Using ArcGIS Model Builder to assist in pipeline geohazard monitoring.

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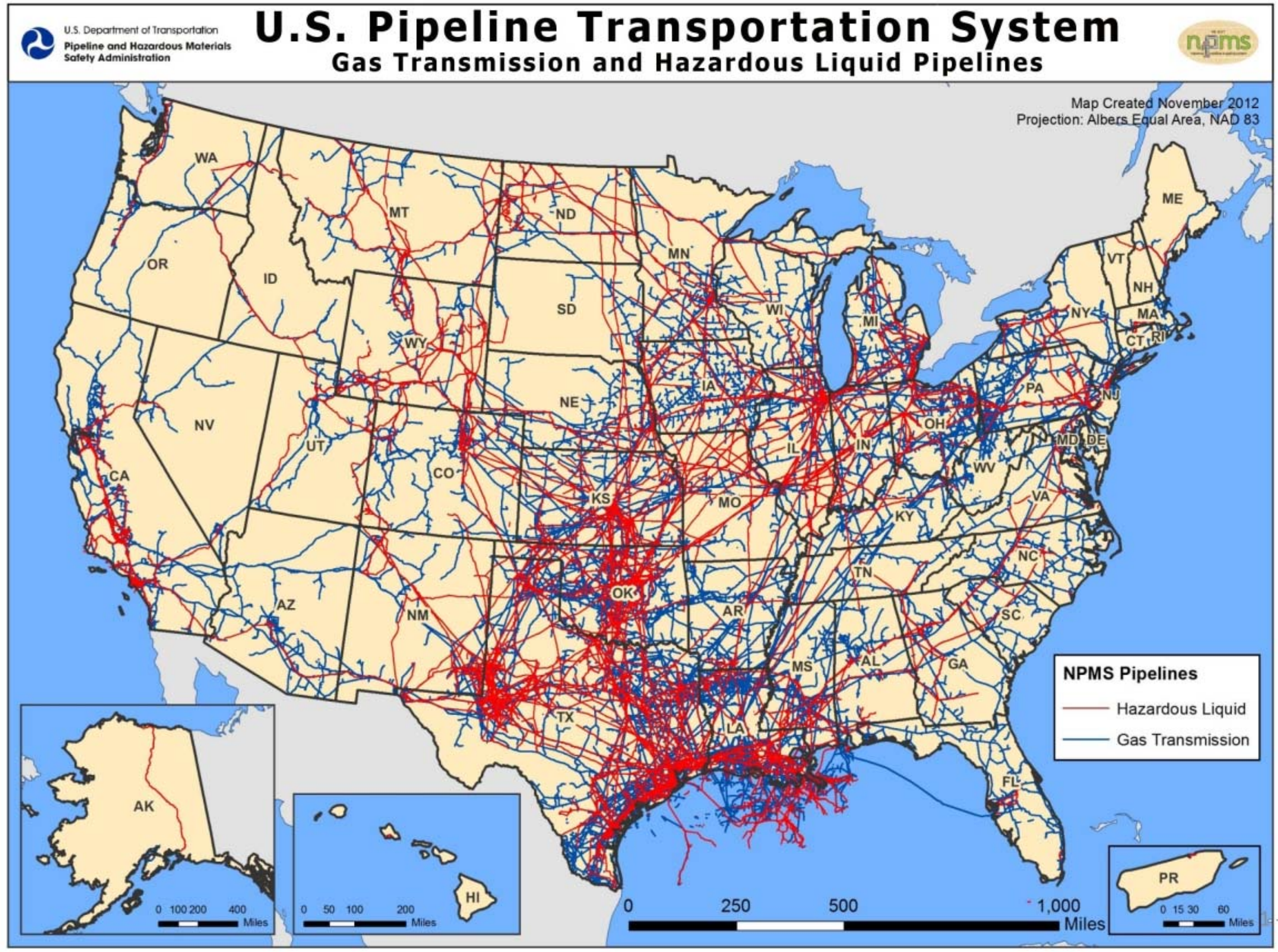
Background

- As of 2014, the United States had almost 200,000 miles of hazardous liquid pipelines and over 300,000 miles of gas transmission pipelines.



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Background

- These pipelines cross waterbodies, traverse steep slopes, and are subject to seismic activity at thousands of locations.
- Single operators can have thousands of miles of pipeline and must monitor geohazards across huge geographic areas.

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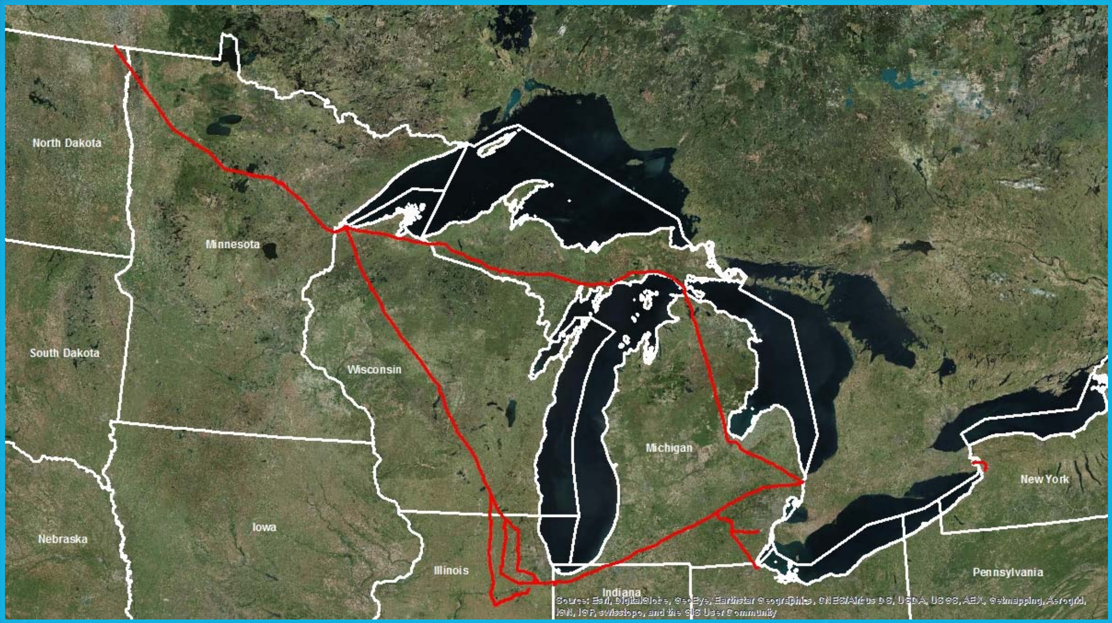
Background

- A large pipeline operator wanted to monitor geohazards across its extensive pipeline network covering 8 states in the upper Midwest.
- With potentially thousands of point monitoring locations, in addition to over 5,000 miles of pipeline potentially subject to non-point geohazards, a method was needed to efficiently use large regional datasets to evaluate point-specific and non-point geohazard risks on a recurring basis and flag potential areas of concern for further investigation.



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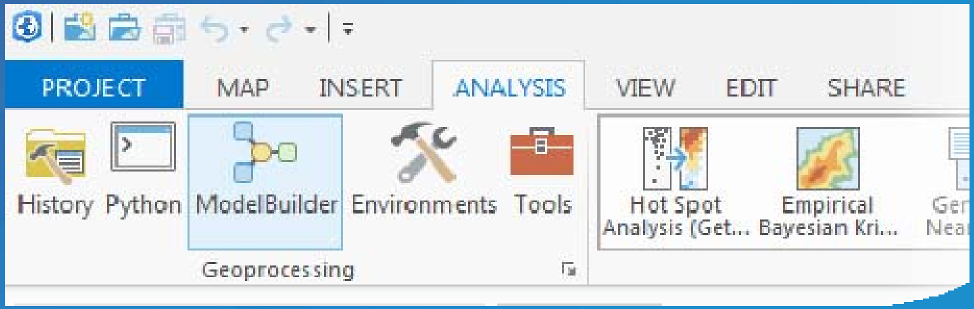
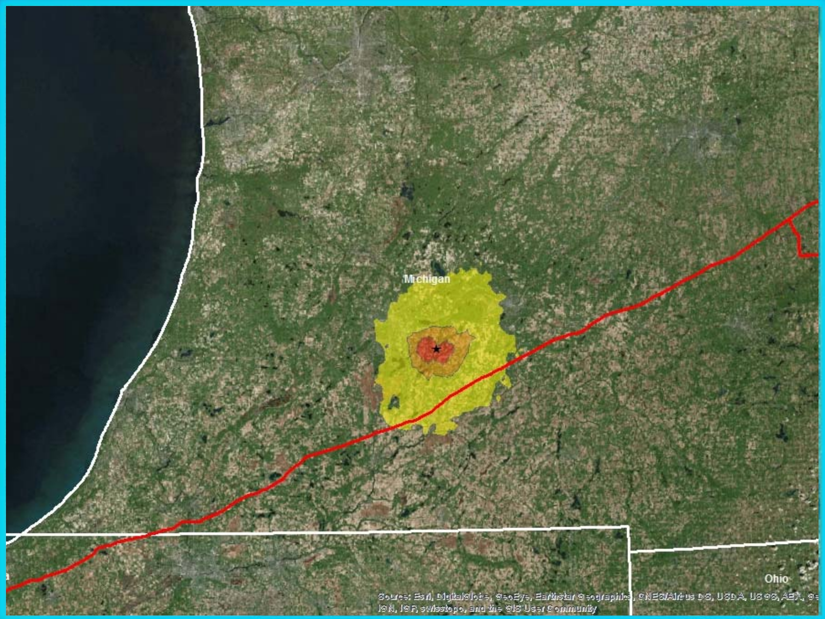
Objective

- **Use GIS data processing tools, via ArcGIS ModelBuilder, to efficiently monitor flooding, precipitation, and seismic activity for a pipeline network spanning 5,000 miles in 8 states in the upper Midwest, USA.**



Methods

- Develop a list of questions we want to answer:
  - Where are the pipelines at risk of flood-related damage?
  - Where do the pipelines have an elevated risk of damage from mass failure of underlying soils and sediments?
  - Where are the pipelines most susceptible to impacts from seismic activity?



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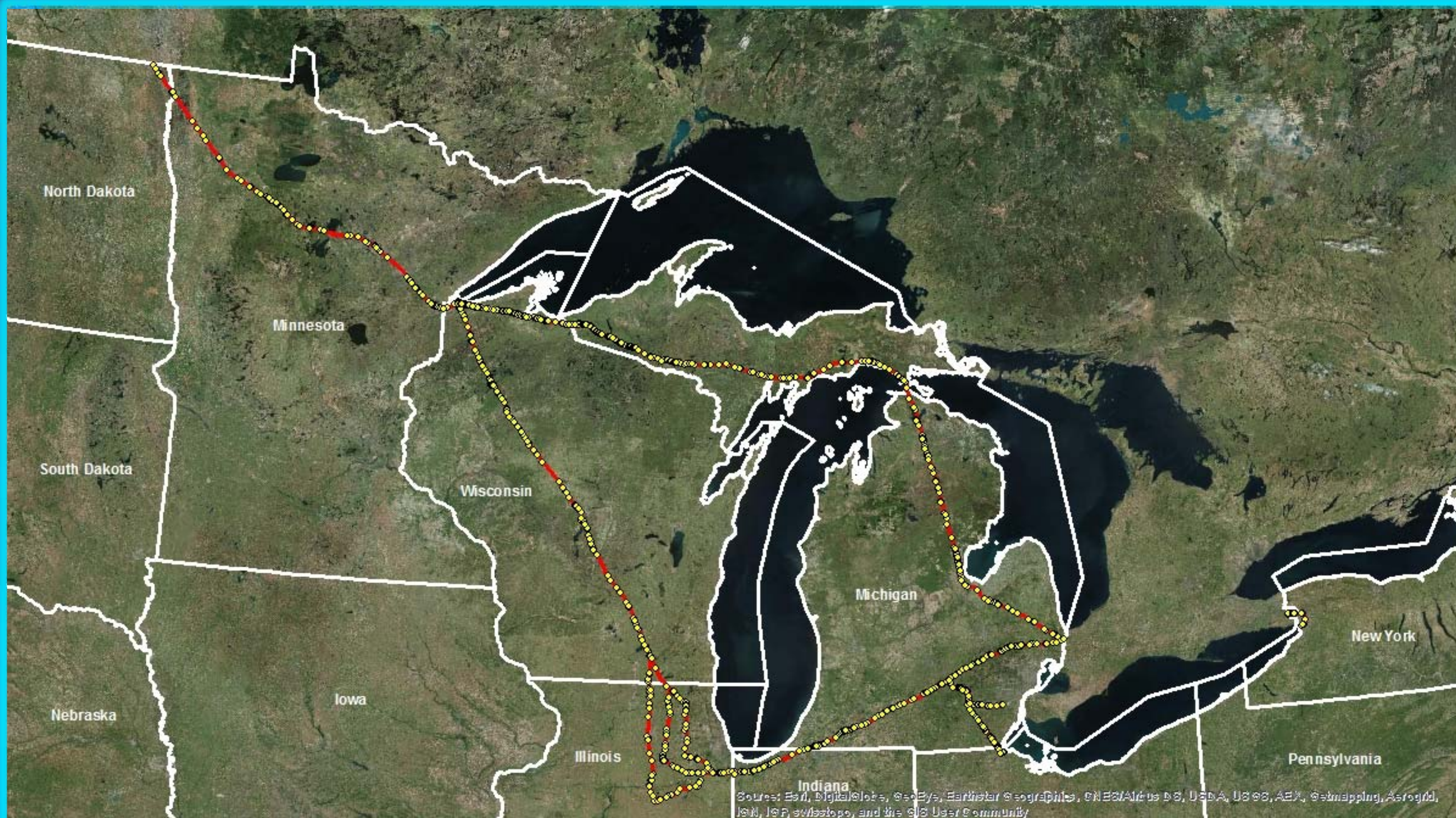
Methods

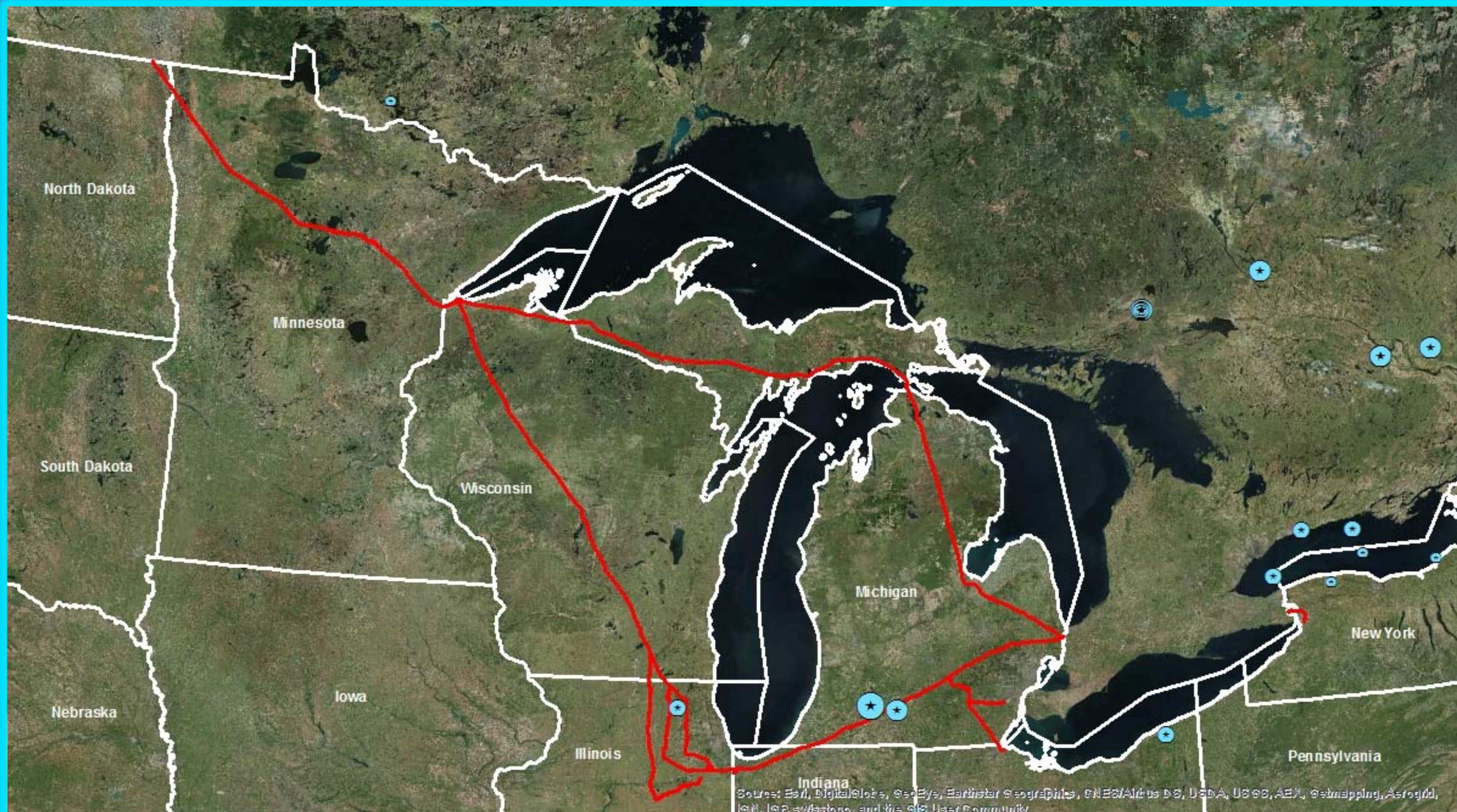
- Determine geohazard monitoring locations using available data



Point Locations

Methods

- **Evaluate available data that can be used to measure, calculate, or estimate conditions at the monitoring locations**



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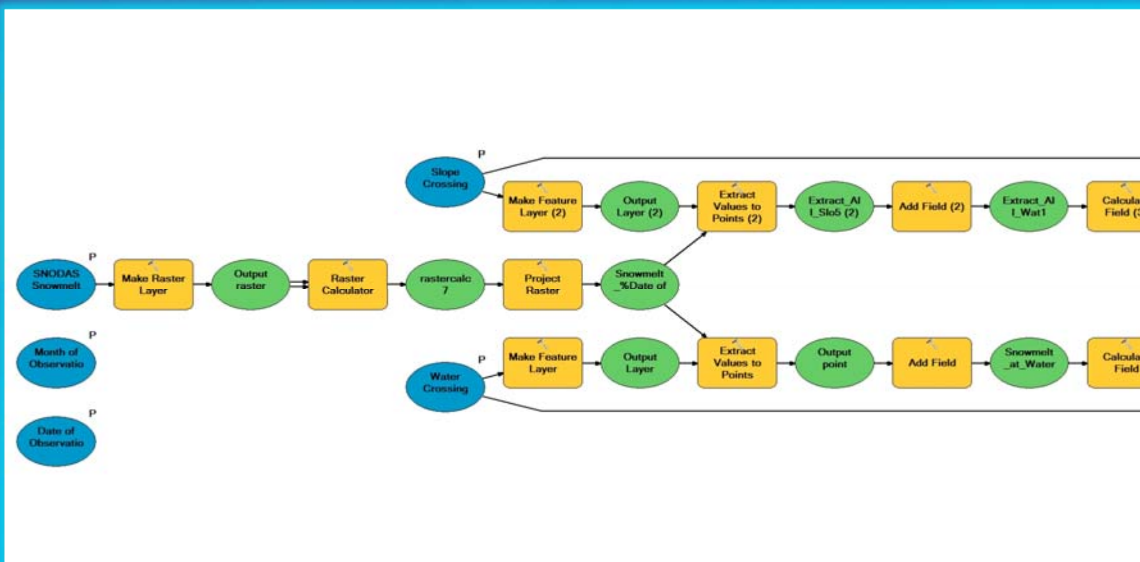
Methods

- **Determine which geoprocessing steps are needed to transform the input data into a format that answers the questions we have asked**
  - **Where are the pipelines at risk of flood-related damage?**
    - **In the vicinity of gage-indicated flooding**
    - **After high-recurrence-interval precipitation events**
    - **Where significant snowmelt occurs**



Precipitation Model

1. Calculate liquid precipitation at each monitoring location
2. Estimate basal snowmelt at each monitoring location
3. Sum the total infiltration at each monitoring location and compare against location-specific threshold recurrence intervals
4. Flag locations that exceed specified thresholds.

Flooding Model

1. Join each monitoring location with appropriate USGS gage
2. Check each gage status for flood level
3. Flag appropriate location crossings when indicator gage is in flood stage.

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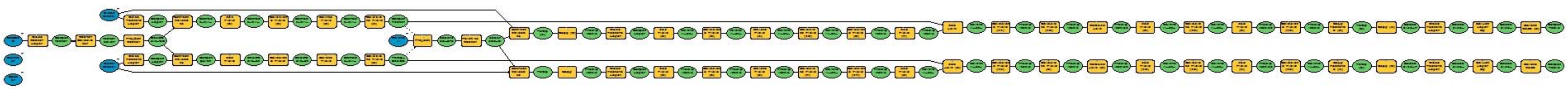
Methods

- **Determine which geoprocessing steps are needed to transform the input data into a format that answers the questions we have asked**
  - **Where do the pipelines have an elevated risk of damage from mass failure of underlying soils and sediments?**
    - **At areas of high slope**
    - **After high-recurrence-interval precipitation events**
    - **Where significant snowmelt occurs**
    - **At locations where the gound accelerates due to seismic shaking**

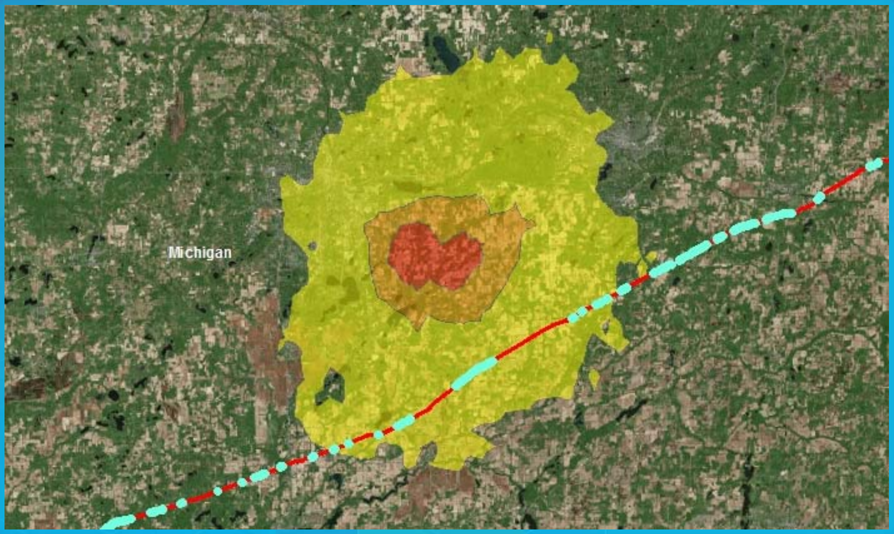


Seismic Model

1. **Compare pipeline locations to estimated peak ground accelerations (PGA) to determine PGA at each monitoring location**
2. **Compare PGA to critical acceleration theshold**
3. **Flag locations that exceed specified thresholds.**

Methods

- Determine which geoprocessing steps are needed to transform the input data into a format that answers the questions we have asked
  - Where are the pipelines most susceptible to impacts from seismic activity?
    - At areas of high slope
    - Where the surrounding soil is susceptible to liquefaction
    - Where estimated PGA is high



Seismic Model

1. Compare pipeline locations to estimated peak ground accelerations (PGA) to determine PGA at each pipeline segment
2. Compare PGA and magnitude to liquefaction susceptibility tables
3. Flag locations that exceed specified thresholds.

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Results

- By using ArcGIS ModelBuilder we can automate daily geoprocessing tasks that when run individually would take significant amounts of time.
- By running the model we can flag all locations that may be affected by a certain geohazard based on that day's conditions.

Table

Flood Model Output

Monitoring_Gage	Floodlevel	Gage_Loc	Observed	ObsTime	Units	Action	Flood	Moderate	Major	Gage_URL
LSLI2	moderate	Illinois River at La Salle, IL	28.02	2016-01-02 16:45:00	ft	19	20	27	31	http://water.weather.gov/ahps2/hydrograph.php?wfo=lot&gage=lsli2
OTWI2	minor	Illinois River at Ottawa, IL	463.69	2016-01-02 16:30:00	ft	461	463	466	469	http://water.weather.gov/ahps2/hydrograph.php?wfo=lot&gage=otwi2
LSLI2	moderate	Illinois River at La Salle, IL	28.02	2016-01-02 16:45:00	ft	19	20	27	31	http://water.weather.gov/ahps2/hydrograph.php?wfo=lot&gage=lsli2
DAVI3	minor	Kankakee River at Davis, IN	10.01	2016-01-02 17:00:00	ft	9	10	12	13	http://water.weather.gov/ahps2/hydrograph.php?wfo=iwx&gage=davi3

1 (0 out of 4 Selected)

Flood Model Output

Table

Precip Model Output

TenYr_24hr_Precip	TwentyFiveYr_24hr_Precip	FiftyYr_24hr_Precip	OneHundredYr_24hr_Precip	Precip24hr	Snowmelt_Inches	Combined_Rainfall_Snowmelt	AvgRI
4.379	5.512	6.57	7.836	0.06	0	0.06	No Excessive Precipitation
4.349	5.338	6.171	7.074	0.09	0.35	0.44	No Excessive Precipitation
4.452	5.454	6.299	7.215	0.1	0.1	0.2	No Excessive Precipitation
4.473	5.473	6.316	7.229	0.1	0.49	0.59	No Excessive Precipitation
4.395	5.514	6.574	7.854	0.02	0	0.02	No Excessive Precipitation
4.393	5.509	6.568	7.845	0.02	0	0.02	No Excessive Precipitation
4.502	5.497	6.334	7.241	0.1	0.9	1	No Excessive Precipitation
4.443	5.54	6.533	7.691	0.04	0	0.04	No Excessive Precipitation

1 (0 out of 747 Selected)

Precip Model Output

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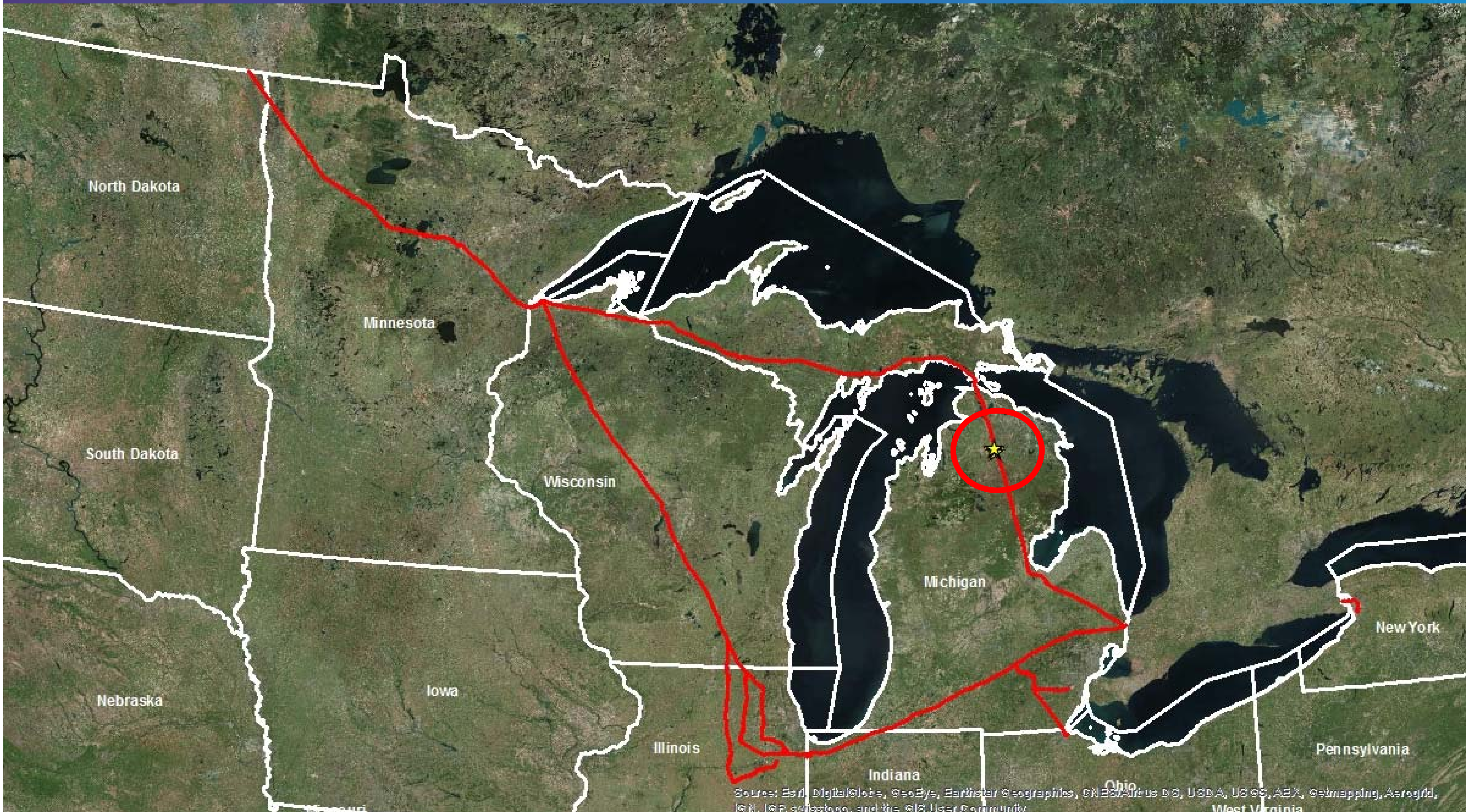
Results

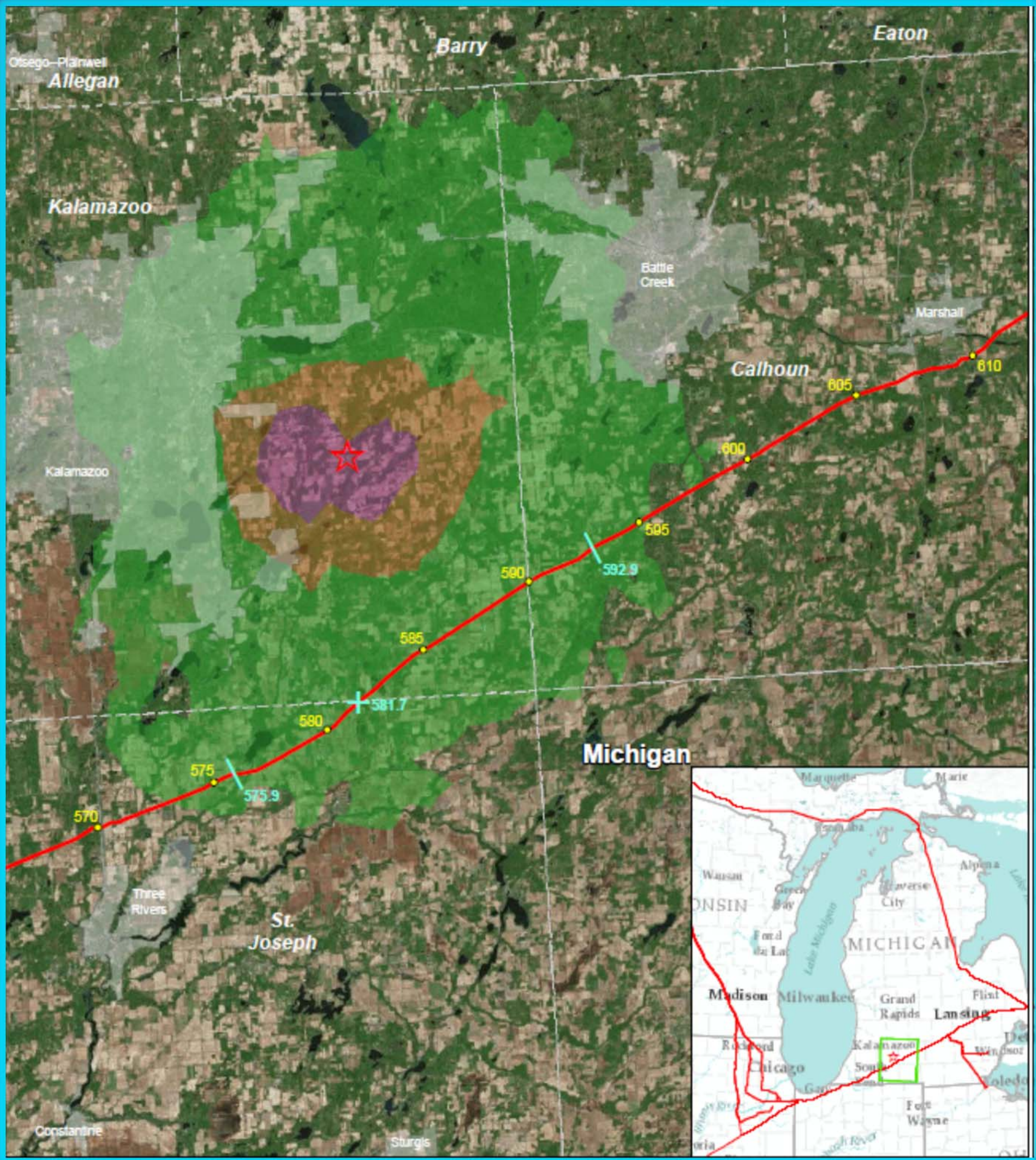


North Dakota
Minnesota
South Dakota
Wisconsin
Michigan
New York
Nebraska
Iowa
Illinois
Indiana
Ohio
Pennsylvania
Missouri
West Virginia
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Results

Seismic Model

1. Modified Mercalli Intensity
2. Peak MMI
3. Maximum PGA



nclusions

. ArcGIS data processing tools were used to select over 1,000 point monitoring locations based on region-wide datasets.

. ArcGIS was critical in evaluating the available monitoring data at these point locations and along the entire pipeline network.

. Model Builder was used to automate daily monitoring tasks and create an efficient workflow to handle large datasets over a large geographic area.

. Specific locations were flagged for further investigation based on the results of the automated processing.