Building a Stormwater Digital Twin for Kane County

Rob Linke, P.E., CFM
Kane County Dept of Environmental & Water Resources

Have we built a digital twin of the stormwater drainage system for Kane County?

Sort of…

Digital Twins in Architectural & Construction Industry

Digital Twins in Water Resources Industry

Digital Twins in Stormwater?

Five Components of a Stormwater Digital Twin[1]

- Geospatial representation of the system
  - Streams, channels, culverts, pipes, inlets, detention basins, Green Infrastructure / BMPs, etc.

1 From Colby Manwaring, Innovyze 2023
[The 5 Components of the Digital Twin for Water - Innovyze - World WaterTech North America]

Five Components of a Stormwater Digital Twin

- Direct observation or sensor data about the affecting environment
  - Rain gages, radar rainfall, water level sensors, stream gages, etc.

Five Components of a Stormwater Digital Twin

- Performance Data
  - Previous event information: high water marks, rainfall records, etc.

Five Components of a Stormwater Digital Twin

- Analytics
  - Geoprocessing of GIS datasets (simplified analytics)
  - Physics-based model using Machine Learning / Geospatial AI (complex analytics).

Five Components of a Stormwater Digital Twin

- Digitalization
  - Translating the analytics into useful visualizations of the results <u>that will lead to action</u>

Building a Stormwater Digital Twin for Kane County

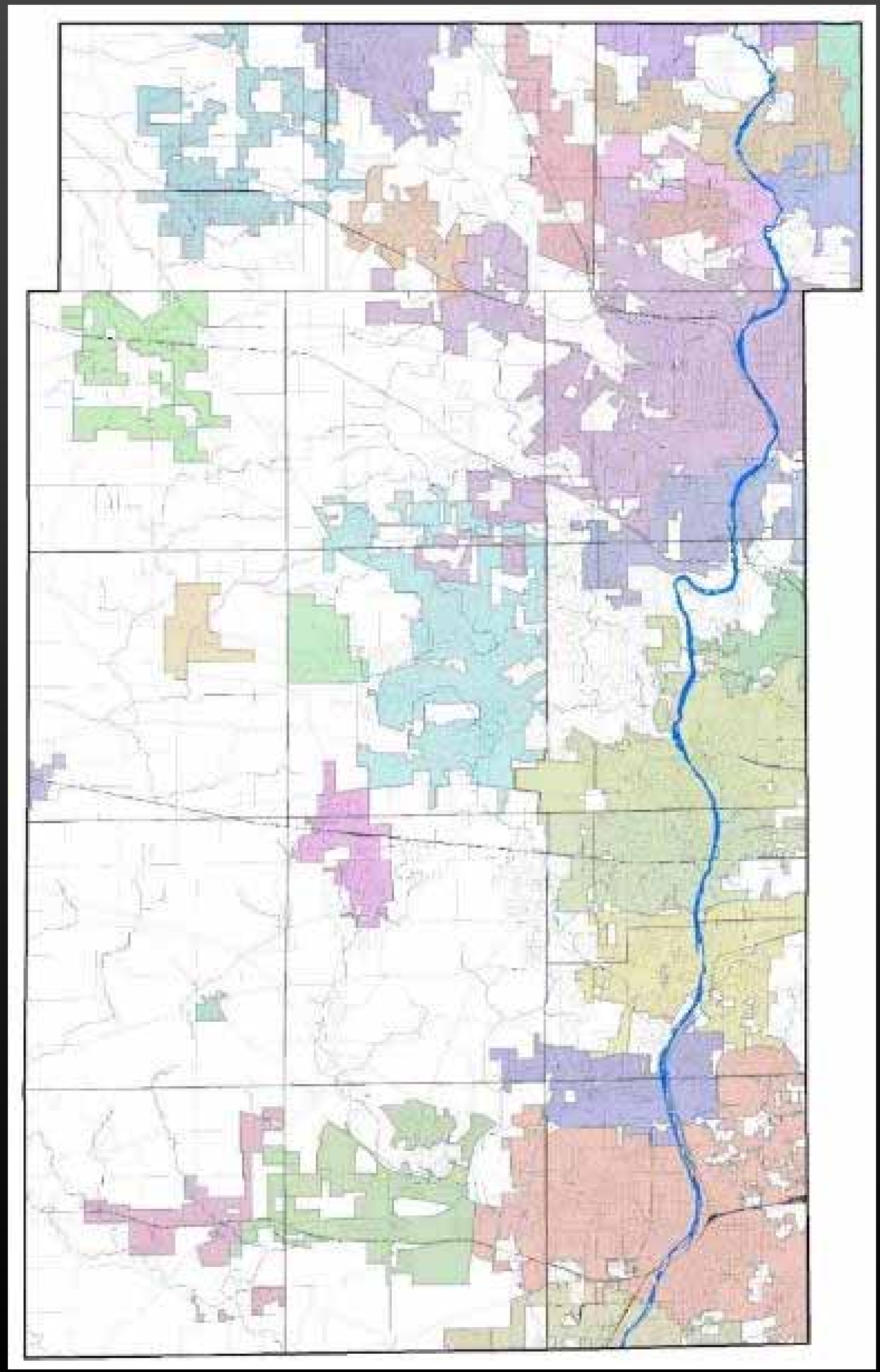
Why is the County taking the lead in this effort?

Kane County Area: 524 mi^2

Unincorporated Areas: 312 mi^2

Municipalities: 212 mi^2

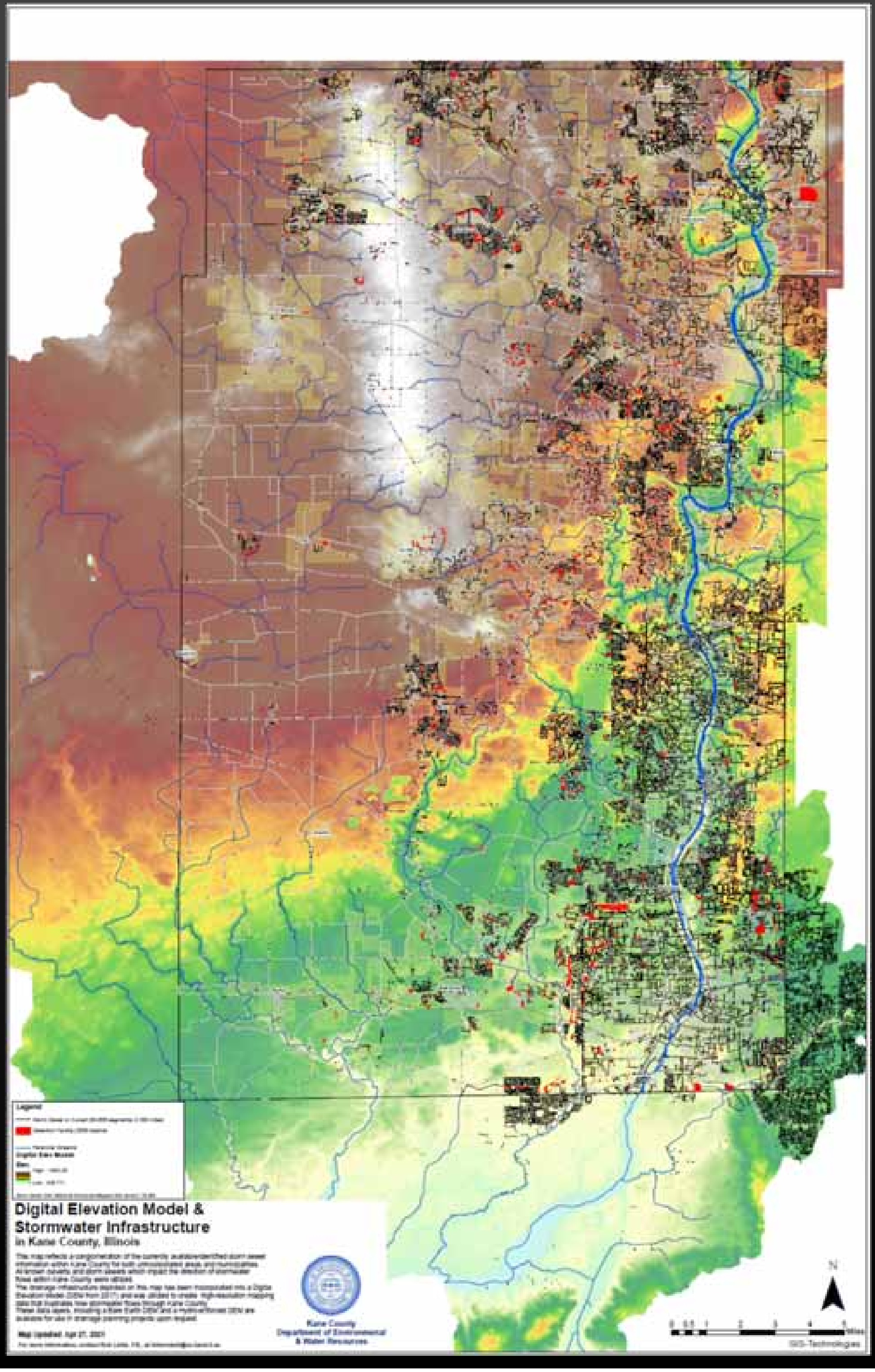
<u>645 miles of shared boundary between the municipalities and unincorporated Kane County</u>



Building a Stormwater Digital Twin for Kane County

Our Goal:

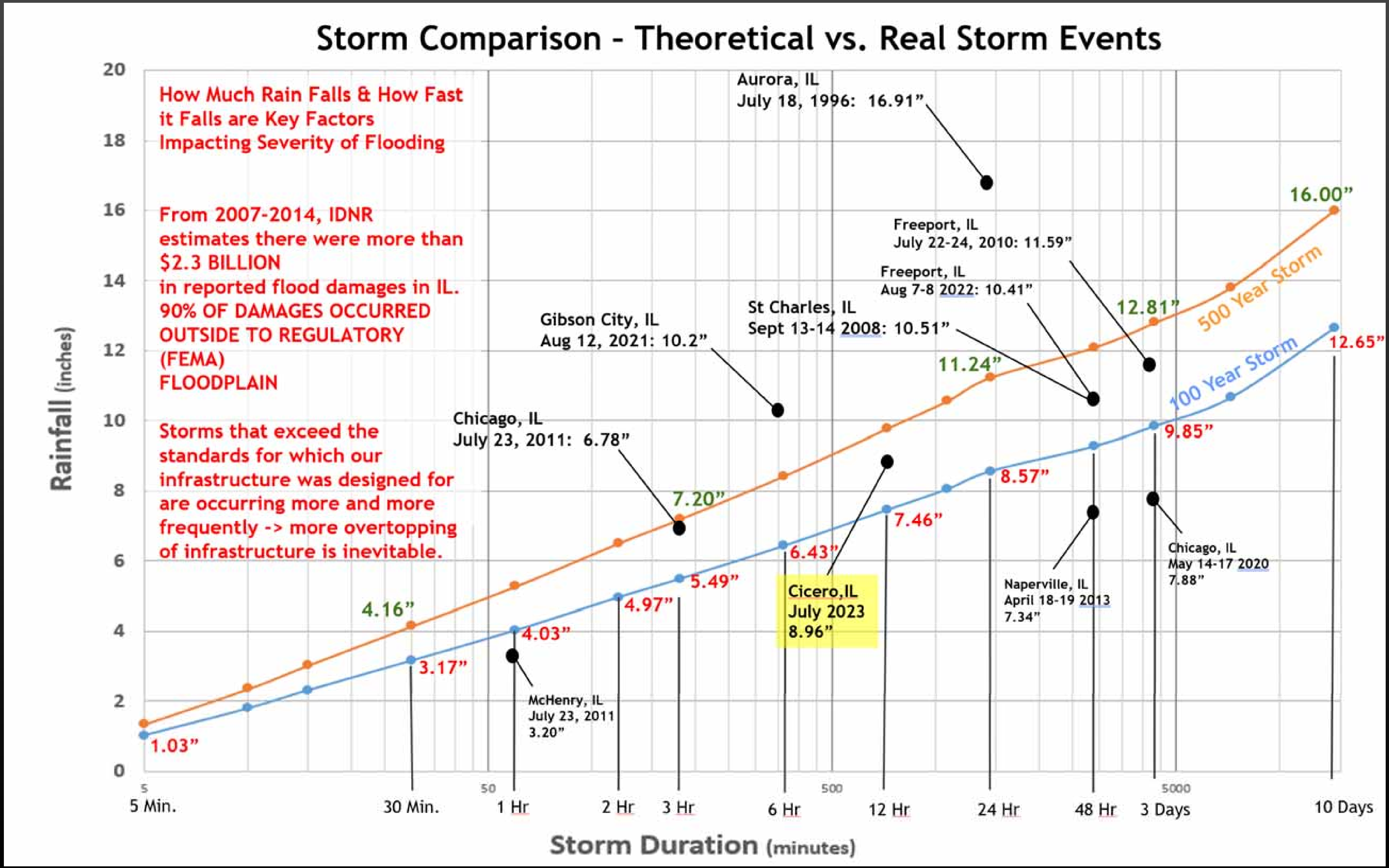
- Provide comprehensive, stormwater infrastructure information that traces stormwater's origin & flow path, irrespective of political boundaries.
- Facilitate discussion and improve collaboration between local government agencies to address drainage problems & environmental resource issues from a watershed perspective.
- Create a tools that allows users to accurately answer fundamental questions.
    - Short-Term
    1. How much area drains to the point of concern?
    2. Where does the water flow to and exactly what flow path does it take to get there?
    - Long-term
    3. How much, how deep & how fast is the water

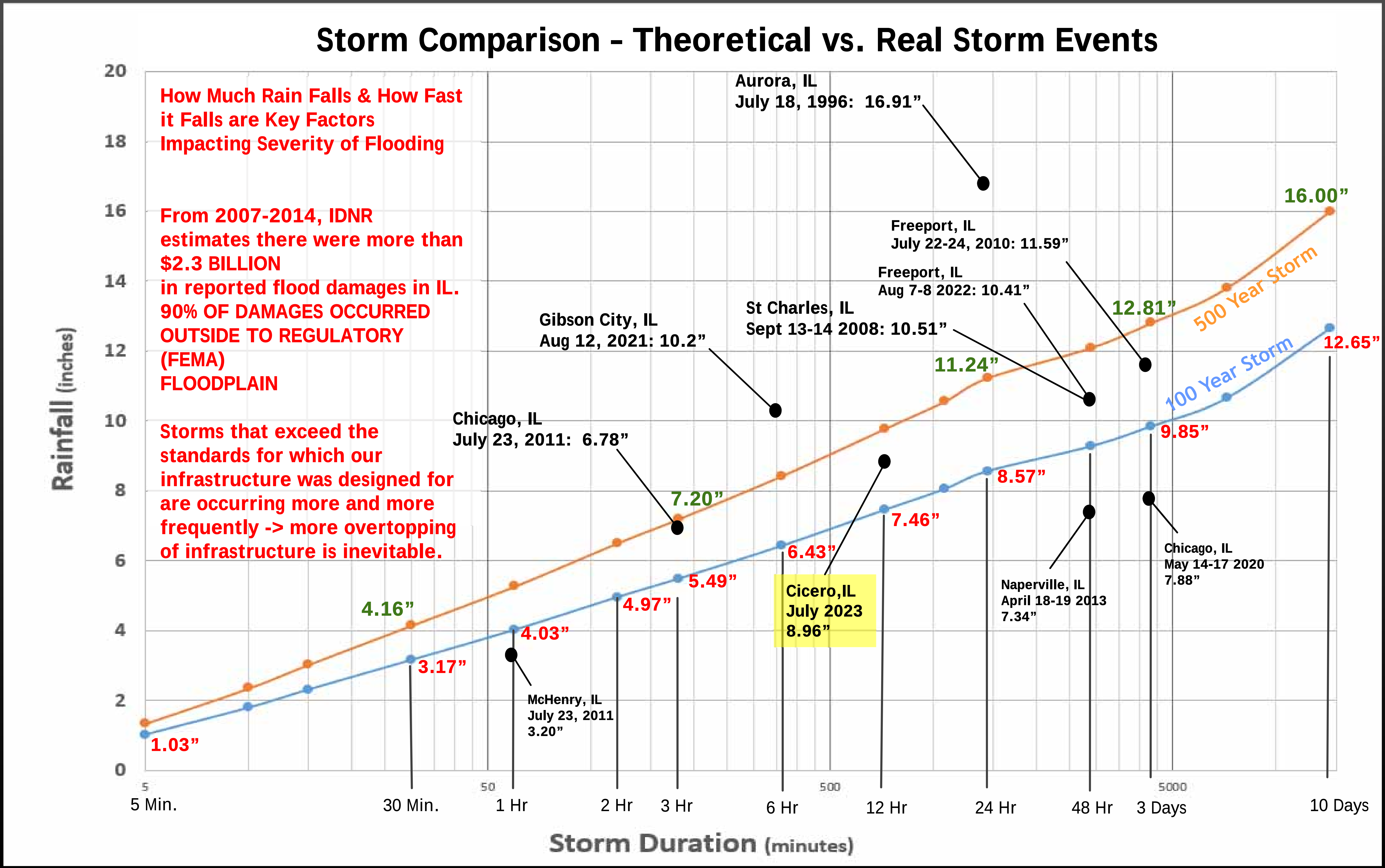


By creating & maintaining a Stormwater Digital Twin, we can:

- Confirm current flooding issues
- Predict future flooding issues (in a changing climate)
- Evaluate and prepare mitigation strategies for flooding

Why is this important?





Storm Comparison - Theoretical vs. Real Storm Events
How Much Rain Falls & How Fast it Falls are Key Factors Impacting Severity of Flooding
From 2007-2014, IDNR estimates there were more than $2.3 BILLION in reported flood damages in IL. 90% OF DAMAGES OCCURRED OUTSIDE TO REGULATORY (FEMA) FLOODPLAIN
Storms that exceed the standards for which our infrastructure was designed for are occurring more and more frequently -> more overtopping of infrastructure is inevitable.
Aurora, IL July 18, 1996: 16.91”
Freeport, IL July 22-24, 2010: 11.59”
Freeport, IL Aug 7-8 2022: 10.41”
St Charles, IL Sept 13-14 2008: 10.51”
Gibson City, IL Aug 12, 2021: 10.2”
Chicago, IL July 23, 2011: 6.78”
Cicero,IL July 2023 8.96”
McHenry, IL July 23, 2011 3.20”
Naperville, IL April 18-19 2013 7.34”
Chicago, IL May 14-17 2020 7.88”
500 Year Storm
100 Year Storm
16.00”
12.81”
11.24”
7.20”
4.16”
12.65”
9.85”
8.57”
7.46”
6.43”
5.49”
4.97”
4.03”
3.17”
1.03”
Rainfall (inches)
Storm Duration (minutes)
5 Min.
30 Min.
1 Hr
2 Hr
3 Hr
6 Hr
12 Hr
24 Hr
48 Hr
3 Days
10 Days

By creating & maintaining a Stormwater Digital Twin, we can:

- Better assess water quality and develop BMP strategies to meet state and local water quality goals

What If…

What If…

- You had an accurate & up to date 3D model of the entire landscape?

What If…

- You had all storm sewers located & knew their sizes and inverts?

What If…

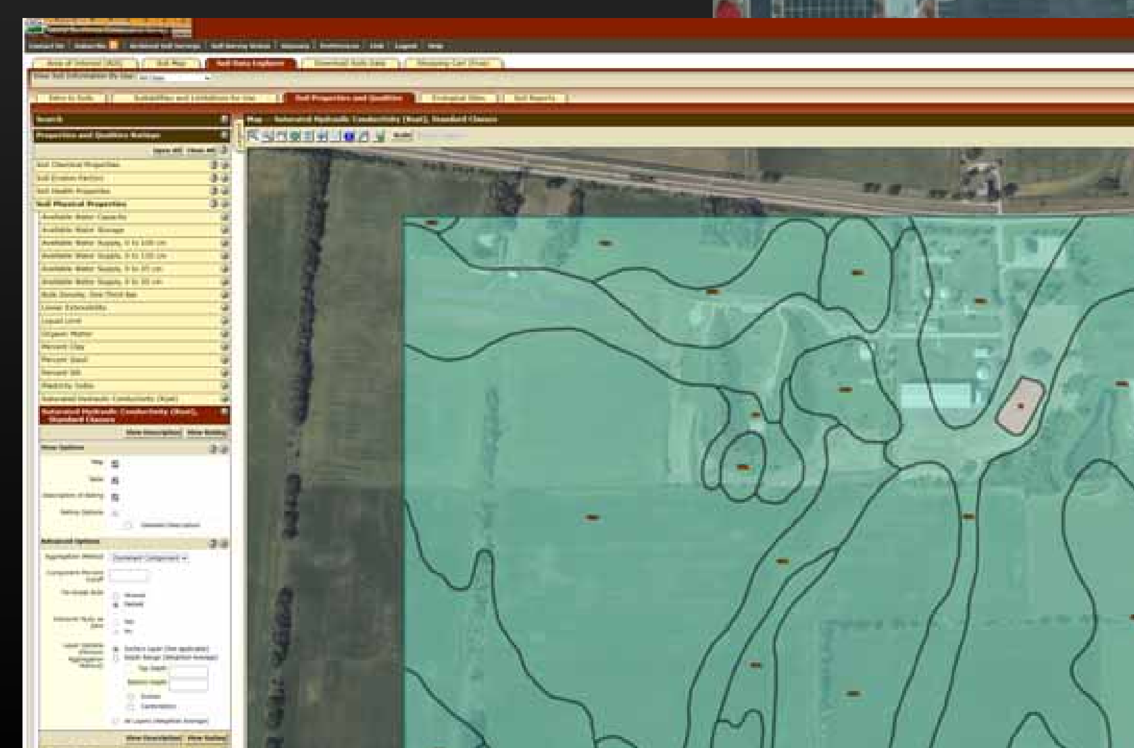
- You had all roadway, railroad culverts AND driveway culverts located & measured?

What If…

- You had every catch basin, inlet, manhole and flared end section identified? Location, frame type, lid type, etc.

What If…

- You had impervious surfaces mapped?
- You knew the soil properties?



Building a Stormwater Digital Twin for Kane County

Deliverables – GIS Layers

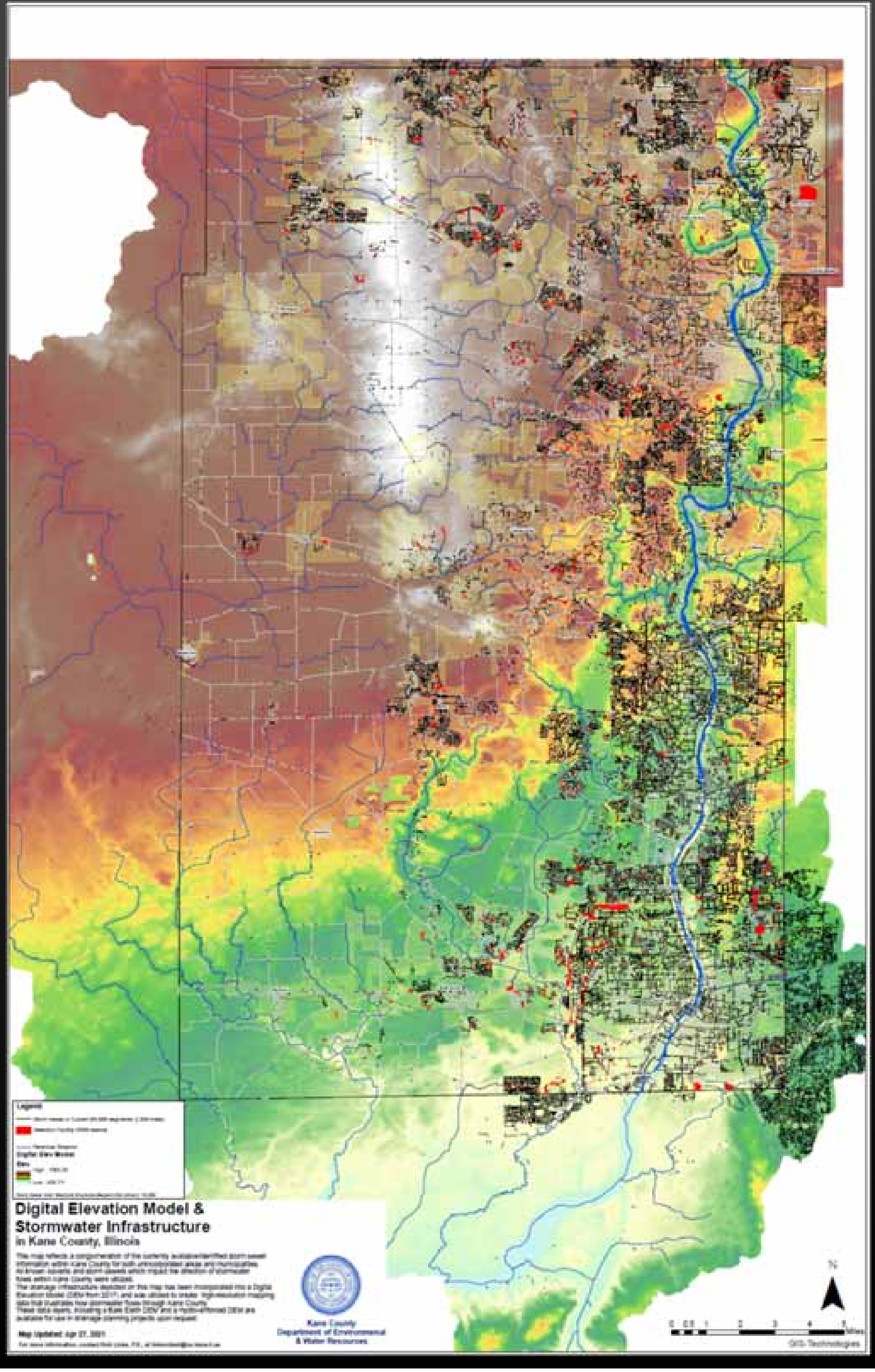
- Stormwater Detention Basins
- Storm sewers, roadway, railroad & driveway culverts
- Storm structures – catch basins, inlets, manholes, etc.
- Countywide storm flow path network
- Potential Flood Inundation Areas & True Depressional Storage Areas
- Bare Earth Digital Elevation Model
- Hydro-enforced Digital Elevation Model

~~Deliverables – PDF Maps~~

- ~~By Township; Showing stormwater basins, storm sewer, culverts, storm flow paths, regulatory floodplain, depressional storage areas, areas potentially vulnerable to urban flooding, hydric soils, ADID wetlands, dams, etc.~~

Deliverables – On-line Interactive GIS Maps

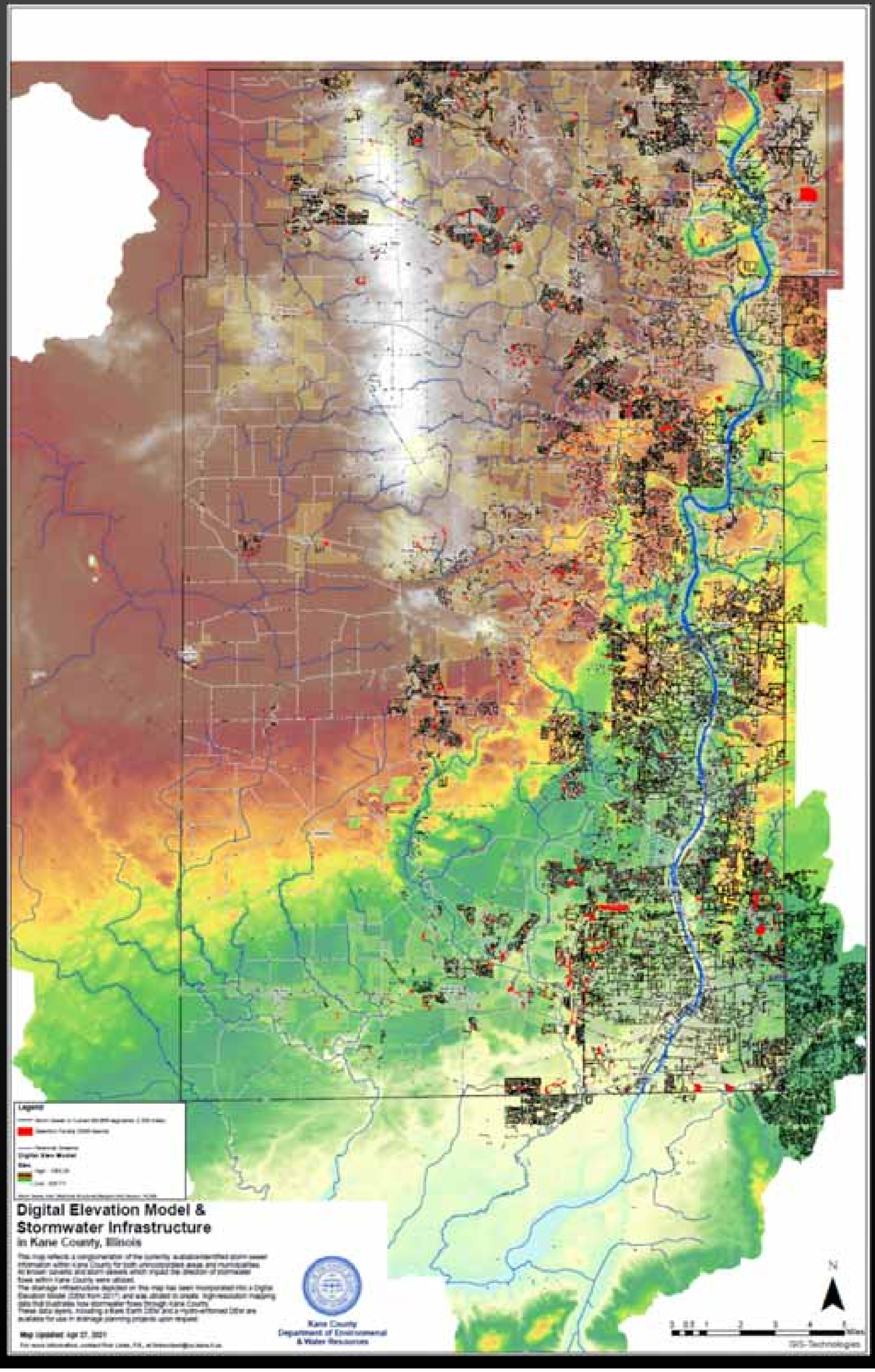
Deliverables – Real Time Flow Trace & Watershed Tools



Building a Stormwater Digital Twin for Kane County

Data, Maps & Tools can be used for:

- Drainage Investigations
- Stormwater Permitting
- Watershed Planning
- Stormwater Modeling & Master Planning
- Floodplain Modeling & Remapping
- MS4 Illicit Discharge Tracing
- Hazard Mitigation Planning
- Public Education / Outreach to increase stormwater awareness



Making the Layers that Drive the Tools

Digital Elevation Model

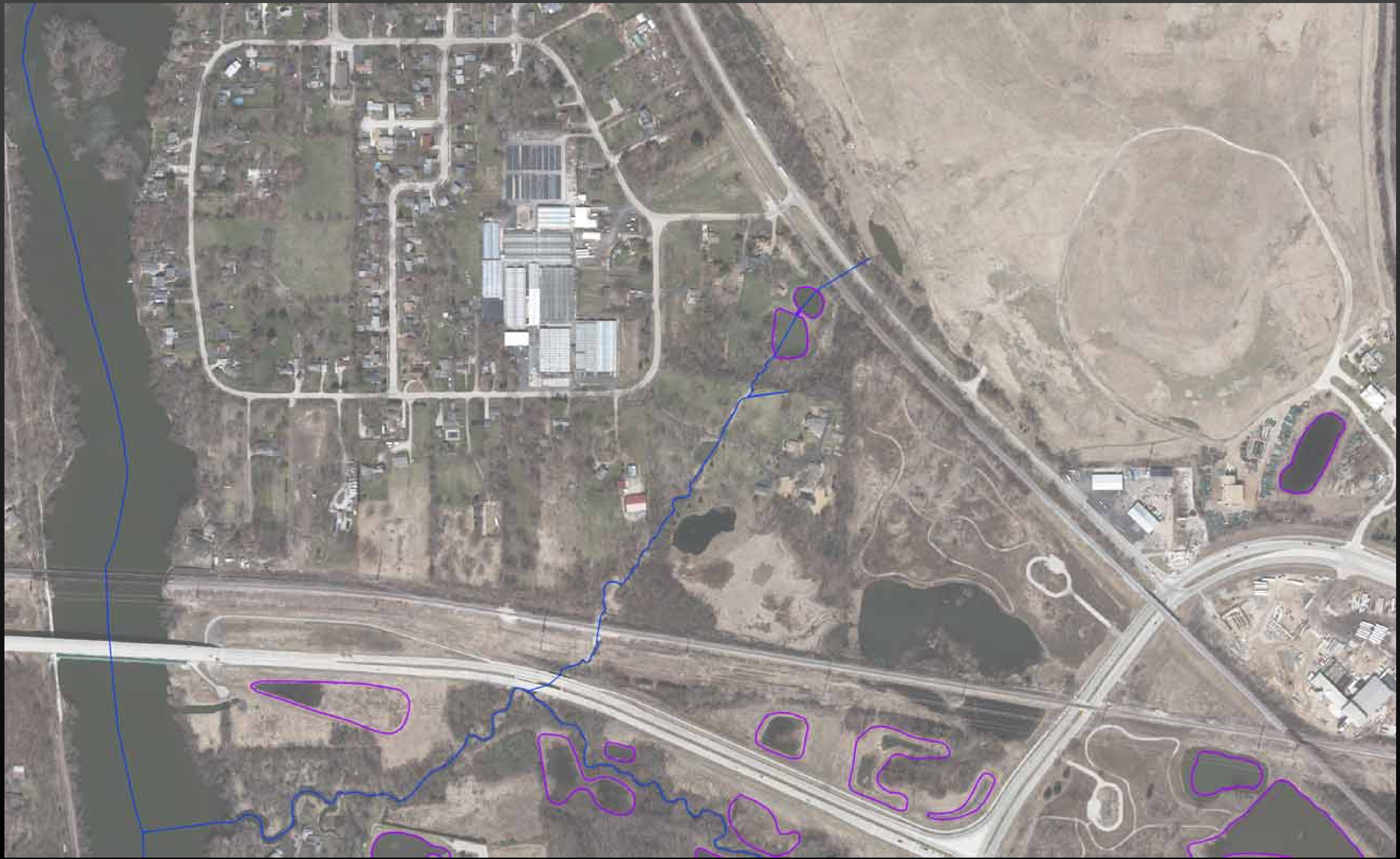
- Derived from LiDAR points flown Spring 2017
  - 20 points per square meter;
  - 0.2ft +/- Vertical Resolution (on hard surfaces)
- 2ft X 2ft Horizontal Resolution
- 30.8 miles E-W by 39.3 miles N-S
- 832 sq. miles (Kane County = 524 sq. mi.)
- 5.8 Billion Pixels

Making the Layers that Drive the Tools

Aerial Imagery

Streams

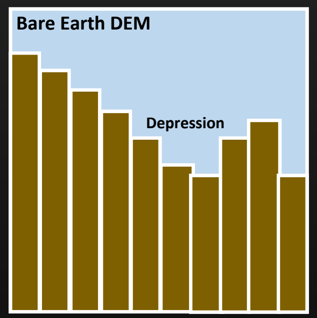
Detention Ponds



Making the Layers that Drive the Tools

2017 Digital Elevation Model

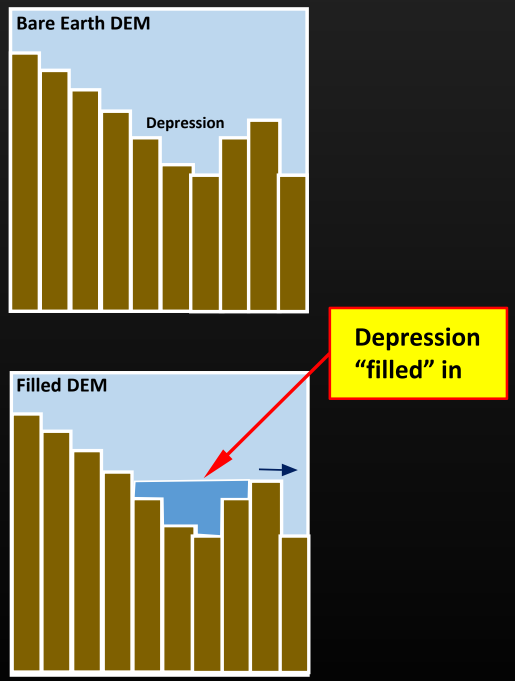
- Bare Earth DEM
  - Bridge decks removed
  - Buildings removed
- Hydro-flattened
  - Water surface made flat
- Underground sewers & culverts are NOT reflected in the DEM



Making the Layers that Drive the Tools

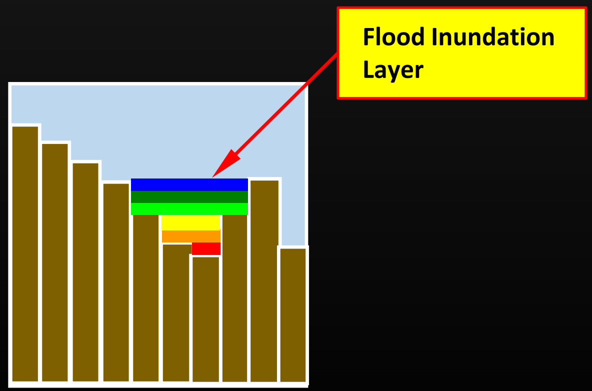
2017 Digital Elevation Model

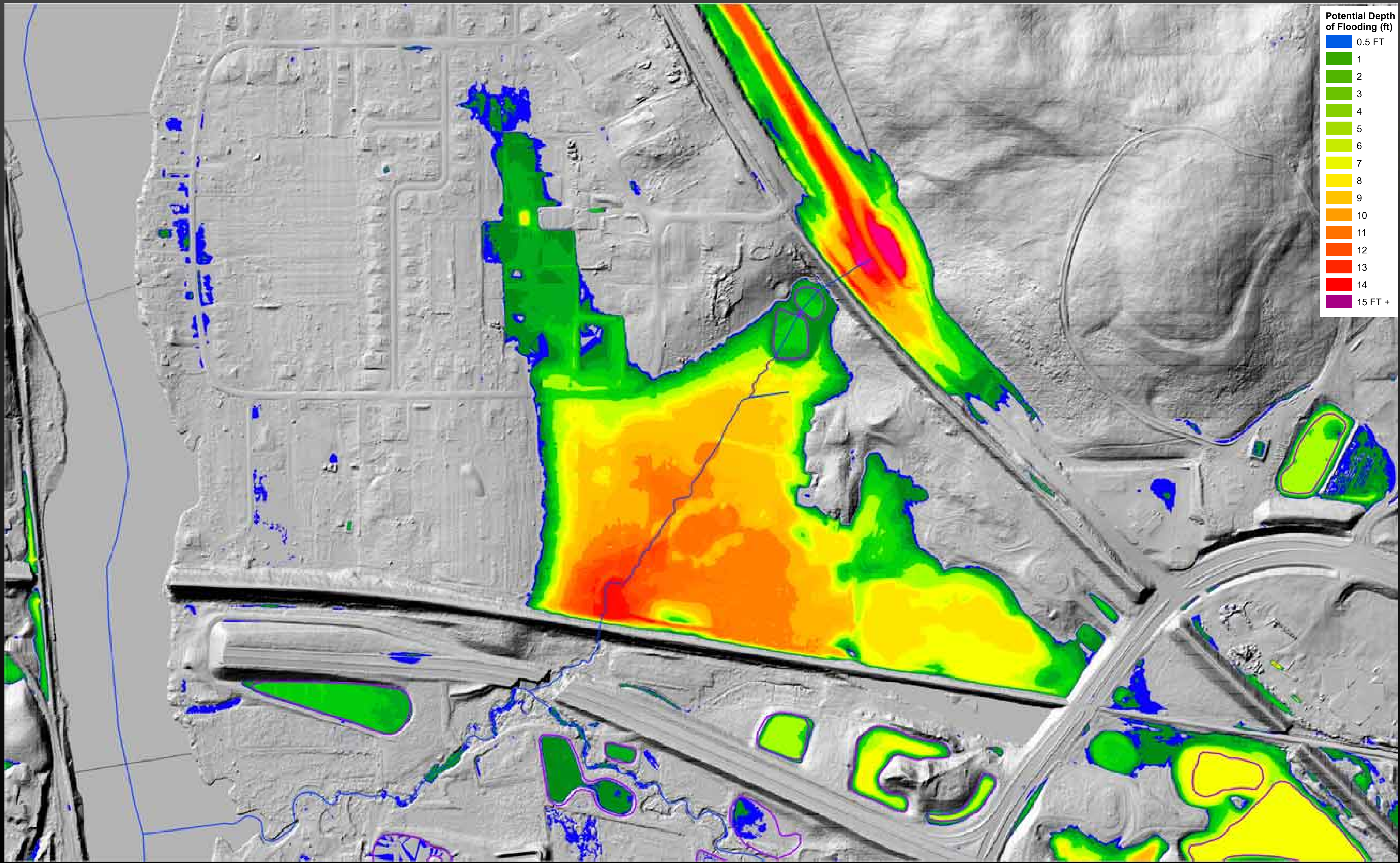
- “Filled” DEM or “Depressionless” DEM



Making the Layers that Drive the Tools

Comparing Bare Earth DEM to the Filled DEM to generate a Flood Inundation Layer





Making the Layers that Drive the Tools

Flood Inundation Layer displayed over aerial photography

Aids in identifying & visualizing potential urban flooding problems.

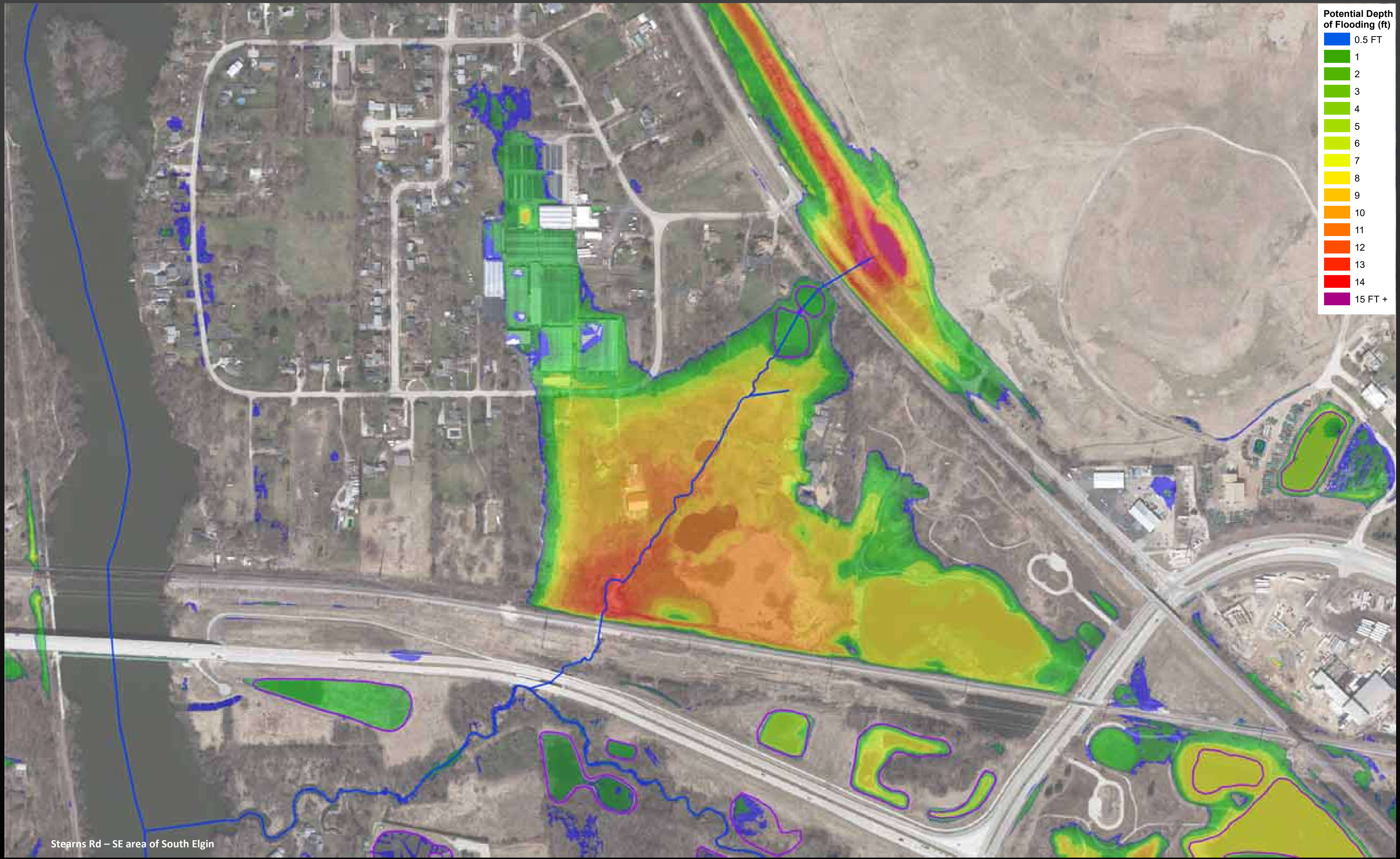
Helps answer questions:

"How deep could the water get around that house?"

"How deep could the water get on our street if the storm sewer failed during a storm & could it impact emergency vehicle access during a flood?"

This summer the dataset will answer:

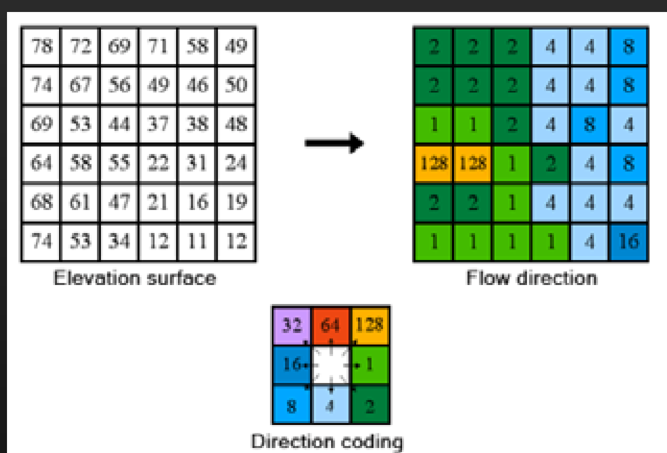
"How many acre-feet of stormwater is stored in our detention basins & in those potential flood areas?"

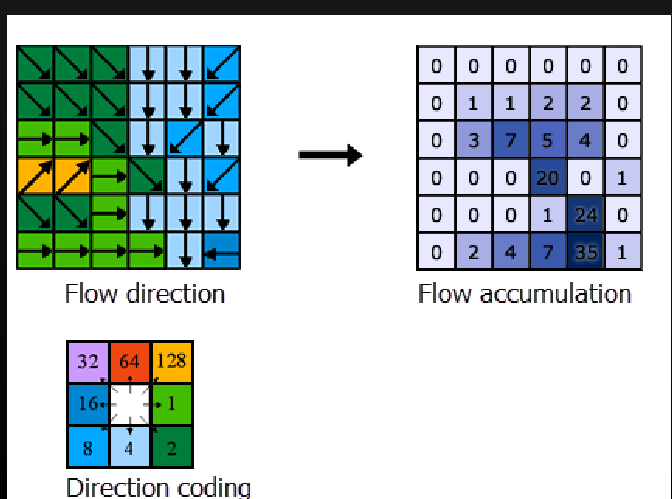


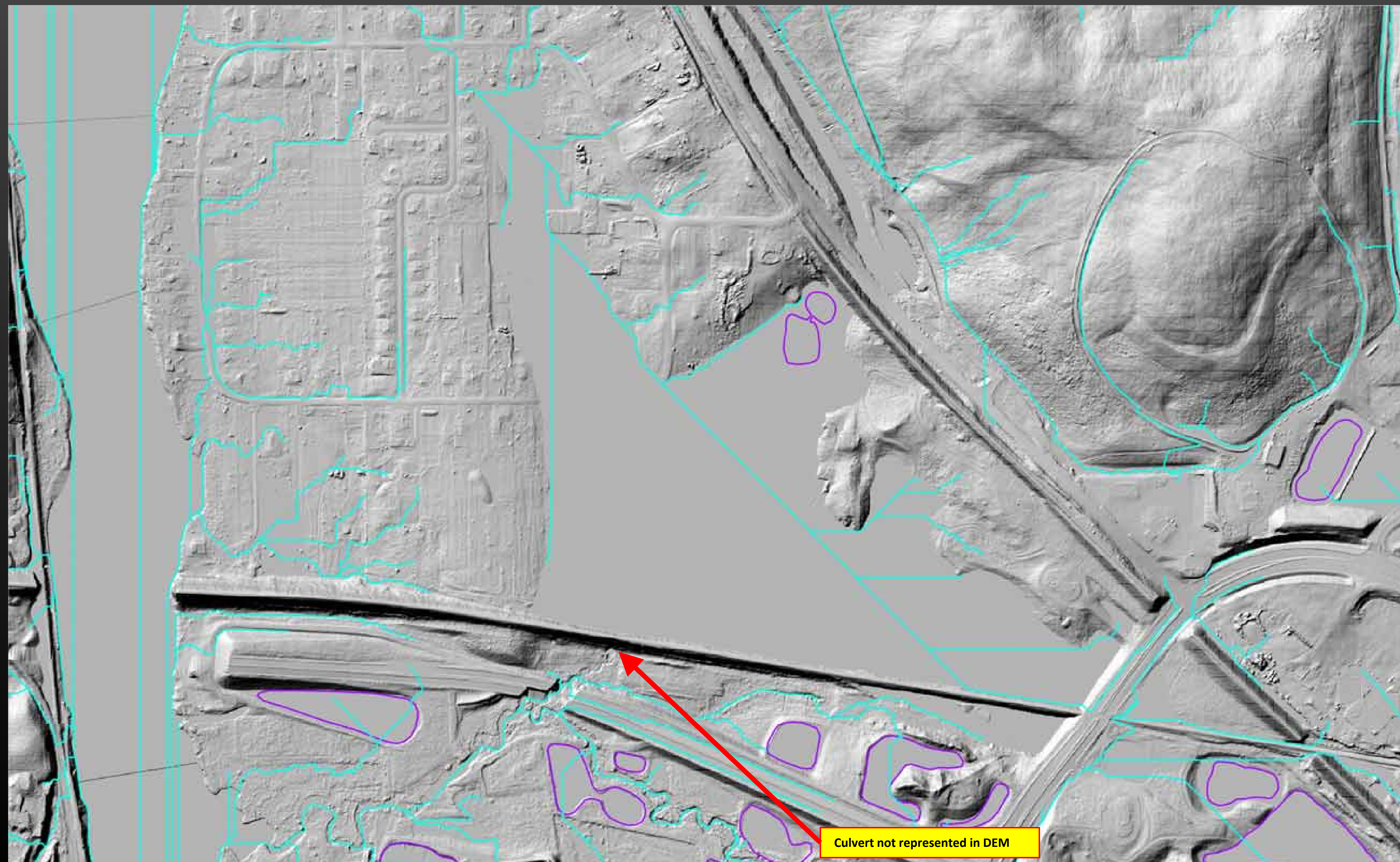
Making the Layers that Drive the Tools

Developing an accurate Storm Path Network

Storm flow path without manmade drainage infrastructure incorporated into DEM







Making the Layers that Drive the Tools

Developing an accurate Storm Path Network

Manmade drainage infrastructure & stream centerlines to be incorporated into Bare Earth DEM

Making the Layers that Drive the Tools

Developing an accurate Storm Path Network

Manmade drainage infrastructure & stream centerlines “burned” into Bare Earth DEM

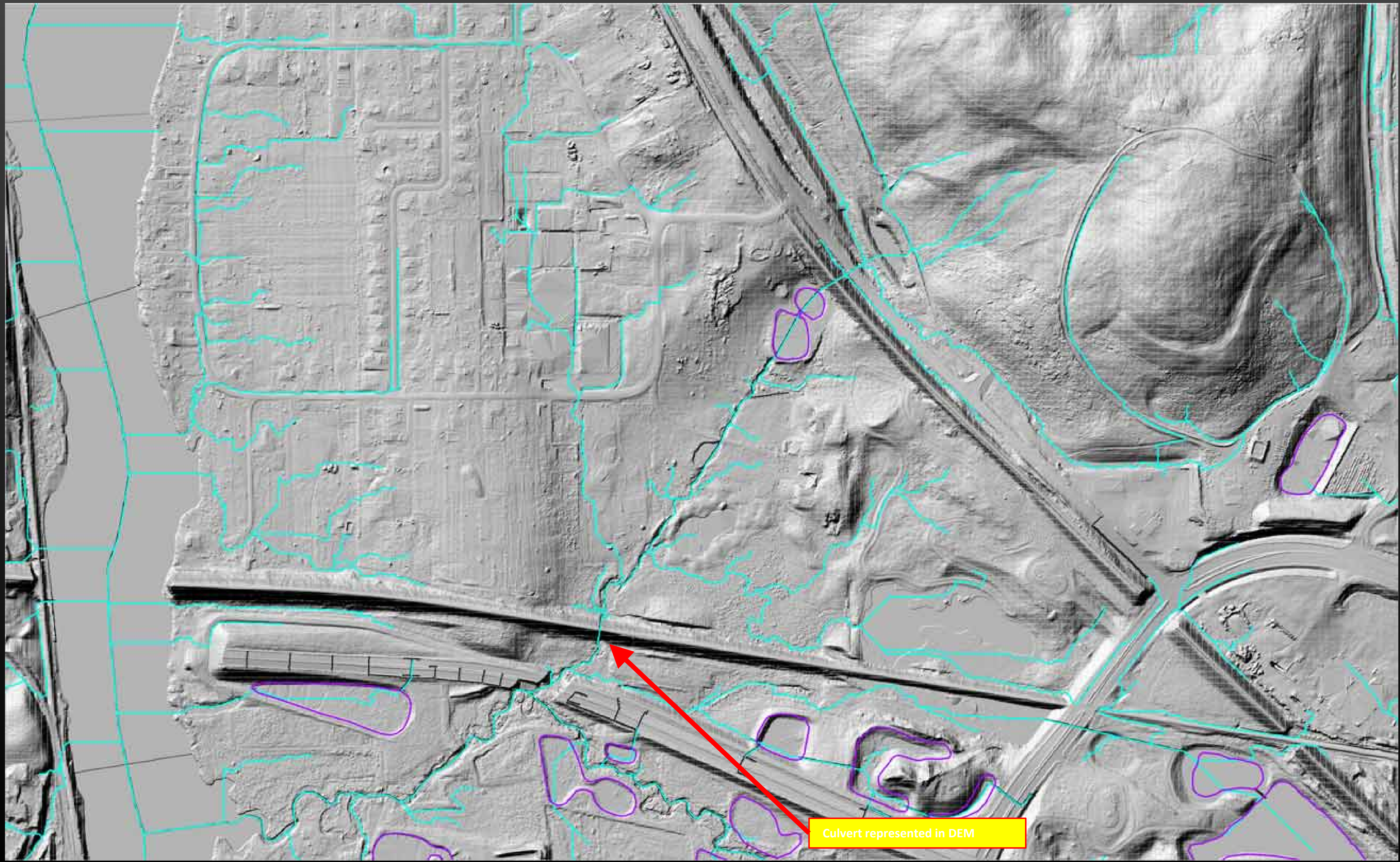
Making the Layers that Drive the Tools

Developing an accurate Storm Path Network

Burning the drainage infrastructure into the Bare Earth DEM creates a hydro-enforced Digital Elevation Model

Storm flow path WITH manmade drainage infrastructure incorporated into DEM

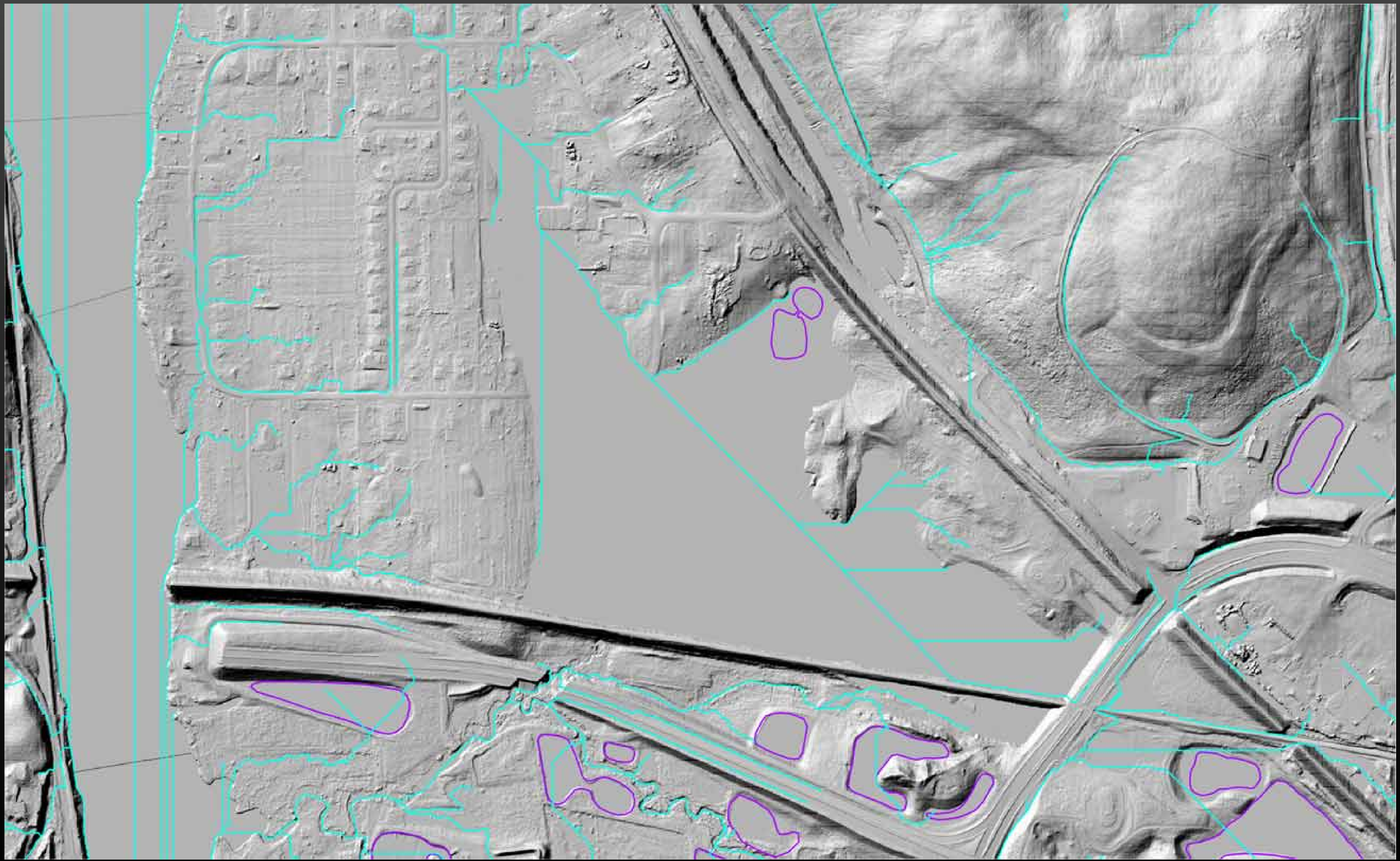
Resolution of Storm Path Network can be adjusted to any drainage area threshold desired (this image shows 1 acre threshold)



Making the Layers that Drive the Tools

No hydro-enforcement

Not necessarily an incorrect Storm Path Network – but a Storm Path Network that sheds light on how stormwater may flow during extreme events if parts of the underground drainage infrastructure fails.



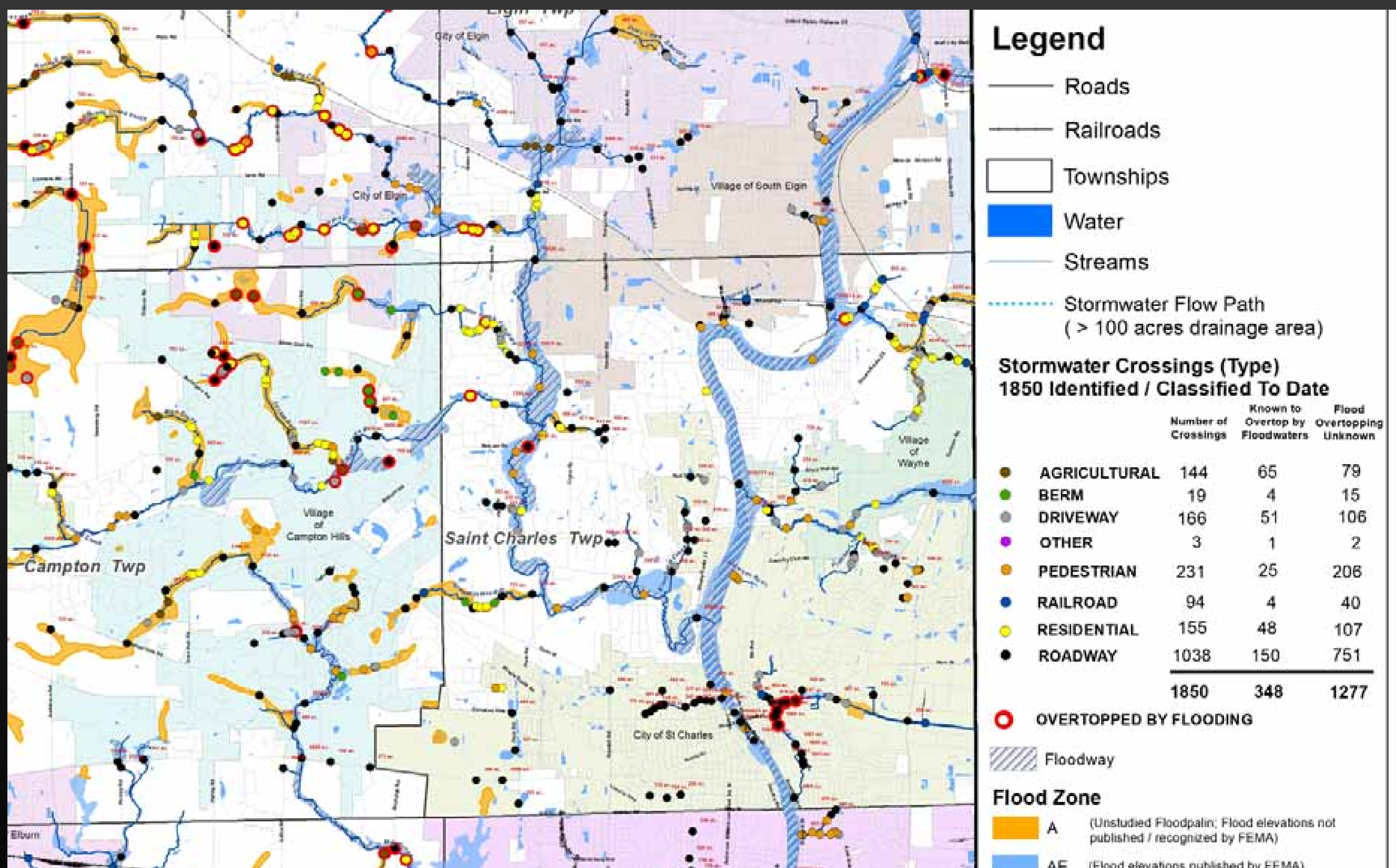
Building a Stormwater Digital Twin for Kane County

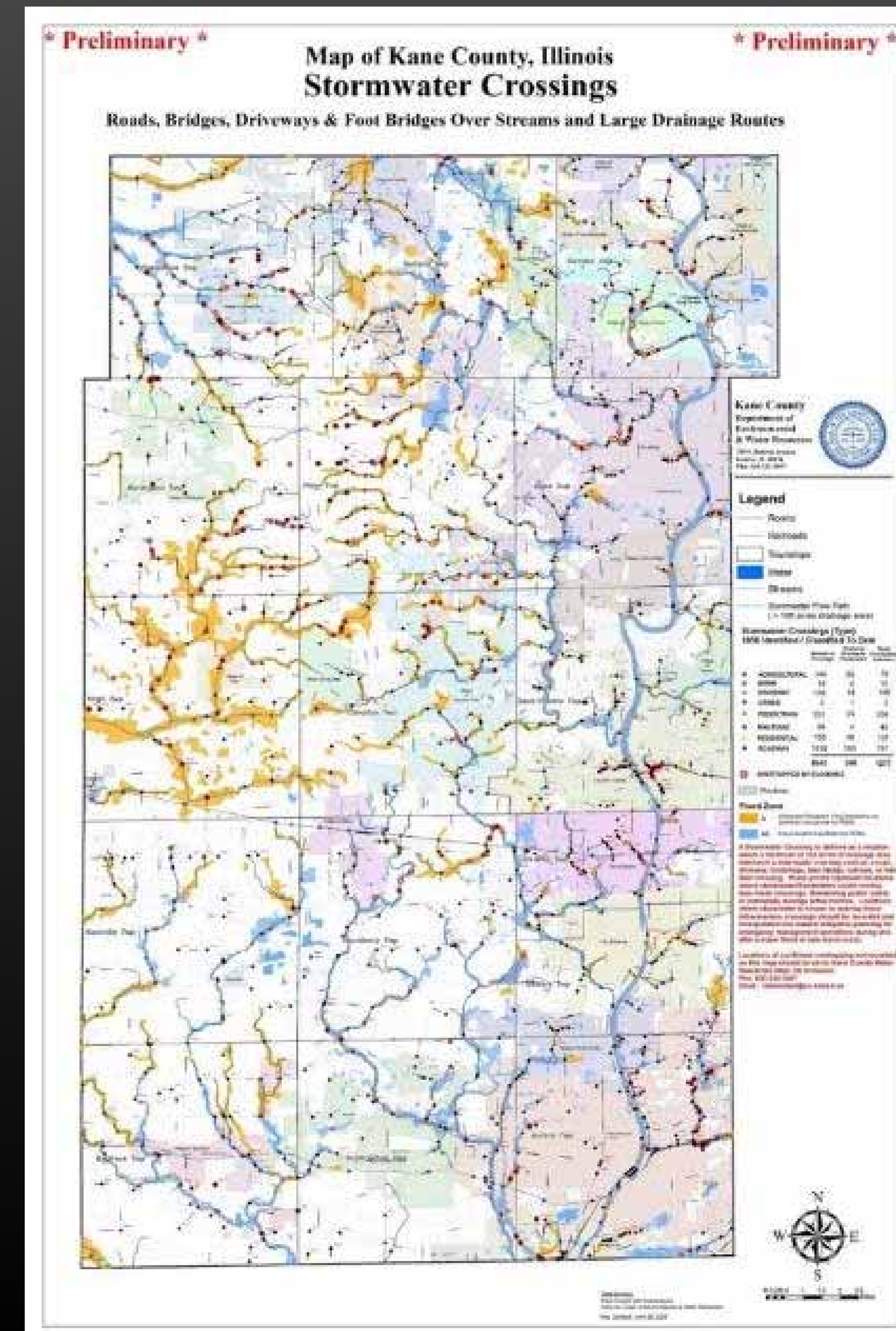
Other Derivatives from this initiative:

- **Stormwater Crossings (Preliminary)**
- **BMP Mapping Tools (Future Work)**

Building a Stormwater Digital Twin for Kane County

Stormwater Crossings





Building a Stormwater Digital Twin for Kane County

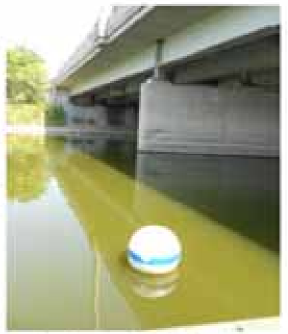
Local Water Quality Goals

FOX RIVER IMPLEMENTATION PLAN (FRIP) ***Final Draft***

December 2022

EXECUTIVE SUMMARY

The Fox River Study Group (FRSG) began meeting in the summer of 2001 after the Illinois Environmental Protection Agency (Illinois EPA) added the Fox River to its list of impaired waters under Section 303(d) of the Clean Water Act. Communities along the Fox River are required to address water quality issues identified by Illinois EPA. The Fox River Implementation Plan (FRIP) was first developed in 2015 to address phosphorus-related dissolved oxygen (DO) and nuisance algae impairments in a 98-mile stretch of the Fox River in Illinois (FRSG, 2015). This document is an update of the FRIP and is based on a new river model framework and recent water quality studies. The major findings of the 2022 FRIP are:



Algae bloom on the Fox River in 2012: Photo Credit: Karen Clementi

- Major wastewater treatment plants (WWTPs) should proceed with capital improvements to achieve a 0.5 milligram per liter (mg/L) annual geometric mean total phosphorus (TP) limit by 2030;
- The FRSG should focus on collaborating with partners to support removal of dams along the mainstem river and monitor the resulting water quality impacts after the U.S. Army Corps of Engineers completes the Fox River Connectivity & Habitat Study (anticipated in 2024);
- The FRSG should encourage state-of-the-art watershed management practices that can mitigate the impact of projected population growth in the FRIP Study Area;
- The FRSG should continue to support and direct research into nutrient control and management in the watershed, both natural and anthropogenic. The FRSG should leverage statewide work on evaluation of streambank erosion and quantify its impact on phosphorus loads in the watershed;

4.4.6 MS4 Spreadsheet Tool Update

The 2015 FRIP included the development of an MS4 spreadsheet tool to calculate phosphorus load reductions resulting from BMPs implemented in the tributary watersheds. The following updates should be made to the MS4 spreadsheet tool:

- Updated estimated unit area loadings for phosphorus based on the HSPF model outputs for the period of 2012 to 2016
- Development of a web-based platform for the load calculations
- Incorporation of load reduction calculations for total nitrogen and TSS
- Incorporation of reporting features that auto generate an annual report on proposed and completed projects for submittal to regulatory agencies

The FRSG and member communities can use this tool in several ways to support planning, implementation, and reporting requirements for FRIP projects including:

1. Documenting annual load reductions from completed projects for annual reports to Illinois EPA.
2. Assessing how new and individual site development opportunities can alter nonpoint source loading.
3. Assessing how a community could allocate resources to offset development and reduce community aggregate loading or loads in a specific area (industrial park, near river area, etc.).

To maximize the benefits of such a tool, the FRSG will need to coordinate with member communities to collect and maintain sufficient data and information for landscape-based improvement and development projects.

FOX RIVER IMPLEMENTATION PLAN (FRIP)

Final Draft

Fox River, IL

Submitted to

FOX RIVER STUDY GROUP

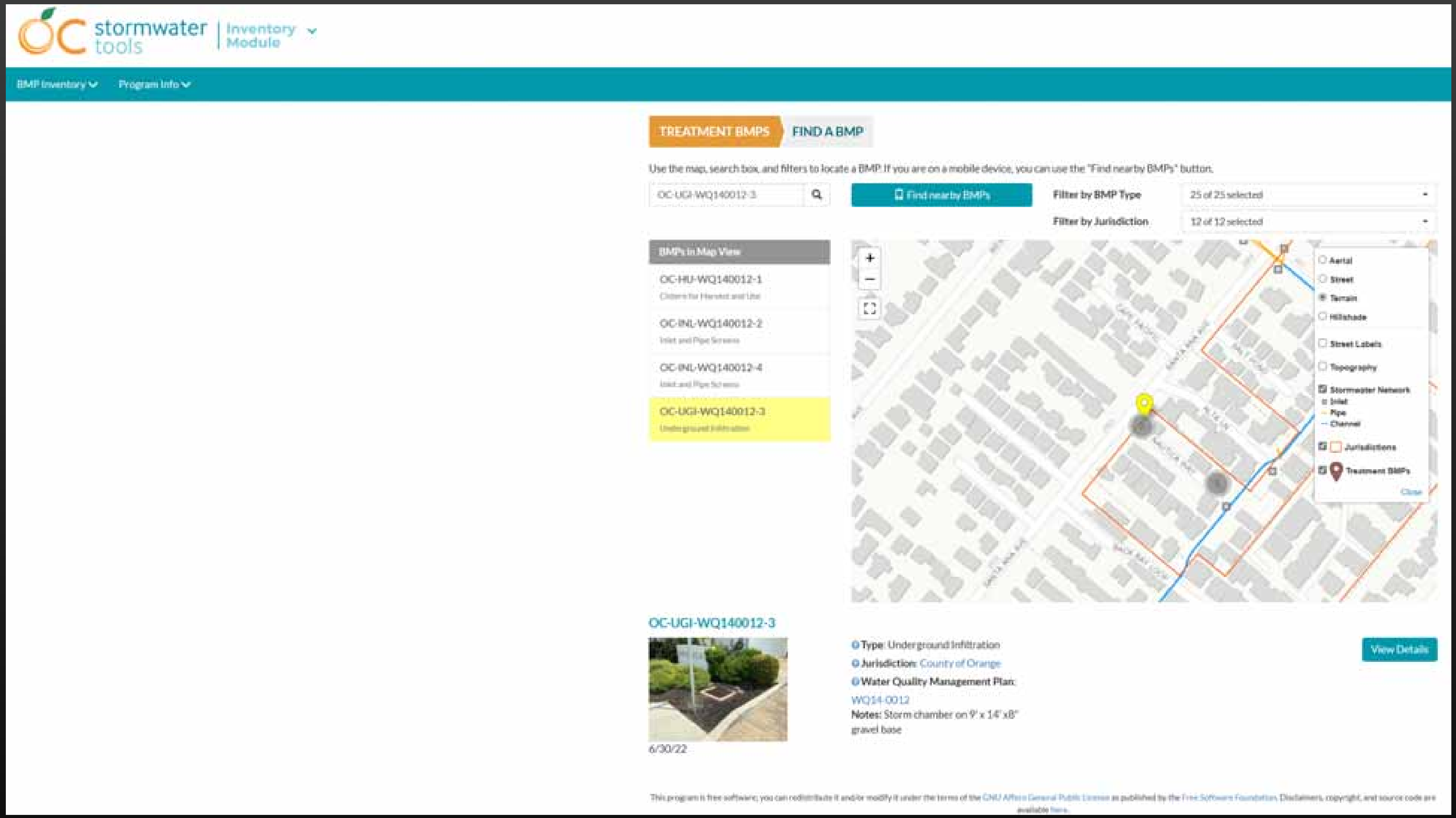
Submitted by

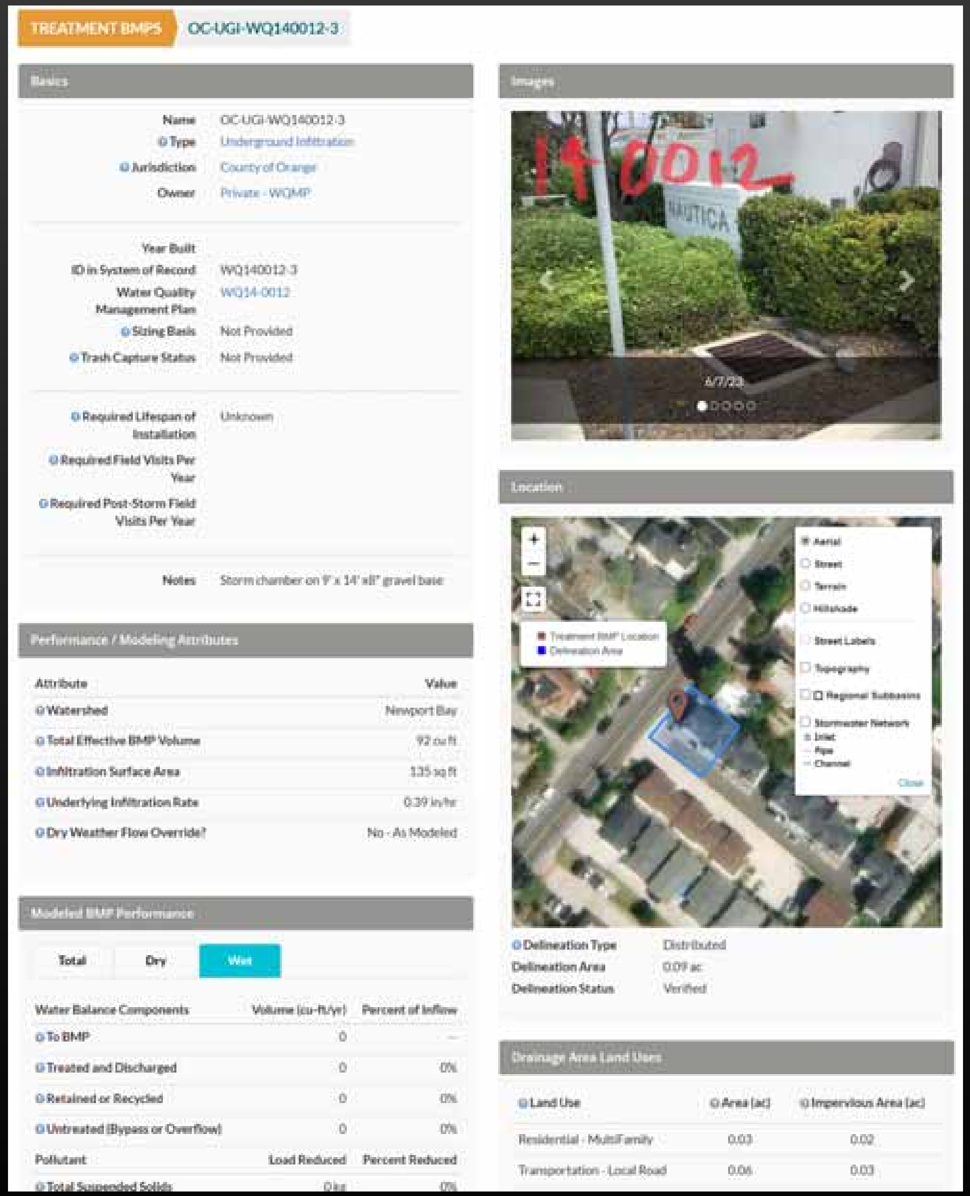
Geosyntec consultants

engineers | scientists | innovators

Building a Stormwater Digital Twin for Kane County

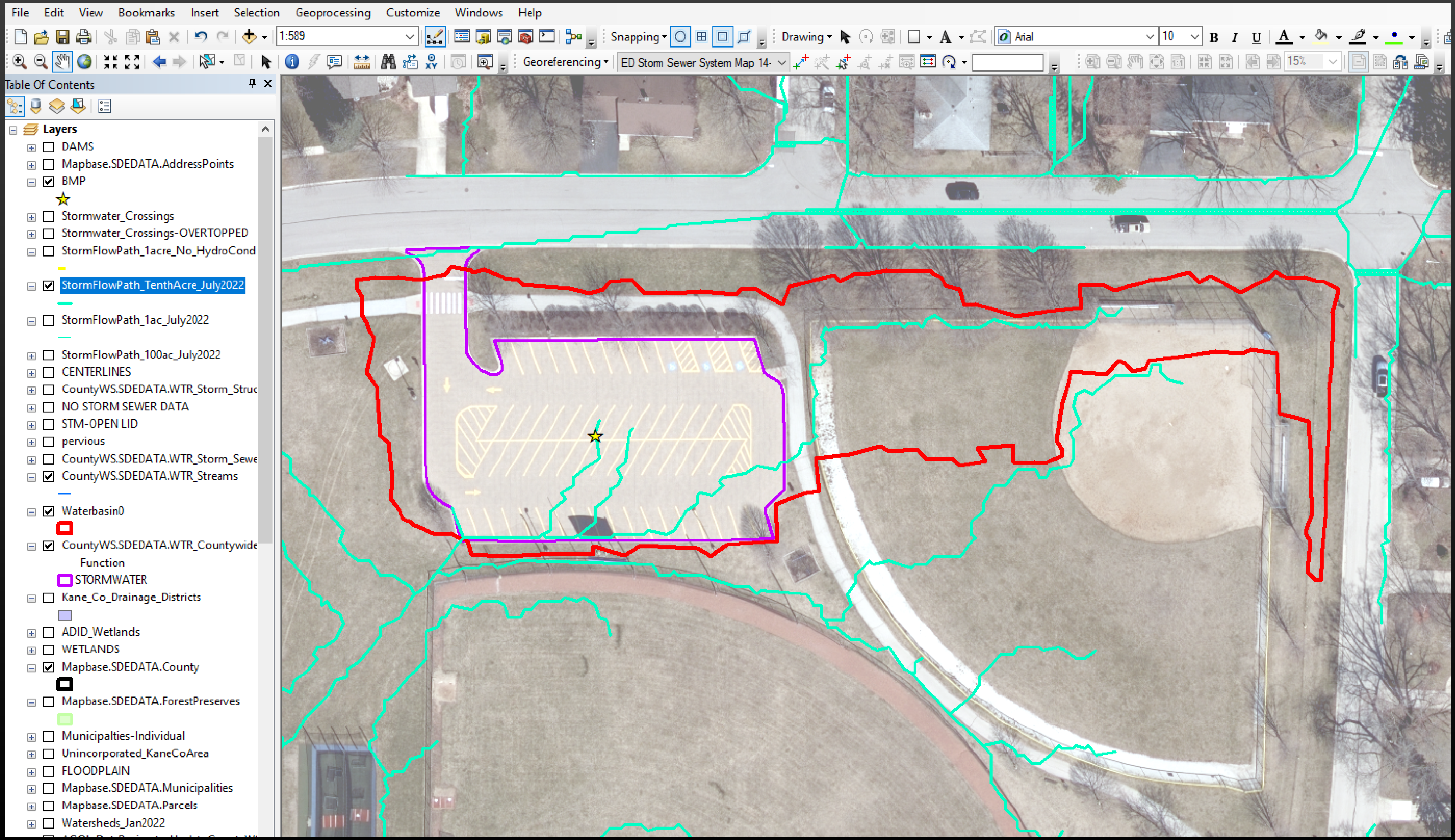
BMP Mapping





Building a Stormwater Digital Twin for Kane County

BMP Mapping

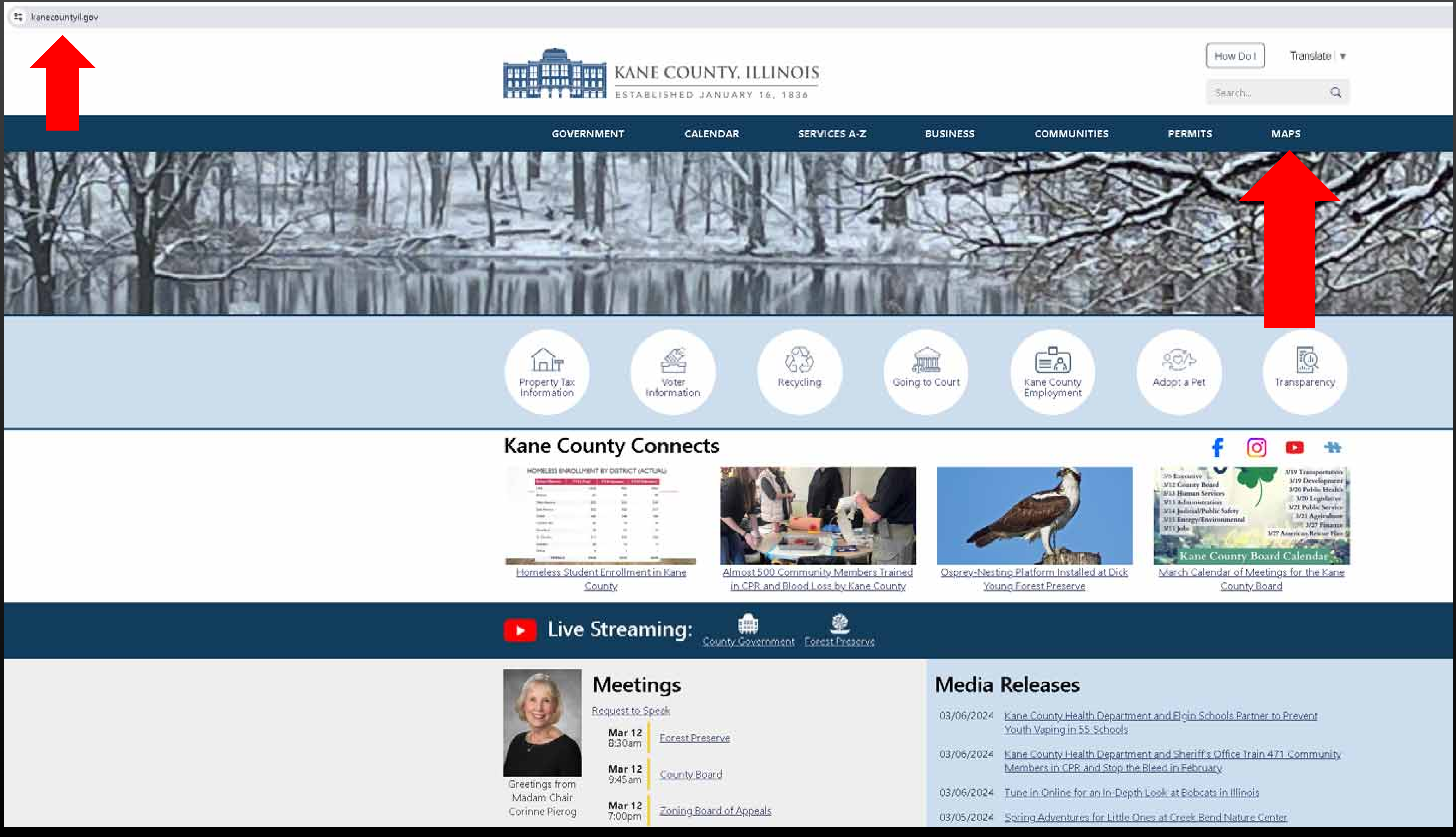


Kane County Stormwater Viewer

Stormwater Infrastructure Mapping & Tools

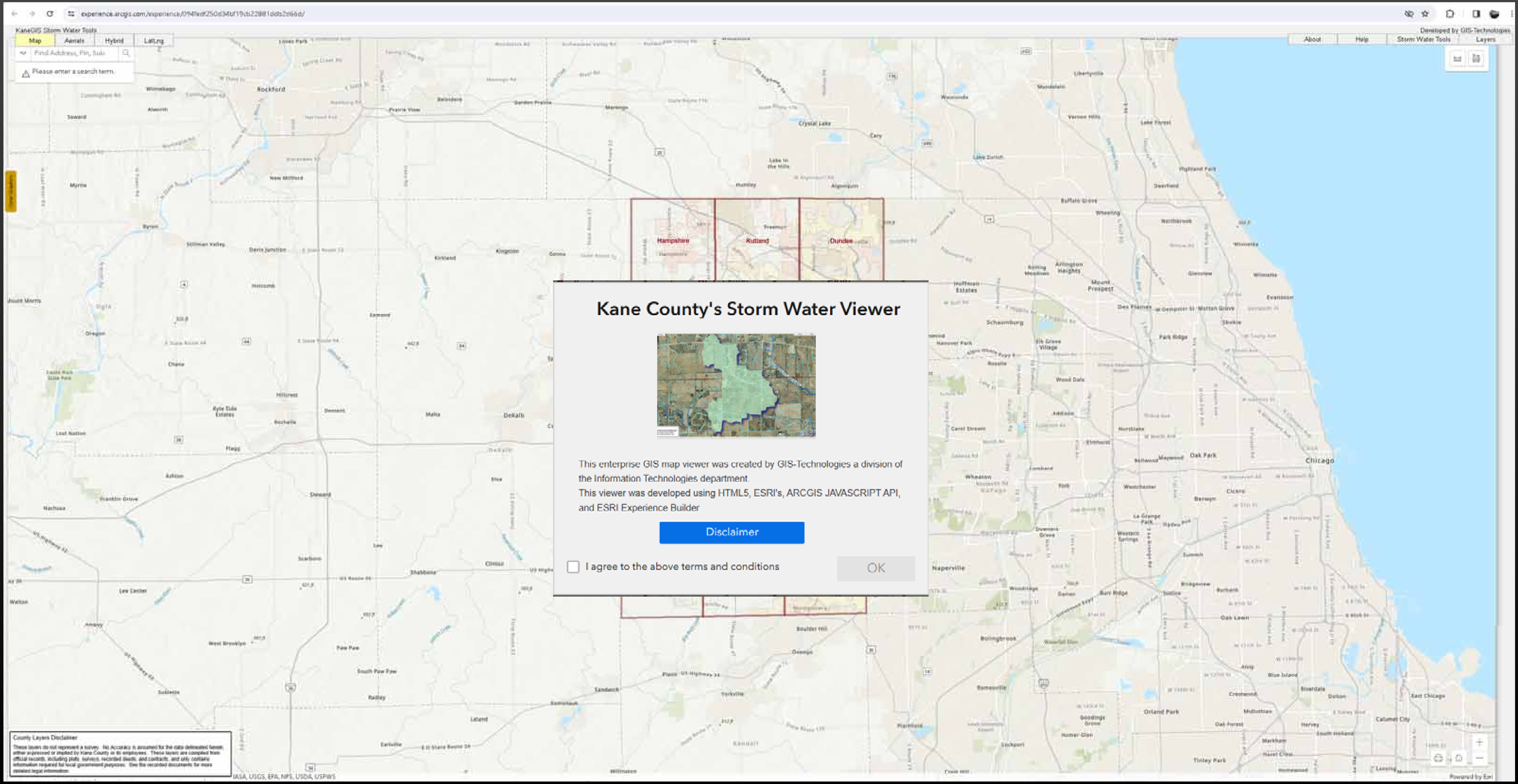
Kane County Department of Environmental & Water Resources, working with Kane County GIS Technologies Department has published a set of stormwater mapping layers and tools to help planners, engineers, emergency responders and the general public better understand how stormwater moves through Kane County. These layers include infrastructure features such as storm sewers, culverts, drain tiles, detention basins and represent the best available data. Additionally, storm flow paths and areas of potential flood inundation have been mapped and are included as informational stormwater layers. Accessing these layers on the County's Stormwater Viewer is outlined in the accompanying slides.

Accessing the Map



Accessing the Map

Navigating the Map

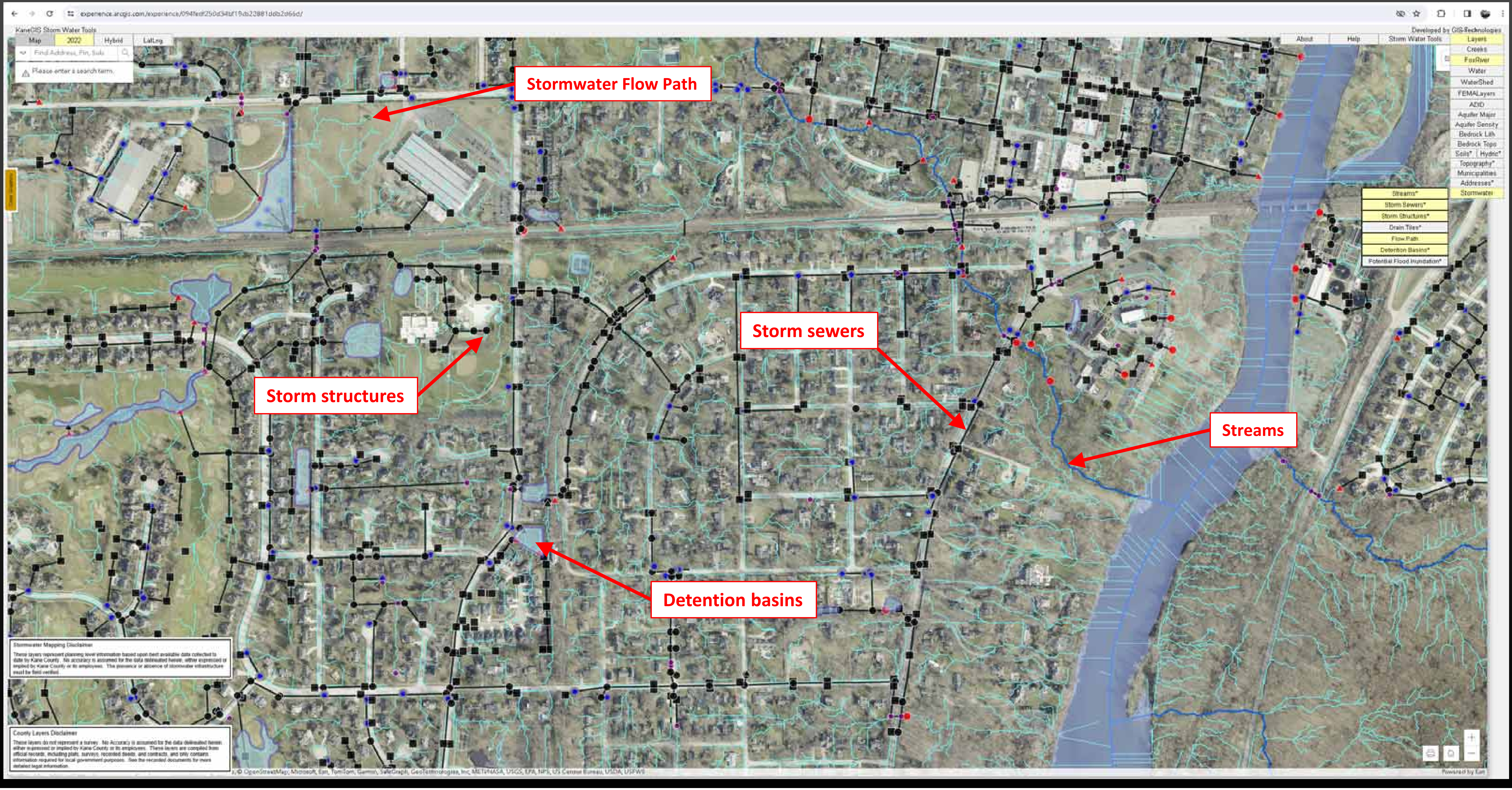


Navigating the Map

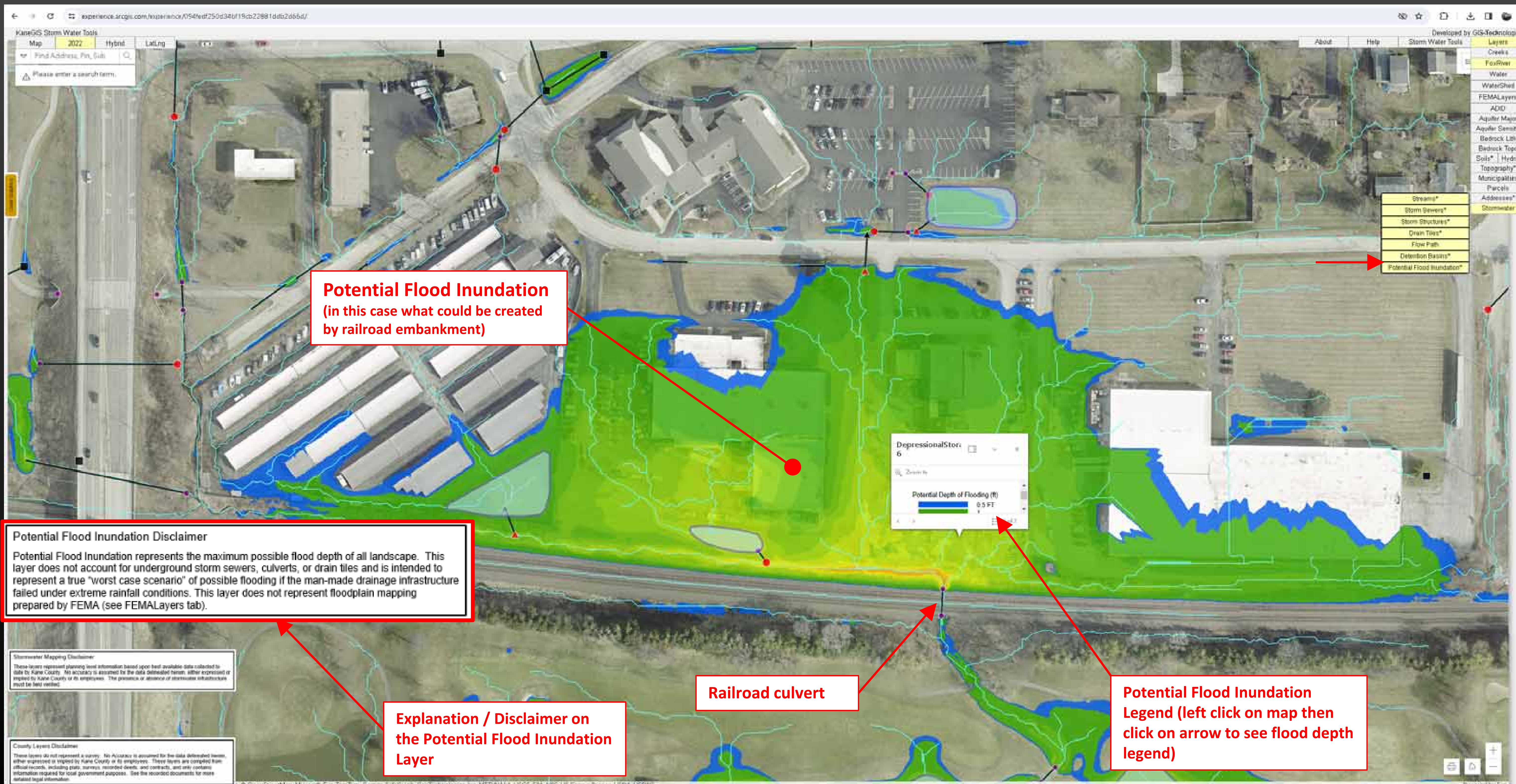
Navigating the Map

Navigating the Map

Navigating the Map



Navigating the Map

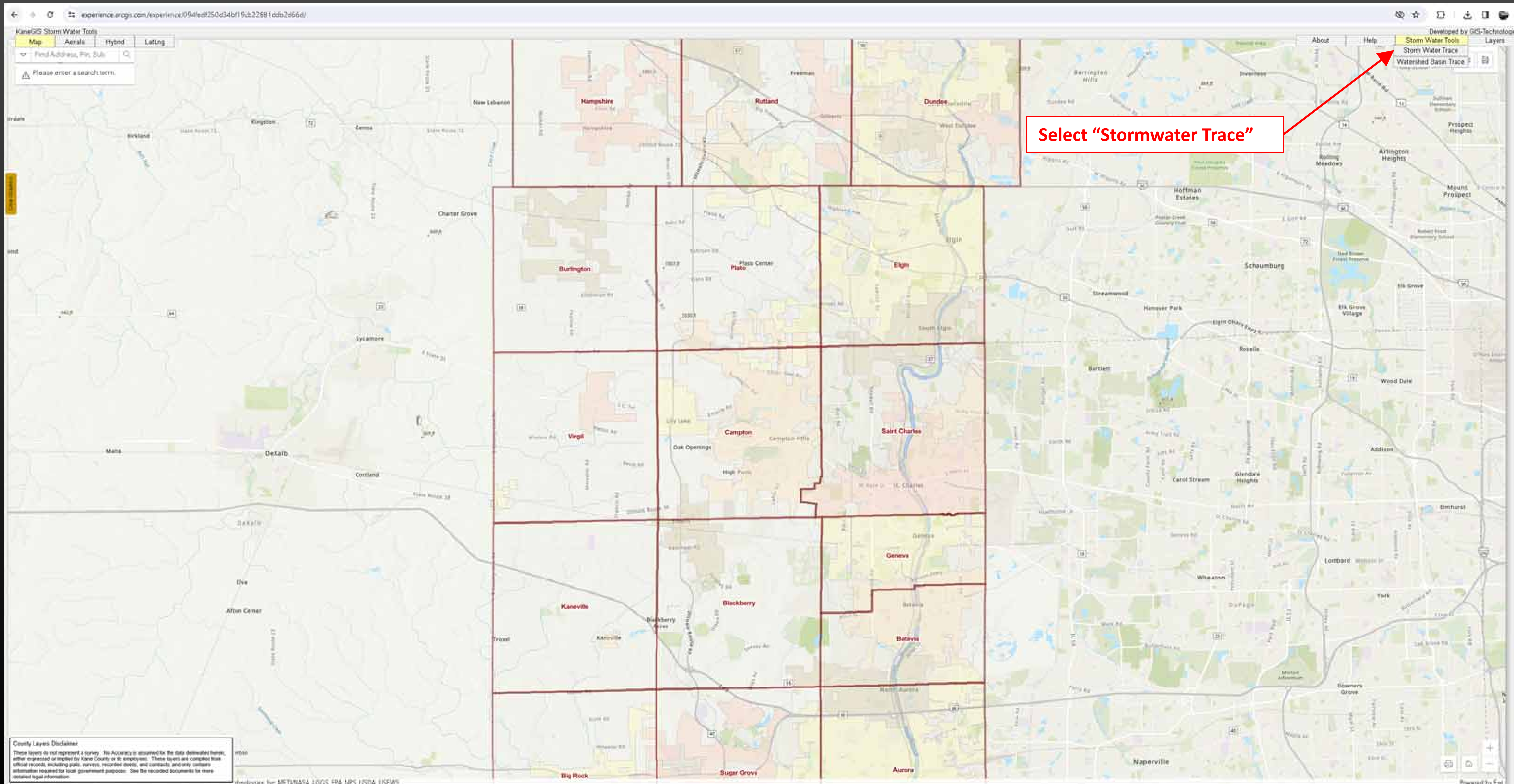


Kane County Stormwater Viewer

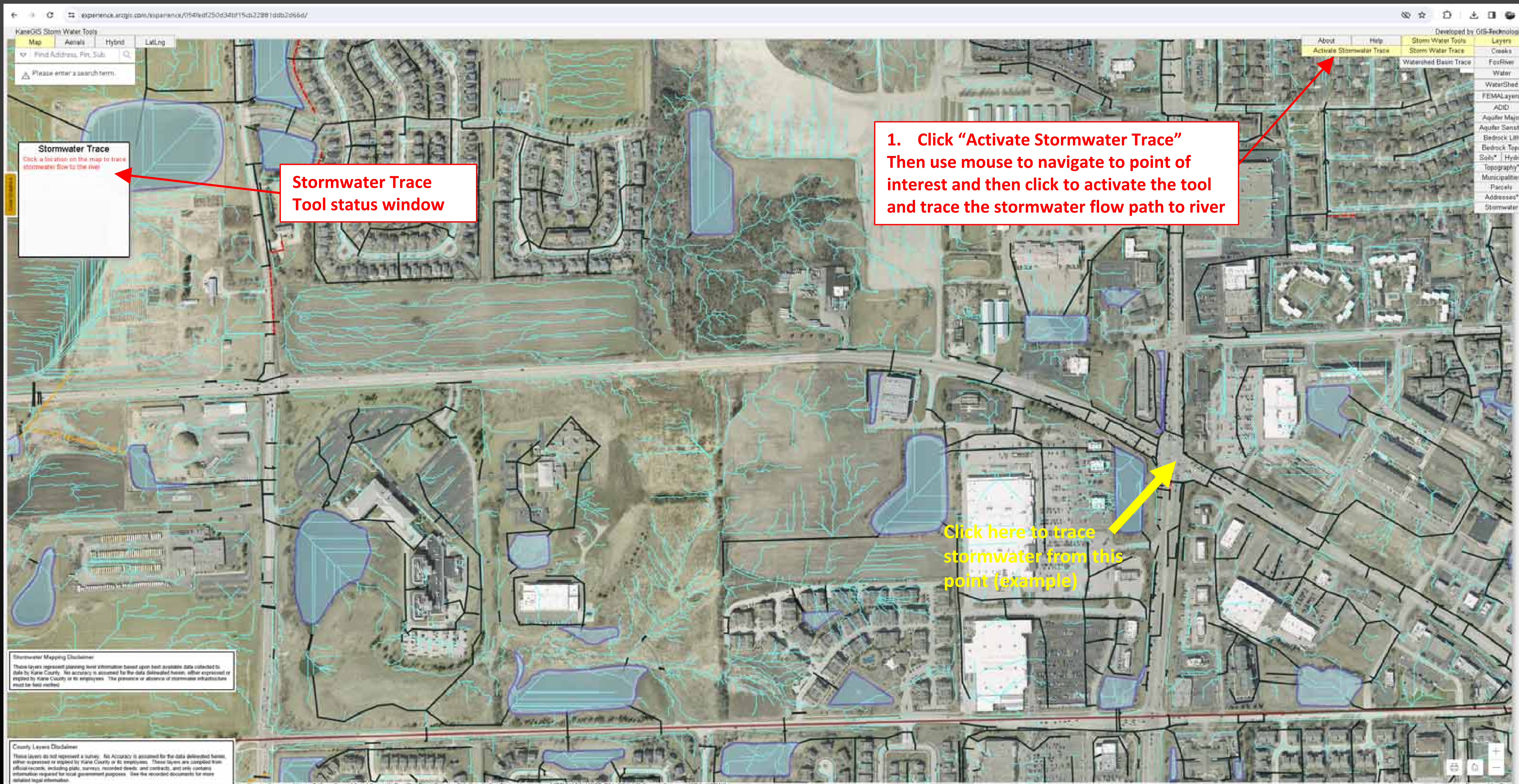
Part 2: Stormwater Tracing Tool

Using the stormwater mapping data compiled by KCDEWR, Kane County GIS Technologies Department has created a Stormwater Tracing Tool which allows a user to trace the flow of stormwater from any point in the County to the nearest river (Fox River/Kishwaukee River). This tracing tool takes into account all channels, culverts, and main storm sewers across the entire county. Accessing the tool on the Stormwater Viewer is outlined in the accompanying slides.

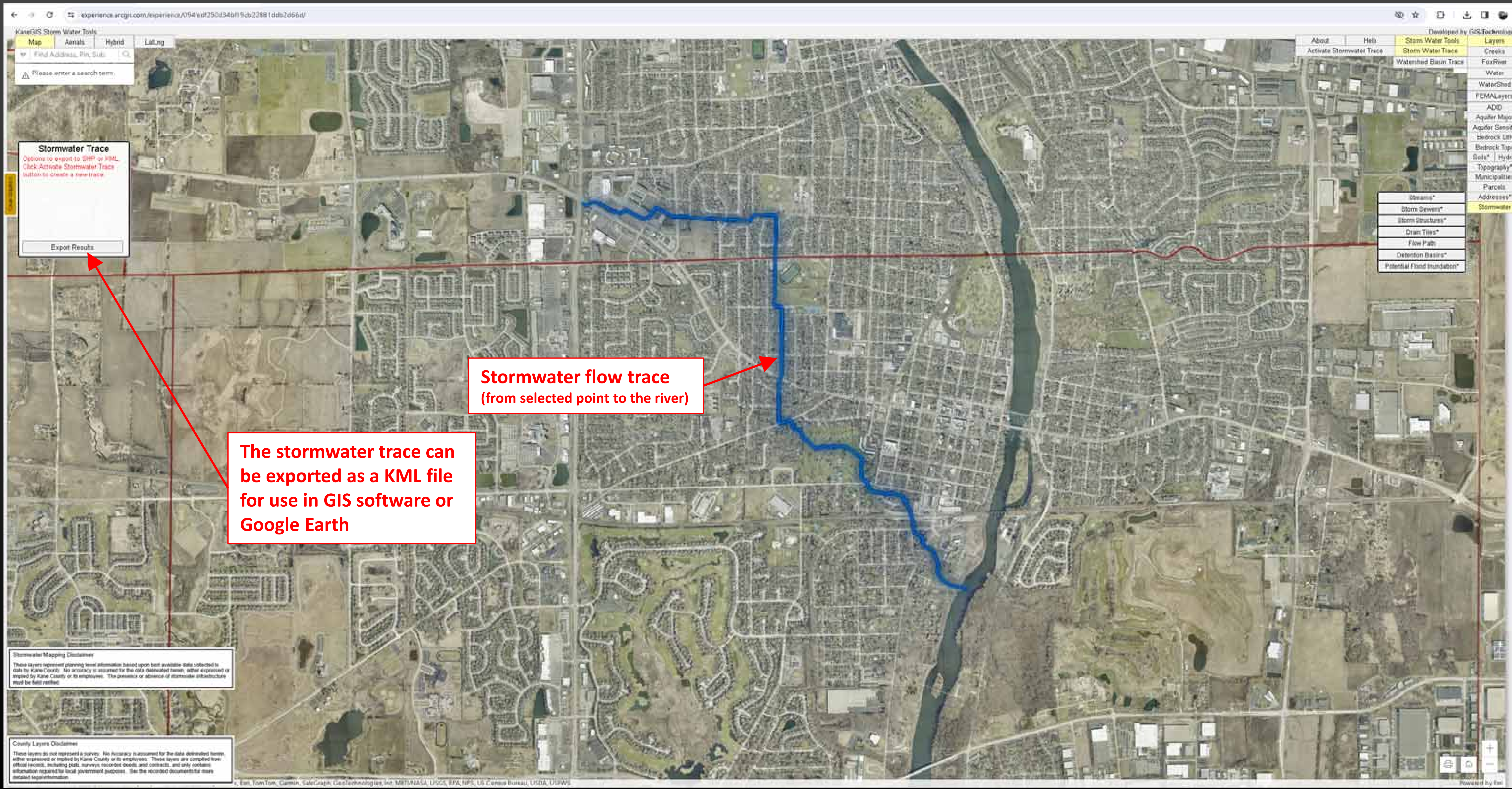
Stormwater Tracing Tool



Stormwater Tracing Tool



Stormwater Tracing Tool

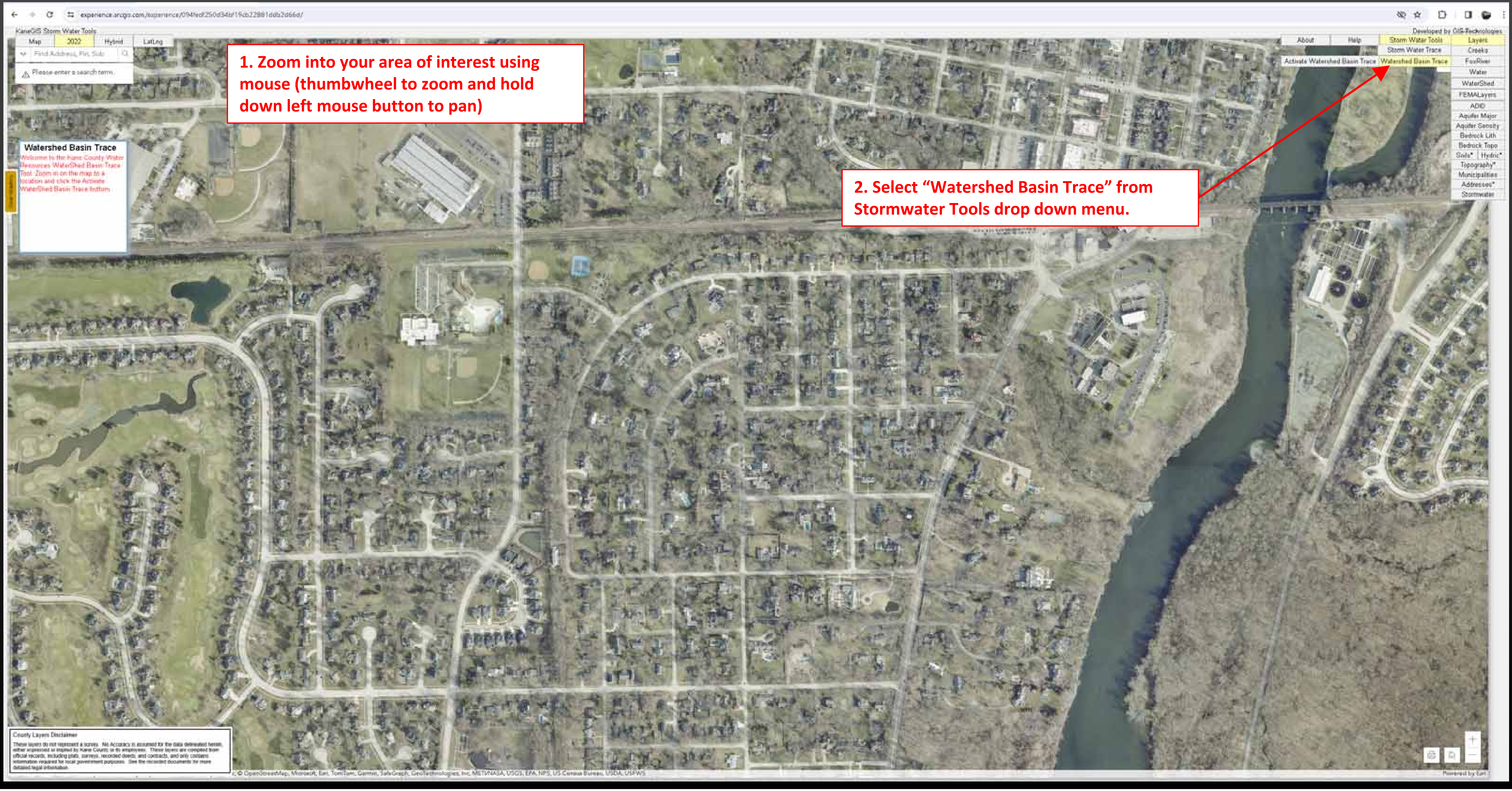


Kane County Stormwater Viewer

Part 3: Watershed Delineation Tool

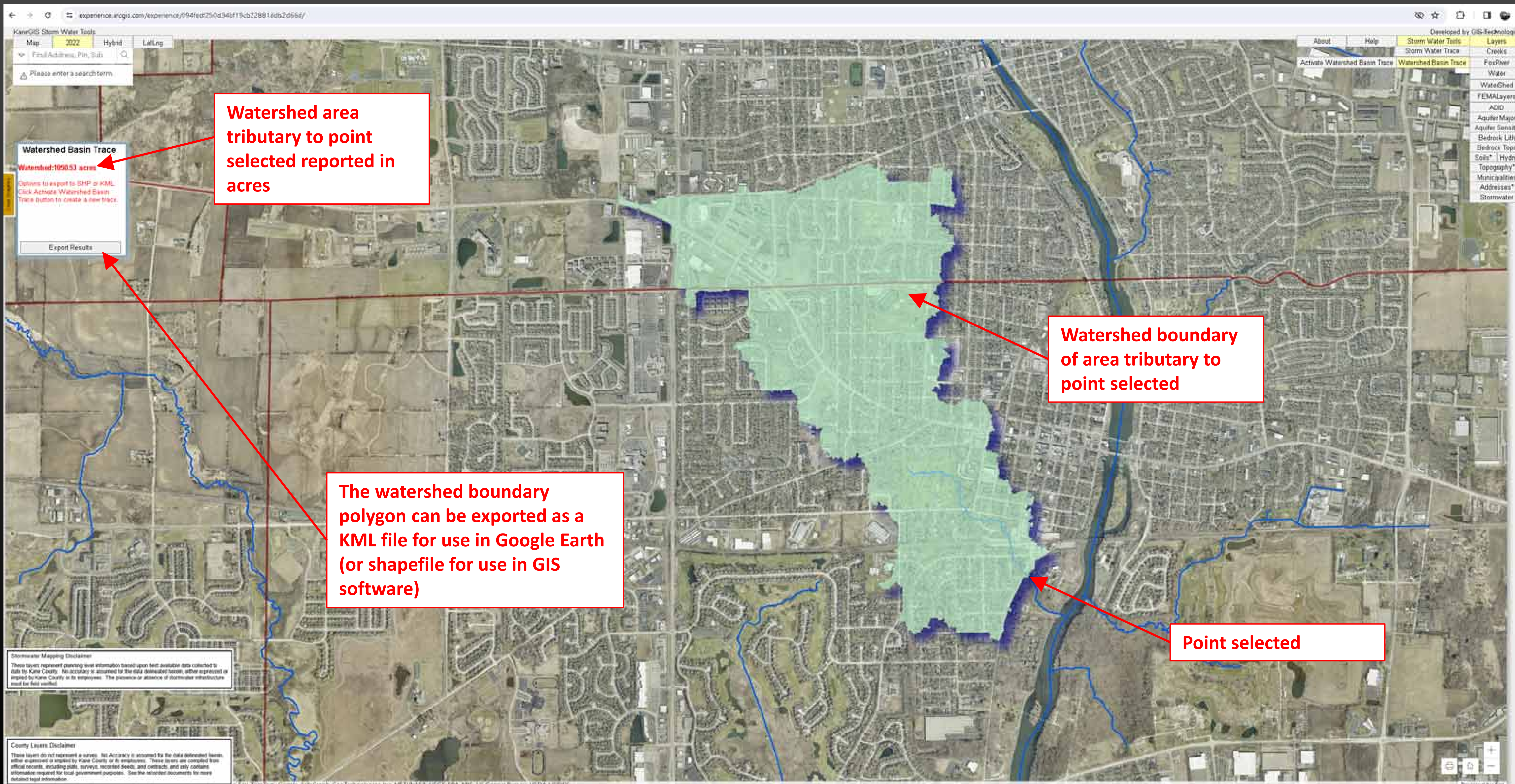
Using the stormwater mapping data compiled by KCDEWR, Kane County GIS Technologies Department has created a Watershed Tracing Tool which allows a user to map the land area draining to any point in the County. This tracing tool takes into account all channels, culverts, and known storm sewers across the entire county. Accessing the tool on the Stormwater Viewer is outlined in the accompanying slides.

Watershed Delineation Tool



Watershed Delineation Tool

Watershed Delineation Tool



Watershed Delineation Tool

Building a Stormwater Digital Twin & Sharing it with Practitioners and the Public will:

- Expedite solutions to current urban flooding problems
- Provide tools & data to help prevent future flooding exacerbated by changing climate conditions
- Allow for better assessment of current and proposed water quality BMPs to maximize their effectiveness
- Allow for better assessment of the true impacts of past and future development decisions.
- Allow for the public to be better informed about the impacts of their choices on the water that they (and the local environment) depend on

Nippersink Creek at dawn
Photo by Ray Mathis

Questions?

Rob Linke, P.E., CFM
Kane County Dept of Environmental
& Water Resources
Linkerobert@KaneCountyIL.gov **phn. 630-232-3498**

Appendix:
Stormwater Infrastructure Mapping & Tools Guide

Real-time Demonstration of Mapping Tools