


B-21 Watershed Management Plan

Prepared for:

County of Volusia

Volusia County
FLORIDA

Prepared by:

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Introduction

In 2008, the Volusia County Department of Public Works contracted with Environmental Consulting & Technology, Inc. (ECT) to provide engineering services for a Watershed Management Plan Update for the B-21 basin of the Spruce Creek Watershed. The flooding events of Hurricane Frances in 2004 and Tropical Storm Fay in 2008 were critical indicators of the need for a more detailed and updated watershed management plan for the B-21 area. A prior study of this basin was previously done and included as part of a 1996 report entitled "*Spruce Creek and Rose Bay Engineering Report*" by Marshall, Provost & Associates.

The goal of this study is to evaluate and identify stormwater infrastructure deficiencies and to identify and recommend capital improvement projects to address these deficiencies, with the primary goal of reducing flooding and improving water quality.

Study Area Description

The B-21 study area is in the northwestern headwaters of the Spruce Creek watershed. The 33.5 square mile basin begins slightly north of International Speedway Blvd., near the County Services Complex on Indian Lake Rd, and extends south along Tomoka Farms Rd (C.R. 415), from the Volusia County Solid Waste Facility to just south of State Road 44 (Figure 1).

The majority of the study area is located in unincorporated Volusia County. A small portion of the basin includes the City of Port Orange (a segment of the Coquina Cove subdivision and Coraci Park). The developed land use is generally low density residential, pasture lands, equestrian facilities, and a scattering of small businesses along the north–south corridor of Tomoka Farms Rd. The vast majority of the basin is undeveloped, most of which is in public ownership in the form of conservation lands west of Tomoka Farms Rd. The largest land cover type is forested, mostly pine flatwoods and mixed forested wetland, which accounts for 71% of the watershed. Wetlands account for 31% of the watershed, which includes those forested wetlands included in the preceding percentage of the forest areas.

A total of 11,016 acres or 51.5% of the watershed is located in Flood Zone “A”, the 100 year flood zone. While there is significant residential development throughout the study area within the flood zone, only a small area near the flood fringe of Spruce Creek is in Zone “AE”, where the base 100 year flood elevation is known.

Topographically, the highest elevations within the study area are 48.0 *ft* NAVD 88 (North American Vertical Datum of 1988) in the western portion, sloping generally eastward to a low of 2.3 *ft* NAVD 88 at the confluence of Spruce Creek. The B-21 Canal begins as a tributary system near Taylor Rd and extends generally to the north and west. Some of these natural tributaries have been channelized and extended to achieve better drainage of adjacent land, primarily for mosquito control purposes. Since the manmade channels and extensions of natural drainage systems were intended to drain land to reduce mosquito breeding, the capacity of these drainage features to reduce flooding is limited. This is especially true during periods of high tidal conditions in the Spruce Creek outlet to the coastal receiving waters. Other drainage conveyances include overland flow, roadside ditches, and culverts. The dominant soils within the study area are poorly drained B/D soils, which comprise 83% of the watershed. This soil type, being poorly drained, especially so during the wet season, contributes to increased flooding potential within the study area.

Data Collection and Model Development

Data collection for this project includes an inventory of primary stormwater infrastructure, and historic rainfall data from three gauge locations installed and maintained by St. Johns River Water Management District (SJRWMD), Port Orange Utilities, and a private rain station on a residential property. Other data, such as previous permits, land use and cover, soils, roads, and studies were obtained from various agencies, including SJRWMD, U. S. Geological Survey (USGS), and Volusia County.

The watershed model was developed using Inter-Connected Pond Routing (ICPR) software. ECT engineers performed an analysis for the 10-yr., 25-yr., and 100-yr., 24-hr. storm events. The watershed delineation utilized LiDAR (**Li**ght **D**etection **a**nd **R**anging) data. The LiDAR data was collected in 2006, as part of a county wide effort to perform aerial contour mapping. Field verification checks were performed by ECT engineers to ensure accuracy of data.

A total of seven sub basins were delineated for the B-21 study area. Based on these seven sub basins, a total of eight outfall locations to Spruce Creek were identified (Figure 2).

Historic information from Tropical Storm Fay (2008) was used to verify the results of the model. The average total rainfall from August 17 to August 24 was 14.7 inches (Table 1). Actual rainfall data indicated some variability in rainfall distribution from north to south, with the highest totals recorded just south of State Road 44.

Table 1. Daily Rainfall Amount for T. S. Fay in August 2008

Date (mm/DD)	08/17	08/18	08/19	08/20	8/21	08/22	08/23	08/24	Total
Rainfall 1[1] (*in*)	0.7	0.05	0.71	5.08	2.05	2.74	0.15	0.14	11.62
Rainfall 2 (*in*)	0.0	0.96	0.52	4.12	3.94	6.8	0.84	0.93	18.11
Rainfall 3 (*in*)	0.2	0.0	0.2	2.6	4.8	3.8	2.5	0.3	14.4
Average (*in*)	0.30	0.34	0.48	3.93	3.60	4.45	1.16	0.46	14.72

Note: 1. Tiger Bay gauge – SJRWMD;
2. Private rain gauge, at Rasley Rd and SR 415;
3. Shunz Road gauge – Port Orange Utilities.

Flood Problem Areas

Verification of flooding was accomplished by extensive field observations and photographic documentation by Volusia County staff and ECT field personnel. In addition, a public meeting was held on August 27, 2008 (three days after the end of T. S. Fay) which provided further information on the nature and extent of flooding in the basin.

The public comments identified 35 problem areas, including flooding of homes, properties, roads, driveways, and pastures. Other problems cited were inadequate ditch maintenance, mosquitoes, and livestock/horses in floodwaters, septic system impairment, and well malfunction.

ECT engineers identified flood problem areas as shown by the model and which were verified by field investigation. The flooding areas simulated in the 10-yr., 25-yr., and 100-yr., 24-hr. storm events are identified, analyzed, and checked for accuracy of calibration, based on known problem areas. The identification of problem areas is intended to document and characterize flooding throughout the basin. To further refine that effort in developing capital improvement projects, ECT worked with County staff to develop a flood "level of service" (LOS) rating (Table 2). This rating is designed to set standards for roads which are County maintained. The priority for capital project development is focused on addressing those areas under public maintenance authority, such as county roads and rights of ways. The development of capital project plans to address flooding on private roads would be dependent on community support for funding alternatives, such as special assessment districts.

Figure 3 shows the specific locations of level of service deficiencies, that is, areas where flooding exceeded the level of service for a particular road category (arterial, collector, or local).

Maintenance and Infrastructure

ECT inspected and surveyed all primary drainage infrastructure. Based on the field survey, there are approximately 230 pipes and culverts of various sizes, generally ranging from 18" to 36". The simulation model utilized 85 primary structures. Primary structures are those that are hydraulically significant, in terms of being near identified flooding areas and which interconnect large tributary drainage ditches or canals. Overall, the primary drainage infrastructure was determined to be in good condition. However, some structures were in need of routine maintenance, such as sediment removal. Based on field observations, the following table (Table 3) shows pipes judged to be too small to operate effectively. The table also lists those ditches that need maintenance.

Table 2. Level of Service (LOS) Rating

LOS	Description
A	Roads are free of flooding; applying mainly to arterial roads.
B	Less than half the width of the road is flooded and the maximum flooding depth is less than 3"; applies to collector roads.
C	Roads are fully flooded but the maximum flooding depth is less than 6"; applies to local residential roads.
D	Roads are fully flooded and maximum water depth exceeds 6".
F	Houses are flooded.

Table 3. Maintenance Requirements and Infrastructure Deficiencies in the Study Area

Site	Comments
Pipe under Palm Dr. north of Orange Dr.	The existing pipe does not have enough capacity to drain stormwater from west to east of Palm Dr. in large storms.
Pipe under Country Circle Dr. W near Quiet Trail Dr.	The invert of the box culvert is higher than the ditch. Water stays in the ditch for a long time. Either re-set the pipe or re-construct the ditch.
Pipe under Powerline Rd	The existing 36" pipe is too small to drain the water from west to east in large storms.
Ditch west of Mitchell Lane	The ditch needs to be cleaned.
Ditch along Meadow Lane	The ditch does not drain properly. Cleaning and outlet needed
The north-south ditch under the power line west of Palm Dr.	The ditch is too small to handle even a 10-year storm flow.
Hart Ditch	The vegetation in the ditch needs to be cleaned.
Ditch located north of Orange Dr. between Palm Dr. and Guava Dr.	The debris dumped in ditch needs to be cleaned

Capital Improvement Project Alternatives

Several capital improvement projects were evaluated based on the extent of flood reduction, land acquisition needs, ability to meet regulatory requirements, construction cost, preservation and enhancement of natural systems, water quality benefits, aquifer recharge, and public interest.

Based on the above criteria, the six projects shown in Figure 4 and summarized in Table 4, are very cost effective in achieving the desired flood reduction and are likely to meet regulatory requirements. None of the projects require the purchase of land, which is usually the most expensive and challenging portion of project planning and development. In addition, the use of public land for flood reduction while achieving environmental benefits, such as hydration of wetlands and aquifer recharge will provide added value to a project.

Table 4. Recommended Improvement Projects for B-21 Study Area

No	Improvement	Description	Pre LOS	Post LOS	Cost
1	Lakeshore Improvement	Raising Pioneer Trail and adding an additional pipe on Powerline Road	F	B	$457,800
2	Hart/Langford Improvement #1	Replacing Culverts at Spruce Creek Congregation of Jehovah's Witnesses Church	C	B	$81,300
3	Hart/Langford Improvement #2	Cleaning the Hart Ditch and adding additional culverts	C	B	$80,040
4	B-21 Canal Improvement #1	Raising Power Line Access Road and replacing Spruce Creek Circle pipe	D/F	C	$426,000
5	B-21 Canal Improvement #2	Old Daytona Road box culvert replacement	D/F	B	$266,100
6	B-21 Canal Improvement #3	Meadow Lane ditch construction	D	A	$53,280

Water Quality

Although the major focus of this management plan is to address flooding, the importance of water quality must be included in any discussion of a comprehensive stormwater management plan. When preparing a capital improvement project, a water quality component of that project must be included. The project must be designed to show a generalized water quality improvement or specifically address a pollution reduction goal. In addition, regulatory programs such as the National Pollutant Discharge Elimination System (NPDES) and Total Maximum Daily Load (TMDL) require the development of various strategies which reduce the discharge of pollutants in the watershed. Finally, the majority of grant funding and stormwater cost share programs from federal (EPA) and state (FDEP & SJRWMD) agencies are specifically designed to support water quality projects.

A portion of the B-21 basin (6.4 sq. mi.) is located in an impaired water body segment of the Spruce Creek watershed, as determined by the Florida Department of Environmental Protection. The March 2008 report "*Fecal Coliform TMDL for Spruce Creek, WBID 2674*" includes a detailed review of the water quality problem area, assessment of sources, and a determination of the TMDL. A TMDL is defined as the maximum pollutant that a water body can assimilate and still retain its designated uses. The likely pollutant sources for fecal coliform impairment in the B-21 study area are septic system impairment and animal waste (livestock, horses, pets, etc.).

In addressing the TMDL issue, Volusia County, in partnership with other stakeholders, will be involved in the process of developing a Basin Management Action Plan (BMAP). This plan will detail activities and projects which will reduce pollutant sources over time to meet the TMDL. The plan will include load reduction strategies among local stakeholders, timetables for implementation, funding sources, and other activities as identified.

According to the Spruce Creek TMDL report, the timetable for BMAP development was projected to commence in March 2009. As of this writing, FDEP has not issued a revised schedule for development of a basin management plan for WBID 2674.

Table 5. FDEP Estimated Potential Annual Fecal Coliform Loading From Various Sources For Spruce Creek WBID 2674

Source	Fecal Coliform
Septic Tanks	3.12×10^{13}
Pets	8.49×10^{14}
Cattle	4.13×10^{16}
Horses	1.88×10^{13}
Collection Systems	5.56×10^{13}

It is recommended that the county initiate a proactive approach in TMDL strategic planning. This includes activities which can be targeted to specific Best Management Practices (BMP's) which are likely to have the desired reduction of pollutant sources. The planning process will allow the county sufficient time to build a cost effective strategy to address the TMDL issue in the watershed, thus allowing for more effective transition in the development of the BMAP.

Examples of Action Planning Activities:

- Develop a septic tank inspection and monitoring program.
- Obtain updated and more detailed land use data to refine fecal coliform source identification.
- Establish BMP's for each land use, such as "animal free" pasture buffers near creeks and other drainage conveyances. The Florida Department of Agricultural and Consumer Services (DACS) has published a BMP guide for a variety of land uses.
- Target water quality monitoring to better identify sources of fecal coliform.
- Develop a public information program to educate and inform on methods to reduce pollutant sources.

A water quality specific update to the B-21 basin and other (unincorporated) portions of the Spruce Creek basin would be an effective tool in addressing the TMDL. Actions which are taken early on will be recognized as a contribution to pollutant reduction strategies in meeting the TMDL and would be incorporated into the BMAP.

Section 1 - Introduction

1.1 Background

This study represents an ongoing effort by Volusia County to identify, characterize, and periodically update information on all sixteen major watersheds that were identified within the County. The goal of such efforts is to protect water quality, reduce flooding, and promote aquifer recharge. This study will update a portion of the 1996 engineering report prepared by Marshall, Provost & Associates entitled "*Spruce Creek and Rose Bay OFW Watershed Management Plan*". This study will update several drainage units that have experienced flooding within the Spruce Creek watershed. The drainage units are generally located along Tomoka Farms Road from State Road 44 to the Volusia County Landfill.

The origin of the "B-21" designation goes back to the early days of the East Volusia County Mosquito Control District. The naming of ditches and canals was based on a geographic coverage of canals and ditches designated as "zones". The coverage begins with Zone "A" near the Flagler County line and proceeds southerly through Zone "E' to the Brevard County line. Thus "B-21" represents the location and identification number of a drainage feature of the original mosquito control ditch system within Volusia County.

Early records indicate that the first channelization of existing creeks and streams within the B-21 basin dates back to 1962. Successive efforts by the East Volusia Mosquito Control District to expand and extend the drainage system continued through the early 1970's. The goal of the mosquito control district at that time was to drain land sufficiently to prevent excessive mosquito breeding, not for the purpose of flood control. Therefore, many of the mosquito drainage systems provide limited flood protection.

The B-21 Basin has experienced rapid growth since the original Spruce Creek watershed study was completed in 1996. Although most of the current land use in the study area consists of low density residential development, the cumulative effect of such recent growth has created a greater awareness of study area issues and impacts, such as flooding and water quality. This was highlighted by the flooding events of Hurricane Frances in 2004 and Tropical Storm Fay of 2008, and their effects within this area. Consequently, Volusia County has identified this basin as an important candidate for an update to more accurately predict flood stages under a variety of storm events. This effort has been aided by the recently acquired topographic information through the use of LiDAR (Light Detecting and Ranging) technology.

This Management Plan update for the B-21 study area includes an inventory of stormwater structures, field data collection and verification, photographic documentation, permitting history review, and solicitation of comments from the public. A primary goal of the study is to identify stormwater infrastructure deficiencies and to recommend capital improvement projects to address flooding. Flooding from Hurricane Frances in 2004 and Tropical Storm Fay (T. S. Fay) in 2008 within the B-21 study area was documented by the County staff and ECT, thus allowing for an accurate inventory of flood problem areas. This documentation, both photographic and field observations, has been used for model validation. The Florida Department of Environmental Protection (FDEP) has designated a portion of the B-21 study area as being impaired for fecal coliform. Water quality improvement planning and project development will be a major component of future needs to address this impairment within the basin.

1.2 Study Area

The study area is located in the southeast quadrant of Volusia County, at the northwest corner of the Spruce Creek watershed. The study area is comprised of several basins within the Spruce Creek watershed. The B-21 Basin is the largest basin within the study area and therefore the namesake for the study area. The northern basin boundary begins north of Interstate 4 (I-4), near the County Government complex on Indian Lake Road. The study area boundary then extends southerly from the County Landfill along Tomoka Farms Road (CR 415) to State Road 44 (SR 44). The western boundary is located near Campsite Road and extends slightly east of Tomoka Farms Road to the headwaters of Spruce Creek proper, as shown on Figure 1-1. The total area encompassed by these study area boundaries is approximately 33.5 square miles.

The majority of this study area is rural and semi-rural with a land cover of upland forest and wetlands. A large part of the basin, west of Tomoka Farms Road, is in public ownership as conservation and surficial aquifer recharge land use. Land use along Tomoka Farms Road, north of Taylor Road, is predominantly low density residential. Generally, the majority of development is along the Tomoka Farms Road corridor. Land use varies from small acreage equestrian and agriculture to mixed use residential. Commercial land uses consists of a feed store, convenience store, equestrian complexes, and special event camp grounds. A medium density subdivision known as Daytona Highridge Estates is located in the northern part of the basin study area, between I-4 and U.S. Highway 92. A portion of the Volusia County government complex and an auto auction center are located at the northern extent of the basin. The majority of the study area is located within the unincorporated area of Volusia County.

The study area topography generally slopes from west to east, from a high elevation of approximately 48 ft (NAVD 88) to 2.3 ft (NAVD 88) at the confluence of Spruce Creek. In the east residential area, a connected channel network consisting mostly of farm drainage ditches and mosquito control channels conveys surface runoff to Spruce Creek, which ultimately discharges into Turnbull Bay. Spruce Creek and Turnbull Bay are both designated as Outstanding Florida Waters (OFW) and are afforded the highest level of protection by the Florida Department of Environmental Protection (FDEP).

1.3 Project Objectives

The objective of this project is to develop a watershed management plan, to evaluate and identify stormwater infrastructure deficiencies, and to recommend capital improvement projects for flooding and water quality improvement within the B-21 Basin study area. The following project tasks were designed for the study:

1.3.1. Data Acquisition and Review

In addition to collecting data from previous studies, data acquisition and review tasks also consist of documenting all existing structures and channels within the study area using Geographic Information Systems (GIS) and Global Positioning Satellite (GPS) technologies. Data collection includes:

- Locating and mapping all primary drainage infrastructures in a GIS database. The locations of structures were recorded using a GPS unit, and stored in a GIS feature class.
- Measuring the dimension of structures. Lengths of pipes and channels were measured using GPS, with pipe sizes, material and condition recorded in the field.
- Determining invert elevations and cross-sections. Upstream and downstream invert elevations of pipes were measured. Environmental Resource Permit (ERP) and as-built information was utilized, if available. Otherwise, invert information was developed from the LiDAR data if a valid LiDAR point was near the structure. However, in most cases, a LiDAR point was not available near the invert, so a field survey was performed. Channel cross-sections were determined using terrain maps.
- Data collection for rainfall and stream flow. Rainfall data from the St. Johns River Water Management District (SJRWMD) gauge at Tiger Bay, the City of Port Orange gauge station at Shunz Road, and a private rain gauge at Rasley Road and State Road 415 was used. Stream flow from the USGS stream gauge at Spruce Creek, near the community of Samsula, was used to analyze the time distribution of flow.
- Other data, such as land use and land cover, soils, road maps, etc. was obtained from the St. Johns River Water Management District (SJRWMD) and relevant Volusia County government agencies.

1.3.2. Watershed Model Development and Verification

An Inter-Connected Pond Routing (ICPR) watershed model was developed to simulate the hydrology and hydraulics of the watershed. The ICPR model has been widely used in central Florida and is approved for use by the SJRWMD and FDEP. Geographic Information System (GIS) and Arc Hydro tools were used to develop sub-basin delineation and to generate parameters for watershed modeling. Since no stream gauges exist within the study area, the model was calibrated and validated by using reported flood elevations of T. S. Fay, which caused significant flooding within the study area in 2008. The reported flood depth of this storm was used to calibrate the model.

After stormwater model calibration, flood conditions for the 10-year, 25-year, and 100-year, 24-hour storms were simulated.

1.3.3. Watershed Management Plan Development and Alternative Analysis

This task evaluates alternatives to alleviate the flooding problems identified by the modeling, and which were verified by residents and County personnel. These alternatives were evaluated for their ability to reduce flooding, with project considerations including cost, land acquisition needs, ability to meet regulatory requirements, constructability, preservation of natural systems, water quality, and public interest.

1.3.4. Recommendations for Capital Improvement Projects

Recommendation of structural and non-structural improvements to alleviate problems are made, and cost estimates presented for each improvement. These proposed improvements were presented for review and comment by Volusia County staff and incorporated into a list of proposed public improvement projects for capital expenditure.

Section 2 - Data Review and Evaluation

2.1 Introduction

The B-21 Basin study area is primarily a rural area, with about 40% covered by forest and 31% covered by wetlands. Development is primarily located in the eastern and northern sections of the study area, generally along the north-south alignment of Tomoka Farms Road (C.R. 415), where low and medium density residential, small patches of commercial lots, and retail businesses are found. Topographically, the highest elevation is 48.0 *ft* NAVD 88 in the western portion, sloping easterly to the low of 2.3 *ft* NAVD 88 at the confluence of Spruce Creek. The undeveloped areas are generally located in the western portions of the study area, most of which is in public ownership as conservation lands. Historically, to control flooding, a man-made canal network, comprising a total of approximately 20 miles in length, has been built to work together with the existing natural channels to convey surface runoff into Spruce Creek. Many of these man-made systems are extensions of existing natural creeks and tributaries, modified to provide additional drainage of adjacent lands. The dominant soils are poorly drained, hydrologic B/D soils, which contributes to their increased flooding potential within the study area.

During T. S. Fay, in August 2008, several road and street sections were closed and several residences were flooded. Rainfall analysis shows the total accumulated rainfall during Fay was 11.62 inches at the Tiger Bay gauge, and 18.11 inches at the rain station near the intersection of S.R. 415 and Rasley Road, just south of the study area boundaries.

Comparing the maps of the FEMA floodplain and land use/land cover in the study area, it is noted that the FEMA floodplain is predominately wetlands, with some scattered commercial and residential areas located within the floodplain. The current FEMA floodplain boundaries were set mainly through existing elevation and land cover (such as wetlands), and are largely lacking the establishment of a base flood elevation, except in those areas within the main channel of the canal. A more accurate FEMA flood map could be developed based on a specific flood plain map amendment process.

Stream flow data from the USGS stream gauge at Spruce Creek near Samsula (Figure 2-1) was used to analyze the stream flow pattern. This data shows that stream flow is most concentrated in August, September, and October, with discharge from these three months making up more than half of the annual total discharge. The highest discharges occur in September, at three times the annual average discharge, and the lowest discharges occur in May. Historical rainfall analysis shows that June, July, August, and September have an approximately equal amount of rainfall over this wet season period.

To fully understand the drainage network of the study area, ECT conducted a thorough field investigation using LiDAR data, field data from the *Spruce Creek Master Plan,* GPS infrastructure locates, information from Environmental Resource Permits (ERP's), as-built information, and other relevant sources of information. Data from six ERP's and as-built permits were utilized.

Culverts and open channel networks comprise the man-made drainage system of the study area. Field investigation and survey indicated a total of 73 culverts and 20 miles of major ditches and canals within the study area, with most of these culverts located in either the eastern or northern portions of the study area.

As a result of the above data review and field investigation, the B-21 Canal study area was divided into seven separate basins with a total of eight discharge outlets. These outlets were modeled and calibrated for model validation.

2.2 Rainfall Data

A rain gauge operated and maintained by the SJRWMD is located in the north boundary of the study area (Figure 2-1). This gauge (No. 05190117 Tiger Bay at Tomoka Fire Tower) started recording rainfall in March 1999. Figure 2-2 presents daily rainfall amounts at this gauge location, for the period from 1999 through the end of 2008. This gauge recorded a maximum daily rainfall event of 7.85 inches on September 05, 2004. When T. S. Fay hit central Florida, the total rainfall at this gauge location over a period of eight days (August 17 - 24) was 11.6 inches, with over five inches of that total recorded on one day (August 20). Fay caused significant flooding within the study area, with several sections of roads closed and seven houses reported to be flooded. For the period from 1999 to 2008, there were five rain events in which daily rainfall exceeded five inches.

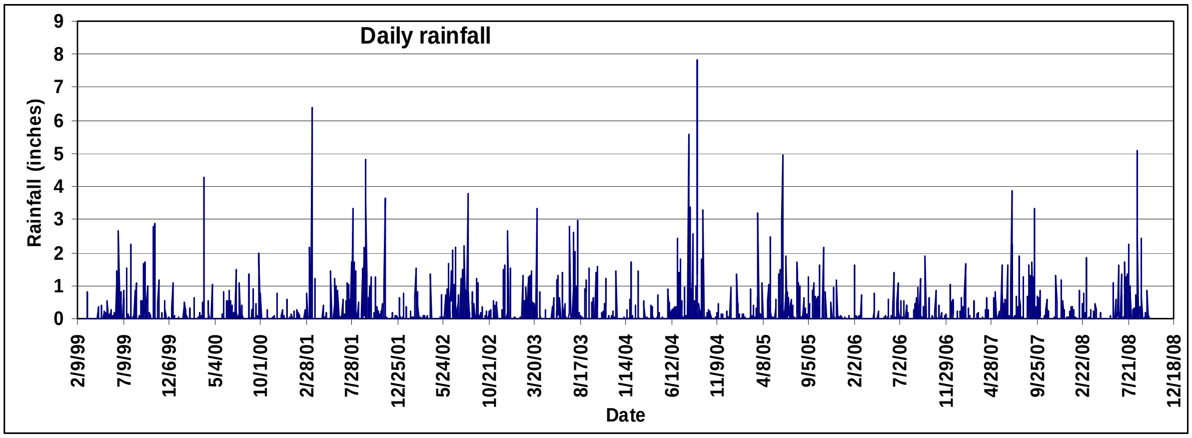

Figure 2-2. Daily Rainfall, 1999 to 2008, USGS Rain Gauge at Tiger Bay

Figure 2-3 presents both annual and monthly statistics for rainfall at the Tiger Bay location. In the period from 1999 through 2008, annual rainfall is shown to have varied from 28 inches to 68 inches. These records indicate that in the five year period of 2001 through 2005, annual rainfall was above normal.

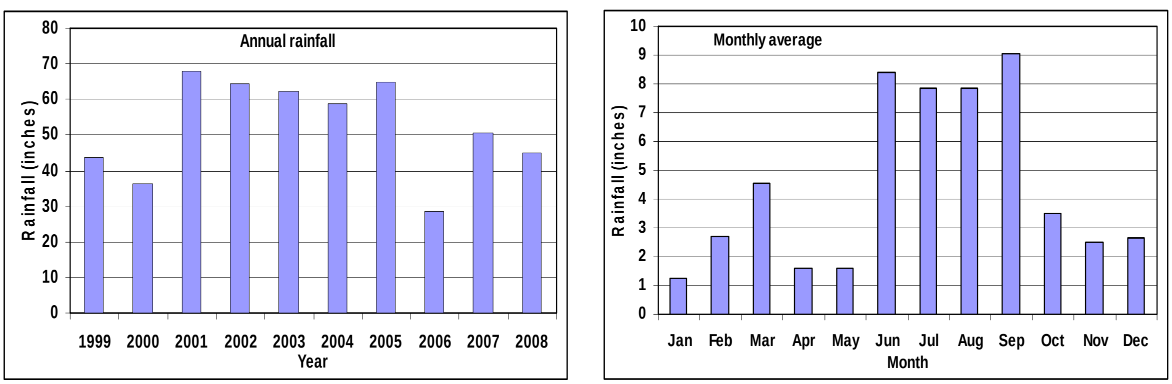

Figure 2-3. Statistics of Annual Rainfall and Monthly Average Rainfall 1999 to 2008, at USGS Rain Gauge at Tiger Bay State Forest

Within the year, rainfall is shown to be most concentrated from June through September, with rainfall in those four months totaling 62% of the annual total rainfall. The least amount of rainfall occurs in January, averaging only 1.3 inches rainfall. April and May, which proceed the “wet season” actually receive only a little more rainfall than January, which underscores the sometimes dramatic shifts in rainfall pattern in central Florida. According to the SJRWMD, the mean annual 24-hour maximum rainfall within the study area is 4.7 inches. For 24-hour duration storms, the 10-year, 25-year, and 100-year maximum rainfall are 7.3, 8.8, and 12.0 inches, respectively.

2.3 Flow and Stages

Only one United States Geological Survey (USGS) stream gauge is found near the study area. This gauge number is located on the downstream side of the Pioneer Trail (CR 4118) bridge over Spruce Creek (USGS # 02248000), about two miles north of the community of Samsula. This gauge measures a drainage area of 33.4 square miles. These are stream gauge records at this location which date to May 1951, and it remains in active operation.

Figure 2-4 presents the annual statistics of discharge from 1952 to 2007 at this USGS stream gauge. The average annual discharge at this location is 31.6 *cfs*. The maximum annual discharge of 72.9 *cfs* occurred in 1964, and the minimum annual discharge is 2.9 *cfs*, occurring in 1981. Figure 2-4 shows a declining trend in this annual discharge.

The annual peak stream flow generally varied between 300 *cfs* and 800 *cfs*, with only two peak flows exceeding 1000 *cfs*. The largest peak flow (1610 *cfs*.) occurred in September 1964 with the second largest peak flow (1070 *cfs*) occurring in September 1979.

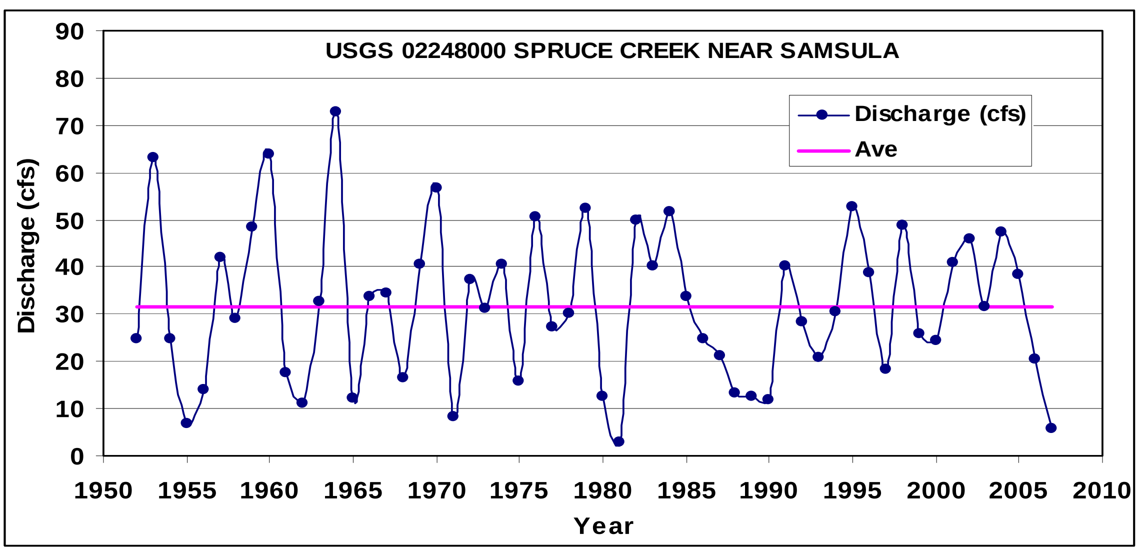

Figure 2-4. Annual Variation of Stream Discharge at USGS Spruce Creek Stream Gauge Station.

Figure 2-5 presents monthly distribution of discharges at this location. The period of August to October generally produces the highest discharge. Discharges in September average 95 *cfs*, about three times the average discharge. Discharge for the period of April to June is less than the average, which corresponds as expected to the driest average rainfall period of the year. Historically, the lowest discharges occur in May, averaging 4.1 *cfs*, which is only 1/8 of the annual average.

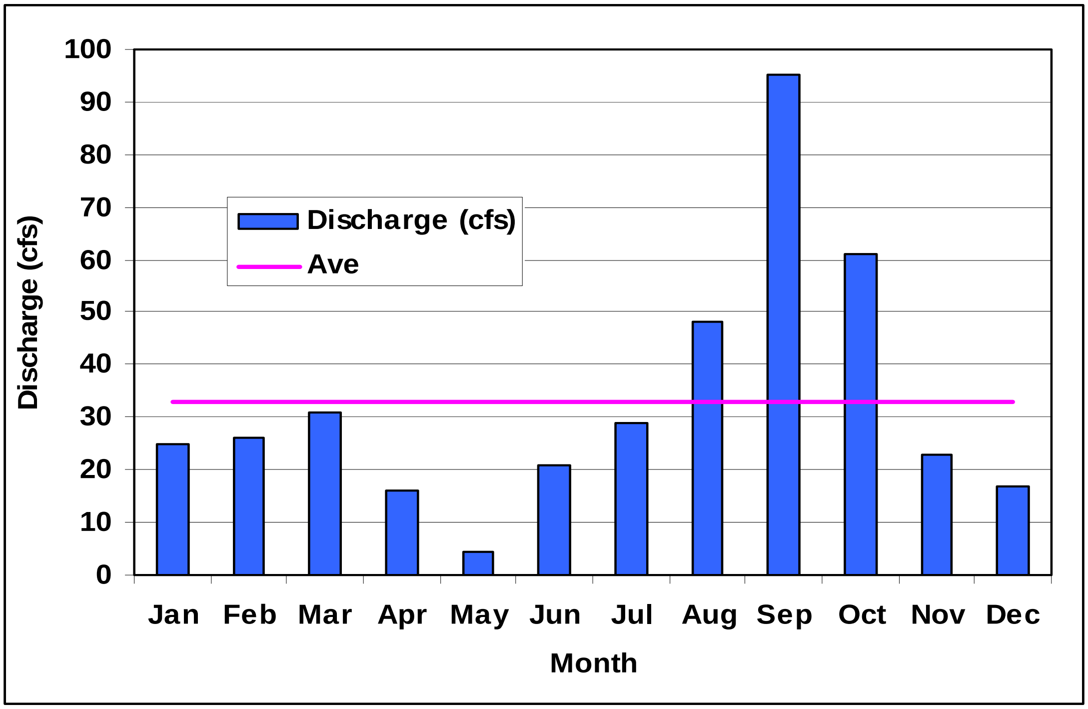

Figure 2-5. Monthly Distribution of Discharge at USGS Spruce Creek Stream Gauge Station

2.4 Soils

According to the Natural Resources Conservation Service (NRCS), there are 33 soil types found within the 33.5 square mile study area. Table 2-1 presents the area and percentage of each of these 33 soil types (in descending order) within the study area. Figure 2-6 specifically displays these soils and their location.

Soils that occupy more than 5% of the study area include Immokalee, Myakka, Pomona, Pineda, Samsula, and Malabar.

One of the most significant properties of soil is its hydrologic property, which is its ability to affect runoff. The NRCS classifies soils into four Hydrologic Soil Groups (HSG) according to their runoff potential, ranked as Groups A, B, C, and D. Group "A" soils generally have the smallest runoff potential, while Group "D" soils have the greatest runoff potential, and Groups B and C rank in order between these two extremes accordingly. The hydrologic properties of some soils change when saturated, so dual hydrologic soil classifications are used for these situations. These dual groups include Hydrologic Groups A/D, B/D, and C/D. A more detailed description of each of these soil types follows:

Hydrologic Soil Group "A" – This soil group has a high infiltration rate and low runoff potential when saturated. Soils comprising this group generally are well-drained to excessively-drained sands.

Hydrologic Soil Group "B" – This soil group has a moderate infiltration rate when saturated. This group is chiefly comprised of moderately deep to deep, moderately well-drained soils, or well-drained soils that have moderately fine texture or moderately coarse texture.

Hydrologic Soil Group "C" – This soil group has a slow infiltration rate when thoroughly wet. This group consists chiefly of those soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture.

Hydrologic Soil Group "D" – This soil group has a very slow infiltration rate and a high runoff potential. This group consists of soils having a high water table or soils that have a claypan, clay layer, or relatively impermeable material at or near the surface.

Hydrologic Soil Group "A/D" – These soils were originally Hydrologic Soil Group "D" soils but contain drainage improvements in place in an attempt to alleviate the naturally slow infiltration rate and remove standing water. In reality, A/D soils are rarely improved to the point that they act as Hydrologic Soil Group "A" soils, particularly later in the wet season.

Hydrologic Soil Group "B/D" – These soils that were originally Hydrologic Soil Group "D" soils but contain drainage improvements in place in an attempt to alleviate slow infiltration rates and remove standing water. B/D soils are rarely improved to the point that they act as Hydrologic Soil Group "B" soils, particularly late in the wet season, though the potential for improvement is greater than Hydrologic Soil Group A/D soils.

Hydrologic Soil Group "C/D" – These Soils were originally Hydrologic Soil Group "D" soils, but have drainage improvements in place in an attempt to improve their slow infiltration rate and remove some of the typical standing water. There is a much greater potential for drainage improvements with a Hydrologic Soil Group D to Hydrologic Soil Group C/D, compared to those commonly found in Groups A/D and B/D.

Figure 2-7 shows that Hydrologic Soil Groups A, B, B/D, C, C/D, and D are all found within the study area, and provides the percentage of each representative HSG. The vast majority of these are Hydrologic Group B/D soils, which cover over 83% of the study area. This B/D HSG is distributed throughout the study area, except for a small area near Spruce Creek in the east where C and D soils dominate. In addition to this Spruce Creek outlet in the east, D soil is also located within the central part of the study area, in southeast-northwest strips (as shown on Figure 2-8). The total coverage of HSG D soils is 935 acres, or 4.4% of the total study area. HSG C soils are distributed primarily in the western half of the study area, covering 5.3%. HSG C/D soils are found within the eastern half of the study area, generally in a north-south alignment, and covering 4.6% of the study area. Only 173 acres (0.8%) of A soils and 500 acres (2.3%) of B soils are found in scattered portions of the study area. The total area of open water within the study area comprises 3.5 acres.

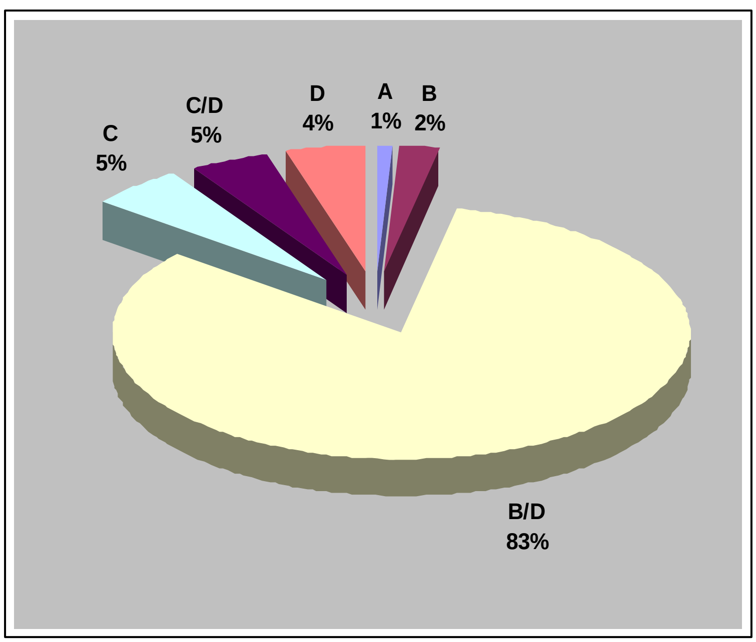

Figure 2-7. Percentage of Soil Hydrologic Groups in B-21 Basin

Table 2-1. Summary Statistics of Soil in the Study Area

Soil Name	HSG*	Area (acres)	Percentage
IMMOKALEE	B/D	3504.69	16.37
MYAKKA	B/D	2499.82	11.68
POMONA	B/D	2159.93	10.09
PINEDA	B/D	1749.29	8.17
SAMSULA	B/D	1603.46	7.49
MALABAR	B/D	1321.08	6.17
HONTOON	B/D	1013.78	4.74
RIVIERA	C/D	983.76	4.60
SATELLITE	C	956.73	4.47
ST. JOHNS	B/D	818.55	3.82
SMYRNA	B/D	799.33	3.73
WAUCHULA	B/D	513.88	2.40
DAYTONA	B	500.83	2.34
EAUGALLIE	B/D	495.94	2.32
POMPANO	B/D	491.45	2.30
WABASSO	B/D	331.50	1.55
FARMTON	D	318.61	1.49
BASINGER	D	245.49	1.15
ELECTRA	C	151.31	0.71
SCOGGIN	D	149.34	0.70
TAVARES	A	141.41	0.66
FLUVAQUENTS	D	119.13	0.56
PLACID	D	102.13	0.48
VALKARIA	B/D	93.31	0.44
HOLOPAW	B/D	80.72	0.38
WATER	W	63.25	0.30
TEQUESTA	B/D	56.54	0.26
TOMOKA	B/D	49.31	0.23
PINELLAS	B/D	35.03	0.16
CASSIA	C	14.14	0.07
QUARTZIPSAMMENTS	A	14.00	0.07
ASTATULA	A	9.56	0.04
PAOLA	A	8.41	0.04
ARENTS	C	7.97	0.04
PITS		3.68	0.02

* HSG -- Hydraulic Soil Group

2.5 Topography

As shown in Figure 2-9, the general topography of the study area slopes from its highest elevations in the west to lower elevations in the east. A north-south aligned ridge, about 8,000 to 9,000 *ft* wide, is located in the western portion of the study area. The elevation of the ridge decreases from 48 *ft* NAVD 88 at its western edge to about 26 *ft* NAVD 88 in its central portion. East of the ridge, the study area is relatively flat, at elevations around 26 *ft* NAVD 88.

2.6 Land Use

The base information source for development of the land use and land cover characterizations for the study area was the SJRWMD 2004 land use and land cover GIS layer. Figure 2-10 presents the land use distribution for the primary level of classification. Table 2-2 presents the statistics for a more detailed level of land use and land cover within the study area.

Forest, mainly pine flatwood forest, regeneration forest, and mixed forested wetland, was found to be the predominant type, covering 71% of the study area. These forested land covers are located mainly in the western and central areas of the study area. The eastern portion of the study area, along Tomoka Farms Road (C.R. 415), is dominated by low density rural residential, which comprises 14% of the total study area. Agricultural land uses are sporadically located and are primarily improved pasture, comprising 6.7% of the study area. In the northwest boundary area along U.S. Highway 92 (US 92) (International Speedway Blvd.), there are some medium density residential land uses and smaller parcels used for commercial services. A solid waste disposal site (Volusia County Landfill), which is about 180 acres in size, is located near the northeast boundary of the study area.

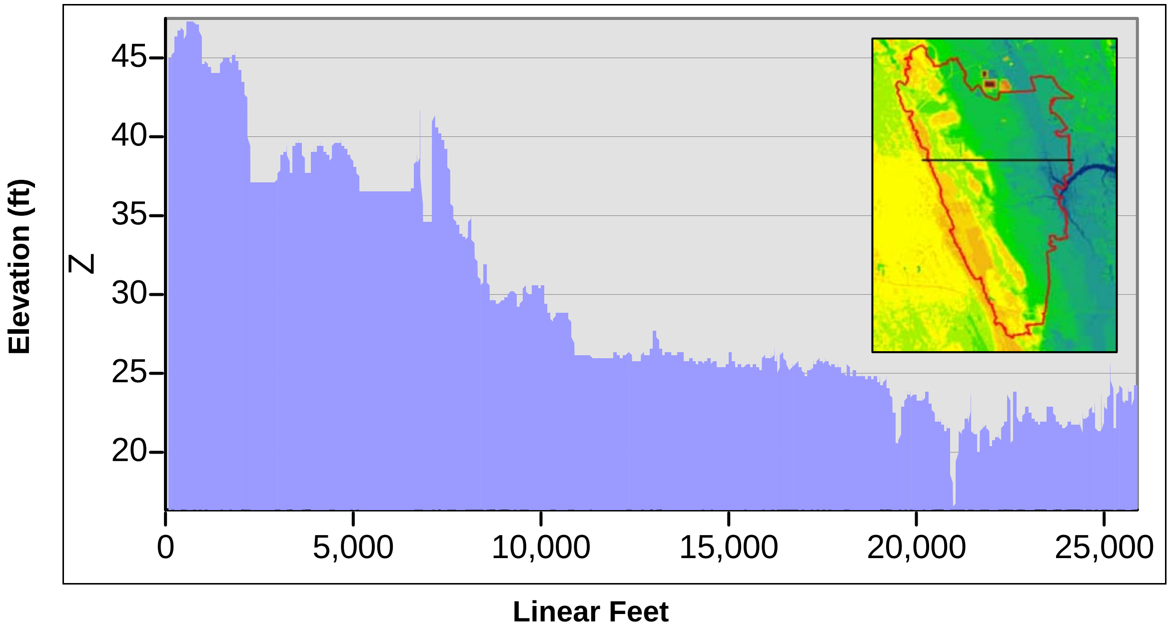

Figure 2-9. Typical Profile of Study Area Elevation (see black line – inset)

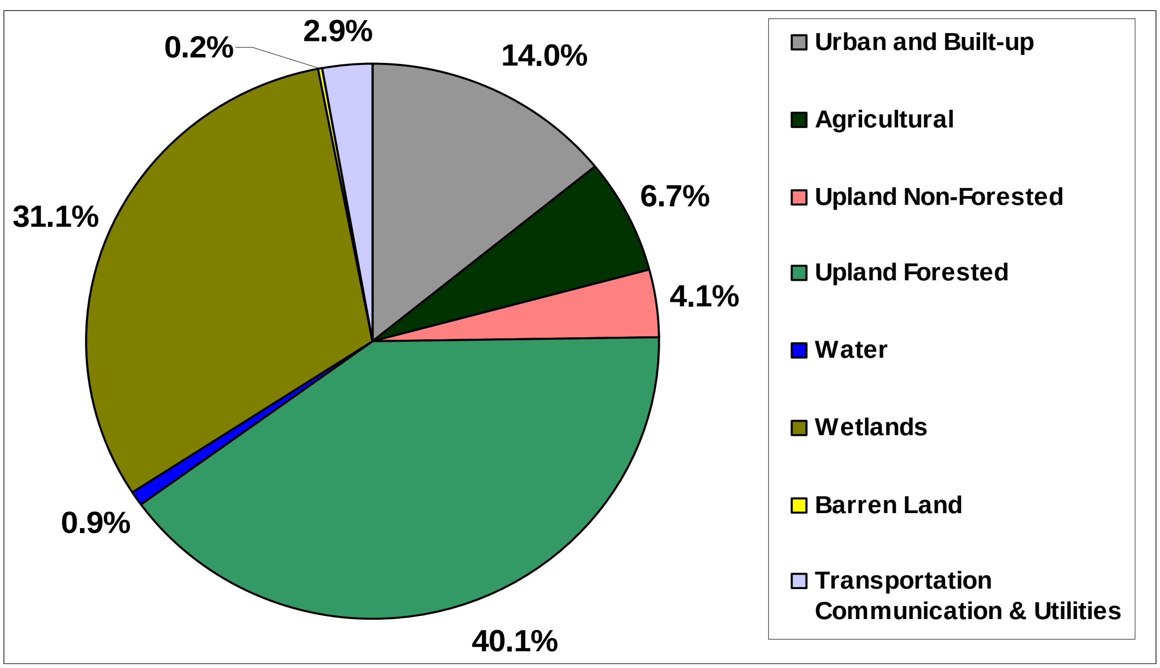

Figure 2-10. Percentage of Land Use and Land Cover

Table 2-2. Summary Statistics of Land Use in B-21 Study Area

Land Use CODE		Land Use Type	Area (acres)	% of Area
1000	**Urban and Built-up**		**3003.90**	**14.04**
	1100	Residential, Low Density	2579.21	12.06
	1200	Residential, Medium Density	166.62	0.78
	1300	Residential, High Density	28.06	0.13
	1400	Commercial and Services	100.73	0.47
	1500	Industrial	0.23	0.00
	1600	Extractive	9.25	0.04
	1700	Institutional	21.01	0.10
	1800	Recreational	48.05	0.22
	1900	Open Land	50.74	0.24
2000	**Agricultural**		**1438.8**	**6.73**
	2100	Cropland and Pastureland	1389.01	6.49
	2300	Feeding Operations	4.93	0.02
	2400	Nurseries and Vineyards	23.21	0.11
	2500	Specialty Farms	21.66	0.10
3000	**Upland Non-Forested**		**874.70**	**4.09**
	3100	Herbaceous (Dry Prairie)	162.201	0.76
	3200	Upland Shrub and Brushland	129.3773	0.60
	3300	Mixed Rangeland	583.12	2.73
4000	**Upland Forested**		**8573.88**	**40.08**
	4100	Upland Coniferous Forest	4940.11	23.09
	4300	Upland Hardwood Forests	245.44	1.15
	4400	Tree Plantations	3388.32	15.84
5000	**Water**		**182.44**	**0.85**
	5200	Lakes	17.25	0.08
	5300	Reservoirs	165.19	0.77
6000	**Wetlands**		**6649.19**	**31.08**
	6100	Wetland Hardwood Forest	2016.76	9.43
	6200	Wetland Coniferous Forest	648.24	3.03
	6300	Wetland Forested Mixed	1426.00	6.67
	6400	Non-Vegetated Wetlands	2436.31	11.39
7000	**Barren Land**		**47.43**	**0.22**
	7400	Disturbed Barren Land	47.43	0.22
8000	**Transportation Communication & Utilities**		**622.42**	**2.91**
	8100	Transportation	196.59	0.92
	8300	Utilities	425.83	1.99
Total Study Area			**21392.74**	**100**

2.7 Floodplains

Figure 2-11 presents the current FEMA floodplain map. A total of 11,016 acres, or 51.5%, of the study area are located within Flood Zone “A”, the 100-year flood zone, but no base flood elevation established. Approximately 140 acres (approximately 1.3%) are designated as Zone “AE” (known 100-year base flood elevation), which is along the floodway and the flood fringe of Spruce Creek. Residential areas inside the floodplain include the area between Highridge Avenue and Roosevelt Blvd located south of US 92, along Palm Drive in the eastern portion of the study area, between Western Road and Canal Road in the southeast portion, and between Pine Oak Lane and Powerline Road in the southern part of the study area. Commercial land in the floodplain is located west of C.R. 415 between Langford Road and Pioneer Trail, and the area located east of Indian Lake Road between Old Deland Road and Olson Drive.

2.8 Wetlands

Wetlands are the second largest land cover type within the study area, occupying 31% of the study area. Figure 2-12 shows the extent of the wetlands within the study area. Wetlands are primarily concentrated west of Tomoka Farms Road (C.R. 415), and sporadically distributed elsewhere throughout the study area. Most of the wetlands are narrow strips aligned in the south-east and north-west direction. The largest area of wetlands is located along the eastern valley. Approximately 37% of the wetlands are open water (non-vegetated). 30% of the wetlands are hardwood forest, 21% are mixed forest, and 11% are coniferous forest wetlands.

2.9 Environmental Resource Permits

One hundred and twenty Environmental Resource permits (ERP’s) previously issued by the SJRWMD within the study area have been researched and documented. The majority of these permits are for minor modifications or projects that have not been completed. However, certain ERP’s were identified that contained relevant information for the study area. Their locations are shown in Figure 2-13. The data from these permits has been incorporated into the data collection and modeling.

Coquina Cove is a large single-family residential development project located in the City of Port Orange, east of Tomoka Farms Road (C.R. 415), south of Shunz Road, and north of Town West Blvd. The project area is 127.4 acres and the development includes 332 lots, associated roads, and eight wet detention ponds. About 50% of the development is within the study area.

The Spruce Creek Congregation of Jehovah's Witness Church is located on the west side of Tomoka Farms Road (C.R. 415), south of Langford Road. A wet detention pond has been built to treat the surface runoff from the development with treated water released to the ditch that runs parallel to Tomoka Farms Road.

Coraci Park is a 28-acre local government municipal park. The project is located about a half mile northeast of the intersection of Tomoka Farms Road and Town West Boulevard in western Port Orange. The park consists of ball fields, parking areas, an activity center, and two interconnected wet detention ponds.

Whispering Creek Units I, II, & III is a single family residential development project. The project is located on Country Farms Road, west of Tomoka Farms Road. The total project area is 50.05 acres and this development includes a total of 49 lots.

The Volusia County Solid Waste Facility, located west of Tomoka Farms Road, contains a number of stormwater treatment ponds and drainage features that have been permitted in the northern section of the study area. Most of this facility falls outside and north of the study area.

Other ERP's reviewed include a stormwater retrofit project for the Daytona Highridge Estates, north of Interstate 4, and the City of Port Orange water reuse facility, off Shunz Road.

2.10 System Inventory and Mapping

To fully inventory the study area for management, maintenance, and modeling purposes, a complete field reconnaissance and survey was performed. The structures investigated include culverts, channels, ditches, canals, and ponds. Data collected for culverts includes culvert types, shapes, size, material, upstream and downstream invert elevations, and maintenance notes. Data for channels, ditches, and canals includes length, upstream and downstream inverts, roughness, and cross section information.

ECT adopted the following procedures and methodology in field data collection:

1. *Inventory of Hydraulic Structures and Conveyances in the Study Area*

   Existing structures and conveyances are first inventoried from ERP permits. The data was saved in a spreadsheet database so that the inventory coverage can be easily generated using GIS import technology.
2. *GIS Mapping of Hydraulic Structures*

   Prior to field reconnaissance, locations of existing hydraulic structures were mapped into GIS features using aerial photos. Points were used for representing the location of point structures, such as weirs, inlets, and manholes, and lines were used for representing line structures, such as channels, canals, and pipes.
3. *Hydraulic Structure Dimension and Construction Materials*

   Dimension and construction materials of structures without an ERP were obtained by field survey.
4. *Locating Hydraulic Structures*

   A GPS Trimble unit was used in determining the horizontal coordinates of structures. Vertical elevation was developed by using LiDAR generated terrain or field measurement.
5. *Field Measurement*

   Field measurement of structures was conducted by technician(s) under the supervision of a professional engineer at ECT. The measured data was recorded on the GPS unit.
6. *Digital Photos*

Depending upon the structures and surrounding environment, a variety of digital photos were taken looking upstream and the downstream of the structure.

7. *Cross Section*

   Cross sections of channels and earth weirs between neighboring basins and the crown of roads were obtained from terrain by using GIS tools.

8. *Data Collection for Water Bodies*

   Water body (lakes, ponds and wetlands) information collected included surface water elevations, surface areas, and stage-area relationships. Surface area and stage-area relationships were obtained either from design maps for man-made structures or developed from GIS Arc Hydro tools.

9. *Verification of Watershed Delineation*

   Field reconnaissance activities also included verification of ridges, berms, depressions, hydraulic control points, and storage areas developed in the study area delineation to ensure the accuracy of the delineation.

Figure 2-14 presents the location of all structures, pipes and channels found in the study area. A total of 315 culverts were found in the study area. The majority are located in the eastern and southern developed area, and are circular storm sewer culverts. Culverts 24 inches and larger were inventoried; however in areas of hydraulic significance, smaller culverts were inventoried. The majorities of the culverts inventoried ranged from 24 to 36 inches in diameter, with most of these culverts for driveway crossings less than 50 *ft* in length. However, three longer culverts were found along Tomoka Farms Road (C.R. 415) and Taylor Road (C.R. 421), with the longest one along Taylor Road being 570 *ft* and the longest along Tomoka Farms Road at 508 *ft*.

The total length of man-made channels, or canals, is 19.3 miles. The total length of natural channels is 3 miles. Most canals are trapezoidal with grass and brush cover, and the natural channels are all grassed and brush covered channels. For field surveys, the channel system was divided into 72 segments. The division points are turning points of channel courses, cross sections where channel width or shape changed, junctions where multiple-channels merged, or where channels are connected by culverts. The cross section or the size of the structures at each division point were measured and surveyed.

2.11 Study Area Basins

Eight canals and streams drain surface water out of the study area to Spruce Creek. Based on the locations of the eight outlets, the study area is divided into seven basins (Figure 2-15), labeled and identified below.

The B-21 Canal Basin is located in the northern part of the study area that includes the northern and eastern residential areas. The basin has an area of 9,812 acres. A large channel network exists in the east residential area. The B-21 Canal flows from north to south and drains to Spruce Creek at the southwest corner of the intersection of Taylor Road (C.R. 421) approximately 500 *ft* east of Tomoka Farms Road.

The Spruce Creek Circle Basin is located in the middle of the study area. The basin has an area of 5,867 acres. The outlet for this basin is located between Spruce Creek Circle West and Country Circle Drive East.

The Quiet Trail Basin drains a small area of the study area (308 acres) located east of Tomoka Farms Road, south of Country Circle Drive East, and North of H L Ainsley Drive.

The Langford Basin drains an area of 1,251 acres. Langford Canal is parallel to Langford Road, and runs from west to east where it joins Spruce Creek.

The Hart Basin is located south of Langford Outfall and north of Pioneer Trail (C.R. 4118). The basin has an area of 510 acres. There are two outlets in this basin. The Hart Outfall is a man-made ditch flowing from west to east. After passing through a culvert underneath Tomoka Farms Road, the ditch joins the C-36 Canal. The C-36 Canal is a north-south ditch that is parallel to and between Tomoka Farms Road and Samsula Drive (C.R. 4095), and joins Spruce Creek at the north end of Samsula Drive North. Another outlet of the Hart Basin is the ditch along the north side of Pioneer Trail (C.R. 4118).

The Lakeshore Basin has an area of 2,678 acres. The Lakeshore Basin originates north of Pioneer Trail near the western boundary of the study area, and water from there is conveyed south under Pioneer Trail to cross under Powerline Road through two-30 inches pipes. A north-south ditch along Canal Road collects water flowing from west to east and conveys it to the north. The water drains from the Lakeshore Basin through a culvert beneath Tomoka Farms Road (C.R. 415), between Lakeshore Drive and Pioneer Trail (C.R. 4118).

The Kersey Road Basin drains runoff from the southern part of the study area. State Road 44 (SR 44) passes through the middle of this basin, running from west to east. Surface runoff from this basin drains to the Kersey ditch and then flows east to its confluence with Spruce Creek. The area of this basin is 986 acres.

Section 3 - Study Area Model Development

3.1 Introduction

A watershed model was developed to fully understand the hydrological and hydraulic response to proposed improvements. Model results of various alternative improvements were compared to select the most effective and cost-efficient projects for flood reduction. During model development, digital aerial orthophotos and LiDAR (**Li**ght **D**etection **a**nd **R**anging) data were processed by using the ArcGIS and Arc Hydro tools to develop sub-basin delineation, flow path, hydrologic and hydraulic parameters, and results presentation. Data from Tropical Storm Fay was used to calibrate and verify the model. The 10-year, 25-year, and 100-year, 24-hour design storms were simulated to determine the extent of flooding and the levels of service.

3.2 Basin and Sub-Basin Delineation

Watershed delineation was completed by using ArcGIS and Arc Hydro tools. The process includes development of a digital terrain model, sub-basin delineation, and the results were reviewed for quality assurance/quality control (QA/QC).

3.2.1 Digital Terrain Model Development

The basic data for digital terrain development and watershed delineation are the digital aerial orthophotos and LiDAR data. The LiDAR data was collected by Volusia County in 2006 as part of a county wide project to perform digital terrain mapping. Before data processing, field verification checks were performed by ECT's professional engineers. The LiDAR data obtained from the county is in the form of compiled mass points, which are irregularly distributed sample points, each with an X, Y (horizontal) location and a Z (vertical) value, were created from these LiDAR points. Only LiDAR points with classifications Class 2 (Bare Earth), Class 5 (Vegetation), and Class 9 (Water) were used to create the mass points. The mass points were used as the basic elements to build the terrain, with each mass point having equal significance, in terms of defining the terrain surface. An approximate point spacing of 4 feet was specified. A Digital Elevation Model (DEM) (Figure 3-1), with a resolution of 5 feet by 5 feet was generated from the terrain using ArcGIS.

*3.2.2 **Sub-Basin Delineation***

To better define the hydrologic characteristics, the study area was delineated into 89 sub-basins (catchments). The digital elevation model (DEM), together with field observations and field survey results, were used as the basis for sub-basin delineation. The delineation was primarily performed using Arc Hydro tools with the following considerations:

- Ridge lines, hydraulic control points, storage areas, and local collection networks are features that defined a sub-basin boundary.
- Main roads and streets that were evaluated for flood level of service were features that defined a sub-basin boundary.
- Local conveyance or collection systems that have a contributing area greater than or equal to 40 acres before discharging to a significant hydraulic control feature were broken out as a sub-basin.
- Storage areas such as lakes, wetlands, ponds, and stormwater management storage areas (SMSA's) that are greater than or equal to five acres were broken out as a unique sub-basin due to their uniform hydrology and effect on direct runoff.

After initial delineation, a strict QA/QC (Quality Assurance/Quality Control) procedure was performed by field investigation and ground truthing to make sure the delineation was representative of the study area characteristics. Refinements and adjustments were made for sub-basins as deemed necessary. Figure 3-2 presents the delineated result. For areas surrounding Spruce Creek Circle West and Country Farms Road, west of Tomoka Farms Road, where ERP data is available, detailed delineation was performed according to the ERP design plans.

The average area of the 89 sub-basins is 275 acres. Sub-basins in the central and western wetland and forested area are generally larger than the sub-basins in the eastern residential area. The largest sub-basin is 1098.7 acres and the smallest sub-basin is 6.6 acres.

3.3 Computer Model Selection

An Inter-Connected Pond Routing (ICPR) watershed model was developed to evaluate the hydrological and hydraulic responses of the study area and the drainage systems in the B-21 study area. The ICPR model has been widely tested in Florida. Many federal and state agencies, including the Federal Emergency Management Agency (FEMA) and the state water management districts, have accepted the use of the ICPR model for watershed studies. The model was developed with data obtained from the LiDAR-derived terrain, hydraulic inventory, soils maps, field surveys and the aerial photographs.

The ICPR model consists of three primary parts: basins, nodes, and links. Stormwater runoff hydrographs are generated for basins and then assigned to nodes in the drainage network. Nodes are used to represent ponds, inlets and outlets, specific locations along channels, streams, and rivers, and junctions of existing pipe systems. A total of 189 nodes were set for this watershed model. All basin nodes (nodes associated with basins) were set at stage/area nodes. The stage-area relationships for the basin nodes are calculated by the Arc Hydro tool based on terrain.

Links represent streams, channels, and pipes that connect between nodes. Flow entering each node is hydraulically routed through the link into the next downstream node. Seventy three culverts are modeled as pipe links and 77 channel segments are modeled as channel links. Numerous weir links were set to represent the earth weir between adjacent basins and five drop structure links were set to represent the control structures of the ERP ponds. The basin-node-link network for B-21 is shown in Figure 3-3.

3.4 Hydrologic Parameters

Hydrologic parameters include the Natural Resources Conservation Service (NRCS) Curve Number (*CN*), directly connected impervious area (*DCIA*), unit hydrograph shape factor (*UHG*), and time of concentration (T_c).

3.4.1 Curve Number

The NRCS Curve Number method defines the following relationships between the surface runoff (*Q*) and precipitation (*P*):

$$Q = \frac{(P - 0.2S)^2}{(P + 0.8S)} \tag{3-1}$$

Where, *S* is the basin potential maximum retention that is related to the dimensionless Curve Number, *CN*, by

$$S = \frac{1000}{CN} - 10 \tag{3-2}$$

Curve Number *CN* is determined by land use and land cover and hydrologic soil groups (HSG). A large *CN* means more runoff generation in storms. For water and impervious surface, *CN* generally takes the maximum value of 100, with *S* equals to zero and *Q* equals to *P*.

In the calculation of *CN*, the B-21 study area was first delineated into sub-basins. Second, the GIS *Intersect* tool was used to create a soil and land use intersection polygon for each sub-basin. The *CN* designations (Table 3-1) were then used to calculate the *CN* for each intersection polygon. Finally, the *CN* for each whole sub-basin was calculated by the area weighted average of the intersection of the soil and land use polygon within the boundary of the sub-basin as below:

$$CN = \frac{\sum_i CN_i * A_i}{\sum_i A_i} \tag{3-3}$$

Where, CN_i is the curve number for each soil and land use polygon, and A_i is the area of the polygon.

Since soil in the study area is primarily hydrologic group B/D soil, the *CN* value is generally greater than 80.

Table 3-1. CN Table for Various FLUCCS and HSG Designations

Land Use Description	FLUCC	A	B	C	D	B/D	W
Residential LOW Density <2 DUA	1100	50	68	79	84	82	100
Residential MED Density 2->5 DUA	1200	57	72	81	86	84	100
Residential High Density	1300	77	85	90	92	91	100
Commercial and Services	1400	89	92	94	95	95	100
Industrial	1500	81	88	91	93	92	100
Extractive	1600	77	86	91	94	93	100
Institutional	1700	59	81	87	90	89	100
Recreational	1800	49	69	79	84	82	100
Open Land	1900	39	61	74	80	77	100
Cropland and Pastureland	2100	49	69	79	84	82	100
Row Crops	2140	49	69	79	84	82	100
Tree Crops	2200	44	65	77	82	80	100
Feeding Operations	2300	73	83	89	92	91	100
Nurseries and Vineyards	2400	57	73	82	86	84	100
Specialty Farms	2500	59	74	82	86	84	100
Tropical Fish Farms	2550	59	74	82	86	84	100
Other Open Lands (Rural)	2600	30	58	71	78	75	100
Herbaceous	3100	63	71	81	89	85	100
Shrub and Brushland	3200	35	56	70	77	74	100
Mixed Rangeland	3300	49	69	79	84	82	100
Upland Coniferous Forest	4100	45	66	77	83	80	100
Pine Flatwoods	4110	57	73	82	86	84	100
Longleaf Pine – Xeric Oak	4120	43	65	76	82	79	100
Upland Hardwood Forests - Part I	4200	36	60	73	79	76	100
Hardwood Conifer Mixed	4340	36	60	73	79	76	100
Tree Plantations	4400	36	60	73	79	76	100
Streams and Waterways	5100	100	100	100	100	100	100
Lakes	5200	100	100	100	100	100	100
Reservoirs	5300	100	100	100	100	100	100
Bays and Estuaries	5400	100	100	100	100	100	100
Wetland Hardwood Forests	6100	98	98	98	98	98	98
Bay Swamps	6110	98	98	98	98	98	98
Mangrove Swamps	6120	98	98	98	98	98	98
Stream and Lake Swamps (Bottomland)	6150	98	98	98	98	98	98
Wetland Coniferous Forests	6200	98	98	98	98	98	98
Cypress	6210	98	98	98	98	98	98
Wetland Forests Mixed	6300	98	98	98	98	98	98
Vegetated non-Forested Wetlands	6400	98	98	98	98	98	98

Table 3-1. (Cont.) CN Table for Various FLUCCS and HSG Designations

Freshwater Marshes	6410	98	98	98	98	98	98
Saltwater Marshes	6420	98	98	98	98	98	98
Wet Parries	6430	98	98	98	98	98	98
Emergent Aquatic Vegetation	6440	98	98	98	98	98	98
Non-Vegetated	6500	98	98	98	98	98	98
Tidal Flats/Submerged Shallow Platform	6510	98	98	98	98	98	98
Shorelines	6520	98	98	98	98	98	98
Intermittent Ponds	6530	98	98	98	98	98	98
Beaches other than Swimming Beaches	7100	77	86	91	94	93	100
Disturbed Land	7400	77	86	91	94	93	100
Transportation	8100	81	88	91	93	92	100
Communication	8200	81	88	91	93	92	100
Utilities	8300	81	88	91	93	92	100

* Source: TR-55

3.4.2 Unit Hydrograph Shape Factor (UHG)

The SCS Unit Hydrograph with a shape factor 256 is used to simulate a rainfall event for all sub-basins. This type of unit hydrograph has been widely used in Florida, and represents rainfall hydrographs typical for this region.

3.4.3 Time of Concentration (T_c)

Time of Concentration (T_c) represents the amount of time it takes for a particle of water to travel from the hydraulically most distant point in the basin to the basin outlet. Time of Concentration for each sub-basin is computed by summing all the travel times for consecutive flow components of the sub-basin conveyance system, which is generally divided into Sheet Flow, Concentrated Shallow Flow, and Open Channel Flow according to flow patterns. Surface roughness, slope, and travel distance all affect time of concentration.

Surface roughness is a significant factor in determining the time of concentration. Urban development smooth surface roughness, thus surface runoff is more likely to develop into shallow concentrated flow or concentrated flow in streets and paved areas. Flow in gutters, storm sewer systems, ditches and swales along the sides of the road are concentrated flow with relatively less retardance and a higher velocity. Urbanization also reduces overland flow length, by conveying storm runoff into a channel sooner. On the surface of undeveloped land, overland flow is very slow as vegetation significantly resists flow.

Sheet Flow Calculation

Sheet flow generally occurs in the headwater area of a watershed. The commonly used formula for sheet flow calculation is provided by the USDA Urban Hydrology for Small Watersheds, Technical Release TR-55, as follows:

$$T_{ts} = \frac{0.007(nLs)^{0.8}}{P^{0.5} S_s^{0.4}}$$

Where:

T_{ts} = travel time of sheet flow (*hr*)

n = Manning's roughness coefficient

L_s = length of sheet flow (*ft*)

P = 2-year, 24-hour rainfall amount in inch

S_s = slope of overland (*ft/ft*).

The Arc Hydro *Longest Flow Path* tool is used to find the longest flow path in each sub-basin. Sheet flow is generally less than 300 feet in length. After subtracting the length of sheet flow and channel flow from the longest flow path, the remainder is considered to be shallow concentrated flow. Slope S_s was calculated by dividing the elevation difference between the two ends of the sheet flow by the corresponding sheet flow length. Elevation was estimated from DEM. Manning's roughness n was determined by referring to TR-55 manual and other literatures. According to FDOT's Drainage Manual, the 2-year, 24-hour rainfall amount (*P)* is 5 inches in the study area.

Shallow Concentrated Flow Calculation

After a maximum of 300 feet, overland flow generally becomes shallow concentrated flow. Travel time for shallow concentrated flow is proportional to flow length and inversely to average flow velocity, expressed as:

$$T_{tc} = \frac{L_c}{3600V_c}$$

Where:

T_{tc} = travel time of shallow concentrated flow (*hr*)

L_c = length of shallow concentrated flow (*ft*)

V_c = average velocity of shallow concentrated flow (*ft/s*).

The average velocity (V_c) is a function of watercourse slope and type of channel (paved or unpaved). According to TR-55, velocity is determined by the following equations:

$$V_c = 16.1345(S_c)^{0.5}, \quad \textit{for unpaved flow}$$

$$V_c = 16.1345(S_c)^{0.5},$$

Where:

S_c = slope of shallow concentrated flow (*ft/ft*).

Open Channel Flow Calculation

Channels are either visible on aerial photographs, or where blue lines (indicating streams) appear on United States Geological Survey (USGS) quadrangle sheets. Manning's equation is used to estimate open channel flow velocity. The equation is expressed in velocity form as:

$$V_o = \frac{1.49R^{2/3}S_o^{1/2}}{n}$$

Where:

V_o = average velocity of open channel flow (*ft/s*)

R = hydraulic radius (*ft*)

S_o = channel slope (*ft/ft*)

n = Manning's roughness coefficient for open channel flow.

The average flow velocity is usually determined for bank full elevation. Manning's *n* was obtained from literatures.

For each sub-basin, T_c is the sum of the travel time of different flow types. If slope varies significantly in the watercourse, both shallow concentrated flow and channel flow are divided into segments of relative uniform slopes. The maximum T_c is 15.83 hours and the minimum T_c is 0.6 hours. The average T_c is 4.86 hours.

3.5 Hydraulic Parameters

Hydraulic parameters for the ICPR model include parameters that describe the hydraulics of conveyance structures, storage structures, and boundary conditions. These parameters are used to route the flow in the nodes and links of ICPR. Pipes, culverts, and channels are the primary hydraulic features used for routing the flow of water through the drainage system. Manning's equation is used for flow routing in channels, pipes, and culverts. For pipes and culverts, the input parameters include span, rise, invert elevation, top and bottom clips (due to sediment deposition), Manning's coefficient (*n*), for both upstream and downstream, and entrance and exit loss coefficients. For channels, the input parameters include geometry, bottom elevation, cross sections, top and bottom clips (due to sediment deposition), and Manning's *n* for both upstream and downstream. Local Stormwater Management Storage Areas (SMSA's) have been included in the model and are represented by stage-area relationships. The stage-area relationship for each SMSA was developed by using Arc Hydro tools.

3.5.1 Parameters for Pipes and Culverts

The physical parameters (i.e., dimensions, shapes, lengths, and elevations) for pipes and culverts identified in the B-21 study area were obtained from various sources, including SJRWMD permits, roadway plans, previous studies, professional survey data, and field measurements performed under the supervision of professional engineers at ECT. Lengths were measured from aerial maps using GIS tools. The location of structures was determined by a GPS unit in the field, and verified by the aerial maps. Hydraulic parameters, such as Manning's roughness coefficient and entrance and exit loss coefficients for pipes and culverts, were decided according to materials, end treatment, and sediment deposition. Table 3-2 presents the reference values of Manning's *n* for different materials and treatments of the pipes.

Table 3-2. Typical value of Manning's n for culverts composed of different materials

Structure materials	Manning's *n*
Asbestos cement	0.011
Corrugated Metal Pipe.	0.024
Corrugated Polyethylene, Smooth	0.009 – 0.015
Corrugated Polyethylene, Corrugated	0.018 – 0.025
Polyvinyl chloride (PVC)	0.009 - 0.011
Concrete Boxes	0.012 - 0.015
Concrete Pipes	0.010 - 0.011
Metal Pipe	0.012
Spiral Rib Metal Pipe	0.012 - 0.013
Vitrified clay	0.016

Source: U.S. Department of Transportation, Hydraulic design of Highway Culverts. Pub. No. FHWA-NHI-01-020, September, 2001. Modification with other literature data.

3.5.2 Parameters for Channels

About 19.3 miles of open channels exists in the study area, with these channels comprising the main drainage network within the study area. The length of channels was measured from aerial photo maps by using GIS tools. The cross section of each channel was either obtained from design maps (for man-made channels), a previous professional survey, or a recent field survey by ECT engineers. Roughness of channels was assigned for each cross section, based upon channel lining, vegetation, etc. To verify the determination of the roughness, photos taken during the field reconnaissance were reviewed. Literature references were examined and compared, to aid the assignment of appropriate values.

3.5.3 Parameters for SMSA's

Stormwater Management Storage Areas (SMSA's) include lakes and ponds in the B-21 Basin. In ICPR, these features are represented by a variable stage-area relationship. For ponds, if design plans are available, the stage-area relationships from this information were used. Otherwise, the stage-area relationships for ponds, lakes, and storage areas of sub-basins were developed by using the *Drainage Area Characterization* tool in Arc Hydro. The function of the tool is to divide each sub-basin area into vertical slices and then calculate each slice's elevation characteristics, as well as the cumulative area and volume that are below the elevation of the top of the slice. In using this tool, either the number of slices or the number of incremental elevations per slice is assigned. Considering the small elevation difference within these sub-basins, we used the incremental elevation per slice method was used in this modeling, and an incremental elevation of 0.5 to 1 *ft* was assigned.

3.5.4 Initial and Boundary Conditions

Initial watershed hydrological conditions were set as normal condition without large antecedent storm events. Base flow conditions were set for channels and streams. Boundary condition (stage) for each outfall was initially set according to a previous model result of Marshall, Provost & Associates (1996), and later modified according to the modeling result to match with the adjacent stage. Flow data from the USGS stream gauge at Spruce Creek near Samsula was also used in determining the boundary conditions.

3.6 Model Results and Verification

Tropical Storm Fay in August 2008 was used to verify the results of the model. Rainfall from T. S. Fay occurred over an eight (8) day period. The average total rainfall that fell in the period from August 17 to August 24 was 14.72 inches. The daily amount of rainfall over the three stations in this period is presented in Table 3-3. It should be noted (as can be seen in the table) that rainfall intensity in Florida can vary widely, even over small areas. These variations and the lack of more rain gauges within the 19 sub-basins makes model validation difficult, because rainfall in the model is spread evenly over the study area, based on the nearest available data**.**

The model results are presented in Figures 3-4 and 3-5 respectively, for nodes and watershed surfaces. Figure 3-4 presents (in different colors) the predicted flood depth above the roadway surface for each node. The colors represent different levels of flooding:

- Green represents no flooding. The roadway is free of standing water.
- Yellow represents water level over edge of road is less than 3”.
- Brown represents water depth over edge of road is between 3” and 6”.
- Red represents water depth over road exceeds 6”.

Table 3-3. Daily Rainfall Amounts for T. S. Fay in August 2008

Date (mm/DD)	08/17	08/18	08/19	08/20	8/21	08/22	08/23	08/24	Total
Rainfall 1 (in)	0.7	0.05	0.71	5.08	2.05	2.74	0.15	0.14	**11.62**
Rainfall 2 (in)	0.0	0.96	0.52	4.12	3.94	6.8	0.84	0.93	**18.11**
Rainfall 3 (in)	0.2	0.0	0.2	2.6	4.8	3.8	2.5	0.3	**14.4**
Average (in)	0.30	0.34	0.48	3.93	3.60	4.45	1.16	0.46	**14.72**

Note; 1. Tiger Bay gauge – SJRWMD;
2. Private rain gauge, at Rasley Road and S. R. 415;
3. Shunz Road gauge – Port Orange Utilities.

Figure 3-5 presents the water depth in the study area derived from the water stage in each node. The model results were verified by field observation and public report.

3.6.1 *Verification by Field Observation*

On August 21, 2008, engineers from ECT drove to the residential areas in the study area to check the flooding conditions from T. S. Fay. Eighteen photos were taken of the flooding areas at Canal Drive, Lakeshore Drive, Langford Road, Meadow Lane, Old Daytona Road, Palm Drive, Pine Oak Drive, and Powerline Road. These photos are presented in this Appendix B.

Flooding roads simulated by the model include (Figure 3-4):

- ***B-21 Canal Basin***
  - Shunz Road near Industrial Park
  - Driveway along power line west of Palm Drive
  - Landfill Road west section
  - Halifax Drive west of Tomoka Farms Road
  - Old Daytona Road east of Tomoka Farms Road
  - Meadow Lane south

  - Palm Drive north of Orange Drive
- ***Spruce Creek Circle Basin***
  - Area on the southern end of Palm Drive
- ***Langford Basin***
  - Langford Road
  - West side of Tomoka Farms Road
- ***Hart Basin***
  - West Side of Tomoka Farms Road.
- ***Lakeshore Basin***
  - Powerline Road (middle section) between Smith Road and Treadway Road
  - Pine Oak Drive
  - Canal Road south of Lakeshore Drive
  - Western Road south of Lakeshore Drive
  - Lakeshore Drive
  - Kersey Road near Canal Road

In this field observation of flooding from the T. S. Fay event, the model was found to fully reproduce the same flooding conditions.

3.6.2 Verification by Public Comment

To gather flood and drainage information of the study area, ECT and Volusia County conducted a public meeting on August 27, 2008. Local residents reported 35 problem areas. Figure 3-6 indicates those reported problem locations and Table 3-4 summarizes the problems. The last column of this table presents the modeled results for the problem sites.

The reported problems included flooding of houses, properties, roads, driveways, and pastures, caused by T. S. Fay in 2008 or Hurricane Frances in 2004. Other problems noted were maintenance requirements for drainage ditches and pipes, mosquito control problems caused by standing water, impaired septic systems, concerns about potable water wells, and livestock being exposed to standing water. Seven reports were located out of the study area. Hurricane Frances passed the study area on September 5, 2004.

Daily rainfall on September 5 was 7.85 inches, which is somewhat greater than a 10-year, 24-hour storm (7.3 inches). The three day rainfall from September 4 to September 6 was 9.54 inches, an amount slightly greater than a 25-year, 24-hour storm (8.8 inches). Due to accompanying high tidal conditions of the receiving waters of Spruce Creek and Rose Bay during Hurricane Frances, recovery of flood levels was slow, thus prolonging the duration of this standing water.

In general, the model simulated the conditions of the reported problem areas well. Some examples of this follow. Report #7 stated 10” to 12” of standing water occurred in the garage and 2” of water was inside the house at 1944 Poinsettia Drive. The modeled results indicated water depth of between 2” to 10” around this house (Figure 3-7). Report #8 indicated that all lands surrounding the house at 2346 Jerry Circle were flooded, with the modeled results showing that this whole area would be under water at a depth of between 2” to 20”. Reports #15 and #16 stated severe flooding of Langford Road, and the modeled results indicated that Langford Road and adjacent lands would be fully under water. Reports #20 and #21 indicated flooded properties along Western Road, and the model output showed this whole area to be severely flooded, including the road section on Pioneer Trail from the east power line to Tomoka Farms Road West. During T.S. Fay, Pioneer Trail was temporarily closed due to flooding. Reports #17 and #18 indicated no flooding, but ditch problems on Quiet Trail Drive. The modeled results showed no water in the area. Therefore, the modeled results appear to be representative of real world conditions, as reported at the August 2008 public meeting.

3.7 Simulated Flood Elevation for Design Storms

Simulated flood elevation for the 25-year, and 100-year, 24-hour design storms (see section 4.2) are presented in Figures 3-8 and 3-9.

Table 3-4. Public Report Problem and Modeled Result (pg. 1 of 3)

No	Address*	Problem*	Modeled Result
1	1911 Blake Drive	Land and buildings flooded. Excessive fill in back. Road higher than homes. New development blocked drainage	Out of the study area
2	1899 Blake Drive	Towns West SD Construction has worsened flooding. New culverts on CR415 restrict flow.	Out of the study area
3	2113 Mitchell Lane	Land and buildings flooded. Excessive fill in back. Road higher than homes. New development blocked drainage	Out of the study area
4	1855 Halifax Drive	Yard structures flooded. Horses in standing water. Stagnant, mosquitoes.	Local flooding
5	2161 Halifax Drive	Pasture, ditch, and road ditch floods. No house or driveway flooding.	Halifax Dr is lightly flooded
6	2158 Poinsettia Drive	Property (5 acres) floods. Barn and shop floods. Neighbor on Halifax built up and covered ditches.	No floods surrounding house
7	1944 Poinsettia Drive	10-12" water in garage. 2" water in home. WQ concerns: wells, fertilizer, septic systems during flooding	House is in water. Water depth is 2” to 10”
8	2346 Jerry Circle	All land floods around house	Water around the house is 1” to 20”
9	2336 Meadow Lane	Road floods. No access. Pasture, Barns, and back room of home flooded. Sewer backup. Mosquitoes, fungus.	Road is flooded
10	2386 Meadow Lane	Possible undersized and clogged pipes. Ditch needs cleaning and grading. No flow.	Maintenance recommended
11	2376 Meadow Lane	5+ acres floods. Ditches fill up and don't drain. Water stays for weeks.	West of the house area is flooded
12	2533 Guava Drive	2004 Frances - water in house. T.S. Fay - almost in house. County pumped. In flood zone X	The house is surrounded by water
13	2433 Guava Drive	Front drainage ditch overflows onto property. Previous owner flooded. Water flows real fast after big storms	No water in house. But east of house is full of water

* As reported at public meting with area residents, 8/27/08.

Table 3-4. (*Cont.*) Public Report Problem and Modeled Result (pg. 2of 3)

No	Address*	Problem*	Model result
14	2548 Guava Drive	T.S. Fay - Half of property underwater	Water surrounded the house
15	3931 Langford Road	Severe road flooding. Concerns about septic systems and livestock.	Langford Road is severely flooded
16	3971 Langford Road	Road and property floods 1-2 feet deep. (T.S .Fay). Mosquitoes, pasture, animal manure concerns when it floods.	House is in water. Road is severely flooded
17	340 Quiet Trail Drive	Ditch at back of property doesn't drain. Check culvert on Country Circle Dr ditches don't drain. Check grading ditch behind house for mosquitoes	No water in the area
18	330 Quiet Trail Drive	Ditches behind home don't drain. Ditch grading not right. Ditch floods onto road; dangerous driving	No water in the area
19	3660 Pepper Lane	Ditch on east side of Samsula Farms flooded properties	Out of the study area
20	416 Western Road	Water floods property from the west. Barns, out buildings flood. Septic, mosquito, and animal waste concerns.	The whole area is severely flooded
21	401 Western Road	Property floods. Had to move horses. Well pump flooded. Septic system impaired. Need ditch on w. side of road. More maintenances & Mosquito Control	The whole area is severely flooded
22	2277 Tomoka Farms Road	Frances - Home flooded w/ 6" (2004). T.S. Fay 8" on property (2008).	House is flooded. Water depth is between 2" to 9"
23	2377 Tomoka Farms Road	Property floods. Request tree pickup by county.	Water from the ditch reached the property
24	2278 Tomoka Farms Road	Creek overflows into yard w/ 6-8" rain. House/barn flooded 6"- Frances. (2004)	Water surround the house 1" to 10"
25	2290 Tomoka Farms Road	Barn flooded w/ 8" water. Flooding on 8/21/08. Clear by 8/23/08.	House is flooded. Water surrounds house 6" to 10"
26	2281 Tomoka Farms Road	Floods N. of Halifax on east side. Frances (2004)1.5 ft. water on property.	Whole area is flooded

* As reported at public meting with area residents, 8/27/08.

Table 3-4. ***(Cont.)*** **Public Report Problem and Modeled Result (pg 3 of 3)**

No	Address*	Problem*	Model result
27	2147 Tomoka Farms Road	Water flows over property. Ditch N-S can't handle flow. Water stays 1-3 weeks. Causes problems with farm animals/garden	The house is surrounded by water
28	712 Tomoka Farms Road	Home flooding – 4" to 5" deep. From Frances (2004) and T.S. Fay (2008)	House flooded. Water surrounding the house is 4" to 5"
29	2472 Old Samsula Road	Backyard ditch never cleaned. Filled in at various locations. Drains north of Taylor Road to east. Barn floods.	No water in the area
30	2406 Old Samsula Road	Concerned with growth problems. Flooding on property. House OK. Many driveway culverts not sized right.	No water in surrounding area
31	3639 Watermelon Lane	Cackleberry campground floods. Culvert at Kingdom Hall & CR415 too small. Property at NW intersection floods.	Water approaches the property
32	1926 Taylor Road	Yard floods. Flood rises to about 2" below house pad.	Water reached side of the house
33	2169 Swan Drive	Francis (2004) & T.S. Fay (2008) - Property flooded 31" deep	Whole area is flooded. Water surrounding the property is 25" deep
34	2046 Old Daytona Road	Pasture, ditch, and road ditch floods. No house or driveway flooding.	No water around the house
35	2154 Orange Drive	Culverts at Orange and Guava are too small. Debris in ditches. Road acts as dam. Floods everyone west of Guava	Whole area is flooded

* As reported at public meting with area residents, 8/27/08.

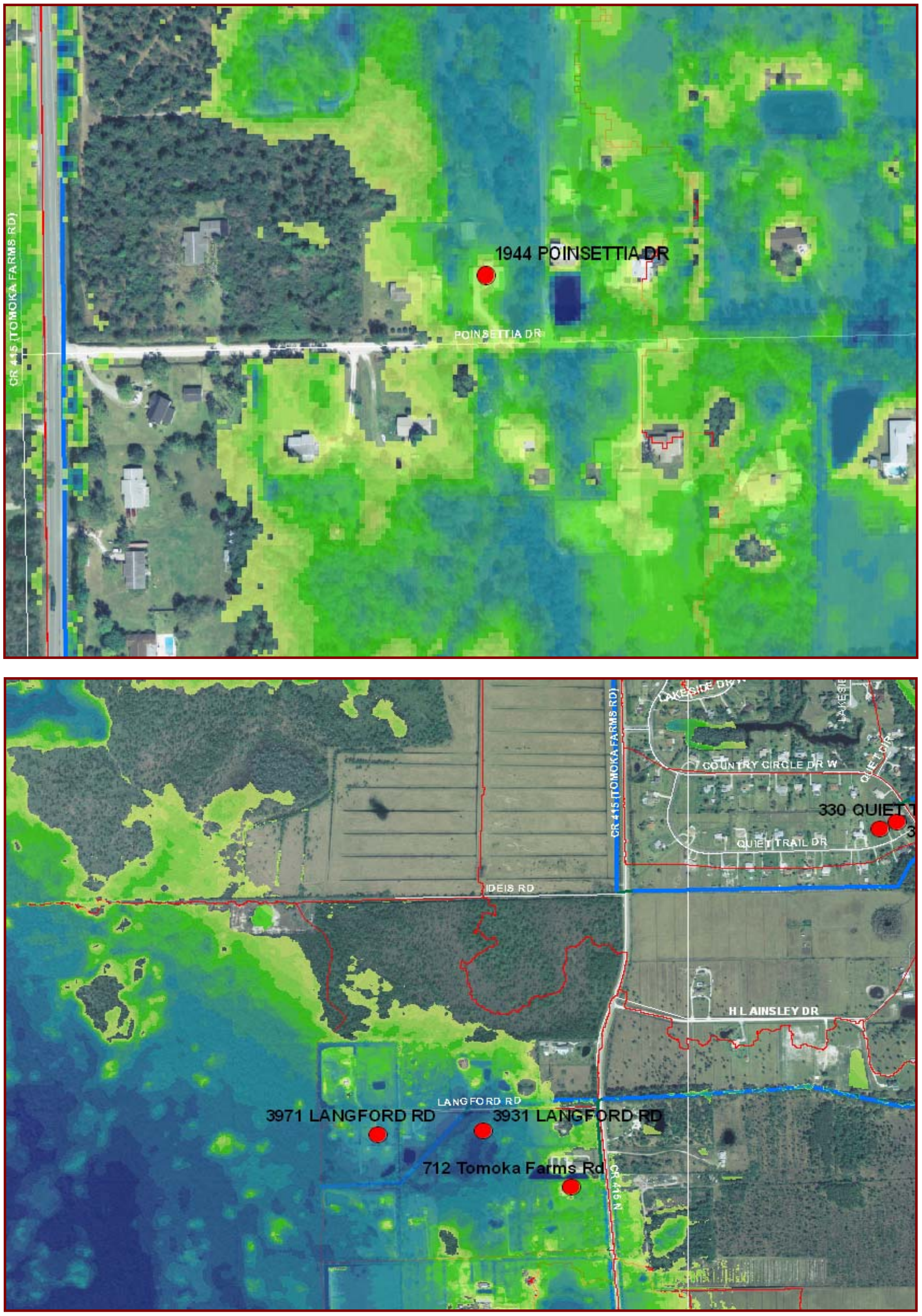

Figure 3-7 (a). Examples compare model results and public problems reported for T. S. Fay (2008). (*Upper*) House at 1944 Poinsettia Drive is flooded. (*Down*) Langford Road and surrounding properties are flooded.

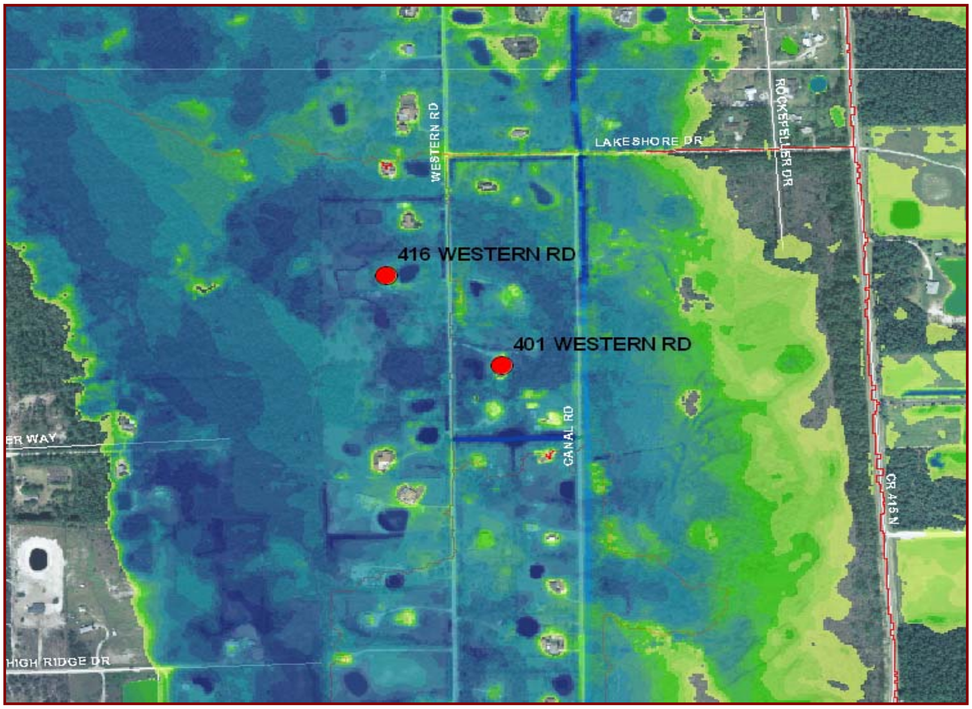

Figure 3-7 (b). Examples compare model results and public problems reported for T. S. Fay (2008). (*Upper*) Properties on Western Road are flooded. (*Down*) No water on Quiet Trail Drive and surrounding lots.

Section 4 - Problem Areas

4.1 Introduction

In this section, the problem areas will be identified and analyzed for the 10-year, 25-year, and 100-year, 24-hour design storm events. Problem areas identified were analyzed for the extent of flooding, severity of flooding, and level of service (LOS) provided to surrounding county maintained roads. The discussion focuses only on the identification of problem areas which arose in the modeling without considering the ownership of the properties. When considering capital improvements, alternatives will focus mainly in areas under maintenance authority of the county. Alternatives identified for non-county maintained roads will likely require additional community support of local funding options, such as the creation of special assessment districts

4.2 Level of Services (LOS)

Level of Service for this study is defined as the maximum allowable flooding for a specific roadway type for any storm event up to the 100-year, 24 hour event. For example, the maximum allowable flooding for a collector roadway would be such that half the roadway width is free from flooding. The Levels of Service defined for this study are:

- LOS A: Roads are free of flooding; applying mainly to arterial roads.
- LOS B: Less than half the width of the road is flooded and the maximum flooding depth is less than 3”; applies to collector roads.
- LOS C: Roads are fully flooded but the maximum flooding depth is less than 6”; applies to local residential roads.
- LOS D: Roads are fully flooded and maximum water depth exceeds 6”.
- LOS F: Houses are flooded.

Figure 4-1 shows the LOS. LOS will be used in this study in two ways:

1) Establish a LOS for each of the road types in the study area.

2) Assess the existing and proposed levels of flooding.

Figure 4-2 presents the roadway LOS for county roads and public right of way.

4.3 Design Storms

The SJRWMD's design storms for the 10-year, 25-year, and 100-year, 24-hour events were used in modeling. Table 4-1 presents the rainfall amount and distributions. The design rainfall is assumed to be uniformly distributed over the study area.

Table 4-1 Design Flood Storm Event Parameters

Design storm recurrence interval	*Design storm duration*	*Total rainfall (in)*	*Rainfall distribution*
10 years	24 hours	7.3	SCS Type II Florida Modified
25 years	24 hours	8.8	SCS Type II Florida Modified
100 years	24 hours	12.0	SCS Type II Florida Modified

4.4 Model Results and Flooding Areas Characterization

Figures 4-3 through 4-5 present the modeling results for the design storm events. The figures show the maximum water depth throughout the study area.

4.4.1 B-21 Canal Basin

In this basin, three problematic areas are identified. The characteristics of each area are described below.

Tomoka Farms Area

The Tomoka Farms area is surrounded by a perimeter ditch system. The ditch system collects drainage from approximately 1,200 acres, including areas north of I-4 and the Volusia County landfill area. At the northwest corner of the Tomoka Farms area, the perimeter ditch splits and flows east to the B-21 Canal and South into the Spruce Creek Circle Basin. The ditch flowing south will be further described in the following section. The westerly flowing ditch conveys the majority of the drainage west to the B-21 Canal.

B-21 Canal Upstream of Old Daytona Road Crossing

The B-21 Canal from Halifax Drive to Old Daytona Road historically has been a flood prone area. Home flooding was reported in this section of the B-21 Canal from T.S. Fay and the Hurricane Frances. This section of the B-21 Canal flows through several private properties and crosses Tomoka Farms Road under a 30' span bridge. The canal then flows south to Old Daytona Road, where it passes through two 96' wide box culverts. Two undersized box culverts under Old Daytona Road cause water to stage-up on the north side (upstream) of the road during large storms. The model predicts a difference of over two feet in water level from the upstream and downstream ends of the culverts. This constriction causes Old Daytona Road, Halifax Drive, and Avocado Drive to overtop in the 100-year design storm simulation. The LOS for this section of Tomoka Farms Road (south of Avocado Drive and north of Old Daytona Road) ranges from B to C, but the desired LOS for Tomoka Farms Road is A. Therefore, improvements are recommended to increase the capacity of the B-21 Canal under Old Daytona Road.

Meadow Lane Area

Meadow Lane historically has not been a flood prone area. However, flow paths have been impeded by filling and other land alterations by private property owners of the canals to the south and west, creating an impounded condition along Meadow Lane. During Tropical Storm Fay, water levels exceeded the roadway surface by up to 8". Predicted water levels along Meadow Lane exceed the warning stage (edge of pavement) by 1.6 *ft* in the 25-year design storm and by more than two feet in the 100-year design storm simulation.

The model simulation shows that for the 10-year, 24-hour design storm, the following areas in B-21 Canal Basin are flooded:

- The western end of Orange Drive, where water depth on Orange Drive near the power line access road exceeds 10".
- Palm Drive north of Orange Drive, where water exceeds Palm Drive surface by 3".
- South of Meadow Lane, where water stage exceeds the warning stage (edge of pavement) by 3".

For the 25-year, 24-hour design storm, more areas are flooded.

- The western end of Landfill Road is flooded. Water depth on the road surface is approximately 5".

- Water stage in B-21 Canal reaches the surface of Old Daytona Road on the east side of Tomoka Farms Road.
- Flooding in the western part of the Orange Drive area has expanded. Palm Drive and power line access road are flooded.
- Meadow Lane is completely inundated. Water stage exceeds 4" ft above the edge of pavement.

For the 100-year, 24-hour design storm, flooding becomes more severe:

- Flooding on the western part of Landfill Road extends to the east. Several sections of the road are flooded.
- Flooding in the Orange Drive area extends north to Avocado Drive and south to Swan Drive. The area along Palm Drive, including Orange Drive, Swan Drive, and south Guava Drive, is flooded.
- Water level in the B-21 Canal on the north side of the Old Daytona Road crossing affects the roads upstream. Old Daytona Road, Avocado Drive, and Halifax Road are all flooded.
- Water level on Meadow Lane is 6" above the edge of pavement.

4.4.2 Spruce Creek Circle Basin

As previously mentioned, the Tomoka Farms area is surrounded by a perimeter ditch system, with the major ditch north of Halifax Drive flowing east into the B-21 Canal. However, this ditch stages up and forces water to flow south, parallel to Palm Drive, then south of Swan Drive (where the ditch turns 90 degrees), and parallel to Swan Drive. The ditch then passes under the south end of Palm and Guava Drives, eventually turning south at Tribble Drive. The ditch flows south from there, under Spruce Creek Circle West, and outfalls to a main tributary of Spruce Creek, which then flows east under Tomoka Farms Road and discharges to Spruce Creek. The ditch between Halifax and Swan Drives also receives runoff from a large contributing area west of the powerline easement. The large contributing area and water being forced south at the northern end, combined with the low lying areas near Palm, Orange, Swan, and Guava Drives, results in the existing flooding conditions. The model predicts a LOS D for this area for the 25-year and 100-year design storm simulations, and the desired LOS for this area is C.

Model result shows that, for the 10-year, 24-hour design storm, area south of Swan Drive is flooded. Water depth at Palm Drive is approximately 2" over the edge of road; Water level approaches the edge of pavement along Spruce Creek Circle West near Echo Farms Drive. In the 25-year, 24-hour design storm, the extent of flooding located south of Swan Drive has increased. In the 100-year, 24-hour design storm, area south of Swan Drive and north of Spruce Creek Circle W is flooded. Water depth on the southern end of Palm Drive area is 1.2 *ft*.

4.4.3 Langford Basin

The Langford Basin receives runoff from an 875 acre forested wetland area west of Langford Road. This wetland area drains to a central point at the western end of Langford Road, at the south property line of a home. At this point a ditch flows to the east traversing the property. The ditch then crosses diagonally across the next property to Langford Road. This diagonal ditch has been partially filled and both ditches have undersized culvert crossings. Once the ditch reaches Langford Road, it flows east to Tomoka Farms Road where it goes through a 30' span box culvert. The ditch system then continues east several thousand feet to Spruce Creek.

The Langford Basin and the Hart Basins are connected by a roadside ditch, along the west side of Tomoka Farms Road. This roadside ditch system has numerous driveway culverts that become inundated during large storm events. However, there is one culvert in front of the Spruce Creek Congregation of Jehovah's Witness Church which is approximately 500 *ft* long. It was installed to accommodate a turn lane to the church. The length of this culvert and the elevation of the turn lane restrict the flow here, and cause water to back up in the upstream ditch. The area along and south of Langford Road was completely flooded during T. S. Fay.

Model results show that Langford Road and the surrounding area west of Tomoka Farms Road are inundated in the 10-year, 24-hour design storm. Water depth over Langford

Road is approximately 4”. In the 25-year, 24-hour design storm, the flooding area in Langford Road is further expanded. Water depth is over 5” on Langford Road. Water level on the west side of Tomoka Farms Road and south of the Spruce Creek Congregation of Jehovah’s Witness Church reaches the surface of Tomoka Farms Road. In the 100-year, 24-hour design storm, the flooding area surrounding Langford Road has further expanded. Water depth over Langford Road exceeds 6”. The maximum water depth over Tomoka Farms Road, located south of the Spruce Creek Congregation of Jehovah’s Witness Church is 3”. The LOS for this section of Tomoka Farms Road is C in the 100-year design storm, while the desired LOS for Tomoka Farms Road is A.

4.4.4 Hart Basin

The Hart Basin, similar to the Langford Basin, receives runoff from a wetland area, approximately 410 acres west of Tomoka Farms Road. Water collects on the west side of Tomoka Farms Road from Pioneer Trail north to Langford Road. This water then flows both north to the Langford Basin (as described above) and under Tomoka Farms Road, through a 30” culvert approximately 1200 *ft* north of Pioneer Trail. From this point, water flows through the Hart ditch to the C-36 Canal and discharges to Spruce Creek. The Hart ditch is relatively clean and straight near Tomoka Farms Road. During T. S. Fay, water overtopped Tomoka Farms Road near the Hart ditch crossing. The model simulation shows that water along the west side of Tomoka Farms Road is approaching the edge of pavement in the 10-year, 24-hour design storm. For the 25-year, 24-hour design storm, water from the Hart ditch overflows Tomoka Farms Road by 3” to 4”. For the 100-year, 24-hour design storm, water level on the west side of Tomoka Farms Road expands to the north. Water from the west side of the Hart ditch overflows Tomoka Farms Road by 5”. The maximum water depth on Tomoka Farms Road section, located on the north boundary area of the basin reaches 6”. The current LOS for this section of Tomoka Farms Roads is a LOS C, whereas the desired LOS is A.

4.4.5 Lakeshore Basin

The Lakeshore Basin originates north of Pioneer Trail and south of SR 44. Water from these two areas drains to Powerline Road, where it flows east through two 30” pipes.

During large storm events, water ponds on the west side of Powerline Road until it overtops the pavement. Home flooding occurred in this area during T. S. Fay. From Powerline Road, water flows east to Canal Road, and from this point water can flow south to the Kersey Basin or north to Lakeshore Drive. The water levels in the Kersey ditch reduce the amount of water flowing south and force the majority of the water to flow north to Lakeshore Drive. The areas along Canal, Western, and Lakeshore Drives experience significant road flooding. Model results show that, for the 10-year, 24-hour design storm, water ponds west of Powerline Road and the northern part of the Pine Oak Lane. Water depth over Powerline Road is approximately 3”. Area around Western Road and Canal Road section east of Pioneer Way is flooded. Water stage exceeds warning stage (edge of payment) more than 7”. For the 25-year, 24-hour design storm, flooding on Powerline Road and Pine Oak Drive has expanded. Water overflows Powerline Road by 7”. Flooding along Western Road and Canal Road extends to Lakeshore Drive on north. For the 100-year, 24-hour design storm, flooding on Power Line Road and Pine Oak Drive has expanded to the west and south. Water overflows Powerline Road by 10”. Flooding along Western Road and Canal Road has extended south to Kersey Road and north to Lakeshore Drive. Water overflows Lakeshore Drive by 6” to 9”. Water over-tops Western Road and Canal Road by 1.6 *ft*. The existing LOS for Powerline Road is LOS F, and the desired LOS for Powerline Road is LOS C.

4.5 Infrastructure Deficiencies and Maintenance Analysis

In the field survey, engineers at ECT surveyed and inspected all primary drainage infrastructures. Generally, most of the infrastructure is in good condition. However, maintenance is needed for some structures to improve drainage efficiency and maximize service life.

Channel and Ditch Cleaning - Field survey and public comments indicate that several channels and ditches are either over-vegetated or clogged, so they can not drain water efficiently and thus increase flooding potential. Many of the restrictions have been caused by dumping debris or other materials in the drainage ditches. Regular inspection of the ditches is important to insure efficient operation of the drainage system. The channels and ditches (including county maintained and non-county maintained) that need cleaning include:

- Ditch east of Mitchell Lane - New development in the area blocked the drainage system and the ditch needs to be cleared.
- Ditch along Meadow Lane – This ditch is filled up and does not drain properly. Large surrounding areas and a few properties were reported flooded from T. S. Fay.
- Ditch under the power line west of Palm Drive (north to south) – This ditch is too small to handle a 10-year storm flow, and land along the ditch was flooded from T. S. Fay.
- Hart Ditch - The overgrown vegetation in the ditch severely reduces its drainage conveyance, and this vegetation needs to be cleaned out.
- Ditch north of Orange Drive (between Palm Drive and Guava Drive) – This ditch also needs to be cleaned out.

Pipe Cleaning and Replacement - Few pipes were found to be blocked or partially blocked. The main issue to address for pipes is insufficient flow capacity to operate efficiently. These pipes (including county maintained and non-county maintained) include:

- Culvert under Palm Drive north of Orange Drive - The existing pipe does not have enough capacity to drain stormwater from west to east of Palm Drive. In T. S. Fay, the road acted as a dam, and a large area was flooded.
- Culvert under Country Circle Drive West near Quiet Trail Drive - The invert of this box culvert is higher than the ditch. Water stays in the ditch for a long time, contributing to complaints of mosquitoes. The culvert needs to either be re-set or re-constructed to match the surrounding ditch elevations.
- Culvert under Country Circle Drive East between East and West Lakeside Drive - This 30” by 19” culvert is too small, and should be upsized to accommodate expected flows.
- Driveway culvert at 2147 Tomoka Farms Road - This culvert is too small to drain water along the ditch, and this property flooded during T. S. Fay.

- Culvert under Powerline Road - The existing 36" culvert is too small to drain from west to east. During T. S. Fay, Powerline Road acted as a dam and water overtopped the road surface here.

Pipes and culverts are an important component of the drainage system in the B-21 Canal study area. There are approximately 230 pipes and culverts of various types and sizes within the study area. Regular inspection and maintenance is essential to prevent and reduce flooding. Eighty five of these pipes were modeled, as they are considered primary structures. The smaller, secondary structures, such as driveway culverts, although not modeled, must still be included in a regular inspection and maintenance program by Volusia County. Table 4-2 presents the updated information for the modeled pipes and culverts, with the update information coming from ECT's field survey.

Table 4-2. Pipes Modeled and Updated in the B-21 Study Area (pg. 1 of 4)

Link No.	Culvert type	Material	Flow Direct	X-Shape	Rise (In)	Span (In)	No	Outfall	Street Name	Nearest Cross Street	Length (ft)	Up Inver	Down Inver
4001	Storm Sewer	RCP	S	Oval	24	20	1	Canal	Landfill		32	27.8	27.4
4002	Storm Sewer	POLY	E	Circular	36	36	3	Ditch			20	33.3	33.7
4003	Storm Sewer	RCP	S	Oval	29	48	2	Ditch	Avocado		30	19.4	19.4
4004	Storm Sewer	RCP	E	Oval	36	60	1	Canal	Tomoka Farms		43	12.9	12.8
4005	Storm Sewer	RCP	E	Circular	48	48	1	Ditch	Tomoka Farms	Old Daytona Rd	69	14.2	10.9
4006	Side Drain	CPP	S	Circular	72	72	2	Canal	Landfill		43	16.26	15.91
4007	Storm Sewer	RCP	S	Rect	60	72	2	Canal	Halifax		31.5	13.7	13.7
4008	Storm Sewer	POLY	E	Circular	36	36	1	Canal	Guava	Orange Drive	30	19.05	18.5
4009	Storm Sewer	RCP	E	Circular	300	300	1	Canal	Old Samsula		28	17.2	17.1
4010	Storm Sewer	RCP	E	Rect	78	300	1	Ditch	Tomoka Farms	Pottery Ln	35	6.8	6.51
4011	Side Drain	CMP	SE	Circular	72	72	1	Canal	NA		22	9	8.85
4012	Storm Sewer	RCP	E	Circular	30	30	1	Ditch	Tomoka Farms		40	14.6	14.3
4013	Storm Sewer	CMP	E	Circular	36	36	1	Ditch	Tomoka Farms		43	14.3	14.3
4014	Storm Sewer	RCP	E	Rect	144	288	1	Canal	Tomoka Farms		36	6.5	6.5
4015	Cross Drain	RCP	SE	Circular	36	36	2	Canal	Spruce Cr. Cir W	Echo Farms Dr	85	17	16.8
4016	Cross Drain	CMP	E	Circular	48	48	1	Canal	Guava Dr		33	20.6	20.14
4017	Storm Sewer	CMP	E	Circular	48	48	1	Ditch	Guava Dr		26	20.6	20.6
4018	Storm Sewer	RCP	N	Circular	24	24	1	None	SR44		178	38.48	38.65
4019	Storm Sewer	RCP	N	Circular	24	24	3	None	SR44		187	31.33	30.75
4020	Storm Sewer	CPP	N	Circular	48	48	2	Canal	Lakeshore Dr		32	24.65	23.79

Table 4-2. (*Cont.*) Pipes Modeled and Updated in the B-21 Study Area (pg. 2 of 4)

Link No.	Culvert type	Material	Flow Direct	X-Shape	Rise (In)	Span (In)	No	Outfall	Street Name	Nearest Cross Street	Length (ft)	Up Inver	Down Inver
4021	Storm Sewer	CMP	E	Circular	36	36	1	Ditch	Western Rd		33	27.33	25.47
4022	Storm Sewer	CMP	E	Circular	36	36	1	Ditch	Canal Rd	Lakeshore	41	24.46	23.67
4023	CBC	CBC	E	Rect	60	72	1	Canal	CR 415 N	Kersey Rd	54	23.24	23.1
4024	Storm Sewer	RCP	N	Circular	48	48	2	Canal	Kersey Rd		53	23.78	23.55
4025	CBC	CBC	E	Rect	36	108	1	Canal	CR 415 N	Lakeshore Dr	48	22.93	22.83
4026	Storm Sewer	RCP	S	Circular	24	24	2	None	Pioneer Dr		48	37.66	37.44
4027	Storm Sewer	RCP	SE	Oval	72	48	2	None	Pioneer Dr		84	34	34
4028	Storm Sewer	RCP	E	Circular	24	24	2	Ditch	Tomoka Farms		45	23.2	23
4029	Storm Sewer	CMP	E	Rect	108	360	1	Canal	Tomoka Farms	Langford Rd	35	19.39	17.99
4031	Storm Sewer	RCP	E	Circular	36	36	1	Ditch		Pioneer Trails	30	21.65	21.55
4032	Storm Sewer	CMP	E	Circular	30	30	1	Ditch			33	22.35	21.75
4033	Storm Sewer	CMP	E	Circular	30	30	1	Ditch	Pioneer		32	22.1	22.05
4034	Storm Sewer	RCP	E	Circular	30	30	1	Ditch	Pioneer	Tomoka Farms	277	23.5	23
4035	Storm Sewer	POLY	S	Circular	24	24	1	Ditch	Tomoka Farms		45	23.42	23.02
4036	Storm Sewer	POLY	S	Circular	24	24	1	Ditch	Tomoka Farms		52	21.17	21.22
4037	Storm Sewer	POLY	S	Circular	24	24	1	Ditch	Tomoka Farms		56	22.72	22.7
4038	Storm Sewer	CMP	N	Circular	24	24	1	Ditch	Tomoka Farms		15	22.16	21.71
4039	Storm Sewer	CMP	S	Circular	24	24	1	Ditch	Tomoka Farms		39	22.36	21.71
4040	Storm Sewer	RCP	E	Circular	30	30	1	Canal	Tomoka Farms		93	21.71	20.61
4041	Storm Sewer	RCP	S	Circular	30	30	1	Ditch	Langford Rd	Tomoka Farms	95	21.17	20.85
4042	Storm Sewer	RCP	N	Circular	30	30	1	Ditch	Langford Rd	Tomoka Farms	508	21.9	21.6
4043	Storm Sewer	RCP	N	Circular	30	30	1	None	Tomoka Farms		32	22	21.9

Table 4-2. (*Cont.*) Pipes Modeled and Updated in the B-21 Study Area (pg. 3 of 4)

Link No.	Culvert type	Material	Flow Direct	X-Shape	Rise (In)	Span (In)	No	Outfall	Street Name	Nearest Cross Street	Length (ft)	Up Inver	Down Inver
4044	Storm Sewer	RCP	N	Circular	30	30	1	Ditch	Tomoka Farms		71	22.48	22.46
4045	Storm Sewer	RCP	N	Circular	24	24	1	None		Tomoka Farms	62	22.7	22.62
4046	Storm Sewer	RCP	N	Circular	24	24	1	None		Tomoka Farms	41	22.3	22
4047	Storm Sewer	RCP	N	Circular	24	24	1	Ditch		Tomoka Farms	16	22.5	21.98
4048	Storm Sewer	CMP	N	Circular	24	24	1	Ditch		Tomoka Farms	50	22.85	22.6
4050	Storm Sewer	CMP	S	Oval	20	30	1	None	Shunz Rd	Shunz Rd	65	23.5	21.98
4051	CBC	RCP	SE	Rect	36	72	2	Canal	I-4 E	Roosevelt Ct	100	33.44	33.38
4052	Storm Sewer	CMP	N	Circular	18	18	1	None	Landfill		38	28.32	27.79
4053	Storm Sewer	RCP	SE	Rect	48	96	2	Ditch	US-92	Us-92	194	25.78	25.46
4054	Storm Sewer	RCP	S	Rect	48	96	2	None	I-4	I-4	104	25.72	24.46
4055	Storm Sewer	RCP	S	Oval	29	48	1	Canal	Shunz Rd	Shunz Rd	62	25.38	24.56
4057	Side Drain	CMP	N	Oval	24	35	1	Canal	Halifax Dr		35	22.6	22.6
4059	Storm Sewer	RCP	E	Circular	48	48	1	None			113	13.45	11.2
4060	Storm Sewer	RCP	E	Circular	48	48	1	None		Taylor Rd	570	11.2	11.2
4061	Storm Sewer	RCP	E	Circular	48	48	1	None		Taylor Rd	516	11.6	8
4062	Storm Sewer	RCP	S	Circular	48	48	1	None	Taylor Rd	Tomoka Farms	70	11.05	11.6
4063	Storm Sewer	CMP	NE	Circular	18	18	1	None	Langford Rd		20	23.07	22.82
4064	Cross Drain	CPP	NE	Circular	48	48	3	Canal	Country Cir Dr E	Country Cir Dr W	19	9.4	10.7
4065	Cross Drain	RCP	NE	Oval	38	60	2	Canal	Country Cir Dr W	Brookside Dr	46	10.91	11.8
4066	Storm Sewer	RCP	E	Oval	48	76	1	None	Tomoka Farms	Ideis Rd	125	20.83	20.74
4067	Cross Drain	RCP	NW	Oval	19	30	1	Canal	Country Cir Dr E	Lakeside Dr E	42	12.3	11
4068	Storm Sewer	CMP	E	Circular	36	36	1	Canal	Powerline Rd		50	31.78	31.39

Table 4-2. (*Cont.)* Pipes Modeled and Updated in the B-21 Study Area (pg. 4 of 4)

Link No.	Culvert type	Material	Flow Direct	X-Shape	Rise (In)	Span (In)	No	Outfall	Street Name	Nearest Cross Street	Length (ft)	Up Inver	Down Inver
4069	Storm Sewer	CMP	E	Circular	36	36	1	Ditch	Canal Rd		31	25.6	25.6
4070	Side Drain	RCP	SE	Circular	60	60	1	Canal	Tribble Dr	Swan Dr	28	19.4	19.1
4071	Storm Sewer	RCP	S	Rect	96	96	2	Canal	Old Daytona Rd	Tomoka Farms	20	10.3	9.5
4072	Side Drain	RCP	E	Circular	54	54	1	Canal	Landfill		37	19.9	19.5
4073	Cross Drain	RCP	NE	Oval	24	38	1	None	Country Cir. Dr W	Quiet Cir	116	7.7	7.71
4074	Side Drain	CMP	E	Circular	48	48	1	Canal	Landfill		36	21.7	20.9
4075	Side Drain	CMP	E	Circular	64	64	1	Canal	Landfill		25	20.25	19.1
4076	Cross Drain	CBC	E	Rect	48	72	2	Canal	Palm Dr	Swan Dr	22	20.61	20.61
4077	Storm Sewer	RCP	E	Circular	24	24	3	None	Power line		20	23.9	23.9
4078	Storm Sewer	RCP	E	Circular	24	24	1	None	Power Line	Poinsettia Dr	40	23.1	23.1
4079	Side Drain	CMP	E	Circular	24	24	1	Canal	Power line	Swan Dr	20	20.6	20.6
4080	Storm Sewer	CMP	E	Circular	18	18	1	None	Power Line		20	21.5	21.3
4081	Cross Drain	CMP	S	Circular	60	60	1	Canal	Orange Dr	Palm Dr	30	22.9	22.9
4082	Storm Sewer	CMP	SE	Circular	24	24	1	None			20	33.8	33.6
4083	Storm Sewer	RCP	E	Circular	36	36	1	None			35	20.3	20
4084	Storm Sewer	RCP	E	Circular	36	36	1	Canal			22	19.3	19
4085	Storm Sewer	CMP	E	Circular	24	24	1	None	Palm Drive		35	20.8	20.8
4086	Storm Sewer	RCP	S	Oval	19	30	5	Canal	Shunz Rd	Shunz Rd	66	25.73	25.78
4087	Storm Sewer	RCP	S	Oval	29	45	1	Canal	Shunz Rd	Shunz Rd	64	24.29	24.44
4088	Storm Sewer	RCP	E	Circular	24	24	1	Ditch	Country Farms	Tomoka Farms	90	15	15
4089	Storm Sewer	RCP	S	Circular	48	48	1	Canal	Taylor Rd	Spruce View	33	20.6	20.14

Section 5 Problem Areas – Description and Project Prioritization

5.1 Introduction

Problem areas for the study area have been previously identified. In this section, improvements will be recommended for each problem area. The recommended improvements are focused on areas under county maintenance authority, such as roads and rights of way. The objective of the improvements is to increase the level of service (LOS) for the county roads to or above the desired level of service. To find the most cost-effective improvements for each problem area, various possible combinations of potential improvements are modeled. The model results of those alternatives are compared hydrologicaly/hydraulically and economically. The potential ecological and water quality impacts arising after implementing each improvement are then analyzed. Only the “best” improvement alternatives are recommended. This section details the recommended improvements and discusses their effects. The cost estimates for each improvement is detailed in the end of the section.

5.2 Improvement Recommendation

5.2.1 Planning Unit

The study area has been divided into seven basins. Hydraulically, basins are inter-connected. This means that eventually, under certain flood stage conditions, water will merge from one basin into another. For planning purposes, the basins are regrouped into three planning units: the Lakeshore unit, including the Lakeshore basin and the Kersey Road basin; the Hart unit, including the Hart basin and the Langford basin; and the B-21 Canal unit, including the B-21 Canal basin, the Spruce Creek basin, and the Quiet Trail basin. Figure 5-1 presents the basin planning units. Different combinations of improvement and alternatives were simulated for each planning unit to find the “best” improvement scheme. These recommendations are believed to be the most suitable improvements for the planning units.

5.2.2 Lakeshore Planning Unit

The major problem areas in the Lakeshore planning unit are at Pioneer Trail, Powerline Road, and the downstream area. During T. S. Fay, Powerline Road was severely flooded, and Pioneer Trail was temporarily closed due to water overtopping the road surface. The recommended improvements for this planning unit include: the construction of an additional 36” pipe under Powerline Road; the creation of a storage area on the north side of Pioneer Trail with a control structure on the north side of Pioneer Trail at the existing culvert crossing (as shown in Figure 5-2).

Currently, there are two 30” circular culverts under the Powerline Road, which drain water from west to east of Powerline Road. Due to the limited capacity of these culverts, water builds up on the west side of the road in large storms, and overtops the road. For the 25-year storm, the stage differential between the west side and the east side of the road exceeds 2 *ft* and 7” of water covers the road. In the 100-year design storm, water exceeds the road surface by 9”. After adding an additional 36” pipe, the flooding is reduced, but not to the desired level. Adding more pipes under Powerline Road would increase downstream flooding in the area along Western and Canal Roads. Therefore, raising Pioneer Trail to the west is proposed. The northern side of Pioneer Trail is a county owned wetlands area. Raising the road surface from the lowest elevation of 39.0 *ft* to 41.0 *ft* will create a 50 *acre-ft* storage area in this wetland area. The additional impoundment of water should not result in adverse impacts to the wetland system. This would also provide a water recharge benefit. Through controlling the discharge (by building a control structure on the wetland outlet), Pioneer Trail will be free from flooding and, at the same time, less water will flow downstream, thus reducing downstream flooding.

As a result of this improvement, the flooding problems in the Lakeshore planning unit would be greatly reduced. Figure 5-3 and Figure 5-4 present, respectively, the modeled water elevation at each node after implementation of the improvement for the 25-year and 100-year design storms. In the 25-year design storm, water depth in the newly created storage area increased about 5” and water depth over Powerline Road decreased approximately 6” (Table 5-1).

Table 5-1. Existing Water Elevations and Proposed Water Elevations After Implementing the Recommended Capital Improvements

Improvements	Location	25-year Elevation (*ft*)			100-year Elevation (*ft*)		
		Existing	Proposed	Diff	Existing	Proposed	Diff
Lakeshore Improvement (Constructing a control structure on north side of Pioneer Trail and adding an additional 36" under Powerline Road).	Storage area north of Pioneer Trail	38.94	39.48	0.54	39.4	39.82	0.42
	Powerline Road crossing the ditch	38.8	38.27	-0.53	39.01	38.84	-0.17
	Western Road south	28.79	28.69	-0.1	30.01	29.83	-0.18
	Canal Road middle section	27.85	27.86	0.01	28.94	28.79	-0.15
Hart Improvement #1 (Replacing the undersized pipes under the church's driveway and Langford Road).	Tomoka Farms Road in front of the church	26.18	25.13	-1.05	26.36	26.1	-0.26
	Tomoka Farms Road north of Langford Road	24.39	23.8	-0.59	25.39	25.47	0.08
Hart Improvement #2 (Cleaning the Hart ditch and adding an additional 36" culvert under Tomoka Farms Road).	Tomoka Farms Road middle section between the church and Hart ditch	26.17	25.8	-0.37	26.34	26.11	-0.23
	Tomoka Farms Road crossing the Hart ditch	26.28	26.1	-0.18	26.38	26.22	-0.16
	Hart Ditch middle section	23.78	23.75	-0.03	23.84	23.79	-0.05
Palm Drive Improvement (Raising power line access road to increase storage of the wetland on west).	Ditch north of Orange Drive	24.15	23.56	-0.59	24.68	23.39	-1.29
	Western end of Swan Drive	24.91	23.39	-1.52	25.53	24.41	-1.12
	Southern end of Palm Drive	24.53	23.39	-1.14	25.23	24.41	-0.82
B-21 Canal Area Improvement (Replacing the two box culverts under Old Daytona Road by a 30' span bridge).	Landfill Road crossing the B-21 Canal west of Tomoka Farms Road	20.66	20.28	-0.38	21.28	21.12	-0.16
	Halifax Drive crossing the B-21 Canal west of Tomoka Farms Road	20.26	19.64	-0.62	20.83	20.62	-0.21
	Tomoka Farms Road crossing the B-21 Canal north of Avocado Drive	19.42	18.17	-1.25	19.98	18.97	-1.01
	Old Daytona Road crossing the B-21 Canal east of Tomoka Farms Road	18.59	16.79	-1.8	18.86	17.61	-1.25
Meadow Lane Improvement (Providing a positive outfall for Meadow Lane ditch).	Meadow Lane area	21.91	21.13	-0.78	22.28	21.61	-0.67
	Taylor Road crossing the ditch	19.71	18.91	-0.8	20.23	19.52	-0.71

The LOS for Powerline Road would be raised from LOS D/F to LOS B, and the improvement would not increase the downstream water level. As modeled, in the existing condition, the water stage at the intersection area of Lakeshore Drive and Canal Road is 27.35 *ft*; after implementation of the improvements, the stage is 27.36 *ft*. In the 100-year design storm, implementation of these improvements would reduce water levels over Powerline Road by 3”. Water levels along Western and Canal Roads would be reduced slightly. As modeled, levels in the intersection area of Lakeshore Drive and Canal Road would be reduced about 1” after the improvement.

After the improvements, the lowest elevation of Pioneer Trail would be 41.00 *ft.* The water elevation in the wetland storage area is 39.82 *ft* in the 100-year design storm. Thus, Pioneer Trail would be free of flooding.

5.2.3 Hart Planning Unit

During T. S. Fay, Langford Road and the surrounding areas were severely flooded. Water depth over the Langford Road surface was 6”. Two houses south of Langford Road were reported flooded. Water in the Hart ditch covered most of Tomoka Farms Road. Residents commented that they felt that culvert pipes under the Jehovah Witness church driveway and were too small to drain efficiently, and thus the upstream area was flooded during T. S. Fay. To solve the problems, two improvements are recommended for this area (see Figure 5-5). Improvement #1 is to replace the undersized pipes under the church’s driveway and also under Langford Road. The existing 30” pipe should be replaced with an equivalent 48” pipe or an additional 30” pipe should be added. It is expected that this improvement would resolve the problem areas around the church and surrounding Langford Road. Improvement #2 would be to clean the Hart ditch. This ditch is over-vegetated due to lack of maintenance, and its capacity is greatly reduced. The length to be cleaned is approximately 700 *ft*. Also, the pipe crossing Tomoka Farms Road and discharging into the Hart ditch is currently a 36” culvert. One additional culvert of the same size should be added, along with cleaning the ditch.

After implementing Improvement #1, the water stage in the church area is reduced by more than 1 *ft* in the 25-year design storm (Table 5-1). In the 100-year design storm, the stage is reduced approximately 3” and the LOS for Tomoka Farms Road would increase from LOS C to LOS B (Figures 5-6 and 5-7).

After implementation of Improvement #2, the water stage in the Hart ditch is reduced about 2” and the LOS for Tomoka Farms Road would increase from LOS C to LOS B (Figures 5-8 and 5-9).

5.2.4 B-21 Canal Planning Unit

The problems in this unit include the Palm Drive area (including Swan, Guava, and Orange Drives), B-21 Canal at Halifax Drive and Old Daytona Road, and the Meadow Lane area.

Three improvements are recommended for solving these problem areas. Improvement #1, the Palm Drive area improvement, intends to use the wetland area west of the power line access road to create stormwater storage and to control the release rate to the east side of the road, by building a berm and three control structures. This project would raise the power line access road to an elevation of 26.0 *ft* from the existing elevations, which vary from 23.0 *ft* to 26.0 *ft*. The pipe connecting the power line ditch and the landfill ditch on the north end would be removed, to prevent water from flowing to the power line ditch from the landfill ditch. Raising the road would cause more water to flow south and discharge to Spruce Creek, and could cause flooding problems downstream. Therefore, this project plans to replace the two 36” pipes under Spruce Creek Circle with two 54” pipes. The project location is shown in Figure 5-10.

Improvement #2, the B-21 Canal area improvement, would replace the two 96” box culverts under Old Daytona Road (on the east side of Tomoka Farms Road) with a 30 foot span bridge. These box culverts are a constraint to the B-21 Canal. In large storms, water on the north side of the road (upstream) is predicted to overtop Old Daytona Road, Halifax Drive and Avocado Drive. As modeled in the 25-year design storm, the stage differential between the north side and the south side of Old Daytona Road is 1.9 *ft*. In the 100-year design storm, the difference is 1.3 *ft*. Old Daytona Road is overtopped by 4”. Figure 5-11 shows the location of the proposed improvement.

Improvement #3, the Meadow Lane area improvements, is targeted to solve flooding problems in this area by providing a positive outfall for the ditch. Historically, this ditch flowed to the south; however, the outfall path is severely restricted. A property owner in the 1960s constructed a ditch on his property connecting it to the B-21 Canal. Since that time property boundaries have become less distinct, and adjacent property owners have expressed that the ditch is a source of problems and not a remedy. Discussions with County field staff indicated that private property owners have altered the outfall path by filling and other land use activities. During T.S. Fay, Meadow Lane was severely flooded. Opening an outfall to the west and letting water from the ditch drain to the B-21 Canal is a relatively inexpensive project. This would involve securing the appropriate drainage easements from the affected property owners. Figure 5-12 shows the location of the proposed improvement.

After implementing Improvement #1, the flooding problem in the Palm Drive area would be significantly reduced (Figures 5-12 and 5-13), and the LOS for Palm Drive would increase from LOS D to LOS B in the 25-year design storm. In the 100-year design storm, the LOS for Palm Drive would increase to LOS C, which matches the desired LOS for this road. In some places, the water level would be reduced over 1 *ft*. As modeled, the existing water elevation in the ditch north of Orange Drive is 24.15 *ft* in a 25-year design storm. After implementing the improvements, the elevation would decrease to 23.56 *ft* (Table 5-1). The elevation at the western end of Swan Drive would be reduced from 24.91 *ft* to 23.39 *ft*. In the 100-year design storm, the elevations in the two locations decrease from 24.68 *ft* to 23.99 *ft*, and from 25.53 *ft* to 24.41 *ft*, respectively. Water elevation at the southern end of Palm Drive would decrease from 25.23 *ft* to 24.41 *ft*. Flooding of the properties in the area during T.S. Fay would not occur after implementation of Improvement #1. Most importantly, this improvement does not create flooding downstream. For instance, the elevation on the north side of Spruce Creek Circle is 23.01 *ft* in the existing condition in the 100-year design storm. After implementing the improvement, it would decrease to 21.03 *ft*.

Through implementing Improvement #2, flooding along the B-21 Canal would be fundamentally solved (Figures 5-14 and 5-15). The modeling indicates the following water level reductions along the canal in the 25-year design storm: Landfill Drive from 20.66 *ft* to 20.28 *ft*; Halifax Drive upstream side from 20.26 *ft* to 19.64 *ft*; and Old Daytona Road upstream side from 18.59 *ft* to 16.79 *ft*. In the 100-year design storm, these reductions would be, respectively, from 21.28 *ft* to 21.12 *ft*; 20.83 *ft* to 20.62 *ft*, and 18.86 *ft* to 17.61 *ft* (Table 5-1). Water level downstream from Old Daytona Road would not change. No roads crossing the B-21 Canal would be flooded with these improvements.

In the existing condition, the water elevation in the Meadow Lane area is 22.28 *ft* in the 100-year design storm (Figures 5-16 and 5-17). After applying Improvement #3, the elevation in the area would decrease to 21.61 *ft* (Table 5-1), with flooding problems in this area essentially solved. This improvement would not appreciably increase downstream water levels in the B-21 Canal. The stage at the north side of Taylor Road is 15.5 *ft* in the existing condition, and after applying Improvement #3, it would be 15.53 *ft*.

5.3 Cost Estimate

Tables 5-2 through 5-7 present the cost estimates for each improvement. The cost for the recommended projects ranges from $53,280 for the Meadow Lane Ditch construction to $457,800 for the Lakeshore improvements. The estimates are based on current labor/material prices.

Table 5-2. Cost Estimate for Lakeshore Improvement
(Raising Pioneer Trail and adding an additional pipe in Powerline Road)

No.	Item	Quantity	Units	Unit Price	Extended Price
1	Insurance and Mobilization	1	LS	$50,000	$50,000
2	Roadway Demolition	5,000	SY	$10	$50,000
3	Fill and Grading	5,000	SY	$15	$75,000
4	Sub-grade, Base and Asphalt	5,000	SY	$35	$175,000
5	Control Structure	1	EA	$5,000	$5,000
6	36" RCP	50	L.F.	$90	$4,500
9	Sod	1,000	SY	$2	$2,000
10	Silt Fence	4,000	L.F.	$5	$20,000
11	Contingency			20%	$76,300
12	Sum				$457,800

Table 5-3. Cost Estimate for Hart/Langford Improvement #1
(Replacing culverts before Spruce Creek Congregation of Jehovah's Witness Church)

No.	Item	Quantity	Units	Unit Price	Extended Price
1	Insurance and Mobilization	1	LS	$8,000	$8,000
2	Pipe Replacement	550	L.F.	$65	$35,750
3	Mitered End Section	4	EA	$5	$2,000
4	Sod	1,000	SY	$2	$2,000
5	Silt Fence	4,000	L.F.	$5	$20,000
6	Contingency			20%	$13,550
7	Sum				$81,300

Table 5-4. Cost Estimate for Hart/Langford Improvement #2
(Cleaning Hart ditch and adding additional culverts)

No.	Item	Quantity	Units	Unit Price	Extended Price
1	Insurance and Mobilization	1	LS	$8,000	$8,000
2	Ditch Maintenance (grading and debris removal)	1,000	L.F.	$15	$15,000
3	36" RCP	130	L.F.	$90	$11,700
4	Headwall	2	EA	$2,000	$4,000
5	Stormwater Inlets	2	EA	$2,500	$5,000
6	Sod	1,500	SY	$2	$3,000
7	Silt Fence	4,000	L.F.	$5	$20,000
8	Contingency			20%	$13,340
9	Sum				$80,040

Table 5-5. Cost Estimate for B-21 Canal Improvement #1
(Raising power line access road and replacing Spruce Creek Circle pipe)

No.	Item	Quantity	Units	Unit Price	Extended Price
1	Insurance and Mobilization	1	LS	$42,000	$42,000
2	Berm Fill, Grading and Stabilization	12,000	L.F.	$15	$180,000
3	Control Structure	4	EA	$5,000	$20,000
4	54" RCP	100	L.F.	$90	$9,000
5	Sub-grade, Base and Asphalt	100	SY	$50	$5,000
6	Sod	12,000	SY	$2	$24,000
7	Erosion and Sediment Control	1	L.S.	$75,000	$75,000
8	Contingency			20%	$71,000
9	Sum				$426,000

Table 5-6. Cost Estimate for B-21 Canal Improvement #2
(Old Daytona Road culverts replacement)

No.	Item	Quantity	Units	Unit Price	Extended Price
1	Insurance and Mobilization	1	LS	$15,000	$15,000
2	Sub-grade, Base and Asphalt	500	SY	$35	$17,500
3	Box Culverts Replacement	1	L.S.	$35,000	$200,000
4	Sod	500	SY	$2	$1,000
5	Erosion and Sediment Control	1	L.S.	$10,000	$10,000
6	Contingency			20%	$22,600
7	Sum				$266,100

Table 5-7. Cost Estimate for B-21 Canal Improvement #3
(Meadow Lane Ditch Construction)

No.	Item	Quantity	Units	Unit Price	Extended Price
1	Insurance and Mobilization	1	LS	$5,5000	$5,500
2	Ditch Construction	1,200	L.F.	$20	$24,000
3	Sod	1,200	SY	$2	$2,400
4	Erosion and Sediment Control	1	L.S.	$12,500	$12,500
5	Contingency			20%	$8,880
6	Sum				$53,280

Section 6 - Water Quality

6.1 Introduction

Although the major focus of this study is to address flooding, the importance of water quality must be included in any discussion of a comprehensive stormwater management plan. Many of the improvements that are intended for the reduction of flooding must also be balanced with appropriate water quality considerations. This is an important component of designing a project which can meet water management permit requirements. In this section, water quality in the study area is reviewed and the planning efforts to meet future pollution reduction goals are discussed. Since limited data has been collected for a water quality study, most of the information presented below is from literature reviews.

6.2 Water Quality Standards and Regulatory Programs

The B-21 study area is a sub unit of Spruce Creek. The Florida Department of Environmental Protection surface water classification for the B-21 basin is Class III, which is for recreation, propagation, and maintenance of a healthy, well-balanced population of fish and wildlife. However, downstream in the main stem of Spruce Creek, the classification is that of an Outstanding Florida Water" (OFW). An OFW is a water designated worthy of special protection because of its natural features and qualities.

According to the Florida Department of Environmental Protection, a portion of the B-21 study area is verified as impaired for fecal coliform. This is contained in a 2008 report entitled "*Fecal Coliform TMDL for Spruce Creek WBID 2674*". Figure 6-1 shows the location of the Water Body I.D. (WBID's) within the study area. A Total Maximum Daily Load (TMDL) is the maximum amount of a given pollutant that a water body can assimilate and still meet its designated use. The TMDL establishes the allowable loadings within the affected portion of the B-21 basin (and Spruce Creek) that would restore the waterbody so that it meets the applicable water quality criteria for fecal coliform. A fecal coliform reduction of 53% is required from nonpoint sources within the designated area of impairment or (WBID). The determination of a TMDL is based on historical water quality data obtained from a variety of sources, such as FDEP, SJRWMD, and the Volusia County Environmental Health Lab.

Future planning efforts by the county and other affected stakeholders will involve developing a basin management action plan (BMAP) to address this impairment. The BMAP will likely include signed agreements among stakeholders, timetables for implementation, milestones, load limitation agreements, funding mechanisms, description of load reduction activities, local ordinances defining or prohibiting certain actions, and descriptions of further data collection or source identification.

The municipal stakeholders identified within the area of impairment include the cities of Port Orange and New Smyrna Beach. It is anticipated that the development of the BMAP will include a consensus among the stakeholders on detailed allocations and how the loads will be reduced. The Spruce Creek TMDL report indicated that FDEP would begin the process of BMAP development in March 2009. As of this writing, FDEP has not provided a revised schedule for BMAP development.

The other regulatory program that is currently affecting the county is the National Pollutant Discharge Elimination System (NPDES). Volusia County is a Phase II MS4 (municipal separate storm sewer system) permit holder. This program requires a number of activities and programs which satisfy the "six minimum measures" included in the program. This multi-pronged approach is structured to address stormwater pollution issues, both structural and non-structural. Examples include construction site runoff control, prohibiting non-stormwater discharges to municipal systems, and requiring public education and outreach efforts.

Future NPDES permits will likely be linked to the TMDL load allocation for fecal coliform in the B-21 (Spruce Creek) basin and would reference the waste load allocation. According to the FDEP report, "it should be noted that all MS4 permits issued in Florida include a reopener clause that allows permit revisions to implement TMDL's when the implementation plan is formally adopted". However, the county would only be responsible for reducing those loads associated with outfalls over which it has control.

6.3 Pollution Sources

Pollution sources are generally classified as point sources and non-point sources. Point sources include the traditionally defined point sources, such as domestic and industrial wastewater treatment facilities that have a continuous flow via a discernable, confined and discrete conveyance facility (such as a pipe), and stormwater systems which require a National Pollutant Discharge Elimination System (NPDES) stormwater permit. Non-point sources are the intermittent, rainfall-driven, diffuse sources of pollution associated with everyday human activities, including runoff from urban land uses, agriculture, silviculture, mining; and discharges from failing septic systems. Only two state permitted point sources are located close to the study area: Samsula Elementary School (to the southeast) for extended aeration with reuse to two septic tank drain fields and the Double D mobile Ranch for extending aeration with effluent to two percolation ponds and a spray field.

Septic tanks are commonly used in the study area. As estimated by FDEP, the failure rate of septic tanks in the watershed is approximately one percent per year with older septic systems particularly vulnerable to leakage. Accordingly, tank failure and malfunctions are likely a significant source of fecal coliform.

Several resident reports from the August 2008 public meeting expressed the concerns regarding the safety of septic tanks, which are widely used in the study area. Some septic tanks were reported flooded in Hurricane Francis and T.S. Fay. A comprehensive inspection and monitoring system of the existing septic tanks should be considered an important best management practice (BMP) strategy in reducing this pollutant source.

In addition to septic system failure, animal waste is another source of fecal coliform. The study area contains 1439 acres (or 6.7% of the total land) of agricultural land (Table 2-2). According to FDEP's estimation of cattle population in the Spruce Creek watershed, which is 0.5 cows/acre, there are about 720 cattle in the study area. Using EPA's average fecal contribution of 1×10^{11} organisms per day per cow gives an estimation of 7.2×10^{13} and 2.63×10^{16} potential for daily and annual fecal contribution, respectively. In large storms like T. S. Fay, large areas of pasture were flooded. This situation results in a large amount of animal waste running off property and into ditches and canals.

Many residents reported their concerns regarding the effect of animal waste to the local environment. Some landowners were concerned about the safety of their livestock during storms like T. S. Fay. The primary animals within the study area are cattle, chicken, horses, and pets (dogs and cats). Without proper management, animal waste is washed into the ditches and channels and enters into the rivers and ultimately into Spruce Creek. Thus a waste management program is recommended to be implemented in the study area. For livestock safety, owners should be informed and educated to take proper protective actions before storms. These protective actions should be based on a pre-selected location to shelter animals and protect them from floodwaters.

For reference purposes, Table 6-1 presents FDEP's estimation of the potential fecal coliform loading from various sources for Spruce Creek. A fecal coliform reduction of 53% is required for Spruce Creek WBID 2674 from non-point sources.

Table 6-1. FDEP estimated potential annual fecal coliform loading from various sources for Spruce Creek area.

Source	Fecal Coliform
Septic Tanks	3.12×10^{13}
Pets	8.49×10^{14}
Cattle	4.13×10^{16}
Horses	1.88×10^{13}
Collection Systems	5.56×10^{13}

6.4 Best Management Practices

As shown and discussed above, septic tanks, cattle, horses, and pets are primary non-point sources of fecal coliform. Proper management of these sources is important in reducing pollutants within the B-21 study area. The following best management practices and planning actions are suggested:

1. Septic tank inspection and monitoring - As described before, this practice seeks to repair and/or replace damaged tanks immediately and thus reduce leaks from the tanks.
2. Establishment of an education program for livestock, horse, and pet owners - A variety of land use best management practices are available that can educate property owners on how to reduce discharges of pollutants from their land, such as animal waste. The Florida Department of Agriculture and Consumer Services (FDACS) offers a best management practices (BMP) guide for a wide variety of land uses, and an example publication is a BMP guide for cow/calf operations. A recommended listed BMP for this type of operation would be to establish vegetated, “animal free” buffers near ditches, creeks, and canals. Other BMP’s can be implemented for other types of land uses.
3. Expanded monitoring plan - As stated in the FDEP’s report, since the sample size and sampling occurred in only one year, relationships between fecal coliform, seasonality, rainfall, or long-term trends was not discerned. So further monitoring of fecal coliform is needed to better define these potential sources. This monitoring can be performed by increasing the number of water sampling stations, conducting more site specific data collection of livestock (type and number) for each parcel, and inspecting septic systems locations to better define the source of fecal coliform loading.
4. Development of a more detailed land use database – This effort could be used to further refine fecal coliform source locations and loadings, and could also involve an inventory of land acreage, livestock, horse, and pet inventories, pasture proximity to ditches and streams, age of waste water systems, and other data useful for predicting load reductions under various BMP scenarios.

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Appendix A
Hydraulic Profiles

Appendix B
Flood Documentation Photographs

The following photos were taken by ECT engineers during Tropical Storm Fay on August 21, 2008, and Hurricane Frances on September 5, 2004.

Appendix C
ICPR Modeling