November 13, 2018

Illinois All-Hazards Transportation System

Vulnerability Assessment

Technical Subcommittee on Risk Management

What is the Purpose?

Update the 2003 Assessment to….

- Include natural hazards threats (previous focused on terrorist threats)
- Develop a geospatial hazard database
- Incorporate a climate change risk factor

What was the role of the Stakeholder Group?

What relevant data is out there?

ICC Crossings Data

Illinois Structure Information System

DHS Freedom Data

USGS Seismic Mapping

National Flight Data Center

Illinois Roadway Information System

What natural hazards should be prioritized?

Earthquakes

Thunderstorms

Flooding

Landslides

Drought

What Transportation Assets?

Corridors (Road & Rail)

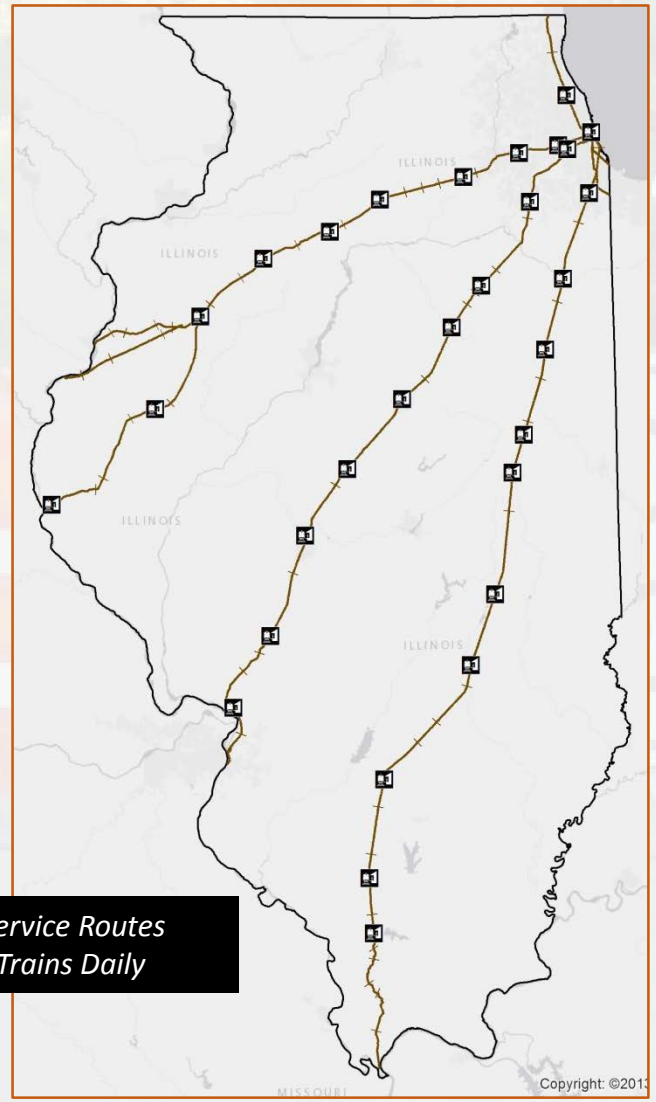
Bridge Infrastructure

Operations (Road)

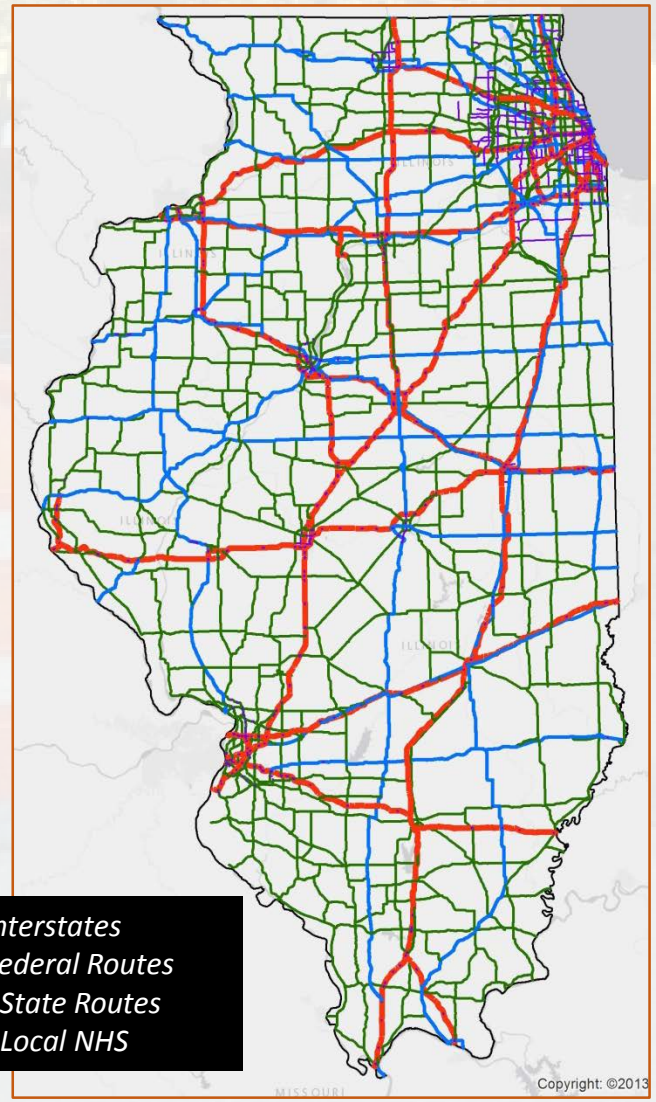
Hubs

What Transportation Assets?

Corridors (Road & Rail)

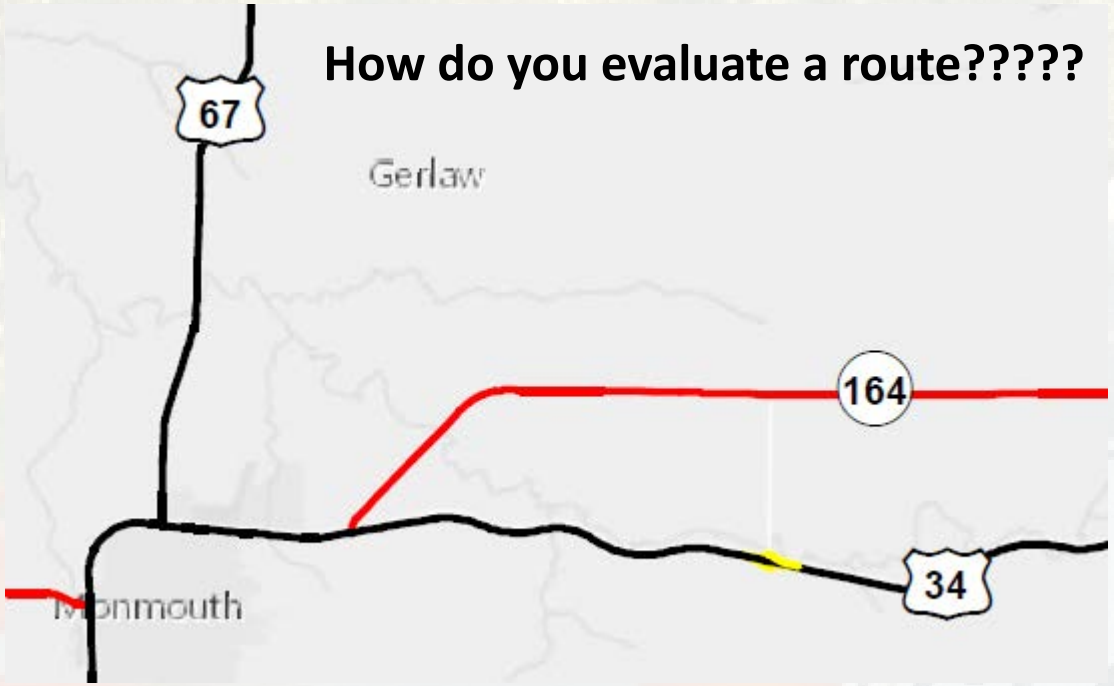


14 Service Routes
~55 Trains Daily



23 Interstates
26 Federal Routes
155 State Routes
300 Local NHS

What Transportation Assets?



What Transportation Assets?

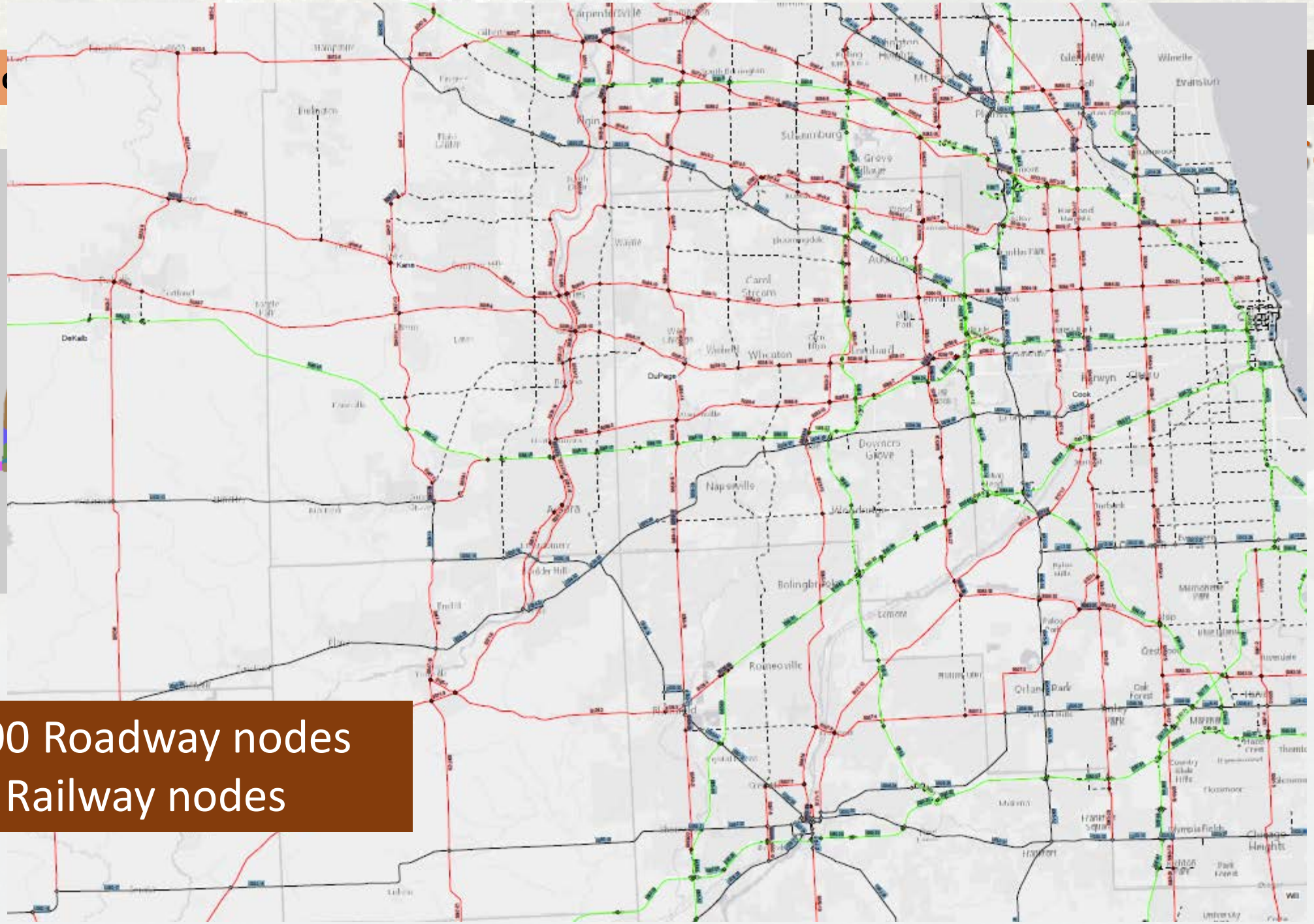
GIS tracks road segments by change in road features

Define rules on what makes a road or rail **'Node'**

Then name them all….

Review o

sets?



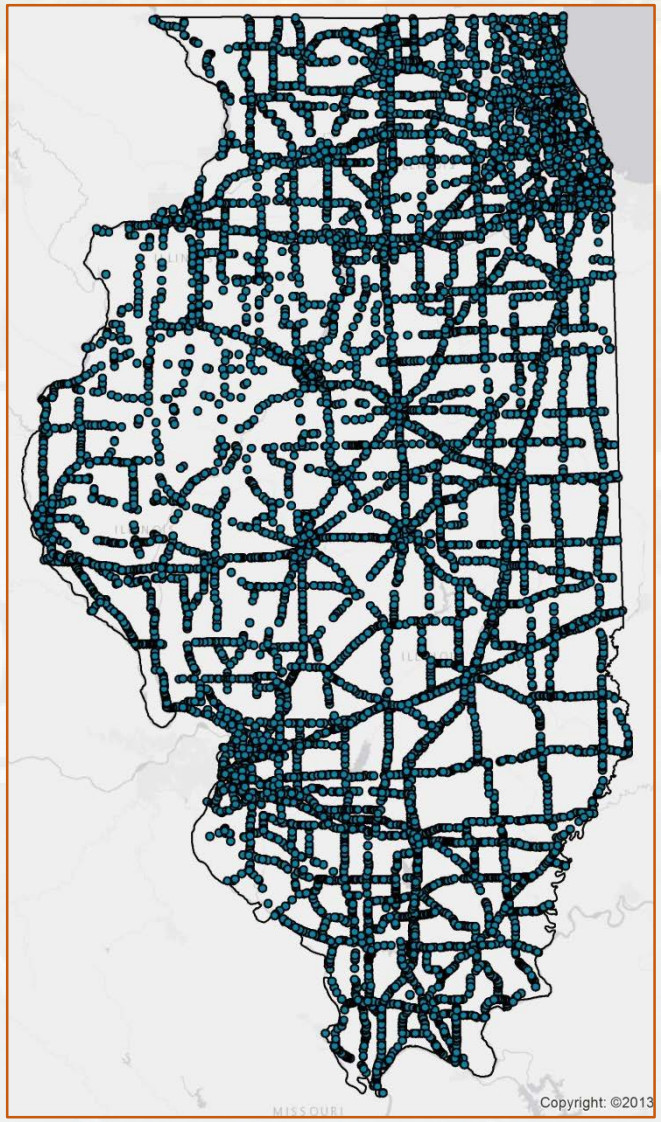
~6,100 Roadway nodes
~150 Railway nodes

What Transportation Assets?

Bridge Infrastructure

~14,500 Bridges*

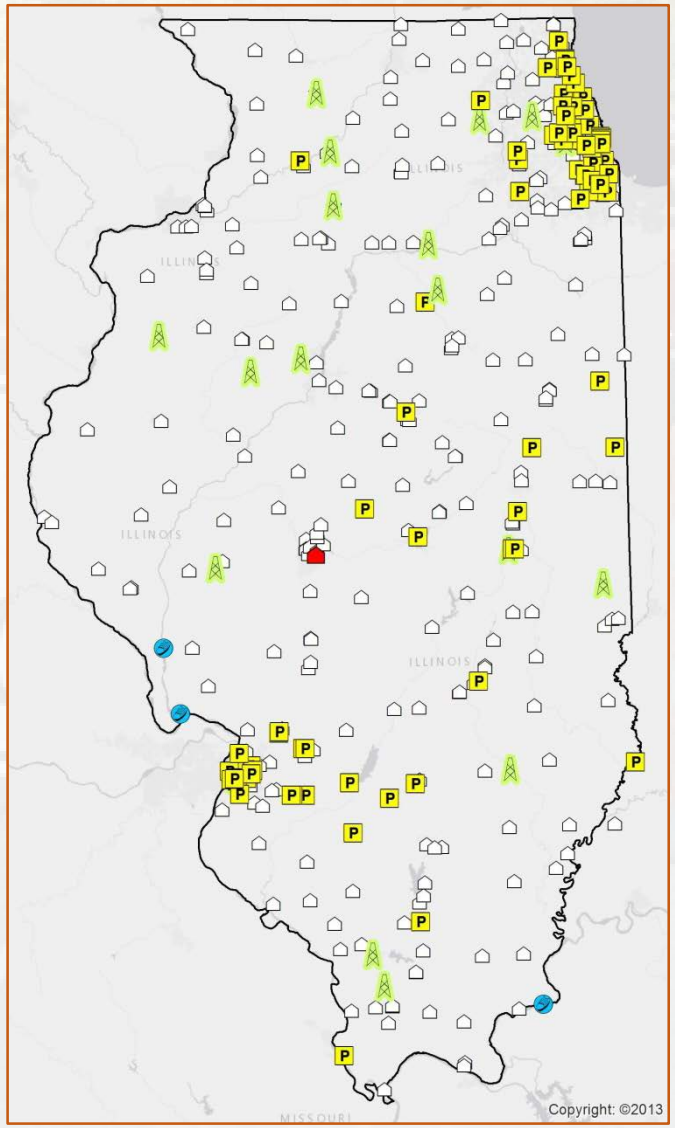
- *Includes bridges & culverts*
- *Includes structures on and over any corridor*



What Transportation Assets?

Operations (Road)

~400 *Properties*



- Rest Areas
- Weigh Stations
- Communication Towers
- Ferries
- Pump House
- Maintenance Yards
- Headquarter Buildings
- Storage Facilities
- Salt Domes

What Types of Hazards?

Manmade

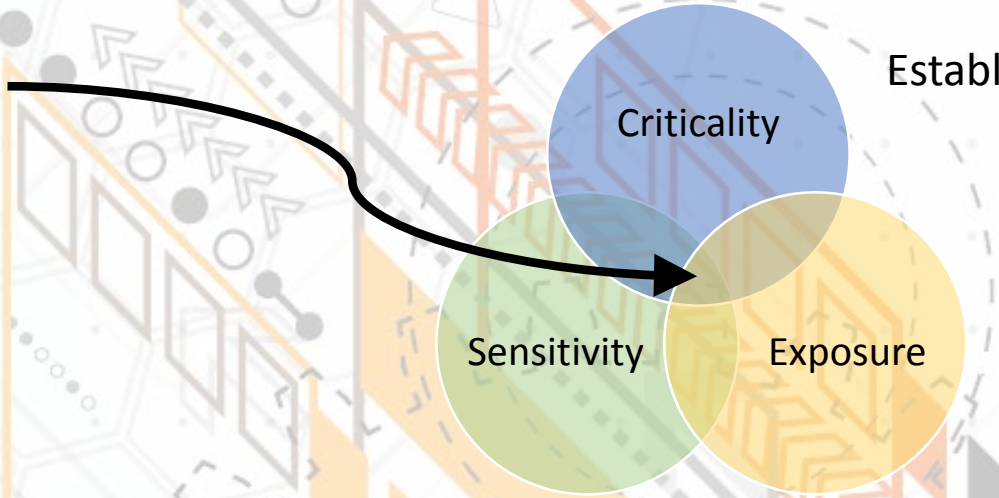
CBRN
Explosives
Small Arms Attack
EMP
Cyber-Attack (Physical)

Natural

Precipitation
Flooding, Snow, Ice
Temperature
F/T, Extreme Heat/Cold
Wind
Tornado & Straight-Line
Geologic
EQ, Landslide, Sinkholes, Subsidence

How were the Assets Evaluated?

Multiple Assessment Products



Each step acts as a separate cog

Establish how important the assets are,

Establish how at risk the assets are now,

Establish how at risk the assets may be in the future

- Criticality Index
- Risk Index
- Vulnerability Index

Review of Assessment

How important is an asset relative to the system it supports?

Criticality Index

Three Independent Measures for each Asset Category

(1) Operational
The immediate impact the asset infrastructure has to the function of the transportation system relative to other parts of the network if lost. Assets such as a bridge or pump house are considered as a whole, while roadways and rail lines are considered as segments of the whole. These variables are intended to measure redundancy or impedances in the system.

(2) Socioeconomic
The ability of the asset infrastructure to affect the local, regional, or national economic movement of goods and services, access to employment centers, and the social characteristics of the local community relative to other parts of the network. These variables measure contributions to community function.

(3) Health and Safety
The potential role asset infrastructure plays during emergency or hazardous situations relative to other parts of the network. These variables measure secondary value.

Examples

Operational
- What is the volume it supports
- What is the volume it handles
- What is the functional level

Socioeconomic
- How much commerce does it support
- Is there intermodal access
- What is the population surrounding

Health & Safety
- Can it serve to assist an evacuation
- Is it important for national defense
- Does it support a role in emergency services

Roadway Node

Node Name	OPR	SOC	H&S	Total
I024-001	17	5	6	**28.0**
I024-002	15	6.5	3	**24.5**
I024-003	15	8	3	**26.0**
I024-004	15	8	3	**26.0**
I024-005	15	3.5	2.5	**21.0**
I024-006	15	4.5	3	**22.5**

Asset scores were categorized into 1 of 4 Criticality Classes, each asset group had their own scoring ranges

How important is an asset relative to the system it supports?

Criticality Index

....asset groups were interconnected and had to be ran in a specific order.

1) Bridges

2) Corridors

3) Operations

Roadway Node

Node Name	OPR	SOC	H&S	Total
I024-001	17	5	6	**28.0**
I024-002	15	6.5	3	**24.5**
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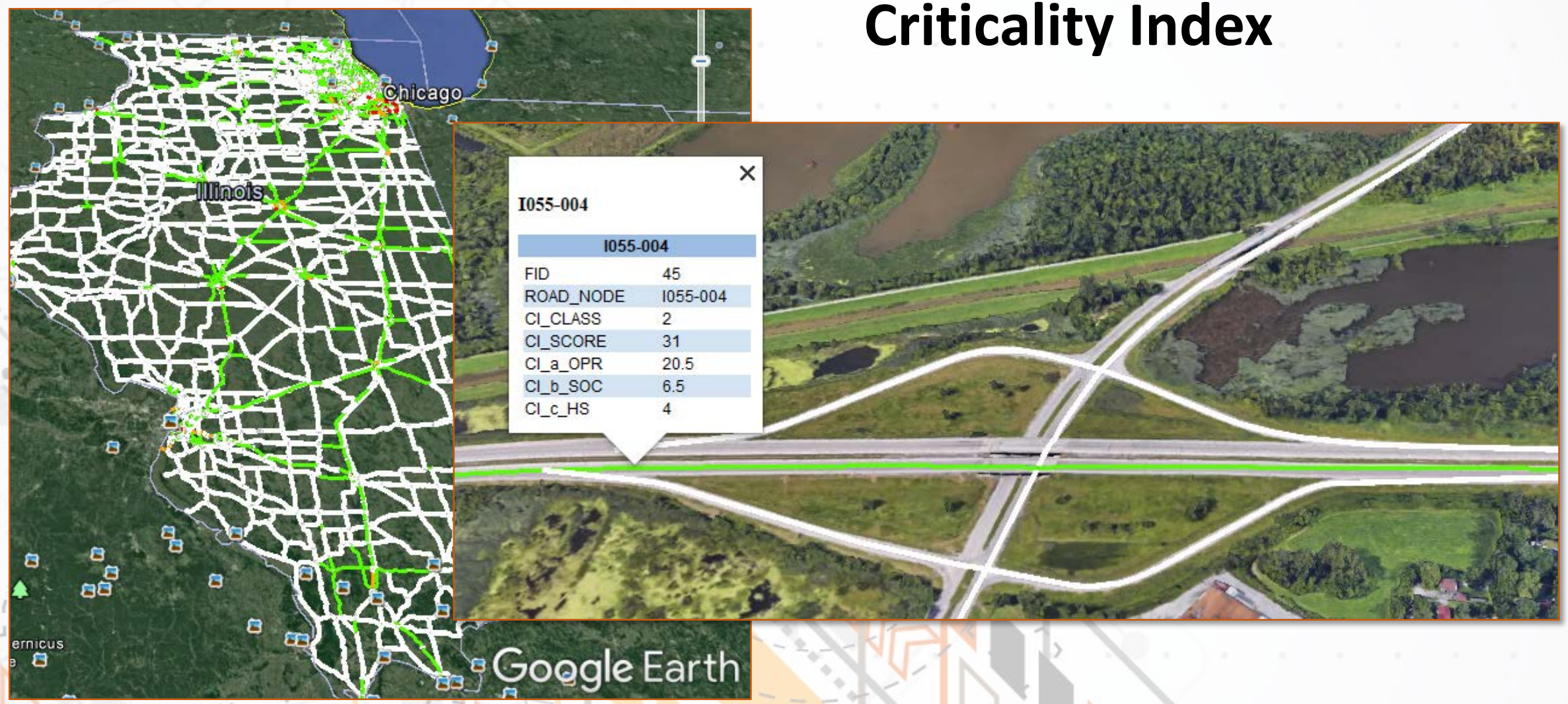
Asset scores were categorized into 1 of 4 Criticality Classes, each asset group had their own scoring ranges, but…

How important is an asset relative to the system it supports?

Criticality Index



*How <u>exposed</u> is the asset to a given hazard, **AND** how <u>sensitive</u> is the asset to the hazard if exposed?*

Risk Analysis

Can the hazard pose an eminent threat to an asset type or is it limited to a cumulative maintenance risk?

<u>Catastrophic Damage Impact</u>

- Flooding
- Tornados/Straight-line Winds
- Landslides
- Earthquakes
- Sinkholes
- Subsidence

<u>Cumulative Maintenance Impact</u>

- Snow
- Ice
- Freeze/Thaw
- Extreme Cold
- Extreme Heat

*How exposed is the asset to a given hazard, **AND** how sensitive is the asset to the hazard if exposed?*

Risk Analysis

Why include cumulative hazards?

Budgets are built on current operational maintenance costs…

Risk Analysis

Exposure & Sensitivity

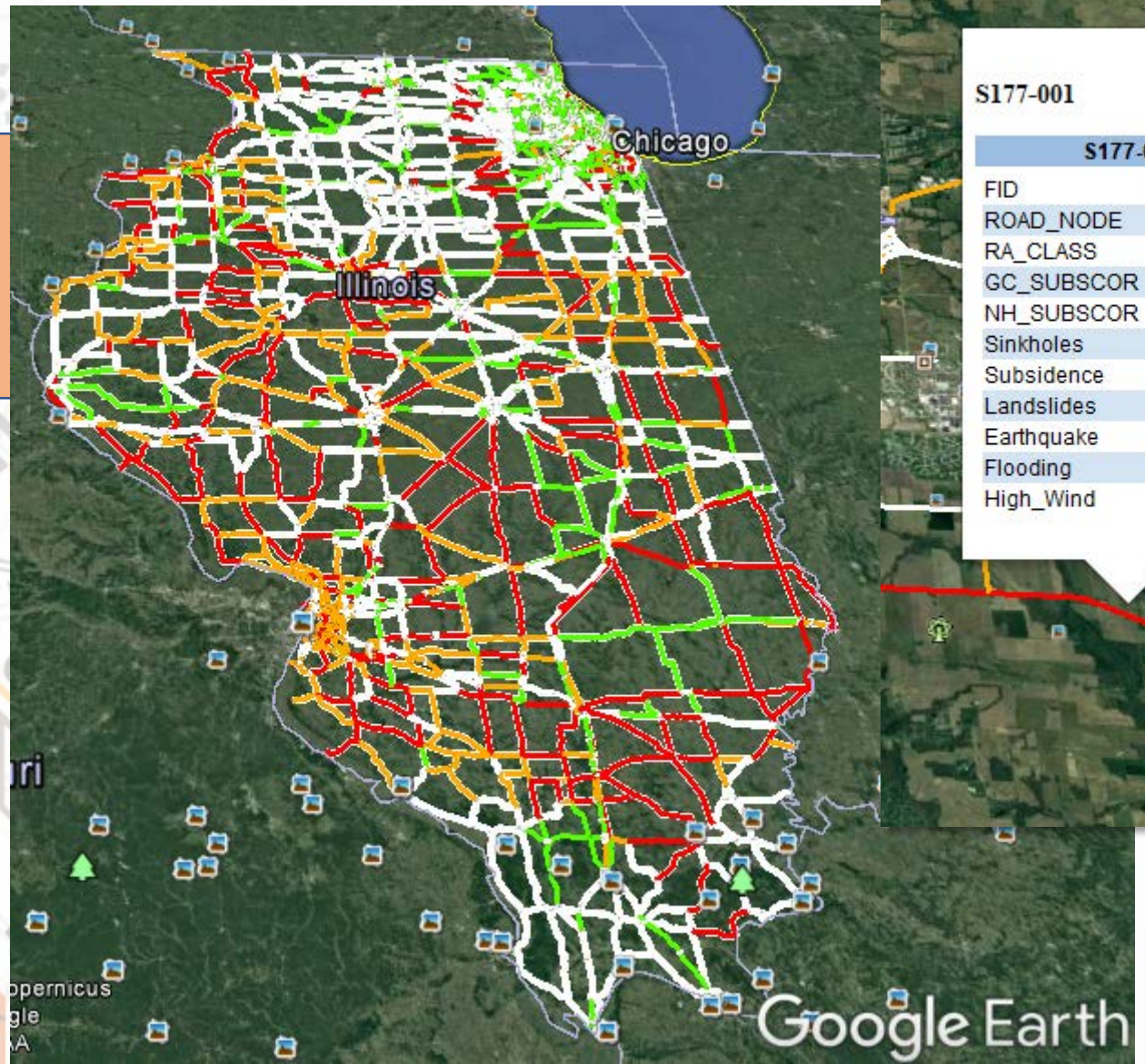
Class 1.	Low Risk	Low Sensitivity / Low Exposure
Class 2.	Medium-Low Risk	High Sensitivity / Low Exposure
Class 3.	Medium-High Risk	Low Sensitivity / High Exposure
Class 4.	High Risk	High Sensitivity / High Exposure

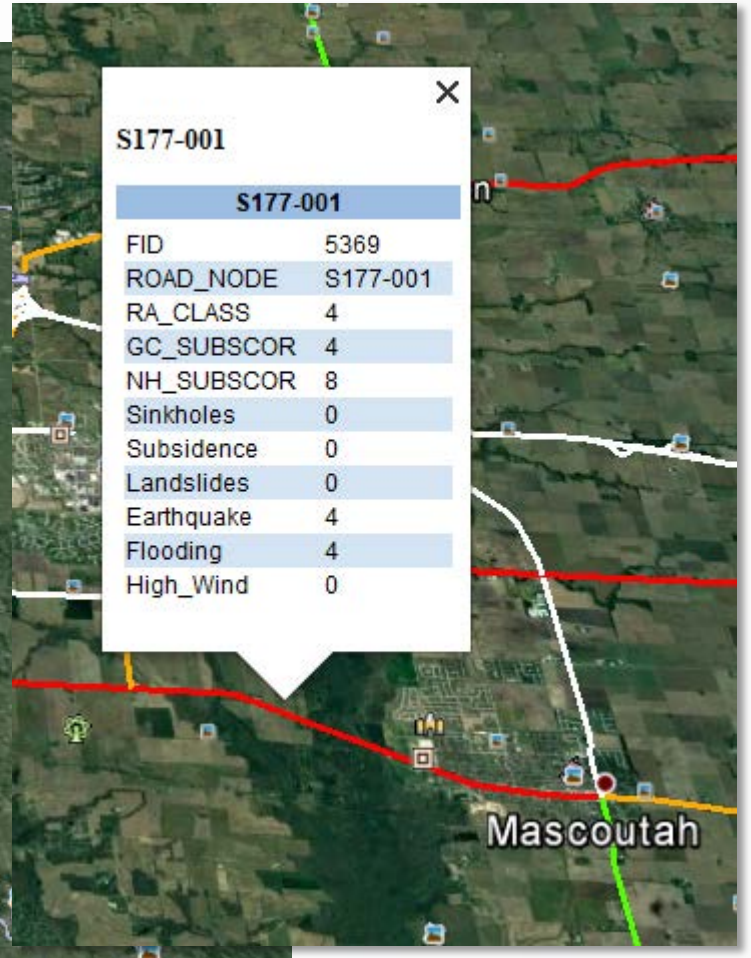
Catastrophic Damage Impact

- Flooding
- Tornados/Straight-line Winds
- Landslides
- Earthquakes
- Sinkholes
- Subsidence

Review of Assessment

Class 1.	Low Risk
Class 2.	Medium-Low Risk
Class 3.	Medium-High Risk
Class 4.	High Risk





Now…… *…..In the Future?*

Criticality Class & Risk Class merge to form the Vulnerability Index

$$\text{Vulnerability Index} = \left\lfloor \frac{(\text{Criticality Class} + \text{Risk Class})}{2} \right\rfloor$$

Class 1.	Low Vulnerability
Class 2.	Medium-Low Vulnerability
Class 3.	Medium-High Vulnerability
Class 4.	High Vulnerability

Now……

Example Breakdown of Road Resources

		Criticality		Risk		Vulnerability		*% Distribution*	
	Nodes	Class 3	Class 4	Class 3	Class 4	Class 3	Class 4	%Class 3	%Class 4
District 1	2,487	131	108	173	96	87	3	*43.7%*	*50.0%*
District 2	590	7	5	192	67	23	1	*11.6%*	*16.7%*
District 3	396	4	0	137	67	17	0	*8.5%*	*0.0%*
District 4	496	5	3	184	70	18	1	*9.0%*	*16.7%*
District 5	429	9	2	26	16	3	0	*1.5%*	*0.0%*
District 6	430	4	2	60	41	11	0	*5.5%*	*0.0%*
District 7	319	5	0	18	38	3	0	*1.5%*	*0.0%*
District 8	658	14	5	296	67	24	1	*12.1%*	*16.7%*
District 9	273	4	0	92	75	13	0	*6.5%*	*0.0%*
	6,078	*183*	*125*	*1,178*	*537*	*199*	*6*	*100.0%*	*100.0%*

.....In the Future?

Which natural hazards are affected by climate change?

Catastrophic Damage Impact

- Flooding
- Tornados/Straight-line Winds
- Landslides
- Earthquakes
- Sinkholes
- Subsidence

Cumulative Maintenance Impact

- Snow
- Ice
- Freeze/Thaw
- Extreme Cold
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Catastrophic Damage Impact

- Flooding
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- Subsidence

Flooding? – Yes

Tornados? – Yes, but

Landslides? – Well…

Sinkholes? – No (in Illinois)

Subsidence? – No (in Illinois)

.....In the Future?

Which natural hazards are affected by climate change?

Cumulative Maintenance Impact

- Snow
- Ice
- Freeze/Thaw
- Extreme Cold
- Extreme Heat

Snow? – Yes

Ice? – Well…

Freeze/Thaw? – Yes

Extreme Cold? – Yes, but

Extreme Heat? – Yes

Vulnerability

.....In the Future?

Change in Vulnerability?

Flooding – Yes

Snow – No

Ice – No

Tornados – No

Freeze/Thaw – Yes

Extreme Cold – No

Extreme Heat – Yes

Landslides – No

Earthquakes – No

Sinkholes – No

Subsidence – No

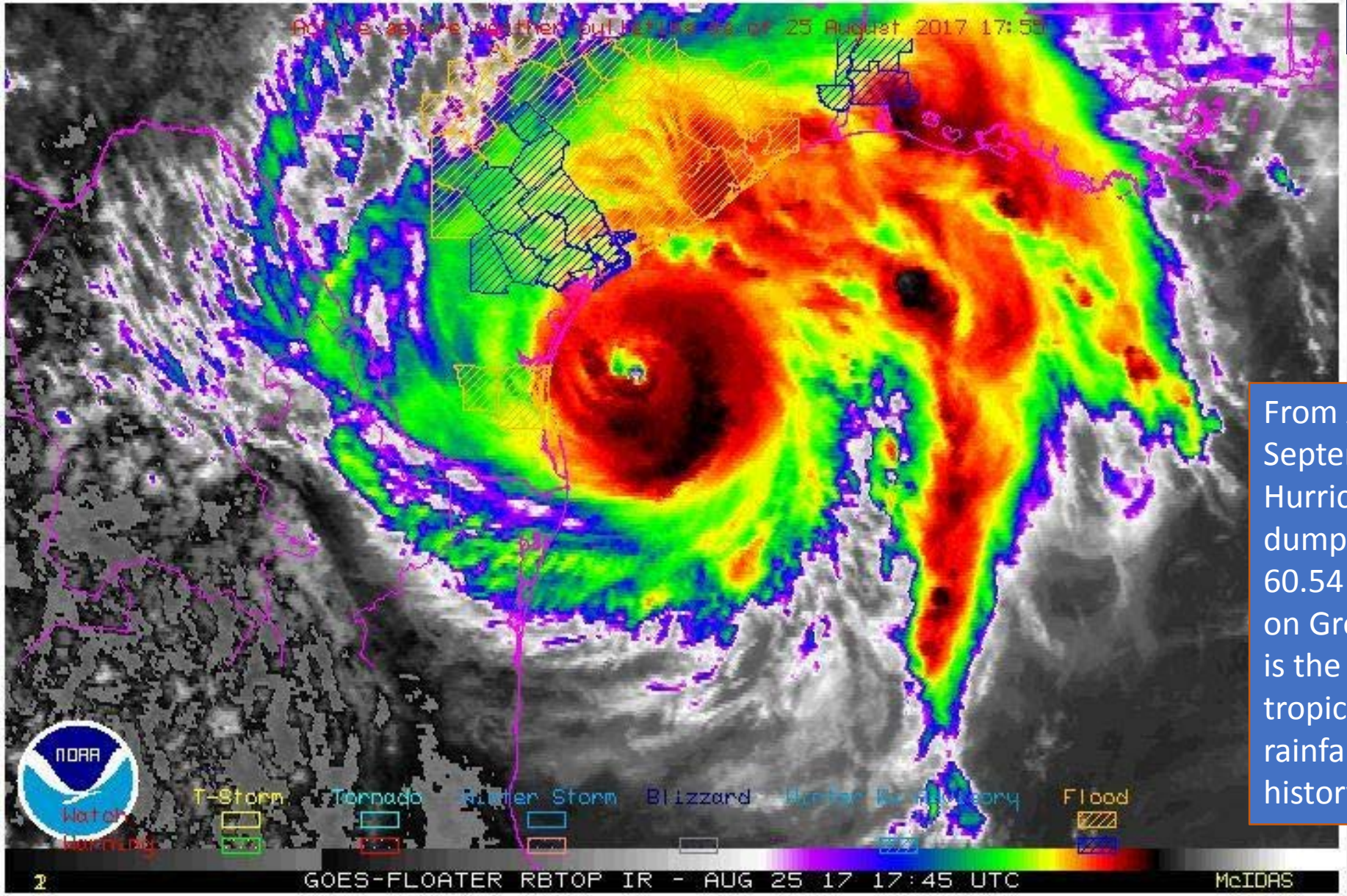
The high points to take away*

We don't have to really wait for climate change, it is already here, we just have to figure out how to calculate the extent in the variability of extreme weather

- Expect a slow transition to a doubling of days above 95 degrees [*Not every year*]
- Expect more days of Freeze/Thaw cycling
- Snow will be on average less, but the need for salt isn't going anywhere
- A small increase in annual precipitation totals, but in a much shorter number of days

**Unless you ask for the details - will spare the charts, graphs, trend analysis, and climate modeling*

.....In the Future?

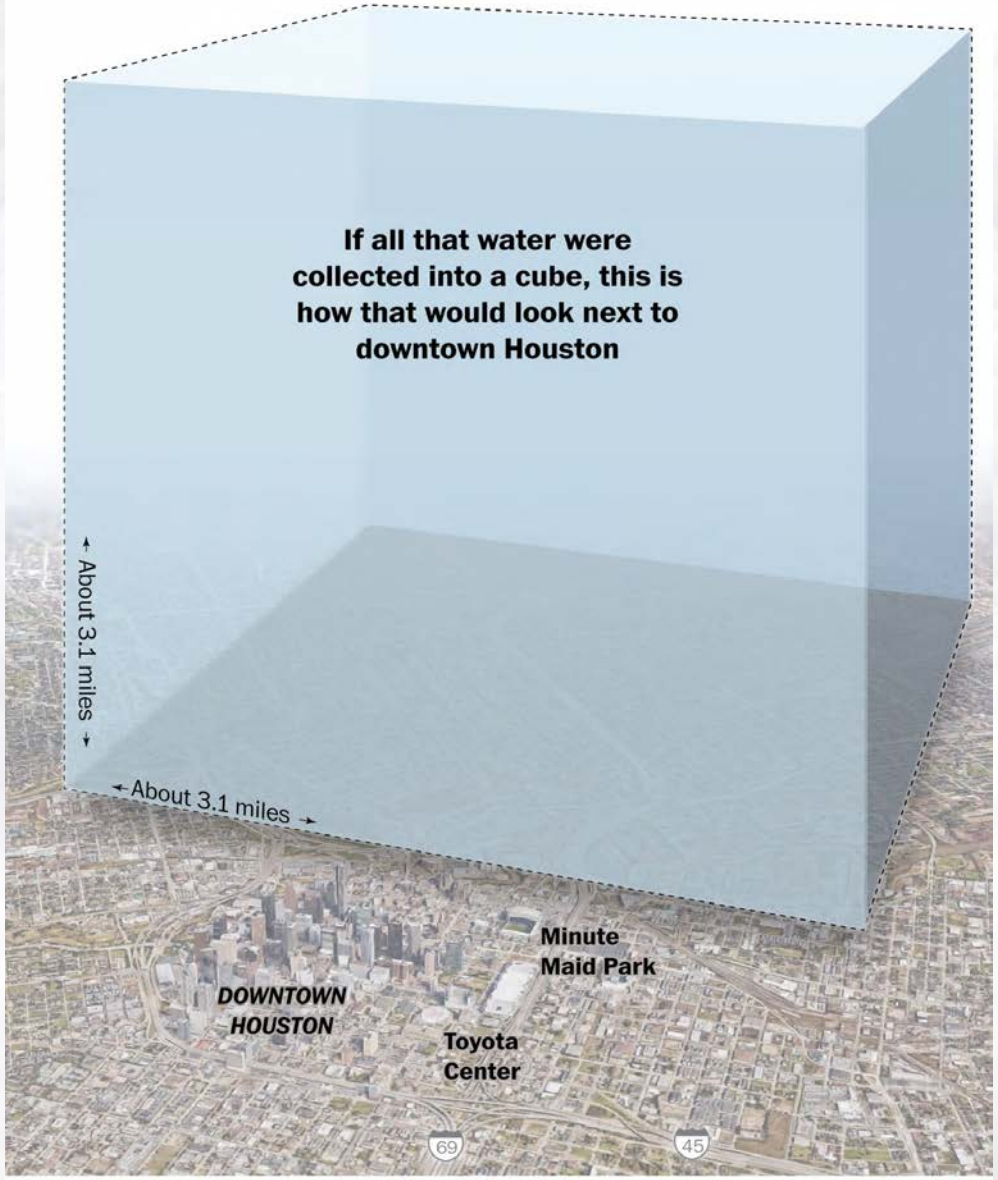


From August 17th to September 1st 2017 Hurricane Harvey dumped a record 60.54 inches of rain on Groves, Texas. This is the most significant tropical cyclone rainfall event in U.S. history.

Vulnerability

What would 33 trillion gallons of water look like?

As of Saturday, Sep. 1, about 33 trillion gallons of rain have fallen along the Gulf of Mexico.



Sources: Ryan Maue, Capital Weather Gang, Google Earth

THE WASHINGTON POST

.....In the Future?

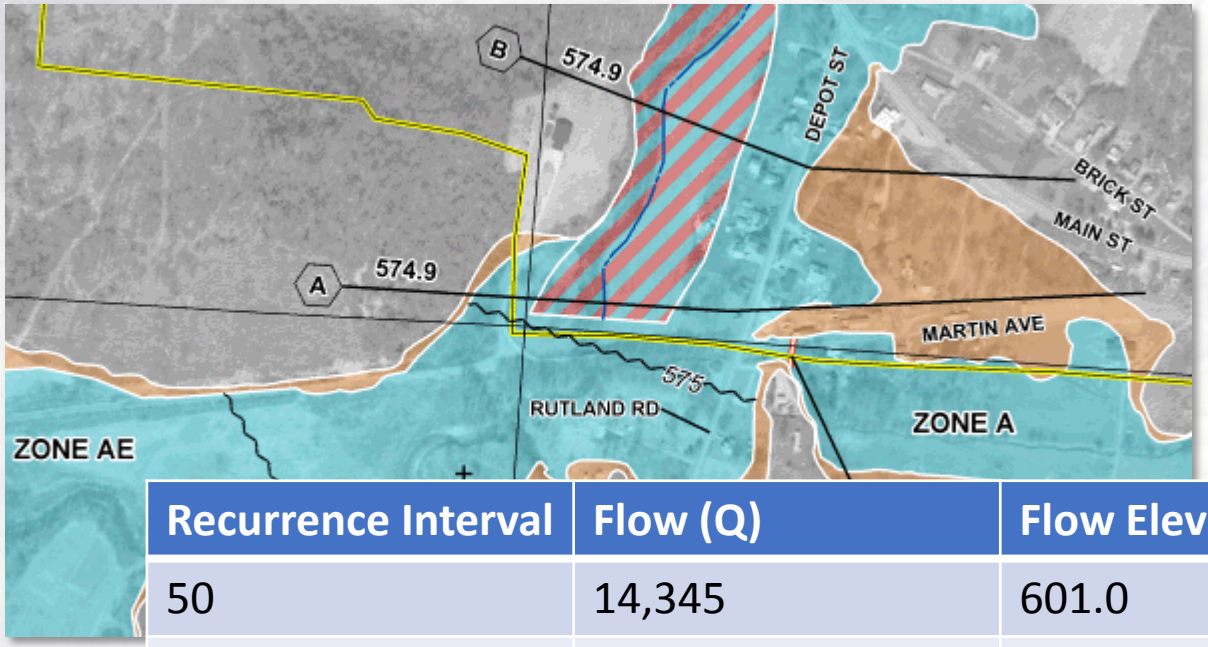
Vulnerability

Flooding

Freeze/Thaw

Extreme Heat

.....In the Future?



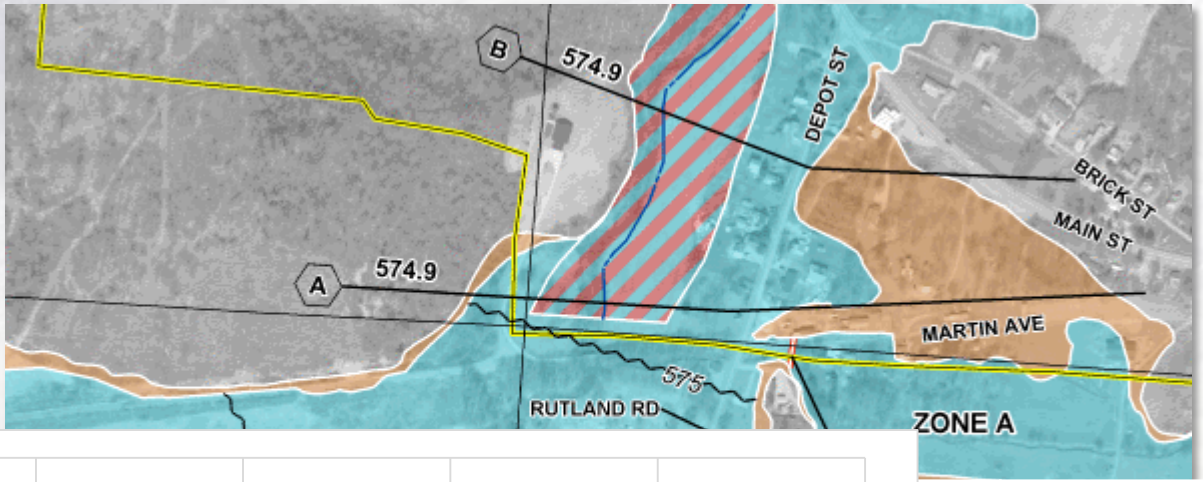
Recurrence Interval	Flow (Q)	Flow Elevation	Stage Elevation
50	14,345	601.0	0.3
100	16,190	601.6	0.9
500	21,320	602.8	2.1

Vulnerability

Flooding

Freeze/Thaw

Extreme Heat



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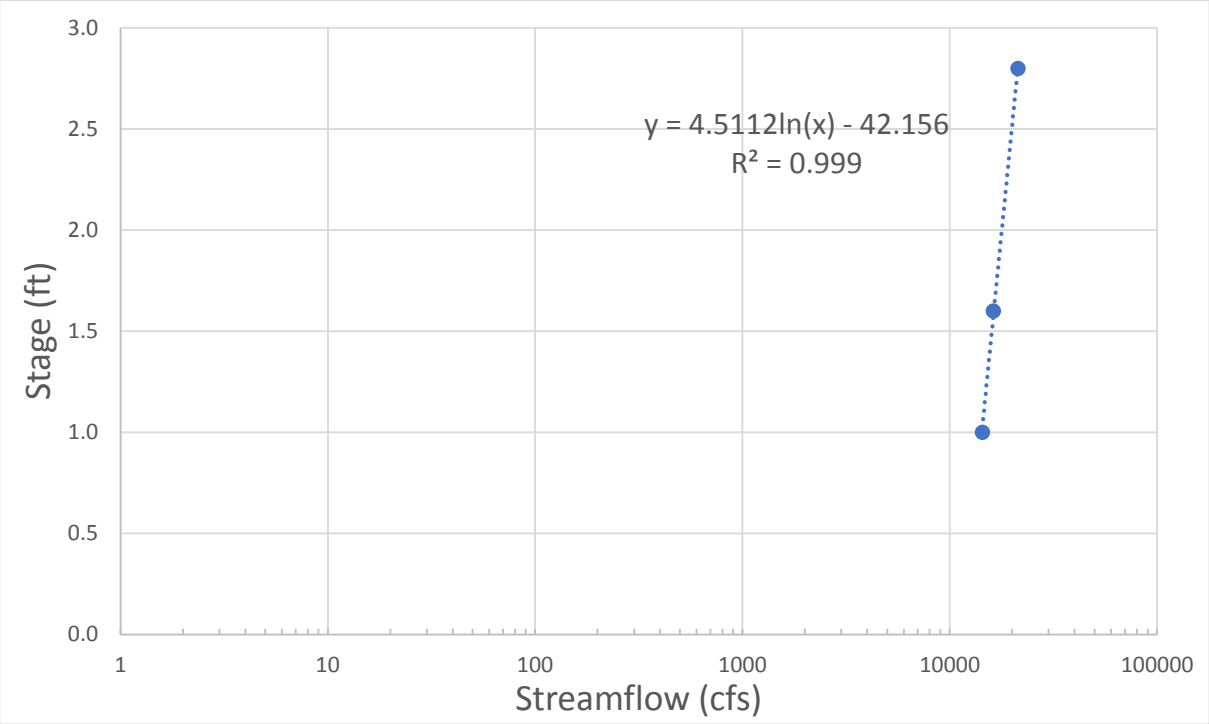


	Flow Elevation	Stage Elevation
	601.0	0.3
	601.6	0.9
	602.8	2.1

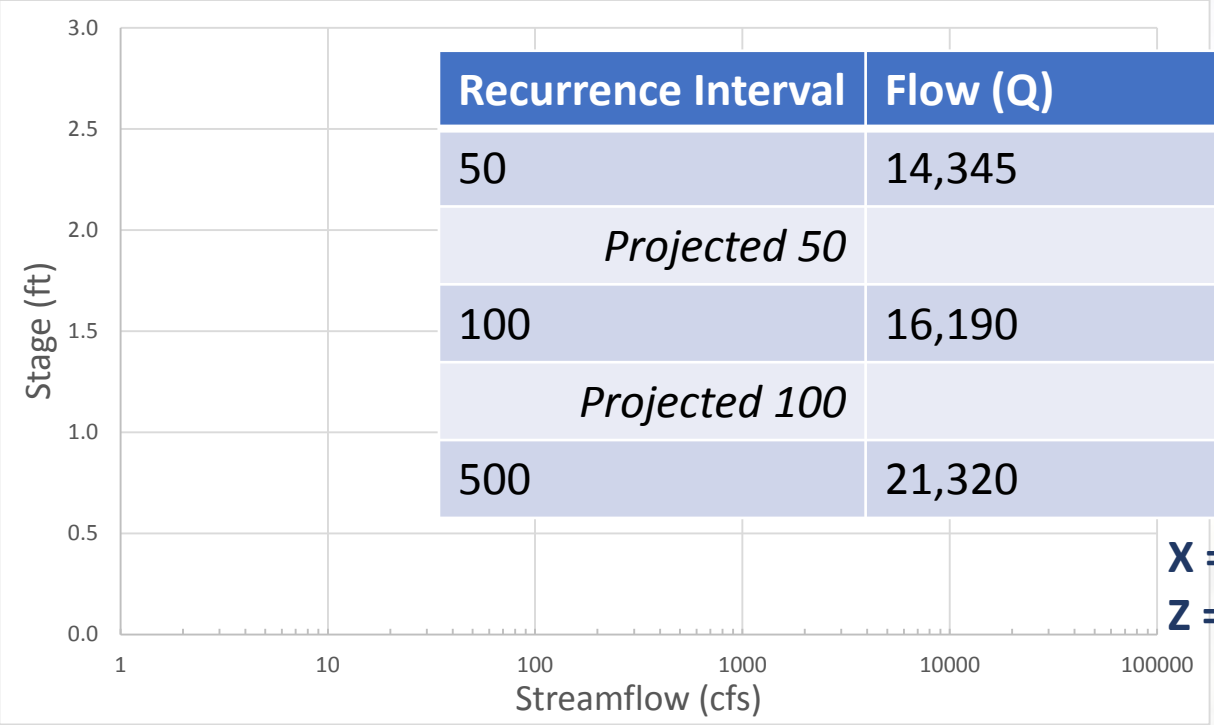
.....In the Future?

Flooding

Freeze/Thaw

Extreme Heat

How do you estimate a projected Q?!?!

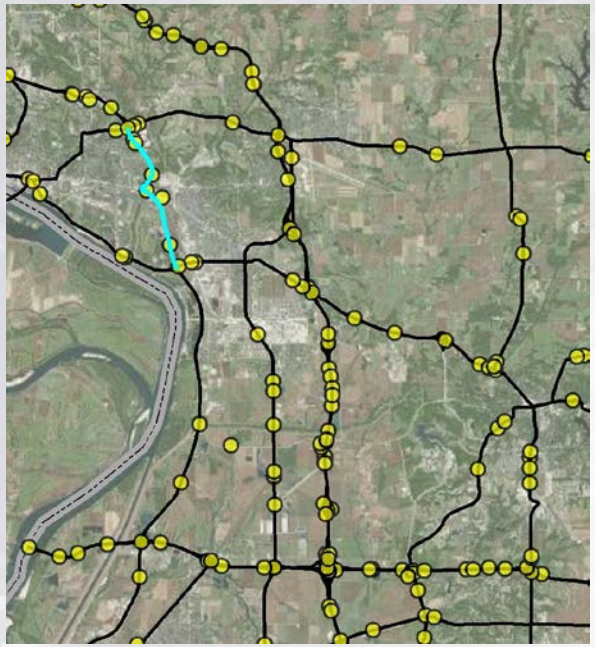


Recurrence Interval	Flow (Q)	Flow Elevation	Stage Elevation
50	14,345	601.0	0.3
Projected 50	X	Z	Z
100	16,190	601.6	0.9
Projected 100	X	Z	Z
500	21,320	602.8	2.1

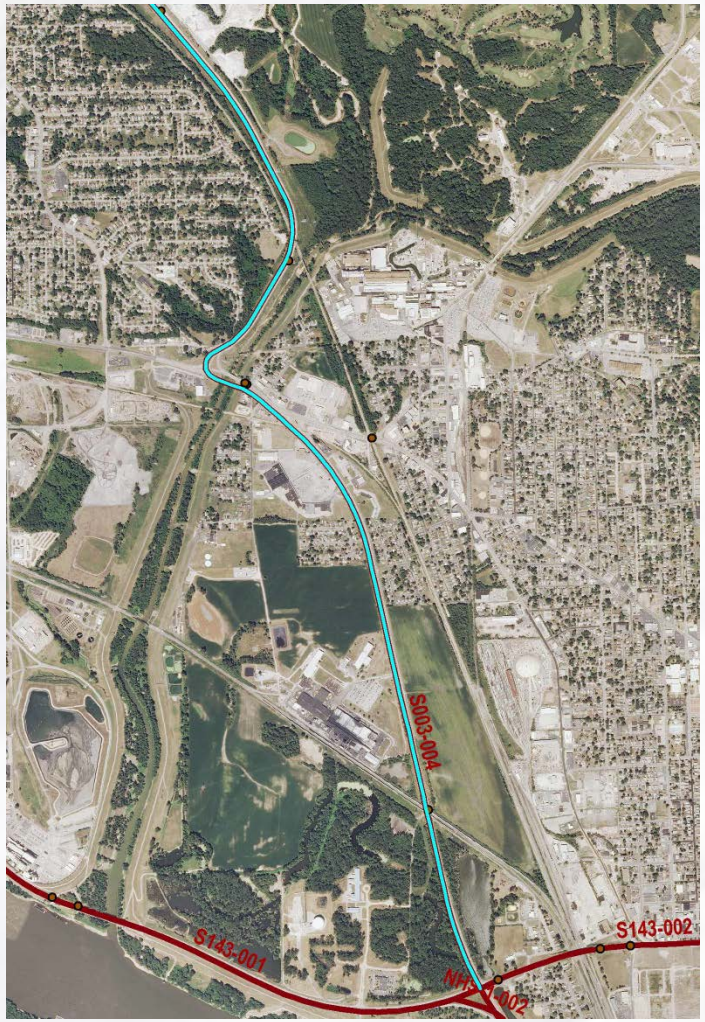
X = Projected change in runoff calculated off climate scenario

Z = Auto-calculated through linear regression equation

Vulnerability



Madison County
East Alton
State Route 3
Node-004
Bridge -060-0228
Over Wood River Creek



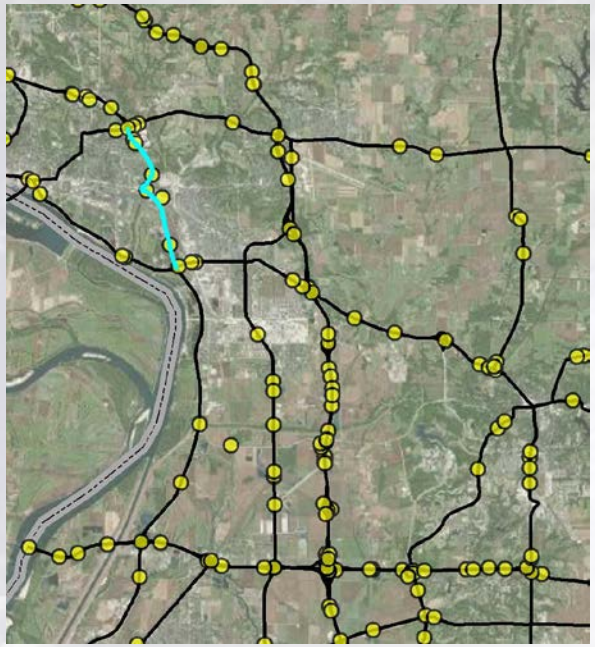
.....In the Future?

2 Factors Necessary

- need to know the bridge hydraulic data
- need to know road elevation (at set intervals)*

**The road segments do need to know what bridge they are associated with though*

Vulnerability



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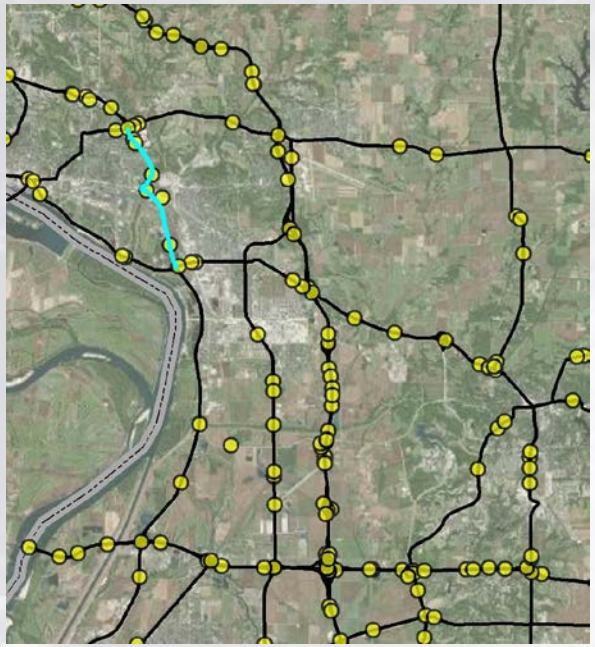
.....In the Future?

Existing Q 100 impact

Vulnerability



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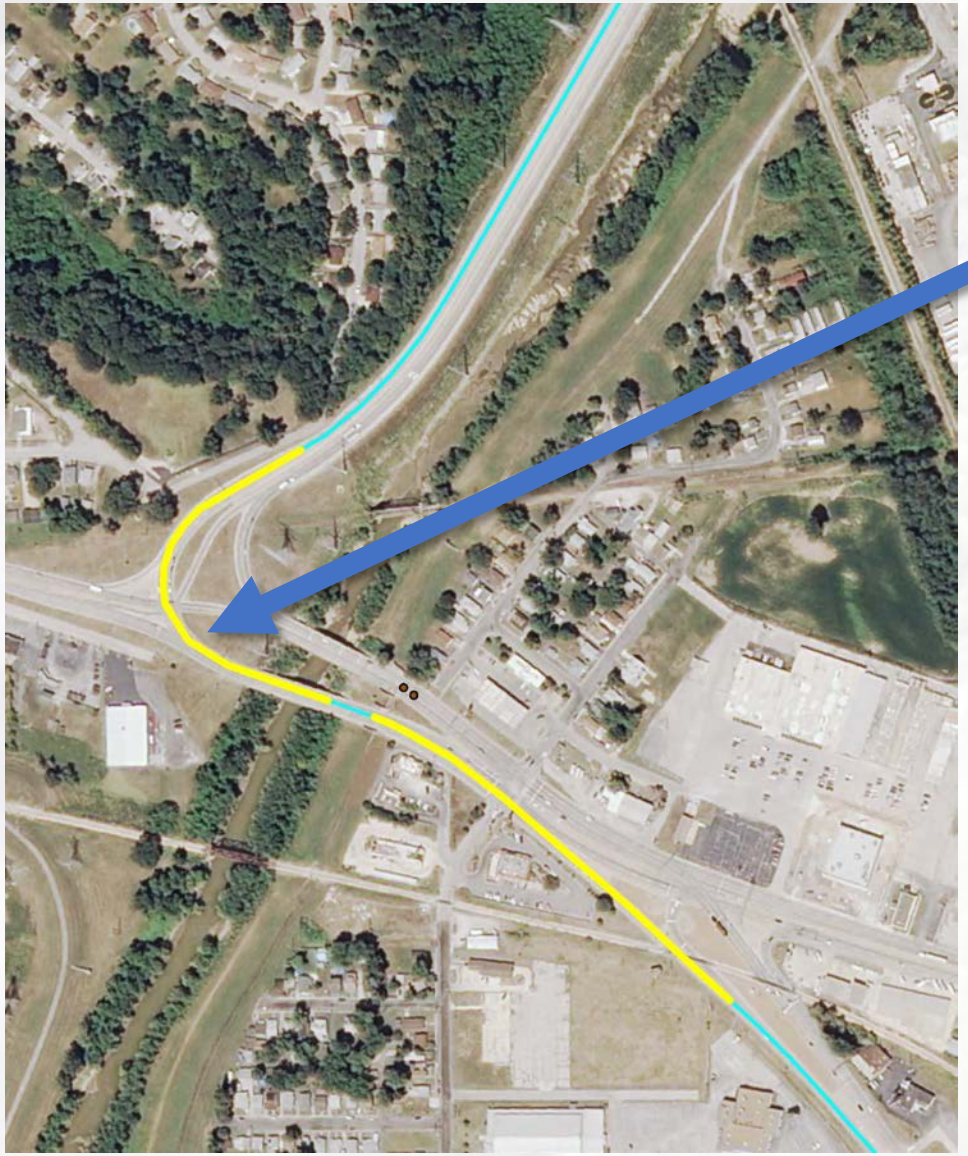
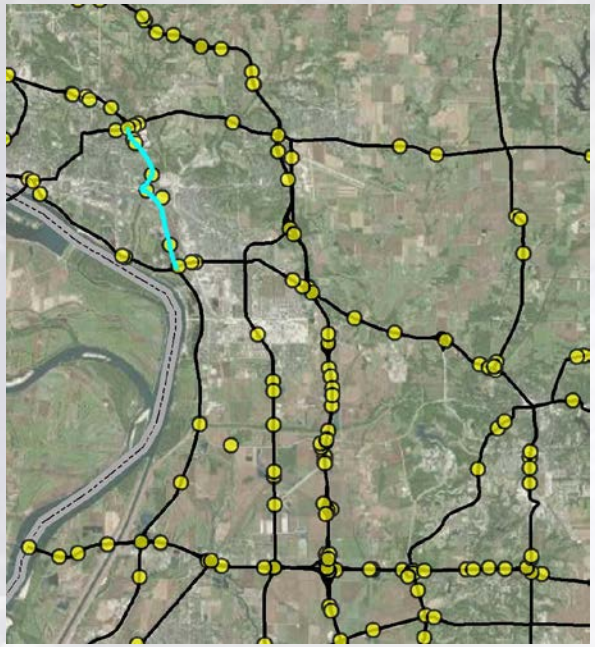


.....In the Future?

3% Q 100 impact

Vulnerability



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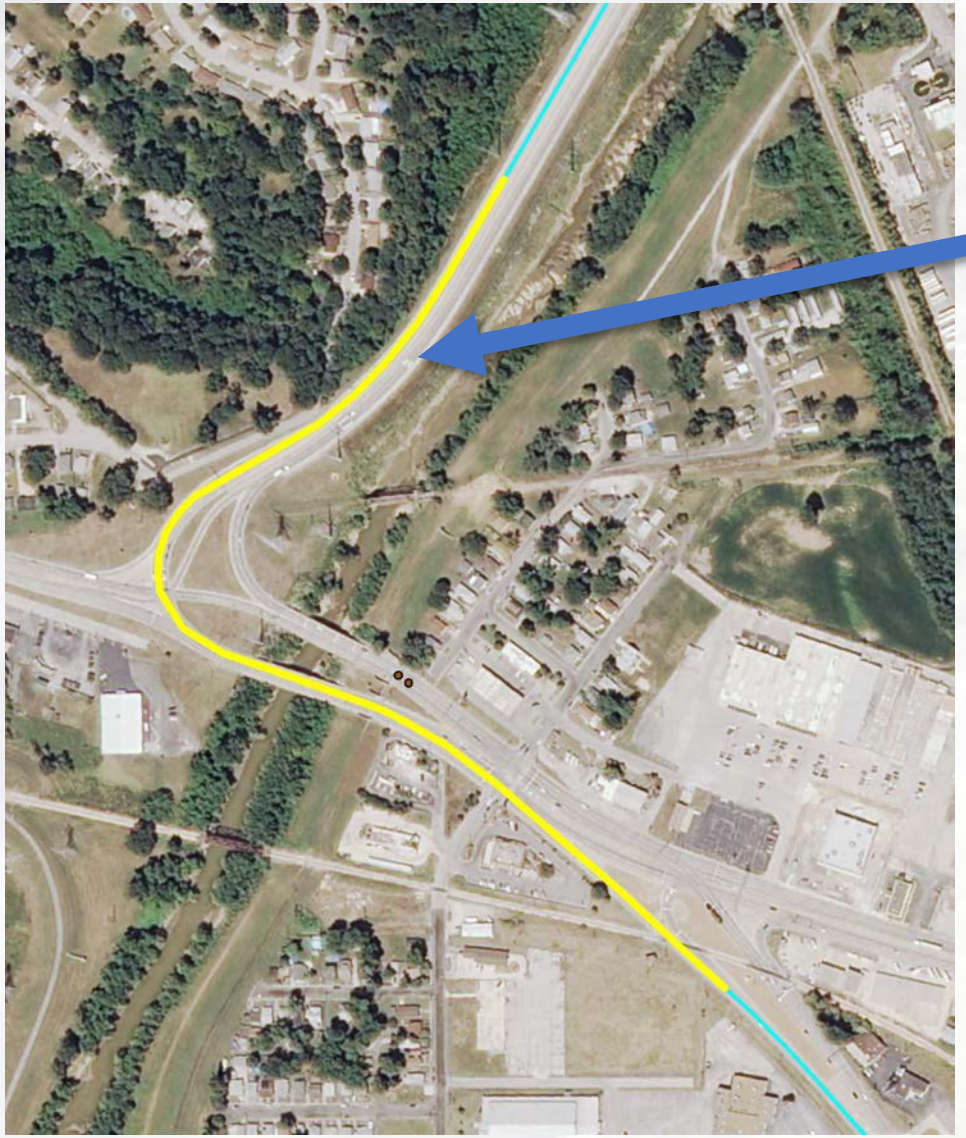

10% Q 100 impact

.....In the Future?

Vulnerability

Flooding

Freeze/Thaw

Extreme Heat

.....In the Future?

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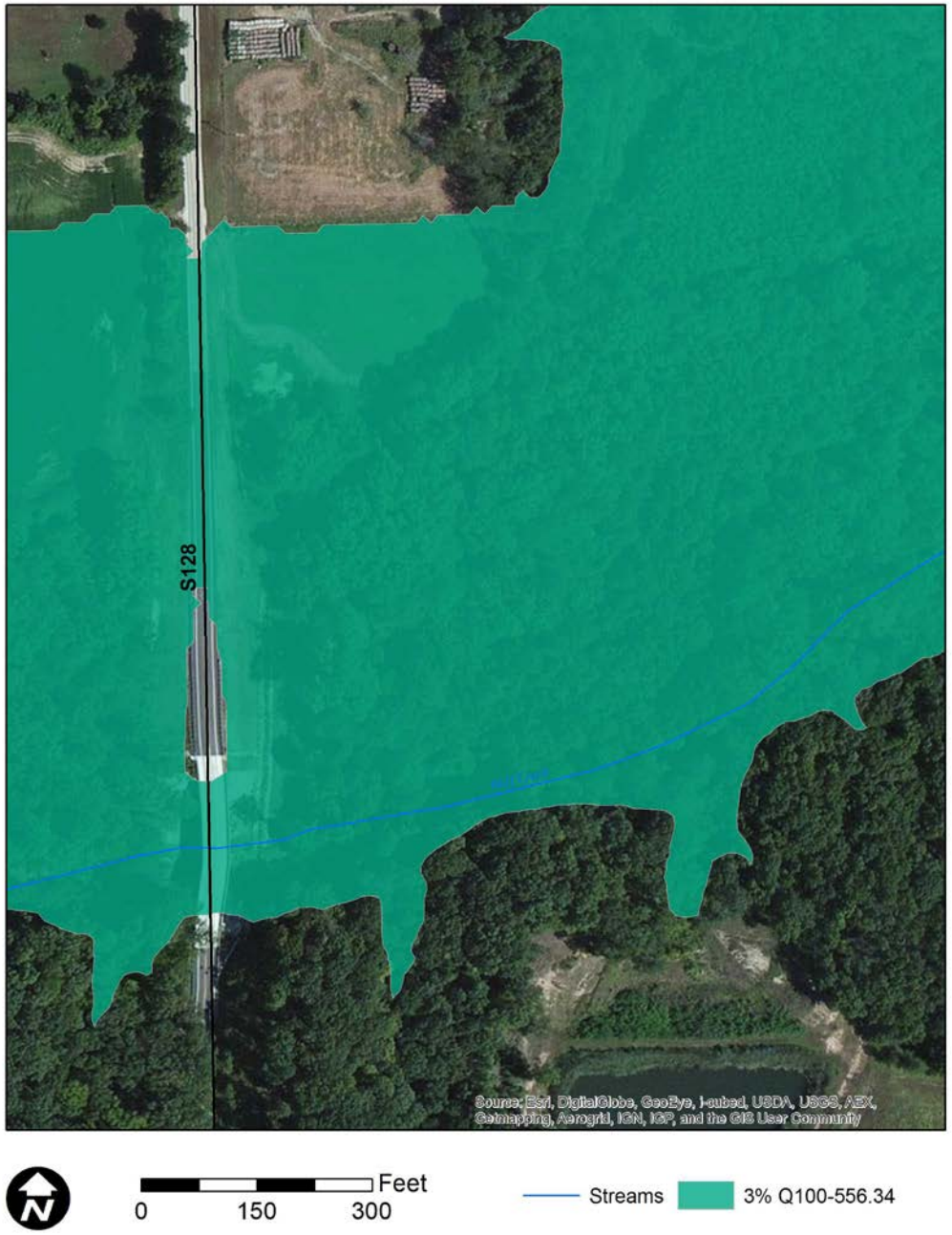
Extreme Heat



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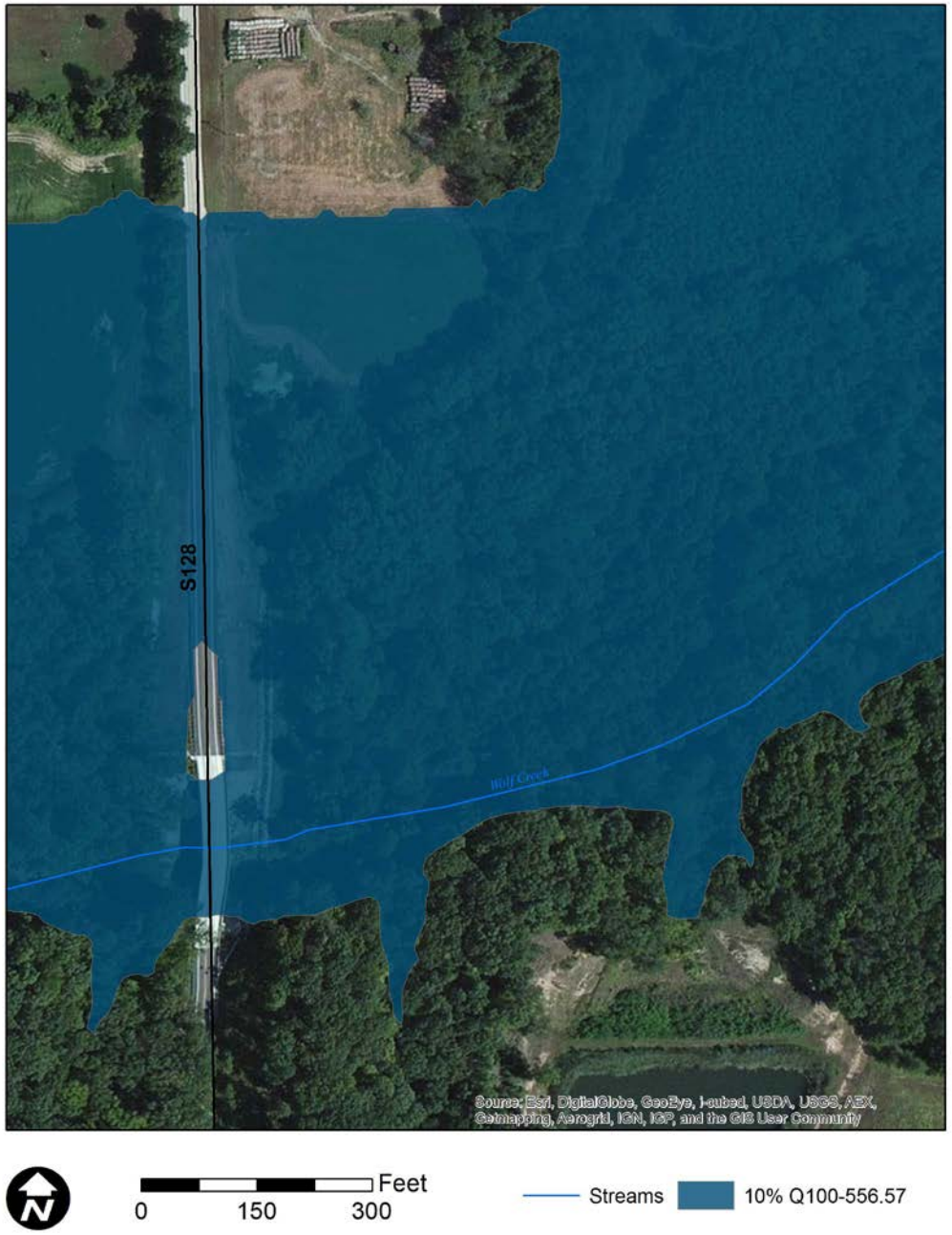

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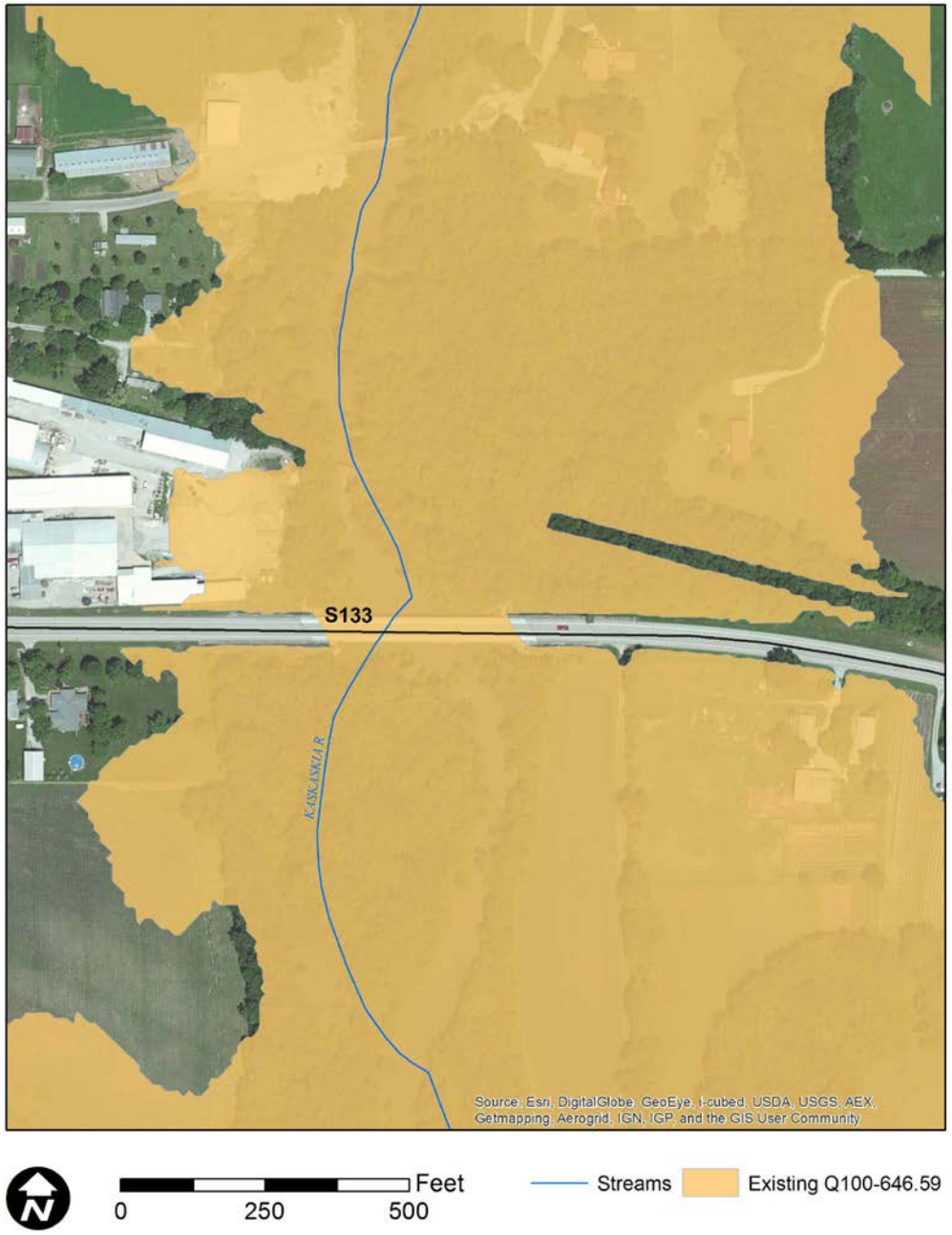

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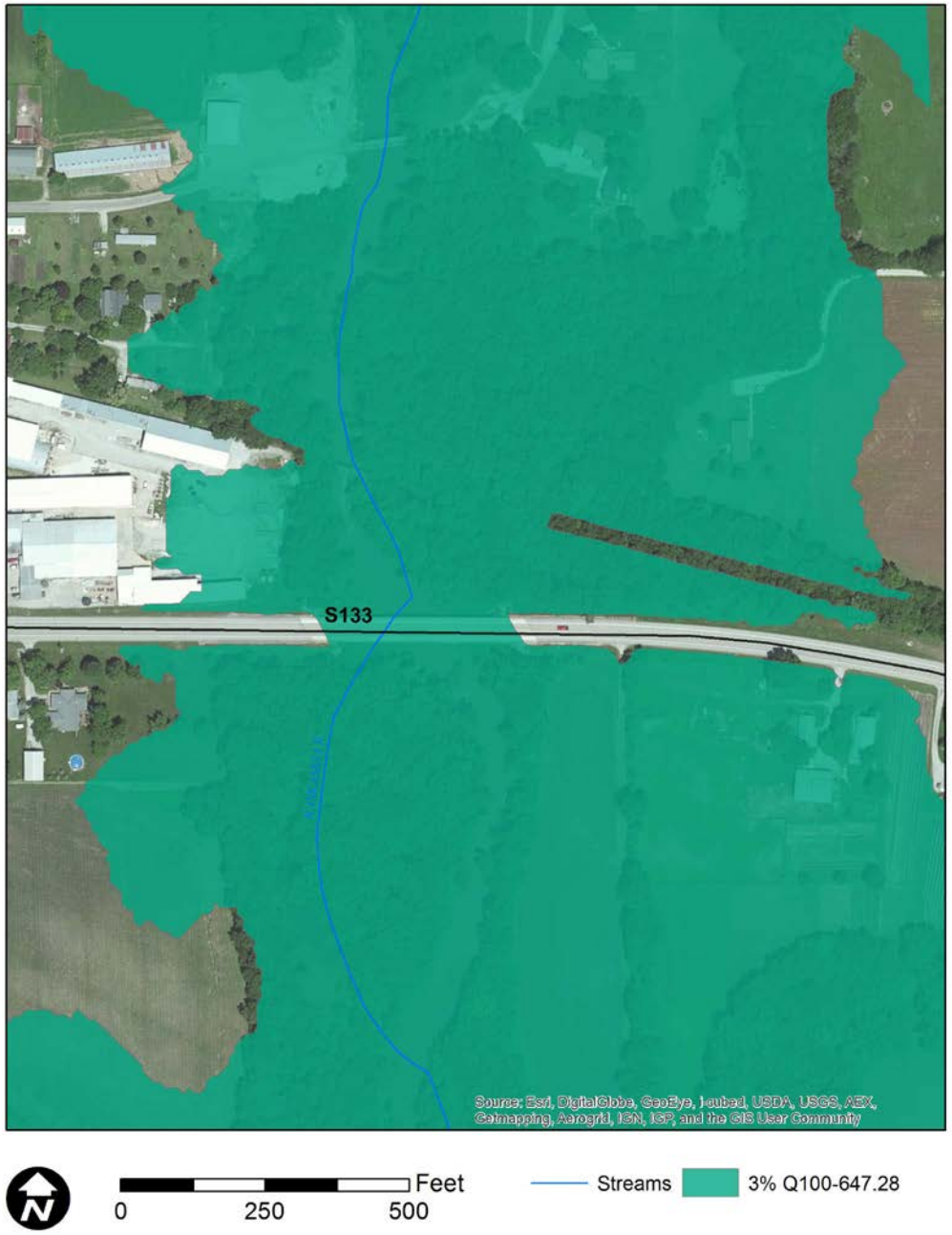


.....In the Future?

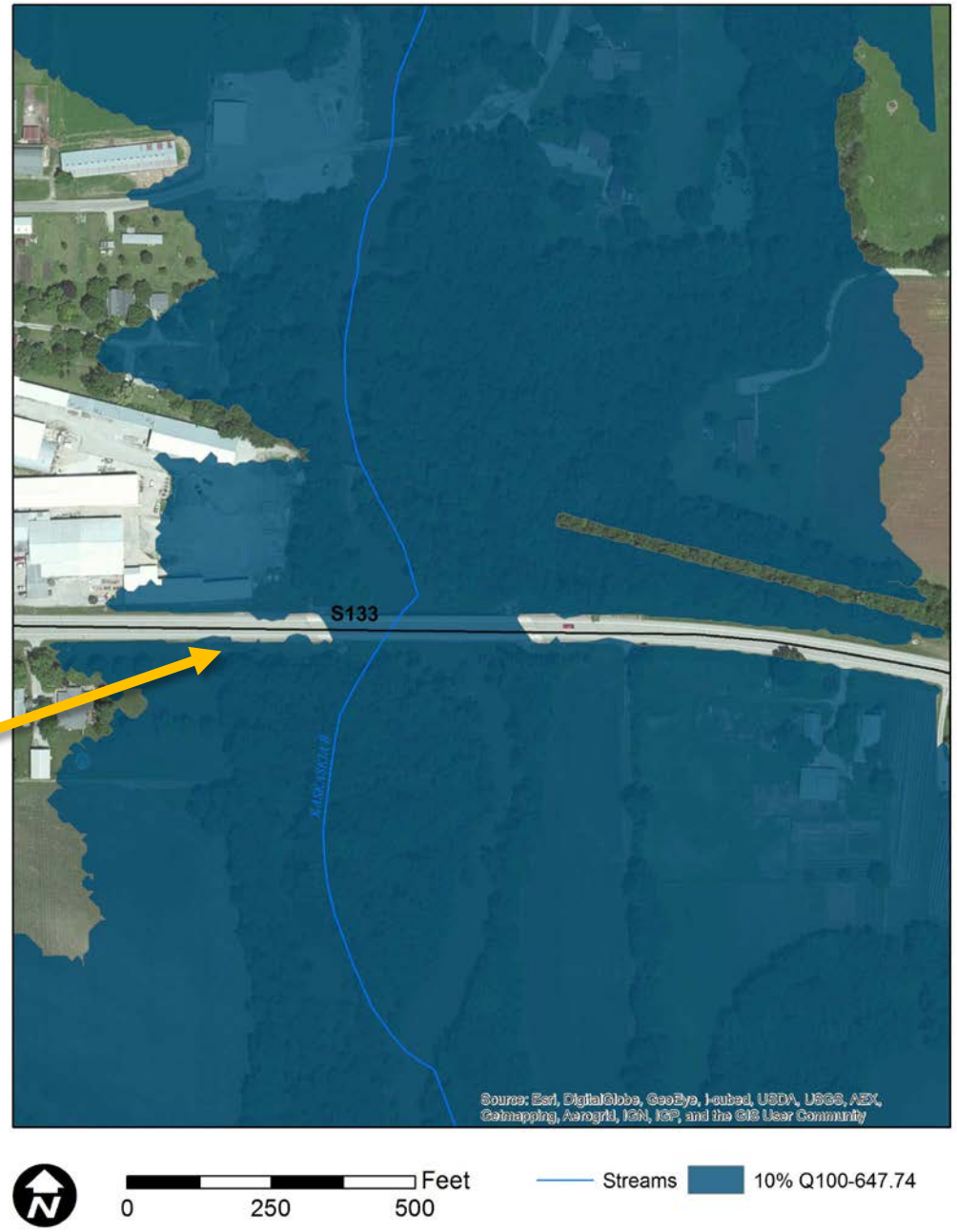
Vulnerability

Flooding

Freeze/Thaw

Extreme Heat

Accuracy of Lidar and road segment data count…



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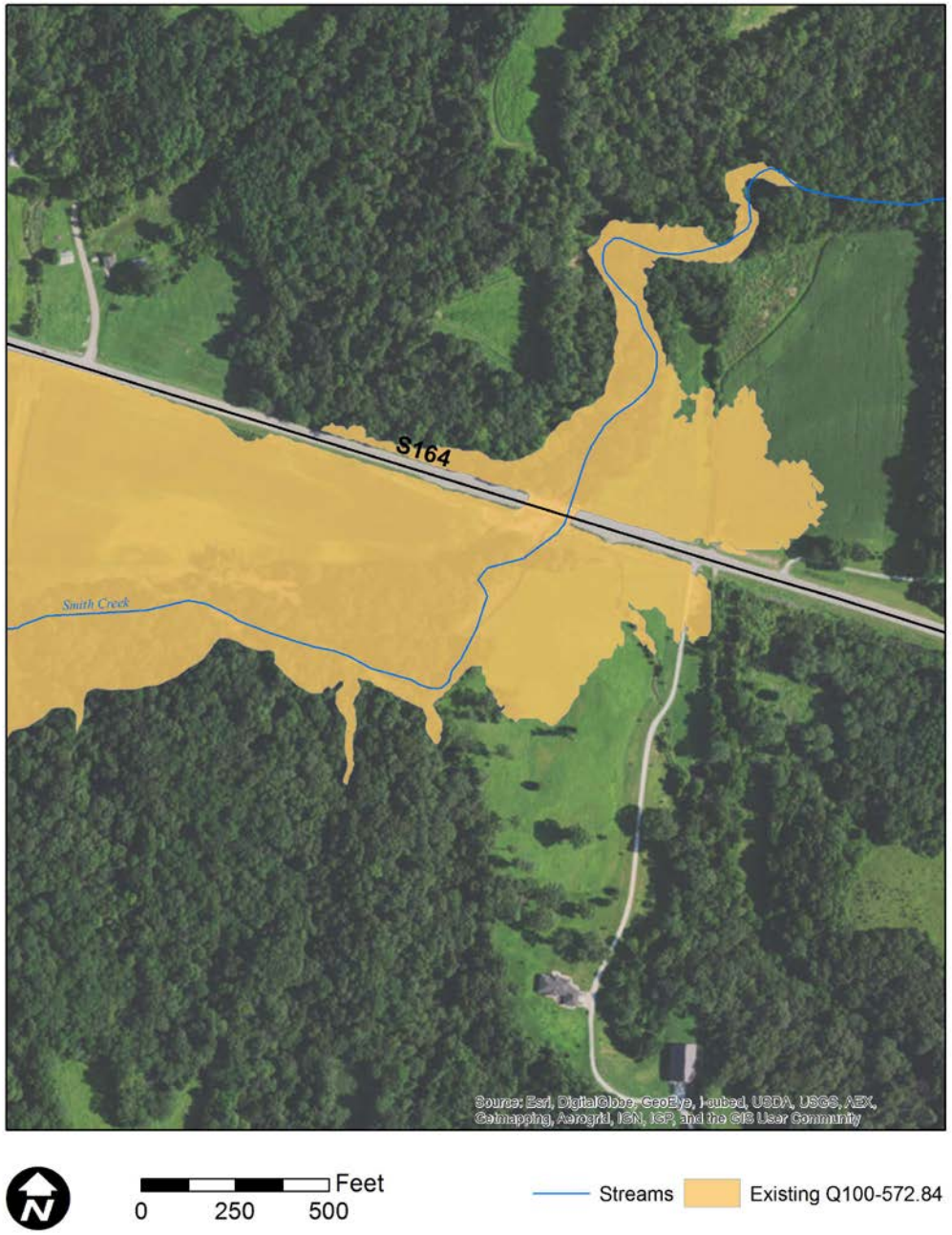

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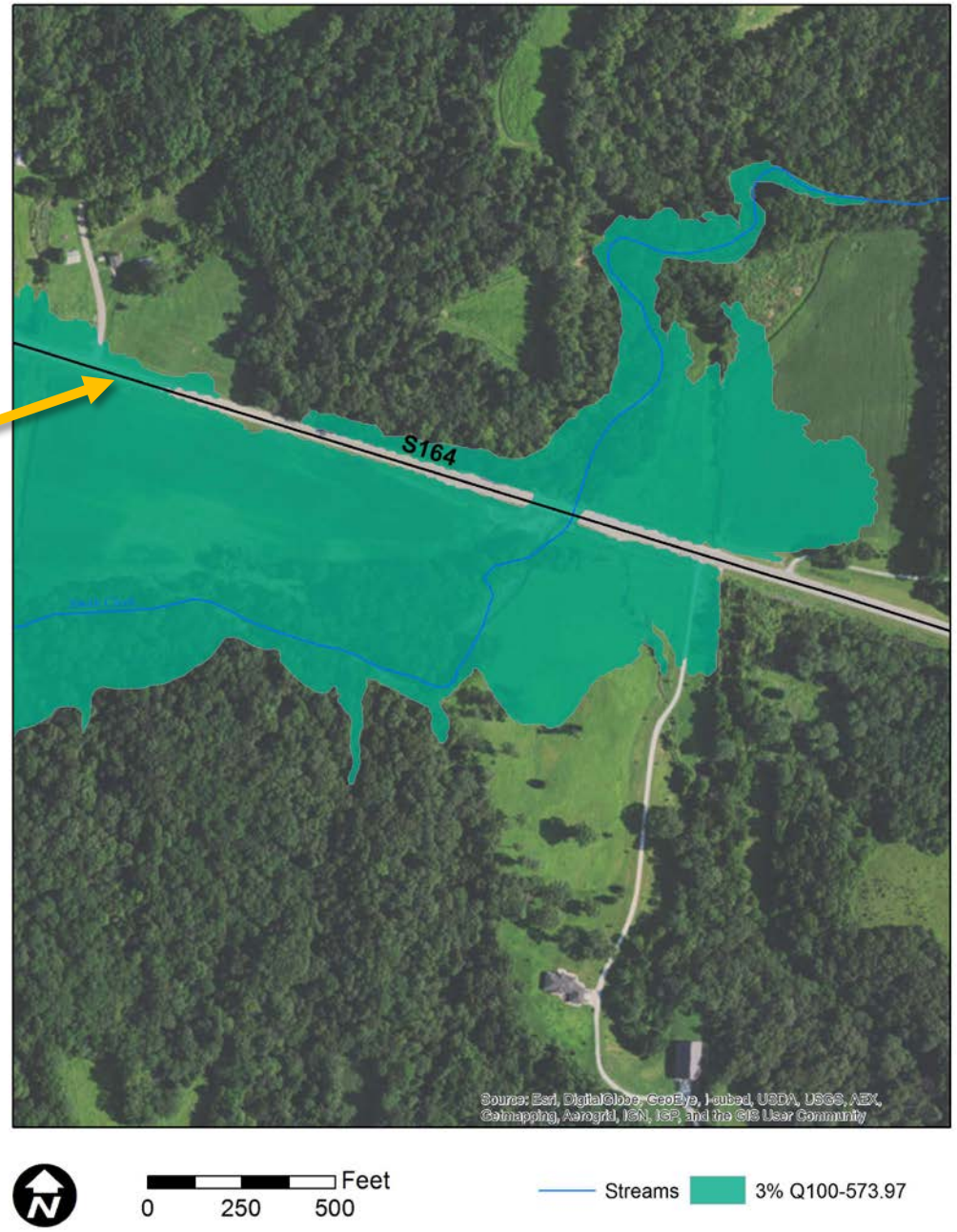

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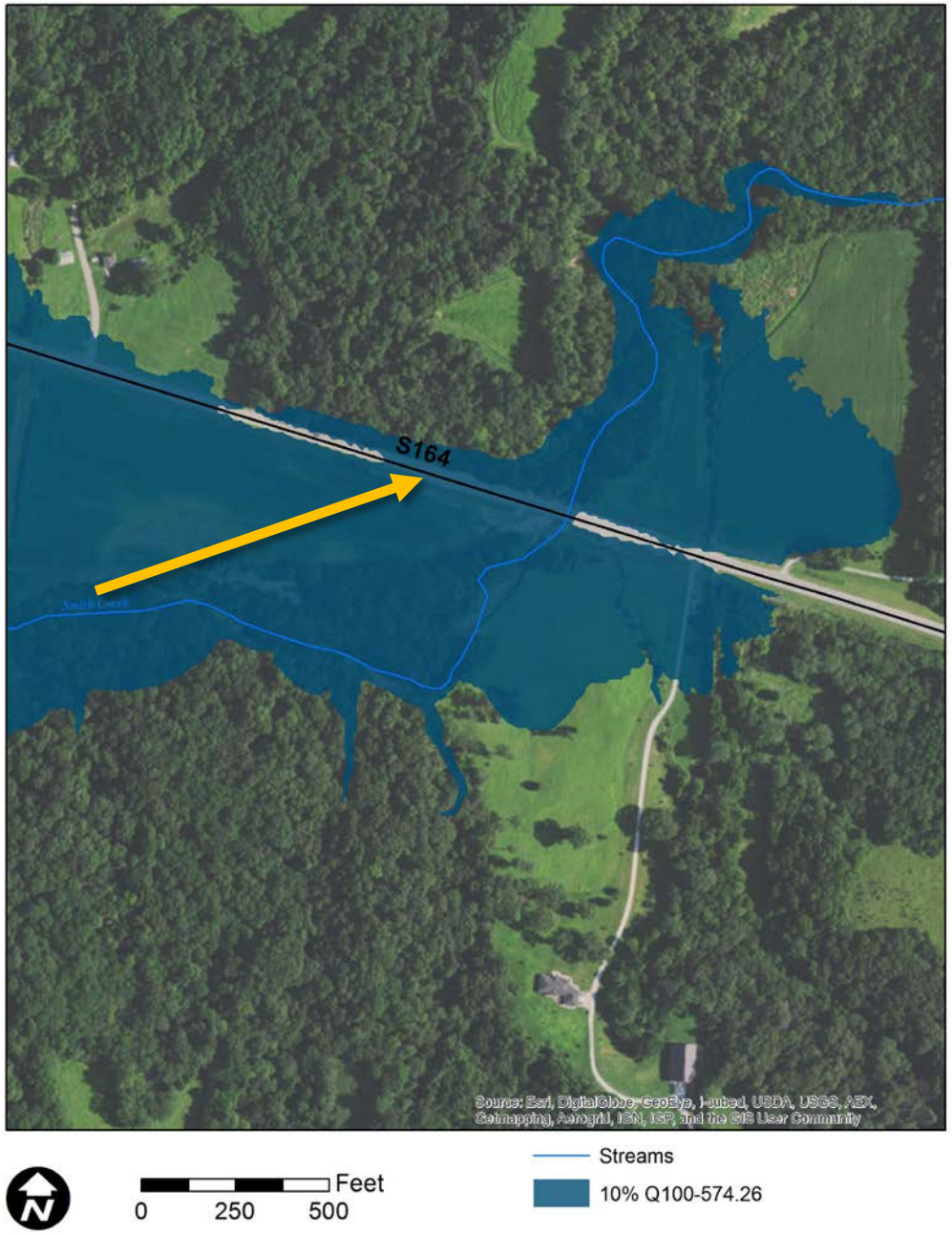

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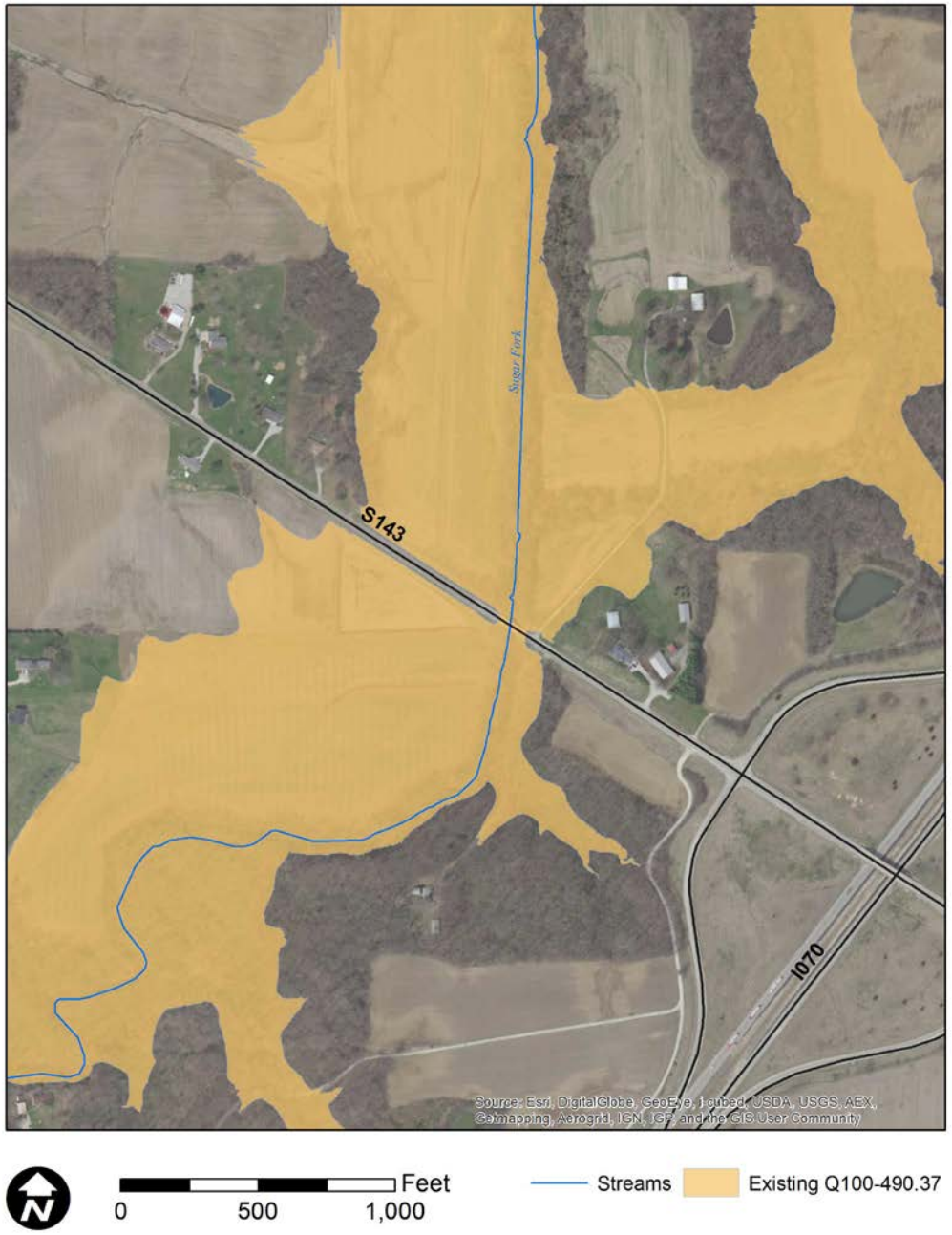

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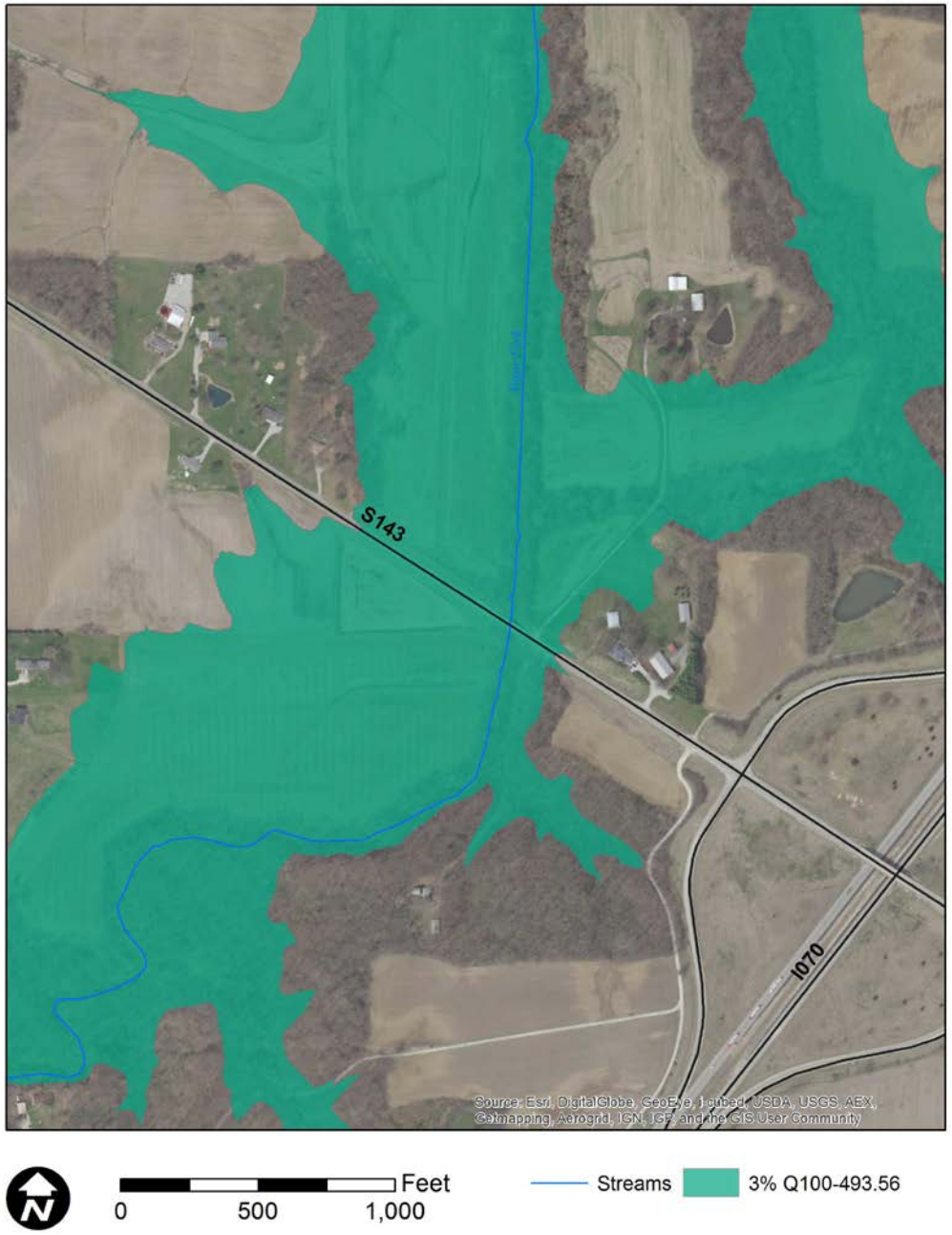

.....In the Future?

Vulnerability

Flooding

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.....In the Future?

Vulnerability

Flooding

Freeze/Thaw

Extreme Heat

.....In the Future?

Illinois All-Hazards Transportation System

Vulnerability Assessment

Thanks for your time today

Christopher.Schmidt@illinois.gov