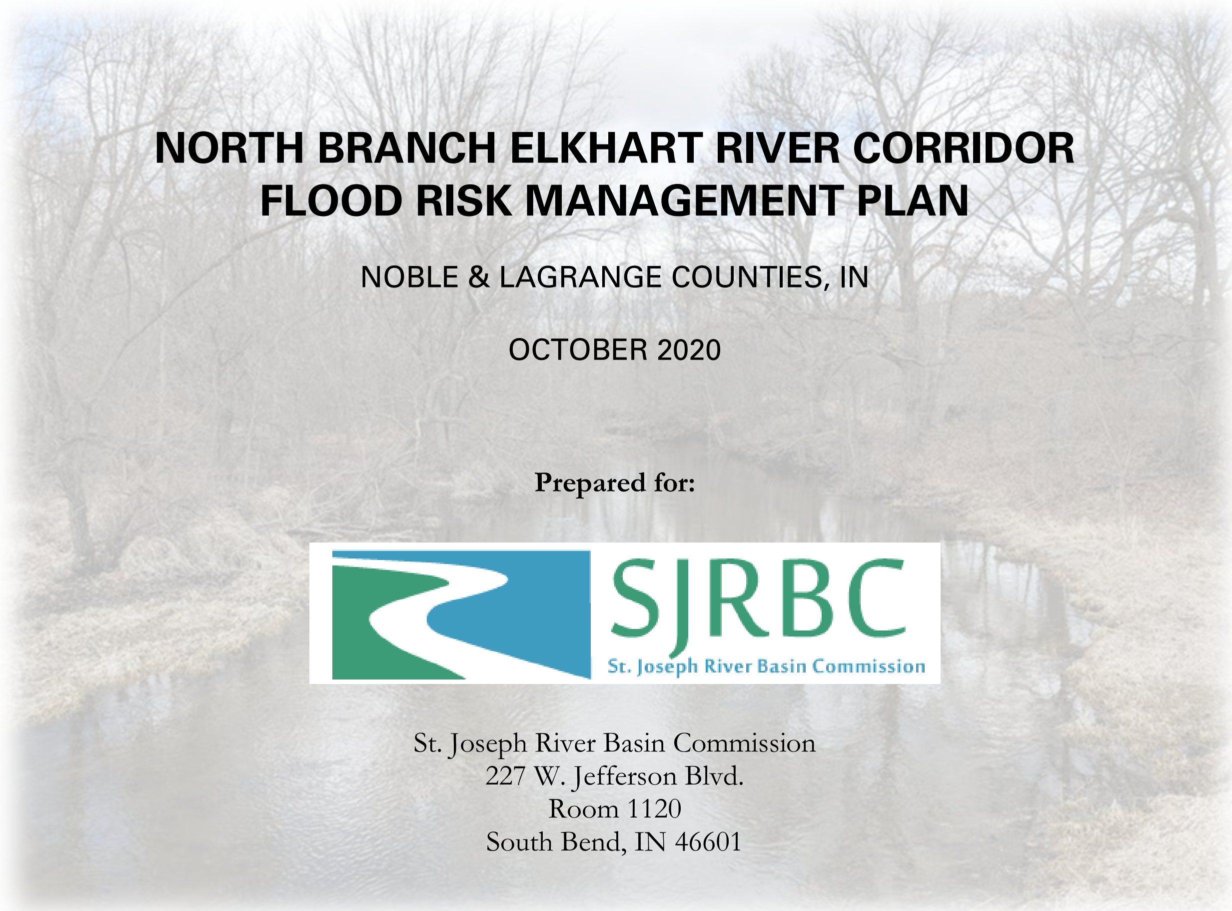

NORTH BRANCH ELKHART RIVER CORRIDOR FLOOD RISK MANAGEMENT PLAN

NOBLE & LAGRANGE COUNTIES, IN

OCTOBER 2020

Prepared for:

St. Joseph River Basin Commission
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EXECUTIVE SUMMARY

To begin addressing the St Joseph River Basin Commission's (SJRBC) need for a comprehensive understanding of the overall functional health of the North Branch Elkhart River (NBER) basin in northeast Indiana, Christopher B. Burke Engineering, LLC (Burke) was asked to develop a flood risk management plan for the NBER based on investigation of overall stream function and flooding in the mainstem NBER from its headwaters on the far east side of Noble County to the confluence with the South Branch Elkhart River near Ligonier. Development of this plan was supported by the SJRBC, the Indiana University Environmental Resilience Institute (IU ERI) and the Indiana University Conservation Law Center.

Based on a detailed functional assessment of the watershed system and detailed analysis of available data, the study concluded that overall, the NBER system is one of the most naturally functioning river systems in the state, and that great care should be taken to preserve this remarkable resource. This conclusion was based on the presence of significant amount of water storage within the extensive wetland complexes, the several lake chains within the watershed, and extensive deposits of muck soil overlaying 100 to 300 feet of outwash sand and gravel. The large potential storage means that basin hydrology is buffered. The best current evidence that we have for a stable basin hydrology is that even with the increase in annual rainfall and the intensity of rainfall, flow volumes in the downstream portion of the watershed do not directly reflect this increase. Previous studies estimated that 80 percent or more of streamflow in the NBER was supplied by groundwater so that river flow is not runoff driven. It is groundwater sourced and controlled by an aquifer with an extremely high transmissivity rate. For the NBER that means stable flows with little annual fluctuation for such a large watershed.

Unlike NBER's main stem, the headwaters of the Middle Branch Elkhart River exhibit a few instability issues. The over 4 miles of Henderson Lake Ditch headwaters from Bixler Lake through Kendallville and then just north of CR E 800 N (W Rimmel Rd.) are channelized and degraded, causing downcutting of channel banks upstream of Sylvan Lake and sending a sediment influx into Sylvan Lake. Although Sylvan Lake has been able to absorb the disturbances occurring upstream, the degradation upstream does have negative localized impacts. The reattachment of the channel in this reach to its geomorphic floodplain through construction of a two-stage or a multi-stage ditch could improve the situation and keep things from getting worse.

Based on a detailed analysis of available long-term lake level data within the watershed, the number of days lake levels have been above their legal levels (normal lake levels) have been increasing, especially within the last 20 years. This observation correlates well with the observed number of days with heavy precipitation in Indiana as presented in a March 2018 report Purdue Climate Change Research Center. In particular, West Lakes has had at least 3 years where lake levels have been more than 1' above legal level for over 250 days of the year. Two of these were in the last 10 years. The level of a lake before the next storm is a big influence on peaks and duration of high water. Lake levels remain high due to increased frequency of rainfall or extended influx of groundwater.

A comparison of measured discharges at the Cosperville gage with the corresponding elevation of Waldron Lake shows that there has been a large range of flow rates in the stream at Cosperville for a given stage on the lake. Variability in vegetation or large wood in the stream from year to year may explain some of the variability but the groundwater driven nature of the stream and the change in aquifers near the lake outlet are likely the bigger factors. The difference in outlet efficiency on approximately a 5-year level event is on the order of 6 inches for the peak elevation and a few days in time to recede, with smaller benefits expected for larger flood events. Groundwater impacts were not directly included in this evaluation.

Based on previous flood records, Sylvan Lake has flooded to 0.4 feet above the Flood Insurance Study (FIS) Base Flood Elevation (BFE) and Indian Lakes reached 0.1 foot over the BFE. Oliver and West Lakes do not have recorded peaks at or above the BFE. The large storage volume available at each lake will lessen the impact of increased rainfall on lake levels but an increase in the frequency of heavy storms and the potential for back to back rainfalls with large groundwater inflows suggest potential increases in flood levels.

A preliminary large-scale hydrologic computer model was developed as part of this study to evaluate the potential impacts of creating additional flood storage in the watershed. For this evaluation, five additional flood control ponds, each being 300 acres in area with 600 acre-feet of active flood storage, were assumed to be constructed within various major sub-basins. The result of this modeling showed only a modest reduction (3 to 6 inches) in flood stages and in flood durations (1 to 3 days), depending on the magnitude of the event simulated (the larger the event, the smaller the impact). Given that for the standard 1% chance flood event the majority of homes within the floodplain around the lakes are expected to sustain between 2 to 3 feet of flooding, the nature of this groundwater-driven lake chain system, and the relatively nominal benefit resulting from such a large investment (estimated at $100 Millions) that would also require taking out of production an enormous amount of land area and significant impact to wetlands, additional consideration of this alternative is not warranted.

The nature and location of flooding along the NBER through Noble and LaGrange Counties is the product of basin geology and climate. As our collective understanding of the natural fluctuations in weather and climate have increased, we have learned that we cannot control climate or geology. Instead of struggling to control the climatic fluctuations we will need to learn to adapt. Based on the findings of this study, we conclude that it is not likely feasible or cost-effective to try to significantly reduce flood problems for homes that were built in the floodplain by creating additional upstream storage, clearing the vegetation downstream of the system, or by more intensive means of increasing the outflow from lakes without creating negative impacts elsewhere. What is recommended instead is to take a series of steps to adapt to the "new normal" high lake level and flooding patterns, protect homes and reduce vulnerability to flood damages, and do everything to maintain the existing inherent resiliency within NBER watershed and keep things from getting worse through implementing flood resilience strategies recommended in this report.

The following is a list of major recommendations of this study:

1. Develop and adopt location-specific Smart Growth flood resilience strategies
2. Update stormwater and floodplain regulations
3. Encourage consideration of agricultural drainage impact mitigation measures
4. Investigate the feasibility of and construct a 2-stage ditch system along a 4-mile reach of Henderson Lake Ditch through and near Kendallville
5. Consider initiating additional studies and models to better understand the groundwater/surface water interaction
6. Preserve the existing USGS gages and commission additional gages
7. Consider requiring a higher flood protection grade when permitting new construction
8. Maintain periodic communication and outreach with Stakeholders

CHAPTER 1: INTRODUCTION

This report documents the findings of an investigation of overall stream function and flooding in the mainstem North Branch Elkhart River (NBER) in northeastern Indiana. This investigation was supported by the St Joseph River Basin Commission (SJRBC), the Indiana University Environmental Resilience Institute (IU ERI) and the Indiana University Conservation Law Center.

NBER is a lake chain, a complex hydrologic system with both river and lake segments, made even more complex by the presence of extensive river corridor wetlands. Climate, lake and stream level fluctuations, floodplain connectivity, large wood in the channel, geology and geomorphology were all assessed to provide an understanding of the river system and inform recommended management of it. The field assessment included the mainstem of the NBER River from the headwaters in eastern Noble County to the confluence with the South Branch Elkhart River upstream of Ligonier, Indiana. An assessment of an additional reach, the Middle Branch Elkhart River (MBER), was also conducted when field observations suggested that its headwaters were much different from what was observed in the NBER.

This report differs significantly from previous studies of the NBER system (Crompton and others,1986; Indiana Silver Jackets, 2010) in its focus on the mainstem river. Most of the earlier work focused on the difficulties in attempting to manage lake levels for conflicting desires in a dynamic hydrologic setting, a challenge now exacerbated by climate change.

In this report the lakes are discussed as part of the larger river system, with an emphasis on how water flows from the watershed into the channel and downstream. This work was designed to complement earlier studies by focusing on the mainstem river. This emphasis allows for holistic assessment of flood risk and management along the river corridor.

Project Setting

The NBER is a 163 square-mile (mi^2) watershed located in LaGrange and Noble Counties, Indiana. It includes both the NBER and the MBER which combine near the outlet of Jones Lake and continue downstream as the NBER. The NBER merges with the South Branch Elkhart River to form the Elkhart River about halfway between Cosperville and Ligonier. The Elkhart River then flows north to the City of Elkhart where it joins the St Joseph River. A map of the watershed is shown in Figure 1. A larger map is provided as Exhibit 1.

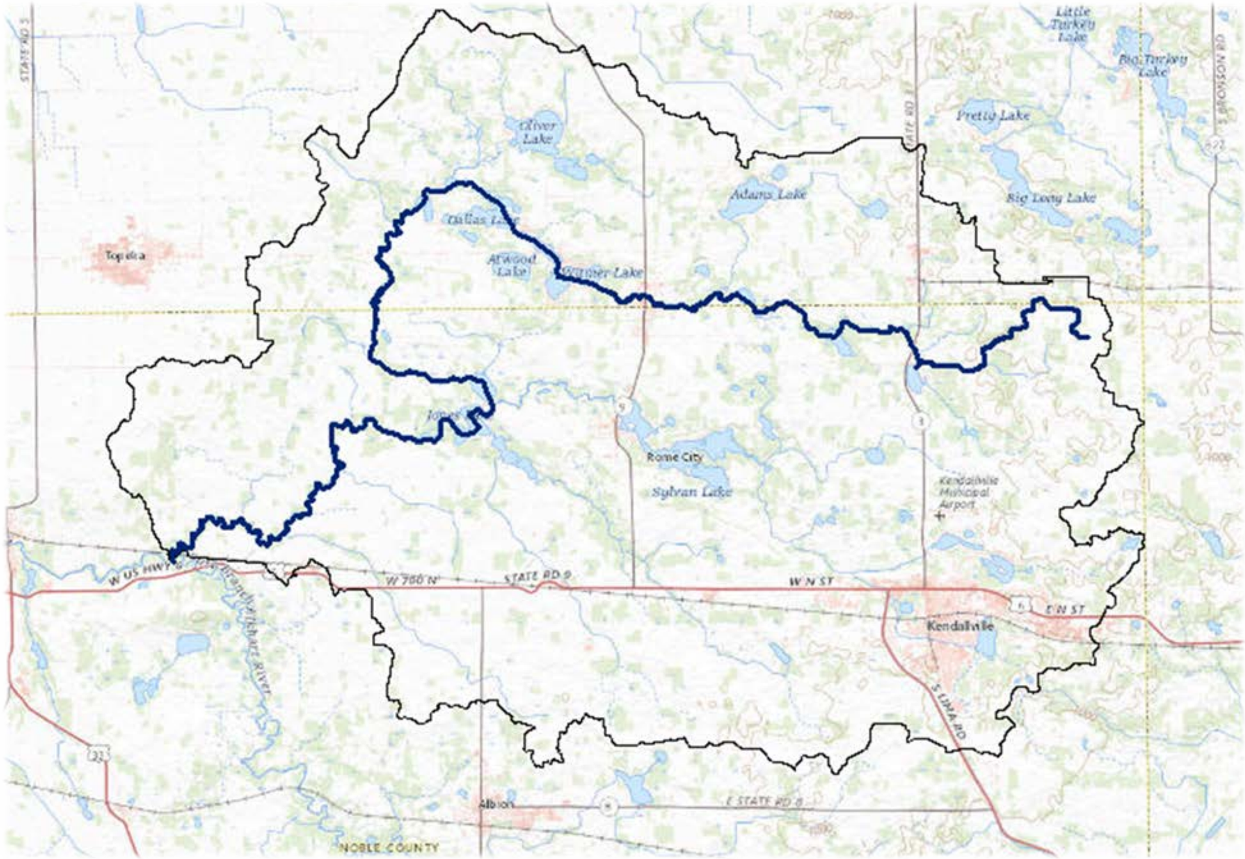

Figure 1: NBER Watershed and Main Study Reach

Project Approach

In any watershed, there are stakeholders with varied interests that are not always compatible. Instead of focusing on one or more interests, this plan focuses on the holistic health of the river corridor and the range of related functions. River corridor health is an assessment of how the processes that create and support a stream system are working or functioning. Stream function means "the physical, chemical, and biological processes that occur in ecosystems", a definition that comes from the Clean Water Act (33 CFR 332.2; 40 CFR 230.92) (Stream Mechanics, USEPA, 2015).

Harman and others developed a functional pyramid to illustrate how stream functions are interrelated and generally build on each other in a specific order (Harman et al, 2012). Note that the pyramid is not one directional. Biology can affect geomorphology which can then affect hydraulics. The functional pyramid, shown in Figure 2, shows how the various interests are dependent on each other.

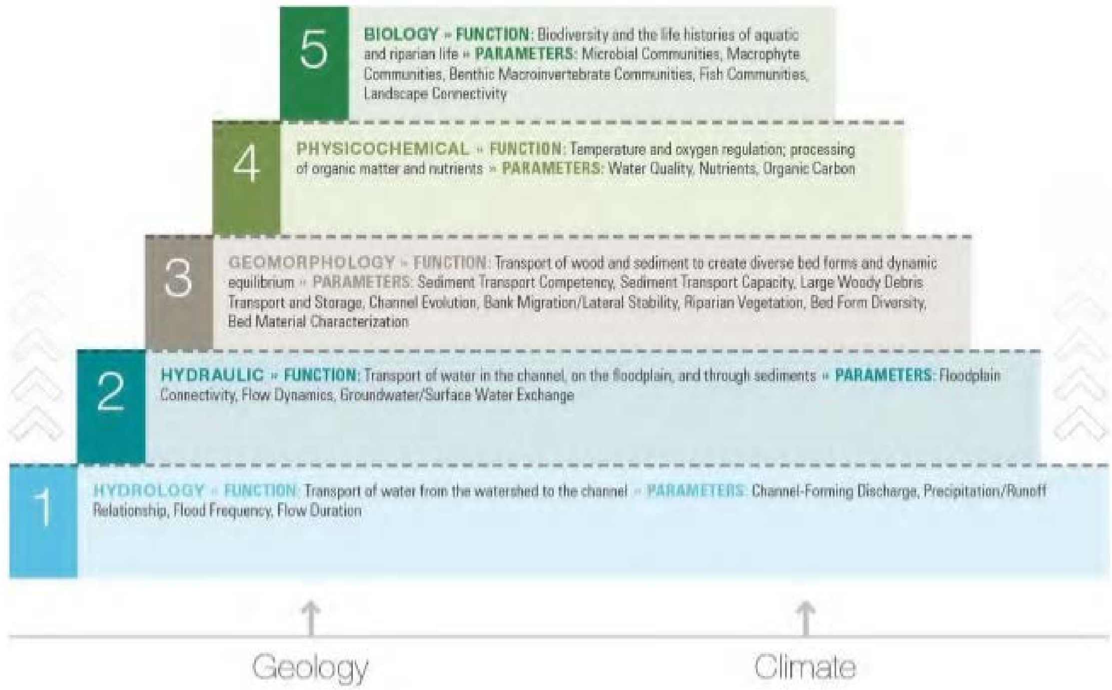

Figure 2: Stream Functional Pyramid (Harman and others, 2012)

Geology, climate, hydrology, hydraulics, and geomorphology are the focus of this study. While the physiochemical and biology aspects are equally important, they involve research and data gathering beyond the scope of this project and therefore, are not included in this plan. The underlying premise of the functional pyramid, however, is that if the foundation aspects of the pyramid are not working it will be impossible to achieve good water quality and a balanced biological community.

Data for the investigation of each aspect was gathered from site visits, historical aerial photography, streamflow data, lake stage data, rainfall data, geologic maps, past reports, and topographic and soils information. Data was then synthesized to determine major aspects of the current morphologic conditions of the river system. This analysis also included development of a preliminary overall hydrologic model of the watershed to quantify how water moves through the system and to evaluate the feasibility and potential benefits to downstream areas of creating additional flood storage basins within the upstream watershed. System functions were summarized, and recommendations were developed for responding to the system and for maintaining a healthy system.

Input from stakeholders in the watershed was gathered from an initial in-person public meeting and a later virtual public meeting. A summary of the input from the initial public meeting is provided in Appendix 1.

This information and understanding of the system are presented according to the stream function pyramid components as follows:

Chapter 2 – Geology
Chapter 3 – Climate
Chapter 4 – Hydrology
Chapter 5 – Hydraulics
Chapter 6 – Geomorphology
Chapter 7 – Summary of Findings
Chapter 8 – Recommendations

CHAPTER 2: GEOLOGY

The NBER watershed is in a portion of the Northern Lakes Natural Region designated as the Steuben Morainal Lake Area. The region is characterized by outwash deposits and lake plains with kame and kettle topography, a complex hummocky landscape dominated by knobs of till and sand, with gravel kame complexes interspersed across the landscape (Casebere, 1997, Fowler, 1994). Underlying the till throughout the basin are extensive deposits of sand and gravel ranging from 100 to over 300 feet thick (Fowler, 1992). These sands and gravels form an extensive unconfined aquifer with very high transmissivity rates (>50,000 ft^2/day) that recharge the river (Crompton and others, 1986; Fowler,1992). Compton and others stated that over 80% of river flow was from this unconfined aquifer.

The flat areas between the knobs are dominated by muck soils and marl deposits underlain with outwash valley train deposits. The larger flat areas are frequently wetlands or lakes. Figure 3 shows the surficial geology of the study area. The city of Kendallville is labeled in the lower right portion of the figure for reference.

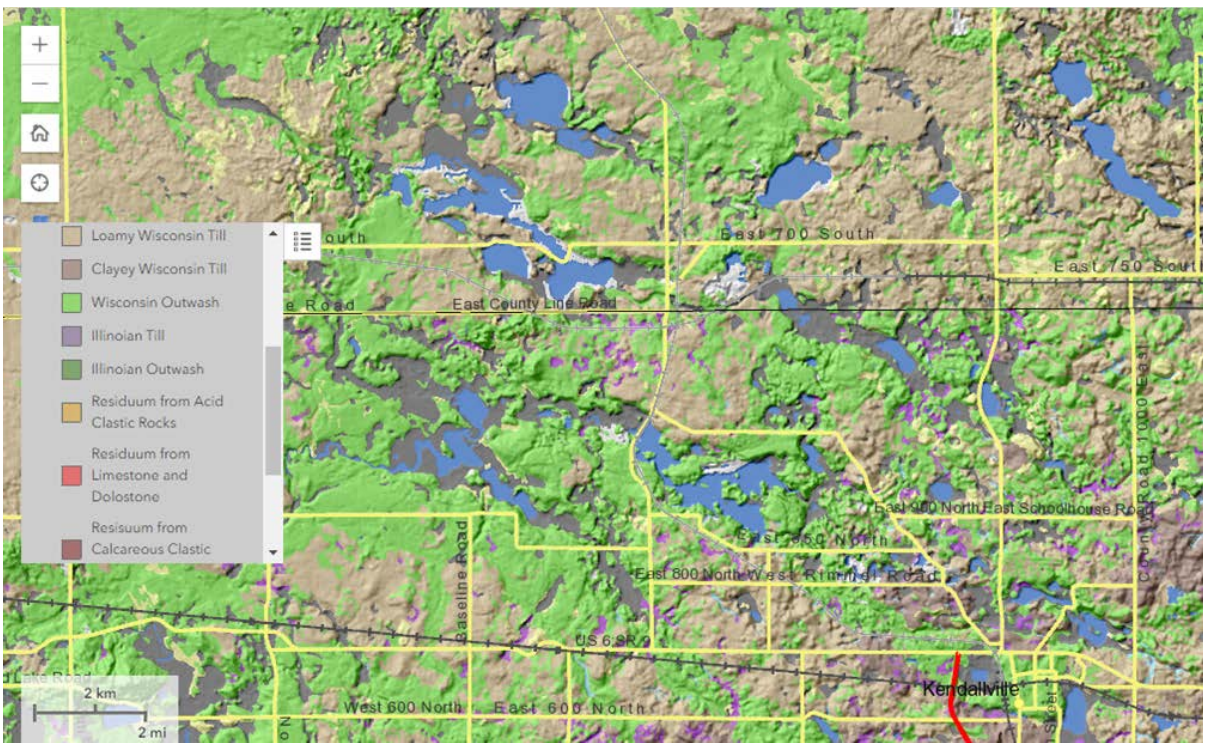

Figure 3: Surficial Geology in the Study Area (Purdue Soil Explorer)

The map illustrates the general southeast to northwest trend of the river corridors. It also shows in dark gray the extensive muck (organic soils that are saturated more than 30 cumulative days in normal years or are artificially drained) deposits in the corridors. As the river flows downstream, it flows through these muck soil dominated corridors. The corridor tends to widen when it flows into complexes of kettle lakes and fringe wetlands then narrows again on the downstream end. Note that the lakes are also bound by muck in many areas. Figure 4 shows a detail from the Waldron Lake area as an example of the extensive muck areas.

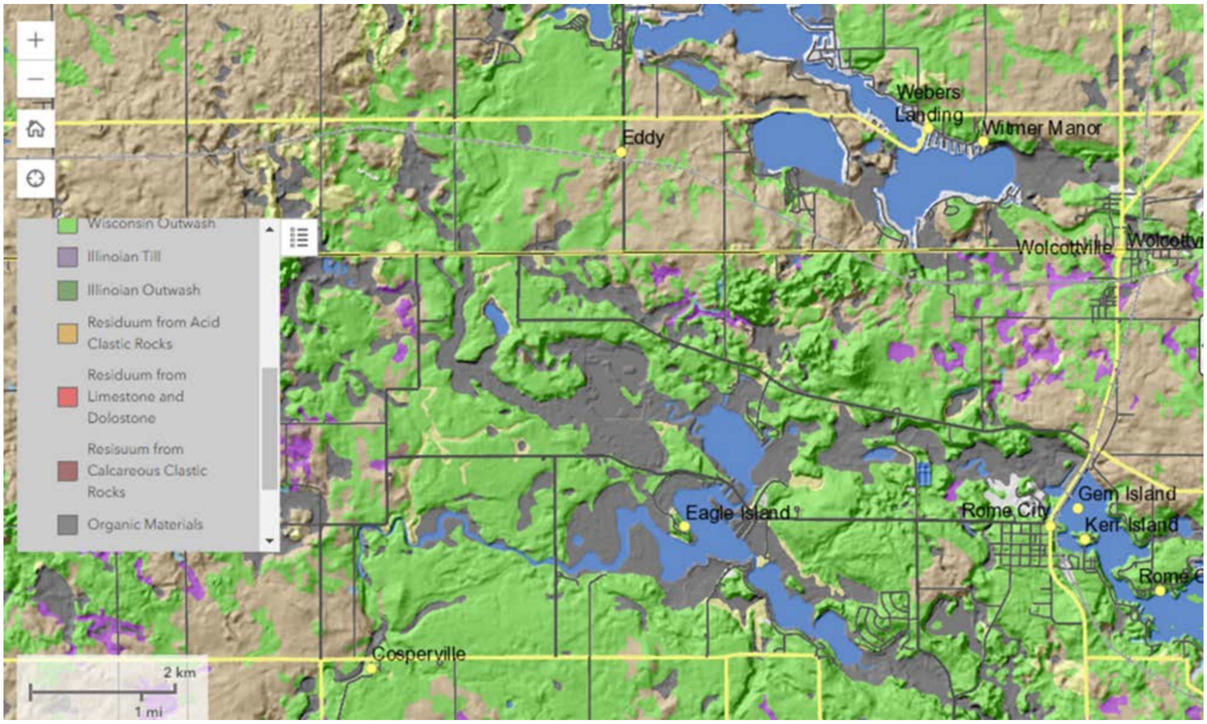

Figure 4: Detail of Surficial Geology around West Lakes (Purdue Soils Explorer)

One popular name for this type of system is "chain of lakes." An understanding of this type of river system is critical for understanding the interaction between the river and the lakes. In the simplest terms the NBER is a long linear wetland with the river flowing through wetland areas and lakes. The muck surrounding the river as well as the underlying sand and gravel outwash deposits are all hydrologically connected so much of the water flow is below or at ground surface. As the groundwater level rises the lakes will expand into the muck wetlands surrounding them, similarly during extended dry periods lake levels can drop. Water flows from the outwash into the muck and ultimately into the river. The rivers then flow into lakes where the water spills out into the wider area and slowly continues downstream. Figure 5 illustrates how this type of lake chain system works with riverine sections developed where there is slope to the landscape, mixed with lakes where there are depressions or flat areas. This creates a series of "buckets" that spill over from one to another as water moves through the system. For this study, the important aspect of understanding how this system works is the recognition that the river, wetlands, and lakes are all interconnected.

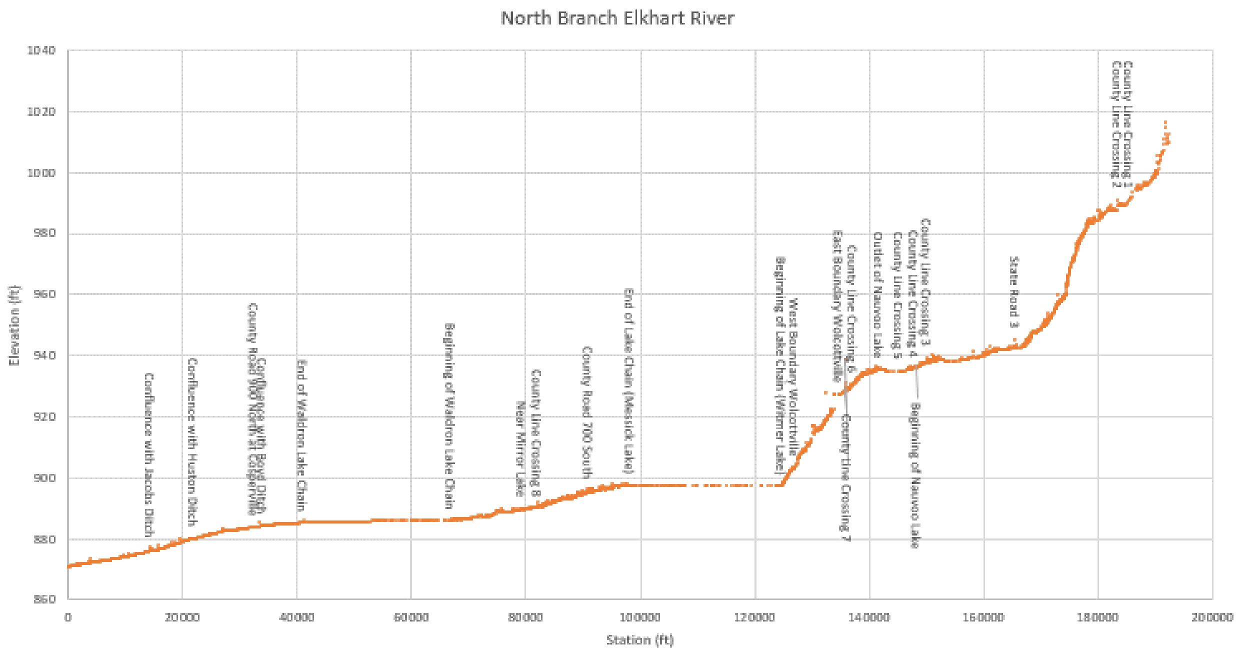

Figure 5: Longitudinal Profile of the NBER Based on 2017 DEM (M. Rummel)

CHAPTER 3: CLIMATE

Climate is the second foundation of the stream function pyramid. Climate is the long-term trends in weather at a place, usually over a period of many years. This report is primarily concerned with changes in precipitation. This chapter discusses the observed climatic trends in the watershed using precipitation and river discharge records and predicted precipitation. It also discusses how these trends are predicted to continue.

Annual rainfall

In the NBER watershed, average annual precipitation is approximately 38 inches according to NOAA's Climate at a Glance website (NOAA) records. As seen in Figure 6 the average annual rainfall since 1895 has varied from less than 25 inches to over 50 inches. The highest annual average is over 30% higher than the current average. The 10-year moving average has varied between 30 and 40 inches per year with the last 30 years near the upper values of the range. Three years have seen over 50 inches per year, 1990 being the most recent year.

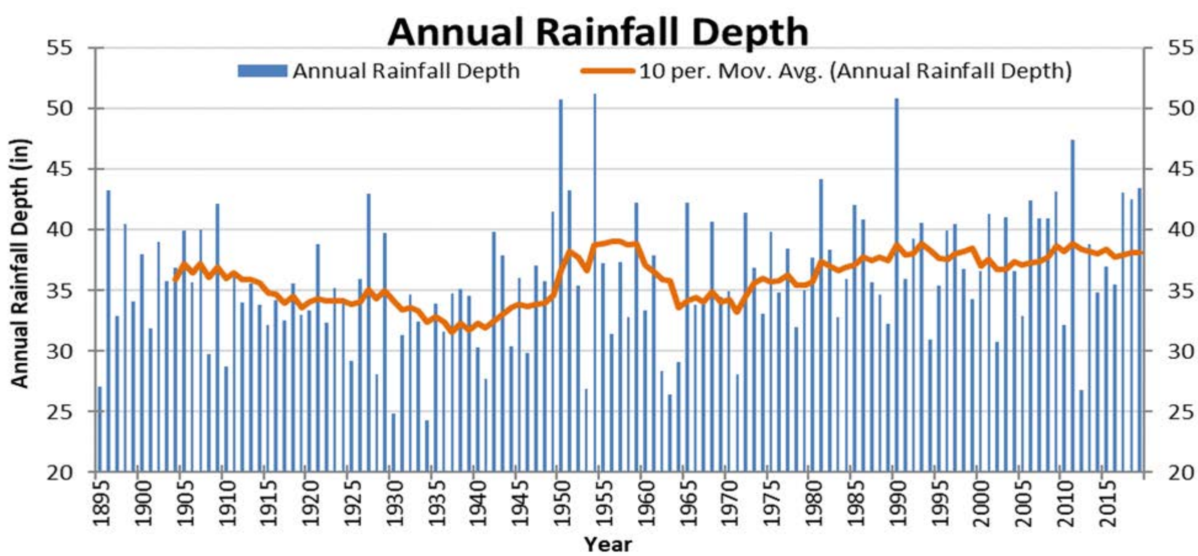

Figure 6: Annual Rainfall Depths for Noble County, Indiana

(Source: NOAA Climate at a Glance Database)

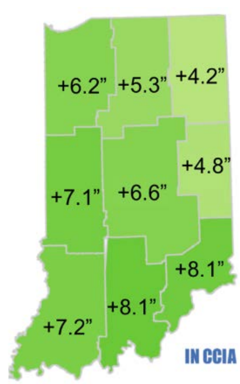

Figure 7: Changes in Average Annual Precipitation from 1895 to 2019 (based on a linear trend)

(Source: PCCRC, 2019)

Recent work by the Purdue Climate Change Research Center (PCCRC) indicates an increase in average yearly precipitation of 4.2 inches for the NBER area over the 125-year period from 1895 to 2019 (PCCRC, 2019). This is a little less than the difference between what Crompton (1986) reported for the basin (35.8 in/year) and what is measured today (38 in/year) or a 2.2-inch increase over 34 years). Increases for other parts of the state are shown in Figure 7. A copy of the PCCRC assessment can be found at https://ag.purdue.edu/indianaclimate/.

Extreme Rainfall Events

Frequency of heavy rainfall events is another piece of information in the precipitation picture. Figure 8 shows the number of days each year with precipitation events exceeding the 1900 to 2016 99th percentile (the highest 1 % of all recorded rainfall depths). The black line shows the increasing trend from 1 day per year to over 3 days per year. As with annual rainfall, the last 30 years have included more of the extreme rainfall events. More frequent extreme events and larger annual precipitation totals result in more water moving thru the system impacting the streams and the lakes that exist in the watershed.

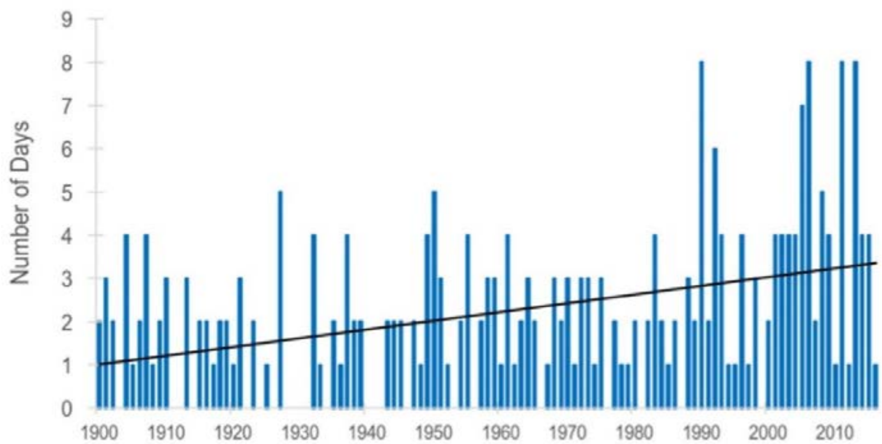

Figure 8: Number of Days with Extreme Precipitation
(Events Exceeding the 1900 – 2016 period's 99th Percentile for Indiana)
(Source: Indiana's Past & Future Climate: A Report from the Indiana Climate Change Impacts Assessment. Purdue Climate Change Research Center, March 2018)

CHAPTER 4: HYDROLOGY

Hydrology of the watershed, that is flow or movement of water in the watershed, is largely controlled by land use and geology.

Land Use

Land use within the NBER watershed is currently a mix of agriculture, forests, wetlands, lakes, and urban areas. According to the 2016 National Land Cover Database (NLCD), approximately 70% of the watershed is agriculture, 5% urban, 5% forest, and 20% water, wetlands, shrub, and grassland. The large areas of agriculture and water can be seen in the land use map in Figure 9. The various land uses affect basin hydrology differently.

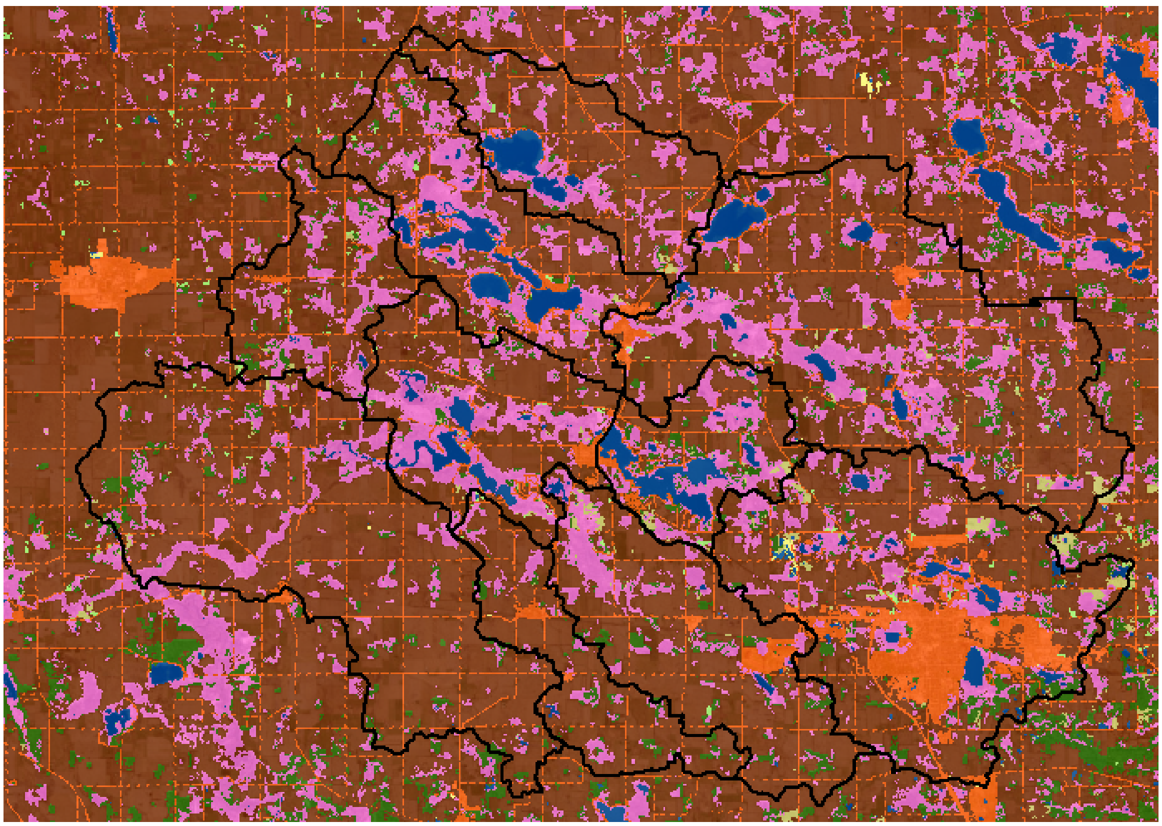

Figure 9: Land Use in the NBER Watershed (NLCD 2016)

For example, successful agriculture in a naturally poorly drained watershed like the NBER requires good drainage. Good drainage for agriculture means more water off the landscape faster so crops can be planted, which in turn means received precipitation gets to the channel faster. In the NBER this agricultural drainage is moderated by the high infiltration rates in most of the basin. This allows for more water to soak into the soil than to runoff. The result is that agricultural drainage does not currently have as much of an impact on river discharge as it does in other parts of the state. As rainfall continues to increase it will be critical to balance any increased drainage with opportunities to increase infiltration. For example, remaining forests and wetland areas need to be protected so they can continue to function as storage areas for precipitation and improve water quality.

Urban and residential interests also want drainage and additional development possibilities. This will mean increased flow just as it does in agricultural areas. As with agricultural drainage, any increased urban or residential drainage will need to be offset.

Available NLCD land use data was not consistent enough between years to provide an accurate representation of land use changes over time. Using Google Earth, however, increases in development around Kendallville and the lakes could be seen but increases were small in comparison to the overall watershed. Even though the changes are small, each change, if not mitigated, reduces the ability of land to absorb runoff bit by bit. Various regulations exist in the entities within the watershed to help mitigate the impacts of changes. As rainfall changes, the pressure to make various land use changes will also change.

Stream Flow

Most Indiana watersheds are dominated by surface water flow. The hydrology of the NBER basin however is dominated by groundwater. Over a third of the basin is underlain by thick (100-300 ft) deposits of sand and gravel. These sands and gravels form an extensive unconfined buried aquifer with very high transmissivity rates that recharge the river (Crompton and others, 1986; Fowler,1992). Crompton and others estimated that 80 percent of the flow in the river is supplied by these aquifers.

Flow Volume

Figure 10 shows annual average daily flow volume. This is the volume of water from the watershed that reaches the Cosperville gage. This data shows that there have been yearly fluctuations, but the average has remained steady. This would seem to indicate that the watershed response to given rainfall has not changed or the system is able to absorb the degree of changes that have occurred so far.

The average daily flow volume recorded at the Cosperville gage of 280 Ac-ft per day is equivalent to 102,200 Ac-ft of water passing the gage per year or the equivalent of 13.5 inches of rain over the entire watershed. The average annual rainfall is 38 inches per year which is equivalent to 287,800 Ac-ft of water per year that falls on the watershed and makes its way to the Cosperville gage or is absorbed, evaporated, or stored somewhere in the system. That means 24.5 inches or about two thirds of the average yearly rainfall on the watershed does not show up in the stream at the Cosperville gage. This highlights the importance of making sure the watershed continues to be able to "keep" this volume from the stream or water surface elevations and duration of given flow levels will increase as the stream has to take more of the rainfall when the watershed can't "keep" it.

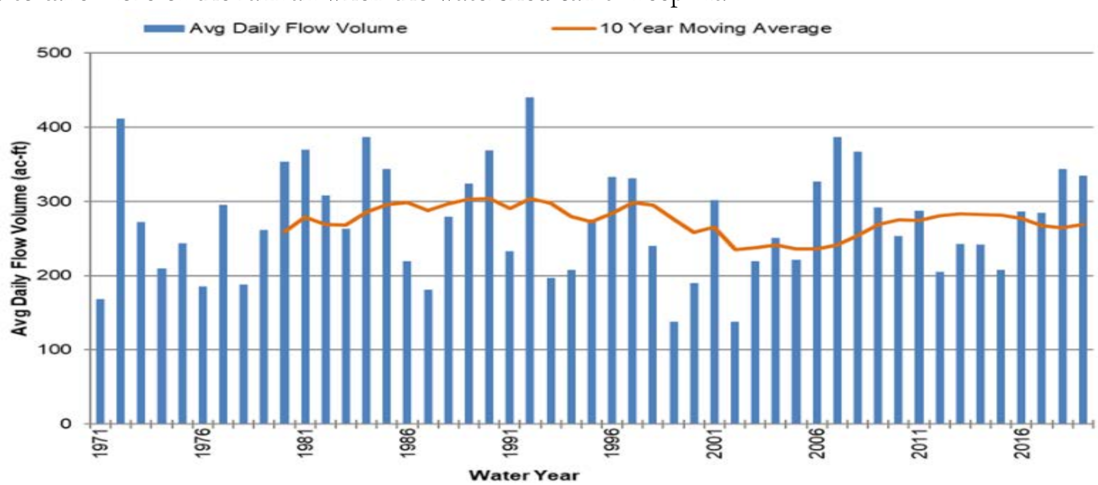

Figure 10: Annual Average Daily Flow Volume at NBER at Cosperville, IN USGS Gage
(Source: USGS National Water Information System)

It is interesting to note that while the year 1990 had 12" more of rainfall than the average year, the daily flow volume was not quite as high as other years that had less annual precipitation. This serves to highlight that many factors affect infiltration, runoff, and streamflow, not just the amount of rainfall. The system can act differently with variations in vegetation, evapotranspiration rates, different temporal and spatial rainfall distributions, and ground conditions, and the dynamic impacts of any of these on the others.

A simple mass balance of yearly rainfall, evapotranspiration, and infiltration averages helps to illustrate the groundwater's significance in this basin. As noted in the previous chapter, the basin currently receives, on average, 38 inches of precipitation per year. Evapotranspiration removes 27-28 inches from the received total, leaving 10 inches to infiltrate or runoff. (Clendenon and Beaty, 1987). Documented regional recharge, or precipitation that infiltrates, varies from 6 to 10 inches (averaging 8.8 inches) per year over the NBER watershed (ISJ, 2010). This means that on average, over 8 inches of the 10 inches of precipitation left to infiltrate or runoff is infiltrating into the soils to recharge or replenish groundwater. That suggests that of the 38 inches of received precipitation, less than 2 inches of an average year's precipitation is available for runoff.

This runoff moving towards the Little Elkhart Creek, MBER, or the NBER will need in most places to flow across more than 800 feet of muck soil. This muck absorbs the runoff. The result is that unlike most Indiana river systems the NBER is not a surface runoff driven river system, but a groundwater driven system. The significance of being a groundwater system is that flow through the ground creates a more stable flow reaching the river. Peak flows are never as high and water levels never as low as they would be in a runoff driven river system. The stable and non-flashy flow also leads to very low erosion rates except in highly disturbed areas.

CHAPTER 5: HYDRAULICS

Along the channel and floodplain there are agricultural, wildlife, residential, and recreation interests. These interests desire drainage of water to allow crops to grow, homes to be accessible and flood free, and lakes to be of use for recreation. They also desire good water quality and sediment movement so that lakes stay as lakes and water can continue to drain away from areas of interest. As a result, water that extends into certain areas of the floodplain or remains in the floodplain for extended periods of time is of concern to those along this corridor. The amount and timing of watershed rainfall reaching the stream and the capacity of the system to transport that water determine both water level and length of time water remains at given levels.

Stream Flow Processes

Most of the time stream flow is confined to the "active channel", a portion of the fluvial plain, or stream corridor, that is carrying water all the time in a perennial stream like the NBER. The flow in most streams will rise out of the channel and onto the functional floodplain in response to receiving more water than the active channel can convey. However, water in the NBER channel does not "spill out" onto the floodplain. In the NBER the water level rises with an influx of more water from the aquifer and any surface runoff. The Geology section of this report noted the absence of "alluvial" or stream influenced soils in the functional floodplain. That is because the functional floodplain throughout the corridor is a band of muck soil up to 80-in thick and ranging from 800 to 3000-ft wide. The muck is saturated to the surface (NRCS, Web Soil Survey). The stream field assessment conducted and summarized in Appendix 2 shows this stream system to be very stable because of this geology. The only exceptions are in areas of disturbance such as the west side of Wolcottville and the headwaters of the MBER around Kendallville.

Stream Flow Capacity

To gain insight into how the capacity of the channel and floodplain relate to the water levels and flood durations, an analysis of available stream and lake gage data was done as well as a preliminary hydrologic computer model created. This information helps provide an understanding of how the system is currently functioning and to identify trends.

To show how flow moves through the system, a hydrologic computer model was used. This model created an approximate inflow to the system using traditional surface water runoff methodology. This is a groundwater system, so the surface runoff methodology is used only as a substitute for groundwater inflow to the system to show how flow interacts with the physical above-ground storage available. Based on this model, Figure 11 shows how flow changes through the system by showing graphs of flow (vertical axis) versus time (horizontal axis) for the 4 downstream lakes directly included in the model. Small dotted lines in the graphs represent the inflows to the lakes. Solid lines represent lake outflows. (There are 2 outflows shown for West Lakes based on the variation of outflow relationships shown to exist for the lake which are discussed later in this chapter.) The hydrographs in Figure 11 are based on a 5-year event. Similar patterns are expected for other frequency events.

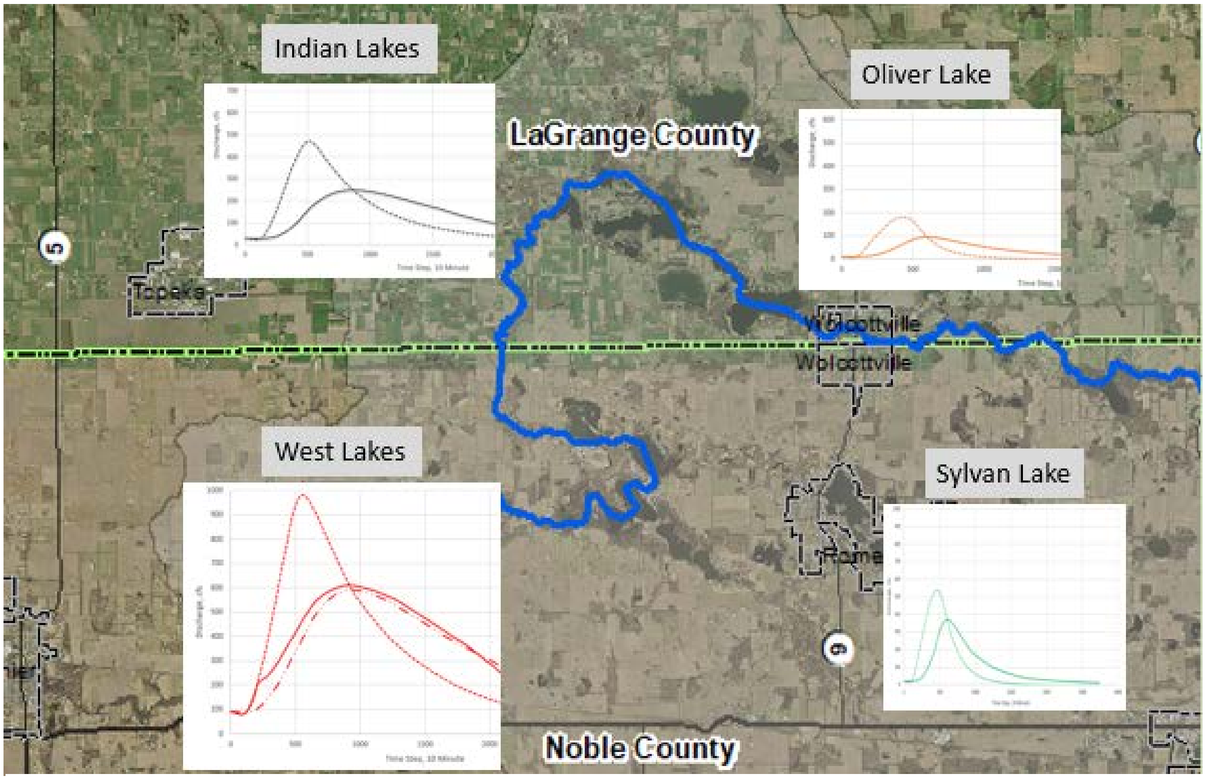

Figure 11: Inflow vs. Outflow of Modeled Lakes

The hydrographs above show how each lake reduces the peak discharge flowing into the lake. Note the high peak of the inflow compared to the much lower peak of the outflow. The outlet controls the rate at which water can be released downstream, so that each lake serves as flood storage by storing water temporarily on its floodplain while the outlet reduces downstream flow. Note in the hydrographs that peak discharge increases moving downstream so that much more water needs to be stored around West Lakes than at Indian Lakes. An analogy that helps to understand this process is that moving downstream on a river the floodplains increase in size as discharge increases. In a lake chain this same function is provided by the lake.

To give an idea of how much storage each of these lakes is providing, the volume available between legal level and one foot above legal level was calculated. Volumes are shown in Table 1. Volume added for each foot of elevation above the one foot shown in the table is more than the volume of the first foot.

Lake	Volume, Ac-Ft
Oliver	600
Indian Lakes chain	500
Sylvan Lake	600
West Lakes chain	400
Total	2,100

Table 1: Approximate Volume of Water That Can Be Stored in the First Foot above Legal Lake Level

The total volume listed in Table 1 is equivalent to 0.35" of precipitation on the entire watershed sitting in the 1 foot above legal level at a given instant. The land around each lake covered in water at one foot above legal level, is shown in black in Figures 12 through 15.

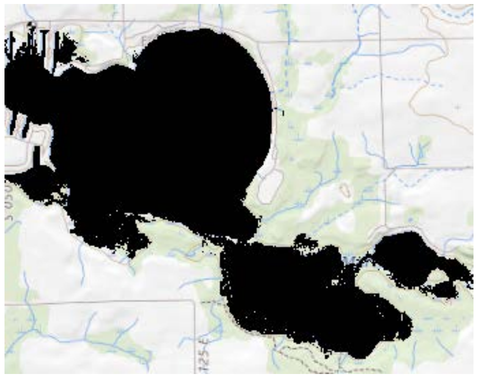

Figure 12: Extent of Flood Waters at 1 Foot above Legal Lake Level on Oliver Lake

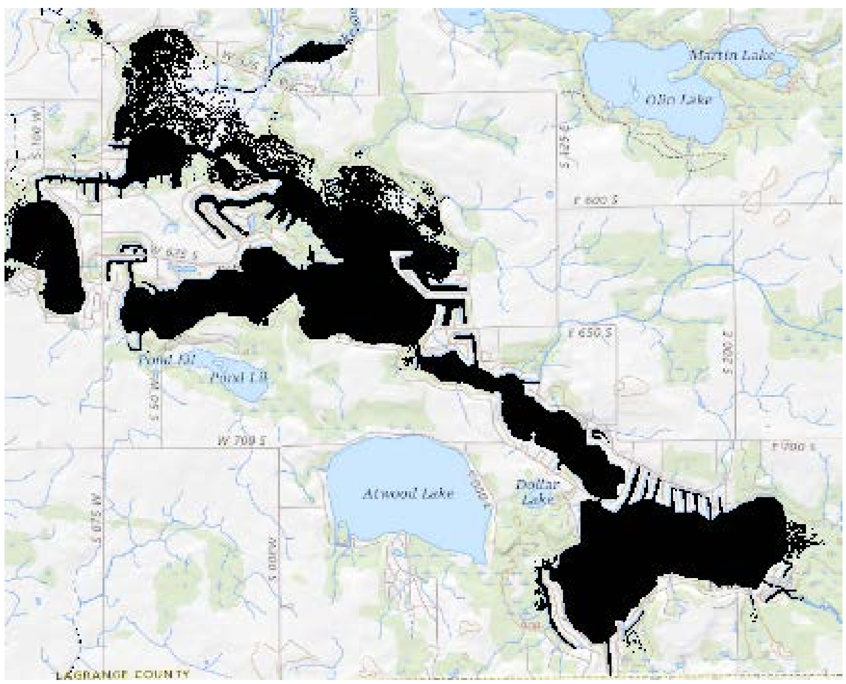

Figure 13: Extent of Flood Waters at 1 Foot above Legal Lake Level on Indian Lake Chain

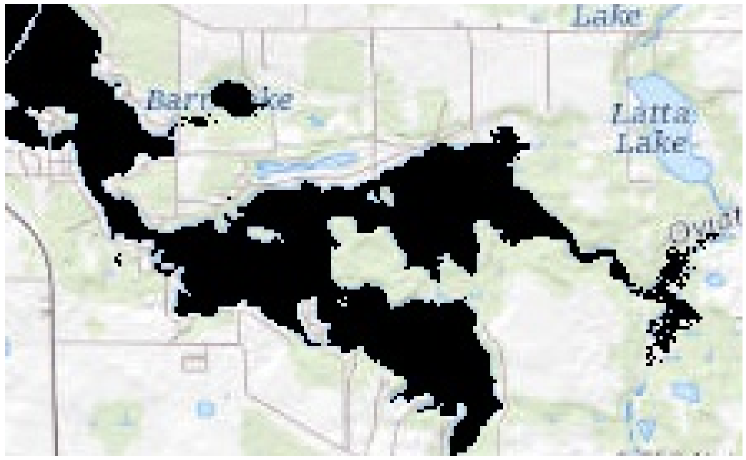

Figure 14: Extent of Flood Waters at 1 Foot above Legal Lake Level on Sylvan Lake

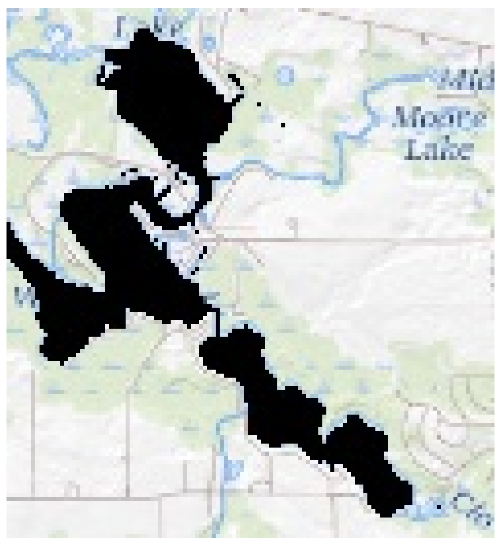

Figure 15: Extent of Flood Waters at 1 Foot above Legal Lake Level on West Lakes Chain

Peak Flow and High Lake Level Trends

In the watershed there are several lake level gages but only one streamflow gage. The location of these gages is shown in Figure 16.

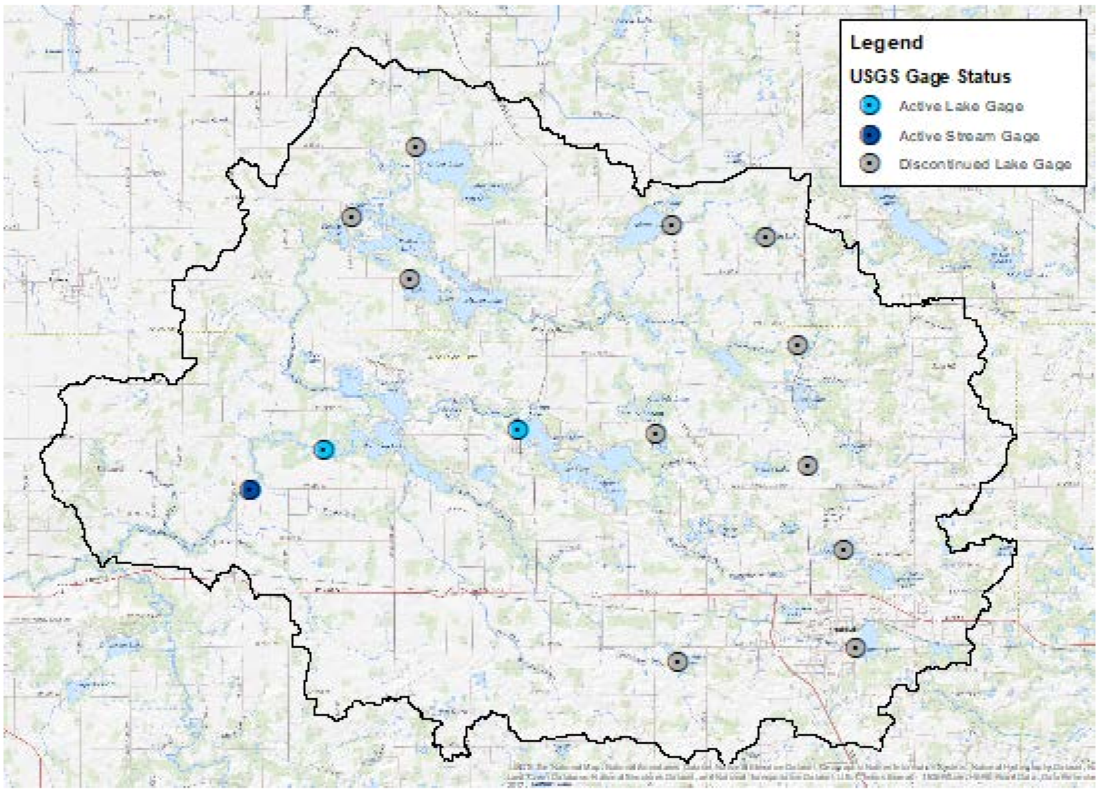

Figure 16: USGS Gages

The peak annual flow rate for the one stream flow gage, NBER streamflow gage at Cosperville, Indiana (USGS Gage 04100222), is shown in Figure 17. The peak discharge has varied from 200 to 900 cfs, with the 10-year moving average varying between 400 and 600 cfs. The 10-year moving average over the last 5 years has been higher than any other time in the 50-year period of record.

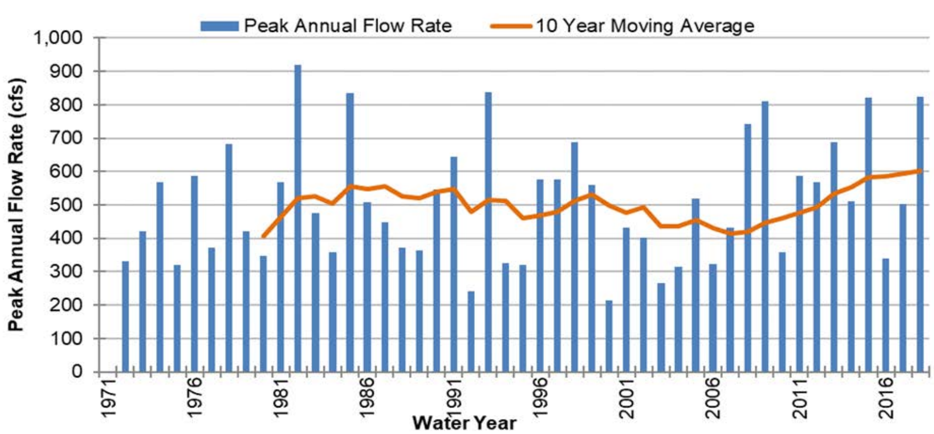

Figure 17: Peak Annual Flow Rate at NBER at Cosperville, IN USGS Gage
(Source: USGS National Water Inventory System)

Peak flows are important, but of equal concern is the length of time that elevated water surface elevations are maintained.

An analysis of the number of days each year that a lake was at or above each 1-foot increment over the legal lake level was graphed for each water year (October through the following September).

The number of days above various 1-foot increments were graphed in Figure 18 and Figure 19 for West Lakes and Indian Lakes chains, respectively. The Noble County annual rainfall for each year was also plotted on the figures to see if there is a correlation. The plots showed that years of equal annual rainfall do not necessarily produce similar numbers of days above certain lake levels. This is not surprising since the system is groundwater driven.

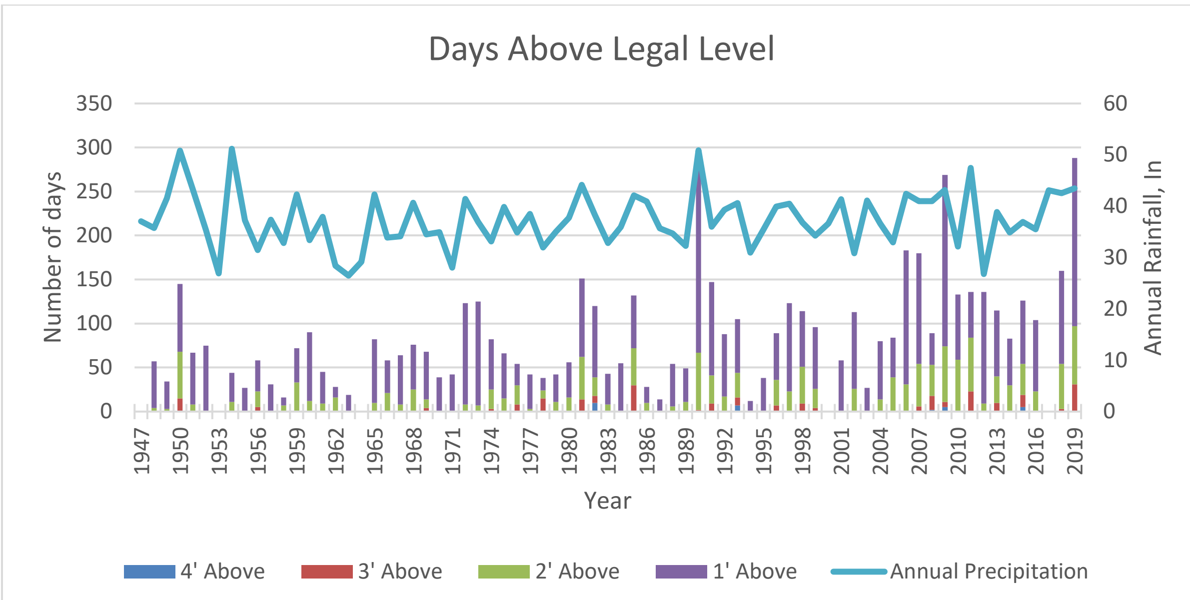

Figure 18: West Lakes Chain - Number of Days above Legal Lake Level

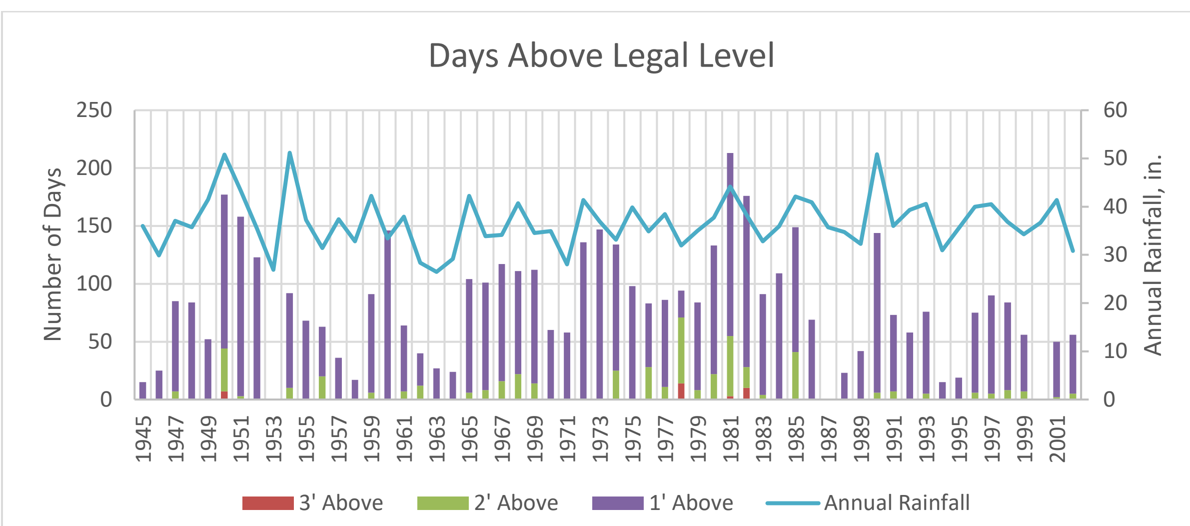

Figure 19: Indian Lakes Chain - Number of Days above Legal Lake Level

While annual rainfall over the entire record had a different pattern than the number of days above legal level in a year, the trend in days above legal level, shown in Figure 20 for West Lakes, is increasing similarly to the trend in number of days of extreme rainfall events (shown earlier in this report as Figure 8 and repeated here for convenience as Figure 21).

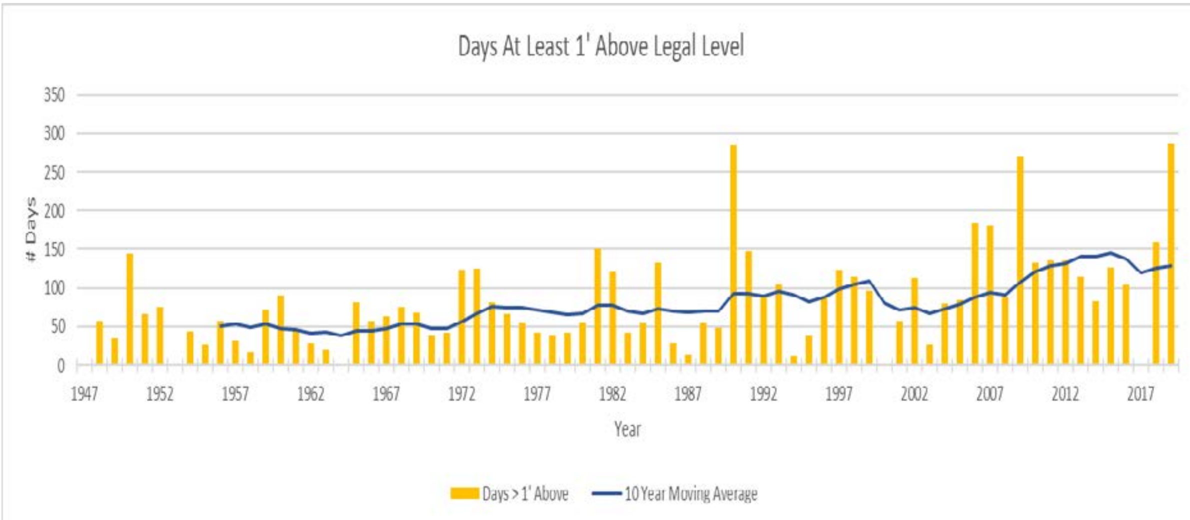

Figure 20: West Lakes Chain Number of Days at Least 1 Food above Legal Level

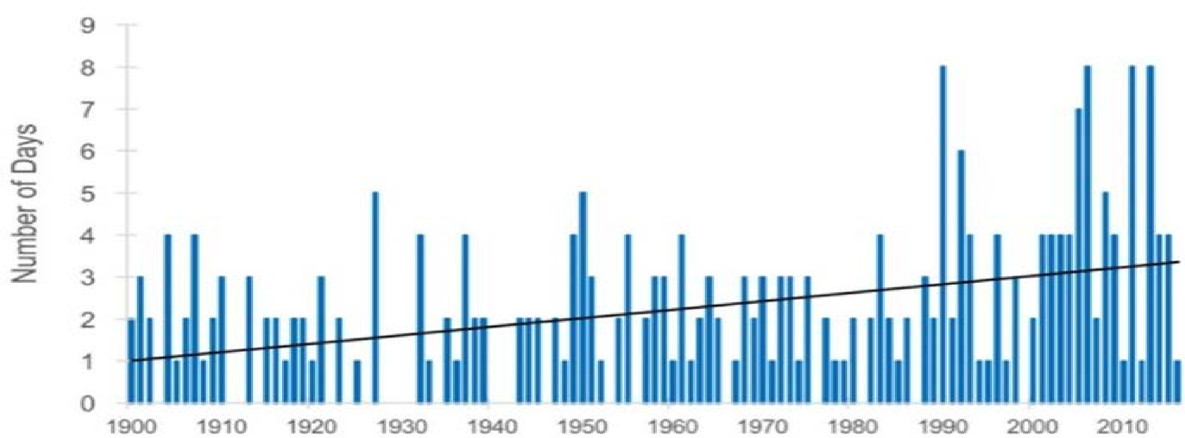

Figure 21: Number of Days of Extreme Rainfall Events

The number of days with elevated lake levels for other gaged lakes in the watershed is shown in Figure 22. These lakes have much fewer days at these levels than Indian or West Lakes do. The closest is Bixler Lake with 4 years of at least 70 days of lake levels more than 1' above legal level for its 57-year period of record from 1945 to 2002. This same period of record is shown for all the lakes.

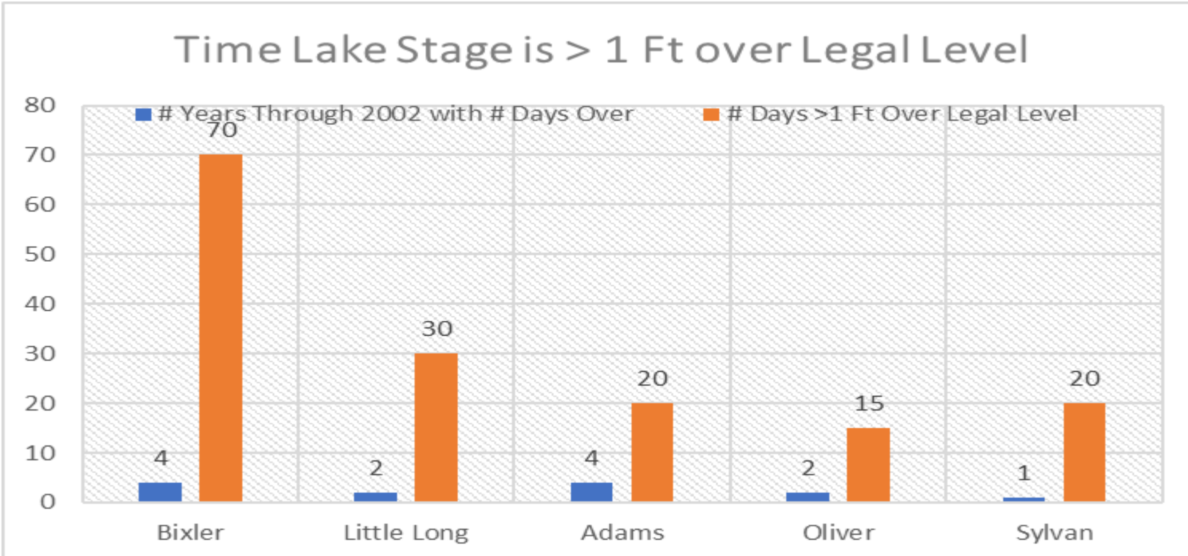

Figure 22: Comparison of Elevated Lake Levels

Residents on West Lakes Chain suspect that log jams and weed growth in the downstream channel contribute to their extended length of elevated lake levels. In order to confirm and substantiate these suspicions, stream flow at the Cosperville gage was graphed and compared with the corresponding West Lakes gage height. Measurements were symbolized based on the month they were taken. The graph is shown in Figure 23 May to August was assumed to be months that vegetation could be growing in the outlet channel. Each dot shows a measured flow and the corresponding lake gage stage at the time of the flow measurement. Any given stage at the lake can be seen to have had a range of corresponding discharges depending on the time of measurement. Similarly, any given discharge has occurred at a range of lake stages. Growing season dots are clumped at a lower range of corresponding discharge than the non-growing season dots.

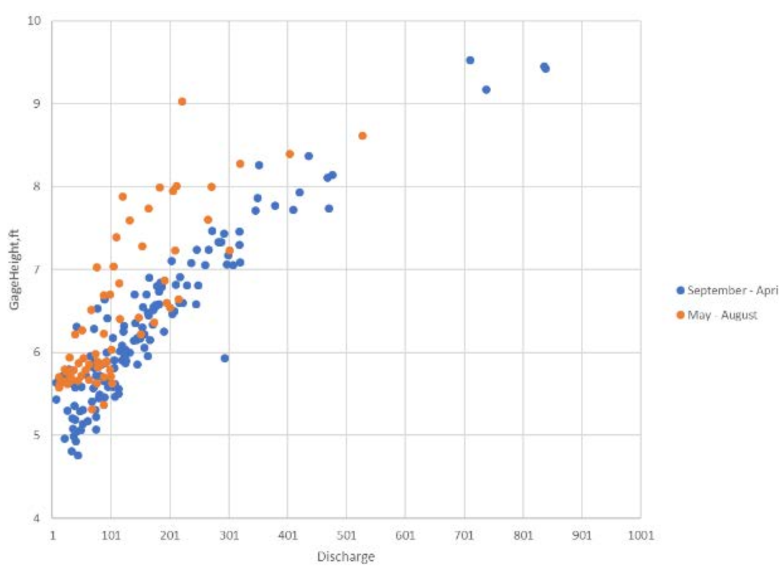

Figure 23: Cosperville Gage Discharge vs. Waldron Lake Gage Height, USGS Measurements

The above graph shows the variation between the growing and non-growing season discharge to lake stage relationships. While lower and higher flows have been measured for a given elevation in each season, the growing season outflow tends to be less for a given stage than the non-growing season outflow at that stage. Non-growing season discharge measurements vary about 100 cfs for a given gage height but the growing season discharges at the same stage can vary over 200 cfs. A sensitivity analysis was done for only the measurements since 1990 and then since 2000 to see if there was a change over time. No significant change was noticed so the variability appears to be consistent through time.

The graph of the measurements does show that there is a large range of possible flow rates in the stream that have been experienced for a given stage on the lake. In addition to the variability in vegetation or large wood in the stream from year to year, possible explanations are the presence of intervening flow under certain rainfall distributions and groundwater conditions and responses. Flow entering the stream (from below or above ground) between the lake and the Cosperville gage could reduce the capacity of the stream for the upstream lake outflow or create a larger discharge than that which created the stage at the lake outlet. Work done by Fowler (1994) does show a change in the groundwater aquifer downstream of Waldron Lake. The aquifer changes from the surficial sand and gravel aquifer system to the buried sand and gravel aquifer. Overall yield (or water availability) is higher in the surficial aquifer. The interaction of these two groundwater systems below Waldron Lake may account for much of the variability seen in stream flow. Streams also typically have a looped rating curve meaning that when downstream elevations are low as flow begins to increase, upstream portions can pass along more flow but as the downstream tries to absorb that flow, elevations increase and the upstream portion has elevated levels to "push against" so can't send as much flow and therefore must increase in elevation until they can overcome the downstream resistance.

Regardless of the reasons behind the observed variations in Waldron Lake stages for a given flow at Cosperville, the impact of such variation on the frequency and duration of high Waldron Lake levels is quite limited. The large-scale computer model previously discussed was used to provide insight into the scale of potential impacts. Results are based on a 5-year 96-hour rainfall using the NOAA Atlas 14 50% all cases distribution (4.1 inches over 4 days). This rainfall was used as an approximation of flow entering the lakes above ground storage areas whether that flow is from groundwater, surface water, or both. As shown in Figure 24 the modeling suggests that for the inflow amount modeled, the difference between the more efficient (dashed line) and less efficient (solid line) rating curves was a few days difference in time near the peak and about a half foot lower peak elevation with the more efficient rating curve.

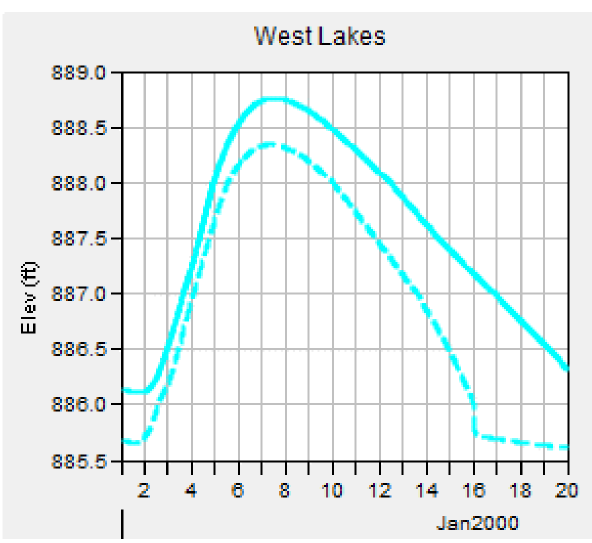

Figure 24: Difference in Lake Hydrograph Based on Outlet Rating

The control for the elevations at the lake may not be something that can be changed by adding channel capacity since it is a groundwater driven system. Even if a project would have impact, it must be remembered that increased capacity by these methods is gained by increasing downstream flows. Increased flow downstream translates into increased flood elevations in downstream reaches. Increased elevations are not desired downstream since the interest in protection of property exists there as it does in the areas along the lakes.

As an illustration of the impact of a lake outlet improvement on downstream reaches, an improvement to the Indian Lakes outlet was estimated by increasing the outlet weir coefficient in the model. The peak elevation on Indian Lakes dropped 0.15' and time near the peak elevation was reduced about 1 ½ days. Downstream at West Lakes the peak elevation using the more efficient outflow rating went up 0.1 foot and the time at peak elevation increased ¼ day. Upstream improvements do have negative impacts on downstream conditions. So, while limited maintenance of aquatic weeds may be beneficial for a small reduction of elevated lake level durations of small and isolated rainfall events, a more intensive alteration of the lake outlet capacity is expected to be detrimental to downstream reaches and also not effective in substantially reducing high lake levels or durations for moderate to large rainfall events. Actual differences in lake elevations and outlet discharges would vary depending on the rainfall total, distribution, preceding rainfall, vegetation, and groundwater conditions at the time of as well as prior to the rainfall event.

With the recent increased lake levels, community officials have questioned whether the Flood Insurance Study (FIS) Base Flood Elevations (BFE) need to be updated and a higher Flood Protection Grade (FPG) be used in the meantime to prevent flooding of new structures constructed around the lakes.

Below is a chart comparing FIS BFE and USGS gage peak elevation of record for each lake.

Lake	FIS 100-yr, Elevation NAVD 1988	Record Peak Elevation, NAVD 1988	Years of Record
West	890.1	889.7	1947-current
Sylvan	917.2	917.6	1942 – current
Indian	900.5	900.6	1945 – 2002
Oliver	901.9	901	1945 - 2002

Table 2: FIS and Peak Lake Elevations

With the extensive storage available around the lakes, a large change in inflow may result in a small change in lake elevation but that increased elevation may continue for a long time. With the length of time required for lake levels to return to normal after a rainfall event and the increase in extreme events, there is also the need to consider the impact of back to back rainfalls or coincident significant groundwater and surface water inflows on lake elevations. While as shown in Table 2 not all the lakes gages have experienced record lake levels within the period of their record higher than the estimated BFE, given the expected climate change impacts, a modest 0.5-foot increase in typical FPG requirement (from 2.0 feet to 2.5 feet) to account for the increased potential for back to back storms or coincident inflows would be prudent. This increase can slightly reduce flood insurance premiums and reduce the frequency at which liveable areas of residences could be flooded.

CHAPTER 6: GEOMORPHOLOGY

The stream assessment conducted along the mainstem of the NBER and the MBER (Appendix 2) found that the upper headwaters of the NBER, Hutchins, and Uhl ditch were remarkably stable for agriculturally modified streams with wide buffers and stable channels (Figure 25). Some of the stability can be attributed to the ditches being cut into Brookston silt loam. That also suggests that the ditches are modified swales in the naturally poorly drained landscape. The stability is also a function of the management of the area. The wide vegetated corridors allow for more natural functioning. The ability for high flows to spill out into the valley floor is critically important to downstream stream conditions as it buffers high flows.

Figure 25: Hutchins Ditch, upstream from confluence with Uhl Ditch
Note well-connected floodplain and grassed buffer.

Hutchins Ditch combines with Uhl Ditch at Cree Lake to form Little Elkhart Creek downstream from Cree Lake. The surficial geology of the stream corridor changes at this point from a ditched upland swale to a linear wetland with a stream flowing through it (Figure 26). The water in the wetland and the stream flow are primarily groundwater. As noted in the Hydrology section, Crompton and others suggest that 80 percent of the stream flow is groundwater, most of it flowing into the channel through the muck soil. Little Elkhart Creek's morphology and planform reflects the wetland boundary conditions and the groundwater flow regime. Most of the creek is a Rosgen E4/5 stream type, a common northern wetland stream type that is inherently stable and characterized by moderate to high sinuosity and low channel slope or gradient. The characteristic narrow and relatively deep channel is a very hydraulically efficient form with a high resistance to channel adjustment. Rosgen notes that these channels are very stable unless the streambanks are disturbed, or if significant changes occur in sediment supply or streamflow (Rosgen, 1994). Only one small area of disturbance was noted along Little Elkhart Creek.

In part because of the lack of disturbance, the sediment load is small, primarily fine to medium sand winnowed from the surrounding upland areas. Large wood is present, but no flow obstructions were noted. With a wide wetland corridor, the average width along Little Elkhart Creek is greater than 1,000 feet, and the active stream channel is less than 40 feet wide, making it unlikely that a large wood blockage would affect anything outside of the riparian corridor.

Figure 26: Little Elkhart Creek Downstream from Cree Lake near SR 3

Little Elkhart Creek flows from the Cree Lake outlet to Tamarack Lake, then through Mud Lake, Nauvoo Lake, and Wolcottville, then into Witmer Lake. The approximate stream length flowing between the lakes is 8.0 miles. After flowing into Witmer Lake, Little Elkhart Creek will merge with the outlet of the Oliver Lake chain as the NBER. In morphology, planform and landscape setting the NBER is simply a larger Little Elkhart Creek. The river is still groundwater sourced and it is still flowing through a forested muck wetland corridor. River width in the NBER averages 60 feet and the wetland corridor ranges from 800 to over 3000 feet wide (Figure 27).

Figure 27: NBER at CR W 1200 N (County Line) Looking Upstream into Lagrange County

The NBER is more modified than Little Elkhart Creek. From the Lagrange – Noble County line to the Jones Lake inlet (over 2.5 miles) the NBER has been straightened. For the first 1,700 feet into Noble County the riparian buffer is gone as shown in Figure 28. This appears to be the only place along the river where the riparian corridor has been removed from both sides of the channel. The floodplain is still functionally attached allowing flood pulses to spill out of the channel.

The Lagrange-Noble County line is also the only place along the mainstem NBER where there has been sand removal. No evidence of sand or sediment accretion or buildup was seen at the site. However, a passerby commented that it should probably be dredged soon to make sure the fishing hole stays deep. Dredging at that site should be done with great caution. Over time, dredging in a low sediment load system like the NBER could result in upstream downcutting.

Figure 28: NBER at CR W 1200 N (County Line) Looking Downstream into Noble County

As the NBER flows into Jones Lake, it combines with the MBER which is flowing in from the east through the Sylvan Lake outlet. The mainstem MBER headwaters originate near Bixler Lake to the east of Kendallville and flow west from Kendallville as the Bixler Lake Ditch-Henderson Lake Ditch. Downstream of Henderson Lake, northwest of Kendallville, Henderson Lake Ditch combines with Waterhouse Ditch and continues to flow to the northwest towards Sylvan Lake. The over 4 miles of Henderson Lake Ditch headwaters from Bixler Lake through Kendallville and then just north of CR E 800 N (W Rimmel Rd.) are channelized and degraded (Figure 29 and Figure 30). North of CR E 800 N the ditch flows into a large wetland complex located along the east end of Sylvan Lake.

Figure 29: Henderson Lake Ditch, Kendallville (looking downstream)

Figure 30: Henderson Lake Ditch, Downstream from Kendallville (looking downstream)

As Henderson Lake Ditch flows into the east end of Sylvan Lake the lake serves as a buffer and sink for sediment and other contaminants. The MBER flows out of the west side of Sylvan Lake at Rome City, forms Spring Lake, and then flows west for just over 3 miles into Jones Lake. The MBER downstream of Sylvan Lake has the same morphology and planform as the NBER and flows through a broad corridor of forested muck wetland (Figure 31).

Figure 31: MBER Downstream from Sylvan Lake (looking upstream)

As the NBER and the MBER flow into Jones Lake they merge and flow into Waldron Lake. At the outlet of Waldron Lake, the NBER flows southwest for approximately 6 miles to the confluence with the South Branch Elkhart River upstream from Ligonier. The planform and morphology of the E4/5 type stream remains the same as the upstream NBER and MBER, it just gets wider (Figure 32). The forested muck wetland corridor is over 3,000 feet wide in places. The sediment load remains low and primarily fine to medium sand. Large wood is common but, as with upstream, no obstructions were observed during the field assessment.

Figure 32: NBER at CR W 900 N (looking downstream)

CHAPTER 7: SUMMARY OF FINDINGS

Flooding concerns have been reported in the NBER basin since the early 1980's (Crompton,1986; Fowler, 1994), and have continued to be a concern (ISJ, 2010). Despite the longtime complaints of flooding, no real assessment of the river had been undertaken. Most of the effort had focused on the lake segments rather than the river. This current study considers the NBER from its headwaters on the far east side of Noble County to the confluence with the South Branch Elkhart River near Ligonier.

River assessments can be conducted with a variety of methods. To meet the needs of the SJRBC, Burke performed a functional assessment of the NBER. The functional assessment follows the methods laid out in the Project Approach Section of Chapter 2 to develop an understanding of how the system is functioning overall. The following is a summary of the findings.

The functional pyramid rests on the dual foundations of geology and climate. If one of the foundations is changing or is altered the pyramid will shift. In the NBER the geology is remarkably stable given over 150 years of landscape modification. Trees have been removed and wetlands drained throughout Lagrange and Noble County, but the extensive deposits of muck soil overlaying 100 to 300 feet of outwash sand and gravel still provide enormous storage.

The large potential storage means that basin hydrology is buffered. Runoff from the predominantly agricultural watershed is very low. As discussed in Chapter 3, current estimates are that on the average less than 2 inches of received annual precipitation are available for runoff. Annual infiltration averaging approximately 8.8 inches per year, or 24 percent of received average annual precipitation that goes to groundwater and is stored in the aquifers.

Crompton and others (1986) estimated that 80 percent or more of streamflow in the NBER was supplied by groundwater so that river flow is not runoff driven. It is groundwater sourced and controlled by an aquifer transmissivity of over 50,000 ft^2/day. For the NBER that means stable flows with little annual fluctuation as shown in the graph of average daily flow volume (Figure 10).

With a stable basin hydrology, the channel hydraulics are equally stable. No significant bank or channel bed erosion was observed. This is in part a function of the river form. As noted in the detailed stream assessment report in Appendix 2, Little Elkhart Creek and the NBER are Rosgen E5/6 channels. This channel type is inherently stable and characterized by moderate to high sinuosity and low channel slope or gradient. The characteristic narrow and relatively deep channel is a very hydraulically efficient form with a high resistance to channel adjustment. Rosgen notes that these channels are very stable unless the streambanks are disturbed, or if significant changes occur in sediment supply or streamflow (Rosgen, 1994)

The best current evidence for a stable basin hydrology is that even with the increase in annual rainfall and the intensity of rainfall, flow volumes in the downstream portion of the watershed do not directly reflect this increase. This is attributed to the lack of change to groundwater control of the system and extensive availability of above-ground storage.

Overall, the NBER system is one of the most naturally functioning river systems in the state. Great care should be taken to preserve this remarkable resource.

Unlike NBER's main stem, the headwaters of the Middle Branch Elkhart River exhibit a few instability issues. The over 4 miles of Henderson Lake Ditch headwaters from Bixler Lake through Kendallville and then just north of CR E 800 N (W Rimmel Rd.) are channelized and degraded. The headwaters of the mainstem NBER provide a model of how this reach could be improved through connecting the channel to a geomorphic floodplain. To connect the floodplain in the headwaters of the MBER the channel could be multi-staged, and corridor could be vegetated, similar to what we find along Uhl Ditch. Reattaching the floodplain in the headwaters would help to reduce the downstream velocity and slow the downcutting observed near Sylvan Lake. The effort would also reduce the sediment influx into Sylvan Lake.

Based on a detailed analysis of available long-term lake level data within the watershed, the number of days when lake levels have been above their legal levels (normal lake levels) have been increasing, especially within the last 20 years. This observation correlates well with the observed number of days with heavy precipitation in Indiana as presented in a March 2018 Purdue Climate Change Research Center report. In particular, West Lakes has had at least 3 years where lake levels have been more than 1' above legal level for over 250 days of the year. Two of these were in the last 10 years. The level of a lake before the next storm is a big influence on peaks and duration of high water. Lake levels remain high due to increased frequency of rainfall or extended influx of groundwater.

While West Lakes' outlet efficiency appears to be generally lower during the growing season, the result of observed inefficiency in the outlet capacity, regardless of the reason, is only in the order of magnitude of 6 inches for the approximate 5-year event peak elevation and a few days shorter recession time. The difference is even smaller for larger events. The comparison of measured discharges at the Cosperville gage with the corresponding elevation of Waldron lake shows that there has been a large range of flow rates in the stream at Cosperville for a given stage on the lake. Variability in vegetation or large wood in the stream from year to year may explain some of the variability but the groundwater driven nature of the stream and the change in aquifers at the lake outlet are likely the bigger factors.

Based on previous flood records, Sylvan Lake has flooded to 0.4 feet above the FIS BFE and Indian Lakes reached 0.1 foot over the BFE. Oliver and West Lakes do not have recorded peaks at or above the BFE. The large storage volume available at each lake will lessen the impact of increased rainfall on lake levels but an increase in the frequency of heavy storms and the potential for back to back rainfalls with large groundwater inflows suggest potential increases in flood levels. While not all the lakes gages have experienced record lake levels within the period of their record higher than the estimated BFE, given the expected climate change impacts, a modest 0.5-foot increase in the required Flood Protection Grade (FPG) for new buildings within and near the floodplain is prudent.

A preliminary large-scale hydrologic computer model was developed as part of this study to evaluate the potential impacts of creating additional flood storage in the watershed. For this evaluation, five additional flood control ponds, each being 300 acres in area with 600 acre-feet of active flood storage, were assumed to be constructed within various major sub-basins. The result of this modeling showed only a modest reduction (3 to 6 inches) in flood stages and in flood durations (1 to 3 days), depending on the magnitude of the event simulated (the larger the event, the smaller the impact). Given that for the standard 1% chance flood event the majority of homes within the floodplain around the lakes are expected to sustain between 2 to 3 feet of flooding, the nature of this groundwater-driven lake chain system, and the relatively nominal benefit resulting from such a large investment (estimated at $100 Millions) that would also require taking out of production an enormous amount of land area and significant impact to wetlands, additional consideration of this alternative is not warranted.

The nature and location of flooding along the NBER through Noble and LaGrange Counties is the product of basin geology and climate. As our collective understanding of the natural fluctuations in weather and climate have increased, we have learned that we cannot control climate or geology. Instead of struggling to control the climatic fluctuations we will need to learn to adapt. Based on the findings of this study, we conclude that it is not likely feasible or cost-effective to try to significantly reduce flood problems for homes that were built in the floodplain by creating additional upstream storage, clearing the vegetation downstream of the system, or by more intensive means of increasing the outflow from lakes without creating negative impacts elsewhere. What is recommended instead is to take a series of steps to adapt to the "new normal" high lake level and flooding patterns, protect homes and reduce vulnerability to flood damages, and do everything possible to maintain the existing inherent resiliency within NBER watershed and keep things from getting worse. These can be accomplished through implementing the recommendations in this report.

CHAPTER 8: RECOMMENDATIONS

The nature and location of flooding hazards present along the NBER through Noble and LaGrange Counties are the products of the basin geology and climate. As our collective understanding of the natural fluctuations in weather and climate have increased, we have learned that we can't control geology or climate. Instead of struggling to control the climatic fluctuations we will need to learn to adapt.

Communities have significant historical knowledge of flood-prone areas as well as availability of the National Flood Insurance Program mapping to identify riverine flood-prone areas. There are also existing regulatory practices being used in the NBER watershed regarding flooding and fluvial erosion. These include:

- Some degree of detention is required in most of the area.
- Some of the counties and municipalities within the watershed have requirements to compensate for loss of floodplain storage.
- The National Flood Insurance Program and the State of Indiana have minimum standards for construction in a floodplain.
- The State of Indiana regulates all construction within the floodway to prevent construction that would increase the 1% annual chance water surface elevation by more than 0.1 feet. It does not address any other frequency impacts.

However, the current safeguards are not adequate to prevent increased flooding and erosion within the watershed, especially as Indiana climate is undergoing changes.

Based on the findings from the assessment described in this plan, the following recommendations are provided for the basin to assist in managing and adapting to the risks due to flooding and preserving the remarkable existing natural functionality and sustainability of this river system.

1) Develop and adopt location-specific flood resilience strategies

The analysis in Chapter 3 shows that the number of extreme rain events is increasing, and climate change studies indicate this trend is expected to continue and worsen. Despite this evidence, most Indiana communities continue to create new risks by allowing construction in areas with high risk of flooding while at the same time trying to mitigate losses in other areas.

As discussed earlier in this report, significant flood risk exists in low-lying areas around the lakes. Given the extent of flood risks, location of vulnerable structures within the floodplain, the increasing trend in rainfall within the watershed, and the size of the drainage area, no feasible solution exists to reduce the existing extent of the flood risk areas. Consequently, flooding for this area should be viewed as a regularly occurring hazard. Adopting appropriate flood resilience strategies specific to each distinct geographical area in each county and community within the watershed can help curb an increase in vulnerability to flood and erosion induced damage, reduce flood damages, reduce interruptions, reduce recovery time, and establish a framework for future economic development in safer areas within the watershed.

A description of each distinct geographical area within the watershed, the intent of strategies for each of the areas, and examples of typical specific resilience strategies for each of these geographical areas is provided in the following paragraphs and summarized in Table 3. The noted distinct geographic planning areas were identified as part of this study for the entire NBER watershed as shown in **Exhibit 2.** Specific resilience strategies suitable for each distinct area (such as the typical strategies provided in this report) should be identified, agreed upon, adopted into comprehensive land use plans and zoning ordinances, and implemented by a resilience team in each county and community.

1. *River Corridor Impact Areas*—The river corridor impact area is defined by the area within the floodway or the erosional corridor along the stream. The erosional corridors along all streams in Indiana have been developed based on regional Fluvial Erosion Hazard (FEH) analysis and hosted on the IDNR website. The intent of strategies in this area is to protect land adjacent to the river where flooding potentials and flood velocities are highest, and to minimize streambank erosion. Preserve undeveloped areas in this zone by adopting a "River Corridor Impact Areas" overlay zone and prohibiting any disturbance (fill or excavation) in this zone. The following is a list of typical specific strategies for this zone:
   - Adopt a River Corridor Impact Area Overlay zone & prohibit development in this area
   - Perpetuate protection of undeveloped land within River Corridor through partnering with land trusts
   - Restore impacted channel corridors/FEH Issues using nature-based solutions, such as a 2-stage ditch or other FEH mitigation

2. *Undeveloped High Flood Hazard/Flood Storage Areas*—These are the remaining high flood hazard areas within the 1% annual chance floodplains. The intent of the strategies in this area is to conserve land and maintain the natural and beneficial function of the floodway fringe, including the very crucial and significant flood storage function. Preserve these areas by adopting a "High Hazard/Flood Storage Areas" overlay zone and limiting the development in these areas to only suitable open space land uses (no buildings), protecting undeveloped land in this zone through incentivizing compatible uses such as parks and trails with help from public land trusts, and requiring compensatory floodplain storage when placement of fill in these areas is unavoidable. The following is a list of typical specific strategies for this zone:
   - Preserve floodplain storage and beneficial floodplain functions through prohibiting or strongly discouraging new development in this area
   - Require floodplain compensation when flood storage loss cannot be avoided
   - Perpetuate protection of undeveloped land within SFHA through partnering with land trusts
   - Prohibit development of new critical facilities in the floodplain and encourage relocation of existing facilities as opportunities arise

3. *Moderate Flood Hazard Areas*—These are areas within the 0.2% annual chance floodplain. The intent of the strategies in this area is to avoid placement of critical facilities and, to the extent possible, preserve these areas as additional flood storage areas that will likely be needed as the impacts of the ongoing changes in climate makes inundation of these areas in the future similar to how the 1% annual chance floodplain is inundated in today's climate. The following is a list of typical specific strategies for this zone:
   - Discourage new development in this area
   - Require buildings to have their FPG equal to or greater than that required in SFHA
   - Require flood protection grade of critical facilities in this area to be above the 0.2% chance flood elevation

4. *Vulnerable Developed Areas*—This designation would identify homes, critical facilities, and non-conforming structures that are already present either within the River Corridor Impact Areas or within the high flood hazard/flood storage areas. These areas have been or are expected to

be vulnerable to future flood events. The goals in these areas would be the acquisition of the most vulnerable structures, floodproofing of existing structures (especially critical structures), the development of new flood storage areas when possible, and the adoption of a flood response plan. The following is a list of typical specific strategies for this zone:

- Protect existing critical facilities in the SFHA through floodproofing/ring levees
- Relocate and/or buyout of homes
- Floodproof or elevate homes and businesses
- Bring nonconforming uses into compliance
- Create new flood storage through redevelopment
- Require building expansions to meet the additional requirements
- Develop a Flood Response Plan
- Encourage Flood Insurance and community participation in the Community Rating System (CRS)

5. *Safer Areas*—This designation would identify areas where public investments and policies should steer development. These areas would be land areas with higher elevations and outside of designated floodplain. Steer public policy and investment to support development in "Safer Areas" within the county and incorporated communities by revising comprehensive land use plans and capital improvement investments (such as expanding new sewer lines, electricity, and water only in these areas) to incentivize development in safer areas, promoting conservation design/Low Impact Development (LID)/Green Infrastructure (GI) in these safer areas, and promoting placement of critical facilities only in these safer areas. The following is a list of typical specific strategies for this zone:

   - Steer public policy and investment into safer areas (Ex.: extend sewer and water, construct infrastructure, tax breaks, etc.)
   - Promote conservation design and development (LID/GI)
   - Promote placement of critical facilities in these safer areas

6. *Watershed*—This designation would identify the land within the entire watershed. Promote coordination and partnership with various jurisdictions within the entire NBER watershed to slow, spread, and infiltrate flood water through encouraging adoption of higher, No-Adverse-Impact development/ drainage standards for both urban and agricultural areas as well as adoption of natural resource overlay zones. The following is a list of typical specific strategies for this zone:

   - Partner in watershed-wide partnerships (Basin Commissions, Joint Drainage Boards, etc.)
   - Encourage uniform No-Adverse-Impact stormwater standards
   - Support USGS stream gages
   - Adopt a Natural Resource Overlay Zone (preserve wetlands, depressional areas)
   - Promote use of cover crops and soil health practices
   - Reduce impact from surface draining and regulated drain improvements in the watershed
   - Promote master planning and construction of regional detention facilities

Flood Resilience Planning Areas	Area Boundaries	Intent of Area Strategies	Typical Strategies
River Corridor Impact Area	Floodway or fluvial erosion hazard area, whichever is greater	To conserve land and prohibit development	• Adopt a River Corridor Impact Area Overlay zone & prohibit development in this area • Perpetuate protection of undeveloped land within River Corridor through partnering with land trusts • Restore impacted channel corridors/FEH Issues using nature-based solutions, such as a 2-stage ditch or other FEH mitigation
Undeveloped High Flood Hazard/Flood Storage Area	Undeveloped land in the floodway fringe	To conserve land and maintain the natural and beneficial function of the floodway fringe	• Preserve floodplain storage and beneficial floodplain functions through prohibiting or strongly discouraging new development in this area • Require floodplain compensation when flood storage loss cannot be avoided • Perpetuate protection of undeveloped land within SFHA through partnering with land trusts • Prohibit development of new critical facilities in the floodplain and encourage relocation of existing facilities as opportunities arise
Moderate Flood Hazard Area	Area within 0.2% annual chance floodplain ((likely future SFHA due to climate change)	To identify areas that are subject to flooding during an extreme event and to discourage future development in these areas	• Discourage new development in this area • Require buildings to have their FPG equal to or greater than that required in SFHA • Require flood protection grade of critical facilities in this area to be above the 0.2% chance flood elevation
Vulnerable Developed Area	Existing developed land in the River Corridor or floodway fringe	To protect people, buildings, and facilities in vulnerable areas and reduce future flood risk	• Protect existing critical facilities in the SFHA through floodproofing/ring levees • Relocate and/or buyout of homes • Floodproof or elevate homes and businesses • Bring nonconforming uses into compliance • Create new flood storage through redevelopment • Require building expansions to meet the additional requirements • Develop a Flood Response Plan • Encourage Flood Insurance and community participation in CRS

Safer Area	Outside the 0.2% annual chance floodplain area but within planning jurisdiction	To plan for and promote development in areas that are less vulnerable to future floods	• Steer public policy and investment into safer areas (Ex.: extend sewer and water, construct infrastructure, tax breaks, etc.) • Promote conservation design and development (LID/GI) • Promote placement of critical facilities in these safer areas
Watershed	Entire drainage area	To promote coordination and partnerships and implement practices to slow, spread, and infiltrate flood water	• Partner in watershed-wide partnerships (Basin Commissions, Joint Drainage Boards, etc.) • Encourage uniform No-Adverse-Impact stormwater standards • Support USGS stream gages • Adopt a Natural Resource Overlay Zone (preserve wetlands, depressional areas) • Promote use of cover crops and soil health practices • Reduce impact from surface draining and regulated drain improvements in the watershed • Promote master planning and construction of regional detention facilities

Table 3: Resilience Planning Areas Summary

2) Update stormwater and floodplain regulations

To further protect from increases in floods due to development, stormwater detention/retention and compensatory storage requirements are needed. These exist in some municipalities and counties; however, such requirements are not consistent throughout the watershed. In many cases the current requirements lack up to date, No-Adverse-Impact measures or exempt certain projects from the requirements. The current stormwater and floodplain regulations within all jurisdictions in the watershed should be updated to include, at a minimum, the following provisions:

- Detention storage, with maximum allowable release rates accurately pre-calculated and presented as unit flow rates (cfs/acre) for each sub-watershed to compensate for increases in flow rates due to new development and redevelopments
- Retention or, if not possible, extended detention of the Channel Protection Volume (the volume of runoff created during the 1-year, 24-hour rainfall event) to prevent further increase in flow volumes and channel forming flows
- A minimum of 1:1 compensatory floodplain storage when the existing floodplain storage is to be eliminated due to fill or berm protection
- Strict prohibition of any development or disturbance within floodways and the erosional hazard corridor impact areas
- Requirements and incentives for using Low Impact Development (LID) and Green Infrastructure (GI) practices throughout the watershed

- Application of requirements to private and public projects alike. In many instances, a public project is more extensive and could create more harm than a private project could if requirements are waived. Exemptions in the case of not meeting the requirement but not harming any other property could be added if needed.
- Until a more in-depth analysis of the expected BFE for the lakes can be completed, it is recommended that the highest flood of record be used as BFE if it is higher than the FIS BFE. Also adding another half foot to the BFE for future conditions may be wise in light of increasing and more intense precipitation events.

Each of the jurisdictions within the watershed should coordinate their stormwater standards with other jurisdictions in the NBER watershed to the greatest extent practicable to promote more consistent stormwater management.

3) Encourage consideration of agricultural drainage impact mitigation measures

Typical stormwater ordinances and technical standards within Indiana (as well as most other states in the country) do not apply to farm drainage practices and county drainage board ditch improvement projects. However, like impacts of new development and re-development in urban areas, farm drainage activities as well as county drainage board ditch improvement projects increase flow in the tributaries and eventually in the NBER. Therefore, it is recommended that the SJRBC encourage county drainage boards in the watershed to determine the impacts of proposed drainage improvement projects through detailed unsteady state modeling techniques and require/provide compensation for impacts of farm drainage and county drainage board ditch improvements. Typical measures to address unintended negative drainage improvement impacts by drainage boards include construction of 2-stage ditches and regional detention ponds. Typical measures that can be undertaken at farm level to address increased runoff as a result of normal farm drainage improvement activities (such as surface ditching) include implementation of soil health practices (such as cover crops) and utilization of agricultural drainage management structures.

4) Investigate the feasibility of and construct a 2-stage ditch system along a 4-mile reach of Henderson Lake Ditch through and near Kendallville

The over 4 miles of Henderson Lake Ditch headwaters from Bixler Lake through Kendallville and then just north of CR E 800 N (W Rimmel Rd.) are channelized and degraded, causing downcutting of channel banks upstream of Sylvan Lake and sending a sediment influx into Sylvan Lake. Although Sylvan Lake has been able to absorb the disturbances occurring upstream, the degradation upstream does have negative localized impacts. The reattachment of the channel in this reach to its geomorphic floodplain could improve the situation and keep things from getting worse. Reattaching the floodplain in the headwaters would help to reduce the downstream velocity and slow the downcutting observed near Sylvan Lake. The effort would also reduce the sediment influx into Sylvan Lake. Floodplain reattachment could be accomplished with a conventional two-stage channel, or given the predicted continued increase in precipitation, a multi-stage channel, along with vegetating the stream corridor much like what exists along the headwaters of the main stem of the NBER. The process can get started by first evaluating the feasibility of constructing such two-stage or multi-stage channel in this reach, followed by securing funding and construction.

5) Consider initiation of additional studies

Given the concern with high water levels in the West Lakes area and the associated recurring discussions of modifying the surface outflow to enable the lake to "drain" faster, a comprehensive study of groundwater and surface water interactions between the Waldron Lake outlet and the USGS gage at Cosperville is strongly recommended. Data suggests there is a change in aquifers in this reach. Given the high percentage of stream flow attributed to groundwater, it is important to better understand the variations in groundwater inflow in this reach. Attempting to modify surface flow without understanding the groundwater contribution could make conditions far worse, both in the lake and downstream.

Once the groundwater/surface water interaction is better understood in this reach, additional modeling should be done to take these interactions along with predictions of increased rainfall into account in order to provide realistic Base Flood Elevations (BFE) for the lakes with current development or likely future development. The modeling should be able to include unsteady flow of the lake outlets so that tailwater impacts can be determined to better understand what impacts the outflow capacity of the lakes under various conditions. Infiltration of rainfall and groundwater flow also need to be considered in the modeling. Such a model can then be used to further analyze the impacts of proposed projects on lake elevations and flood durations as well as to evaluate downstream impacts.

6) Preserve the existing USGS gages and commission additional gages

To aid calibration efforts of modeling to understand the system, the following actions are recommended:

- Maintain the existing USGS gages in the watershed
- Reestablish lake gages on lakes with development
- Add streamflow gages in the following locations (shown in Figure 33):
    - Sylvan Lake watershed near CR 600 N south of Rimmel Rd
    - Indian Lakes watershed upstream of Hackenberg Lake near SR 3
    - Between Indian and West Lakes chains

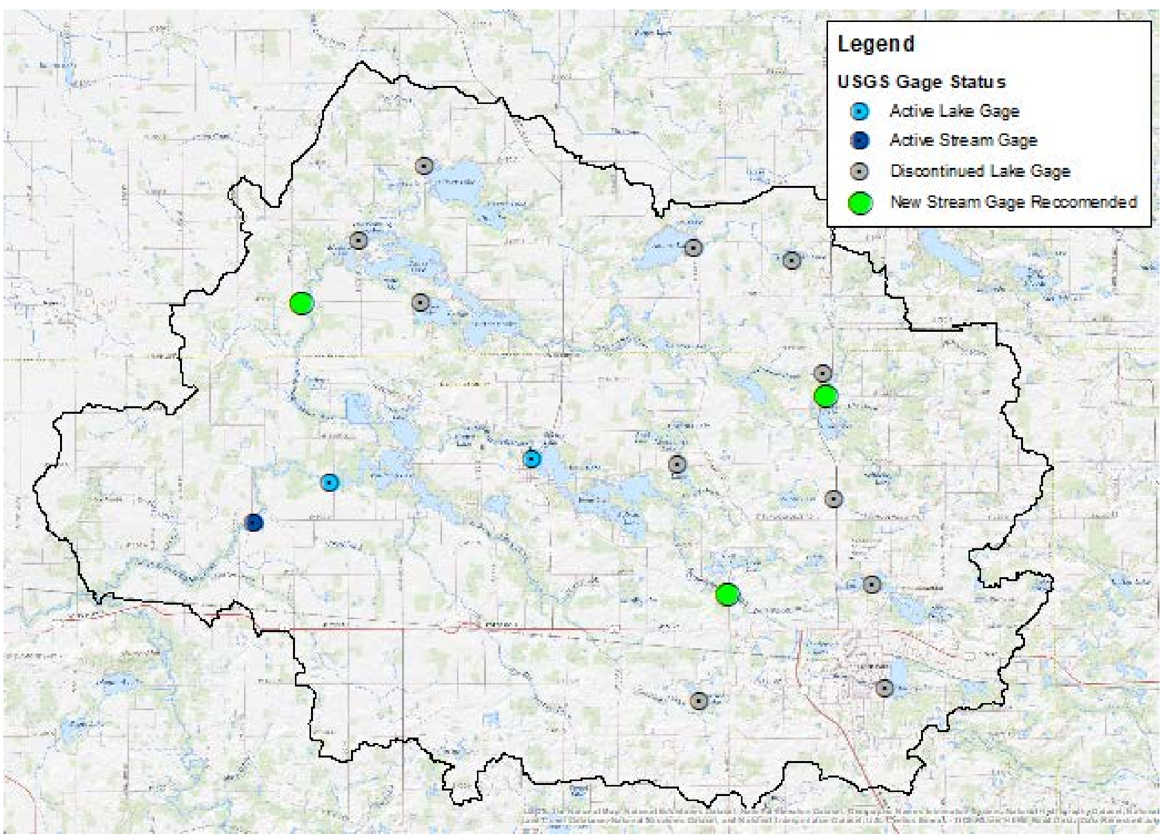

Figure 33: Stream/Lake Gage Recommendations

7) Consider requiring a higher flood protection grade when permitting new construction

With the extensive storage available around the lakes, a large change in inflow may result in a small change in lake elevation but that increased elevation may continue for a long time. With the length of time required for lake levels to return to normal after a rainfall event and the increase in extreme events, there is also the need to consider the impact of back to back rainfalls or coincident significant groundwater and surface water inflows on lake elevations. A modest 0.5-foot increase in typical FPG requirement (from 2.0 feet to 2.5 feet) to account for the increased potential for back to back storms or coincident inflows would be prudent.

8) Maintain periodic communication and outreach with stakeholders

Schedule meetings with watershed stakeholders to discuss the findings and recommendations of this report. This initial report review will then need to transition to continued periodic stakeholder education and outreach. It will also be prudent to reach out to new officials and stakeholders, and to reiterate the main themes of this study's findings. Continuing education is critical in basins like the St Joe River and NBER. As groundwater driven systems, they function differently than the more common runoff driven river systems. As such, many water quality and quantity management practices aren't applicable. Understanding how the system works can avert many problems.

Next Steps

The following list provides the recommended next steps towards the implementation of the recommendations of this study:

1. Establish a Flood Resilience Planning Team in each county and community within the watershed consisting of the Basin Commission director, the county/community elected officials, council member representatives, officials responsible for land use decisions, planning and engineering staff, community leaders, and stakeholder representatives.
2. Consider retaining a consultant/facilitator to help conduct several meetings among the Flood Resilience Planning Team to identify and agree upon suitable flood resilience strategies for each specific resilience planning areas identified in this study.
3. Work together with various communities within the watershed to help the adoption and implementation of agreed upon flood resilience strategies as well as implementation of other recommendations of this study

CHAPTER 9: REFERENCES

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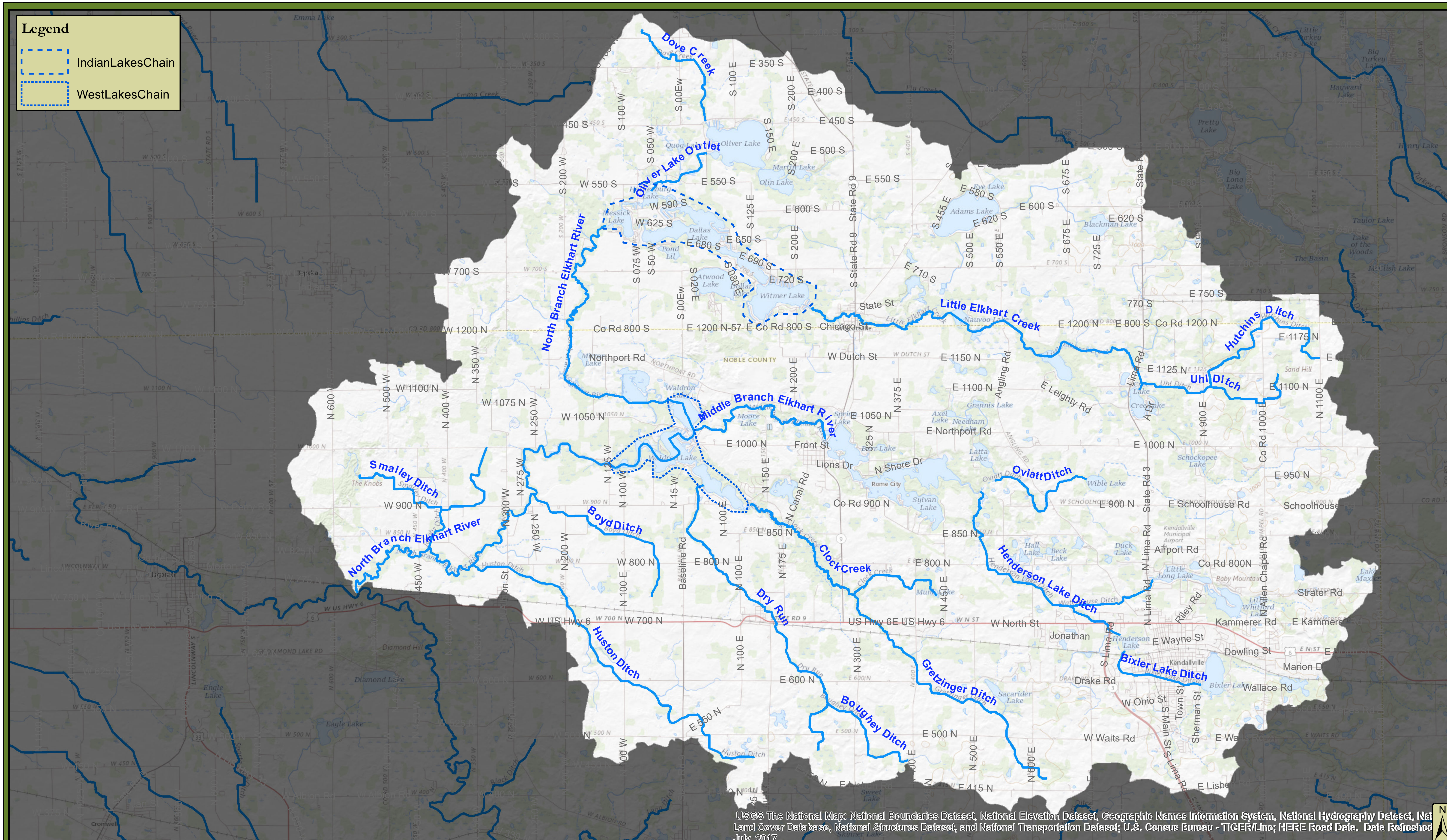
EXHIBITS



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PROJECT:	North Branch Elkhart River Corridor Flood Risk Management Plan	PROJECT NO. 19-0481	APPROX. SCALE 1"=8,000'
			DATE: 8/2020
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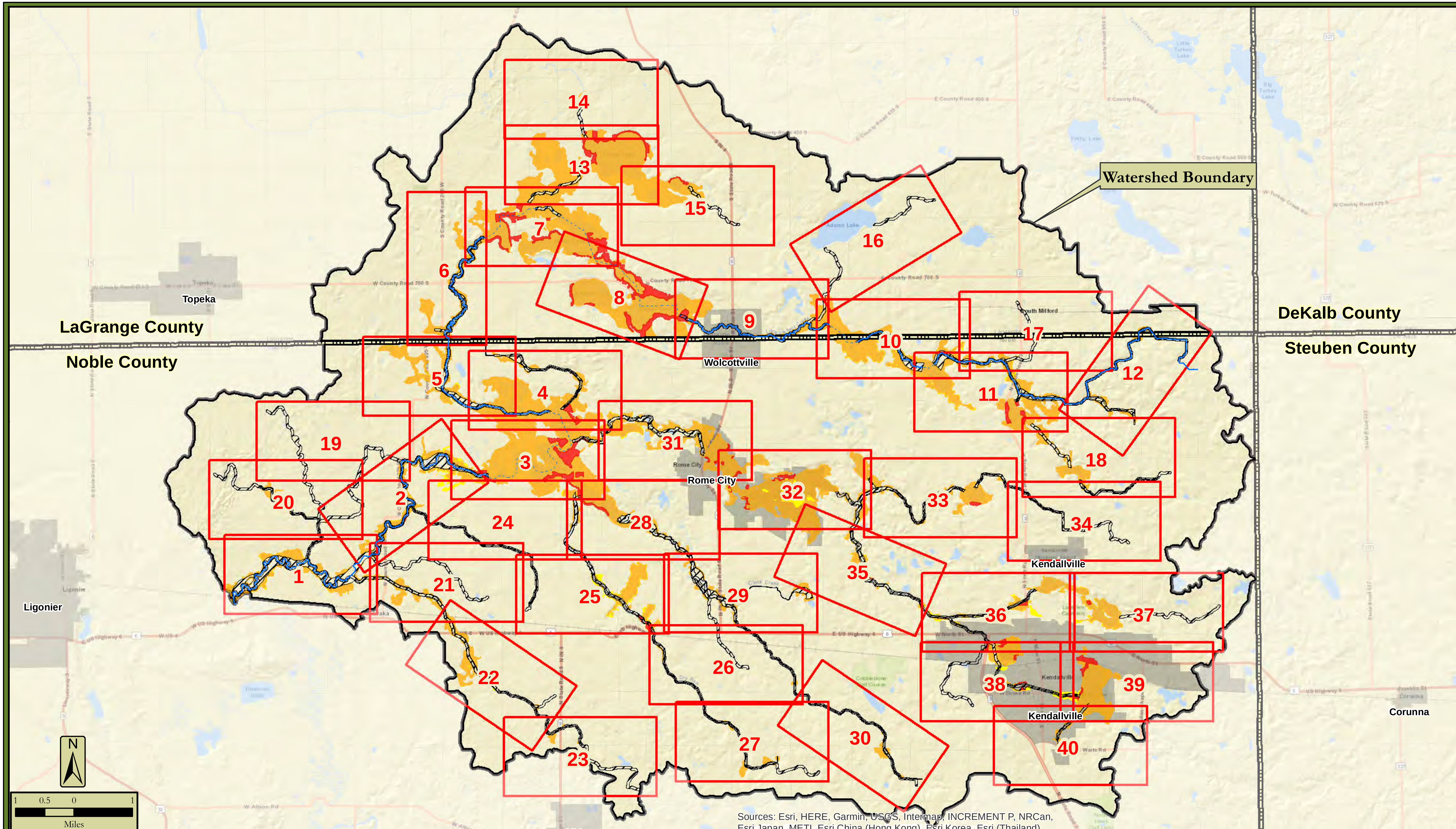

Sources of Data:

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2. National Hydrography Dataset, 2019
3. FEH Boundaries from The Polis Center, 2019
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Floodway

FEH

River Corridor Impact Areas

Vulnerable Developed Areas

Undeveloped High Hazard/ Flood Storage Areas

Moderate Flood Hazard Areas

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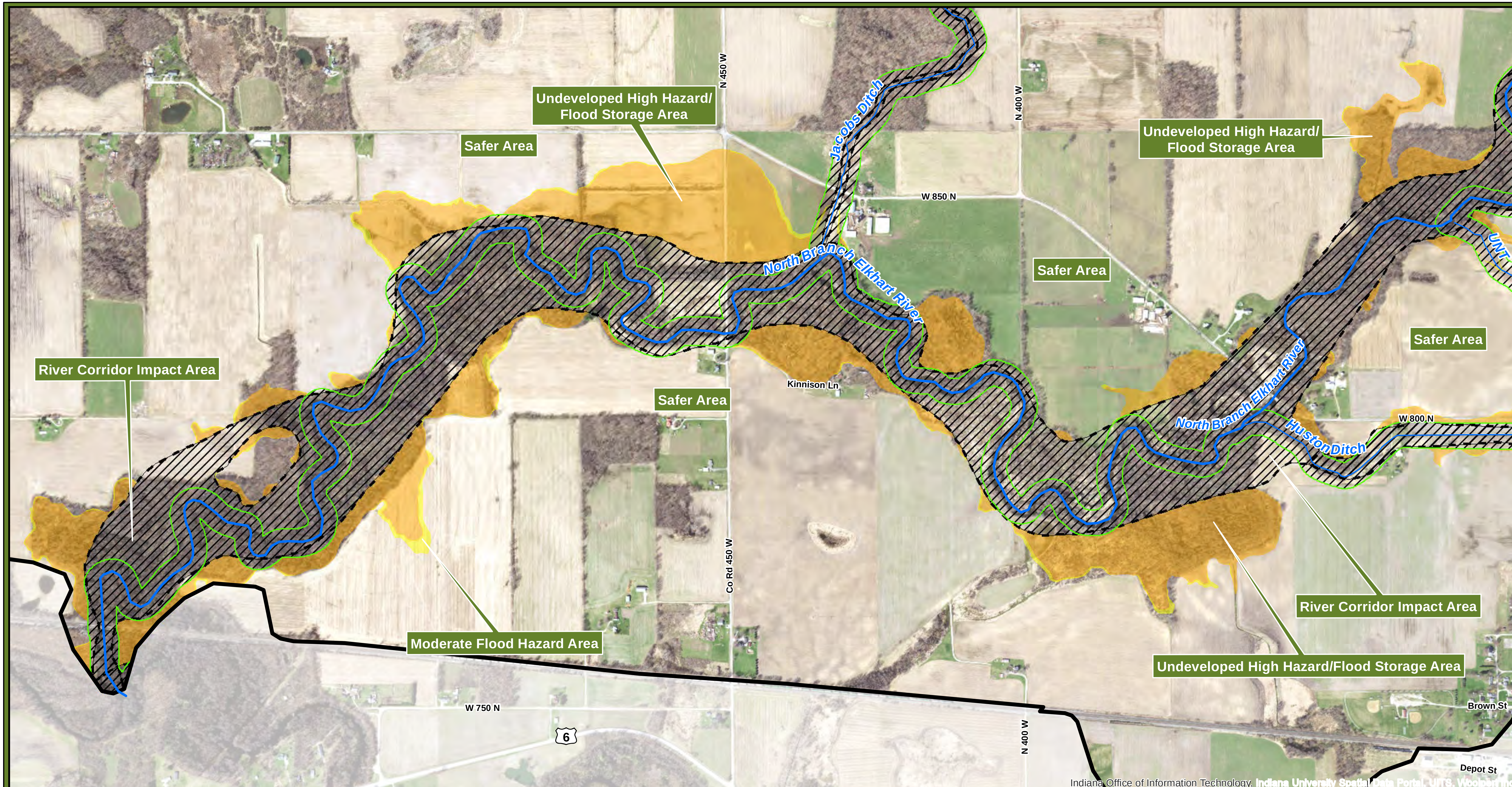
PROJECT: North Branch Elkhart River Assessment	PROJECT NO. 19-0481	APPROX. SCALE 1 " = 1.5 mi	
TITLE: Flood Resilience Planning Areas Index Map		DATE: 08/2020	EXHIBIT: 2



River Corridor Impact Area
Vulnerable Developed Area
Undeveloped High Hazard/ Flood Storage Area
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Floodway
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North Branch Elkhart River Subbasin (HUC 8)

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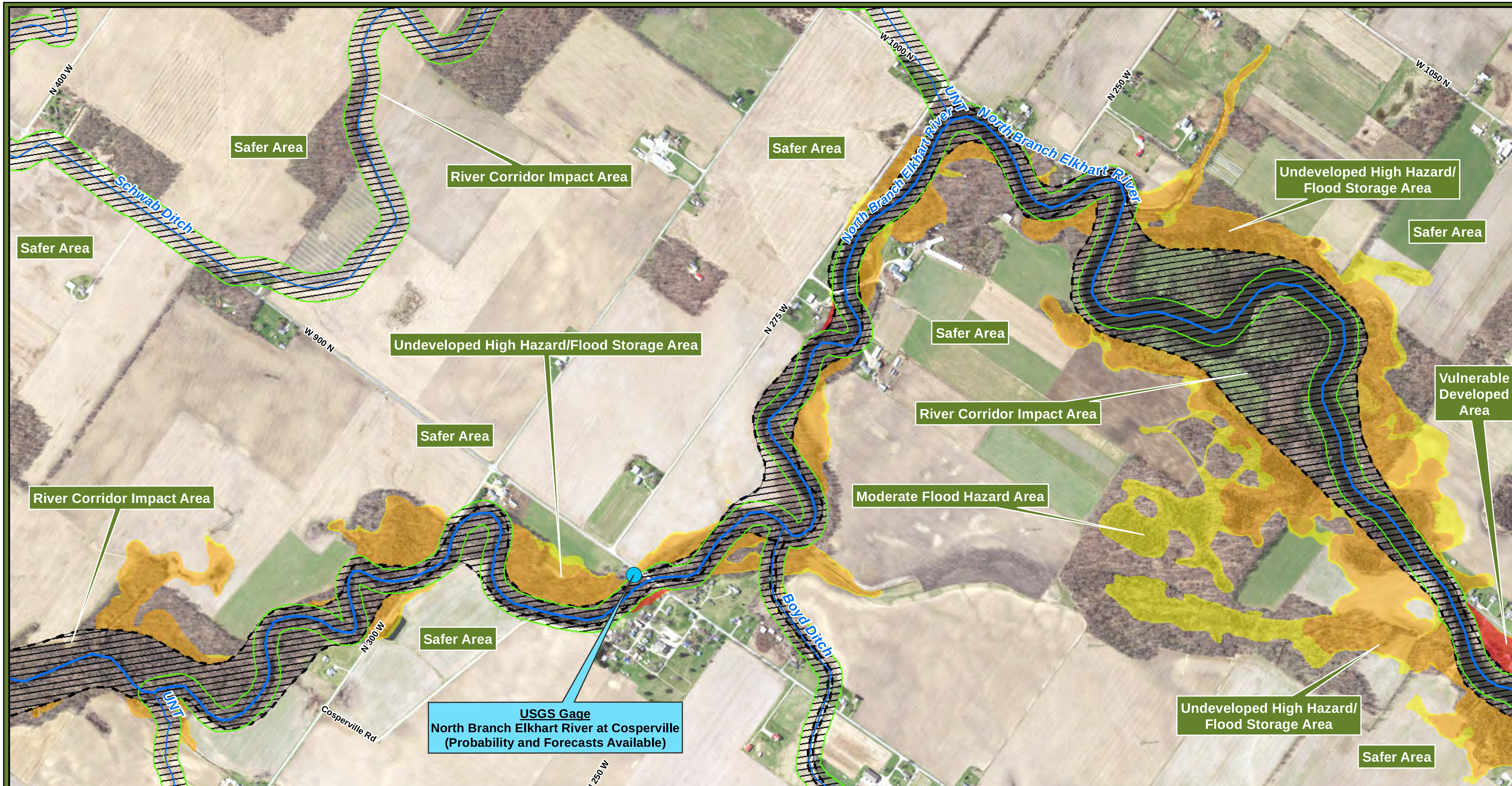

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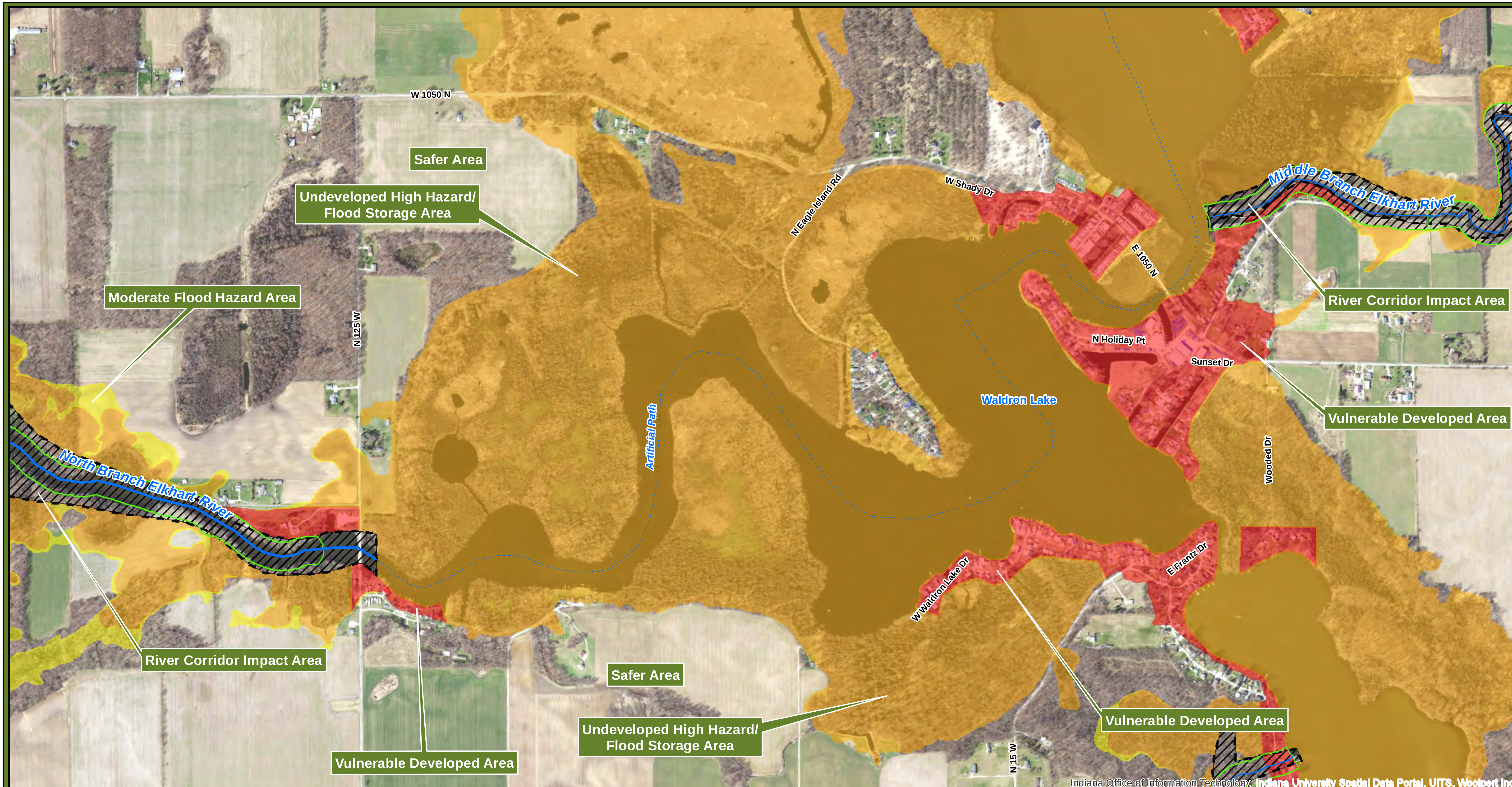

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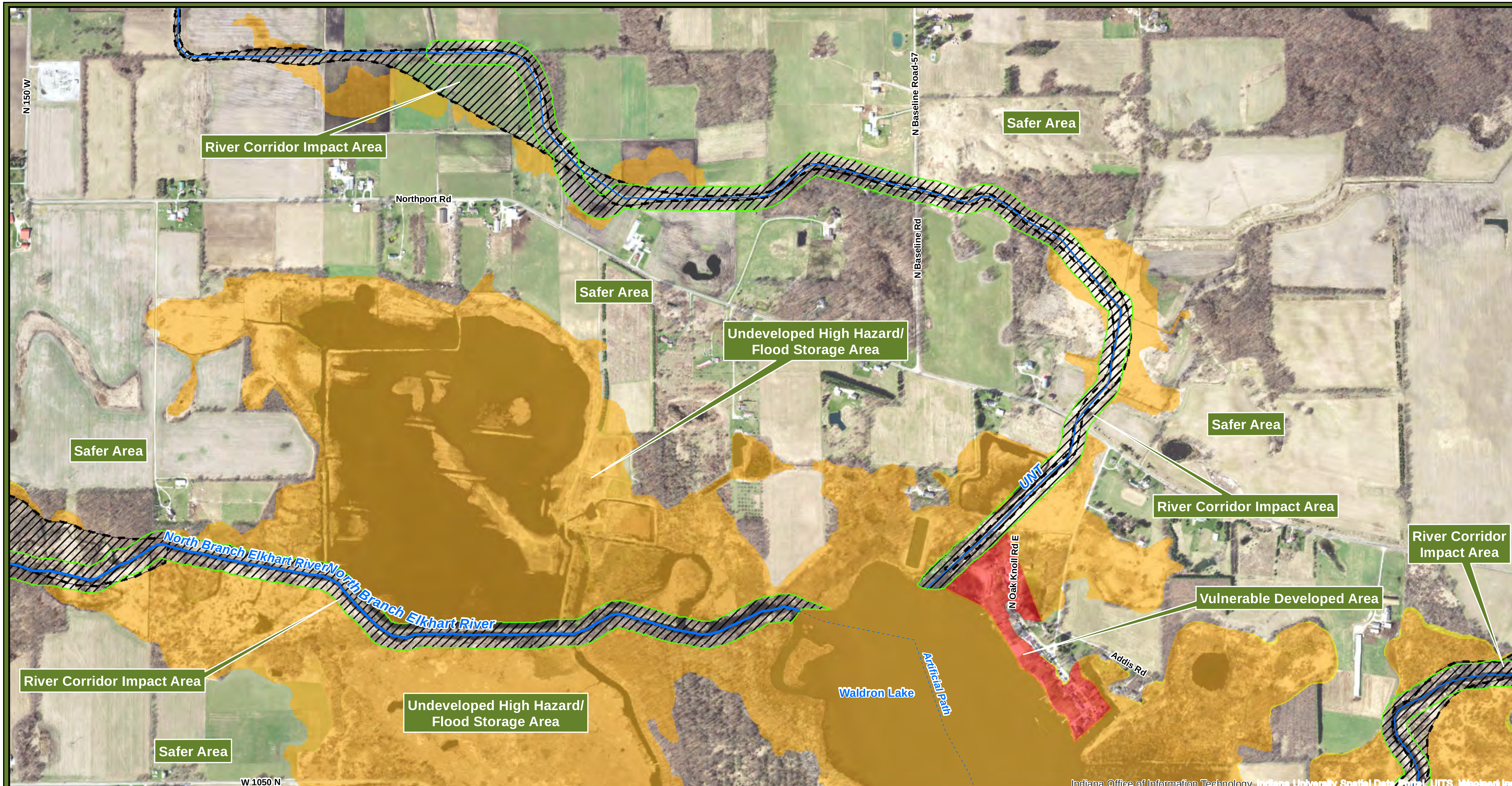

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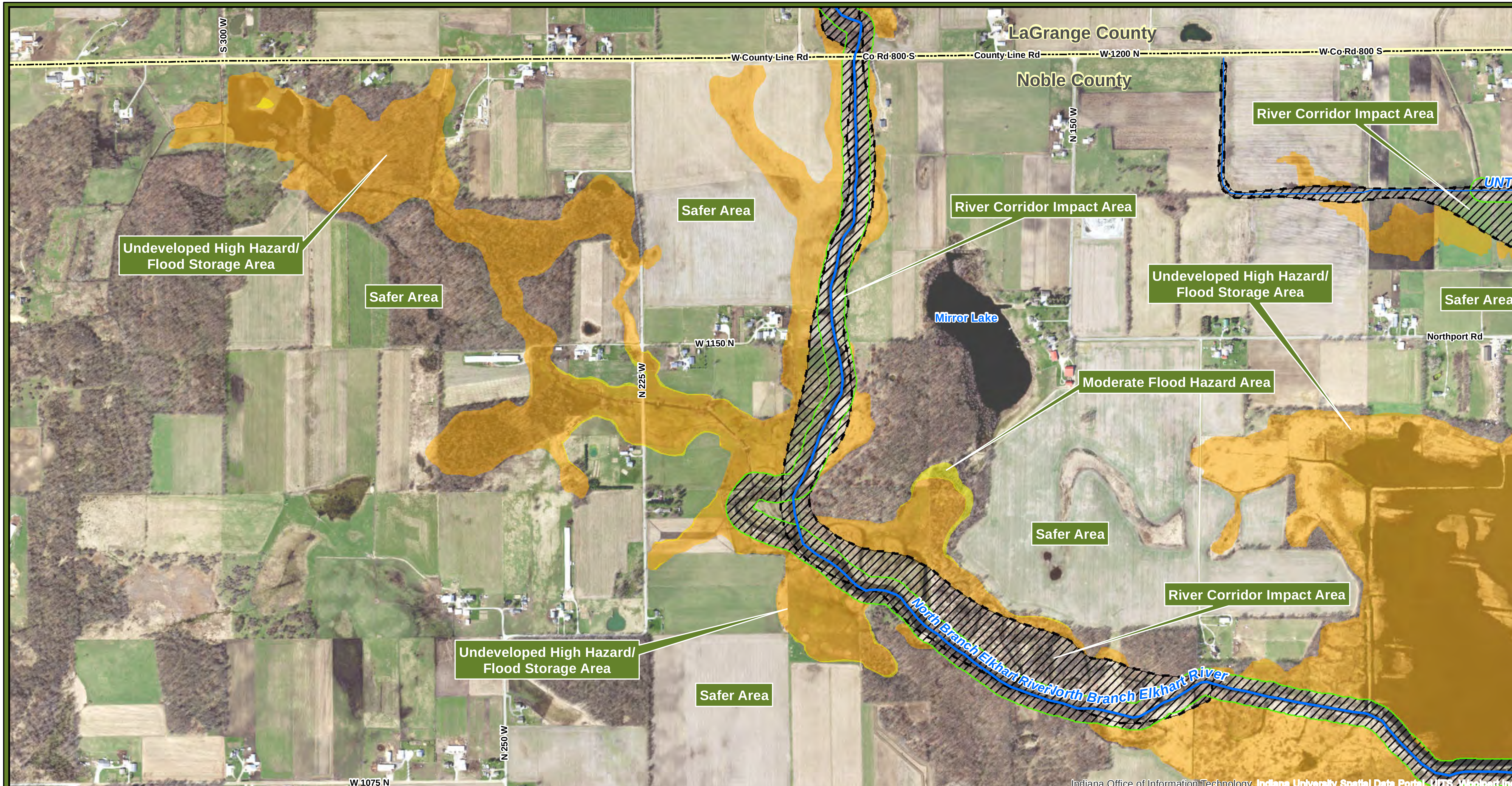

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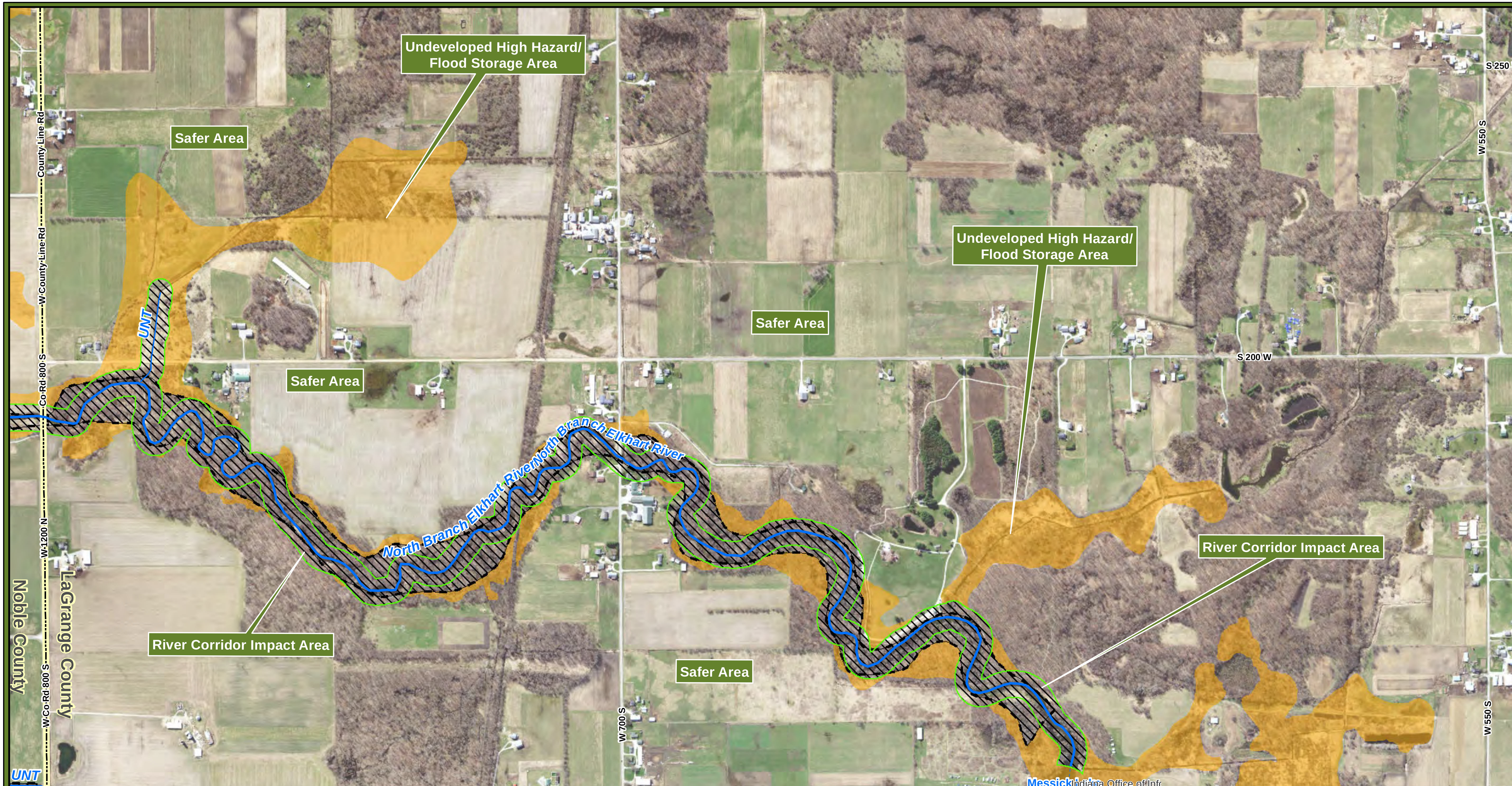

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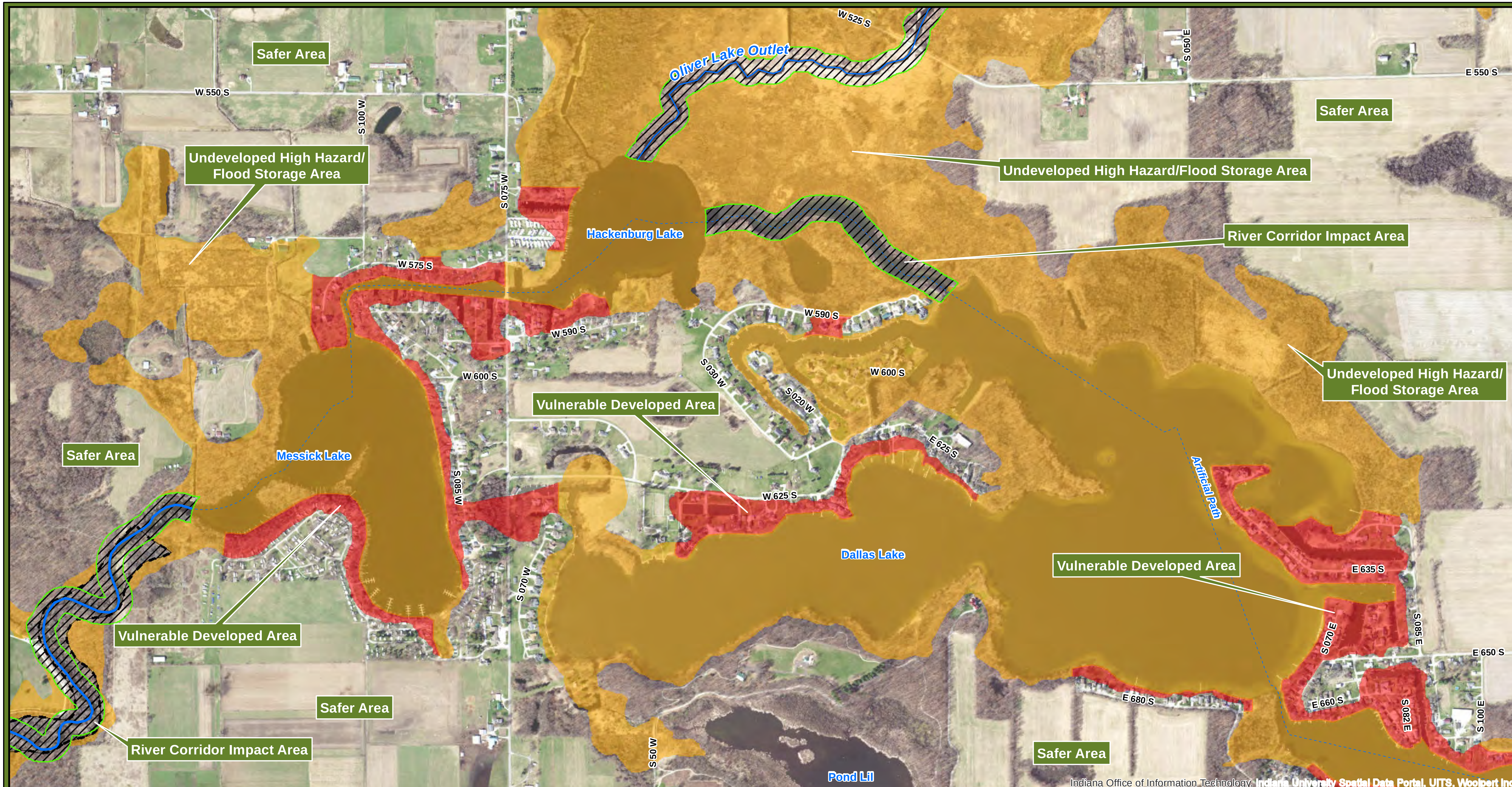

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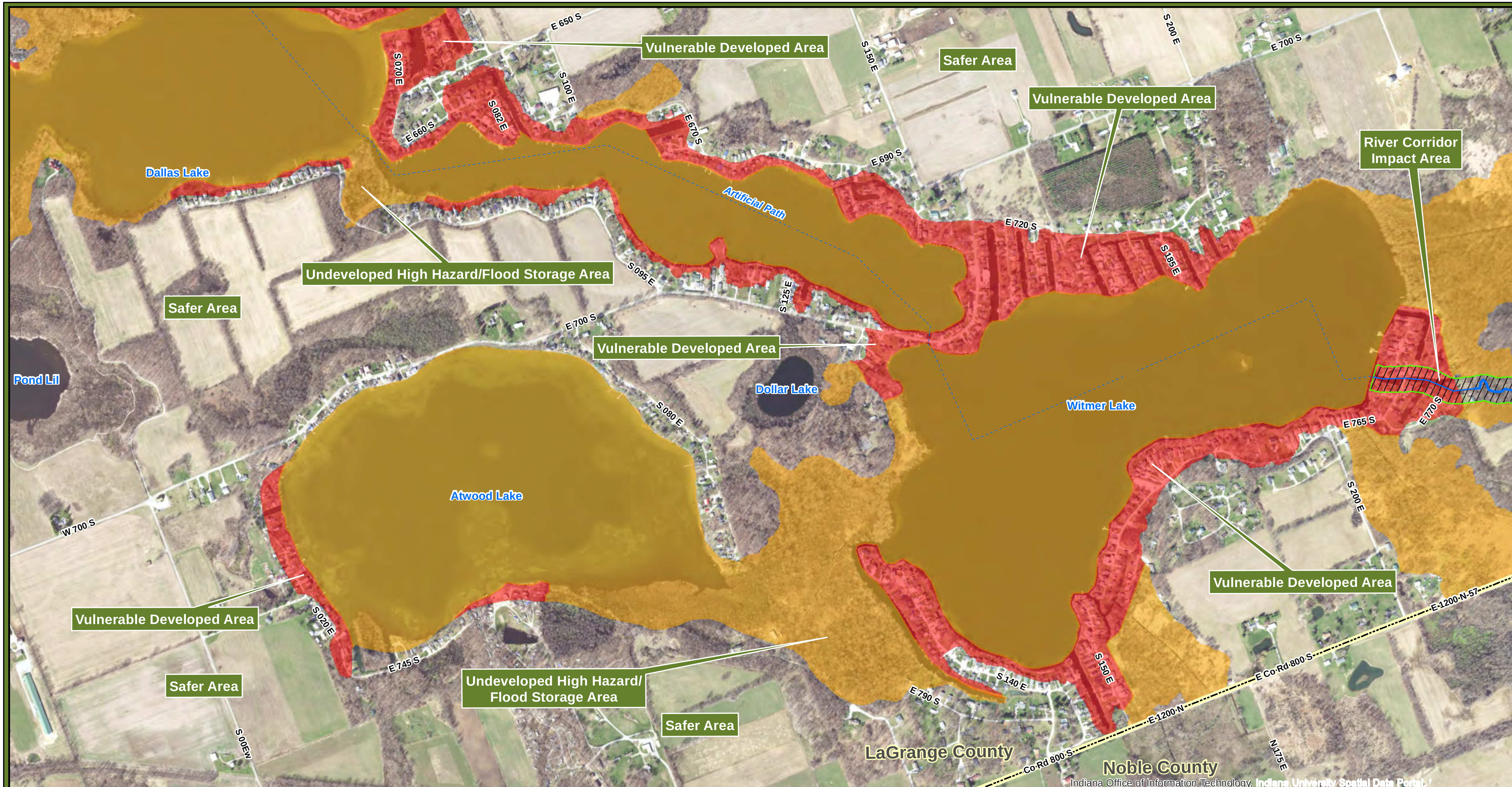

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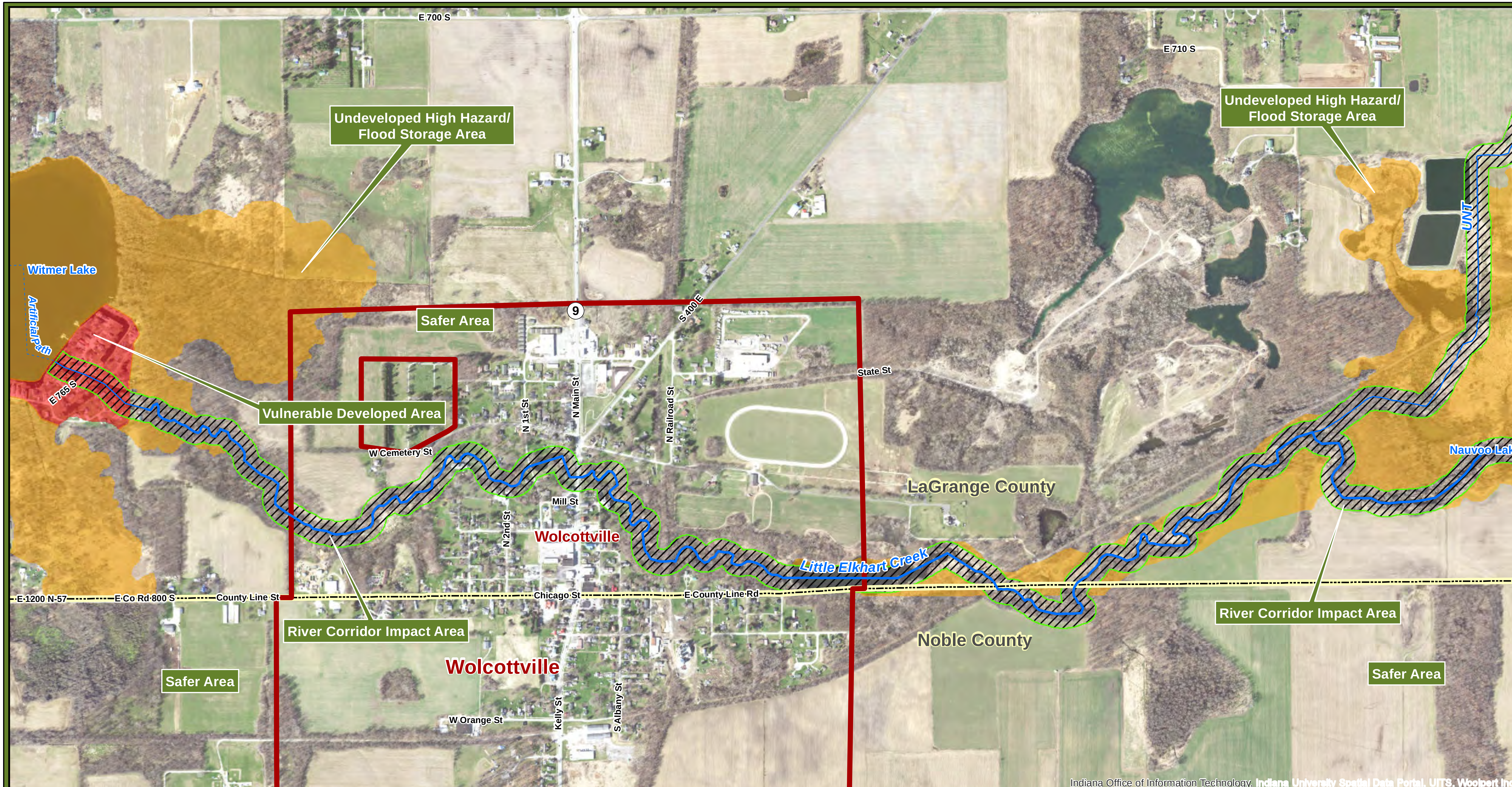
PROJECT: North Branch Elkhart River Assessment	PROJECT NO. 19-0481	APPROX. SCALE 1:10,000	
TITLE: Flood Resilience Planning Areas		DATE: 08/2020	EXHIBIT 2



River Corridor Impact Area
Vulnerable Developed Area
Undeveloped High Hazard/ Flood Storage Area
Moderate Flood Hazard Areas
Floodway
Fluvial Erosion Hazard Area
North Branch Elkhart River Subbasin (HUC 8)

N

500 250 0 500 1,000
Feet

Sources of Data:
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TITLE: Flood Resilience Planning Areas		DATE: 08/2020
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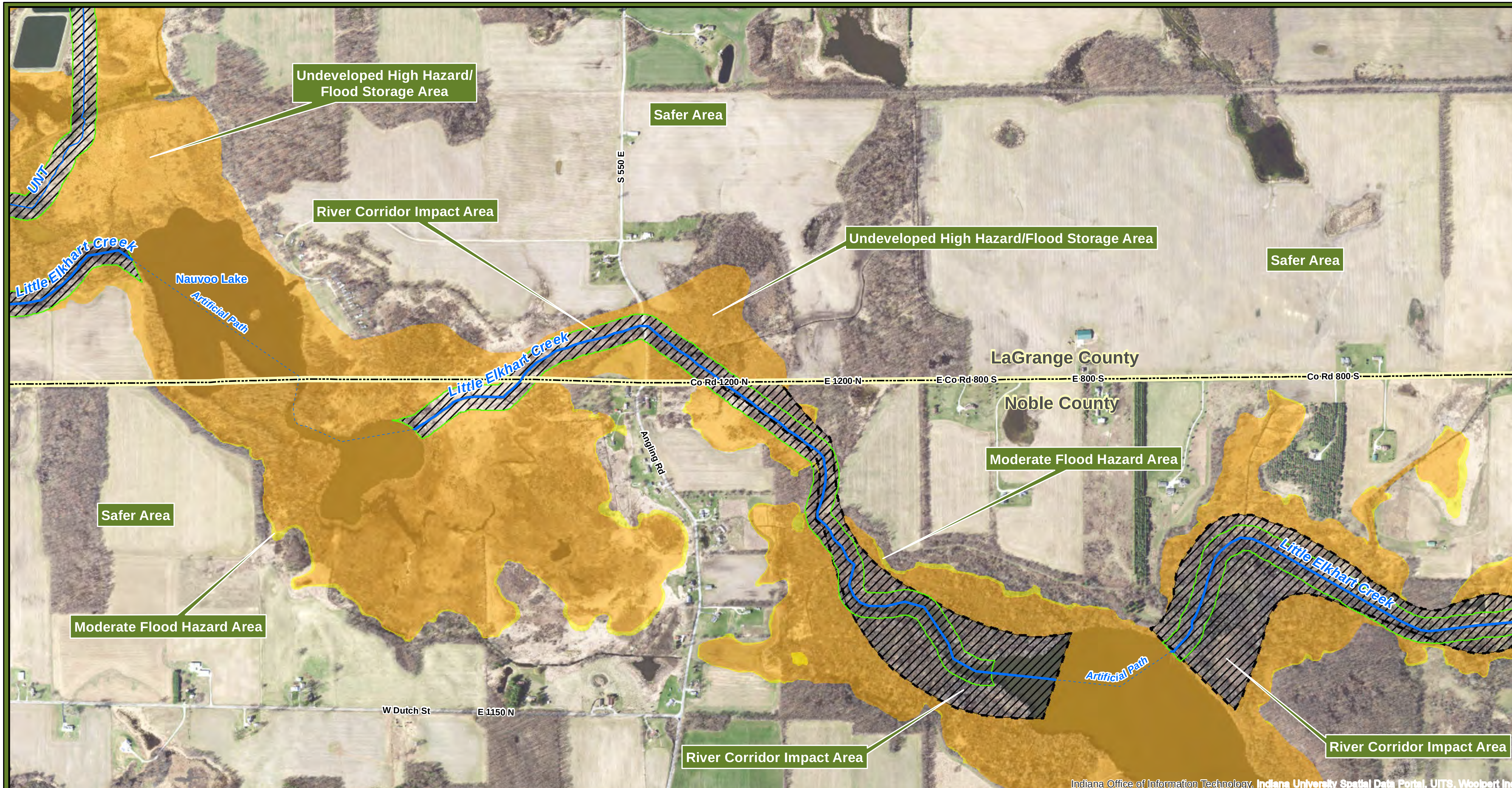

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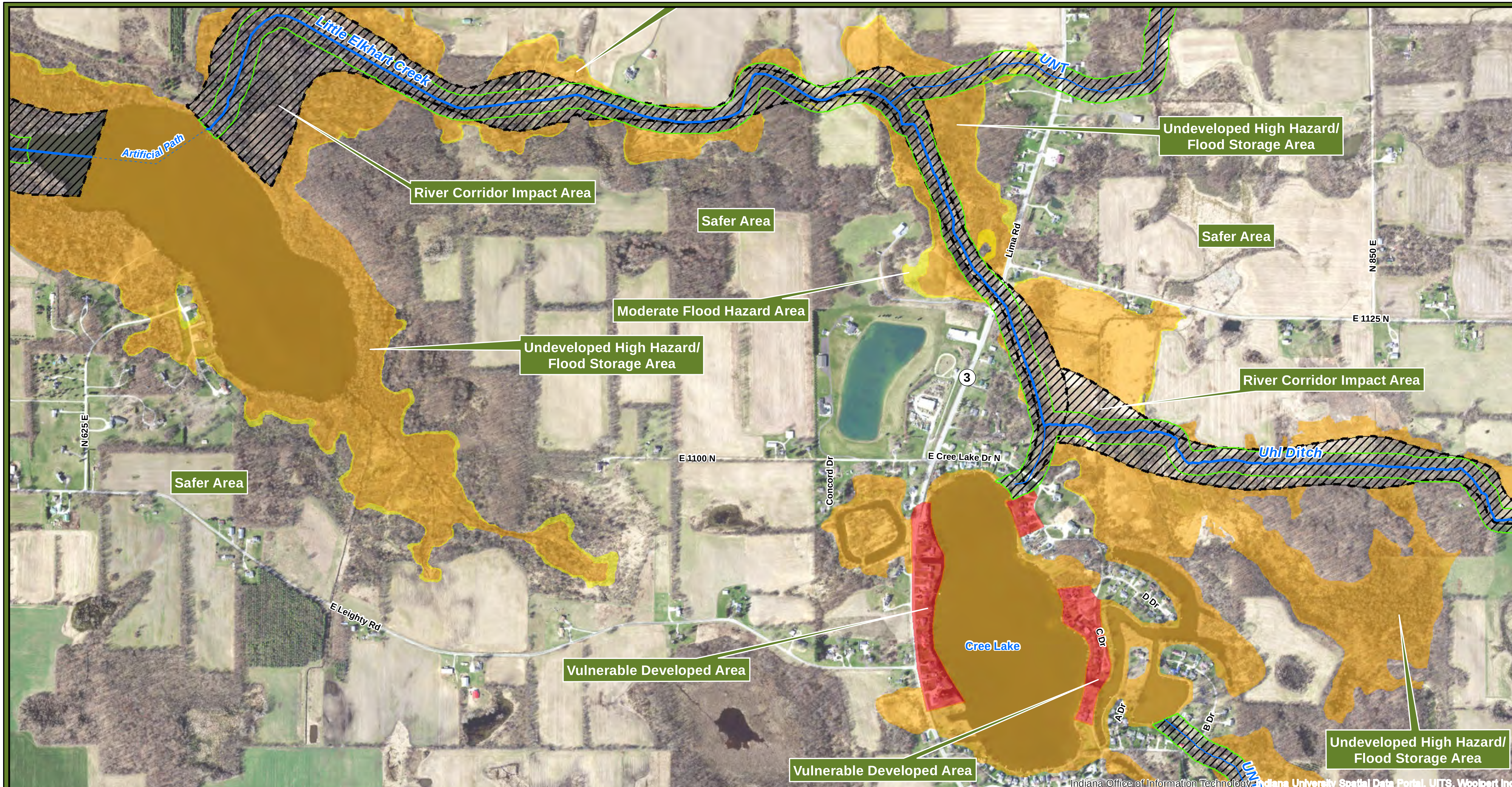

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Vulnerable Developed Area
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Moderate Flood Hazard Areas
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River Corridor Impact Area

Vulnerable Developed Area

Undeveloped High Hazard/ Flood Storage Area

Moderate Flood Hazard Areas

Floodway

Fluvial Erosion Hazard Area

North Branch Elkhart River Subbasin (HUC 8)

N

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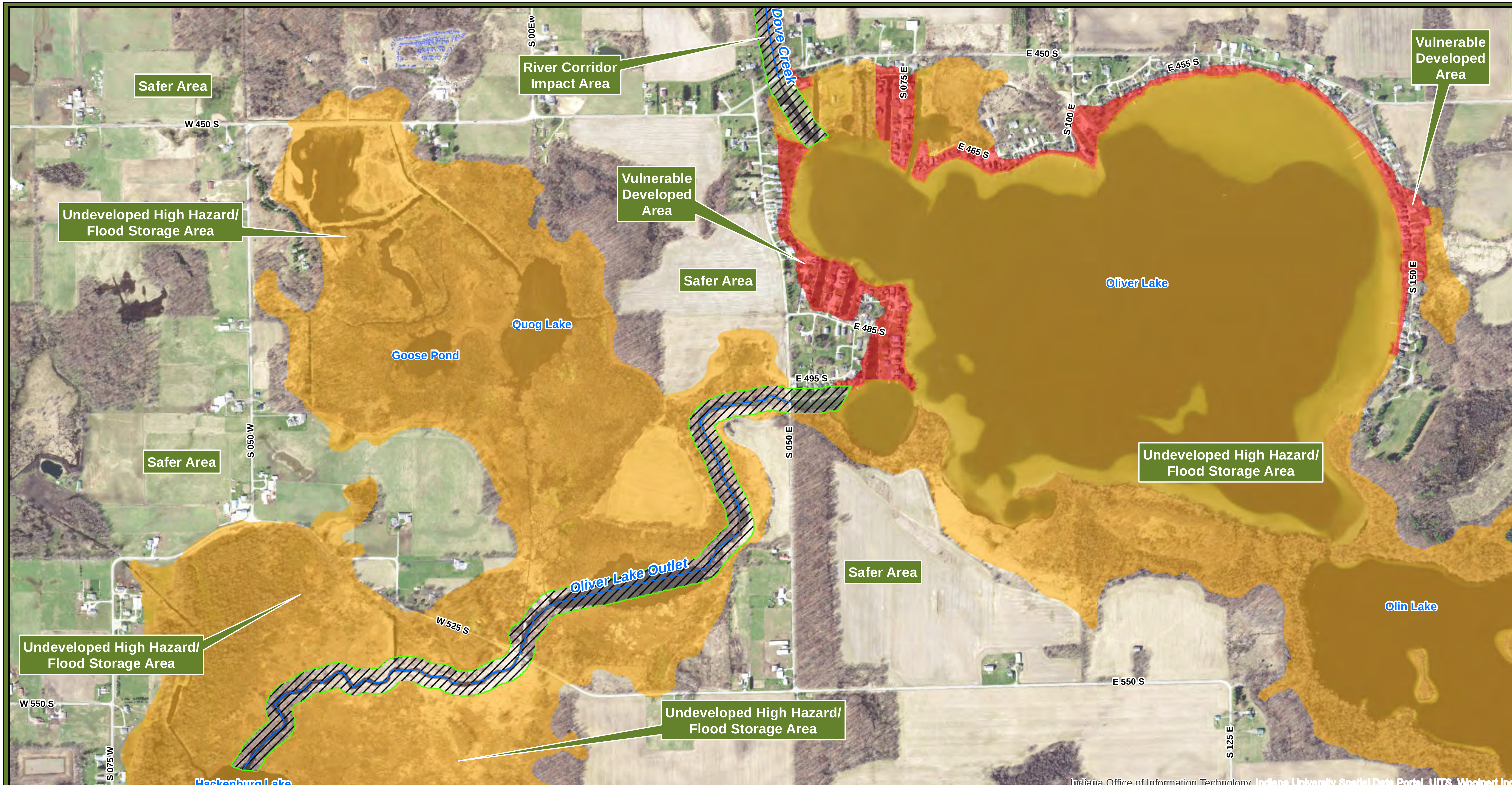

River Corridor Impact Area

Vulnerable Developed Area

Undeveloped High Hazard/ Flood Storage Area

Moderate Flood Hazard Areas

Floodway

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North Branch Elkhart River Subbasin (HUC 8)

N

500 250 0 500 1,000

Feet

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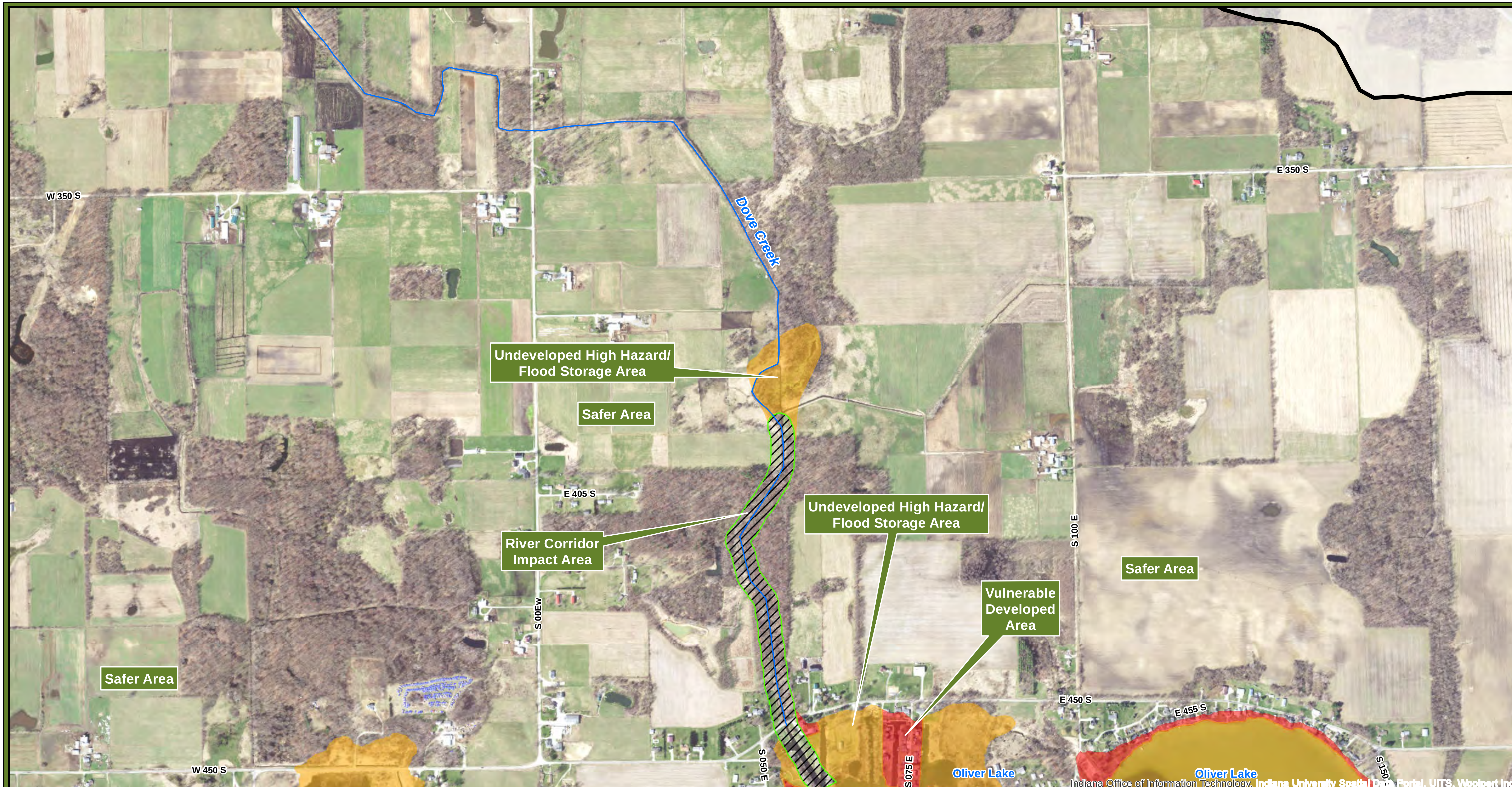

- River Corridor Impact Area
- Vulnerable Developed Area
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- North Branch Elkhart River Subbasin (HUC 8)

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TITLE: Flood Resilience Planning Areas	Page 14 of 40	DATE: 08/2020
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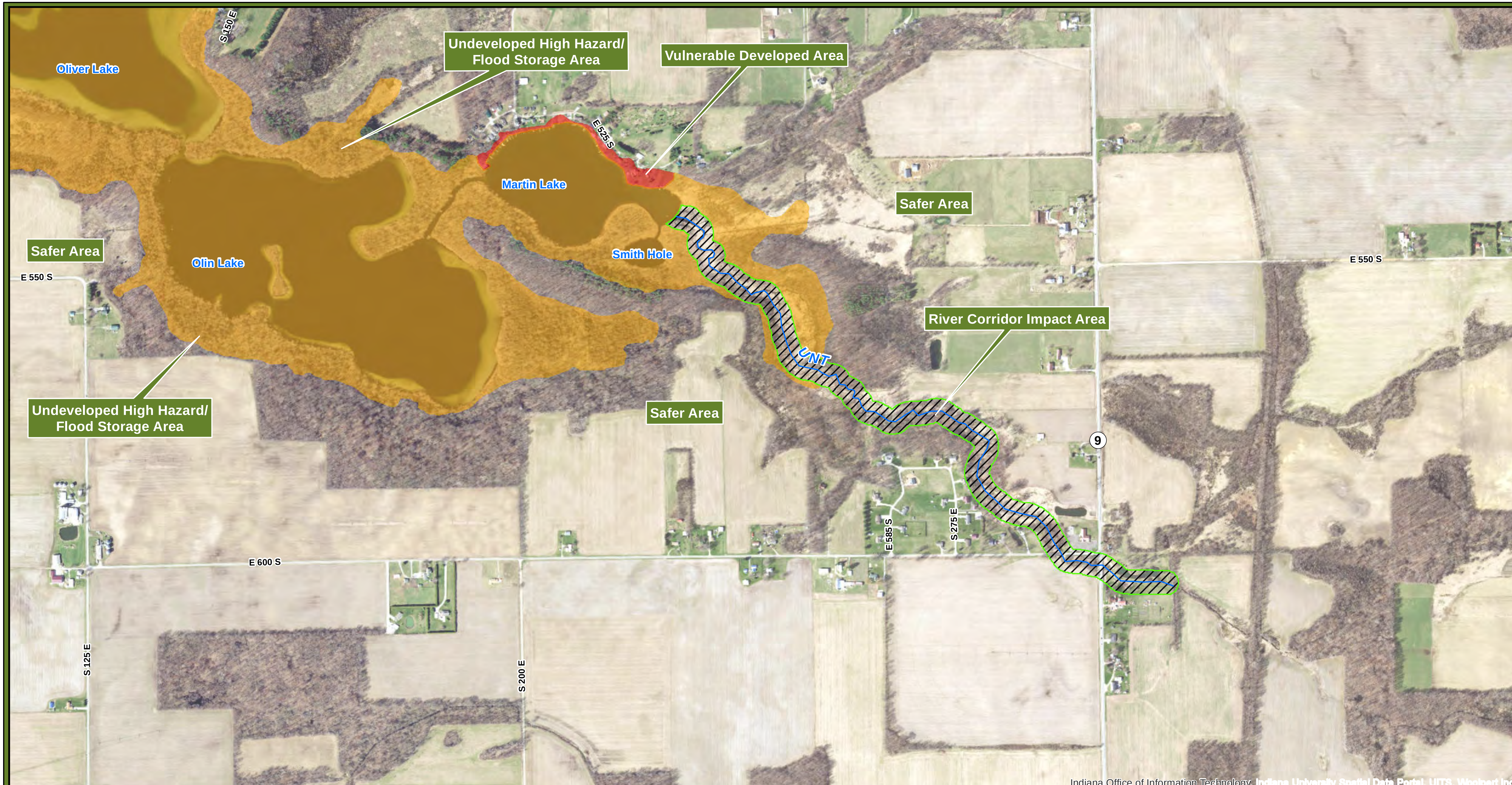

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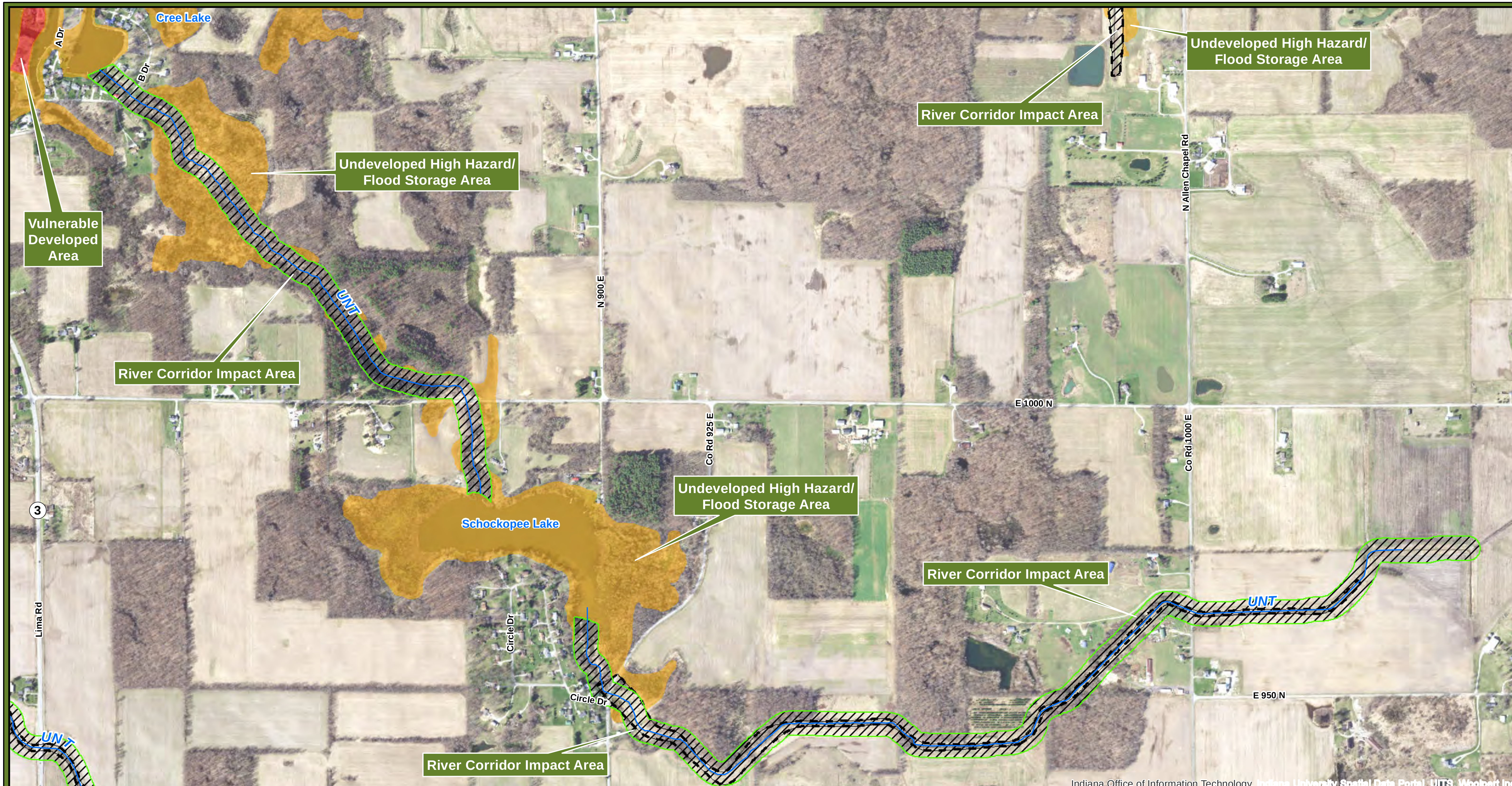

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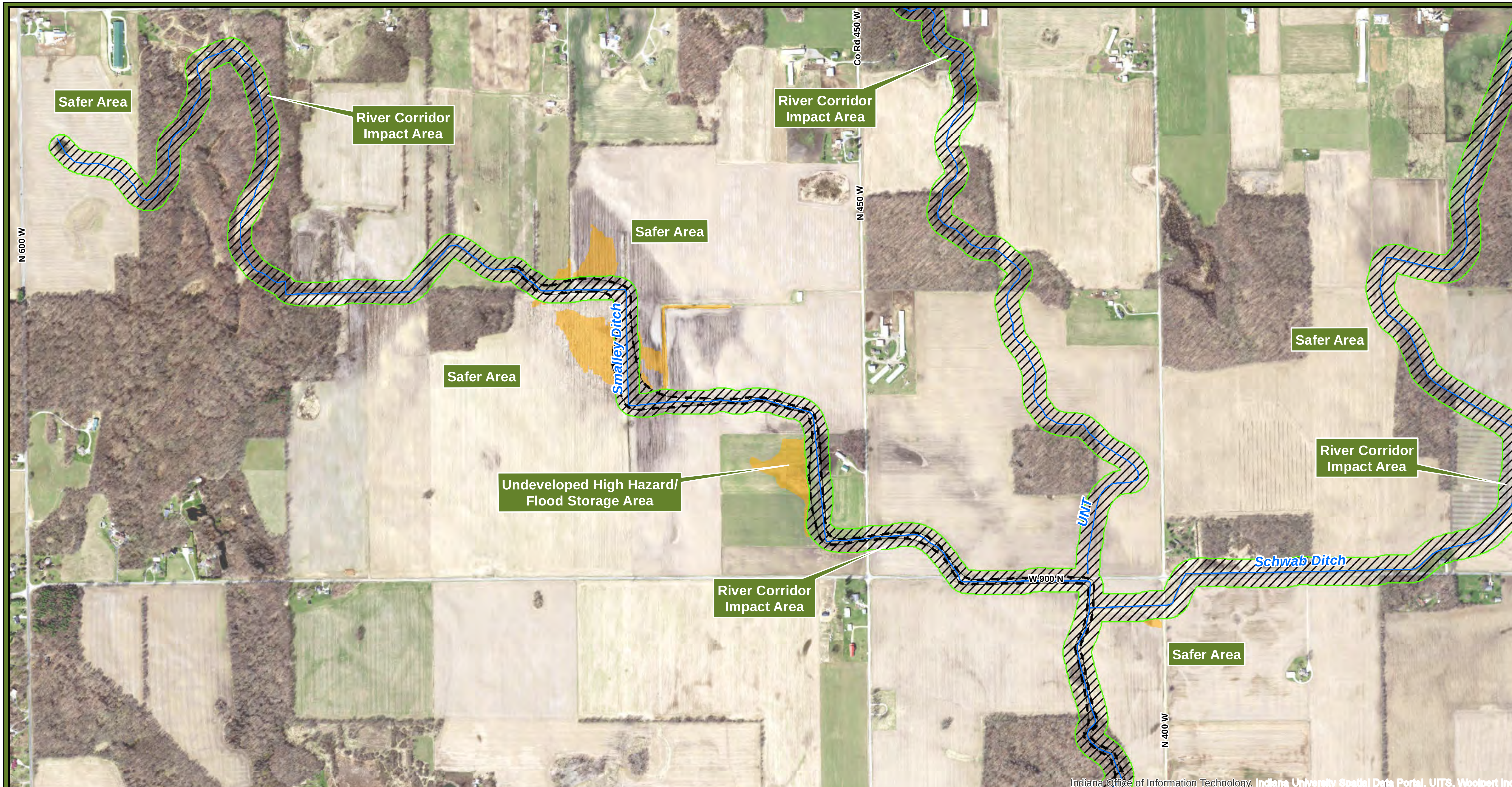

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River Corridor Impact Area

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TITLE: Flood Resilience Planning Areas		DATE: 08/2020
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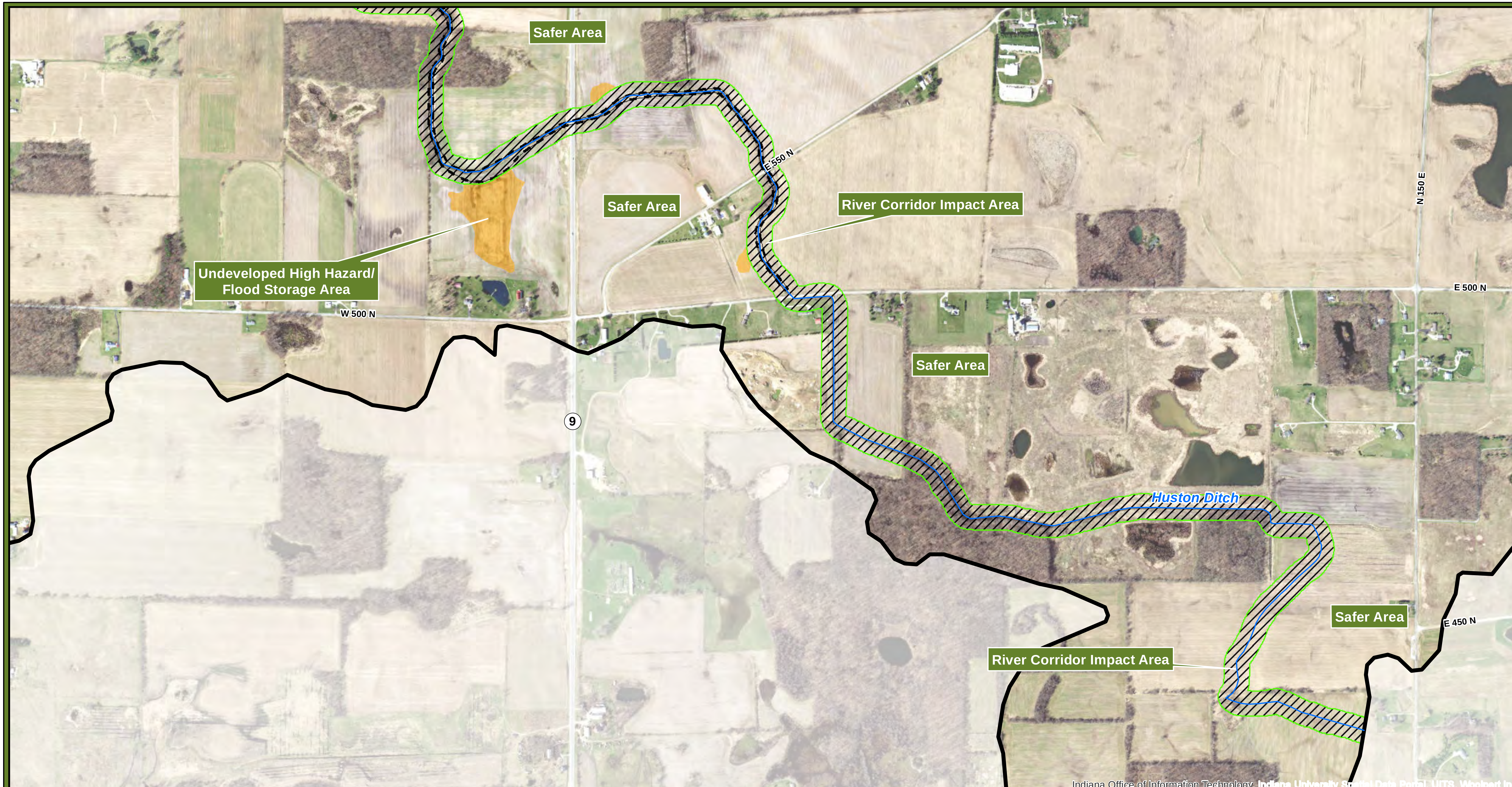

River Corridor Impact Area
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PROJECT NO. 19-0481

APPROX. SCALE 1:10,000

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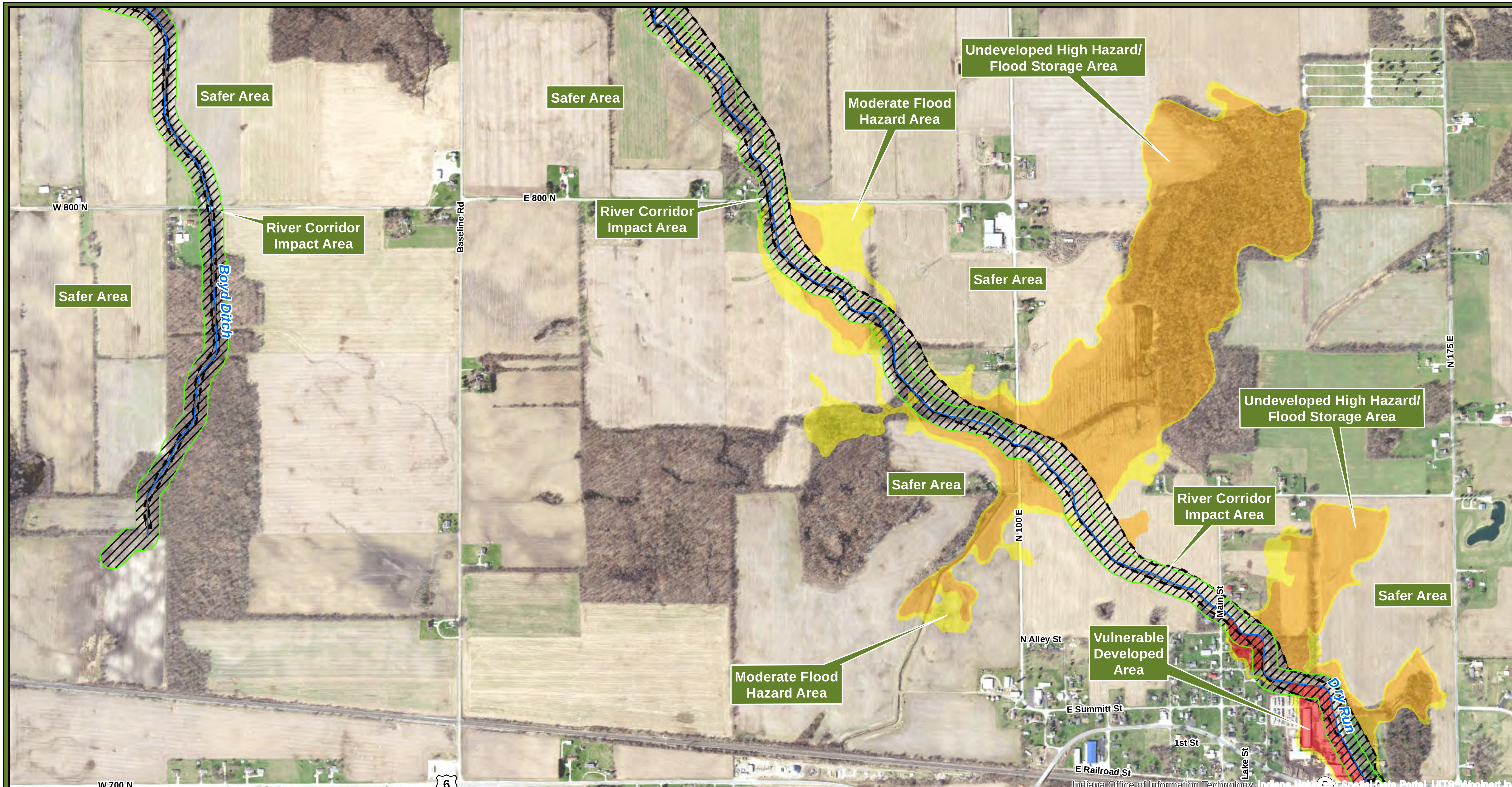

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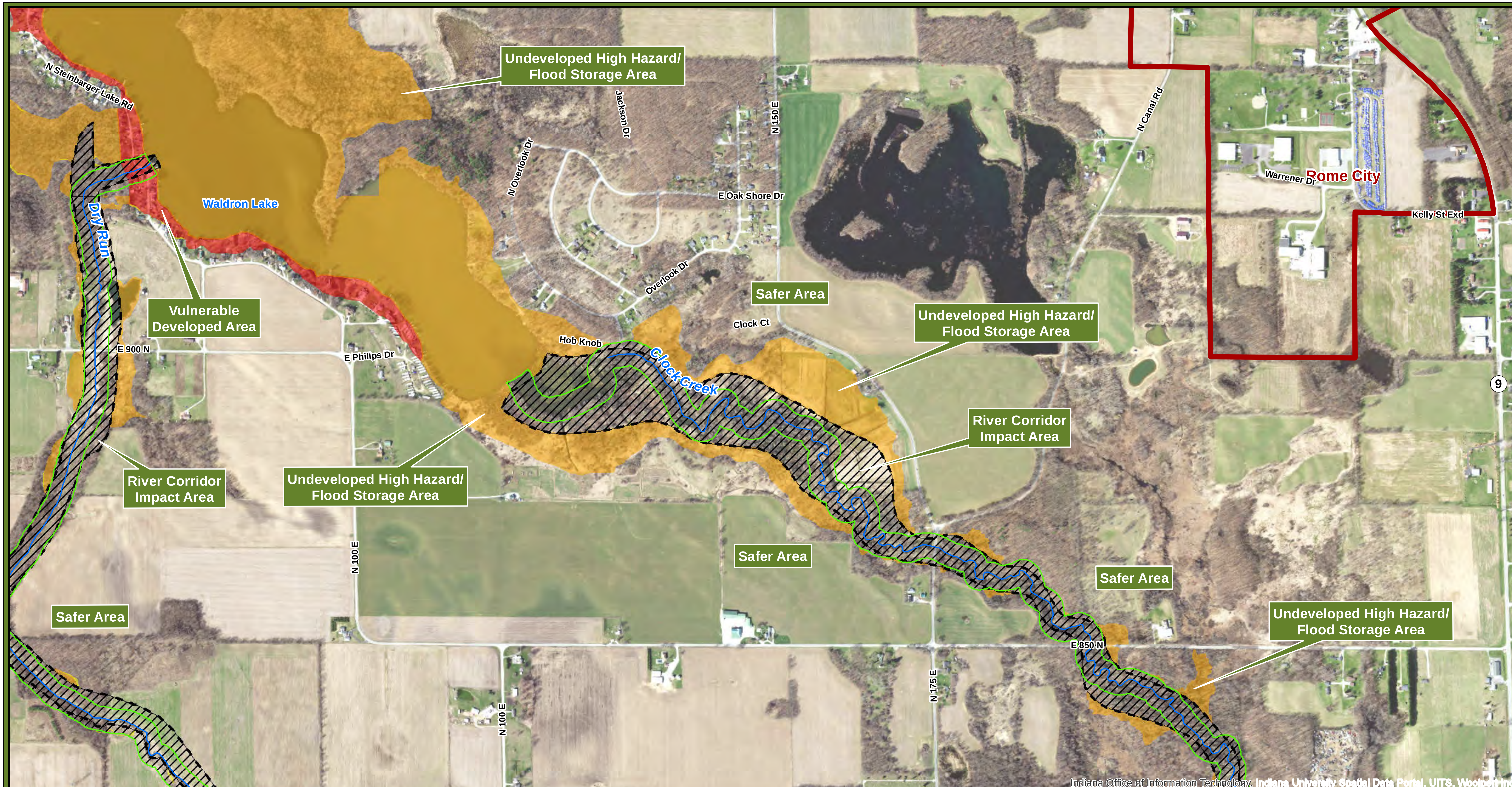

River Corridor Impact Area

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TITLE: Flood Resilience Planning Areas			DATE: 08/2020
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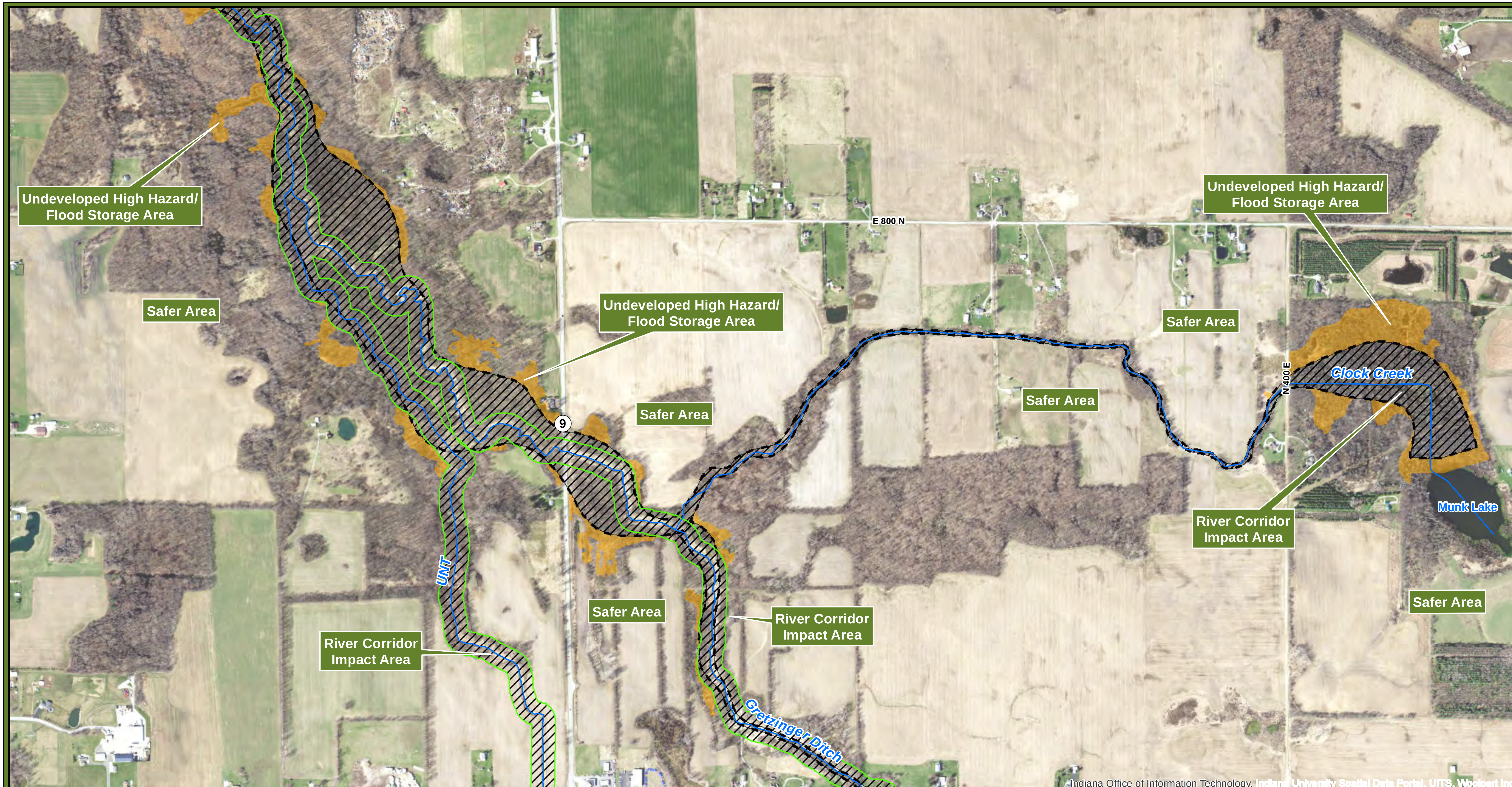

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PROJECT:	North Branch Elkhart River Assessment
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TITLE:	Flood Resilience Planning Areas
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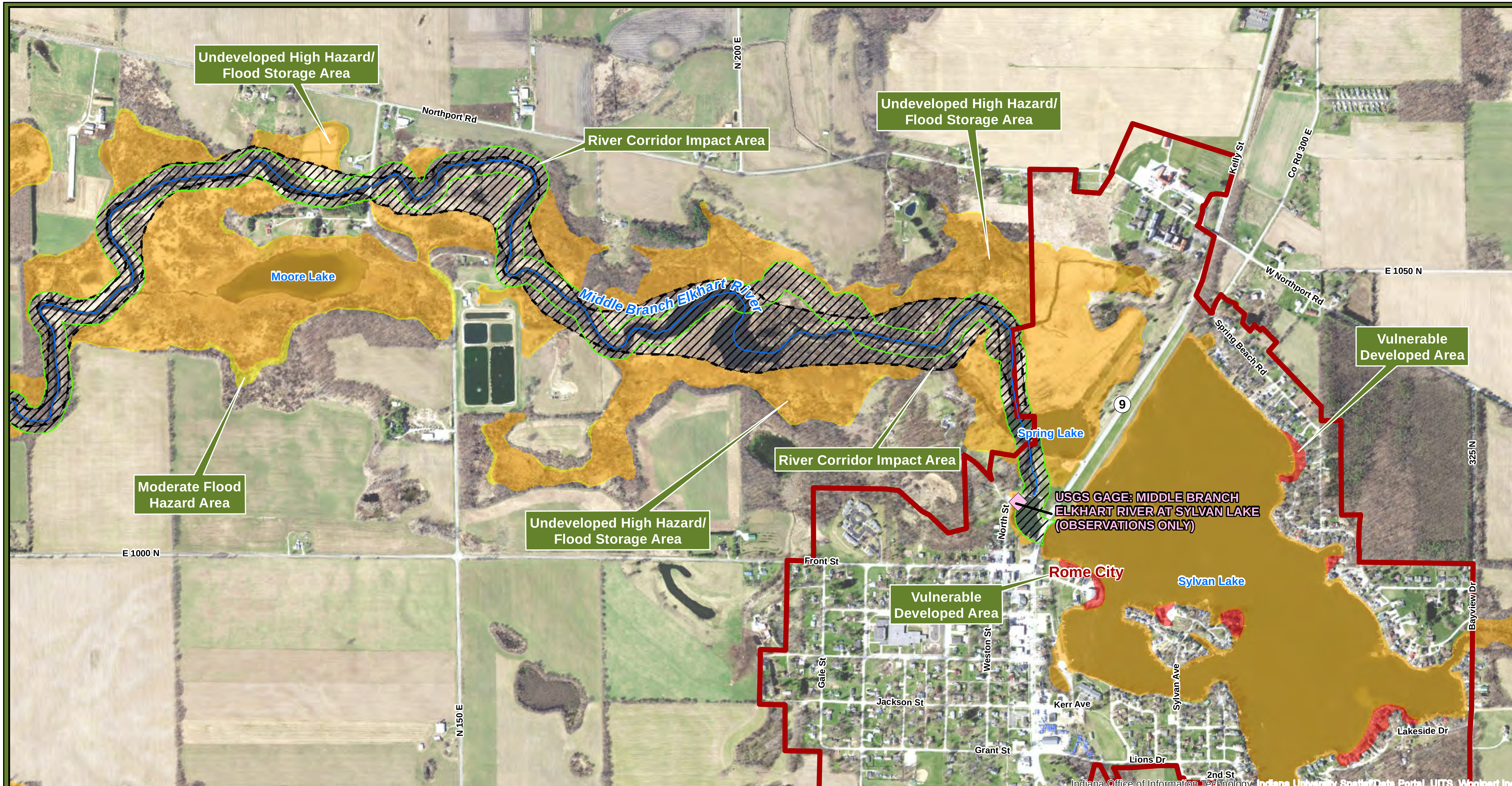

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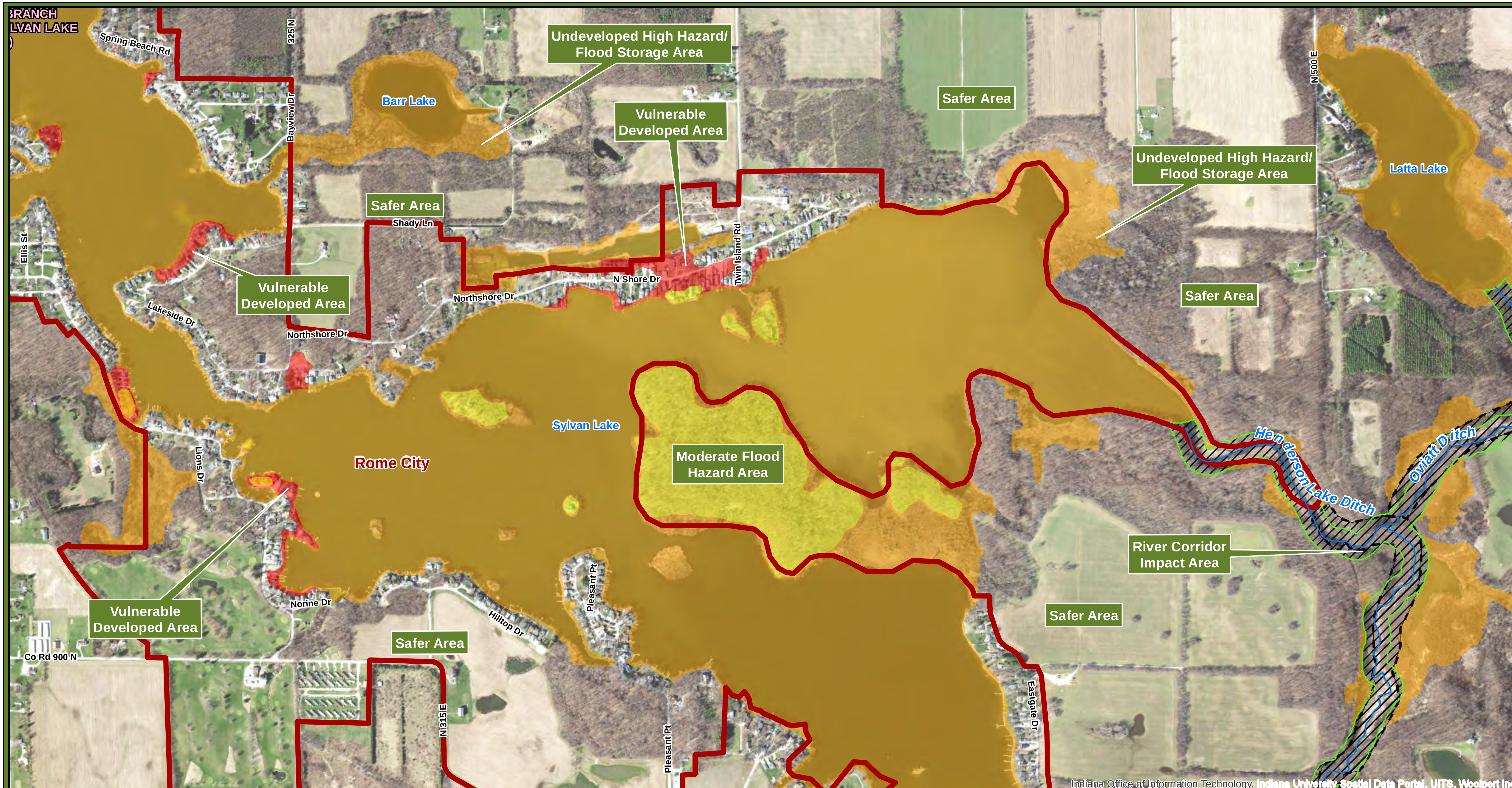

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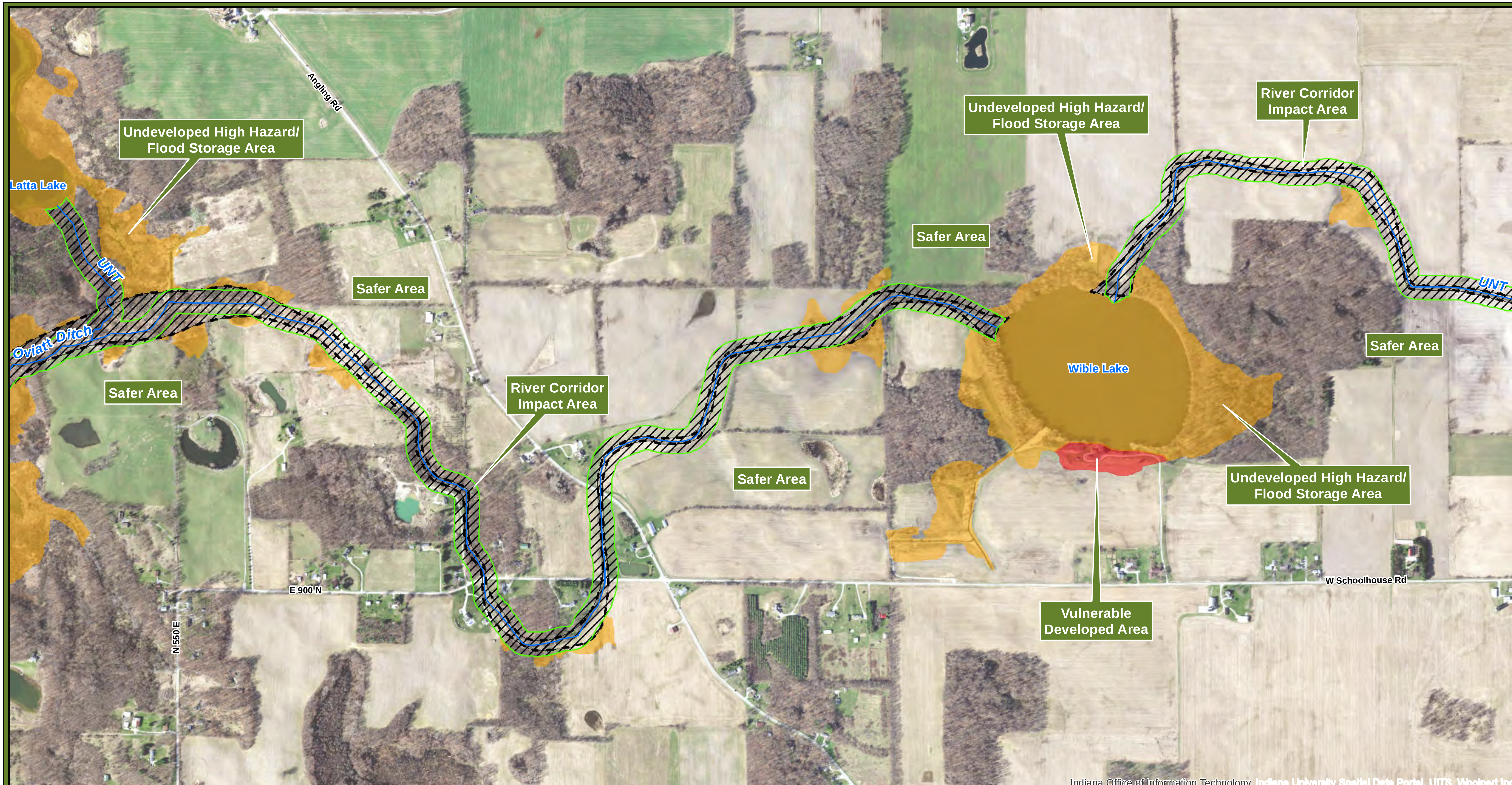

River Corridor Impact Area
Vulnerable Developed Area
Undeveloped High Hazard/ Flood Storage Area
Moderate Flood Hazard Areas
Floodway
Fluvial Erosion Hazard Area
North Branch Elkhart River Subbasin (HUC 8)

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Feet

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PROJECT NO. 19-0481
APPROX. SCALE 1:10,000
DATE: 08/2020
TITLE: Flood Resilience Planning Areas
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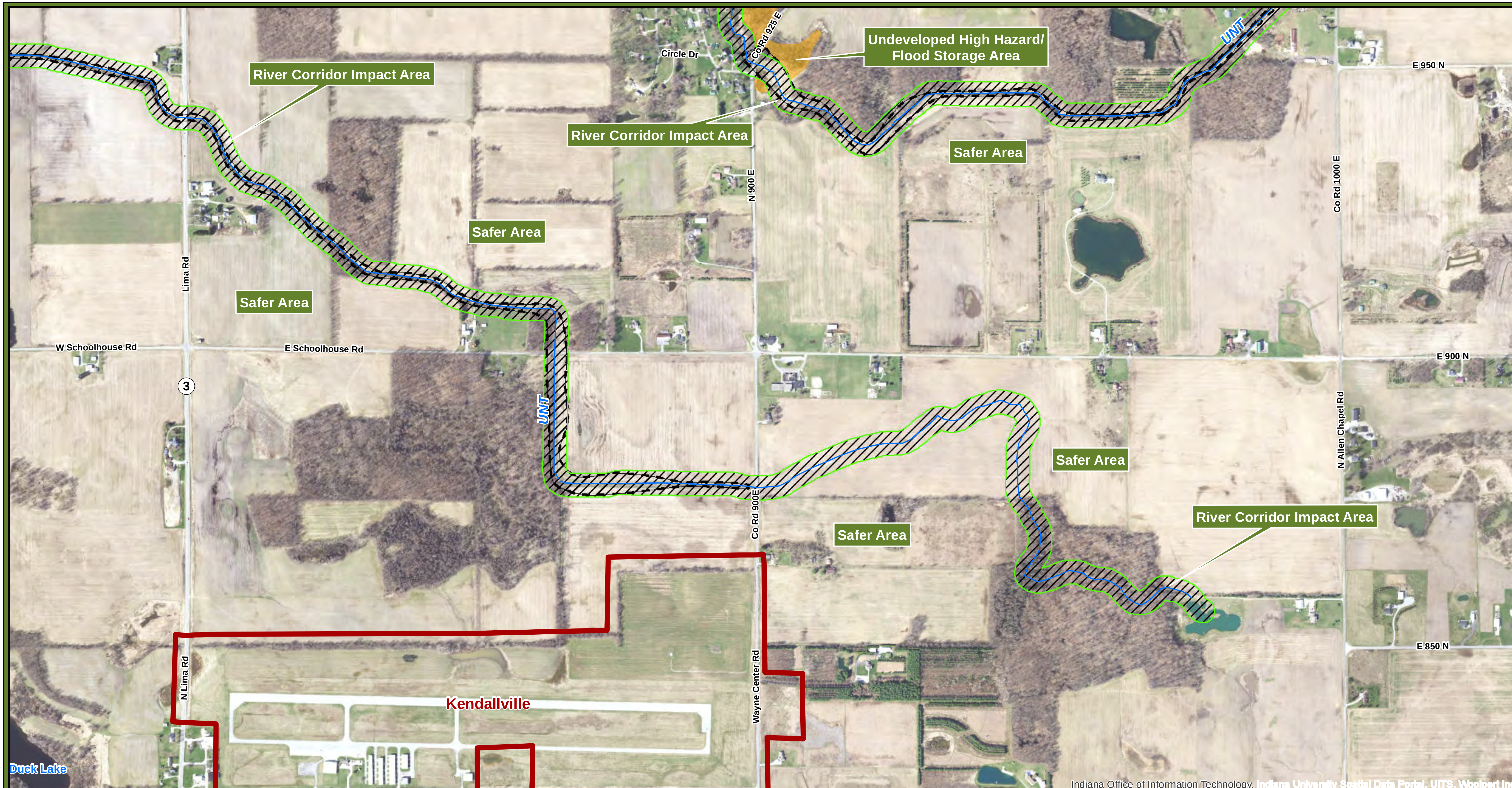

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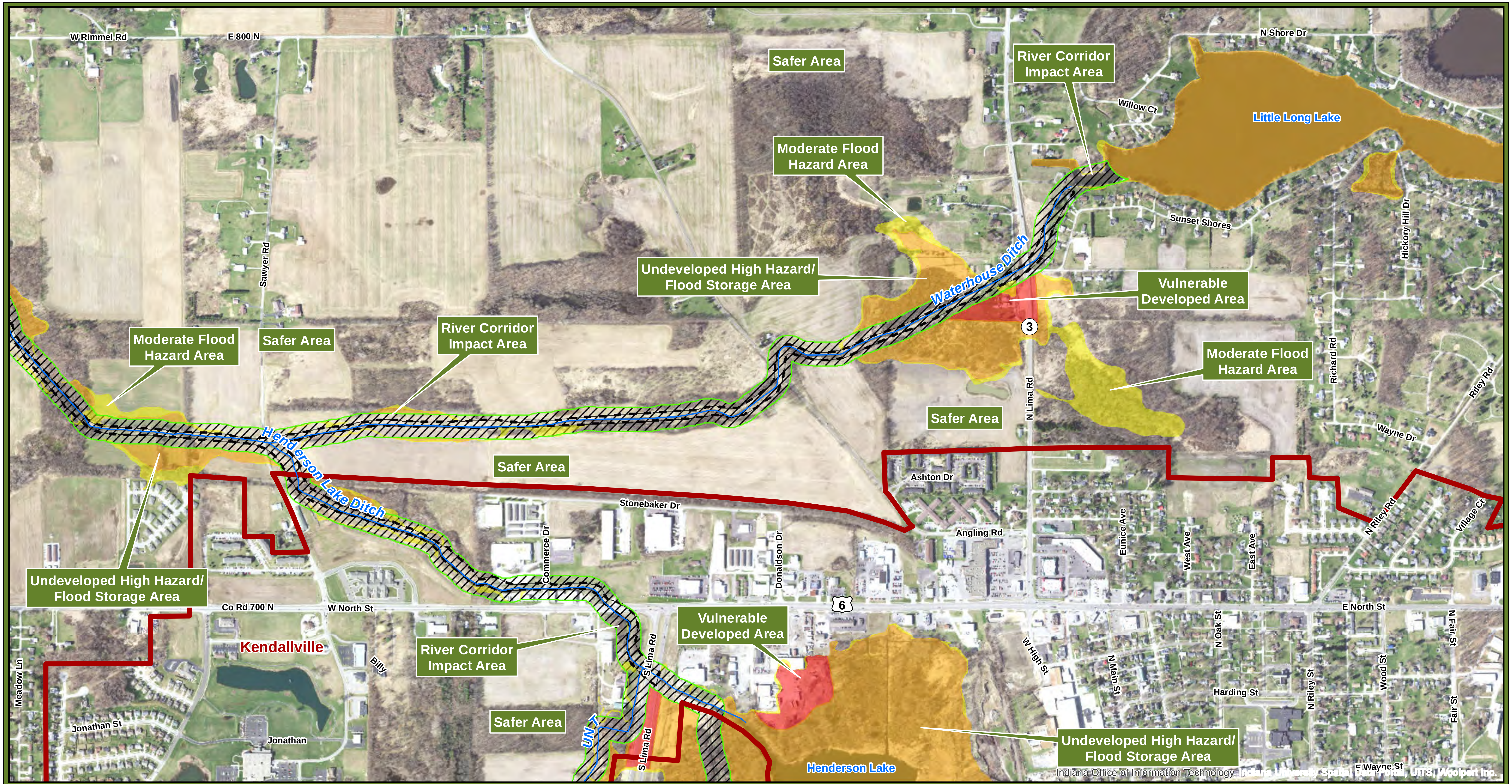

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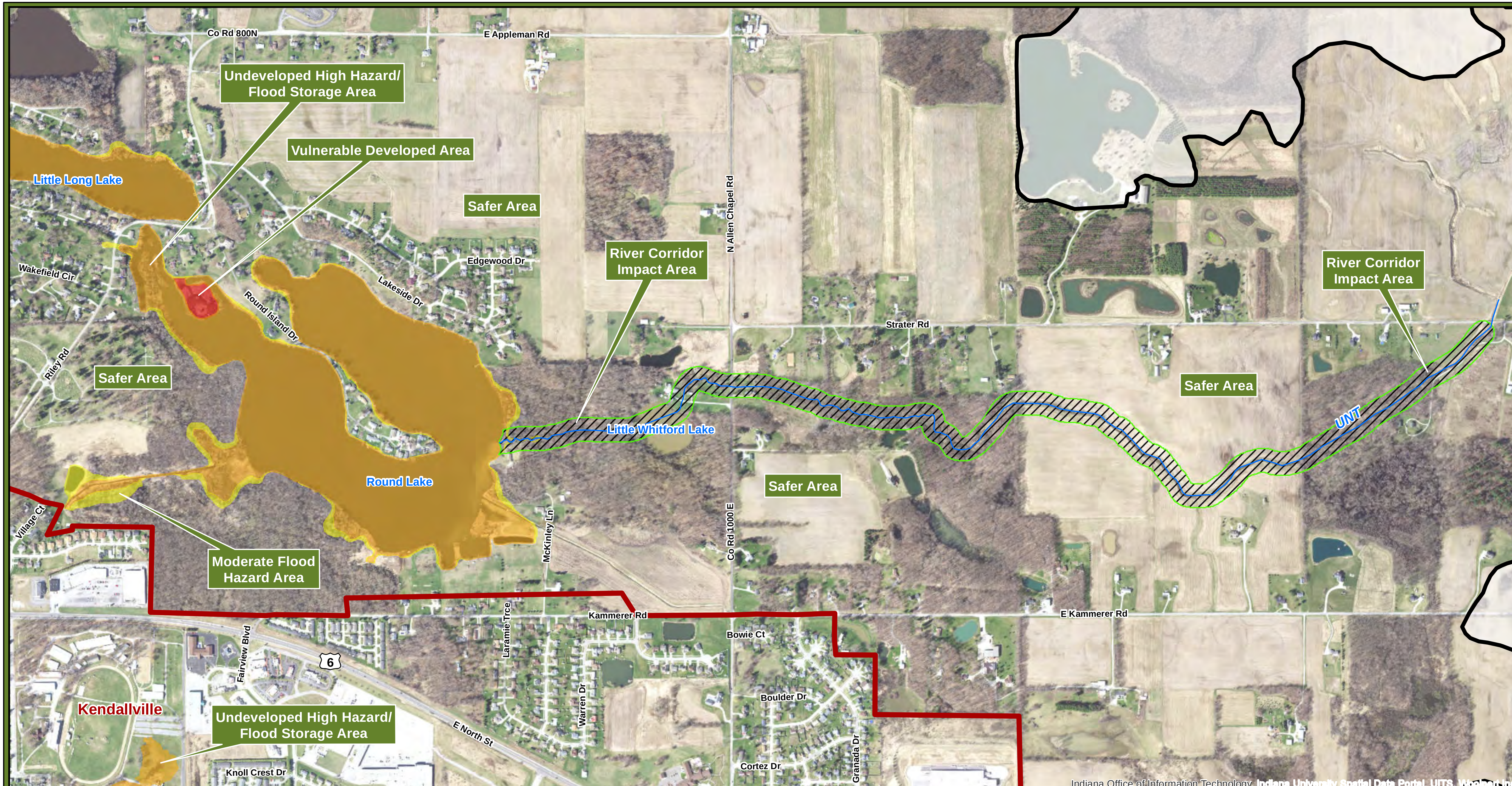

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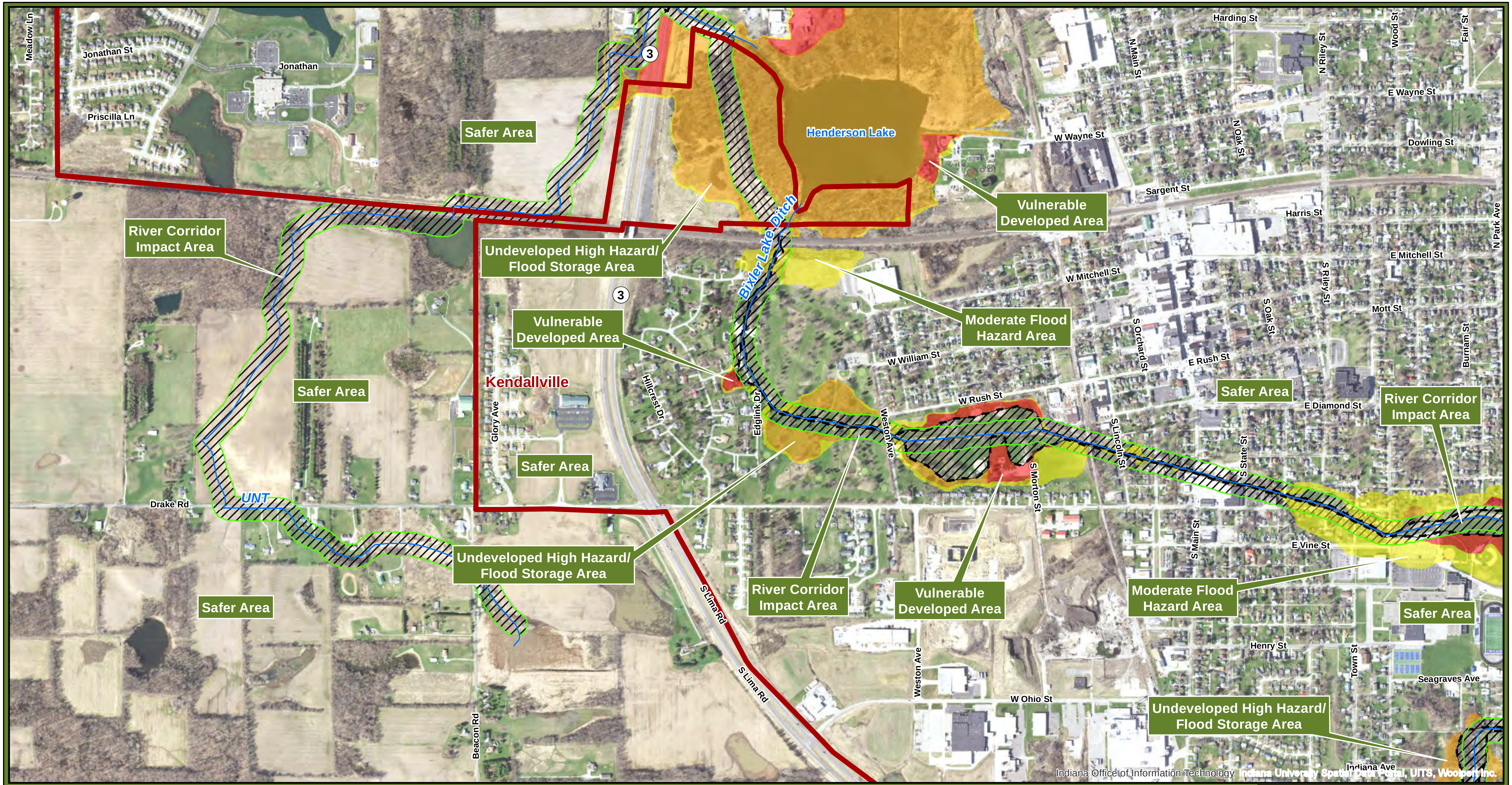

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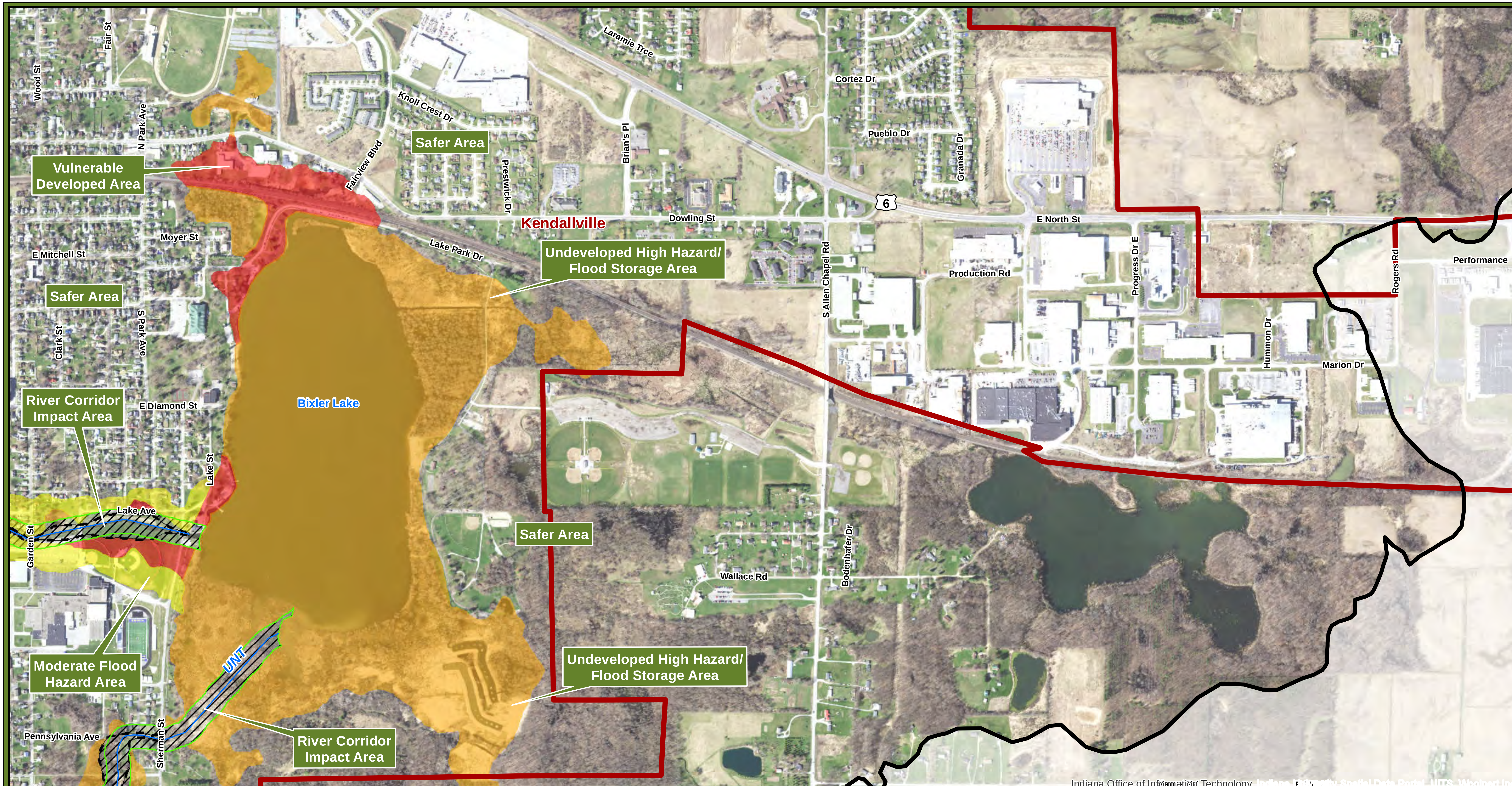

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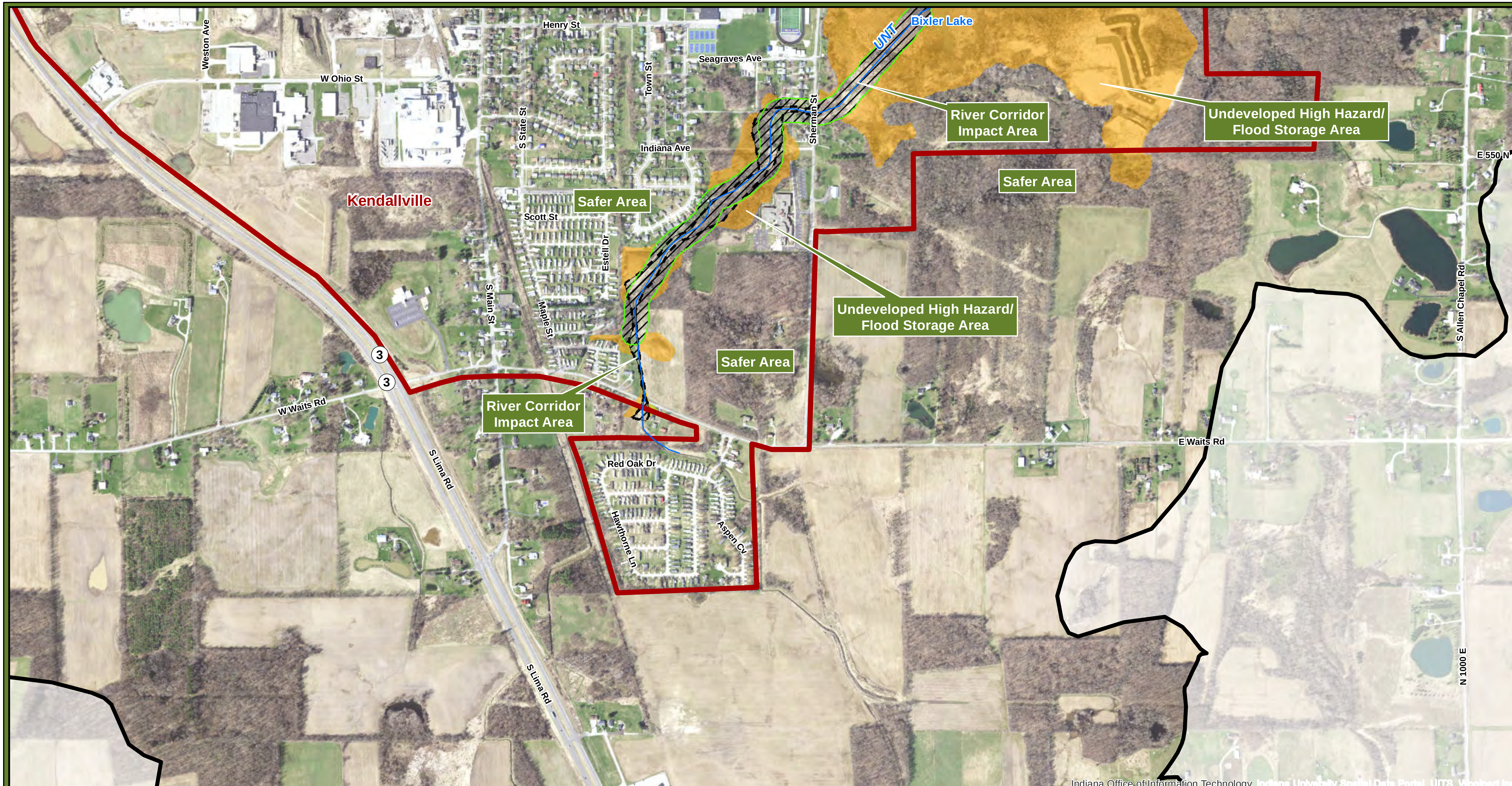

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APPENDIX 1: PUBLIC MEETING SUMMARY

Notes from North Branch Elkhart River stakeholders meeting in Rome City, March 4, 2020

Attendees
Zachary Holsinger - LaGrange Co. Surveyor <zholsinger@lagrangecounty.org>
Steve Vaughn - LaGrange Co. Deputy Surveyor <svaughn@lagrangecounty.org>
Randy Sexton - Noble Co. Surveyor <rsexton@nobleco.us>
Stacey McGinnis - Noble Co. SWCD <stacey.mcginnis@in.nacdnet.net>
Anita Hess - Noble Co. Commissioner <hessanita@hotmail.com>
Dan Lash - West Lakes resident and Proxy for Noble Co. Commissioner Hess on SJRBC <danlash@mchsi.com>
Kenneth J. Hughes - Noble Co. Plan Director and Floodplain Administrator <khughes@nobleco.us>
Mick Newton - Noble County Emergency Manager <mnewton@nobleco.us>
Michael Schaefer - West Lakes Association <h2oauthority@yahoo.com>
Ned Litchsinn - West Lakes Association <nedl1052@gmail.com>
Pete Kelly - Indian Lakes Association <pxkelly72@yahoo.com>
Nancy Brown - Elkhart River Restoration Association <nschlemmerbrown@yahoo.com>
Dave Nance - INDR <dnance@dnr.in.gov>
Siavash Beik - Burke <sbeik@cbbel-in.com>
Peggy Shepherd - Burke <pshepherd@cbbel-in.com>
Robert Barr - IUPUI <rcbarr@iupui.edu>
Bill Weeks - Conservation Law Center <wwweeks@indiana.edu>
Judy Miller - Hackenberg Lake Assoc. <hackenberglake@gmail.com>
Jamie Miller - IDNR <jmiller1@dnr.in.gov>
Vicki Flanot(?) - Sylvan Lake Assoc.
Matt Meersman – SJRBC

Information Discussed Conversation

Field work is being done for the report so that seeing the conditions informs strategy by interpreting the stream or "reading the river"

Lakes are managed almost like legal drains

Protect & enhance storage as beneficial

South & north parts of watershed are different (Dave Nance previous work showed that)

Gene Stratton-Porter (GSP) area where State Road improvement did things to mitigate SR, worked well

Project reach selected since in 2 counties, main stem. Will use to inform similar situations & finding resilience helpful to other locations & be ahead of the crisis of climate change

Tile has changed way water flows

Areas of wetlands are targets for enhanced storage

Natural processes are making flood worse

3 mile area (West lake to Cosperville) cleaned out in the 80s. Not able to clear since 2000 so floods last longer & solids accumulate so now weeds grow & makes lake so long to drain. When weeds go away, lake drains faster

Bridge upstream of Cosperville makes floodplain choke so it pools, slows, and drops sediment

At Point ..?..., field tiles are creating sediment - GSP construction crushed tile but erosion is continuing & making more sediment

Indian, Dallas lakes take forever to drain too

Wolcottsville – east Mill Pond there was a dam study since it acts like a sediment trap but plans says doesn't need dredging (Pete will provide copy of study)

West of SR9, 1st St dam is collecting sediment & no longer is a pond. Is cost justified to clean it out? If make it flow more will it just make more sediment flow?

Is there a way to prove that more sediment is in the main river channel now? It's a belief people have.

All actions have a response – so will actions change the sediment?

Flow has slowed down. Cosperville used to send 800 cfs, now 400. Sediment hits weeds & drops sediment

Regarding upstream storage idea – farmers don't want to store water, natural areas don't want water (mosquitoes, trees die..) GSP area showed that pond can be beneficial & good but a lot of people worked to make that happen so is not the normal situation

lakes have storage – can they be managed March – May to maximize the storage (would involve DNR & COE which would be cumbersome process)

lakes are staying high water until July now – used to go down quicker. Last 5-8 years getting worse due to more flow or outlet issues

want to identify impacts of any plans on others so don't move the problem

could include 2 stage ditches for linear storage

how much of problem is due to agricultural practices

if can't change the situation then figure out how to adapt, may be able to reduce but have strategy to reduce "suffering" & make sure doesn't become worse
make explanations based on data & offer suggestions

future – look at current & future flood elevations – are they raising structures high enough? Floodplain Managers need proper BFE to assure proper protection & help keep insurance costs from going higher. Don't want people to think they solved their problems only to find out they're too low due to changing conditions. Surveyor really wants lake elevation information so know if need change BFEs – also want info on how much to go up so can inform owners of amount to make insurance very low

Hamilton Lake – had low area flooding. Dug more channels and now have less flooding

If there would be large changes in lake levels, banks would fall in

When Sylvan Lake has to open gates – downstream owners worry (haven't had to open)

Can Sylvan lake release more during low flow times so it can store more during higher flows?

Can Lady of Mercy lake downstream of Sylvan Lake help as enhanced storage area?

Soil stability issues exist

WLA – if practices continue as before, continuing to react in the same manner is pointless
- Upstream areas have slope, West Lakes have no fall for their outlet
- are starting the assessment of the tributaries
- are looking at the urban areas
- regarding ag areas
    - practices exist that can capture 30-45% of water by stormwater infrastructure
    - farmer in Carroll Co Ohio measured loses of 5-6T of soil/AC now <100 lb / AC. Volume of water reduced by increased capacity in soil fertility zone with cover crops

Adams Lake & Sylvan Lake – sediment into system w/ nutrients
- ditch velocities go from slow to huge because of tiling & so contaminates go from channel to lake
- Tamarack Lake becoming like Youngs Lake (silted in)

Don't want our report to be a copy of the Silver Jackets report

WLA looking at soil fertility & use around ditches

Individual conversations after the meeting
Tamarack Lake in now brown. It was clear

Matt Meersman has aerial photos that show downstream area sand bars

Near Ned's property the wetland fills with ½ in rain & water can't get out. It should absorb 2". Jan 4" rain raised lake over 3' & it stayed that way till June. May 2017 (lots of rain). Water was around the homes and didn't go down until Aug
Austin (?) is floating the NBR part in 2 weeks & will have more photos

Biology of wetlands has changed & prevents bacteria from working to clean the water
Farmers have tiled all their depression areas

West Lakes provide the filtration for upstream areas where there are lots of confined hog feed lots

Supposedly Noble Co allows creation of impervious surface w/o limits

Would it help to create a low flow channel in the middle of the stream so velocity focuses there and keeps at least that portion cleaned out

APPENDIX 2: NBER CHANNEL STABILITY ASSESSMENT

North Branch Elkhart River Channel Stability Assessment

Robert C. Barr
Hydrology and Fluvial Geomorphology
5515 N Illinois Street
Indianapolis, IN 4608

Prepared for: Christopher B. Burke Engineering, LLC
June 17, 2020

North Branch Elkhart River near Cosperville, Indiana

CBBEL Project 19.R190481.00000

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1.0 Project Description

This report documents the findings of a stream assessment of the North Branch Elkhart River in northeastern Indiana. The assessment is part of a larger Burke project looking into flooding in the North Branch Elkhart River corridor. Floodplain connectivity, large wood in the channel, and erosion or degradation of the channel were assessed as potential indicators of increased flooding. The assessment included the mainstem of the North Branch Elkhart River from the headwaters in eastern Noble County to the confluence with the South Branch Elkhart River upstream from Ligonier, Indiana. A preliminary assessment of the third branch of the river, the Middle Branch Elkhart River, was also conducted when field observations suggested that its headwaters were much different from what was observed in the North Branch.

2.0 Study Area

This report focuses on the main channel and riparian zone of the North Branch Elkhart River from the headwaters in eastern Noble County to the confluence with the South Branch Elkhart River upstream from Ligonier. The overall stream length for the primary study reach is 40.0 miles (Figures 1 and 2), but that 40.0 miles includes over 20 miles of river flowing through lakes. This type of river system with lakes distributed in the river corridor is commonly referred to as a "lake chain". The lake chain system is characterized by complex surface and groundwater interactions between the lakes and the river, with the lake portions frequently behaving more like rivers than lakes. A 2010 report by the Indiana Silver Jackets did an excellent job of reviewing lake management challenges in the basin. This report focuses on the flowing stream and river segments between the lakes. Figure 1 is a longitudinal elevation profile of the river system that helps explain the connection between the riverine portions of the system and the lakes. Figure 2 illustrates in a map view the connected nature of the river and the lakes. Figure 3 shows the watershed.

"These lakes form the head of the northernmost branch of the Elkhart River, the upper course of which is characterized by passage through very extensive marshes, and lakes of considerable depth in the midst of them." (Dryer, 1883).

This report also discusses preliminary observations on the Middle Branch Elkhart River from the headwaters near Kendallville to the confluence with Jones Lake.

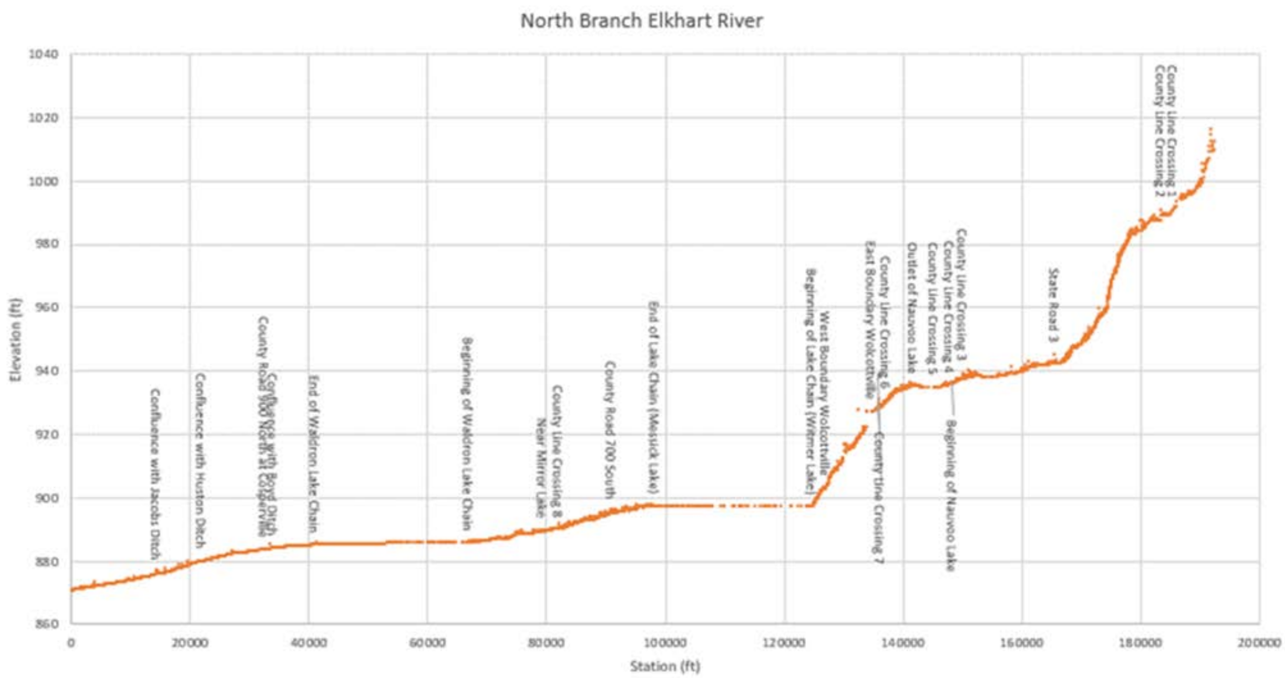

Figure 1: Longitudinal profile of the North Branch Elkhart River (M. Rummel)

Figure 2: Map view of the North Branch Elkhart River showing selected lakes. The mainstem North Branch Elkhart River is indicated by the light blue along the dark blue channel. (M. Rummel)

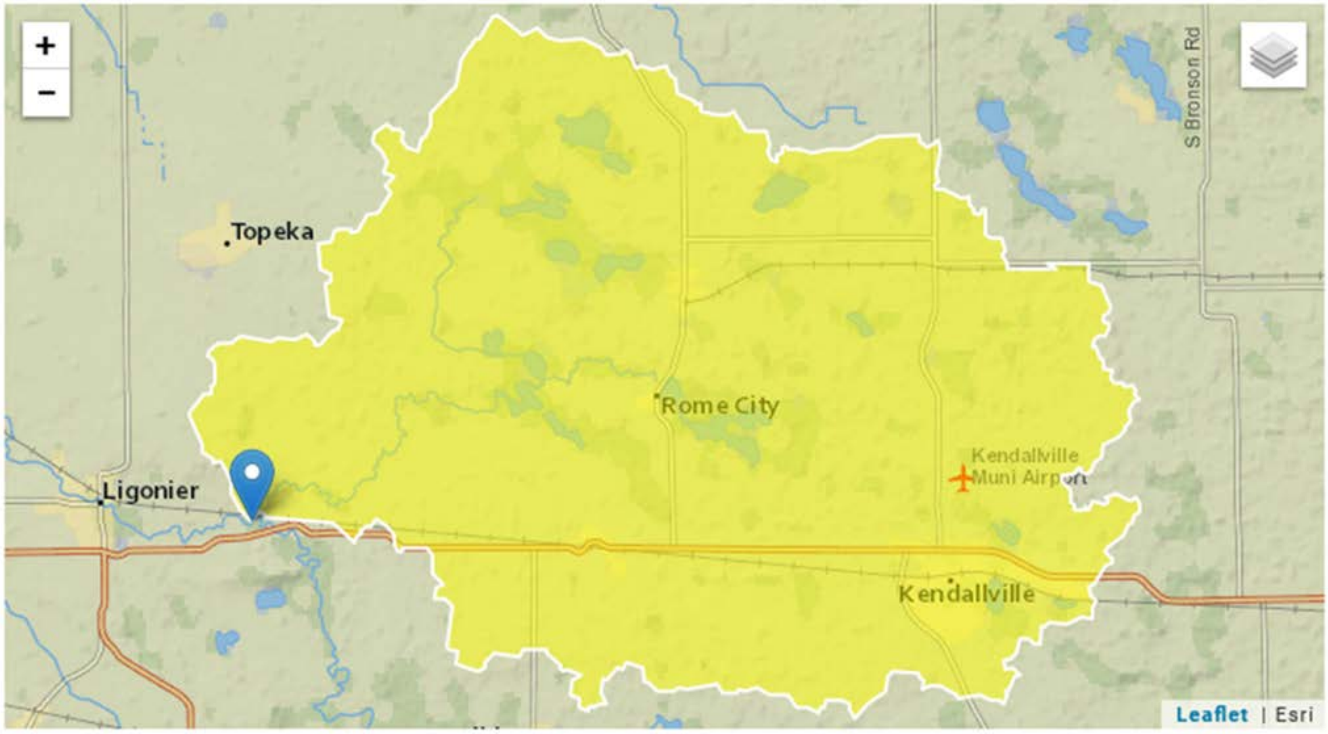

Figure 3: North Branch Elkhart River Watershed (Drainage area (DA) = 163 mi²) Hoggatt, 1975. Map: USGS StreamStats

2.1 Study Area Surficial Geology and Soils

The study area is located in the Northern Lakes Natural Region, a region is characterized by outwash and lake plains with kame and kettle topography, a complex hummocky landscape dominated by knobs of till and sand and gravel kame complexes interspersed across the landscape (Casebere, 1997). Underlying the till throughout the basin are extensive deposits of sand and gravel ranging from 100 to over 300 feet thick (Fowler, 1992). These sands and gravels form an extensive unconfined aquifer with very high transmissivity rates that recharge the river (Crompton and others, 1986; Fowler,1992). The flat areas between the knobs are dominated by muck soils and marl deposits and the larger flat areas are frequently wetlands or lakes. Figure 4 shows the surficial geology of the study area. The city of Kendallville is labeled in the lower right portion of the figure for reference. The map illustrates the general southeast to northeast trend of the river corridors. It also shows, in dark gray, the extensive muck (organic soils that are saturated more than 30 cumulative days in normal years or are artificially drained) deposits in the corridors. As the river flows downstream, it flows through these corridors dominated by muck. The corridor widens when it flows into complexes of kettle lakes and then narrows again on the downstream end. Note the lakes are bounded by muck in many areas. Figure 5 shows a detail from the Waldron Lake area that shows the extensive muck areas. One popular name for this type system is "a chain of lakes". An understanding of this type of river system is critical for understanding the interaction between the river and the lakes. In the simplest terms the North Branch Elkhart River is a long linear wetland with a river flowing through it. The muck surrounding the river as well as the light green sand and gravel outwash deposits are all hydrologically connected. Water flows from the outwash into the muck and ultimately into the river. The rivers then flow into lakes where the water spills out into the wider area and still slowly continues downstream. Figure 1 illustrates how the system works with riverine sections where there is some slope to the landscape, and lakes where there are depressions or flat areas. Think of it as a series of buckets that spill over to the next as water moves through the system. For this study, the important aspect of understanding how this system works is the recognition that it is all interconnected.

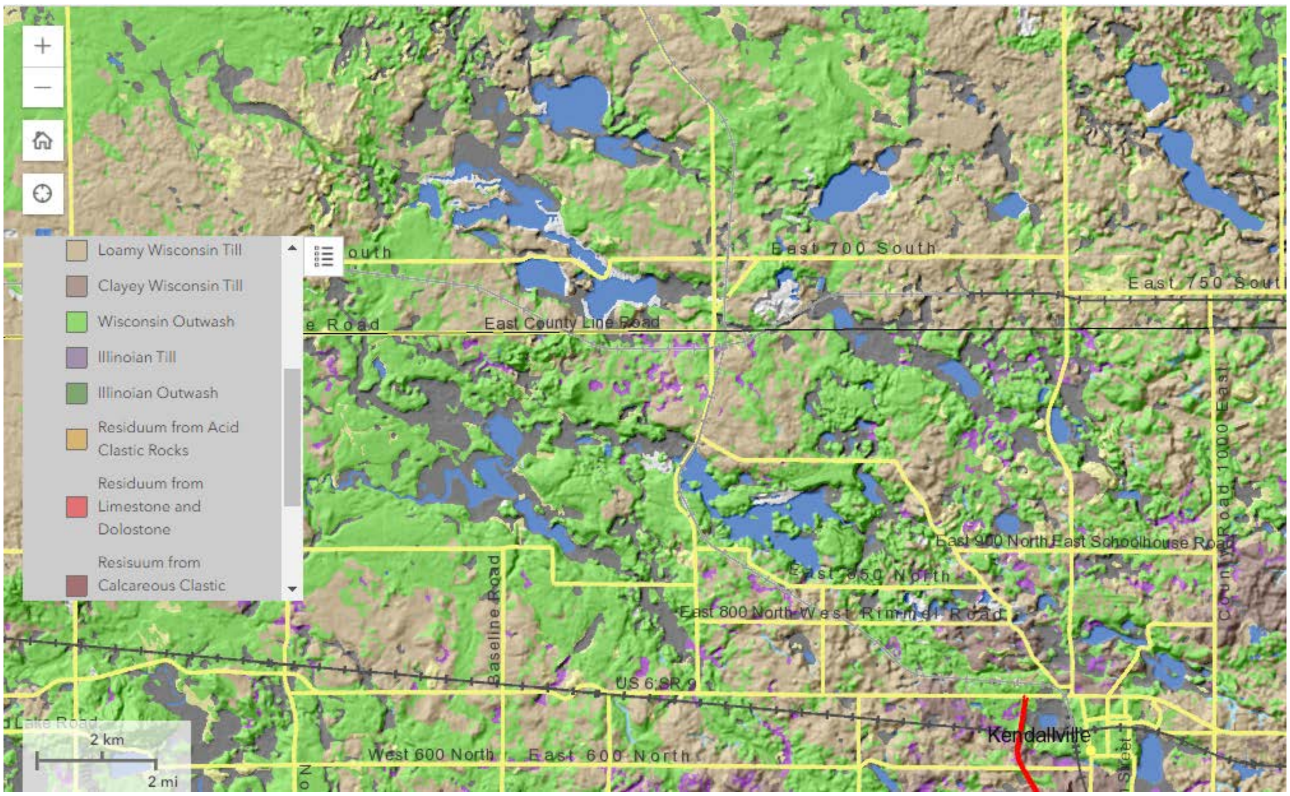

Figure 4: Surficial Geology in the Study Area (Purdue Soil Explorer)

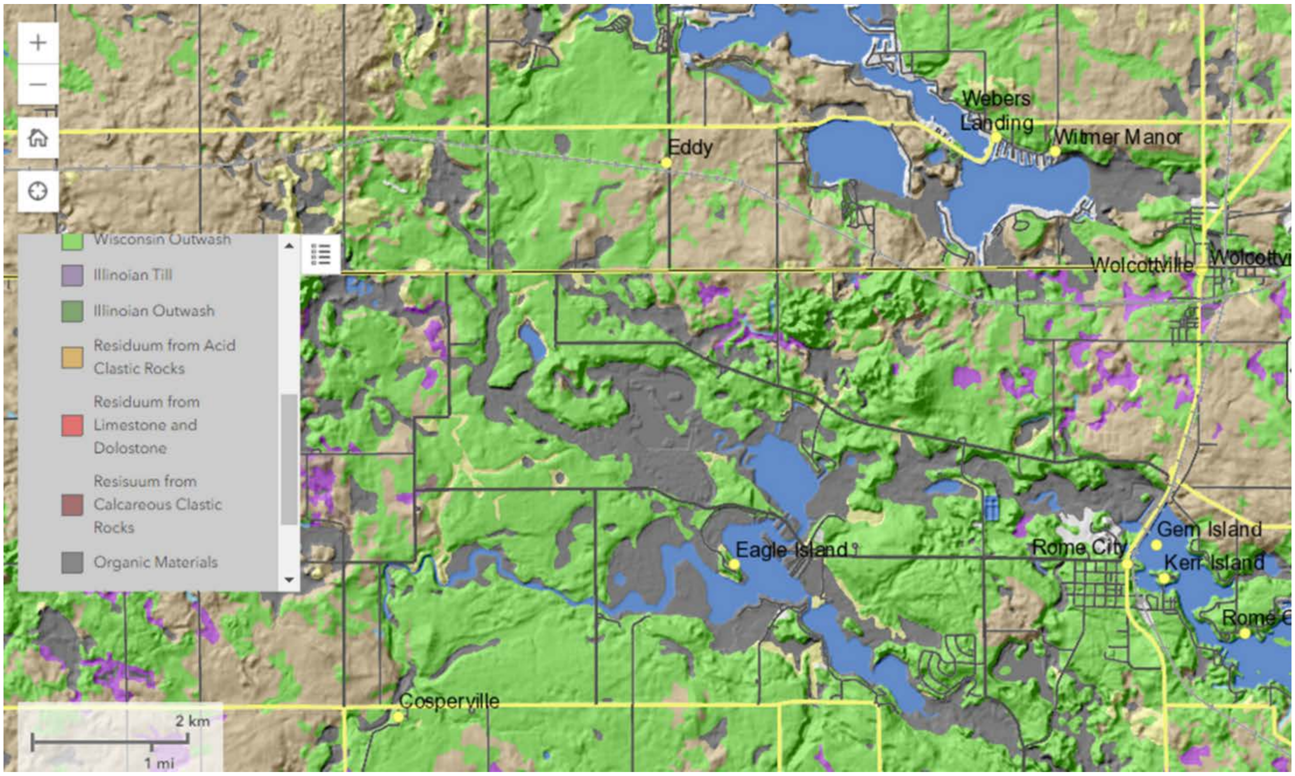

Figure 5: Detail of surficial geology around West Lakes (Purdue Soils Explorer)

3.0 METHODS

The general plan, or method for the field assessment was guided by the Streams Functional Pyramid, a guide for assessing and restoring stream functions (Figure 6; Harman and others, 2012). Using this model, we first look at the foundations for stream function, geology, and climate. If one of these foundational components is changing the stream system will respond and adjust to the new conditions. Likewise if the way water moves from the watershed into the river corridor changes there will be an "in corridor" response that we can usually identify by looking at changes in stream flow (hydraulics) or in the physical characteristics of the channel (geomorphology). All these components help develop an understanding of the river system.

An initial stakeholder meeting was held in Rome City on March 4, 2020. At that meeting areas of concern were mapped on the North Branch Elkhart River. Comments from that meeting were used to guide the initial reconnaissance of the river. The main channel and corridor of the North Branch was assessed for signs of stream instability, bank erosion, large wood, and indicators of incision.

Evidence of incision or channel downcutting is particularly important in a river like the North Branch. Geomorphic, or alluvial floodplains, floodplains naturally formed by depositional processes along an alluvial river, are not present along Little Elkhart Creek or North Branch Elkhart River. The functional "floodplain" along the river is a wide (>1000 ft) corridor of muck soil. Because of the high degree of hydraulic conductivity between the muck soil and water in the active channel the NRCS describes frequency of flooding in the muck as "none", but the frequency of ponding is high. The depth to the water table is given as 0, indicating that these soils, unless drained, are saturated to the surface most of the time. Web Soil Survey was used to measure the width of this corridor in the study reaches.

A literature review was ongoing throughout the project.

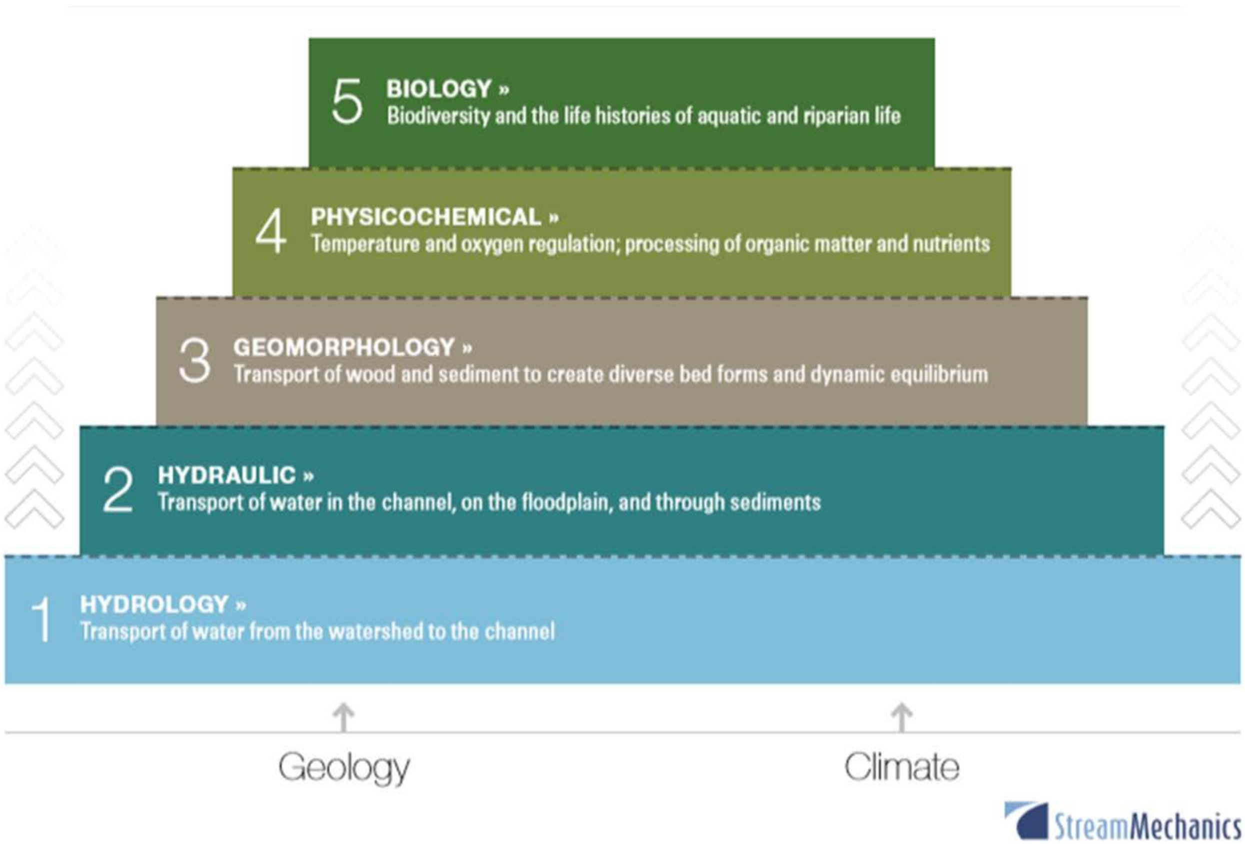

Figure 6: Stream Functions Pyramid (Harman and others, 2012)

4.0 OBSERVATIONS: NORTH BRANCH ELKHART RIVER

The pictures below show representative stream reaches on the North Branch Elkhart River (NBER). These pictures provide a reference for understanding how the NBER evolves as it flows from its heavily modified agricultural headwaters on the eastern edge of Noble County to its confluence with the South Branch Elkhart River upstream from Ligonier.

4.1 Headwaters: Hutchins and Uhl Ditch to confluence with Little Elkhart Creek downstream from Cree Lake

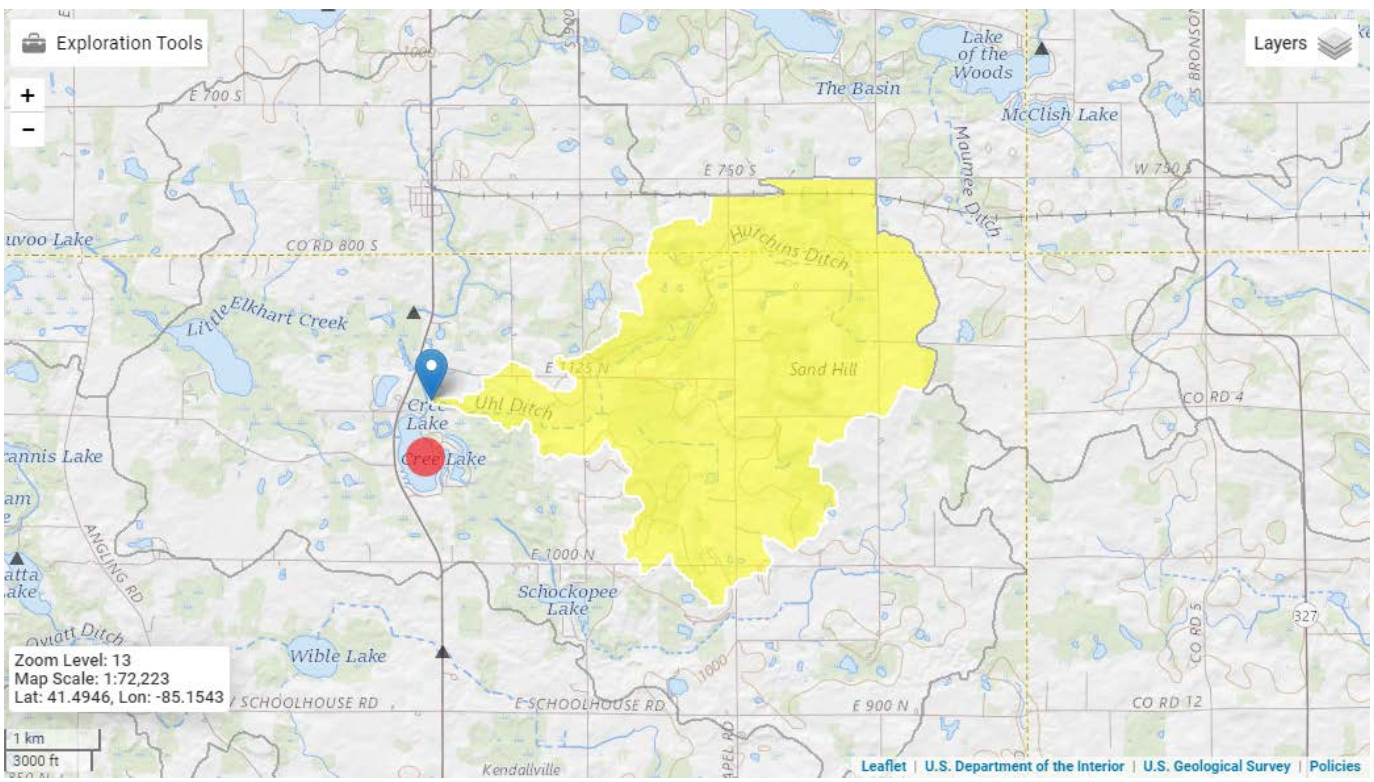

Figure 7: Upper headwaters watershed

Drainage Area (DA) = 4.8 mi^2

Channel slope (s) (CSL 10-85) = 16.7 ft/mi

Channel sinuosity (k) = ditched, some reaches beginning to naturalize

Channel boundary materials = channel cut into Brookston silt loam (Bx) a soil found in morainal depressions. Bordering upland soils are most commonly sandy loams or loamy sands contributing sand to the channel.

Predicted channel dimensions for a natural stable channel at confluence:

W_{bkf} = 28 ft (measured = 18 ft)

Mean depth (d_{bkf})= 1.8 ft

Area (A_{bkf}) = 52 ft^2

Riparian corridor: Grassed buffers throughout watershed, larger ditches have a thin to extensive forested buffer, floodplain connectivity good. Large wood could potentially block the channel on such a small stream, but no problems were observed (Figure 9).

Headwater basin is 3.26 % wetland (USGS Streamstats)

Figure 8: Hutchins Ditch, upstream from confluence with Uhl Ditch (41.5143, -85.2500). Note well connected floodplain and grassed buffer.

Figure 9: Uhl Ditch, looking downstream, note developing woody corridor, sand on channel bed

4.2 Little Elkhart Creek from Cree Lake to Nauvoo Lake. In this reach Little Elkhart Creek flows through Tamarack Lake and Mud Lake. Little Elkhart Creek outlets from the northeast end of Nauvoo Lake.

Figure 10: Hutchins Ditch, upstream from confluence with Uhl Ditch

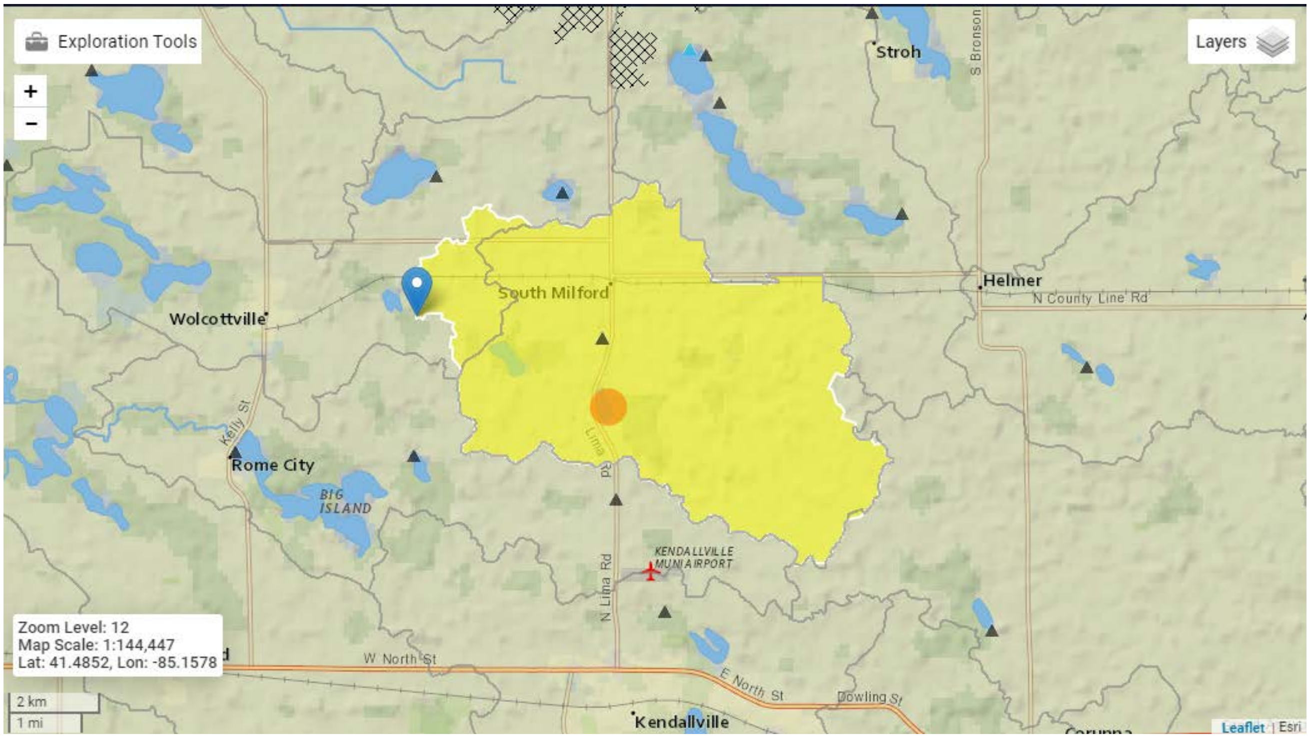

Figure 11: Watershed above Nauvoo Lake

Drainage Area (DA) = 21.0 mi^2

River miles (RM) = 3.7

Channel slope (s) (CSL 10-85) = 7.08 ft/mi

Channel Type = ditched channel, LiDAR shows sinuous channel in places before modification

Channel sinuosity (k) = ditched, some reaches beginning to naturalize

Channel boundary materials = channel cut into muck soils near the lakes and drained muck between the lakes, muck layer can be 80 inches thick. As in the headwaters bordering upland soils are most commonly sandy loams or loamy sands contributing sand to the channel. NRCS describes the frequency of flooding as none, but ponding is frequent. Muck is saturated to the surface unless drained (Streamstats)

Predicted channel dimensions for a natural stable channel at Mud Lake inlet:

W_{bkf} = 35 ft (measured = 26 ft)

Mean depth (d_{bkf})= 1.8 ft

Area (A_{bkf}) = 52 ft^2

Riparian corridor: corridor width in this reach is from 1000 feet along the channel to over 3000 feet near the lakes. Corridor should be considered a forested wetland with a stream flowing through. Floodplain connectivity is good, but this is a non-alluvial system that pulses with a rising water table rather than a depositional floodplain. No apparent large wood issues

Basin is 7.0 % wetland (USGS Streamstats)

Figure 12: Little Elkhart Creek downstream from Cree Lake near SR 3

Figure 13: Little Elkhart Creek between Tamarack Lake and Mud Lake

Figure 14: Little Elkhart Creek between Tamarack Lake and Mud Lake, near Angling Road (41.5276, -85.3176)

4.3 Little Elkhart Creek between Nauvoo Lake and Witmer Lake. This reach includes the town of Wolcottville.

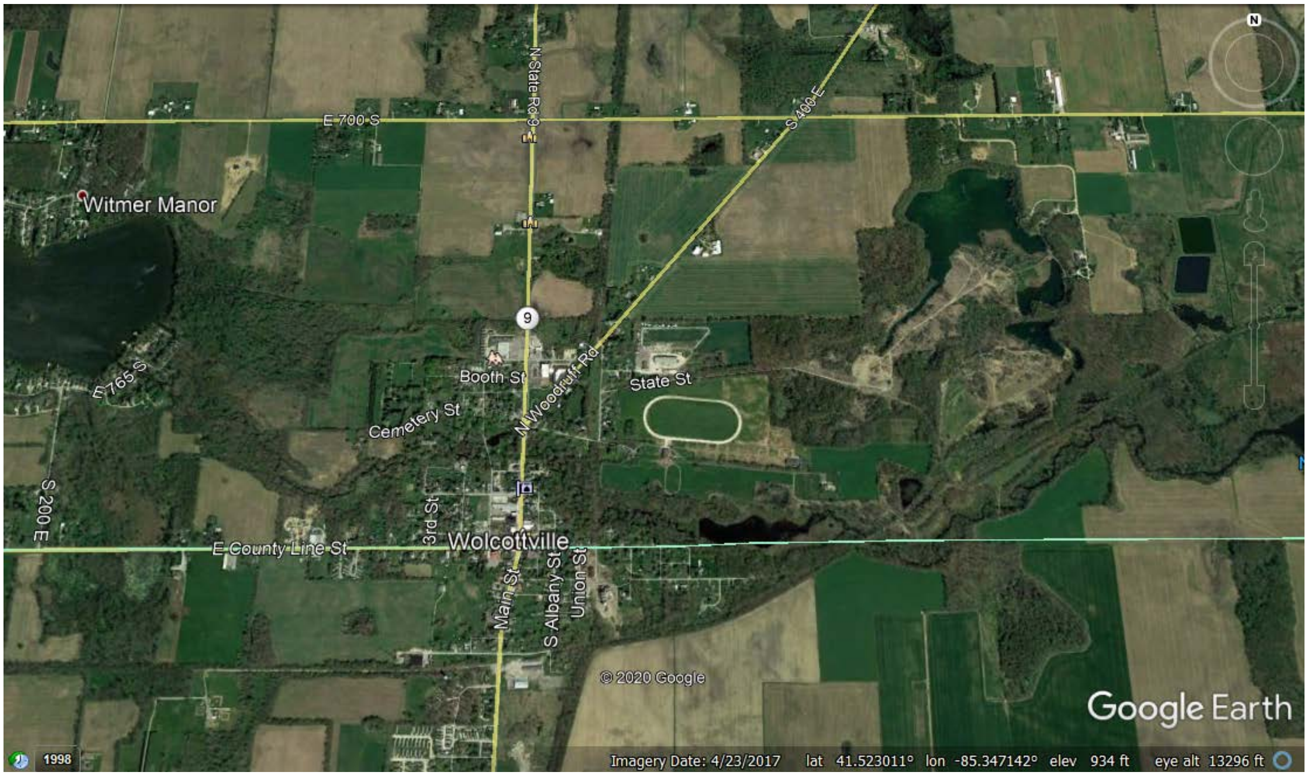

Figure 15: Little Elkhart Creek between Nauvoo Lake and Witmer Lake

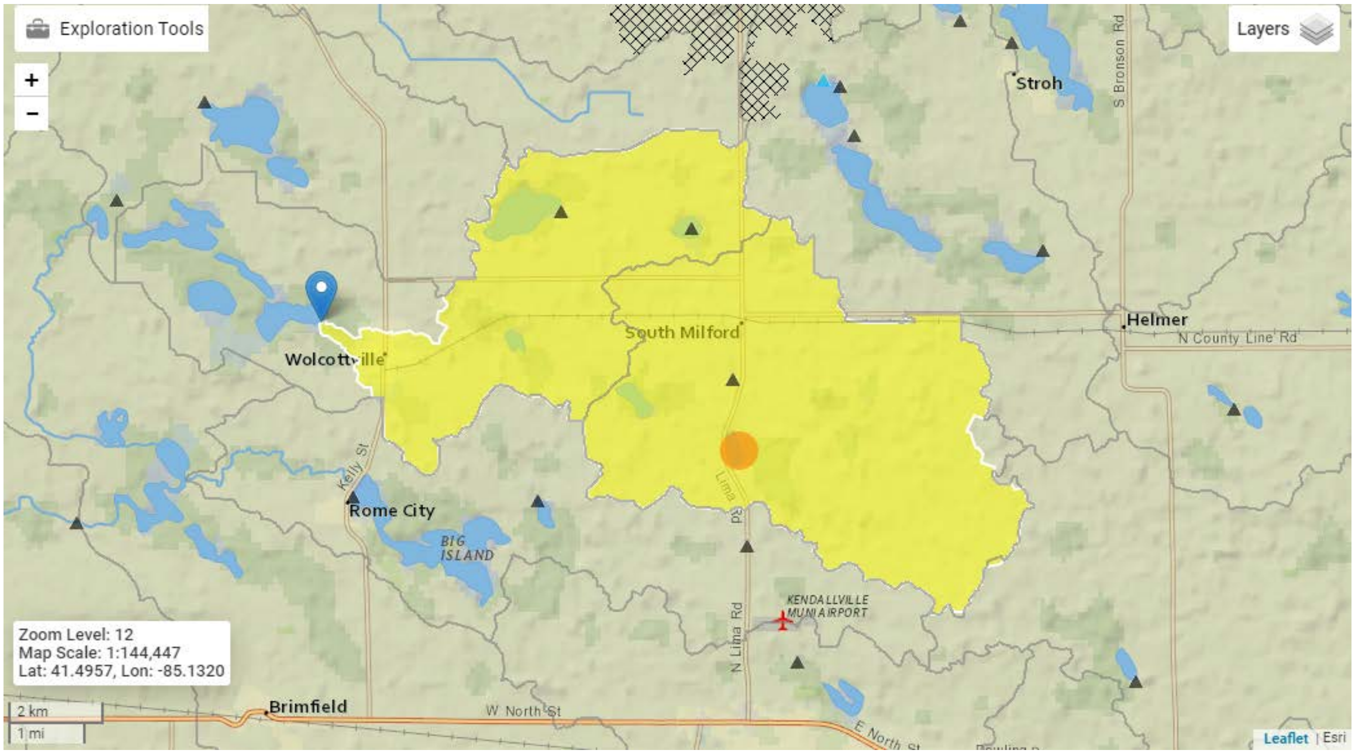

Figure 16: Watershed upstream from Witmer Lake

Drainage Area (DA) = 31.6 mi^2

River miles (RM) = 4.5

Channel slope (s) (CSL 10-85) = 6.18 ft/mi

Channel Type = ditched, straightened channel, LiDAR shows sinuous channel in places before modification

Channel sinuosity (k) = ditched, some reaches beginning to naturalize

Channel boundary materials = channel cut into muck soils near the lakes and drained muck between the lakes, muck layer can be 80 inches thick. As in the headwaters bordering upland soils are most commonly sandy loams or loamy sands contributing sand to the channel. NRCS describes the frequency of flooding as none, but ponding is frequent. Muck is saturated to the surface unless drained (Streamstats)

Predicted channel dimensions for a natural stable channel at inlet to Witmer Lake:

W_{bkf} = 40 ft (measured = 36 ft)

Mean depth (d_{bkf})= 2.2 ft

Area (A_{bkf}) = 92 ft^2

Riparian corridor: corridor width in this reach averages over 1000 feet. Corridor is a forested wetland with a stream flowing through with exception of the Wolcottville section. The 1-mile urban portion of the stream through Wolcottville has been extensively modified by a Mill Pond at the east end of town, and then by a series of modifications west of SR 9. Some bank instability was also noted west of SR 9. Floodplain connectivity is good, but this is a non-alluvial system that pulses with a rising water table rather than a depositional floodplain. Some small trees are in the channel in the Wolcottville area, particularly west of SR 9.

Basin is 9.48 % wetland (USGS Streamstats)

Figure 17:Little Elkhart Creek at Wolcottville (41.5290, -85.3655)

4.4 Oliver Lake outlet above Hackenburg Lake.

The only significant tributary to the North Branch Elkhart River other than Little Elkhart Creek is the small lake chain to the north that consists of Martin Lake, Olin Lake, and Oliver Lake (from east to west and moving downstream). The outlet channel for this chain includes a slightly widened area named the "the spreads" which is illustrative of the lakes in the system simply being wide spots in the river. The Oliver Lake outlet flows into Hackenburg Lake which also receives Little Elkhart Creek flow from the Witmer Lake, Westler Lake, and Dallas Lake system. Hackenburg Lake then flows through a short (2,000 ft) developed outlet into Messick Lake. The outflow from Messick Lake is the North Branch Elkhart River.

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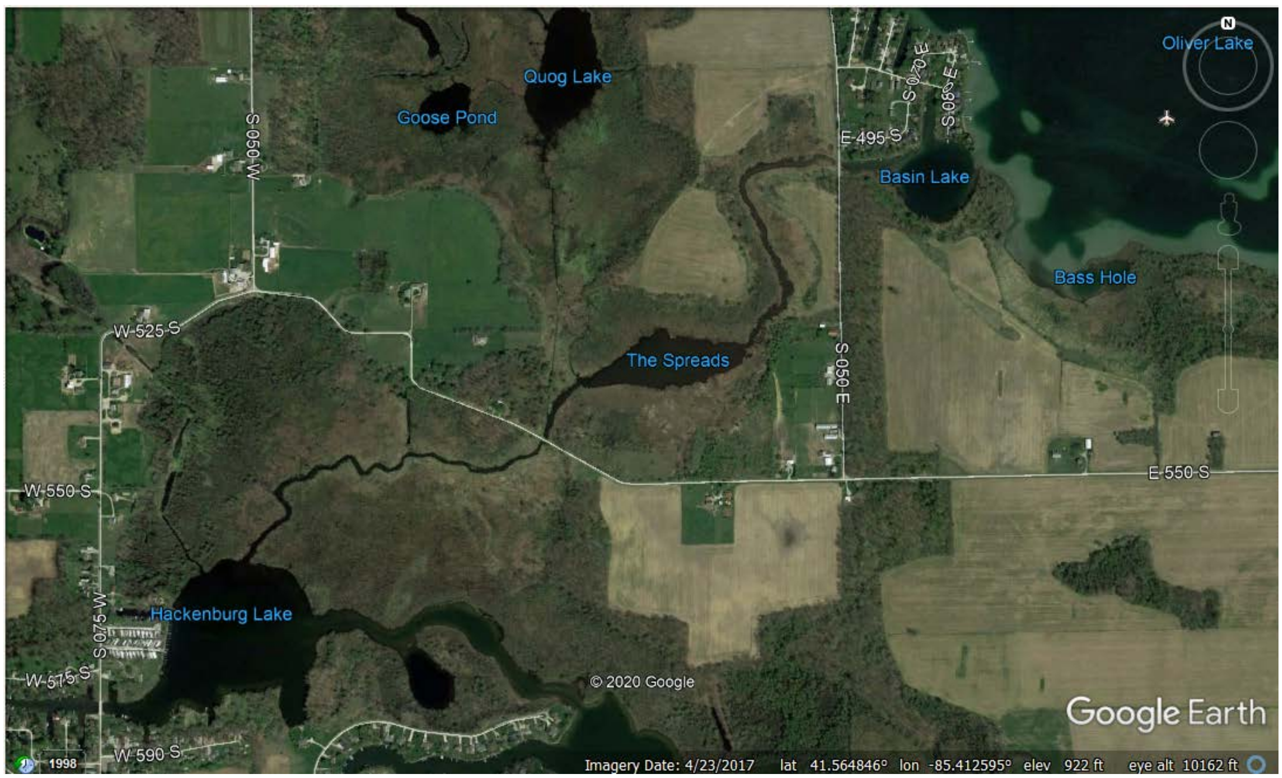


Figure 18: Oliver Lake outlet above Hackenburg Lake

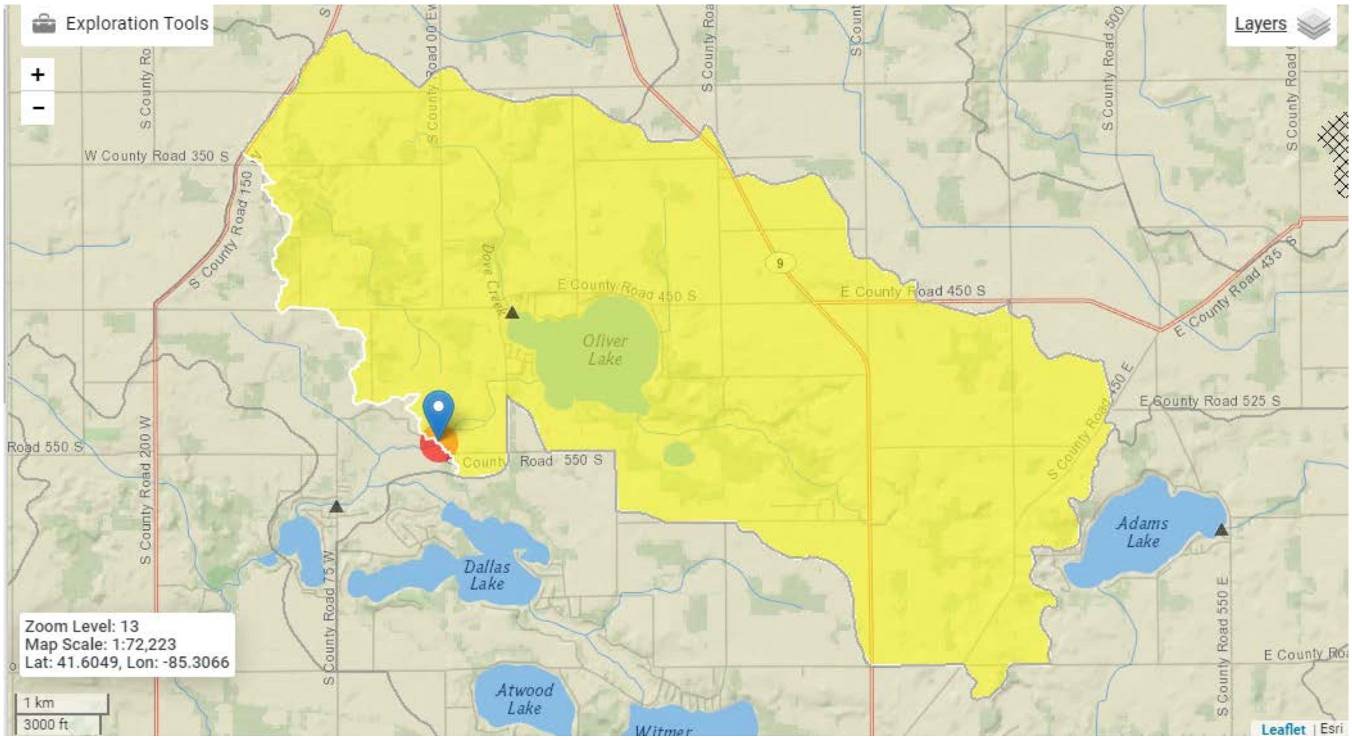


Figure 19: Watershed above Hackenburg Lake

Drainage Area (DA) = 13.5 mi^2 (from central portion of stream reach)

River miles (RM) = 1.5

Channel slope (s) (CSL 10-85) = 6.18 ft/mi

Channel Type = Natural channel, Rosgen E5/6

Channel sinuosity (k) = 1.3

Channel boundary materials = channel cut into muck soils near the lakes and drained muck between the lakes, muck layer can be 80 inches thick. In this reach the muck soil extends from 600 to over 2500 feet around the active channel. Bordering upland soils are most commonly sandy loams or loamy sands that contribute sand to the muck channel. NRCS describes the frequency of flooding as none, but ponding is frequent. Muck is saturated to the surface unless drained (Streamstats).

Predicted channel dimensions for a natural stable channel at inlet to Hackenburg Lake:

W_{bkf} = 31 ft (measured = 36 ft)

Mean depth (d_{bkf})= 1.9 ft

Area (A_{bkf}) = 60 ft^2

Riparian corridor: corridor width in this reach averages over 2000 feet. Corridor is wetland grasses with scattered trees. Floodplain connectivity is good, but this is a non-alluvial system that pulses with a rising water table rather than a depositional floodplain. No evidence of large wood in channel.

Basin is 14.6 % wetland (USGS Streamstats)

Figure 20: Oliver Lake outlet upstream from Hackenburg Lake near CR E 550 S (41.5628, -85.4243)

4.5 North Branch Elkhart River from Messick Lake outlet to the Jones Lake inlet.

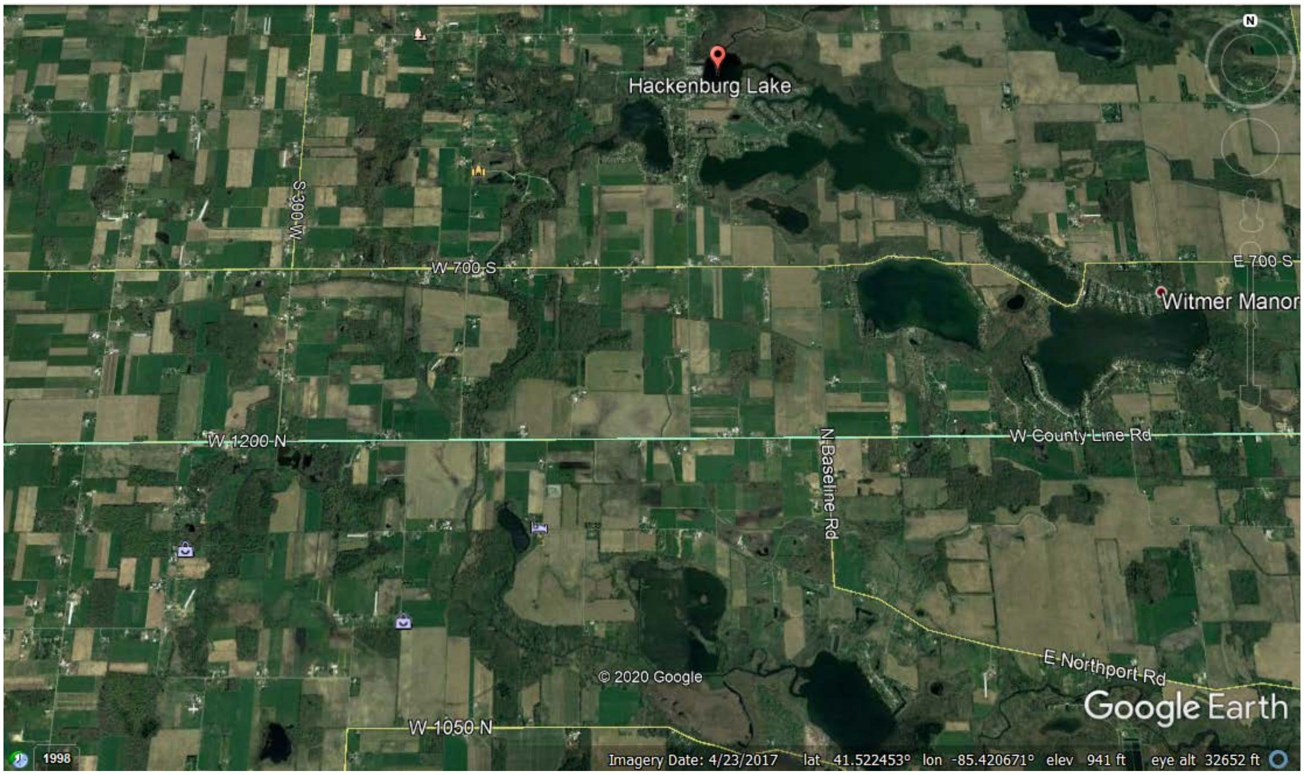


Figure 21: North Branch Elkhart River from Messick Lake outlet to the Jones Lake inlet.

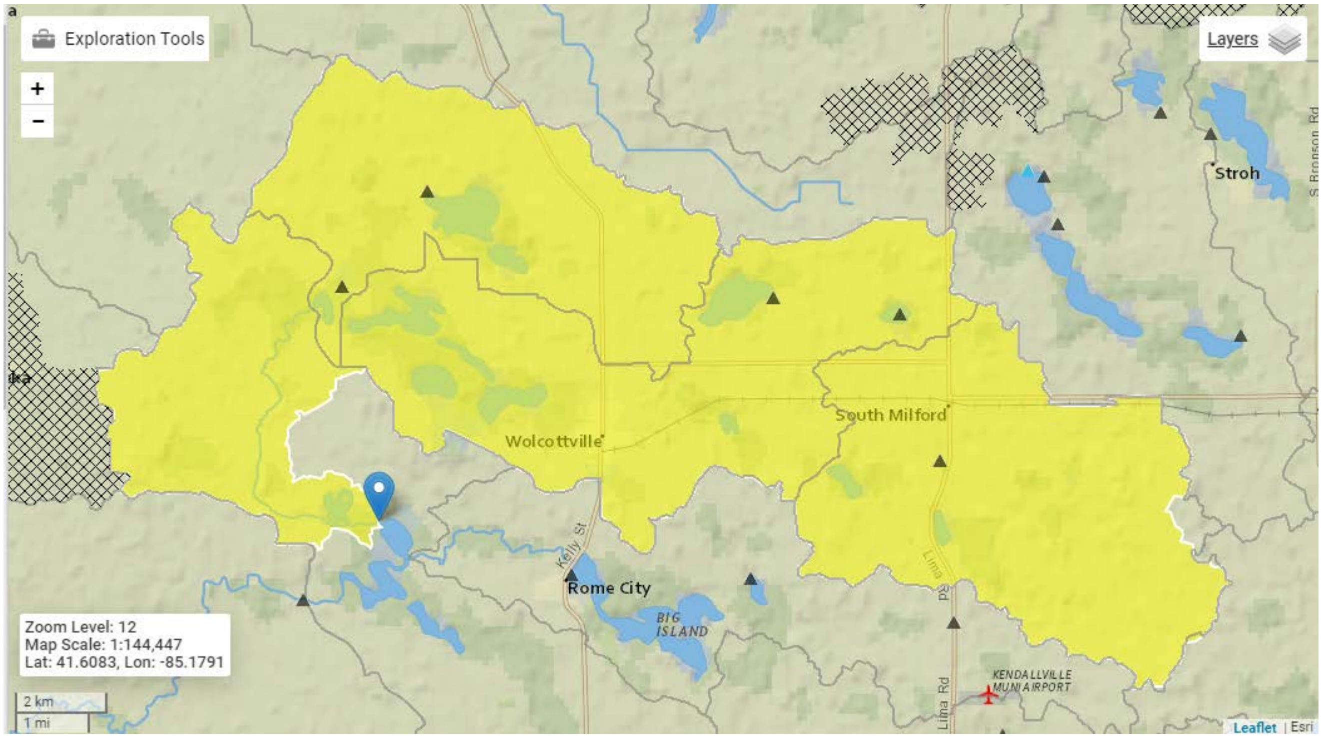


Figure 22: Watershed above Jones Lake

Drainage Area (DA) = 66.5 mi^2 (above the inlet to Jones Lake)

River miles (RM) = 6.3

Channel slope (s) (CSL 10-85) = 3.86 ft/mi

Channel Type = Natural channel in LaGrange County (upper 3.2 miles) Rosgen E5/6. Channel in Noble County above Jones Lake (3.1 miles) has been straightened.

Channel sinuosity (k) = 2.2 LaGrange County portion), 0.93 (Noble County above Jones Lake).

Channel boundary materials = channel cut into muck soils near the lakes and drained muck between the lakes, muck layer can be 80 inches thick. In this reach the muck soil extends from 600 to over 2500 feet around the active channel. Bordering upland soils are most commonly sandy loams or loamy sands that can contribute sand to the muck channel. NRCS describes the frequency of flooding as none, but ponding is frequent. Muck is saturated to the surface unless drained (Streamstats).

Predicted channel dimensions for a natural stable channel at inlet to Jones Lake:

W_{bkf} = 51 ft (measured average = 52 ft)

Mean depth (d_{bkf})= 2.6 ft

Area (A_{bkf}) = 133 ft^2

Riparian corridor: corridor width in this reach is variable and ranges from 850 feet in LaGrange to over 2000 feet near the Jones Lake inlet. Corridor upstream from the lake is forested wetland. The near lake fringe tends to be dominated by grasses and herbaceous plants. Floodplain connectivity is good, but this is a non-alluvial system that pulses with a rising water table rather than a depositional floodplain. No evidence of large wood in channel.

Basin is 13.1 % wetland (USGS Streamstats)

Figure 23: North Branch Elkhart River near CR W700 S (41.5400, -85.4590) downstream from Messick Lake

Figure 24: North Branch Elkhart River at CR W 1200 N (County Line) looking upstream into Lagrange County

Figure 25: North Branch Elkhart River at CR W 1200 N (County Line) looking downstream into Noble County. This is the only portion of the river where the riparian corridor is missing from both sides of the channel. The floodplain is still functionally attached allowing flood pulses to spill out of the channel.

4.6 North Branch Elkhart River from the Waldron Lake outlet at N CR 125 W to the confluence with South Branch Elkhart River upstream from Ligonier. This reach includes the “lake/stream transitional reach” described in the Indiana Silver Jackets Report (ISJ, 2010), and the USGS stream gage at Cosperville.

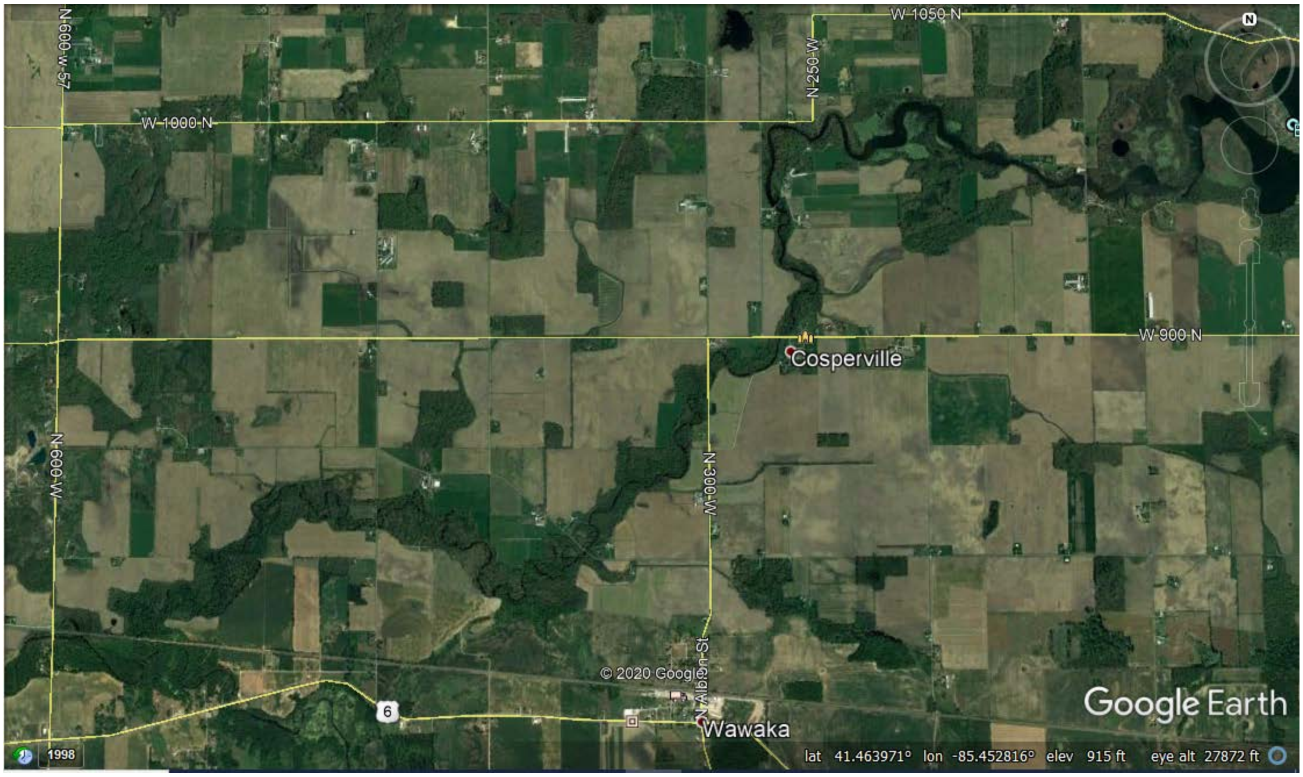


Figure 26: North Branch Elkhart River from the Waldron Lake outlet at N CR 125 W to the confluence with South Branch Elkhart River upstream from Ligonier

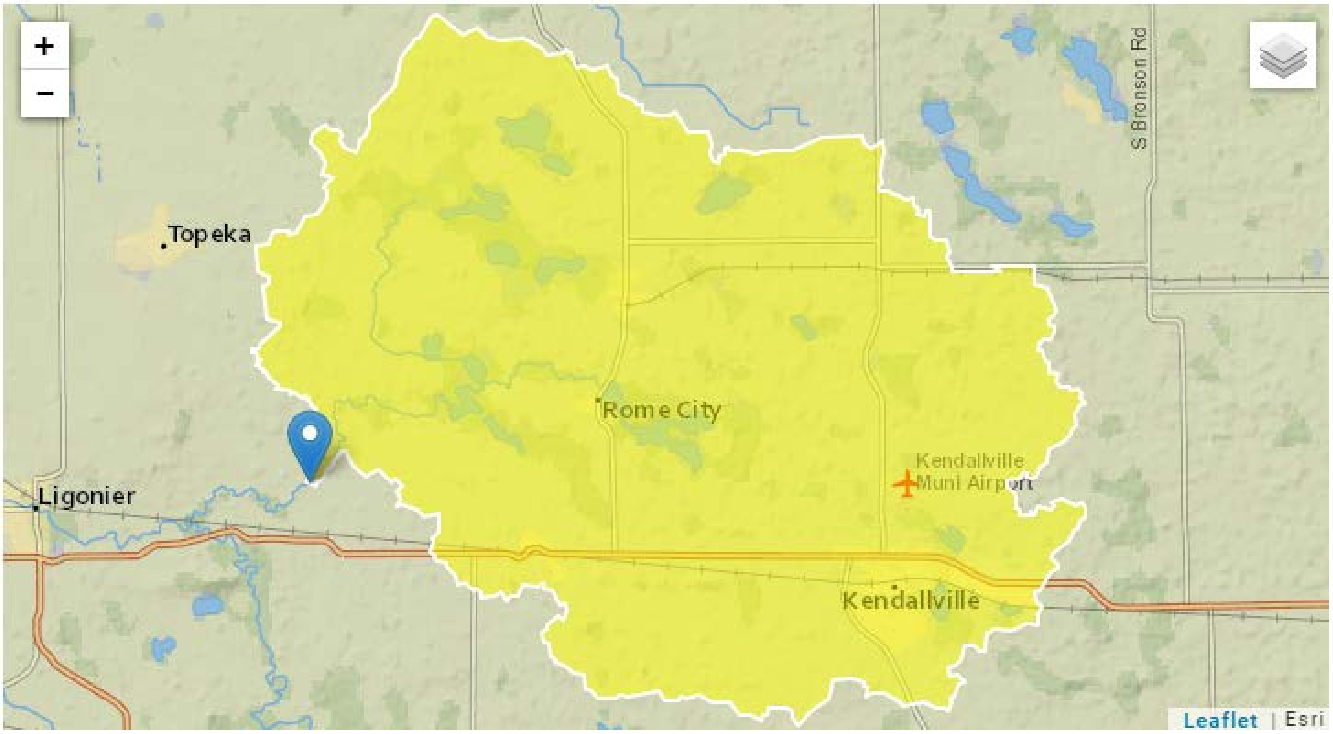


Figure 27: Watershed above the Confluence of the North Branch Elkhart River with the South Branch Elkhart River

Drainage Area (DA) = 142.9 mi^2 (above the confluence)

River miles (RM) in reach = 5.9

Channel slope (s) (CSL 10-85) = 3.17 ft/mi

Channel Type = Natural channel, Rosgen E5/6

Channel sinuosity (k) = 1.8

Channel boundary materials = channel cut into muck soils near the lakes and drained muck between the lakes, muck layer can be 80 inches thick. In this reach the muck soil extends from 600 to over 2500 feet around the active channel. Bordering upland soils are most commonly sandy loams or loamy sands that can contribute sand to the muck channel. NRCS describes the frequency of flooding as none, but ponding is frequent. Muck is saturated to the surface unless drained (Streamstats).

Predicted channel dimensions for a natural stable channel upstream from confluence:

W_{bkf} = 65 ft (measured average = 62 ft)

Mean depth (d_{bkf})= 2.9 ft

Area (A_{bkf}) = 195 ft^2

Riparian corridor: corridor width in this reach is variable and ranges from 350 feet near the farm bridge off CR N 275 W to over 2300 feet downstream from the lake outlet. Downstream from Cosperville the floodplain averages over 800 feet. The corridor throughout the reach is forested wetland. Frequent large wood in channel but no obstructions to flow observed.

Basin is 11.0 % wetland (USGS Streamstats)

Figure 28: North Branch Elkhart River at CR W900 N (Looking downstream)

Figure 29: North Branch Elkhart River near CR N 300 W, downstream from Cosperville and just upstream of the confluence

5.0 OBSERVATIONS: MIDDLE BRANCH ELKHART RIVER

During the assessment of North Branch Elkhart River, it was noted that the headwaters of the Middle Branch Elkhart River appeared very different from what had been seen in the headwaters of the North Branch. Since the Middle Branch ultimately flows into Jones Lake and becomes part of the North Branch system it was considered important to better understand and document the overall health and condition of the Middle Branch. Following is a brief discussion of the watershed and some observations.

5.1 Middle Branch Elkhart River Headwaters, Bixler Lake Ditch-Waterhouse Ditch-Henderson Lake Ditch, Oviatt Ditch

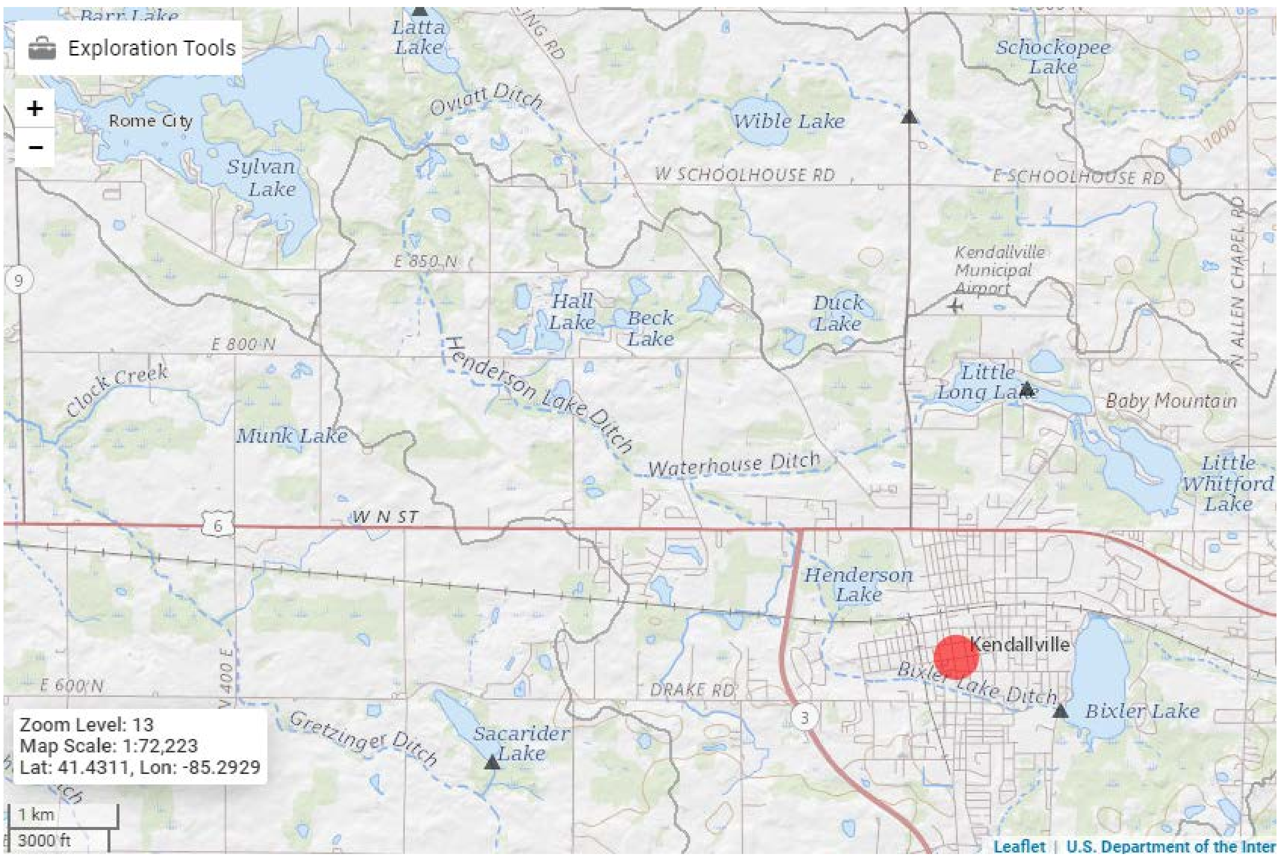


Figure 30: Middle Branch Elkhart River headwaters detail showing primary ditches

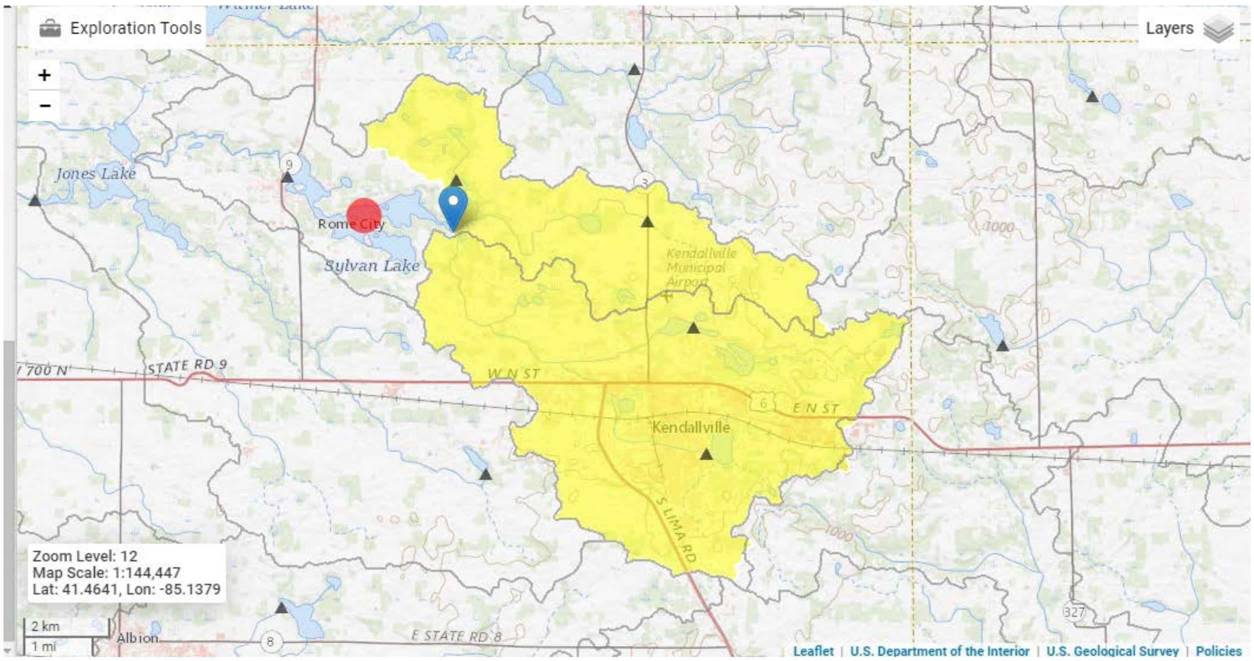


Figure 31: Middle Branch Elkhart River watershed above Sylvan Lake

Drainage Area (DA) = 29.4 mi^2 (above Sylvan Lake)

River miles (RM) in reach = approximately 16 in the main channels of Bixler Lake/Henderson Lake Ditch, Waterhouse Ditch, and Oviatt Ditch, high drainage density throughout headwaters

Channel slope (s) (CSL 10-85) = 9.00 ft/mi

Channel Type = modified channels throughout headwaters

Channel sinuosity (k) = modified and straightened

Channel boundary materials = channel cut into muck soils near the lakes and drained muck between the lakes, muck layer can be > 80 inches thick. Muck soil around the channels in the Middle Branch are narrower than in the NBER, which indicates a scaling of the muck corridor in the larger NBER system. In the headwaters near Kendallville large reaches of the Henderson Lake Ditch are bordered by thin (approximately 30 inches) of loam and clay loam soil on outwash sand and gravel. Bordering upland soils are like those in the NBER. Most are sandy loams or loamy sands that can contribute sand to the channel.

Predicted channel dimensions for a natural stable channel at inlet to Sylvan Lake:

W_{bkf} = 39 ft (measured average = 40 ft)

Mean depth (d_{bkf})= 2.2 ft

Area (A_{bkf}) = 89 ft^2

Riparian corridor: corridor width in this reach is variable and ranges from none near Kendallville to over 1500 feet near the Sylvan Lake inlet. The corridor just upstream from the Sylvan Lake inlet forested wetland. Corridor width around most of the headwater ditches is small to none. Headwater ditches are dredged to transport the range of flows (see Figures 33 and 34). More natural channel near the Sylvan Lake inlet is groundwater dominated and functions like the NBER.

Basin is 8.42 % wetland (USGS Streamstats)

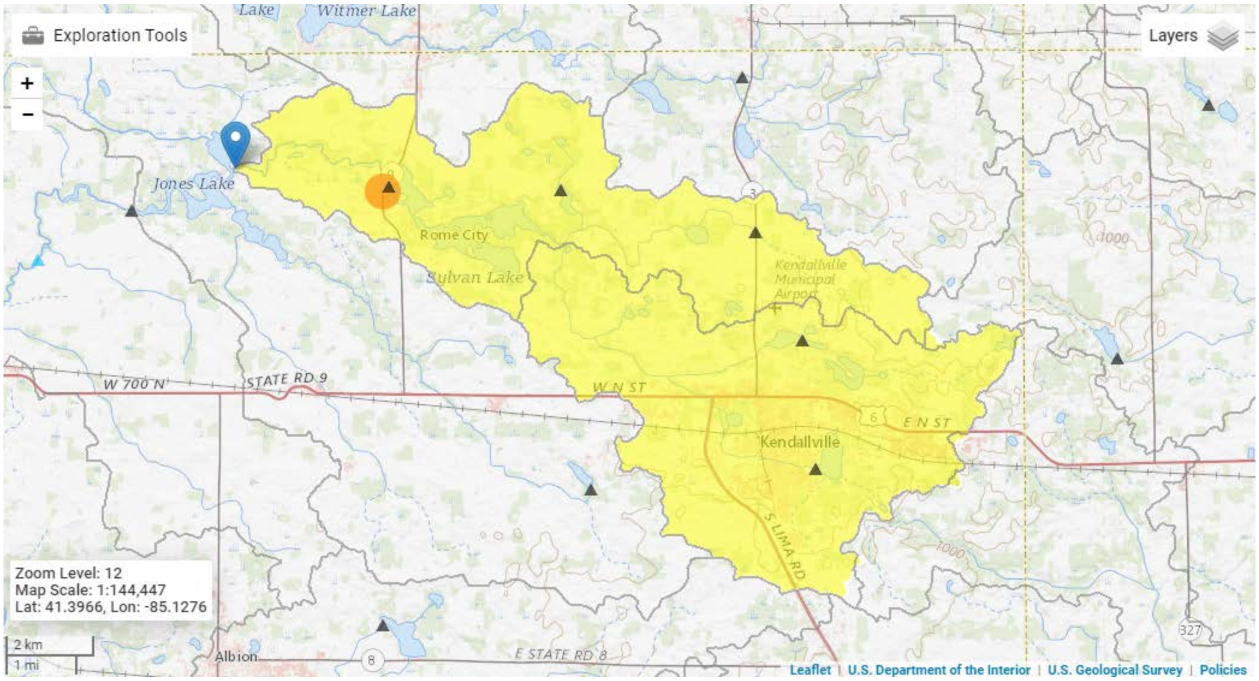
Figure 31: Henderson Lake Ditch, Kendallville (Looking downstream)

Figure 32: Henderson Lake Ditch, Kendallville (Looking upstream)

Figure 33: Henderson Lake Ditch, downstream from Kendallville (looking downstream)

Figure 34: Henderson Lake Ditch looking downstream (41.4756 -85.3262)

5.2 Middle Branch Elkhart River (Sylvan Lake to Jones Lake)



Drainage Area (DA) = 37.3 mi^2 (at Jones Lake inlet)

River miles (RM) in reach = approximately 3.2

Channel slope (s) (CSL 10-85) = 6.61 ft/mi

Channel Type = Rosgen E5/6

Channel sinuosity (k) = 1.6

Channel boundary materials = Muck soil around the channels in the Middle Branch are narrower than in the NBER, which indicates a scaling of the muck corridor in the larger NBER system. Muck in the mainstem MBER extends from 200 to over 400 feet around the active channel. Bordering upland soils are like those in the NBER. Most are sandy loams or loamy sands that can contribute sand to the channel. NRCS describes the frequency of flooding as none, but ponding is frequent in the muck. Muck is saturated to the surface unless drained (Streamstats).

Predicted channel dimensions for a natural stable channel at inlet to Jones Lake:

W_{bkf} = 42 ft (measured average = 45 ft)

Mean depth (d_{bkf})= 2.3 ft

Area (A_{bkf}) = 100 ft^2

Riparian corridor: corridor width in this reach ranges from 1000 to 2000 feet near the Jones Lake inlet. The corridor around the mainstem Middle Branch Elkhart River is floodplain forest. As in the NBER floodplain connectivity in the mainstem is good (see Figure 36), but the mainstem MBER is also a non-alluvial system that pulses with a rising water table rather than a depositional floodplain.

Basin is 10.49 % wetland (USGS Streamstats)

Figure 35: Middle Branch Elkhart River downstream from Sylvan Lake (looking upstream)

Figure 36: Middle Branch Elkhart River downstream from Sylvan Lake, (looking upstream)

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