7000's)

The barren land classification is usually used to describe lands with little vegetation and for which there are no known current or future uses. Barren lands that have been disturbed in association with another known land use, such as mined lands and agricultural areas that have been tiled but not planted, do not fall into this classification.

Transportation, Utilities, and Communication (8000's)

These three land use categories were combined for discussion because they have little impact on the stormwater management of the Cypress Creek Watershed. This land use classification includes utility corridors, easements and transmission lines, roads, railroads, and highways, water supply facilities, sewage treatment plants, solid waste disposal areas, and electrical substations and transformer yards.

CHAPTER 3

MAJOR CONVEYANCE SYSTEMS

3.1 INTRODUCTION

This chapter provides an overview of the hydrological aspects of the Cypress Creek Watershed (CCW) and how the area that the watershed encompasses was divided and defined for the purposes of this study. The entire CCW extends from Pasco County to north central Hillsborough County. For this study, only the Hillsborough County portion of the model was digitized and used in the model with the addition of 13-Mile Run data from the Pasco County Cypress Creek (PCCC) model.

The watershed is bordered on the north by the Cypress Creek (Pasco County) Watershed, to the west by Anclote River, Rocky – Brushy Creek, Sweetwater Creek; and Curiosity Creek Watersheds; on the south by the Duck Pond Watershed; and outfalls to the southeast into Hillsborough River.

The CCW drains approximately 160 square miles total; over 30 square miles in central Hillsborough County. Cypress Creek flows through the eastern portion of the watershed from Pasco County to its confluence with the Hillsborough River. The creek flow is supplemented by additional input from several drainage systems that flow east into the creek prior to the Hillsborough River confluence. These drainage systems form ten separate subwatersheds within the CCW. The watershed is comprised of the Cypress Creek main channel, County Line drainage, Country Oaks, Ridge Lake, Sherry's Brook, Hanna Lake, Blind Pond Avenue, Thirteen Mile Run, Flynn Lake Outfall, 149th Avenue Outfall, and the City of Tampa Subwatersheds. Table 3.1-1 lists the eleven subwatersheds and the area each one drains. A description is provided of each subwatershed in this Chapter. Figure 3.1-1 illustrates the subwatersheds and conveyance systems within the CCW.

TABLE 3.1-1
SUBWATERSHEDS WITHIN THE CYPRESS CREEK WATERSHED

NUMBER	SUBWATERSHED NAME	AREA (acres)
1	Cypress Creek Main Channel	8,837
2	County Line Drainage System	1,316
3	Country Oaks System	517
4	Ridge Lake System	377
5	Sherry Brook System	1,047
6	Hanna Lake System	631
7	Blind Pond Avenue System	400
8	Thirteen Mile Run System	7,660
9	Flynn Lake Outfall System	609
10	149^{th} Avenue Outfall System	1,305
11	City of Tampa Boundary	3,920
	Cumulative Drainage Area	**26,618**

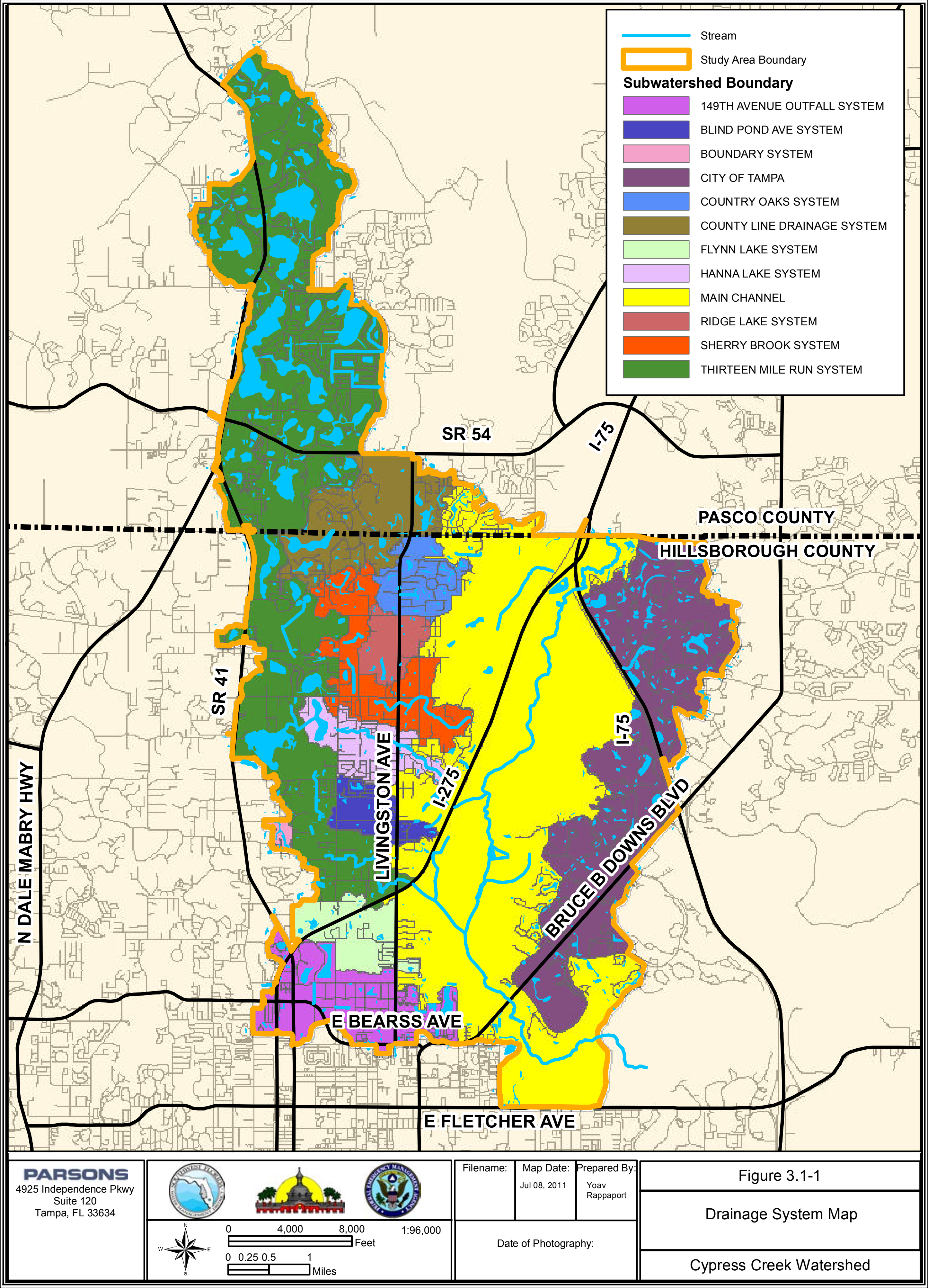

Figure 3.1-1

Drainage System Map

Cypress Creek Watershed

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3.2 CYPRESS CREEK MAIN CHANNEL (Junction ID 5xxxxx series)

The Cypress Creek Main Channel is the largest tributary to the Hillsborough River. Flow originates from low sand hills and karst areas in Northern Pasco County and travels south through large wetland systems toward the Hillsborough River. The total Cypress Creek Watershed is approximately 160 square miles, and is mostly undeveloped or agricultural land. The portion of the watershed in Hillsborough County is approximately 30 square miles. Like many creek systems in the area, several reaches exhibit no flow during the dry season, but unlike most other creek systems, it is estimated that the Upper Floridan Aquifer contributes about 20 percent of the total flow of the creek in the middle reaches of the system (Cheery and others, 1970).

The Cypress Creek main channel enters northern Hillsborough County from Pasco County just east of the Interstate 75/275 interchange. Just south of that interchange, the Creek channel crosses Interstate 75 west, then flows south along the east side of I-275 to SR 581 (Bruce B. Downs Boulevard). The channel continues to the south and joins the Hillsborough River. The channel is poorly defined throughout most of the area. The floodplain characteristics of Cypress Creek include large storage, wide overflow floodplains and small topographic relief.

There are several major cross drain structures along I-75 and I-275 which preserve some of the creek's natural connectivity to the east and west.

3.3 COUNTY LINE DRAINAGE SYSTEM (Junction ID 531xxx and 535xxx series)

Several drainage basins adjacent to the Hillsborough/ Pasco County line drain directly to the Cypress Creek Main channel. Several other basins and Lakes in Hillsborough County drain north to Pasco County. The areas eventually flow to the east into Cypress Creek. These areas include Cool Kell Lake, Hog Island Lake, Hart Lake and several unnamed lakes and wetlands. The Hog Island Lake area was studied in detail in the Stormwater Management Report for Hog Island Lake, URS Corporation, May 2000.

3.4 COUNTRY OAKS SYSTEM (Junction ID 531xxx series)

The Country Oaks system originates west of Livingston Avenue and north of Wallace Road. Runoff flows east under Livingston Avenue through the Country Oaks and Sanctuary at Livingston subdivisions ultimately discharging to the Cypress Creek Main channel floodplain west of I-275.

3.5 RIDGE LAKE SYSTEM (Junction ID 530xxx series)

The Ridge Lake system originates in Ridge Lake within the Ridge Lake subdivision located west of Livingston Avenue and south of Wallace Road. Runoff flows to the south through a large wetland area and open pasture and turns east to Livingston Avenue. Past Livingston, the flow continues east under 30th Street and Carr Drive before discharging to the Cypress Creek main channel floodplain west of I-275. An additional tributary channel ties into the Ridge Lake main channel from the north between 30th Street and Carr Drive

3.6 SHERRY BROOK SYSTEM (Junction ID 530xxx series)

The Sherry Brook system originates in a large wetland/lake area located between the Eagle Crest and Rhodes Woods subdivisions south of Newberger Road. Runoff flows south through several lake areas in the Hanna Pond Estates and San Remo subdivisions. The channel within this area is not well defined. Runoff from several areas west of Hanna Road combine with the Sherry Brook main channel north of Sunset Lane. This runoff then flows east under Walker Road, Sunset Road and Livingston Avenue in a well-defined channel. Runoff from the Meadowlands, Windemere Unit 1 and Timberlane subdivisions flow east into Sherry Brook. The channel widens and continues east to 30th Street and then winds south through the Sherry Brook Estates subdivision and ultimately discharges to the Cypress Creek main channel floodplain west of I-275.

3.7 HANNA LAKE SYSTEM (Junction ID 510xxx and 520xxx series)

. Keene Lake, part of the Thirteen Mile Run System, discharges into discharges south under Sunset Lane to Lake Stemper and Hanna Lake. Hanna Lake then discharges east to Hanna Road. A detailed discussion of the lakes in this system is described later in this chapter. The channel is well defined but not well maintained. The channel flows east through the Cooper's Pond, Windemere and Livingston Acres subdivisions crossing under Swan Lake Drive and Livingston Avenue. Inflow from the south joins the main channel from the Barrington and Livingston Unit 4 subdivisions. The flow then travels east in a steep channel through pasture area and flows into the Cypress Creek main channel floodplain west of I-275.

3.8 BLIND POND AVENUE SYSTEM (Junction ID 512xxx series)

The Blind Pond Avenue system originates in a wetland area located west of Hanna Road and south of Clement Road. Runoff then flows northeast under Green Meadow Drive and Clement Road. Runoff from the Pond Eddy and Livingston Units 2A and 3A subdivisions flow south under Blind Pond Avenue to combine with the area south of Clement Road. These combined areas flow east through the Prairie View Acres subdivision to Livingston Avenue. The flow then travels east in a steep channel through pasture area and flows into the Cypress Creek main channel floodplain west of I-275.

3.9 THIRTEEN MILE RUN SYSTEM (Junction ID 510xxx series)

The Thirteen Mile Run system is one of the largest tributaries within the study area. This system originates in Pasco County and flows south into Hillsborough County at County Line Road near U.S. 41 at Lake Kell. The flow then passes south under Newberger Road to Swamp Lake and Keene Lake. Lake Keene is developed around its shoreline. Runoff from Lake Commiston and Little Hobbs Lake also flows into Keene Lake from the west. Keene Lake discharges south under Sunset Lane to Hanna Lake and Lake Stemper. Lake Stemper discharges through large wetland areas and outfalls to Dubuel Road. The channel at this location is well defined and flows south between the Maniscalco Elementary School and the Willow Pond subdivision. The channel continues south through several wetland areas to Whitaker Road. At Whitaker Road the channel turns east and flows to Hanna Road. Past Hanna Road the channel continues east then south to Vandervort Road. The channel crosses Vandervort Road and meanders through the Park Forest subdivision to Livingston Avenue. The flow then travels east and into the I-275 cross drains to merge with Cypress Creek main channel.

3.10 FLYNN LAKE SYSTEM (Junction ID 505xxx and 506xxx series)

The Flynn Lake System originates in several lake areas located north of I-275 and south of Hanna Road. The lakes discharge south under I-275 to other wetland areas adjacent to the Curry Cove subdivision west of Livingston Avenue. Flynn Lake and the lake located west of north 15th street also drain to these wetland areas. These wetland areas then discharge to the east to Livingston Avenue and ultimately discharge to the Cypress Creek main channel floodplain.

3.11 149TH AVENUE OUTFALL SYSTEM (Junction ID 505xxx series)

The 149th Avenue outfall is the only previously improved outfall in the study area. This outfall was improved by Hillsborough County in 1983. The system originates at Burrell Lake at Apex Lakes Estates subdivision located south of I-275 and East of Nebraska Avenue and the CSX railroad. Burrell Lake outfalls at South Barrel Drive to the southeast to a maintained channel. The channel flows south along North 12th Street to Bearss Avenue. The flow crosses Bearss Avenue and drains south to a low wetland area. Runoff from industrial areas to the south and commercial areas along Nebraska Avenue to the west also drains to the low area. This low area then discharges to the east under Bearss Avenue to the 149th Avenue outfall. The 149th Avenue outfall system is a series of pipes, channels and ponds which flow to the east to Livingston Avenue. Areas to the north of Sinclair Hills Road and to the south to Skipper Road drain to the 149th Avenue outfall via overland flow or swales.

At Livingston Avenue, the 149th Avenue outfall combines with an inflow pipe which drains a portion of Skipper Road and Livingston Avenue. This system then flows east in a channel/ pipe system to a lake at the Lake Forest subdivision. This lake then discharges north to the Cypress Creek floodplain.

3.12 DEVELOPED AREA UNDER CITY OF TAMPA BOUNDARY (Junction ID 500XXX, 513XXX, and 530XXX series)

A portion of the City of Tampa stretching from the Hillsborough and Pasco county line east of Interstate 75 and 275 interchange to Bruce B. Downs Boulevard & Amberly Drive contributes to the CCW. For the purpose of this study, this area was modeled to account for storage and attenuation without modeling every storage area over one acre.

3.13 CYPRESS CREEK LAKE CHAIN

The Cypress Creek Lake chain in the project area extends from southwest Pasco County to Lutz in northwest Hillsborough County. These lakes are interconnected, forming chains of lakes. Lake chains represent surface water conveyance systems similar to streams, but water at the head of the chain flows from lake to lake through a mostly ill-defined slough-way during high-flow conditions instead of within a confined stream channel. The lakes included in a chain are those that currently are or appear to be hydraulically connected to the main flow-way through the chain.
Hydraulic connections between lakes within a chain help stabilize lake water surface elevations by increasing the distribution of inflows to lakes within the chain. However, lakes within the study area have experienced extended periods of below-normal water levels in recent years. The failure of many of these lakes to return to previous levels has led lakefront property owners to be concerned that some event or process has disrupted normal hydrologic conditions. In 1998 however, El Niño rainfall caused flooding conditions in several of the lakes.

Drainage in the western portion of the Cypress Creek watershed is unusual in that almost all drainage is to lakes and wetlands rather than to networks of streams. The combination of relatively flat topography and a high water table results in lakes between which water can flow according to the general topographic gradient in the area, which is approximately north to south. These chains of lakes appear to generally take the place of streams in the watershed.

The numerous lakes and other depressional features in the study area have been formed by sinkhole formation and other processes associated with the dissolution of the underlying limestone formations. Small lakes tend to be round, the most common expression of a sinkhole or solution feature. Larger lakes usually are formed by the coalescence of several or many solution features and do not express a characteristic shape.

The surface materials settling into the solution cavity initially may cause a breach in the confining layer that may enhance the connection between the surface water and the Floridan Aquifer. Subsequent transport of sand, silt, and clay into the depression typically restores the seal between the surficial aquifer or lake and the underlying Floridan Aquifer (Sinclair, et al., 1985).

The degree of connection between lakes in the study area is highly variable. Some lakes are connected by a deep channel or culvert that provides a continuous connection during most lake level conditions. In this case, connected lakes act as a single water body. Other lakes have outfalls that are controlled by natural low-lying sills, road crossings with culverts, or outfall control weirs that hold water in the lakes until lake levels rise enough to flow over or through the outfall. The elevations at which most culverts and structures are placed allow flow during periods of high water levels and hold water in the lakes during periods of low water levels. Natural sills are usually high enough that water flows out of the lakes only during periods of high water levels.

The outfall control weirs that are in place at lakes within the study area are constructed of concrete, with broad, flat bottom sections that are usually 10 to 12 feet wide and side sections that rise 2 to 3 feet. This results in a rectangular orifice open at the top, through which the lake discharges. Large planks called *stop logs* can be inserted across the bottom of the opening to raise the effective elevation of the weir in order to hold more water in the lake. The stop logs are usually 10 to 12 inches high and are long enough (10 to 12 feet) to completely fill the bottom of the weir opening. The Southwest Florida Water Management District (SWFWMD) manages the installation and removal of stop logs based on the season and the lake level conditions. During wet seasons or when heavy storm events are expected, stop logs often are removed to allow more flow through the lake system and to decrease the possibility or magnitude of flooding. The logs also may be managed in order to allow the lake levels to fluctuate in a manner similar to natural lake systems.

Lakes are the surface expressions of the surficial aquifer where the ground surface is below the level of the groundwater table. The water level within the surficial aquifer fluctuates with changes in inflows and outflows. At a specific lake, inflows include direct rainfall, surface water runoff within the watershed, inflows from other lakes, and in some cases artificial augmentation. Outflows include evaporation from the lake surface, transpiration from the plants within the watershed, downward leakage through the lake bottom and the confining layer to the Floridan Aquifer, and outflows to other lakes or streams (Henderson, 1983).

The single most important influence on lake level fluctuations in the northwest Hillsborough County and South Pasco area is rainfall (Henderson, 1983; LBG Inc. and Greeley & Hansen, 1994). Another important variable is the degree of downward leakage. This second variable becomes more important in times of extended drought because water exits the lake through infiltration but is not replenished by rainfall.

Development within the study area has occurred over a long period of time, beginning in the early 1900s and continuing to the present. Over this period, drainage patterns and lake connections for these lake chains have been altered to various degrees to suit agriculture and other development. Alterations have included ditching for draining low-lying lands, dredging to increase lake area or to build up surrounding lands, digging canals to connect lakes or to control lake levels, and constructing dams or roads that act as flow barriers between lakes. These alterations have occurred at different stages of development. Some major alterations occurred in the early stages of development in the study area.

Aerial photography was used to determine alterations in drainage patterns during development of the study area. The earliest available aerial photographs are from 1938. By 1938, the area already had been significantly altered to suit citrus farming. Large canals had been excavated between and from some of the lakes for water management purposes.
The following section describes the major lakes in the study area, including the establishment of the watershed and lakes included in the chains, an overview of development history, an analyses of lake level data, and descriptions of structures, channels, and sills that control the lake connections.

CYPRESS CREEK LAKES

The Cypress Creek chain of lakes extends from, approximately 2 miles north of the Hillsborough-Pasco County line, to Lake Stemper, which lies approximately 3.5 miles south of the Hillsborough-Pasco County line.

The 1938 aerial photographs show major drainage alterations in the Cypress Creek chain of lakes. Dubuel Road was in place, and the connections between Keene Lake and Lakes Hanna and Stemper (including a ditch between these lakes) appear to have been channelized. A number of roads crossed the area, often over lake connections, but no major alterations other than the drainage canals had been made to the lakes.

In the 1950s and 1960s, the land around several of the Cypress Creek lakes was developed considerably to residential land use. The area was dredged extensively to create canals and presumably to obtain fill to raise the adjacent land surface. Lake Keene was affected significantly by this activity. The Cypress Creek lakes have not changed much since the early 1970s with respect to lake shoreline and roadway configurations, but housing density have continued to increase.

Lake Stemper is considered the end of the chain, and discharge from this lake to Thirteen-Mile Run is considered an outflow from the chain. Hanna Lake competes to some degree with Lake Stemper for position at the end of the chain since it also receives outflow from Keene Lake. Hanna Lake also represents outflow from the chain by way of a small intermittent stream, which flows east toward Cypress Creek.

Hog Island Lake, Cool Kell Lake and Dupree Lake were initially thought to be linked hydrologically with the Cypress Creek Lake chain. However, they were found to have no direct connection except possibly during extreme flood events. Hog Island Lake and Cool Kell Lake discharge north to Pasco County and then east towards Cypress Creek through a series of swamps and sloughs. Dupree Lake was found to have no outflow, even for the predicted 100-year flood elevation.

Lake Jo Ann

Lake Jo Ann is approximately 13 acres in surface area and is located in south Pasco County. This flow-through lake receives inflow from Lakes Catfish and Myrtle. Discharge from Lake Jo Ann flows over a low (67 feet NAVD88) sill and through a low area to reach Lake Toni.

Myrtle Lake

Myrtle Lake is approximately 17 acres in surface area and is located in Pasco County. The outlet is a natural sill, possibly channelized to some degree, with an estimated controlling elevation of 66.60 feet NAVD88. Outflow is to Lake Jo Ann, and inflow to the lake occurs only from watershed runoff. Average water level for the period of record (February 1988 to December 2005) was 65.43 feet NAVD88, with a range of 62.78 feet NAVD88 to 68.14 feet NAVD88.

Catfish Lake

Catfish Lake is 23 acres in surface area and is located in Pasco County. The outlet is a natural sill, possibly channelized to some degree, with an estimated controlling elevation of 66.20 feet NAVD88 (SWFWMD, 1988). The outflow channel to Lake Jo Ann is shared by Lakes Catfish and Myrtle, and inflow to the lake occurs only from watershed runoff. The average water level for the period of record (February 1988 to December 2005) was 65.43 feet NAVD88, with a range of 62.78 feet NAVD88 to 68.14 feet NAVD88.

Lake Toni

Lake Toni is approximately 17 acres in surface area and is located in Pasco County. This contributing lake receives inflow from Lakes Jo Ann, Catfish, and Myrtle. Outflow is to the west, under a dirt road by three 48” RCP’s at elevation 63.61, 63.14, and 63.16 feet NAVD88; through a swampy area; and through two 4 foot by 7 foot concrete box culverts under Highway 54. The controlling elevation (culvert invert) is

63.45 feet NAVD88. The average water level for the period of record (February 1988 to December 2005) was 64.96 feet NAVD88, with a range of 61.47 feet NAVD88 to 68.31 feet NAVD88. The average water level is considerably higher than the culvert invert elevation, indicating that the outlet control from this lake is not the culvert under SR 54 but somewhere in the channel downstream (south) of SR 54.

Lake 26

Lake 26 is approximately 12 acres in surface area and is located in Pasco County. This is the last flow-through lake in the Cypress Creek chain north of SR 54. A survey for a 1988 SWFWMD flood study indicated that the controlling elevation for the channel that conveys the flow south of Carson Road is approximately 68.10 feet NAVD88. The outflow crosses SR 54 primarily through a 4' x 14' box culvert with an invert elevation of 64.18 feet NAVD88 (SWFWMD 1988). Several other culverts exist along this highway, the lowest of which is at 64.28 feet NAVD88. The average water level for the period of record (February 1988 to March 1996) was 66.26 feet NAVD88, with a range of 63.10 feet NAVD88 to 69.06 feet NAVD88. The fact that the average water level is considerably higher than the culvert invert elevation indicates the outlet control from this lake is not the culvert under SR 54 but some other location between Lake 26 and Bird Lake, south of SR 54.

Lake Floyd

Lake Floyd is 53 acres in surface area and is located in Pasco County. This contributing lake receives inflow only from its watershed and discharges to Bird Lake. The size of the culvert was not determined, but the controlling elevation is 66.81 feet NAVD88. The average water level for the period of record (December 1986 to December 2005) was 66.18 feet NAVD88 with a range of 63.24 feet NAVD88 to 68.12 feet NAVD88.

Bird Lake

Bird Lake is approximately 150 acres in surface area and is located in Pasco County just north of County Line Road. The lake receives inflow from Lakes 26 and Toni through their outlets under SR 54, and from Lake Floyd. This lake discharges through an outlet channel south to Lake Kell. The channel has been excavated through the swampy area south of Bird Lake. Where the outflow crosses County Line road, the channel invert elevation is 63.15 feet NAVD88. Average water level for the period of record (February 1978 to December 2005) was 64.74 feet NAVD88, with a range of 61.63 feet NAVD88 to 67.58 feet NAVD88. The fact that the average water level is considerably higher than the culvert invert elevations indicates the outlet control from this lake is not the culvert under County Line Road, but at some other location between Bird Lake and Lake Kell.

Hog Island Lake

Hog Island Lake is 47 acres in surface area and is located in Hillsborough County. This lake actually is not part of the Cypress Creek Lake chain, since under normal conditions it neither receives flow from nor discharges to the group. Inflow is from its watershed and from Cool Kell Lake just to the south. Outflow is north to Pasco County then east toward Cypress Creek through a series of swampy areas. The average water level for the period of record (October 1986 to December 2005) is 63.13 feet NAVD88, with a range of 59.63 feet NAVD88 to 66.86 feet NAVD88. During periods of very high water, some water may flow from the chain into Hog Island Lake. The lake elevation is lower than those of the flow-through lakes both upstream (Bird Lake) and downstream (Lake Kell) of this lake, further indicating that it is not part of the chain. The Hog Island Lake area was studied in detail in the Stormwater Management Report for Hog Island Lake, URS Corporation, May 2000.

Lake Kell

Lake Kell is 31 acres in surface area and is located in Hillsborough County just south of County Line Road. Inflow is from Bird Lake in Pasco County through swampy areas both north and south of County Line Road. Outflow from this lake is over a SWFWMD weir, through a small lake (Lake Nell), and through Swamp Lake to Keene Lake. This weir has two concrete bays (openings) for stop logs. The weir invert is 64.45 feet NAVD88 according to the Hillsborough County 2010 Survey. The controlling elevation with no stop logs is assumed to be 64.45 feet NAVD88. The average water level for the period of record (May 1981 to April 2006) was 64.35 feet NAVD88, with a range of 61.12 feet NAVD88 to 66.31 feet NAVD88. This indicates that the lake regularly discharges over the structure probably not more than 1 foot above the outlet elevation because of continual flow over the structure. Occasional periods of water level below the outlet elevation bring the average down below the outlet elevation.

Commston Lake

Commston Lake is 15 acres in surface area and is a contributing lake. Inflow is from only its watershed, and outflow is to Keene Lake by way of a wetland area south of Swamp Lake. The culvert at the outfall of the lake is 45 inches in diameter and has a controlling (invert) elevation of 58.86 feet NAVD88, based on the field investigation and aerial photographs. The average water level for the period of record (September 1989 to June 1996) is 59.41 feet NAVD88, with a range of 56.87 feet NAVD88 to 62.52 feet NAVD88.

Swamp Lake

Swamp Lake is identified on the USGS topographic map as a small body of water located inside a large wetland area between Lakes Kell and Keene. For the purposes of this study, Swamp Lake will refer to the entire wetland area (210 acres), which is a flow-through portion of the chain. No data is collected for this lake by SWFWMD or other agencies. No water level information or outlet controlling elevations are available. Inflow is from Lake Kell and Commston Lake. Outflow is to Keene Lake and also to Sherry Brook.

Hillsborough County 2010 Survey indicates that water in Swamp Lake must rise to approximately 60.5 feet NAVD88 before it flows south to Keene Lake through a channel. The outfall to Sherry Brook is a 38 inch by 60 inch ERCP under a dirt road with an invert elevation of 59.57 feet NAVD88.

Keene Lake

Keene Lake has an area of 31 acres and is a flow-through lake. Inflows are from the Swamp Lake area and Commston Lake. Outflow from Keene Lake is controlled by two weir structures at different locations. One structure discharges to Hanna Lake (Keene Structure, 2), and the other discharges to Lake Stemper (Keene Structure 1). The outfall to Lake Stemper flows through a small pond south of Sunset Lane. The outflow from this pond into Lake Stemper is controlled by Keene Structure 3.

All of these structures have stop logs to allow some control of the outfall elevation. At the time of the Hillsborough County 2010 survey, stop logs were not installed in the weirs. The controlling elevations were determined to be 60.54 feet NAVD88 (Structure 1), 60.77 feet NAVD88 (Structure 2), and 59.96 feet NAVD88 (Structure 3). Structure 2 is higher than the others are, so outflow will flow first towards Lake Stemper; if levels rise higher than 60.77 feet NAVD88, then water also would flow to Hanna Lake. Since Structure 1 is higher than Structure 3, continued flow over Structure 1 would fill the small pond and discharge onward to Lake Stemper. The elevations of the weirs could be altered by adding the stop logs, possibly changing the primary flow to Hanna Lake instead of Lake Stemper.

Hanna Lake

Hanna Lake is approximately 30 acres in surface area. This lake is considered a diversion of water from the chain since it competes with Lake Stemper for outflow from Keene Lake. Outflow from Keene Structure 2 is the only significant inflow to Hanna Lake other than watershed runoff. Outflow from Hanna Lake is via an 11-foot-wide weir. During the Hillsborough County 2010 Survey, no logs were in place and the controlling elevation was surveyed to be 59.4 feet NAVD88. The average water level for the period of record (June 1982 to June 2010) was 58.43 feet NAVD88, with a range of 54.3 feet NAVD88 to 63.7 feet NAVD88.

The outflow from this lake is the source of an intermittent stream that discharges to Cypress Creek. A ditch or canal was dug between Lakes Hanna and Stemper prior to the 1938 aerial photography. Water appears to be in this ditch in the 1938 aerials, but more the Hillsborough County 2010 survey of this channel indicates that water levels have to rise to at least approximately 58.9 feet NAVD88 for water to flow from one lake to the other.

Lake Stemper

Lake Stemper is approximately 126 acres in area and represents the last lake in the Cypress Creek chain. Inflow is from Keene Lake through Structures 1 and 3. Outflow, which is controlled by an 11-foot weir, discharges to the remainder of Thirteen-Mile Run, which flows generally south-southeast to Cypress Creek. At the time of the Hillsborough County 2010 Survey, no logs were in place at the weir, and the controlling elevation was surveyed to be 59.44 feet NAVD88.

The period-of-record (1968 to August 2010) average water level is 58.0 feet NAVD88, with a range of 52.1 feet NAVD88 to 62.90 feet NAVD88. The period-of-record hydrograph indicates that water frequently has been high enough to discharge over the weir, but four extended periods of low water levels have occurred, one from 1970 to 1977,1989 to September 1995, 1999- to 2003, and 2007 to mid-2009. The levels during these periods were low enough that virtually no flow would have occurred over the structure.

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CHAPTER 4

HYDROLOGIC/HYDRAULIC MODEL METHODOLOGY

4.1 INTRODUCTION

This chapter details assumptions and methodologies used to develop the hydrologic and hydraulic models of the Cypress Creek Watershed. For the purpose of this study, Parsons utilized the Hillsborough County version of the EPA SWMM (v.4.31) model (HCSWMM). The County has developed this program as a standard for all stormwater management planning within Hillsborough County as it provides a direct interface between a hydrologic package based on the SCS Curve Number method and the EPA SWMM EXTRAN Block. This was preferred over other SWMM model packages as it utilizes the SCS Curve Number method which is recommended for Hillsborough County stormwater system analyses, per the County's Stormwater Management Technical Manual (SMTM). The hydrologic model output is delivered to EXTRAN, which is the hydraulic model. EXTRAN provides dynamic flood routing of flow through channels, lakes, and control structures such as bridges, culverts, storm sewers, weirs, pumps, and orifices. EXTRAN accounts for conservation of mass, energy, and momentum in its hydraulic algorithms, thereby representing looping, splits, flow reversals, etc. in the hydraulic system network should they occur.

4.2 HYDROLOGIC MODEL TYPE

Hydrologic modeling is an attempt to represent the hydrologic cycle to predict the reaction of a prototype watershed's response to a dynamic set of meteorological conditions. There are two general types of hydrologic models that are in use for this purpose: event models and continuous simulation models. Event models describe the wet portion of the hydrologic cycle: precipitation, runoff, surface-water transport, and storage. They are used extensively and are considered to accurately describe the hydrologic cycle during extreme conditions. However, event models provide no means by which to numerically model the recovery of surface storage during the dry portion of the hydrologic cycle. Continuous simulation models describe both the wet and dry portions of the hydrologic cycle, whereas event models describe a smaller portion of the hydrologic cycle than continuous simulation models.

HYDROLOGIC CYCLE

Water cycles within our environment. Rainwater might soak into the ground or run off across the ground surface. Rainwater that runs off across the ground surface may flow into a ditch, then into a creek, a river, and eventually the ocean. Runoff may also be collected in impoundments such as ponds, lakes, wetlands, or depressional areas. Water in an impoundment or river may evaporate or seep into the ground.

This example describes some of the ways that water cycles through our environment. This example is by no means a complete description. We collectively refer to all the possible ways that water moves through our environment as the hydrologic cycle.

The Hillsborough County Stormwater Management Section modified Version 4.31 of EPA SWMM to allow hydrographs to be generated by the Soil Conservation Service Method, which differs significantly from the EPA SWMM RUNOFF Block method. The County also made minor modifications-of-convenience to the EXTRAN Block. These modifications increase the utility of the EXTRAN block. This model, referred to as HCSWMM, is a one-dimensional, junction-conduit, hydrodynamic event model.

HCSWMM was utilized, as required by contract with Hillsborough County, to model the hydrologic response to extreme storm events within the Cypress Creek Watershed. This model describes flood hazards within the watershed. These data were generated using highly variable factors determined by a study of the watershed, as it existed in 2007. Many judgements and assumptions are required to establish these factors. The resultant data are sensitive to changes, particularly of antecedent conditions, urbanization, channelization, and land use. Users of these data are cautioned against assumptions of precision that cannot be attained; and that flood hazards within the watershed will change with anthropogenic and natural influences on the watershed.

4.3 DATA SOURCES

Data from numerous sources are incorporated into this model. Specific citations are made throughout this report. In general, the following data were utilized in the development of the original 2002 WMP study model or the 2007 WMP study update:

- Lake Atlas Database at the University of South Florida's Center for Community Design and Research
- Geographic Information System Database at the Southwest Florida Water Management District
- Hillsborough County Soil Survey by the U.S. Department of Agriculture, Natural Resources Conservation Service
- Streamflow and lake gaging station records from the U.S. Geological Survey
- Rainfall records by the National Oceanic and Atmospheric Administration and Southwest Florida Water Management District
- Aerial photography at 1"=200' scale by Hillsborough County
- Aerial photography at 1"=200' scale with 1-foot and 2-foot topographic contours, respectively, by the Southwest Florida Water Management District
- Quadrangle maps at 1"=2000' scale with 5-foot topographic contours by the U.S. Geological Survey
- Digital Ortho Quarter Quadrangles by the U.S. Department of the Interior, Geological Survey
- Environmental Resource Permits at the Southwest Florida Water Management District

- Stormwater management master plans, comprehensive plans, and Development of Regional Impact plans at Hillsborough County
- Cross section geometry and flood hazard risk assessment maps from the Federal Emergency Management Agency
- Drainage plans at the Florida Department of Transportation
- Input from County residents
- Interviews with Hillsborough County personnel
- Future land use data from the Hillsborough County Planning Commission
- Conventional field survey by the County
- Hydrologic and hydraulic reconnaissance survey by Parsons
- Hillsborough County digital elevation model (DEM) data
- Hillsborough County Capital Improvement Projects (CIP) data
- Hillsborough County 2010 Survey
- City of Tampa Stormwater Inventory
- SWFWMD NexRad rainfall data

4.4 MODEL RESOLUTION

Hydrologic and hydraulic model development requires the abstraction or generalization of an infinitely complex natural system into a finite network. One-dimensional hydrodynamic models are built on a network of conduits and junctions. Clearly, a challenge of resolution exists. A balance must be struck between a prohibitively expensive high resolution, and a non-descriptive low resolution. It is model use that dictates resolution. The Cypress Creek Watershed covers portions of Hillsborough and Pasco Counties, but this is a planning model intended for use in Hillsborough County. Model resolution was strictly defined for the model update. This project is co-funded by the SWFWMD and as such, the District now requires model network and subbasin resolution to meet or exceed the SWFWMD's Guidelines and Specifications (G&S) (August 2002) for the watershed model resolution.

Even with the detailed model resolution mandated by the G&S, this model may not, in some cases, be sufficiently detailed to study complex, localized hydraulic phenomena nor design hydrologic or hydraulic structures at any given location within the watershed. Future design users of these data are cautioned to carefully examine the level of resolution within the area-of-concern, and independently ascertain the sufficiency of these data for design purposes. Future design users of these data are also cautioned to determine the effect that anthropogenic and natural change in the watershed since late 2007 may have on model assumptions.

4.5 HYDROLOGIC MODEL

The hydrologic modeling of the Cypress Creek Watershed was conducted using Hillsborough County's modified version of the EPA SWMM hydrologic model. This model uses the U.S. Soil Conservation Service (SCS) Runoff Curve Number (CN) method to estimate runoff volume as the result of rainfall. The SCS Method conceptually separates rainfall into three components: runoff, an initial abstraction, which represents rainfall lost at the beginning of a storm, and losses. The computation of runoff depth within any given time step is based on an accounting of precipitation components, and two empirical relationships.

> ***WHAT IS A WATERSHED?***
>
> A watershed is an area of land, which contributes runoff to a point on the surface of the earth. The point can be somewhat arbitrary, such as a location in a river; or specific, such as a lake, the confluence of two rivers, or the outfall of a river into a bay or the ocean.
>
> Watersheds are separated from other watersheds by ridges of land, or by elevated barriers such as roads or fill associated with development. The area that contributes runoff to the point is said to be a watershed to the point.
>
> Hydrologically, the terms watershed, subwatershed, and subbasin all share the same definition, with one important difference: scale. It is the convention of this report that watersheds are divided into subwatersheds, and subwatersheds are further broken down into subbasins.

The following hydrologic variables are required by the HCSWMM model: rainfall data, rainfall distribution, subbasin number, junction number, time of concentration, curve number, subbasin area, initial abstraction, and shape factor. The SCS Hydrograph Method generates subbasin runoff hydrographs with these variables using the Dimensionless Unit Hydrograph Method. These runoff hydrographs are assigned to the hydraulic routing model at specified junction locations in the hydraulic model network.

4.5.1 Watershed-Subwatershed-Subbasin Definition

Hydrologists sometimes use the terms watershed, basin, catchment, subwatershed, subbasin, and subcatchment interchangeably. By convention, within this document and the accompanying model, the term watershed describes the area that drains to the outfall of the Cypress Creek. The term subwatershed describes the areas that drain to the major tributaries of the Cypress Creek, at the confluence of the major tributaries and the Cypress Creek. The term subbasin describes further aerial subdivision within the subwatersheds.

The Cypress Creek Watershed is divided into the following eleven subwatersheds: Cypress Creek Main Channel, County Line Drainage System, County Oaks System, Ridge Lake System, Sherry Brook System, Hanna Lake System, Blind Pond Avenue System, Thirteen Mile Run System, Flynn Lake Outfall System, 149th Avenue Outfall System, and Developed Area Under City of Tampa Boundary.

Each subwatershed is divided into a number of subbasins (i.e. a basin consists of a set of subbasins). Each subbasin is numbered with the junction number to which the subbasin drains. A subbasin is not always delineated for every junction.

4.5.2 Subbasin Delineation

In large, the SWFWMD G&S dictates the level of detail that was deemed necessary to accurately define and properly analyze the primary drainage facilities within the Cypress Creek Watershed. The delineation of individual subbasins was also dictated to a large extent by the primary drainage network itself and the need to properly define the contributing drainage area to individual elements of the conveyance system and storage facilities. Subbasin designations could also be selected to segregate drainage areas of homogeneous land use and/or define the complete contributing drainage area of a secondary drainage system at its outfall to the modeled primary network.

The means of defining subbasin boundaries employed a number of sources of information and methods. The principle source was the County-supplied DEM dataset. This mapping shows overland topography, thus indicating direction of overland flow. In addition, various reports describing hydrologic studies conducted in the basin were reviewed and the information was incorporated into this study. However, much of the watershed drainage patterns have been modified due to development with a variety of residential, commercial, industrial, and institutional developments. As a result of these activities, man-made drainage systems comprised of swales, gutters, storm sewer systems, ditches, and detention ponds have interrupted the natural overland flow patterns within the watershed and, in many cases, diverted storm runoff in directions that are not readily apparent from inspection of the topographic mapping. Such activities have resulted in the alteration of the original drainage patterns, including the complete severance of drainage through creation of closed impoundments, or through integration of previously existing closed basins to the creek system.

To assist in the delineation of subbasin boundaries, available record drawings of county roads within the basin were also used to define the drainage facilities and contributing drainage areas that are served by these systems. Parsons also conducted a thorough review of record drawings of permitted stormwater management facilities within the basin on file with SWFWMD as a means of defining the drainage systems and contributing drainage areas for new development that did not show up on any of the other information sources. Additionally, development plans and Capital Improvement Project plans were used to define subbasin boundaries. The final check of subbasin delineations was field reconnaissance of the watershed to; (1) confirm the initial boundaries and to inspect the drainage facilities and conditions in the basin firsthand, (2) investigate areas where there was no information available from the previously listed sources, and (3) resolve discrepancies where there were conflicts between different sources of information regarding drainage facilities.

4.5.3 Time of Concentration

A necessary input parameter for the unit hydrograph method that is used by the County's version of the SWMM model is the subbasin time of concentration. The time of concentration (Tc) represents the amount of time it takes for a particle of water to travel from the hydraulically most distant point in the drainage basin to its outlet. As more thoroughly documented in detail in previous discussion, the County has adopted a standard method for Tc calculation that is documented in its Stormwater Management Technical Manual (SMTM). In this method, the Tc is computed by summing all the travel times for consecutive flow components of the subbasin conveyance system. The SMTM provides methods for computing flow times for overland flow (sheetflow), shallow concentrated flow, and open channel flow as a function of slope and the type of flow path.

As detailed in the SMTM, the overland flow component was calculated based on the kinematic wave solution applied to overland flow. The following formula was applied:

$$t_1 = 0.093 \frac{L^{0.6} N^{0.6}}{I^{0.4} S^{0.3}}$$

Where:
t_1 = Travel time (min)
L = Length of overland flow (feet)
N = Manning's roughness coefficient for overland flow
S= Average overland flow Slope (feet/feet)
I = Rainfall intensity (inches/hour)

For the Cypress Creek Watershed, the subbasin length of overland flow and slope data were obtained from the topographic maps. Surface roughness, represented by the Manning's coefficient (n), was determined using literature values expressed as a function of land cover. A maximum overland flow length of 300 feet was used for computations, although it should be noted that the latest version of the TR-55 has a maximum overland flow length of 100 feet. The type of land cover for the subbasin overland flow path was identified from aerial mapping. The shallow concentrated and channel flow components of the time of concentration were calculated based on length and velocity. Again, the method outlined in the SMTM for shallow concentrated flow was used to calculate this component. The entire method of Tc calculation was automated within a spreadsheet designed for this purpose. It should be noted that, in many cases, the studies and design plans for the residential and commercial developments, along with the road improvement projects, included time of concentration calculations. Where such information was available, these data were used in lieu of any new calculations and referenced within the time of concentration spreadsheet. Also, a minimum subbasin Tc of 10 minutes was assumed for the purpose of this study. It should be noted that the HCSWMM minimum time of concentration is 7 minutes.

4.5.4 Runoff Curve Number

Hydrologic modeling with the Hillsborough County version of the SWMM model was performed using the U.S. Soil Conservation Service (SCS) Runoff Curve Number Method to compute a runoff volume from rainfall. This method uses a family of curves to relate direct runoff depth to rainfall depth. Numbers between 0 and 100, which are referred to as curve numbers (CN), describe the family of curves. Recall that the SCS Method conceptually separates rainfall into three components: runoff, initial abstraction, and losses. The CN is a lumped representation of the initial abstraction and loss components and is an index that represents the combined hydrologic effect of hydrologic soil group, cover type, land use, hydrologic condition, and antecedent soil moisture condition. Curve numbers were determined over the course of this study for each subbasin by an area-weighted averaging procedure that assigned a universal CN value to each combination of land use category and hydrologic soil group classification, and then calculated the subbasin average based on the relative percentages of each combination within it. The universal CN values were selected based on values provided by Hillsborough County (antecedent moisture condition (AMC) II) and is shown in Table 4.5-1.

4.5.5 Existing Land Use Conditions

Derivation of subbasin runoff curve numbers is dependent on the type of land use conditions within the subbasin. Existing land use conditions in the Cypress Creek Watershed were defined by use of digital coverages obtained from the Southwest Florida Water Management District (SWFWMD) Geographic Information System (GIS) database. The 2005 GIS dataset is based on the Florida Land Use and Cover Classification System (FLUCCS).

A great deal of effort was exerted as a part of this study to verify and update the original SWFWMD land use database to reflect a consistent and up-to-date set of hydrologically valid land use coverages. It was deemed necessary by visual examination of aerial mapping to reclassify some of the residential areas to a different density to maintain a consistency throughout the basin and watershed. Also, large areas of open, undeveloped land that were observed to be contained within the confines of the commercial, industrial, institutional, and the transportation, communications, and utilities parcels were segregated from these parcels digitally and reclassified as open land. The resultant existing land use GIS database for the Cypress Creek Watershed that was used for model development purposes is contained within the Hillsborough County geodatabase delivered as part of this project. This land use coverage was intersected with the digitized subbasin delineations using GIS overlay techniques to develop an accurate measurement of the distribution of the various land use classifications within each of the defined subbasins in the watershed.

Table 4.5-1

Cypress Creek Watershed Management Plan

Universal SCS Runoff Curve Numbers by FLUCCS for All Subwatersheds

LAND USE CLASSIFICATION	FLUCCS CODES	HYDROLOGIC SOIL GROUP CLASSIFICATION					
		A	B	B/D	C	D	Water
Low Density Residential	1100	50	68	82	79	84	100
Medium Density Residential	1200	57	72	84	81	86	100
High Density Residential	1300	77	85	91	90	92	100
Commercial	1400	89	92	95	94	95	100
Industrial	1500	81	88	92	91	93	100
Transportation, Communications, and Utilities	8100,8200,8300	81	88	92	91	93	100
Institutional	1700	69	81	89	87	90	100
Open Land and Rangeland	1800	49	69	82	79	84	100
	1820	44	65	80	77	82	100
	1900	39	61	77	74	80	100
	2600	30	58	75	71	78	100
	3100	63	71	85	81	89	100
	3200	35	56	74	70	77	100
	7400	77	86	93	91	94	100
Cropland and Pastureland	2100	49	69	82	79	84	100
	2200	44	65	80	77	82	100
Specialty Farms	2400	57	73	84	82	86	100
	2500	59	74	84	82	86	100
Forest	4100	45	66	80	77	83	100
	4110	43	65	79	76	82	100
	4120	43	65	79	76	82	100
	4200,4340,4400	36	60	76	73	79	100
Wetland	6110,6120,6150,6200, 6210,6300,6410,6420, 6430,6440,6530,6600	98	98	98	98	98	98
Water	5100,5200,5300,5400	100	100	100	100	100	100

4.5.6 Hydrologic Soil Type

For discussion of the soils in the Cypress Creek, please refer to section 2.3 of this report.

4.5.7 Initial Abstraction Ratio

The computation of runoff depth in the SCS Hydrograph Method is based on two empirical relationships: one between runoff curve number and losses, and the second between losses and initial abstraction. The initial abstraction ratio drives the second relationship. The HCSWMM model dictates that a standard initial abstraction ratio of 0.2 is to be used throughout the watershed.

4.5.8 Unit Hydrograph Shape Factor

Analyses of large volumes of measured data form the basis of the SCS Hydrograph Method. An observation that three-eighths of the total volume of a hydrograph occurs before the peak and five-eighths after the peak is one generalization born from these analyses. This generalization is largely a function of watershed geography and topology. Where watersheds are steep and mountainous, a larger fraction of the total hydrograph volume occurs before the peak; where watersheds are shallower and flat, a smaller fraction of the total hydrograph volume occurs before the peak.

The SCS recommends use of a hydrograph shape factor of 484 in typical applications. The flatter topographic relief characteristic in watersheds in Florida, result in a smaller hydrograph shape factor. Because of the flat terrain within Hillsborough County, the HEC-1 hydrologic model was modified to use a unit hydrograph shape factor of 256. This was a standard adopted to be consistent with the guidance provided in the Hillsborough County Stormwater Management Technical Manual (SMTM). This standard equates to an assumption that one-fifth of the total subbasin hydrograph volume occurs before the peak, and four-fifths occurs after the peak.

4.6 HYDRAULIC MODEL

The hydraulic model used for this study was a version of the EXTRAN block of the U.S. Environmental Protection Agency Stormwater Management Model, Version 4.31b (SWMM) Extended Transport Block (EXTRAN) that was modified by Hillsborough County for use in its watershed management planning program. This program (HCSWMM) is a hydraulic flow routing model for open channel and/or closed conduit conveyance systems with conduit-junction representation of the drainage system. HCSWMM receives hydrograph input at specific junctions by file transfer from the hydrologic model and performs dynamic routing of stormwater flows through the defined storm drainage system. Simulation output takes the form of water surface elevations and discharges at each junction and conduit within the model network, respectively.

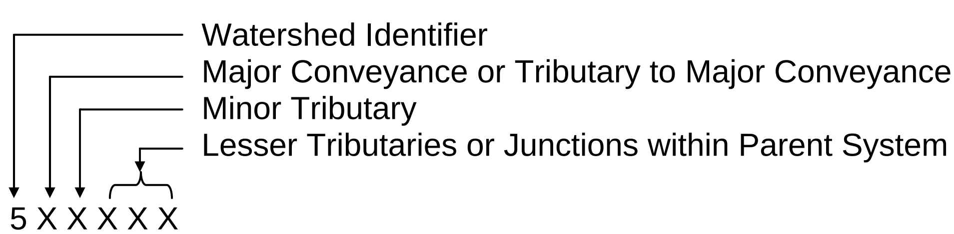
4.6.1 Hydraulic Model Network

The hydraulic model (HCSWMM) of the Cypress Creek Watershed consists of a network of open channel segments, culverts, bridges, storm sewers, weirs, lakes, ponds, and wetlands that comprise the primary drainage system within the watershed. HCSWMM uses a conduit-junction concept to idealize the prototype drainage system. A junction is a discrete location in the drainage system where conservation of mass (continuity) is maintained. Conduits are the connections between junctions and are used to convey water through the system. The entire network of junctions and conduits forms the hydraulic model network and serves as the computational framework for HCSWMM.

The first step in development of a model schematic was to identify the primary drainage system and all drainage facilities within it. This task was accomplished through the research and review of all available sources of information that have been previously described, and through field reconnaissance of the watershed. All such information was compiled and a watershed drainage map developed which depicts the primary drainage system. To achieve the required planning level of resolution, junction locations are established at most primary and some secondary drainage structures, surface water outfall points, storage areas, and other locations with significant hydrologic control. Junction locations are also established at the confluence of most primary and some secondary drainage system conveyances, and at locations of interest with respect to flood level of service analysis. Finally, junctions are established at some locations to ensure numerical stability within the primary drainage system.

Junction and Subbasin Numbering Scheme

Hillsborough County employs a junction-conduit numbering convention: six digits for junctions, seven digits for conduits. All junction numbers must be unique and generally, junction numbers increase from downstream to upstream. It is not required that junction numbers increment by one. More often than not, junction numbers increment by no specific increment or by fives or tens. The following figure illustrates the Hillsborough County numbering convention that was utilized for model development:



By convention, all junctions within the Cypress Creek Watershed begin with the number “5”. The following table defines the major conveyance numbering scheme. These codes represent the first three register locations in the six-digit junction number.

Code	*Conveyance*
500	Cypress Creek Main Channel
505	149th Avenue Outfall System
506	Flynn Lake Outfall System
510	Thirteen Mile Run System
512	Blind Pond Avenue System
520	Hanna Lake System
530	Ridge Lake System
530	Sherry Brook System
531	Country Oaks System
535	County Line Drainage System
513	Developed Area Under City of Tampa Boundary

The task of observing the junction numbering convention within a model that contains over eight hundred junctions is complicated and challenging. The junction numbering convention is an ideal; it is not possible to observe the convention everywhere. Violations of the convention are rare, but manageable. The reader is cautioned to check the conduit connection network and invert elevations to ascertain direction of flow.

To complete the naming conventions, subbasins are also assigned the same 6-character name as the receiving (load) junction for subbasin inflows.

Conduit Numbering Scheme

The root of the seven-digit conduit number is equivalent to the upstream junction number. A single-digit prefix is attached to the root to denote conduit type. The following table presents the Hillsborough County conduit prefix convention:

Prefix	*Conduit Type*
1, 2, 3, 4, or 5	Closed Conduit
6	Overland Flow Weir
7	Roadway Overtop Weir
8, 4 or 5	Sharp-Crested or Broad-Crested Weir
9	Open Channel

The first closed conduit in a pair of parallel closed conduits takes the prefix “1”; the second takes the prefix “2”, etc. In some cases the Hillsborough County numbering convention was violated to account for multiple weir connections and the number of different hydraulic connections to a specific junction.

4.6.2 Drainage Facility Inventory

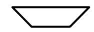
The initial and most important step in the development of the hydraulic model of the Cypress Creek Watershed was the inventory of the drainage structures along the designated primary drainage system. This information provides the foundation for the model representation of the hydraulic system. The drainage facility inventory of the study area was compiled from an array of sources and methods. Hydraulic data for channels, culverts, storm sewers, bridges, and control structures were obtained from previous studies, development plans, roadway plans, field survey, and field identification. Data collected included elevations, lengths, dimensions, construction materials, channel vegetation, structure entrance and exit conditions, and any other pertinent features. This task required a considerable amount of effort, but it was necessary to develop the appropriate level of detail to accurately define the hydrologic and hydraulic conditions of the study area.

As a part of this investigation, Parsons developed a field survey plan to establish the size, location, dimensions and inverts of drainage structures, and to define current stream channel and floodplain cross sections within the Cypress Creek Watershed based on the specific needs of the hydraulic model. The emphasis of this survey was placed on areas within the basin where there were no available sources of as-built record drawings and surveys. Conventional field survey was performed for the original 2002 WMP study and additional locations were surveyed by the County and added to the model for the 2007 model update.

To augment the collection of available information and field survey activities, limited field reconnaissance of the watershed was conducted. This consisted of driving and walking the basin to record drainage patterns, map drainage facilities, measure facility dimensions, inspect the condition of the drainage facilities in the field, assemble a photographic log of drainage facilities, and confirm information collected from the previously discussed sources and/or resolve differences between different sources. In some instances, field measurements were used as model input where there were no other available sources of information for that particular drainage structure, or where surveys and other data sources were incomplete for proper representation in the HCSWMM model.

4.6.3 Closed Conduits

Eight different types of conduits can be modeled in HCSWMM. The following table lists conduit types, the corresponding model code, and a graphical representation of the conduit shape:

Conduit Type	***Model Code (NKLASS)***	***Shape***
Circle	1	
Rectangle	2	
Ellipse	3	
Arch	3	
Baskethandle	5	
Trapezoid	6	
Parabola/power function	7	
Irregular	8	

HCSWMM has internally automated the procedure by which hydraulic head losses are computed for closed conduits. The original EPA EXTRAN version had an input requirement for the friction loss coefficient (Manning's n) that was the sole basis for the calculation of the total head loss in a closed conduit. It was necessary to adjust this coefficient to account for the other minor losses of the conduit such as entrance, exit, and transition losses. In addition, equivalent conduits or pipes were created to ensure model stability and simplify the total number of conduits in the model. Conduits were lengthened, had slope adjusted and/or combined as necessary for model stability and Manning's n roughness coefficients were adjusted to maintain equal flow for an equal head loss. It should be noted that, for this model update, Arch-shaped pipes were entered into the model as model code 3. This was due to the concern that type 4 pipe areas were not correctly calculated by the model (according to model input echo).

The Hillsborough County version of EXTRAN has additional data fields that allow the user to directly include the entrance, exit, and transition loss coefficients, and an elongation factor to lengthen a short conduit segment for model stability. This allows for the internal computation and creation of an equivalent conduit that includes the minor losses, while the roughness coefficient that is input by the user represents just the friction loss component. Standard engineering references were utilized to assign the various entrance, exit, transition and friction loss coefficients based on observations of the site-specific physical conditions of drainage conveyances.

It is necessary within the framework of the EXTRAN model to represent bridge structures as either an open channel or some combination of equivalent closed conduits. In the Cypress Creek Watershed model application, some bridge spans were modeled as their respective surveyed cross-section, with roughness for the piers, unless it was determined that, during expected flooding conditions, the bridge would be in a full flow condition (i.e. water would reach the low chord of the structure, creating a surcharge or pressure flow condition). In such cases, the bridge structures were entered into the model using the guidelines for an equivalent combination of box culverts with different dimensions and/or inverts. The procedure that was followed was to:

- Plot the bridge cross section, including piers and bridge low chord elevations;

- Estimate a parallel set of box culverts which appear to fit the approximate flow area of the bridge opening at respective depths across the cross-section.

4.6.4 Channel Cross-Section and Floodplain Definition

The HCSWMM model data requirements for definition of the open channel reaches of the primary drainage system of the Cypress Creek Watershed included channel cross section information that is of sufficient detail to define not only the shape of the channel within the confines of its banks, but for a sufficient distance outward from the banks into the floodplain. For this Update of the Cypress Creek WMM, channel cross section storage and static (or overbank) storage were distinguished and accounted for separately (this process is described in detail in section 4.6.6). Parsons used what was judged to be the most current, detailed, and representative source of information available for any particular reach of the open channel system. In many cases, channel cross sections were extended by the addition of endpoints that defined the full extent of the natural floodplain.

One of the most overlooked, but extremely important, needs of the HCSWMM model representation of open channel reaches is the selection of an appropriate channel roughness coefficient, or Manning's n value. This value is a measure of the relative degree of hydraulic efficiency (retardance) of a channel and is dependent upon factors such as the extent and type of channel vegetation, channel bottom material, channel irregularity, channel alignment, obstructions, and depth of flow. Selection of an appropriate Manning's n value for a particular channel reach is a highly subjective procedure and requires a certain level of experience. Parsons personnel relied primarily upon published guides and past modeling experience in the selection of channel and floodplain Manning's n values for the EXTRAN model representation of the Cypress Creek Watershed open channel segments. These values were either confirmed or adjusted during the model calibration process. For the most part, the channel roughness coefficients ranged from a low of 0.030 for the "cleanest" channel reaches to 0.100 for the most highly vegetated. The floodplain roughness coefficients generally ranged from 0.080 to 0.160.

4.6.5 Overflow Weirs

The proper definition of overflow weirs in the HCSWMM model representation of the Cypress Creek Watershed was an important element of the hydraulic model development. These flowpaths are necessary to represent pond control structures, pond banks, overtopping of roadways at channel crossings, and overland flow. The data for weir crest elevations and widths for pond control structures were obtained from the structure surveys, construction plans, and/or field measurements conducted by Parsons staff. All pond representations included a top of bank weir that allowed for overtopping during extreme flood events. Roadway overtopping was simulated using broad-crested weirs as the conveyance mechanism. The weir crest elevation was obtained from the structure surveys or as-built construction drawings, if available, or from the SWFWMD topographic mapping.

In certain cases within the basin, overland flow provides a conduit for floodwater that circumvents the normal flowpath or drainage system. Again, broad-crested weirs were used to simulate these drainage paths, with the weir crest elevations and weir lengths obtained from the SWFWMD topographic mapping. The following table summarizes the range of weir coefficients for various weir flow situations as used in the Cypress Creek Watershed model application, and the general prefix required by the Hillsborough County conduit numbering convention. Because of model naming limitations the model prefix numbers could not always be strictly adhered to.

Weir Type	***Coefficient Range***	***Model Prefix***
Overland Flow	1.0	6
Roadway Overtop	2.6 to 2.8	7
Broad-Crested	2.6 to 2.8	8
Sharp-Crested	3.2	8,4,5

4.6.6 Storage Facility Stage-Area Relationships

To properly represent the hydrologic and hydraulic processes of stormwater runoff within a watershed, it is important that all significant storage facilities and their hydraulic functions be defined. This is especially important in the Cypress Creek Watershed, where much of the drainage throughout the basin is controlled by man-made reservoirs, stormwater detention and retention ponds, natural lakes, and wetlands.

The EXTRAN model allows the user to specify a variable stage-area relationship at any model junction (node) that defines the storage properties at that point, be it a pond, lake, wetland, depression, or other such open surface waterbody. The DEM dataset which was supplied by the County and compiled by Parsons was utilized extensively for this purpose. For areas where topographic voids exist, available record drawings and permits were utilized as a means of establishing stage-area relationships of constructed stormwater management facilities. All stage-area relationships were defined to an elevation such that the 100-year peak stages did not exceed the highest stage in the data entry. This avoided extrapolation of the storage curves.

To avoid duplication of storage in the model network it was important to “separate” the channel storage from the overbank or static storage (which is assigned to the node in the stage-area data in the E1, E2 cards). This was accomplished by creating exclusion polygons for the modeled channels. These polygons were created using the extent of the cross section (for the polygon width), the length of the channel (for the polygon length) and the shape/configuration of the channel itself (using the GIS database channel line segment as the channel “centerline”). The resulting polygon areas were excluded from the DEM datasets before stage-area data was extracted from it.

The initial (starting) water surface elevations for these variable storage facilities were established through several methods. For storage facilities where a control structure exists, the starting elevation was assumed to be the crest elevation of the control weir, or the invert elevation of the bleeddown orifice. The exception to this was for dry retention ponds, where the starting elevation was the pond bottom. For natural ponds, lakes and wetlands, the initial elevation was assumed to be the normal high water elevation, as could best be determined from topographic mapping and/or other collected data.

4.6.7 Boundary Conditions

The HCSWMM model requires specification of hydraulic boundary conditions at all outfall points of the model schematic. In the Cypress Creek Watershed application, the primary watershed outlet is located at the downstream end of Cypress Creek where it discharges to Hillsborough River and is represented with a variable time-stage boundary. The primary watershed inlet consists of a variable time-discharge boundary of Cypress Creek as it passes from Pasco County to Hillsborough Count. One (1) constant stage boundary and eleven (11) variable time stage boundaries represent the connectivity of the Hillsborough County Cypress Creek Model domain with the Pasco County Cypress Creek model domain. These boundary conditions were developed using the FEMA-approved, Pasco County Cypress Creek (PCCC) model. The primary watershed outlet is at the Cypress Creek junction with Hillsborough River and is represented with a variable time-stage boundary from the Hillsborough River Model.

Additional boundary connections were specified at locations around the watershed perimeter wherever it was anticipated that flood elevations might reach the point at which the Cypress Creek Watershed might interconnect with an adjacent watershed such as the Curiosity Creek, Duck Pond, and Sweetwater Creek Watersheds. The nature of these possible interconnections was quantified through coordination with the other engineering consultant firms engaged in similar studies of these watersheds for Hillsborough County or the SWFWMD. In some cases adjacent watershed boundary conditions were minor relative to the magnitude of the volume of water during flood events. These connections to adjacent watersheds were usually modeled as weirs and in some cases as conduits. There are two constant stage boundary nodes from the Curiosity Creek Model, five constant stage boundaries with the Duck Pond watershed, three constant stage boundaries with the Sweetwater Creek Watershed, and three additional constant stage boundaries with the Hillsborough River watershed.

4.6.8 Initial Conditions

Initial water surface elevations for the Cypress Creek model were determined using various sources of data. The type of hydraulic element modeled determined the most appropriate data source to be used for the initial stage. The major types are as follows;

ERP Permitted Ponds and Wetlands

- Wet pond – All permitted wet ponds/wetlands were assigned the weir overflow elevation (no orifices were modeled)
- Dry ponds – All permitted dry pond were assigned the pond bottom as the starting elevation

Unpermitted Ponds, Ungaged Lakes, and Wetlands

Natural unpermitted ponds, ungaged lakes and wetlands were either assigned the outfall elevation (i.e. outfall pipe invert) or, if no structural outfall existed, the aerial and DEM data was used to determine the typical "wet season" elevation by aerial interpretation (i.e. wetland tree lines, etc.)

Free Flowing Channel and Culvert Reaches

Approximately 150 cfs was recorded at the Cypress Creek stream flow gage in Pasco County (Worthington Gardens, 02303420) and approximately 200 cfs was recorded at the Cypress Creek stream flow gage in Hillsborough County (Sulphur Springs, 02303800) at the onset of Hurricane Frances in 2004. This event was the basis for calibration for the Cypress Creek model. *Because this event occurred in the heart of the Florida "wet" season, it was determined by Parsons that this flow was a reasonable representation of typical average "wet" season baseflow conditions and used it as such for design storm event model runs.* This was accomplished by distributing baseflow (constant inflows) in model junctions at flowing reaches throughout the watershed totaling ~150 cfs at the Cypress Creek gage in Hillsborough County and applying a time-discharge boundary node at the Pasco-Hillsborough Boundary. After the baseflow was assigned to the nodes the model was run for several thousand hours to attain a flowing equilibrium. The resulting stages were assigned to the nodes as starting elevations for all existing conditions and proposed conditions design storm events in the CCEU.hot file.

Gaged Lakes

There are 17 gaged lakes for which viable gage data was available (mostly monthly data). Careful evaluation of these data was used to assign reasonable starting elevations which would simulate typical "wet" season elevations in these lakes. Additionally, factors such as control outfall elevations of the lakes were taken into account.

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CHAPTER 5

HYDROLOGIC/HYDRAULIC MODEL CALIBRATION AND VERIFICATION

This chapter contains the data, calibration and verification procedure used for the Cypress Creek existing conditions model. The goal of the calibration effort is to develop a hydraulic model that reflects observed conditions in the watershed which can be used to predict hydrologic and hydraulic response of the system for future flood and design storm events, and could be used to evaluate alternative projects in the watershed.

The calibration process includes simulating a measured event by adjusting the hydraulic input parameters within accepted literature values and then comparing computed water surface elevations and flows to the measured values. The model is considered well-calibrated when the results of stage, flow, timing and volume are in reasonable agreement with the recorded data at the established gauge stations. The model is then adjusted with specific parameters and verified with another storm event's data.

5.1 BOUNDARY CONDITIONS

The HCSWMM model requires specification of hydraulic boundary conditions at all outfall points of the model schematic. In the Cypress Creek Watershed application, the primary watershed outlet is located southeast of Bruce B. Downs Blvd. and north of Fowler Ave. at the confluence of Cypress Creek and the Hillsborough River. There is one (1) tailwater boundary condition node representing the water elevation in the Hillsborough River. This was specified using variable time-stage data. The variable time-stage data, representing the stage in the Hillsborough River, was obtained from the Frances calibration simulation from the latest version of the Hillsborough River model which was finished, in draft form, in September of 2010 by PBS&J.

For the March 11-12, 2010 verification event, no existing model data was available. The tailwater boundary condition for this model simulation was developed from existing gage data. Hourly gage data was obtained from the SWFWMD SCADA site for the streamflow gage at Fowler Ave. (located approximately 14,300 feet downstream of the Cypress Creek/Hillsborough River confluence) and the gage on the downstream side of the S-155 gate structure (located approximately 11,400 feet upstream of the confluence). A linear interpolation between the stages at the two gages on an hourly basis was used to derive the resulting time-stage tailwater boundary condition for this model simulation.

Approximately two-thirds of the entire Cypress Creek watershed lies within Pasco County. Since a FEMA-approved model exists for the Pasco County portion of the watershed, it was considered prudent to use the Pasco County Cypress Creek

(PCCC) model to establish Frances boundary inflows for the Cypress Creek main channel at County Line Rd. Only the PCCC model hydraulics were used to establish inflows for the Cypress Creek main channel from Pasco County. Recorded historical hourly flow data from USGS gage 02303480 was input into the Pasco County model at the model node that coincides with the gage location. The model was then run for 384 hours to establish a flow time series at County Line Rd. (further downstream) to be input as boundary inflow for the Hillsborough County HCSWMM model. For the March 11-12, 2010 verification event, the same methodology was utilized to derive the boundary inflow data at County Line Rd.

A complete description of all boundary conditions specified within the Cypress Creek model structure is discussed in detail in Section 4.6.7.

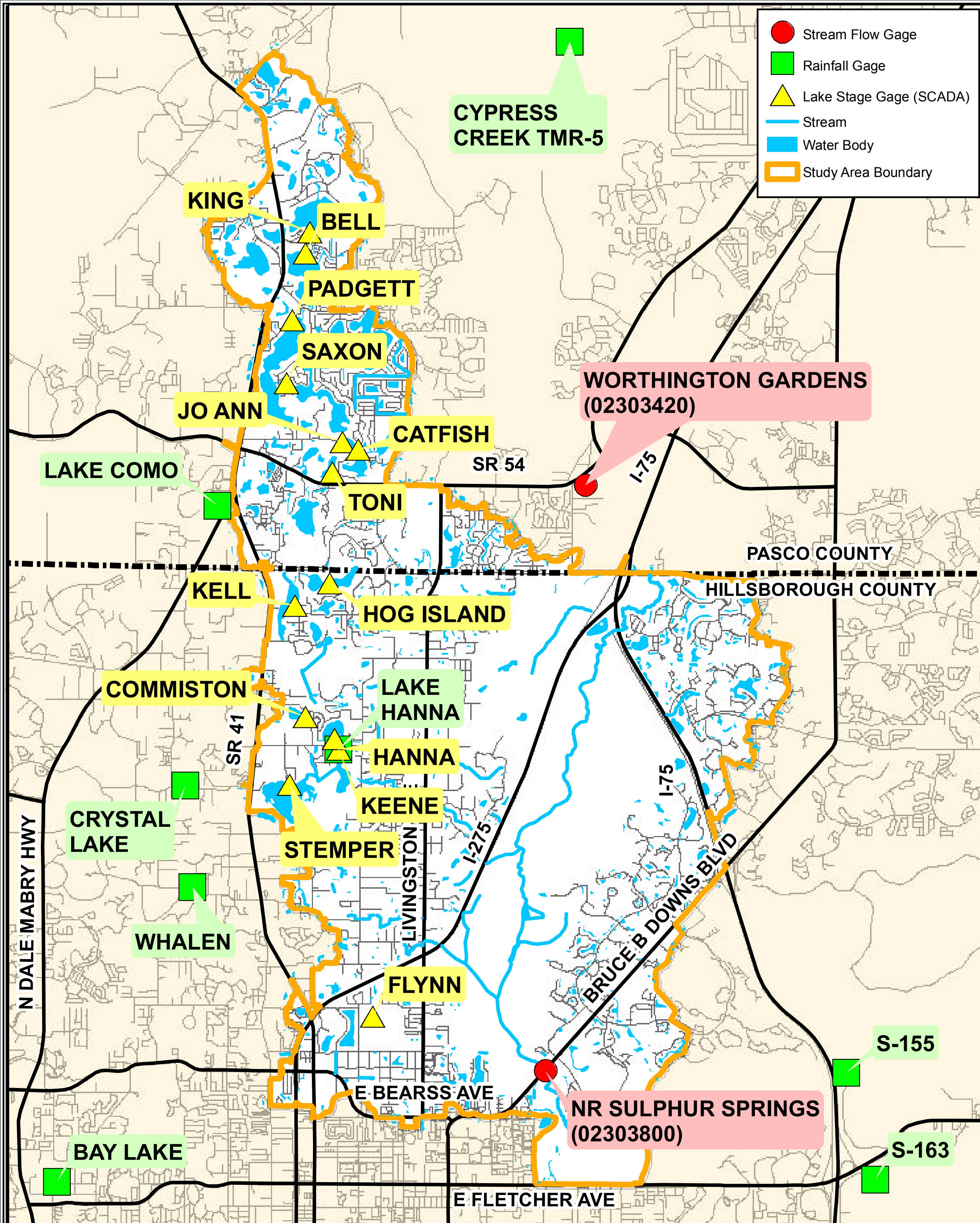
5.2 AVAILABLE STREAMFLOW, LAKE LEVEL AND RAINFALL GAGING STATION RECORDS

Within the Hillsborough County portion of the Cypress Creek Watershed, historical streamflow and precipitation data are available for the purpose of model calibration and model verification. Parsons obtained hourly streamflow and stage data from the U.S. Geological Survey streamflow gaging station for Cypress Creek near Sulphur Springs, FL (USGS 02303800) located on the downstream side of S.R. 581 (Bruce B. Downs Blvd.). For informational purposes, the historical peak data for this gage location is provided below.

USGS Gage Historical Data

Gage	Period of Record	Peak Flow (cfs)	Peak Stage (ft NAVD88)	Date of Peak
02303800	1956 - Current	2060	33.30	Aug 1, 1960

In addition to the streamflow gage calibration point, several lakes within the watershed have historical data available for calibration/verification of the model. Hourly lake stage data was obtained for four (4) lakes within the Hillsborough County portion of the model: Lake Kell, Lake Stemper, Lake Hanna and Lake Keene. This data was obtained from the SWFWMD website's SCADA real-time data records. Figure 5.2-1 shows the locations of the streamflow gaging station, lake water surface gages as well as the rainfall gage stations considered within the vicinity of the Cypress Creek Watershed. Monthly lake level readings were also available for many of the lakes within the Pasco County portion of the watershed. These were also considered in the calibration/verification process. These data were used, as appropriate, to analyze the stage in these lakes compared to the simulated lake stages at the same time within the model run. Additionally, high watermark data from the SWFWMD's database was obtained and used to verify the model. The results of the calibration/verification are discussed in section 5.4.



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Tampa, FL 33634

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	Jul 08, 2011	Yoav Rappaport

Date of Photography:

Figure 5.2-1

Gage Location Map

Cypress Creek Watershed

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5.3 CALIBRATION AND VERIFICATION STORM EVENTS

Calibration of the Cypress Creek Watershed was performed using NEXRAD rainfall and streamflow gaging station data for the September 4-8, 2004 (Hurricane Frances) historical storm event. This was the basis for adjusting the initial model input data, including the hydraulic input parameters. The verification of the model was conducted using the March 11-12, 2010 historical storm event.

The Cypress Creek Watershed is calibrated to the September 4-8, 2004 Hurricane Frances event, at the USGS streamflow gaging station discussed in section 5.2. Stage and flow data were available for this calibration period. Rainfall data for the calibration were established using NEXRAD Doppler data obtained from the SWFWMD. NEXRAD rainfall data, for this time period, compared well to the available rainfall gage data. A total of 46 2-kilometer NEXRAD rainfall grids were needed to cover the extent of the watershed. After review of the rainfall depths and distributions for the various rainfall grid data, it was determined that, it would be prudent to "lump" some of the grids together rather than creating 46 separate rainfall "JR" cards in the HCSWMM .WPX file. This was done by averaging rainfall totals into the following groupings;

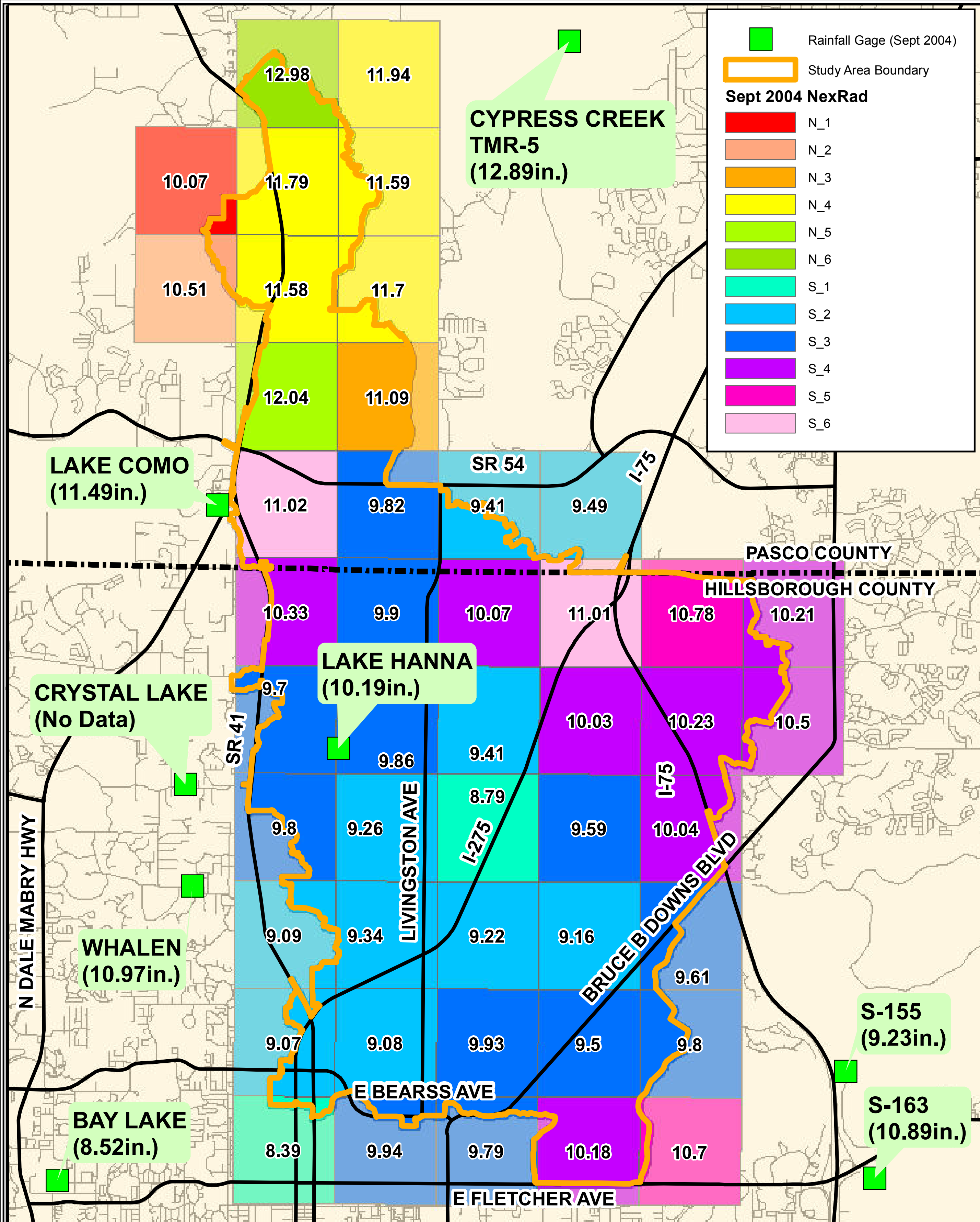
- Group N-1 - 10.07 in.
- Group N-2 - 10.51 in.
- Group N-3 – 11.09 in.
- Group N-4 – 11.66 in.
- Group N-5 – 12.04 in.
- Group N-6 – 12.98 in.
- Group S-1 – 8.79 in.
- Group S-2 – 9.23 in.
- Group S-3 – 9.78 in.
- Group S-4 – 10.15 in.
- Group S-5 – 10.78 in.
- Group S-6 – 11.02 in.

The appropriate representative distribution was given to each of the rainfall groupings. Figure 5.3-1 presents the rainfall data and groupings for the Frances calibration event.

Verification of the model was performed using the March 11-12, 2010 rainfall event. Stage and flow data were also readily available for this verification period. NEXRAD rainfall data was available for this period to perform this verification. Rainfall totals were used from the following groupings:

- Group 1 - 2.87 in.
- Group 2 - 3.29 in.
- Group 3 - 3.85 in.
- Group 4 - 4.24 in.
- Group 5 - 4.73 in.
- Group 6 - 5.32 in.

Again, an appropriate representative distribution was also given to each of the rainfall depth distributions. Figure 5.3-2 presents the rainfall data and groupings for the verification event.



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Tampa, FL 33634

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0 0.25 0.5 1 Miles

Filename:	Map Date:	Prepared By:
	Jul 08, 2011	Yoav Rappaport

Date of Photography:

Figure 5.3-1

September 2004 Calibration – NEXRAD Rainfall Map

Cypress Creek Watershed

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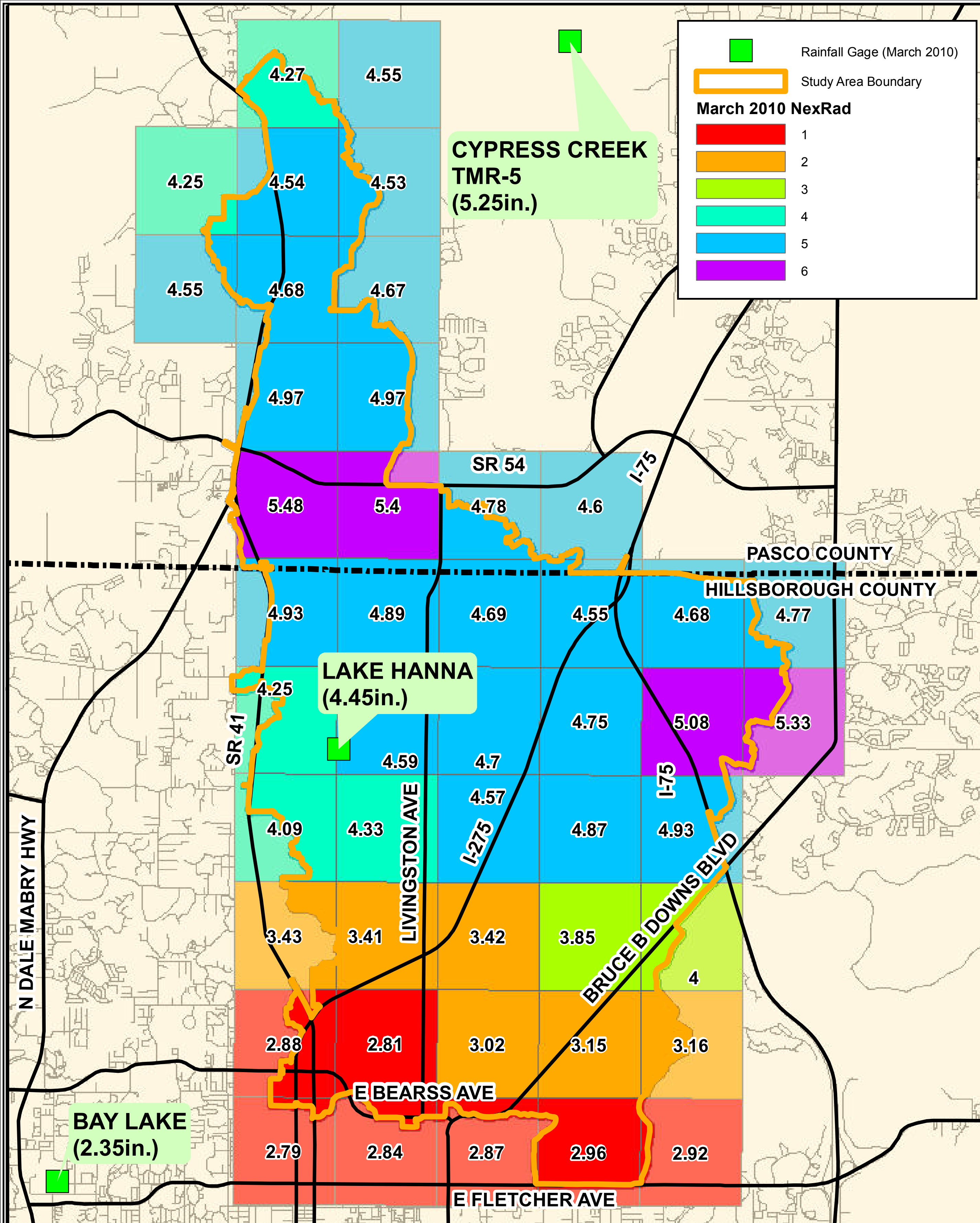

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Tampa, FL 33634

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0 0.25 0.5 1 Miles

Filename:

Map Date: Jul 08, 2011

Prepared By: Yoav Rappaport

Date of Photography:

Figure 5.3-2

March 2010 Verification
Rainfall Distribution Map

Cypress Creek Watershed

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5.4 RESULTS

5.4.1 Calibration Parameters

Most of the SWMM model input data are used simply to describe the geometry and size of the hydrologic and hydraulic units of the study area and are subject to very little interpretation. Calibration parameters are somewhat limited. Those model parameters that **could** be considered to be calibration parameters include:

- Runoff curve number calculation data, i.e. soil groups and/or land use classifications,
- Channel, floodplain, and culvert roughness coefficients (Manning's n) and loss coefficients,
- Times of concentration for individual subbasins

In the SWMM model calibration for the Cypress Creek Watershed, these parameters were initially derived using accepted methods and values from literature research and from past model applications in the region. Their final values were ultimately derived through the model calibration process.

Channel and floodplain roughness coefficients (Manning's n) were the primary calibration parameter and were calibrated by using the rating curve developed by the USGS for its streamflow gaging station as the means of comparison. A rating curve is the relationship between stage (elevation) and discharge at a particular location along the length of a stream channel. The USGS establishes this relationship through a series of flow measurements, determined by measuring velocities across a flow transect, at times of different flow conditions at that same location. Once established, the rating curve is then used to convert stage measurements at the gaging station to streamflow. Therefore, for the SWMM model to accurately reproduce both the historical streamflow and stage hydrographs at the USGS streamflow gaging station, it should also match the rating curves at the station. If a reasonable fit to the rating curve is not attained, there is not a good calibration of both stage and flow at that location.

The method for calibrating to the gaging station rating curve was to adjust the channel and floodplain Manning's n values in the most immediate downstream channel reaches from the gaging station. Since a rating curve is available only at the gaging station, there is insufficient information to calibrate the channel roughness coefficients for the entirety of the Cypress Creek Watershed. What this exercise provided was the basis for the estimation of the channel and floodplain roughness coefficients in the other channel reaches of the basin. References found in engineering literature were also used in this process.

5.4.2 Calibration and Verification Results

Calibration

The Cypress Creek Watershed model was calibrated to the September 4, 2004 through September 8, 2004 Hurricane Frances storm event. The calibration was performed by examining data at each gage discussed in 5.2. Figures 5.4-1 and 5.4-2 show comparisons of the recorded and simulated flows and stages at the USGS 02303800 streamflow gaging station at Cypress Creek (SR 581). For this calibration simulation, it was necessary to initiate flows that matched existing flows at the gage prior to the onset of the storm event, approximately 200 cfs on September 4, 12:00 AM, by creating baseflow using the existing PCCC model initial base conditions. This model was developed by Parsons (for the SWFWMD and Pasco County). The baseflow consisted of approximately 150 cfs of inflow from the Cypress Creek main channel from Pasco County and approximately 50 cfs of inflow from the Thirteen-Mile Run lake chain (which extends up to King Lake in Pasco County). Existing model configuration was allowed to run with no rainfall for a period of 30 days, sufficient to allow for hydraulic flow equilibrium to be attained.

Looking at the stage hydrograph, Figure 5.4-1, the calibration looks relatively good. Looking at the flow hydrograph, some flow discrepancies are more apparent. As can be seen from the calibration graph Figure 5.4-2, a runoff volume surplus exists. Based on recorded data, the flow volume between September 4 and September 20, 2004 was 56,148 ac-ft. Model results, for the same time period, produce 59,483 ac-ft, an excess of 3,335 ac-ft (a 6% surplus) at the SR 581 gage. By looking at the figure, it is apparent that the majority of the volume surplus occurs during the first peak at the gage.

When dissecting the gage hydrograph results, it is obvious that the first portion of the flow volume is produced primarily by the area for this study, and the second (larger) portion primarily from the inflow hydrograph from the Pasco County portion of the Cypress Creek watershed (grey dashed line on the graph). It can be seen that this portion of the calibration matches well, indicating these inflows are an accurate representation of flow volume and timing from the upper portion of the overall watershed. To further analyze the flow contributions to the overall runoff volume, the model was simulated without using the inflows and runoff from the Pasco County model (dashed grey line). These model results were then dissected further by simulating the model with only inflows and runoff from the Cypress Creek Main Channel area and the New Tampa contributing area, east of the main channel (green line on the graph). A flow subtraction on an hourly basis was carried out to determine the remaining flow volume contributed by the rest of the watershed (that portion west of the creek, including the 13-Mile Run Lake chain that extends into Pasco County) (black line on the graph). Figure 5.4-2 also presents the results of these model runs and Figure 5.4-3 is included to illustrate the geographical areas discussed above.

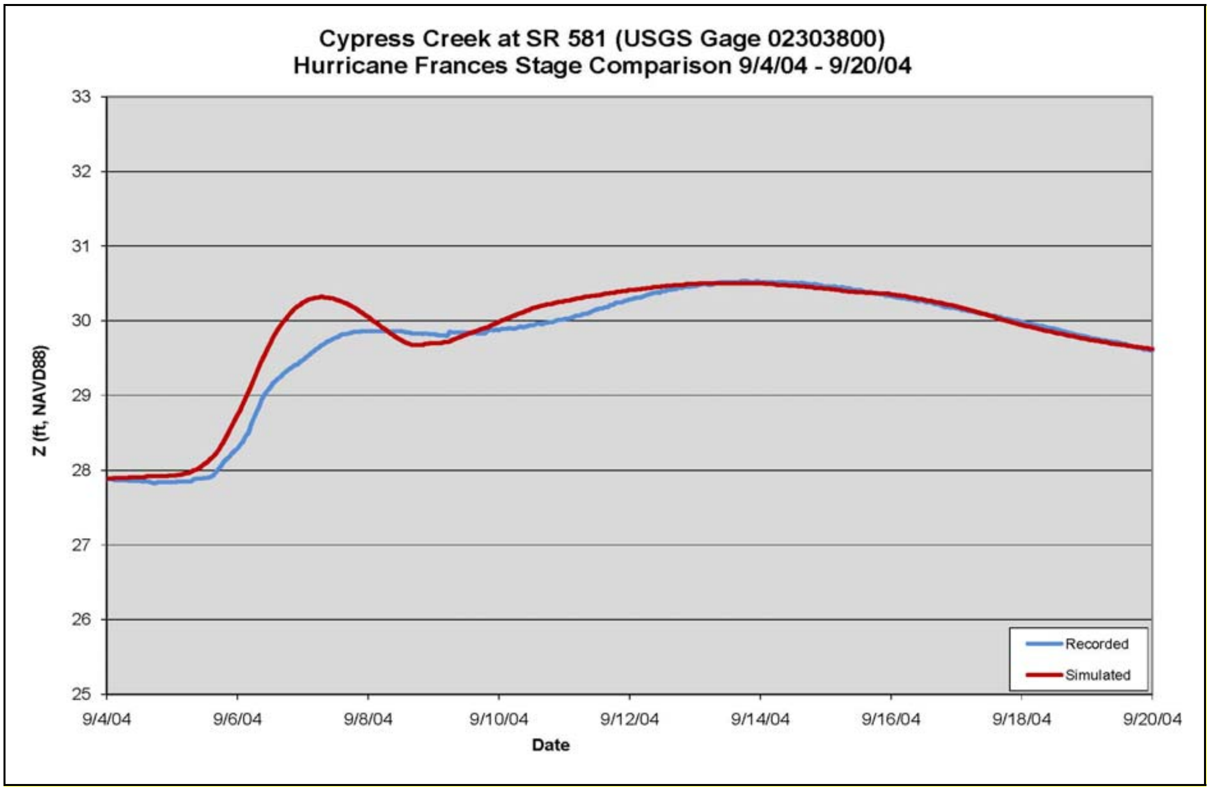


Figure 5.4-1

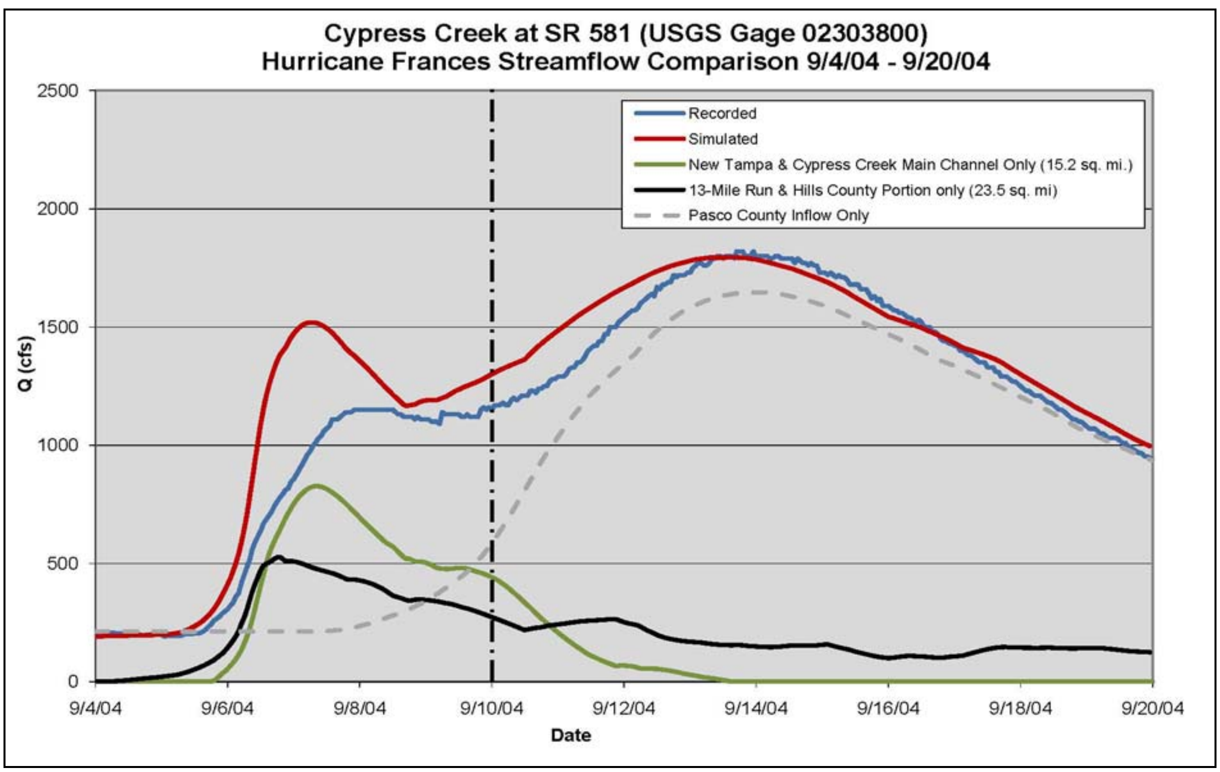
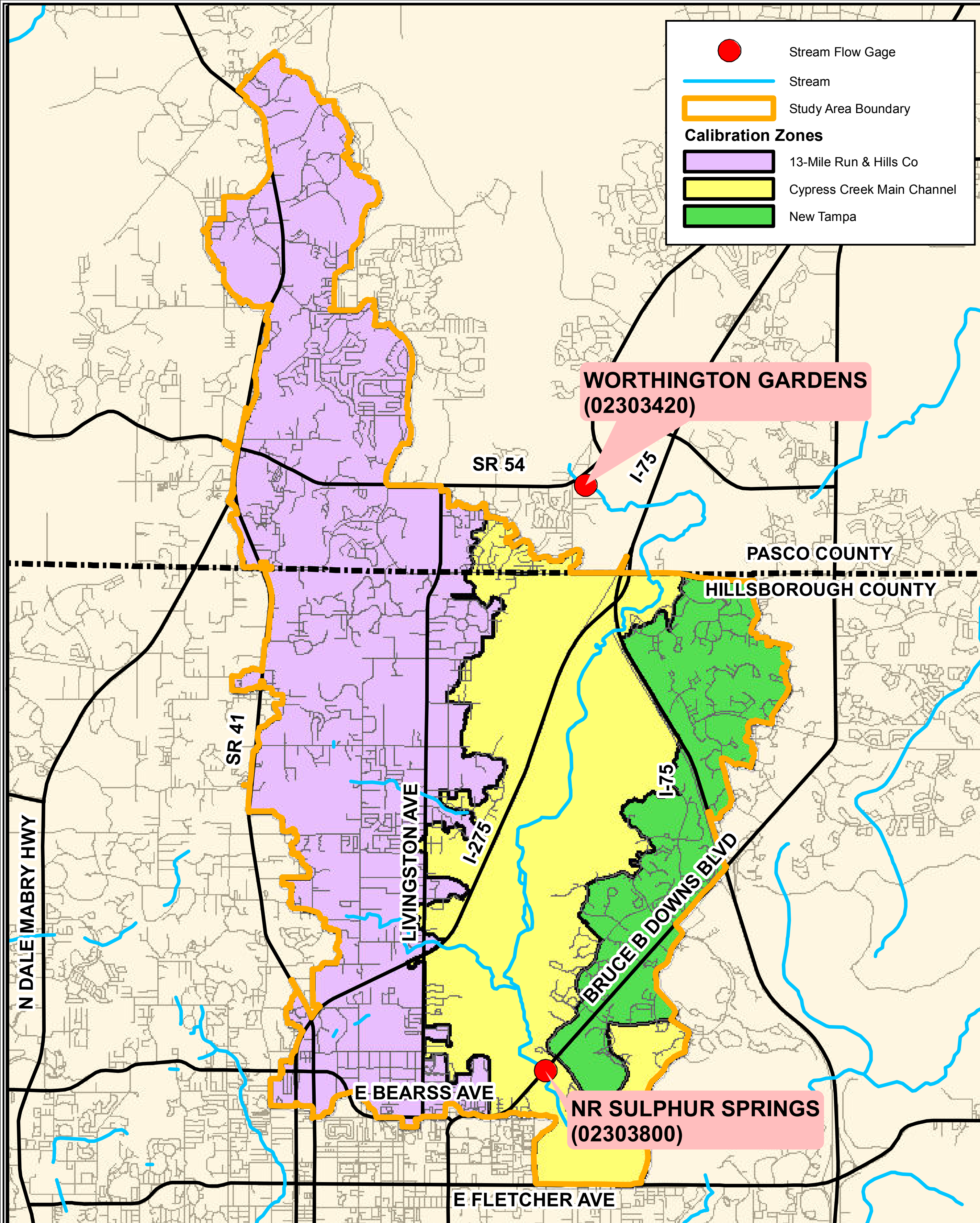


Figure 5.4-2

The flow volume simulated by the New Tampa/Cypress Creek Main Channel area generated 4,341 ac-ft (a 15.2 sq. mi. contributing area) compared to 4,122 ac-ft of flow generated from the 13-Mile Run/Hillsborough County western area (a 23.5 sq. mi. area). This is 220 ac-ft more runoff from an approximately 35% smaller area. The New Tampa/Cypress Creek Main Channel area also peaks much higher than the rest of the watershed causing the large spike in simulated runoff. Considering that the New Tampa portion of the watershed was not modeled with the same detail as the rest of the watershed and the amount of wetland storage within this area, it is likely that this has a significant impact on peak flows, volumes, and timing at the SR 581 gage. Furthermore, DEM data within the wetland Cypress Creek Main Channel area is very course and is likely not defining pockets of wetland storage responsible for containing and attenuating flows through the Cypress Creek Main Channel. Additional flow volume can also be attributed to the second rainfall event which occurs on September 8-9, for which, all rainfall simulated appears as runoff in the model. In a rural watershed, where runoff is governed by soil storage availability, the 2-3 days between rainfall occurrences for this time period would lend to some soil storage recovery, likely decreasing actual runoff quantities. For these reasons it is concluded that the deviations of flow for the calibration can be attributed to the New Tampa/Cypress Creek Main Channel portion (which is that portion substantially outside the detailed study area).

Figure 5.4-4 presents the rating curve comparisons for the Cypress Creek at Sulphur Springs gage (02303800). An excellent fit was achieved by adjusting channel model parameters. At the low end of the rating curve the model deviates to some extent, but overall is certainly within reasonable limits. Floodplain (overbank) manning’s n values are generally about 0.15 for channels in the area. This manning’s n value was used to assign manning’s n values for the rest of the Cypress Creek main channel.



PARSONS
4925 Independence Pkwy
Suite 120
Tampa, FL 33634

0 4,000 8,000 Feet
0 0.25 0.5 1 Miles
1:96,000

Filename:	Map Date:	Prepared By:
	Jul 08, 2011	Yoav Rappaport

Date of Photography:

Figure 5.4-3

Calibration Zones

Cypress Creek Watershed

Path: J:\DATA\260464_Cypress_Creek _Update_HC\GIS\Maps\MXD\Final_Report\CC_Figures_Final.mxd

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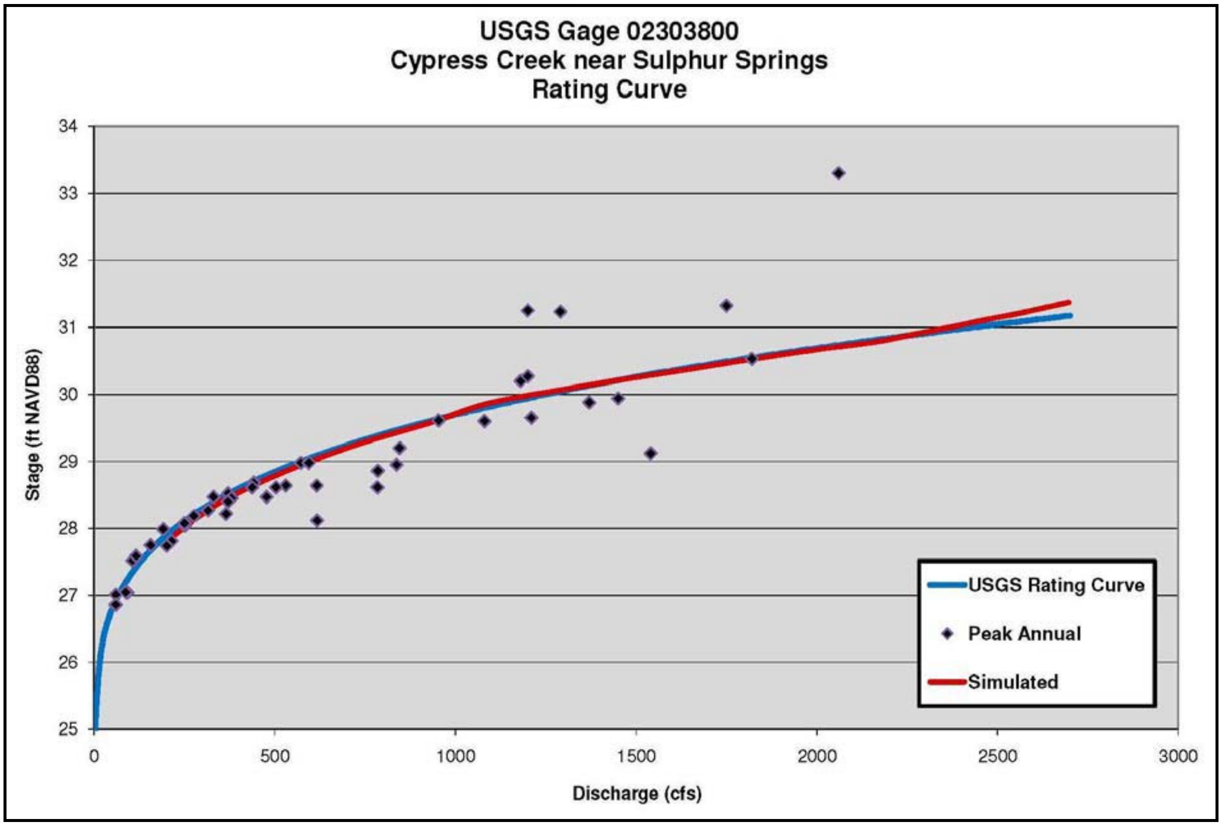


Figure 5.4-4

Table 5.4-1 presents the calibration results for the lakes of the Thirteen-Mile Run lake chain. As noted in section 5.2, many of the lakes in this chain (generally those in Pasco County) had only a single staff gage recording (on 9/14-15/2004). For these lakes, the best correlation to make was to compare the recorded stage to the corresponding model stage in the model simulation (recorded stages were assumed to be at 12:00 PM on the date of the staff gage reading), these stages are not necessarily the peak stage, and in fact, most likely are not. Therefore, simulated peak stages are also given for informational purposes. As can be seen in this table, model simulation stages compare quite well to those of recorded data with most differences within (+/-) 0.2 feet.

Table 5.4-1

13-Mile Run Lake Chain Model Calibration
Maximum Lake Stage Comparison

Model Junction Number	Lake Name	Model Junction Number	September 4 - 20, 2004 (Hurricane Frances) Maximum Lake Stage (NAVD88)						
			Date of Recorded Lake Stage	Recorded Lake Stage	Model Corresponding Lake Stage	Modeled - Recorded (Diff)	Model Maximum Lake Stage	Stage on 9/4/2004	Model Initial Stage
511810	Flynn	505930	2004 HWM	49.61	49.74	**0.13**	**49.74**	- -	48.47
510960	Stemper	510650	9/9/2010	60.87	60.68	**-0.19**	**61.14**	60.05	60.05
511370	Hanna	510750	9/6/2004	61.78	61.90	**0.12**	**61.89**	60.37	60.36
510790	Keene	510770	9/6/2004	62.28	62.40	**0.12**	**62.45**	61.36	61.35
505930	Commiston	510790	2004 HWM	62.11	62.49	**0.38**	**62.49**	- -	61.36
535000	Kell	510930	9/10/2004	65.94	65.83	**-0.11**	**65.87**	65.29	65.29
510770	Toni	511320	9/15/2004	68.16	68.05	**-0.11**	**68.40**	- -	66.14
510930	Catfish	511370	9/15/2004	68.14	68.06	**-0.08**	**68.40**	- -	66
512090	Jo Ann	511370	9/15/2004	68.06	68.06	**0.00**	**68.40**	- -	66
511510	Padgett	511510	9/15/2004	70.60	70.48	**-0.12**	**71.22**	- -	69.02
511560	Saxon	511560	9/15/2004	70.58	70.49	**-0.09**	**71.40**	- -	69.02
510650	Bell	511810	9/15/2004	71.97	71.61	**-0.36**	**72.38**	- -	69.88
510830	King	512090	9/15/2004	73.10	72.97	**-0.13**	**73.37**	- -	70.93
511320	Hog Island	535000	9/15/2004	66.13	66.30	**0.17**	**66.44**	- -	65.27

Figures 5.4-5 through 5.4-8 present hourly stage hydrograph results for Lakes Kell, Keene, Stemper and Hanna. The Lake Kell calibration (Figure 5.4-5) is quite good in timing, shape and magnitude, with the maximum stage difference of 0.17 feet at any time during mode simulation. The Lake Keene simulation (Figure 5.4-6) is a good fit as well. The simulated peak stage is 62.46 ft NAVD88 on at 12:00 PM on 9/06/04 while the recorded peak stage is 62.28 ft NAVD88 on at 2:00 PM on 9/06/04. The recession limb is slightly lower for the calibration which is likely due to groundwater. A concave-down recession limb is usually a good indication of groundwater influence which cannot be simulated using an event-based model such as HCSWMM. Figure 5.4-7 presents the Lake Hanna calibration, which is also calibrated well with a simulated peak of 61.89 ft NAVD and a recorded peak of 61.78 ft NAVD. Again, the concave recession limb is an indicator of groundwater influencing the recession divergence. Figure 5.4-8 presents the Lake Stemper calibration. The results for this lake are not as good as the other hourly lake comparisons. Although, when the simulation is peaking, the recorded data is fluctuating when all other lake stages are peaking. It is a distinct possibility that the peak stage was not recorded by the gage due to fluctuation. Again, the graph shows the concave down recession limb, which could not be simulated by any changes in model setup, indicating probable groundwater influence.

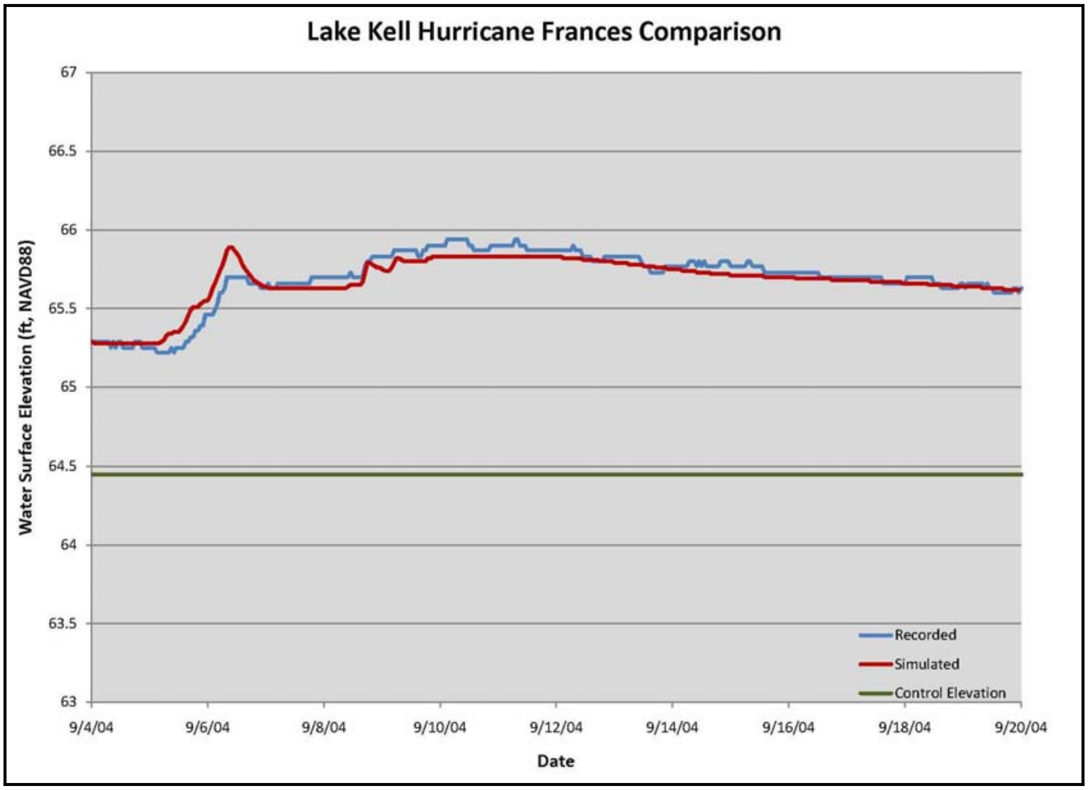


Figure 5.4-5

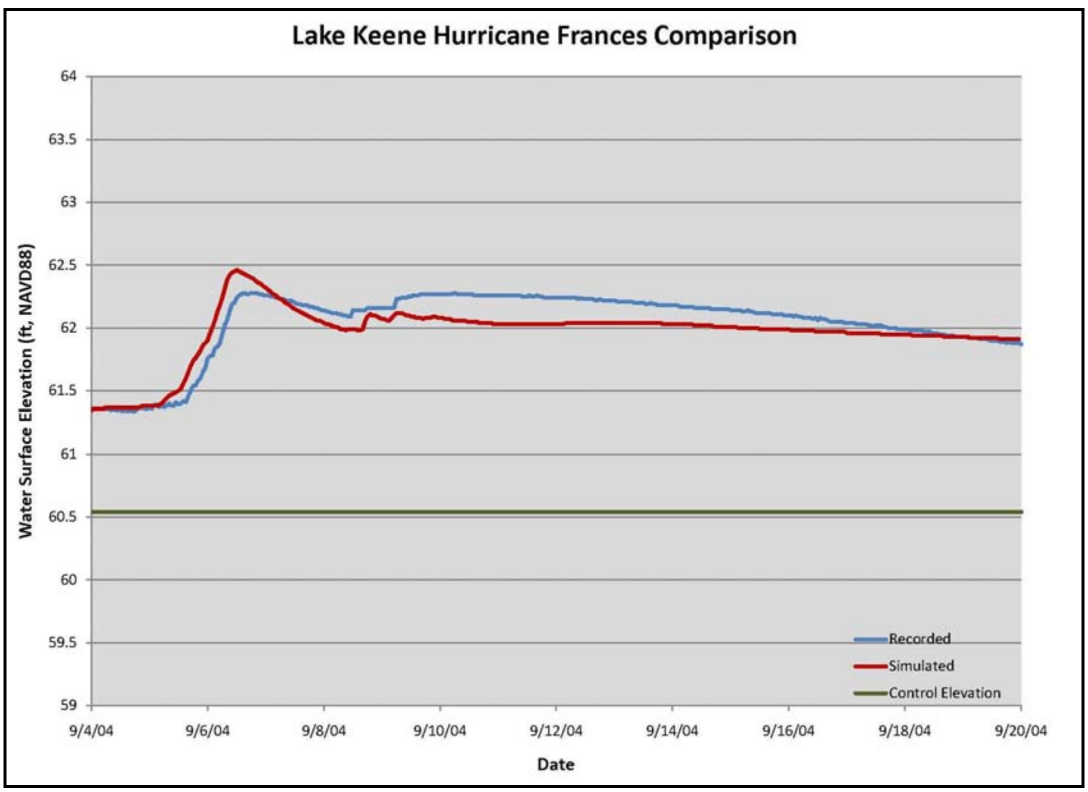


Figure 5.4-6

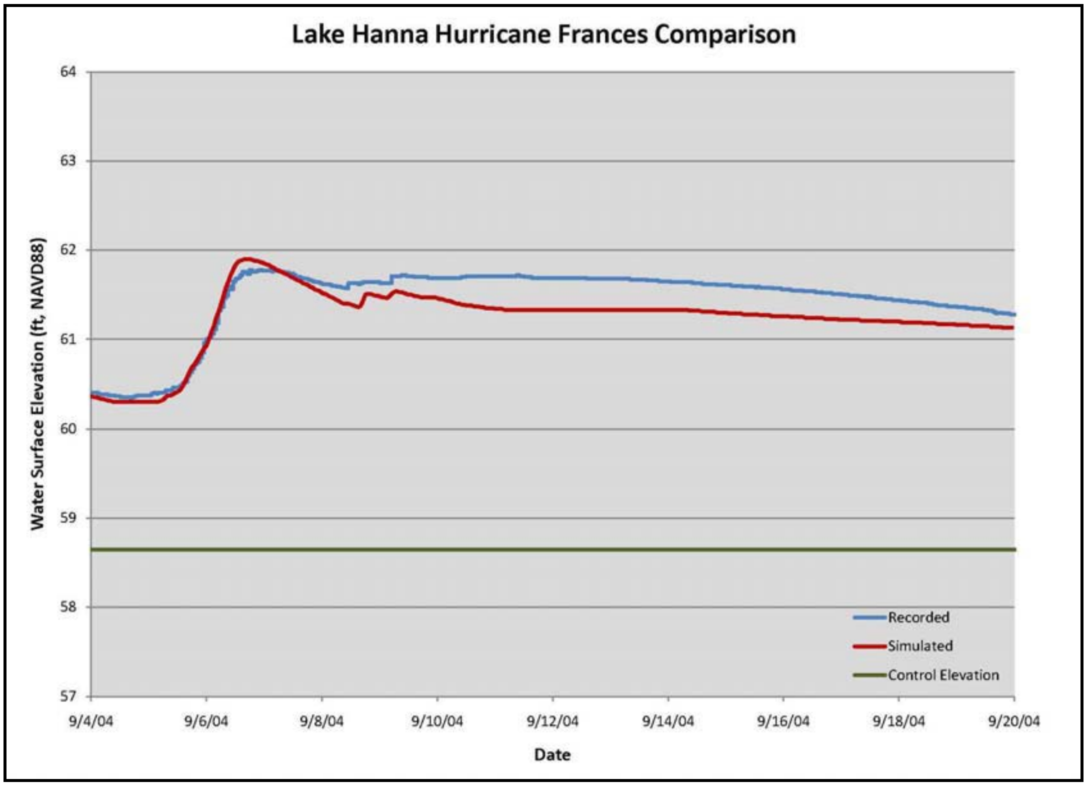


Figure 5.4-7

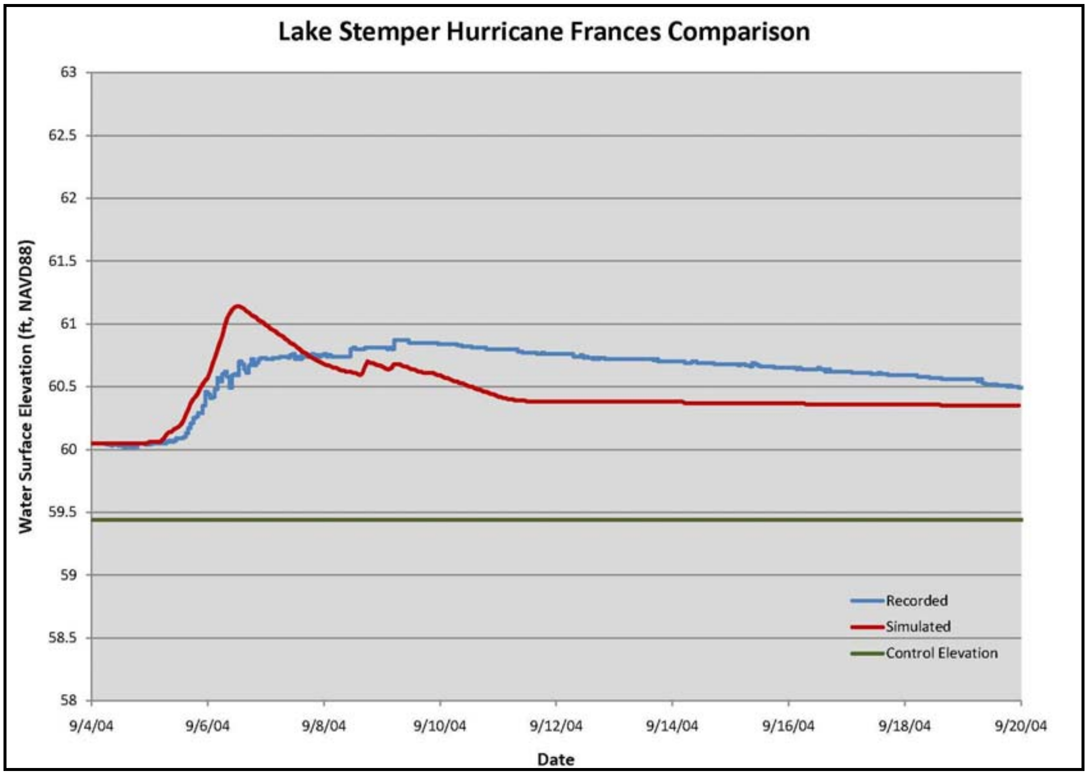


Figure 5.4-8

Verification

The verification event for the Cypress Creek model was run for a 16-day time period from March 10 through March 26. Figures 5.4-9 and 5.4-10 show comparisons of the recorded and simulated flows and stages for the Cypress Creek at Sulphur Springs gage (02303800). Groundwater base flows at the initiation of the model simulation totaled 20 cfs at SR 581 and were distributed in flowing reaches and set at a hydraulic equilibrium at the onset of the simulation. Similarly to the Calibration results, the simulated stage hydrograph comparison appears reasonable and within an acceptable, conservative range. The peak stage for the simulation is 28.59 ft NAVD compared to 28.11 ft NAVD for the recorded. Although, when the simulated flow hydrograph is compared to the recorded, it is evident that there is excess flow volume, specifically in the rising limb. This portion of the graph rises early and higher than the recorded data (similar to the calibration). The recorded flow volume from March 10 – March 25 is 8,830 ac-ft compared to 9,642 ac-ft for the simulated. This comparison, again, demonstrates the limitations of the model with respect to the probable storage within the Cypress Creek Main Channel (DEM data) and the storage in the New Tampa area which is out of the detailed study area.

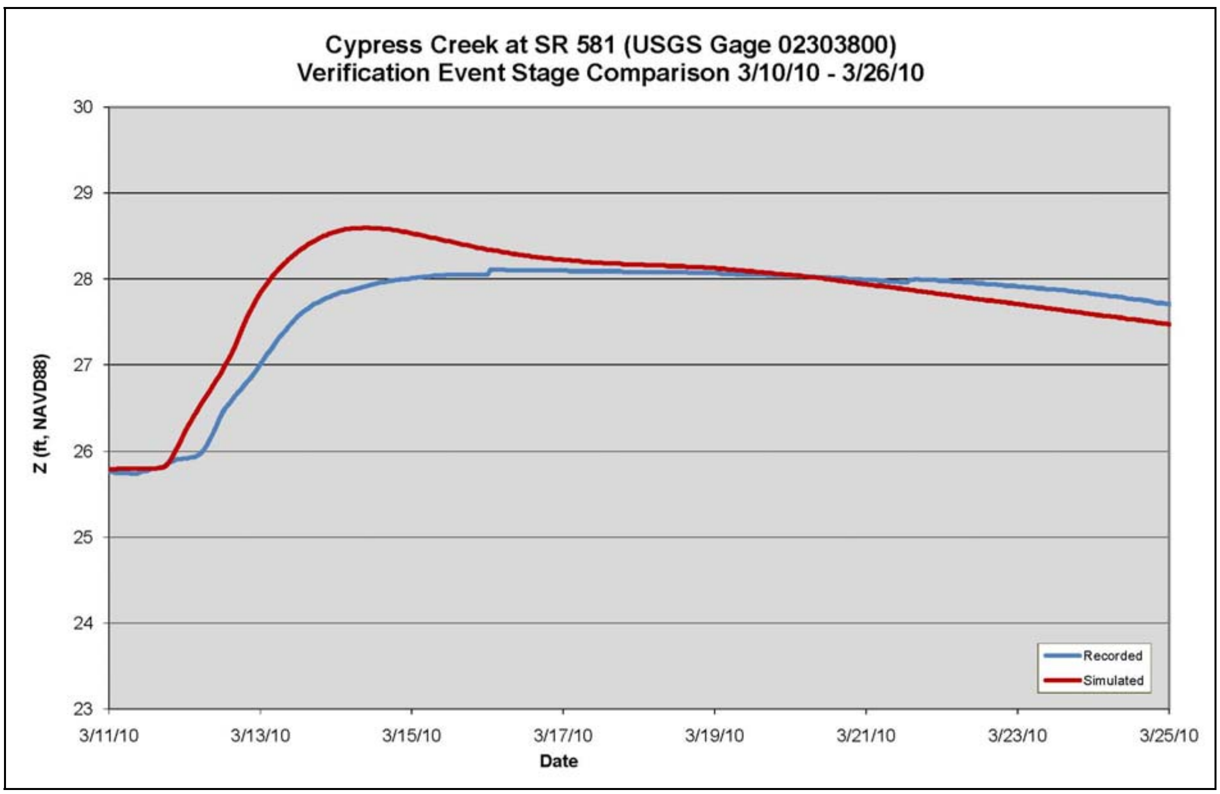


Figure 5.4-9

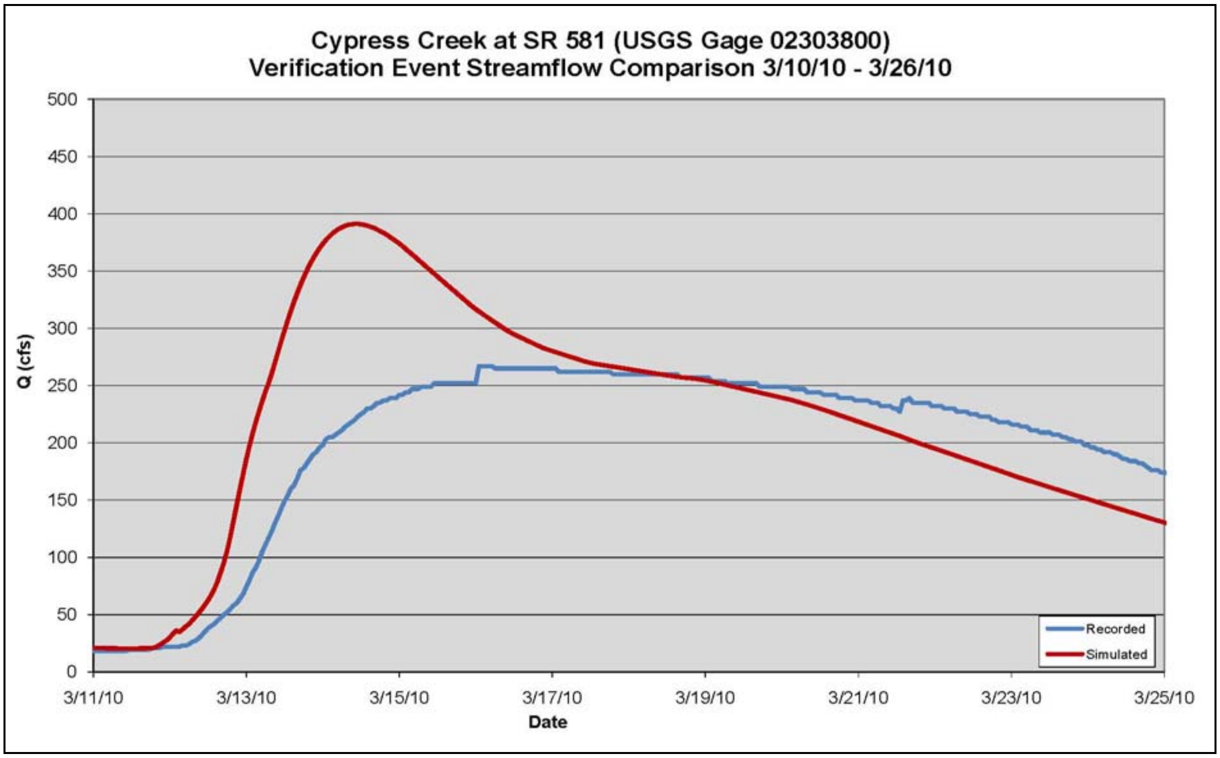


Figure 5.4-10

Table 5.4-2 presents the verification results for the lakes of the Thirteen-Mile Run lake chain. Again, the overall comparison of recorded lake stages throughout the watershed shows a good correlation with an average differential of 0.23 feet. In fact, the Lake Kell simulated and recorded stages are identical at 65.01 ft NAVD.

Table 5.4-2

13-Mile Run Lake Chain Model Verification
Maximum Lake Stage Comparison

Lake Name	Model Junction Number	March 10-12, 2011 (Verification Event) Maximum Lake Stage (NAVD88)					
		Date of Recorded Lake Stage	Recorded Lake Stage	Model Corresponding Lake Stage	Modeled - Recorded (Diff)	Model Maximum Lake Stage	Mode Initial Stage
Stemper	510650	3/17/2010 0:00	59.03	59.58	0.55	60.50	58.05
Hanna	510750	3/17/2010 0:00	60.83	60.60	-0.23	60.74	59.74
Keene	510770	3/12/2010 17:00	61.36	61.40	0.04	61.41	60.9
Kell	510930	3/17/2010 0:00	65.01	65.01	0.00	65.11	64.59
Toni	511320	3/15/2010 0:00	66.32	66.11	-0.21	66.11	65.7
Catfish	511370	3/15/2010 0:00	66.77	67.03	0.26	67.09	66
Jo Ann	511370	3/15/2010 0:00	66.70	67.03	0.33	67.09	66
Padgett	511510	3/29/2010 0:00	69.17	68.94	-0.23	69.19	68.13
Saxon	511560	3/14/2010 8:00	69.34	69.19	-0.15	69.19	68.16
Joyce	511760	3/15/2010 0:00	74.75	74.43	-0.32	75.04	74.5
Bell	511810	3/15/2010 0:00	70.80	71.00	0.20	71.00	69.8
King	512090	3/15/2010 0:00	71.54	71.81	0.27	71.85	70.75

Figures 5.4-11 through 5.4-14 present hourly stage hydrograph results for Lakes Kell, Keene, Hanna, and Stemper for the March 2010 verification event. For all the lakes in the verification, stages do not change much approximately 1 foot, so any deviations in the graphs appear exaggerated. A good overall fit was achieved for Lake Kell (Figure 5.4-11). There is a slight spike in the graph likely due to the simulated NEXRAD rainfall data. Although it appears drastic in the figure, the difference is only 0.16 ft. higher than the recorded at this time of 64.94 ft NAVD. The recession for this lake looks very good. The Lake Keene (Figure 5.4-12) comparison also looks good overall. The peak is within 0.06 ft of the recorded peak of 61.4 ft NAVD and, although the recession is slightly low, it is only 0.25 ft low seven (7) days into the simulation. It is curious that the recorded lake data continues to climb and not recede. This lends to the probability of lake outfall alterations by private parties which has happened in the past. Although the Lake Hanna (Figure 5.4-13) graph does not match well, it is reasonable considering the overall difference in peak stage is only 0.09 ft. The recession limb for this graph continues to rise, again introducing a good possibility of intentional blockage by local residents. The Lake Stemper comparison (Figure 5.4-14) matches well for the first few days but does deviate as the simulation continues. For this lake, the initial stage is so low that the outfall elevation is never attained during the rainfall event. This deviation indicates that the model stage-area is under-accounting or that inflows (NEXRAD simulated rainfall runoff) are over-estimated. Stage-area data was scrutinized and was even augmented slightly using hardcopy SWFWMD aerial contour data. Model data was verified throughout this area and determined of good quality. The maximum stage difference is only 0.35 feet with the model producing reasonable but conservative results.

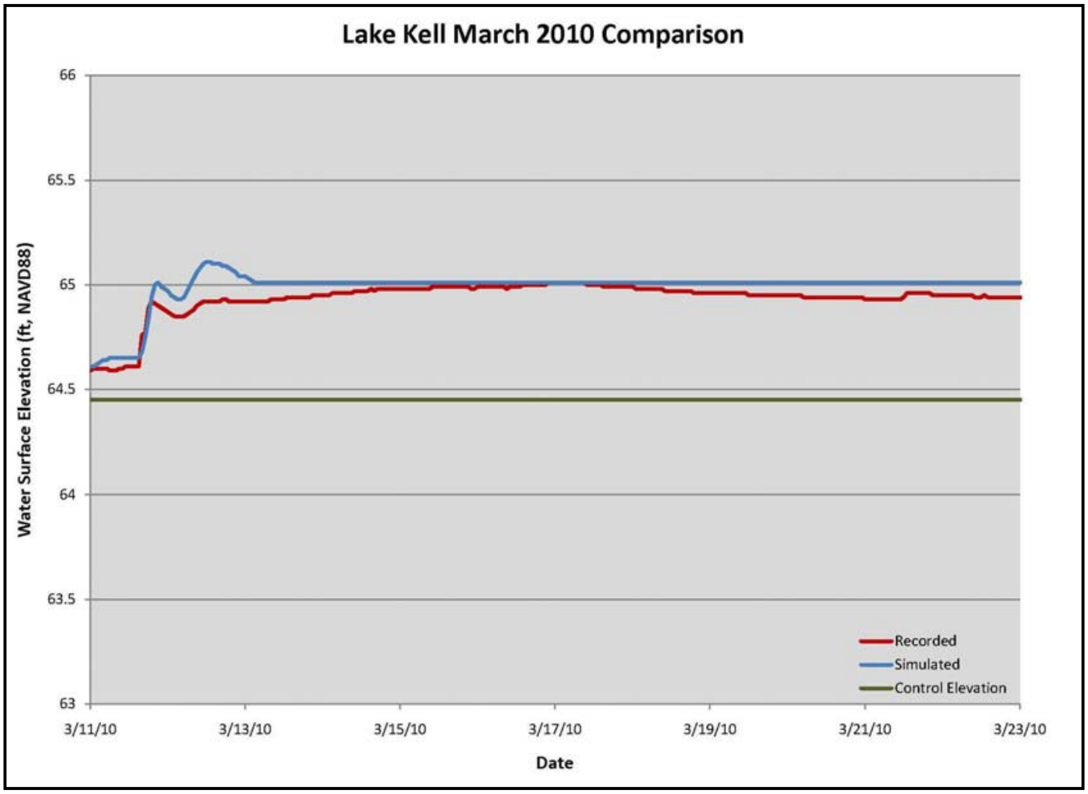


Figure 5.4-11

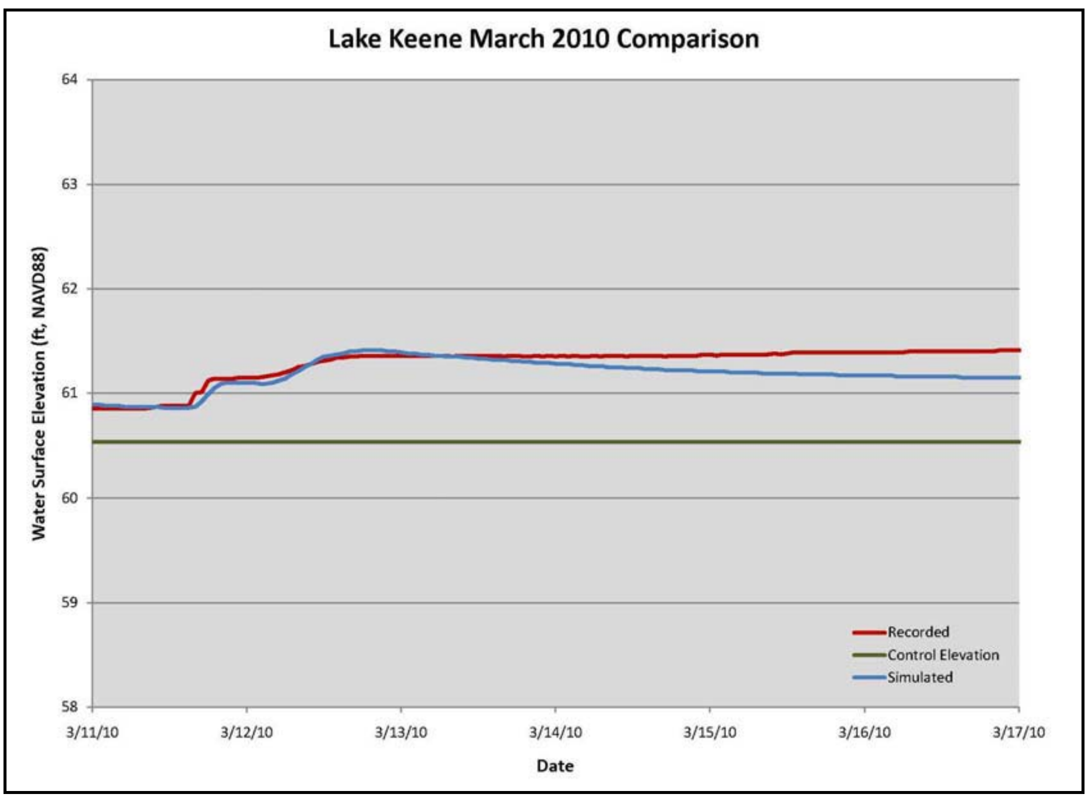


Figure 5.4-12

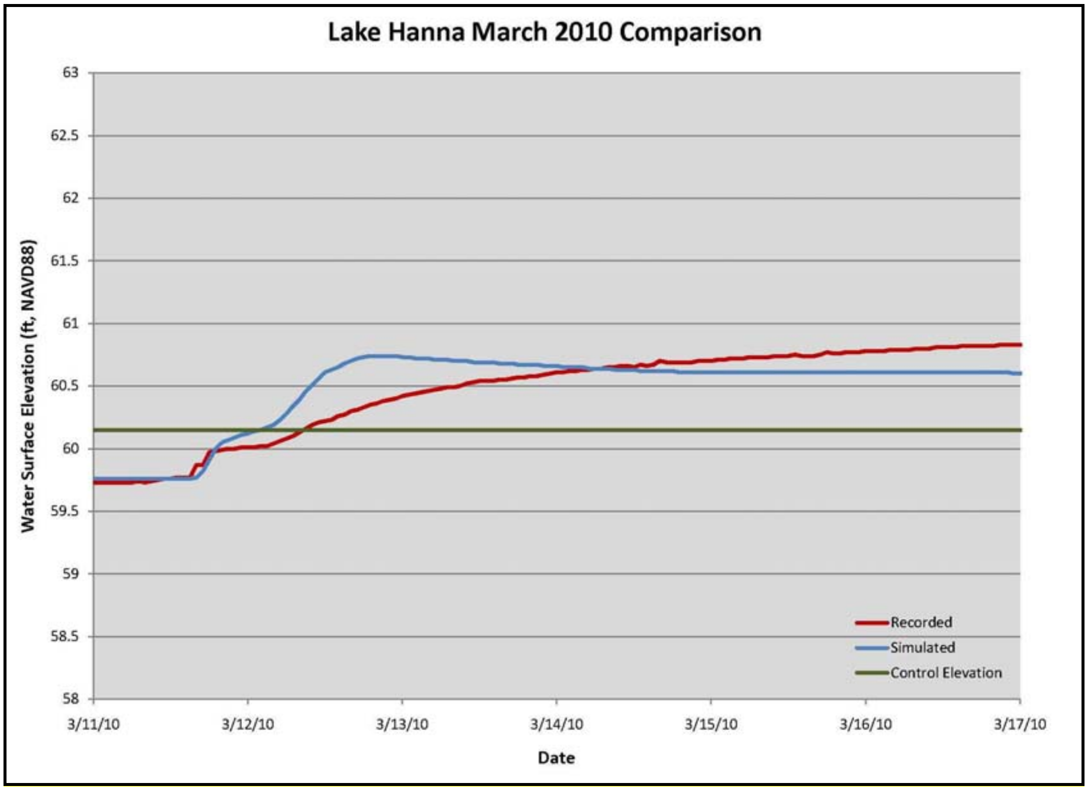


Figure 5.4-13

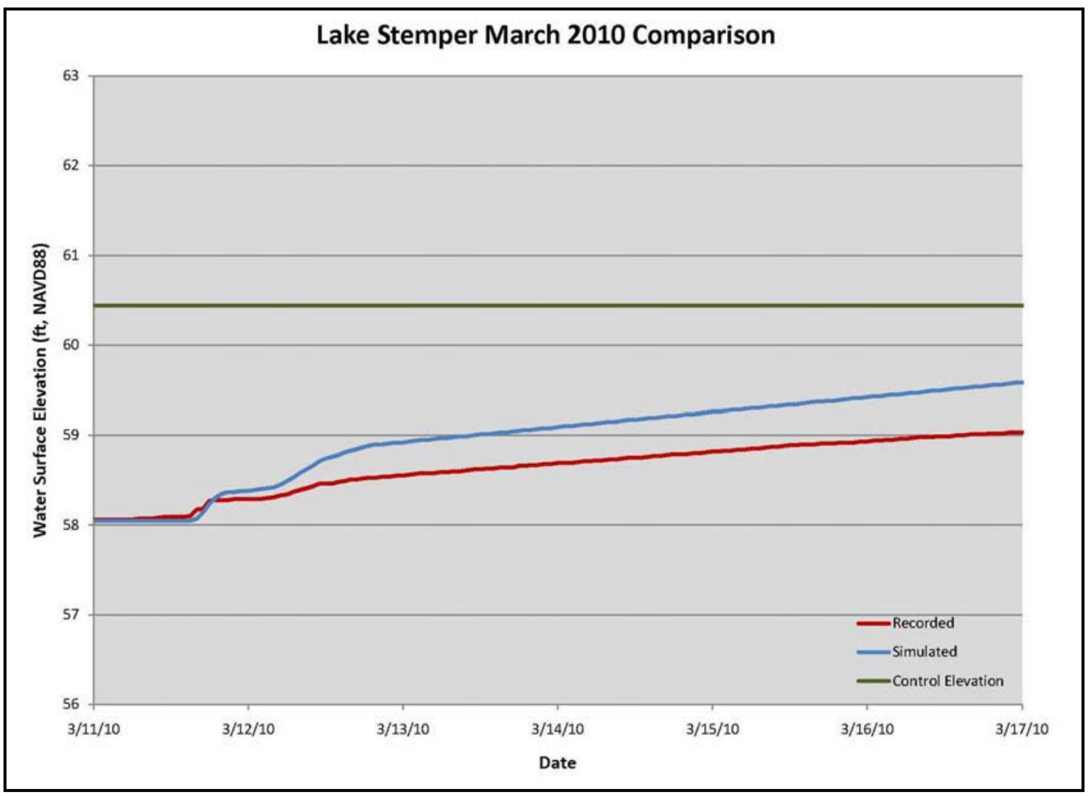


Figure 5.4-14

5.5 CONCLUSIONS

A great deal of diligence and effort went into the development of the Cypress Creek Watershed model update. The model detail meets the SWFWMD G&S for WMPs within the unincorporated Hillsborough County area. The model creation, calibration and verification for Hillsborough portion of Cypress Creek, was a complex task with several challenges with its assorted boundary conditions and interconnected lake chain. The results show that the model, particularly for the area within unincorporated Hillsborough County (the detailed project study area), is certainly giving reasonable results regarding peak stages. Furthermore, the model results can be regarded as conservative, which is a beneficial aspect. The overall results of the process should be regarded a success. It is concluded that the model does reproduce the watershed's response to stormwater runoff reasonably and is appropriate for the use of predicting event-based model flood elevations for floodplain mapping and the evaluation of possible alternatives for resolving flood problems within the watershed.

CHAPTER 6

EXISTING CONDITIONS AND FLOOD LEVEL OF SERVICE

Upon completion of the development and calibration of the hydrologic and hydraulic model(s) of the Cypress Creek Watershed primary drainage systems, the next step of the flooding conditions analysis was to apply the model(s) to assess the performance of the basin-wide drainage facilities for a given set of design storm events.

6.1 DESIGN STORM EVENTS

For the evaluation of flooding conditions in the Cypress Creek Watershed, Hillsborough County has adopted as the following 11 design storms: 2.33-year, 5-year, 10-year, 25-year, 50-year, 100-year, and 500-year return period, 24-hour duration design storm events; and 10-year, 50-year, 100-year, and 500-year 120-hr duration design storm events. The total 24-hour and 120-hour rainfall depths are listed below for each of the return periods. It is an assumption of these analyses that the rainfall intensity is spatially and temporally uniform and equivalent at all points within the watershed-in-question. Accordingly, this type of hypothetical design storm will sometimes generate conservative designs of stormwater management facilities.

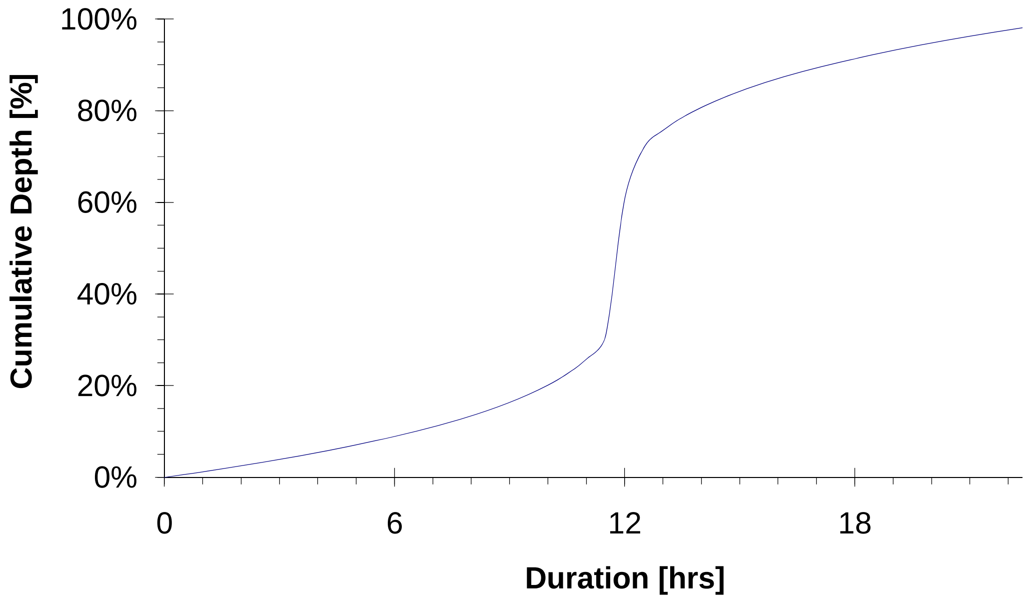
Design Storm Event	Cypress Creek Watershed Rainfall Depth (in.)
Mean Annual	5.0
5-year/24-hour	5.75
10-year/24-hour	7.0
25-year/24-hour	8. 5
50-year/24-hour	10.0
100-year/24-hour	12.0
500-year/24-hour	14.0
10-year/120-hour	11.3
50-year/120-hour	15.9
100-year/120-hour	17.8
500-year/120-hour	18.9

The total 24-hour rainfall depths associated with the design storms were determined based on the SWFWMD Environmental Resource Permitting (ERP) Information Manual (December 2009). These depths are expressed for the Cypress Creek Watershed as a function of annual exceedance probability and average recurrence interval, and are the result of region-wide probabilistic analyses of historic maximum annual rainfall depths over a long period of record. Annual exceedance probability is an expression of risk. It is the probability that, in any given year, the maximum annual 24-hour or 120-hour rainfall depth will exceed the cited rainfall depth.

It is important to note that there is an inherent assumption in the design storm approach that the hypothetical design rainfall event with a given recurrence interval will produce a flood with the same recurrence interval, and at all locations within the watershed. This is not necessarily the case; a 24-hour duration storm with a 100-year rainfall depth may not produce a 100-year peak flood flow, or a 100-year floodplain. Variations in antecedent soil moisture conditions, water table, rainfall distribution, and initial lake elevations will affect the convolution of the occurrence probability of a rainfall depth to the occurrence probability of a flood elevation or floodplain.

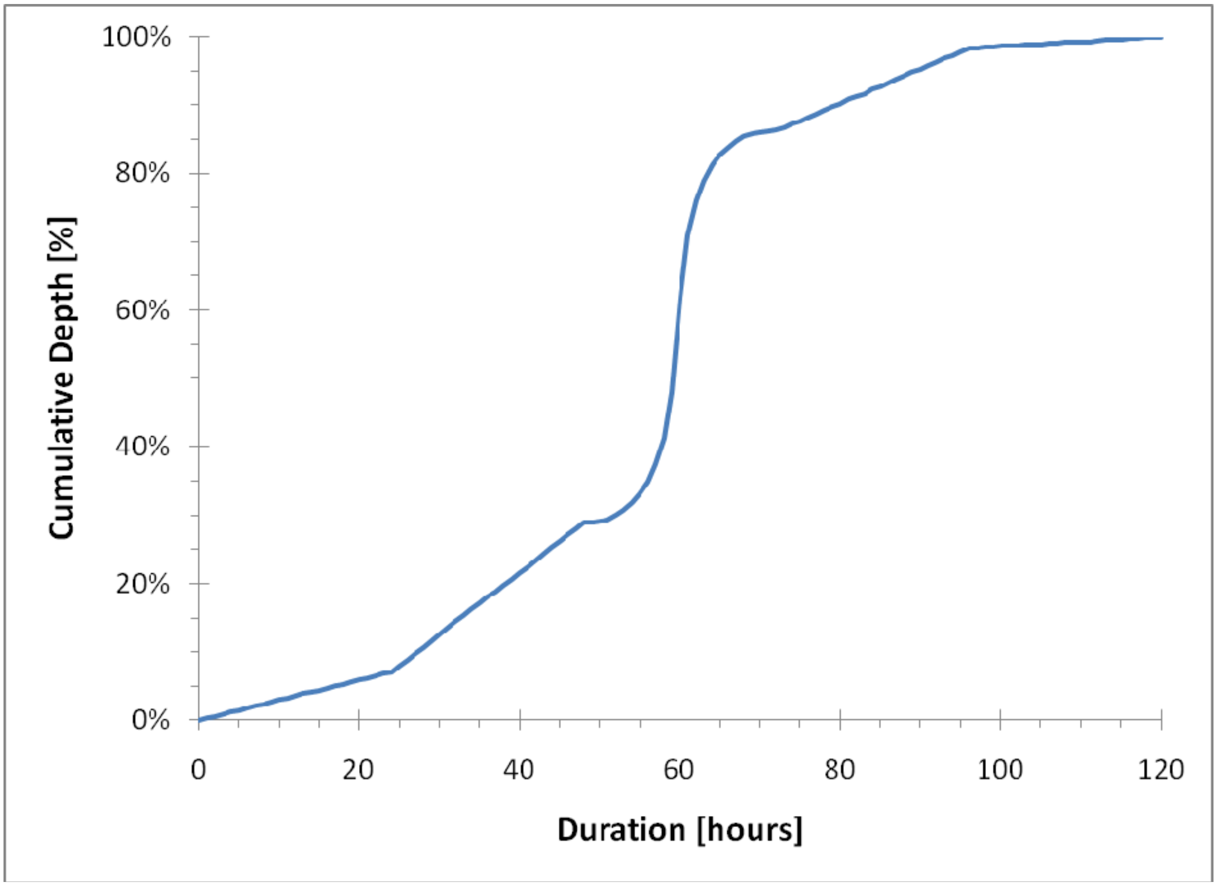
In accordance with SWFWMD design criteria, the SCS Type II Florida-Modified rainfall distribution curve was used to distribute the total storm depth over the 24-hour and 120-hour storm durations. This reference is consistent with that cited in the Hillsborough County Stormwater Management Technical Manual (SMTM). The following figures and tables present this cumulative temporal rainfall distribution, which is based on a balanced storm method that centers the highest rainfall intensities at the middle of the 24-hour and 120-hour storm durations. As shown, the design storm is represented in 30-minute and 60-minute increments of rainfall calculated by multiplying the total storm depth by the incremental changes in the cumulative distribution curve for the 24-hour and 120-hour design storms. The product of this procedure is called a design storm hyetograph.

SCS Type II Florida-Modified Rainfall Distribution for 24-Hour Duration Storm



Time (hours)	Cumulative % of Total Storm Depth	Time (hours)	Cumulative % of Total Storm Depth	Time (hours)	Cumulative % of Total Storm Depth
0.0	0.000	8.5	0.148	16.5	0.882
0.5	0.006	9.0	0.164	17.0	0.893
1.0	0.012	9.5	0.181	17.5	0.904
1.5	0.019	10.0	0.201	18.0	0.913
2.0	0.025	10.5	0.226	18.5	0.923
2.5	0.032	11.0	0.258	19.0	0.931
3.0	0.039	11.5	0.308	19.5	0.940
3.5	0.047	12.0	0.607	20.0	0.948
4.0	0.054	12.5	0.719	20.5	0.955
4.5	0.062	13.0	0.757	21.0	0.962
5.0	0.071	13.5	0.785	21.5	0.969
5.5	0.080	14.0	0.807	22.0	0.976
6.0	0.089	14.5	0.826	22.5	0.983
6.5	0.099	15.0	0.842	23.0	0.989
7.0	0.110	15.5	0.857	23.5	0.995
7.5	0.122	16.0	0.870	24.0	1.000
8.0	0.134				

SCS Type II Florida-Modified Rainfall Distribution for 120-Hour Duration Storm



SCS Type II Florida-Modified Rainfall Distribution for 120-Hour Duration Storm

Time (hours)	Cumulative % of Total Storm Depth	Time (hours)	Cumulative % of Total Storm Depth	Time (hours)	Cumulative % of Total Storm Depth
0	0.000	41	0.225	81	0.908
1	0.003	42	0.234	82	0.912
2	0.006	43	0.244	83	0.917
3	0.009	44	0.253	84	0.923
4	0.012	45	0.262	85	0.927
5	0.015	46	0.271	86	0.933
6	0.018	47	0.28	87	0.937
7	0.021	48	0.289	88	0.943
8	0.024	49	0.29	89	0.948
9	0.027	50	0.291	90	0.953
10	0.03	51	0.294	91	0.958
11	0.033	52	0.3	92	0.963
12	0.036	53	0.308	93	0.968
13	0.039	54	0.318	94	0.973
14	0.041	55	0.331	95	0.978
15	0.044	56	0.349	96	0.983
16	0.047	57	0.374	97	0.984
17	0.05	58	0.413	98	0.985
18	0.053	59	0.48	99	0.985
19	0.056	60	0.619	100	0.986
20	0.059	61	0.709	101	0.986
21	0.062	62	0.76	102	0.987
22	0.065	63	0.79	103	0.988
23	0.068	64	0.812	104	0.989
24	0.071	65	0.827	105	0.989
25	0.08	66	0.839	106	0.99
26	0.089	67	0.847	107	0.991
27	0.098	68	0.854	108	0.992
28	0.107	69	0.858	109	0.992
29	0.116	70	0.86	110	0.993
30	0.126	71	0.862	111	0.993
31	0.135	72	0.864	112	0.994
32	0.144	73	0.867	113	0.995
33	0.153	74	0.872	114	0.996
34	0.162	75	0.877	115	0.996
35	0.171	76	0.882	116	0.997
36	0.18	77	0.887	117	0.998
37	0.189	78	0.892	118	0.999
38	0.198	79	0.898	119	0.999
39	0.207	80	0.902	120	1
40	0.216				

6.2 LEVEL OF SERVICE DESIGNATIONS

The Hillsborough County Comprehensive Plan, Stormwater Management Element contains definitions for level of service flood protection designations. According to these definitions, a storm return period and duration (i.e. 25-year/24-hour) and letter designation (i.e. B) are needed to define the level of flood protection (i.e. 25-year/24-hour LOS B). The flood level designations contained in the Comprehensive Plan are A, B, C and D, A being the highest level and D being the lowest. However, these criteria are somewhat subjective. Therefore, it is necessary to establish quantitative criteria by which to assign LOS designations. An allowable tolerance that is demographically representative for Hillsborough County before flooding can be classified and was assigned to LOS designations A-D as shown in the table below. This table contains the interpretation of the Comprehensive Plan definitions used in the LOS analysis herein.

Flooding Level of Service	Hillsborough County Comprehensive Plan Definition	Cypress Creek Watershed Management Plan Definition
A	No significant street flooding	Street flooding is less than 3” above the crown of road
B	No major residential yard flooding (Minor street flooding. At least one lane drivable)	Street flooding is more than 3” above the crown of road, but less than 6”
C	No significant structure flooding (Level C - Street flooding. Flooding depth above road crown is less than one foot.)	Street flooding is more than 6” above the crown of road, but less than 12”
D	No limitation on flooding	Street flooding is more than 12” above the crown of road or flood elevation is greater than finished floor elevation
O	N/A	No structure and no street to compare with flood elevation

Hillsborough County has assigned three levels of service to all its major stormwater conveyance systems: (a) Adopted, (b) Target, and (c) Ultimate, as defined below:

(a) The ***Adopted Level of Service*** describes the existing condition: the response of the existing stormwater conveyance system to the suite of hypothetical design storm events.

(b) Hillsborough County's goal is to achieve the ***Target Level of Service*** throughout the county. Target level of service is uniform throughout the county and promulgated by the Board of County Commissioners in the Comprehensive Plan.

(c) ***Ultimate Level of Service*** is a practical goal, where physical or environmental constraints prohibit the achievement of the target level of service. It is stated in the Comprehensive Plan that at some locations, "physical and/or environmental constraints will not allow an existing system to be modified to the Target (level of service)." At these defined locations, the ultimate level of service is deemed the highest achievable.

The goal of the County's Watershed Management Planning program is to develop a capital improvement program to improve the flooding level of service for all watersheds from the adopted to either the target or ultimate LOS. The Board of County Commissioners, in the Comprehensive Plan, promulgated the 25-year/24-hour/B flooding level of service as the target level of service for all watersheds within the county. The ultimate LOS standards have not been determined for the major stormwater conveyance systems located outside of the areas for which completed watershed management plans currently exist. These standards are to be established via the Comprehensive Stormwater Management Master Planning Program, of which this study is a part.

6.3 LEVEL OF SERVICE ANALYSIS METHODOLOGY

Level of service is a functional performance designation given to public works facilities that provides a way of grading facility efficiency and prioritizing facility upgrades. The Stormwater Management Element of the Comprehensive Plan for Unincorporated Hillsborough County defines flood level of service by the attainment of incremental performance milestones during severe storms.

The methodology used to assess the flooding levels of service provided by the Cypress Creek Watershed major drainage system was to use the County DEM dataset and compare the SWMM model results of the design storm events to road and residential finished floor slab elevations at selected points throughout the watershed. In order to evaluate the LOS for a watershed, LOS elevations must first be determined. These elevations refer to roads and structures. LOS elevations were established for every subbasin in the watershed that lies within unincorporated Hillsborough County. Subbasins with substantial topo voids were not considered n this analysis. These LOS elevations then serve as a tool for determining the level of service for the subbasin and on a broader scale, the system and the watershed. The LOS elevations established for this analysis are the critical or lowest landmark elevations in a subbasin. The critical LOS elevations are reflective of the worst case flooding that could occur in a subbasin. Each subbasin in the watershed was assigned a low road elevation and a low structure elevation (given the existence of each in within a subbasin). These elevations were obtained from County DEM dataset. Elevations for structures were assumed to be the highest elevation in the immediate vicinity of the structure (in the aerial) and the road elevations were obtained directly from the DEM. Points used for LOS analysis (CC_LOS_POINT.shp) are included in the digital deliverable data for this project.

Parsons utilized this general methodology to establish the flooding LOS elevations at close to a 520 locations throughout the Cypress Creek Watershed. Due to the high degree of uncertainty in the derivation of these elevations, it is emphasized that the assessment of the flooding LOS provided within the watershed and the identification of problem areas should be confirmed. This assessment should be supplemented with further investigations in the form of field surveys of streets and residential finished floor slab elevations to confirm the existence and/or magnitude of the LOS deficiencies and flooding problems that are identified in the subsequent sections.

For assigning peak flood elevations to each of the LOS points, they were intersected with the 25-year and 100-year floodplain surfaces. The elevation of the floodplain at the exact location of the LOS point was used in the LOS evaluation. It should be noted that subbasins with channelized flow modeled were mapped as conveyance ways and the flood elevation varies along the length of the channel; for this reason, the structure and street LOS point elevations in these subbasins vary from one another.

Once the set of street and structure flooding elevations were determined and compared to the model results for the 25- and 100-year design storm events, it was a relatively simple procedure to assign the appropriate flooding LOS provided at each individual location for existing conditions in the watershed.

Because the County recently adopted a LOS by subbasin approach, the LOS for each point location (structure or low point of road) had to be translated to the subbasins. This was accomplished by associating the junction related to the points with the subbasin. If the LOS point was located inside the subbasin boundary the LOS for the given point would be calculated based on the flood elevation from the appropriate (usually the closest) junction. The LOS for this point would be compared to the LOS for the other point within the subbasin (structure or road) and the lowest LOS value would be assigned to the subbasin. In some cases, the LOS point (usually for a road) would lie on a subbasin boundary. If this was the case, the point would be considered in determining the LOS for the subbasin on each side of the subbasin divide. Thus, a road on a subbasin divide could dictate the LOS for two different subbasins.

6.4 HISTORICAL FLOODING PROBLEMS

2004 Hurricane Frances Floods

Hurricane Frances made landfall on the west coast of Florida on September 4, 2004 and emerged onto the Gulf of Mexico north of Tampa on September 8, 2004 resulting in a basinwide NexRAD average total precipitation of 7.1 inches. Flooding in the Cypress Creek watershed began on September 6, 2004. Incidents reported from this event were added to the Hillsborough County flood database. Complaints located within the Cypress Creek Watershed are listed in Table 6.4-1, and the locations of the individual complaints are plotted in Figure 6.4-1. There were a total of 22 individual flooding complaints within the Cypress Creek Watershed.

6.5 EXISTING CONDITIONS MODEL SIMULATION RESULTS

Using the 11 design storm events as the basis for simulations, the hydrologic/hydraulic computer model was run to generate predictions of basin-wide flooding conditions for the existing land use conditions and the existing drainage facilities throughout the Cypress Creek Watershed. For the purpose of this study, existing conditions refers to Year 2007 land use conditions and drainage facilities. The "stormwater_junctions" feature class provided in the Hillsborough County geodatabase includes the junction maximum flood stages for all 11 design storm events.

6.6 FLOODING LEVEL OF SERVICE ANALYSIS

As previously discussed, the County has adopted a minimum basin-wide goal of Level 'B' for the 25-year, 24-hour design storm event. Based on this criterion, there are 47 subbasins identified where the County's minimum acceptable level of service is not met, as indicated by shaded cells in Table 6.6-1. Additionally, the level of service matrix is also a useful way of identifying additional problem areas and showing the severity of a flooding problem. Figure 6.6-1 shows the LOS by subbasin as required by County standards. Table 6.6-1 presents the LOS evaluation matrix table complete with street and structure elevation (based on the County DEM) by subbasin, the corresponding flood elevation and subsequent LOS designation for each storm event. Subbasins that violate the Cypress Creek LOS are highlighted in blue.

The results of the LOS analysis were compared to the flooding complaint records for the 2004 Hurricane Frances flooding event and there is good correlation between listed problem areas that might be impacted by conditions in the primary drainage system and the problem areas which were identified in Table 6.4-1. Complaint record sites not shown as problem areas in Table 6.4-1 are generally an indication of secondary system problems or possible maintenance problems.

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Table 6.4-1
Cypress Creek Watershed Reported Flooding Problems

INFORMATION SOURCE	MAP REFERENCE NUMBER	FLOOD TYPE	LOCATION	DESCRIPTION
September 2004 Hurricane Frances Flood Complaints	1	LIVINGSTON AVE	ROAD FLOODING	Not very many inlets on Regal Dr to handle flow of water west of Livingston Ave.
	2	SUNSET LN	ROAD FLOODING	Roadside pond surcharged.
	3	SUNRISE DR	ROAD FLOODING	Roadside pond surcharged.
	4	SPRING HOLLOW DR	ROAD FLOODING	Heavey street flooding at Spring Hollow & Spring Green Dr- Private road
	5	WINDSOR OAKS	ROAD FLOODING	Road underwater.
	6	LIVINGSTON AVE	ROAD&STRUC FLOODING	There are no ditches or stormwater system on the West side.
	7	LIVINGSTON AVE	STRUCTURE FLOODING	Ditch overflow by water drainage to East from Vistarra which is causing yard flooding.
	8	HANNA RD	YARD FLOODING	Lake water elevation too high.
	9	TIFFANY SHORE DR	ROAD FLOODING	Road underwater. Blockage found Downstream.
	10	TIFFANY LAKE PL	ROAD FLOODING	Lake water elevation too high. There is no outfall from the lake.
	11	LIVINGSTON AVE	YARD FLOODING	House at 17520 located between South of Sunset and North of Blind Pond is flooded. Pipe need to be cleaned along side road.
	12	LIVINGSTON AVE	ROAD FLOODING	Road underwater.
	13	1ST AVE NW	ROAD FLOODING	Standing water of 6 to 8 ft past his fence line, lake is 30 ft above regular level & County drainage is clogged.
	14	N 13TH ST	ROAD FLOODING	Flooding on 13th St in Lutz coming from Sinclair Hills Rd
	15	1ST AVE NW	YARD FLOODING	Lake's water level behind unit 87,89,91,93 of 1st Ave is high with visible sign of possible structural flooding. Incoming culvert from US 41 near 4th Ave has no visible flow of water.
	16	N 13TH ST	ROAD FLOODING	Road underwater.
	17	BORDEAUX WAY	ROAD FLOODING	Road underwater.
	18	N US HIGHWAY 41	ROAD FLOODING	Road underwater.
	19	WILDROSE DR	ROAD FLOODING	Road underwater.
	20	SWAN LAKE DR	ROAD FLOODING	Road underwater.
	21	SINCLAIR HILLS RD	ROAD FLOODING	Road underwater.
	22	VANDERVORT RD	ROAD FLOODING	Heavy steet flooding. Water elevation reaching near structural elevation.

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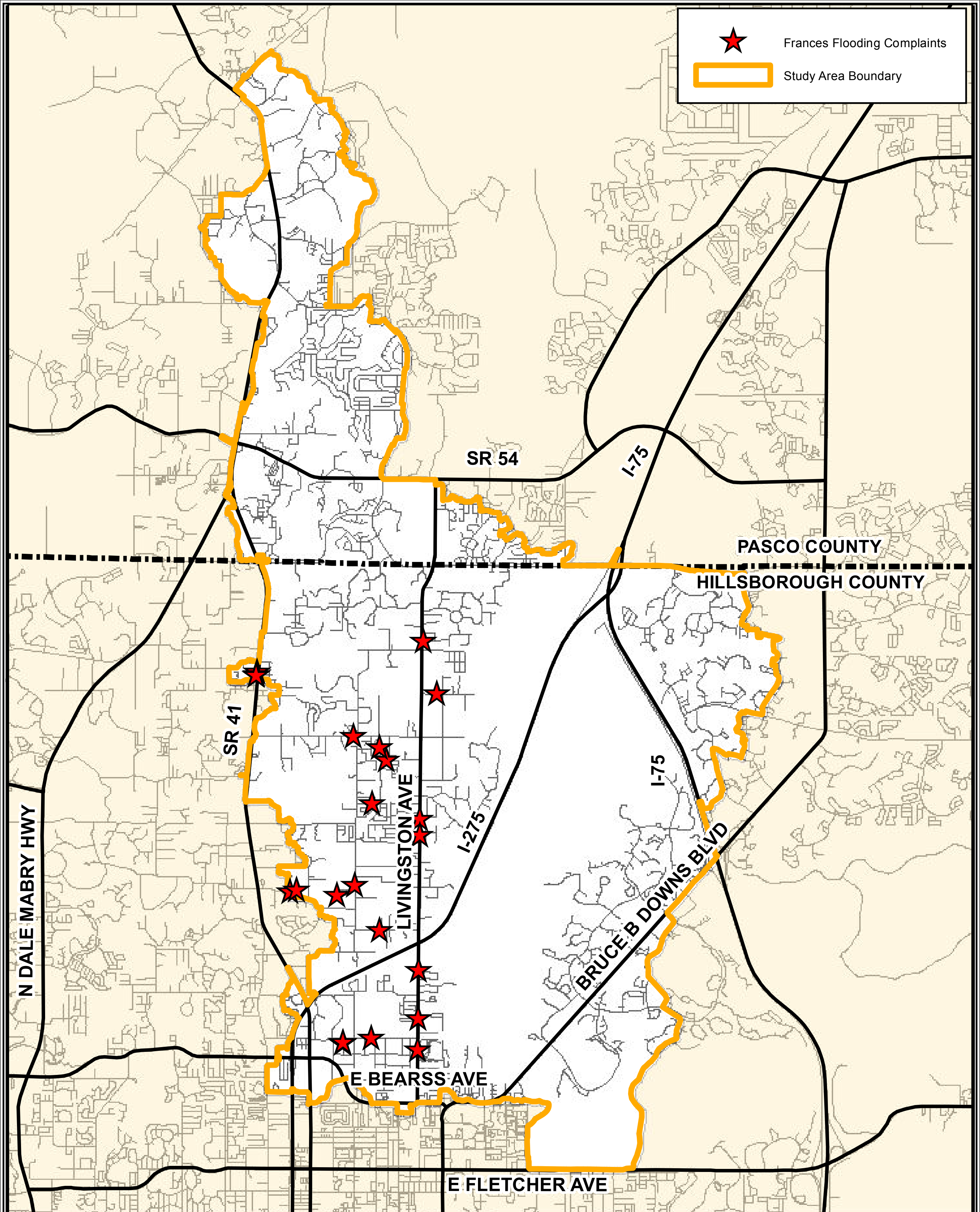

PARSONS
4925 Independence Pkwy
Suite 120
Tampa, FL 33634

0 4,000 8,000 Feet 1:96,000
0 0.25 0.5 1 Miles

Filename:	Map Date:	Prepared By:
	Jul 08, 2011	Yoav Rappaport

Date of Photography:

Figure 6.4-1

Historical Flooding Complaint Locations (Frances)

Cypress Creek Watershed

Path: J:\DATA\260464_Cypress_Creek_Update_HC\GIS\Maps\MXD\Final_Report\CC_Figures_Final.mxd

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TABLE 6.6-1
UPDATE OF CYPRESS CREEK WATERSHED MANAGEMENT MASTERPLAN
EXISTING CONDITIONS LEVEL OF SERVICE ANALYSIS

LEGEND

[shaded box] Minimum Acceptable Level of Service Not Met

SUBBASIN	CONVEYANCE-WAY	STRUCTURE FLOODING ELEVATION, ft (NAVD 88)	STREET FLOODING ELEVATION, ft (NAVD 88)	24-HOUR DURATION DESIGN STORM MAXIMUM FLOOD ELEVATION, ft NAVD 88				FLOODING LEVEL OF SERVICE PROVIDED	
				STRUCTURE		STREET			
				25-YR	100-YR	25-YR	100-YR	25-YR	100-YR
500000	NA	N/A	N/A	N/A	N/A	N/A	N/A	O	O
500030	YES	31.54	30.12	29.79	31.9	29.75	31.87	A	D
500040	YES	29.83	N/A	29.94	31.99	N/A	N/A	O	D
500050	YES	30.71	31.87	30.12	32.1	30.62	32.41	A	D
500051	NO	32.85	31.44	31.16	32.14	31.16	32.14	A	C
500053	NO	31.58	35.91	30.21	32.14	30.21	32.14	A	D
500060	YES	30.82	35.93	30.78	32.48	30.98	32.65	A	D
500070	YES	29.74	29.9	31.26	32.9	31.25	32.89	D	D
500080	NO	29.61	29.87	31.27	32.91	31.27	32.91	D	D
505000	YES	32.74	34.08	31.33	32.95	31.34	32.95	A	D
505003	NA	N/A	N/A	N/A	N/A	N/A	N/A	O	O
505010	NO	35.81	34.09	33.15	33.4	33.15	33.4	A	A
505020	NO	42.45	39.85	34.2	34.5	34.2	34.5	A	A
505030	YES	43.31	43.75	38.37	38.82	37.91	38.44	A	A
505040	NO	51.34	48.23	38.41	38.84	38.41	38.84	A	A
505050	NO	42.32	41.34	38.3	38.7	38.3	38.7	A	A
505051	NA	N/A	N/A	N/A	N/A	N/A	N/A	O	O
505060	YES	41.87	42.55	36.92	37.5	38.03	38.62	A	A
505080	NO	43.48	42.45	41.93	41.97	41.93	41.97	A	A
505090	YES	42.34	N/A	42.21	42.85	N/A	N/A	O	D
505100	NO	44.83	43.4	43.8	43.99	43.8	43.99	B	C
505110	NA	N/A	N/A	N/A	N/A	N/A	N/A	O	O
505120	NO	49.64	48.85	49.2	49.29	49.2	49.29	B	B
505140	NO	43.81	42.11	43.77	44.34	43.77	44.34	D	D
505150	NO	43.9	43.71	43.07	43.77	43.07	43.77	A	A
505160	YES	N/A	43.73	N/A	N/A	44.29	45.07	C	D
505170	YES	43.82	N/A	44.1	44.41	N/A	N/A	O	D
505190	NO	44.24	45.4	44.42	44.92	44.42	44.92	D	D
505210	NO	45.45	44.49	45.61	45.77	45.61	45.77	D	D
505220	YES	46.43	N/A	44.3	45.09	N/A	N/A	O	A
505230	NO	44.51	43.73	44.34	45.1	44.34	45.1	C	D
505240	NO	47.4	48.88	46.62	46.79	46.62	46.79	A	A
505250	NA	N/A	N/A	N/A	N/A	N/A	N/A	O	O
505260	NO	47.72	44.28	46.32	46.76	46.32	46.76	D	D
505265	NO	45.18	45.3	43.37	44.26	43.37	44.26	A	A
505270	NO	45.83	46.55	43.72	44.73	43.72	44.73	A	A
505290	NO	47.31	48.29	47.84	48.26	47.84	48.26	D	D
505295	YES	N/A	48.29	N/A	N/A	48.46	48.54	A	B
505310	NO	49.45	48.21	48.05	48.73	48.05	48.73	A	C
505320	NO	48.9	49.51	47.18	48.75	47.18	48.75	A	A
505330	NA	N/A	N/A	N/A	N/A	N/A	N/A	O	O
505340	NO	53.13	52.48	49.2	51.06	49.2	51.06	A	A
505350	NO	45.4	45.34	44.59	45.97	44.59	45.97	A	D
505360	NO	47.67	48.76	45.13	46.57	45.13	46.57	A	A

TABLE 6.6-1
UPDATE OF CYPRESS CREEK WATERSHED MANAGEMENT MASTERPLAN
EXISTING CONDITIONS LEVEL OF SERVICE ANALYSIS

LEGEND

(shaded box) Minimum Acceptable Level of Service Not Met

SUBBASIN	CONVEYANCE-WAY	STRUCTURE FLOODING ELEVATION, ft (NAVD 88)	STREET FLOODING ELEVATION, ft (NAVD 88)	24-HOUR DURATION DESIGN STORM MAXIMUM FLOOD ELEVATION, ft NAVD 88				FLOODING LEVEL OF SERVICE PROVIDED	
				STRUCTURE		STREET			
				25-YR	100-YR	25-YR	100-YR	25-YR	100-YR
505370	NO	44.87	48.81	45.68	47.26	45.68	47.26	D	D
505380	NO	50.43	46.46	45.74	47.28	45.74	47.28	A	C
505390	YES	N/A	47.43	N/A	N/A	48.27	48.36	C	C
505400	NO	47.05	47.01	47.3	47.36	47.3	47.36	D	D
505410	NO	48.13	47.66	48.29	48.39	48.29	48.39	D	D
505420	YES	51.46	N/A	48.76	48.92	N/A	N/A	O	A
505430	NO	49.44	51.3	50.12	50.3	50.12	50.3	D	D
505440	NO	49.04	48.66	45.84	47.43	45.84	47.43	A	A
505450	NO	46.38	51.21	47.47	47.88	47.47	47.88	D	D
505460	NO	52.96	50.58	48.92	50.24	48.92	50.24	A	A
505465	YES	53.54	N/A	50.64	51.05	N/A	N/A	O	A
505470	NA	N/A	N/A	N/A	N/A	N/A	N/A	O	O
505480	YES	49.7	N/A	48.93	50.27	N/A	N/A	O	D
505490	YES	N/A	50.47	N/A	N/A	50.32	50.47	A	A
505510	NO	52.89	52.9	48.97	50.27	48.97	50.27	A	A
505520	NA	N/A	N/A	N/A	N/A	N/A	N/A	O	O
505530	YES	N/A	53.91	N/A	N/A	48.77	50.18	A	A
505540	NO	51.04	49.77	48.77	49.93	48.77	49.93	A	A
505550	NA	N/A	N/A	N/A	N/A	N/A	N/A	O	O
505560	YES	N/A	55.42	N/A	N/A	48.22	48.42	A	A
505580	YES	51.18	N/A	49.1	50.26	N/A	N/A	O	A
505590	NO	52.07	52.78	50.84	52.25	50.84	52.25	A	D
505600	NO	60.75	53.54	54.59	55.64	54.59	55.64	D	D
505610	NO	53.73	52.76	49	50.3	49	50.3	A	A
505620	NO	50.86	49.96	49.63	50.31	49.63	50.31	A	B
505630	YES	48.91	N/A	49.74	50.3	N/A	N/A	O	D
505660	NO	51.04	50.56	48.4	49.35	48.4	49.35	A	A
505670	NO	51.91	51.27	49.78	51.06	49.78	51.06	A	A
505680	YES	53.4	N/A	49.59	50.96	N/A	N/A	O	A
505690	NO	53.32	52.8	53.03	53.1	53.03	53.1	A	B
505700	NO	53.08	59.72	53.44	53.72	53.44	53.72	D	D
505710	NO	59.68	54.39	52.97	53.32	52.97	53.32	A	A
505820	NO	40.73	39.53	37.88	38.13	37.88	38.13	A	A
505830	NO	41.63	40.27	40.72	40.98	40.72	40.98	B	C
505870	NO	42.26	47.95	41.71	42.16	41.71	42.16	A	A
505900	NO	51.19	47.12	49.26	49.74	49.26	49.74	D	D
505910	NO	48.18	47.15	47.1	47.83	47.1	47.83	A	C
505930	NA	N/A	N/A	N/A	N/A	N/A	N/A	O	O
505940	NO	56.76	53.97	52.95	53.6	52.95	53.6	A	A
505950	NO	52.34	51.35	51.38	51.45	51.38	51.45	A	A
505960	NO	48.29	48.21	46.96	47.9	46.96	47.9	A	A
505970	YES	55.12	N/A	46.26	47.62	N/A	N/A	O	A
505980	NA	N/A	N/A	N/A	N/A	N/A	N/A	O	O
505990	NO	55.55	58.65	49.97	51.28	49.97	51.28	A	A

TABLE 6.6-1
UPDATE OF CYPRESS CREEK WATERSHED MANAGEMENT MASTERPLAN
EXISTING CONDITIONS LEVEL OF SERVICE ANALYSIS

LEGEND

(shaded) Minimum Acceptable Level of Service Not Met

SUBBASIN	CONVEYANCE-WAY	STRUCTURE FLOODING ELEVATION, ft (NAVD 88)	STREET FLOODING ELEVATION, ft (NAVD 88)	24-HOUR DURATION DESIGN STORM MAXIMUM FLOOD ELEVATION, ft NAVD 88				FLOODING LEVEL OF SERVICE PROVIDED	
				STRUCTURE		STREET			
				25-YR	100-YR	25-YR	100-YR	25-YR	100-YR
506000	NO	56.04	53.79	52.55	52.81	52.55	52.81	A	A
506010	NO	52.81	52.68	50.54	51.75	50.54	51.75	A	A
506020	NO	53.06	58.44	50.54	51.75	50.54	51.75	A	A
506030	NO	55.51	62.17	53.93	54.84	53.93	54.84	A	A
506040	NO	53.95	59.58	53.93	54.84	53.93	54.84	A	D
506050	NO	56.72	58.69	51.73	53.49	51.73	53.49	A	A
506060	YES	57.41	N/A	51.54	53.36	N/A	N/A	O	A
506070	YES	56.37	N/A	55.17	56.54	N/A	N/A	O	D
506080	NO	57.91	58.15	50.13	51.28	50.13	51.28	A	A
506085	NO	58.32	57.15	56.11	56.95	56.11	56.95	A	A
506090	NA	N/A	N/A	N/A	N/A	N/A	N/A	O	O
506100	YES	57.44	N/A	51.09	52.74	N/A	N/A	O	A
510000	YES	34.59	35.67	31.34	32.95	32.03	33.41	A	A
510010	YES	N/A	43.08	N/A	N/A	35.01	35.38	A	A
510020	NA	N/A	N/A	N/A	N/A	N/A	N/A	O	O
510030	YES	51.95	41.94	39.39	40.23	35.39	36.08	A	A
510040	YES	52.12	47.87	40.26	41.11	41.25	42.25	A	A
510050	YES	52.37	48.23	43.16	44.35	41.27	42.3	A	A
510060	YES	52.92	51.55	45.93	47.17	45.68	46.95	A	A
510070	NO	56.07	57.46	52.11	52.66	52.11	52.66	A	A
510080	YES	N/A	57.93	N/A	N/A	52.11	52.84	A	A
510090	NO	55.12	54.38	55	55.84	55	55.84	C	D
510100	NO	56.34	56.78	55	55.84	55	55.84	A	A
510110	NO	58.01	57.28	55.9	56.1	55.9	56.1	A	A
510120	NO	59.42	57.45	57.85	57.99	57.85	57.99	B	C
510130	NO	57.14	58.07	53.42	55.75	53.42	55.75	A	A
510140	YES	51.73	52.1	46.77	47.9	46.61	47.75	A	A
510150	YES	52.35	51.44	47.8	49.53	51.03	52.27	A	C
510170	YES	51	51.45	51.62	52.4	51.48	52.32	D	D
510180	YES	54.5	56.03	52.05	52.97	52.11	53.03	A	A
510190	YES	55.71	N/A	53.72	54.26	N/A	N/A	O	A
510200	NA	N/A	N/A	N/A	N/A	N/A	N/A	O	O
510210	YES	58.45	N/A	53.67	54.19	N/A	N/A	O	A
510220	NO	55.51	56.93	55.18	55.8	55.18	55.8	A	D
510230	NO	59.13	59.35	57.07	58.11	57.07	58.11	A	A
510240	NO	59.15	58.72	57.07	58.11	57.07	58.11	A	A
510250	NO	59.34	59.44	57.46	58.87	57.46	58.87	A	A
510260	YES	56.85	54.4	53.71	54.27	53.75	54.3	A	A
510270	YES	55.51	57.25	54.19	54.84	54.56	55.24	A	A
510340	NA	N/A	N/A	N/A	N/A	N/A	N/A	O	O
510350	YES	56.1	58.55	54.51	55.23	54.75	55.46	A	A
510360	YES	56.12	56.7	54.53	55.24	54.03	54.76	A	A
510370	NO	59.15	57.17	55.77	56.76	55.77	56.76	A	A
510380	YES	57.79	57.44	55.85	56.73	54.82	55.62	A	A

TABLE 6.6-1
UPDATE OF CYPRESS CREEK WATERSHED MANAGEMENT MASTERPLAN
EXISTING CONDITIONS LEVEL OF SERVICE ANALYSIS

LEGEND

[shaded box] Minimum Acceptable Level of Service Not Met

SUBBASIN	CONVEYANCE-WAY	STRUCTURE FLOODING ELEVATION, ft (NAVD 88)	STREET FLOODING ELEVATION, ft (NAVD 88)	24-HOUR DURATION DESIGN STORM MAXIMUM FLOOD ELEVATION, ft NAVD 88				FLOODING LEVEL OF SERVICE PROVIDED	
				STRUCTURE		STREET			
				25-YR	100-YR	25-YR	100-YR	25-YR	100-YR
510390	YES	59.67	N/A	56.04	56.78	N/A	N/A	O	A
510400	NO	57.89	56.14	56.54	57.44	56.54	57.44	B	D
510410	NO	61.63	59.46	56.82	57.44	56.82	57.44	A	A
510420	NO	58.72	58.82	59.06	59.19	59.06	59.19	D	D
510430	NA	N/A	N/A	N/A	N/A	N/A	N/A	O	O
510440	NA	N/A	N/A	N/A	N/A	N/A	N/A	O	O
510450	NO	59.4	59.49	58.45	59.07	58.45	59.07	A	A
510460	NO	60.19	57.91	56.92	58.08	56.92	58.08	A	A
510470	YES	60.56	N/A	58.69	59.29	N/A	N/A	O	A
510480	NO	61.31	59.88	58.81	59.95	58.81	59.95	A	A
510490	NA	N/A	N/A	N/A	N/A	N/A	N/A	O	O
510500	YES	60.23	N/A	58.58	58.87	N/A	N/A	O	A
510510	YES	59.87	N/A	58.46	59.09	N/A	N/A	O	A
510520	YES	60.64	N/A	59.17	59.38	N/A	N/A	O	A
510530	NA	N/A	N/A	N/A	N/A	N/A	N/A	O	O
510540	YES	62.28	N/A	55.31	59.25	N/A	N/A	O	A
510550	YES	62.25	N/A	58.99	59.5	N/A	N/A	O	A
510560	NO	60.03	59.39	59.59	59.67	59.59	59.67	A	B
510570	YES	N/A	61.64	N/A	N/A	58.7	59.3	A	A
510580	YES	N/A	61.34	N/A	N/A	59.48	59.85	A	A
510590	YES	N/A	60.9	N/A	N/A	60.22	60.93	A	A
510600	NO	60.72	64.12	60.97	61.19	60.97	61.19	D	D
510630	NA	N/A	N/A	N/A	N/A	N/A	N/A	O	O
510640	NO	64.86	66.3	62.05	62.84	62.05	62.84	A	A
510650	NO	63.61	63.86	61.24	61.86	61.24	61.86	A	A
510660	YES	N/A	65.89	N/A	N/A	63.02	64.57	A	A
510670	NO	67.04	65.29	66.46	66.54	66.46	66.54	D	D
510680	NO	66.07	65.89	63.68	64.68	63.68	64.68	A	A
510690	NO	68.2	63.76	63.17	63.71	63.17	63.71	A	A
510700	YES	61.78	63.72	61.39	61.94	61.37	61.92	A	D
510730	NO	64.13	64.04	62.06	62.64	62.06	62.64	A	A
510745	NA	N/A	N/A	N/A	N/A	N/A	N/A	O	O
510750	NO	62.76	61.29	62.05	62.84	62.05	62.84	C	D
510770	NO	64.35	63.93	62.56	63.32	62.56	63.32	A	A
510780	NO	65.04	63.99	62.59	63.35	62.59	63.35	A	A
510790	NO	66.17	64.68	62.61	63.36	62.61	63.36	A	A
510800	NO	66.74	64.16	64.06	64.65	64.06	64.65	A	B
510810	NO	66.69	65.22	62.23	63.63	62.23	63.63	A	A
510820	NO	66.76	65.16	63.38	63.61	63.38	63.61	A	A
510830	NO	62.69	66.09	63.02	63.6	63.02	63.6	D	D
510840	NO	68.96	70.64	64.93	65.76	64.93	65.76	A	A
510860	NO	68.59	69.12	66.2	67.06	66.2	67.06	A	A
510870	YES	N/A	70.91	N/A	N/A	68.93	69.19	A	A
510880	NO	70.72	69.28	63.28	64.08	63.28	64.08	A	A

TABLE 6.6-1
UPDATE OF CYPRESS CREEK WATERSHED MANAGEMENT MASTERPLAN
EXISTING CONDITIONS LEVEL OF SERVICE ANALYSIS

LEGEND

(shaded) Minimum Acceptable Level of Service Not Met

SUBBASIN	CONVEYANCE-WAY	STRUCTURE FLOODING ELEVATION, ft (NAVD 88)	STREET FLOODING ELEVATION, ft (NAVD 88)	24-HOUR DURATION DESIGN STORM MAXIMUM FLOOD ELEVATION, ft NAVD 88				FLOODING LEVEL OF SERVICE PROVIDED	
				STRUCTURE		STREET			
				25-YR	100-YR	25-YR	100-YR	25-YR	100-YR
510890	YES	N/A	67.08	N/A	N/A	65.92	66.12	A	A
510900	NO	70.85	71.76	70.51	70.91	70.51	70.91	A	D
510910	NO	68.96	70.75	64.09	65.05	64.09	65.05	A	A
510930	NO	69.87	67.72	66.05	66.49	66.05	66.49	A	A
510940	NO	69.99	68.76	67.13	67.51	67.13	67.51	A	A
510950	NA	N/A	N/A	N/A	N/A	N/A	N/A	O	O
512500	YES	N/A	40.83	N/A	N/A	34.73	34.98	A	A
512520	NO	54.74	53.82	51.7	53.49	51.7	53.49	A	A
512600	YES	N/A	40.36	N/A	N/A	34.81	35.05	A	A
512690	NO	55.59	55.61	56.6	56.92	56.6	56.92	D	D
512700	YES	N/A	60.88	N/A	N/A	60.39	60.54	A	A
512710	NO	57.74	56.15	56.6	56.92	56.6	56.92	B	C
512720	NO	57.99	55.77	56.6	56.93	56.6	56.93	C	D
512730	NO	57.45	55.37	56.65	57.16	56.65	57.16	D	D
512740	NO	57.51	57.08	56.73	57.12	56.73	57.12	A	A
512750	NA	N/A	N/A	N/A	N/A	N/A	N/A	O	O
512760	YES	62.44	N/A	57.84	58.4	N/A	N/A	O	A
512770	NO	57.87	56.38	56.53	57.62	56.53	57.62	A	D
512780	NO	57.72	56.35	56.53	57.62	56.53	57.62	A	D
512790	YES	57.58	N/A	56.53	57.6	N/A	N/A	O	D
512800	NO	58.03	58.8	58.99	59.18	58.99	59.18	D	D
512810	NO	59.76	59.61	59.13	59.55	59.13	59.55	A	A
512820	NO	57.78	59.44	57.84	58.44	57.84	58.44	D	D
512830	NO	57.89	58.07	57.84	58.45	57.84	58.45	A	D
512840	YES	58.33	N/A	57.28	57.41	N/A	N/A	O	A
512850	NO	60.53	62.02	60.04	60.7	60.04	60.7	A	D
513220	NO	55.95	56.56	56.62	56.7	56.62	56.7	D	D
513500	NA	N/A	N/A	N/A	N/A	N/A	N/A	O	O
513550	NA	N/A	N/A	N/A	N/A	N/A	N/A	O	O
513560	NA	N/A	N/A	N/A	N/A	N/A	N/A	O	O
513570	NA	N/A	N/A	N/A	N/A	N/A	N/A	O	O
513580	YES	N/A	40.13	N/A	N/A	35.15	35.44	A	A
520000	YES	N/A	40.41	N/A	N/A	35.26	35.54	A	A
520090	NO	57.56	57.9	57	57.33	57	57.33	A	A
520100	NO	59.64	61.26	55.91	57.83	55.91	57.83	A	A
520120	NO	57.11	57.53	57.91	58.18	57.91	58.18	D	D
520122	YES	61.89	N/A	61.06	61.19	N/A	N/A	O	A
520124	NA	N/A	N/A	N/A	N/A	N/A	N/A	O	O
520128	NO	64.3	64.25	61.17	61.32	61.17	61.32	A	A
520130	NO	57.19	57.55	57.91	58.19	57.91	58.19	D	D
520140	NO	58.28	58.48	57.94	58.25	57.94	58.25	A	A
520170	NO	56.88	56.15	57.93	58.25	57.93	58.25	D	D
520180	NO	57.45	58.81	57.94	58.27	57.94	58.27	D	D
520190	YES	58.54	N/A	58.64	58.79	N/A	N/A	O	D

TABLE 6.6-1
UPDATE OF CYPRESS CREEK WATERSHED MANAGEMENT MASTERPLAN
EXISTING CONDITIONS LEVEL OF SERVICE ANALYSIS

LEGEND

[shaded cell] Minimum Acceptable Level of Service Not Met

SUBBASIN	CONVEYANCE-WAY	STRUCTURE FLOODING ELEVATION, ft (NAVD 88)	STREET FLOODING ELEVATION, ft (NAVD 88)	24-HOUR DURATION DESIGN STORM MAXIMUM FLOOD ELEVATION, ft NAVD 88				FLOODING LEVEL OF SERVICE PROVIDED	
				STRUCTURE		STREET			
				25-YR	100-YR	25-YR	100-YR	25-YR	100-YR
520200	NO	59.04	58.83	59.55	59.8	59.55	59.8	D	D
520210	NO	60.53	59.24	60.52	60.78	60.52	60.78	D	D
520230	YES	59.91	N/A	56.72	58	N/A	N/A	O	A
520240	NO	59.84	63.42	56.52	57.05	56.52	57.05	A	A
520250	YES	61.41	60.12	58.28	58.88	58.22	58.81	A	A
520252	NA	N/A	N/A	N/A	N/A	N/A	N/A	O	O
520270	YES	63.91	N/A	60.17	60.83	N/A	N/A	O	A
520272	NA	N/A	N/A	N/A	N/A	N/A	N/A	O	O
520290	YES	61.3	62.85	60.89	61.48	61.68	62.28	A	D
520300	NO	63.42	62.51	60.88	61.48	60.88	61.48	A	A
520310	NO	62.12	63.33	60.87	61.47	60.87	61.47	A	A
520330	NO	64.55	63.19	62.52	63.17	62.52	63.17	A	A
520340	NO	63.43	63.16	62.75	63.25	62.75	63.25	A	A
520540	YES	N/A	41.02	N/A	N/A	37.87	38.22	A	A
520600	NA	N/A	N/A	N/A	N/A	N/A	N/A	O	O
520610	NA	N/A	N/A	N/A	N/A	N/A	N/A	O	O
530000	YES	N/A	43.06	N/A	N/A	36.16	36.67	A	A
530010	NO	57.8	36.63	37.51	38.23	37.51	38.23	C	D
530020	YES	N/A	36.96	N/A	N/A	37.53	38.25	C	D
530040	NO	54.45	55.37	51.32	51.43	51.32	51.43	A	A
530050	YES	53.93	N/A	44.07	44.5	N/A	N/A	O	A
530060	YES	55.4	58.5	51.14	51.97	51.84	52.38	A	A
530070	NO	59.07	58.87	58.02	58.68	58.02	58.68	A	A
530080	YES	59.35	56.91	54.16	54.84	56.36	56.99	A	A
530100	YES	57.08	57.02	57.04	57.56	56.85	57.4	A	D
530110	YES	58.17	60.64	57.1	57.63	57.9	58.91	A	A
530120	YES	59.57	60.01	57.2	57.74	57.97	59.07	A	A
530140	NO	60.77	59.1	58.78	59.68	58.78	59.68	A	C
530150	YES	59.26	60.18	58.63	59.76	58.17	59.46	A	D
530160	NO	59.45	59.18	59.35	59.91	59.35	59.91	A	D
530180	NO	62.96	62.54	61.31	61.47	61.31	61.47	A	A
530200	NO	63.33	61.71	63.82	64.35	63.82	64.35	D	D
530210	NO	62.22	61.52	61.63	61.79	61.63	61.79	A	B
530220	YES	N/A	64.71	N/A	N/A	63.49	63.93	A	A
530230	NO	63.15	63.15	62.39	63.18	62.39	63.18	A	D
530250	NO	66.88	63.41	63.63	63.72	63.63	63.72	A	B
530260	NO	62.58	62.26	63	63.32	63	63.32	D	D
530270	NO	64.31	62.35	63.02	63.32	63.02	63.32	C	C
530280	NO	63.49	63.35	63.02	63.32	63.02	63.32	A	A
530290	NO	63.14	61.76	61.71	62.57	61.71	62.57	A	C
530300	NO	63.87	64.17	62.4	63.19	62.4	63.19	A	A
530310	YES	N/A	65.27	N/A	N/A	62.41	63.2	A	A
530340	NA	N/A	N/A	N/A	N/A	N/A	N/A	O	O
530350	NO	66.51	64.17	62.6	63.35	62.6	63.35	A	A

TABLE 6.6-1
UPDATE OF CYPRESS CREEK WATERSHED MANAGEMENT MASTERPLAN
EXISTING CONDITIONS LEVEL OF SERVICE ANALYSIS

LEGEND

[shaded cell] Minimum Acceptable Level of Service Not Met

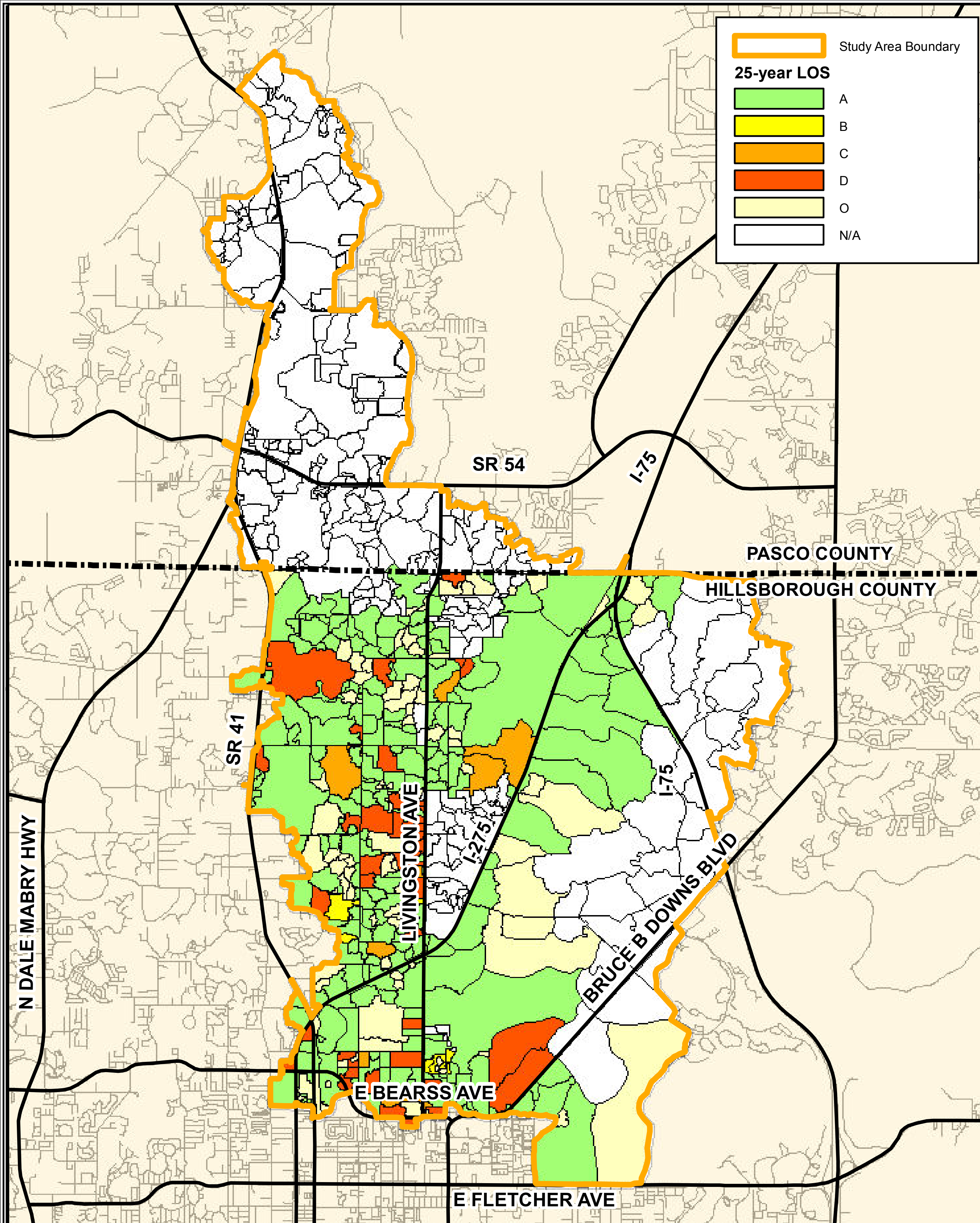
SUBBASIN	CONVEYANCE-WAY	STRUCTURE FLOODING ELEVATION, ft (NAVD 88)	STREET FLOODING ELEVATION, ft (NAVD 88)	24-HOUR DURATION DESIGN STORM MAXIMUM FLOOD ELEVATION, ft NAVD 88				FLOODING LEVEL OF SERVICE PROVIDED	
				STRUCTURE		STREET			
				25-YR	100-YR	25-YR	100-YR	25-YR	100-YR
530360	NA	N/A	N/A	N/A	N/A	N/A	N/A	O	O
530370	NO	66.18	64.53	62.71	63.34	62.71	63.34	A	A
530380	NO	64.17	64.23	62.43	63.22	62.43	63.22	A	A
530400	YES	69.5	64.22	63.5	64.18	62.91	63.98	A	A
530420	NO	62.61	65.53	64.1	64.52	64.1	64.52	D	D
530425	NO	69.33	67.99	67.01	67.31	67.01	67.31	A	A
530430	NO	66.48	64.94	64.41	65.09	64.41	65.09	A	A
530440	NO	65.19	65	64.41	65.09	64.41	65.09	A	A
530450	NO	67.69	67.21	63.77	64.96	63.77	64.96	A	A
530460	NO	70.23	70.38	64.08	65.08	64.08	65.08	A	A
530470	NO	69.3	67.1	67.3	67.81	67.3	67.81	A	C
530480	NA	N/A	N/A	N/A	N/A	N/A	N/A	O	O
530490	YES	66.93	N/A	64.41	65.1	N/A	N/A	O	A
530500	NO	66.77	66.52	64.42	65.1	64.42	65.1	A	A
530520	YES	66.75	N/A	63.83	63.98	N/A	N/A	O	A
530530	YES	65.92	N/A	64.38	65.19	N/A	N/A	O	A
530540	YES	75.66	N/A	64.38	65.19	N/A	N/A	O	A
530550	NA	N/A	N/A	N/A	N/A	N/A	N/A	O	O
530560	NA	N/A	N/A	N/A	N/A	N/A	N/A	O	O
530570	NO	66.08	65.63	62.73	63.9	62.73	63.9	A	A
530580	NO	65.75	65.45	63.51	64.17	63.51	64.17	A	A
530590	NA	N/A	N/A	N/A	N/A	N/A	N/A	O	O
530600	NA	N/A	N/A	N/A	N/A	N/A	N/A	O	O
530610	NO	65.61	64.85	61.77	62.79	61.77	62.79	A	A
530620	YES	62.75	N/A	60.61	60.78	N/A	N/A	O	A
530630	NO	64.54	64.82	60.62	60.8	60.62	60.8	A	A
530650	NO	59.8	60.76	59.27	59.47	59.27	59.47	A	A
530660	NO	60.56	61.06	59.72	60.48	59.72	60.48	A	A
530665	NO	61.59	62.69	60.66	61.16	60.66	61.16	A	A
530670	YES	N/A	61.28	N/A	N/A	59.72	60.52	A	A
530675	YES	63.05	N/A	61.12	61.37	N/A	N/A	O	A
530680	NO	60.52	59.39	59.93	60.49	59.93	60.49	C	D
530750	YES	N/A	42.97	N/A	N/A	36.55	37.07	A	A
530760	YES	N/A	43.02	N/A	N/A	36.9	37.48	A	A
530775	YES	N/A	43.79	N/A	N/A	37.24	37.86	A	A
530780	YES	N/A	38.77	N/A	N/A	38.35	39.46	A	C
530910	YES	N/A	43.81	N/A	N/A	38.19	38.67	A	A
530920	YES	N/A	38.73	N/A	N/A	38.12	38.54	A	A
530940	YES	N/A	46.02	N/A	N/A	39.57	39.84	A	A
531050	YES	43.12	43.05	37.53	38.25	37.42	38.11	A	A
531060	NO	57.96	58.39	50.57	50.65	50.57	50.65	A	A
531070	YES	56.05	N/A	55.35	55.95	N/A	N/A	O	A
531080	YES	55.5	N/A	55.2	55.95	N/A	N/A	O	D
531090	NO	58.01	58.4	57.78	58.87	57.78	58.87	A	D

TABLE 6.6-1
UPDATE OF CYPRESS CREEK WATERSHED MANAGEMENT MASTERPLAN
EXISTING CONDITIONS LEVEL OF SERVICE ANALYSIS

LEGEND

(shaded) Minimum Acceptable Level of Service Not Met

SUBBASIN	CONVEYANCE-WAY	STRUCTURE FLOODING ELEVATION, ft (NAVD 88)	STREET FLOODING ELEVATION, ft (NAVD 88)	24-HOUR DURATION DESIGN STORM MAXIMUM FLOOD ELEVATION, ft NAVD 88 — STRUCTURE 25-YR	STRUCTURE 100-YR	STREET 25-YR	STREET 100-YR	FLOODING LEVEL OF SERVICE PROVIDED 25-YR	100-YR
531100	YES	60.23	N/A	55.56	59.17	N/A	N/A	O	A
531110	NO	60.42	59.75	59.93	60.49	59.93	60.49	A	D
531120	YES	N/A	57.19	N/A	N/A	38.91	39	A	A
531130	NO	58.33	57.54	60.2	60.64	60.2	60.64	D	D
531190	NO	60.99	61.46	61	61.38	61	61.38	D	D
531200	YES	62.11	62.84	60.62	61.06	60.73	61.23	A	A
531210	NO	62.17	61.83	61.28	61.38	61.28	61.38	A	A
531220	YES	66.27	N/A	61.25	61.95	N/A	N/A	O	A
531240	NO	65.3	65.62	61.9	62.2	61.9	62.2	A	A
531250	NO	66.29	65.06	62.92	64.24	62.92	64.24	A	A
531260	YES	N/A	64.29	N/A	N/A	63.41	64.63	A	B
531270	YES	64.75	N/A	64.52	64.63	N/A	N/A	O	A
531280	YES	72.56	N/A	63.97	64.74	N/A	N/A	O	A
531290	NO	66.74	66.31	65.66	66.22	65.66	66.22	A	A
531300	YES	72.98	N/A	67.08	67.21	N/A	N/A	O	A
531310	NO	72.09	68.32	66.85	67.17	66.85	67.17	A	A
531320	NA	N/A	N/A	N/A	N/A	N/A	N/A	O	O
531350	NO	65.47	67.88	62.7	66.22	62.7	66.22	A	D
531370	NA	N/A	N/A	N/A	N/A	N/A	N/A	O	O
531380	YES	N/A	67.2	N/A	N/A	64.14	66.41	A	A
531420	YES	N/A	61.24	N/A	N/A	64.14	66.45	D	D
531500	NA	N/A	N/A	N/A	N/A	N/A	N/A	O	O
531590	NO	63.72	60.44	44.79	44.92	44.79	44.92	A	A
531610	NA	N/A	N/A	N/A	N/A	N/A	N/A	O	O
531640	YES	64.2	N/A	62.55	62.72	N/A	N/A	O	A
531750	YES	N/A	66.68	N/A	N/A	63.05	63.37	A	A
531800	YES	57.02	44.2	39.64	40.2	40.66	41.17	A	A
531810	NA	N/A	N/A	N/A	N/A	N/A	N/A	O	O
531850	NA	N/A	N/A	N/A	N/A	N/A	N/A	O	O
531860	YES	N/A	46.81	N/A	N/A	45.87	46.04	A	A
531950	YES	N/A	53.15	N/A	N/A	40.37	41.13	A	A
531960	YES	N/A	51.59	N/A	N/A	41.57	42.35	A	A
531970	YES	N/A	50.12	N/A	N/A	42.54	43.29	A	A
531980	YES	N/A	55.68	N/A	N/A	49.18	49.45	A	A
531990	NA	N/A	N/A	N/A	N/A	N/A	N/A	O	O
532000	NA	N/A	N/A	N/A	N/A	N/A	N/A	O	O
532010	YES	N/A	51.23	N/A	N/A	47.08	47.89	A	A
532020	YES	N/A	53.87	N/A	N/A	46.38	47.16	A	A
535010	NO	71.28	68.59	66.89	67.43	66.89	67.43	A	A
535020	NO	73.11	72.1	69.46	70.14	69.46	70.14	A	A
535030	NO	71.59	70.69	68.54	70.3	68.54	70.3	A	A
535035	NO	70.85	70.47	68.93	69.24	68.93	69.24	A	A
535040	NO	70.8	68.77	68.89	68.98	68.89	68.98	A	A
535200	NO	71.58	68.98	66.53	66.89	66.53	66.89	A	A



PARSONS
4925 Independence Pkwy
Suite 120
Tampa, FL 33634

0 4,000 8,000 Feet 1:96,000
0 0.25 0.5 1 Miles

Filename:	Map Date:	Prepared By:
	Jul 08, 2011	Yoav Rappaport

Date of Photography:

Figure 6.6-1

Existing Conditions Flooding 25-year Level of Services by Subbasin

Cypress Creek Watershed

Path: J:\DATA\260464_Cypress_Creek_Update_HC\GIS\Maps\MXD\Final_Report\CC_Figures_Final.mxd

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