Hillsborough County, Florida's Stormwater GIS

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Abstract

Geographic Information System (GIS) plays a very important role in stormwater management. Hillsborough County, Florida, has developed a sophisticated system: StormwaterGIS. In this system, 45 feature classes have been developed. To enhance this system, 15 more layers will be developed. These layers include watershed delineation, lakes and ponds, ditches and rivers, stormwater conduits, stormwater structures, stormwater hydrology/hydraulics model setup and results, flood plain delineation, land use, soil type, and stormwater capital projects, to name a few.

Key Words: *GIS, Stormwater, Hydrology, Hydraulics, Modeling.*

Introduction

Hillsborough County, located in the west coast of Florida, has a population of more than one million residents and coveres over 2,560 km^2 (1,000 mile^2). It is one of the fastest growing areas in the State. Due to natural conditions, stormwater is a very important issue in Hillsborough County. Since early 1990's, Hillsborough County has been developing a sophisticated geographic information system, StormwaterGIS. This system, although still under development, has been applied to countless projects, and has already derived many benefits to in-house staff, consulting engineers and scientists, decision makers, and citizens. In this paper, we will briefly demonstrate what has already been completed, what we are developing, and what we propose to do in the near future.

Completed Layers

Forty five feature classes have been developed. These feature classes include primary layers, asset layers, application layers, derived layers, and tools.

- **Primary Layers**. The primary layers of Hillsborough County's StormwaterGIS are: streets, aerial photos, railroads, Township-Range-Section, jurisdictional boundaries, location of maintenance service units, commissioner districts, parcels, planning area, and Tampa Bay boundary, etc.

- **Asset Layers**.
    1. Stormwater Culverts. Hillsborough County has more than 70,000 culverts. Since mid-1990s, millions of dollars have been spent on the data collection of these culverts. Attributes of stormwater culverts are culvert ID, culvert size, culvert material, culvert condition, culvert configuration, culvert location, etc. A unique Hansen Information Systems ID was also assigned to each culvert. Starting in 2001, all stormwater culverts are being re-inventoried with advanced GPS to include road side ditches.
    2. Stormwater Structures. We collected data on stormwater structures at the same time we collected information on culverts. Stormwater Structures include manholes, weirs, headwalls, inlets, etc. Attributes of stormwater structures are structure ID, structure type, structure location, structure condition, and a unique Hansen ID. At least one picture is linked to each stormwater structure.
    3. Stormwater Ponds. Hillsborough County has more than 1,000 stormwater detention/retention ponds. All these ponds have been digitized as polygons. Attributes of stormwater ponds are pond ID, location, and size.
    4. Stormwater Pump Stations. This is a point theme. Attributes are pump ID number, pump type, pump location, operation method, etc.
    5. Completed Capital Improvement Project (CIP) during the last five years. Over 500 stormwater capital projects were completed in the past 5 years at a cost of over $93 million. This is a point theme. Attributes are project ID number, project name, project location, project manager, etc. A text file, which contains brief information of this project, is linked to each project.
    6. Completed Culvert Replacements. This is a point theme. Attributes are the same as the Completed CIPs.
    7. Unfunded CIPs. With the completion of the stormwater watershed master plan, 200 projects with a proposed budget of over $212 million were identified. A point theme was developed to show the project locations, project names, project ranking, and brief description of the projects.

8. Adopt-a-pond. To effectively educate the citizens, Hillsborough County has a special program, Adopt-a-Pond. A polygon theme has been developed to show the ponds that have been adopted.

- **Application Layers.**
  Application layers are for the development of hydrology/hydraulics models. Layers in this category are:
  1. Land Use. Three land use layers are included in Hillsborough County's Stormwater GIS. The first one is 1995 land use; the second is 1999 land use; and the third is future land use. Land use layers can be used to calculate curve number, a very important hydrology parameter, which reflects infiltration rate. By comparing curve numbers calculated based on 1995 land use and 1999 land use, one can find the trend of stormwater management in a certain area. Future land use can be used to predict future stormwater management requirements.
  2. Soil Type. Same as Land Use, the Soil Type layer is also for curve number calculation purposes.
  3. Wetland Soil. This is a sub-layer of Soil Type. The usage of this layer is for stormwater engineers and scientists to conveniently identify appropriate locations of wetlands. Figure 6 shows wetland soils. From this figure we can easily identify natural water features.
  4. Contours. Three contour layers are included in Hillsborough County's Stormwater GIS, which are 1-foot contour (still under development), 2-foot contour (completed in 1988), and 5-foot contour. These contours are very useful for engineers to determine basin delineation, storage, floodplain delineation, and DTM. Figure 7b shows 3D topography derived from 2-foot contour.
  5. Water Features. There are two water feature layers in Hillsborough County's Stormwater GIS. One is a polygon layer, and another is a polyline layer.

- **Derived Layers**
  Derived layers are either directly derived from primary and/or application layers, or derived from hydrology/hydraulics computer model setup and/or results. Layers in this category are:
  1. Watershed Delineation. Based on major water features and contours, Hillsborough County is divided into 17 watersheds .
  2. Basin Delineation. For hydrology model purposes, the 17 watersheds were further delineated into more than 7,000 sub-basins. Attributes of this polygon are basin ID number, watershed, time of concentration, curve number, area, shape factor, and initial abstraction. Besides, some model results are also included in this layer, such as total pollutant (TP, TN, TSS, BOD5, etc.) loads, and peak runoffs of 6 design storm events, which 2.33 year/24 hour, 5

year/24 hour, 10 year/24 hour, 25 year/24 hour, 50 year/24 hour, and 100 year/24 hour, respectively.

3. 100-Year Flood Plain Delineation. Three 100-year floodplain delineations are included in Hillsborough County's Stormwater GIS. These are FEMA's 1988 100-year floodplain delineation, FEMA's 1990 100-year floodplain delineation, and the proposed 100 year floodplain delineation.

4. Peak-Sensitive and Volume-Sensitive Areas. Peak sensitive and volume sensitive layers are for the purpose of determining the extent of permitting in the areas of growth and development. As mentioned in the Introduction, Hillsborough County is a fast growing county. To better regulate development without any negative impact not only for flood control, but also from a water quality point of view, Hillsborough County developed a "Stormwater Management Technical Manual" for developers, engineers, and consulting firms. In this manual, peak sensitive area is defined as areas where receiving waters are sensitive to changes in timing and/or magnitude of peak flows; while a volume sensitive area is defined as areas where the receiving waters do not have positive outfall for storm events less than or equal to the 25-year/24-hour event, and areas which do not directly discharge into a well defined conveyance system (i.e., ditch, storm sewer, etc.). Based on this manual and hydrology/hydraulics model results, two polygon layers, Peak Sensitive Area and Volume Sensitive Area, were developed .

5. Major Pollutant Outfall. This is a point layer. In this layer, pipes greater 30" flowing into receiving waters, and pipes greater than 15" flowing out of industrial areas were identified.

6. Administrative Referrals. This is a point layer. In this layer, administrative referrals pertaining to stormwater infrastructure or dealing with flooding issues are hyperlinked to the location of the referral. With this system, it is very convenient to track historical data at any given location by merely clicking this site, without digging out files. So far, more than 15,000 administrative referrals have been linked to more than 1,400 sites. This system is updated every week.

7. Stormwater Reaches. This is a polyline layer built from Hillsborough County's version of Storm Water Management Model (HCSWMM). Attributes of this layer are reach ID, from junction ID to junction ID, reach type, reach size, reach material, reach length, reach upstream invert, reach downstream invert, reach hydraulic resistance, and reach initial flow, etc.

8. Stormwater Junctions. This is a point layer. Attributes of this layer are junction ID, junction invert, junction initial elevation, etc.

9. Stormwater Weirs. Unlike the stormwater asset layer, where weirs were defined as points, this is a line layer. In this layer, not only real weirs, but also overtopping weirs and basin-to-basin weirs used in

HCSWMM are included. Attributes of this layer are weir ID, weir from junction, weir to junction, weir type, weir length, weir top elevation, weir crow elevation, weir flow coefficient, etc.

- **Tools**

  While working on the stormwater watershed master plan, Hillsborough County developed many GIS tools. These tools are very helpful for engineers. These tools are:

  1. Curve Number Calculation. This is an ArcMap 8.3 extension written in VBA. To calculate the curve number of a polygon, users can either draw a polygon, or select a polygon feature from a polygon layer, such as basin delineation, when land use and soil type layers are available.
  2. Connectivity Diagram Builder. This is an ArcView 3.X extension. Users can build HCSWMM connectivity diagrams from HCSWMM setup without difficulty.
  3. NGVD29 and NAVD88 Converter. Hillsborough County is moving vertical datum from NGVD29 to NAVD88. Engineers are suffering from headaches converting calculations. NGVD29 and NAVD88 converter is an ArcView 3.X project. With this project, users can conveniently find out the difference between NGVD29 and NAVD88 at any location inside Hillsborough County by clicking in this location.
  4. CIP Tracking. This is an ArcView 3.X project. With this project, users can find the location of a recently completed CIP by entering either key words, CIP name, CIP ID, CIP project manager's name, etc.
  5. Pollutant Load Model. This is an ArcMap 8.3 extention written in VBA. With this model, users can calculate a sub-basin's annual pollutant load, such as BOD4, TP, TN, etc., by selecting the sub-basin with mouse.
  6. HCSWMM personnel geo data base builder. This is an ArcMap 8.X project written in VB and VBA. Users can builder geo data base from HCSWMM setup without difficulty.
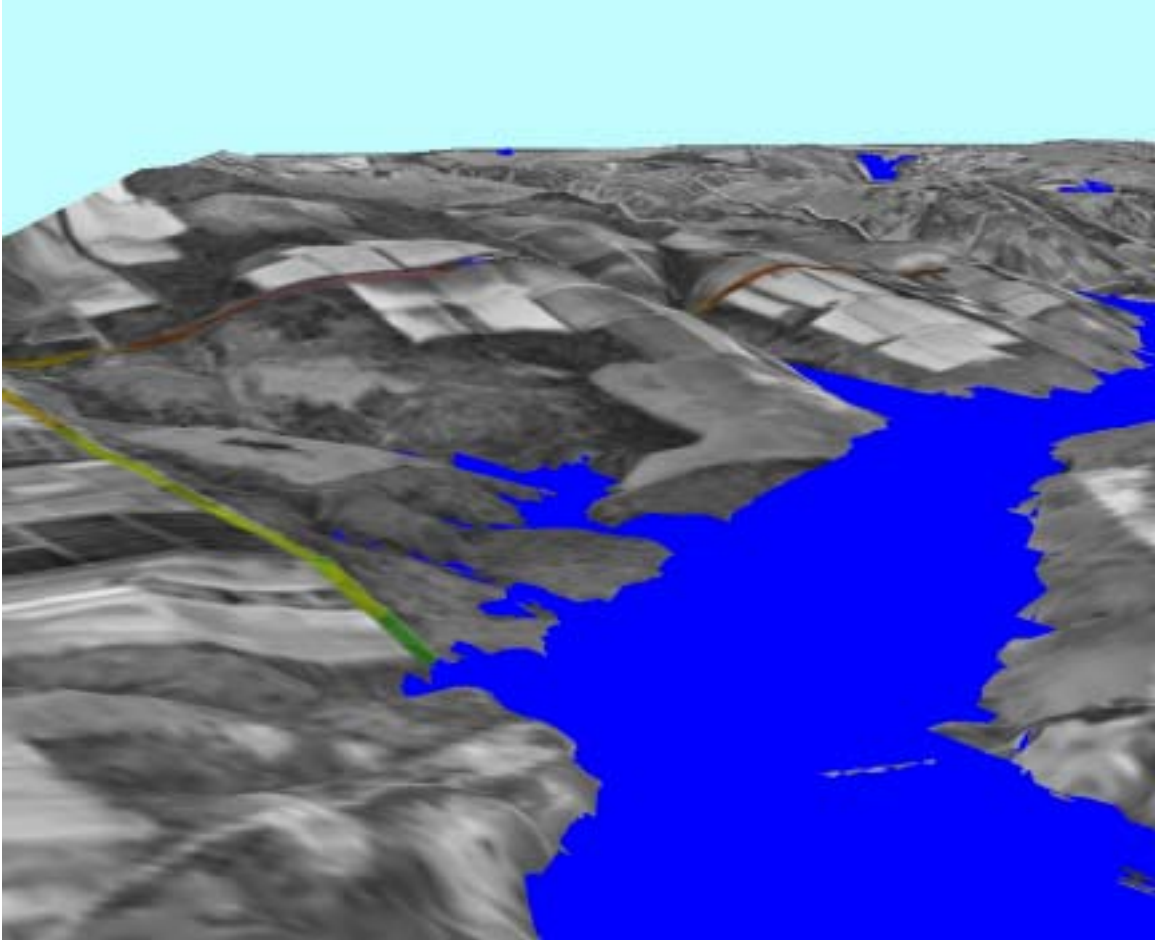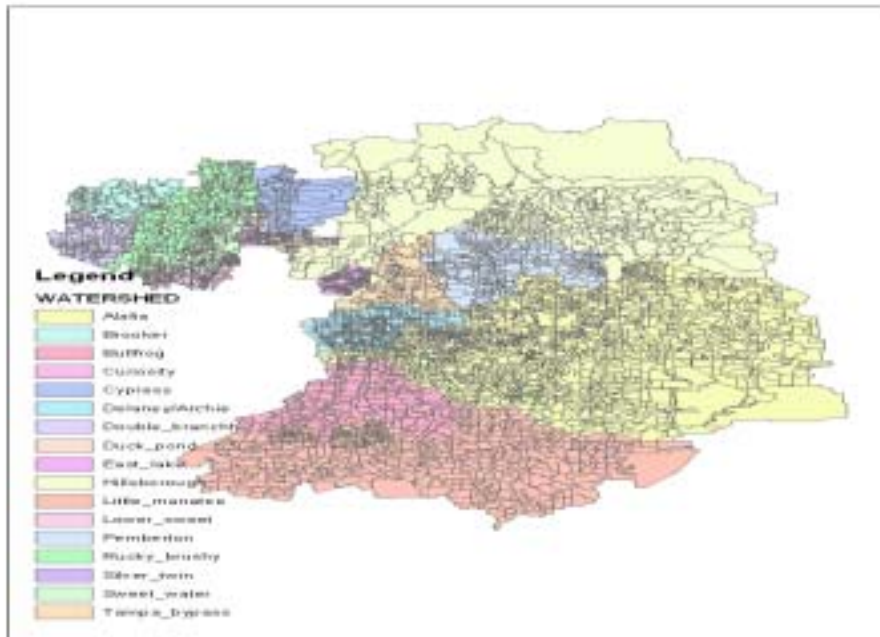
Figure 7b Three Dimensional Show

Legend

WATERSHED
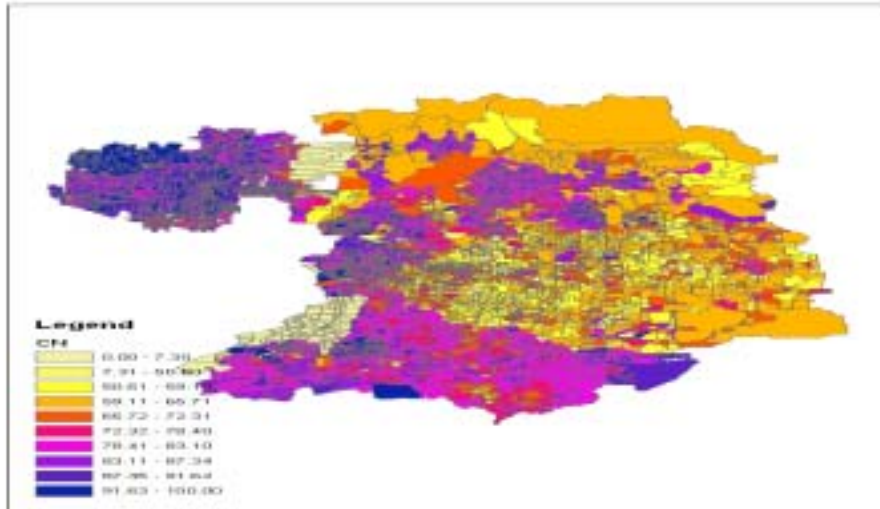
- Alafia
- Booker
- Bullfrog
- Curiosity
- Cypress
- Delaney/Archie
- Double_branch
- Duck_pond
- East_lake
- Hillsborough
- Little_manatee
- Lower_sweet
- Pemberton
- Rocky_brushy
- Silver_twin
- Sweet_water
- Tampa_bypass

Figure 9 Basin Delineation

Legend

CN
- 0.00 - 7.30
- 7.31 - 50.60
- 50.61 - 59.10
- 59.11 - 65.71
- 65.72 - 72.31
- 72.32 - 78.40
- 78.41 - 83.10
- 83.11 - 87.34
- 87.35 - 91.62
- 91.63 - 100.00

Figure 10 Curve Number Distribution

Legend

TP (ton/yr)
- 0.00 - 0.57
- 0.58 - 1.42
- 1.43 - 2.42
- 2.43 - 3.66
- 3.67 - 4.73
- 4.74 - 6.06
- 6.07 - 7.82
- 7.83 - 16.12
- 16.13 - 33.12
- 33.13 - 51.62
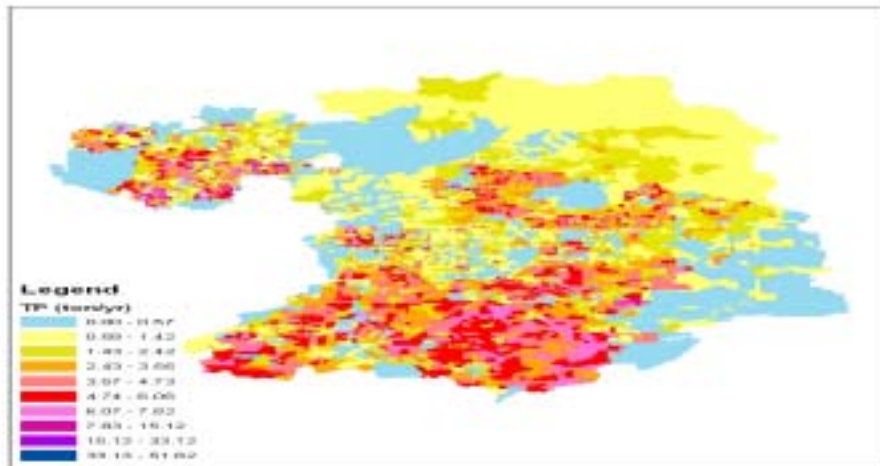
Figure 11 TP Distribution

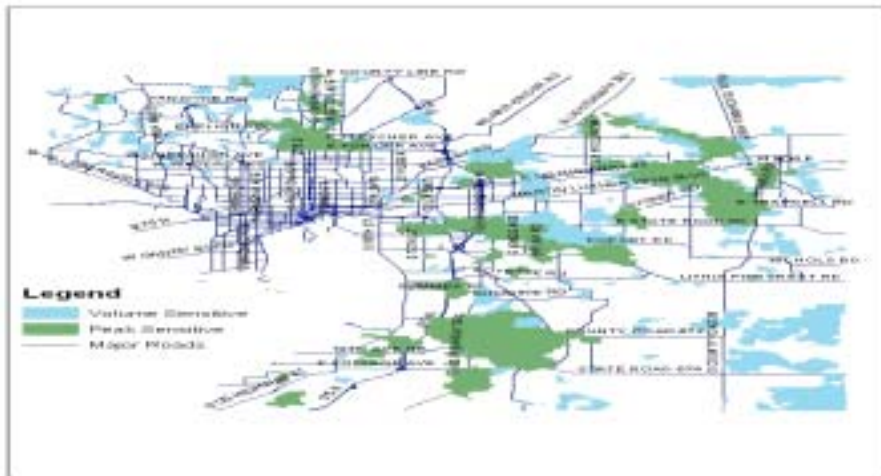Figure 12 Floodplain Delineation

Figure 13 Peak and Volume Sensitive Areas

Layers under Development

Five layers are under development: integration of stormwater management master plan hydrology/hydraulics computer model setup with stormwater asset; Hillsborough County lakes; hydrology/hydraulics model junctions; hydrology/hydraulics model reaches; and hydrology/hydraulics model weirs.

- Hillsborough County is in the process of integrating the stormwater watershed master plan computer model with its stormwater asset inventory. This is a three phase project: phase I, integrate the model setup with the assets; phase II: integrate the six design storm event model outputs of existing conditions with the assets; and phase III, integrate the six design storm event model outputs of proposed conditions with the assets. Right now, we are working on phase I. In this phase, attributes of culvert upstream and downstream inverts, culvert model ID, culvert upstream junction ID, culvert downstream ID, culvert hydraulic resistance coefficient, etc. are transferred from storm water master plan model set up layers to the storm water asset layer. Attributes of culvert size, culvert length, culvert material, and culvert location, etc., will be verified against each other. Since the storm water asset data and storm water master plan data were collected by different groups of people, it is a good time to QA/QC both data by comparing them with each other. Intensive field trips have been undertaken to identify any discrepancies. In the meantime, the major channels, which were included in the master plan model, but not included in the asset inventory, will also be transferred from master plan to asset database. The 0.5 foot resolution color 2002 aerial photos and 2-foot digital contours are used to determine the location and the configuration of the channels. So far, more than 50% of phase I has been completed. Figure 14 shows the conveyance system before integration. Figure 15 shows the conveyance system after integration. The major benefit of this project is that engineers and decision makers can easily figure out the flow pattern for a given area, and quickly make decisions if flooding occurs. Because of the flat topography of Hillsborough County, it is usually not easy for an engineer to determine the flow direction in an area without the help of this system.
- Hillsborough County Lakes. Hillsborough County has more than 200 natural lakes. Following the standard of ArcGIS Hydro Data Model, a polygon layer, Hillsborough County lakes, is under development. Attributes of this layer are lake master junction ID, name of the lake, lake size, lake location, watershed, normal lake depth, maximum lake volume, normal lake volume, average lake water level, six design storm event

water level, seasonal high water level, drainage area, annual load of major pollutant, etc.

- Model Junctions, Model Reaches, and Model Weirs. These three layers will be enhanced to include model outputs. A personal GEO database will be developed. Besides the attribute tables of these three feature classes, tables of storages, and natural channel cross sections will also be included and linked to appropriate junctions.
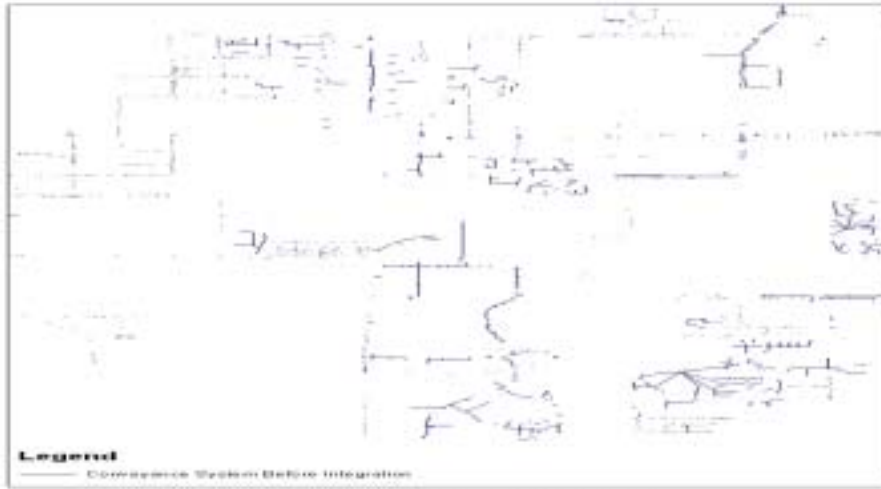
Legend
— Conveyance System Before Integration

Figure 14 Conveyance System Before Integration

Legend
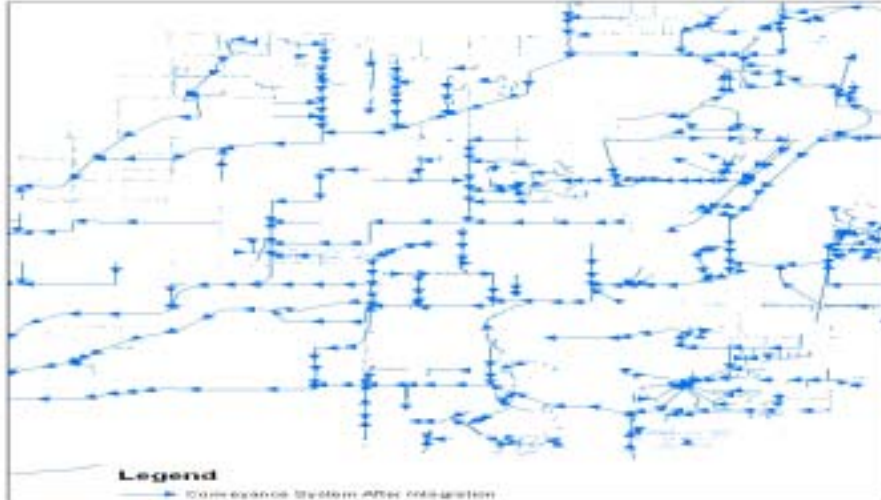→ Conveyance System After Integration

Figure 15 Conveyance System After Integration

Future Development

Future development includes, but not limited to: dynamic relationship between storm water computer models and storm water GIS; Flood impact factor of sub-basin to peak sensitive site data base development; Completed GEO data base development following ArcGIS Hydro Data model; Three dimensional 25 year/24 hour and 100 year/24 hour flood plain map; Enhanced GIS interface of HCSWMM input and output; Stand alone GIS viewer of Hillsborough County storm water GIS; Animations of water levels at major stormwater junctions; GIS interface of HCSWMM to be able to clip a sub-model and integrate the sub-model to the whole model; etc.

Summary

Hillsborough County, Florida, has been developing a sophisticated system -- Hillsborough County Stormwater GIS. This system, although still under developing, has been applied to many projects and saved a lot of time and energy for engineers and decision makers. Hillsborough County understands that it is expensive to collect and derive GIS layers, so it is very important to update and maintain these layers regularly. A special team has been built up, which includes scientists, engineers, GIS analysts, and GIS technicians, to develop and maintain this system.

Reference

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