PACE

Pithlachascotee/Anclote Conservation Effort
Watershed Management Program (L738)

Anclote West Watershed Evaluation

WATERSHED EVALUATION REPORT

August 17, 2015

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water resources and civil engineering

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Pithlachascotee/Anclote Conservation Effort (L738)
Anclote West Watershed Evaluation

WATERSHED EVALUATION REPORT

August 17, 2015. The purpose of this report is to document efforts toward completing the Anclote West Watershed Evaluation for the Pithlachascotee/Anclote Conservation Effort (PACE) project. This report expands upon previous work performed by Ardaman & Associates, Inc. (Ardaman) as described in "Pithlachascotee and Anclote River Watersheds (L738) Data Collection Completion Report" (2012), and documents subsequent tasks performed by DeLoach Engineering Science, PLLC (DES) under SWFWMD TWA No. 14TW-42. A complete set of project deliverables, including GWIS geodatabase, TSDN, and project-specific QA/QC document, accompanies this report on DVD.

Introduction

The Pithlachascotee/Anclote Conservation Effort (PACE) is a cooperatively funded project by and between the Southwest Florida Water Management District and Pasco County, performed under the District's Watershed Management Program (WMP). The PACE study area is comprised of three watersheds: Pithlachascotee River, Anclote East of Suncoast, and Anclote West (Figure 1). Watershed models for the Pithlachascotee River and Anclote East of Suncoast were previously developed, by others, under separate WMP agreements.

A Task Work Assignment (TWA No. 14TW-42) was issued to DeLoach Engineering Science, PLLC (DES) on November 21, 2014, under SWFWMD Agreement No. 14MA00000018, to perform Watershed Evaluation elements of the WMP in the Anclote West watershed. The Anclote West watershed is a particularly important part of the overall PACE study area, as:

- it includes areas that are, historically, the most flood-prone of the three watersheds;
- it is the site of significant flow exchange between the Pithlachascotee River and the Anclote River during extreme flood conditions;
- it encompasses a rapidly growing area of Pasco County, including the SR 54 corridor (South Market Area, aka, Gateway Crossings) with its many planned developments: Mitchell Ranch, Western Hub, Trinity East, Starkey, Asturia, and Suncoast Crossings;
- it includes District-owned lands with the potential to provide regional storage for conservation and flood mitigation.

Once the Anclote West watershed model is assembled, it will be joined with the Pithlachascotee and Anclote East models to provide a single model domain covering the entire PACE study area. This combined PACE model will then be used to determine and map flood risk and to evaluate various Best Management Practice (BMP) alternatives, including those for flood mitigation and diversion of excess flows from the rivers onto District land for water conservation.

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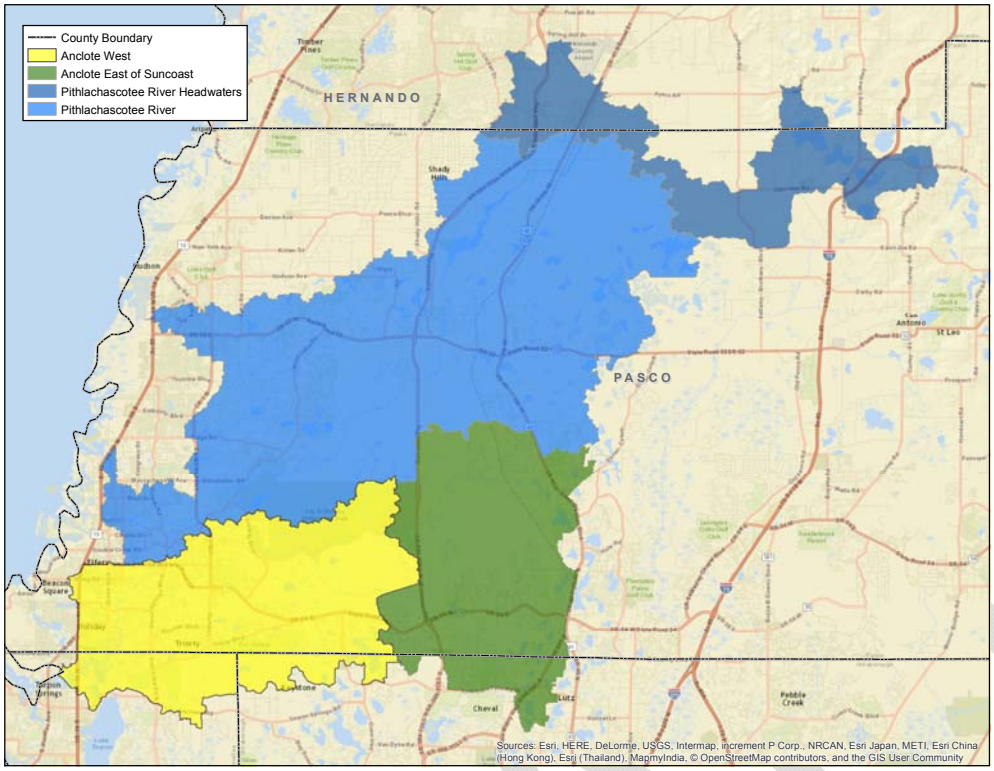

Figure 1: Anclote West Watershed and the PACE Study Area

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Previous Work Completed

Flood studies of both the Pithlachascotee River and the Anclote East of Suncoast watersheds have recently been completed under the District's WMP program. Those projects included watershed evaluation, model development, peer review, and floodplain mapping. Some Watershed Evaluation elements of the WMP were completed for the Anclote West watershed by Ardaman in 2012. In addition, District staff collected as-built and construction plans from Environmental Resource Permit files and compiled additional high water mark information to document recent high water conditions and flood events in the Anclote West watershed area.

Under TWA No. 14TW-42, DES reviewed the prior Ardaman work products and completed all remaining Watershed Evaluation tasks for the Anclote West watershed. Under separate contract, Ardaman continues to provide certain support services (field reconnaissance and GWIS data entry, terrain updates, and third party QA/QC) for the PACE project.

Prior Watershed Evaluation Deliverables. DES staff, quite familiar with the WMP work performed by Ardaman through 2012, reviewed all reports and data files submitted as prior project deliverables. In performing that review, it appeared that all final approved project deliverables from that prior effort were furnished to DES by the District, along with the additional information more recently collected by District staff.

A summary of data furnished to DES by the District includes:

- PACE WMP final project submittal (Ardaman, 2012). This comprehensive submittal includes all final deliverable files, including aerials, terrain, TSDN, reports, etc. 2011 aerial photos were not included in this submittal and will be provided by the District separately.
- Additional as-built and construction plans not included in the Ardaman final submittal. (\TSDN_Report\5_Misc_Ref_Materials\ERP_DOT)
    - Approximately 220 additional scanned ERP as-built or construction plans were provided
    - Approximately 160 ERPs with as-built or construction plans were made available through WMIS
- Pubic responses to Anclote West Notification and Questionnaire direct mailing, 2014. Includes Pasco County responses only. Does not include Pinellas or Hillsborough County information. (\TSDN_Report\5_Misc_Ref_Materials\SWFWMD_Public_Flooding_Questionnaire_2014)
- Pasco County Stormwater Inventory database, 2014. (\TSDN_Report\5_Misc_Ref_Materials\Pasco_County_Stormwater_Inventory_2014)
- High Water Database, 2014. (\TSDN_Report\5_Misc_Ref_Materials\HighWater_Database)

Other Previous Reports. The Anclote River and adjacent watersheds have been the focus of numerous prior evaluations, including studies related to flood risk, water quality, and environmental restoration and enhancement. The following table lists reports that were collected by DES to provide background information for the watershed study. Each report was either supplied by District staff at the commencement of the project or collected by Ardaman as part of the prior work effort. These reports can be found on the accompanying hard drive in the "Reports_Pertaining_To_PACE" subfolder of the "TSDN_Report\5_Misc_Ref_Materials" folder.

Table 1: Previous Reports on the Anclote

Report Title	Date	Source
Anclote River Survey from USACOE	Nov. 2008	SWFWMD
Anclote River System Recommended Minimum Flows and Levels	Feb. 2010	SWFWMD
Anclote River Watershed Study, Pasco County	April 2000	SWFWMD
Hillsborough River Watershed Management Plan	2000	SWFWMD
Pasco County Flood Insurance Study	1992	FEMA
Pinellas-Anclote River Basin Board FY2007 Accomplishments	2007	SWFWMD
Preliminary Analysis of Wetland and Hydrologic Restoration, Serenova Tract, Pasco County	Dec. 2006	SWFWMD
Serenova (Starkey Addition) Wetland Restoration and Enhancement Project, Site Evaluation and Recommendations	May 2002	SWFWMD
Serenova Tract Prelimiary Engineering and Evnironmental Analysis of Wetland and Hydrologic Restoration	Sept. 2006	SWFWMD
Starkey Ecosystem Enhancement Project, Feasibility Study, Pasco County	Feb. 2004	SWFWMD
Starkey Ecosystem Enhancement Project, Feasibility Study, Pasco County	Feb. 2012	SWFWMD
Starkey Ranch Site Conditions Assessment Permit	Oct. 2007	SWFWMD
Tampa Bay/Anclote River Comprehensive Watershed Management Plan	June 2005	SWFWMD

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Project Area Description

As illustrated in Figure 1, the contributing area associated with the PACE project spans approximately 420 square miles in Pasco, Hernando, Pinellas, and Hillsborough counties. Portions of the cities of New Port Richey and Tarpon Springs lie within the study area. Major roads that pass through the area include I-75, US-41, US-19, State Road 52, State Road 54, Suncoast Parkway, Ridge Road, and Little Road.

Boundaries of the Anclote West and Adjacent Watersheds

Figure 2 depicts watersheds within and adjacent to the PACE study area. The following watersheds are adjacent to the PACE study area: Squirrel Prairie and Toachodka to the north; Cypress Creek to the east; Brooker Creek to the south; and Lower Coastal, Double Hammock, Port Richey, Hammock Creek, and Weeki Wachee to the west.

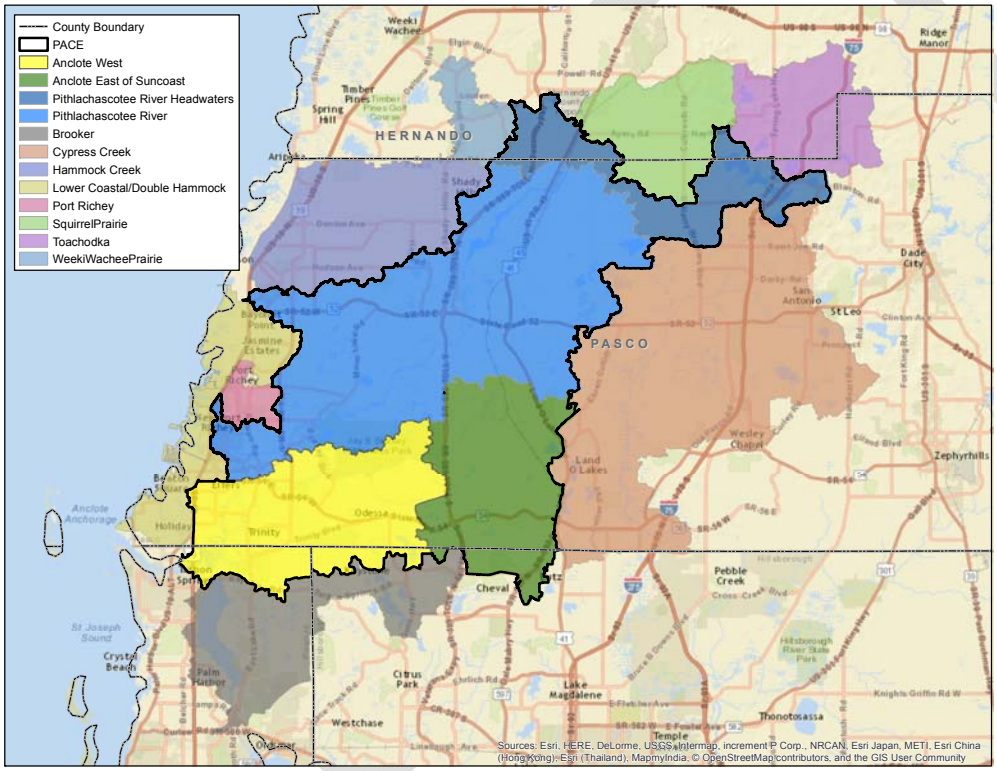

Figure 2: PACE and Adjacent Watersheds

Major Conveyance Systems and Drainage Patterns within the Anclote West Watershed

The Anclote River begins east of the Suncoast Parkway and flows southwesterly towards the Gulf of Mexico. Tributaries that feed into the river within the 66 square mile Anclote West watershed include Cross Cypress Branch, Sandy Branch, Duck Slough, and Hollin Creek, as well as the South Branch of the Anclote River.

Named lakes within the Anclote West watershed include Ann, Dan, Frances, Geneva, Hiawatha, Minniola, Osceola, Salt, and Seminole. In the downstream portion of the watershed, close to where the river discharges into the Gulf, are several bayous including Kreamer, Tarpon, and Whitcomb.

Major waterways and water bodies are illustrated in Figure 3.

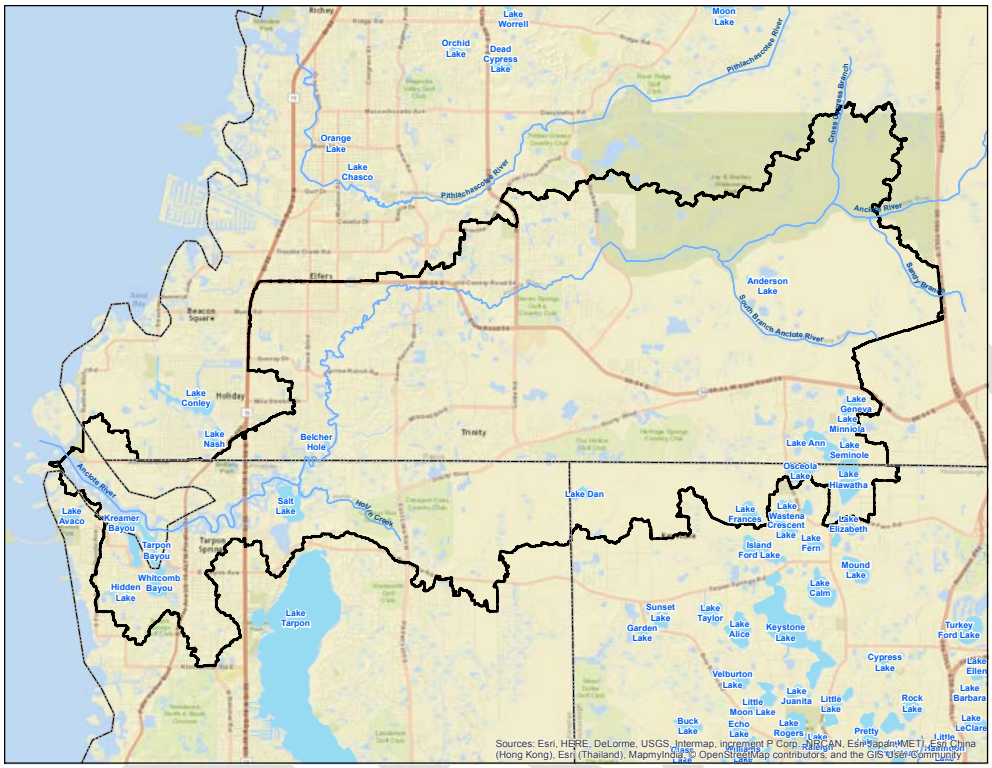

Figure 3: Waterways and Water Bodies in the Anclote West Watershed

Topography of the Anclote West Watershed

Figure 4 illustrates terrain elevations across the Anclote West watershed. At the highest point along the eastern ridge that defines the watershed boundary, land elevation is approximately 70 feet, NAVD88. At the lowest point in the watershed, near the mouth of the Anclote River, land elevation is approximately 0.4 feet, NAVD88.

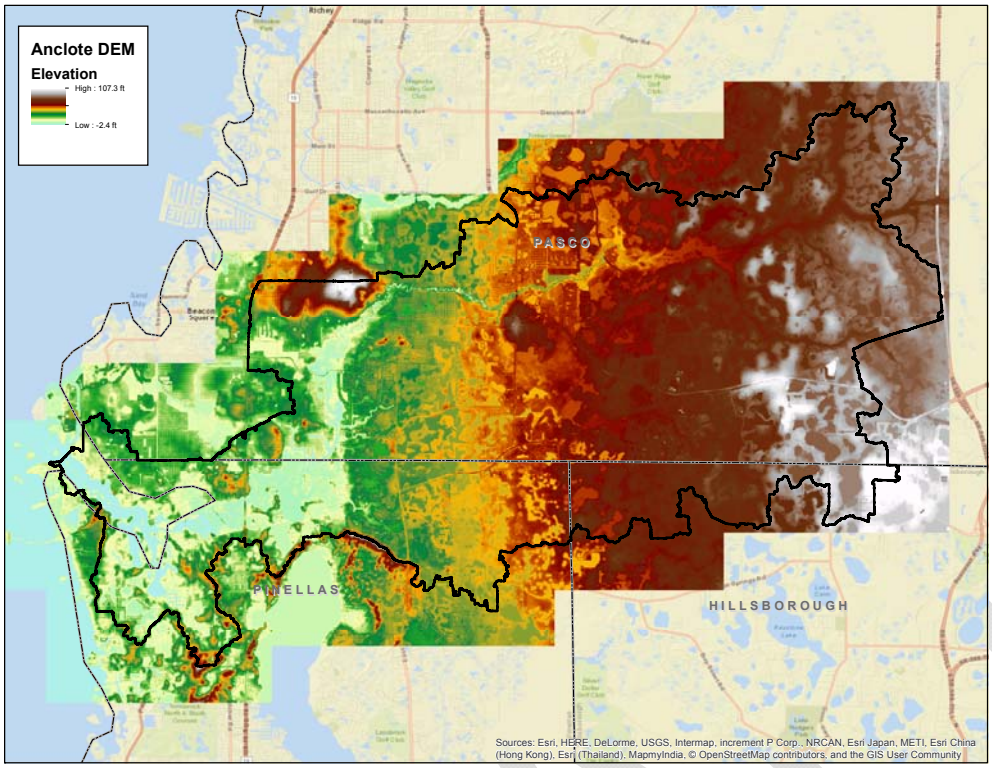

Figure 4: Terrain

<u>Existing Soil and Land Use Conditions</u>

Soils. Figure 5 illustrates the spatial distribution of hydrologic soil groups across the Anclote West watershed, demonstrating runoff potential, based upon soil surveys published by the U.S. Department of Agriculture, Natural Resource Conservation Service (USDA-NRCS). Low permeability, hydric soils associated with depressional areas and floodplains are predominant. These soils exhibit low infiltration rates and available storage capacity. Deep sands, which exhibit high infiltration and high available storage, comprise approximately 20 percent of the watershed.

As seen in the figure, soils throughout most (nearly 60 percent) of the watershed fall into the dual HSG A/D and B/D categories. In agricultural areas and other regions where pumping has historically kept surficial aquifer water levels low, these soils may provide high infiltration rates and storage capacity. Conversion from agricultural to residential land use and reductions in regional pumping may reverse this effect, resulting in higher runoff potential.

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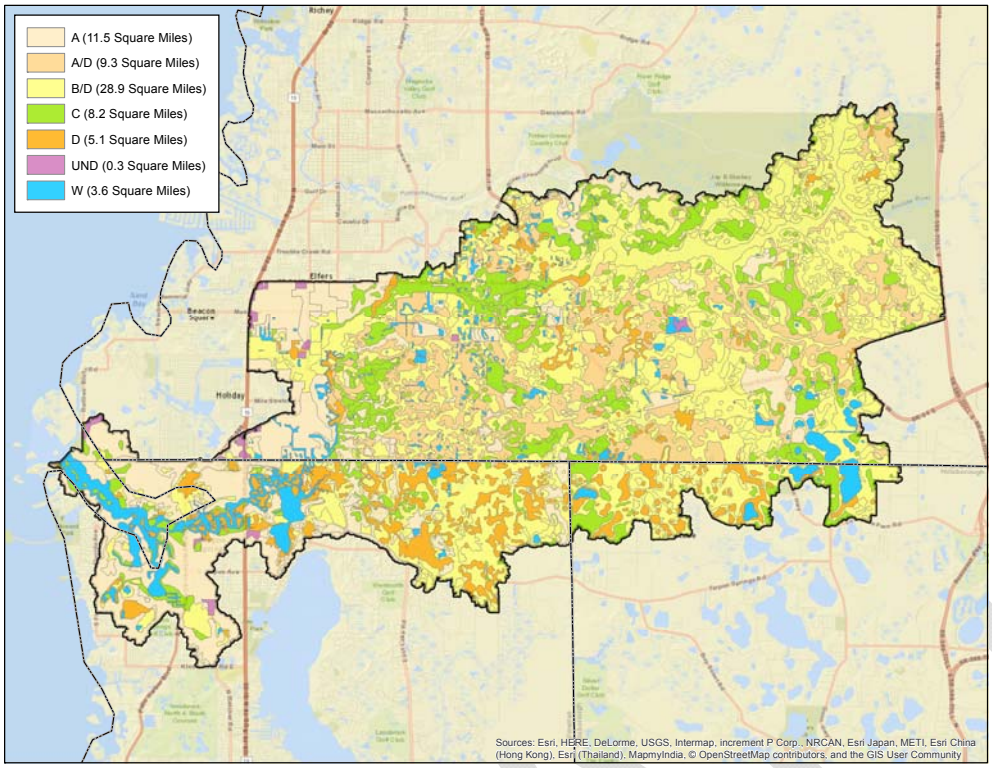

Figure 5: Hydrologic Soil Groups

Land Use. Land use categories are used along with soil types to define runoff potential. Categories that are used to describe land use are based upon the Florida Land Use, Cover, and Forms Classification System. A cutoff date of 2011 was established by SWFWMD, defining the "existing condition" for the project. The 2009 land use coverage provided by the District was updated by Ardaman, using aerial photographs, to include development that occurred through 2011.

There is a wide variety of land use within the Anclote West watershed, including a significant amount (nearly 40 percent of the overall watershed area) of urban land which occurs primarily in the western half. A large amount of agricultural and open range lands cover much of the eastern half of the watershed. Many of those lands are transforming to urban use through continued development, particularly along the SR 54 corridor. Nearly 30 percent of the area is in water and wetlands. Figure 6 illustrates the various land use types within the Anclote West watershed.

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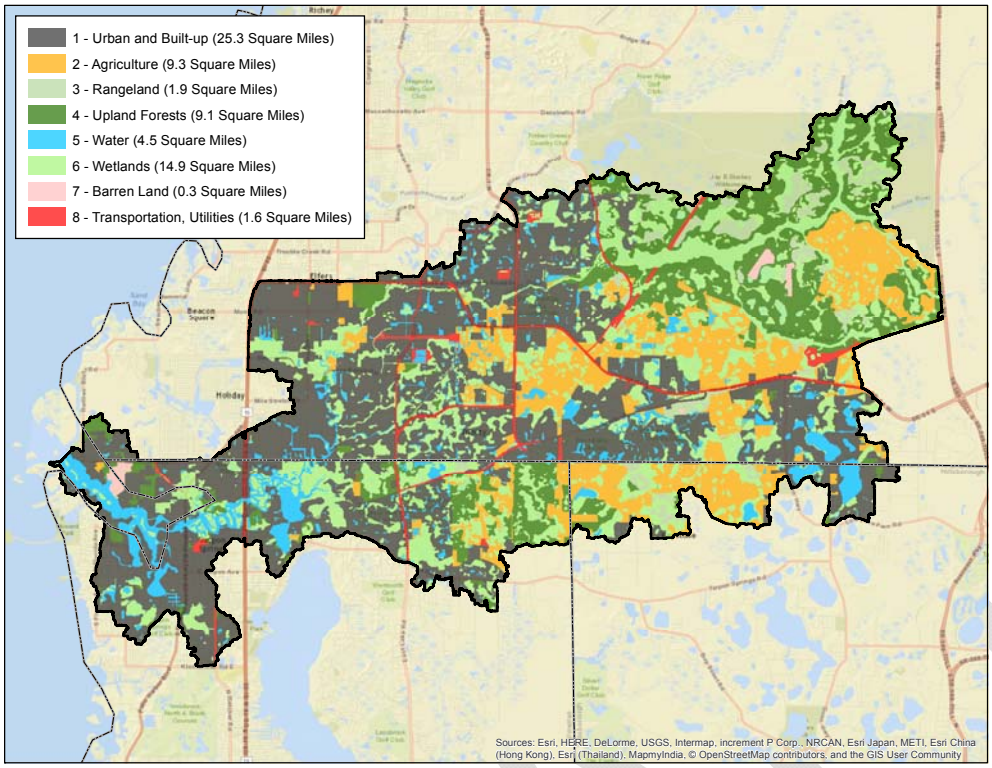

Figure 6: Land Use Coverage within the Anclote West Watershed

<u>Existing Committed (Permitted Future Buildout) Watershed Conditions</u>

While a cutoff date of 2011 was established for purposes of ERP data collection for this project, it was recognized that certain large planned residential and mixed-use developments have moved far along in the design, permitting, and, in some cases, construction stages. District and County staff instructed DES that those particular communities should be represented in their build-out condition, being effectively an "existing committed" land use condition, for the PACE project.

Specifically, planned topographic, land use, soils, and other relevant information (such as information describing stormwater collection, storage, and conveyance facilities) associated with permitted buildout conditions for the Trinity, Heritage Springs, and Starkey communities will be acquired and incorporated into the geodatabase and subsequently employed for the modeling effort. That data collection effort will be performed during a future TWA, in close coordination with engineering firms representing those development communities.

It should be emphasized that this existing committed development condition does not represent ultimate buildout conditions for the entire watershed, nor does it attempt to define conditions that are planned or expected to exist across the entire watershed at any one specific future point in time. Furthermore, incorporation of the buildout condition for these planned communities does not relieve those developments of any permitting requirements associated with Federal or State environmental regulations and/or the County's land development code.

Groundwater Conditions and Percolation as an Outfall

The District has provided its consultants with a layer describing the potentiometric surface for a typical wet season condition. This surface, shown in Figure 7, was created using contours developed by the USGS from well data in the Floridan Aquifer for the month of September 2004. The District also provided a layer depicting the 1960 potentiometric surface, which represents an extreme wet condition. Both of these layers are included on the accompanying hard drive in the "DTM" folder.

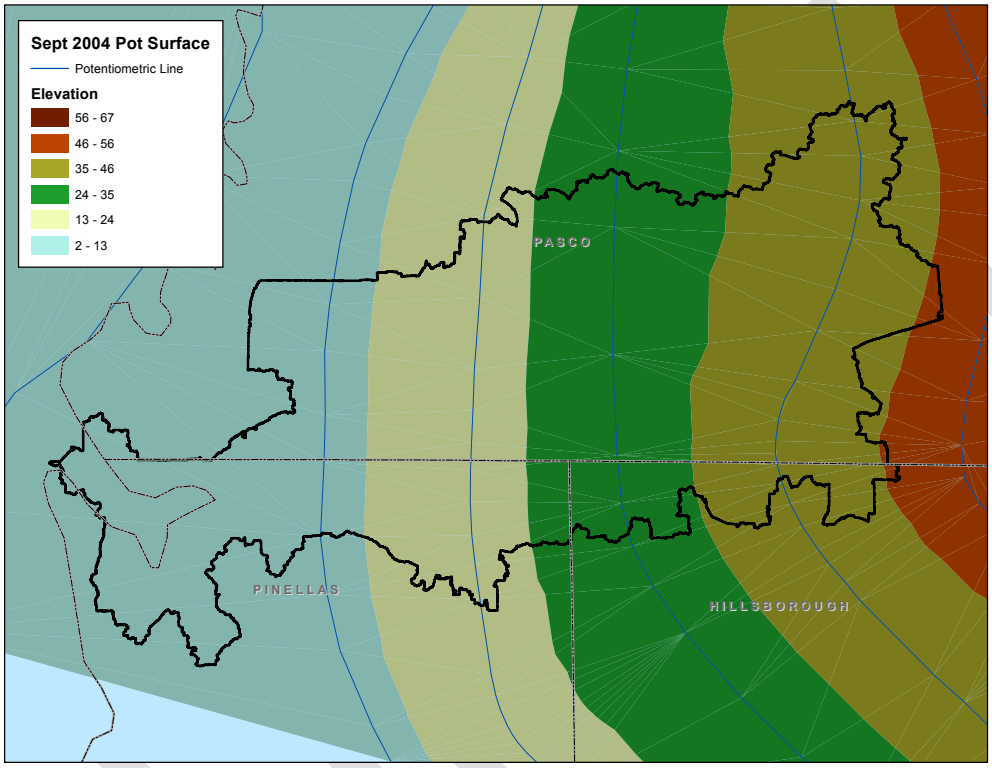

Figure 7: Potentiometric Surface

The typical wet season potentiometric surface is used, along with natural ground elevation, soil types, and pond bottom elevations to identify potential sites for percolation as an outfall. In addition, there are numerous sinkhole features throughout the Anclote West watershed. Figure 8 illustrates some of the major named sinks and springs. A sinkhole layer that was developed by the District is provided as part of the highwater database in the "TSDN_Report" folder on the accompanying hard drive. The typical wet season potentiometric surface may be used to define boundary conditions for surface flow to sinkholes.

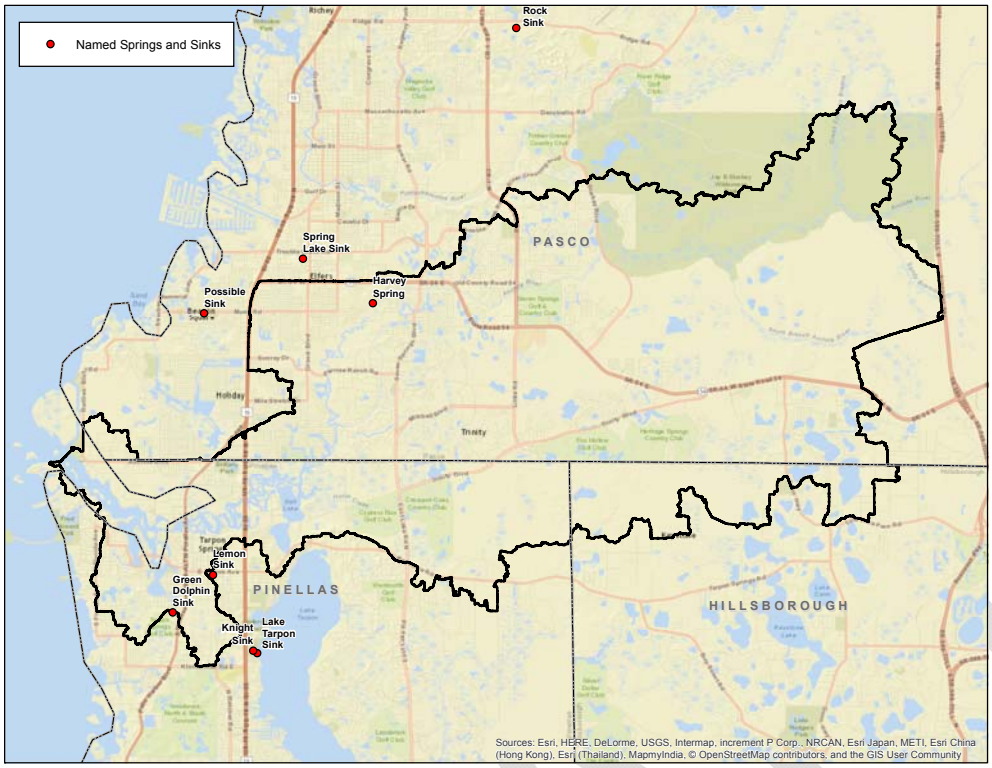

Figure 8: Springs and Sinks

Historical Conditions and Water Levels

Historical meteorological, hydrological, and water quality monitoring is performed by a number of agencies. Monitoring site location shapefiles downloaded from the SWFWMD website were used to locate U.S. Geological Survey (USGS) Streamflow Stations and SWFWMD Atmospheric, Groundwater, and Surface Water Monitoring Sites within the Anclote West watershed. The USGS Streamflow Stations and SWFWMD Surface Water Monitoring Sites provide historical stages and discharges. SWFWMD Atmospheric Monitoring Sites provide historical rainfall. SWFWMD Groundwater Monitoring Sites provide historical groundwater levels.

All available data was downloaded from the respective agencies and can be found on the accompanying hard drive under the “Gage_Data” subfolder of the “TSDN_Report” folder. Figure 9, Figure 10, and Figure 11 illustrate the various monitoring locations within the watershed.

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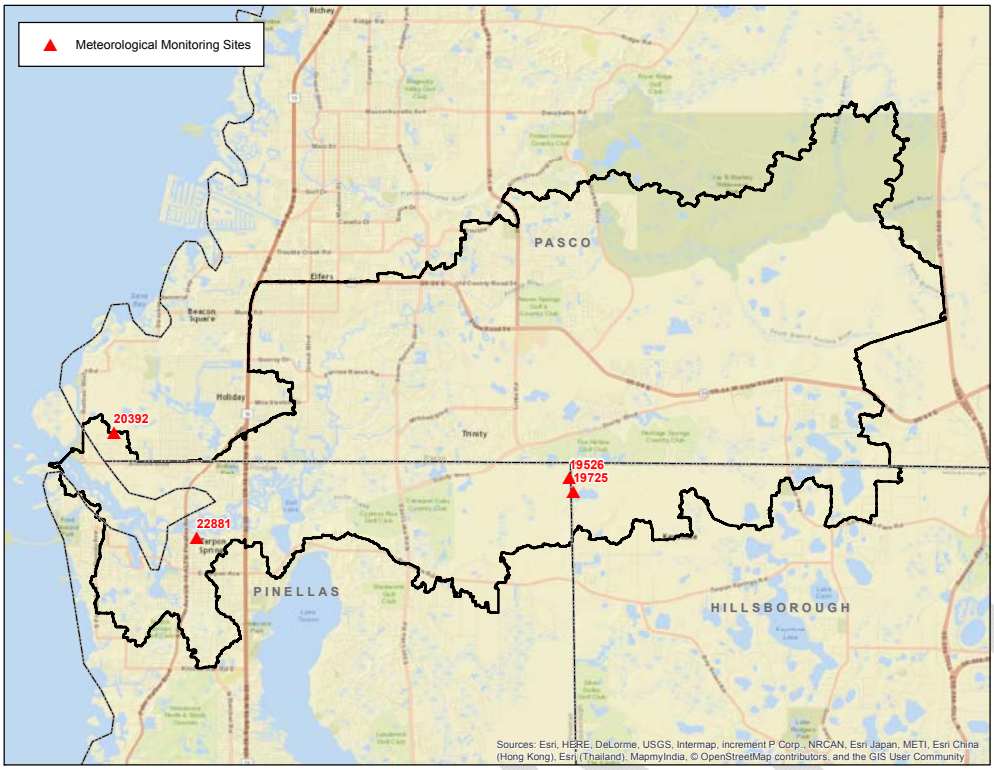

Figure 9: Meteorological Monitoring Sites

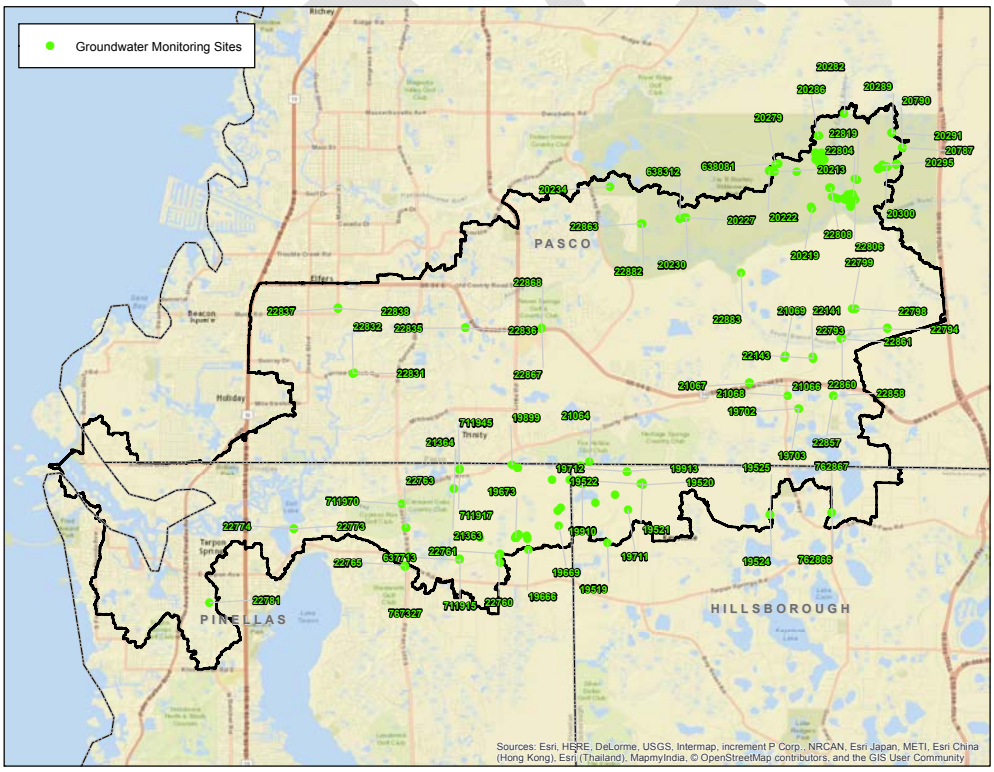

Figure 10: Groundwater Monitoring Sites

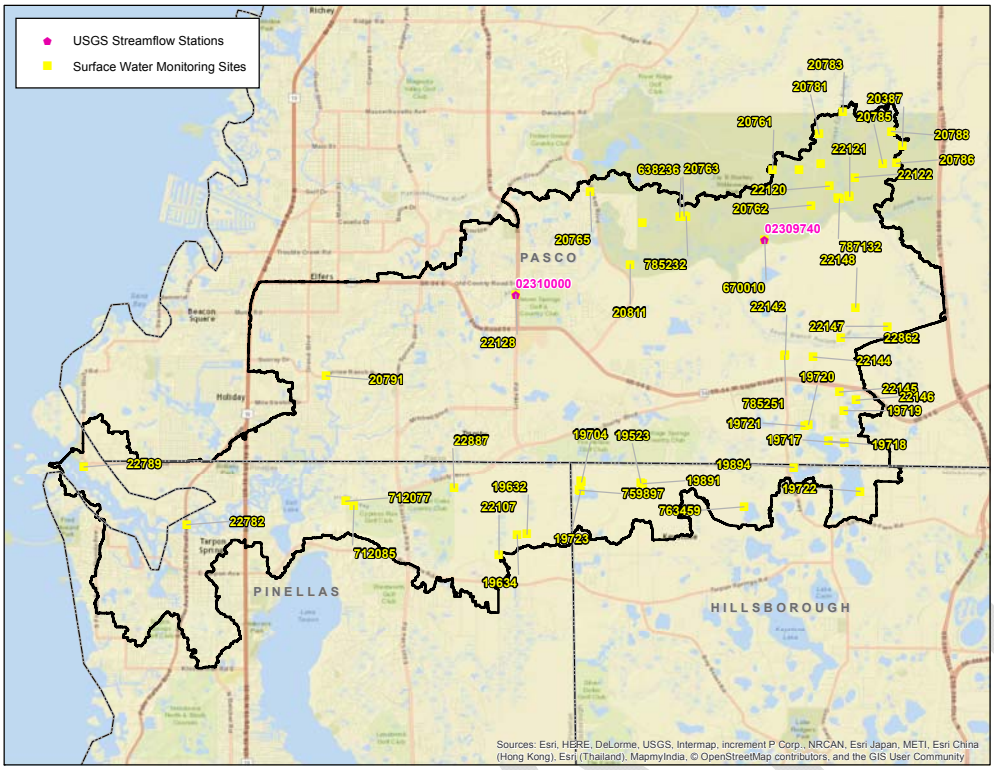

Figure 11: Surface Water Monitoring Sites

High Water Marks

The District has assembled a high water database that includes recorded water levels from a variety of sources, including FDOT, Pasco County, and SWFWMD's hydrologic data section. Figure 12 illustrates the location of these high water marks within the Anclote West watershed. The database is submitted on the accompanying hard drive in the "HighWater_Database" subfolder of the "TSDN_Report" folder.

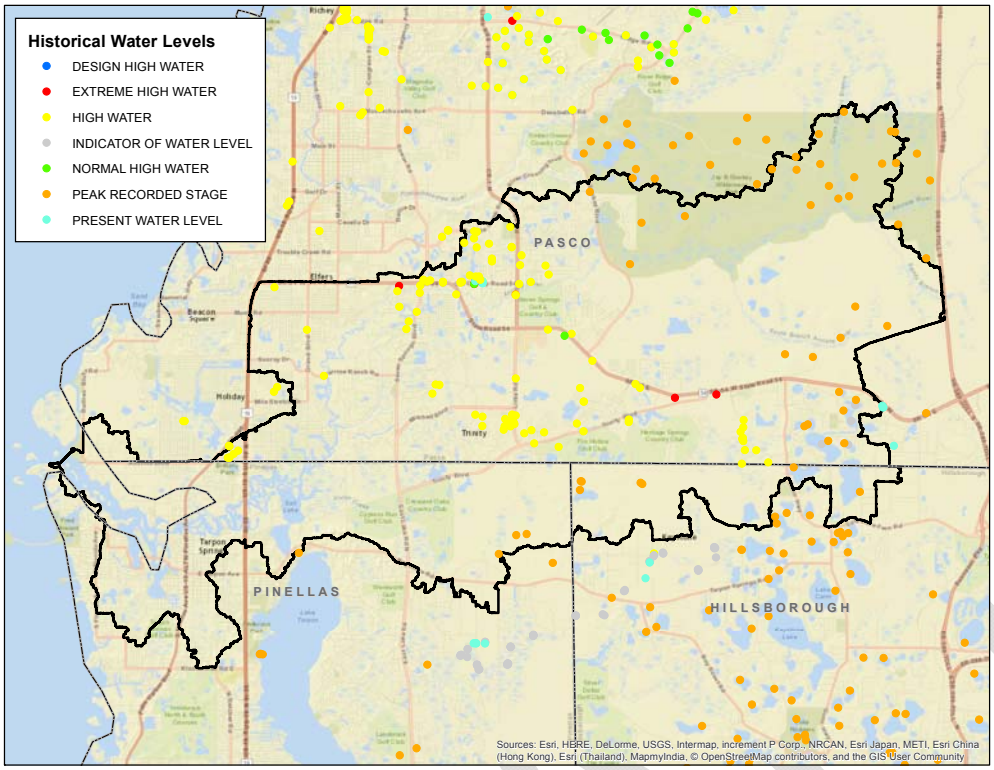

Figure 12: Historical Water Level Data

Observed Flooding

As part of their high water database, the District provided flood complaint and damage inventory data that has been collected from their regulatory department as well as local counties. Figure 13 illustrates this data within the Anclote West watershed. It includes damage inventory data from Pasco County for 2003 and 2004, flood complaints, and flooding areas digitized from 1998 aerial imagery.

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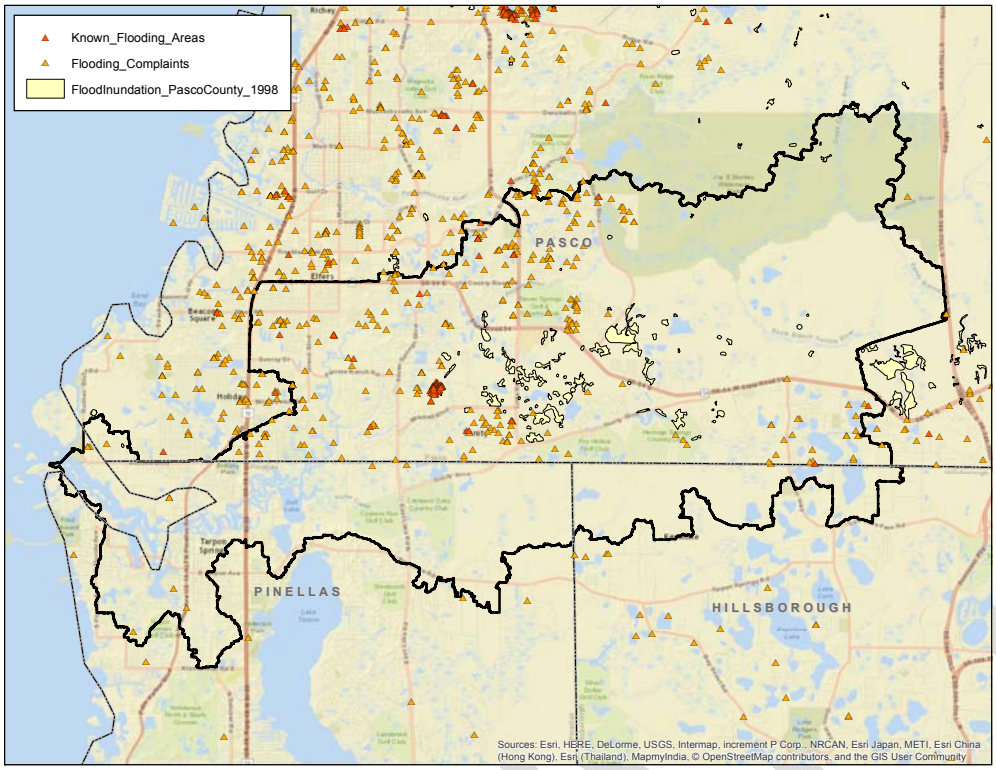

Figure 13: Flood Inundation, Complaints, and Damage Inventory

FEMA Flood Zones

Figure 14 illustrates current Federal Emergency Management Agency (FEMA) flood zones in the Anclote West watershed. The flood zones are provided on the accompanying hard drive in the "Basemap" geodatabase.

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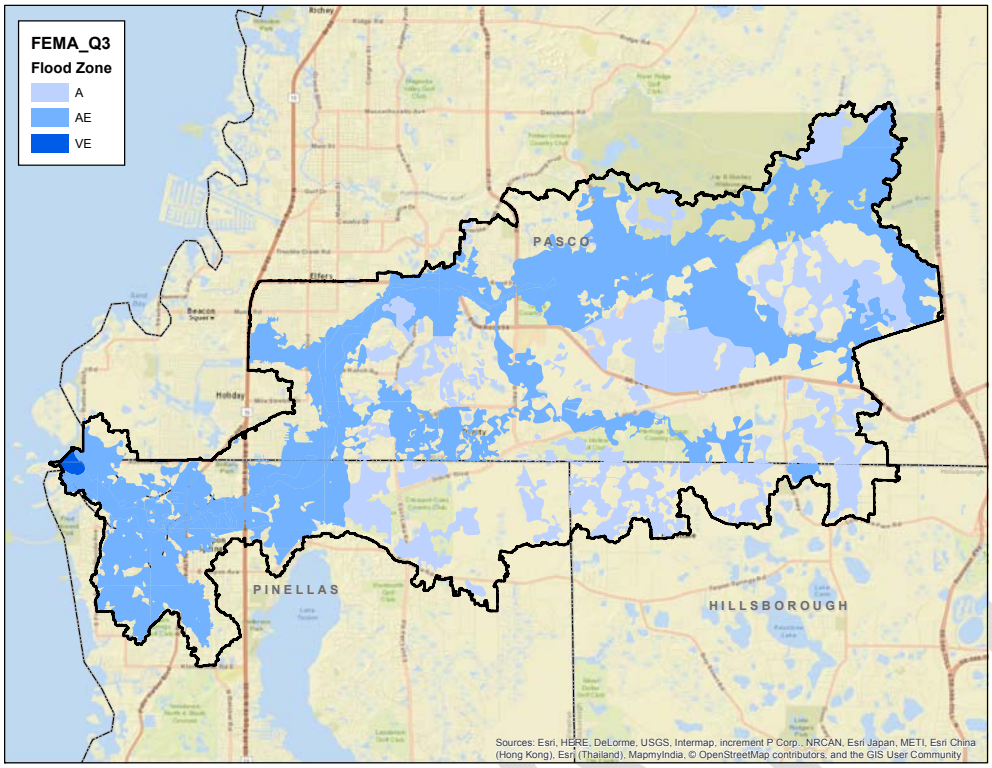

Figure 14: FEMA Floodzones

Acquisition of Data to Describe Hydraulic Features

Some watershed evaluation elements were previously performed for the Anclote West watershed by Ardaman, including portions of Acquisition of Data from Environmental Resource Permit and Roadway Plans. Figure 15 shows locations of drainage features collected by Ardaman through desktop acquisition from ERP plans. This data served as the starting point for development of a GWIS geodatabase for the Anclote West watershed.

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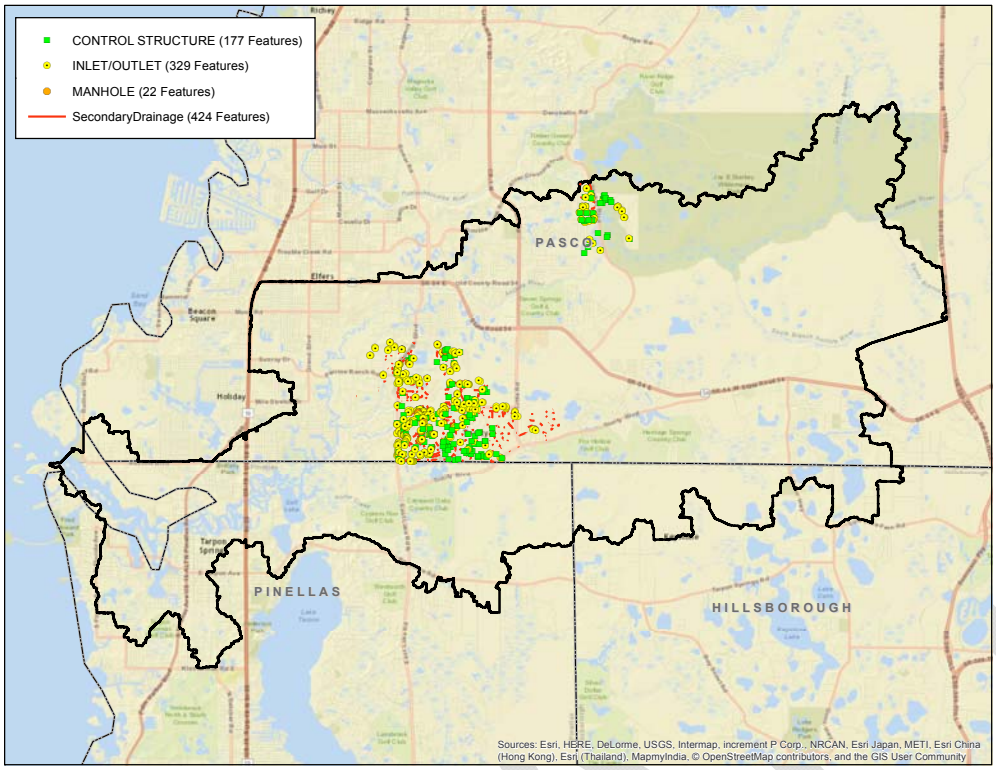

Figure 15: Preliminary GWIS Geodatabase by Ardaman

<u>Data Acquisition Plan</u>

Data acquisition to support the Anclote West Watershed Evaluation project was previously planned by Ardaman during their performance of Work Order No. 3 of the PACE WMP project. Updates by DES to the data acquisition plan take into consideration:

- New and relevant information provided to DES by SWFWMD and Pasco County, including availability of a stormwater inventory database from Pasco County
- Assumptions regarding the numbers of features that will be retrieved from ERP plans, from the stormwater inventory database, and from field reconnaissance
- The coverage of ERP plans that have been collected by SWFWMD for use in performing the project
- Other information provided during or immediately following the Project Development team meeting such as the updated Pasco County stormwater inventory

Updates to the data acquisition plan also take into consideration the assignment of responsibilities between the two firms, DES and Ardaman, working as a team to expedite ERP and field data collection tasks, respectively. Data acquisition tasks completed or to be performed by Ardaman include:

- Field reconnaissance and field data collection by approximate methods
- Data entry and QC of collected recon information as HEP Points

Field data collection to describe major conveyance ways (e.g. riverine cross sections and large bridge crossings) will be performed by a professional land surveyor under a future TWA.

Some of the basic assumptions related to Data Acquisition (from ERPs and field reconnaissance) that were made in developing TWA NO. 14TW-42 are as follows:

- All available ERP plans will be furnished to DES by SWFWMD
- All relevant available GIS and terrain data will be furnished to DES by SWFWMD
- All PACE WMP deliverables by Ardaman & Associates, Inc. will be furnished to DES by Ardaman & Associates, Inc, and copied to SWFWMD
- Estimated number of catchments in the Anclote West watershed: 5000
- Estimated number of structures* in Watershed: 5000
- Number of structures collected by Ardaman, previously: 800
- Data collection from ERP
    - Remaining structures to be acquired from ERP plans: 3150
    - Typical number of structures per ERP plan sheet: 5
    - Approximate number of ERP plan sheets: 630
    - Time to identify, organize and georeference each ERP sheet: 0.5 hours
    - Time to identify, organize and georeference all ERP sheets: 315 hours
    - Time to extract structure data from ERP plan sheet: 6 structures per hour
    - Time to extract all structure data from ERP plans sheet: 525 hours
- Data collection during field reconnaissance
    - Remaining Primary Structures (to be modeled) to be acquired in the field: 1050
    - Number of field weeks to perform data collection: 16 weeks
    - Number of structures per day: 13-14 structures per day
- A third-party engineering firm (Ardaman), under separate contract to the District, will:
    - Perform field reconnaissance and field data collection by approximate methods, consistent with District Guidance documents, in a timely manner (max. 16 weeks).
    - Enter collected field data as HEP points into a GWIS format geodatabase
    - Perform quality control on all field data collection and data entry work products
    - Deliver data semi-weekly to the SWFWMD for review and pass-through to DES

** "structures" include primary features that will be modeled, as well as, secondary features that will not be modeled but are to be collected and used to delineate catchment divides.*

Over the course of performing desktop data collection, various findings related to watershed characteristics, data availability, and timing of field data collection activities led to minor changes in project approach. Some resulting points to note regarding development of the geodatabase include:

- *Watershed Boundary*. As desktop data collection was performed, the area of interest was found to extend beyond the preliminary watershed boundary previously developed by Ardaman, and that boundary will need to be updated to reflect stormwater infrastructure identified during the course of this task. Minor reductions in watershed extents were found in other areas. It is expected, however, that there will be a small net increase in the previously identified watershed area.
- *Pasco County Inventory*. Deficiencies found in the Pasco County Inventory database precluded direct reliance on that existing available data for a significant number of primary features. Additional field data collection needs were identified at numerous locations, to rectify or supplement information contained in the County database.
- *HydroNetwork and HEP Data*. DES will add all HydroJunction and HydroEdge features to the geodatabase in order to develop a complete, topologically correct HydroNetwork describing the primary storage and conveyance system.

  - HEP points will be added and structure tables will be populated by DES using data from existing available plan sets (typically as-built and approved ERP plans).
  - HEP points will be added and structure tables will be populated by DES using supplemental data collected in the field (provided to DES by the District), for cases where only select information is required to fill data gaps for a specific feature.
  - HEP points will be added and structure tables will be populated by Ardaman for those features that are collected, in their entirety, in the field. Ardaman will assign appropriate relates to existing HydroNetwork features and will provide all required hyperlinks and documentation for those collected features.
  - While recording collected field data as HEP points and in structure tables, Ardaman will make minor adjustments to the HydroNetwork in order to correctly position geodatabase features relative to what is found in the field. This includes Ardaman moving HydroJunction and HydroEdge features to correctly snap to appropriate HEP locations. If needed, DES will place additional HydroNetwork features in the geodatabase, based upon Ardaman direction, so as to be in better agreement with conditions found by Ardaman in the field.
- *Field Data Collection*. Field data collection will be performed by Ardaman and District staff, depending upon the types of data to be collected. Ardaman staff will be employed to collect features needing full data collected. District staff will be employed to collect partial data, such as datum verifications and collection of partial structure information (where the majority of the data is already available from a reliable source).
- *Feature Count*. Secondary drainage features have been identified in ERP plans and digitized into the geodatabase for future use (e.g., to aid in accurate sub-basin delineation). Individual drainage features that comprise collection systems contributing to a single outfall were grouped, and each group was counted as a single feature.
- *Level of Detail in Pinellas County*. As directed by the District, model detail in Pinellas County will be sufficient to provide accurate boundary conditions for adjacent portions of the watershed in Pasco County and will allow for evaluation of impacts in Pinellas County that may result from BMPs designed to mitigate flooding conditions in Pasco County. The level of detail in Pinellas County portions of the watershed will be lower than it is in Pasco County and will focus on major features that store and convey stormwater to the Anclote River via Hollin Creek. More localized stormwater collection systems in Pinellas County will not be included in the current structure inventory or field data collection. Decisions regarding level of detail and inclusion of features in the geodatabase will be coordinated with District staff. Additional detail may be added, at a future date, as needed to support flood mitigation BMP development.
- *Existing Conditions*. Stormwater collection, storage, and conveyance features contained in the project geodatabase generally reflect conditions which describe facilities constructed by 2012. Sites identified for field data collection were selected based upon review of available data including aerial photos through 2011. Therefore, the resulting model will generally reflect 2012 conditions on the ground.
- *Build-out Conditions*. District and County staff directed that build-out conditions will be assumed for select areas of rapid growth through inclusion of planned development conditions in the geodatabase. For HydroNetwork development and population of conveyance system data, structure information will be taken directly from construction plans for the build-out condition. For other watershed parameterization, planned land use, soils, site grading, pond geometry, and other site characteristics will be used. These specific areas (selected by the District and County) include the Trinity and Heritage Springs planned communities.

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Existing Pasco County Stormwater Inventory

Pasco County provided Ardaman staff with the portion of their stormwater inventory performed, through 2012, within the area of interest. Pasco County provided DES with a version updated to reflect inventory performed through 2014. The data collected by Pasco County includes location, connectivity, elevation, dimensions, and photos of hydraulic structures. Figure 16 illustrates the extent of the inventory within the Anclote West watershed. This data is submitted in the "Pasco_County_Stormwater_Inventory_2012" and "Pasco_County_Stormwater_Inventory_2014" subfolders of the "TSDN_Report" folder.

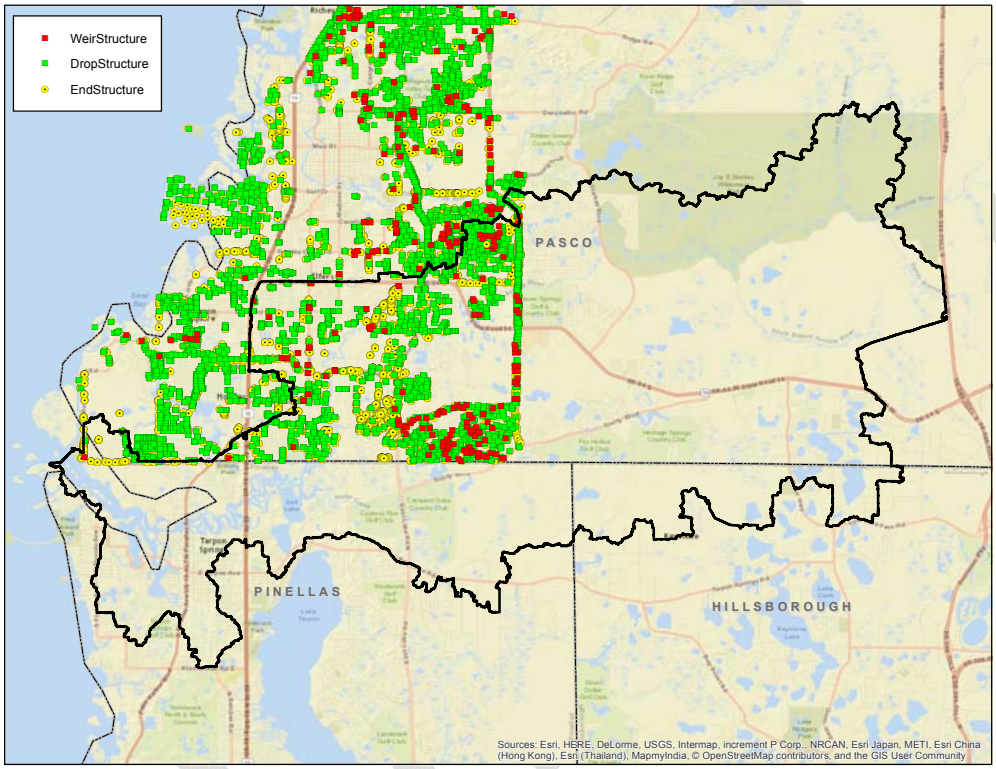

Figure 16: Pasco County Inventory

Desktop Acquisition from ERP and Roadway Plans

DES staff collected available information from ERP and roadway plans, as well as from the existing Pasco County Stormwater Inventory database, to describe primary drainage system features that will likely be modeled. A large number of secondary collection system features that may not be modeled, but which are needed to correctly delineate sub-catchment areas, were also collected. This information was added to sites similarly collected from available ERP plans by Ardaman as previously described.

List of ERP and Roadway Plans to Incorporate. Using an Environmental Resource Permit (ERP) shapefile downloaded from SWFWMD, a complete list of ERPs within the Anclote West watershed was created.

The “ERP_DOT” subfolder in the “TSDN_Report” folder contains all ERP and transportation plans available. Figure 17 depicts ERPs within the watershed that were reviewed and used for data acquisition.

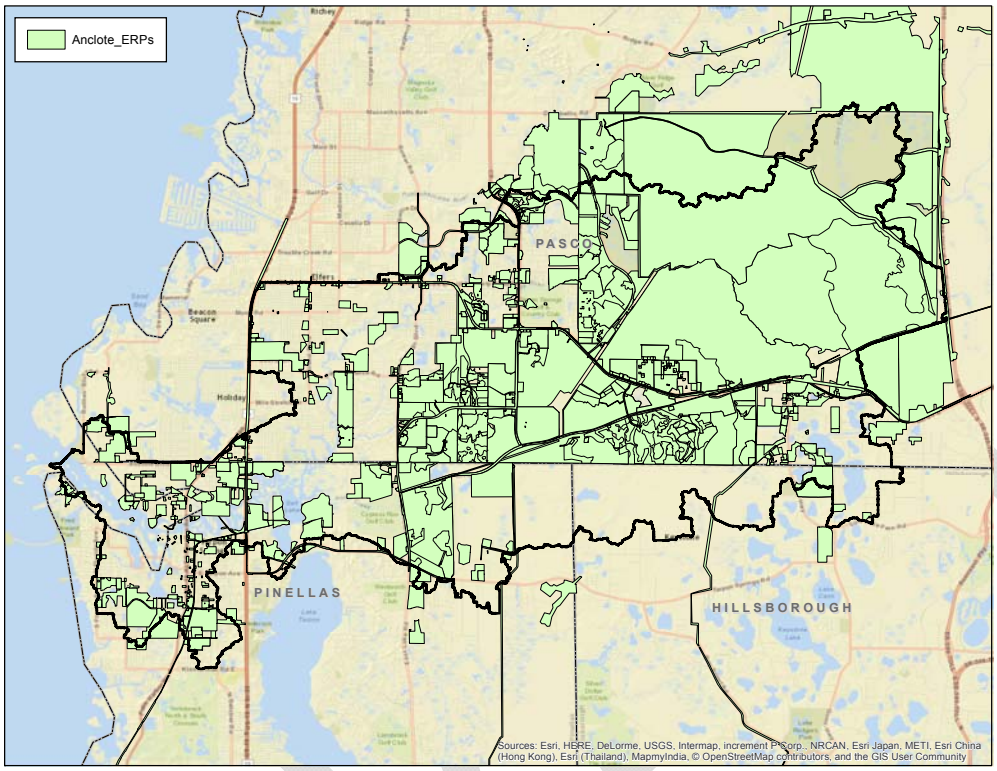

Figure 17: ERP Coverage

<u>Field Data Acquisition by Approximate Methods</u>

Where unable to locate existing data from available sources, DES selected sites for field data collection of primary drainage system features that will be modeled. Field data collection needs ranged from vertical datum confirmation of ERP plans, to collection of specific missing feature data (inverts, geometry, etc.), to the complete description of primary features and connectivity.

Field data acquisition, including coordination with DES on transfer of data and dispatching of field crews, field data collection by approximate methods, data entry, all required hyperlinking and document attaching, quality control of collected data, and weekly delivery of all information to DES, is to be performed by Ardaman under separate contract to the District. The District will also perform some limited field data collection activities, depending on staff availability, and will provide information for DES to include in the geodatabase.

Development of the Anclote West GWIS Geodatabase

Edge Matching of Boundaries

Preliminary edge matching of boundaries ensures that no gaps exist between adjacent watersheds as data is gathered and work is performed. To perform this task, DES acquired all available boundaries for adjacent watersheds from SWFWMD and performed edge matching of the previously developed (by Ardaman) Anclote West watershed boundary to those adjacent watershed extents.

As desktop data collection was performed, the area of interest was found to extend beyond the preliminary watershed boundary previously developed by Ardaman, and that boundary will need to be updated to reflect stormwater infrastructure identified during the course of this task. Minor reductions in watershed extents were found in other areas. It is expected, however, that there will be a small net increase in the previously identified watershed area.

A rigorous edge matching of the shared boundary will be particularly important, as the Anclote West model will ultimately be joined to model domains for adjacent watersheds. As such, shared boundaries must be very well defined in order to correctly describe hydraulic interaction across those divides.

Topographic Information Refinement

Terrain information will serve as the basis for numerous model development tasks, including but not limited to catchment delineation, surface storage area takeoffs, basin overflow geometry, and floodplain mapping. It is important, then, that the terrain information be as accurate and up-to-date as reasonably possible, and that any inaccuracies be identified, documented and understood.

Topographic Voids Locations. A shapefile documenting topographic low confidence areas, developed by Ardaman, was reviewed and updated to identify topographic voids within the Anclote West Watershed (Figure 18). This work was performed to locate and prioritize areas requiring terrain modification. The terrain modifications are being performed by Ardaman, with DES guidance, under separate contract.

Several fields within the low confidence area shapefile have been populated by DES staff to provide guidance for, and track, the terrain update process. Other attributes provide direction to be taken once the model network has been finalized.

- Comment – Populated by Ardaman & DES to describe the type of topographic void. Areas to be considered for terrain modification are populated with “Area of New Development.”
- TerrainMod – Populated by DES to describe recommended action.
    - Yes – Area of recommended terrain modification
    - Yes. Build-out Condition – Area of recommended terrain modification within Trinity, Heritage, or Starkey to represent ultimate build-out condition.
    - Wait until model network has been finalized – Areas which may require terrain modification to support model development depending upon future decisions made relative to level of model detail.
- SOURCE – Indicates the source of data used to identify the topographic void. Where an ERP was identified associated with the topographic void, it is noted here. If there was no ERP found, that is also noted.

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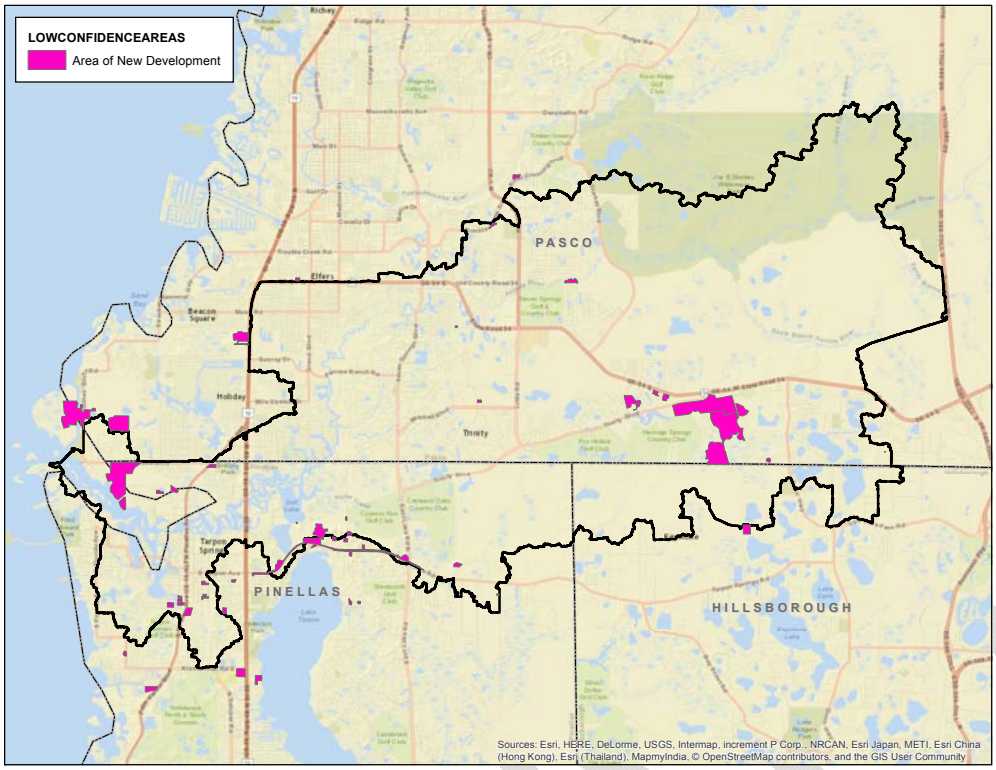

Figure 18: Areas of New Development

Land Use and Soil Characteristics

Runoff potential is, in part, determined by the imperviousness of various land uses within an area. DES performed calculations of impervious areas within residential land use categories for inclusion in lookup tables to support model development. Five sample locations (Figure 19**Error! Reference source not found.**) were selected for each residential classification (low density, medium density, and high density). Impervious areas within each sample location were digitized and classified as rooftop, driveway, or street, thus allowing for the calculation of percent impervious area (Figure 20**Error! Reference source not found.**). Averages across the five sample locations were calculated for each land use category, as shown in **Error! Reference source not found.**. The resulting percent impervious values were found to be in good agreement with values previously used in the Bear Creek / Pithlachascotee River Watershed WMP project as well as with typical values provided in District guidance documents.

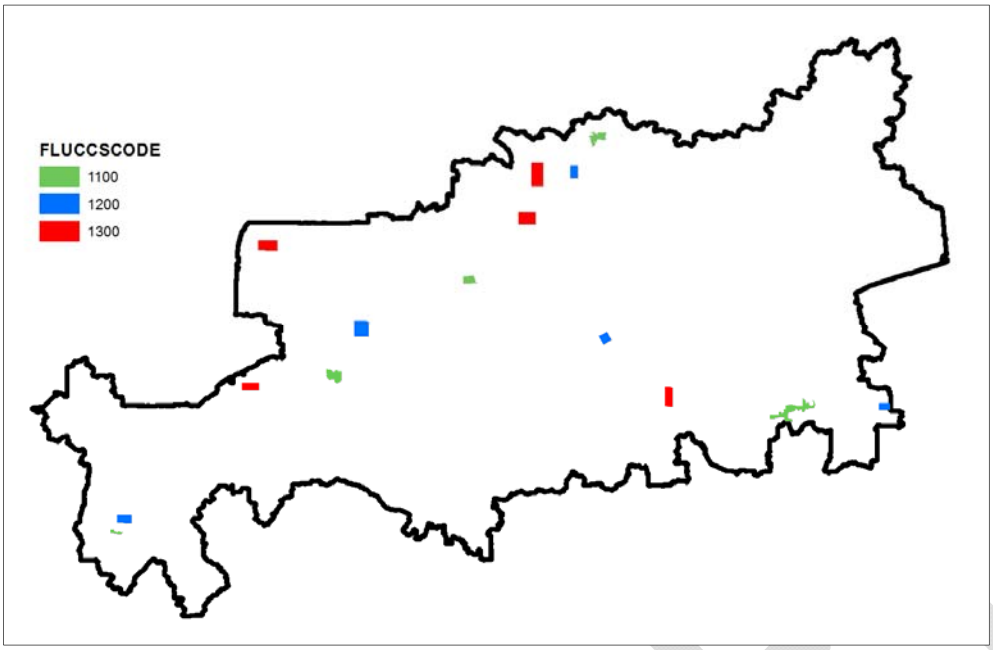

Figure 19: Land Use Sample Locations for Each Residential Classification

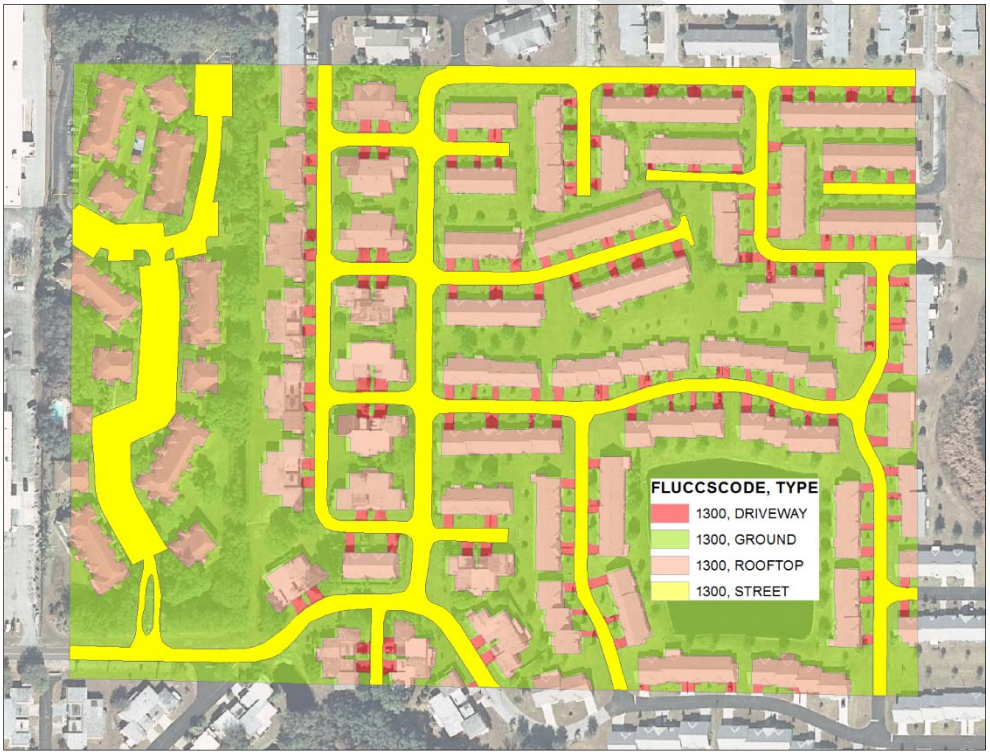

Figure 20: Impervious Area Sample Location

Table 2: Average Impervious Area by Land Use Code from Impervious Area Takeoff

Impervious Area by Land Use Code	1100 Low Density	1200 Medium Density	1300 High Density
DCIA	10%	13%	21%
Percent Impervious	19%	34%	47%

Values for directly connected impervious area (DCIA) represent streets and driveways, and would typically be assigned during model development if an area is found to have curb and gutter drainage. That determination will be made at a later time in the model development process.

Table 3 presents the resulting watershed-specific land use lookup table for the Anclote West Watershed.

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Table 3: Anclote West Watershed Land Use Lookup Table

FLUCCSCODE	FLUCSDESC	MAN	DCIA	PCTIMP
1100	RESIDENTIAL LOW DENSITY < 2 DWELLING UNITS	0.16	10	19
1200	RESIDENTIAL MED DENSITY 2->5 DWELLING UNIT	0.13	13	34
1300	RESIDENTIAL HIGH DENSITY	0.08	21	47
1400	COMMERCIAL AND SERVICES	0.05	52	52
1500	INDUSTRIAL	0.07	43	59
1700	INSTITUTIONAL	0.13	31	42
1800	RECREATIONAL	0.13	15	21
1820	GOLF COURSES	0.13	1	1
1900	OPEN LAND	0.30	0	3
2100	CROPLAND AND PASTURELAND	0.15	0	2
2200	TREE CROPS	0.30	2	4
2400	NURSERIES AND VINEYARDS	0.20	1	2
2500	SPECIALTY FARMS	0.20	0	2
2600	OTHER OPEN LANDS <RURAL>	0.15	0	0
3100	HERBACEOUS	0.30	0	0
3200	SHRUB AND BRUSHLAND	0.30	0	0
3300	MIXED RANGELAND	0.30	0	0
4100	UPLAND CONIFEROUS FOREST	0.45	0	0
4200	UPLAND HARDWOOD FORESTS - PART 1	0.45	0	0
4340	HARDWOOD CONIFER MIXED	0.45	0	0
4400	TREE PLANTATIONS	0.45	0	0
5100	STREAMS AND WATERWAYS	0.00	100	100
5200	LAKES	0.00	100	100
5300	RESERVOIRS	0.00	100	100
5400	BAYS AND ESTUARIES	0.00	100	100
5720	GULF OF MEXICO	0.00	100	100
6100	WETLAND HARDWOOD FORESTS	0.45	100	100
6110	BAY SWAMPS	0.30	100	100
6120	MANGROVE SWAMPS	0.30	100	100
6150	STREAM AND LAKE SWAMPS (BOTTOMLAND)	0.30	100	100
6200	WETLAND CONIFEROUS FORESTS	0.35	100	100
6210	CYPRESS	0.35	100	100
6300	WETLAND FORESTED MIXED	0.30	100	100
6410	FRESHWATER MARSHES	0.06	100	100
6420	SALTWATER MARSHES	0.06	100	100
6430	WET PRAIRIES	0.06	100	100
6440	EMERGENT AQUATIC VEGETATION	0.06	100	100
6520	SHORELINES	0.06	100	100
6530	INTERMITTENT PONDS	0.06	100	100
6600	SALT FLATS	0.06	100	100
7400	DISTURBED LAND	0.30	0	0
8100	TRANSPORTATION	0.15	46	50
8200	COMMUNICATIONS	0.15	0	0
8300	UTILITIES	0.15	25	34

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While hydrologic modeling will most likely employ the Green-Ampt method for infiltration and rainfall excess determination, Hydrologic Soil Group (HSG) values provide a convenient way to envision runoff potential. HSG classifications of soils range from A to D, depending on infiltration rate and rate of water transmission.

Hydrologic Soil Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These soils consist mainly of deep, well drained to excessively well drained sands or gravelly sands. These soils have a high rate of water transmission.

Hydrologic Soil Group B. Soils having a moderate infiltration rate when thoroughly wet. These soils consist mainly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Hydrologic Soil Group C. Soils having a slow infiltration rate when thoroughly wet. These soils consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Hydrologic Soil Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These soils consist chiefly of clays that have high shrink-swell potential, soils that have a permanent high water table, soils that have a clay pan or clay layer at or near the surface, and soils that are shallow over nearly impervious material.

Some soil types are classified as belonging to dual hydrologic soil groups, such as A/D, B/D, or C/D. These ratings mean that, under natural conditions, the soil is classified as belonging to Hydrologic Soil Group D, with high runoff potential, but by artificial methods (e.g., ditching, pumping, etc.) the water table could be lowered sufficiently so that the soil would fit into a lower runoff potential category.

HydroNetwork Development

DES added HydroNetwork features and populated Hydraulic Element Points (HEPs) with data collected from available ERP and roadway plans. HydroNetwork “shell” features were included in the geodatabase as placeholders for future collected field data. Additional HydroNetwork features may be added by Ardaman while field data is collected and reviewed. Ardaman staff will coordinate with DES to refine the HydroNetwork, if needed, to better reflect observed field conditions, and will populate HEP and related structure attribute tables.

Figure 21 depicts the current GWIS geodatabase for the Anclote West watershed. The accompanying Atlas.mxd (MXD/ArcMap_Templates) contains the HydroNetwork of features collected, to date.

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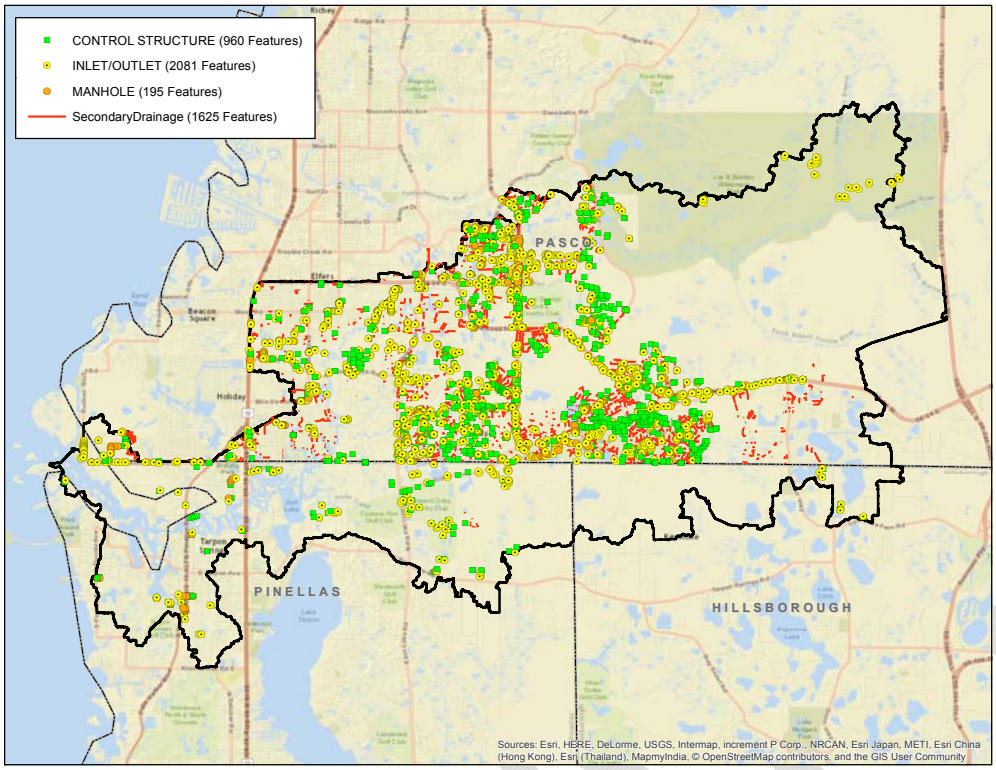

Figure 21: Current Comprehensive GWIS Network

GIS Processing

DES was directed to perform additional GIS processing, when deemed necessary, to update catchment, surface connectivity, and preferential flow path feature sets previously developed by Ardaman. Some prior work products used to delineate preliminary catchments were received from Ardaman, including a multipart sink file, a "primary" sink file, and the processed catchment features. However, intermediate files, key GIS processing parameters, and specific workflow documentation (for tasks where Ardaman deviated from the standard District workflow), necessary for DES to be able to replicate work previously performed, were not provided.

Without key files, parameters, and documentation, it was not possible for DES to update existing feature sets. Instead, a new, complete set of features was developed by DES, as described in the following.

<u>Catchments</u>

DES followed the District's Revised ArcHydro Workflow in order to develop catchments and connectivity. Workflow deviations in how sinks were handled for catchment delineation are outlined, here.

Ardaman's primary sink file was used as a starting point, combining it with other features developed by DES to generate a more complete deranged polygon sink file. Those other features include:

- A 5-foot buffer of secondary drainage features digitized by DES
- True sinks generated by DES (using ArcHydro) having an area greater than or equal to 0.1 acres

- Deranged polygons in lake/wetland areas generated by DES from the lowest contour line characterizing the depression. These were generated in order to replicate the functionality of Ardaman's original multipart sink file without causing flow direction grid processing errors
- Deranged polygons digitized by DES to characterize a sump or similar small drainage area

Since neither the original primary sinks file supplied by Ardaman nor the subsequent file produced by DES was entirely composed of true sinks, the DEM had to be conditioned to allow for flow direction grid generation. The deranged polygon sink file produced by DES was burned into the DEM using the ArcHydro "Level DEM" tool, with a level elevation being assigned one foot lower than the elevation of the lowest grid cell intersecting the polygon boundary. Using this DEM conditioning technique, ArcHydro interpreted the depressions, user-identified deranged polygons, and secondary drainage features as true sinks and delineated catchment boundaries around them appropriately.

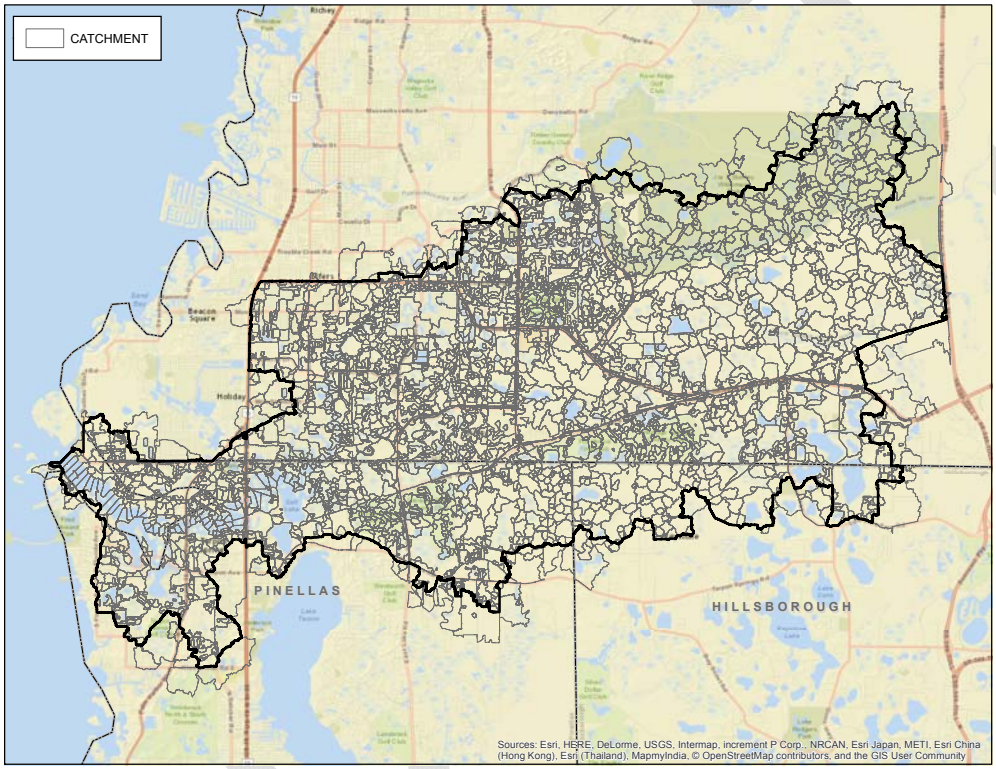

Figure 22: Catchments

Surface Connectivity

Connectivity was recreated by DES using the ArcHydro "Drainage Connectivity Characterization" tool along with the deranged polygon file and catchments developed by DES.

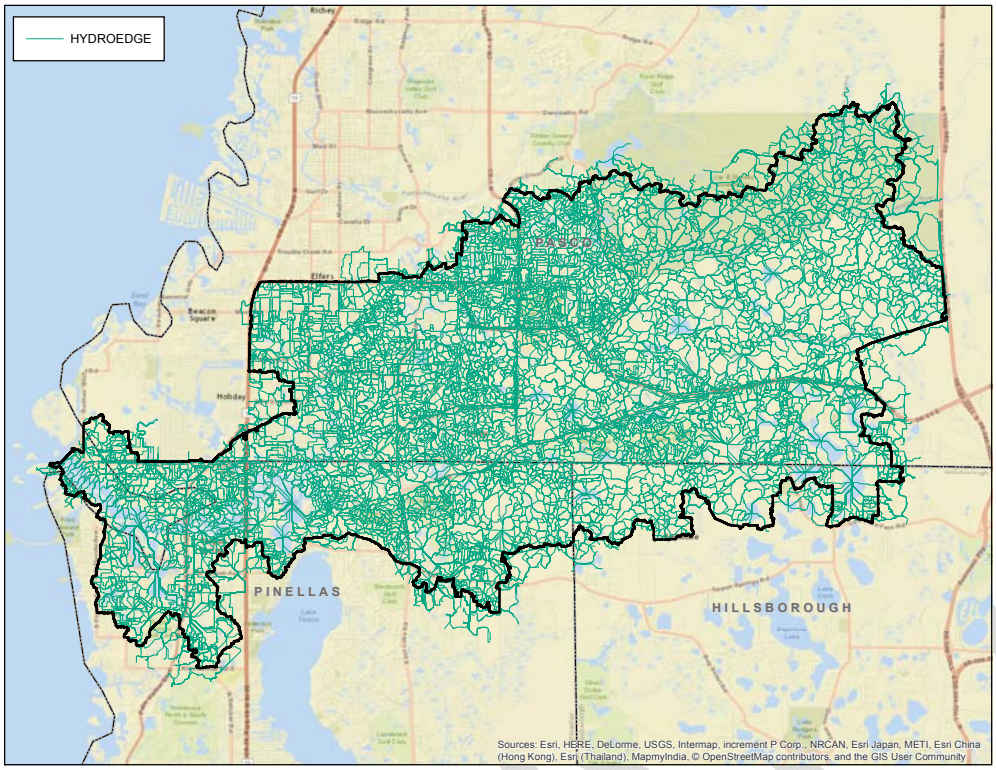

Figure 23: Surface Connectivity

Preferential Flow Paths

Preferential flow paths were recreated by DES according to the District's standard workflow. However, the "Define Overland Preferential Link" was found to over-aggregate the catchments and the resulting connectivity and outputs were judged not to be particularly useful.

Preliminary Model Schematic

A preliminary network of Basins, Nodes, and Links was developed using inventory data collected from ERPs and Roadway plans.

- ICPR_Basins. Catchments intersecting the original Ardaman-developed watershed boundary were loaded into the ICPR_Basin feature class. It may be necessary to adjust the watershed boundary as field data is received and the model network is refined.
- ICPR_Nodes. Hydrojunctions representing low points of basins, inlets/outlets, and manholes were loaded into the ICPR_Node feature class.
- ICPR_Links. Hydroedges representing conduits or those of the FType "structure link" (flowlines for free standing weirs) were loaded into the ICPR_Link feature class. Weirs represented by Hydrojunctions were connected to the network using the "Connect Hydrojunctions" tool. Of the 582 weirs contained in the current geodatabase, 246 are represented as an ICPR_Link. The remaining 336 weirs will be reviewed and may be added as the model network is refined.

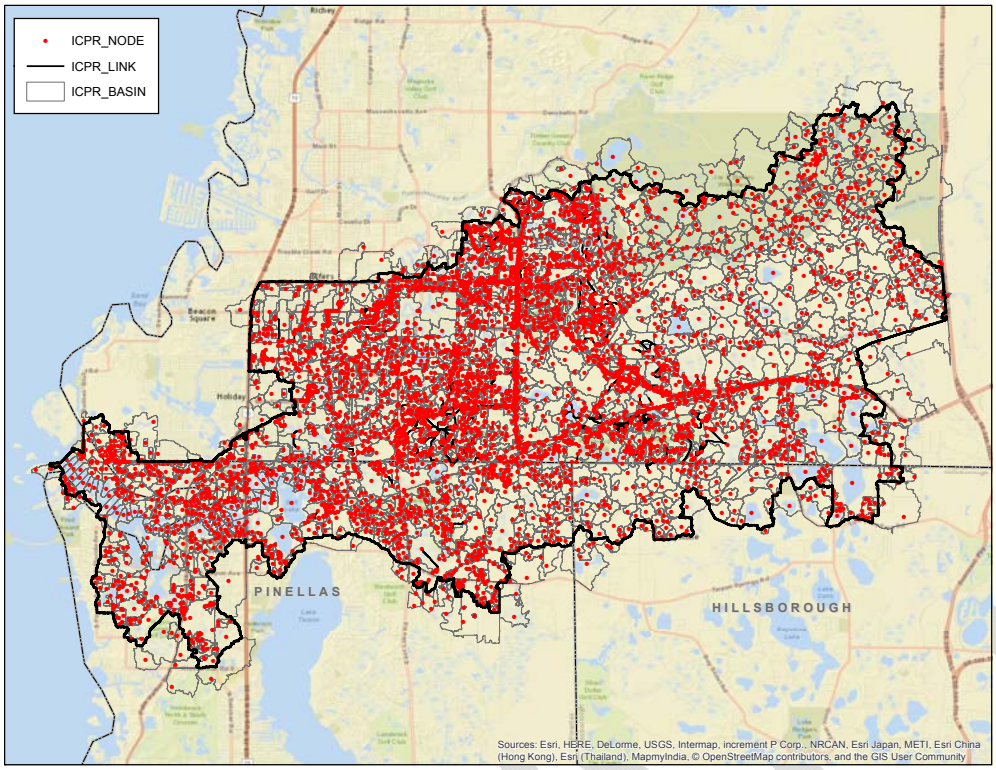

Figure 24: Preliminary Model Features

All basin, node, and link schematic features should be considered preliminary. While representative of the general level of detail expected to be employed in modeling the watershed, additional information gathered through ongoing field data collection will undoubtedly result in substantive changes to these model features. Furthermore, model schematic features included in the current deliverable include only those which can be developed using automated tools and processes at our disposal. The addition of features by manual methods (as in cases where automated tools do not exist or fail to perform adequately) will be completed only after field data collection has been completed and catchment delineation and model node placement has been finalized.

Model Parameterization Approach

The PACE Anclote West Watershed model parameterization approach generally follows the protocols and procedures contained within several WMP Guidance documents, including:

- Southwest Florida Water Management District's Watershed Management Program, Guidance For Digital Topographic Information Watershed Evaluation, Watershed Management Plan, Watershed Management Plan Database Maintenance And Watershed Model Updates, August 2002, Modified June 2009, Modified January 2011
- Southwest Florida Water Management District, Environmental Resource Permit Applicant's Handbook, Volume II, Design Requirements For Stormwater Treatment And Management Systems,

Water Quality And Water Quantity, For Use Within The Geographic Limits Of The Southwest Florida Water Management District, Effective October 1, 2013)
- White Paper, Physically Based Determination Of Rainfall Excess In The Southwest Florida Water Management District, January 2008
- Urban Hydrology for Small Watersheds (TR-55), USDA, June 1986.
- Drainage Hydrology Handbook, FDOT, February 2012

Protocols and procedures that are contained within WMP Guidance documents are not repeated, verbatim, here. Instead, only certain elements of the model parameterization approach that are unique to the Anclote West Watershed Model development or that are of particular importance to highlight, in terms of meeting project goals or addressing project constraints, are discussed in the following.

Software Selection

Initial hydrologic and hydraulic evaluations to support flood risk determination, flood inundation mapping, level of service determination, and development of Best Management Practices (BMPs) for flood mitigation will be performed using the ICPR Version 3 (Streamline Technologies, Inc.) software. Selection of this FEMA-approved software package is consistent with that made for WMP projects in adjacent watersheds and allows for combination of existing available models of those adjacent watershed areas, as may be desirable. Combination of models, in their entirety, for all adjacent watershed areas may be impractical, however, due to software limitations.

Model Domain

The primary focus of model development under the current task order is the Anclote River Watershed located west of the Suncoast Parkway. The exact downstream limit of the model has yet to be determined. It may be advantageous and most expeditious to define a tidal boundary condition at some point upstream from the river's mouth at the Gulf of Mexico. Candidate boundary condition locations include sites where the Anclote River crosses the Pasco-Pinellas County line, US 19, or Alt US 19.

With regard to headwaters, a detailed hydrologic and hydraulic model of the Anclote River Watershed located east of the Suncoast Parkway has already been developed, by others, also using ICPR Version 3. It is recommended that, during model development and testing, the existing "Anclote East" watershed model be joined to the "Anclote West" model, so that inflows from those upstream areas are properly and rigorously handled. This will provide a single model domain for simulation of the entire Anclote River watershed's response to storm event rainfall.

Software Constraints on Model Domain

It is well known that significant flow exchange occurs between the Anclote River and the Pithlachascotee River under large rainfall events. In addition, it is thought that some proposed regional BMPs related to retention of stormwater runoff in the Anclote and Pithlachascotee River watersheds may contribute to flood level and/or flood duration reductions in the lower portions of those watersheds. A model domain that combines the Anclote and Pithlachascotee river watersheds would allow for rigorous model calibration and verification under very large storm events, including flow exchange between the two watersheds, and would provide a means for evaluation of regional BMP alternatives for flood level reduction and water conservation. However, due to current software limitations of ICPR Version 3

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(described above), no attempt will be made at this time to join the complete Pithlachascotee River and Anclote River watershed models. Discussion is ongoing related to joining partial model domains and to the possible expansion of the ICPR Version 3 software, by the vendor, to support a larger combined model. Consideration is also being given to the level of effort required to employ ICPR Version 4, including conversion and recalibration of existing watershed models and the adoption of the newer groundwater flow methodology.

Model Level of Detail

It is expected that the Anclote West model will be comprised of approximately 5000 sub-catchments. Portions of the Anclote West watershed within Pasco County will be developed to a very high level of detail, while remaining portions will be developed to a lesser degree. Portions of the Anclote West watershed in Pinellas County will be developed to provide a reasonable representation of that system in order to support preliminary assessment of BMPs to alleviate flooding in portions of Pasco County, and to evaluate impacts of those BMPs on downstream systems within Pinellas County.

Sub-basin Storage

Precise and accurate representation of the watershed's surface storage is crucial in developing accurate floodplain information. Storage can be represented by different methods. Model nodes can have assigned stage-area or stage-volume curves, stream reach storage can be dynamically allocated by the modeling software using cross section information, or a combination of both methods can be used. It is important to ensure that watershed storage is accurately represented, not duplicated, and is contained within the respective sub-basin. Individual sub-basin stage area relationships will be developed using a Digital Terrain Model (DTM), updated with acquired survey information and any newly acquired topographic information. The base DTM is derived from LiDAR data collected in 2004. That data will be supplemented with updated information from ERPs to describe as-built conditions and to describe future build-out conditions for select developments (e.g., the planned Starkey, Trinity, and Heritage Springs communities).

Conveyance Ways

To ensure that sub-basin storage is accurately represented in the model, a map set will be developed that distinguishes between storage contained in overbank areas and storage contained within a defined stream section or "conveyance way." To accomplish this task, an overlay of the digital contours with the effective conveyance ways is required. The updated and approved DTM of the watershed will be used to generate a digital contour map. A coverage will then be developed that defines the extents of all conveyance ways. Conveyance ways will be delineated using cross sectional information superimposed on the same coordinate base as the digital contours. That conveyance way coverage identifies all areas where model allocation of watershed storage will automatically occur and where that storage volume should be subtracted from stage area curves for affected sub-basins to prevent double accounting.

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Model Nodes

Model nodes may serve as simple junctions to provide connectivity for the conveyance system as well as represent pond, lake, wetland, overbank, and other types of storage features in a watershed. Basin runoff is assigned to nodes, as is sub-basin storage that is not already automatically accounted for in open channel conveyance ways. Percolation will be accounted for, as an outfall from nodes (surface storage areas), where the depth to water table is greater than three feet.

Channel Conveyance

Rivers, streams, tributaries, man-made channels, creeks, ditches, etc. represent open conveyance systems or channels. Hydraulic characterization of a channel shall be based on a defined conveyance way. Conveyance and storage within the channel extents are to be represented by cross section information that terminates at the flow boundary of the conveyance way. Channel sections will be defined using field survey data or DTM information. DTM information can also be used to extend surveyed cross sections, when necessary. Storage beyond the effective conveyance is considered overbank storage that is assigned to a junction.

The District has provided guidance for defining channel reaches within the Junction/Reach Coverage and database, as follows:

- Channel reaches connected to an internal boundary (i.e., culvert, bridge, weir, etc.) are not permitted to span more than one sub-basin boundary. Additional junctions are allowed within the sub-basin to ensure that the open channel control volume is contained within the sub-basin.
- A stream flowing through an expansive irregular shaped wetland or floodplain is a condition where the use of both types of storage (junction and channel) can be used. The condition for using dual storage is when the effective conveyance can be accurately defined and the simulated water surface elevation difference between reach junctions is 1 foot or less.
- Multiple reaches can be used to define channels through a sub-basin when it is advantageous or the conveyance varies significantly. Channel conveyance ratios (KR) within a reach should not vary outside the limits of 0.7< KR<1.4. If conveyance ratios vary beyond these limits then additional reaches will be required to represent the channel through the sub-basin. Further subdividing of the sub-basin may also be required to account for distributed inflow and better definition of the control volume. Channel conveyance “K” is defined using the following form of the Manning’s Eqn: K = (1.49/n)*AR0.6667 . The equation implies that if there is a significant change in the cross sectional flow area, channel roughness, or both then another reach shall be included.
- Conveyance parameters such as roughness factors, expansion and contraction coefficients, etc. shall be based on recognized sources such as Chow, NRCS, Kings Hydraulic Tables, United States Army Corps of Engineers, USDA, etc.
- Natural earthen overflows from depression areas shall be represented by broad crested or irregular weirs that are equivalent to the overflow configuration (length and corresponding elevation of the saddle, as practical).
- Long open channel reaches are to be avoided where significant inflow along the reach occurs.

Structural Conveyance

Culverts, bridges, weirs, drop structures, etc., are structural conveyance features found in a typical watershed. Hydraulic characterization of structural features is based on geometric data, material

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properties, elevations, and other characteristics taken from ERP as-built drawings or collected field data. Hydraulic data contained in the project geodatabase include measured and/or observed data such as stage areas, lengths, diameters, end treatments, elevations, cross sections, digital photos, construction materials, etc. Hydraulic parameters consisting of roughness values, entrance and exit loss coefficients, conveyance way, and overbank identification, etc., are interpreted by the engineer from the data.

Accuracy of Structural Data

For structures such as bridges, culverts, and weirs, all reported elevations for reference marks, inverts, headwalls, low chords, road centerlines over structures, etc., shall be acquired (by others) in accordance within the vertical accuracy specified for the project. All dimensional information reported, such as lengths, widths, diameters, etc., shall be measured (by others) to within an accuracy of ± 0.01 feet. The center of the structure shall be located (by others) to the horizontally accuracy specified. Documentation regarding field survey information is referenced (by others) to the Hyd-ID as provided in the Survey Work Requirement Form.

Adjacent Watersheds

Connections to adjacent watersheds usually have to be considered in the watershed model. These interconnects can exist as overtopped land saddles, culverts, or open channel connections. At these locations, surface water can flow in or out of a watershed depending on conditions. As discussed, some adjacent watershed models may be joined in the model domain.

Calibration, Verification, and Validation

Before it can be used to predict watershed response to various hypothetical rainfall conditions, the assembled model is to be tested and refined for accuracy through simulation of, and comparison to, various historical conditions. Sufficient historical data is available to perform calibration, verification, and validation of the Anclote West Watershed Model, as follows:

- Calibration – simulations will be performed of the Tropical Storm Debby multi-day storm event, with simplified (single value or time series stage) boundary conditions at select locations along the Pithlachascotee River. Model parameters will be adjusted within reasonable ranges of values to tune simulation results to recorded flows on the Anclote River and other gaged streams. Successful calibration will result in a model that can replicate watershed response to other historical rainfall events of similar magnitude, accounting for differences in initial and boundary conditions.
- Verification – simulations will be performed of the Hurricane Frances multi-day storm event, with simplified (single value or time series stage) boundary conditions at select locations along the Pithlachascotee River. Model parameters will not be adjusted, unless also adjusted to better tune the aforementioned calibration model. These simulations will serve to verify that the calibrated model can reliably predict watershed response to a variety of large rainfall events relative to recorded flows on the Anclote River and other gaged streams.
- Validation – simulations will be performed of the Tropical Storm Debby, Hurricane Frances, and other historical events, with simplified (single value or time series stage) boundary conditions at select locations along the Pithlachascotee River, to compare simulation results to other discrete water level measurements and other available records throughout all portions of the watershed. Model parameters will not be adjusted. These simulations will serve to validate that the watershed

model can reliably predict watershed response to a variety of large rainfall events relative to recorded water levels at sites located throughout the watershed.

Historical Rainfall

Development of accurate rainfall patterns over the watershed will be necessary to successfully validate the watershed model. The spatial and temporal distribution of historical rainfall events (including Tropical Storm Debby, Hurricane Frances, and others) will be described using single event Doppler Radar rainfall data. A maximum of one-hour incremental rainfall (depth in inches) distributed over a maximum of a 2-kilometer square grid will be developed for each selected event. Selected rainfall events will be 10 hours or longer in continuous duration, generating water surface elevations with a magnitude of a mean-annual event or greater. A rainfall coverage will be developed along with associated rainfall distribution tables for overlay assignment to each sub-basin. A rainfall distribution table will be assigned to each sub-basin according to the grid percentages contributing to that sub-basin (i.e., a weighted average distribution shall be generated for each sub-basin based on the grid overlay area).

Historical Streamflow

Streamflow data are also needed to verify the simulated runoff resulting from each historical rainfall event. Hourly stages and flows are available from the USGS while other elevation data are available from the District and Pasco County. Water surface elevation and flow data acquired will be evaluated for accuracy. Hydrograph comparison, hydrograph deconvolution, base flow analysis, and volumetric analysis can be used to determine the validity of simulation model parameters.

Synthetic Storm Events

Once validated and approved for use by the District, the watershed model will be used to predict the response of the Anclote River Watershed to a range of synthetic rainfall events with 1-day and 5-day durations and recurrence intervals from 2.33 to 500 years. The premise behind the 1-day and 5-day event modeling is that the 1-day event will address peak rate sensitivity while the 5-day event will address volume sensitivity. The Florida Type II Modified Rainfall Distribution provided in the ERP Information Manual will be used to distribute rainfall over 24-hours. Distribution of the rainfall over the 5-day period will be based on a 5-day dimensionless curve provided by the District.

The District has developed rainfall maps for a 24-hour storm duration for the 2-year, 2.33-year, 5-year, 10-year, 25-year, 50- year, and 100-year return periods. Those rainfall maps will be utilized to determine depth of rainfall in inches for each return period. Other rainfall depths provided by the District, tabulated below, will be used for selecting the 1-day 500-year volume and the 5-day rainfall volumes. While portions of the watershed are within Hillsborough and Pinellas County, rainfall depths for Pasco County will be used for simulations performed under this task order.

Table 4: District Recommended Rainfall Depths, inches

County	1-day 500-year	5-day 10-year	5-day 50-year	5-day 100-year	5-day 500-year
Hillsborough	14.0	11.3	15.9	17.8	18.9
Pasco	15.1	11.3	15.7	17.0	21.4
Pinellas	15.0	11.8	16.8	19.2	23.6

Boundary Conditions for Storm Events

For each storm event simulated, conditions and available data will dictate how boundary conditions are formulated and modeled. Tailwater conditions at the mouth of the Anclote River are tidally influenced by the Gulf of Mexico. For tidally influenced outfalls, the mean high water elevation (MHW) at the outfall location shall be used for the tailwater elevation (i.e., a single elevation). The MHW level provided by the SWFWMD for use at this location (Tarpon Springs at Anclote River mouth) is 1.3 feet, NAVD. Outfalls to other receiving water bodies with time varying elevations, such as the Pithlachascotee River, shall use stage hydrographs corresponding to the events simulated, when available. The stage hydrographs can be developed from historical data for a corresponding return frequency event or from the results of a simulation model of the receiving water body. If stage hydrographs are not available, biological indicators, seasonal high water level information, downstream hydraulic controls, or other supporting information may be used.

Quality Assurance and Quality Control

Quality Assurance (QA) is achieved through appropriate assignment of project tasks and responsibilities to team members; staff training; development of and adherence to protocols (including protocols for quality control); adherence to the baseline schedule and budget; and daily task oversight.

- Assignment of Team Members. DES staff members were assigned to the Data Acquisition task by the DES Project Manager, taking into consideration capabilities and experience, as follows.
    - Task Leader – Trillian Baldassari, PE
    - GIS Analyst – Chris Gilhooley
    - Project Engineer – Chris Hardin, PE

  These staff assignments are in agreement with the TWA and project plan documents.
- Development and Adherence to Protocols. Task-specific DES Protocols were developed as a supplement to the District's Guidance documents, and include work flow procedures for all related activities, including documentation of work, communication and quality control checks throughout task completion. The work flow document indicates team member assignments and includes reference to coordination with the District and a third party consultant who will be performing related work under separate contract.
- Prior to initiating a task under the District's WMP, the associated task protocol document(s) were reviewed by and discussed among assigned team members in a task kickoff meeting. Based on team discussion, a determination is made whether the standard protocols can be applied to the project. Any deviations from the standard protocols will be identified and a description provided of the special conditions necessitating those deviations.
- Adherence to Baseline Schedule and Budget. An initial project timeline, extending approximately ten (10) months from Notice To Proceed (NTP), was developed and incorporated into TWA No. 14TW-42. Similarly, the TWA contains initial staff allocations, manhour estimates, and associated costs for each discrete task that makes up the Watershed Evaluation project. At this time, both the project schedule and the budget contained in the TWA are judged to be accurate, and staff allocations appear sufficient.

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- DES management and staff fully understand the critical importance of the expeditious completion of the PACE project and are absolutely committed to meeting the project timeline as it has been developed for the Anclote West Watershed Evaluation phase, within the allocated budget. As work proceeds, DES will provide monthly updates to the District regarding both the schedule and the budget. As project tasks are completed and project needs and data limitations (if any) are better understood, recommendations may be made to the District's Project Manager for changes to staffing allocations and/or project approach, including potential adjustments to the timeline and costs.
- Daily Task Oversight. As discussed above, DES has assigned Ms. Trillian Baldassari, PE, as the team's Lead Project Engineer. Ms. Baldassari has been responsible for daily oversight of project-related activities. Mr. DeLoach has also been fully engaged in the management of all aspects of the work and involved in the day-to-day operation. Ms. Baldassari and Mr. DeLoach have performed the oversight needed to provide for quality assurance on this task.
- Quality Control (QC) has been performed according to well-designed protocols to check for errors and omissions, to verify that staff are using tools and following procedures correctly and effectively, and to fully understand why certain processes result in certain outcomes. QC protocols include those for raw data collection, data manipulation and calculations; parameter selection, processing and computations; reporting, mapping, and deliverables production.
- Typically, a rigorous internal peer review is undertaken as part of our standard QA/QC protocol for all tasks, and is performed and/or directed by the DES Project Manager. **Under this TWA, however, QC is to be performed by a third-party consultant.** Specific QC checks, which were developed by the third-party consultant (Ardaman & Associates, Inc.) and the District, for the review of all project tasks to be performed by DES under TWA No. 14TW-42 are included as a reference attachment to this document. Consequently, QC for the Anclote West Watershed Evaluation will consist of:
    - protocol review by Task Leader and team member(s), prior to start of work
    - self-check of work by team members while performing project tasks
    - handoff of task materials to third-party QA/QC Team Leader
    - QA review and QC checks by third-party QA/QC Team
    - return of task materials, comments and QA/QC report from third-party QA/QC Team Leader
    - review of third-party findings by DES Project Manager and DES Task Manager for resolution
    - incorporation of QA/QC work products and reports into project deliverables for District review

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