



Geospatial Activities within Location & Design Mobile Technology – Leading the Way into the 21st Century

March 19, 2019

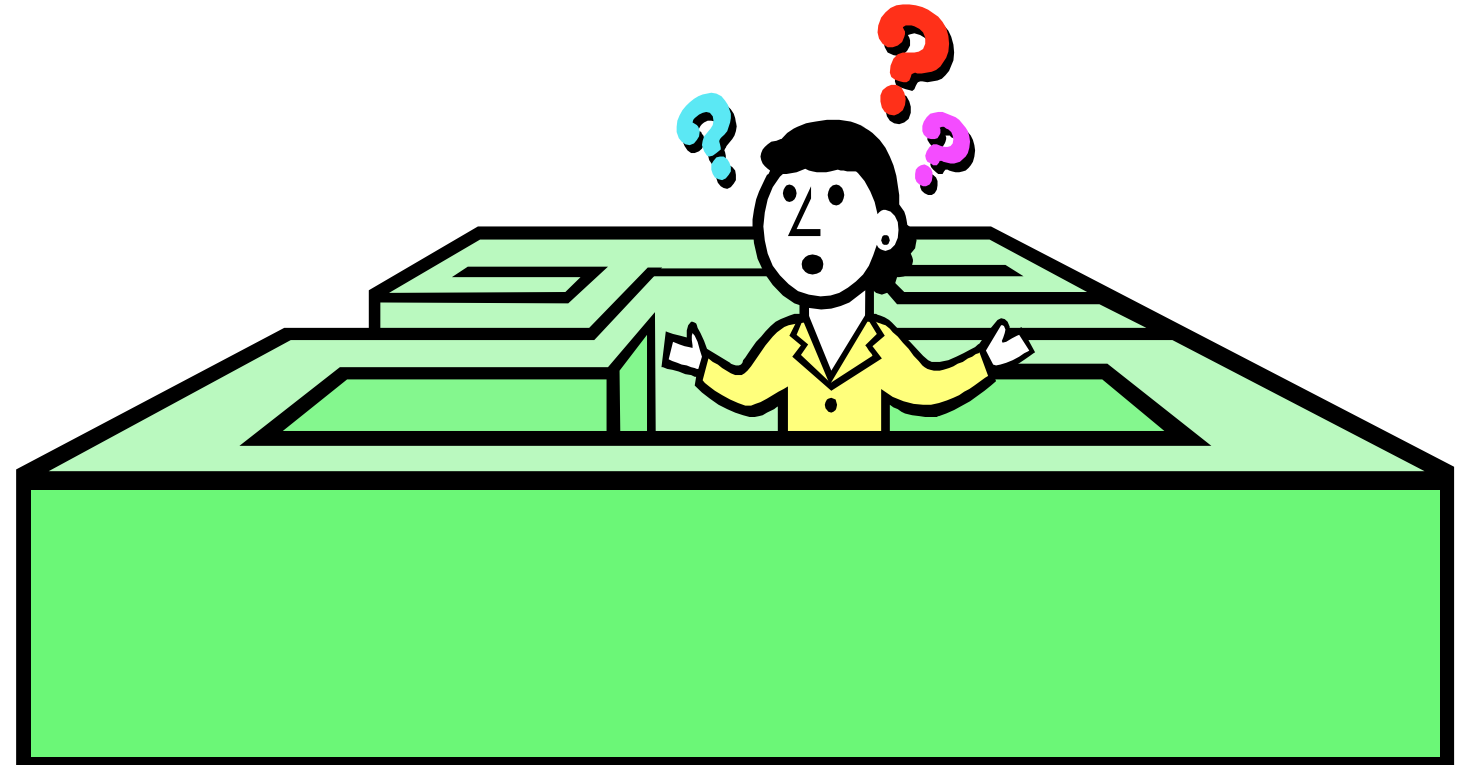
ASCE Lunch

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ArcGIS Overview

What is ArcGIS?



What is Geospatial?



GIS and Cartography



- 25000 BC Cave drawings of animals
- 14500 BC Stars depicted caves
- Egyptian Tombs
- 1832 France - Cholera outbreak mapped
- 1854 London England – Cholera outbreak, leading to the source of the disease, contaminated water pump
- 1960 GIS used as a term in mapping

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ArcIMS

Data

Coordinate System

Line

ArcSDE

Attribute

A Geographic Information System (GIS), also know as a geographical information system or geospatial information system, is any system for capturing, storing, analyzing, managing and presenting data and associated attributes which are spatially referenced to Earth (Wikipaedia)

Point

Shapefile

ArcMap

Layer

Metadata

Data is the fundamental component of any GIS and the power of a GIS is determined by its ability to relate different data in a spatial context and to reach a conclusion about this relationship

Relational Database

ArcExplorer

ArcGIS Online

A combination of two data types: spatial (locational) and attributes (descriptive data) are related and presented visually by means of an interactive user interface

Geocoding

ArcGIS

Georeferencing

IN SIMPLE TERMS:

A COMPUTER SYSTEM, CAPABLE OF HOLDING AND USING DATA DESCRIBING PLACES ON THE EARTH'S SURFACE.

Digitizing

Projection

ArcGIS Workgroup

Polygon

Query

ESRI

Orthophotography

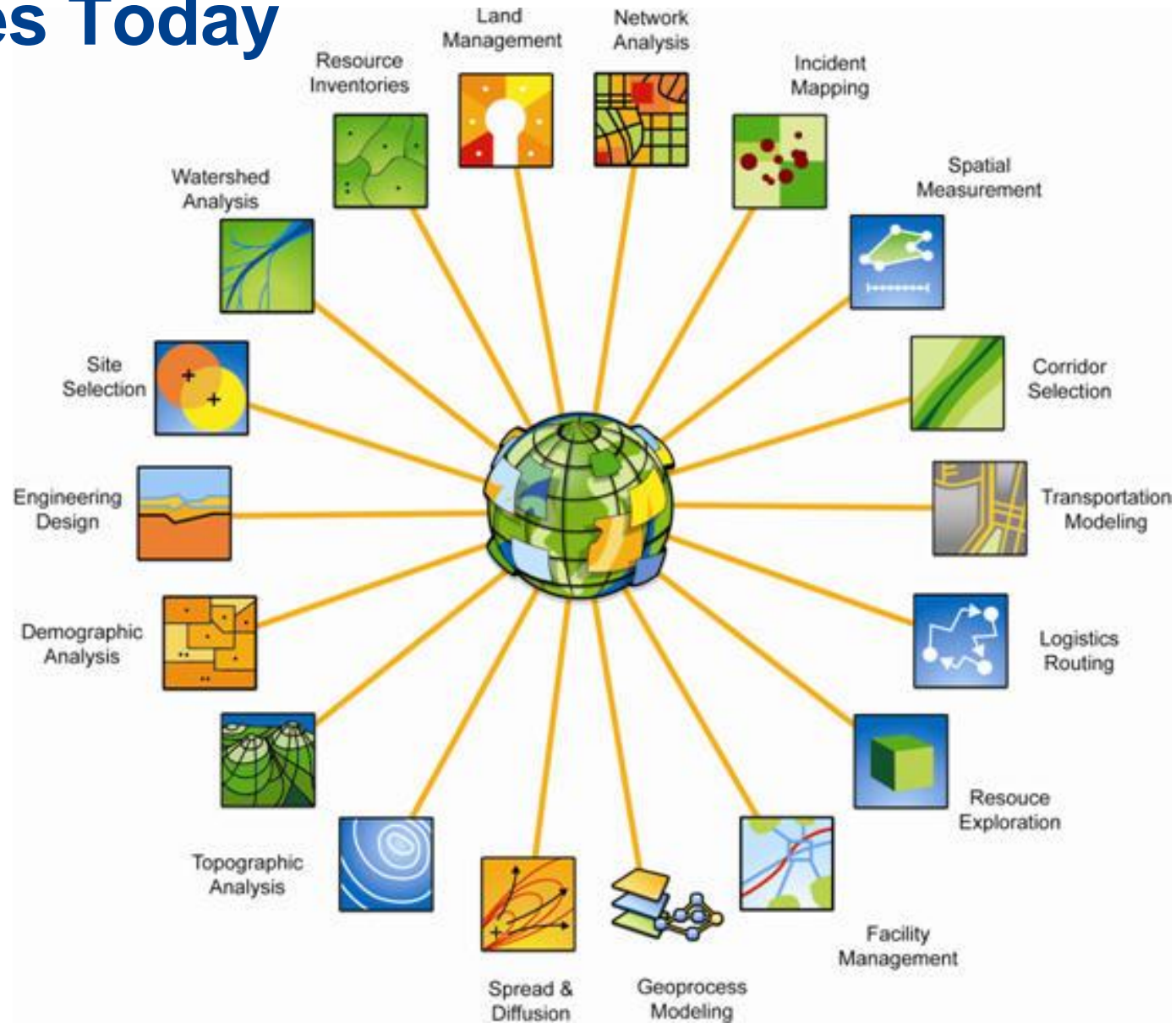
Components of a GIS System



- People
- Hardware
- Software
- Data
- Organizational Procedures

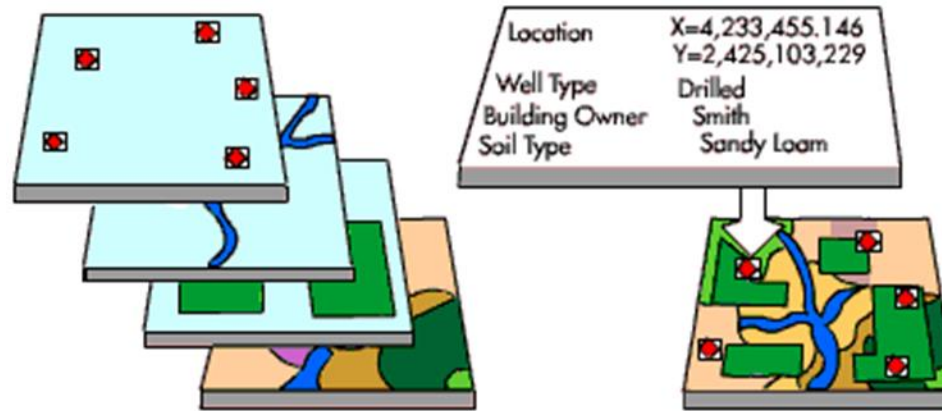


GIS Uses Today

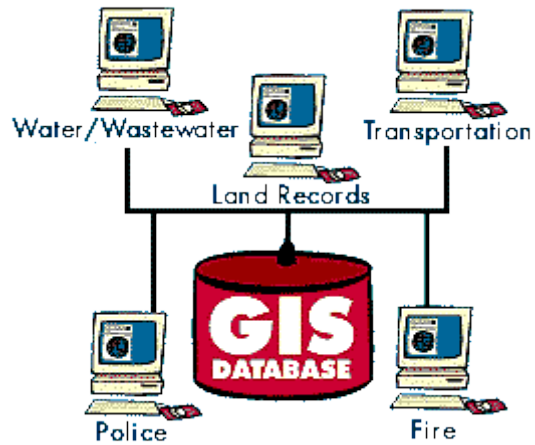


GIS Essential Tasks or Processes

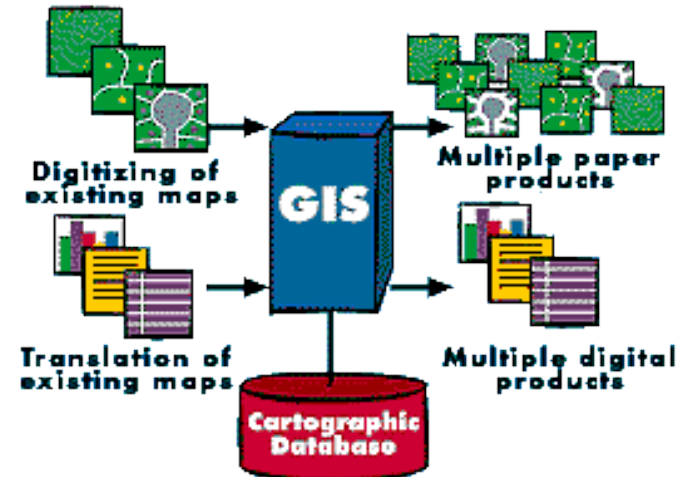
Input
Manipulation
Management
Query and Analysis
Visualization



What Can GIS Do for Us



- Streamlining service
- Reducing data collection through electronic collection
- Reducing costs through better logistics
- Keep cleaner records
- Analyzing data quickly
- Improving organizational integration



Good Geo-Information Solutions

- Provide Timely Information
- Disseminate Knowledge
- Communicate Importance
- Show Status and Performance (Dashboards)
- Support Decision Making
- Illustrate Change
- Show the Future



....Helping Us Make Better Decisions

Effectively Telling a Story . . .

Capabilities of GIS

GIS uses advanced analytical tools to explore at a scientific level the

- **Spatial relationships**
- **Patterns**
- **Processes of cultural, biological, demographic, economic, geographic, and physical phenomena**

Capabilities of GIS

- **GIS stores related geographic features in separate collections of files called map layers**
- **Map layers can be reused easily, assembled into any number of map compositions, and overlaid for analysis**
- **Scale: Global to Local**
- **Create maps that help answer questions**
- **GIS is really a merging of cartography, statistical analysis, and database technology**

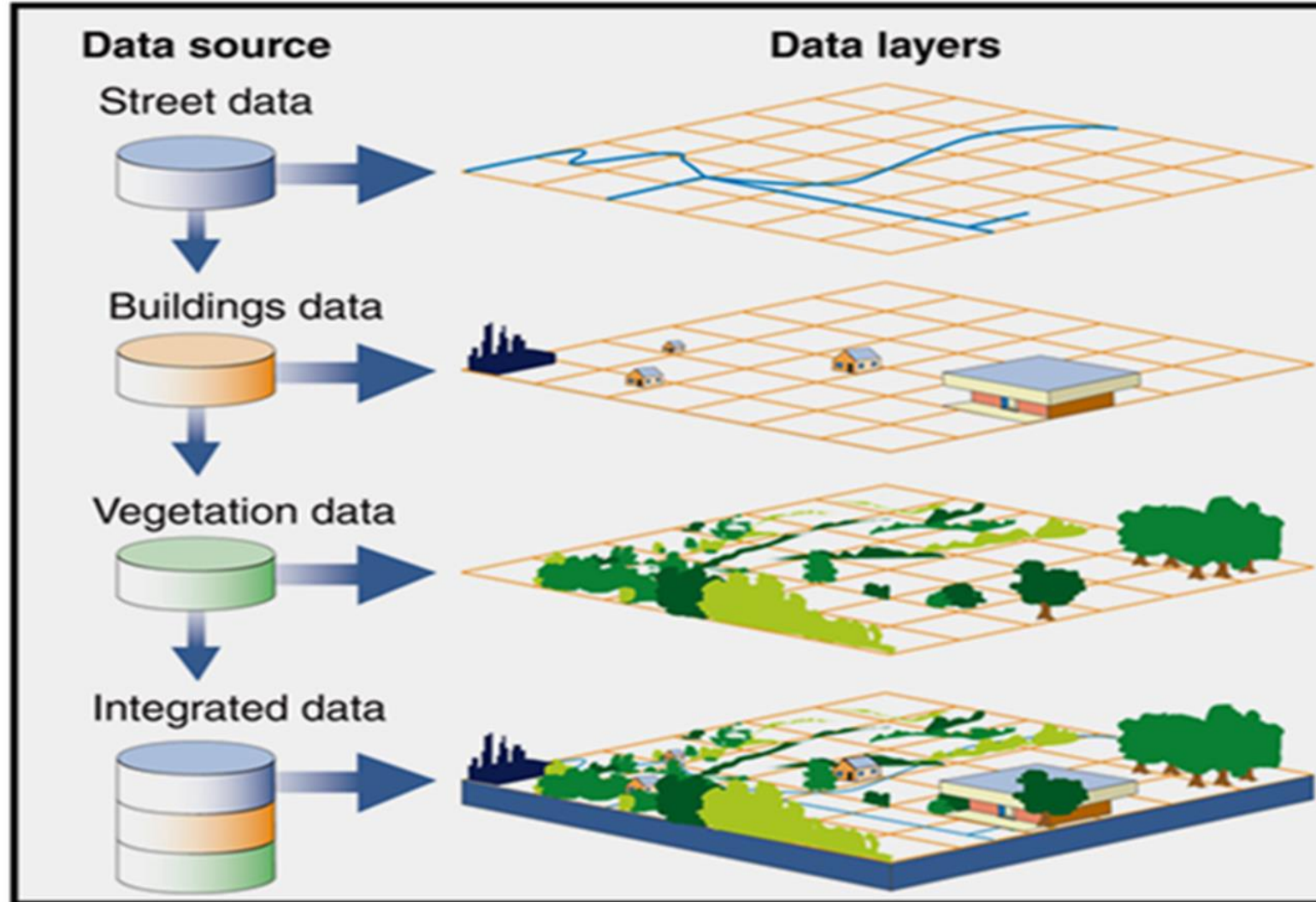
Overall Features of ArcGIS

- **Data Types – Vector (points, lines, polygons) and Raster (imagery)**
- **Store Data - ArcGIS allows you to access, use, and store GIS data using the method that fits and optimizes your existing workflows.**
- **Individual Files – ArcGIS supports many data formats, such as shapefiles, file geodatabases, tables/spreadsheets, CAD, and raster's**
- **Geodatabases - stores GIS data in a central location for easy access and management.**
 - **It can be leveraged in desktop, server, or mobile environments**
 - **It sits on top of any RDBMS, such as SQL Server, Oracle, or PostgreSQL, and supports all types of GIS data.**

Overall Features of ArcGIS

- **Cloud (mobile) - store data in the Esri cloud with ArcGIS Online or in your own personal cloud infrastructure (Azure)**
- **Interactive**
 - **Identify features**
 - **Select features**
 - **Buffer/Clip features**
 - **Query features**
- **Produce statistics/graphics**

Example of GIS Data Layers or Themes



GIS creates maps and all maps have a purpose

The Map	Example Purpose
Location Map	Show the location of something within a broader geographic context of common knowledge to audience (e.g. state, country, world)
Geology Map	Show spatial distribution of underlying geology
Habitat Map	Show spatial distribution of different habitat types
Topographic Map	Show spatial distribution of elevations
Watershed Map	Show delineated boundary of watershed
Election Map	Show which areas voted for which candidate
Grading Plan	Shows an engineering design for grading and drainage (i.e. how to manipulate topography)

Different ESRI ArcGIS systems



➤ ArcGIS Desktop

- ✓ It is a powerful GIS authoring, editing, and geoprocessing application that allows you to create beautiful maps, edit and manage spatial data, and perform the full spectrum of analyses needed to turn your raw data into valuable information

- ✓ Use ArcMap, ArcCatalog, ArcGlobe, or ArcScene, to create maps, perform spatial analysis, manage geographic data, and share your results

➤ ArcGIS Online

- ✓ An online, collaborative web GIS that allows you to use, create, and share maps, scenes, apps, layers, analytics, and data. Use to visualize, share 2D and 3D data, and perform analysis

- ✓ Access ArcGIS Online through web browsers, mobile devices, and desktop map viewers

Different ArcGIS systems

➤ ArcGIS Collector

- ✓ Collect and update data in the field, log your current location, and put the data you capture to work so you can make more informed and timely decisions. Returns data in near real time

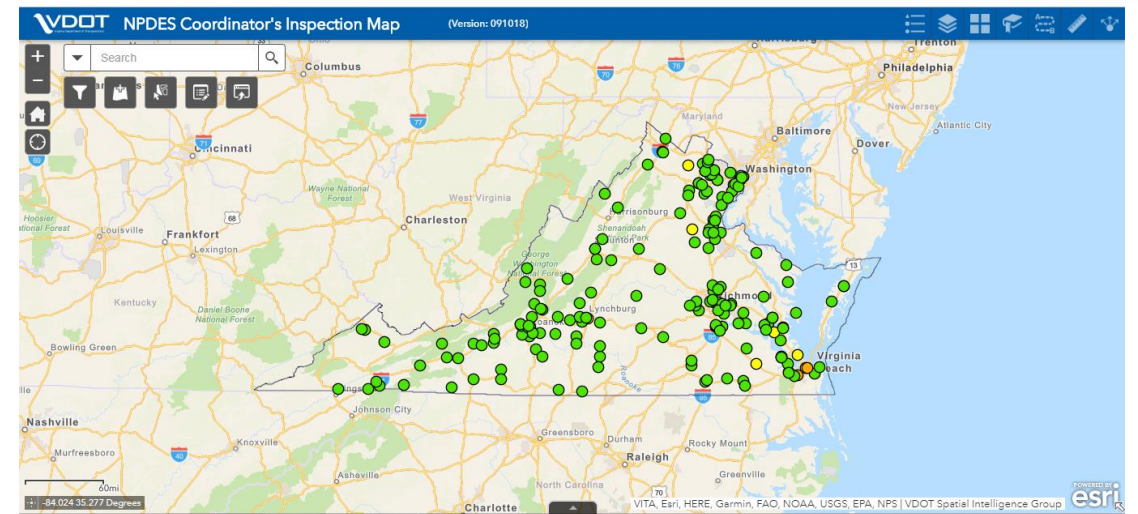
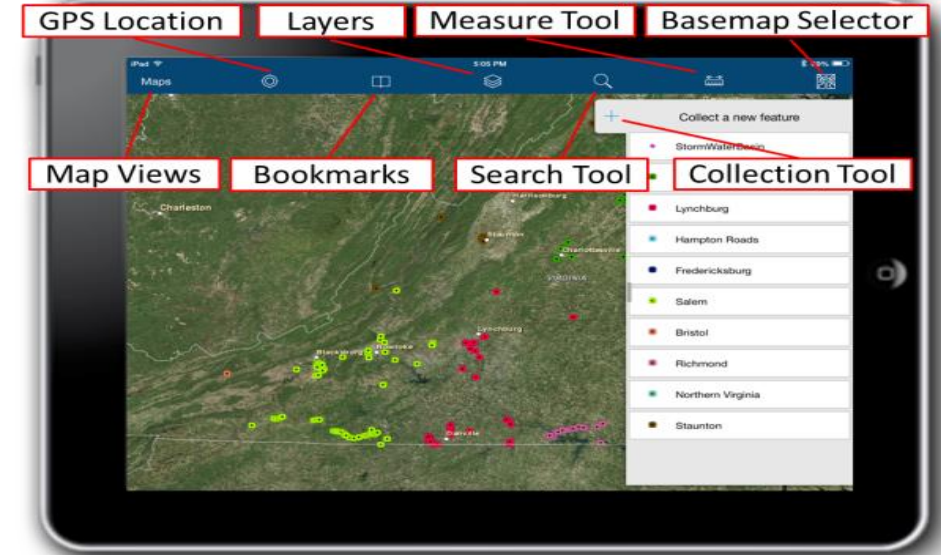
➤ ArcGIS Web AppBuilder

- ✓ Interactive WYSIWYG application to develop user friendly maps and forms
- ✓ User friendly front-end map

➤ Other Products

- Navigator
- Workforce
- Development
- ArcPro

<https://www.esri.com/en-us/arcgis/products/index>



One Solution – Mobile Data Collection and Spatial Orientation

- ✓ **Easy to use COTS software (Collector)**
- ✓ **Data-driven form development (based on database)**
- ✓ **Create and configure maps to fit organization's workflows**
- ✓ **Collect points, lines, polygon features**
- ✓ **Can access information from the desktop or mobile**
- ✓ **Can create dashboards**
- ✓ **Ability to show “real-time” data collection**
- ✓ **Effective integration of different data sources**
- ✓ **Standardize information being collected, reduce paperwork**
- ✓ **Ability to take and store pictures**
- ✓ **Improve efficiency and being proactive**
- ✓ **Meeting Business Requirements (EPA, DEQ, VDOT)**

General Applications of GIS: Integration and Visualization

GIS software is inter-operable allowing the merging of many data designs in the infrastructure development and permitting of projects.

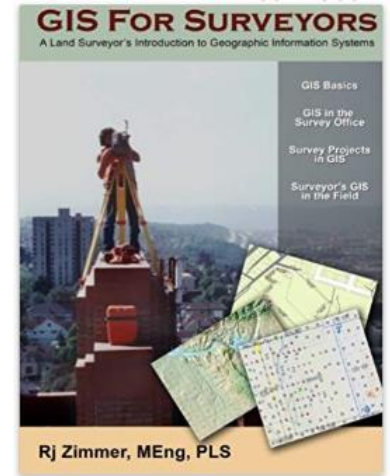
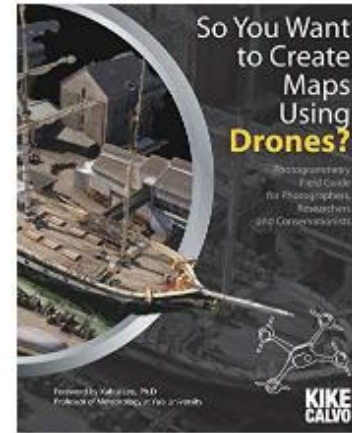
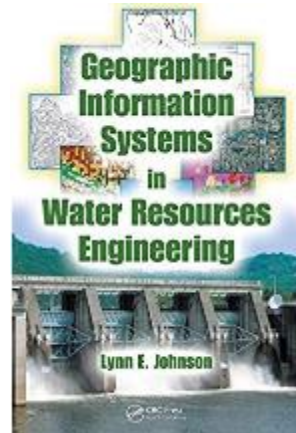
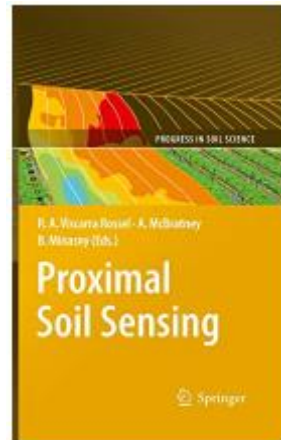
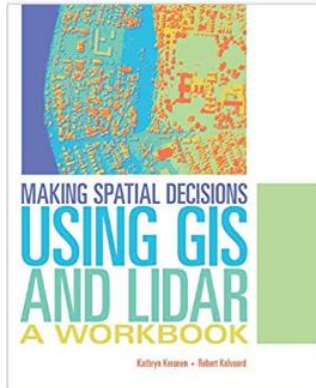
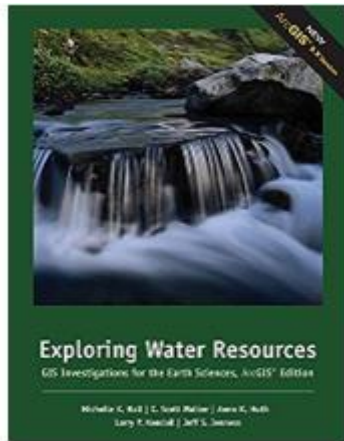
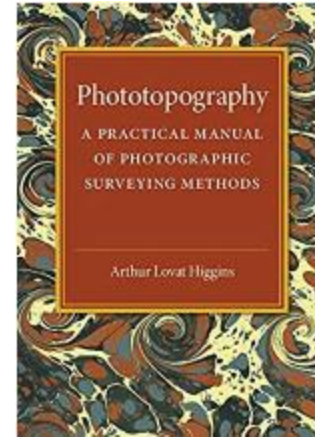
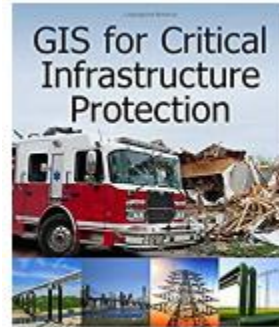
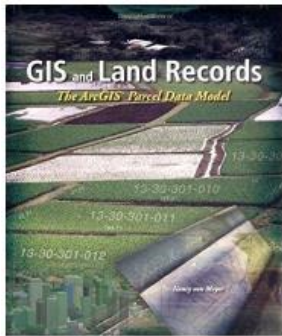
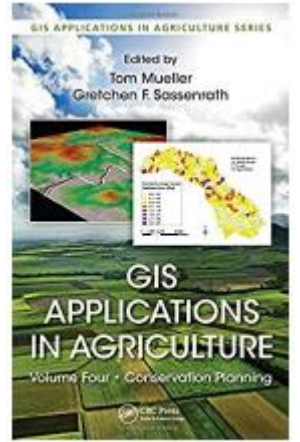
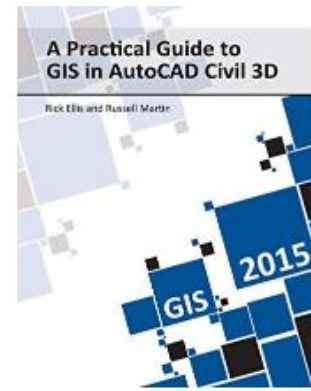
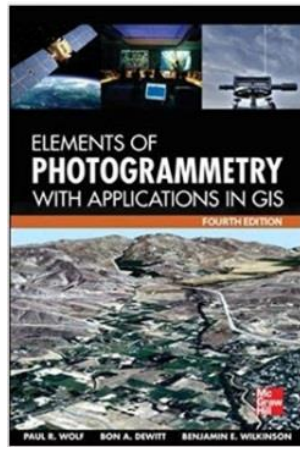
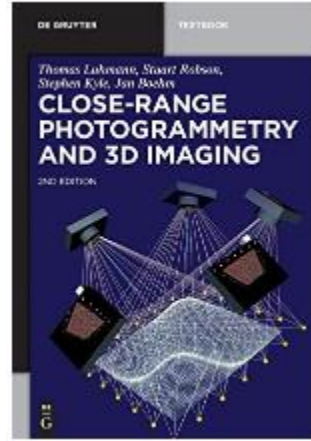
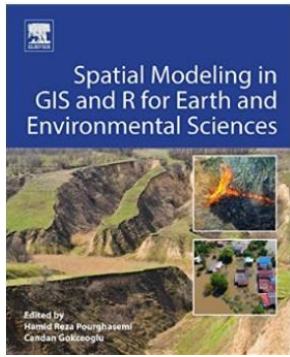
Some of the following is where GIS can be used in various aspects of engineering:

- **Cartography**
- **Database technology**
- **Statistical analysis**
- **Spatial locations**
- **Feasibility**
- **Interpret and combine data**
- **Integrate CAD drawings, satellite images, and parcel maps**
- **Build relationship between data**
- **Validates data, geometric and topologies networks, and control access**

<https://grindgis.com/30-gis-uses-in-civil-engineering/> (9/2/18)
<https://www.quora.com/What-are-GIS-applications-in-civil-engineering> (2/1/18)

What is Geospatial/Geospatial Technology/Geospatial Information

- **Geospatial is used to define the collective data and associated technology** which has a geographic or locational component beneath, on or above the earth's surface
- **Geospatial technology refers to all of the technology used to acquire, manipulate, and store geographic information.**
- **Form of geospatial technology:**
 - **GIS**
 - **GPS**
 - **Remote sensing**
 - **Georeferencing**



Application of GIS in Different Environments

- **Infrastructure Development/Management**
- **Land Fill Site Assortment**
- **Urban Development and Town Planning**
- **Site Analysis**
- **Computerized document**
- **Spatial Analysis/Spatial Data Management**
- **Terrain Mapping and Analysis**
- **Transportation Engineering/Planning**
- **Environmental Engineering/Analysis**
- **Providing Construction Requirements**
- **Data collection of As-Built Surveying**
- **CAD integration**
- **Land Analysis**
- **Model Application**
- **Construction Engineering/Management**
- **Regional Planning**
- **Surveying**
- **Project Management**
- **Structural Engineering**
- **Geotechnical Engineering**
- **Earthquake Engineering**
- **Remote Sensing**
- **Water Resources**
- **Soil and Foundation**
- **Wastewater, Stormwater and Solid Waste Management**
- **Landslides**
- **Disaster Management**

<https://grindgis.com/30-gis-uses-in-civil-engineering/> (9/2/18)
<https://www.gcwengineering.com/civil-engineering-fields-service/> (2/10/16)
<https://www.quora.com/What-are-GIS-applications-in-civil-engineering> (2/1/18)

Civil Engineering

Civil engineers design, build, and maintain the foundation for our modern society – our roads and bridges, drinking water and energy systems, sea ports and airports, and the infrastructure for a cleaner environment, to name just a few

**Transportation
Coastal Engineering
Structural
Environmental
Geotechnical
Construction
Architectural
Engineering Mechanics
And more**

https://www.asce.org/about_civil_engineering/

Infrastructure Life Cycle of Civil Engineering

GIS plays a vital role and serves as a complete platform for every phase of the Civil Engineering Life Cycle

- Planning
- Data Collection
- Analysis (Environmental)
- Design
- Construction
- Data Collection As-Built Surveying
- Operations/Modeling



<https://www.esri.com/engineering> GIS Solutions for Civil Engineering – Modern Platform for Civil IT (2008)
<https://cesnitsblog.wordpress.com/2012/10/28/gis-and-its=-application-in-civil-engineering/>

GIS and Civil Engineering

GIS gives your entire team access to the most current information supporting better decision making.

GIS enhances workflows in

- Project management
- Analysis and design
- Logistics

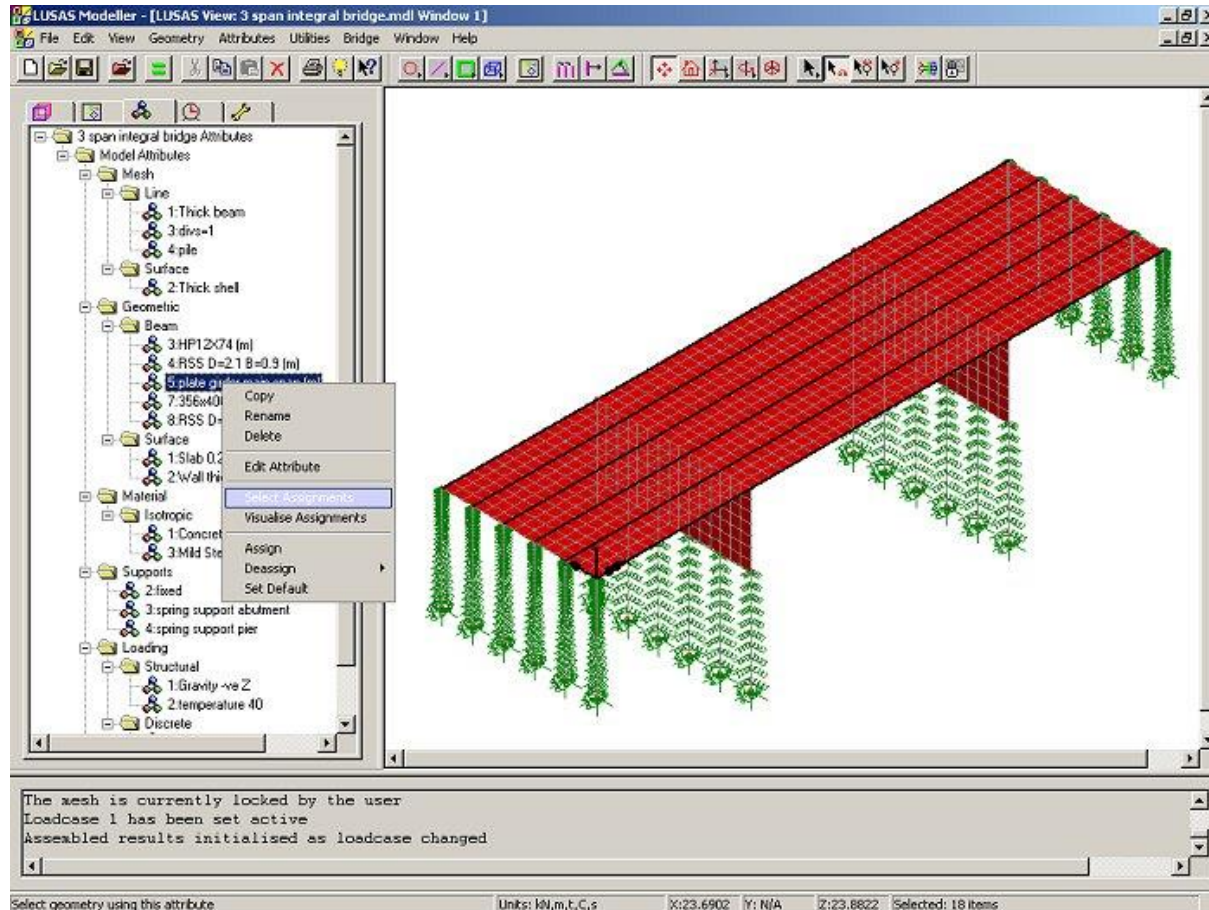
GIS provides

- Data accuracy
- Data sharing
- Analysis capability
- Modeling



<https://www.esri.com/engineering> GIS Solutions for Civil Engineering – Modern Platform for Civil IT (2008)

GIS and Civil Engineering

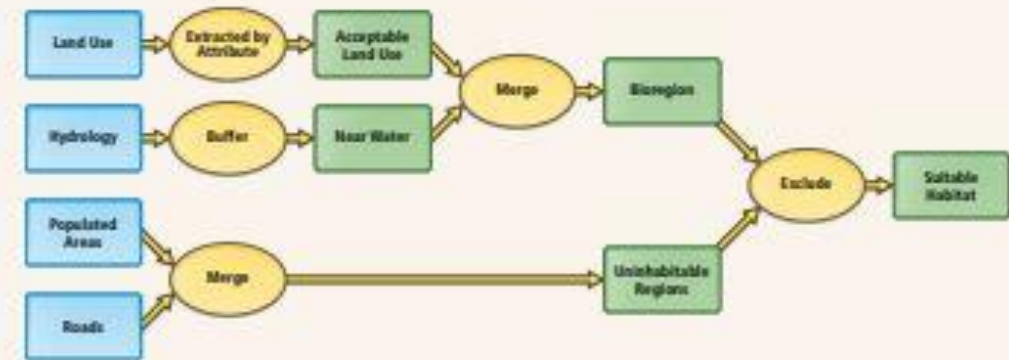


Modeling and Analysis

Geoprocessing is the framework for modeling and analysis. Some of the common modeling applications include

- Composite overlay models for assessing suitability, sensitivity, capacity, and risk
- Evaluation models for comparing alternatives
- Growth models for assessing future conditions
- Statistical models for assessing trends and generating predictive surfaces

The geoprocessing framework can also be used for integrating external models, sharing models with others, documenting a spatially dependent decision process, and developing interactive decision support systems.



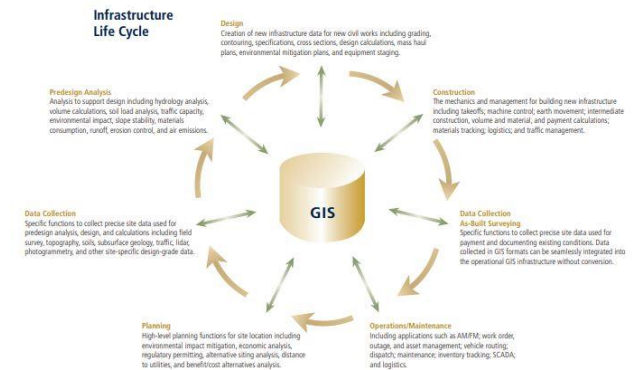
Create new data by combining existing data.

GIS and Surveying

Surveying is a vital part of infrastructure development, from building roads and communication systems to establishing transportation networks and pipelines.

A centralized information system based on ESRI GIS software provides the framework for:

- **maintaining and deploying critical data**
- **applications across every aspect of the infrastructure project including data collection, planning, construction, and operations management.**



<https://www.esri.com/library/brochures/pdfs/gis-sols-for-surveying.pdf>

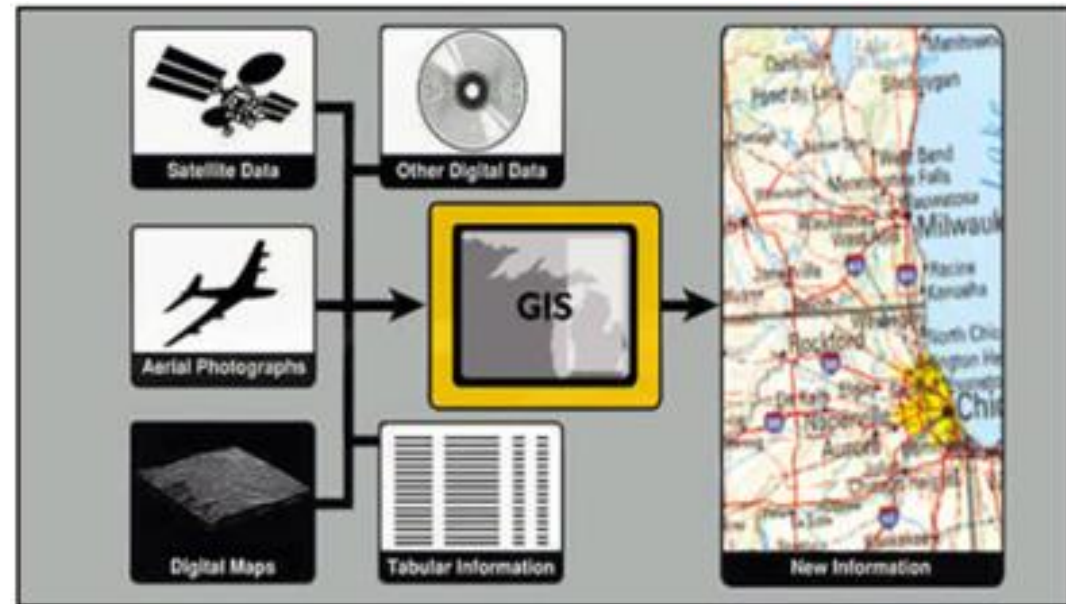
GIS in Surveying

GIS and Surveying complement each other

- Survey data contributes to the GIS dataset
- Data sets built on measurements of location provided by survey and geodetic measurements
- Can use LiDAR, Imagery, laser scanning, mobile mapping

Uses in Survey

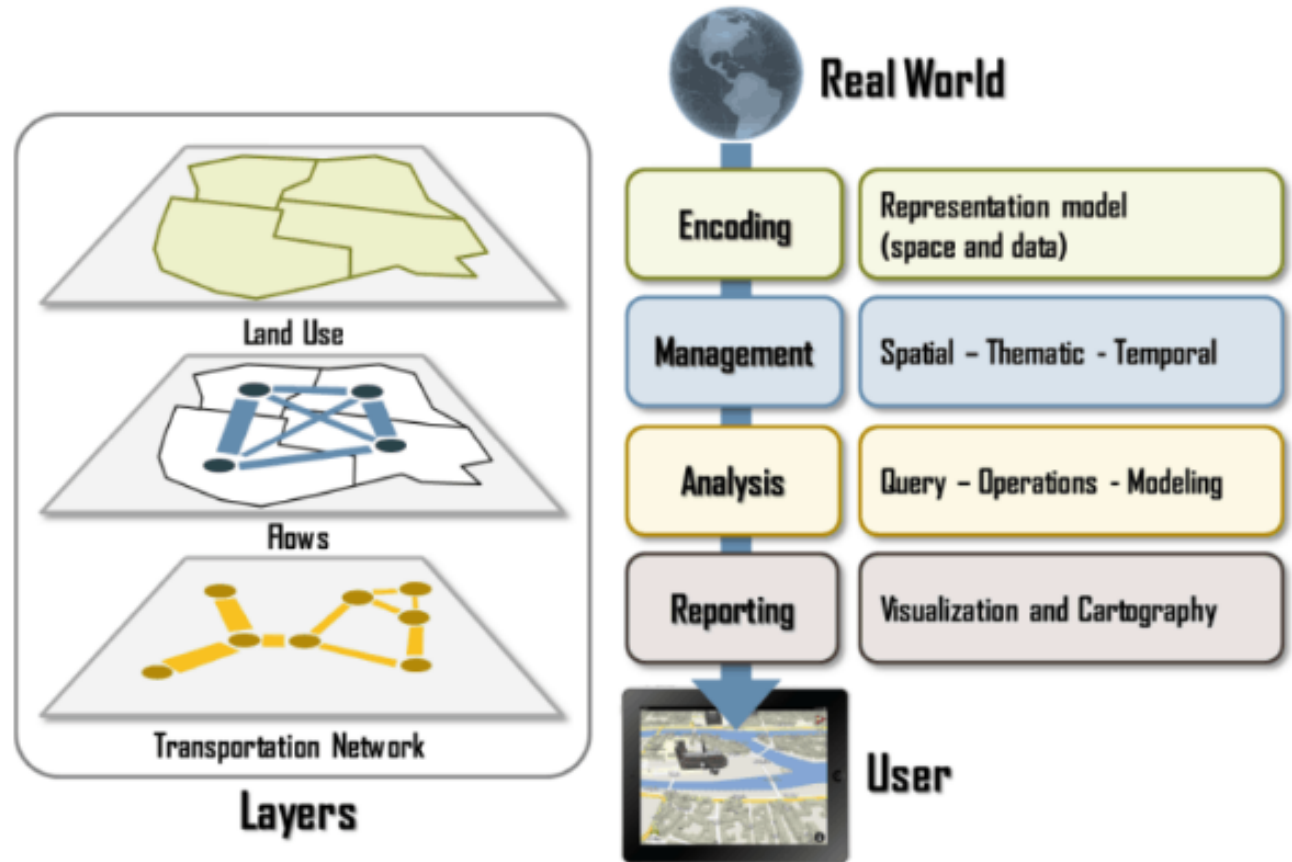
- Project Planning
- Data Collection
- Design/Predesign Analysis
- Construction
- As-Built Surveys
- Land Development
- Survey Data Management
- Facility Management



<https://info.courthousedirect.com/blog/how-gis-tools-are-changing-the-practice-of-land-surveying>

GIS and Transportation

Also known as GIS-T



Geographic Information Systems and Transportation

GIS in Transportation

Most important objective in GIS is Visualization through maps

Major areas of applications include:

- Highway maintenance
- Traffic modeling
- Accident analysis
- Route planning
- Work order management system



<https://www.geospatialworld.net/blogs/gis-in-transportation/> (5/30/18)

GIS and Transportation

Four Major Components

- **Encoding** – representation of a transport system and spatial components
- **Management** – database storage and organization
- **Analysis** – wide array of methodologies and tools
- **Reporting** – visualization and data reporting

Summary: GIS IS

Database centric - handles data in a single seamless spatial database

Form centric for field collection (Survey123)

Offers full complement of geographic functional elements

- **Data input**
- **Storage**
- **Management**
- **Retrieval**
- **Manipulation**
- **Analysis and modeling**
- **Output**
- **Display**



<https://cseengineermag.com/article/a-gis-perspective/>

Benefits of Using GIS

- **Better Decisions**
- **Access to data that impacts plan locations and designs**
- **Data required by Environmental Impact Statements and Biological Assessments**
- **Provides a central storage space for data for basis of project feasibility**
 - **Historical**
 - **Documents**
 - **Maps**

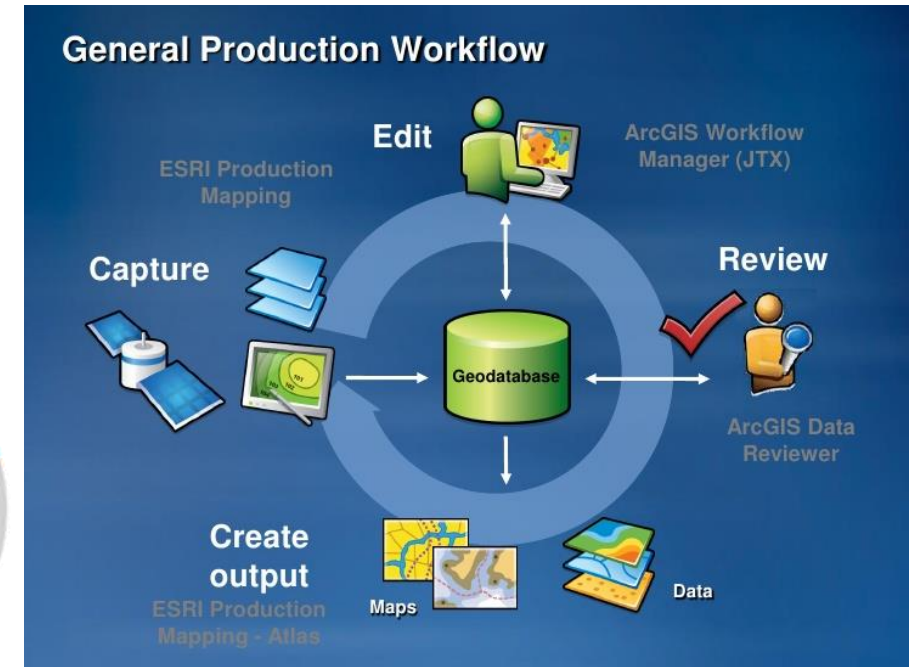
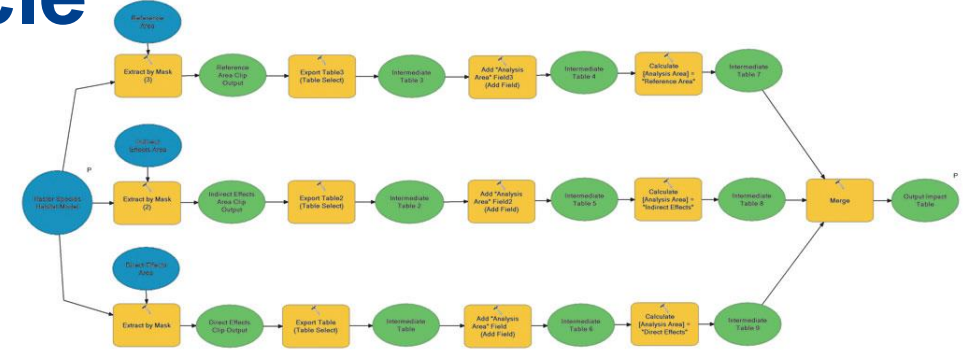
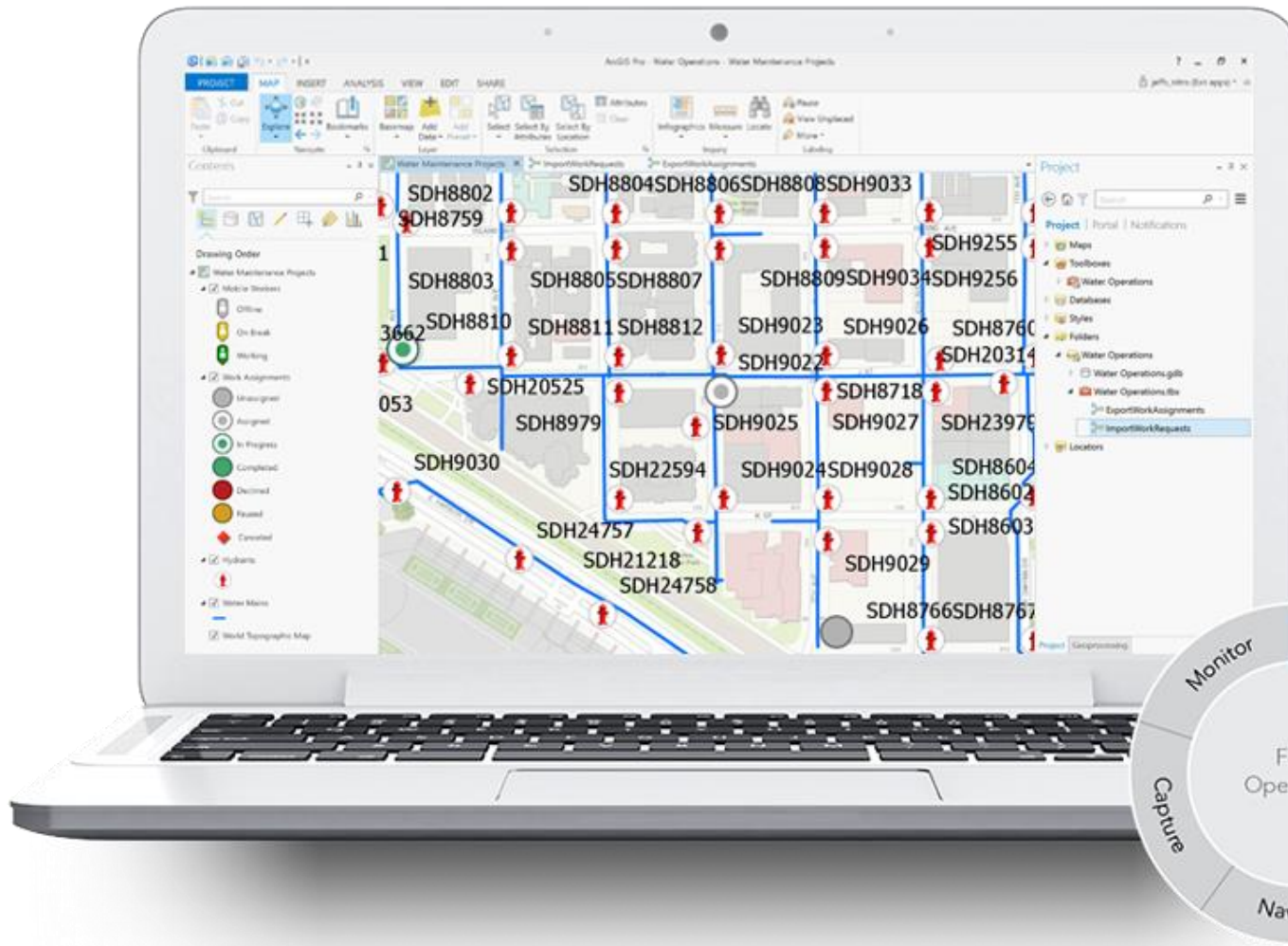
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<http://www.landpoint.net/overlooked-benefits-of-gis-and-land-surveying/>

Benefits of Using GIS

- **Reliable Records Retention**
- **Stores as-builts, updated base maps, current data**
- **Improves land management**
- **Good tool for spatial information**
- **Add value to surveying, planning, construction, and management, commercial, industrial, and oil/gas construction projects**

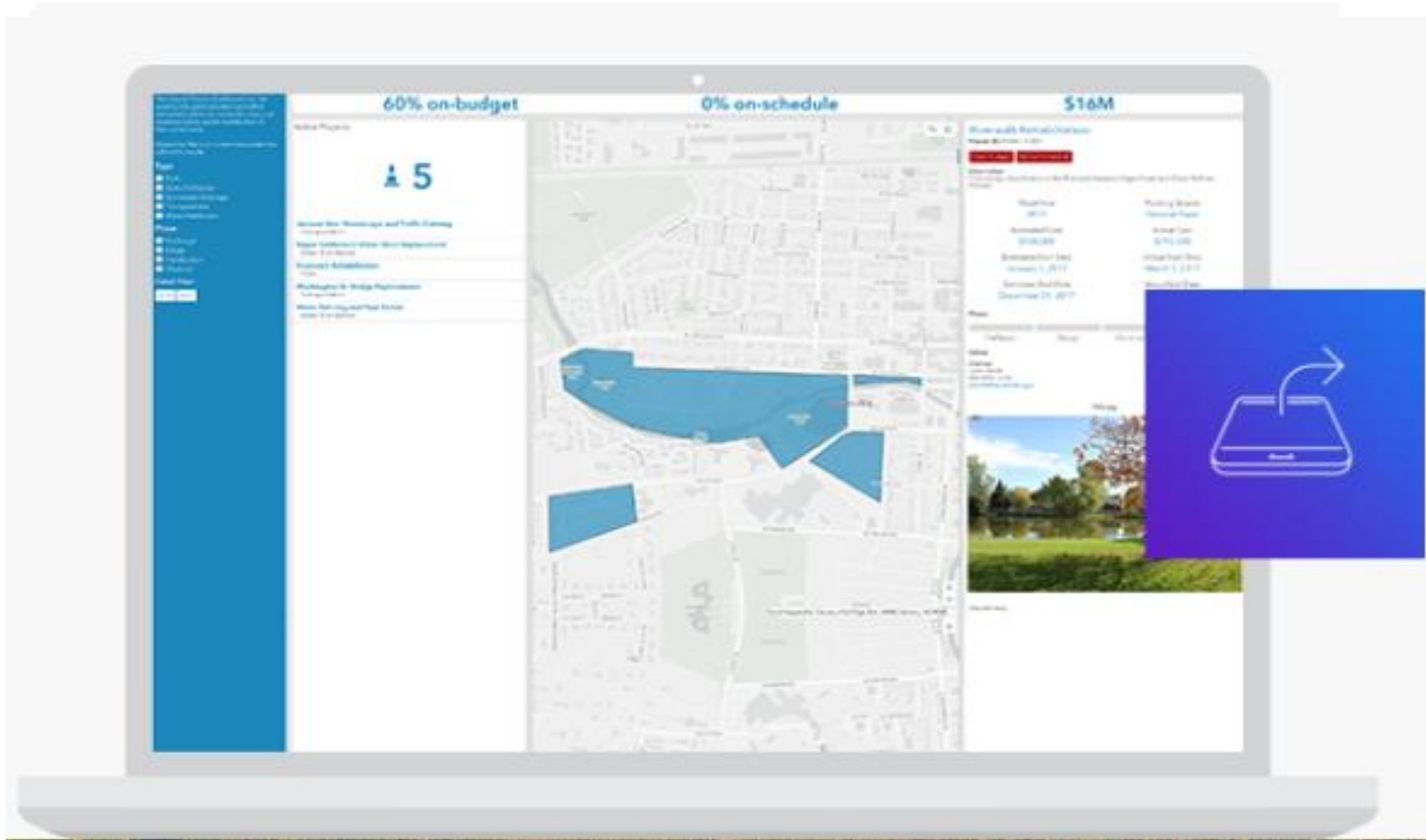
<https://info.courthousedirect.com/blog/how-gis-tools-are-changing-the-practice-of-land-surveying>
<http://www.landpoint.net/overlooked-benefits-of-gis-and-land-surveying/>

Five Stages of Repeatable Life Cycle



<https://www.esri.com/en-us/arcgis/products/field-operations/overview>

Five Stages of Repeatable Life Cycle



- Plan
- Understand
- Capture
- Monitor
- Share

<https://www.esri.com/en-us/arcgis/products/field-operations/overview>

GIS at VDOT – Location and Design



http://proceedings.esri.com/library/userconf/proc18/tech-workshops/tw_1861-267.pdf

MS4 program and associated projects

The screenshot displays the VDOT website interface. At the top left is the VDOT logo with the text "Virginia Department of Transportation". To the right, a navigation bar includes links for "About", "Jobs", "Contact", "Maps", "511", and "SMART SCALE Dashboard". Below this, a dark blue bar features a "REPORT A ROAD PROBLEM" button with a person icon and a "800-FOR-ROAD (800-367-7623)" button with a phone icon. A breadcrumb trail reads "Home > Business > Location and Design". An orange navigation bar contains links for "Travel Center", "Newsroom", "Info Center", "Business Center", "Programs", and "Projects & Studies". A large image of a car in a tunnel is shown, with a search box on the right that says "Search this site" and a magnifying glass icon. On the left side, there are two sections: "Traffic Information" with a "511" logo and text stating "511 offers real-time traffic info. Anytime you need it, anywhere you are." and "SMART SCALE Dashboard" with a bar chart and the text "Funding the right transportation projects." On the right side, the "Location and Design Division" section is highlighted in orange, followed by a list of links: "L&D Home", "Business Administration", "CADD Support", "Hydraulics and Utilities", "MS-4/Stormwater Management", "Project Management Office", "Roadway Design and Special Projects", "Standards, Special Design, Policy and Quality Assurance", "GeoSpatial Program", and "Traffic Design". Below the links, a paragraph describes the Statewide Location and Design Team's responsibilities, and another paragraph describes the expertise of the highway engineering professionals.

Location and Design Program Areas

Program Areas

The Central Office Location and Design Division consists of nine different Program Areas. These Program Areas are responsible for the development, implementation and training of policies, procedures, technical guidance as well as design and project management.

Select one of the links below to learn more about our expert team of professionals working in each Program Area and to see additional information you can use.

- [Business Administration](#)
- [CADD Support](#)
- [GeoSpatial Program](#)
- [Hydraulics and Utilities](#)
- [MS-4/Stormwater Management](#)
- [Project Management Office](#)
- [Roadway Design and Special Projects](#)
- [Standards, Special Design, Policy and Quality Assurance](#)
- [Traffic Design](#)

Desktop and Mobile Applications in L&D

- Using Collector as the base map for the inventory on all projects
 - Using Survey123 for all forms
 - Numerous Webmap Application Builder

Projects include:

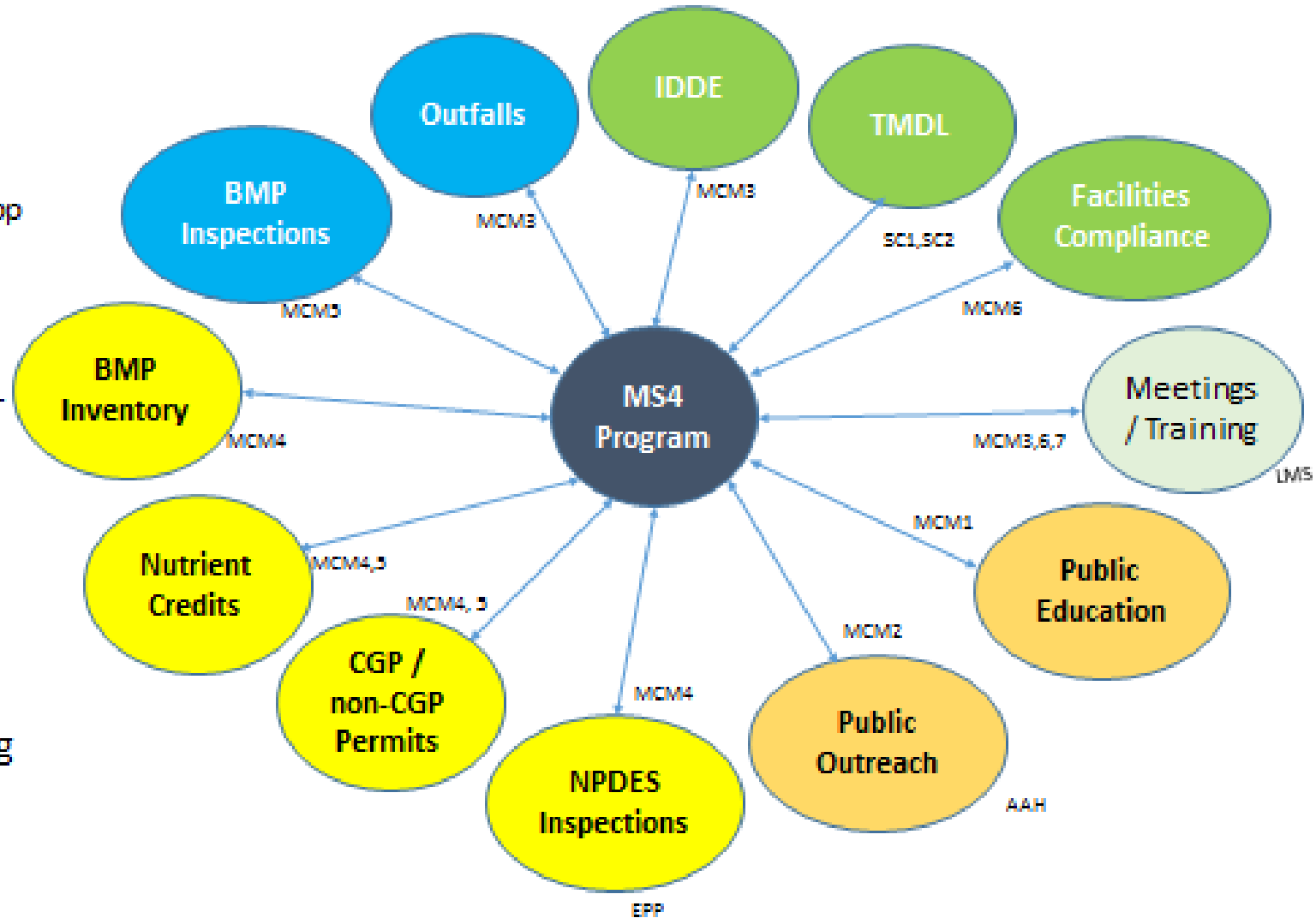
- Outfall Reconnaissance Inventory
- Stormwater Basins Inventory and Inspection
- NPDES Coordinator Inspections
- IDDE Investigations
- Nutrient Credits
- Adopt-A-Highway
- Surveying (Courthouse Reviews, Flown Imagery)
- ROW/Parcel Determination
- Drones



MS4 program and associated projects

LEGEND

- Permit Tracking
- Standalone DB / app
- Environmental (CEDAR)
- Multiple Divisions – Env, L&D, CN, MNT
- Public-Facing



MS4 Permit Tracking
Context Diagram

MS4 General Permit (WQ)

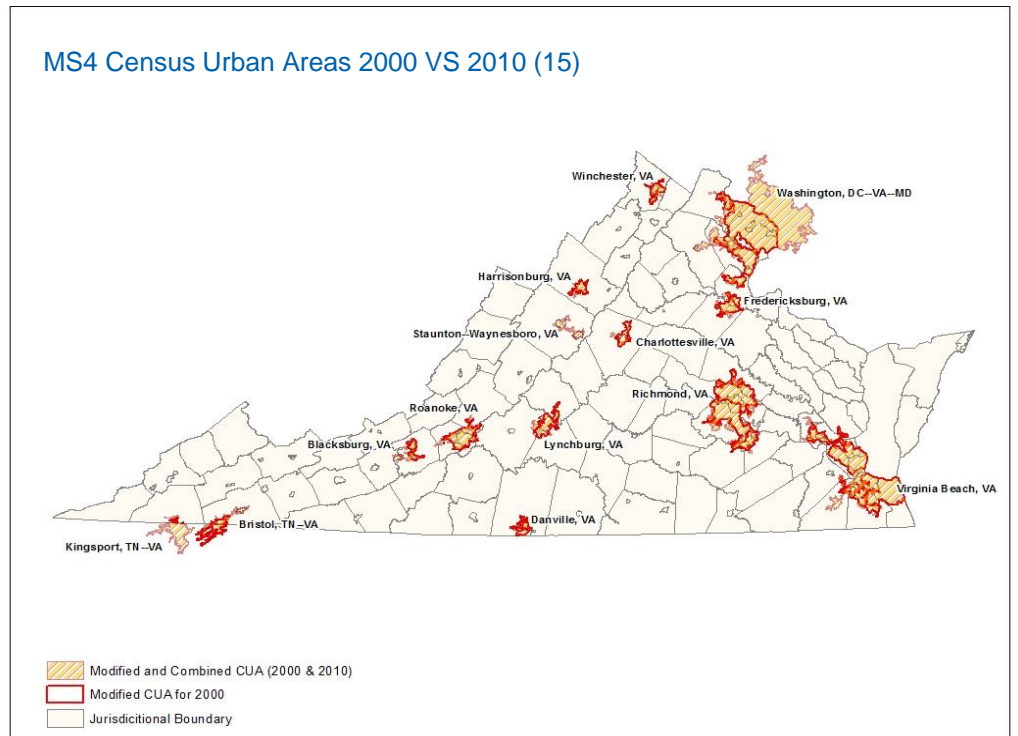
- **Location and Design has general oversight of the MS4 Program**
- **VDOT Central Office Division are responsible for specific Best Management Practices (BMPs) for the different Minimum Control Measures (MCMs) of which there are six with a special one for TMDLs**
 - ✓ **Minimum Control Measures (MCM)**
 - ✓ **MCM 1 – Public Education & Outreach**
 - ✓ **MCM 2 – Public Involvement/Participation**
 - ✓ **MCM 3 – Illicit Discharge Detection and Elimination**
 - ✓ **MCM 4 – Construction Site Stormwater Runoff Control**
 - ✓ **MCM 5 – Post-Construction Stormwater Management**
 - ✓ **MCM 6 – Pollution Prevention/Good Housekeeping**
 - ✓ **MCM 7 – Locality and TMDLs**

Lead Division	Associated BMPs
Construction	4(C)1, 6(D)3
Environmental	2(B)1, 3(C)2, 3(D)2, 6(A)2, 6(B), 6(D)1, 7(A), 7(B)
Learning Center	6(D)4
Location & Design	2(B)2, 3(B), 4(A), 4(B), 4(C)2, 5(A), 5(B)
Maintenance	1(A)2, 2(B)3, 3(A), 3(C)1, 3(D)1, 5(C), 6(A)1, 6(C), 6(D)2, 6(E)
Communications	1(A)1, 2(A), 2(B)4, 2(C)
Traffic Engineering	1(A)4
Transportation Planning	1(A)3, 3(C)3

Each District is generally responsible for program implementation within the specific urbanized areas

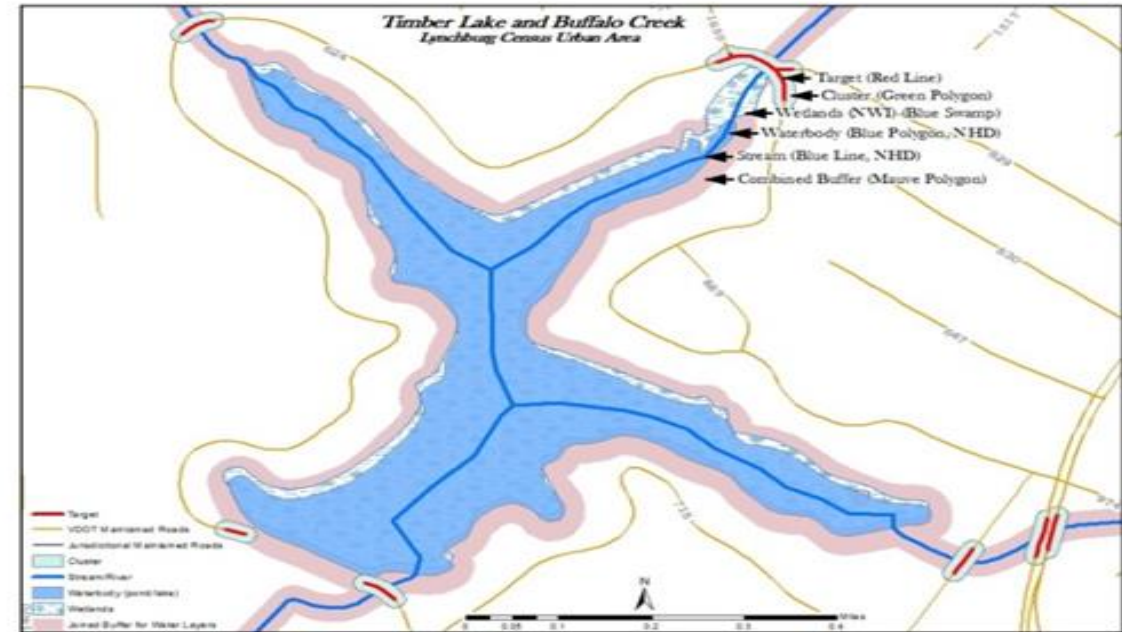
VDOT's MS4 Mobile Program Overview

- Responsible for mapping target outfall locations in Census Urban Areas
 - 15 Census Urban Areas located in Virginia (2010)
 - ~21,000 centerline miles of roadway
- Stormwater discharged from a pipe, ditch or drop inlet



VDOT's MS4 Program Background (cont.)

- Steps to achieve the outfall information
 - Office data collection and research through the Target Selection Model
 - Field data collection
 - Database population
 - Maintaining and updating outfall information
 - Generating a bi-weekly IDDE report



MS4 Stormwater Basin Management (+2400) (MCM5)

The screenshot displays the VDOT Stormwater Basin App interface. At the top, the VDOT logo and 'Stormwater Basin App' are visible, along with the version number 'Version:10/09/2018'. The main area is a satellite map of a stormwater basin, overlaid with a network of grey lines representing stormwater infrastructure. Numerous colored circular markers (blue, red, green, yellow, orange, black) are scattered across the map, representing different types of Best Management Practices (BMPs). A search bar and several navigation icons (home, refresh, zoom in, zoom out, pan, print) are located in the top-left corner. A popup window is open over one of the markers, displaying the following information:

(1 of 4)

BMP_Inventory: 02028

SWMID: 02028
General BMP Type: Infiltration
Specific Type:
UPC Number: 95113
Status: Existing

[Open Inspection Form](#)
[Open Maintenance Form](#)

Attachments:
No attachments found

Edited by achpman@jmttg.com on 7/25/18
at 4:45 PM

Related tables:
Components

[Zoom to](#)

Survey123 form for Stormwater Basin Management (MCM5)

BMP Inspection

VDOT
Virginia Department of Transportation

BMP ID & Type

SWMID *
02028

General BMP Type
Infiltration

Specific BMP Type
Water Quality Swale%2FBioswale - IICOther
Miscellaneous Type

BMP Function

Inspector Name *
Michelle.Fults@vdot.virginia.gov_VDOT

Inspection Type *

Inspection Date *
Monday, March 18, 2019

Next inspection date
Tuesday, March 17, 2020

BMP Inspection

SWMID *

BMP GlobalID *

General BMP Type *
Basin

- Basin
- Filtration
- Infiltration
- Manufactured (Filtering)
- Manufactured (Hydrodynamic)

Inspector Name *

Inspection Date *
7/17/2017 12:37 PM

Next inspection date
7/17/2018 12:37 PM

Inspection Type *

- Annual Inspection
- Semiannual Inspection
- Weather-related Inspection

BMP Overview Photo

Add BMP to Inventory

SWMID *

Alternate ID
Ex. Name from plan sheets, municipality ID, etc.

Background Data

Location Information

Geometry *

37.867°N 75.509°W

Latitude
37.86669

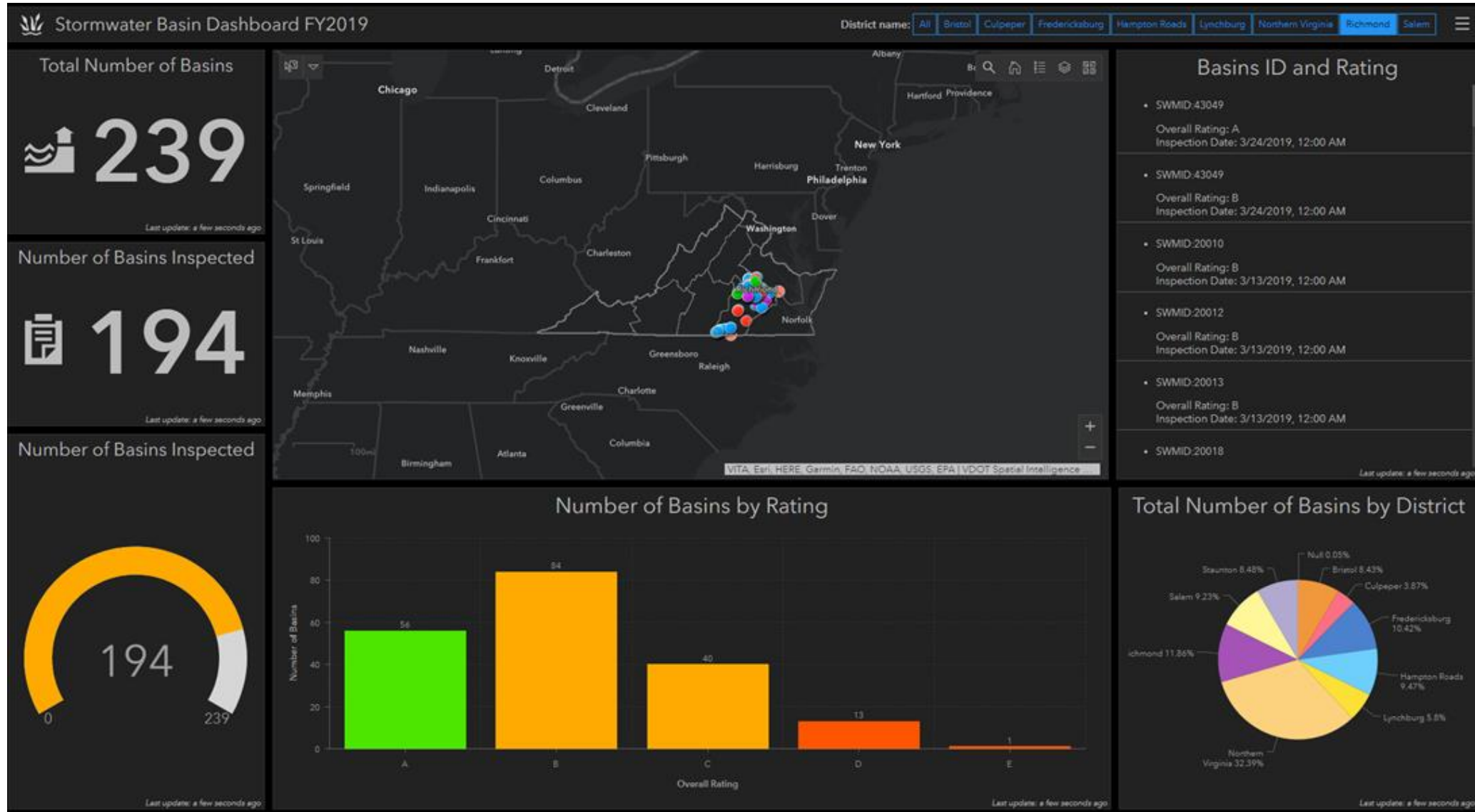
Longitude
-75.50947

District *

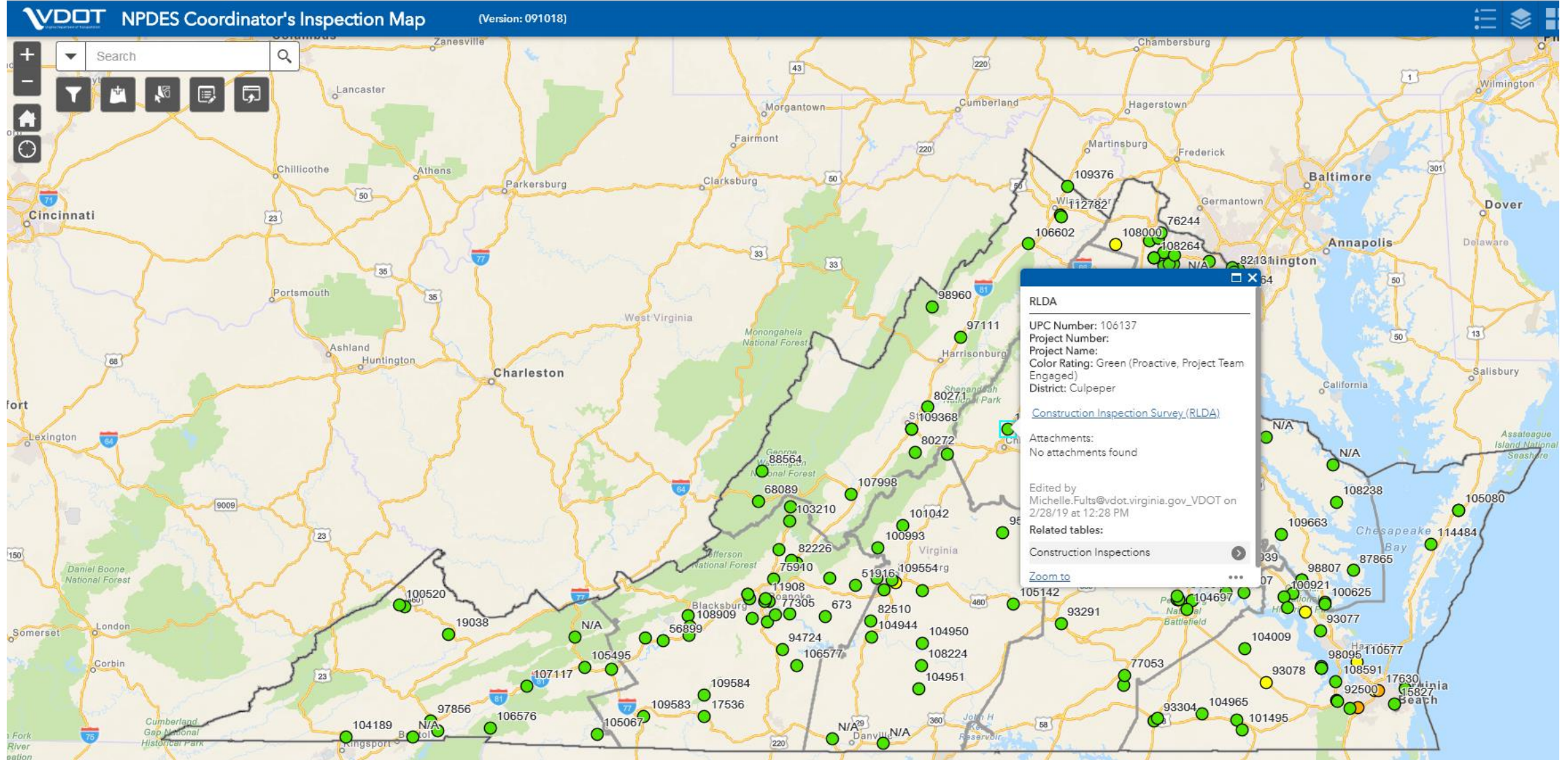
- Bristol
- Culpeper
- Fredericksburg
- Hampton Roads
- Lynchburg

Jurisdiction *

Dashboard for Stormwater Basin Management (MCM5)



MS4 NPDES Coordinator's Inspection (<200) (MCM4)



MS4 Construction Inspection Reports (NPDES)

Survey123 for ArcGIS

Construction Inspection Survey (RLDA)

VDOT
Virginia Department of Transportation

Construction Runoff Control Inspection

Choose a form.

- NPDES Coordinator's Inspection Form 1
- NPDES Coordinator's Inspection Form 2
- NPDES Coordinator's Inspection Form 3

NPDES DETAILED INSPECTION SHEET - PART I

- ▶ Project Information
- ▶ Inspection Information
- ▶ ESC Inspection Questions
- ▶ Pollution Prevention (P2) Inspection Questions
- ▶ SWPPP Update and Modification Questions
- ▶ Color Rating

Survey123 for ArcGIS

Construction Inspection Survey (RLDA)

VDOT
Virginia Department of Transportation

Construction Runoff Control Inspection

Choose a form.

- NPDES Coordinator's Inspection Form 1
- NPDES Coordinator's Inspection Form 2
- NPDES Coordinator's Inspection Form 3

NPDES SHORT INSPECTION SHEET - PART II

- ▶ Project Information
- ▶ Inspection Information
- ▶ Inspection Questions
- ▶ Color Rating

Survey123 for ArcGIS

Construction Inspection Survey (RLDA)

VDOT
Virginia Department of Transportation

Construction Runoff Control Inspection

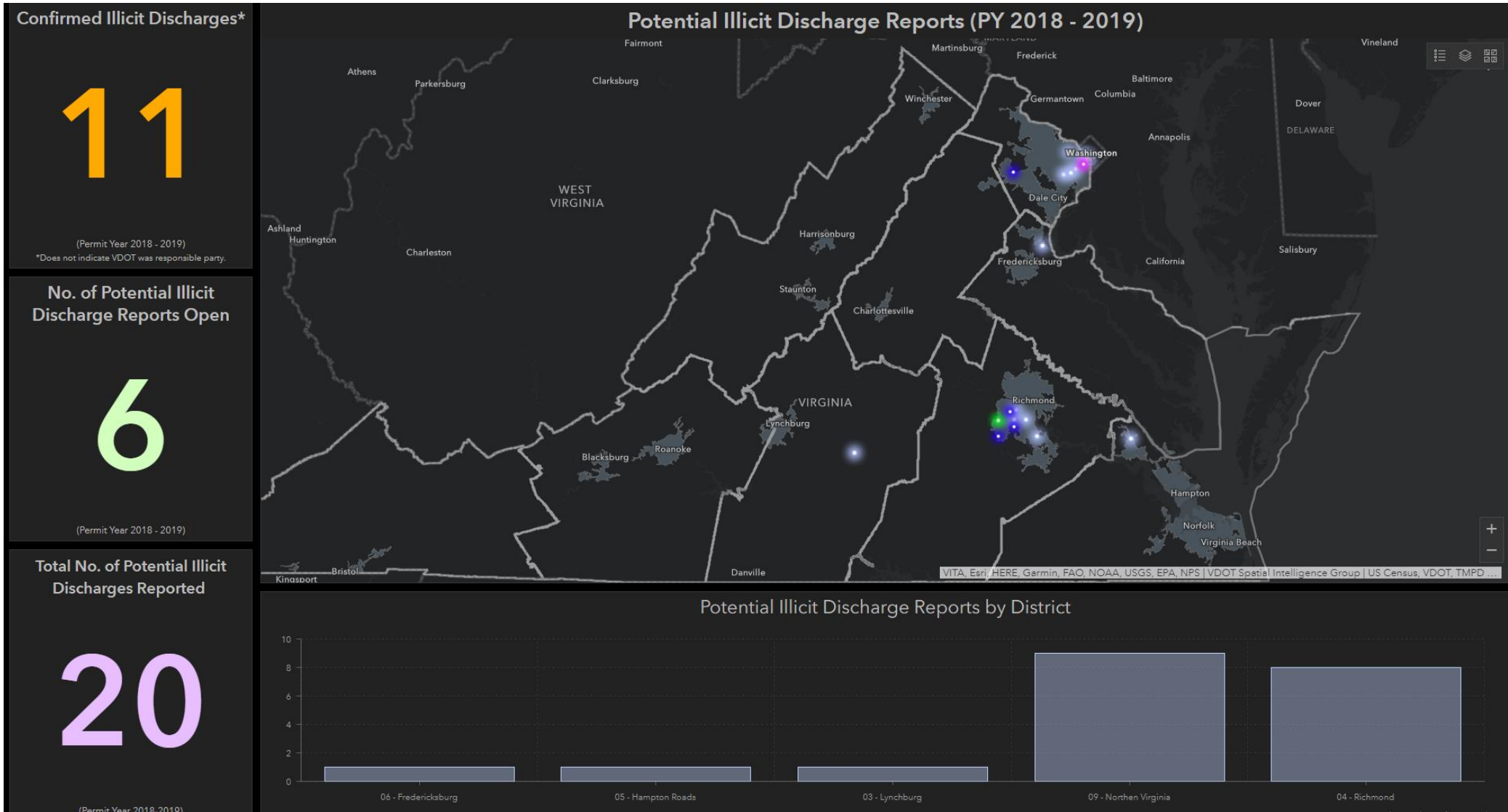
Choose a form.

- NPDES Coordinator's Inspection Form 1
- NPDES Coordinator's Inspection Form 2
- NPDES Coordinator's Inspection Form 3

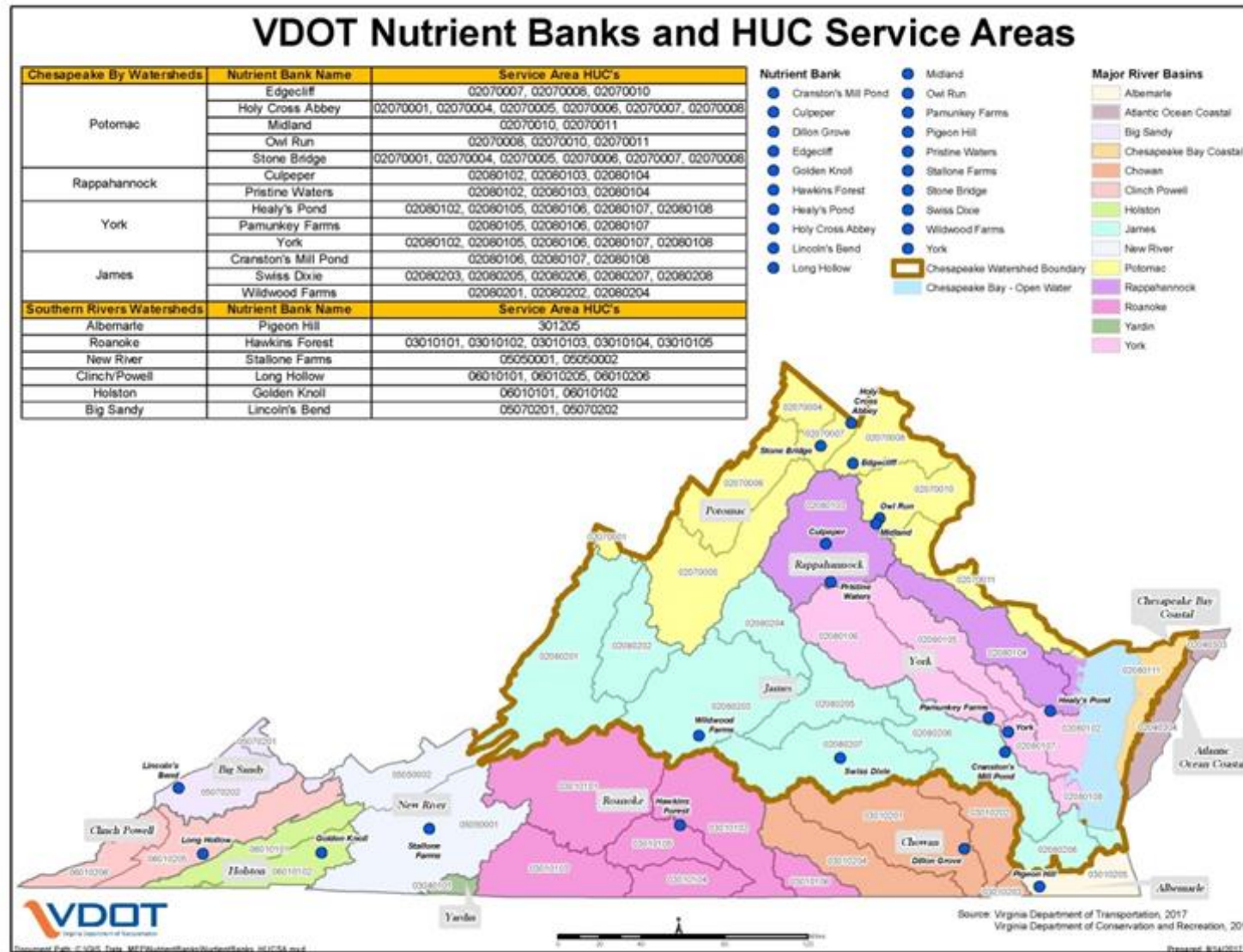
NPDES COORDINATOR'S GENERAL INSPECTION SHEET

- ▶ Project Information
- ▶ Inspection Information
- ▶ Attendee Information
- ▶ Enter up to 50 Observations and Recommendations
- ▶ Observations & Recommendations 1
- ▶ Color Rating

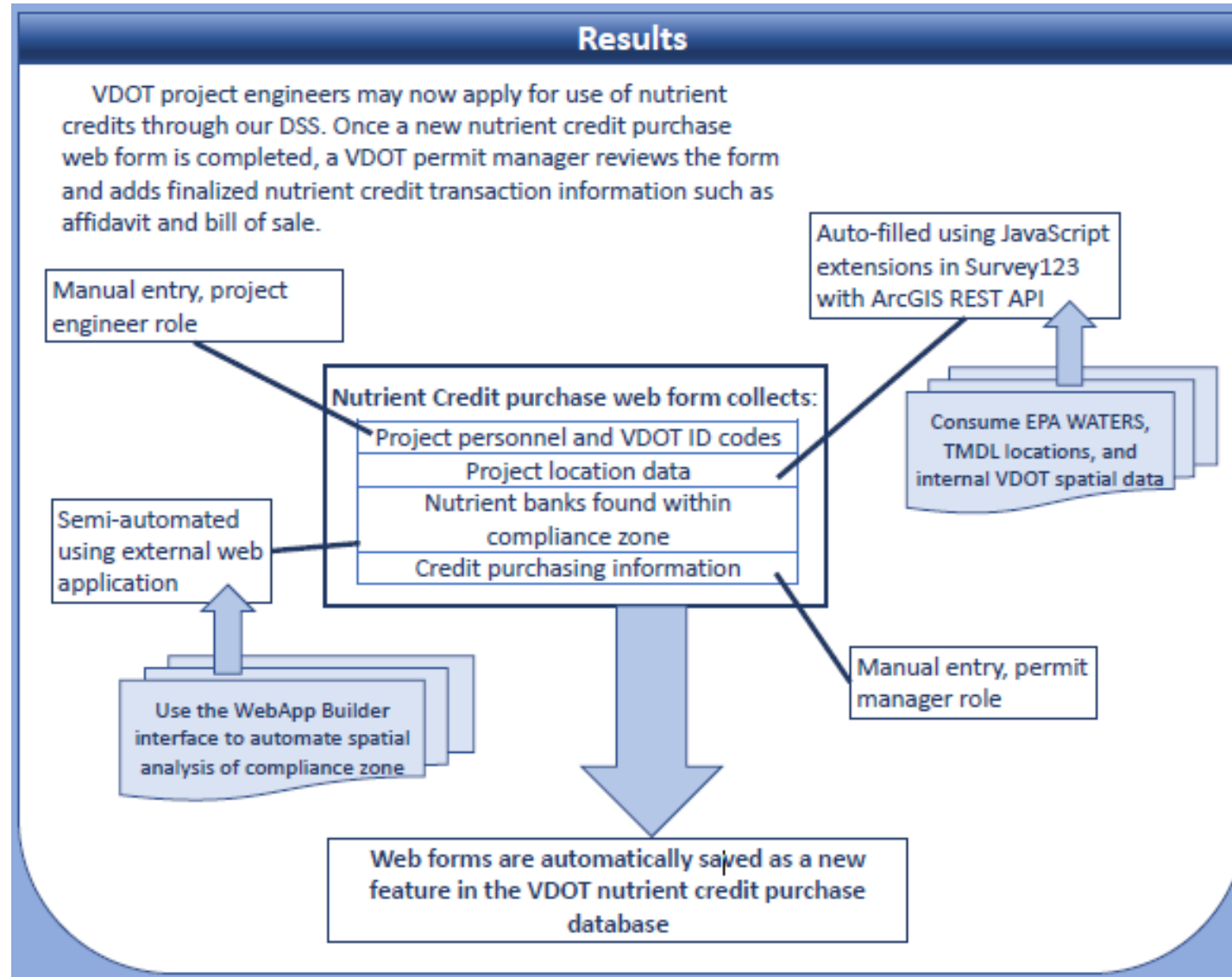
MS4: Illicit Discharge Elimination System (MCM3)



MS4: Nutrient Credits (MCM5)



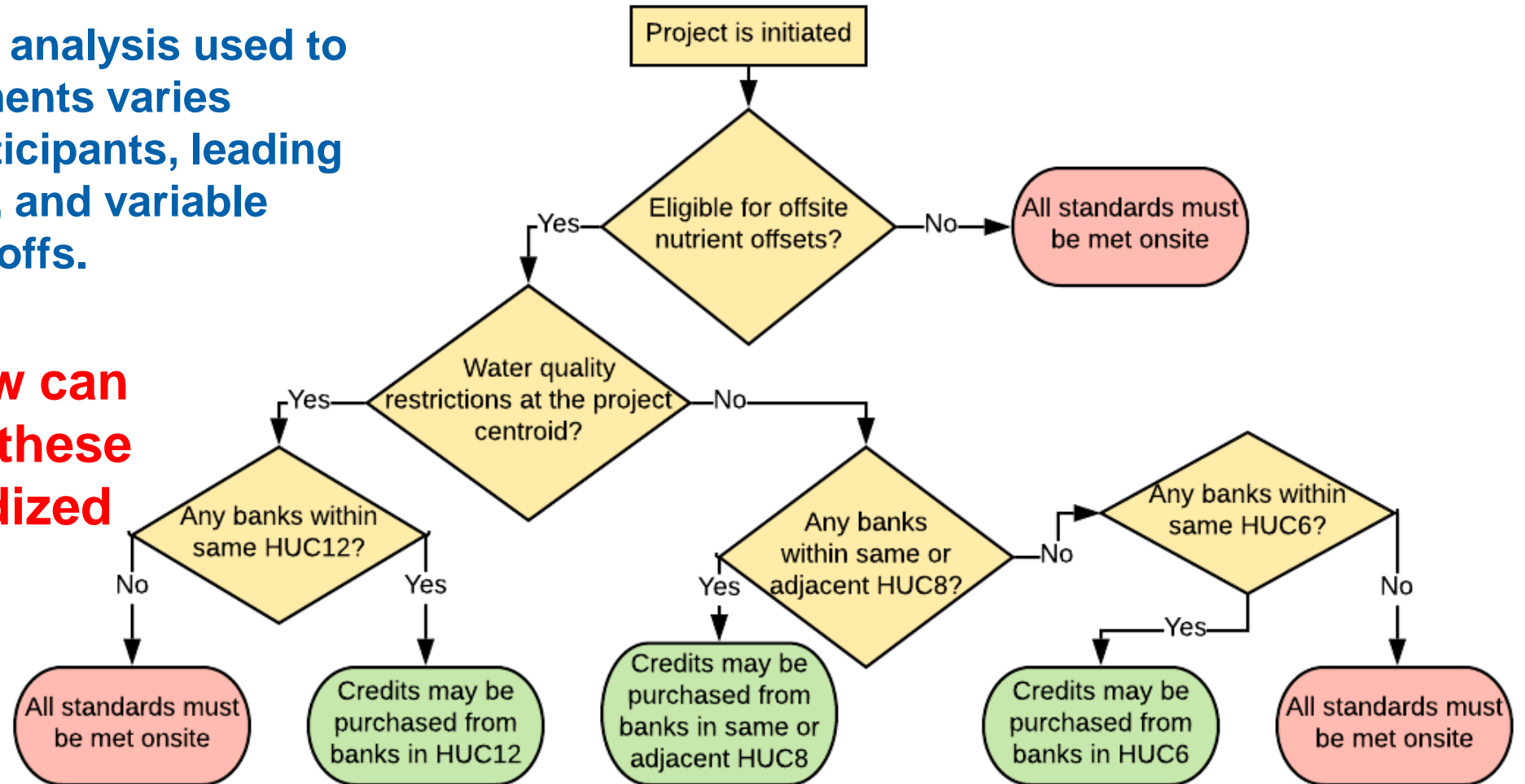
MS4: Nutrient Credits (MCM5)



Nutrient Credits (MCM5): Overview of relevant trading rules and restrictions

The spatial data and analysis used to meet these requirements varies between market participants, leading to confusion, errors, and variable environmental tradeoffs.

The problem: how can compliance with these rules be standardized and enforced?



UVA Work

Two-Step repeatable process for nutrient credit purchase compliance:

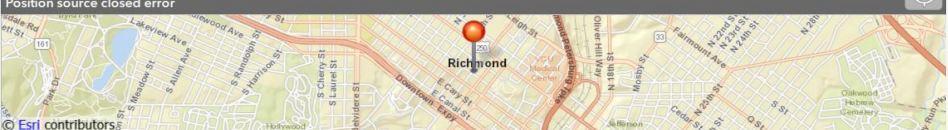
1. Complete partially automated webform
2. Use web app to complete pre-evaluation using standard procedure

Example webform:

Location information

Select project centroid location: *

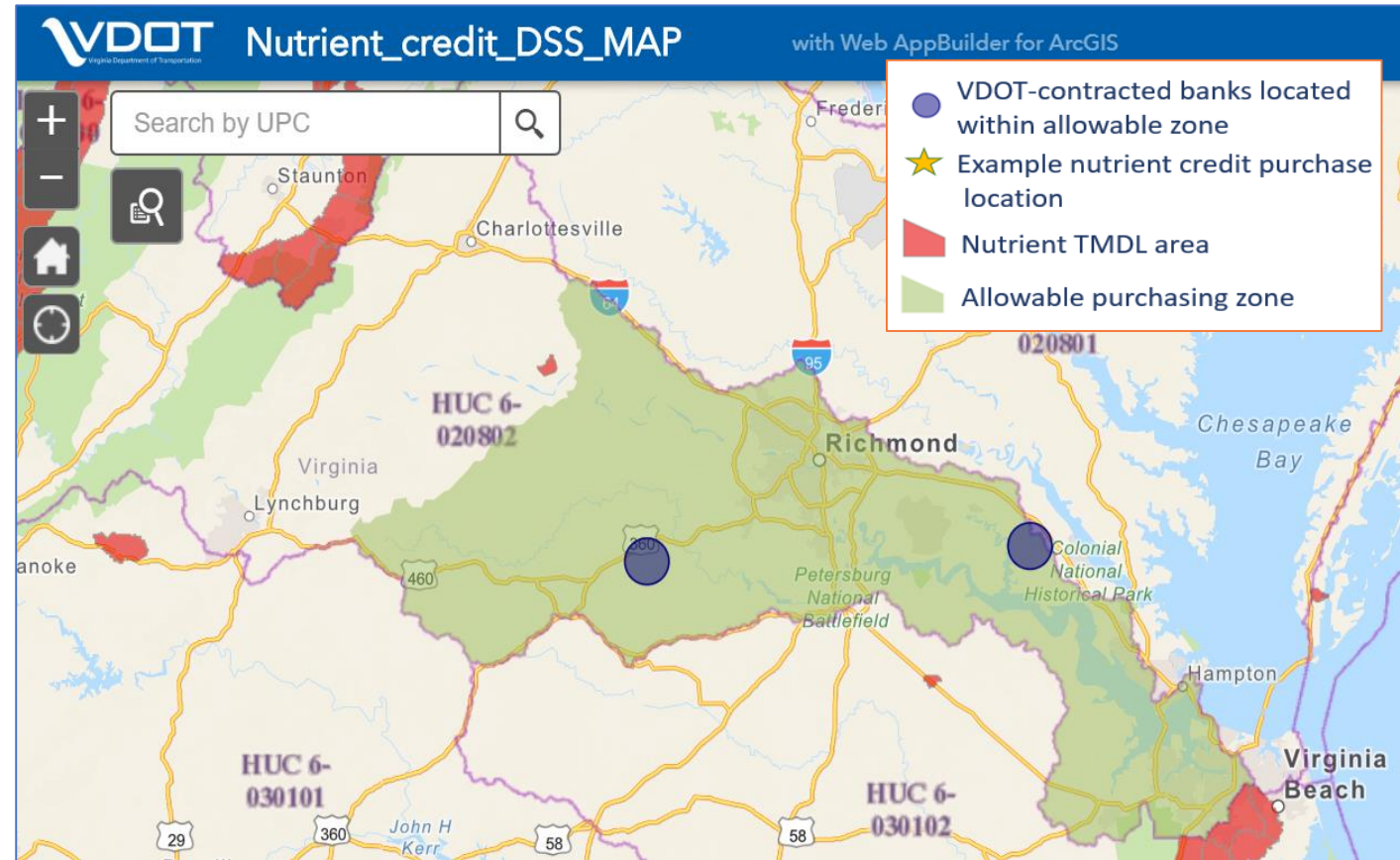
37°32'N 77°26'W
Position source closed error



HUC8
02080205

HUC12
020802050607

Example use of the web application to find banks:



Other GIS Software – FREE: Open Source

QGIS

ILWIS

gVSIG

GeoDa

Whitebox GAT

uDig

SAGA GIS

OpenJump

GRASS GIS

Diva GIS

MapWindow

OrbisGIS

<https://gisgeography.com/free-gis-software/>

MS4 Desktop Demonstration (If time allows)



BMP



NPDES





Thank You!

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