MS4 Mapping & GIS Data Connectivity in the Rocky Branch Watershed

Jingting Sun

USC MEERM-AWNES Project

City of Columbia Stormwater & GIS Division

April 24, 2013

WWW.Columbia.SC.Gov/Engineering

Special Thanks To:

- **Internship Supervisors**

  Karen Swank Kustafik, Christopher D. Clifton, Tracy Mitchell & Victoria Kramer

- **Faculty Advisors**

  Dr. Allan James, Dr. Gwendelyn Geidel

Department of Utilities and Engineering

Regulation Background

- **Clean Water Act NPDES Permit**
  - Issued through SC DHEC in 2010
  - Phase I Medium MS4: Pop. between 100,000 and 250,000
  - City's Responsibility: SWMP & BMPs
  - 11 Elements: element 4– Flood Control; element 7– Illicit Discharge and Improper Disposal
  - 4 Watersheds

| Phase	Watershed	Contained Waterbodies	Hydrologic Unit Code
I	Lower Saluda River Watershed	Saluda River, Stoops Creek, Kinley Creek	03050109-210
II	Congaree River Watershed	**Rocky Branch**, Congaree River, Reeder Mill Branch	03050110-010
III	Broad River Watershed	Broad River, Smith's Branch, Crane Creek, Nicholas Creek	03050106-07
IV	Gills Creek Watershed	Gills Creek, Penn Branch, Wildcat Creek, Kilbourne Creek	03050110-030

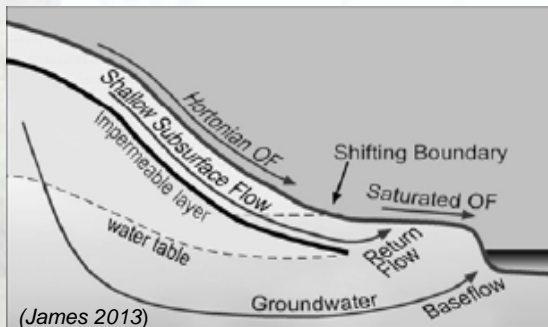**Department of Utilities and Engineering**

Urban Runoff

- **Hortonian Flow**
  - Infiltration-excess runoff
  - Dominant flow type on urbanized land
  - Rainfall intensity $>$ infiltration cap.
  - Rapid: flooding, erosion, water pollution
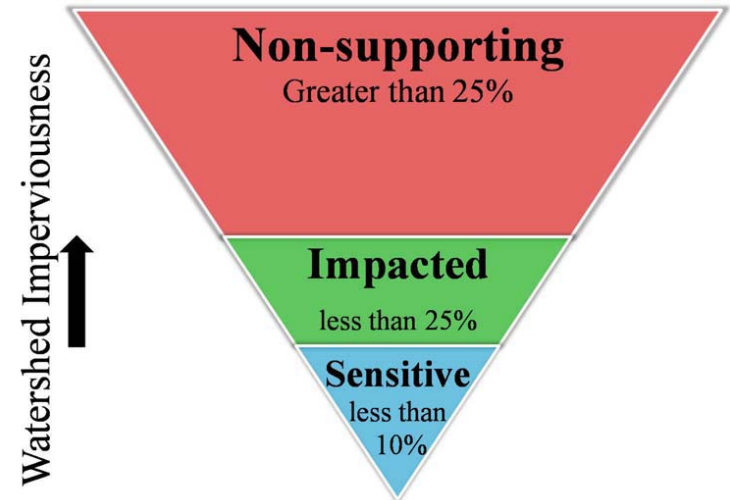
(Schueler & Claytor 1997)

(James 2013)

- **Impervious Areas & Stream**
  - RBC: non-supporting stream
  - Bank instability
  - Inadequate habitat for fish & aquatic insects
  - High level bacteria
  - Poor water quality

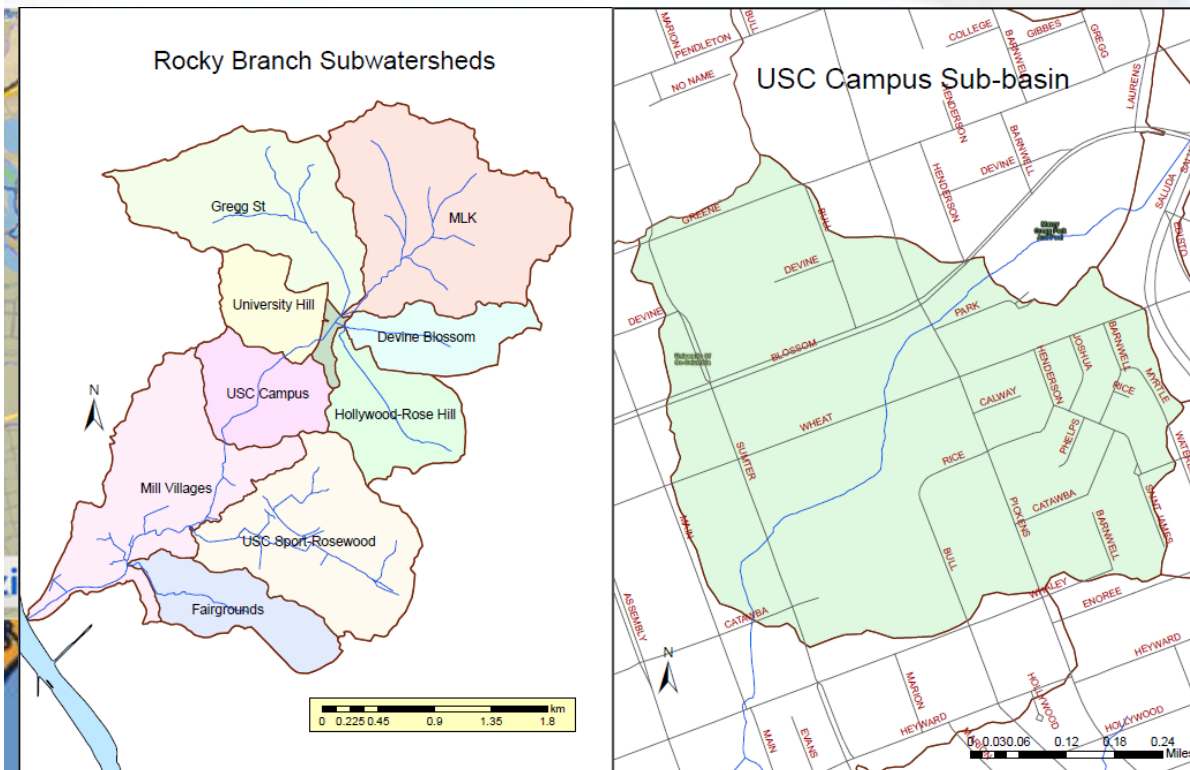**Department of Utilities and Engineering**

Study Area & Objectives

- **Rocky Branch Watershed**
  - Rocky Branch Creek: 2.2 miles
  - 4 mi^2, 49.1% impervious areas
  - 9 sub-basins

- **Objectives**
  - MS4 mapping
  - Stormwater database editing
  - Verify the basin divides
  - Pollutant source tracking & other recommendations

(James 2012)

Why Mapping MS4?

- **RBW has been facing flooding issues over the years**
- **Essential to flooding risk management**
  - Where storm intakes are located
  - Where storm sewers flows to
  - What are their flow capacities
  - →Where the MS4 is inefficient
- **Pollutant Source Tracking**

(RBWA 2011)

Department of Utilities and Engineering

Stormwater Features

- **Stormwater is dispensed through the natural & artificial stormwater infrastructure:**
  - Catchbasins
  - Junction boxes
  - Drainage points
  - Stream points
  - Outlet structures
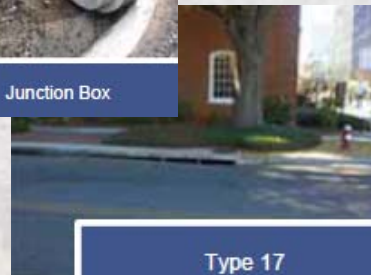 - Open channels
  - Ponds
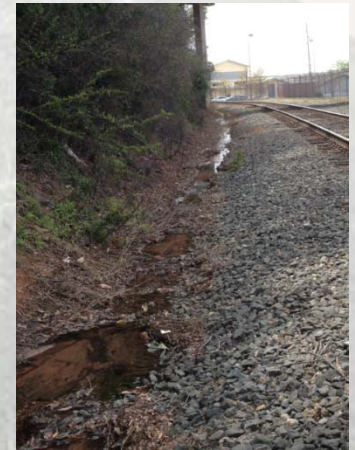 - Drain pipes

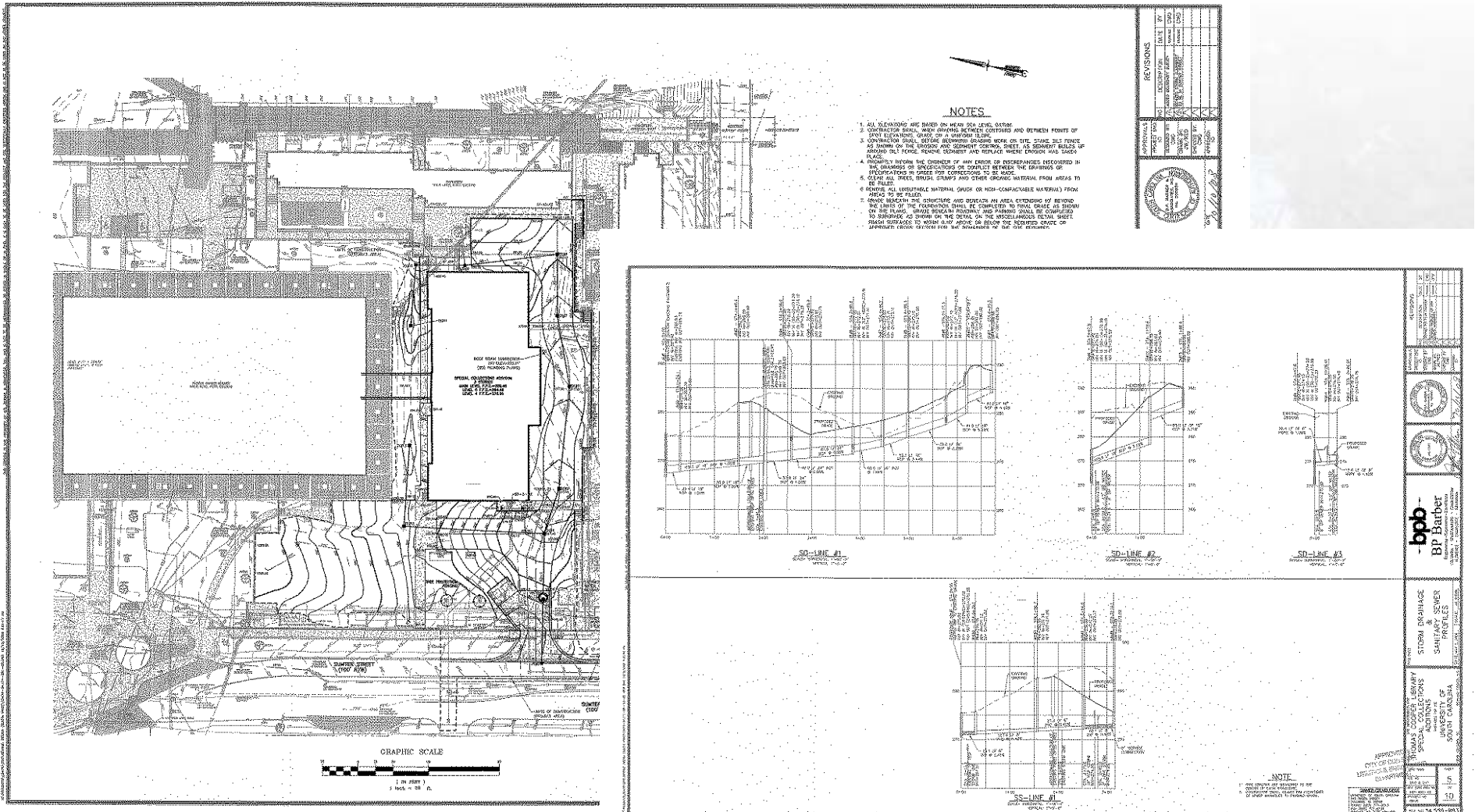
Drop Inlet

Type One with Hood

Junction Box

Type 16

Type 17

COLUMBIA, S.C.

Department of Utilities and Engineering

Methodology

- Flat File Search
- City File Search
- Print & Mark SW Infrastructure to distinguish MS4 with Sanitary Sewer, Water, Steam, Telephone lines

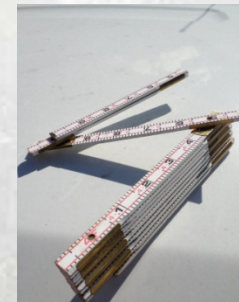**Department of Utilities and Engineering**

Plan Drawings

Thomas Cooper Library
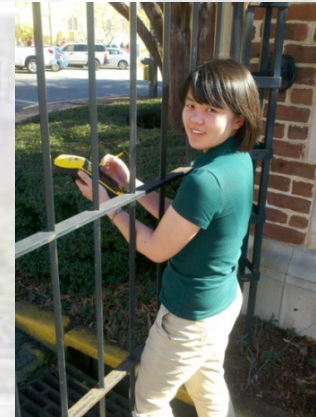
Field Methods

GPS Data Collection

- GPS Device: Trimble GeoXT 6000
- Software: ArcGIS, ArcPad, Trimble GPS Analyst (version 2.40)
- Collect the data on the middle of the SW feature
- Avoid Obstruction: trees, buildings, etc.
- Record: pipe size, direction, materials, etc.

Department of Utilities and Engineering
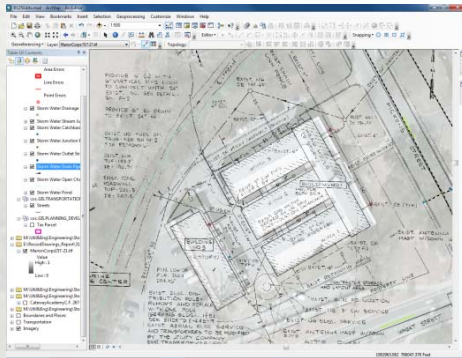
Methodology

Mapping & Edit SW Database

- **Georeference Plan Drawings**
  - Add the Plan Drawing into ArcMap
  - Fit to Display
  - Add Control Points

- **Edit SW Database**
  - Snapping
  - Add Points & pipes based on the drawing or field work comments
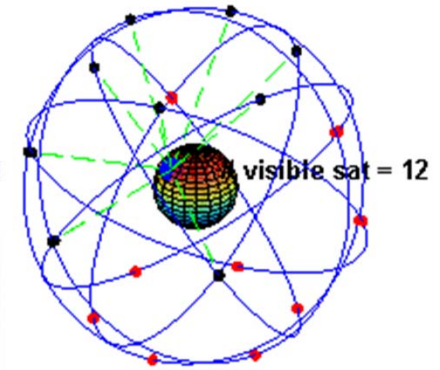 - Pipe Attributes

Department of Utilities and Engineering

GPS Data Quality

visible sat = 12

- **GPS Accuracy**
  - ○ Signals can be affected by many factors:

    satellite clock drift, atmospheric conditions, measurement noise, and multipath
  - ○ Estimated horizontal accuracy based on the error of the satellites
  - ○ Measure of Accuracy: PDOP (position dilution of precision)
  - ○ Ideal Values: $< 1m$ (after differential correction)

- **Active/Inactive**
  - ○ Active data: functioning SW infrastructure
  - ○ Inactive data: not functioning: e.g. abandoned pipes or JB
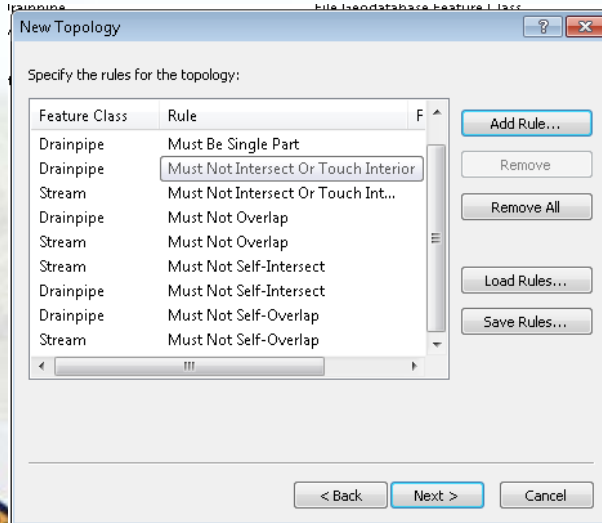
Department of Utilities and Engineering
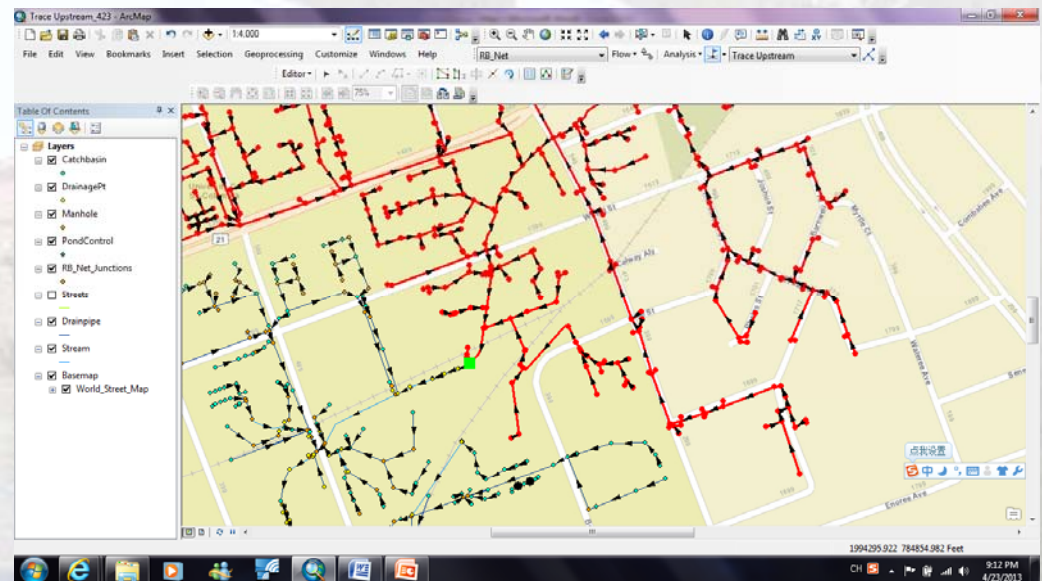
QA/QC- GIS Methods

Topology

o Manage point, line and polygon features when they share coincident geometry

o Topology Rules for pipes/streams

Geometric Network

o Check data connectivity

o Whether all pipes connect to the MS4

o Is there loop or disconnected features

Department of Utilities and Engineering

Project Challenges

- **File Search Limitation**
  - Hard to find the drawing for a specific building/area: time consuming
  - Different names for the same building: e.g. Cliff Apartment="Apartment 73"
  - Rebuilt or Expanded
    e.g. Children Development Center was relocated
  - Drawings are too old to use
  - SW info. is mixed in with others: hard to read
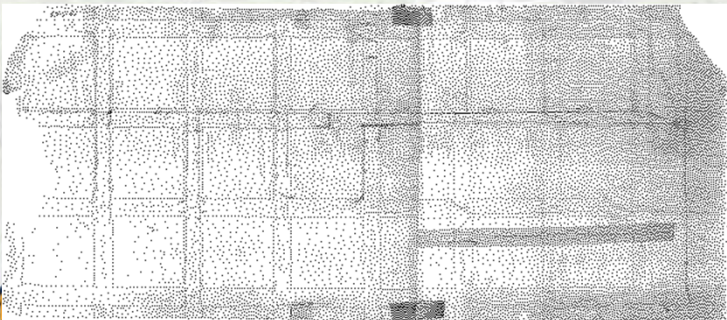
- **Field Work**
  - Satellite signal is blocked by tall buildings in downtown, or the points are under bridge
  - CB is full of leaves or soils
  - JB is on busy streets
  - MH is hard to pull up
  - Hard to define whether the MH is SW or SS, Water, Steam, etc.
  - Too deep to measure the pipe size

- **Database Editing**
  - Control Points Determination: through Tax Parcel or SS points
  - Lack of pipe size, material & elevation information

Pipe Size?

Sanitary MH

Steam MH

Department of Utilities and Engineering

GIS Data Connectivity

Contour Lines Application

- **Topographical Lines**
  - As a reference to estimate the direction of the SW flow direction
  - Three types in CoC's database: 2 feet, <u>4 feet</u> & 10 feet
  - Limitations

- **Field Verification**
  - The most reliable way to connect the MS4

Department of Utilities and Engineering

Results

Revise USC Subbasin Boundaries

SW sewer: 10 miles
Drainage pipes: 739
Catch basins: 533
Junction boxes: 179
Drainage points: 82
Outlet structures: 2
Area: from 0.72 k m^2 to 0.91 km^2

Storm Sewer Networks (USC Campus Subbasin)

Legend:
- Catchbasin
- DrainagePt
- Manhole
- PondControl
- RB_Net_Junctions
- Drainpipe
- Stream
- RBSubBasin

Sources: Esri, DeLorme, NAVTEQ, USGS, Intermap, iPC, NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), TomTom, 2013

Revised Rocky Branch Subwatersheds

- Robert Mills
- MLK
- University Hill
- Devine Blossom
- USC Campus
- Hollywood-Rose Hill
- Mill Villages
- USC Sport-Rosewood
- Fairgrounds
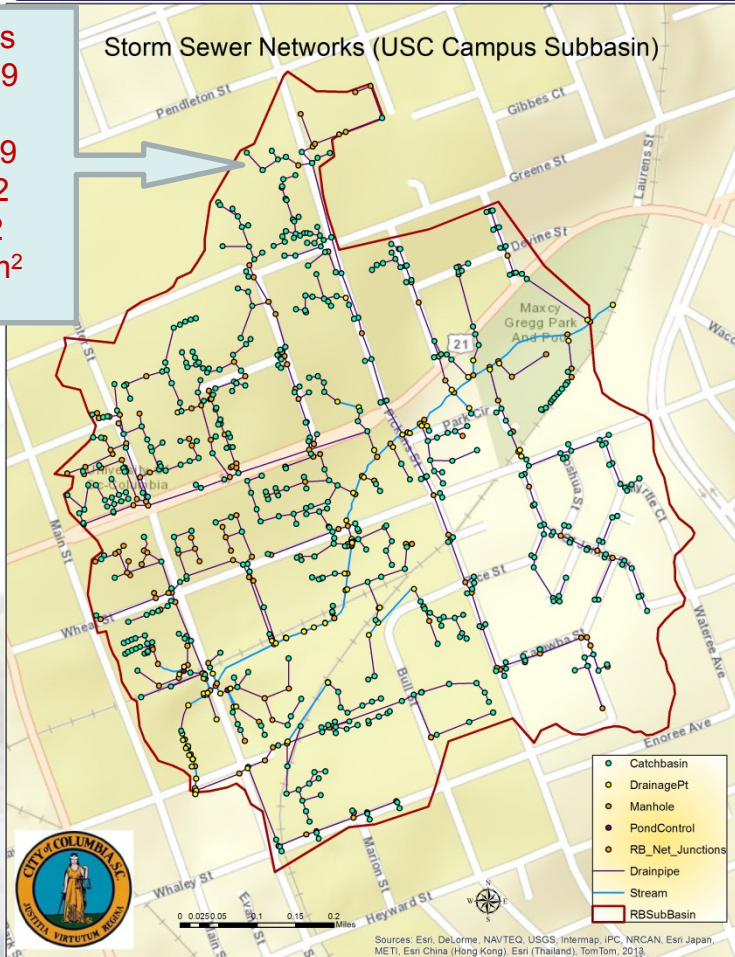
Department of Utilities and Engineering

Geometric Network Analysis

Trace Upstream for Sediment

Geometric Network Analysis: Trace Upstream

Source: water leakage repair
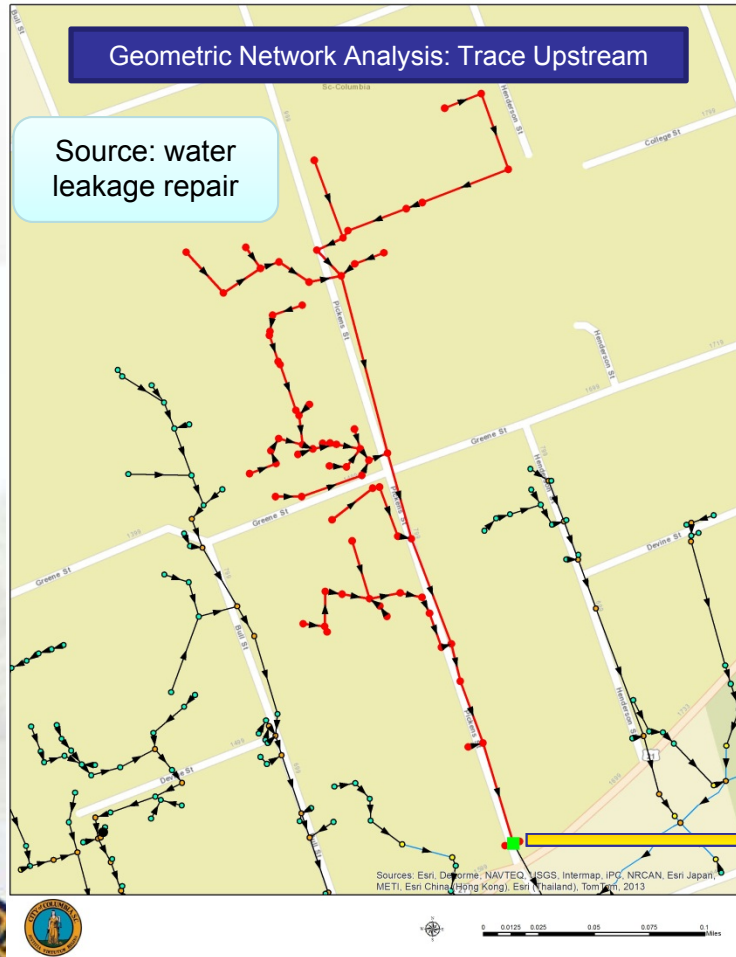
Sediment near Maxcy Gregg Park

Sources: Esri, DeLorme, NAVTEQ, USGS, Intermap, iPC, NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), TomTom, 2013

Department of Utilities and Engineering

Geometric Network Analysis

Trace Downstream for Pollutants

White Water near Chemistry & Biochemistry Building

Other Illicit Discharges

Geometric Analysis: Trace Downstream

Department of Utilities and Engineering

Recommendations

- **Hydraulic and hydrology analysis**
  - Pipe-size information
  - Estimate the potential flooding points
  - Subsequent flood-control measures to minimize downstream effects
  - Elevation and depth is still lacking in CoC's database
  - Application of Stormwater Management Model (SWMM)

- **Nonpoint source pollution control supported by GIS**
  - BMPs: Stormwater Pollutant Prevention Plans (SWPPP) for construction activities

Department of Utilities and Engineering

Conclusions

- USC Campus subbasin enlarged from 0.72 km^2 to 0.91 km^2
  - Surrounding subbasins, such as University Hill and Mill Villages, reduced accordingly
  - Similar MS4 mapping is being done for other subbasins and applied to revised watershed map

- In adjusted USC subbasin there are 10 miles of storm sewers, 739 drainage pipelines, 533 catch basins, 179 junction boxes, 82 drainage points, and 2 outlet structures

- Geometric analysis tool can trace up or down MS4 networks for source or fate of sed & other pollutants
  - Narrows possible sources of contamination
  - Reduces time to ID source as required by NPDES BMPs

Department of Utilities and Engineering