Kankakee River Flood and Sediment Management Work Plan

August 2019 (Final)

Prepared for:

Kankakee River Basin and Yellow River Basin Development Commission, IN
&
City of Watseka, Iroquois County, and Kankakee County, IL

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Table of Contents

List of Tables and Figures

List of Exhibits

List of Appendices

EXECUTIVE SUMMARY (OVERALL)

This report provides the results of a study conducted for the Kankakee River Basin Commission (KRBC) in Indiana as well as the City of Watseka and Kankakee and Iroquois Counties in Illinois by Christopher B. Burke Engineering, LLC (CBBEL) to develop a Work Plan for management of flooding and sediment in the Kankakee River. Robert Barr, a research scientist from IUPUI-CEES, assisted CBBEL in this effort. The Work Plan was commissioned to address concerns with sediment aggradation and sediment load in the Kankakee River, as well as more frequent and severe flooding along the Kankakee and Iroquois Rivers. A system-based approach as well as a new two-dimensional hydraulic model developed as part of this Work Plan were utilized to evaluate the stability of the river system and to identify the flooding, erosion, and sedimentation issues ..

Field observations, analysis of available data, and review of previous study findings all indicate that the Kankakee is remarkably stable despite the extensive drainage modifications that have taken place since the early 1900s. The location, cross-sectional shape, and profile have generally been maintained over a relatively long period of time. The investigation identified several key factors that are affecting the stability and flow capacity of the system; recommendations to alleviate the issues were also provided:

Spoil Piles / Berms – The spoil material from the dredging/straightening of the Kankakee that was cast to one or both sides of the channel is perceived by some as providing flooding protection. The investigation discovered that the berms are discontinuous, inconsistent, and unstable in many locations. These facts confirm that the material was placed out of convenience rather than to provide flooding protection. The strategic removal of some of the berms and termination of maintenance of the berms is recommended to improve the stability and capacity of the system.

Increased Flooding – Evaluation of rainfall data, climate studies, and stream gage data suggest that storm events are becoming more frequent and intense, which has contributed to a strong increasing trend in peak flow rates. Drainage improvements and elimination of floodplain storage have also caused flooding conditions to worsen. Strategic flood protection measures, rather than a river-wide flood control system, are recommended for critical infrastructure and facilities, as well as for clusters of residential development. Maintenance or improvement of the existing berms is not expected to provide the desired flood protection due to the previously stated deficiencies in the berms and the likelihood for flooding events to worsen in the future. The removal/replacement of abandoned/deficient bridges is recommended to eliminate obstructions and to better align the flow. Improved activation and connectivity of critical floodplain storage areas is also recommended with the strategic removal of berms. Improvements to existing stormwater ordinances and technical standards should be used to help offset the detrimental impact of previous and future development and drainage efforts, as well as anticipated increases in storm severity. Despite the recommended flood protection/prevention measures, the risk of flooding will persist for most of the river corridor; the development of flood response and flood resilience plans is recommended to further mitigate the risk to communities and landowners.

Heavy Sediment and Flow Loading from Yellow River and Iroquois River – The Yellow River and Iroquois River have long been identified as critical issues in the

Kankakee system. The results of this study further confirm that theory. The Yellow River regularly provides a disproportionate amount of flow and sediment (sand) during significant flow events that reduces the stability and overloads the Kankakee. The recommended improvements to two segments of the Yellow River in Starke County as part of the CBBEL 2015 study are restated and included in this Work Plan; the improvements are expected to result in direct benefits in the Kankakee by reducing the sediment load and inconsistency in conveyance. The Iroquois River contributes a large amount of fine sediment (silt and clay) to the Kankakee. Watershed-based improvements focused on land use and ground cover are expected to reduce the amount of fine-grained sediment that has been cited as the primary source of sediment accumulating in the Six-mile Pool area.

Recognizing the extent of the existing risks and the likely increased future risks with a changing climate will be a challenge., Addressing the flooding and sedimentation issues within the Kankakee River system will require both adaptation and mitigation. Adaptation, or learning to live with flooding will be necessary because there are no feasible structural solutions to eliminate the vulnerability to flooding along the Kankakee River, especially given the increasing trends in peak flows and volumes. Mitigation will be necessary to combat the increasing flows and reduce the vulnerabilities as much as possible, when feasible and as funding allows. The following is a list of recommendations from this plan:

Active Management Recommendations

1. Reduce Sediment Supply from Yellow River Upstream of Knox (Sec 5.1.1)
2. Reduce Sediment Supply from Severely Eroded Kankakee Slopes (Sec 5.1.2)
3. Zone-Specific Access and Logjam Management (Sec 5.1.3)
4. Large Wood Removal in the Most Downstream Reach of Yellow River (Sec 5.1.4)
5. Selective and Temporary Berm Maintenance (Sec 5.1.5)
6. Strategically Remove Berms & Mitigate Flooding using Setback Berms (Sec 5.1.6)
7. Yellow River Restoration Downstream of Knox (Sec 5.1.7)
8. Bridge Removal / Replacement (Sec 5.1.8)
9. Construct Storage Areas along Laterals to Offset Increased Runoff (Sec 5.1.9)
10. Strategic Flood Protection Measures (Sec 5.1.10)

Passive Management Recommendations

1. Update Stormwater Ordinances and Technical Standards (Sec 5.2.1)
2. Mitigate Agricultural & County Drainage Project Impacts (Sec 5.2.2)
3. Incentivize Cover Crops (Sec 5.2.3)
4. Rill / Gully Mitigation (Sec 5.2.4)
5. Develop Flood Response Plans (Sec 5.2.5)
6. Develop Flood Resilience Plans (Sec 5.2.6)
7. Resilience Strategies for Watseka, IL (Sec 5.2.7)
8. Strategically Relocate Infrastructure from Berm-Reliant Areas (Sec 5.2.8)

A reach by reach summary of the active recommendations are contained in Tables 12 and 13, and graphically highlighted in Exhibits 3, 4, and 10.

The estimated cost for implementing the improvements, which are more thoroughly discussed in Chapter 5 is expected to be a minimum of $134 million. The improvements should be implemented over time and in the suggested sequence shown in the figure below:

Management Recommendation	**2020**	**2022**	**2024**	**2026**	**2028**	**2030**	**2032**	**2034**	**2036**	**2038**	**2040**	**2042**	**2044**	**2046**	**2048**	**2050**	**2052**	**2054**	**2056**	**2058**	**2060**
Yellow River Upstream Improvements	🟥	🟥	🟥	🟥																	
Kankakee Bank Stabilization Improvements	🟥	🟥	🟥	🟥	🟥	🟥	🟥														
Zone-Specific Access and Logjam Management	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
Large Wood Removal along Yellow River at Kankakee Fish and Wildlife Area	🟥																				
Selective and Temporary Berm Maintenance	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
Strategic Berm Removal & Setback Berm Construction		🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
Yellow River Downstream Improvements							🟥	🟥													
Bridge Removal / Replacement					🟥	🟥															
Storage Areas along Laterals to Offset Increased Runoff	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
Update Stormwater Ord. and Tech. Standards	🟦	🟦																			
Education, Outreach, and Implementation Program Management	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦
Develop Flood Response and Resilience Plans			🟦	🟦	🟦																
Relocate Infrastructure from Berm-Reliant Areas	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦

The recommended improvements and implementation timeline suggest that up to $5.8 million of annual funding is necessary to adequately address the issues present in the Kankakee system, which exceeds the anticipated annual assessment funding of approximately $3 million in Indiana. The implementation sequence may need to be revised in the future as needed, with some tasks started earlier and some postponed for later, depending on the availability of additional funding and other circumstances that may present themselves.

While the ecological benefits have not necessarily been the primary target for this Work Plan, many of the recommended strategies are expected to result in substantial ecological benefit. Maximizing this ancillary benefit may be key to streamlining the permitting process and, more importantly, helping to attract funding partners.

Ancillary benefits and secondary improvement objectives, such as ecological, water quality, and alternative land uses should be more thoroughly evaluated and leveraged while exploring alternative funding sources. It is anticipated that multiple organizations that could provide supplementary funding will be more interested in supporting the secondary benefits of the Work Plan. Slight adjustment of the recommended details may open opportunities for significant cost-sharing. In many cases, monetary compensation for land acquisition along the river corridor could be provided by outside sources if the land were managed in a desired condition.

The successful implementation of this Work Plan will likely require on-going education, outreach, and implementation-related assistance due to the nature and extent of the recommended improvements, and the fact that many of the recommendations are drastically different than what has been practiced within the last century.

EXECUTIVE SUMMARY (KANKAKEE COUNTY, ILLINOIS)

This report provides the results of a study conducted for the Kankakee River Basin Commission (KRBC) in Indiana as well as the City of Watseka and Kankakee and Iroquois Counties in Illinois by Christopher B. Burke Engineering, LLC (CBBEL) to develop a Work Plan for management of flooding and sediment in the Kankakee River. Robert Barr, a research scientist from IUPUI-CEES, assisted CBBEL in this effort. The Work Plan was commissioned to address concerns with sediment aggradation and sediment load in the Kankakee River, and more frequent and severe flooding along the Kankakee and Iroquois Rivers. A system-based approach as well as a new two-dimensional hydraulic model developed as part of this Work Plan were utilized to evaluate the stability of the system and to identify the flooding, erosion, and sedimentation issues. This Executive Summary highlights a summary of findings and recommendations specific to the Kankakee County, Illinois.

The following paragraphs summarize the findings of this study with respect to issues within the Illinois portion of the Kankakee River watershed in Illinois:

> **Channel Blockage Upstream of Momence** - The Kankakee River in Illinois is a naturally meandering river. It is highly sinuous upstream of Momence in the remnant of the Kankakee Marsh with a decreasing sinuosity downstream of Momence. Based on the morphology of the cutoff meander scrolls visible in Indiana and the apparent channel width of the old meanders, the Kankakee upstream of Momence is representative of the pre-straightened natural Kankakee River in Indiana. The sinuous nature of the channel upstream of Momence, combined with the decrease in slope through the reach also causes the section to be prone to channel blockages by large wood. If large wood gets through the State Line Bridge, it has an increased chance of being wedged in the channel due to the alignment of the channel relative to the bridge. Management of large wood in the Momence wetlands reach will be difficult and should only occur selectively and with much care, if needed. Large wood adds both complexity and stability in a sand bed river. Indiana has recently placed large wood along eroding banks in a portion of the Yellow River to add stability and form to the banks. Excessive removal of large wood in the Momence wetland reach in Illinois could trigger bank instability and send large amounts of sand downstream. Currently the reach serves a “shock absorber” for the downstream Kankakee and provides storage for both water and sediment. Those functions are critical to the overall health of the downstream Kankakee. The tortuous meanders throughout the wetland reach are a testament to the continuing function of this reach. Channels move and shift through the wetland as they alternately store and then slowly release sediment. Any attempt to form a persistent main channel through the reach will reduce the storage function.
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> **Sediment Aggradation** - Several islands have formed in the Kankakee, downstream from Momence, near Aroma Park. Earlier analysis in 1981 using aerial photographs of the islands attributed most of the aggradation and island forming to sand deposited during and after the channelization in Indiana which was completed in 1918, and prior to 1939. That study indicated that the river was near equilibrium after recovering from the original disturbance from dredging. Analysis of aerial

photographs from 2017 and comparisons with the images published in the 1981 report suggests that there is now degradation of some of the islands. This may indicate that sediment supply is now too low relative to the increasing discharge to allow for continued accretion, or growth of the islands. This may indicate that sediment supply is now too low relative to discharge to allow for accretion, or growth of the islands. Sediment supply reduction efforts recommended as part of this Work Plan through streambank stabilization along Yellow River upstream of Knox, stabilization improvements along severely eroding Kankakee River slopes in Indiana, and addressing rill/gully erosion within the Iroquois River corridor are expected to reduce the amount of sediment entering Kankakee River in Illinois. However, as most studies of the Kankakee River have noted, the river is dynamic. A large event may leave a substantial mid-channel sand bar. The river can slowly winnow the deposit away or another flood may replace the sand bar with an even larger deposit. The Kankakee sediment cycle may take a significant amount of time to balance after a major event and with the steady increase in peak discharge being observed along the Kankakee River, the sediment cycle may not stabilize until there is an extended period of climate stability.

Current Flooding Risks - A river the size of the Kankakee will always use its floodplain during periods of high discharge, if it is accessible. This means agricultural areas or infrastructure developed in the floodplain will be subject to flooding. The marsh-like origin and low-lying topography of the Kankakee produces a significant flooding risk as a result of the water spilling out to inundate vast areas as soon as the floodplain is activated. The flooding experienced in February and March of 2018 produced the highest flooding elevations on record in several locations. The flooding inundated vast areas of farmland and affected several roads and residential clusters. However, as extensive as the 2018 flooding was, it does not represent the worst conditions that are likely occur along the Kankakee and its tributaries. The Federal Emergency Management Agency (FEMA) has developed maps showing the areas subject to a high risk of flooding, known as the Special Flood Hazard Area (SFHA). FEMA defines the SFHA as areas inundated by a flood having a 1% annual probability of occurrence in any given year (1% AEP). Most recent FEMA mapping of flood risk areas along the Kankakee River in the Kankakee County, Illinois is provided in Exhibit 2 (sheets 1 and 2) of this Work Plan. The maps indicate that large areas along the Kankakee, especially upstream of Momence which are mostly in agricultural use, are susceptible to flooding. There are also several development clusters in Momence, Sun River Terrace, and Kankakee as well as transportation corridors along the Kankakee River in Illinois that are located within the floodplain and as such are expected to flood during major events. These vulnerable assets and dwellings are highlighted in yellow and red colors, respectively, in Exhibit 2.

Increased Flooding – Evaluation of rainfall data, climate studies, and stream gage data suggest that storm events are becoming more frequent and intense, which has contributed to a strong increasing trend in peak flow rates. The analysis of stream gages along the Kankakee River in Illinois show that peak discharges have increased as much as 70% to 110% over the period of record, a trend that is expected to continue and likely worsen within the next decades. Section 3.3.2 of this Work Plan discusses this alarming increasing trend in more detail. Drainage improvements and elimination of floodplain storage have also caused flooding conditions to worsen. Strategic flood protection measures, rather than a river-wide flood control system, are recommended for critical infrastructure and facilities, as well as for clusters of residential development. Improvements to existing stormwater ordinances and technical standards should be used to help offset the detrimental impact of previous and future development and drainage efforts, as well as anticipated increases in storm severity. Despite the recommended flood protection/prevention measures, the risk of flooding will persist for most of the river corridor; the development of flood response and flood resilience plans is recommended to further mitigate the risk to communities and landowners.

Heavy Sediment and Flow Loading from Iroquois River –The Iroquois River contributes a large amount of fine sediment (silt and clay) to the Kankakee at its confluence in Aroma Park. Watershed-based improvements concerning land use and ground cover, as well as addressing rill/gully erosion areas along the Iroquois River corridor discussed earlier, are expected to reduce the amount of fine-grained sediment that has been cited as the primary source of sediment accumulating in the Six-mile Pool area.

Recognizing the extent of the existing risks and the likely future vulnerabilities in the face of a changing climate, addressing the flooding and sedimentation issues within the Kankakee River system will require both adaptation and mitigation. Adaptation and learning how to live with floods will be necessary because there are no feasible structural solutions to eliminate the vulnerability to flooding along the Kankakee River, especially given the increasing trends in peak flows and volumes. Mitigation is necessary to combat the increasing flows and reduce the vulnerabilities as much as possible, when feasible and as funding allows. The following is a list of recommendations of this plan along with the section of the report each is detailed in, specifically applicable to the portion of the river and watershed in Kankakee County, Illinois:

Active Management Recommendations

1. Reduce Sediment Supply from Severely Eroded Kankakee Slopes (Sec 5.1.2)
2. Zone-Specific Access and Logjam Management (sec 5.1.3)
3. Construct Storage Areas along laterals to Offset Increased Runoff (Sec 5.1.9)
4. Strategic Flood Protection Measures (Sec 5.1.10)

Passive Management Recommendations

1. Update Stormwater Ordinances and Technical Standards (Sec 5.2.1)
2. Mitigate Agricultural & County Drainage Project Impacts (Sec 5.2.2)
3. Incentivize Cover Crops (Sec 5.2.3)
4. Develop Flood Response Plans (Sec 5.2.5)
5. Develop Flood Resilience Plans (Sec 5.2.6)

A reach by reach summary of the active recommendations for Kankakee County, Illinois is contained in Table 12 and graphically highlighted in Exhibit 3 (sheets 1 through 3).

The successful implementation of the Kankakee County-specific work plan components will require a dedicated and sustainable funding source. A funding structure such as that established for the Kankakee River Basin and Yellow River Basin Development Commission in Indiana (Indiana Kankakee Basin Development Commission) or that established for the Iroquois County Conservancy District in Indiana should be explored to enable the implementation of the recommended strategies.

Also, due to the nature and extent of the recommended improvements and the fact that many of the recommendations are drastically different than what has been practiced within the last century, an on-going education, outreach, and implementation-related assistance will likely be necessary.

The Kankakee River is a system and what happens along the river and in the watershed in Indiana impacts what occurs in Illinois. As such, continued participation of a Kankakee County representative on the Indiana Kankakee Basin Development Commission is crucial to ensure that the recommended Work Plan components in Indiana are implemented as stipulated in the Work Plan and also to learn about and weigh in against activities that may negatively impact the Illinois reach.

EXECUTIVE SUMMARY (IROQUOIS COUNTY, ILLINOIS)

This report provides the results of a study conducted for the Kankakee River Basin Commission (KRBC) in Indiana as well as the City of Watseka and Kankakee and Iroquois Counties in Illinois by Christopher B. Burke Engineering, LLC (CBBEL) to develop a Work Plan for management of flooding and sediment in the Kankakee River. Robert Barr, a research scientist from IUPUI-CEES, assisted CBBEL in this effort. The Work Plan was commissioned to address concerns with sediment aggradation and sediment load in the Kankakee River, more frequent and severe flooding along the Kankakee and Iroquois Rivers. A system-based approach as well as a new two-dimensional hydraulic model developed as part of this Work Plan were utilized to evaluate the stability of the system and to identify the flooding, erosion, and sedimentation issues. This Executive Summary highlights a summary of findings and recommendations specific to the Iroquois County, Illinois.

The following paragraphs summarize the findings of this study with respect to issues within the Illinois portion of the Iroquois River watershed in Illinois:

> **River System and Bank Stability** - The Iroquois River is the largest tributary to the Kankakee River with drainage area of 2,135 mi^2, nearly equal to the 2,380 mi^2 of the main stem Kankakee at the confluence of the rivers. The Iroquois River doubles in size near Watseka at the confluence with Sugar Creek and the confluence with several other significant tributaries between Watseka and Aroma Park, Illinois. The headwaters above Rensselaer, Indiana, are extensively channelized. Downstream from Rensselaer there is evidence of cutoff meanders like the channel straightening on the Kankakee, but the modifications on the Iroquois were not as extensive. Also like the Kankakee, the Illinois portion of the Iroquois is much less modified. Bank instability is rare, in part due to the erosion-resistant, clay-rich channel banks and bed. The only instabilities noted during the field study were numerous rills that were head-cutting into the surrounding uplands in western Newton County and in Illinois east of Watseka. Based on field observations these rills may be contributing a significant portion of the downstream sediment load.
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> **Current Flooding Risks** - Several populated areas appear to have significant flooding risk, most notably Watseka, IL. This community is particularly floodprone as the population center is low-lying and near the confluence of two major streams, Sugar Creek and Iroquois River. The overall size of the contributing drainage area and the intense runoff accumulated in the Sugar Creek portion of the watershed produce exceptionally high flow rates that result in frequent and severe flooding. Figure 9 of this Work Plan highlights the flood risk areas in Watseka.
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> A river the size of the Iroquois will always uses its floodplain during periods of high discharge, if it is accessible. This means agricultural areas or infrastructure developed in the floodplain will be subject to flooding. The marsh-like origin and low-lying topography of the Iroquois River produces a significant flooding risk as a result of the water spilling out to inundate vast areas as soon as the floodplain is activated. The flooding experienced in February and March of 2018 produced the highest flooding elevations on record in several locations. The flooding inundated

vast areas of farmland and affected several roads and residential clusters, especially in Watseka, Illinois. However, as extensive as the 2018 flooding was, it does not represent the worst conditions that are likely occur along the Iroquois River and its tributaries. The Federal Emergency Management Agency (FEMA) has developed maps showing the areas subject to a high risk of flooding, known as the Special Flood Hazard Area (SFHA). FEMA defines the SFHA as areas inundated by a flood having a 1% annual probability of occurrence in any given year (1% AEP). The most recent FEMA mapping of flood risk areas along the Iroquois River in the Iroquois County, Illinois is provided in Exhibit 2 (sheets 11 through 13) of this Work Plan. The maps indicate that large areas along the Iroquois, especially in Watseka and upstream of Watseka which are mostly in agricultural use, are susceptible to flooding. There are also several development clusters as well as transportation corridors along the Iroquois in Illinois that are located within the floodplain and as such are expected to flood during major events. These vulnerable assets and dwellings are highlighted in yellow and red colors, respectively, in Exhibit 2.

Increased Flooding – Evaluation of rainfall data, climate studies, and stream gage data suggest that storm events are becoming more frequent and intense, which has contributed to a strong increasing trend in peak flow rates. The analysis of stream gages along the Iroquois River and Sugar Creek show that peak discharges have increased as much as 80% over the period of record, a trend that is expected to continue and likely worsen within the next decades. Section 3.3.2 of this Work Plan discusses this alarming increasing trend in more detail. Drainage improvements and elimination of floodplain storage have also caused flooding conditions to worsen. Strategic flood protection measures, rather than a river-wide flood control system, are recommended for critical infrastructure and facilities, as well as for clusters of residential development. Improvements to existing stormwater ordinances and technical standards should be used to help offset the detrimental impact of previous and future development and drainage efforts, as well as anticipated increases in storm severity. Despite the recommended flood protection/prevention measures, the risk of flooding will persist for most of the river corridor; the development of flood response and flood resilience plans is recommended to further mitigate the risk to communities and landowners.

Need for Significant Resilience Strategies in Watseka - As discussed earlier, significant flood risk exists in Watseka. Given the extent of flood risks, the special situation of the low-lying areas within the City at the confluence of two major streams, and the size of the drainage area, no feasible solution exists to reduce the existing extent of the risk areas. Consequently, flooding for this area should be viewed as a regularly occurring hazard. Adopting appropriate flood resilience strategies specific to the City 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 in Watseka and its planning areas. Specific resilience strategies have been identified in the Work Plan. These should be agreed upon, adopted, and implemented by the City of Watseka within distinct resilience planning areas as specified below and summarized in Exhibit 9 of the Work Plan.

Heavy Sediment and Flow Loading from Iroquois River – The geology is significant in understanding the sediment load of the Iroquois River. The river forms in a proglacial lake bed in central Jasper County, Indiana and then flows through an area of clayey glacial till and fine-textured, water-laid sediments. Fine silt and clay dominate the sediment supply, making it a wash load dominated river. That means that once sediment enters the river it will tend to stay in suspension until flow is slowed as a result of a dam or a larger receiving water. The Iroquois River supplies much of the sediment deposited in the Six-Mile Pool reach, based on the composition of the sediment. The sediments in the reach are typically fine-grained material that apparently settle out and accumulate in the middle third of the reach. Watershed-based improvements concerning land use and ground cover, as well as addressing rill/gully erosion areas, especially from western Newton County to near Sheldon, Illinois, along the Iroquois River corridor are expected to reduce the amount of fine-grained sediment that has been cited as the primary source of sediment accumulating in the Six-mile Pool area.

Need for Additional Assessments - The Iroquois River contributes more water and sediment to the Kankakee River downstream from the confluence than the Kankakee but has been studied much less than the Kankakee. Extensive assessment of the areas of interest was beyond the scope of this Work Plan; however, a preliminary set of problem areas were identified during a reconnaissance survey and provided in this work plan because there are areas of significant instability and sediment production that should be addressed to improve the overall health of the Kankakee River downstream from the confluence. The identified problem areas confirm the need for a Work Plan for the entirety of the Iroquois River, both in Indiana and in Illinois. A detailed system assessment would provide a comprehensive list of locations of instability, an evaluation of the condition of the system and the likely causes of the instabilities, schematic layouts of conceptual solutions, and cost estimates for recommended improvements.

This Work Plan also provided clear evidence that the flooding risk in and around Watseka, IL is largely related to the conditions in Sugar Creek and its contributing drainage area. A detailed assessment of the causes of the disproportionate amount of runoff originating in the Sugar Creek Watershed was beyond the scope of this Work Plan. A more detailed assessment of the watershed and channel are necessary to produce a holistic evaluation of the cause of the problems and to develop appropriately detailed potential solutions and cost estimates

Recognizing the extent of the existing risks and the likely future vulnerabilities in the face of a changing climate, addressing the flooding and sedimentation issues within the Iroquois River system will require both adaptation and mitigation. Adaptation and learning how to live with floods will be necessary because there are no feasible structural solutions to eliminate the vulnerability to flooding along the Iroquois River, especially given the increasing trends in peak flows and volumes. Mitigation is necessary to combat the increasing flows and reduce the vulnerabilities as much as possible, when feasible and as funding allows. The following is a list of recommendations of this plan along with the section of the report each is detailed in, specifically applicable to the portion of the river and watershed in Iroquois County, Illinois:

Active Management Recommendations

1. Strategic Flood Protection Measures (Sec 5.1.10)

Passive Management Recommendations

1. Update Stormwater Ordinances and Technical Standards (Sec 5.2.1)
2. Mitigate Agricultural & County Drainage Project Impacts (Sec 5.2.2)
3. Incentivize Cover Crops (Sec 5.2.3)
4. Rill / Gully Mitigation (Sec 5.2.4)
5. Develop Flood Response Plans (Sec 5.2.5)
6. Develop Flood Resilience Plans (Sec 5.2.6)
7. Resilience Strategies for Watseka, IL (Sec 5.2.7)

Additional Study Needs

1. Complete a Detailed Assessment of Iroquois River (Sec 5.4.3)
2. Complete a Detailed Assessment of Iroquois River (Sec 5.4.4)

A reach by reach summary of the active recommendations for Iroquois County, Illinois is contained in Table 13 and graphically highlighted in Exhibit 10.

The successful implementation of the Iroquois County-specific work plan components will require a dedicated and sustainable funding source. A funding structure such as that established for the Kankakee River Basin and Yellow River Basin Development Commission in Indiana (Indiana Kankakee Basin Development Commission) or that established for the Iroquois County Conservancy District in Indiana should be explored to enable the implementation of the recommended strategies.

Also, due to the nature and extent of the recommended improvements and the fact that many of the recommendations are drastically different than what has been practiced within the last century, an on-going education, outreach, and implementation-related assistance will likely be necessary.

The Iroquois River is a system and what happens along the river and in the watershed in Indiana impacts what occurs in Illinois. As such, continued participation of an Iroquois County representative on the Indiana Kankakee Basin Development Commission as well as participation in the Indiana Iroquois County Conservancy District meetings is crucial to ensure that the recommended Work Plan components in Indiana are implemented as stipulated in the Work Plan and also to learn about and weigh in against activities that may negatively impact the Illinois reach.

CHAPTER 1 INTRODUCTION

This report document presents the results of a study conducted for the Kankakee River Basin Commission (KRBC) in Indiana as well as for the Kankakee and Iroquois Counties in Illinois by Christopher B. Burke Engineering, LLC (CBBEL) to develop a Work Plan for management of flooding and sediment in the Kankakee River. Robert Barr, a fluvial geomorphologist with the Indiana University-Purdue University, Indianapolis (IUPUI) Center for Earth and Environmental Science, assisted CBBEL in this effort. The Work Plan encompasses proposed activities in both the Indiana and Illinois portions of the watershed, from its headwaters in St. Joseph County, Indiana to Aroma Park in Illinois.

1.1 RIVER HISTORY

The Kankakee River Basin has a watershed area of 5,165 square miles, 2,989 square miles of which is in Indiana, and is one of the most extensively modified watersheds in Indiana and the United States. Often referred to as the ‘Everglades of the North’, the Kankakee basin was once a vast, low marshland located on a sandy outwash plain that was substantially drained through extensive channel dredging and straightening in Indiana in the early 1900s.

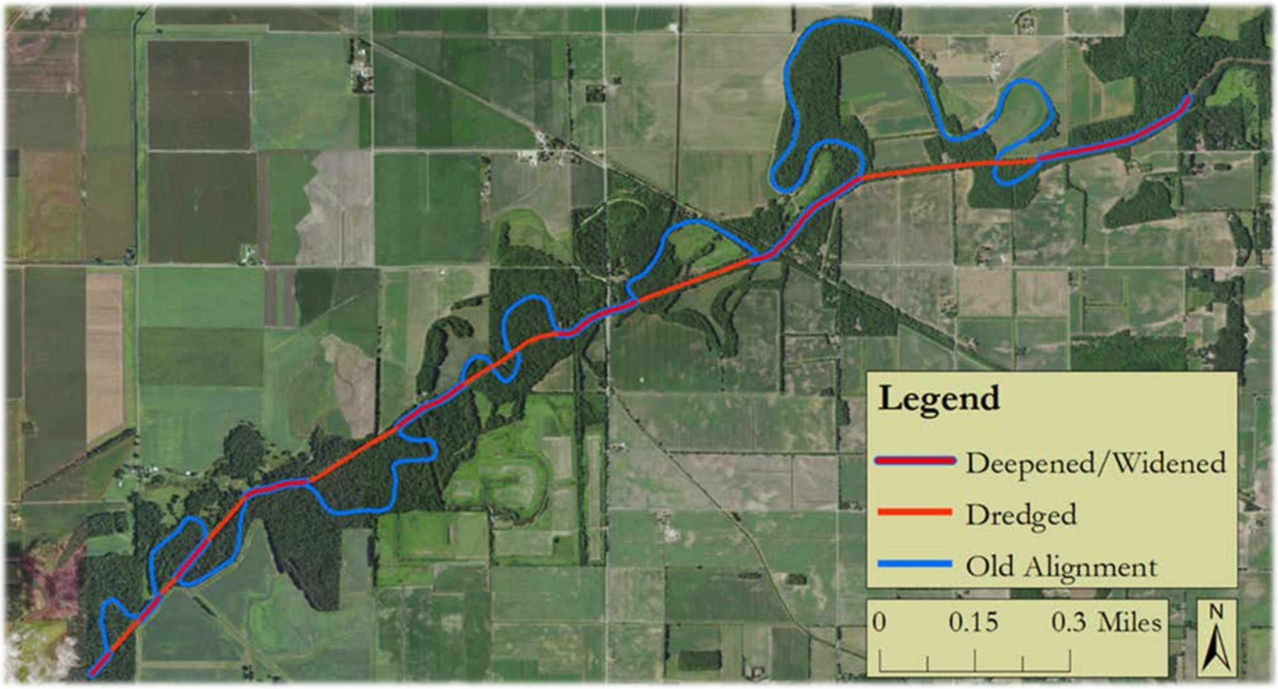


Figure 1: Original Alignment vs. Modified Kankakee River near English Lake

The former marsh area now supports a variety of land uses. Streams in the Kankakee watershed bear witness to the effects of glaciation through the complex surficial geology. The bed and banks of the Kankakee can be composed of muck, sand, gravel, cobble, or dense till. Wind-blown sand, which is highly susceptible to erosion, dominates the central and lower portions of the river corridor, and is the primary material found in the spoil piles that were cast from side to side as the channel was straightened (Figure 1). Those spoil piles are now eroding in response to increase in frequency of high discharges. That erosion results in large amounts of sand flowing through the Kankakee from Indiana into

Illinois, especially after heavy rain events. The excessive erosion and sedimentation can cause temporary aggradation in the channel during flood events, potentially resulting in higher flood stages and ever more damaging floods.

The environmental impacts and the costs of repeated maintenance to shore up areas of slope failure and to reduce erosion and sedimentation is a contentious issue. Severe flooding and excessive sediment load led to legal battles between Indiana and Illinois in the 1980s, as each state struggled to deal with the effects of historical stream modifications.

1.2 PROJECT BACKGROUND

In 2015, the KRBC funded a project to employ a systems approach to address erosion in Yellow River, the largest tributary to the Kankakee in Indiana. The Yellow River had been identified by earlier studies as the primary source of sand in the Kankakee. The KRBC commissioned CBBEL to complete the Yellow River System Assessment, which was designed to identify the root causes of the erosion and sedimentation issues, identify the potential sources of sand, clarify some of the sediment transport processes, and to recommend sustainable solutions. The CBBEL assessment varied considerably from past work in that it used a field-based geomorphic assessment coupled with data from three USGS Sentry gages to determine where potential solutions were needed and could be implemented. CBBEL developed a detailed Work Plan for better management of erosion and sedimentation along Yellow River, which recommended the following actions:

- Watershed-wide use of soil health conservation practices to help prevent erosion from agricultural fields during heavy rain events
- Flatter side slopes and appropriate vegetative cover to minimize bank erosion in the headwater area
- The use of toe wood and floodplain benches in the Knox to Marshall County Line reach to reduce bank erosion and minimize the sediment production.
- The use of toe wood benches in the Knox to Kankakee River reach to increase the low-flow velocity so that the sand would be conveyed downstream in a more consistent manner. This recommendation was in contrast to more traditional methods of reducing sedimentation in streams such as dredging and sediment traps, which can cause head-cutting and actually increase upstream slope and bank failure.

The KRBC started implementing these recommendations in 2017 by addressing severe slope and bank erosion along a pilot reach of Yellow River upstream of Knox. Early results are very promising and illustrate that nature-based stream restoration techniques can provide an effective, self-mitigating, and cost-effective means for addressing stream instability. The severe bank erosion along the pilot reach has stopped and the sediment is now moving through the system efficiently. The flattening of the side slopes along the channel banks above the newly created benches resulted in a significant increase in the flood carrying capacity of this reach, which served the area well during the February-March 2018 flood of record.

Based on these early successes in the Yellow River watershed, the KRBC has decided to apply the systems management approach on a larger scale – to address not only erosion and sedimentation issues but also flooding in the larger Kankakee River system. The

KRBC, with the help of state legislators, eight Indiana counties, and the Indiana Silver Jackets are working together with CBBEL to develop the Kankakee River Flood and Sediment Management Work Plan. Kankakee and Iroquois Counties in Illinois have also come back to the table to forge a new relationship, overcoming long-standing issues, to provide support and assistance for the Work Plan.

1.3 PROJECT GOALS AND EXTENT OF EVALUATION

The development of the Work Plan was undertaken to address several major goals. These included explaining the root causes of and recommending strategies to address:

1. the impacts of sediment aggradation in the Kankakee River on agricultural drainage within the basin and increased flooding along the Kankakee River corridor;
2. seemingly increased and more frequent flooding of the agricultural fields, infrastructure, critical facilities, and residential clusters along the Kankakee River;
3. deposition of extraordinary loadings of sand and long flood inundation within agricultural fields along the Kankakee River corridor;
4. repeated and costly maintenance of berms along the Kankakee River banks; and
5. seemingly increased sediment aggradation in the Kankakee River in Illinois as well as increased flooding in Illinois along the Kankakee and Iroquois Rivers

To achieve these objectives, the following analyses and assessments were completed:

1. Detailed field assessments of the main stem of the Kankakee River from the LaPorte County – St. Joseph County border to Aroma Park, Illinois and along Singleton Ditch from State Road 2 to the confluence with the Kankakee.
2. Desktop analyses and field visits were completed along the Iroquois River, as well as other major tributaries when observations along the Kankakee River and Singleton Ditch suggested a more thorough investigation was necessary for the current project.
3. A hydrologic analysis for the entirety of the Kankakee River Watershed to the confluence with the Illinois River.
4. A two-dimensional hydraulic model of the main stem of the Kankakee and Singleton Ditch and the associated floodplain areas.

Exhibit 1 provides the extent of the assessment used to inform the Work Plan.

CHAPTER 2 PREVIOUS STUDIES & DATA ANALYZED

2.1 PREVIOUS STUDIES

A significant amount of relevant previous studies and evaluations of the Kankakee River system have been completed by government agencies, interest groups, and engineering consultants. The following list summarizes the previous work that was found to be significantly informative to the evaluations used to complete the project objectives. Additional reports, particularly with regard to water quality and wetland conditions along the rivers, are available and provide valuable information for restoration efforts; however, these details are beyond the scope of the conceptual / feasibility-level considerations of the Work Plan.

Study No.	Study Name	Author	Date
1	Regression Models for Estimating Sediment and Nutrient Concentrations and Loads at the Kankakee River, Shelby, Indiana, December 2015 through May 2018	Lathrop et al.	2019
2	Yellow River System Assessment	CBBEL	2015
3	Continuous Hydrologic Modeling of Snow-Affected Watersheds in the Great Lakes Basin Using HEC-HMS	Gyawali and Watkins	2013
4	Kankakee River Basin: Evaluation of Sediment Management Strategies	Little and Jonas	2013
	Northwest Indiana Watershed Management Framework, Chapter 3, The Kankakee Sub-Basin	NIRPC	2011
5	SIAM Case Study: Kankakee River Basin, Indiana and Illinois	Jonas and Little, Jr.	2010
6	Illinois River Basin Restoration Comprehensive Plan with Integrated Environmental Assessment	USACE	2007
7	Yellow River Watershed, Draft Preliminary Reconnaissance Report	USACE	2007
8	Bank Erosion Survey of the Main Stem of the Kankakee River in Illinois and Indiana	Bhowmik and Demissie	2001
9	Kankakee River Basin in Illinois: Hydraulics, Hydrology, River Geometry, and Sand Bars (Interim Report)	Bhowmik and Demissie	2000
10	Bank Erosion Field Survey Report on the Upper Mississippi River and Illinois Waterway, Volume I and II (Interim Report)	Bhowmik et al.	1997
11	Suspended-Sediment Budget for the Kankakee River Basin, 1993-95	Holmes	1997
12	Changes in Cross-Section Geometry and Channel Volume in Two Reaches of the Kankakee River in Illinois, 1959-94	Terrio and Nazimek	1997
13	Suspended-Sediment Characteristics of Indiana Streams, 1952-1984	Crawford and Mansue	1996
14	Dendrogeomorphic Estimate of Changes in Sedimentation Rate along the Kankakee River near Momence, Illinois	Phipps et al.	1995
15	Kankakee River Basin. *In:* Hydrogeologic Atlas of Aquifers in Indiana	Fenelon	1994
16	Kankakee River Area Assessment Critical Trends Assessment Program, Illinois Department of Natural Resources, Volume 2	Knapp	1992

Study No.	Study Name	Author	Date
17	Water Resource Availability in the Kankakee River Basin, Indiana	IDNR	1990
18	Kankakee River Master Plan: A Guide for Flood Control and Land Use Alternatives in Indiana	KRBC	1989
19	Hydrology, Hydraulics, and Sediment transport, Kankakee and Iroquois Rivers	Demissie et al.	1983
20	Sediment Transport and Hydraulics of Flow in the Kankakee River, Illinois – Phase II	Bhowmik and Bogner	1981
21	The Effects of Sedimentation on Aquatic Life of the Kankakee River, Phase II: Quantitative Studies and Threatened, Endangered, and Rare Species	Brigham et al.	1981
22	Geology of the Kankakee River System in Kankakee County, Illinois	Gross and Berg	1981
23	The Kankakee River: Yesterday and Today	Ivens et al.	1981
24	Hydraulics of Flow and Sediment Transport in the Kankakee River in Illinois	Bhowmik et al.	1980
25	The Momence Wetlands of the Kankakee River in Illinois: An Assessment of Their Value, A Descriptive and Economic Approach to the Appraisal of Natural Ecosystem Function	Mitsch et al.	1979
26	Environmental Observations of a Riparian Ecosystem During Flood Season	Mitsch et al.	1979
27	Kankakee River Survey Report for Drainage in Indiana and Illinois	USDA SCS	1963
28	Factors Controlling the Size and Shape of Stream Channels in Coarse Noncohesive Sands	Wolman and Brush	1961
29	The Kankakee "Marsh" of Northern Indiana and Illinois	Meyer	1935
30	A Geological Survey of Starke County	Thompson	1886

The referenced studies were found to agree on many topics with most disagreements between the sources being relatively minor or indirectly related to the current objectives. Notable agreements or disagreements with the Work Plan are mentioned in the following, associated sections of the report.

2.2 DATA ANALYZED

Topographic Data

The analysis of the Kankakee River basin required detailed topographic data to define the channel shape, determine the approximate slopes of the river banks and berms, and provide necessary information for the hydraulic models of the system. County-wide DEMs for each county in the study area were the primary sources of topographic data. All DEMs were based on LiDAR data no older than 2011, with most counties utilizing data from 2013 or later. The DEMs cover the entire study area and have a 5-foot cell resolution.

Land Use Data

Land use information was gathered from the 2011 National Land Cover Dataset (NLCD). Aerial photography from 2016 or 2018, depending on county, was inspected to generally confirm the land uses shown in the NLCD data. The land use information was used to evaluate the makeup of the watershed and, when compared to previous NLCD datasets, to determine how land usage has changed over time.

Rainfall & Streamflow Data

Rainfall information was gathered from the Earth Observing Laboratory, a project of the National Science Foundation. The data were collected as hourly precipitation totals on a 4 km grid covering the entire Kankakee River Basin. These gridded data made it possible to represent the varying nature of precipitation over large spatial scales.

Streamflow information was obtained from the United States Geological Survey's (USGS) online data portal, to provide an extensive record of the hydrology for the Kankakee, Yellow, and Iroquois Rivers, as well as Sugar Creek, a tributary of the Iroquois River. Streamflow information was used to determine long-term trends in flow rates, flow volume, and the frequency of significant storm events. Gages used for streamflow analysis are shown in Table 1.

Table 1: USGS Gages Used in Streamflow Analyses

Stream	Nearest City	Gage Number
Kankakee River	Davis, IN	05515500*
	Dunns Bridge, IN	05517500
	Kouts, IN	05517530*
	Shelby. IN	05518000*
	Momence, IL	05510500*
	Wilmington, IL	05527500*
Yellow River	Plymouth, IN	05516500
	Knox, IN	05517000
Iroquois River	Rensselaer, IN	05522500
	Foresman, IN	05524500
	Iroquois, IL	05525000
	Chebanse, IL	05526000*
Sugar Creek	Milford, IL	05525500

*Gage used in hydrologic model calibration

Aerial Photography

Aerial photography of the Kankakee River basin was obtained from multiple sources. The aerial imagery for Indiana was obtained from the IndianaMap data framework using the Indiana Spatial Data Portal. The imagery for the Illinois counties considered in the study was collected from the Illinois State Geological Survey's (ISGS) online geospatial data repository. Historical aerial imagery was collected from Google Earth for watershed-wide consistency.

Soil Data & Surficial Geology

Soil survey data used for hydrologic analyses were collected from the United States Department of Agriculture (USDA) Natural Resource Conservation Service's (NRCS) Web Soil Survey. Surficial geology is from the Quaternary Map of Indiana (Gray, 1989) and the Surficial Geologic Map of Illinois (ISGS Survey, modified by ISGS Staff, 2005). Characterization of the channel bed and bank material at select sites was based on visual observations, the Quaternary Map of Indiana, the Surficial Geologic Map of Illinois, and county soil surveys.

2.3 SITE OBSERVATION SUMMARY

Field observations related to this Work Plan have been on-going in the Kankakee River basin since 2014 when field work to support the current Yellow River pilot project began. Those initial surveys of the Yellow River informed early work in and around the Indiana Department of Fish and Wildlife Area near English Lake, the confluence of the Yellow River and the Kankakee River, and the Kline Arm and Hanna Ditch. Observations were also made in and around the Momence Wetlands and on a portion of the mainstem Kankakee River near the Jasper-Newton County line.

Additional field observations were made to supplement the previous site observations and to evaluate changes that have occurred over time. The project team also inquired about known problems or observations of instability on the river from the county surveyors in each county bordering the Kankakee or Yellow River and from the property managers at Kingsbury, Kankakee, and LaSalle Fish and Wildlife Areas (FWA). The team also met with a member of the Friends of the Kankakee (Illinois) in July 2018 and toured the Kankakee River in Illinois from Aroma Park to just downstream of Momence.

Following the initial field visits and obtaining information regarding the areas of concern from local stakeholders, the team floated the Kankakee from the confluence of the Yellow River and the Kankakee River, downstream to the State Line Bridge. Based on the findings of these field visits, additional visits were made to take a series of 16 detailed channel cross sections from the Yellow and Kankakee rivers confluence downstream to the Jasper County line. Three additional field visits were also made to observe sediment transport at and near the State Line Bridge. Follow-up field visits were also made at the Kankakee and LaSalle FWAs; Kingsbury FWA reported no real issues along the river.

A field assessment of stability in Singleton Ditch was conducted from State Road 2 in Lake County, Indiana to near the confluence with the Kankakee upstream of Momence, Illinois. The ditch banks in Indiana were steeper sloped than desirable for stability but were generally well vegetated with minimal erosion. Ditch banks in Illinois showed more evidence of instability and erosion, particularly downstream of the railroad crossing east of State Road 52 and E 4000 N Road. Banks in that area were eroding with frequent areas of concrete debris and rubble placed on and around the banks. The concrete debris was observed to be increasing erosion in several locations.

The Iroquois River was assessed from the headwaters in Jasper County to the confluence with the Kankakee River at Aroma Park, Illinois. Information on the upper Iroquois was provided by the Jasper County surveyor's office and the Jasper County SWCD. The City of Watseka and Iroquois and Kankakee Counties all supported the assessment by indicating areas of interest and concern.

2.4 HYDROLOGIC AND HYDRAULIC ANALYSIS

Hydrologic and hydraulic models were developed to analyze the Kankakee River basin. Brief descriptions of the uses, methods, and areal extents for the different models are provided here. Additional details and information regarding the models are provided in Appendix 3.

2.4.1 Hydrologic Analysis

The hydrologic model was used to characterize the accumulation of runoff from the watershed to the stream following a precipitation event. The model was developed using HEC-HMS and included the entire watershed contributing to the Kankakee River at the Wilmington, IL gage (05527500). This includes approximately 5,000 square miles of land. A small fraction of this drainage area is in Berrien County, MI. Approximately 3,000 square miles of drainage area exists in Indiana and is split among 13 counties in the northwestern part of the state: Elkhart, Kosciusko, St. Joseph, Marshall, La Porte, Starke, Pulaski, Porter, Jasper, White, Lake, Newton, and Benton. The remaining 2,000 square miles is divided among six counties in northeastern Illinois: Vermilion, Ford, Iroquois, Kankakee, Will, and Grundy. The hydrologic model was used to evaluate the accumulation of runoff and to provide necessary input for the hydraulic model.

The hydrologic model was calibrated to the April 2013 and February 2018 storm events based on runoff volume and peak flow rates. The modeled peak discharges at the USGS gages along each modeled stream are summarized in Table 2. The table also includes a statistical estimate of the peak flow during 50%, 10%, and 1% annual exceedance probability (AEP) events based on gage analyses utilizing the Advisory Committee on Water Information (ACWI) B17C guidelines.

Table 2: Hydrologic Model Results Summary

Storm Event	Davis	Kouts	Momence	Wilmington	Chebanse
	542 mi^2	**1,376 mi^2**	**2,294 mi^2**	**5,150 mi^2**	**2,091 mi^2**
April 2013	1,469 [1,460]	4,826 [4,650]	9,431 [8,670]	40,672 [42,200]	16,778 [16,500]
February 2018	2,218 [2,040]	6,686 [5,650]	12,662 [12,300]	50,383 [52,300]	33,811 [28,900]
50% AEP	1,337 (1,310)	3,623 (4,000)	7,028 (6,890)	27,029 (25,400)	16,423 (13,500)
10% AEP	1,674 (1,700)	5,051 (5,130)	9,806 (10,500)	39,473 (49,100)	24,521 (23,300)
1% AEP	2,810 (2,120)	8,040 (6,330)	15,274 (15,000)	61,256 (85,200)	38,264 (36,800)

* Observed flow rates during the April 2013 and February 2018 events are shown in brackets [ ]
** B17C Estimates for the 50%, 10%, and 1% AEP events are shown in parenthesis ( )

The hydrologic model was developed to determine the amount and timing of runoff entering the Kankakee River; as a result, the model does not have sufficient detail to determine flow rates at multiple points along the tributaries, with the exception of Iroquois River. The model has also been calibrated to specific events and will therefore be more representative of those conditions (degree of soil saturation, land cover, wintery conditions, etc) than the conditions that have existed in other past events or will be present in future events. It must be noted that in general the peak flow rates from the calibrated hydrologic model were modeled to be intentionally slightly higher than the flow rates observed at the stream gages. The calibration was performed in this manner to account for the dampening effect of floodplain storage in the hydraulic model, which is not accounted for in the hydrologic model but is observed at the stream gages, and to allow the hydraulic model to achieve a higher quality calibration.

2.4.2 Hydraulic Analysis

A two-dimensional, HEC-RAS hydraulic model was used to analyze the Kankakee River and adjacent land that experiences riverine flooding, focusing on the reach of the Kankakee that extends from the western edge of St Joseph County, IN to the northwestern corner of Kankakee County, IL, incorporating approximately 111 miles along the Kankakee River and approximately 23 miles along the Singleton Ditch.

The hydraulic model was calibrated using gage data, aerial photography, and personal accounts of flooding from the February 2018 event. A summary of the existing condition peak flow rate and elevation at each gage location is provided in Table 3.

Table 3: Hydraulic Model Results Summary

Storm Event	Davis*		Kouts*		Shelby*		Momence*	
	542 mi^2		1,376 mi^2		1,779 mi^2		2,294 mi^2	
	Flow (cfs)	Elev.** (ft)	Flow (cfs)	Elev.** (ft)	Flow (cfs)	Elev.** (ft)	Flow (cfs)	Elev.** (ft)
Feb 2018	1,971 [2,040]	676.0 [677.2]	5,115 [5,650]	658.5 [658.9]	5,484 [6,380]	640.2 [641.2]	9,399 [12,300]	616.1 [616.1]
50% AEP	1,275	673.9	3,447	655.0	4047	638.1	6,514	613.7
10% AEP	1,510	674.7	4,192	656.9	4823	638.9	7,573	614.0
1% AEP	2,058	676.2	6,021	659.0	7344	640.4	9,803	615.2

*Observed values are provided in brackets.
**All elevations are referenced to the North American Vertical Datum of 1988 (NAVD88)

The hydraulic model was used to simulate various flooding events to better illustrate how water moves through the Kankakee River itself, how it interacts with its floodplain and tributaries, and how it floods certain areas behind berms. The model was also simulated to help form a better understanding of the impacts of removing/breaching the spoil piles/berms, the effectiveness of compensatory setback berms, and the hydraulic impacts of dredging the river in Indiana.

Given the limited scope of new modeling as part of the development of this Work Plan and noting the significant effort and complexities involved in the 2D modeling of the system, the 2D modeling was limited to the main stems of the Kankakee River and Singleton Ditch. The model was developed to simulate riverine flooding originating from the Kankakee River, and does not represent flooding conditions along tributaries and ditches, except for flooding resulting from Kankakee River backwater. It should be noted that this limitation results in an under-prediction of flooding near the downstream end of tributaries and along berm-protected areas.

Several areas of the land immediately adjacent to the Kankakee River are served by complex drainage networks that include pumps, backflow preventers, and redundant channels. The hydraulic model was configured to allow for connectivity between the floodplain and a ‘bermed’ area where aerial photography suggested that backflow prevention devices were not in use; areas where the connectivity was unclear were configured to have no connectivity until the adjacent berms were overtopped.

CHAPTER 3 SYSTEM ASSESSMENT KEY FINDINGS

The resources and previous work discussed in Chapter 2 were used to establish a framework in which to view current challenges, identify changes in river morphology and basin characteristics, to observe field conditions along the river, and inform the findings and recommendations of the Work Plan. Synthesis of the data described in Chapter 2 enabled identification of issues affecting flooding and bank stability along the Kankakee in Indiana and Illinois. The key findings are presented in the following paragraphs.

3.1 RIVER MORPHOLOGY

The shape of a river channel and how it changes over time is referred to as the morphology of the river. The morphology of a river integrates changes in land use and precipitation and can be important to understanding the processes affecting the river and the overall stability of the channel and the river system. A standard definition of channel stability is “a river or stream’s ability in the present climate to transport the stream-flows and sediment of its watershed over time in such a manner that the channel maintains its dimension, pattern, and profile without either aggrading or degrading” (Rosgen, 1996, 2001b). Lane’s Balance, as shown in Figure 2, is a commonly used illustration of the general relationships involved in channel stability, which is also referred to as dynamic equilibrium.

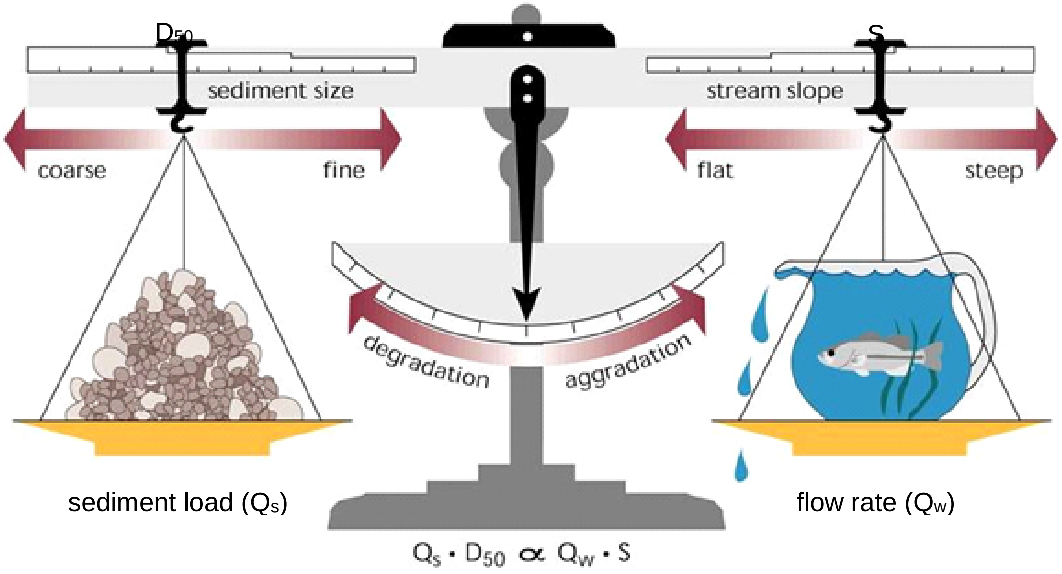


Figure 2: Lane’s Balance
(after Rosgen 1996)

Different scenarios can be illustrated by visually sliding the sediment load and flow rate on the balance beam, as well as changing the amount of sediment and water on the weighing platforms. When the supply of sediment is balanced with streamflow, the river can “over time” transport the sediment and water through the system. This illustration can be used to start exploring the current and future expected conditions of the Kankakee system that may result from the improvements discussed in Chapter 4.

The ability of a river system to accommodate changes in the inputs of water and sediment without instability requires that the river have a shape that provides natural resilience. The cross-section of a natural channel shown in Figure 3 demonstrates the components that must be present in a resilient channel. The most important component of a resilient channel is a floodplain that is connected/accessible at the bankfull stage. The connected floodplain provides the critical function of dissipating energy that would otherwise result in erosion, storage of floodwater which reduces flow rates, and storage of mobilized sediment and debris after flooding events. Channels are typically stable where these features are intact; where a stream has not been allowed to maintain a natural form, instabilities should be expected and can be observed most easily through an evaluation of the channel morphology.

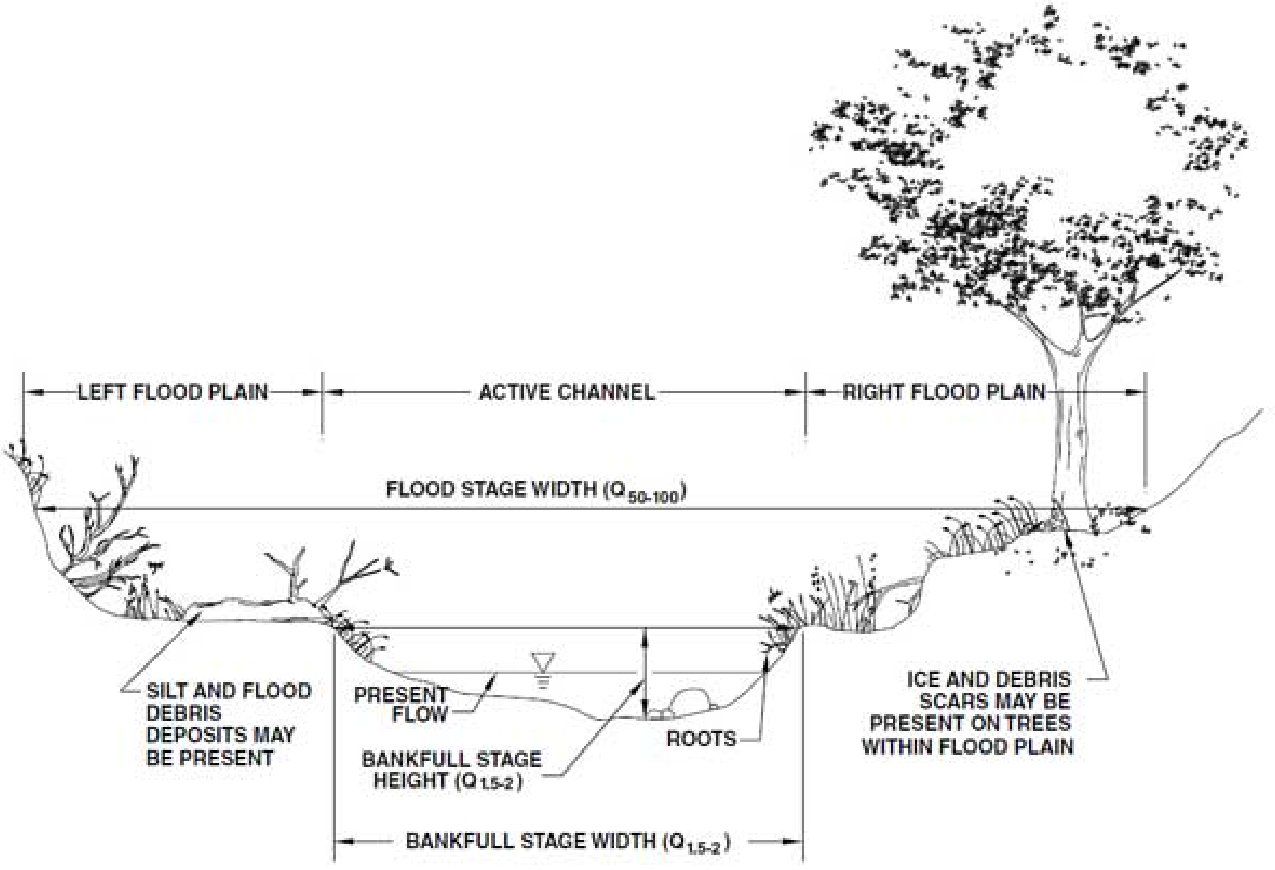


Figure 3: Natural Channel Cross-section
(USDA)

The following sections describe the morphology for the main stem of the Kankakee River, Yellow River, Singleton Ditch, and Iroquois River. The discussion of the main stem of the Kankakee River has been divided into separate sections for the Indiana and Illinois reaches. Management strategies within the Kankakee system have differed between Indiana and Illinois in terms of both stream and watershed practices. The differing management practices and other natural differences have resulted in the Kankakee River having different functions, morphology, and problems on either side of the Indiana-Illinois State Line.

3.1.1 Kankakee River in Indiana

The main channel of the Kankakee River in Indiana was extensively channelized by a series of projects starting in the late 19th century, which were substantially completed by 1918. Descriptions of the modification of the Kankakee River in Indiana can be found in Ivens et al, 1981 and IDNR, 1990. The primary method of channelization was to cut from meander to meander and connect the straight sections, as shown in Figure 1. This process left the overall planform of the river intact but removed the sinuosity and reducing the connectivity of the floodplain. The length of the Kankakee River was reduced from 250 miles to 82 miles, and the channel slope was increased from 0.45 feet per mile to 0.83 feet per mile. These modifications increased the rate of discharge and the transport of sediment. The Kankakee Marsh surrounding the Kankakee River was also extensively ditched during that period and continuing to present day, greatly increasing the rate of runoff and sediment flow into the Kankakee River.

Stable cross-sectional channel dimensions are an indicator of channel stability. Measurements of the Kankakee River at the state line in 1882 describe a channel with a “cross-sectional area of 543 square feet, and a mean hydraulic depth of 4.5 feet…” (Campbell, 1882). Those measurements are almost exactly what is measured today. Even more striking is that the measured width and depth at the state line today correlate well with predicted channel dimensions from the Indiana regional curves (Robinson, 2013). Even upstream near the confluence of the Kankakee with Yellow River at English Lake the measured channel dimensions at the site are very similar to predicted channel dimensions. The Indiana regional curves were derived from measurements of stable natural channels. These data suggest that the current Kankakee River has naturalized itself to a relatively stable form.

This conclusion was also supported by a large study of the Kankakee system completed in 1981; two separate reports described the Kankakee at that time as being at a state of near equilibrium. That assessment was based in part on a geomorphic analysis that included a review of aerial photographs and extensive field assessment of in-channel islands, sand bars and spits; depositional features that are very responsive to changing sediment supply. Their assessment concluded that sediment supply was fairly stable by the early 1950s following a period of instability triggered by the dredging and straightening on the Indiana side of the river that was completed in 1918 (Gross and Berg, 1981). In the same year a summary report on the Kankakee concluded that “The Kankakee has now balanced itself and is quite stable – in both states…any change in this new, balanced regime will only unbalance the system once again. Further dredging, clearing, or construction can lead to more bed and bank erosion and more sediment and to serious disturbance to aquatic life” (Ivens, et al, 1981). Despite natural disturbances in Jasper County, the main stem Kankakee continues to be a remarkably stable river, just as it was 38 years ago.

Extensive field assessments have shown neither extensive erosion nor deposition in the channel. Erosion is occurring in non-vegetated spoil piles (berms) above the channel banks but not the channel banks themselves. The river banks appear to be stable, but the eroding spoil piles complicate the assessment of channel bank instability by making it appear that channel banks are eroding when it is actually a spoil pile placed on the floodplain that is eroding. Deposition is observed primarily in the English Lake area near the confluence of the Kankakee and the Yellow River and near the Indiana – Illinois state line. Both of these areas are places where deposition would be expected in a natural system. The Kankakee Valley is constricted by bedrock near the state line that causes deposition to naturally occur in that area. In fact, the only in-channel sediment deposition seen in Indiana after the flood of February 2018 was at the misaligned railroad bridge upstream of Shelby, Indiana.

Figure 4 provides the cross-sectional velocity profile downstream of the confluence of Kankakee and Yellow Rivers taken in October 2018. The velocity profile shows a channel that is not erosive near the banks but has enough velocity in the central portion of the channel to convey sediment without aggrading or degrading. Additional cross-sectional velocity profiles along the River are contained in Appendix 1. These data further suggest that the current Kankakee River has recovered to a stable form since the straightening of the river.

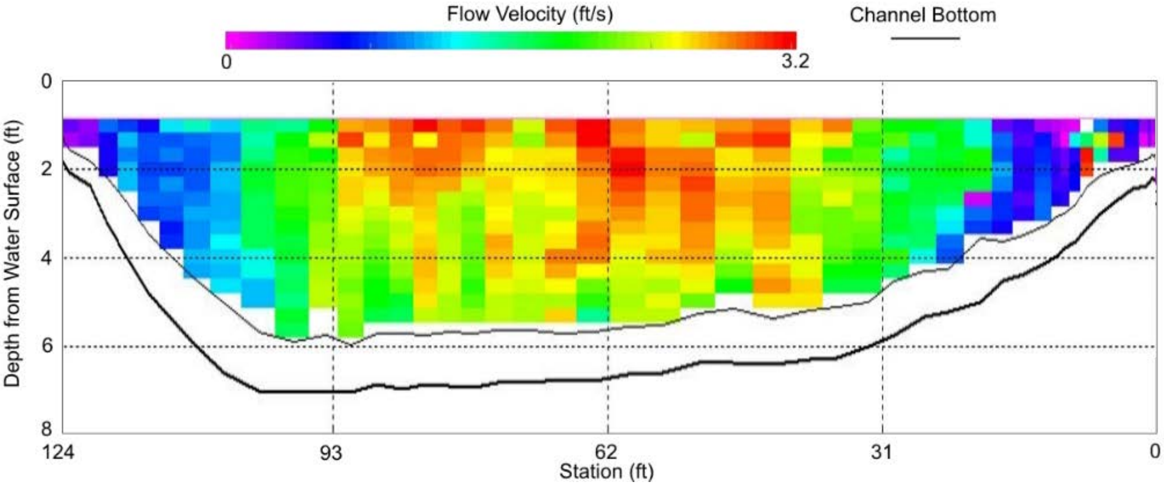


Figure 4: Cross-section Velocity Profile
(Kankakee River downstream of the confluence with Yellow River)

Several Kankakee River studies also note that since the Indiana portion of the river was straightened, the river has not been prone to meandering. Observations in 2018 found only three locations where the channel is migrating very slowly toward the outer bank. Most low gradient alluvial rivers that are straightened begin to re-meander almost immediately; however, that has not occurred in the Kankakee. This appears to be a result of the fact that the dredging was completed by dredging between meanders (see Figure 1), which maintained the original large-scale river planform along the valley bottom, the fine-grained sand dominating the bed and banks, and the presence of the bedrock constriction near Momence. This unusual stability has also been commented on in other studies (Ivens et al, 1981; IDNR, 1990).

3.1.2 Kankakee River in Illinois

The Kankakee River in Illinois is a naturally meandering river. It is highly sinuous upstream of Momence in the remnant of the Kankakee Marsh (sinuosity, s = 1.46) with a decreasing sinuosity downstream of Momence (s = 1.09). Based on the morphology of the cutoff meander scrolls visible in Indiana and the apparent channel width of the old meanders, the Kankakee upstream of Momence is representative of the pre-straightened natural Kankakee River in Indiana. The slope of the channel through the Momence Wetlands reach is about 1.6 ft/mi, 1.1 ft/mi, and 0.5 ft/mi, respectively, for the upstream, middle, and downstream thirds, based on water-surface elevations (Terrio and Nazimek, 1997).

Terrio and Nazimek also note that the channelized river in Indiana provides an efficient conveyance for water and sediment transport compared to the natural channel in Illinois. This observation is supported by the appearance of a mid-channel bar at the State Line Bridge and numerous sidebars and in-channel bars downstream from the state line. The sinuous nature of the channel upstream of Momence, combined with the decrease in slope through the reach also causes the section to be prone to channel blockages by large woody debris. If large wood gets through the State Line Bridge, it has an increased chance of being wedged in the channel due to the alignment of the channel relative to the bridge. Management of large wood in the Momence wetlands reach will be difficult and should only occur selectively and with much care, if needed. Large wood adds both complexity and stability in a sand bed river. Indiana has recently placed large wood along eroding banks in a portion of the Yellow River to add stability and form to the banks. Excessive removal of large wood in the Momence wetland reach in Illinois could trigger bank instability and send large amounts of sand downstream. Currently the reach serves a “shock absorber” for the downstream Kankakee, provided storage for both water and sediment. Those functions are critical to the overall health of the downstream Kankakee. The tortuous meanders throughout the wetland reach are a testament to the continuing function of this reach. Channels move and shift through the wetland as they alternately store and then slowly release sediment. Any attempt to form a persistent main channel through the reach will reduce the storage function.

Several islands have formed in the Kankakee, downstream from Momence, near Aroma Park. Gross and Berg (1981) used a series of aerial photographs of the islands in their study to document the stabilization of the Kankakee sediment supply and attributed most of the aggradation and island forming to sand deposited prior to 1939.The study also noted some evidence for aggradation near the confluence of the Iroquois and Kankakee Rivers from 1939 to 1954. They saw little evidence in aerial photographs for sand accretion after 1954 and felt that the river was near equilibrium after recovering from the original disturbance from dredging. Analysis of aerial photographs from 2017 and the images published in the Berg and Gross report supports their conclusions and suggests that there is now degradation of some of the islands, with one small island no longer being visible, as shown in Figure 5. This may indicate that sediment supply is now too low relative to discharge to allow for accretion, or growth of the islands.

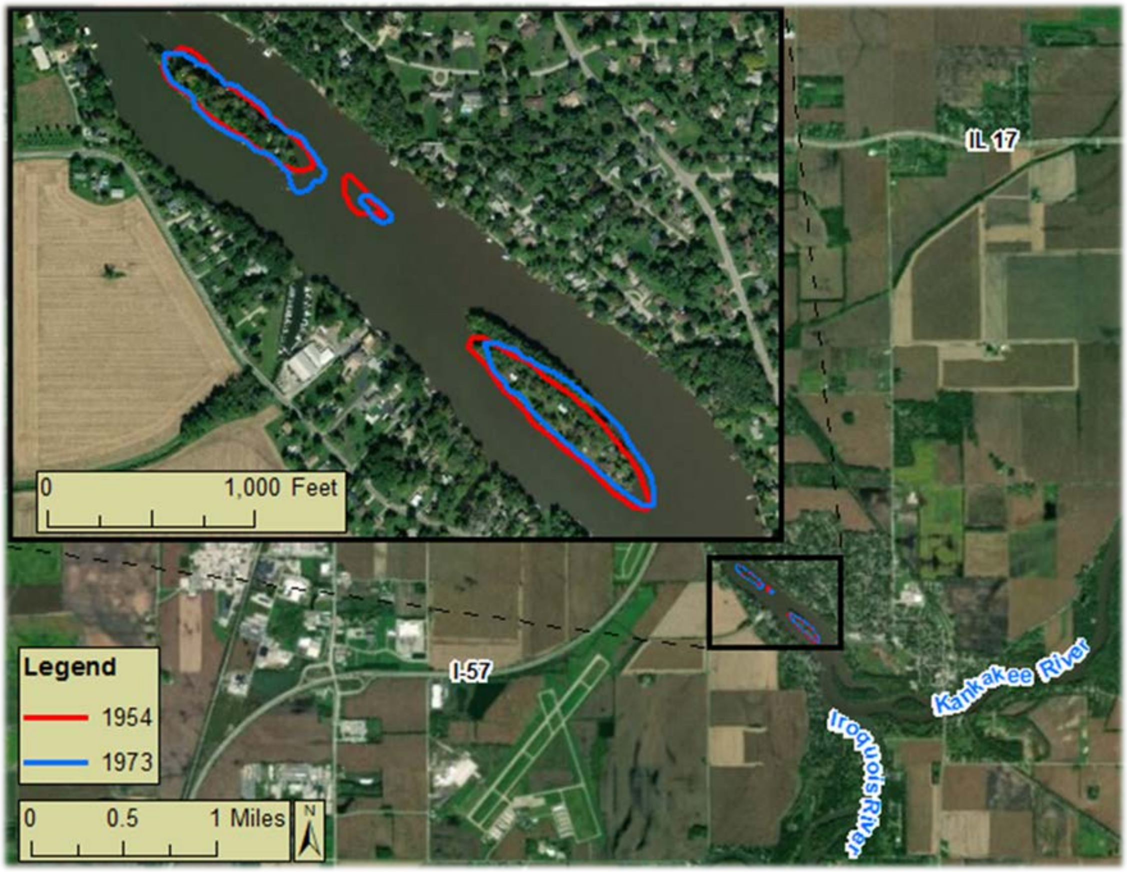


Figure 5: Changes in Illinois Island Extent from 1954 – 2017

However, as most studies of the Kankakee River have noted, the river is dynamic. A large event may leave a substantial mid-channel sand bar. The river can slowly winnow the deposit away or another flood may replace the sand bar with an even larger deposit. The Kankakee sediment cycle may take a significant amount of time to balance after a major event (Little and Jonas, 2013), and with the steady increase in peak discharge the sediment cycle may not stabilize until there is an extended period of climate stability.

Analysis of the Wilmington and Momence USGS gage data indicates that widespread aggradation (an increasing bed elevation due to sedimentation) has not occurred. Figure 6 provides the results of a specific gage analysis, which evaluated the water elevation associated with the same flow rate over time; an increasing elevation would suggest aggradation. The chart shows that over the last decade, the water elevation for a range of flow rates has remained essentially unchanged, with only a very slight decrease in the trendline for the Wilmington gage during smaller events.

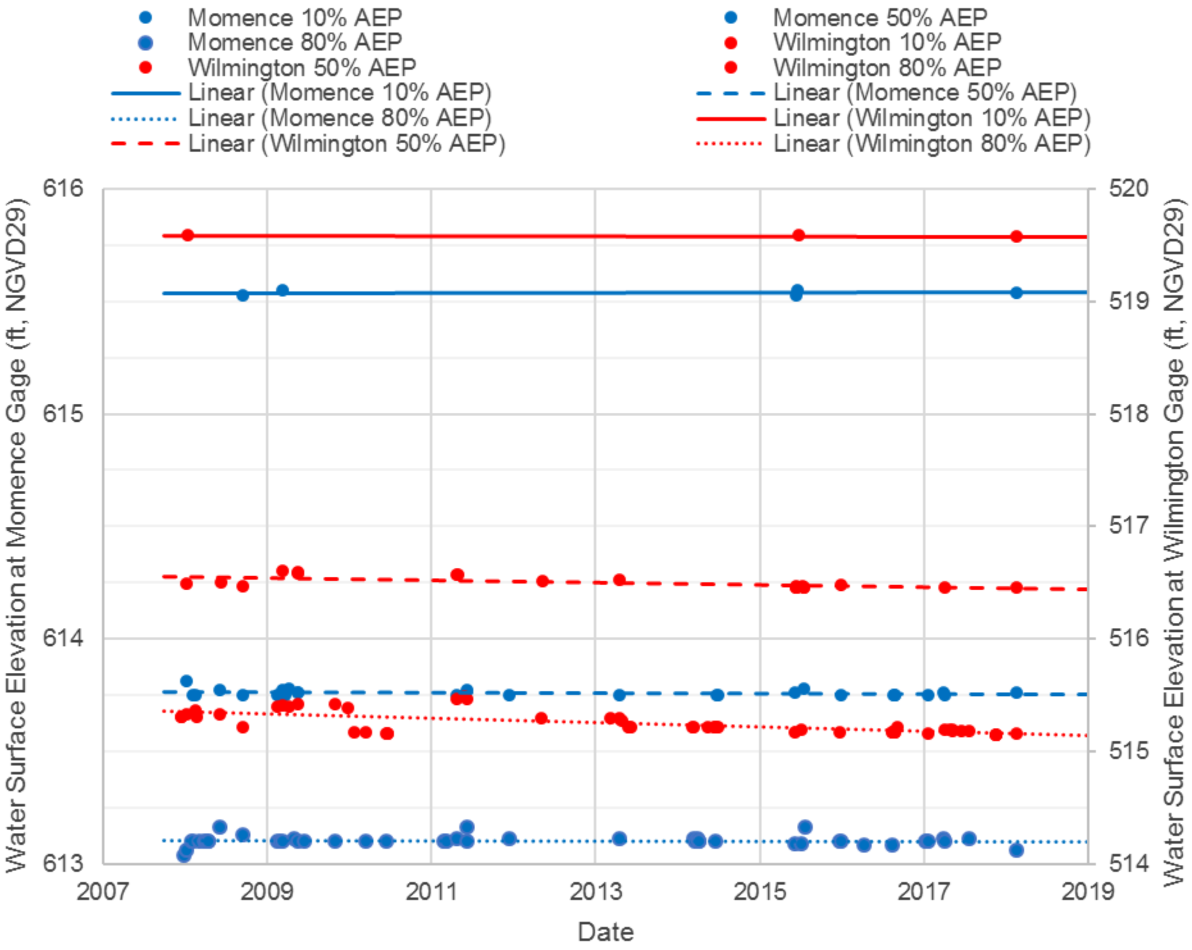


Figure 6: Specific Gage Analysis at Wilmington, IL and Momence, IL

While the specific gage analysis shows that the channel is not aggrading at the Momence and Wilmington gages, previous studies and visual observations confirm that sediment deposition occurs within the Momence wetland area. Repeated channel survey data collected by the USGS and Illinois State Water Survey in the Momence wetland area showed that approximately 127,500 cubic yards of sediment was accumulated between 1980 and 1994 (Terrio and Nazimek, 1997). Evaluation of the cross-section survey data shows that most cross-sections exhibit both erosion and deposition, which is expected for an alluvial river. The USGS study noted that additional repeat-survey data is desirable to better understand the trends of erosion and deposition. Visual observations between 2014 and 2019 revealed the occurrence of significant sediment deposits immediately following significant flow events; however, repeat site visits noted a winnowing of the deposits over time. This effect was also noted by Terrio and Namizek when clarifying that the amount of sediment deposition within the wetlands is affected by the amount of time that has passed since a significant event.

The results of the USGS repeat-survey, current visual observations, and sediment gage analysis provide an unclear conclusion concerning the presence or absence of an aggradational trend in the Momence Wetlands, and the Kankakee River in Illinois as a whole. Additional years of sediment gage monitoring and more detailed and current bathymetric data would provide a better understanding of the trend and how sediment is being conveyed.

3.1.3 Yellow River

The Yellow River is the largest tributary (435 mi^2) to the Kankakee River in Indiana. Extensive analysis of the Yellow River was done as part of an earlier study of the Yellow River that was designed in part to inform this current Work Plan for the Kankakee. The overall conclusion of the system assessment was that the Yellow River is significantly impaired and that the instability extends from just upstream of the Starke-Marshall County line to the confluence with the Kankakee. Upstream of Knox, IN the river is experiencing widespread erosion and bank failures that result in an abnormally high sediment load. Downstream of Knox, in the most extensively modified portion of the river channel, slope decreases and channel width increases, reducing the sediment carrying capacity and resulting in an inability to convey the high sediment load being delivered by the upstream reach. A clear aggradational trend was noted in the downstream reach using both visual observations and analysis of sediment gage data. Additional details concerning the Yellow River are provided in the “Yellow River System Assessment” (CBBEL, 2015).

3.1.4 Singleton Ditch

Singleton Ditch is a channelized tributary in Indiana that joins the Kankakee River just above Illiana Heights in Illinois. It has a drainage area of 262 mi^2 (USGS Streamstats, 2019), most of which is in Indiana. Singleton Ditch has received considerable attention because of its perceived contribution to the sediment load of the Kankakee. The sediment load in Singleton Ditch is primarily silt and clay carried in the channel as wash load. At its confluence with the Kankakee, the cloudy water merging with the relatively clear Kankakee is striking. Little and Jonas (2013) estimated the annual sediment load from Singleton Ditch at 38,900 tons/year, of which 35,000 tons was silt and clay, and 3,900 tons was sand. Current visual observations found that the ditch banks are steeper than would be recommended, but well-vegetated and relatively stable in Indiana. The banks observed in Illinois were eroding and covered with concrete and rubble.

3.1.5 Iroquois River

The Iroquois River is the largest tributary to the Kankakee River with drainage area of 2,135 mi^2, nearly equal to the 2,380 mi^2 of the main stem at the confluence of the rivers. The Iroquois River doubles in size near Watseka at the confluence with Sugar Creek and the confluence with several other significant tributaries between Watseka and Aroma Park, Illinois. The headwaters above Rensselaer, Indiana, are extensively channelized. Downstream from Rensselaer there is evidence of cutoff meanders like the channel straightening on the Kankakee, but the modifications on the Iroquois were not as extensive. Also like the Kankakee, the Illinois portion of the Iroquois is much less modified. Bank instability is rare, in part due to the erosion-resistant, clay-rich channel banks and bed. The only instabilities noted during the field study were numerous rills that were head-cutting into the surrounding uplands in western Newton County and in Illinois east of Watseka. Based on field observations these rills may be contributing a significant portion of the downstream sediment load.

The geology is significant with regard to the sediment load of the Iroquois River. The river forms in a proglacial lake bed in central Jasper County, Indiana and then flows through an area of clayey glacial till and fine-textured, water-laid sediments. Fine silt and clay dominate the sediment supply, making it a wash load dominated river. Wash load is sediment that moves by being suspended in the water column and is rarely deposited; the suspended load of a river is similar to the wash load, except that it is more prone to settlement. A study by Bhowmik noted that at the Iroquois and Chebanse gages, the suspended load should be close to the total sediment load since the sediment transported in the Iroquois River is mainly silt and clay (Bhowmik et al., 1980). The Iroquois River supplies much of the sediment deposited in the Six-Mile Pool reach, based on the composition of the sediment. The sediments in the reach are typically fine-grained material that apparently settle out and accumulate in the middle third of the reach (Terrio and Nazimek,1997).

3.1.6 Kankakee System Sediment Budget and Transport Processes

Multiple sediment transport studies have been completed for the Kankakee River, some focused on in-channel sediment transport and others included watershed sediment contribution. As noted in the discussion of river morphology for each stream in Section 3.1.1 through 3.1.5, much of the sediment in the Kankakee River system is transported as suspended load. The quantity and source of sediment contributions is critical to evaluating the function of the river, as well as providing a context for developing potential solutions to mitigate problems. The following description of the source and quantity of sediment moving through the system is based on previous studies and analysis of USGS stream gages that measure suspended sediment.

Ivens, et al. reported that based on 375 samples of the bed and banks of the Kankakee River in Indiana and Illinois that the characteristics of the materials are almost identical. The median diameters range from 0.2 – 0.4 mm, or fine to medium sand. The uniform nature of the bed and bank materials makes it very difficult to determine the source of any sediment (Ivens, 1981). The fine to medium sand is primarily transported as suspended load. Ivens et al. state that in all probability the suspended load measured at Momence and Wilmington represents the total load carried by the Kankakee River at those two stations. However, Bhowmik noted that the sand bar at the State Line was moving at about 18 to 24 inches a day in 1979, indicating that at least a small portion of the sediment does sometimes move as bedload. Bhowmik et al. (2004) estimated bed load percentage as 5 to 10 percent of total load (for the Stateline Bridge to the Kankakee Dam).

A comprehensive sediment analysis for the Kankakee was conducted by Little and Jonas (2013). The conclusions of that study have been adjusted based on more recent USGS sediment gage data where additional years of data have been accumulated and new gages have been installed. Many of the assumptions regarding sediment contribution from Yellow River were also generally confirmed by the data from the sediment gages installed in 2012. A summary of the sediment budget for the Kankakee River is provided in Table 4, which shows the annual sediment load using USGS gage data only.

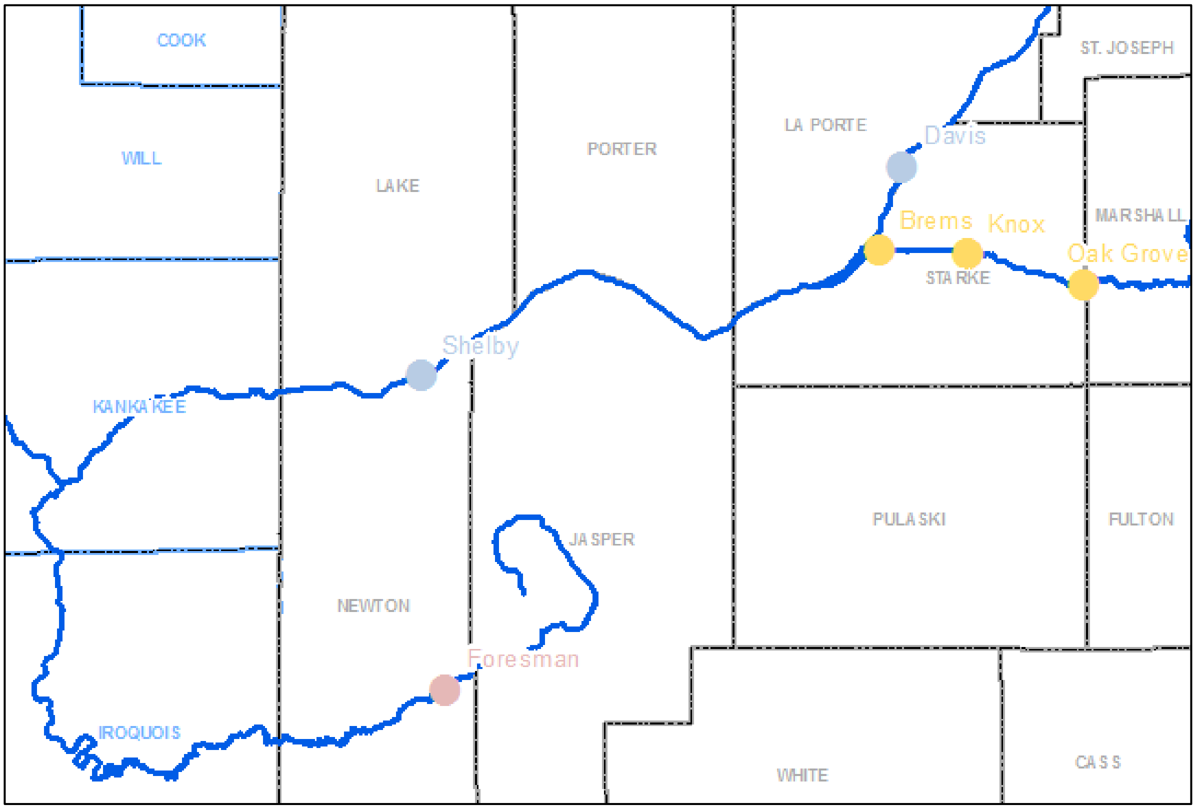


Figure 7: USGS Sediment Gage Locations

Table 4: Sediment Budget for the Kankakee River System

Year	Sediment Load (tons)					
	Davis	Oak Grove	Knox	Brems	Shelby	Foresman
	542 mi^2	377 mi^2	435 mi^2	438 mi^2	1,779 mi^2	449 mi^2
2013	-	22,700	73,600	89,900	-	-
2014	23,700	15,300	37,700	17,800	-	-
2015	23,700	20,200	45,900	34,600	122,300	31,800
2016	27,000	17,200	41,800	36,800	105,000	25,000
2017	27,800	21,800	56,700	63,200	91,000	32,100
2018	29,100	29,200	102,900	114,400	117,600	36,200
AVG	26,300	21,100	59,800	59,400	109,000	31,300

Several notable facts can be derived from the individual years of sediment data at each gage, but also from the average annual sediment loads.

1. The sediment load observed at the Davis, Oak Grove, and Foresman gages are consistent from year-to-year, suggesting that the sediment is derived largely from the watershed and is not heavily impacted by very wet and very dry years. Visual observations confirm that few areas of channel instability exist upstream of the gages.
2. A comparison of the Oak Grove and Knox gages indicates a significant amount of sediment contribution between the gages. The 2015 CBBEL study indicates that the additional sediment is almost entirely attributable to streambank erosion.
3. The sediment contribution from Yellow River is more than double that of the Kankakee despite having only 80% of the drainage area, as observed at the Brems and Davis gages. The difference in sediment contribution is almost equivalent to the estimated sediment contribution from Yellow River identified in the 2015 CBBEL study.
4. The sediment load at Brems was notably lower than the sediment load at Knox for 3 out of 6 years, indicating significant aggradation. On average, the downstream reach of Yellow River appears to accumulate 400 tons of sediment each year.
5. The sediment load at the Knox and Brems gages is highly variable from year-to-year, indicating a significant amount of instability in the Yellow River system.
6. The sediment load at Shelby is reasonably consistent, despite the highly variable sediment input from Yellow River. This indicates that the Kankakee is a capacity limited river; in other words, the river conveys as much sediment as it is able to, regardless of what is supplied to the river from the upstream watershed and streambanks. In some years, there is clearly some sediment storage that occurs, as the total sediment load at Shelby is less than the sum of the Brems and Davis gages; the sum of the Brems and Davis gages is significantly less than what is conveyed at Shelby in other years, but the sediment load at Shelby is relatively stable year-to-year. This indicates that a reduction in the sediment supplied to the Kankakee should result in a reduction in temporary sediment storage. This observation is further discussed in Section 3.5.1 in more detail.

3.2 SPOIL PILES / BERMS

The system of berms that exists along the Indiana portion of Kankakee today began as a result of the original dredging of the Kankakee. The berms are spoil piles that were deposited along the bank of the river out of convenience and were not engineered as levees meant to provide flood protection. Although they appear to provide some degree of flood protection to some areas, many of the properties that are seemingly protected from the river by the berms may still be at risk of flooding due to gaps or dips in the berm upstream. The berms are discontinuous, do not have a consistent height from one berm to another, and do not maintain a consistent elevation along the berm, as shown in Figure 8. Due to being mostly unconsolidated and porous, the berms are also subject to being breached during large floods and cannot be qualified as a reliable flood risk reduction measure. Additionally, once floodwater enters the floodplain, either by overtopping the spoil piles or by flowing between them, it may remain on the land longer than if the berms were absent because intact portions of the berms prevent the water from returning to the river unimpeded.

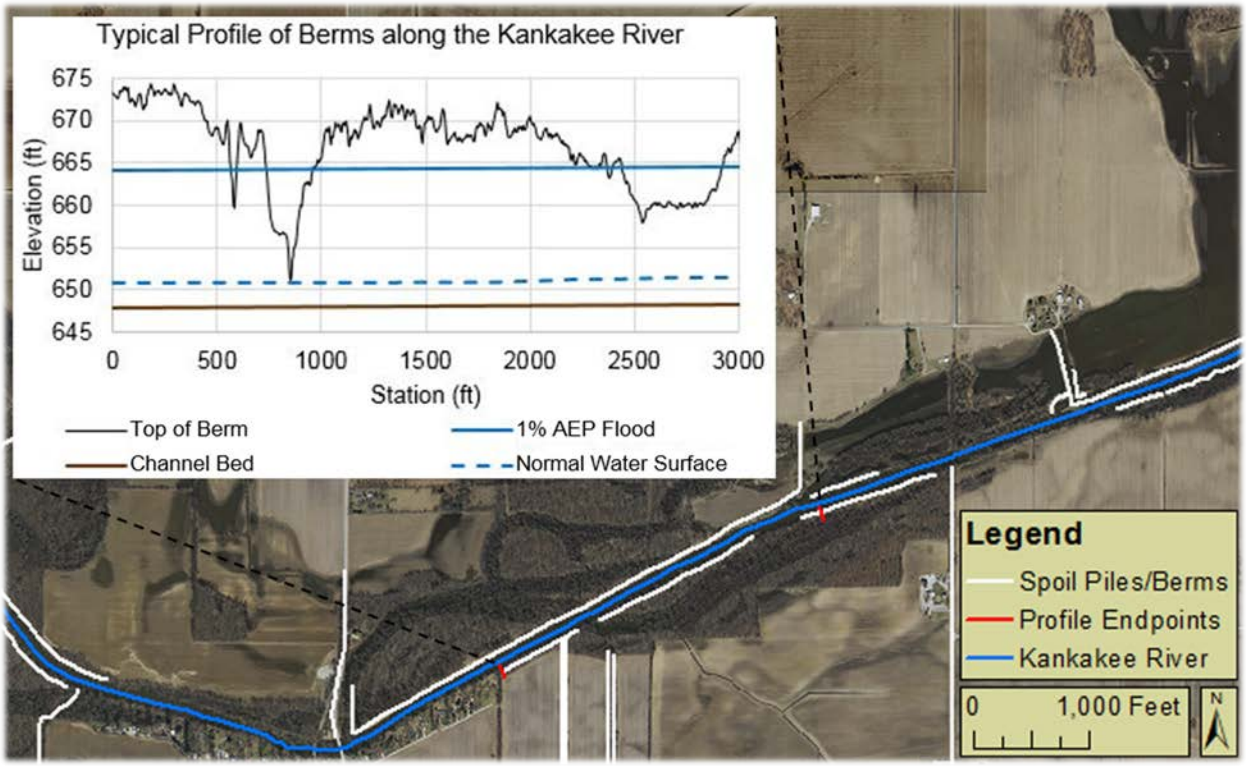


Figure 8: Discontinuous Berms and Uneven Berms

The non-cohesive nature of the material and the haphazard way it was deposited has also resulted in a number of persistent river management issues. Much of the berm system is maintained at slopes steeper than those that are required to provide confidence in bank stability, e.g. slopes at or steeper than 1.5H:1V for sandy material. The berms are susceptible to slope failures at such steep angles, particularly when poorly vegetated, and mass bank failures can lead to sedimentation issues downstream. The berm instability has also caused increased maintenance expenditure as the top of the berm is currently used for access along the river. To keep the access route serviceable, instabilities have been repaired. This has required costly work within the environmentally sensitive and regulated portion of the river and in many cases, mitigation for impacts to wetlands that are commonly found on the landward side of the berms. In several cases, the cost of the environmental mitigation has rivaled the cost of the actual repairs.

3.3 FLOODING RISKS

A river the size of the Kankakee will always activate the floodplain during periods of high discharge. This means agricultural areas or infrastructure developed in the floodplain will be subject to flooding. The marsh-like origin and low-lying topography of the Kankakee produces a significant flooding risk as a result of the water spilling out to inundate vast areas as soon as the floodplain is activated. The flooding risk can be assessed by evaluating aerial photography following the recent major flooding in February 2018, the results from the hydraulic model, existing floodplain mapping, the relationship of property and infrastructure to the flooding, and an assessment of how flow rates and flooding are likely to change due to more severe weather patterns.

3.3.1 Existing Flooding and At-risk Infrastructure

The flooding experienced in February and March of 2018 produced the highest flooding elevations on record in several locations. The flooding inundated vast areas of farmland and affected several roads and residential clusters. Review of aerial photography that was collected for Lake, Newton, Porter, Jasper, and LaPorte Counties provides a real-world visual image of the flooding extent shortly after the peak of the flooding had subsided. The noted aerial photography may be obtained from the Indiana Geographic Information Office.

As extensive as the 2018 flooding was, it does not represent the worst conditions that are likely occur along the Kankakee and its tributaries. The Federal Emergency Management Agency (FEMA) has developed maps showing the areas subject to a high risk of flooding, known as the Special Flood Hazard Area (SFHA). FEMA defines the SFHA as areas inundated by a flood having a 1% annual probability of occurrence in any given year (1% AEP). Exhibit 2 shows the flood risk areas along the Kankakee, Yellow, and Iroquois as depicted on the FEMA maps. As can be seen from these maps, large areas along the Kankakee, which are mostly in agricultural use, are susceptible to flooding. There are also several development clusters as well as transportation corridors within both Indiana and Illinois that are located within the floodplain and as such are expected to flood during major events.

Estimates of flooding inundation for various frequencies, including the 1% AEP event, were also developed based on the calibrated 2D hydraulic model discussed in Section 2.4.2. The modeled floodplain areas associated with the 2D modeling are discussed and presented in Appendix 3. Given the better methodology and topographic information used for this more recent modeling, the height and extent of flooding predicted by the model are more accurate for the current conditions. However, this modeling assumes that all the existing berms remain intact during flooding and the vast flood storage areas will continue to be accessible to flooding as they are today. Given the nature of the unstable and non-engineered berms along the Kankakee River and also the fact that there is no regulatory mechanism currently in place to ensure that the flood storage areas remain accessible to flood flows during future events, the 2D modeling is expected to underestimate the extent and magnitude of potential flood risks along the Kankakee, especially in areas behind continuous berms. As such, these data are not suitable or meant for use for regulatory or potential flood risk determination purposes.

Several populated areas appear to have significant flooding risk, most notably Watseka, IL. This community is particularly floodprone as the population center is low-lying and near the confluence of two major streams, Sugar Creek and Iroquois River. The overall size of the contributing drainage area and the intense runoff accumulated in the Sugar Creek portion of the watershed produce exceptionally high flow rates that result in frequent and severe flooding.

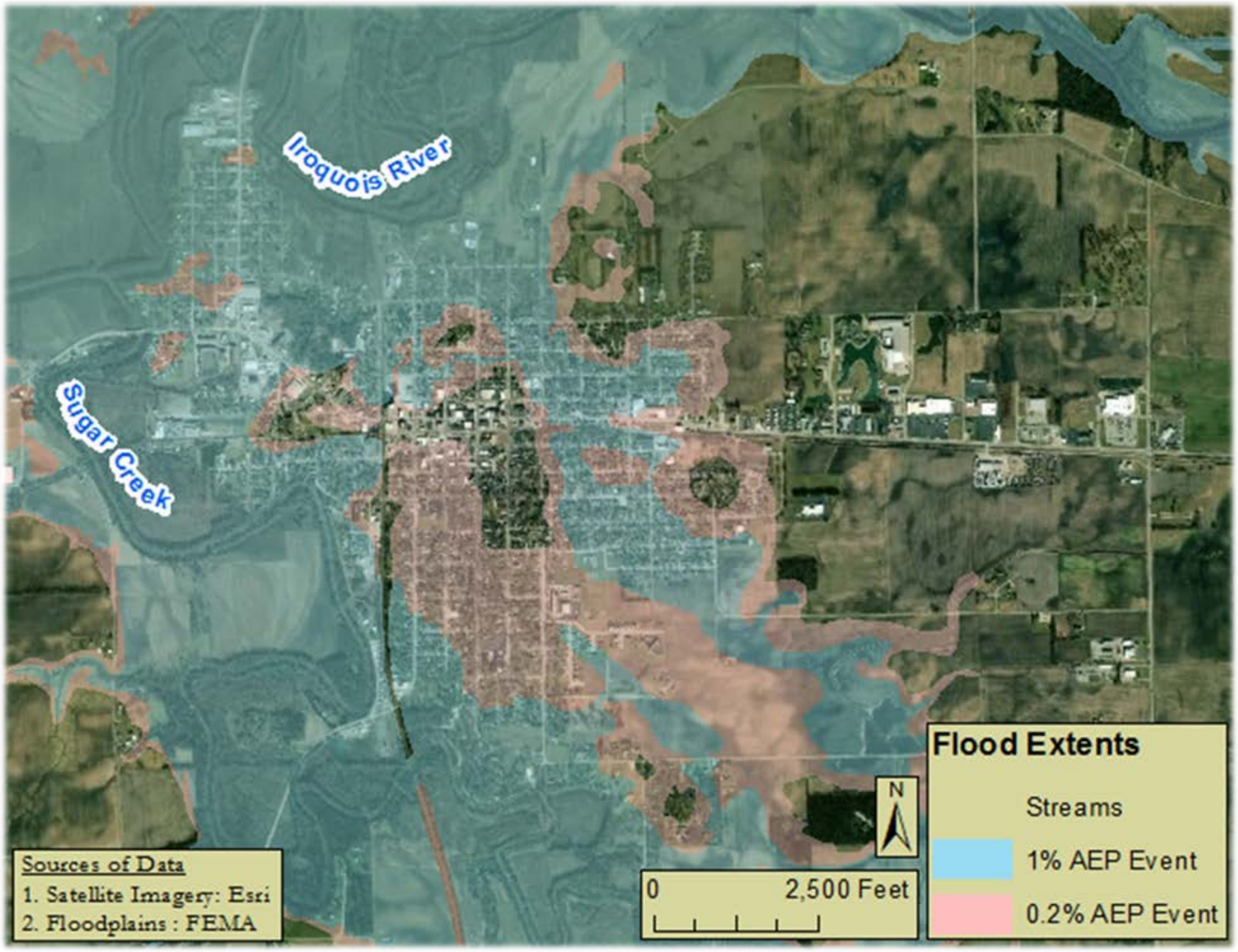


Figure 9: Flooding in Watseka, Illinois

Table 5 summarizes the frequency analysis using the USGS B17C methodology for each gage in the study area, including those on the Kankakee, Yellow, and Iroquois rivers. In general, the estimated flows for the gages along the Yellow and Iroquois rivers are 2-3 times as high as those estimated for gages with similar drainage areas along the Kankakee River in Indiana; see Section 3.5 for more details. Even though there have been significant modifications to the watershed of the Kankakee, there is a significant amount of flood storage in the system that helps maintain relatively low flow rates in comparison to the other river systems.

Table 5: Existing Condition Flow Rates & Flooding Elevations at USGS Gages

Event		**Davis[3]**	**Dunns Bridge[3]**	**Kouts[2]**	**Shelby[3]**	**Momence[2]**	**Wilmington[2]**	**Knox[2]**	**Singleton Ditch[1]**	**Rensselaer[3]**	**Foresman[2]**	**Iroquois[2]**	**Milford[2]**	**Chebanse[2]**
Drainage Area (mi^2)		542	1,352	1,376	1,779	2,294	5,150	435	262	203	449	686	446	2,091
Gage Datum		664.34	649.18	645.00	627.94	609.18	510.86	679.93	-	642.32	624.00	614.34	622.00	595.99
50% AEP	**Flow**	1,310	3,770	4,000	4,440	6,890	25,400	2,360	1,720	1,470	2,990	4,110	6,690	13,500
	Stage	674.47	659.37	656.56	638.69	613.65	516.52	688.92	-	654.40	640.80	631.37	642.60	609.93
10% AEP	**Flow**	1,700	4,970	5,130	5,880	10,500	49,100	3,730	2,750	2,200	5,100	7,320	15,400	23,300
	Stage	676.05	661.44	658.45	640.64	615.48	519.58	690.95	-	656.94	645.32	638.14	648.50	614.40
2% AEP	**Flow**	2,000	5,900	5,990	7,000	13,600	73,700	4,960	3,620	2,840	7,100	10,500	25,800	32,600
	Stage	677.18	662.93	659.78	641.94	616.95	522.42	692.58	-	658.88	-	640.66	653.03	-
1% AEP	**Flow**	2,120	6,270	6,330	7,450	15,000	85,200	5,490	3,990	3,100	7,990	11,900	31,000	36,800
	Stage	677.62	663.50	-	-	617.59	-	693.24	-	659.61	-	-	-	-
0.2% AEP	**Flow**	2,380	7,110	7,090	8,470	18,100	115,000	6,750	4,800	3,730	10,200	15,400	45,200	47,000
	Stage	678.55	664.76	-	-	618.96	-	694.74	-	661.27	-	-	-	-
2018	**Flow**	2,040	5,840	5,650	6,380	12,300	52,300	5,900	-	3,010	5,140	9,900	19,600	28,900
	Stage	677.33	662.84	659.26	641.24	616.34	519.96	693.74	-	659.36	648.38	640.23	650.52	616.58

[1] Flow rates for Singleton Ditch are from the StreamStats regression equations.

[2] Gage datum references the National Geodetic Vertical Datum of 1929

[3] Gage datum references the North American Vertical Datum of 1988

Note: All flow values were established using a B17C analysis of the individual gages; values for the 2018 event are as observed by the gage. All stages are relative to and reflect the current rating curve for each individual gage; stage values are absent where rating curves to not extend to the stated AEP event

🟦 = Kankakee River 🟨 = Yellow River 🟩 = Singleton Ditch 🟥 = Iroquois River

3.3.2 Increased Flooding

The extent of flooding and at-risk infrastructure identified in Exhibit 2 and the inundation maps provided in Appendix 3 show the current flooding risk; however, current science and analysis of USGS gage history suggests that the future flooding risk will be greater than the current flooding risk. There has been an increasing trend in peak annual flowrate in the Kankakee over the past 100 years. This trend is quite visible at the USGS gages along the river, most notably at the gage near Shelby, Indiana. Figure 10 clearly shows the increasing trend in the peak annual discharge at the Shelby gage over the last 95 years of operation. This conclusion is found in nearly every previous study that evaluated the hydrology of the Kankakee system. There are many factors that affect peak flow rates; however, based on experience with similar areas in Northern Indiana, the major factors contributing to peak discharge increases along the Kankakee are increased frequency, intensity, and depth of precipitation resulting from climate change, increasing volume and intensity of runoff resulting from urban development and agricultural drainage practices, and encroachment and loss of floodplain storage within the river corridor.

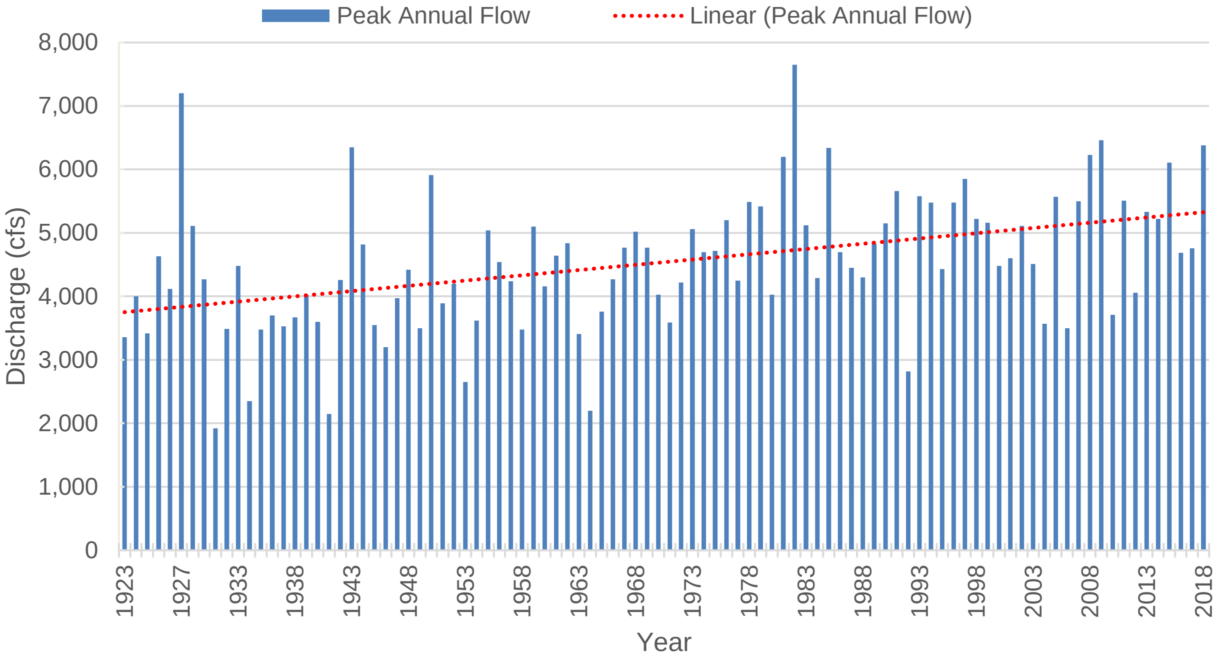


Figure 10: Peak Annual Flow Rate Trend at USGS Gage near Shelby, Indiana

Figure 10 shows the peak annual flow rate for each year of the gage record at Shelby, Indiana (blue bars) and a linear trendline for the peak annual flow rate (red, dashed line). Similar data is provided in Appendix 2 for other gages within the Kankakee River Watershed. The trendlines for all the gages in the Kankakee system are shown in Figure 11 with the individual peak annual flow rates being omitted for clarity.

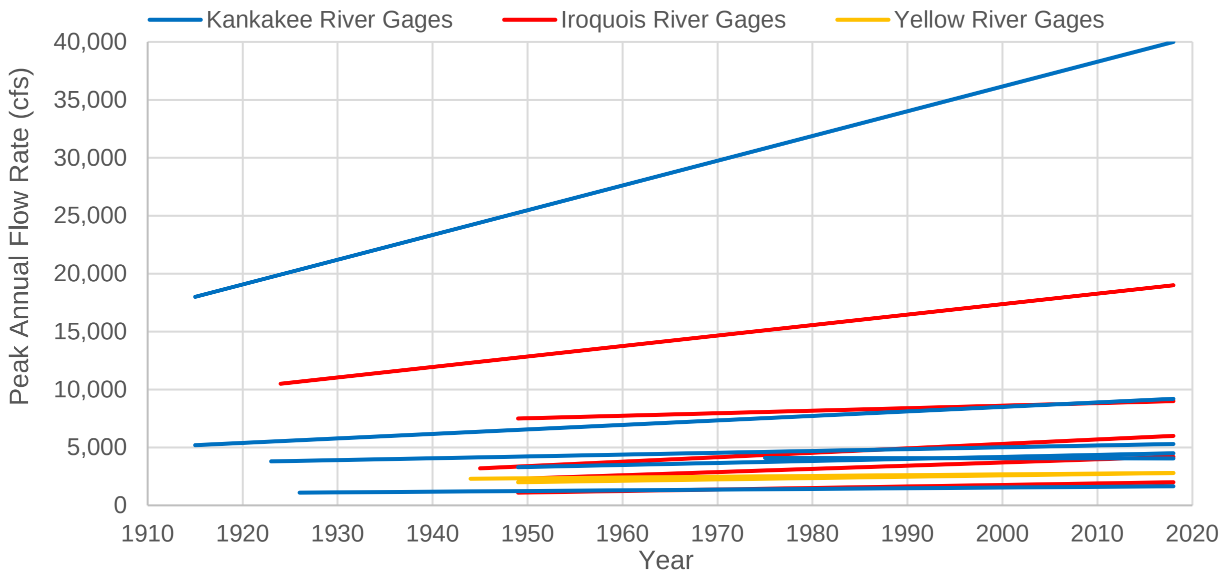


Figure 11: Peak Annual Flow Rate Trend at USGS Gages in Kankakee System

Table 6: Summary of Peak Annual Flow Rate Trends

Gage		Year	Peak Annual Flow Rate (cfs)	Percent Increase over Gage Record
Kankakee River	Wilmington	1915	18,000	122%
		2018	40,000	
	Momence	1915	5,200	77%
		2018	9,200	
	Shelby	1923	3,800	39%
		2018	5,300	
	Kouts	1975	4,100	-1%
		2018	4,050	
	Dunns Bridge	1949	3,300	36%
		2018	4,500	
	Davis	1926	1,100	50%
		2018	1,650	
Yellow River	Plymouth	1949	2,000	40%
		2018	2,800	
	Knox	1944	2,300	22%
		2018	2,800	
Iroquois River	Chebanse	1924	10,500	81%
		2018	19,000	
	Iroquois	1945	3,200	88%
		2018	6,000	
	Foresman	1949	2,300	83%
		2018	4,200	
	Rensselaer	1949	1,100	82%
		2018	2,000	
	Milford	1949	7,500	20%
		2018	9,000	

The trendlines shown in Figure 11 show a strong increasing trend most notably for the Kankakee River gage at Wilmington, IL and the Iroquois River gage at Iroquois, IL. It is expected that these locations would experience the greatest increase as they accumulate the increases that are observed by upstream gages. Kouts is the only gage that has a relatively stationary trend; however, the short gage record is likely the reason for the anomaly. While Figure 11 does not make the increase in flow for gages with a peak annual flow rate less than 5,000 cfs seem dramatic, Table 6 shows that all gages (except for Kouts) have had an increase of at least 20%, with the average being 57%.

The information in Figure 11 and Table 6 show the relative increase in flow rates that has already happened. A recent study by the University of Notre

Dame indicates that this trend is expected to continue and worsen in the future due to changes in temperature and rainfall patterns. The current 1% AEP discharge will likely occur twice as often in the future, and the current 0.2% AEP storm is predicted to be five times as likely to occur in a given year under these changing conditions (Hamlet et al., 2017). In essence, the future 2% AEP (AKA 50-year) event is expected to be similar to the current 1% AEP (AKA 100-year) event and the future 1% AEP event is expected to be similar to the current 0.2% AEP (AKA 500-year) event; see Table 5 to compare these events for each of the gaged locations in the Kankakee system.

In addition to the continuation of the increasing trend in the magnitude of flow rates, there is also evidence to suggest that flood stages are increasing for a given flow rate. For example, the flood of spring 2018 produced the highest flood stage at Shelby, IN in the past 100 years, but the flowrate associated with this event has been equaled or exceeded 2 times in the past decade, and 4 times in the 95 years of gage record.

3.4 DRAINAGE AND LAND USE PRACTICES

The drainage and land use practices of an area can have a dramatic effect on the amount of runoff created during storm events and the amount of sediment that washes off the land and enters the river system. The land use within the Kankakee system is 5 percent urban and 84 percent agricultural, with natural areas constituting the remaining 11 percent. Since the vast majority of the drainage area is agriculturally-based, the following discussion of drainage and land use practices is approached entirely from the viewpoint that drainage is one of, if not the most critical, elements of agricultural production in the Kankakee system. Much of the prime farmland in the area is subject to high groundwater levels and the flat topography makes efficient drainage difficult. An extensive network of drainage ditches, dikes, pumps, and pervasive tiling have been employed to provide drainage for these areas. In some particularly low-lying areas the drainage network is used to artificially depress the groundwater to prevent surface ponding. The intensity of runoff entering the Kankakee is heavily affected by the density of this drainage network; the higher the network density, the higher the intensity as the runoff is collected and conveyed to the Kankakee much faster. Figure 12 and Table 7 show a comparison of the drainage density for several major river systems in northern Indiana.

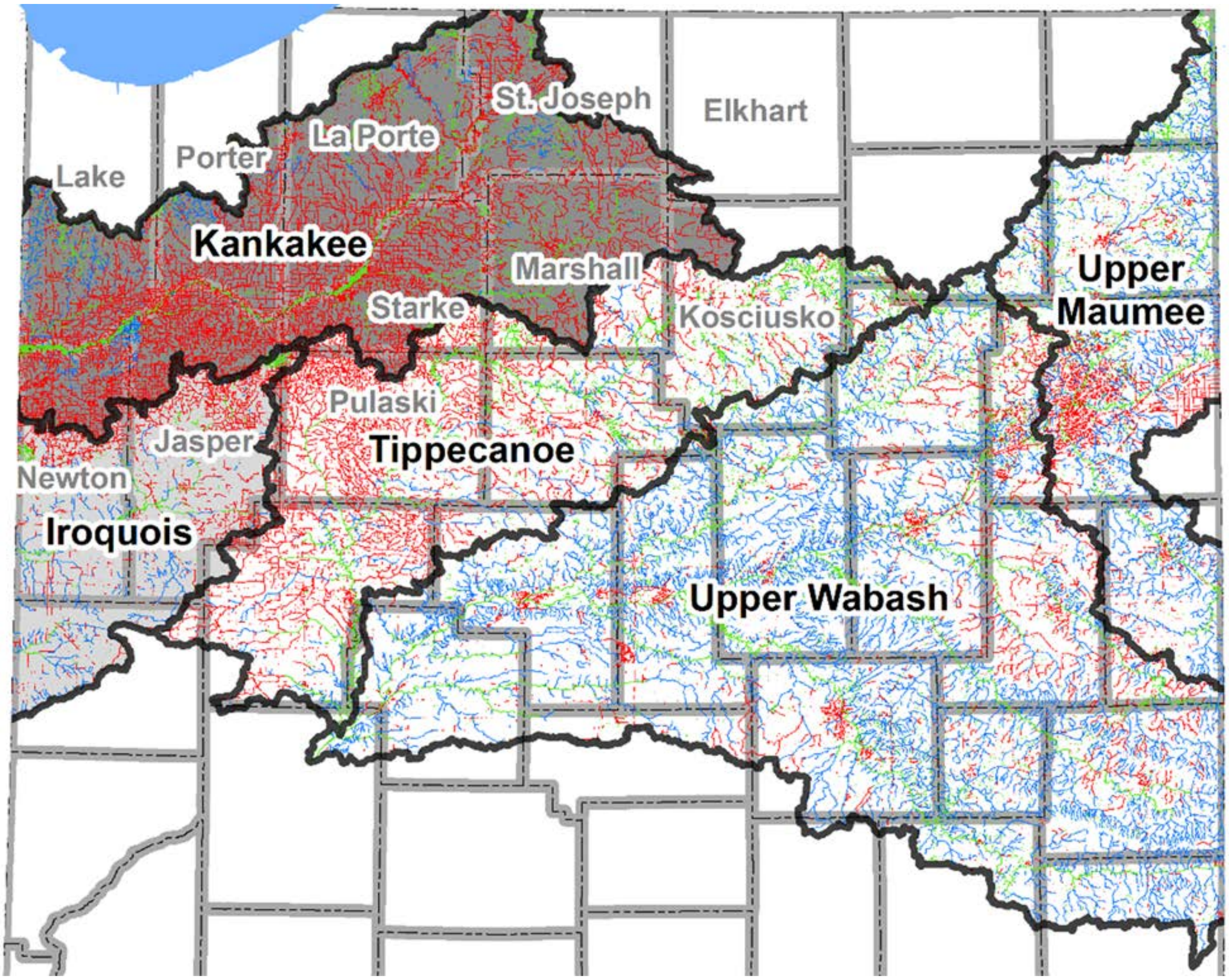


Figure 12: Map of Natural and Man-made Drainage Channels in Northern Indiana

Table 7: Summary of Drainage Density for Select Rivers in Indiana

Watershed	Total Drainage Area (mi²)	Total Drainage Network Length (mi)	Drainage Density (mi/mi²)
Upper Wabash	4,163.5	7,788.0	1.9
Upper Maumee	1,181.6	2,757.8	2.3
Iroquois	843.8	1,379.7	1.6
Tippecanoe	1,949.7	4,089.2	2.1
Upper Wabash	4,163.5	7,788.0	1.9
TOTAL	**12,302.2**	**23,802.8**	**1.9**

Table 8 shows the drainage density of the Kankakee River system for each Indiana county. The comparison reveals that for each square mile of drainage area, there is approximately 1.5 times as many miles of drainage infrastructure in the Kankakee River system.

Table 8: Kankakee System Drainage Density by Indiana County

County	Total Drainage Area (mi^2)	Total Drainage Network Length (mi)	Drainage Density (mi/mi^2)
La Porte	466.3	1,229.5	2.6
Marshall	324.4	625.7	1.9
St. Joseph	274.3	655.8	2.4
Starke	259.0	985.6	3.8
Lake	237.2	797.5	3.4
Porter	221.8	665.9	3.0
Jasper	161.8	790.0	4.9
Newton	124.2	602.5	4.9
Kosciusko	51.1	61.7	1.2
Pulaski	13.5	43.6	3.2
Elkhart	11.4	13.1	1.2
TOTAL	**2,145.0**	**6,471.0**	**3.0**

The type of ground cover also plays a role in the amount of runoff and sediment generated by agricultural areas. The presence of vegetation promotes an increased infiltration capacity due to water uptake by the plants and by the creation of pathways along the root system. Conversely, tillage disrupts the soil structure and frees up soil particles for erosion from rainfall and runoff concentration in rills and gullies. Information from the Indiana State Department of Agriculture (ISDA) shows that only 23 percent of agricultural lands are no-tilled and only 9 percent are cover cropped. A summary of no-till and cover crop usage by county is provided in Table 9.

Table 9: Summary of No-till & Cover Crop Usage by County
(Developed from ISDA, 2017)

County	Total Corn & Soybeans (acres)	2017 Spring No-till Usage (acres [%])	2017 Fall Cover Crop Usage (acres [%])
Lake	110,805	28,729 [26%]	4,481 [4%]
Newton	179,898	46,659 [26%]	11,927 [7%]
Porter	118,150	24,826 [21%]	4,061 [3%]
Jasper	264,228	52,927 [20%]	13,801 [5%]
LaPorte	204,788	45,863 [22%]	28,790 [14%]
Starke	97,966	16,569 [17%]	3,280 [3%]
St Joseph	124,920	48,449 [39%]	25,161 [20%]
Marshall	169,265	30,739 [18%]	21,377 [13%]
TOTAL	**1,270,019**	**294,761 [23%]**	**112,878 [9%]**

The low usage of these conservation practices is particularly detrimental to the amount of sediment dislodged from the watershed in areas with fine-grained soils; silts and clays are easily detached and kept in suspension by the rainfall and runoff. This is especially relevant for the Iroquois River portion of the Kankakee system. The typical soil types in the Iroquois watershed coupled with the low usage of no-till, and more importantly cover crops, contributes to the high sediment load for the Iroquois, as discussed in Section 3.1.5 and 3.1.6.

Low usage of conservation practices also leads to poor soil health. Conventional tillage, very low usage of cover crops, and non-diversified crop rotation practices have led to a decrease in the organic content of the soil and the overall soil health. The agricultural practices that have been employed in the watershed have undoubtedly caused a decrease in the infiltration and storage capacity of the soil, which has contributed to the increase in runoff rates and volume. Continued degradation of the soil health should be expected to promote a continuation of the increasing trend in runoff rates and volume.

3.5 DISPROPORTIONATE FLOW AND SEDIMENT INPUTS

Although the Kankakee River itself has been heavily modified over the past 150 years through straightening, dredging, and bank modifications, many of the flooding and sedimentation problems within the Kankakee Basin are disproportionately influenced by tributaries rather than the main stem of the river. Singleton Ditch and the Yellow and Iroquois Rivers contribute much higher volumes of flow and sediment during storm events than the Kankakee on a per-square-mile basis. The flow and sediment dynamics of these tributaries are summarized in the following paragraphs and in Table 10 below. A more detailed description of the sediment budget is provided in Section 3.1.6.

Table 10: Runoff per Acre Comparisons

Location	Runoff Rate (cfs) Per Square Mile		
	50% AEP	10% AEP	1% AEP
Yellow River	5.4	8.5	12.5
Kankakee @ Yellow River	3.2	4.2	5.2
Singleton Ditch	7.1	10.4	15.9
Kankakee @ Singleton Ditch	2.5	3.9	5.4
Iroquois River	6.4	11.1	17.5
Kankakee @ Iroquois River	3.0	4.6	6.5

3.5.1 Yellow River Inputs

Flow and sediment gage data show that a disproportionate amount of flow and sediment originate from the Yellow River during significant flow events. The Yellow River routinely produces 1.5 times the flow and 5 times the sediment compared to the main stem of the Kankakee on a per acre basis, as observed during significant flow events at the Davis and Brems USGS gages. The sediment that moves through the Yellow River into the Kankakee is not transported proportionally to flow during these events. Although high flows typically lead to high sediment loads, there are instances in which individual events discharge twice as much sediment or more as recent events with similar flows. Figure 13 illustrates this relationship between flow and sediment at gages upstream of the confluence of the Kankakee and the Yellow. These sediment 'slugs' lead to high rates of localized, temporary aggradation that is winnowed away during subsequent events. Sediment gage data from Brems (Yellow River) and Shelby (Kankakee River, downstream of confluence) show that these sediment pulses can be absorbed and proportionally conveyed by the flow in Kankakee before the river reaches the state line.

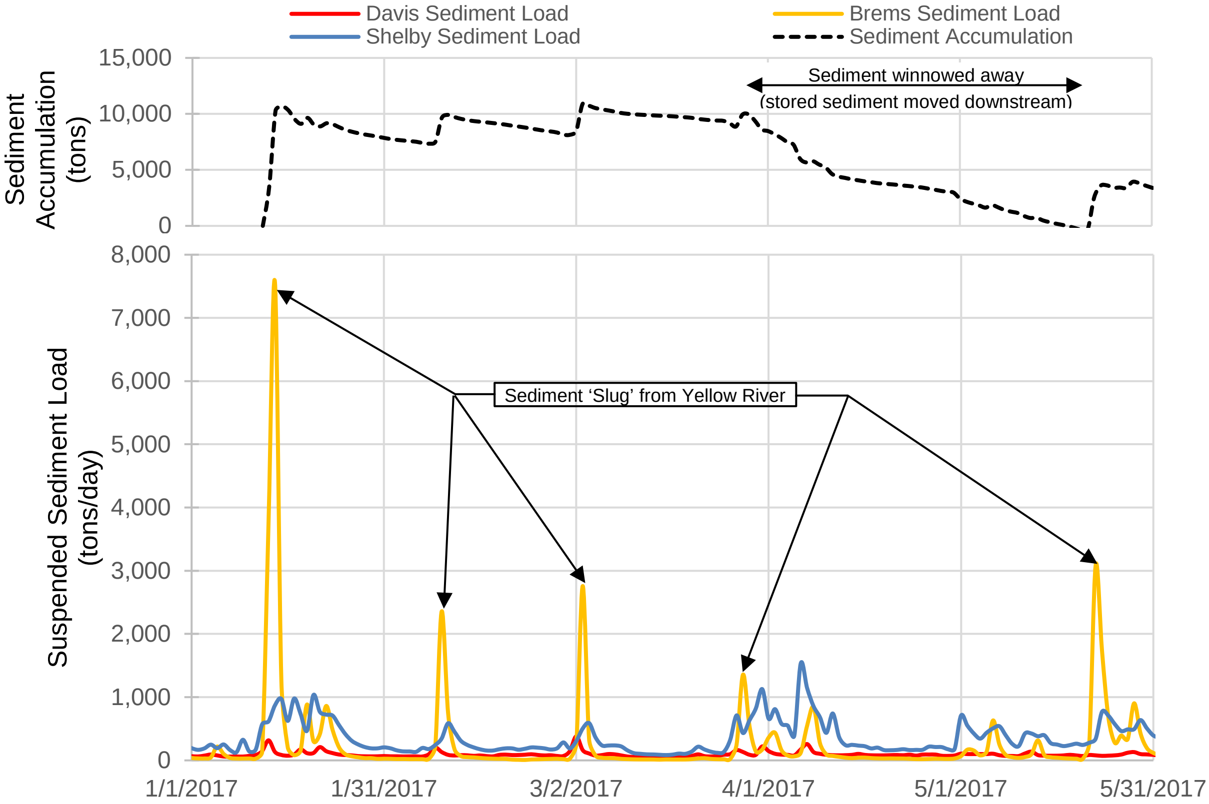


Figure 13: Sediment Load in Kankakee and Yellow Rivers

Figure 13 shows the sediment load measured at the Brems, Davis, and Shelby USGS gages. For the purpose of presenting the information, it has been assumed that the only sediment being contributed to the Kankakee upstream of the Shelby gage is observed by the Brems and Davis gages. The sharp spikes in the Brems sediment load indicate times when 'slugs' of sediment were transported from Yellow River into the Kankakee. The amount of sediment conveyed far exceeds the amount moving through at the Shelby gage, indicating that the sediment was stored on the bed of the Kankakee between the confluence with Yellow River and the Shelby gage. The black, dashed line indicates the amount of sediment stored on the bed of the Kankakee over time. The amount of sediment stored in the Kankakee sharply increases after each sediment 'slug'. The amount of stored sediment then slowly decreases after each 'slug' until the next one moves into the Kankakee; this indicates a winnowing of the stored sediment and is most notable between March 30, 2017 and May 18, 2017. Little and Jonas also suggested this process in their 2013 report on sediment management in the Kankakee River but lacked the USGS sediment data to document the sediment movement in the channel. Figure 13 demonstrates that the sediment 'slugs' from Yellow River are not permanent, but move through the system over a period of time. This particular example shows that up to approximately 10,000 tons of sediment was deposited, stored, and moved downstream over a period of 126 days.

3.5.2 Singleton Ditch Inputs

Singleton Ditch enters the Kankakee River near Momence, IL, approximately three miles upstream of USGS gaging station at Momence (05520500). The ditch drains approximately 260 square miles of land in northwestern Indiana and northeastern Illinois, most of which is in the southern half of Lake County, IN. Based on estimates derived from USGS gage data, the StreamStats online hydrology toolset, and hydrologic modeling, Singleton contributes more than twice as much flow to the Kankakee River on a per acre basis as the portion of the Kankakee watershed upstream of the confluence with Singleton Ditch during significant flow events.

3.5.3 Iroquois River Inputs

The Iroquois River is the largest tributary of the Kankakee River. At their confluence near Aroma Park, IL, their respective drainage areas are 2,380 square miles for the Kankakee and 2,130 square miles for the Iroquois. Based on long term gaging data at Momence, IL (Kankakee) and Chebanse, IL (Iroquois), mean annual flows in the two rivers have remained nearly equal to each other on a per acre basis for the past 90 years. However, the Iroquois River has produced more than twice as much flow and sediment during high flow events as the mainstem Kankakee on a per acre basis.

The City of Watseka is located at the confluence of the Iroquois River and Sugar Creek, a large tributary. Watseka's position in a low-relief area near this confluence makes it vulnerable to flooding from both streams. Although the mean annual flow has been nearly identical for the two streams on a per acre basis over the past 70 years, the contribution from Sugar Creek is more than twice the contribution of the Iroquois on a per acre basis during high flow events.

3.6 CHANNEL ACCESS AND MAINTENANCE

Access is currently necessary to complete maintenance work along the eroded berms and channel banks, as well as to remove logjams. Logjams along the main stem of the river do not appear to be an issue downstream of the confluence with Yellow River. The width of the channel downstream of this point is far greater than the height of the vast majority of trees, making the development of logjams very unlikely, except for at bridge crossings. Logjams are much more prevalent upstream of the confluence with Yellow River, as well as along the downstream end of Yellow River. In these areas, access along and immediately adjacent to the river may be warranted to allow for logjam removal. However, such an access does not need to be from a continuous berm with the same height, and in many cases it can be accommodated even when portions of a berm are breached for floodplain access.

CHAPTER 4 ALTERNATIVE ANALYSIS

The system assessment key findings suggest that multiple mitigation strategies will be most effective in improving/maintaining the stability and resilience of the Kankakee River system. The river suffers from problems that exist throughout the entire system, issues that are localized to specific sub-watersheds, and issues that are specific to a location along a channel. Mitigation of the systemic stressors is often accomplished with passive measures that involve no channel intrusion and focus on removing the source of instability rather than constructing improvements. Active management measures, or direct intervention in the channel and construction of site-specific improvements, may be warranted when passive measures are not sufficient to reduce or eliminate a stressor. The following sections discuss the active and passive management strategies that were evaluated in the process of developing the Work Plan.

4.1 ACTIVE MANAGEMENT STRATEGIES CONSIDERED

Active river management includes modifications to the stream corridor that directly combat or eliminate the instabilities that are present. Various types of active management strategies can be combined to create robust improvements to specific portions of the channel or the entire channel through a given reach.

4.1.1 Active Management Strategies Recommended for Implementation

The following active management strategies were evaluated and were ultimately selected for recommendation. The selection was based on the measures being beneficial to the overall objectives of the Work Plan discussed in Section 1.3. The complexity of the issues in the Kankakee system make it improbable that a management strategy could be conceived that has no adverse impact to any party/stakeholder. As a result, the selections were based on the solutions that provided the greatest overall value while considering the number and severity of negative impacts. Significant efforts were made to equitably distribute the benefits and negative impacts for the overall Work Plan so that no single entity was disproportionately affected. These selected strategies that are listed generally in the order of priority and effectiveness will be further described in Chapter 5.

1. Reduce Sediment Supply from Yellow River Upstream of Knox
2. Reduce Sediment Supply from Severely Eroded Kankakee Slopes
3. Zone-Specific Access and Logjam Management
4. Large Wood Removal in the Most Downstream Reach of Yellow River
5. Selective and Temporary Berm Maintenance
6. Strategically Remove Berms and Mitigate Flooding using Setback Berms
7. Yellow River Restoration Downstream of Knox
8. Bridge Removal / Replacement
9. Construct Storage Areas along Laterals to Offset Increased Runoff
10. Strategic Flood Protection Measures

4.1.2 Active Management Strategies Not Recommended for Implementation

The following active management strategies were evaluated but are not recommended for implementation. The strategies included in this section were found to provide a benefit to one (or more) of the overall objectives of the Work Plan discussed in Section 1.3, but have a significant negative impact on the remaining overall objectives.

1. **Dredging in the Kankakee and Yellow River**

   Dredging in the Kankakee and Yellow River has obviously been a major part of the history of the system. Dredging was originally used to straighten, widen, and deepen the rivers and it has been used more recently in attempts to increase flow conveyance and provide for sediment storage in sediment traps. The original dredging work that was completed resulted in a tremendous amount of sand being conveyed to Illinois, as well as head-cutting and bank instability upstream of the dredged areas; this outcome is well-documented and cited in nearly every Kankakee study. More recent dredging to construct sediment traps was much more limited and resulted in very short-lived projects that provided little-to-no discernable benefit, as reported by personal accounts from involved parties.

   The potential peril of completing new dredging, both system-wide and localized, is echoed throughout the available studies. Much of the main stem of the Kankakee, particularly the area east of Momence, has deposits of sand that can be over 50-feet deep, making it almost impossible to differentiate between indigenous soil and sand recently transported by the river. Great care must be taken if any sand removal is considered, as removal of sand past the point of the naturally graded channel slope is expected to trigger head-cutting and erosion upstream. As Ivens and others wrote in 1981 – “if at all possible, leave the river alone – work on improving the land around it”. Other studies (Bhowmik, 2001;Little and Jonas, 2013) also concur that strategies aimed at reducing sediment sources are expected to be much more effective than providing in-channel sediment storage.

   The likely negative impact on channel stability is compounded by the anticipated cost of dredging the Kankakee and Yellow River. The Indiana Department of Natural Resources (IDNR) prepared a cost estimate for wholesale dredging of a combined 130 miles of channel. The IDNR cost estimate is provided in Appendix 4 for reference and a listing of the many assumptions used in the analysis. Several of the assumptions list excluded costs that CBBEL believes to be potentially significant. Approximately 510,000 truckloads of material would be removed and hauled on local, state, and federal roadways. This volume of heavy traffic would undoubtedly cause major deterioration of roadways, which would require costly repairs. This cost also excludes land acquisition and disposal site handling and reclamation, which could also be large budget items. Despite the anticipated underprediction, the overall cost for 130 miles of dredging was estimated at $85.5 million.

   A dredging scenario was also considered using the 2D hydraulic model to determine the anticipated impact of dredging the entire bed of the Kankakee by 4 feet from the confluence with Yellow River to the Indiana-Illinois State Line. The anticipated increase in channel capacity allows for flooding depth reduction in the majority of Indiana and increased flooding depths in Illinois, including the downstream portion of Singleton Ditch. The increase in channel capacity also led to a decrease in floodplain activation and an increase in channel velocities that would be expected to increase the amount of sediment conveyed to the Momence wetlands, which would worsen the aggradational trend. Additional details and results concerning the hydraulic model are provided in Appendix 3.

Though system-wide dredging would be expected to have serious detrimental impacts, more strategic, small-scale dredging may be possible without creating significant issues. Locations where there is a consistent, documented over-supply of sediment, such as the downstream end of Yellow River could likely have sediment dredged from the channel without widespread detrimental impact, so long as the work is designed and constructed carefully. However, the effect of such dredging would be expected to be short-lived. Consider the following hypothetical situation: a 40-foot width of the bottom of the channel could be dredged by two feet from the confluence with the Kankakee to a point 1 mile upstream, resulting in approximately 15,600 cubic yards of sediment removal. Had this work been completed prior to February 16, 2018, sediment gage data suggests that the dredged area would have been filled back to the previous condition by April 5, 2018, assuming that only 25% of the incoming sediment load was captured. Based on the per-cubic-yard cost estimated by IDNR (approximately $21/cy) and assuming 10% additional cost for engineering and permitting, this limited dredging project would cost approximately $360,000, likely to be repeated after each major flood!

2. **Modification to the Control Section Downstream of Momence Wetland**

The detailed 2D hydraulic modeling shows that in smaller flood conditions and the initial stages of larger floods prior to floodplain activation, the reach of Kankakee just downstream of Stateline through the Momence wetland controls the elevations upstream; however, as flooding continues and the Momence wetlands fill with water, the control shifts further downstream. Based on the detailed hydraulic modeling performed as part of this Work Plan, it appears that an approximately one-mile reach of Kankakee River, located about a mile downstream of the Singleton Ditch confluence, which is completely within bedrock (Gross and Berg, 1981) acts as a hydraulic control for the upstream reach of the River during large floods. Suggestions have been made in the past regarding attempting to modify this control reach to relieve upstream flooding. However, it should be noted that this restrictive section is also considered as the outlet for the upstream, nationally significant Momence Wetland. Aside from its environmental significance, the Momence wetland also stores a significant volume of floodwater during extreme events. Enlarging the downstream outlet/control section will likely result in degradation of the wetland and the loss of flood storage volume in the wetland, resulting in increased flooding and sedimentation downstream. Such a modification is therefore not recommended due to significant negative impacts to the wetland and to flooding and sedimentation impacts downstream.

3. **Converting Berms to Levees for Flood Control**

   Converting the existing spoil piles and berms to qualified flood control levees along the Kankakee River will reduce the floodplain storage that currently occurs. The disconnection of the flood storage that is currently provided will result in an increase in flow rates downstream of the levee due to the loss of flood storage, and an increase in flooding elevations upstream due to the constriction of the flow. These issues will become more severe if the height of the berm is increased during the conversion process as well.

   Attempting to improve the current berm system to the point where it could provide flood protection along the entire river corridor is not feasible under current conditions and will only become less attainable as floods worsen in the future.

4. **Clearing Trees from Banks**

   Trees should not be cleared from the channel banks as a maintenance strategy. The removal of the trees is not necessary to avoid the potential for logjams, particularly in the portion of the Kankakee downstream of Yellow River. Upstream of Yellow River, selective tree removal should only be used to remove trees that have fallen down or those that lean more than 45 degrees to the bank. In all cases, the root system should be left intact to allow for continued reinforcement/stabilization of the bank sediments. Disturbance of surface vegetation and root systems during tree removal and/or grubbing opens up the sandy material for erosion and can lead to instability.

5. **Bypass Channel near Watseka, IL**

   Constructing a bypass channel to reduce peak flows at Watseka, IL is not feasible. Topographic constraints would limit construction to only Sugar Creek, and thus flooding due to the Iroquois River would not be reduced. Due to the extremely low channel bed slopes of Sugar Creek and the Iroquois in the Watseka area, a channel designed to intercept enough flow to reduce the 2018 flood to a 10-yr event on Sugar Creek would need to be approximately 450 feet wide at the upstream end and approximately 75 feet wide at the downstream end, 6 miles long, and an average cut depth of 28 feet, requiring approximately 12 million cubic yards of excavation. Regardless of a likely $300 million order of magnitude of estimated cost of such a bypass channel, were such a channel constructed, Watseka would receive less direct flooding from Sugar Creek but would still experience backwater effects from the Iroquois River on the downstream side of the city. The bypass channel would also increase the flow rate in the channel downstream of Watseka, potentially worsening flooding downstream, due to the increased flood conveyance capacity.

6. **Flood Control Ponds Upstream of Watseka, IL**

   Constructing flood control ponds upstream of Watseka, IL along either the Iroquois River or Sugar Creek would be prohibitively expensive due to the topography of the region. For example, to capture enough flood volume to reduce the 2018 event to a 10-yr flooding event would require the storage of approximately 12,000 ac-ft of water along the Iroquois River and 5,000 ac-ft along Sugar Creek, taking thousands of acres of agricultural land out of production.

Constructing the ponds outside of the current regulatory floodplain extent would require the removal of several feet of overburden before flood storage could begin, on top of the thousands of acre-feet that would need to be removed for the pond itself.

4.2 PASSIVE MANAGEMENT STRATEGIES CONSIDERED

While implementation of active mitigation measures will be necessary to address some of the most pressing hazards along the corridor, passive measures are expected to help mitigate the current risks and to reduce the likelihood of an increase in future streambank erosion and flooding risks.

Some of the factors that are contributing to channel instability in the Kankakee system are beyond anyone’s ability to eliminate or even reduce. The height and soil composition of the banks are one example. While the soil can be armored and the embankment reinforced in select locations, it is not feasible (or advisable) to armor and reinforce the whole stream. Increasing rainfall intensity is also beyond the control of local jurisdictions. These factors have a significant cumulative effect on the channel/bank stability and flooding risk along the river corridor.

The inability to control certain factors does not preclude the ability to make good river and risk management decisions. Keeping a watchful eye on areas that are at risk is paramount to mitigating that risk. Being aware of the factors contributing to instability will also allow informed decisions on the types of improvements to the stream corridor and watershed that can help reduce instability, such as additional floodplain storage and maintaining/improving floodplain connectivity and promoting more sustainable land management practices that reduce runoff. Despite all the efforts that can be made, there will always be some residual risk of flooding and erosion. Understanding what and where the risks are is the first step to managing that risk. The passive management recommendations focus on changes that can be implemented both within the river corridor landward of the channel banks and watershed-wide to help manage the unavoidable risks associated with flooding and fluvial erosion.

The apparent severity of the hydrologic stressors in the contributing watershed (e.g. increased rainfall, more frequent high flows, more runoff volume, etc.) suggests that efforts should be made to promote more conservative and environmentally friendly drainage practices, particularly in agricultural settings. Control structures on tile drainage systems, cover crops, no-till, and preserving depressional storage areas could help to limit further increases in flow rates and volume and possibly reverse some of the detrimental effect of past drainage activities.

4.2.1 Passive Management Strategies Recommended for Implementation

The following passive management strategies were evaluated and were ultimately selected for recommendation. The selection was based on the measures being beneficial to the overall objectives of the Work Plan discussed in Section 1.3. The recommended passive measures differ from the active measure recommendations in that the strategies have no meaningful negative impacts, except for adding mitigation requirements to activities that would otherwise harm other stakeholders. These selected strategies will be discussed in detail in Chapter 5.

1. Update Stormwater Ordinances and Technical Standards
2. Mitigate Agricultural & County Drainage Project Impacts
3. Incentivize Cover Crops
4. Rill / Gully Mitigation
5. Develop Flood Response Plans
6. Develop Flood Resilience Plans
7. Resilience Strategies for Watseka, IL
8. Strategically Relocate Infrastructure from Berm-Reliant Areas

4.2.2 Passive Management Strategies Not Recommended for Implementation

The following passive management strategies were evaluated but are not recommended for implementation. The strategies included in this section were found to provide a benefit to one (or more) of the overall objectives of the Work Plan discussed in Section 1.3, but have a significant negative impact on the remaining overall objectives.

1. **Increased Tile Drainage to Reduce Flooding**

   As noted in Section 3.4, increasing the drainage density of an area increases the volume and intensity of runoff. The use of tile drainage to reduce flooding in areas that are currently not tiled will result in increased runoff. Significant increases in flows should be expected if tile drainage improvements in areas that are not currently tiled occurs on a system-wide basis. While addition of tiles in a newly-tiled area will likely reduce the severity and duration of flooding, it merely transfers the problem to another location.

2. **Construction/Improvement of Ditches to Increase Flood Conveyance**

   Flood-conveyance construction and improvement projects on ditches that contribute to tributaries of the Kankakee should be avoided, unless the flooding poses a risk to critical infrastructure or human life. Conveyance improvements along tributary ditches have the same effect as expanding or improving the tile drainage system - downstream flow rates are increased. Where improvement projects are deemed necessary, runoff detention should be implemented to mitigate the negative impacts to downstream areas, as discussed in Section 5.2.2.

3. **Berm Improvements along Tributaries**

   Improving berms along tributaries would result in a similar loss of floodplain storage as improving berms along the Kankakee. As a result, increasing the height of berms along tributaries and drainage ditches should not be done. This includes the disposal of spoil material when cleaning ditches. Side-cast material should be spread out such that the heights of the bank along the ditch is not increased. Raising berms along these waterways would result in worse flooding along the channel immediately upstream of the improved berms and potentially increased flow rates downstream due to the loss of floodplain storage.

CHAPTER 5 RECOMMENDATIONS

The preliminary findings and discussions provided in previous chapters provide the background information for making prudent decisions regarding improvements within the Kankakee watershed and river corridor. Recognizing the extent of the existing risks and the likely future vulnerabilities in the face of a changing climate, addressing the flooding and sedimentation issues within the Kankakee River Watershed will require both adaptation and mitigation. Adaptation and learning how to live with floods is necessary because there are no feasible structural solutions to eliminate the vulnerability to flooding along the Kankakee River, especially given the increasing trends in peak flows and volumes. Mitigation is necessary to combat the increasing flows and reduce the vulnerabilities as much as possible, when feasible and as funding allows.

The following recommendations focus on providing sustainable, cost-efficient strategies for reducing the flooding and sediment-related issues present in the system. The recommendations are divided into active management recommendations (i.e. projects that include physical changes within the river corridor) and passive management recommendations (i.e. regulatory changes and watershed-based improvements).

5.1 ACTIVE MANAGEMENT RECOMMENDATIONS

The following active management strategies have been listed in the order or priority and recommended implementation. Exhibit 3 is composed of 15 panels that show the recommended Work Plan components along the Kankakee River. Exhibit 4 is composed of 4 panels that show the recommended Work Plan components along the Yellow River.

5.1.1 Reduce Sediment Supply from Yellow River Upstream of Knox

The Yellow River upstream of Knox has been historically cited as a significant source of sediment to the Kankakee system due to the pervasive bank instability. This was further confirmed and discussed in detail in a 2015 system assessment study by CBBEL. As part of that study, recommended strategies were developed to improve the stability of the Yellow River in Starke County, ultimately reducing the sediment load to the Kankakee River. The proposed improvements also include mitigation of several unstable banks near the Starke-Marshall County line that pose a particular threat as a result of the bank height and proximity to homes.

The upstream portion of Yellow River should be stabilized/restored to reduce the supply of sediment into the river, as shown in Exhibit 5. The improvement concept is based on the Yellow River Pilot Project which has proven to be successful. The pilot project involved installation of toe wood, bankfull benches, and vegetated soil lifts to stabilize the sandy soils that form the channel banks. These methods are nature-based techniques that utilize vegetation and natural materials to produce stable slope and a more appropriate channel cross section, as discussed in Section 3.1. This type of stream stabilization/restoration is more appropriate for a sand-bed system, such as the Yellow and Kankakee Rivers, as the methods provide a more resilient channel shape that is reinforced with robust vegetation. The remaining portion of the identified area contains varying degrees of instability and bank heights. As a result, minor adjustment of the details used in the Pilot Project may be warranted. The restoration efforts should begin at the upstream end of the impaired area and continue downstream in a contiguous fashion.

The stabilization of these severely eroded and failing slopes is expected to greatly reduce the contribution of sediment from the Yellow River. Elimination of the sediment load from the bank failures, estimated at 25,000 tons per year, is expected to improve the performance of the portion of the Yellow River downstream of Knox by decreasing the size of the sediment ‘slugs’ that are pushed into the Kankakee during significant flow events.

The recommended improvements to the upstream portion of Yellow River are shown in Exhibit 4 and include approximately 13 miles of streambank restoration; typical proposed improvement details are shown in Exhibit 5. The anticipated cost for the improvements is approximately $23.1 million; additional details concerning the anticipated cost for the improvements is provided in Appendix 4. This cost includes two high-bank areas near the Starke-Marshall County border that are notably more expensive to mitigate due to the extreme height of the banks.

5.1.2 Reduce Sediment Supply from Severely Eroded Kankakee Slopes

Several locations along the Kankakee are currently severely eroded and appear to be contributing a significant amount of sediment to the river. Future berm/slope failures and erosion are also anticipated as a result of the over-steepened slopes, bank and berm height, and highly erodible materials. The eroded sediments should be stabilized using bioengineering techniques in most cases. Some particularly severe slope failures may require additional remediation; site specific improvements should be developed on a case-by-case basis. Previous studies and the current assessment agree that in-channel modifications are challenging when trying to develop long-term solutions in the Kankakee. Implementing improvements to and in the floodplain, as described in Section 5.1.5, allow for benefit without the heightened potential for inciting instability or undue cost.

The location of identified slope failures are shown in Exhibit 3 and a typical detail of the recommended remedial action is shown in Exhibit 6. A summary of the unstable bank length for each county along the Kankakee is provided in Table 11. The anticipated cost for stabilizing the impaired banks in Indiana is $5.2 million; the anticipated cost for stabilizing the banks in Kankakee County is $460,000. More details concerning the estimated cost for the improvements are provided in Appendix 4.

Table 11: Summary of Unstable Slopes along the Kankakee by County

County	Length of Unstable Banks (mi)
LaPorte	1.2
Starke	3.5
Jasper	11.3
Porter	4.8
Newton	2.4
Lake	0.1
Kankakee	2.1
TOTAL	**25.4**

5.1.3 Zone-Specific Access and Logjam Management

Much of the river does not require continuous access along the bank, and it is not advisable and not necessary to maintain the berms for that sole purpose. Maintenance of existing berms should only be completed in accordance with Section 5.1.5. The remainder of the berms and access routes should not be maintained. Access for logjam removal is not necessary along the main stem of the Kankakee downstream of the confluence with Yellow River. In the unlikely event that a logjam develops and threatens channel stability and capacity, amphibious equipment should be used, rather than continual maintenance of the existing access roads on top of the berms. A 37.6 mile-long, single-sided access route along the Kankakee upstream of the confluence with Yellow River may be used due to the increased risk of logjams; however, amphibious log removal equipment can be used in both segments to prevent the need for channel-side access. Exhibits 3 and 4 provide the location and alignment for the access route along the upper reach of the Kankakee and downstream reach of Yellow River.

Logjam removal at bridges will always be a maintenance concern. As a result, improvements at bridges should be made to promote better and more permanent access for logjam removal. A total of 25 access points at bridges should be improved to allow for easier access and debris removal.

The estimated access improvement cost for the 25 bridge locations and maintaining the access route along the upper reach of the Kankakee River is $2.2 million. More details concerning the estimated cost for the improvements are provided in Appendix 4.

5.1.4 Large Wood Removal along Yellow River at Fish and Wildlife Area

The removal of large wood in Yellow River downstream of State Road 39 should be performed to reduce bed aggradation and to help reduce the potential for logjam-induced bank instability. The log removal should be done carefully so as not to disturb/destabilize the adjacent channel banks. The use of amphibious log removal equipment is preferred. An allowance of $117,000 has been allocated to the large wood removal.

5.1.5 Selective and Temporary Berm Maintenance

Although desirable for the overall stability and flood damage reduction goals, the extent of the berms along the Kankakee River and its tributaries is too great to make the complete elimination or breaching of the berms and constructing setback berms feasible in the short term. It is currently recommended that a few selected berms are maintained in cases where they are continuous and appear to provide some level of flood protection for large areas, serve as access along the Kankakee upstream of Yellow River, or will be very challenging to remove from a logistical, political, or cost perspective. It was not considered reasonable to attempt to undo more than 100 years of modifications in less than 40 years. It is also important to recognize that the river will continue to adjust to changes in the amount and frequency of received precipitation - it is a dynamic river.

A total of 8.6 miles of existing berms should be maintained, as needed and mostly in a reactive approach, for the duration of the current Work Plan, with the intent that they will ultimately be breached and have setback berms constructed at a later date when that becomes feasible. The locations of these existing berms are shown in Exhibit 3. The intent of the maintenance is to implement the minimum amount of repair to keep the berms in place until the eventual goal of replacing the berm's function with a setback berm becomes financially and logistically feasible as circumstances change and funding opportunities arise; the maintenance efforts should not seek to improve the berms to a point where they will be resilient to deterioration in perpetuity. The maintenance and repairs should focus on preventing bank failures from releasing sediment into the Kankakee (see Section 5.1.2) and to maintain the current top of berm elevation. A hypothetical example of the measures that should be employed are shown in Figure 14.

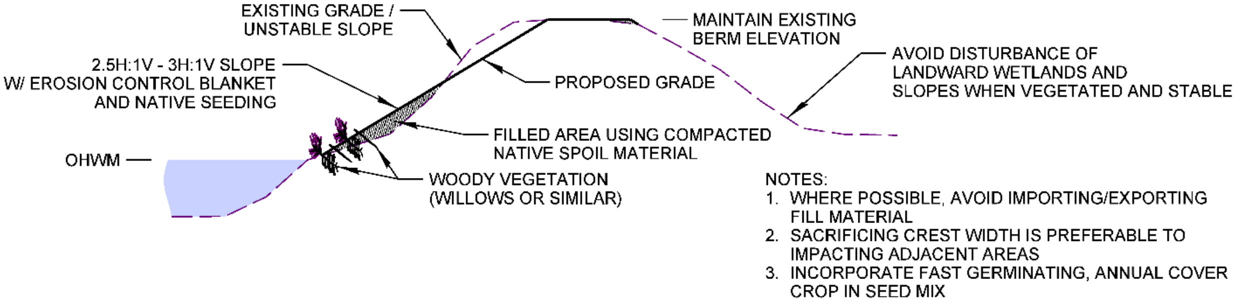


Figure 14: Example of Temporary Berm Maintenance Measures

An allowance of approximately $9.3 million has been allocated to maintain the 81.6 miles of berms over the next 40 years, which is approximately $232,000 per year. More details concerning the estimated cost for the improvements are provided in Appendix 4. It should be noted that the allotted funding is not sufficient for complete rehabilitation of the berms, as that is not the intent of the maintenance.

5.1.6 Strategically Remove Berms and Mitigate Flooding using Setback Berms

A system-wide set of constructed breaches in existing berms is recommended to activate inadvertently cut-off, naturalized floodplain areas and increase floodplain storage in particularly low-lying areas. The berm segments selected for breaching were carefully evaluated, preferentially selecting non-agricultural areas. Where the riverside berms were found to be continuous and provide some level of flood protection, alignments for setback levees were established to provide the same elevation of flood protection as the lowest point in the riverside berms protecting the area. The intent of the berm breaches and setback berms is to remove the need for maintaining the existing riverside berms, to provide more room for the river and connect it to its floodplain, and to eliminate the constant concern over bank and berm conditions.

In general, the berms along the Kankakee and its tributaries should not be maintained, and in many cases should be partially or completely removed. Berms that prevent effective use of areas identified as critical floodplain storage should be breached for a minimum of 100 feet at the upstream and downstream end of the berm to increase floodplain connectivity; additional breaches between the upstream and downstream ends may be necessary for larger floodplain areas and longer berms. Figure 15 and Figure 16 show a typical profile and a typical cross section of the suggested strategic breaches.

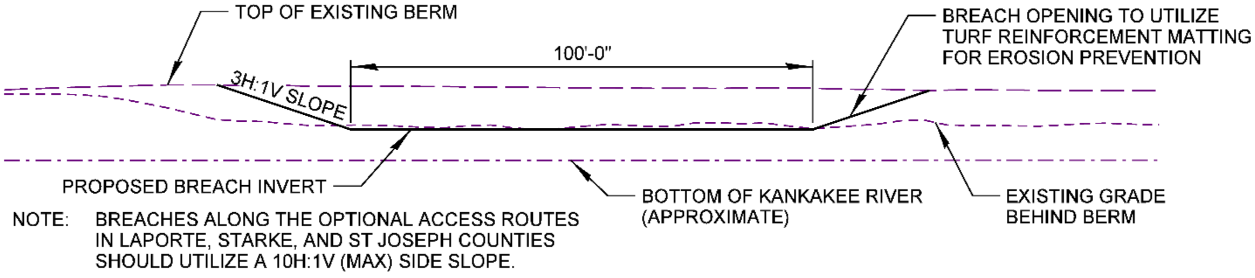


Figure 15: Typical Profile View of Strategic Breach in Existing Berm

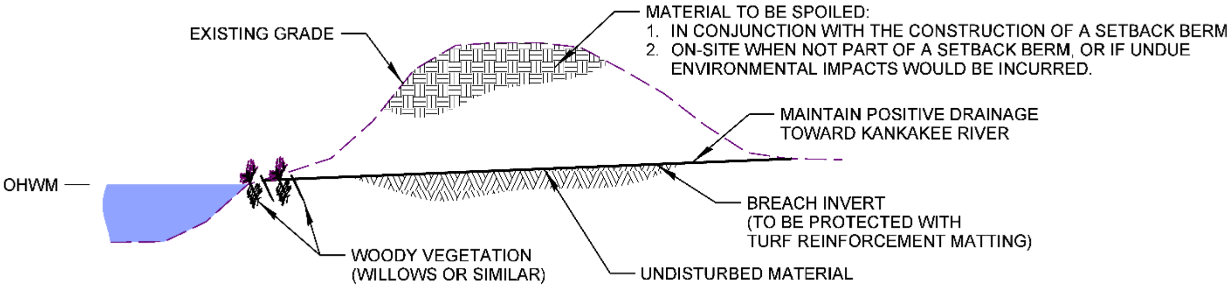


Figure 16: Typical Section View of Strategic Breach in Existing Berm

Berms that provide meaningful flood protection to critical facilities or residential clusters away from the river channel should be removed or breached and replaced with strategic flood protection measures closer to the infrastructure or property being protected, as discussed in Section 5.1.10. Reinforcement or expansion of existing berms along the Kankakee by private landowners should be strongly discouraged and prohibited where possible. The ultimate objective of the strategic berm removal/breaching is to reestablish a functional floodplain adjacent to the main stem of the Kankakee and to eliminate the costs associated with maintaining features (berms) that are non-essential. The berm removal/breaching is intended to be strategic in that the reactivated floodplain areas are typically limited to natural wetlands or sub-marginal farmland.

Included in this recommendation is the removal/breaching of the internal berms at the Kankakee Fish and Wildlife Area to allow the free exchange of water between the Kankakee and Yellow River during flooding events. This will allow the rivers the greatest possible access to natural flood storage areas, return the Fish and Wildlife Area to a more natural hydrologic regime, and remove the need for active management by State entities in response to flood events.

Strategic removal/breaching of berms should be used to focus storage in designated areas to reduce impacts elsewhere. Storage opportunities may be encouraged and incentivized by purchasing property and leasing lands adjacent to the river, or by purchasing flood easements. Purchasing the property and leasing it to the previous (or other) landowner prevents the landowner from experiencing a loss of land value while maintaining the ability to farm the area. Purchasing a flood easement provides the landowner with one-time compensation for potential future losses and allows the farmer to either farm the area or leave the area fallow. It may be more appropriate for some of the more flood prone areas to be purchased and kept in permanent wetland management.

Hydraulic analysis of a scenario where all of the berms adjacent to the Kankakee are removed suggests that flow rates could be reduced by approximately 15% and flooding elevations in certain areas being lowered by 1.5 feet. This scenario was simulated to gain an understanding of the full potential of Kankakee River berm removal; however, the existing berms along tributaries and field ditches were left in place, which prevents a full activation of all potential floodplain areas. The proposed breaches and setback berms were also simulated in the hydraulic model to determine the anticipated impact. Flow rates and flooding elevations were reduced by a smaller margin, 9% and 0.9 feet, respectively. These reductions in flow rates and flood elevations were variable depending on the location along the Kankakee and the current condition of local berms. Reaches of the river with smaller cross-sectional areas and/or berms that currently inhibit activation of available flood storage (e.g. near Davis, IN) generally saw greater reductions in flood elevation under alternative berm management scenarios than portions of the Kankakee that are wider and/or currently have greater access to floodplain storage (e.g. Dunns Bridge or Shelby, IN).

The improvements are primarily aimed at producing a more resilient river, reducing flooding and erosion-related losses, and preventing future losses by providing additional floodplain storage and eliminating incompatible land uses; however, reactivation of disconnected floodplain and wetland areas is also expected to result in substantial ecological benefit. While the ecological benefits have not necessarily been the primary target for this Work Plan, maximizing this ancillary benefit may be key to streamlining the permitting process and, more importantly, helping to attract funding partners, as discussed in Section 6.3.

A schematic showing the location of recommended berm breaches is provided in Exhibits 3 and 4. The anticipated cost for the constructing the berm breaches and setback berms is approximately $58.8 million; additional details concerning the cost of constructing the improvements is provided in Appendix 4.

It should be noted that the selection and alignment of setback berms, either existing or proposed/improved, shown on Exhibit 3 was based on a conceptual level of analysis using desktop methods. The location and condition of these berms have not been field-verified. The final decision as to the location of constructed berm breaches as well as the alignment and the need for improvement of any existing berm to act as a setback line of protection will be made prior to the design and construction phase of each berm segment and expected to involve detailed field visits, consultations with local authorities/property owners having more intimate knowledge about the condition of these berms, and additional hydraulic analysis (as needed).

5.1.7 Yellow River Restoration Downstream of Knox

The imbalance in the sediment carrying capacity and the sediment supplied to the 8.6-mile reach of the Yellow River downstream of Knox, IN causes the channel to aggrade heavily and release pulses of sediment during large events. These sand pulses result in a sediment imbalance in the Kankakee that contributes to temporary aggradation in the Kankakee and the aggradational trend in the Momence wetland area. Constructing a more stable geometry that allows the downstream end of Yellow River to convey an amount of sediment that is proportional to flow will help to eliminate the sediment pulses and subsequent aggradation downstream.

Emergency measures could be completed earlier in the implementation sequence, as discussed in Sections 4.1.2 (1) and 6.2, to temporarily reverse the aggradation in the downstream end of Yellow River; this is best done by narrowing the width of the river in this area through building of toe wood reinforced benches, with the soil material needed for the bench coming from deepening the river bottom to create pools. In lieu of such long-lasting restoration method, temporary and selective dredging in this particular area may be considered. However, the dredging of sediment must be carefully done to a limited area. It must be noted that this is a discretionary improvement that is expected to have temporary and limited benefit.

The improvements to Yellow River upstream of Knox are expected to reduce the overall sediment load and the size of the ‘slugs’ pushed into the Kankakee during significant events; however, a more consistent delivery of sediment from Yellow River that is proportional to the amount of flow in the stream is critical to the overall improvement of the Kankakee. Improvements to the downstream portion of the Yellow River are necessary to achieve this objective. The recommended improvements from the 2015 CBBEL Yellow River System Assessment are expected to allow for an improved balance between the sediment carrying capacity of the Kankakee and the sediment supplied to the river, which ultimately produce a system that is stable over the long term.

The performance of the improvements to the upstream portion of Yellow River and the resulting reduction in sediment load should be monitored for 2 – 3 years prior to designing the downstream improvements to promote a more sustainable design.

The recommended improvements to the downstream portion of Yellow River are shown in Exhibit 7. The total anticipated cost for the improvements is approximately $13.9 million. A cost estimate for the improvements is provided in Appendix 4.

5.1.8 Bridge Removal / Replacement

There are 27 bridges along the main stem of the Kankakee in Indiana. Several of the bridges are abandoned and others have poorly located or poorly aligned piers. The number and location of piers is a critical feature as the piers result in debris jams at the bridges. Previous hydraulic analyses suggest that the bridges themselves do little to back-up water during flooding events, which indicates that the back-up of water observed during flooding events is almost entirely due to debris being caught on the piers. Removal and reconfiguration of several key bridges will help to reduce the overall issue with log/debris jams and will help to reduce unnecessary flooding during storm events.

Several problematic bridges that impede the transport of flow and sediment during flooding events were identified during field observations of the river corridor. Bridges that still serve a purpose should be removed and replaced to better align the bridge supports to minimize flow interference, most notably the State Line Bridge, the railroad bridge upstream of the mouth of Dehaan Ditch, and the railroad downstream of US Highway 30. Bridges that have been abandoned should be removed entirely. A map of the identified bridges and the recommended action is provided in Exhibit 3. The anticipated cost of removing and replacing the identified bridges is $8.4 million. A summary of the costs associated with the bridge removal/replacements is provided in Appendix 4.

5.1.9 Construct Storage Areas along Laterals to Offset Increased Runoff

Where possible, it would be advantageous to either construct new retention/detention ponds along drainage ditches and tributaries to the Kankakee or take advantage of existing low-lying, non-arable land in these areas to increase temporary storage capacities during runoff events. This would help attenuate the shorter runoff hydrographs and more intense peak flows that have developed due to increased urbanization and agricultural drainage within the Kankakee watershed. Utilization of “off-line” storage adjacent to ditches or tributaries would allow the agricultural lands to benefit from the increased drainage capacity that has been developed over time but reduce the impact that these activities have on downstream areas.

Storage areas (i.e. detention basins) should be constructed along tributaries to the Kankakee where possible. Future drainage improvements that increase runoff volume and flow rates, both urban and agriculturally-based improvements, should be required to implement volume and flow reduction measures to mitigate the detrimental impact to downstream areas. Detention basins should be constructed off-line (i.e. adjacent to, not in the channel) to maximize the benefit. The intent of this recommendation is to promote more sustainable and responsible stormwater management and to help reduce the magnitude of the effects of a changing climate on the Kankakee system as a whole. Determination of the location and required storage volumes to significantly reduce peak runoff is beyond the scope of this Work Plan. An annual allocation of $315,000 has been accounted for in the Work Plan for constructing detention storage. Details concerning the cost of constructing the detention basins is provided in Appendix 4

Future drainage improvements and the recommended off-setting detention basins should not be funded by the KRBC, but rather the developer or farmer implementing the drainage improvements.

5.1.10 Strategic Flood Protection Measures

A strategic approach is recommended for implementing flood protection measures due to the inability to sustainably protect the entire river corridor outside of the channel. Active flood protection efforts should be limited to critical facilities, key infrastructure, and development clusters.

Although there are numerous isolated structures and roads that are vulnerable to flood risks, providing perimeter protection around these isolated structures or roads is typically cost prohibitive. However, a better chance for finding an economic solution exists when many vulnerable structures are clustered. Four separate significant development clusters were identified as being at risk in Indiana; the locations are shown in Exhibit 8. The anticipated cost of constructing flood protection measures for these four areas is $48.4 million. The summary of the costs associated with the improvements is provided in Appendix 4 and represents a preliminary estimate at this time. A more detailed analysis is necessary to evaluate the details of the improvements due to the more stringent requirements for certified flood control infrastructure. In addition to the noted four residential clusters, the Knox Wastewater treatment plant and several major transportation routes are also located within the floodplain that would need to be protected through appropriate strategic flood control and/or erosion prevention measures. Cost estimates for these latter at risk infrastructure has not been determined.

The flood risk reduction measures discussed above are intended to protect the public from existing flooding risk, not associated with the management decisions regarding the health and stability of the Kankakee and Yellow River corridors - the primary responsibility and focus of the KRBC. These types of improvements should be further evaluated and funded primarily through State or Federal programs, or through the municipalities as part of a comprehensive flood resilience plan developed for each at-risk community. As a result, the estimated costs of these measures were not included as part of the Work Plan estimated costs.

Momence, Sun River Terrace, and Kankakee in Illinois all have areas that are at flooding risk. Multiple concerns/issues prevent these locations from being good candidates for flood protection measures. The properties along the Momence wetlands are within the regulatory floodway; furthermore, a line of protection could not be created on the riverward side of the properties without impacting the wetland. Few other properties within the municipal limits of Momence are at significant flooding risk from the Kankakee. A cluster of properties on the northwest side of Sun River Terrace are mapped within the regulatory floodplain; however, an evaluation of the regulatory flooding elevation reveals that the mapping is in error. As a result, mapping updates should be sought, rather than flood protection measures. Finally, the development on the south side of Kankakee is situated at the confluence of the Kankakee and Iroquois River. This area is particularly difficult to protect against flood, as there are two flooding sources that are both major rivers. A more sustainable approach is recommended to alleviate the flooding risk in this area due to the likelihood for further increased flow rates in the future. Current and future development should be promoted in flood-free areas and efforts should be taken to reduce the amount of infrastructure and number of properties within the floodplain in this area.

5.2 PASSIVE MANAGEMENT RECOMMENDATIONS

5.2.1 Update Stormwater Ordinances and Technical Standards

The analysis of the Kankakee stream gage data and other recent studies show a clear increasing trend in flow rates despite the current level of stormwater detention requirements within the watershed. Up-to-date and progressive stormwater standards may address some of the contributing factors and help reduce further increases in peak flow rates caused by new development and redevelopment.

Some degree of detention is already required in most of the counties and municipalities within the Kankakee and Iroquois watersheds in Indiana, and some of the counties and municipalities within the watershed also have additional requirements to compensate for loss of floodplain storage; however, such requirements are not consistent throughout the watershed. In many cases the current requirements lack up-to-date, No-Adverse-Impact measures. The current stormwater and floodplain regulations within all jurisdictions in the watershed should be updated to include, at a minimum, the following provisions:

- Retention (preferably) or 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 1.5:1 compensatory floodplain storage when the existing floodplain storage is proposed 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 along the rivers and tributaries
- Requirements and incentives for using Low Impact Development (LID) and Green Infrastructure (GI) practices throughout the watershed

These updates should be undertaken and funded directly by each respective drainage board or municipality within the watershed. The respective counties and municipalities should coordinate their stormwater standards to the greatest extent practicable to promote more consistent stormwater management throughout the Kankakee watershed (including areas within the Yellow River and Iroquois River Watersheds).

5.2.2 Mitigate Agricultural & County Drainage Project Impacts

Typical stormwater ordinances and technical standards within Indiana and Illinois (as well as other states in the country) do not apply to farm drainage practices and county drainage boards’ ditch improvement projects. However, similar to the impacts of new development and re-development in urban areas, the farm drainage activities as well as county drainage board ditch improvement projects significantly increase the runoff in the Kankakee and Iroquois River tributaries and eventually in the Iroquois River and Kankakee River themselves. Provisions such as the use of cover crops, agricultural drainage management structures, 2-stage ditches, and construction of detention ponds as part of any drainage board ditch improvement projects can help compensate for these increases.

The use of 2-stage ditches (as opposed to conventional trapezoidal ditches) should also be encouraged or required when the tributary is experiencing instability. The introduction of a floodplain within the overall channel banks will help to increase the stability and capacity of the ditch while also providing water quality and ecological benefits. Additionally, runoff detention should be incorporated as constructed or restored wetlands, where possible, to improve the overall benefit and potentially open opportunities for shared funding.

Therefore, it is recommended that the KRBC encourage the county drainage boards in the watershed to require/provide compensation for impacts of farm drainage and county drainage board ditch improvements. Similar measures should be instituted by Kankakee and Iroquois counties in Illinois.

5.2.3 Incentivize Soil Health Practices

In agricultural areas, adoption of soil health practices has been found to have a noticeable impact on runoff amounts. More organic material in the soil equates to an increase in soil moisture potential, or the ability of the soil to store water. Essentially, organic material in the soil is the agricultural equivalent of bioinfiltration/rain gardens in the urban setting. There are also substantial benefits for agriculture in terms of decreased energy overhead and increased drought tolerance. The set of practices that

Figure 17: Cover Crop Growing in Harvested Corn Field

the NRCS terms “soil health” appear to be the future of sustainable agriculture and have the potential to change water management in agricultural regions of the United States.

Current farming practices focus on tillage and clearing the land for ‘the crop’. Soil health practices instead focus on continuing the crop and continuing to improve the soil. An example of a cover crop implementation is shown in Figure 17. Soil health is a work in progress, with experiments across the country attempting to document the benefits of a soil health system. Farmers in Indiana are reporting increased drought tolerance and an increase of as much as 27,000 gallons of water storage per acre with a 1% increase in soil organic matter, an increase that could reasonably be expected after several years of soil health improvement practices. That number will certainly vary with soil texture, antecedent conditions, and a number of other factors, but the significance is that small increases in soil organic matter content can lead to very large increases in the infiltration and moisture holding capacity of a watershed.

It is recommended that soil health practices be promoted through education and outreach programs to inform landowners of the benefits and available federal assistance for implementing the measures. The specific soil health practices that should be employed in the Kankakee and Iroquois River watersheds are as follows:

1. Cover crops (with perennial plants in seed mixes)
2. No-till
3. Integrated pest management
4. Diverse crop rotations
5. Rotational livestock grazing

Historically, the Kankakee watershed in Indiana contained vast wetland areas that provided ample water storage throughout the year. Currently, over 80% of this watershed is occupied by agriculture. Thus, increasing the infiltration and runoff storage potential of farmlands by employing soil health practices is one of the most effective ways to reduce basin-wide runoff today.

5.2.4 Rill / Gully Mitigation

Rill erosion occurs when shallow overland flow becomes concentrated, allowing the water to erode small channels in the soil. Over time, these small channels concentrate the runoff further, which continues to deepen and widen the rills until they form gullies. This process increases the amount of runoff and soil loss that occurs during precipitation events. In extreme cases, gullies can become severe enough to prevent the passage of farm equipment. The NRCS has identified several methods of reducing rill and gully erosion both during and outside of the traditional growing season. Planting crop rows perpendicular to the land slope (contour cropping) can decrease runoff velocity and erosive potential. Planting a cover crop and/or leaving residue on the field after harvest helps increase infiltration and decrease water and sediment losses. Additional conservation practices such as grassed waterways and water and sediment control basins (WASCOBs) can be effective strategies in certain areas. Local NRCS agents can provide information about all of these practices, as well as discuss possibilities for financial assistance through programs such as the Environmental Quality Incentives Program (EQIP) and Conservation Reserve Program (CRP).

Numerous rills were identified during the assessment of the Iroquois River. Rills were most extensive from western Newton County to near Sheldon, Illinois. Rill development was particularly significant in western Newton County. Based on the overall observed stability and absence of bank erosion along most of the mainstem of the Iroquois River, these rills may be a significant source of fine-grained sediment into the Iroquois River and ultimately the Kankakee.

5.2.5 Develop Flood Response Plans

Flooding along the Kankakee, Yellow River, Iroquois River, and other tributaries is unavoidable. Flood response plans should be developed for each flood-prone community along the corridor to help emergency responders take appropriate actions in response to flooding of homes, critical infrastructure, and transportation corridors. Such plans would provide guidelines on how to forecast, detect, and classify the severity of the flooding event, communicate with emergency response personnel, notify affected citizens, take appropriate flood fight actions, and implement post-flood recovery. Similar to other flood response plans developed within the State of Indiana, the funding and development of these flood response plans in Indiana can likely be undertaken directly by Indiana Office of Community and Rural Affairs (OCRA) and Indiana Department of Homeland Security (IDHS). Similar agencies in Illinois may be able to help fund the development of such plans for at-risk Illinois communities.

5.2.6 Develop Flood Resilience Plans

Resilience strategies should be adopted by counties and communities affected by flooding along the Kankakee, Yellow River, Iroquois River, and other tributaries to help curb an increase in flood vulnerability and mitigate flood damages. Flood resilience plans include identifying and agreeing upon strategies specific to each distinct geographical planning area within each community, including: River Corridor Impact Areas, Undeveloped Flood Hazard/Storage Areas, Moderate Flood Risk Areas, Vulnerable Developed Areas, Safer Areas, and the Watershed. Typical mitigation measures identified through resilience plans include flood protection around critical infrastructure such as water and wastewater treatment plans, hospitals, and other major facilities. Similar to other flood resilience plans developed within the State of Indiana, the funding and development of these flood resilience plans in Indiana can likely be undertaken directly by Federal Emergency Management Agency (FEMA), IDNR, OCRA, and/or IDHS. Similar agencies in Illinois may be able to help fund the development of such plans for at-risk Illinois communities.

5.2.7 Resilience Strategies for Watseka, Illinois

As discussed in Section 3.3.1 and illustrated in Figure 9, significant flood risk exists in Watseka. Given the extent of flood risks, the special situation of the low-lying areas within the City at the confluence of two major streams, and the size of the drainage area, no feasible solution exists to reduce the existing extent of the risk areas. Consequently, flooding for this area should be viewed as a regularly occurring hazard. Adopting appropriate flood resilience strategies specific to the City 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 in Watseka and its planning areas.

Specific resilience strategies should be identified, agreed upon, adopted, and implemented by the City of Watseka within distinct resilience planning areas as specified below and summarized in Exhibit 9.

1. *River Corridor Impact Areas*—The river corridor impact area is defined by the floodway. The intent of strategies in this area is to protect land adjacent to the river and 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.
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. 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.
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 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.
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 other high flood hazard 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 flood storage areas, and the adoption of a flood response plan. Potential buyout/acquisition priorities have already been identified by the City of Watseka and the properties are being bought out and removed through FEMA grants.

5. *Safer Areas*—This designation would identify areas where public investments and policies should encourage 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 community 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/LID/Green Infrastructures in these safer areas, and promoting placement of critical facilities only 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 Iroquois River watershed, including the Iroquois Conservancy District in Indiana, to slow, spread, and infiltrate flood water through encouraging adoption of higher, No-Adverse-Impact development/drainage standards for both urban and agricultural areas, adoption of natural resource overlay zones, and watershed-wide stormwater and flood risk management master plans.

The above resilience planning areas and strategies should be incorporated in the various community comprehensive land use plans. Exhibit 9 shows the resilience planning areas within the City of Watseka and its planning areas, and notes a summary of these strategies on each.

5.2.8 Strategically Relocate Infrastructure from Berm-Reliant Areas

The current dependence on berms to provide flood protection along the bank of the Kankakee results in costly maintenance that has negative environmental impacts. Several of the recommended active management strategies focus on reducing the amount of infrastructure at-risk in berm-reliant areas, particularly breaching berms and constructing setback berms further from the river. As mentioned in Section 5.1.5, it is not feasible or advisable to remove or breach all of the berms along the entire river at once. To reduce the future cost of moving or eliminating the berms that are recommended to be temporarily maintained in Section 5.1.5, concerted efforts should be made to reduce or eliminate the at-risk infrastructure currently within those berm-reliant areas over the implementation timeline for the remaining recommendations. Ideally, infrastructure would be removed from the areas behind the temporarily maintained berms to the extent of the 1% AEP floodplain.

5.3 SUMMARY OF RECOMMENDATIONS

A detailed description of the locations and extent for each of the recommended improvements along the Kankakee and Yellow Rivers is provided in Exhibit 3, Exhibit 4, and Table 12.

A description of the locations and extent for the recommended improvements along Iroquois River are provided in Exhibit 10 and Table 13. These Work Plan components were based on a much more limited assessment of channel and watershed conditions. Additional and/or revised Work Plan components may result upon completion of a more detailed assessment, as recommended in Section 5.4.3 and 5.4.4.

Table 12: Summary of Recommended Work Plan Components

Notes:

1. Unless explicitly stated in the Work Plan, existing berms should be maintained along their current alignment and at the current height/elevation.
2. New setback berms should be construct and maintained at proposed alignment and height; the height or alignment of the berms should not be altered/increased to provide more protection.
3. Where berms are not called out to be maintained, no maintenance should be completed on berms; non-maintained berms should be allowed to deteriorate naturally.
4. Bracketed numbers such as [5.1.1] provide the section of the Work Plan report that discuss the improvement methods to be employed.

County	Extent of Improvement (IDNR River Mile)	Exhibit and Sheet	DS Limit Description	US Limit Description	Recommended Action
Kankakee	34.4	E3:S1	I-57	I-57	Improve access point on the upstream side of the bridge [5.1.3]
Kankakee	34.4 – 37.0	E3:S1	US of I-57	DS of Bridge Street	None
Kankakee	37.0	E3:S1	Bridge Street	Bridge Street	Improve access point on the upstream side of the bridge [5.1.3]
Kankakee	37.0 – 41.6	E3:S1	US of Bridge Street	DS of State Road 17	None
Kankakee	41.6	E3:S1	State Road 17	State Road 17	Improve access point on the upstream side of the bridge [5.1.3]
Kankakee	41.6 - 41.8	E3:S1	US of State Road 17	-	None
Kankakee	41.8 – 42.2	E3:S1	-	-	Stabilize approximately 2,400 feet of unstable slope [5.1.2]
Kankakee	42.2 – 44.5	E3:S1-2	-	-	None
Kankakee	44.5 – 44.9	E3:S2	-	-	Stabilize approximately 2,100 feet of unstable slope [5.1.2]
Kankakee	44.9 – 45.4	E3:S2	-	-	None
Kankakee	45.4 - 45.6	E3:S2	-	DS of Tower Creek	Stabilize approximately 1,100 feet of unstable slope [5.1.2]
Kankakee	45.6 – 45.7	E3:S2	DS of Tower Creek	US of Tower Creek	None
Kankakee	45.7 - 47.3	E3:S2	US of Tower Creek	-	Stabilize approximately 1,400 feet of unstable slope [5.1.2]
Kankakee	47.3 – 47.6	E3:S2	-	State Road 17	None
Kankakee	47.6	E3:S2	State Road 17	State Road 17	Improve access point on the upstream side of the bridge [5.1.3]
Kankakee	47.6 – 57.7	E3:S2-3	State Road 17	Indiana - Illinois State Line	None

Table 12: Summary of Recommended Work Plan Components (continued)

Notes:

1. Unless explicitly stated in the Work Plan, existing berms should be maintained along their current alignment and at the current height/elevation.
2. New setback berms should be construct and maintained at proposed alignment and height; the height or alignment of the berms should not be altered/increased to provide more protection.
3. Where berms are not called out to be maintained, no maintenance should be completed on berms; non-maintained berms should be allowed to deteriorate naturally.
4. Bracketed numbers such as [5.1.1] provide the section of the Work Plan report that discuss the improvement methods to be employed.

County	Extent of Improvement (IDNR River Mile)	Exhibit and Sheet	DS Limit Description	US Limit Description	Recommended Action
Lake	57.7	E3:S3	State Line Road	State Line Road	Remove and replace State Line Road bridge [5.1.8]
Lake	57.7 – 71.3	E3:S3-6	State Line Road	US of I-65	Maintain existing setback berm [5.1.5]
Lake	63.9	E3:S4	-	-	Stabilize approximately 300 feet of unstable slope [5.1.2]
Lake	63.9 – 66.4	E3:S4-5	-	-	Construct breach in existing berm [5.1.6]
Lake	67.0	E3:S5	-	-	Construct breach in existing berm [5.1.6]
Lake	67.9	E3:S5	State Road 55	State Road 55	Improve access point on the upstream side of the bridge [5.1.3]
Lake	69.6	E3:S5	-	-	Construct breach in existing berm [5.1.6]
Lake	70.7	E3:S6	-	-	Construct breach in existing berm [5.1.6]
Lake	71.2	E3:S6	DS of I-65	DS of I-65	Construct breach in existing berm [5.1.6]
Lake	71.4	E3:S6	US of I-65	US of I-65	Construct breach in existing berm [5.1.6]
Lake	71.5 - 72.1	E3:S6	US of I-65	-	Construct new setback berm that ties into Clay St improvements [5.1.6]
Lake	72.1 - 72.2	E3:S6	-	Clay St	Construct improvements to Clay St to complete line of protection [5.1.6]
Lake	72.3	E3:S6	US of Clay St	US of Clay St	Construct breach in existing berm [5.1.6]
Lake	72.3 - 75.3	E3:S6	US of Clay St	-	Construct new setback berm that ties into existing berm [5.1.6]
Lake	72.8	E3:S6	-	-	Construct breach in existing berm [5.1.6]
Lake	73.0	E3:S6	-	-	Construct breach in existing berm [5.1.6]
Lake	73.7	E3:S6	-	-	Construct breach in existing berm [5.1.6]
Lake	74.4	E3:S6	-	-	Construct breach in existing berm and internal berms [5.1.6]
Lake	74.5	E3:S6	-	-	Construct breach in existing berm and internal berms [5.1.6]
Lake	75.2	E3:S6	-	-	Construct breach in existing berm and internal berms [5.1.6]
Lake	75.3 – 75.6	E3:S6	-	Lake - Porter Co Line	Maintain existing berm [5.1.5]

Table 12: Summary of Recommended Work Plan Components (Continued)

Notes:

1. Unless explicitly stated in the Work Plan, existing berms should be maintained along their current alignment and at the current height/elevation.
2. New setback berms should be construct and maintained at proposed alignment and height; the height or alignment of the berms should not be altered/increased to provide more protection.
3. Where berms are not called out to be maintained, no maintenance should be completed on berms; non-maintained berms should be allowed to deteriorate naturally.
4. Bracketed numbers such as [5.1.1] provide the section of the Work Plan report that discuss the improvement methods to be employed.

County	Extent of Improvement (IDNR River Mile)	Exhibit and Sheet	DS Limit Description	US Limit Description	Recommended Action
Newton	57.7 – 58.4	E3:S4	State Line Road	-	None
Newton	58.4	E3:S4	-	-	Construct breach in existing berm [5.1.6]
Newton	59.1	E3:S4	-	-	Construct breach in existing berm [5.1.6]
Newton	61.8	E3:S4	US Hwy 41	US Hwy 41	Improve access point on the upstream side of the bridge [5.1.3]
Newton	61.8 – 63.3	E3:S4	US Hwy 41	-	None
Newton	63.3 – 64.4	E3:S4-5	-	-	Stabilize approximately 1,000 feet of slope [5.1.2]
Newton	64.4 – 67.2	E3:S5	-	-	None
Newton	67.2 – 67.4	E3:S5	-	-	Stabilize approximately 4,300 feet of slope [5.1.2]
Newton	67.4 – 68.8	E3:S5	-	-	None
Newton	68.9 - 69.7	E3:S5	Mouth of Dehaan Ditch	-	Construct new setback berm that ties into existing berm [5.1.6]
Newton	68.9	E3:S5	Mouth of Dehaan Ditch	Mouth of Dehaan Ditch	Construct breach in existing berm [5.1.6]
Newton	69.0 - 69.5	E3:S5	-	DS of Railroad	Stabilize approximately 1,800 feet of slope [5.1.2]
Newton	69.7	E3:S5	Railroad	Railroad	Realign railroad bridge piers; construct breach in existing berm [5.1.6]
Newton	69.7 - 69.9	E3:S5	Railroad	-	None
Newton	69.9	E3:S5	-	-	Construct breach in existing berm [5.1.6]
Newton	69.9 - 70.8	E3:S6	-	-	Stabilize approximately 4,900 feet of slope [5.1.2]
Newton	70.7	E3:S6	-	-	Construct breach in existing berm [5.1.6]
Newton	70.8 - 71.1	E3:S6	-	-	None
Newton	71.1 – 71.2	E3:S6	-	DS of I-65	Stabilize approximately 1,000 feet of slope [5.1.2]
Newton	71.2	E3:S6	-	-	Construct breach in existing berm [5.1.6]
Newton	71.3	E3:S6	DS of I-65	I-65	Improve access point on the upstream side of the bridge [5.1.3]
Newton	71.3 – 72.2	E3:S6	I-65	Newton - Jasper Co Line	Maintain existing berm [5.1.5]

Table 12: Summary of Recommended Work Plan Components (Continued)

Notes:

1. Unless explicitly stated in the Work Plan, existing berms should be maintained along their current alignment and at the current height/elevation.
2. New setback berms should be construct and maintained at proposed alignment and height; the height or alignment of the berms should not be altered/increased to provide more protection.
3. Where berms are not called out to be maintained, no maintenance should be completed on berms; non-maintained berms should be allowed to deteriorate naturally.
4. Bracketed numbers such as [5.1.1] provide the section of the Work Plan report that discuss the improvement methods to be employed.

County	Extent of Improvement (River Mile)	Exhibit and Sheet	DS Limit Description	US Limit Description	Recommended Action
Porter	75.6 – 76.6	E3:S6-7	Lake-Porter Co Line	-	Construct new setback berm that ties into existing berm [5.1.6]
Porter	75.7	E3:S7	-	-	Construct breach in existing berm [5.1.6]
Porter	76.3	E3:S7	-	-	Construct breach in existing berm [5.1.6]
Porter	76.4	E3:S7	-	-	Stabilize approximately 300 feet of slope [5.1.2]
Porter	76.6 – 77.2	E3:S7	-	US Hwy 231	Maintain existing berm and US Hwy 231 embankment [5.1.5]
Porter	77.2 – 77.4	E3:S7	US Hwy 231	-	None
Porter	77.4	E3:S7	-	-	Construct breach in existing berm [5.1.6]
Porter	77.4 – 77.8	E3:S7	-	-	None
Porter	77.8	E3:S7	-	-	Construct breach in existing berm [5.1.6]
Porter	77.9 – 78.1	E3:S7	-	CR 625 W	Stabilize approximately 1,000 feet of slope [5.1.2]
Porter	78.1 – 78.4	E3:S7	CR 625 W	-	None
Porter	78.4	E3:S7	-	-	Construct breach in existing berm and internal berms [5.1.6]
Porter	78.4 – 79.2	E3:S7	-	-	Construct breach in existing berm and internal berms [5.1.6]
Porter	79.2 – 79.4	E3:S7	-	-	None
Porter	79.4	E3:S7	-	-	Construct breach in existing berm [5.1.6]
Porter	79.4 – 81.6	E3:S7	-	Mouth of Phillips Ditch	Maintain existing berm and 4,700 feet along Phillips Ditch [5.1.5]
Porter	81.2 – 81.4	E3:S7	-	-	Stabilize approximately 800 feet of slope [5.1.2]
Porter	81.7	E3:S7	US of Phillips Ditch	US of Phillips Ditch	Stabilize approximately 600 feet of slope [5.1.2]
Porter	81.8 – 82.5	E3:S7-8	US of Phillips Ditch	-	Stabilize approximately 3,600 feet of slope [5.1.2]
Porter	81.9	E3:S8	US of Phillips Ditch	US of Phillips Ditch	Construct breach in existing berm [5.1.6]
Porter	82.2 – 82.5	E3:S8	US of Phillips Ditch	-	Construct new setback berm that ties into existing berm [5.1.6]
Porter	82.5 – 82.7	E3:S8	-	-	None
Porter	82.7	E3:S8	-	-	Stabilize approximately 400 feet of slope [5.1.2]
Porter	82.7 – 82.9	E3:S8	-	-	None
Porter	82.9	E3:S8	-	-	Construct breach in existing berm [5.1.6]
Porter	82.9 – 83.2	E3:S8	-	-	None
Porter	83.2 – 83.7	E3:S8	-	-	Stabilize approximately 2,100 feet of slope [5.1.2]
Porter	83.7 – 84.3	E3:S8	-	US of Baums Bridge Rd	None
Porter	84.3 – 84.9	E3:S8	US of Baums Bridge Rd	US of Crooked Creek	Stabilize approximately 6,500 feet of slope [5.1.2]
Porter	85.1	E3:S8	US of the Mouth of Reeves Ditch	US of the Mouth of Reeves Ditch	Construct breach in existing berm [5.1.6]
Porter	86.0	E3:S8	US of Crooked Creek	US of Crooked Creek	Construct breach in existing berm [5.1.6]
Porter	86.0 – 86.2	E3:S8	US of Crooked Creek	US of Crooked Creek	None
Porter	86.3	E3:S8	US of Crooked Creek	US of Crooked Creek	Construct breach in existing berm [5.1.6]
Porter	86.3 – 86.4	E3:S8	US of Crooked Creek	-	Stabilize approximately 700 feet of slope [5.1.2]
Porter	86.4 – 86.6	E3:S8	-	DS of State Road 49	None
Porter	86.6 – 86.7	E3:S8	DS of State Road 49	US of State Road 49	Stabilize approximately 300 feet of slope [5.1.2]
Porter	86.7 – 87.8	E3:S8	US of State Road 49	-	None
Porter	87.8- 88.7	E3:S8-9	-	-	Stabilize approximately 4,100 feet of slope [5.1.2]
Porter	88.7 – 89.0	E3:S9	-	DS of Heimburg Ditch	None
Porter	89.0 – 89.3	E3:S9	DS of Heimburg Ditch	DS of Heimburg Ditch	Stabilize approximately 300 feet of slope [5.1.2]
Porter	89.3 – 90.1	E3:S9	DS of Heimburg Ditch	-	None
Porter	90.1 – 90.3	E3:S9	-	-	Stabilize approximately 900 feet of slope [5.1.2]
Porter	90.4	E3:S9	-	-	Stabilize approximately 200 feet of slope [5.1.2]
Porter	90.4 – 93.2	E3:S9	-	Porter-LaPorte Co Line	None

Table 12: Summary of Recommended Work Plan Components (Continued)

Notes:

1. Unless explicitly stated in the Work Plan, existing berms should be maintained along their current alignment and at the current height/elevation.
2. New setback berms should be construct and maintained at proposed alignment and height; the height or alignment of the berms should not be altered/increased to provide more protection.
3. Where berms are not called out to be maintained, no maintenance should be completed on berms; non-maintained berms should be allowed to deteriorate naturally.
4. Bracketed numbers such as [5.1.1] provide the section of the Work Plan report that discuss the improvement methods to be employed.

County	Extent of Improvement (IDNR River Mile)	Exhibit and Sheet	DS Limit Description	US Limit Description	Recommended Action
Jasper	72.2 - 73.1	E3:S6	Newton - Jasper Co Line	Mouth of Hodge Ditch	Maintain existing berm (continues along Hodge Ditch and US 231 for 3.2 miles) [5.1.5] Stabilize approximately 14,800 feet of slope [5.1.2]
Jasper	73.1 - 73.5	E3:S6	Mouth of Hodge Ditch	-	Stabilize approximately 2,100 feet of slope [5.1.2]
Jasper	73.5	E3:S6	-	-	Construct breach in existing berm [5.1.6]
Jasper	73.5 – 76.0	E3:S6	-	-	Stabilize approximately 3,200 feet of slope [5.1.2]
Jasper	76.0	E3:S6	-	-	Construct breach in existing berm [5.1.6]
Jasper	76.0 – 77.2	E3:S7	-	US Hwy 231	Stabilize approximately 6,000 feet of slope [5.1.2]
Jasper	77.2	E3:S7	US Hwy 231	US Hwy 231	Improve access point on the upstream side of the bridge [5.1.3]
Jasper	77.2 – 77.2	E3:S7	US Hwy 231	-	None
Jasper	77.2 – 77.4	E3:S7	-	-	Maintain existing berm [5.1.5] Stabilize approximately 6,000 feet of slope [5.1.2]
Jasper	77.4 – 78.0	E3:S7	-	-	Maintain existing berm [5.1.5]
Jasper	78.0 – 78.3	E3:S7	-	-	Maintain existing berm [5.1.5] Stabilize approximately 1,400 feet of slope [5.1.2]
Jasper	78.3 – 78.7	E3:S7	-	-	Maintain existing berm [5.1.5]
Jasper	78.7 – 78.9	E3:S7	-	-	Stabilize approximately 500 feet of slope [5.1.2]
Jasper	78.7 – 81.7	E3:S7	-	CR 400 W	Construct new setback berm that ties into an US 231 embankment [5.1.6]
Jasper	79.5	E3:S7	-	-	Construct breach in existing berm [5.1.6]
Jasper	79.6 – 80.8	E3:S7	-	-	Stabilize approximately 5,900 feet of slope [5.1.2]
Jasper	81.2	E3:S7	-	-	Construct breach in existing berm [5.1.6]
Jasper	81.2 – 81.5	E3:S7	-	-	Stabilize approximately 1,300 feet of slope [5.1.2]
Jasper	81.7	E3:S7	CR 400 W	CR 400 W	Improve access point on the upstream side of the bridge [5.1.3]
Jasper	81.7 – 83.2	E3:S7-8	CR 400 W	-	Construct new setback berm that ties into existing berm [5.1.6]
Jasper	82.0 – 85.0	E3:S8	-	-	Stabilize approximately 15,600 feet of slope [5.1.2]
Jasper	83.2 – 84.5	E3:S8	-	-	Maintain existing berm [5.1.5]
Jasper	84.5 – 86.8	E3:S8	-	State Road 49	Construct new setback berm that ties into the State Road 49 embankment [5.1.6]
Jasper	84.6	E3:S8	-	-	Construct breach in existing berm [5.1.6]
Jasper	85.3 – 85.4	E3:S8	-	-	Stabilize approximately 500 feet of slope [5.1.2]
Jasper	85.7	E3:S8	-	-	Stabilize approximately 200 feet of slope [5.1.2]
Jasper	86.3	E3:S8	-	-	Stabilize approximately 200 feet of slope [5.1.2]
Jasper	86.4	E3:S8	-	-	Construct breach in existing berm [5.1.6]
Jasper	86.7	E3:S8	State Road 49	State Road 49	Improve access point on the upstream side of the bridge [5.1.3]
Jasper	86.8	E3:S8	US of State Road 49	US of State Road 49	Construct breach in existing berm [5.1.6]
Jasper	86.8 – 87.6	E3:S8	US of State Road 49	-	None
Jasper	87.6 – 88.2	E3:S9	-	-	Stabilize approximately 3,100 feet of slope [5.1.2]
Jasper	88.2 – 90.9	E3:S9	-	CR 400 E	None
Jasper	90.9	E3:S9	CR 400 E	CR 400 E	Improve access point on the upstream side of the bridge [5.1.3]
Jasper	91.1 – 91.6	E3:S9	-	-	Stabilize approximately 1,200 feet of slope [5.1.2]
Jasper	91.6 – 93.2	E3:S9	-	Jasper - Starke Co Line	None

Table 12: Summary of Recommended Work Plan Components (Continued)

Notes:

1. Unless explicitly stated in the Work Plan, existing berms should be maintained along their current alignment and at the current height/elevation.
2. New setback berms should be construct and maintained at proposed alignment and height; the height or alignment of the berms should not be altered/increased to provide more protection.
3. Where berms are not called out to be maintained, no maintenance should be completed on berms; non-maintained berms should be allowed to deteriorate naturally.
4. Bracketed numbers such as [5.1.1] provide the section of the Work Plan report that discuss the improvement methods to be employed.

County	Extent of Improvement (IDNR River Mile)	Exhibit and Sheet	DS Limit Description	US Limit Description	Recommended Action
LaPorte	93.2 – 95.4	E3:S9	Porter-LaPorte Co Line	DS of US Hwy 421	None
LaPorte	95.4 – 95.5	E3:S9	DS of US Hwy 421	DS of US Hwy 421	Stabilize approximately 600 feet of slope [5.1.2]
LaPorte	95.5 – 96.1	E3:S9	DS of US Hwy 421	US of the Mouth of Pitner Ditch	None
LaPorte	96.1 – 96.2	E3:S9	US of the Mouth of Pitner Ditch	US of the Mouth of Pitner Ditch	Stabilize approximately 800 feet of slope [5.1.2]
LaPorte	96.2 – 96.9	E3:S10	US of the Mouth of Pitner Ditch	-	None
LaPorte	96.9 – 97.1	E3:S10	-	-	Stabilize approximately 1,000 feet of slope [5.1.2]
LaPorte	97.1 – 97.3	E3:S10	-	-	None
LaPorte	97.3 – 97.6	E3:S10	-	-	Stabilize approximately 1,500 feet of slope [5.1.2]
LaPorte	97.6 – 97.8	E3:S10	-	-	None
LaPorte	97.8	E3:S10	-	-	Construct breach in existing berm [5.1.6]
LaPorte	97.8 – 98.4	E3:S10	-	-	None
LaPorte	98.4	E3:S10	-	-	Construct breach in existing berm [5.1.6]
LaPorte	98.4 – 98.7	E3:S10	-	-	None
LaPorte	98.7	E3:S10	-	-	Construct breach in existing berm [5.1.6]
LaPorte	98.8 – 99.0	E3:S10	-	-	Stabilize approximately 800 feet of slope [5.1.2]
LaPorte	99.0 – 99.3	E3:S10	-	Mouth of Hanna Arm	None
LaPorte	99.3 – 100.0	E3:S10	Mouth of Hanna Arm	-	Maintain existing berm along Hanna Arm [5.1.5]
LaPorte	99.5	E3:S10	-	-	Improve access point on the upstream side of the bridge [5.1.3]
LaPorte	100.0 – 102.5	E3:S10-11		-	Construct new setback berm that ties into existing berm along Hanna Arm [5.1.6]
LaPorte	100.5	E3:S10	-	-	Construct breach in existing berm and internal berms [5.1.6]
LaPorte	101.1	E3:S11	-	-	Construct breach in existing berm and internal berms [5.1.6]
LaPorte	101.9	E3:S11	-	-	Construct breach in existing berm and internal berms [5.1.6]
LaPorte	102.4 – 104.6	E3:S11	-	DS of State Road 8	Maintain existing berm along Hanna Arm [5.1.5]
LaPorte	102.5	E3:S11	-	-	Construct breach in existing berm [5.1.6]
LaPorte	102.7	E3:S11	-	-	Construct breach in internal berms [5.1.6]
LaPorte	103.4	E3:S11	-	-	Construct breach in existing berm and internal berms [5.1.6]
LaPorte	104.7 – 106.0	E3:S11	US of State Road 8	-	Construct new setback berm that ties into existing berm [5.1.6] Maintain channel-side access route (optional) [5.1.3]
LaPorte	104.8	E3:S11	-	-	Construct breach in existing berm [5.1.6]
LaPorte	105.4	E3:S11			Construct breach in existing berm [5.1.6]
LaPorte	105.8	E3:S11			Construct breach in existing berm [5.1.6]
LaPorte	106.0 – 107.1	E3:S11	-	DS of Railroad	Maintain existing berm [5.1.5] Maintain channel-side access route (optional) [5.1.3]
LaPorte	106.3 – 109.2	E3:S11-12	State Road 39	-	Maintain existing State Road 39 embankment [5.1.5]
LaPorte	106.6	E3:S11	-	-	Construct breach in existing berm [5.1.6]
LaPorte	107.2	E3:S11	US of Railroad	US of Railroad	Construct breach in existing berm [5.1.6]
LaPorte	107.2 – 109.0	E3:S12	-	Mouth of Marquardt Ditch	Maintain channel-side access route (optional) [5.1.3]
LaPorte	107.7	E3:S12	-	-	Construct breach in existing berm [5.1.6]
LaPorte	108.0	E3:S12	Mouth of Marquardt Ditch	Mouth of Marquardt Ditch	Construct new setback berm that ties into existing berm and high ground [5.1.6]
LaPorte	109.2	E3:S12	-	-	Construct breach in existing berm [5.1.6]
LaPorte	109.2 – 109.9	E3:S12	-	-	Construct new setback berm that ties into existing berm [5.1.6]
LaPorte	109.7	E3:S12	-	-	Construct breach in existing berm [5.1.6]
LaPorte	109.9 – 110.9	E3:S12	-	DS of US Hwy 30	Maintain existing berm [5.1.5]

County	Extent of Improvement (IDNR River Mile)	Exhibit and Sheet	DS Limit Description	US Limit Description	Recommended Action
LaPorte	110.2– 110.9	E3:S12	US of CR 1500 N	US of US Hwy 30	Maintain channel-side access route (optional) [5.1.3]
LaPorte	110.9	E3:S12	US Hwy 30	US Hwy 30	Improve access point on the upstream side of the bridge [5.1.3]
LaPorte	111.0	E3:S12	Mouth of Whitman Ditch	Whitman Ditch	Maintain existing berm [5.1.5] along Whitman Ditch Construct breach in existing berm along Whitman Ditch [5.1.6]
LaPorte	111.0 – 111.8	E3:S12	Whitman Ditch	Salisbury Ditch	Construct new setback berm that ties into existing berm [5.1.6]
LaPorte	111.6	E3:S12	-	-	Construct breach in existing berm [5.1.6]
LaPorte	111.8 - 112.9	E3:S12	Salisbury Ditch	Hildenbrandt Ditch	Construct new setback berm that ties into existing berm [5.1.6]
LaPorte	111.8 – 114.7	E3:S12-13	-	DS of Railroad	Maintain channel-side access route (optional) [5.1.3]
LaPorte	112.3	E3:S12	-	-	Construct breach in existing berm [5.1.6]
LaPorte	112.9 – 113.5	E3:S12	Hildenbrandt Ditch	Long Ditch	Construct new setback berm that ties into existing berm [5.1.6]
LaPorte	113.3	E3:S12	-	-	Construct breach in existing berm [5.1.6]
LaPorte	113.5	E3:S12	US of the Mouth of Long Ditch	US of the Mouth of Long Ditch	Construct breach in existing berm [5.1.6]
LaPorte	113.5 – 114.7	E3:S12-13	US of the Mouth of Long Ditch	DS of CR 1200 S (LaPorte-Starke Co Line)	Construct new setback berm that ties into existing berm and road embankment [5.1.6]
LaPorte	114.7 – 116.2	E3:S13	US of CR 1200 S	DS of US Route 35	Right Bank: Maintain existing berm [5.1.5]; Maintain channel-side access route (optional) [5.1.3] Left Bank: Maintain existing berm [5.1.5]
LaPorte	116.2 – 116.7	E3:S13	US of US Route 35	-	Right Bank: Maintain channel-side access route (optional) [5.1.3] Left Bank: None
LaPorte	116.6	E3:S13	-	-	Right Bank: Construct breach in existing berm [5.1.6] Left Bank: None
LaPorte	116.7 – 117.2	E3:S13	-	DS of CR 1000 S	Right Bank: Maintain channel-side access route (optional) [5.1.3] Left Bank: Construct new setback berm that ties into high ground and road embankment [5.1.6]
LaPorte	117.2	E3:S13	DS of CR 1000 S	DS of CR 1000 S	Right Bank: Maintain channel-side access route (optional) [5.1.3] Left Bank: Construct breach in existing berm [5.1.6]; Construct new setback berm that ties into high ground and road embankment [5.1.6]
LaPorte	117.4	E3:S13	US of CR 1000 S	US of CR 1000 S	Right Bank: Maintain channel-side access route (optional) [5.1.3] Left Bank: Construct breach in existing berm [5.1.6]; Construct new setback berm that ties into high ground and road embankment [5.1.6]
LaPorte	117.7	E3:S13	DS of the Mouth of Winchell Arm	DS of the Mouth of Winchell Arm	Right Bank: Maintain channel-side access route (optional) [5.1.3]; Construct breach in existing berm [5.1.6] Left Bank: Construct new setback berm that ties into high ground and road embankment [5.1.6]
LaPorte	117.8	E3:S13	US of the Mouth of Winchell Arm	US of the Mouth of Winchell Arm	Right Bank: Maintain channel-side access route (optional) [5.1.3]; Construct breach in existing berm [5.1.6] Left Bank: Construct new setback berm that ties into high ground and road embankment [5.1.6]
LaPorte	118.3	E3:S13	DS of US Hwy 6	DS of US Hwy 6	Right Bank: Maintain channel-side access route (optional) [5.1.3] Left Bank: Construct breach in existing berm [5.1.6]; Construct new setback berm that ties into high ground and road embankment [5.1.6]
LaPorte	118.3 – 118.4	E3:S13	DS of US Hwy 6	DS of US Hwy 6	Stabilize approximately 300 feet of slope [5.1.2]
LaPorte	118.5	E3:S13	US of US Hwy 6	US of US Hwy 6	Right Bank: Maintain channel-side access route (optional) [5.1.3]; Construct breach in existing berm [5.1.6] Left Bank: None
LaPorte	118.5 – 118.8	E3:S13	US of US Hwy 6	DS of Railroad	Right Bank: Maintain channel-side access route (optional) [5.1.3] Left Bank: None
LaPorte	118.9 – 119.7	E3:S13	US of Railroad	DS of Breckenridge Ditch	Right Bank: None Left Bank: Maintain channel-side access route (optional) [5.1.3]
LaPorte	119.7	E3:S13	DS of Breckenridge Ditch	DS of Breckenridge Ditch	Right Bank: None Left Bank: Maintain channel-side access route (optional) [5.1.3]; Stabilize approximately 200 feet of slope [5.1.2]
LaPorte	119.7- 122.2	E3:S13-14	DS of Breckenridge Ditch	-	Right Bank: None Left Bank: Maintain channel-side access route (optional) [5.1.3]
LaPorte	122.2	E3:S14	-	-	Right Bank: None Left Bank: Maintain channel-side access route (optional) [5.1.3]; Construct breach in existing berm [5.1.6]
LaPorte	122.2- 122.5	E3:S14	-	DS of State Road 104	Right Bank: None Left Bank: Maintain channel-side access route (optional) [5.1.3]

County	Extent of Improvement (IDNR River Mile)	Exhibit and Sheet	DS Limit Description	US Limit Description	Recommended Action
LaPorte	122.5	E3:S14	DS of State Road 104	DS of State Road 104	Right Bank: None Left Bank: Maintain channel-side access route (optional) [5.1.3]; Construct breach in existing berm [5.1.6]
LaPorte	122.5 – 123.2	E3:S14	DS of State Road 104	Mouth of Pine Creek	Right Bank: None Left Bank: Maintain channel-side access route (optional) [5.1.3]
LaPorte	123.2 - 123.4	E3:S14	Mouth of Pine Creek	-	Right Bank: Maintain channel-side access route (optional) [5.1.3] Left Bank: Maintain existing berm [5.1.5]
LaPorte	123.4	E3:S14	-	-	Right Bank: Maintain channel-side access route (optional) [5.1.3]; Construct breach in existing berm [5.1.6] Left Bank: Maintain existing berm [5.1.5]
LaPorte	123.4 - 123.8	E3:S14	-	-	Right Bank: Maintain channel-side access route (optional) [5.1.3] Left Bank: Maintain existing berm [5.1.5]
LaPorte	123.8	E3:S14	-	-	Right Bank: Maintain channel-side access route (optional) [5.1.3]; Construct breach in existing berm [5.1.6] Left Bank: Maintain existing berm [5.1.5]
LaPorte	123.8 - 124.1	E3:S14	-	DS of CR 525 S	Right Bank: Maintain channel-side access route (optional) [5.1.3] Left Bank: Maintain existing berm [5.1.5]
LaPorte	124.1 – 124.2	E3:S14	US of CR 525 S	Mouth of Little Kankakee River	Right Bank: None Left Bank: Maintain channel-side access route (optional) [5.1.3]; Maintain existing berm [5.1.5]
LaPorte	124.2 - 124.6	E3:S14	Mouth of Little Kankakee River	-	Right Bank: Construct new setback berm that ties into existing berm [5.1.6] Left Bank: Maintain channel-side access route (optional) [5.1.3]; Maintain existing berm [5.1.5]
LaPorte	124.6	E3:S14	-	-	Right Bank: Construct new setback berm that ties into existing berm [5.1.6]; Construct breach in existing berm [5.1.6] Left Bank: Maintain channel-side access route (optional) [5.1.3]; Maintain existing berm [5.1.5]
LaPorte	124.6 - 125.4	E3:S14	-	-	Right Bank: Construct new setback berm that ties into existing berm [5.1.6] Left Bank: Maintain channel-side access route (optional) [5.1.3]; Maintain existing berm [5.1.5]
LaPorte	125.2 - 125.4	E3:S14			Right Bank: Maintain channel-side access route (optional) [5.1.3] Left Bank: Maintain existing berm [5.1.5]
LaPorte	125.4	E3:S14	-	-	Right Bank: Maintain channel-side access route (optional) [5.1.3]; Construct new setback berm that ties into existing berm [5.1.6]; Construct breach in existing berm [5.1.6] Left Bank: Maintain existing berm [5.1.5]
LaPorte	125.4 – 125.6	E3:S14	-	DS of State Road 4	Right Bank: Maintain channel-side access route (optional) [5.1.3]; Construct new setback berm that ties into existing berm [5.1.6]; Maintain State Road 4 embankment [5.1.5] Left Bank: Maintain existing berm [5.1.5]
LaPorte	125.7 - 126.7	E3:S15	US of State Road 4	LaPorte - St Joseph Co Line	Right Bank: Maintain channel-side access route (optional) [5.1.3] Left Bank: Maintain existing berm [5.1.5]
LaPorte	126.7 - 127.6	E3:S15	-	LaPorte - St Joseph Co Line	Maintain channel-side access route (optional) [5.1.3]

Table 12: Summary of Recommended Work Plan Components (Continued)

Notes:

1. Unless explicitly stated in the Work Plan, existing berms should be maintained along their current alignment and at the current height/elevation.
2. New setback berms should be construct and maintained at proposed alignment and height; the height or alignment of the berms should not be altered/increased to provide more protection.
3. Where berms are not called out to be maintained, no maintenance should be completed on berms; non-maintained berms should be allowed to deteriorate naturally.
4. Bracketed numbers such as [5.1.1] provide the section of the Work Plan report that discuss the improvement methods to be employed.

County	Extent of Improvement (IDNR River Mile)	Exhibit and Sheet	DS Limit Description	US Limit Description	Recommended Action
Starke	93.2 – 93.7	E3:S9	Jasper - Starke Co Line	-	None
Starke	93.7- 93.9	E3:S9	-	DS of Elkheim Ditch	Stabilize approximately 1,300 feet of slope [5.1.2]
Starke	93.9 – 94.3	E3:S9	DS of Elkheim Ditch	US of Elkheim Ditch	None
Starke	94.3- 94.5	E3:S9	US of Elkheim Ditch	-	Stabilize approximately 600 feet of slope [5.1.2]
Starke	94.5- 95.1	E3:S9	-	-	None
Starke	95.1	E3:S9	-	-	Stabilize approximately 400 feet of slope [5.1.2]
Starke	95.1- 95.4	E3:S10	-	-	None
Starke	95.4	E3:S10	-	-	Stabilize approximately 300 feet of slope [5.1.2]
Starke	95.4 - 95.7	E3:S10	-	US Hwy 421	None
Starke	95.7	E3:S10	US Hwy 421	US Hwy 421	Improve access point on the upstream side of the bridge [5.1.3]
Starke	95.7- 95.9	E3:S10	-	-	None
Starke	95.9 – 96.4	E3:S10	-	-	Stabilize approximately 2,600 feet of slope [5.1.2]
Starke	96.4	E3:S10	-	-	Remove abandoned Erie Blvd bridge [5.1.8]
Starke	96.5 – 96.9	E3:S10	-	-	None
Starke	96.9 – 97.3	E3:S10	-	-	Stabilize approximately 2,200 feet of slope [5.1.2]
Starke	97.3 – 97.5	E3:S10	-	-	None
Starke	97.5 – 97.7	E3:S10	-	-	Stabilize approximately 600 feet of slope [5.1.2]
Starke	97.8 – 97.9	E3:S10	-	-	Stabilize approximately 400 feet of slope [5.1.2]
Starke	97.9 – 99.3	E3:S10	-	DS of Railroad	None
Starke	99.3	E3:S10	DS of Railroad	DS of Railroad	Remove abandoned railroad bridge [5.1.8]
Starke	99.3 – 99.5	E3:S10	DS of Railroad	CR 650 W	None
Starke	99.5 – 99.7	E3:S10	CR 650 W	Kankakee FWA	Stabilize approximately 600 feet of slope [5.1.2]
Starke	99.7 – 99.9	E3:S10	Kankakee FWA	Kankakee FWA	Maintain channel-side access route (optional) [5.1.3]
Starke	99.9 – 100.0	E3:S10	Kankakee FWA	Kankakee FWA	Stabilize approximately 500 feet of slope [5.1.2]
Starke	100.0 – 100.6	E3:S10	Kankakee FWA	Kankakee FWA	None
Starke	100.6	E3:S10	Kankakee FWA	Kankakee FWA	Construct breach in existing berm and internal berms [5.1.6]
Starke	100.6 – 101.2	E3:S10	Kankakee FWA	Kankakee FWA	None
Starke	101.2	E3:S10	Kankakee FWA	Kankakee FWA	Construct breach in existing berm and internal berms [5.1.6]
Starke	101.2 – 102.0	E3:S11	Kankakee FWA	Kankakee FWA	None
Starke	102.0	E3:S11	Kankakee FWA	Kankakee FWA	Construct breach in existing berm and internal berms [5.1.6]
Starke	102.0 – 102.6	E3:S11	Kankakee FWA	Kankakee FWA	None
Starke	102.6	E3:S11	Kankakee FWA	Kankakee FWA	Construct breach in existing berm [5.1.6]
Starke	102.6 – 103.1	E3:S11	Kankakee FWA	Kankakee FWA	None
Starke	103.1	E3:S11	Kankakee FWA	Kankakee FWA	Stabilize approximately 300 feet of slope [5.1.2]
Starke	103.1 – 103.4	E3:S11	Kankakee FWA	Kankakee FWA	None
Starke	103.4	E3:S11	Kankakee FWA	Kankakee FWA	Stabilize approximately 300 feet of slope [5.1.2] Construct breach in existing berm [5.1.6]
Starke	103.4 – 105.8	E3:S11	Kankakee FWA	Kankakee FWA	Maintain existing State Road 8 embankment
Starke	105.8 – 106.2	E3:S11	Kankakee FWA	US of State Road 8	Stabilize approximately 2,200 feet of slope [5.1.2] Maintain existing State Road 8 embankment [5.1.5]
Starke	106.3	E3:S11	US of State Road 8	US of State Road 8	Construct breach in existing berm [5.1.6]
Starke	106.4 – 106.8	E3:S11	US of State Road 8	DS of CR 300 N	None
Starke	106.9 – 107.0	E3:S11	DS of CR 300 N	DS of CR 300 N	Stabilize approximately 400 feet of slope [5.1.2]

County	Extent of Improvement (IDNR River Mile)	Exhibit and Sheet	DS Limit Description	US Limit Description	Recommended Action
Starke	107.0 – 107.5	E3:S12	DS of CR 300 N	-	None
Starke	107.5	E3:S12	-	-	Construct breach in existing berm [5.1.6]
Starke	107.5 – 107.8	E3:S12	-	Mouth of Robbins Ditch	None
Starke	107.8 – 108.5	E3:S12	Mouth of Robbins Ditch	-	Maintain channel-side access route (optional) [5.1.3]
Starke	108.5 – 108.6	E3:S12	-	-	Construct new setback berm that along CR 450 N [5.1.6]
Starke	108.6 – 110.2	E3:S12	-	US of CR 600 N	Maintain existing berm [5.1.5]
Starke	110.2	E3:S12	-	-	Construct breach in existing berm [5.1.6]
Starke	110.2 – 110.8	E3:S12	-	DS of US Hwy 30	None
Starke	110.8	E3:S12	-	-	Construct breach in existing berm [5.1.6]
Starke	110.9	E3:S12	Railroad DS of US Hwy 30	Railroad DS of US Hwy 30	Realign railroad bridge piers [5.1.8]
Starke	111.0	E3:S12	US of US Hwy 30	US of US Hwy 30	Construct breach in existing berm [5.1.6]
Starke	111.0 – 111.6	E3:S12	US of US Hwy 30	DS of CR 50 E	Maintain channel-side access route (optional) [5.1.3]
Starke	111.6	E3:S12	-	-	Construct breach in existing berm [5.1.6]
Starke	111.6 – 112.2	E3:S12	-	DS of the Mouth of Place Ditch Arm	None
Starke	112.2	E3:S12	DS of the Mouth of Place Ditch Arm	DS of the Mouth of Place Ditch Arm	Construct breach in existing berm [5.1.6]
Starke	112.2 – 114.8	E3:S12-13	DS of the Mouth of Place Ditch Arm	Starke-LaPorte Co Line	None
Starke	Yellow River 0.1 - 5.6	E4:S1	Confluence w/ Kankakee River	DS of State Road 39	Remove logjams [5.1.4]
Starke	Yellow River 0.1 - 0.2	E4:S1	Confluence w/ Kankakee River	DS of CR 650 W	Stabilize approximately 500 feet of slope [5.1.7]
Starke	Yellow River 0.3 - 0.5	E4:S1	US of CR 650 W	-	Construct bankfull channel [5.1.7] Right: Maintain channel-side access route (optional) [5.1.3] Left: None
Starke	Yellow River 0.5 - 2.5	E4:S1	-	Mouth of Lemke Ditch	Construct bankfull channel [5.1.7] Right: Maintain channel-side access route (optional) [5.1.3] Left: Maintain existing setback berm [5.1.5]
Starke	Yellow River 0.6	E4:S1	-	-	Left: Construct breach in existing berm along Kline Arm [5.1.6]
Starke	Yellow River 0.8	E4:S1	-	-	Right: Construct breach in existing berm [5.1.6]
Starke	Yellow River 1.0	E4:S1	-	-	Left: Construct breach in existing berm along Kline Arm [5.1.6]
Starke	Yellow River 1.5	E4:S1	-	-	Left: Construct breach in existing berm along Kline Arm [5.1.6]
Starke	Yellow River 2.0	E4:S1	-	-	Left: Construct breach in existing berm along Kline Arm [5.1.6]
Starke	Yellow River 2.2	E4:S1	-	-	Right: Construct breach in existing berm [5.1.6]
Starke	Yellow River 2.5	E4:S1	DS of the Mouth of Lemke Ditch	DS of the Mouth of Lemke Ditch	Left: Construct breach in existing berm along Kline Arm [5.1.6]
Starke	Yellow River 2.5 - 5.5	E4:S1	Mouth of Lemke Ditch	DS of State Road 39	Construct bankfull channel [5.1.7] Right: Maintain channel-side access route (optional) [5.1.3] Left: Construct new setback berm that ties into existing berm [5.1.6]
Starke	Yellow River 2.9	E4:S1	-	-	Left: Construct breach in existing berm along Kline Arm [5.1.6]
Starke	Yellow River 3.3	E4:S1	-	-	Left: Construct breach in existing berm [5.1.6]
Starke	Yellow River 3.5	E4:S1	-	-	Right: Construct breach in existing berm [5.1.6]
Starke	Yellow River 4.2	E4:S1	-	-	Left: Construct breach in existing berm [5.1.6]
Starke	Yellow River 4.4	E4:S1	-	-	Right: Construct breach in existing berm [5.1.6]
Starke	Yellow River 5.2	E4:S1	-	-	Right: Construct breach in existing berm [5.1.6] Left: Construct breach in existing berm [5.1.6]
Starke	Yellow River 5.6	E4:S1	State Road 39	State Road 39	Maintain existing State Road 39 embankment [5.1.5]
Starke	Yellow River 5.6 - 9.3	E4:S1-2	US of State 39	-	Construct bankfull channel [5.1.7] Right: Maintain existing setback berm [5.1.5] Left: Maintain existing setback berm [5.1.5]
Starke	Yellow River 9.3 - 10.3	E4:S2	-	-	Construct bankfull channel [5.1.7] Right: Construct new setback berm that ties into existing berm [5.1.6] Left: Maintain existing setback berm [5.1.5]

County	Extent of Improvement (IDNR River Mile)	Exhibit and Sheet	DS Limit Description	US Limit Description	Recommended Action
Starke	Yellow River 10.3 - 10.5	E4:S2	-	DS of Railroad	Construct bankfull channel [5.1.7] Right: Maintain existing setback berm [5.1.5] Left: Maintain existing setback berm [5.1.5]
Starke	Yellow River 10.6 - 21.1	E4:S2-3	US of Railroad	Starke - Marshall Co Line	Stabilize/restore channel [5.1.1]

Table 12: Summary of Recommended Work Plan Components (Continued)

Notes:

1. Unless explicitly stated in the Work Plan, existing berms should be maintained along their current alignment and at the current height/elevation.
2. New setback berms should be construct and maintained at proposed alignment and height; the height or alignment of the berms should not be altered/increased to provide more protection.
3. Where berms are not called out to be maintained, no maintenance should be completed on berms; non-maintained berms should be allowed to deteriorate naturally.
4. Bracketed numbers such as [5.1.1] provide the section of the Work Plan report that discuss the improvement methods to be employed.

County	Extent of Improvement (IDNR River Mile)	Exhibit and Sheet	DS Limit Description	US Limit Description	Recommended Action
Marshall	Yellow River 21.1 - 24.0	E4:S3	Starke - Marshall Co Line	-	Stabilize/restore channel [5.1.1]

Table 13: Summary of Recommended Work Plan Components along Iroquois River

Notes:

1. Table 13 lists several areas of concern identified along the Iroquois River in Iroquois and Kankakee Counties (Illinois). The location, type, and extent the areas were located during a reconnaissance survey of the Iroquois River that was conducted January – March of 2019. The reconnaissance survey was a challenge because of the heavily wooded corridor of the Iroquois River, particularly from the Jasper – Newton County line to Watseka, Illinois, and the frequent meanders. Additional evaluation is necessary to confirm the extent of the issue and the adequacy of the recommended measures.
2. Bracketed numbers such as [5.1.1] provide the section of the Work Plan report that discuss the improvement methods to be employed.

County	Extent of Improvement (River Mile)	Exhibit and Sheet	DS Limit Description	US Limit Description	Recommended Action
Kankakee	0.0 – 7.0	E10:S1	Mouth of Iroquois River	Kankakee - Iroquois Co Line	None
Iroquois	7.0 – 17.7	E10:S1-2	Kankakee - Iroquois Co Line	US of US Hwy 52	None
Iroquois	17.7	E10:S2	US of US Hwy 52	DS of CR 2400 N	Left: Stabilize/restore erosion rill along channel [5.2.4] Right: None
Iroquois	17.7 – 30.7	E10:S2	DS of CR 2400 N	US of CR 2000 N	None
Iroquois	30.7	E10:S2	US of CR 2000 N	US of CR 1950 N	Left: None Right: Stabilize/restore erosion rill along channel [5.2.4]
Iroquois	30.7 – 42.0	E10:S2	US of CR 1950 N	-	None
Iroquois	42.0	E10:S2	-	-	Left: Stabilize/restore erosion rill along channel [5.2.4] Right: None
Iroquois	42.0 – 44.2	E10:S2	-	DS of CR 2500 E	None
Iroquois	44.2	E10:S2	DS of CR 2500 E	US of CR 2500 E	Left: Stabilize/restore erosion rill along channel [5.2.4] Right: Stabilize/restore erosion rill along channel [5.2.4]
Iroquois	44.2 – 49.7	E10:S2-3	US of CR 2500 E	-	None
Iroquois	49.7	E10:S3	-	DS of Railroad Bridge	Left: Stabilize/restore erosion rill along channel [5.2.4] Right: None
Iroquois	49.7 – 49.9	E10:S3	DS of Railroad Bridge	-	None
Iroquois	49.9	E10:S3	-	DS of CR 2980 E	Left: Stabilize/restore erosion rill along channel [5.2.4] Right: None
Iroquois	49.9 – 51.6	E10:S3	DS of CR 2980 E	DS of Blackston Branch	None
Iroquois	51.6	E10:S3	DS of Blackston Branch	DS of Blackston Branch	Left: Stabilize/restore erosion rill along channel [5.2.4] Right: None
Iroquois	51.6 – 55.2	E10:S3	DS of Blackston Branch	Iroquois - Newton Co Line	None
Iroquois	Sugar Ck 0.0 – 0.1	E10:S2	Mouth of Sugar Ck	DS of Lafayette St	Left: None Right: Stabilize slope [similar to 5.1.1]
Iroquois	Sugar Ck 0.1 – 0.7	E10:S2	US of Lafayette St	DS of Railroad Bridge	None
Iroquois	Sugar Ck 0.7	E10:S2	US of Railroad Bridge	-	Left: Stabilize/restore erosion rill along channel [5.2.4] Right: None
Iroquois	Sugar Ck 0.7 – 3.4	E10:S2	-	DS of State Hwy 43	None

5.4 ADDITIONAL STUDY NEEDS

The recommendations of this Work Plan are conceptual in nature. Additional analysis and considerations are necessary to answer questions concerning areas adjacent to the Kankakee floodplain, and to answer questions that the Work Plan was not originally designed to address. The following additional study needs were identified in the process of developing the Work Plan:

5.4.1 Complete Detailed Designs for Recommended Improvements

To adequately implement the recommended management strategies, particularly active management measures, detailed design calculations and plans must be completed. The detailed design considerations should be used to confirm the conclusions and configuration of the recommended measures, as well as to maximize the ability of the proposed improvements to serve multiple purposes; most notably for the areas that will be subjected to more frequent flooding as a result of constructing breaches in the berms.

5.4.2 Additional Hydrologic and Hydraulic Modeling

Questions concerning flooding along tributaries of the Kankakee and the interplay between them and the main stem of the River were asked throughout the development of the Work Plan. The analysis included in the Work Plan was not designed to address those questions due to the complexity and cost of completing the analyses. Additional hydrologic and hydraulic modeling should be completed to better define flooding along tributaries that do not currently have detailed studies, as well as areas that will be adjacent to setback berms. A non-inclusive list of streams that should be evaluated further is provided below based on model observations during the development of the Work Plan:

- Robbins Ditch from Danielson Ditch to the confluence with the Kankakee
- Yellow River from upstream of Knox, IN to the confluence with the Kankakee
- Hanna Arm from the headwaters to the confluence with the Kankakee
- Kline Arm from the headwaters to the confluence with the Kankakee
- Breyfogel Ditch from the headwaters to the confluence with the Kankakee
- Hodge Ditch from the headwaters to the confluence with the Kankakee
- Brown-Levee Ditch from the headwaters to the confluence with the Kankakee
- Dehaan Ditch and Brent Ditch from the headwaters to the confluence with the Kankakee

5.4.3 Complete a Detailed Assessment of Iroquois River

At their confluence near Aroma Park, Illinois, the Iroquois River and Kankakee River basins are essentially the same size (2,135 mi^2 vs 2,380 mi^2), but the Iroquois River is now longer than the Kankakee because it retains more of its original planform. The Iroquois River also contributes more water and sediment to the Kankakee River downstream from the confluence than the Kankakee but has been studied much less than the Kankakee. Extensive assessment of the areas of interest was beyond the scope of this Work Plan; however, a preliminary set of problem areas were identified during a reconnaissance survey. This preliminary information has been provided because there are areas of significant instability and sediment production that should be addressed to improve the overall health of the Kankakee River downstream from the confluence. The identified problem areas listed in Table 13 also confirm the need for a Work Plan for the entirety of the Iroquois River, both in Indiana and in Illinois. A detailed system assessment would provide a comprehensive list of locations of instability, an evaluation of the condition of the system and the likely causes of the instabilities, schematic layouts of conceptual solutions, and cost estimates for recommended improvements.

5.4.4 Complete a Detailed Assessment of Sugar Creek

This Work Plan provided clear evidence that the flooding risk in and around Watseka, IL is largely related to the conditions in Sugar Creek and its contributing drainage area. A detailed assessment of the causes of the disproportionate amount of runoff originating in the Sugar Creek Watershed was beyond the scope of this Work Plan. A more detailed assessment of the watershed and channel are necessary to produce a holistic evaluation of the cause of the problems and to develop appropriately detailed potential solutions and cost estimates.

CHAPTER 6 IMPLEMENTATION CONSIDERATIONS

The availability of sufficient funding and the recommended timeline for implementing the improvements are critical to the overall success of this Work Plan. The following paragraphs summarize the overall estimated hard cost of the Work Plan and lay out the recommended timeline and priorities for the improvements. The combination of these key components allows for the determination of an annual funding need for implementation. Also included in this Chapter are additional considerations for an effective and efficient implementation of this Work Plan.

6.1 ESTIMATED COST OF RECOMMENDED MANAGEMENT STRATEGIES

The estimated hard costs associated with designing, permitting, and constructing improvements and modifications within the corridor are summarized in Appendix 4 for each of the active management recommendations. An overall summary is provided in Table 14.

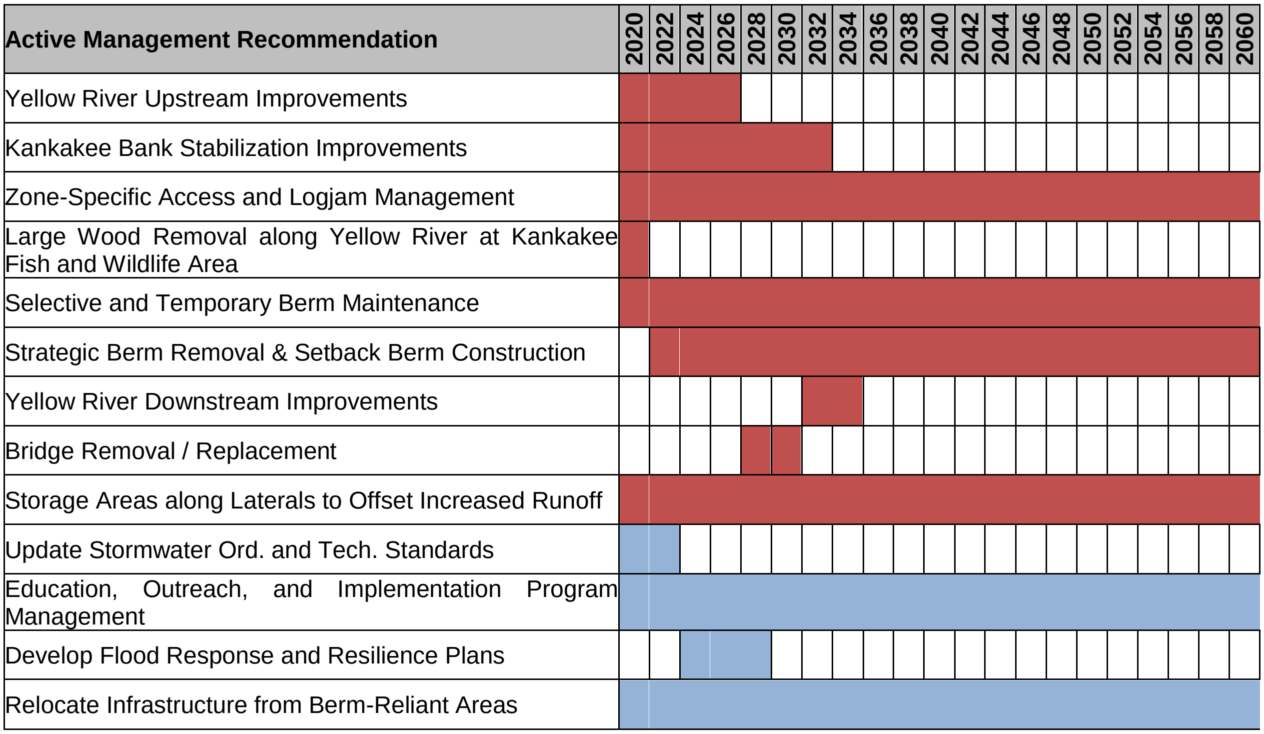
Table 14: Summary of Active Management Costs

No.	Active Management Recommendation	Design & Permitting Cost	Construction Cost	Total Cost
1	Yellow River Upstream Improvements	$2,298,000	$20,778,000	$23,076,000
2	Kankakee Bank Stabilization Improvements	$555,000	$4,620,000	$5,175,000
3	Zone-Specific Access and Logjam Management	$236,000	$1,953,000	$2,189,000
4	Large Wood Removal along Yellow River	$0	$117,000	$117,000
5	Selective and Temporary Berm Maintenance	$999,000	$8,316,000	$9,313,000
6	Strategic Berm Removal & Setback Berm Construction[1]	$15,225,000	$43,536,000	$58,761,000
7	Yellow River Downstream Improvements	$1,380,000	$12,478,000	$13,858,000
8	Bridge Removal / Replacement	$903,000	$7,535,000	$8,438,000
9	Storage Areas to Offset Increased Runoff	$1,350,000	$11,250,000	$12,600,000
	TOTAL COST	$12,910,000	$110,275,000	$133,185,000

[1] The design and permitting cost of the strategic berm removal and setback berm construction includes $10 million is easement acquisition.

6.2 IMPLEMENTATION SEQUENCE AND TIMELINE

Figure 18 provides a suggested timeline and a preliminary sequence for the recommended active and passive management strategies.



Active Management Recommendation	**2020**	**2022**	**2024**	**2026**	**2028**	**2030**	**2032**	**2034**	**2036**	**2038**	**2040**	**2042**	**2044**	**2046**	**2048**	**2050**	**2052**	**2054**	**2056**	**2058**	**2060**
Yellow River Upstream Improvements	🟥	🟥	🟥	🟥																	
Kankakee Bank Stabilization Improvements	🟥	🟥	🟥	🟥	🟥	🟥	🟥														
Zone-Specific Access and Logjam Management	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
Large Wood Removal along Yellow River at Kankakee Fish and Wildlife Area	🟥																				
Selective and Temporary Berm Maintenance	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
Strategic Berm Removal & Setback Berm Construction		🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
Yellow River Downstream Improvements							🟥	🟥													
Bridge Removal / Replacement					🟥	🟥															
Storage Areas along Laterals to Offset Increased Runoff	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
Update Stormwater Ord. and Tech. Standards	🟦	🟦																			
Education, Outreach, and Implementation Program Management	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦
Develop Flood Response and Resilience Plans			🟦	🟦	🟦																
Relocate Infrastructure from Berm-Reliant Areas	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦

Figure 18: Implementation Timeline

6.3 ANNUAL FUNDING NEED AND POTENTIAL SOURCES

The cumulative cost of the proposed improvements and maintenance costs included in this Work Plan is approximately $134 million. This total estimated cost does not include the cost associated with strategic flood protection measures for clusters of residential structures, major roads, or critical infrastructure located in floodplain that are not expected to be the primary focus of KRBC as part of this Work Plan at this time, as discussed in Section 5.1.10. The anticipated annual funding from the recently enacted State-levied assessment fee for the system in Indiana is about $3.0 million, a total of $120 million between 2020 and 2060. An additional $2.4 million was allocated from the State budget for 2019 – 2021.

An appropriate suggested timeline for each recommended activity was developed. Figure 19 provides the projected expenditures for the duration of the Work Plan implementation. The annual expenditures range from $2.0 - $5.8 million, with the majority of the years requiring more funding than is currently anticipated from the State-levied assessment fee. Several of the projects will require financing, most likely through bonding or grant funding from Federal programs. More detail concerning the allocation of funds and annual expenditures is provided in Appendix 4.

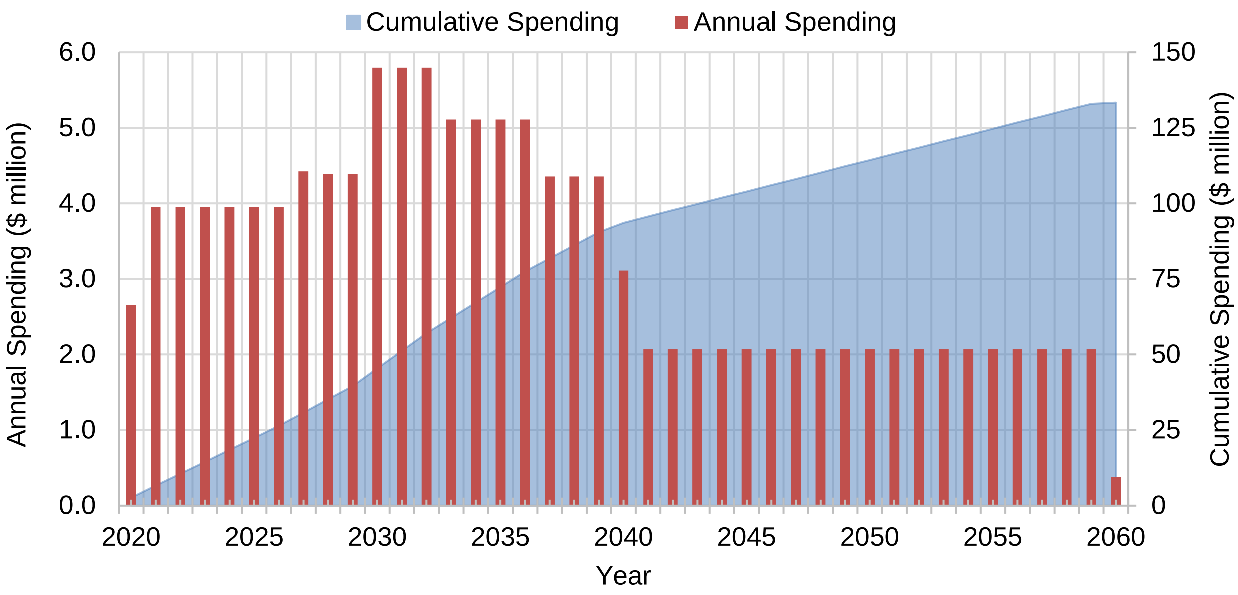


Figure 19: Projected Annual and Cumulative Spending

The total cost-share of the Work Plan to the KRBC may be reduced with the use of multiple funding sources. Federal programs have been utilized for improvement of land management in the watershed and it is anticipated that this practice will continue. An expanded evaluation of the available funding from federal agencies should be completed in light of the recommended improvements to determine if there are opportunities for supplementary funding. In addition, there are a few private foundations that may be interested in acquiring land along the River.

Ancillary benefits and secondary improvement objectives, such as ecological, water quality, and alternative land uses should be more thoroughly evaluated and leveraged while exploring alternative funding sources. It is anticipated that multiple organizations that could provide supplementary funding will be more interested in supporting the secondary benefits of the Work Plan. Slight adjustment of the recommended details may open opportunities for significant cost-sharing. Stakeholder feedback from the preliminary recommendations of this Work Plan suggest that the monetary compensation for land acquisition along the river corridor could be provided by outside sources if the land were managed in a desired condition.

At the time of preparation of this Work Plan, no dedicated sources of funding existed for the Kankakee River and Iroquois River in Illinois. The implementation of strategies noted in this Work Plan for areas in Illinois would require a sustainable, dedicated source(s) of funding. It is recommended that the County leaders and legislators in Illinois research and establish adequate sources of funding for further studies and implementation of the strategies suggested in this Work Plan.

6.4 OTHER IMPLEMENTATION CONSIDERATIONS

The nature and extent of the recommendations in this Work Plan and the fact that many of the recommendations are drastically different than what has been practiced within the last century suggest that program management will be necessary. The success of this

Work Plan will depend, to a large degree, on how it is perceived and how consistently and seamlessly various recommendations come together throughout the multiple years of implementation. It is recommended that an on-call, as-needed miscellaneous engineering contract be initiated to provide the following services:

- Continual or as-needed education and outreach presentations to keep the purpose and the achieved implementation results fresh in the minds of various stakeholders throughout the implementation period.
- Provide support to the Commission's Executive Director in answering various questions from stakeholders.
- Assist with deciding implementation nuances that come up throughout the multi-year implementation process.

CHAPTER 7 REFERENCES

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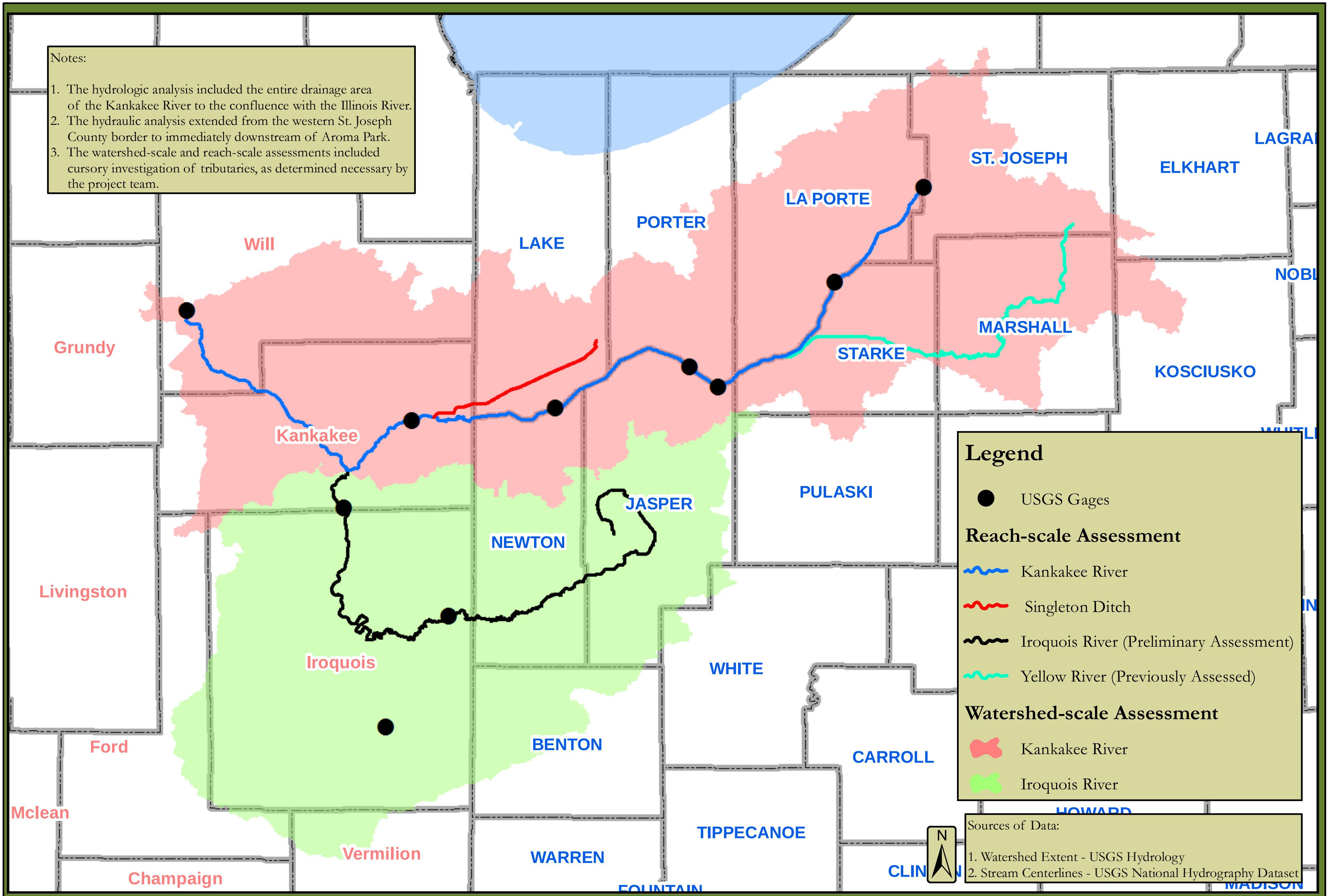
EXHIBITS



Notes:

1. The hydrologic analysis included the entire drainage area of the Kankakee River to the confluence with the Illinois River.
2. The hydraulic analysis extended from the western St. Joseph County border to immediately downstream of Aroma Park.
3. The watershed-scale and reach-scale assessments included cursory investigation of tributaries, as determined necessary by the project team.

Legend

● USGS Gages

Reach-scale Assessment

Kankakee River

Singleton Ditch

Iroquois River (Preliminary Assessment)

Yellow River (Previously Assessed)

Watershed-scale Assessment

🟥 Kankakee River

🟩 Iroquois River

Sources of Data:

1. Watershed Extent - USGS Hydrology
2. Stream Centerlines - USGS National Hydrography Dataset

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PROJECT: **Kankakee River Flood and Sediment Management Work Plan**

PROJECT NO. 18-0290

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DATE: 6/2019

TITLE: **Work Plan Assessment Extent**

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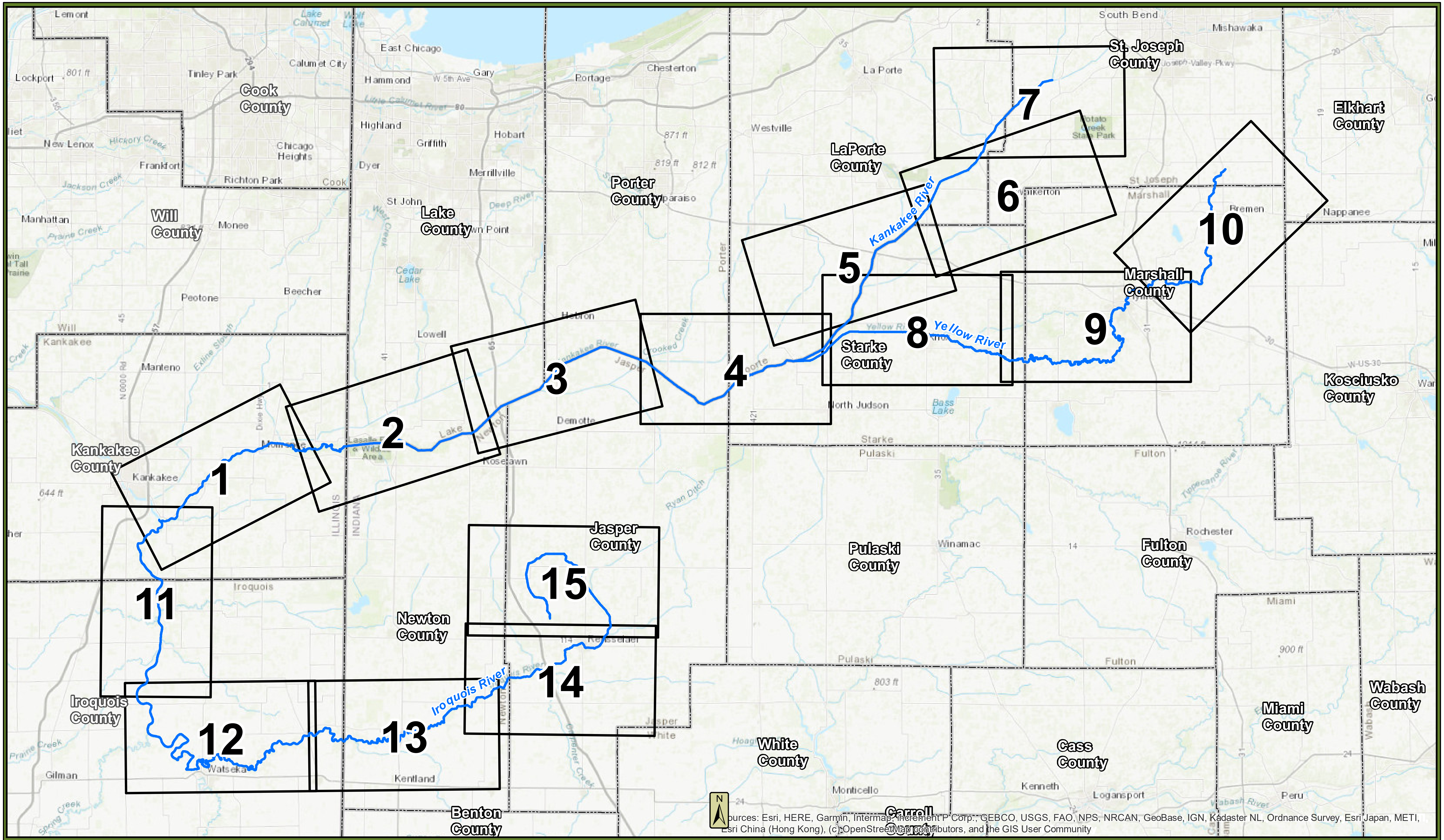

⬚ County Boundary
☐ Map Panel

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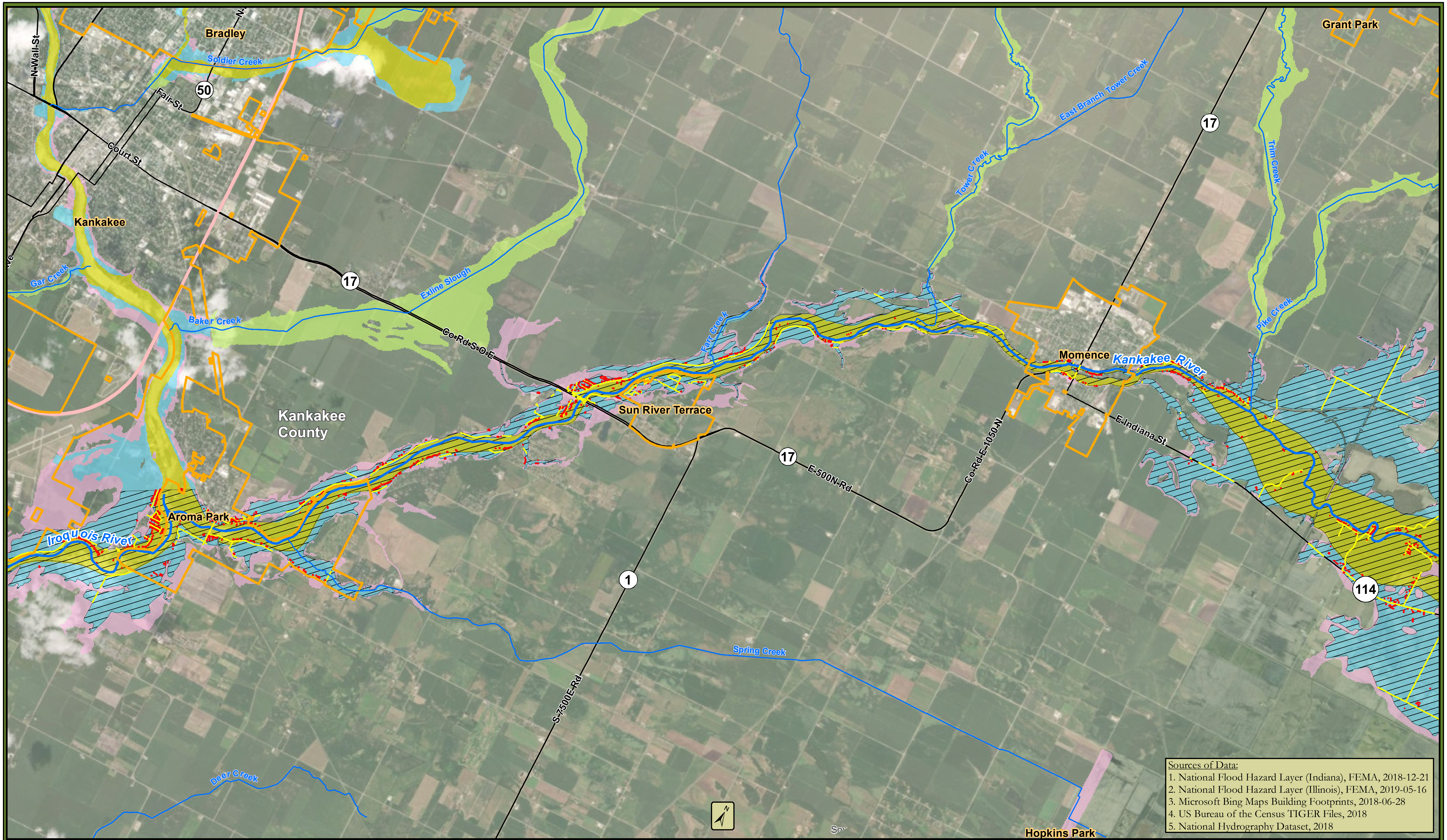
DATE: 06/2019

TITLE: Significant Flood Hazard Area and Potentially Flooded Structures and Roads

Index Map

EXHIBIT 2



Sources of Data:
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2. National Flood Hazard Layer (Illinois), FEMA, 2019-05-16
3. Microsoft Bing Maps Building Footprints, 2018-06-28
4. US Bureau of the Census TIGER Files, 2018
5. National Hydrography Dataset, 2018

🟥 Potentially Flooded Structures
⟋ Potentially Overtopped Roads
☐ County Boundary
▨ Significant Flood Hazard Area (Study Area Only)

Effective Flood Zones
🟨 Floodway
🟦 1.0% Annual Exceedance Probability
🟪 0.2% Annual Exceedance Probability
🟩 Unnumbered Zone A

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PROJECT NO. 18-0290

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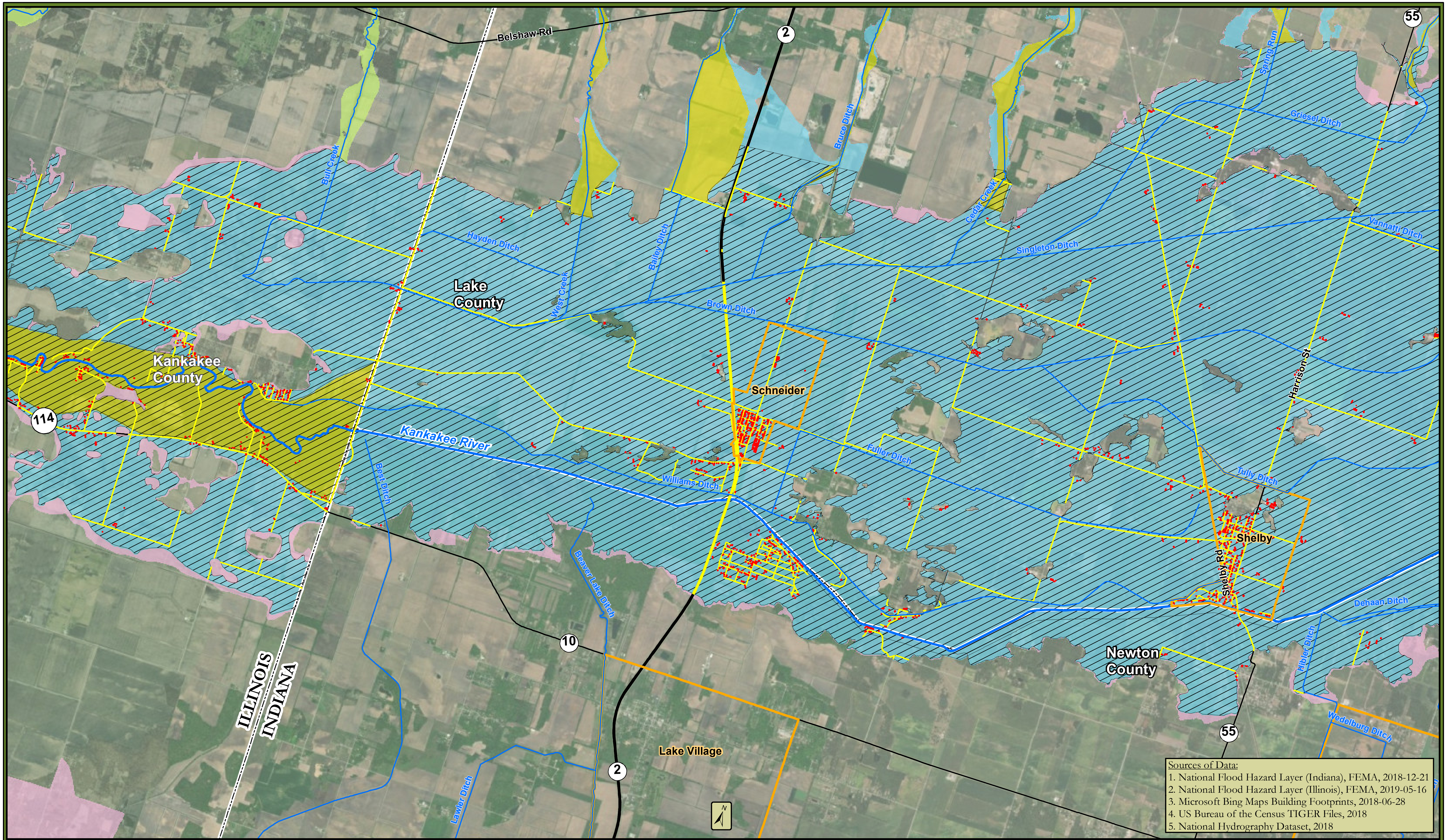
TITLE: **Significant Flood Hazard Area and Potentially Flooded Structures and Roads**

Sheet 1 of 15

DATE: 05/2019

EXHIBIT 2



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⁄ Potentially Overtopped Roads
▭ County Boundary
▨ Significant Flood Hazard Area (Study Area Only)

Effective Flood Zones
🟨 Floodway
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Sheet 2 of 15

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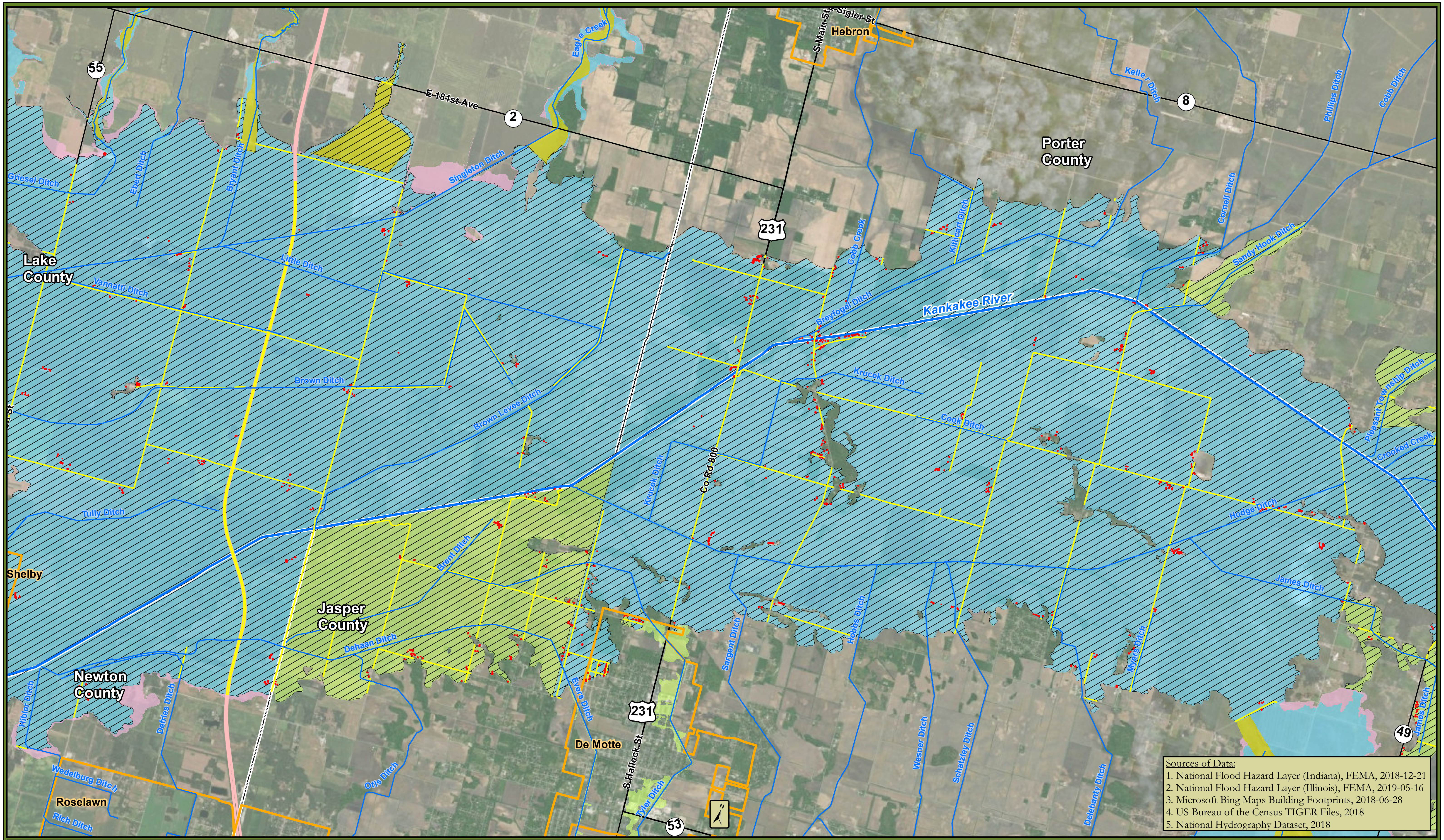

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🟥 Potentially Flooded Structures	▭ County Boundary	**Effective Flood Zones**	🟪 0.2% Annual Exceedance Probability
— Potentially Overtopped Roads	▨ Significant Flood Hazard Area (Study Area Only)	🟨 Floodway	🟩 Unnumbered Zone A
		🟦 1.0% Annual Exceedance Probability	

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Sheet 3 of 15

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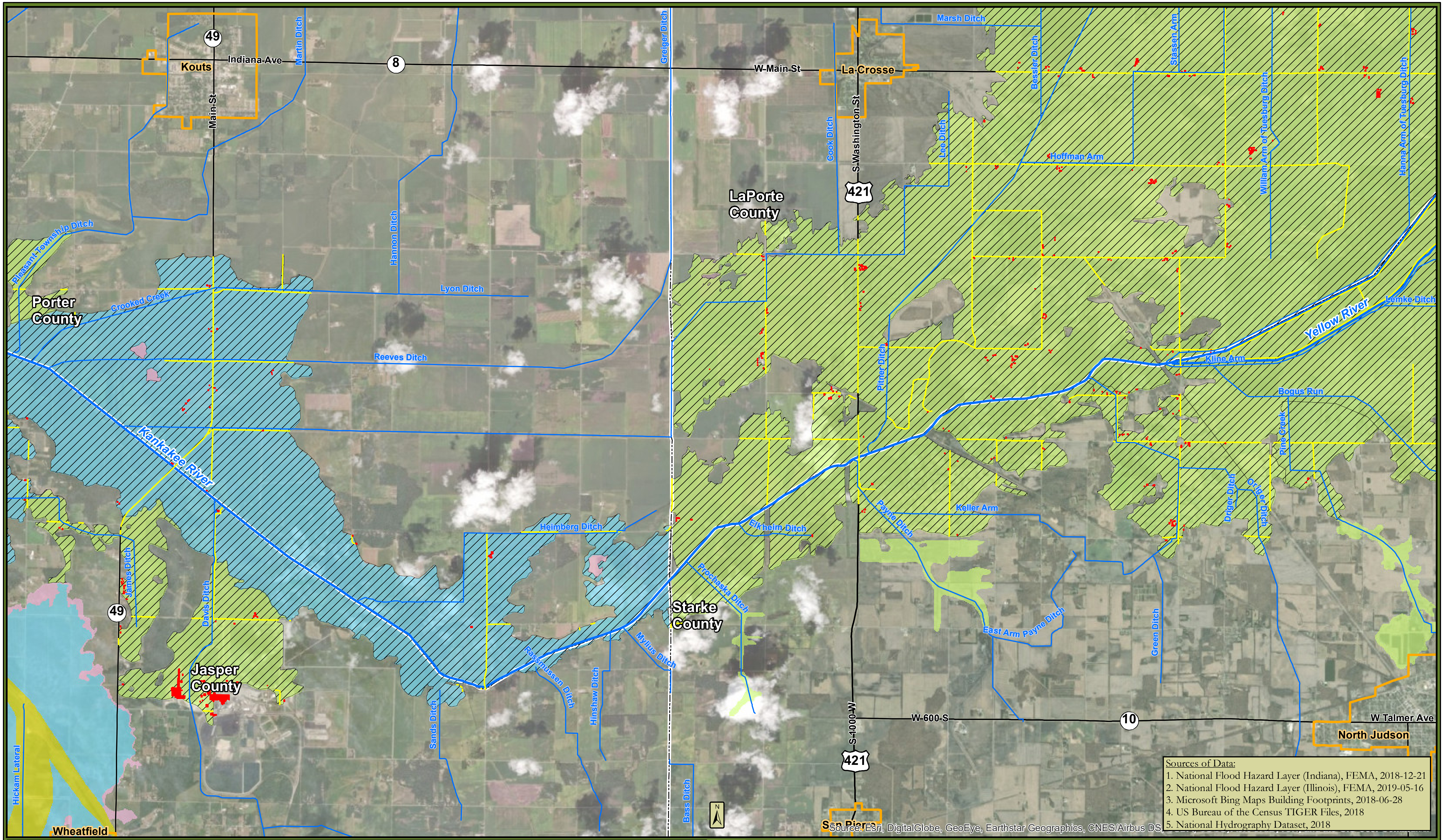

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⁄ Potentially Overtopped Roads
☐ County Boundary
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Effective Flood Zones
🟨 Floodway
🟦 1.0% Annual Exceedance Probability
🟪 0.2% Annual Exceedance Probability
🟩 Unnumbered Zone A

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Sheet 4 of 15

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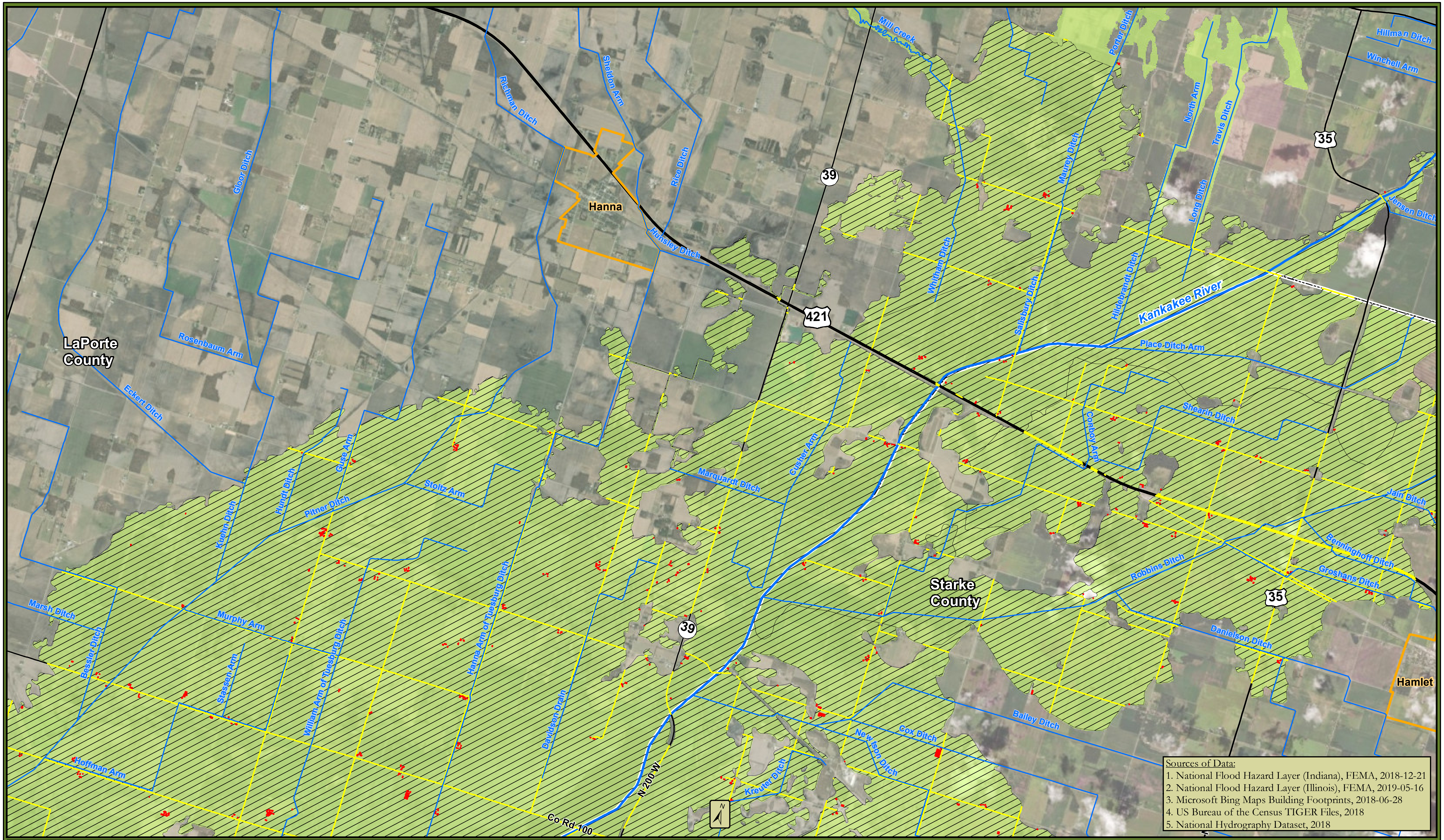

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/ Potentially Overtopped Roads
☐ County Boundary
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Effective Flood Zones
Floodway
1.0% Annual Exceedance Probability
0.2% Annual Exceedance Probability
Unnumbered Zone A

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Sheet 5 of 15

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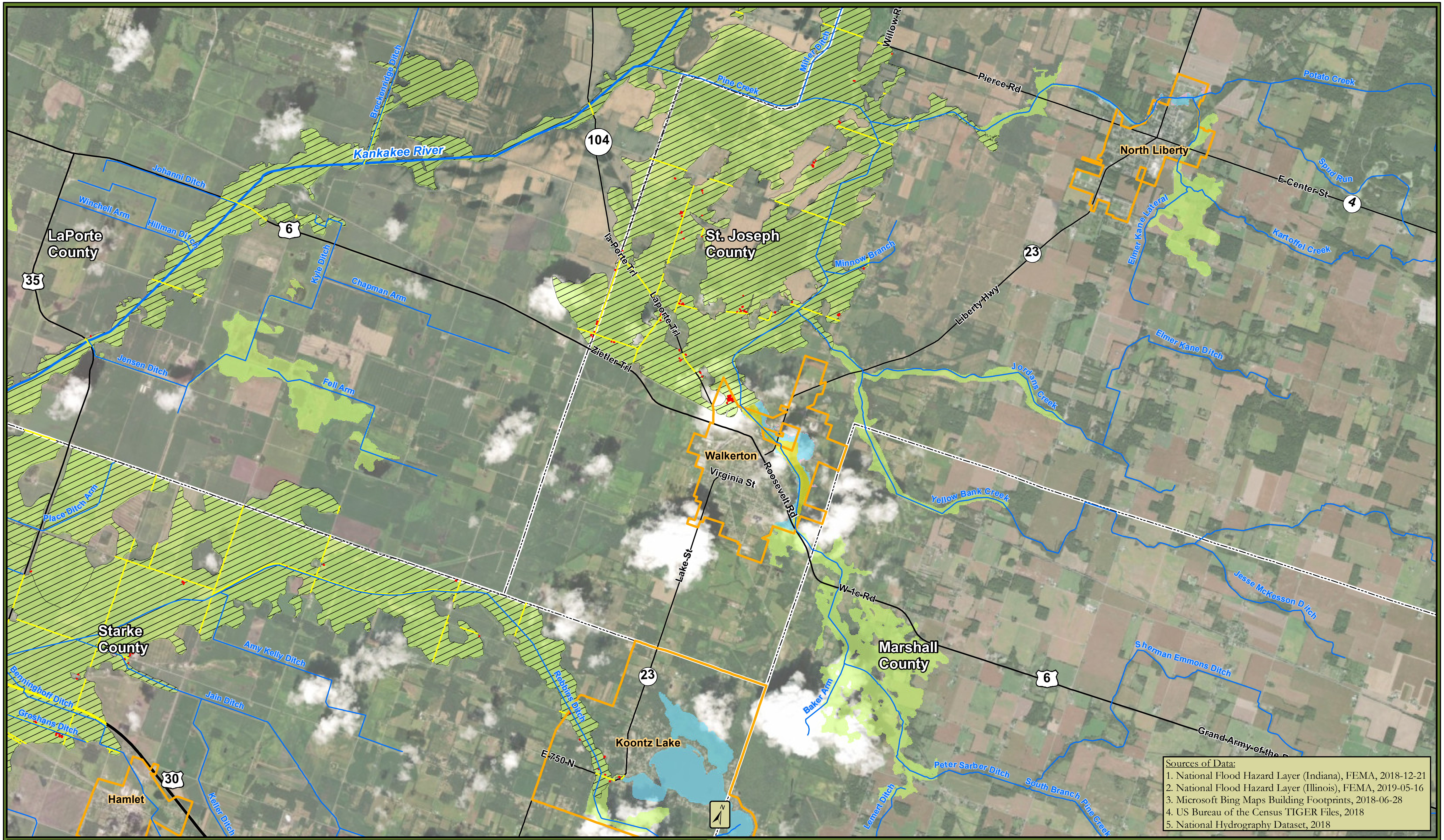

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Potentially Overtopped Roads
County Boundary
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Effective Flood Zones
Floodway
1.0% Annual Exceedance Probability
0.2% Annual Exceedance Probability
Unnumbered Zone A

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PROJECT: **Kankakee River Flood and Sediment Managemet Work Plan**

PROJECT NO. 18-0290

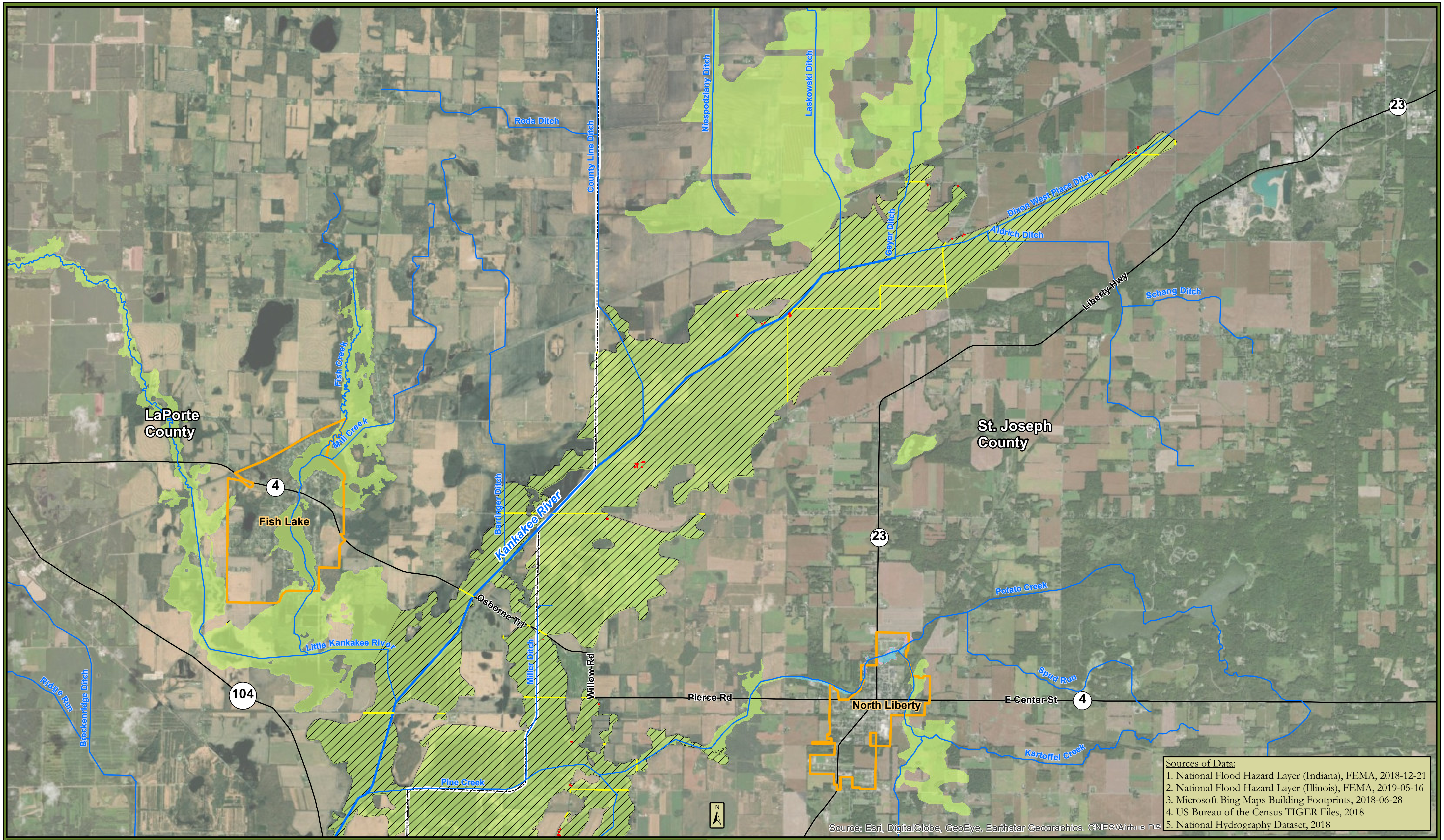
APPROX. SCALE 1"=5,000 '

TITLE: **Significant Flood Hazard Area and Potentially Flooded Structures and Roads**

DATE: 05/2019

Sheet 6 of 15

EXHIBIT 2



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS

Sources of Data:
1. National Flood Hazard Layer (Indiana), FEMA, 2018-12-21
2. National Flood Hazard Layer (Illinois), FEMA, 2019-05-16
3. Microsoft Bing Maps Building Footprints, 2018-06-28
4. US Bureau of the Census TIGER Files, 2018
5. National Hydrography Dataset, 2018

🟥 Potentially Flooded Structures
Potentially Overtopped Roads
County Boundary
▨ Significant Flood Hazard Area (Study Area Only)

Effective Flood Zones
Floodway
1.0% Annual Exceedance Probability
0.2% Annual Exceedance Probability
Unnumbered Zone A

Christopher B. Burke Engineering, LLC
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PROJECT: **Kankakee River Flood and Sediment Managemet Work Plan**

PROJECT NO. **18-0290**

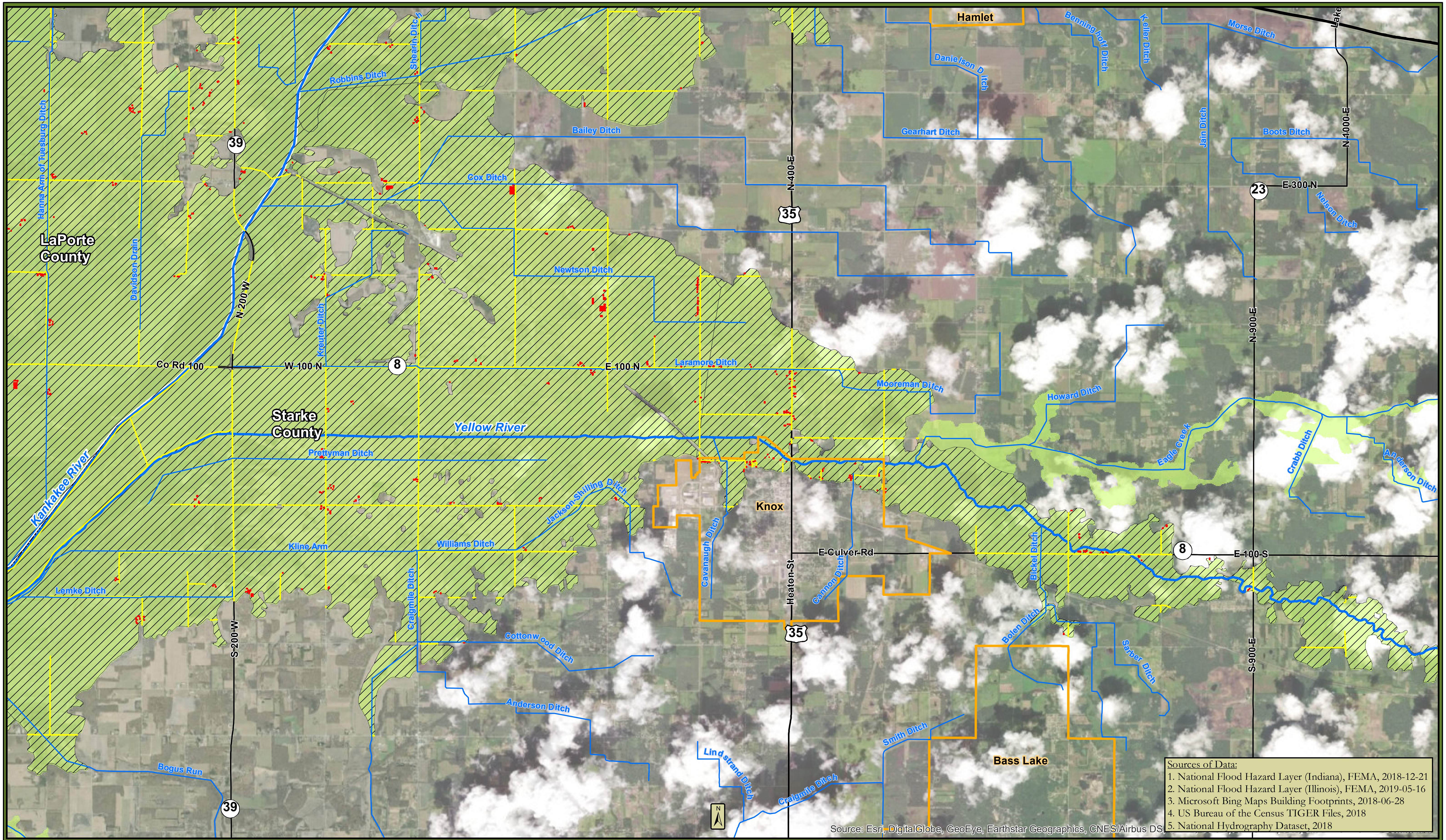
APPROX. SCALE **1"=5,000 '**

DATE: **05/2019**

TITLE: **Significant Flood Hazard Area and Potentially Flooded Structures and Roads**

Sheet 7 of 15

EXHIBIT 2



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3. Microsoft Bing Maps Building Footprints, 2018-06-28
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Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS

🟥 Potentially Flooded Structures
Potentially Overtopped Roads
County Boundary
▨ Significant Flood Hazard Area (Study Area Only)

Effective Flood Zones
Floodway
1.0% Annual Exceedance Probability
0.2% Annual Exceedance Probability
Unnumbered Zone A

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PROJECT: Kankakee River Flood and Sediment Managemet Work Plan

PROJECT NO. 18-0290

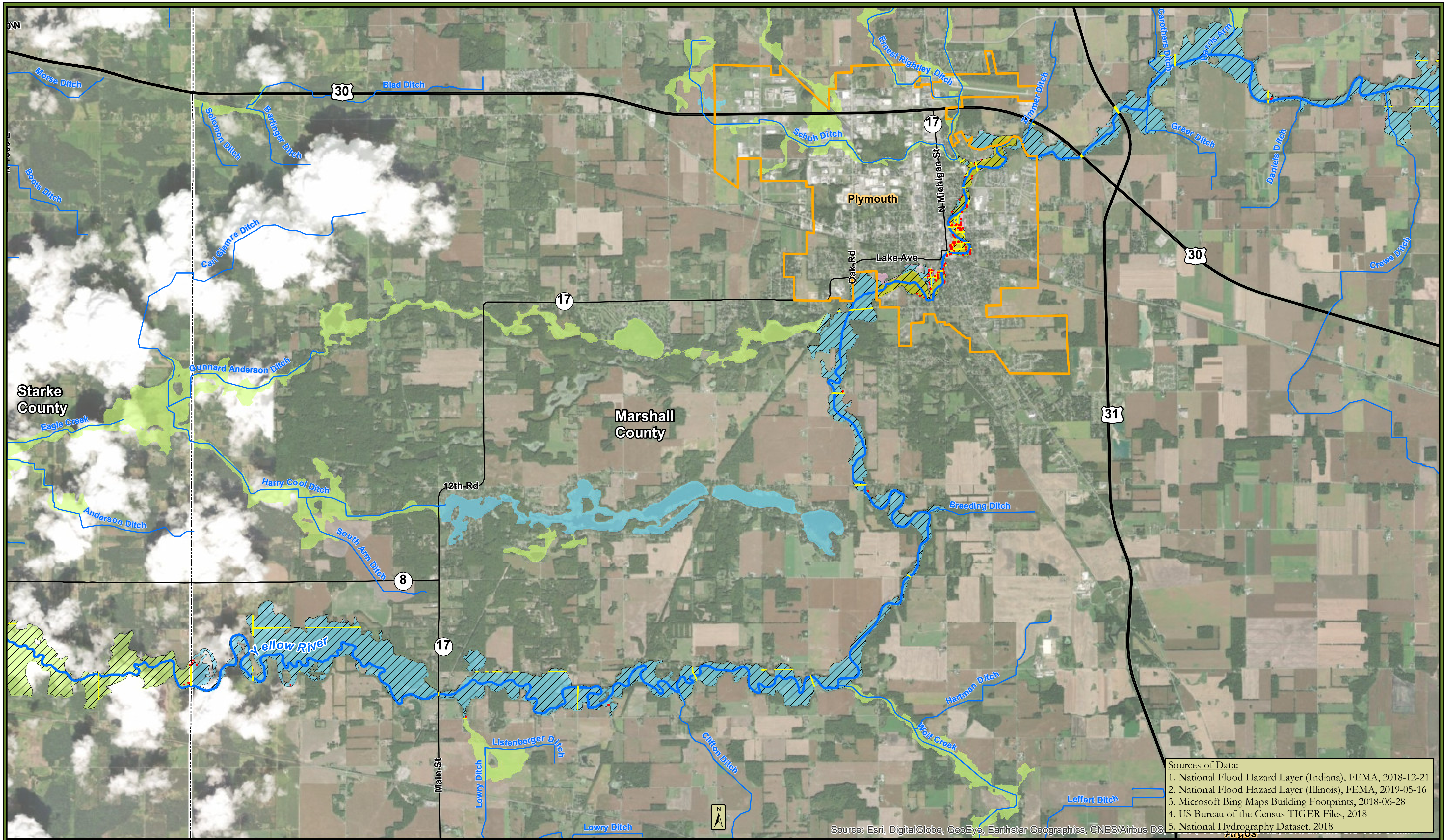
APPROX. SCALE 1"=5,000 '

DATE: 05/2019

TITLE: Significant Flood Hazard Area and Potentially Flooded Structures and Roads

Sheet 8 of 15

EXHIBIT 2



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🟥 Potentially Flooded Structures

〰 Potentially Overtopped Roads

▭ County Boundary

▨ Significant Flood Hazard Area (Study Area Only)

Effective Flood Zones

🟨 Floodway

🟦 1.0% Annual Exceedance Probability

🟪 0.2% Annual Exceedance Probability

🟩 Unnumbered Zone A

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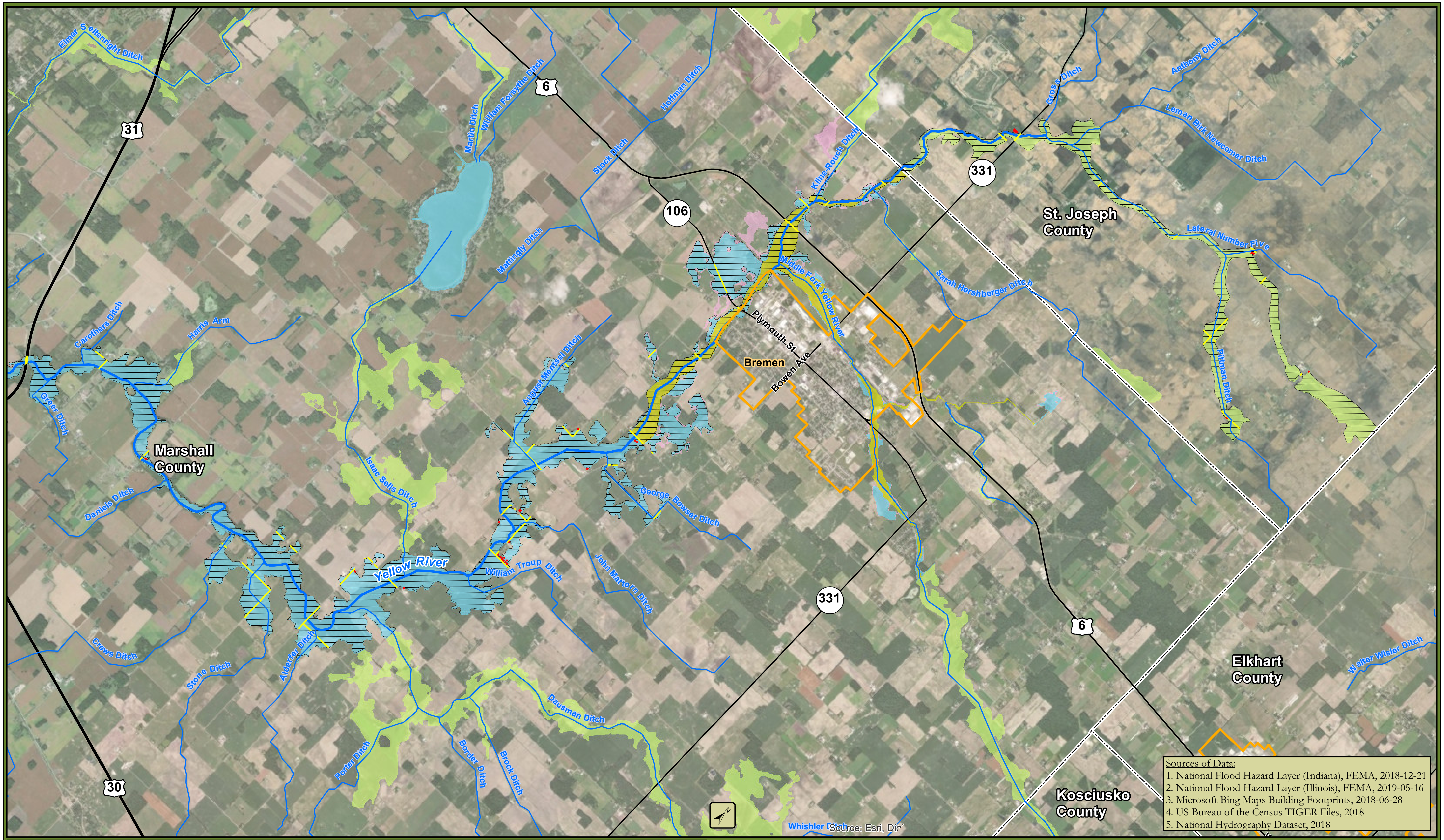
PROJECT:	Kankakee River Flood and Sediment Managemet Work Plan	PROJECT NO. 18-0290	APPROX. SCALE 1"=5,000 '
TITLE:	Significant Flood Hazard Area and Potentially Flooded Structures and Roads	Sheet 9 of 15	DATE: 05/2019
			EXHIBIT 2



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🟥 Potentially Flooded Structures
Potentially Overtopped Roads
County Boundary
▨ Significant Flood Hazard Area (Study Area Only)

Effective Flood Zones
Floodway
1.0% Annual Exceedance Probability
0.2% Annual Exceedance Probability
Unnumbered Zone A

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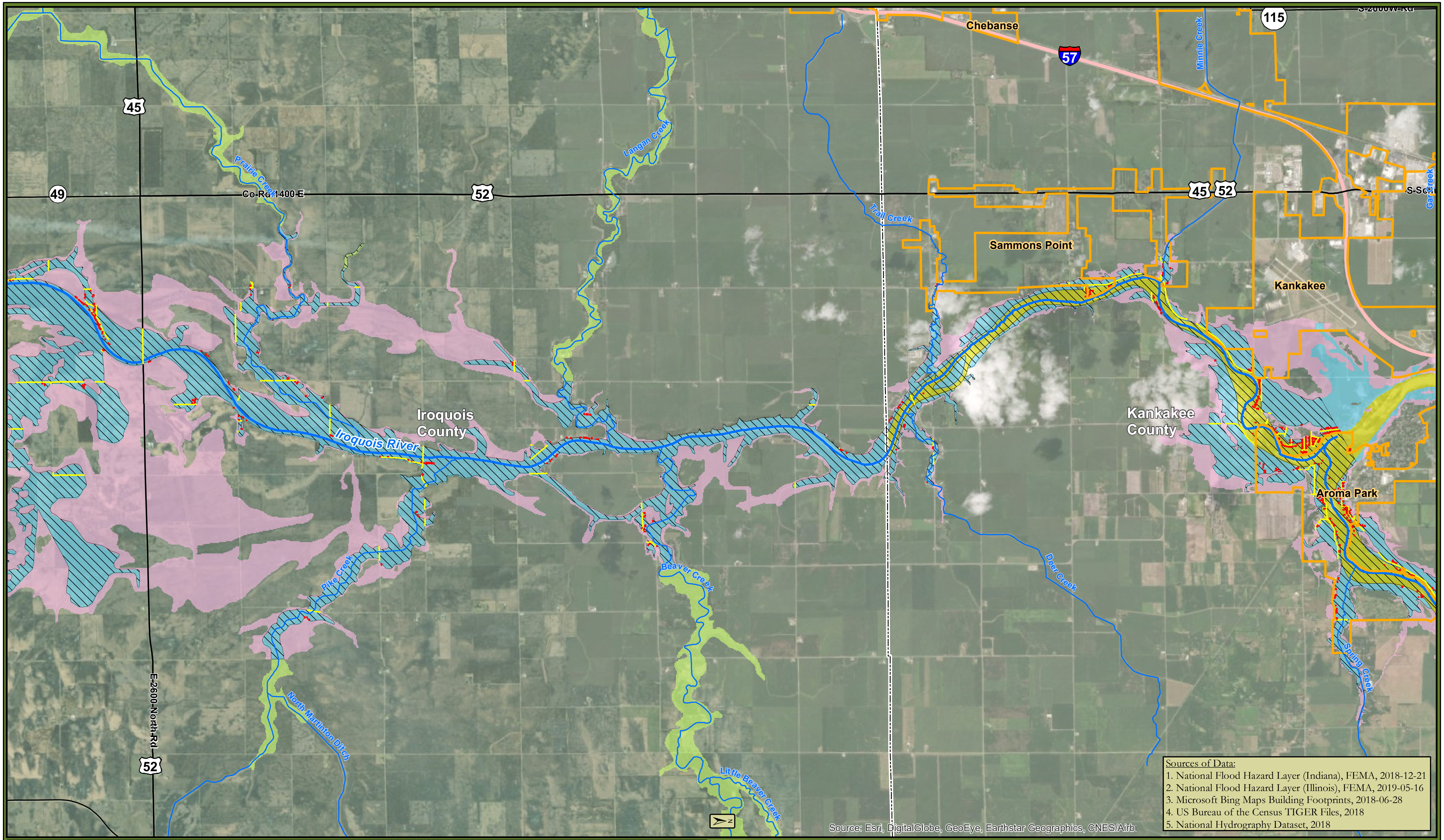
PROJECT: Kankakee River Flood and Sediment Managemet Work Plan		PROJECT NO. 18-0290	APPROX. SCALE 1"=5,000 '
TITLE: Significant Flood Hazard Area and Potentially Flooded Structures and Roads	Sheet 10 of 15		DATE: 05/2019
			EXHIBIT 2



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- 🟥 Potentially Flooded Structures
- Potentially Overtopped Roads
- ☐ County Boundary
- ▨ Significant Flood Hazard Area (Study Area Only)

Effective Flood Zones
- Floodway
- 1.0% Annual Exceedance Probability
- 0.2% Annual Exceedance Probability
- Unnumbered Zone A

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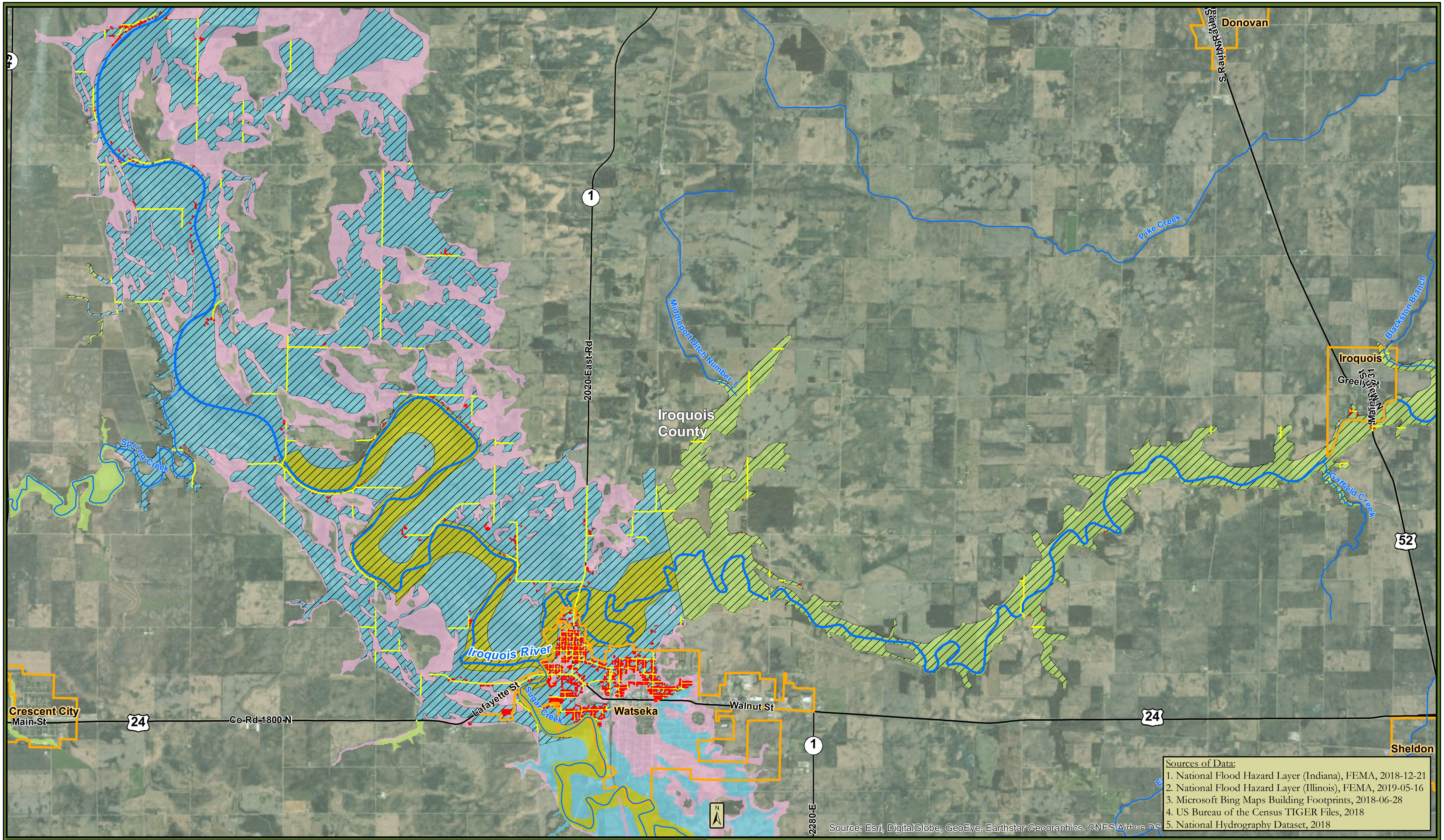
PROJECT: Kankakee River Flood and Sediment Managemet Work Plan	PROJECT NO. 18-0290	APPROX. SCALE 1"=5,000 '
TITLE: Significant Flood Hazard Area and Potentially Flooded Structures and Roads	Sheet 11 of 15	DATE: 05/2019 EXHIBIT 2



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🟥 Potentially Flooded Structures
⟋ Potentially Overtopped Roads
☐ County Boundary
▨ Significant Flood Hazard Area (Study Area Only)

Effective Flood Zones
🟨 Floodway
🟦 1.0% Annual Exceedance Probability
🟪 0.2% Annual Exceedance Probability
🟩 Unnumbered Zone A

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PROJECT: **Kankakee River Flood and Sediment Managemet Work Plan**

PROJECT NO. **18-0290**

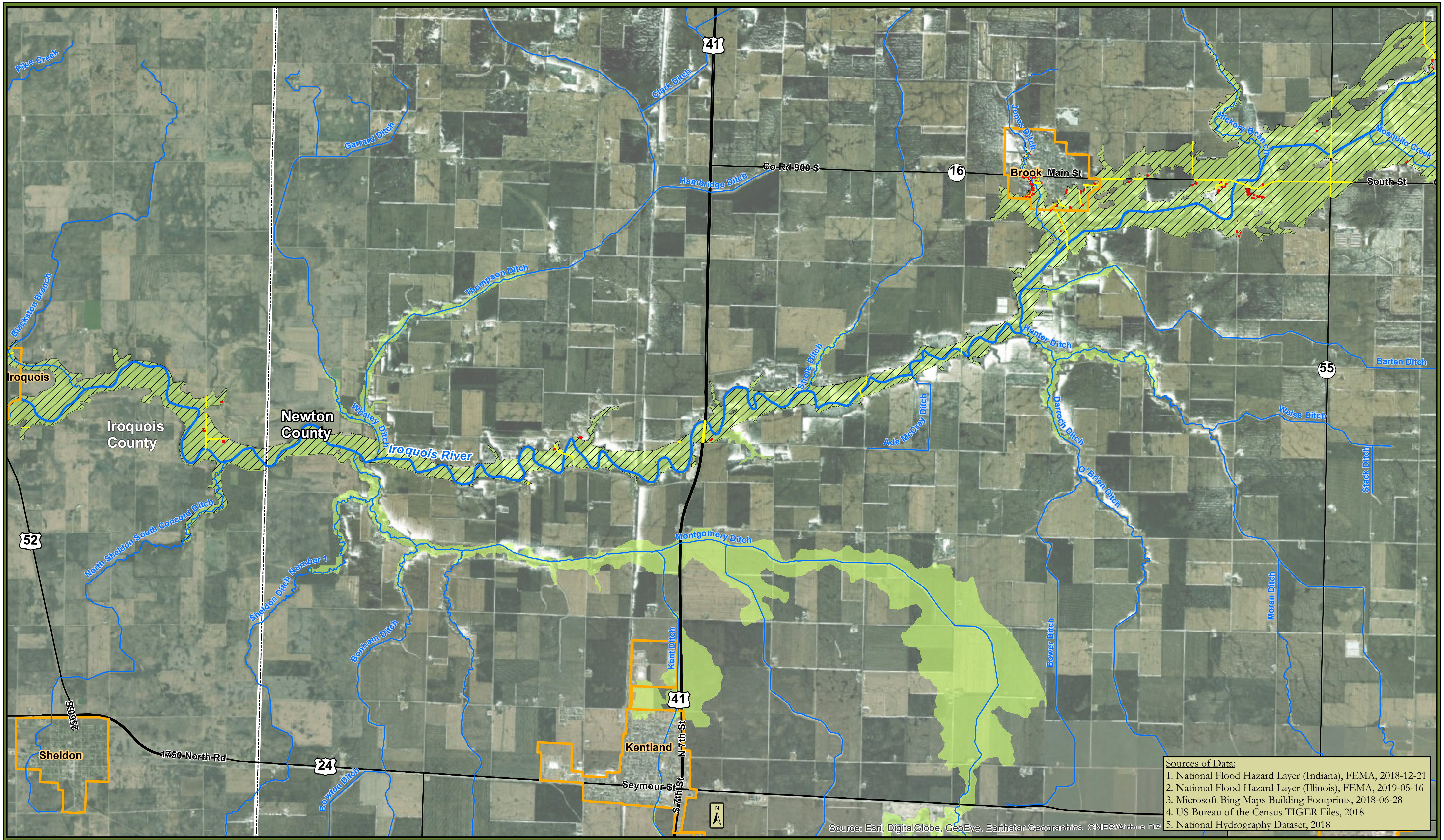
APPROX. SCALE **1"=5,000 '**

TITLE: **Significant Flood Hazard Area and Potentially Flooded Structures and Roads**

Sheet 12 of 15

DATE: 05/2019

EXHIBIT 2



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🟥 Potentially Flooded Structures
— Potentially Overtopped Roads
▭ County Boundary
▨ Significant Flood Hazard Area (Study Area Only)

Effective Flood Zones
- Floodway
- 1.0% Annual Exceedance Probability
- 0.2% Annual Exceedance Probability
- Unnumbered Zone A

CB
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PROJECT: Kankakee River Flood and Sediment Managemet Work Plan

PROJECT NO. 18-0290

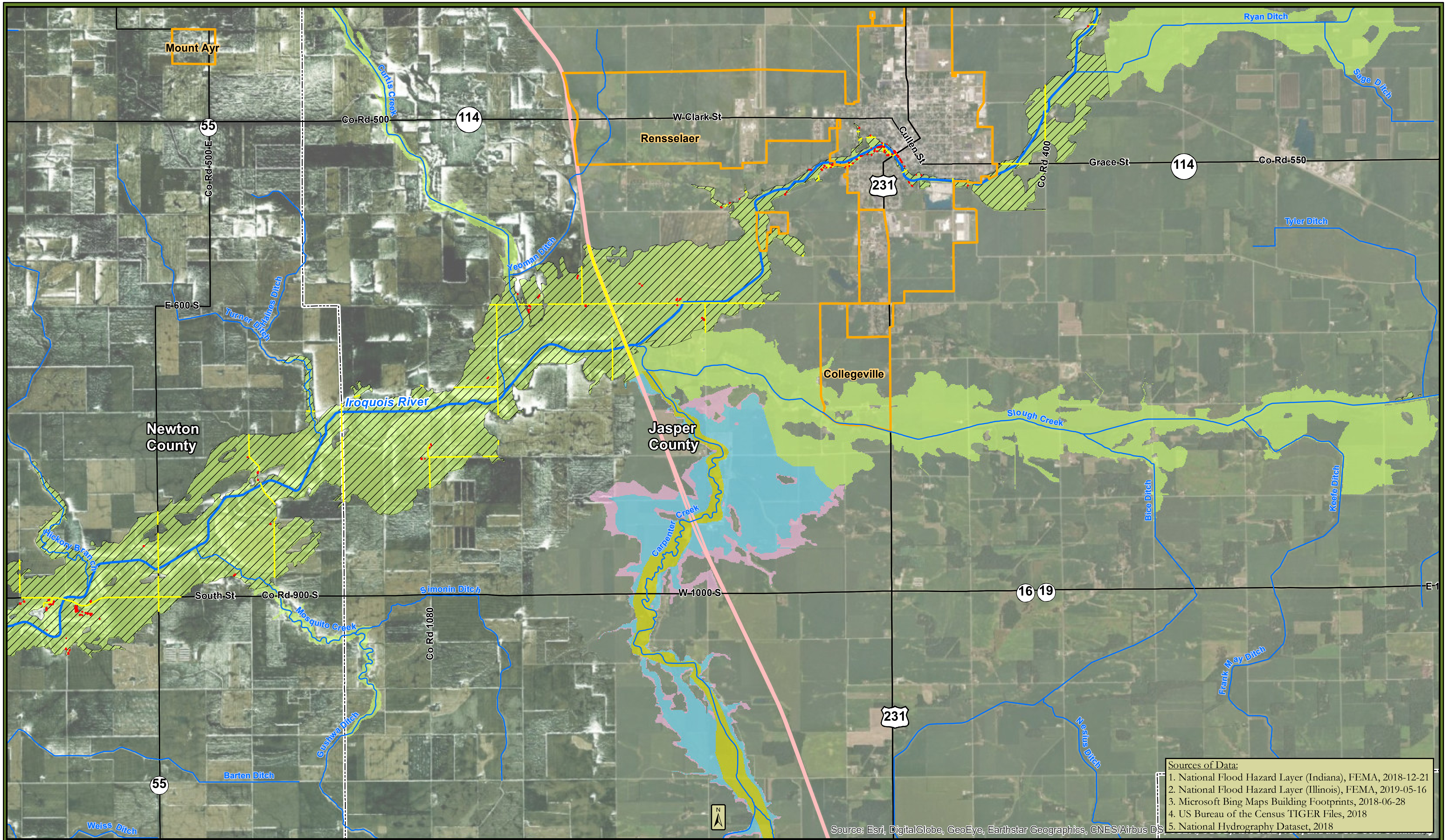
APPROX. SCALE 1"=5,000 '

DATE: 05/2019

TITLE: Significant Flood Hazard Area and Potentially Flooded Structures and Roads

Sheet 13 of 15

EXHIBIT 2



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS

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🟥 Potentially Flooded Structures
Potentially Overtopped Roads
☐ County Boundary
▨ Significant Flood Hazard Area (Study Area Only)

Effective Flood Zones
Floodway
1.0% Annual Exceedance Probability
0.2% Annual Exceedance Probability
Unnumbered Zone A

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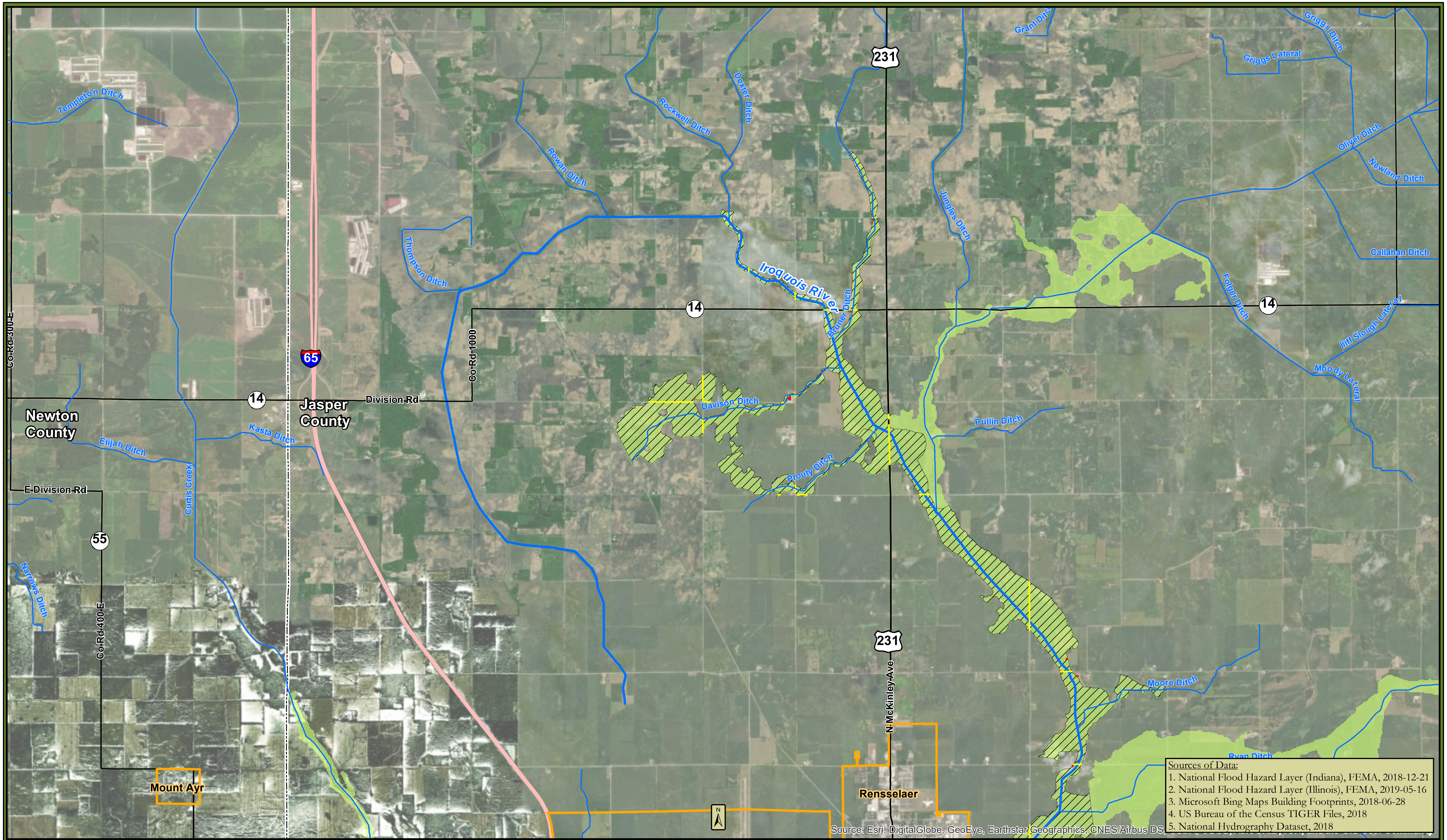
PROJECT: Kankakee River Flood and Sediment Managemet Work Plan	PROJECT NO. 18-0290	APPROX. SCALE 1"=5,000 '
TITLE: Significant Flood Hazard Area and Potentially Flooded Structures and Roads	Sheet 14 of 15	DATE: 05/2019 EXHIBIT 2



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2. National Flood Hazard Layer (Illinois), FEMA, 2019-05-16
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🟥 Potentially Flooded Structures
Potentially Overtopped Roads
County Boundary
▨ Significant Flood Hazard Area (Study Area Only)

Effective Flood Zones
Floodway
1.0% Annual Exceedance Probability
0.2% Annual Exceedance Probability
Unnumbered Zone A

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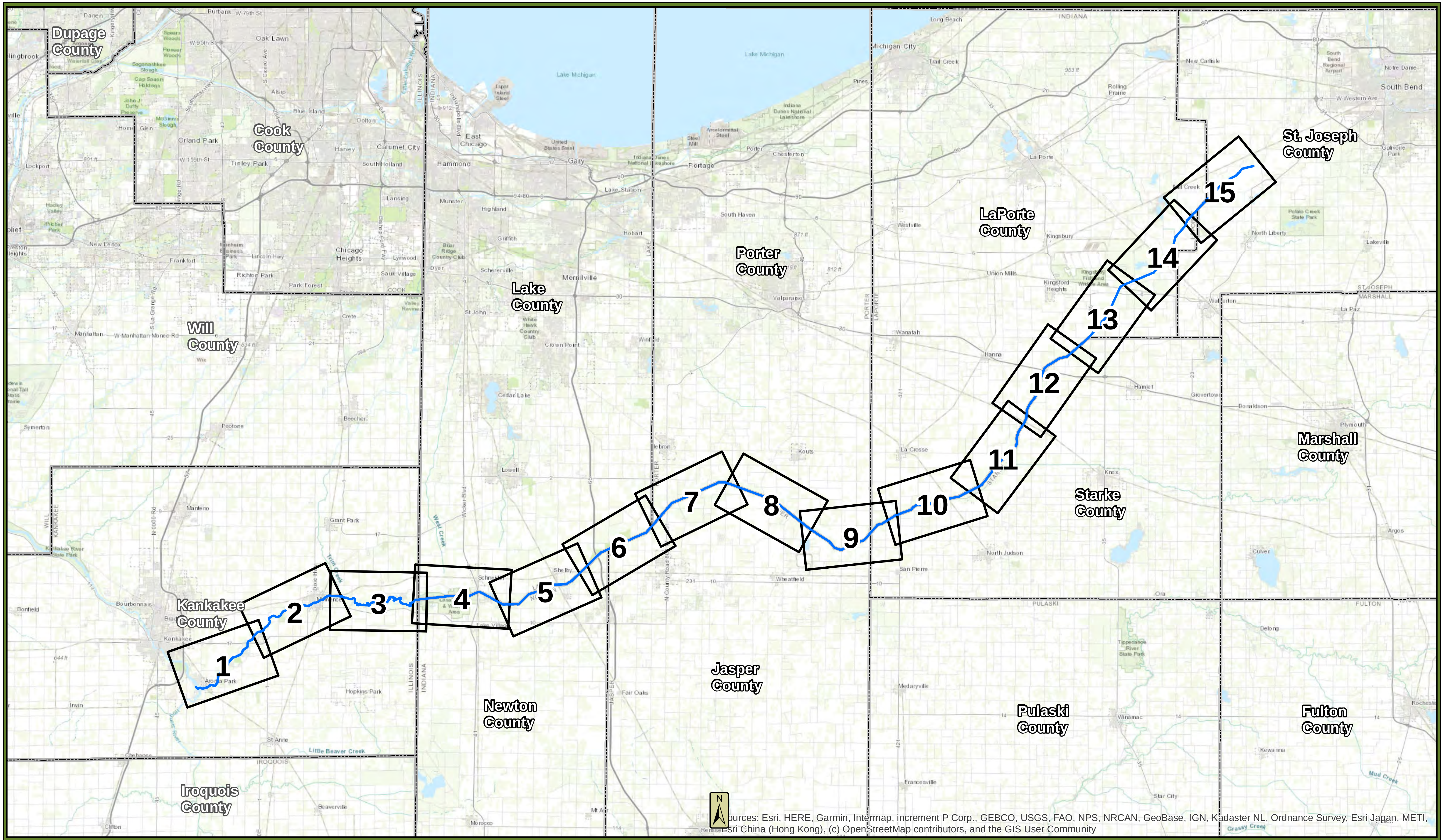
PROJECT: Kankakee River Flood and Sediment Managemet Work Plan		PROJECT NO. 18-0290	APPROX. SCALE 1"=5,000 '
TITLE: Significant Flood Hazard Area and Potentially Flooded Structures and Roads	Sheet 15 of 15		DATE: 05/2019
			EXHIBIT 2



ources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

⬚ County Boundary
☐ Map Panel

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PROJECT: Kankakee River Flood and Sediment Managemet Work Plan

PROJECT NO. 18-0290

APPROX. SCALE 1"=6miles

DATE: 06/2019

TITLE: Recommended Work Plan Components along Kankakee River Index Map

EXHIBIT 3

Legend

Berm Modifications
- Constructed Breach
- New / Improved Setback Berm
- Stabilize Unstable Slope

Berm Modifications (Continued)
- Maintain Existing Berm
- Road Improvement as Part of Setback Berm

Bridge Modifications
- ✓ Remove & Replace
- × Remove

Maintenance Access Improvements
- Channel-side Access Route
- ● Improved Bridge Access Point

County & Municipal Boundaries
- Indiana Counties
- Illinois Counties
- Corporate Limits

- IDNR River Mile
- Rivers / Streams / Ditches

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PROJECT:	Kankakee River Flood and Sediment Management Work Plan
PROJECT NO.	18-0290
APPROX. SCALE	1"=1,000'
DATE:	06/2018
TITLE:	Recommended Workplan Components (Kankakee River) (Sheet 1 of 15)
EXHIBIT	3

Legend

- ● IDNR River Mile
- 〰 Rivers / Streams / Ditches

Berm Modifications

- ● Constructed Breach
- 〰 New / Improved Setback Berm
- 🟥 Stabilize Unstable Slope

Berm Modifications (Continued)

- 〰 Maintain Existing Berm
- 〰 Road Improvement as Part of Setback Berm

Bridge Modifications

- ★ Remove & Replace
- ✕ Remove

Maintenance Access Improvements

- 〰 Channel-side Access Route
- ● Improved Bridge Access Point

County & Municipal Boundaries

- ▢ Indiana Counties
- ▢ Illinois Counties
- ▢ Corporate Limits

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PROJECT: Kankakee River Flood and Sediment Management Work Plan	PROJECT NO. 18-0290	APPROX. SCALE 1"=1,000'
TITLE: Recommended Workplan Components (Kankakee River) (Sheet 2 of 15)		DATE: 06/2018
		EXHIBIT 3

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Legend

- ● IDNR River Mile
- 〰 Rivers / Streams / Ditches

Berm Modifications

- ● Constructed Breach
- 〰 New / Improved Setback Berm
- 🟥 Stabilize Unstable Slope

Berm Modifications (Continued)

- 〰 Maintain Existing Berm
- 〰 Road Improvement as Part of Setback Berm

Bridge Modifications

- ★ Remove & Replace
- ✕ Remove

Maintenance Access Improvements

- 〰 Channel-side Access Route
- ● Improved Bridge Access Point

County & Municipal Boundaries

- ▢ Indiana Counties
- ▢ Illinois Counties
- ▢ Corporate Limits

Christopher B. Burke Engineering, LLC PNC Center, Suite 1368 South 115 West Washington Street Indianapolis, Indiana 46204 (t) 317.266.8000 (f) 317.632.3306	PROJECT: Kankakee River Flood and Sediment Management Work Plan	PROJECT NO. 18-0290	APPROX. SCALE 1"=1,000'
	TITLE: Recommended Workplan Components (Kankakee River) (Sheet 3 of 15)		DATE: 06/2018
			EXHIBIT 3

Legend

- • IDNR River Mile
- 〰 Rivers / Streams / Ditches

Berm Modifications

- ● Constructed Breach
- New / Improved Setback Berm
- Stabilize Unstable Slope

Berm Modifications (Continued)

- Maintain Existing Berm
- Road Improvement as Part of Setback Berm

Bridge Modifications

- ★ Remove & Replace
- ✕ Remove

Maintenance Access Improvements

- Channel-side Access Route
- ● Improved Bridge Access Point

County & Municipal Boundaries

- ☐ Indiana Counties
- ☐ Illinois Counties
- ☐ Corporate Limits

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TITLE: Recommended Workplan Components (Kankakee River) (Sheet 4 of 15)			DATE: 06/2018
			EXHIBIT 3

Legend

- ● IDNR River Mile
- 〰 Rivers / Streams / Ditches

Berm Modifications

- ● Constructed Breach
- 〰 New / Improved Setback Berm
- 🟥 Stabilize Unstable Slope

Berm Modifications (Continued)

- 〰 Maintain Existing Berm
- 〰 Road Improvement as Part of Setback Berm

Bridge Modifications

- ★ Remove & Replace
- ✕ Remove

Maintenance Access Improvements

- 〰 Channel-side Access Route
- ● Improved Bridge Access Point

County & Municipal Boundaries

- ☐ Indiana Counties
- ☐ Illinois Counties
- ☐ Corporate Limits

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PROJECT:	Kankakee River Flood and Sediment Management Work Plan	PROJECT NO. 18-0290	APPROX. SCALE 1"=1,000'
TITLE:	Recommended Workplan Components (Kankakee River) (Sheet 5 of 15)		DATE: 06/2018
			EXHIBIT 3

Legend

- • IDNR River Mile
- 〰 Rivers / Streams / Ditches

Berm Modifications

- ● Constructed Breach
- 〰 New / Improved Setback Berm
- 🟥 Stabilize Unstable Slope

Berm Modifications (Continued)

- 〰 Maintain Existing Berm
- 〰 Road Improvement as Part of Setback Berm

Bridge Modifications

- ★ Remove & Replace
- ✕ Remove

Maintenance Access Improvements

- 〰 Channel-side Access Route
- ● Improved Bridge Access Point

County & Municipal Boundaries

- ☐ Indiana Counties
- ☐ Illinois Counties
- ☐ Corporate Limits

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TITLE:	Recommended Workplan Components (Kankakee River) (Sheet 6 of 15)		DATE: 06/2018
			EXHIBIT 3

Legend

- IDNR River Mile
- Rivers / Streams / Ditches

Berm Modifications

- ● Constructed Breach
- New / Improved Setback Berm
- Stabilize Unstable Slope

Berm Modifications (Continued)

- Maintain Existing Berm
- Road Improvement as Part of Setback Berm

Bridge Modifications

- ★ Remove & Replace
- ✕ Remove

Maintenance Access Improvements

- Channel-side Access Route
- ● Improved Bridge Access Point

County & Municipal Boundaries

- Indiana Counties
- Illinois Counties
- Corporate Limits

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PROJECT: Kankakee River Flood and Sediment Management Work Plan		PROJECT NO. 18-0290	APPROX. SCALE 1"=1,000'
TITLE: Recommended Workplan Components (Kankakee River) (Sheet 7 of 15)			DATE: 06/2018
			EXHIBIT 3

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus

Legend

- IDNR River Mile
- Rivers / Streams / Ditches

Berm Modifications

- ● Constructed Breach
- New / Improved Setback Berm
- 🟥 Stabilize Unstable Slope

Berm Modifications (Continued)

- Maintain Existing Berm
- Road Improvement as Part of Setback Berm

Bridge Modifications

- ★ Remove & Replace
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Maintenance Access Improvements

- Channel-side Access Route
- ● Improved Bridge Access Point

County & Municipal Boundaries

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TITLE: Recommended Workplan Components (Kankakee River) (Sheet 8 of 15)		DATE: 06/2018
		EXHIBIT 3

Legend

- ● IDNR River Mile
- 〰 Rivers / Streams / Ditches

Berm Modifications

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- 〰 New / Improved Setback Berm
- 🟥 Stabilize Unstable Slope

Berm Modifications (Continued)

- 〰 Maintain Existing Berm
- 〰 Road Improvement as Part of Setback Berm

Bridge Modifications

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Maintenance Access Improvements

- 〰 Channel-side Access Route
- ● Improved Bridge Access Point

County & Municipal Boundaries

- ▢ Indiana Counties
- ▢ Illinois Counties
- ▢ Corporate Limits

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TITLE:	Recommended Workplan Components (Kankakee River) (Sheet 9 of 15)		DATE: 06/2018
			EXHIBIT 3

Legend

- ● IDNR River Mile
- 〰 Rivers / Streams / Ditches

Berm Modifications

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Berm Modifications (Continued)

- 〰 Maintain Existing Berm
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Bridge Modifications

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Maintenance Access Improvements

- 〰 Channel-side Access Route
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County & Municipal Boundaries

- ▢ Indiana Counties
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PROJECT:	Kankakee River Flood and Sediment Management Work Plan	PROJECT NO. 18-0290	APPROX. SCALE 1"=1,000'
TITLE:	Recommended Workplan Components (Kankakee River) (Sheet 10 of 15)		DATE: 06/2018
			EXHIBIT 3

Legend

- IDNR River Mile
- Rivers / Streams / Ditches

Berm Modifications
- ● Constructed Breach
- New / Improved Setback Berm
- Stabilize Unstable Slope

Berm Modifications (Continued)
- Maintain Existing Berm
- Road Improvement as Part of Setback Berm

Bridge Modifications
- ★ Remove & Replace
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Maintenance Access Improvements
- Channel-side Access Route
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County & Municipal Boundaries
- Indiana Counties
- Illinois Counties
- Corporate Limits

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	TITLE: Recommended Workplan Components (Kankakee River) (Sheet 11 of 15)		DATE: 06/2018
			EXHIBIT 3

Legend

- ● IDNR River Mile
- 〰 Rivers / Streams / Ditches

Berm Modifications

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Berm Modifications (Continued)

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PROJECT: Kankakee River Flood and Sediment Management Work Plan

PROJECT NO. 18-0290

APPROX. SCALE 1"=1,000'

DATE: 06/2018

TITLE: Recommended Workplan Components (Kankakee River) (Sheet 12 of 15)

EXHIBIT 3

Legend

- IDNR River Mile
- Rivers / Streams / Ditches

Berm Modifications
- ● Constructed Breach
- New / Improved Setback Berm
- 🟥 Stabilize Unstable Slope

Berm Modifications (Continued)
- Maintain Existing Berm
- Road Improvement as Part of Setback Berm

Bridge Modifications
- ★ Remove & Replace
- ✕ Remove

Maintenance Access Improvements
- Channel-side Access Route
- ● Improved Bridge Access Point

County & Municipal Boundaries
- ☐ Indiana Counties
- ☐ Illinois Counties
- ☐ Corporate Limits

CBB
BURKE

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(t) 317.266.8000 (f) 317.632.3306

PROJECT: Kankakee River Flood and Sediment Management Work Plan	PROJECT NO. 18-0290	APPROX. SCALE 1"=1,000'
TITLE: Recommended Workplan Components (Kankakee River) (Sheet 13 of 15)		DATE: 06/2018
		EXHIBIT 3

Legend

- IDNR River Mile
- Rivers / Streams / Ditches

Berm Modifications

- ● Constructed Breach
- New / Improved Setback Berm
- Stabilize Unstable Slope

Berm Modifications (Continued)

- Maintain Existing Berm
- Road Improvement as Part of Setback Berm

Bridge Modifications

- ★ Remove & Replace
- ✕ Remove

Maintenance Access Improvements

- Channel-side Access Route
- ● Improved Bridge Access Point

County & Municipal Boundaries

- Indiana Counties
- Illinois Counties
- Corporate Limits

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PROJECT: Kankakee River Flood and Sediment Management Work Plan		PROJECT NO. 18-0290	APPROX. SCALE 1"=1,000'
TITLE: Recommended Workplan Components (Kankakee River) (Sheet 14 of 15)			DATE: 06/2018
			EXHIBIT 3

Legend

● IDNR River Mile
〰 Rivers / Streams / Ditches

Berm Modifications
● Constructed Breach
〰 New / Improved Setback Berm
🟥 Stabilize Unstable Slope

Berm Modifications (Continued)
〰 Maintain Existing Berm
〰 Road Improvement as Part of Setback Berm

Bridge Modifications
★ Remove & Replace
✕ Remove

Maintenance Access Improvements
〰 Channel-side Access Route
● Improved Bridge Access Point

County & Municipal Boundaries
▢ Indiana Counties
▢ Illinois Counties
▢ Corporate Limits

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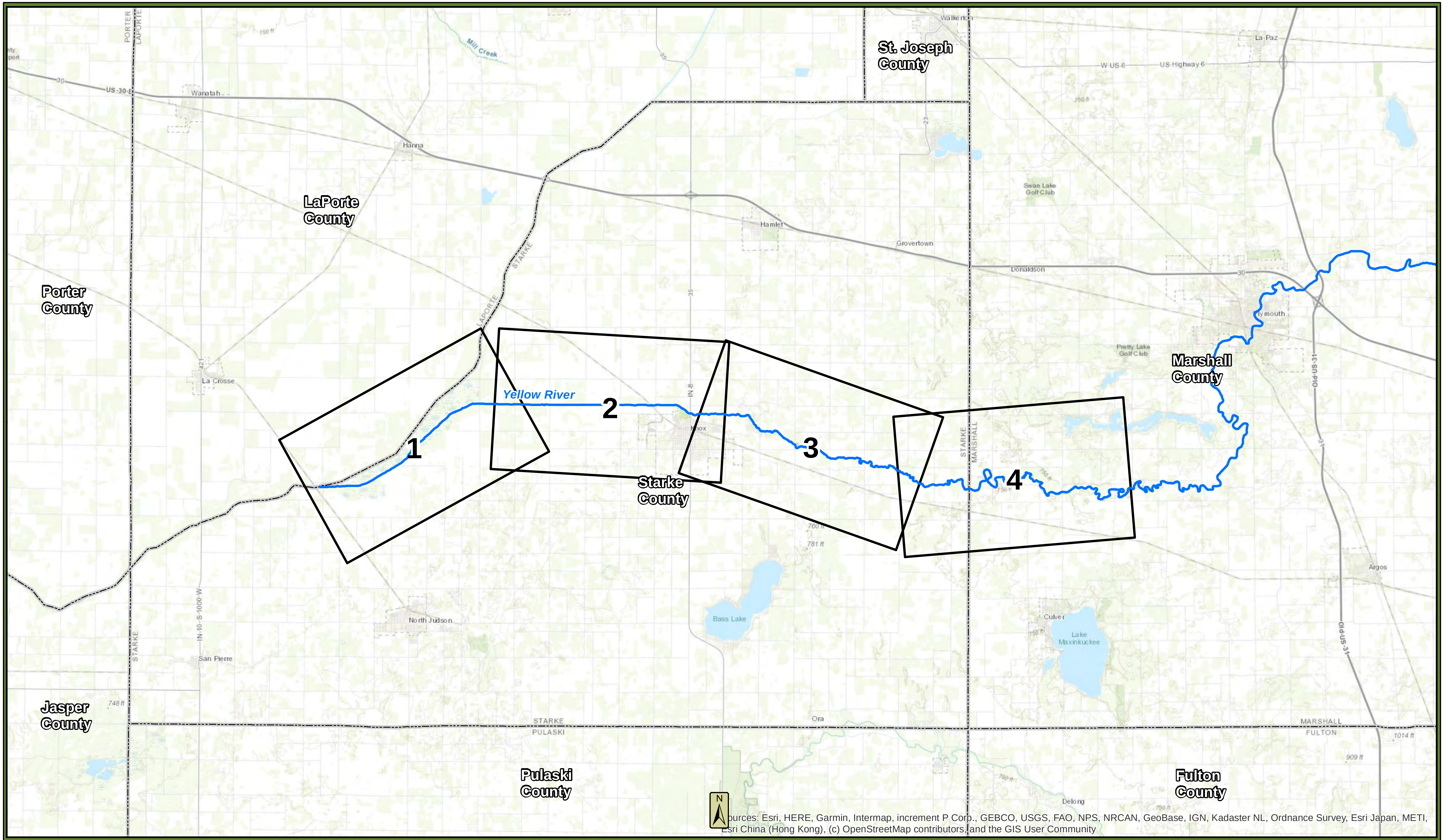
PROJECT:	Kankakee River Flood and Sediment Management Work Plan	PROJECT NO. 18-0290	APPROX. SCALE 1"=1,000'
TITLE:	Recommended Workplan Components (Kankakee River) (Sheet 15 of 15)		DATE: 06/2018
			EXHIBIT 3



ources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

☐ Map Panel
⬚ County Boundary

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PROJECT: Kankakee River Flood and Sediment Managemet Work Plan		PROJECT NO. 18-0290	APPROX. SCALE 1"=2.5miles
			DATE: 06/2019
TITLE: Recommended Work Plan Components along Yellow River	Index Map		EXHIBIT 4

Legend

- • IDNR River Mile
- Rivers / Streams / Ditches

Berm Modifications

- ● Constructed Breach
- New / Improved Setback Berm
- Stabilize Unstable Slope

Berm Modifications (Continued)

- Maintain Existing Berm
- Road Improvement as Part of Setback Berm

Bridge Modifications

- ★ Remove & Replace
- ✕ Remove

Maintenance Access Improvements

- Channel-side Access Route
- ● Improved Bridge Access Point

County & Municipal Boundaries

- ☐ Indiana Counties
- ☐ Illinois Counties
- ☐ Corporate Limits

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(t) 317.266.8000 (f) 317.632.3306

PROJECT:	Kankakee River Flood and Sediment Management Work Plan
PROJECT NO.	18-0290
APPROX. SCALE	1"=1,257'
TITLE:	Recommended Workplan Components (Yellow River) (Sheet 1 of 4)
DATE:	06/2018
EXHIBIT	3

Legend

- ● IDNR River Mile
- 〰 Rivers / Streams / Ditches

Berm Modifications

- ● Constructed Breach
- 🟪 New / Improved Setback Berm
- 🟥 Stabilize Unstable Slope

Berm Modifications (Continued)

- 🟩 Maintain Existing Berm
- ■ Road Improvement as Part of Setback Berm

Bridge Modifications

- ★ Remove & Replace
- ✕ Remove

Maintenance Access Improvements

- 〰 Channel-side Access Route
- ● Improved Bridge Access Point

County & Municipal Boundaries

- ▢ Indiana Counties
- ▢ Illinois Counties
- ▢ Corporate Limits

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PROJECT: Kankakee River Flood and Sediment Management Work Plan

PROJECT NO. 18-0290

APPROX. SCALE 1"=1,558'

TITLE: Recommended Workplan Components (Yellow River) (Sheet 2 of 4)

DATE: 06/2018

EXHIBIT 3

Legend

- ● IDNR River Mile
- Rivers / Streams / Ditches

Berm Modifications

- ● Constructed Breach
- New / Improved Setback Berm
- Stabilize Unstable Slope

Berm Modifications (Continued)

- Maintain Existing Berm
- Road Improvement as Part of Setback Berm

Bridge Modifications

- ★ Remove & Replace
- ✕ Remove

Maintenance Access Improvements

- Channel-side Access Route
- ● Improved Bridge Access Point

County & Municipal Boundaries

- ▭ Indiana Counties
- ▭ Illinois Counties
- ▭ Corporate Limits

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PROJECT: Kankakee River Flood and Sediment Management Work Plan

PROJECT NO. 18-0290

APPROX. SCALE 1"=1,807'

DATE: 06/2018

TITLE: Recommended Workplan Components (Yellow River) (Sheet 3 of 4)

EXHIBIT 3

Legend

- ● IDNR River Mile
- 〰 Rivers / Streams / Ditches

Berm Modifications

- ● Constructed Breach
- 〰 New / Improved Setback Berm
- 🟥 Stabilize Unstable Slope

Berm Modifications (Continued)

- 〰 Maintain Existing Berm
- 〰 Road Improvement as Part of Setback Berm

Bridge Modifications

- ★ Remove & Replace
- ✕ Remove

Maintenance Access Improvements

- 〰 Channel-side Access Route
- ● Improved Bridge Access Point

County & Municipal Boundaries

- ▢ Indiana Counties
- ▢ Illinois Counties
- ▢ Corporate Limits

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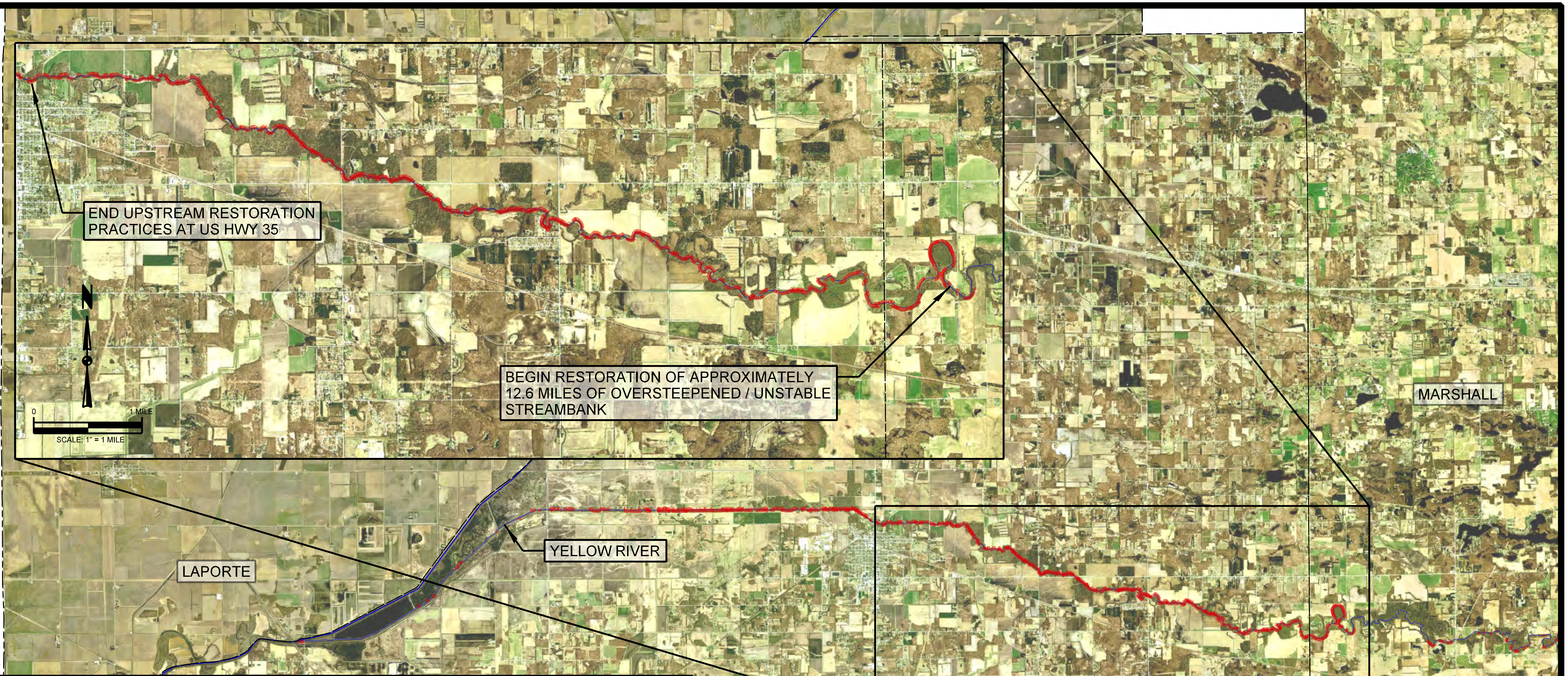
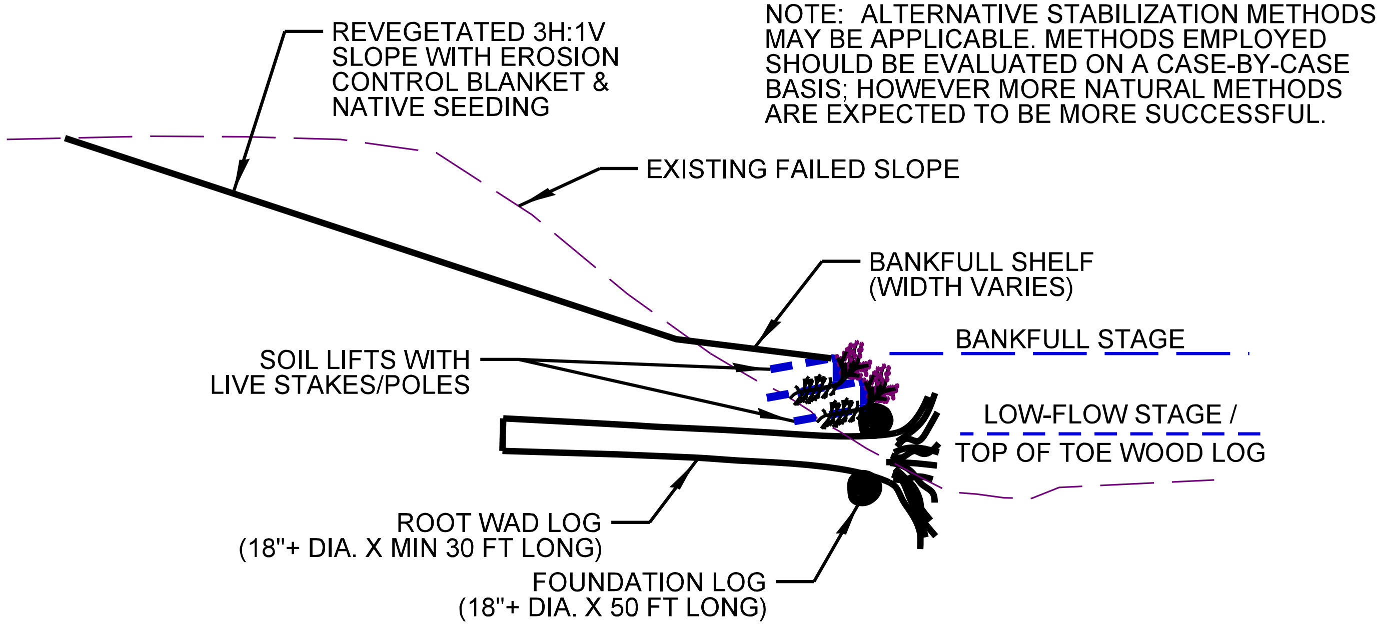
PROJECT:	**Kankakee River Flood and Sediment Management Work Plan**	PROJECT NO. 18-0290	APPROX. SCALE 1"=1,381'
TITLE:	**Recommended Workplan Components (Yellow River) (Sheet 4 of 4)**		DATE: 06/2018
			EXHIBIT 3





NOTE: ALTERNATIVE STABILIZATION METHODS MAY BE APPLICABLE. METHODS EMPLOYED SHOULD BE EVALUATED ON A CASE-BY-CASE BASIS; HOWEVER MORE NATURAL METHODS ARE EXPECTED TO BE MORE SUCCESSFUL.

② TYPICAL SECTION - TOE WOOD DETAIL
NOT TO SCALE

R:\2018\18-0290.00000\CAD\EX1 - Yellow River Upstream Improvements.dgn
6/10/2019

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PNC Center, Suite 1368 South
115 West Washington Street
Indianapolis, Indiana 46204
(317) 266-8000 FAX: (317) 632-3306

CERTIFIED:
NOT FOR CONSTRUCTION

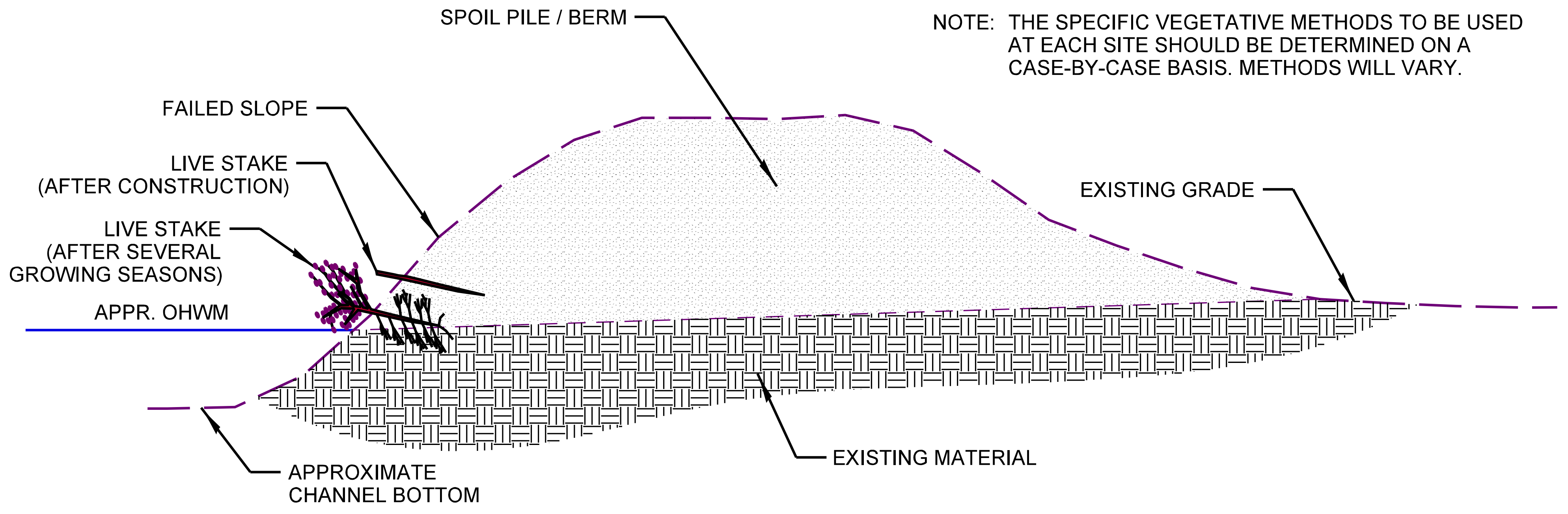
TITLE:
YELLOW RIVER
UPSTREAM IMPROVEMENTS

PROJECT:
KANKAKEE RIVER FLOOD &
SEDIMENT MANAGEMENT WORK PLAN

PROJECT NO.
19.R180290.00000

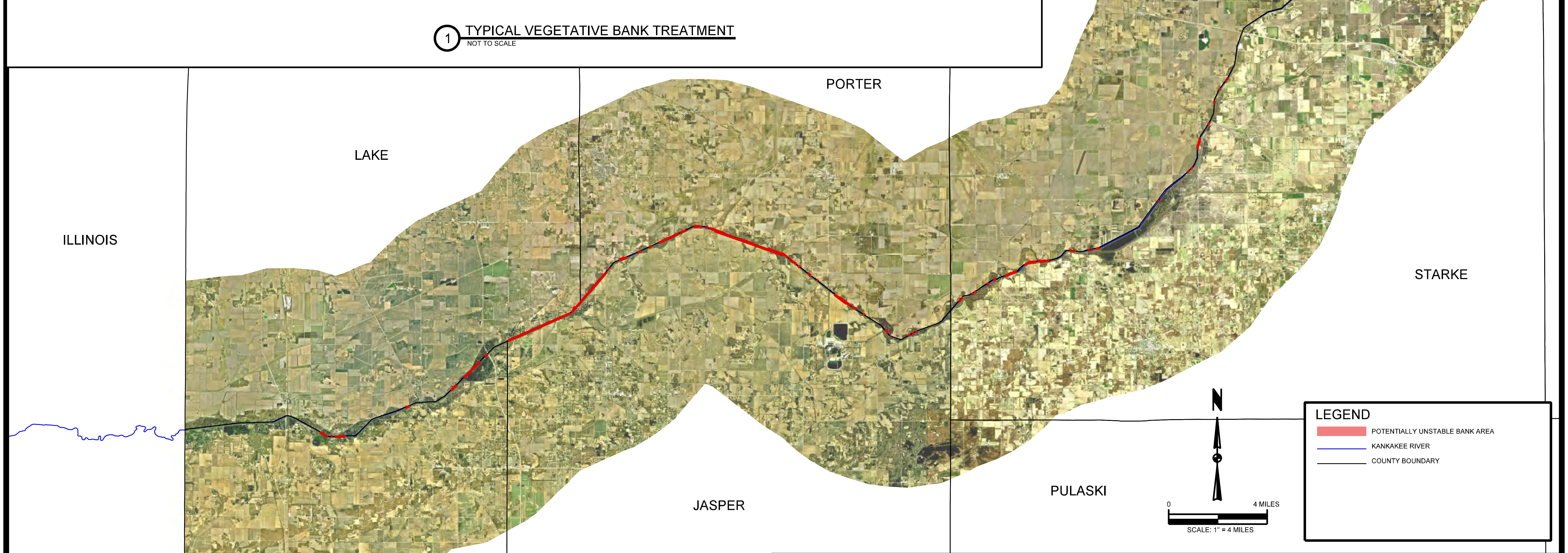
SHEET 5 OF 9

DRAWING NO.
EX5



NOTE: THE SPECIFIC VEGETATIVE METHODS TO BE USED AT EACH SITE SHOULD BE DETERMINED ON A CASE-BY-CASE BASIS. METHODS WILL VARY.

① TYPICAL VEGETATIVE BANK TREATMENT
NOT TO SCALE



LEGEND

🟥	POTENTIALLY UNSTABLE BANK AREA
─	KANKAKEE RIVER
─	COUNTY BOUNDARY

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CERTIFIED:
NOT FOR CONSTRUCTION

TITLE:
KANKAKEE BANK STABILIZATION IMPROVEMENTS

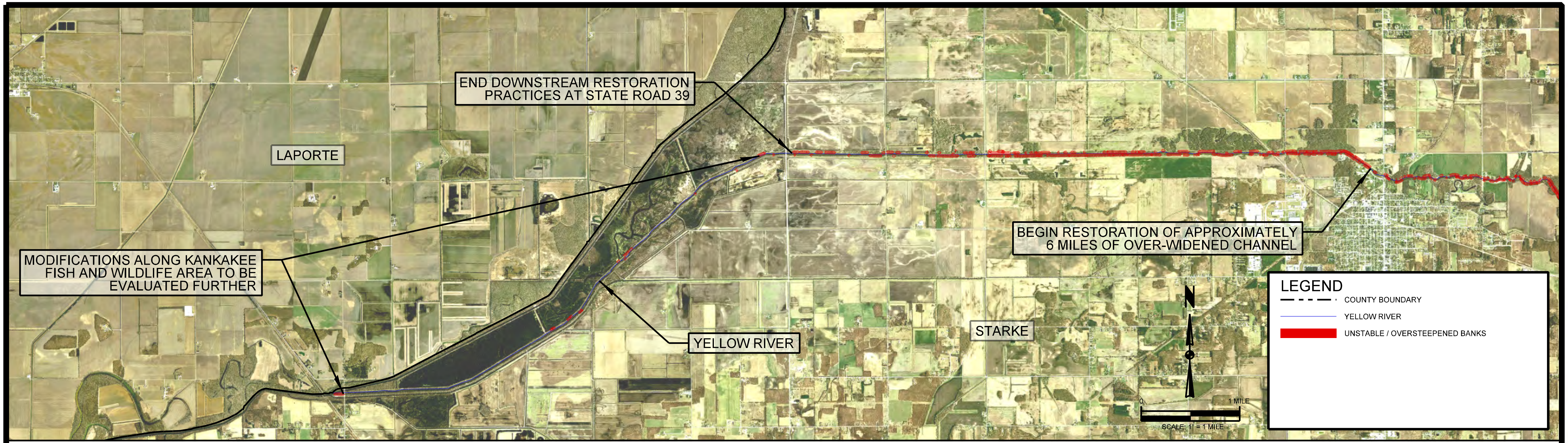
PROJECT:
KANKAKEE RIVER FLOOD & SEDIMENT MANAGEMENT WORK PLAN

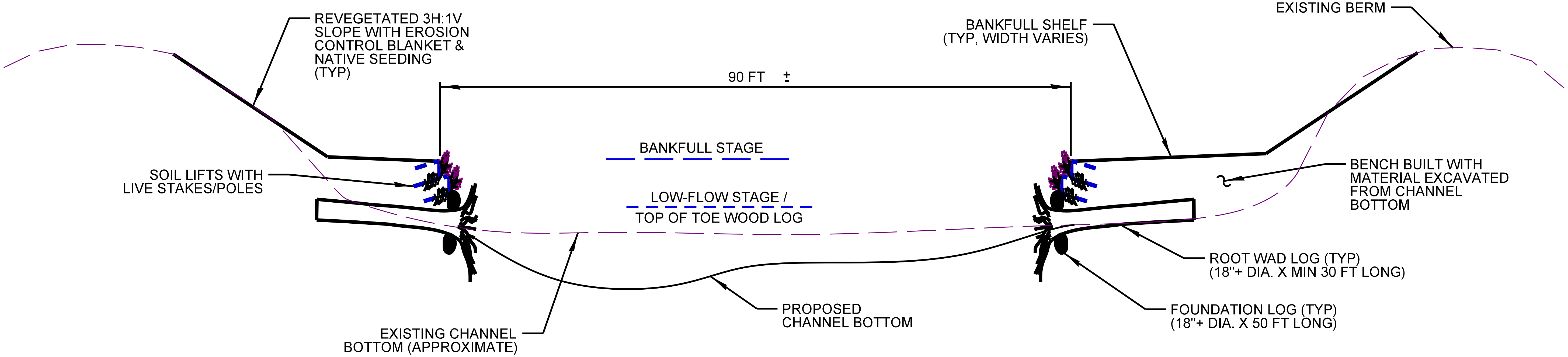
PROJECT NO.
19.R180290.00000

SHEET 6 OF 9

DRAWING NO.
EX6

R:\2018\18-0290.00000\CAD\EX2 - Kankakee Bank Stabilization Improvements.dgn
6/12/2019





① TYPICAL SECTION - CHANNEL RESTORATION
NOT TO SCALE

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Indianapolis, Indiana 46204
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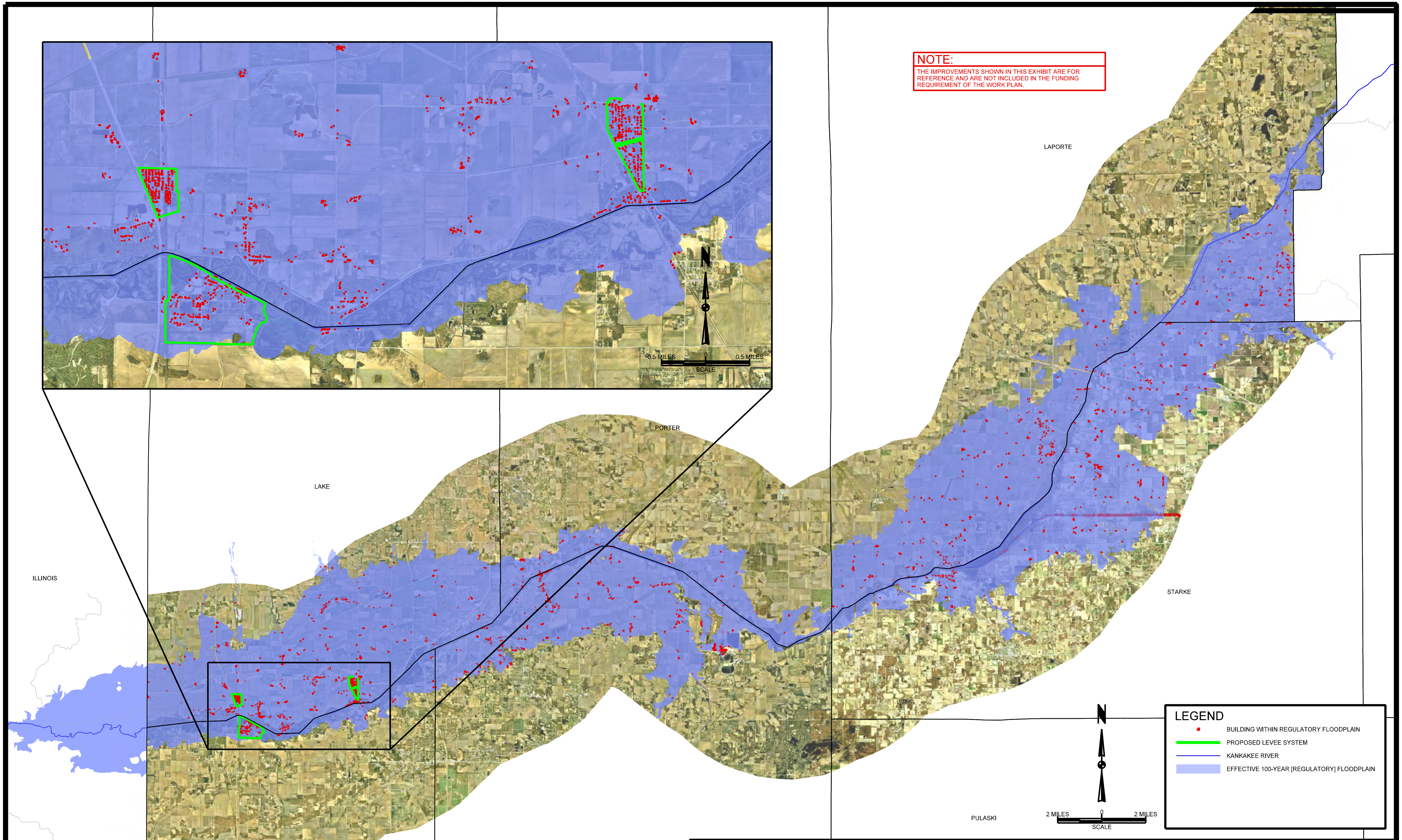
CERTIFIED:
NOT FOR CONSTRUCTION

TITLE:
YELLOW RIVER
DOWNSTREAM IMRPOVEMENTS

PROJECT:
KANKAKEE RIVER FLOOD &
SEDIMENT MANAGEMENT WORK PLAN

PROJECT NO.
19.R180290.00000
SHEET 7 OF 9
DRAWING NO.
EX7

R:\2018\18-0290.00000\CAD\EX6 - Yellow River Downstream Improvements.dgn
6/10/2019



NOTE:

THE IMPROVEMENTS SHOWN IN THIS EXHIBIT ARE FOR REFERENCE AND ARE NOT INCLUDED IN THE FUNDING REQUIREMENT OF THE WORK PLAN.

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Indianapolis, Indiana 46204
(317) 266-8000 FAX: (317) 632-3306

CERTIFIED:
NOT FOR CONSTRUCTION

TITLE:
STRATEGIC FLOOD PROTECTION MEASURES

PROJECT:
KANKAKEE RIVER FLOOD & SEDIMENT MANAGEMENT WORK PLAN

PROJECT NO.
19.R180290.00000

SHEET 8 OF 9

DRAWING NO.
EX8

R:\2018\18-0290.00000\CAD\EX5 - Strategic Flood Protection Measures.dgn
6/12/2019

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Planning Area	Areas Included	Intent of Strategy
River Corridor Impact Areas	Regulatory floodway	To conserve land and prohibit development
Vulnerable Developed Areas	Existing developed land in the SFHA (floodway and floodway fringe)	To protect people, buildings, and facilities in the vulnerable areas and reduce future flood risk
Undeveloped High Hazard/Flood Storage Areas	Undeveloped land in the floodway fringe	To conserve land and maintain the natural and beneficial function of the floodway fringe, and discourage future development in these areas
Moderate Flood Hazard Areas	0.2% Annual Exceedance Probability flood zone	To identify areas that are subject to flooding during an extreme event and to discourage placement of critical facilities in these areas
Safer Areas	Outside the SFHA, but within the planning jurisdiction	To plan for and promote development in areas that are less vulnerable to future floods
Watershed	Entire drainage area	To promote coordination and partnerships and implement practices to slow, spread and infiltrate flood water

Sources of Data:
1. City of Watseka 2014 Comprehensive Plan
2. Digital Flood Insurance Rate Map, Iroquois County, 8/16/2011
3. National Hydrography Dataset, 2018
4. US Bureau of the Census TIGER files, 2018

◯	Planning Area Boundary
🟩	City of Watseka
🟨	Moderate Flood Hazard Areas
🟧	Undeveloped High Hazard/Flood Storage Areas
🟥	Vulnerable Developed Areas
▨	River Corridor Impact Areas
●	Fire Department
H	Hospital
✚	Nursing Home
●	Police Department
●	School

N

1,000 500 0 1,000

Feet

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PROJECT: **Kankakee River Flood and Sediment Management Work Plan**

PROJECT NO. **18-0290**

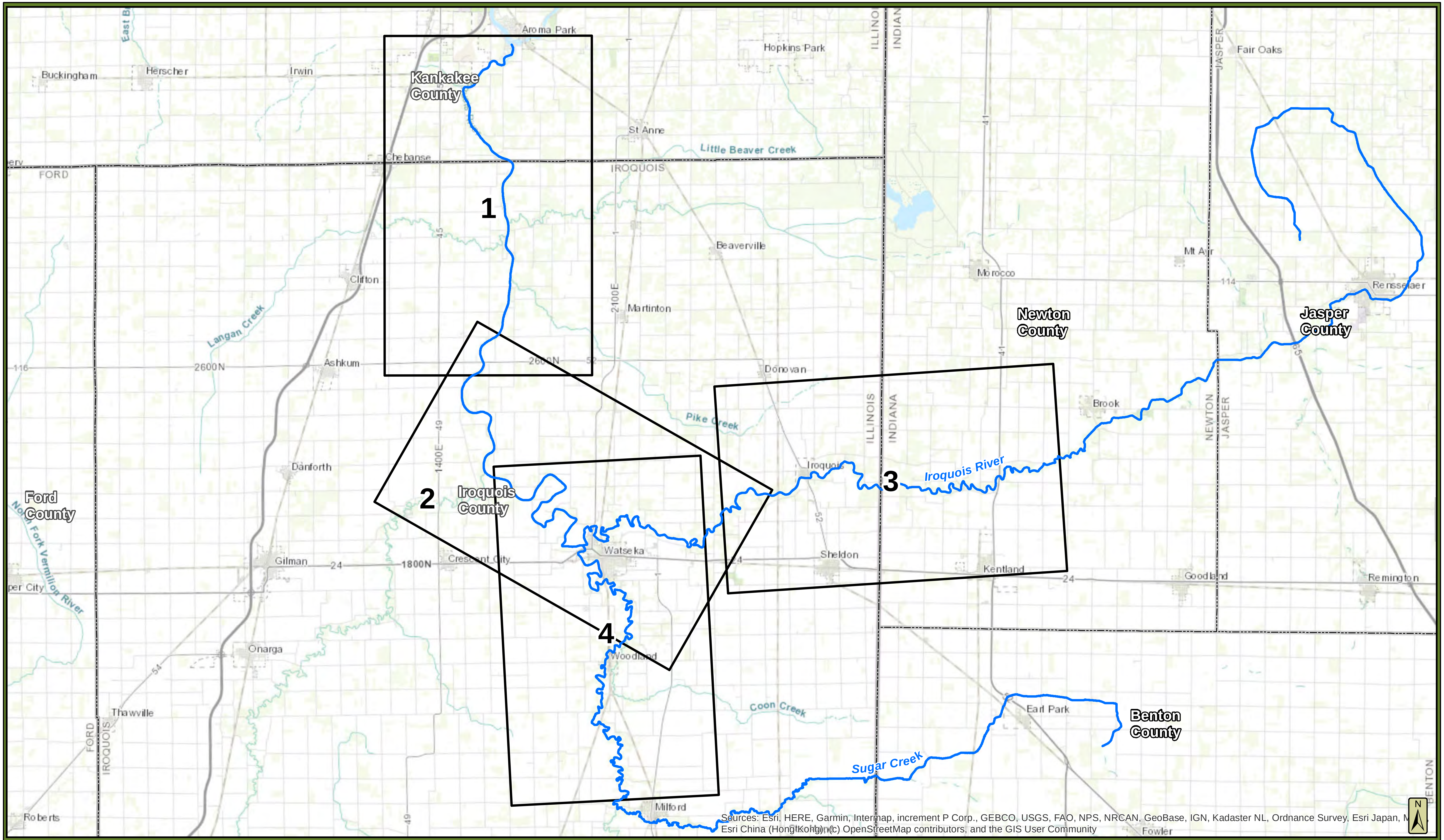
APPROX. SCALE **1:10,000**

DATE: **06/2019**

TITLE: **Flood Resilience Planning Areas Watseka, Illinois**

EXHIBIT 9

Document Path: R:\2018\18-0290.00000\GIS\Exhibits\MXD\Resilience_Watseka.mxd



Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

⬚ County Boundary
☐ Map Panel

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PROJECT: **Kankakee River Flood and Sediment Managemet Work Plan**

PROJECT NO. 18-0290

APPROX. SCALE 1"=3.5miles

DATE: 08/2019

TITLE: **Recommended Work Plan Components along Iroquois River**

Index Map

EXHIBIT 10

DISCLAIMER:
The problem areas identified in this exhibit are approximate and are based on a reconnaisance-level field survey.

Legend

- ● IDNR River Mile
- 〰 Rivers / Streams / Ditches

Problem Areas

- ● Erosion Rill
- ● Streambank Erosion

- ▭ IroquoisIndex

County & Municipal Boundaries

- ▭ Indiana Counties
- ▭ Illinois Counties
- ▭ Corporate Limits

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	TITLE: Recommended Workplan Components (Iroquois River) (Sheet 1 of 4)		DATE: 06/2018 EXHIBIT 10

DISCLAIMER:
The problem areas identified in this exhibit are approximate and are based on a reconnaisance-level field survey.

Legend

- • IDNR River Mile
- 〰 Rivers / Streams / Ditches

Problem Areas

- ● Erosion Rill
- ● Streambank Erosion

- ▭ IroquoisIndex

County & Municipal Boundaries

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PROJECT: Kankakee River Flood and Sediment Management Work Plan		PROJECT NO. 18-0290	APPROX. SCALE 1"=2,000'
TITLE: Recommended Workplan Components (Iroquois River) (Sheet 2 of 4)			DATE: 06/2018
			EXHIBIT 10

DISCLAIMER:
The problem areas identified in this exhibit are approximate and are based on a reconnaisance-level field survey.

Legend

- 🟢 IDNR River Mile
- 〰 Rivers / Streams / Ditches

Problem Areas

- 🔴 Erosion Rill
- 🔵 Streambank Erosion

- IroquoisIndex

County & Municipal Boundaries

- ▭ Indiana Counties
- ▭ Illinois Counties
- ▭ Corporate Limits

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	TITLE: Recommended Workplan Components (Iroquois River) (Sheet 3 of 4)		DATE: 06/2018 EXHIBIT 10

DISCLAIMER:
The problem areas identified in this exhibit are approximate and are based on a reconnaisance-level field survey.

Legend

- ● IDNR River Mile
- 〰 Rivers / Streams / Ditches

Problem Areas

- 🔴 Erosion Rill
- 🔵 Streambank Erosion

- ▭ IroquoisIndex

County & Municipal Boundaries

- ▭ Indiana Counties
- ▭ Illinois Counties
- ▭ Corporate Limits

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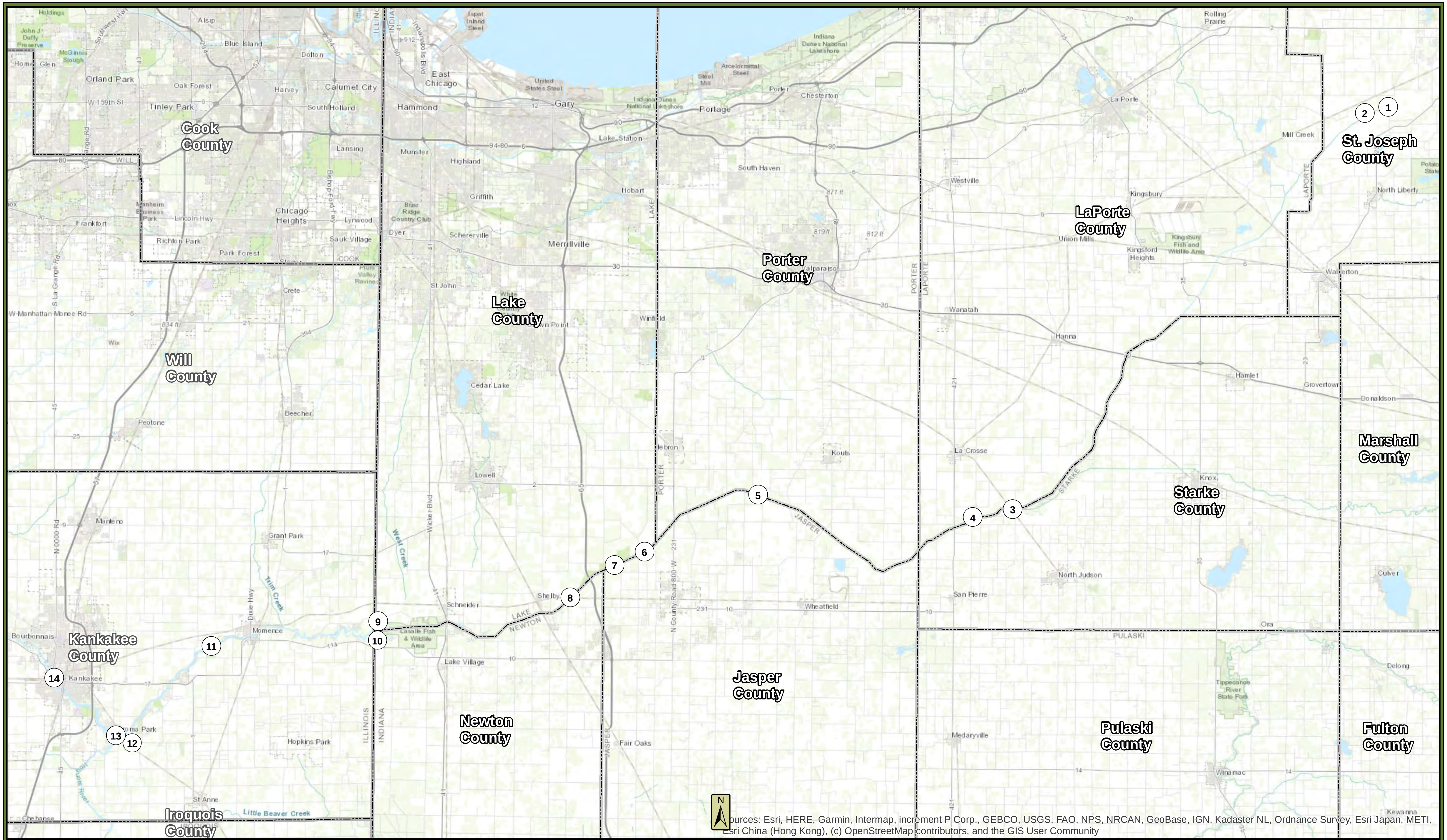
PROJECT:	Kankakee River Flood and Sediment Management Work Plan	PROJECT NO. 18-0290	APPROX. SCALE 1"=2,000'
TITLE:	Recommended Workplan Components (Iroquois River) (Sheet 4 of 4)		DATE: 06/2018
			EXHIBIT 10

APPENDICES

Appendix 1 – Field Observations: Photographs & Data Sheets

Field Observation Photographs



ources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

○ PhotoLocations
▭ County Boundary

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PROJECT: **Kankakee River Flood and Sediment Managemet Work Plan**

PROJECT NO. 18-0290

APPROX. SCALE 1"=5miles

DATE: 06/2019

TITLE: **Field Observation Photograph Log**

EXHIBIT A1.1

Photo 1: Kankakee River, Looking Downstream from Crumstown Hwy Bridge

Photo 2: Heavily Vegetated Banks at Mouth of a Ditch in St. Joseph County

Photo 3: Debris Behind Bridge, Looking Downstream from Confluence of Kankakee and Yellow Rivers

Photo 4: Sediment Deposit Near Oxbow in Laporte County

Photo 5: Unstable Berm in Porter County

Photo 6: Rubble and Eroding Berm Near Home in Newton County

Photo 7: Failing Berm in Newton County

Photo 8: Sediment and Debris Behind Rail Bridge in Lake and Newton Counties

Photo 9: Williams Ditch, Looking Downstream from State Line

Photo 10: Kankakee River Fork, Looking Downstream from State Line

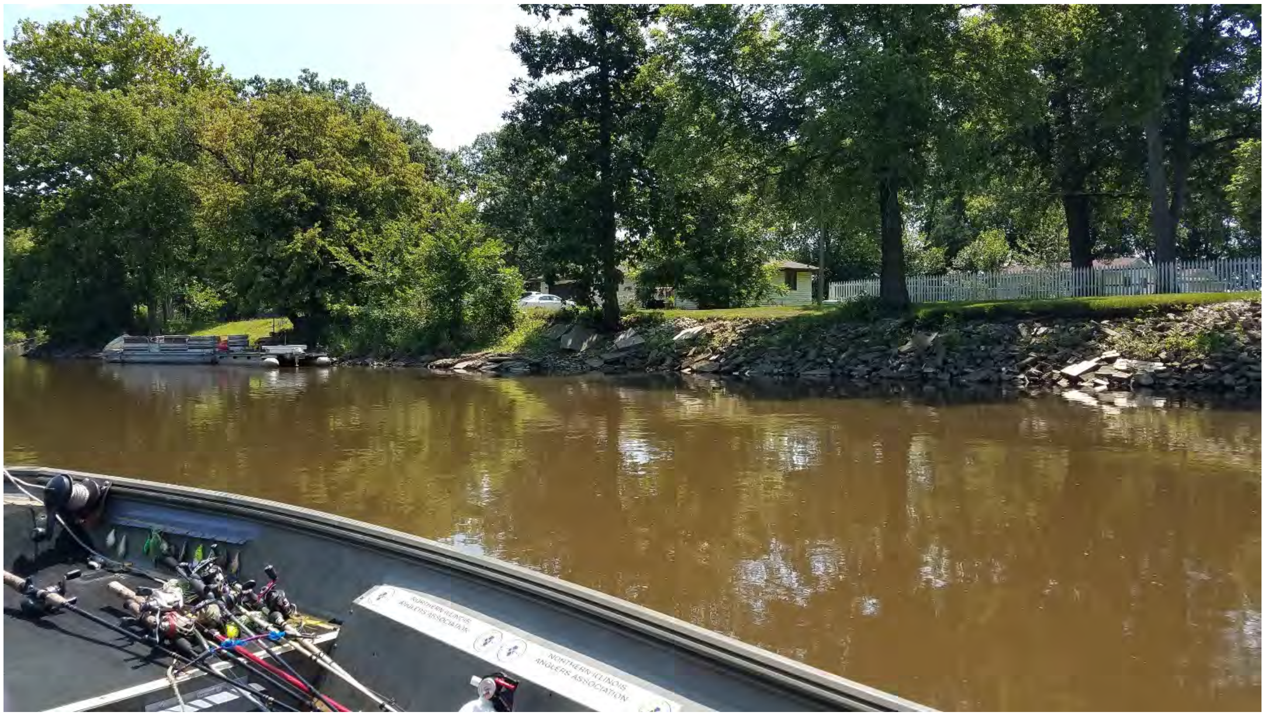


Photo 11: Rubble on Banks Between Koops and Maple Islands, Kankakee County

Photo 12: Wooded Island, Looking Downstream from Bridge St., Aroma Park, IL

Photo 13: In-Channel Sediment, Looking Upstream Towards Bridge St., Aroma Park, IL

Photo 14: Sediment Deposit on Bank of Kankakee River, Downstream of Court St., Kankakee, IL

Bank Erosion Hazard Index Data Sheets

Kankakee 3

Worksheet 20. BEHI variable worksheet

Stream: kankakee	Cross Section: K-3	Date: 8.27.18	Observers: rcb

Bank Height/Max Depth Bankfull (C)

Study Bank Height (ft) 4.0 A	Bankfull Height (ft) 1 B	A/B = 4.0 C

Root Depth/Bank Height (E)

Root Depth (ft) 0.5 D	Study Bank Height (ft) 4.0 A	D/A = 0.125 E

Weighted Root Density (G)

Root Density (%) <5 F	F*E = 0.4 G

Bank Angle (H)

Bank Angle (Degrees) 90 H

Surface Protection (I)

Surface Protection % 75 I

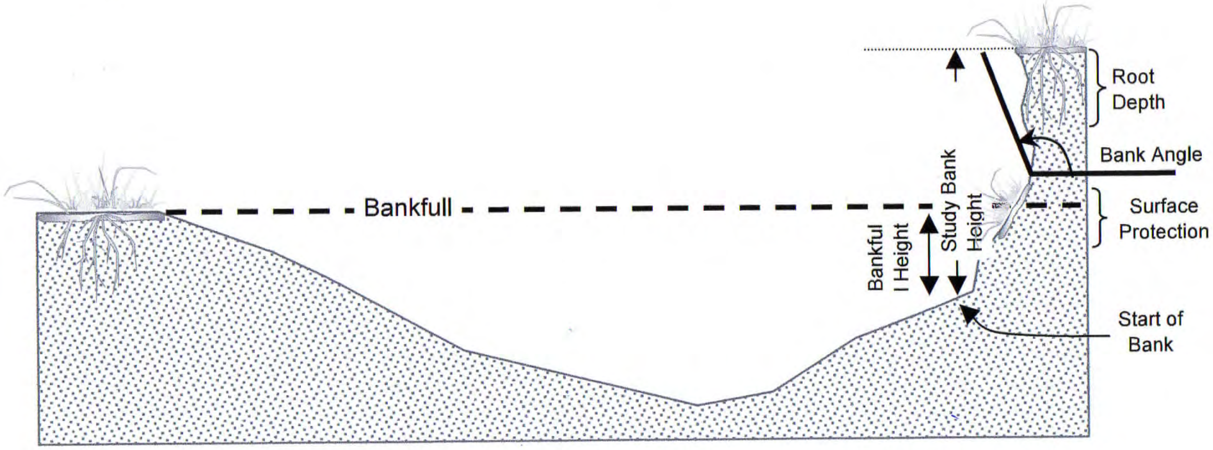
Bank Sketch

See kankakee 3

(typical for rocked/ protected reaches in both states)

Vertical Distance (ft)

Horizontal Distance (ft)



Worksheet 21. Summary of bank erosion hazard index (BEHI)

Bank Erosion Hazard Rating Guide

Stream　Reach　Date　Crew

Bank Erosion Potential

Bank Height (ft): Bankfull Height (ft):		**Bank Height/ Bankfull Ht**	**Root Depth/ Bank Height**	**Root Density %**	**Bank Angle (Degrees)**	**Surface Protection%**
VERY LOW	Value	1.0-1.1	1.0-0.9	100-80	0-20	100-80
	Index	1.0-1.9	1.0-1.9	1.0-1.9	1.0-1.9	1.0-1.9
	Choice	V: I:	V: I:	V: I:	V: I:	V: I:
LOW	Value	1.11-1.19	0.89-0.5	79-55	21-60	[✓ 79-55]
	Index	2.0-3.9	2.0-3.9	2.0-3.9	2.0-3.9	2.0-3.9
	Choice	V: I:	V: I:	V: I:	V: I:	V: I:
MODERATE	Value	1.2-1.5	0.49-0.3	54-30	61-80	54-30
	Index	4.0-5.9	4.0-5.9	4.0-5.9	4.0-5.9	4.0-5.9
	Choice	V: I:	V: I:	V: I:	V: I:	V: I:
HIGH	Value	1.6-2.0	0.29-0.15	29-15	[✓ 81-90]	29-15
	Index	6.0-7.9	6.0-7.9	6.0-7.9	6.0-7.9	6.0-7.9
	Choice	V: I:	V: I:	V: I:	V: I:	V: I:
VERY HIGH	Value	2.1-2.8	[✓ 0.14-0.05]	14-5.0	91-119	14-10
	Index	8.0-9.0	8.0-9.0	8.0-9.0	8.0-9.0	8.0-9.0
	Choice	V: I:	V: I:	V: I:	V: I:	V: I:
EXTREME	Value	[✓ >2.8]	<0.05	[✓ <5]	>119	<10
	Index	10	10	10	10	10
	Choice	V: I: 10	V: I: 9	V: I: 10	V: I: 7.5	V: I: 3
V = value, I = index					**SUB-TOTAL** (Sum one index from each column)	39.5

Bank Material Description:

bank material sand -
may be covered

Bank Materials

- **Bedrock** (Bedrock banks have very low bank erosion potential)
- **Boulders** (Banks composed of boulders have low bank erosion potential)
- **Cobble** (Subtract 10 points. If sand/gravel matrix greater than 50% of bank material, then do not adjust)
- **Gravel** (Add 5-10 points depending percentage of bank material that is composed of sand)
- **Sand** (Add 10 points)
- **Silt Clay** (+ 0: no adjustment)

BANK MATERIAL ADJUSTMENT

Stratification Comments:

Stratification

Add 5-10 points depending on position of unstable layers in relation to bankfull stage

STRATIFICATION ADJUSTMENT

VERY LOW	**LOW**	**MODERATE**	**HIGH**	[✓ **VERY HIGH**]	**EXTREME**
5-9.5	10-19.5	20-29.5	30-39.5	[✓ 40-45]	46-50

Bank location description (circle one)

Straight Reach　Outside of Bend

GRAND TOTAL
BEHI RATING　>39.9

Newton 1

Worksheet 20. BEHI variable worksheet

Stream: Kankakee	Cross Section: Newton 1	Date: 8.27.18	Observers: rcb

Bank Height/Max Depth Bankfull (C)

Study Bank Height (ft) 7 A	Bankfull Height (ft) 1.5 B	A/B = 4.6 C

Root Depth/Bank Height (E)

Root Depth (ft) 0.5 D	Study Bank Height (ft) 7 A	D/A = .007 E

Weighted Root Density (G)

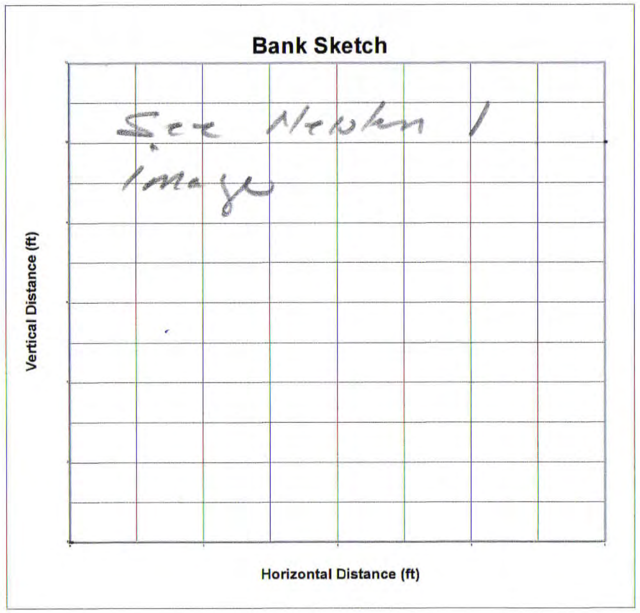
Root Density (%) 10 F	F*E = 0.7 G

Bank Angle (H)

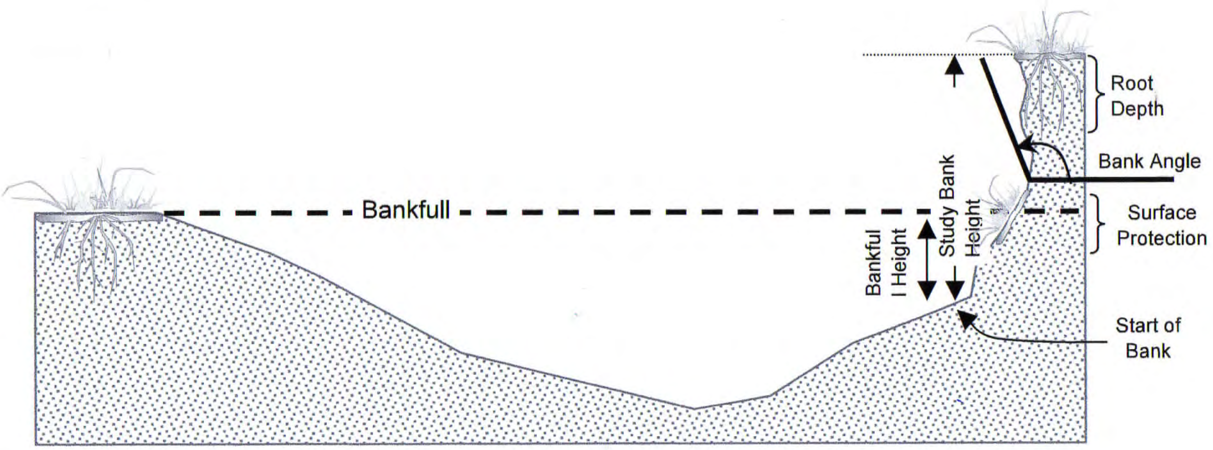
Bank Angle (Degrees) 45 H

Surface Protection (I)

Surface Protection % 40 I



See Newton 1 image



Worksheet 21. Summary of bank erosion hazard index (BEHI)

Bank Erosion Hazard Rating Guide

Stream Kankakee Reach Newton 1 Date 8.27.18 Crew rcb

Bank Height (ft): 7.0
Bankfull Height (ft): 1.5

Bank Erosion Potential			Bank Height/ Bankfull Ht	Root Depth/ Bank Height	Root Density %	Bank Angle (Degrees)	Surface Protection%
	VERY LOW	Value	1.0-1.1	1.0-0.9	100-80	0-20	100-80
		Index	1.0-1.9	1.0-1.9	1.0-1.9	1.0-1.9	1.0-1.9
		Choice	V: I:	V: I:	V: I:	V: I:	V: I:
	LOW	Value	1.11-1.19	0.89-0.5	79-55	[✓ 21-60]	79-55
		Index	2.0-3.9	2.0-3.9	2.0-3.9	2.0-3.9	2.0-3.9
		Choice	V: I:	V: I:	V: I:	V: I:	V: I:
	MODERATE	Value	1.2-1.5	0.49-0.3	54-30	61-80	[✓ 54-30]
		Index	4.0-5.9	4.0-5.9	4.0-5.9	4.0-5.9	4.0-5.9
		Choice	V: I:	V: I:	V: I:	V: I:	V: I:
	HIGH	Value	1.6-2.0	0.29-0.15	29-15	81-90	29-15
		Index	6.0-7.9	6.0-7.9	6.0-7.9	6.0-7.9	6.0-7.9
		Choice	V: I:	V: I:	V: I:	V: I:	V: I:
	VERY HIGH	Value	2.1-2.8	0.14-0.05	[✓ 14-5.0]	91-119	14-10
		Index	8.0-9.0	8.0-9.0	8.0-9.0	8.0-9.0	8.0-9.0
		Choice	V: I:	V: I:	V: I:	V: I:	V: I:
	EXTREME	Value	[✓ >2.8]	[✓ <0.05]	<5	>119	<10
		Index	10	10	10	10	10
		Choice	V: I: 10	V: I: 10	V: I: 8.5	V: I: 3.0	V: I: 5
	V = value, I = index				**SUB-TOTAL** (Sum one index from each column)		36.5

Bank Material Description:

Bank Materials

- **Bedrock** (Bedrock banks have very low bank erosion potential)
- **Boulders** (Banks composed of boulders have low bank erosion potential)
- **Cobble** (Subtract 10 points. If sand/gravel matrix greater than 50% of bank material, then do not adjust)
- **Gravel** (Add 5-10 points depending percentage of bank material that is composed of sand)
- **Sand** (Add 10 points)
- **Silt Clay** (+ 0: no adjustment)

BANK MATERIAL ADJUSTMENT 10

Stratification Comments:

Stratification

Add 5-10 points depending on position of unstable layers in relation to bankfull stage

STRATIFICATION ADJUSTMENT

VERY LOW	LOW	MODERATE	HIGH	VERY HIGH	EXTREME
5-9.5	10-19.5	20-29.5	~~30-39.5~~	40-45	[✓ 46-50]

Bank location description (circle one)
Straight Reach Outside of Bend

GRAND TOTAL ~~36.5~~ 46.5
BEHI RATING ~~High~~

Newton 2

Worksheet 20. BEHI variable worksheet

Stream: Kankakee	Cross Section: Newton 2	Date: 8.27.18	Observers: rcb

Bank Height/Max Depth Bankfull (C)

Study Bank Height (ft) 7 A	Bankfull Height (ft) 1 B	A/B = 7 C

Root Depth/Bank Height (E)

Root Depth (ft) 1.0 D	Study Bank Height (ft) 7 A	D/A = 0.14 E

Weighted Root Density (G)

Root Density (%) 25 F	F*E = 3.5 G

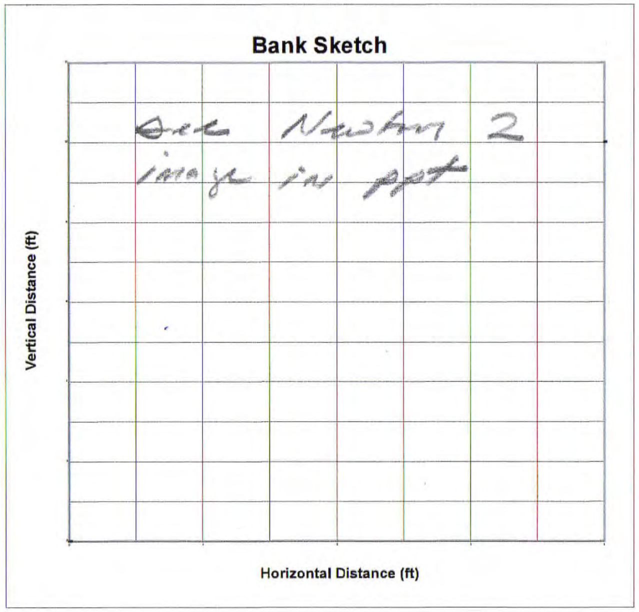
Bank Angle (H)

Bank Angle (Degrees) 45 H

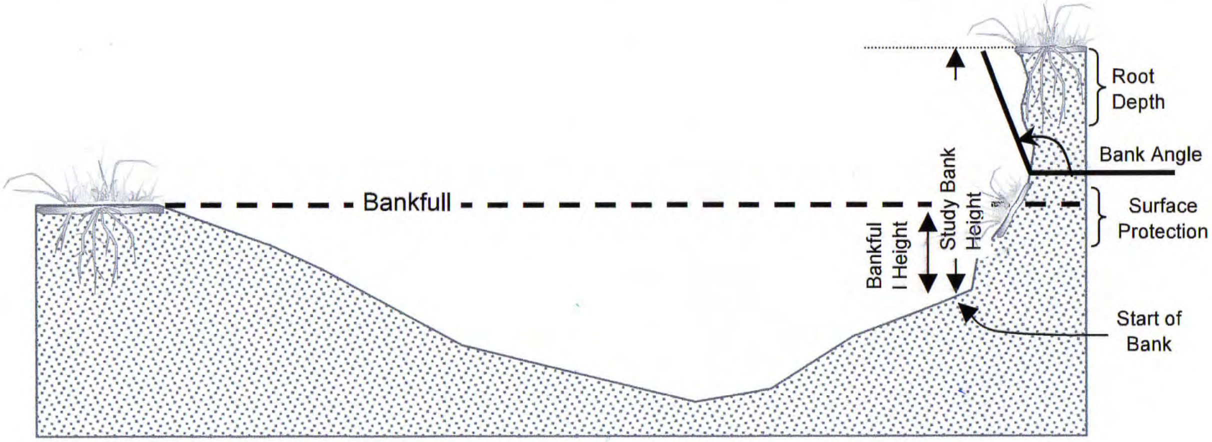
Surface Protection (I)

Surface Protection % 50 I

Bank Sketch



See Newton 2 image in ppt



Worksheet 21. Summary of bank erosion hazard index (BEHI)

Bank Erosion Hazard Rating Guide

Stream Kankakee Reach Newton 2 Date 8.27.18 Crew rek

Bank Erosion Potential	Bank Height (ft): Bankfull Height (ft):		Bank Height/ Bankfull Ht	Root Depth/ Bank Height	Root Density %	Bank Angle (Degrees)	Surface Protection%
	VERY LOW	Value	1.0-1.1	1.0-0.9	100-80	0-20	100-80
		Index	1.0-1.9	1.0-1.9	1.0-1.9	1.0-1.9	1.0-1.9
		Choice	V: I:	V: I:	V: I:	V: I:	V: I:
	LOW	Value	1.11-1.19	0.89-0.5	79-55	[✓ 21-60]	79-55
		Index	2.0-3.9	2.0-3.9	2.0-3.9	2.0-3.9	2.0-3.9
		Choice	V: I:	V: I:	V: I:	V: I:	V: I:
	MODERATE	Value	1.2-1.5	0.49-0.3	54-30	61-80	[✓ 54-30]
		Index	4.0-5.9	4.0-5.9	4.0-5.9	4.0-5.9	4.0-5.9
		Choice	V: I:	V: I:	V: I:	V: I:	V: I:
	HIGH	Value	1.6-2.0	0.29-0.15	[✓ 29-15]	81-90	29-15
		Index	6.0-7.9	6.0-7.9	6.0-7.9	6.0-7.9	6.0-7.9
		Choice	V: I:	V: I:	V: I:	V: I:	V: I:
	VERY HIGH	Value	2.1-2.8	[✓ 0.14-0.05]	14-5.0	91-119	14-10
		Index	8.0-9.0	8.0-9.0	8.0-9.0	8.0-9.0	8.0-9.0
		Choice	V: I:	V: I:	V: I:	V: I:	V: I:
	EXTREME	Value	[✓ >2.8]	<0.05	<5	>119	<10
		Index	10	10	10	10	10
		Choice	V: I: 10	V: I: 8.5	V: I: 6.0	V: I: 3	V: I: 5
	V = value, I = index				SUB-TOTAL (Sum one index from each column)		32.5

Bank Material Description:

Bank Materials

- **Bedrock** (Bedrock banks have very low bank erosion potential)
- **Boulders** (Banks composed of boulders have low bank erosion potential)
- **Cobble** (Subtract 10 points. If sand/gravel matrix greater than 50% of bank material, then do not adjust)
- **Gravel** (Add 5-10 points depending percentage of bank material that is composed of sand)
- [✓ **Sand** (Add 10 points)]
- **Silt Clay** (+ 0: no adjustment)

BANK MATERIAL ADJUSTMENT 10

Stratification Comments:

Stratification

Add 5-10 points depending on position of unstable layers in relation to bankfull stage

STRATIFICATION ADJUSTMENT 0

VERY LOW	LOW	MODERATE	HIGH	[✓ VERY HIGH]	EXTREME
5-9.5	10-19.5	20-29.5	30-39.5	[✓ 40-45]	46-50

Bank location description (circle one)

Straight Reach Outside of Bend

GRAND TOTAL 42.5

BEHI RATING Very high

Jasper 1

Worksheet 20. BEHI variable worksheet

Stream: Kankakee	Cross Section: 2-1	Date: 8.27.18	Observers: rb

Bank Height/Max Depth Bankfull (C)

Study Bank Height (ft) 8 A	Bankfull Height (ft) 1 B	A/B = 8 C

Root Depth/Bank Height (E)

Root Depth (ft) 0.5 D	Study Bank Height (ft) 8 A	D/A = 0.06 E

Weighted Root Density (G)

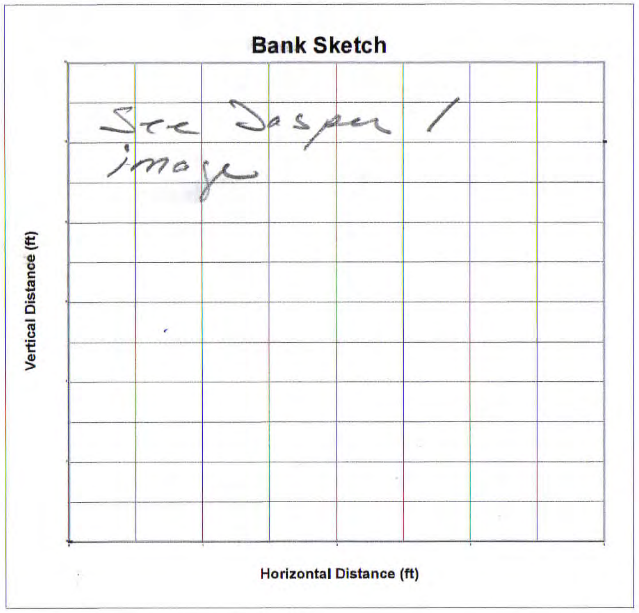
Root Density (%) 40 F	F*E = 2.5 G

Bank Angle (H)

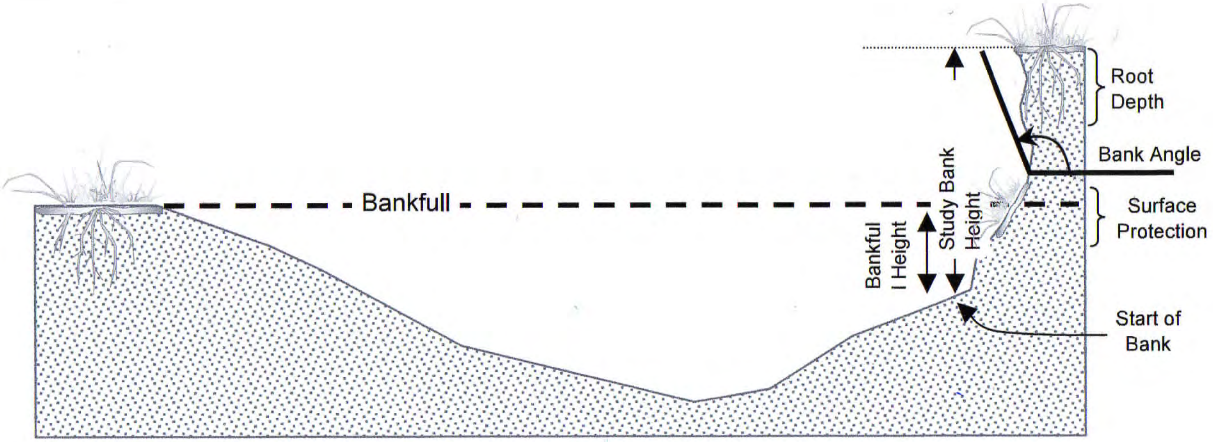
Bank Angle (Degrees) ~70 H

Surface Protection (I)

Surface Protection % 40 I



See Jasper 1 image



Worksheet 21. Summary of bank erosion hazard index (BEHI)

Bank Erosion Hazard Rating Guide

Stream Kankakee Reach S-7 Date 8.27.18 Crew rcb

Bank Erosion Potential

Bank Height (ft): Bankfull Height (ft):		Bank Height/ Bankfull Ht	Root Depth/ Bank Height	Root Density %	Bank Angle (Degrees)	Surface Protection%
VERY LOW	Value	1.0-1.1	1.0-0.9	100-80	0-20	100-80
	Index	1.0-1.9	1.0-1.9	1.0-1.9	1.0-1.9	1.0-1.9
	Choice	V: I:	V: I:	V: I:	V: I:	V: I:
LOW	Value	1.11-1.19	0.89-0.5	79-55	21-60	79-55
	Index	2.0-3.9	2.0-3.9	2.0-3.9	2.0-3.9	2.0-3.9
	Choice	V: I:	V: I:	V: I:	V: I:	V: I:
MODERATE	Value	1.2-1.5	0.49-0.3	[✓ 54-30]	[✓ 61-80]	[✓ 54-30]
	Index	4.0-5.9	4.0-5.9	4.0-5.9	4.0-5.9	4.0-5.9
	Choice	V: I:	V: I:	V: I:	V: I:	V: I:
HIGH	Value	1.6-2.0	0.29-0.15	29-15	81-90	29-15
	Index	6.0-7.9	6.0-7.9	6.0-7.9	6.0-7.9	6.0-7.9
	Choice	V: I:	V: I:	V: I:	V: I:	V: I:
VERY HIGH	Value	2.1-2.8	[✓ 0.14-0.05]	14-5.0	91-119	14-10
	Index	8.0-9.0	8.0-9.0	8.0-9.0	8.0-9.0	8.0-9.0
	Choice	V: I:	V: I:	V: I:	V: I:	V: I:
EXTREME	Value	[✓ >2.8]	<0.05	<5	>119	<10
	Index	10	10	10	10	10
	Choice	V: I: 10	V: I: 8.5	V: I: 5	V: I: 5	V: I: 5
V = value, I = index					**SUB-TOTAL** (Sum one index from each column)	35

Bank Material Description:

Bank Materials

- **Bedrock** (Bedrock banks have very low bank erosion potential)
- **Boulders** (Banks composed of boulders have low bank erosion potential)
- **Cobble** (Subtract 10 points. If sand/gravel matrix greater than 50% of bank material, then do not adjust)
- **Gravel** (Add 5-10 points depending percentage of bank material that is composed of sand)
- **Sand** (Add 10 points)
- **Silt Clay** (+ 0: no adjustment)

BANK MATERIAL ADJUSTMENT 10

Stratification Comments:

Stratification

Add 5-10 points depending on position of unstable layers in relation to bankfull stage

STRATIFICATION ADJUSTMENT 5

VERY LOW	LOW	MODERATE	HIGH	VERY HIGH	EXTREME
5-9.5	10-19.5	20-29.5	30-39.5	40-45	46-50

Bank location description (circle one)

[✓ Straight Reach] Outside of Bend

GRAND TOTAL 50

BEHI RATING extreme

Jasper 2

Worksheet 20. BEHI variable worksheet

Stream: Kankakee	Cross Section: J-2	Date: 8.27.18	Observers: rcb

Bank Height/Max Depth Bankfull (C)

Study Bank Height (ft) 8.5 A	Bankfull Height (ft) 0.5 B	A/B = 17 C

Root Depth/Bank Height (E)

Root Depth (ft) 0.5 D	Study Bank Height (ft) 8.5 A	D/A = .06 E

Weighted Root Density (G)

Root Density (%) < 5 F	F*E = 3.0 G

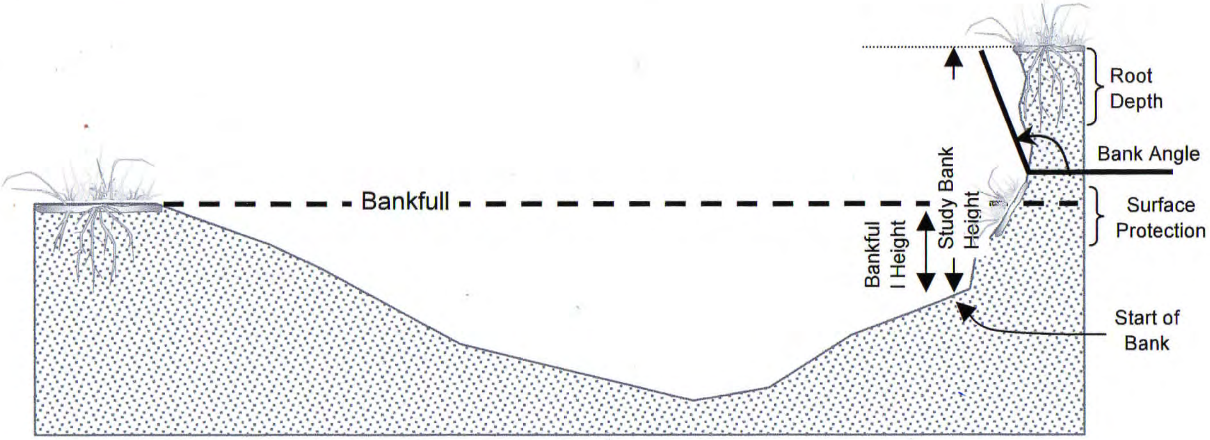
Bank Angle (H)

Bank Angle (Degrees) 60 H

Surface Protection (I)

Surface Protection % 40 I

See Jasper 2
in ppt



Worksheet 21. Summary of bank erosion hazard index (BEHI)

Bank Erosion Hazard Rating Guide

Stream Kankakee Reach Jasper 2 Date 8.27.14 Crew rcb

Bank Erosion Potential

Bank Height (ft): Bankfull Height (ft):		Bank Height/ Bankfull Ht	Root Depth/ Bank Height	Root Density %	Bank Angle (Degrees)	Surface Protection%
VERY LOW	Value	1.0-1.1	1.0-0.9	100-80	0-20	100-80
	Index	1.0-1.9	1.0-1.9	1.0-1.9	1.0-1.9	1.0-1.9
	Choice	V: I:	V: I:	V: I:	V: I:	V: I:
LOW	Value	1.11-1.19	0.89-0.5	79-55	[✓ 21-60]	79-55
	Index	2.0-3.9	2.0-3.9	2.0-3.9	2.0-3.9	2.0-3.9
	Choice	V: I:	V: I:	V: I:	V: I:	V: I:
MODERATE	Value	1.2-1.5	0.49-0.3	54-30	61-80	[✓ 54-30]
	Index	4.0-5.9	4.0-5.9	4.0-5.9	4.0-5.9	4.0-5.9
	Choice	V: I:	V: I:	V: I:	V: I:	V: I: 5
HIGH	Value	1.6-2.0	0.29-0.15	29-15	81-90	29-15
	Index	6.0-7.9	6.0-7.9	6.0-7.9	6.0-7.9	6.0-7.9
	Choice	V: I:	V: I:	V: I:	V: I:	V: I:
VERY HIGH	Value	2.1-2.8	0.14-0.05	14-5.0	91-119	14-10
	Index	8.0-9.0	8.0-9.0	8.0-9.0	8.0-9.0	8.0-9.0
	Choice	V: I:	V: I:	V: I:	V: I:	V: I:
EXTREME	Value	[✓ >2.8]	[✓ <0.05]	[✓ <5]	>119	<10
	Index	10	10	10 10	10	10
	Choice	V: I: 10	V: I: 10	V: I: 10	V: I: 3.5	V: I: 5

V = value, I = index

SUB-TOTAL (Sum one index from each column) 38.5

Bank Material Description:

Bank Materials

- **Bedrock** (Bedrock banks have very low bank erosion potential)
- **Boulders** (Banks composed of boulders have low bank erosion potential)
- **Cobble** (Subtract 10 points. If sand/gravel matrix greater than 50% of bank material, then do not adjust)
- **Gravel** (Add 5-10 points depending percentage of bank material that is composed of sand)
- **Sand** (Add 10 points)
- **Silt Clay** (+ 0: no adjustment)

BANK MATERIAL ADJUSTMENT 10

Stratification Comments:

Stratification

Add 5-10 points depending on position of unstable layers in relation to bankfull stage

STRATIFICATION ADJUSTMENT 0

VERY LOW	LOW	MODERATE	HIGH	VERY HIGH	[✓ EXTREME]
5-9.5	10-19.5	20-29.5	30-39.5	40-45	46-50

Bank location description (circle one)

Straight Reach Outside of Bend

GRAND TOTAL
BEHI RATING 48.9

Jasper 3

Lake 1

Worksheet 20. BEHI variable worksheet

Stream: Kankakee	Cross Section: Lake 1	Date: 8.27.18	Observers: rcb

Bank Height/Max Depth Bankfull (C)

Study Bank Height (ft) 8.5 A	Bankfull Height (ft) 1.5 B	A/B = 5.7 C

Root Depth/Bank Height (E)

Root Depth (ft) 0.5 D	Study Bank Height (ft) 8.5 A	D/A = 0.05 E

Weighted Root Density (G)

Root Density (%) 20 F	F*E = 1.8 G

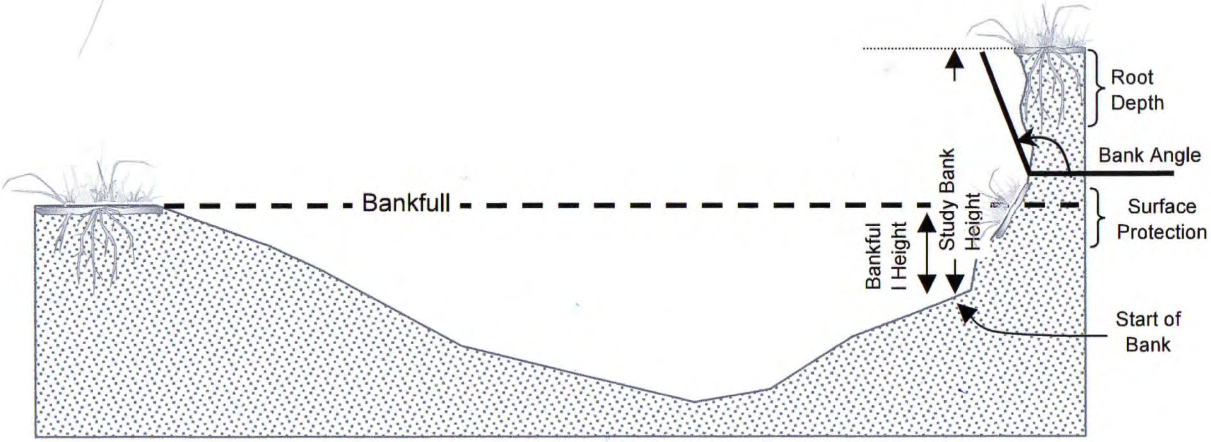
Bank Angle (H)

Bank Angle (Degrees) 60 H

Surface Protection (I)

Surface Protection % 30 I

see Lake 1 in ppt



Worksheet 21. Summary of bank erosion hazard index (BEHI)

Bank Erosion Hazard Rating Guide

Stream Kankakee Reach Lake 1 Date 8.27.18 Crew reb

Bank Erosion Potential

Bank Height (ft): Bankfull Height (ft):		Bank Height/ Bankfull Ht	Root Depth/ Bank Height	Root Density %	Bank Angle (Degrees)	Surface Protection%
VERY LOW	Value	1.0-1.1	1.0-0.9	100-80	0-20	100-80
	Index	1.0-1.9	1.0-1.9	1.0-1.9	1.0-1.9	1.0-1.9
	Choice	V: I:	V: I:	V: I:	V: I:	V: I:
LOW	Value	1.11-1.19	0.89-0.5	79-55	[✓ 21-60]	79-55
	Index	2.0-3.9	2.0-3.9	2.0-3.9	2.0-3.9	2.0-3.9
	Choice	V: I:	V: I:	V: I:	V: I:	V: I:
MODERATE	Value	1.2-1.5	0.49-0.3	54-30	61-80	[✓ 54-30]
	Index	4.0-5.9	4.0-5.9	4.0-5.9	4.0-5.9	4.0-5.9
	Choice	V: I:	V: I:	V: I:	V: I:	V: I:
HIGH	Value	1.6-2.0	0.29-0.15	[✓ 29-15]	81-90	29-15
	Index	6.0-7.9	6.0-7.9	6.0-7.9	6.0-7.9	6.0-7.9
	Choice	V: I:	V: I:	V: I:	V: I:	V: I:
VERY HIGH	Value	2.1-2.8	[✓ 0.14-0.05]	14-5.0	91-119	14-10
	Index	8.0-9.0	8.0-9.0	8.0-9.0	8.0-9.0	8.0-9.0
	Choice	V: I:	V: I:	V: I:	V: I:	V: I:
EXTREME	Value	[✓ >2.8]	<0.05	<5	>119	<10
	Index	10	10	10	10	10
	Choice	V: I: 10	V: I: 9	V: I: 7	V: I: 3.5	V: I: 5.5
V = value, I = index					**SUB-TOTAL** (Sum one index from each column)	35.8

Bank Material Description:

Bank Materials

Bedrock (Bedrock banks have very low bank erosion potential)

Boulders (Banks composed of boulders have low bank erosion potential)

Cobble (Subtract 10 points. If sand/gravel matrix greater than 50% of bank material, then do not adjust)

Gravel (Add 5-10 points depending percentage of bank material that is composed of sand)

Sand (Add 10 points)

Silt Clay (+ 0: no adjustment)

BANK MATERIAL ADJUSTMENT 10

Stratification Comments:

Stratification

Add 5-10 points depending on position of unstable layers in relation to bankfull stage

STRATIFICATION ADJUSTMENT 0

VERY LOW	LOW	MODERATE	HIGH	VERY HIGH	EXTREME
5-9.5	10-19.5	20-29.5	30-39.5	40-45	[✓ 46-50]

Bank location description (circle one)

Straight Reach Outside of Bend

GRAND TOTAL 45.8

BEHI RATING EX

Porter 2

Worksheet 20. BEHI variable worksheet

Stream: Kankakee	Cross Section: Porter 2	Date: 10.18.18	Observers: rcb

Bank Height/Max Depth Bankfull (C)

Study Bank Height (ft) 8.5 A	Bankfull Height (ft) 0.5 B	A/B = 17 C

Root Depth/Bank Height (E)

Root Depth (ft) 0.5 D	Study Bank Height (ft) 8.5 A	D/A = 0.06 E

Weighted Root Density (G)

Root Density (%) <5 F	F*E = 3.0 G

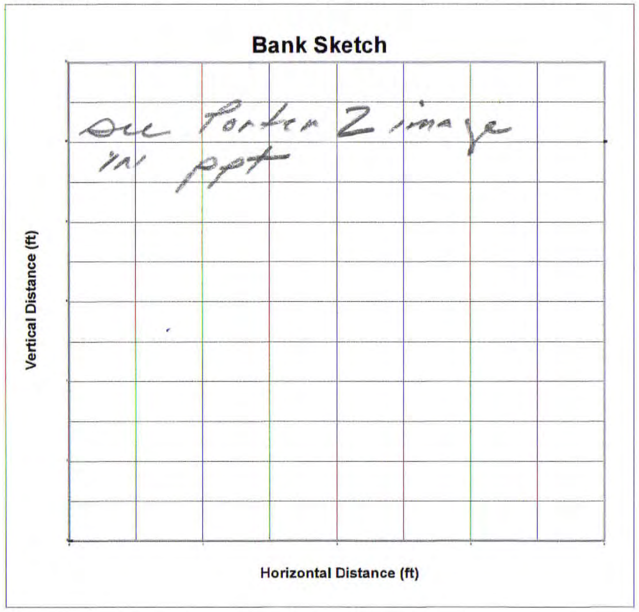
Bank Angle (H)

Bank Angle (Degrees) 65 H

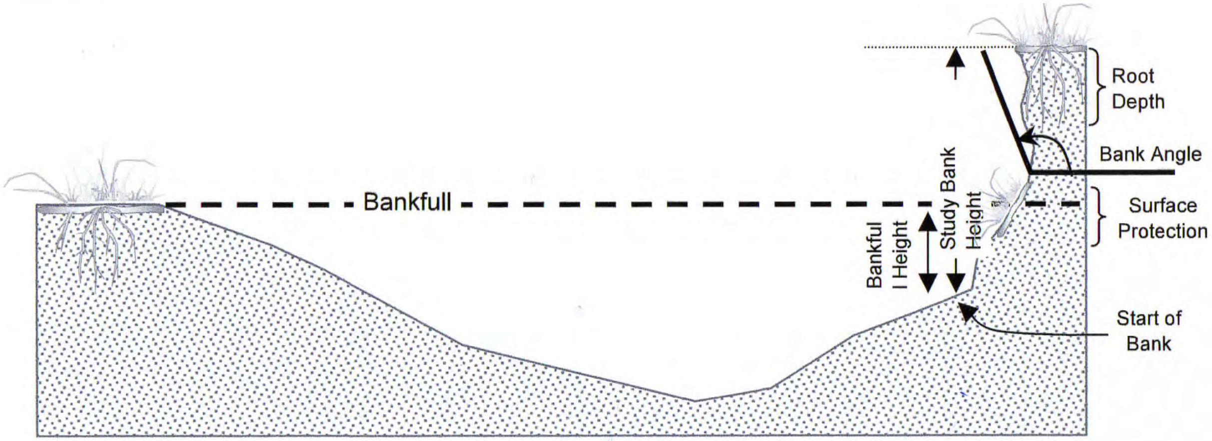
Surface Protection (I)

Surface Protection % 25 I

Bank Sketch



see Porter 2 image in ppt



Worksheet 21. Summary of bank erosion hazard index (BEHI)

Bank Erosion Hazard Rating Guide

Stream Kankakee Reach Porter 1 Date 10.18.18 Crew reb

Bank Erosion Potential

Bank Height (ft): Bankfull Height (ft):		**Bank Height/ Bankfull Ht**	**Root Depth/ Bank Height**	**Root Density %**	**Bank Angle (Degrees)**	**Surface Protection%**
VERY LOW	Value	1.0-1.1	1.0-0.9	100-80	0-20	100-80
	Index	1.0-1.9	1.0-1.9	1.0-1.9	1.0-1.9	1.0-1.9
	Choice	V: I:	V: I:	V: I:	V: I:	V: I:
LOW	Value	1.11-1.19	0.89-0.5	79-55	21-60	79-55
	Index	2.0-3.9	2.0-3.9	2.0-3.9	2.0-3.9	2.0-3.9
	Choice	V: I:	V: I:	V: I:	V: I:	V: I:
MODERATE	Value	1.2-1.5	0.49-0.3	54-30	[✓ 61-80]	54-30
	Index	4.0-5.9	4.0-5.9	4.0-5.9	4.0-5.9	4.0-5.9
	Choice	V: I:	V: I:	V: I:	V: I:	V: I:
HIGH	Value	1.6-2.0	0.29-0.15	29-15	81-90	[✓ 29-15]
	Index	6.0-7.9	6.0-7.9	6.0-7.9	6.0-7.9	6.0-7.9
	Choice	V: I:	V: I:	V: I:	V: I:	V: I: 7
VERY HIGH	Value	2.1-2.8	0.14-0.05	14-5.0	91-119	14-10
	Index	8.0-9.0	8.0-9.0	8.0-9.0	8.0-9.0	8.0-9.0
	Choice	V: I:	V: I:	V: I:	V: I:	V: I:
EXTREME	Value	[✓ >2.8]	[✓ <0.05]	[✓ <5]	>119	<10
	Index	10	10	10	10	10
	Choice	V: I: 10	V: I: 10	V: I: 10	V: I: 5	V: I: 7
V = value, I = index					**SUB-TOTAL** (Sum one index from each column)	42

Bank Material Description:

Bank Materials

- **Bedrock** (Bedrock banks have very low bank erosion potential)
- **Boulders** (Banks composed of boulders have low bank erosion potential)
- **Cobble** (Subtract 10 points. If sand/gravel matrix greater than 50% of bank material, then do not adjust)
- **Gravel** (Add 5-10 points depending percentage of bank material that is composed of sand)
- **Sand** (Add 10 points)
- **Silt Clay** (+ 0: no adjustment)

BANK MATERIAL ADJUSTMENT 10

Stratification Comments:

Stratification

Add 5-10 points depending on position of unstable layers in relation to bankfull stage

STRATIFICATION ADJUSTMENT 0

VERY LOW	LOW	MODERATE	HIGH	VERY HIGH	[✓ EXTREME]
5-9.5	10-19.5	20-29.5	30-39.5	40-45	[✓ 46-50]

Bank location description (circle one)

Straight Reach Outside of Bend

GRAND TOTAL 52

BEHI RATING

LaPorte 1

Worksheet 20. BEHI variable worksheet

Stream: Kankakee	Cross Section: LaPorte 1	Date: 8.27.18	Observers: rck

Bank Height/Max Depth Bankfull (C)

Study Bank Height (ft) 8 A	Bankfull Height (ft) 1.0 B	A/B = 8 C

Root Depth/Bank Height (E)

Root Depth (ft) 1 D	Study Bank Height (ft) 8 A	D/A = 0.12 E

Weighted Root Density (G)

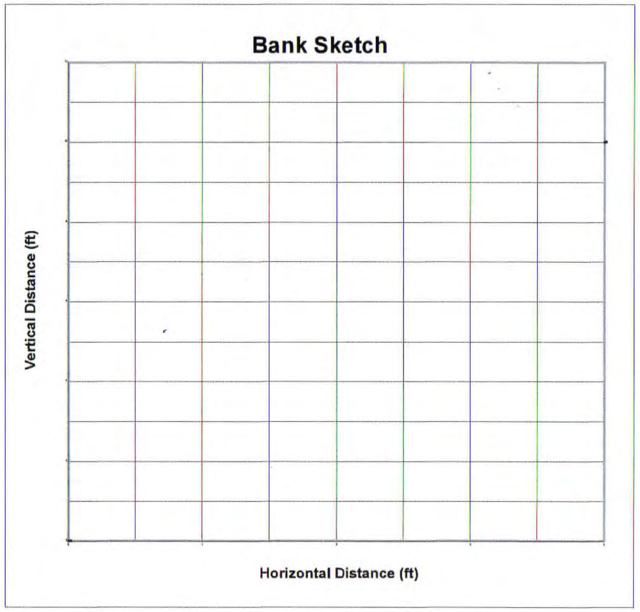
Root Density (%) 15 F	F*E = 1.8 G

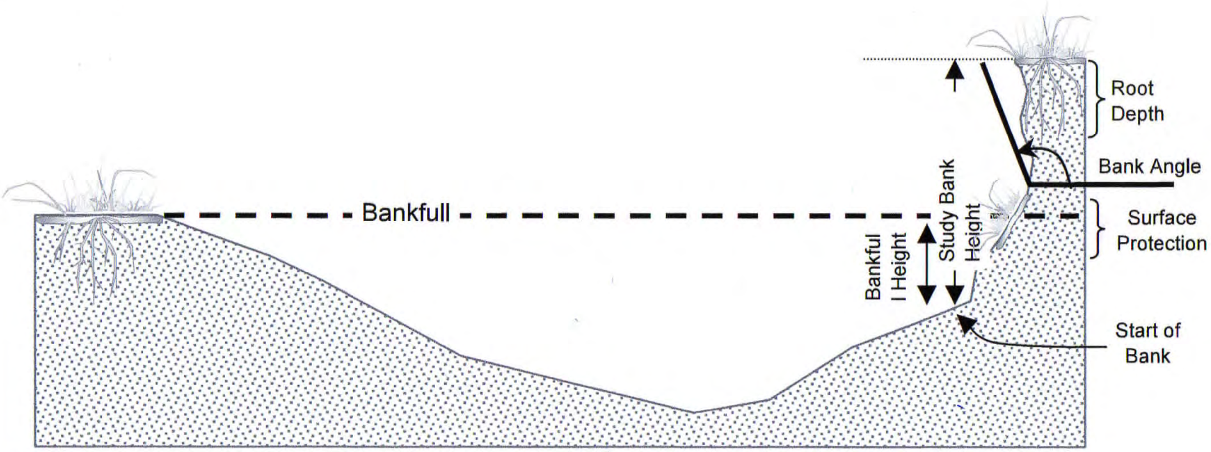
Bank Angle (H)

Bank Angle (Degrees) 80 H

Surface Protection (I)

Surface Protection % 30 I





Worksheet 21. Summary of bank erosion hazard index (BEHI)

Bank Erosion Hazard Rating Guide

Stream Reach Date Crew

Bank Erosion Potential

Bank Height (ft): Bankfull Height (ft):		**Bank Height/ Bankfull Ht**	**Root Depth/ Bank Height**	**Root Density %**	**Bank Angle (Degrees)**	**Surface Protection%**
VERY LOW	Value	1.0-1.1	1.0-0.9	100-80	0-20	100-80
	Index	1.0-1.9	1.0-1.9	1.0-1.9	1.0-1.9	1.0-1.9
	Choice	V: I:	V: I:	V: I:	V: I:	V: I:
LOW	Value	1.11-1.19	0.89-0.5	79-55	21-60	79-55
	Index	2.0-3.9	2.0-3.9	2.0-3.9	2.0-3.9	2.0-3.9
	Choice	V: I:	V: I:	V: I:	V: I:	V: I:
MODERATE	Value	1.2-1.5	0.49-0.3	54-30	[✓ 61-80]	[✓ 54-30]
	Index	4.0-5.9	4.0-5.9	4.0-5.9	4.0-5.9	4.0-5.9
	Choice	V: I:	V: I:	V: I:	V: I:	V: I:
HIGH	Value	1.6-2.0	0.29-0.15	[✓ 29-15]	81-90	29-15
	Index	6.0-7.9	6.0-7.9	6.0-7.9	6.0-7.9	6.0-7.9
	Choice	V: I:	V: I:	V: I:	V: I:	V: I:
VERY HIGH	Value	2.1-2.8	[✓ 0.14-0.05]	14-5.0	91-119	14-10
	Index	8.0-9.0	8.0-9.0	8.0-9.0	8.0-9.0	8.0-9.0
	Choice	V: I:	V: I:	V: I:	V: I:	V: I:
EXTREME	Value	[✓ >2.8]	<0.05	<5	>119	<10
	Index	10	10	10	10	10
	Choice	V: I: 10	V: I: 8.5	V: I: 7.9	V: I: 5.9	V: I: 5.9
V = value, I = index					**SUB-TOTAL** (Sum one index from each column)	38.2

Bank Material Description:

Bank Materials

- **Bedrock** (Bedrock banks have very low bank erosion potential)
- **Boulders** (Banks composed of boulders have low bank erosion potential)
- **Cobble** (Subtract 10 points. If sand/gravel matrix greater than 50% of bank material, then do not adjust)
- **Gravel** (Add 5-10 points depending percentage of bank material that is composed of sand)
- **Sand** (Add 10 points)
- **Silt Clay** (+ 0: no adjustment)

BANK MATERIAL ADJUSTMENT 10

Stratification Comments:

Stratification

Add 5-10 points depending on position of unstable layers in relation to bankfull stage

STRATIFICATION ADJUSTMENT 0

VERY LOW	**LOW**	**MODERATE**	**HIGH**	**VERY HIGH**	[✓ **EXTREME**]
5-9.5	10-19.5	20-29.5	30-39.5	40-45	[✓ 46-50]

Bank location description (circle one)

Straight Reach Outside of Bend

GRAND TOTAL BEHI RATING 48.2

LaPorte 2

Worksheet 20. BEHI variable worksheet

Stream: Kankakee	Cross Section: LaPorte 2	Date: 8,27,18	Observers: rcb

Bank Height/Max Depth Bankfull (C)

Study Bank Height (ft) 20 A	Bankfull Height (ft) 1.5 B	A/B = 13.3 C

Root Depth/Bank Height (E)

Root Depth (ft) 1 D	Study Bank Height (ft) 20 A	D/A = 0.05 E

Weighted Root Density (G)

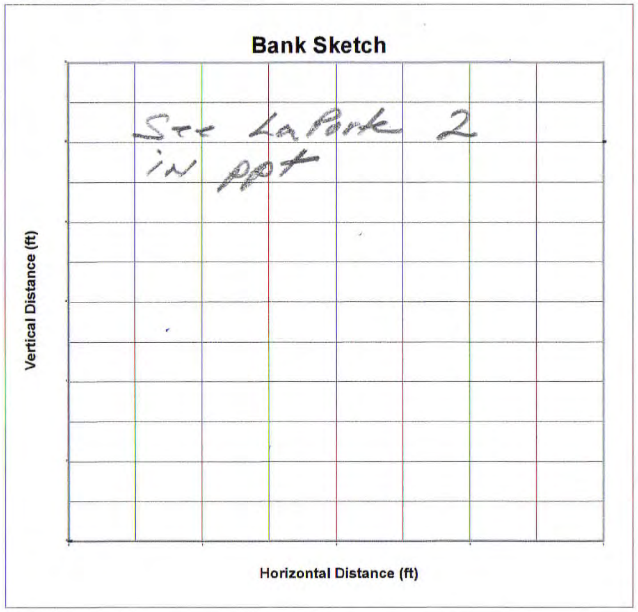
Root Density (%) 15 F	F*E = 0.75 G

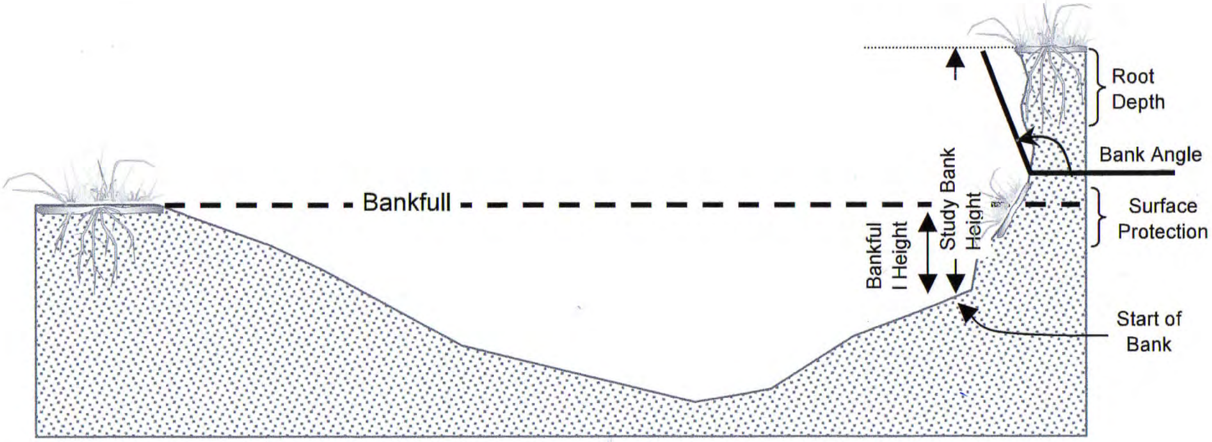
Bank Angle (H)

Bank Angle (Degrees) 75 H

Surface Protection (I)

Surface Protection % 60 I





Worksheet 21. Summary of bank erosion hazard index (BEHI)

Bank Erosion Hazard Rating Guide

Stream Kankakee Reach LaPorte 2 Date 8.27.18 Crew reb

Bank Erosion Potential

Bank Height (ft): Bankfull Height (ft):		**Bank Height/ Bankfull Ht**	**Root Depth/ Bank Height**	**Root Density %**	**Bank Angle (Degrees)**	**Surface Protection%**
VERY LOW	Value	1.0-1.1	1.0-0.9	100-80	0-20	100-80
	Index	1.0-1.9	1.0-1.9	1.0-1.9	1.0-1.9	1.0-1.9
	Choice	V: I:	V: I:	V: I:	V: I:	V: I:
LOW	Value	1.11-1.19	0.89-0.5	79-55	21-60	[✓ 79-55]
	Index	2.0-3.9	2.0-3.9	2.0-3.9	2.0-3.9	2.0-3.9
	Choice	V: I:	V: I:	V: I:	V: I:	V: I:
MODERATE	Value	1.2-1.5	0.49-0.3	54-30	[✓ 61-80]	54-30
	Index	4.0-5.9	4.0-5.9	4.0-5.9	4.0-5.9	4.0-5.9
	Choice	V: I:	V: I:	V: I:	V: I:	V: I:
HIGH	Value	1.6-2.0	0.29-0.15	[✓ 29-15]	81-90	29-15
	Index	6.0-7.9	6.0-7.9	6.0-7.9	6.0-7.9	6.0-7.9
	Choice	V: I:	V: I:	V: I:	V: I:	V: I:
VERY HIGH	Value	2.1-2.8	0.14-0.05	14-5.0	91-119	14-10
	Index	8.0-9.0	8.0-9.0	8.0-9.0	8.0-9.0	8.0-9.0
	Choice	V: I:	V: I:	V: I:	V: I:	V: I:
EXTREME	Value	[✓ >2.8]	[✓ <0.05]	<5	>119	<10
	Index	10	10	10	10	10
	Choice	V: I: 10	V: I: 10	V: I: 7	V: I: 5.5	V: I: 3
V = value, I = index				**SUB-TOTAL** (Sum one index from each column)		35.5

Bank Material Description:

Bank Materials

- **Bedrock** (Bedrock banks have very low bank erosion potential)
- **Boulders** (Banks composed of boulders have low bank erosion potential)
- **Cobble** (Subtract 10 points. If sand/gravel matrix greater than 50% of bank material, then do not adjust)
- **Gravel** (Add 5-10 points depending percentage of bank material that is composed of sand)
- **Sand** (Add 10 points)
- **Silt Clay** (+ 0: no adjustment)

BANK MATERIAL ADJUSTMENT 10

Stratification Comments:

Stratification

Add 5-10 points depending on position of unstable layers in relation to bankfull stage

STRATIFICATION ADJUSTMENT 0

VERY LOW	**LOW**	**MODERATE**	**HIGH**	[✓ **VERY HIGH**]	**EXTREME**
5-9.5	10-19.5	20-29.5	30-39.5	[✓ 40-45]	46-50

Bank location description (circle one)

Straight Reach Outside of Bend

GRAND TOTAL
BEHI RATING 45.5

Starke 1

Worksheet 20. BEHI variable worksheet

Stream: Kankakee	Cross Section: Starke 1	Date: 8.27.18	Observers: rcb

Bank Height/Max Depth Bankfull (C)

Study Bank Height (ft) 8 A	Bankfull Height (ft) 0.5 B	A/B = 16 C

Root Depth/Bank Height (E)

Root Depth (ft) 1 D	Study Bank Height (ft) 8 A	D/A = 0.125 E

Weighted Root Density (G)

Root Density (%) 10 F	F*E = 1.25 G

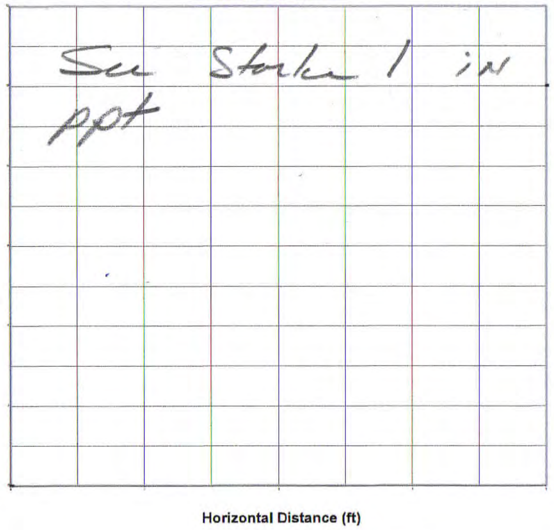
Bank Angle (H)

Bank Angle (Degrees) 55 H

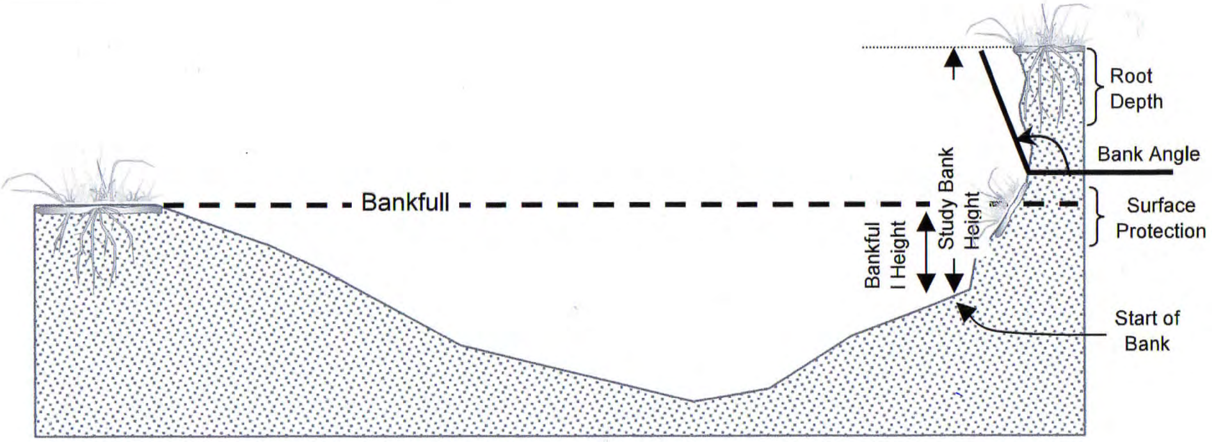
Surface Protection (I)

Surface Protection % 4/8 I

Bank Sketch



See Starke 1 in ppt



Worksheet 21. Summary of bank erosion hazard index (BEHI)

Bank Erosion Hazard Rating Guide

Stream Kankakee Reach Strike 1 Date 8.27.14 Crew rcb

Bank Erosion Potential

Bank Height (ft): Bankfull Height (ft):		Bank Height/ Bankfull Ht	Root Depth/ Bank Height	Root Density %	Bank Angle (Degrees)	Surface Protection%
VERY LOW	Value	1.0-1.1	1.0-0.9	100-80	0-20	100-80
	Index	1.0-1.9	1.0-1.9	1.0-1.9	1.0-1.9	1.0-1.9
	Choice	V: I:	V: I:	V: I:	V: I:	V: I:
LOW	Value	1.11-1.19	0.89-0.5	79-55	[✓ 21-60]	79-55
	Index	2.0-3.9	2.0-3.9	2.0-3.9	2.0-3.9	2.0-3.9
	Choice	V: I:	V: I:	V: I:	V: I:	V: I:
MODERATE	Value	1.2-1.5	0.49-0.3	54-30	61-80	[✓ 54-30]
	Index	4.0-5.9	4.0-5.9	4.0-5.9	4.0-5.9	4.0-5.9
	Choice	V: I:	V: I:	V: I:	V: I:	V: I:
HIGH	Value	1.6-2.0	0.29-0.15	29-15	81-90	29-15
	Index	6.0-7.9	6.0-7.9	6.0-7.9	6.0-7.9	6.0-7.9
	Choice	V: I:	V: I:	V: I:	V: I:	V: I:
VERY HIGH	Value	2.1-2.8	[✓ 0.14-0.05]	[✓ 14-5.0]	91-119	14-10
	Index	8.0-9.0	8.0-9.0	8.0-9.0	8.0-9.0	8.0-9.0
	Choice	V: I:	V: I:	V: I:	V: I:	V: I:
EXTREME	Value	[✓ >2.8]	<0.05	<5	>119	<10
	Index	10	10	10	10	10
	Choice	V: I: 10	V: I: 8.5	V: I: 8.5	V: I: 3	V: I: 5
V = value, I = index				**SUB-TOTAL** (Sum one index from each column)		35

Bank Material Description:

Bank Materials

- **Bedrock** (Bedrock banks have very low bank erosion potential)
- **Boulders** (Banks composed of boulders have low bank erosion potential)
- **Cobble** (Subtract 10 points. If sand/gravel matrix greater than 50% of bank material, then do not adjust)
- **Gravel** (Add 5-10 points depending percentage of bank material that is composed of sand)
- **Sand** (Add 10 points)
- **Silt Clay** (+ 0: no adjustment)

BANK MATERIAL ADJUSTMENT 10

Stratification Comments:

Stratification

Add 5-10 points depending on position of unstable layers in relation to bankfull stage

STRATIFICATION ADJUSTMENT 5

VERY LOW	LOW	MODERATE	HIGH	VERY HIGH	[✓ EXTREME]
5-9.5	10-19.5	20-29.5	30-39.5	40-45	[✓ 46-50]

Bank location description (circle one)

Straight Reach Outside of Bend

GRAND TOTAL 50

BEHI RATING

```
                     RIVERMORPH BEHI SUMMARY REPORT

----------------------------------------------------------------------

River Name: Kankakee River
Reach Name: Reach 1

----------------------------------------------------------------------


----------------------------------------------------------------------
Table 1.  Bank Identification Summary

Bank      Name
 1        Newton County
 2        Jasper County
 3        Porter County
 4        Lake County
 5        Starke County
 6        LaPorte County


----------------------------------------------------------------------
Table 2.  Predicted Annual Bank Erosion Rates

     BEHI    BEHI      NBS
     Numeric Adjective Adjective    Length       Loss     Loss
Bank Rating  Rating    Rating           ft cu yds/yr tons/yr

1    45.6    Very High Very Low      12390 1266.5333(1646.4933)
2    47.9    Extreme   Very Low      31626 9806.9883(12749.0848)
3    49.8    Extreme   Very Low       6231 1932.1869(2511.843)
4    48.7    Extreme   Very Low        400   124.037(161.2481)
5    46.9    Extreme   Very Low        528   154.0978(200.3271)
6    42.5    Very High Very Low       1426    19.4359(25.2666)

Totals                               5260113303.279217294.2629

Total Reach Ln: 52601   Total Loss (tons/yr) per ft of Reach: 0.3288
```

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

○ ADCP Cross-section Locations
▢ County Boundary

CBB BURKE

Christopher B. Burke Engineering, LLC
PNC Center, Suite 1368 South
115 West Washington Street
Indianapolis, Indiana 46204
(t) 317.266.8000 (f) 317.632.3306

PROJECT: Kankakee River Flood and Sediment Managemet Work Plan

PROJECT NO. 18-0290

APPROX. SCALE 1"=2,000ft

DATE: 06/2019

TITLE: ADCP Cross-section Locations

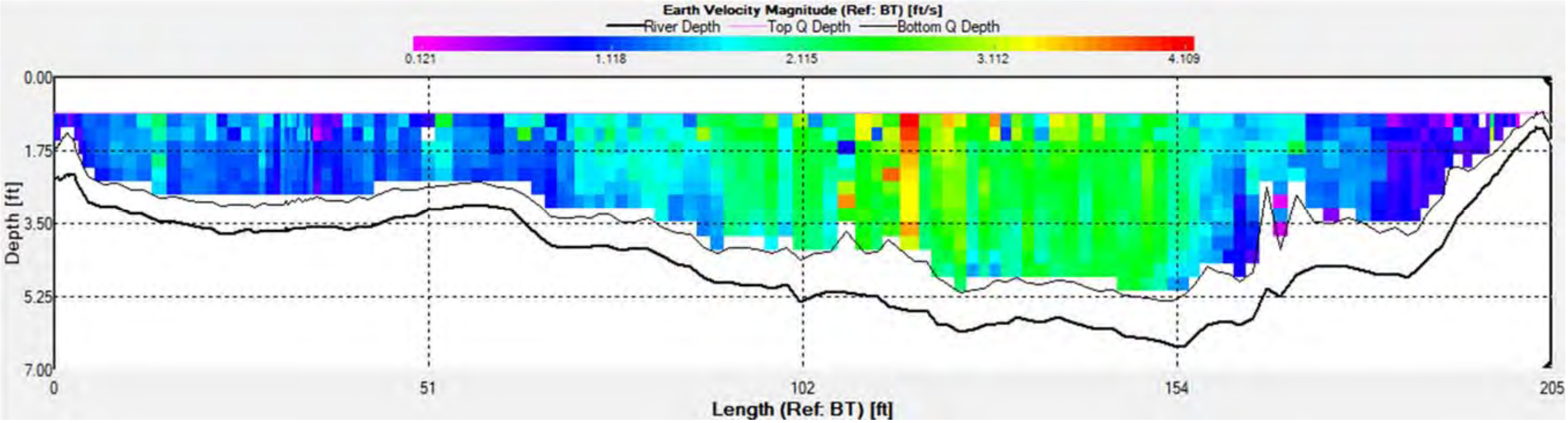
EXHIBIT A1.2

Cross-sections of the Kankakee were recorded using an acoustic dopple channel profiler (ADCP). An ADCP has the ability to measure the geometric shape of the channel bottom to produce a cross-section ‘profile’. The ADCP also allows the velocity of the flow in the channel to be determined, producing a map of depth- and horizontally-varied velocity. The cross sections plot as wider than the actual width of the channel due to drift of the watercraft during data collection. The channel width with drift and the actual perpendicular width for each cross-section are provided in Table 1. The cross-section profiles and velocity plots are provided in Cross-section 1 trough Cross-section 16

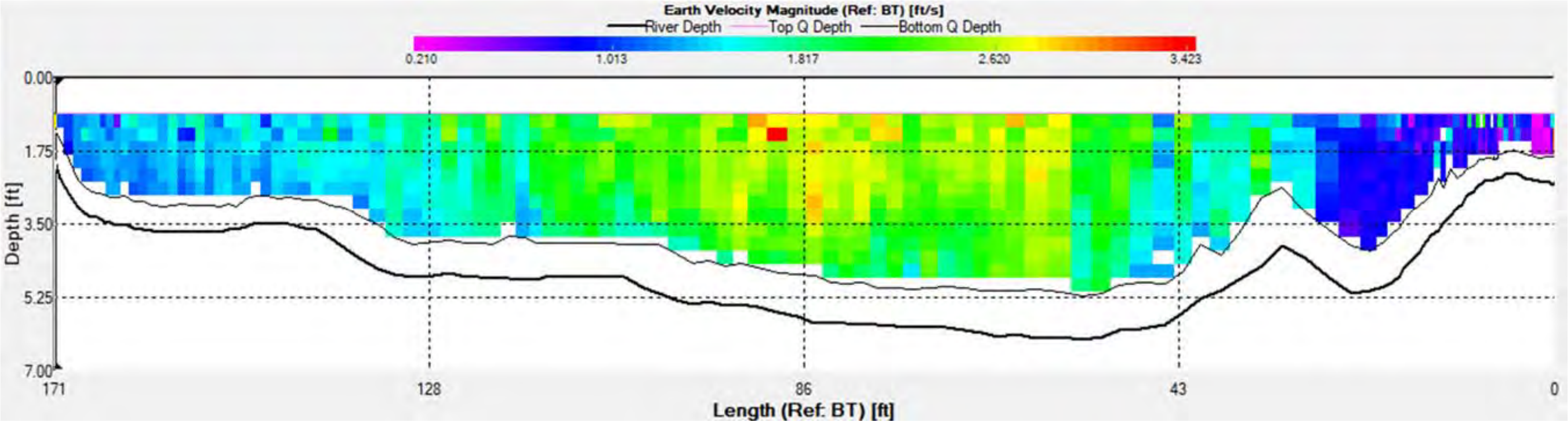
Table 1: ADCP Cross-section Information

Cross-Section Number	Latitude (Decimal Deg.)	Longitude (Decimal Deg.)	Channel Width with Drift (ft)	Perpendicular Channel Width (ft)
1	41.27118839	-86.82682232	205	177
2	41.27161764	-86.82683467	171	153
3	41.2713897	-86.82882237	143	122
4	41.27151099	-86.83033953	120	101
5	41.27144825	-86.84074341	107	91
6	41.26723149	-86.84668586	124	106
7	41.26617078	-86.85452435	117	113
8	41.26532127	-86.86567831	114	107
9	41.26443005	-86.87086096	124	110
10	41.2596052	-86.87981036	116	109
11	41.25810586	-86.88501887	118	109
12	41.25518235	-86.89535824	124	119
13	41.25278186	-86.90131836	123	112
14	41.24548334	-86.91959847	124	117
15	41.23953266	-86.92713355	118	109
16	41.2369752	-86.92954971	124	133

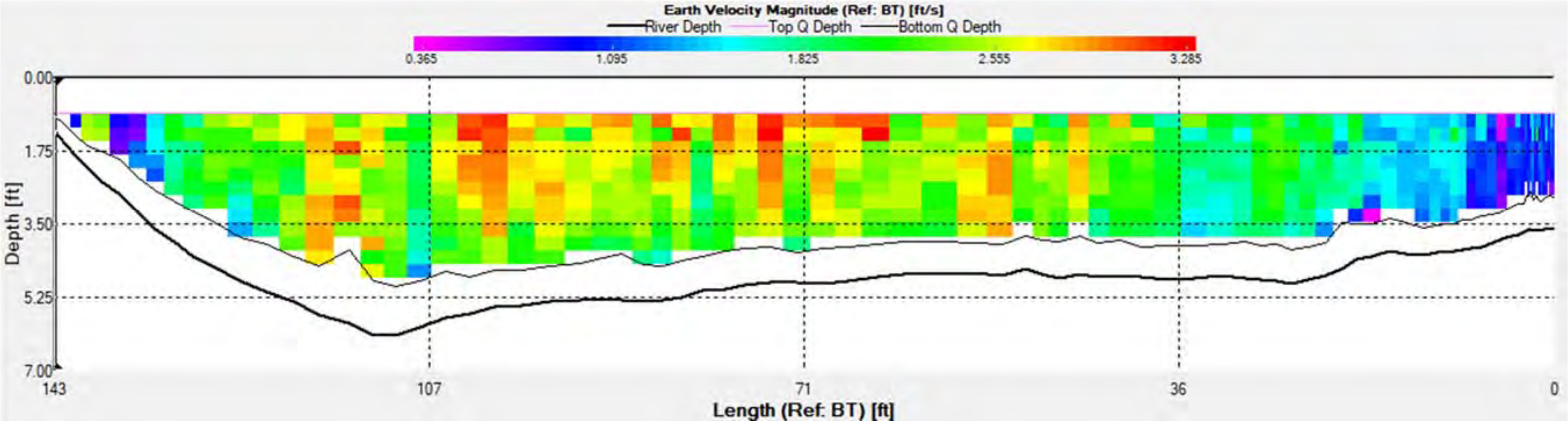
Cross-section 1



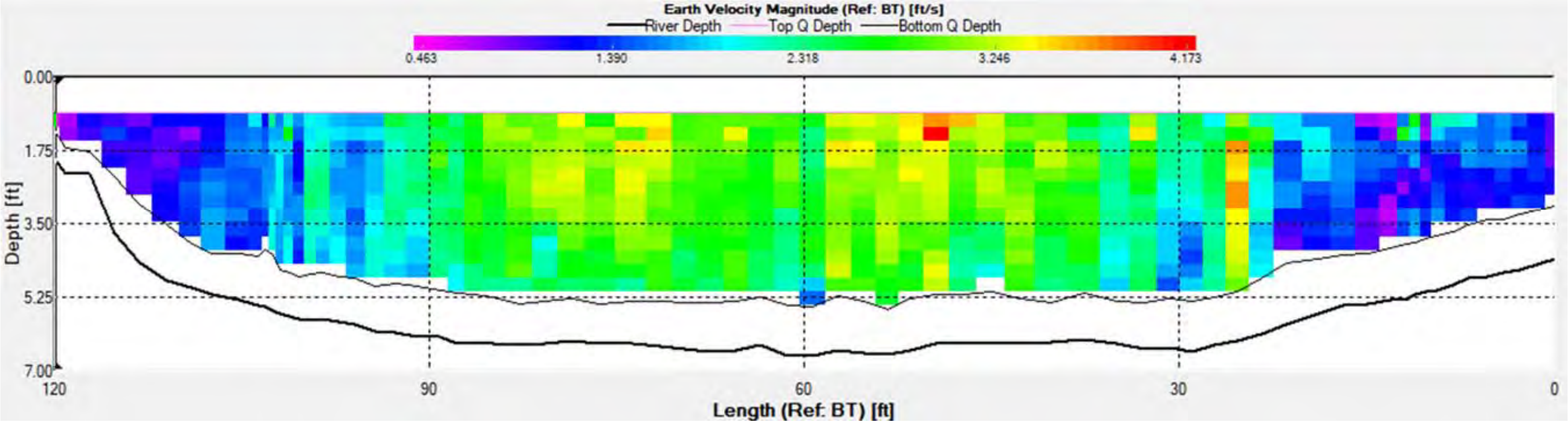
Cross-section 2



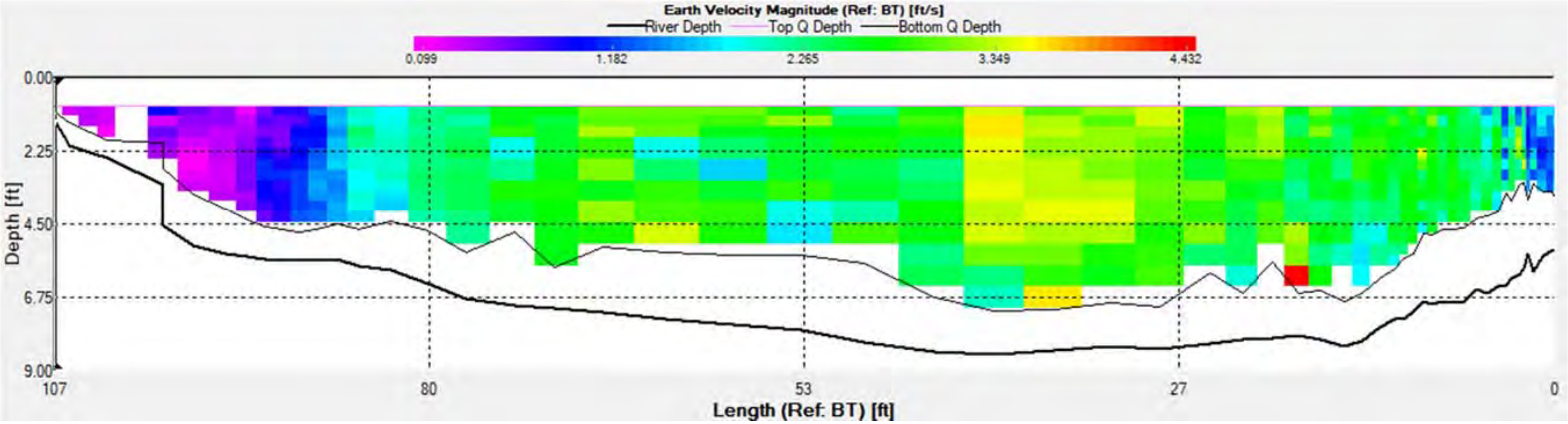
Cross-section 3



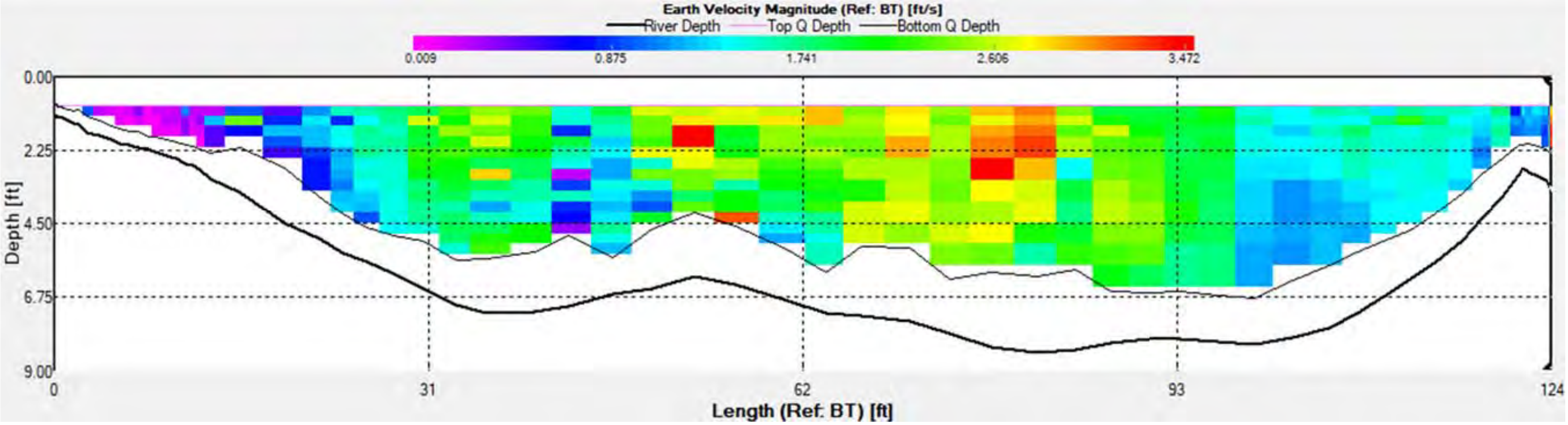
Cross-section 4



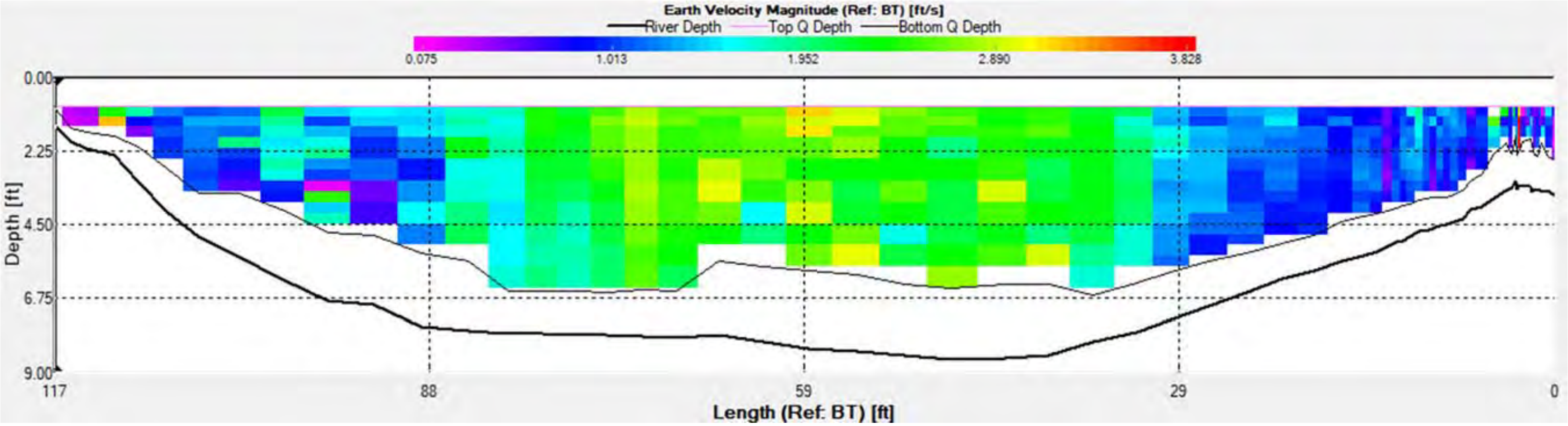
Cross-section 5



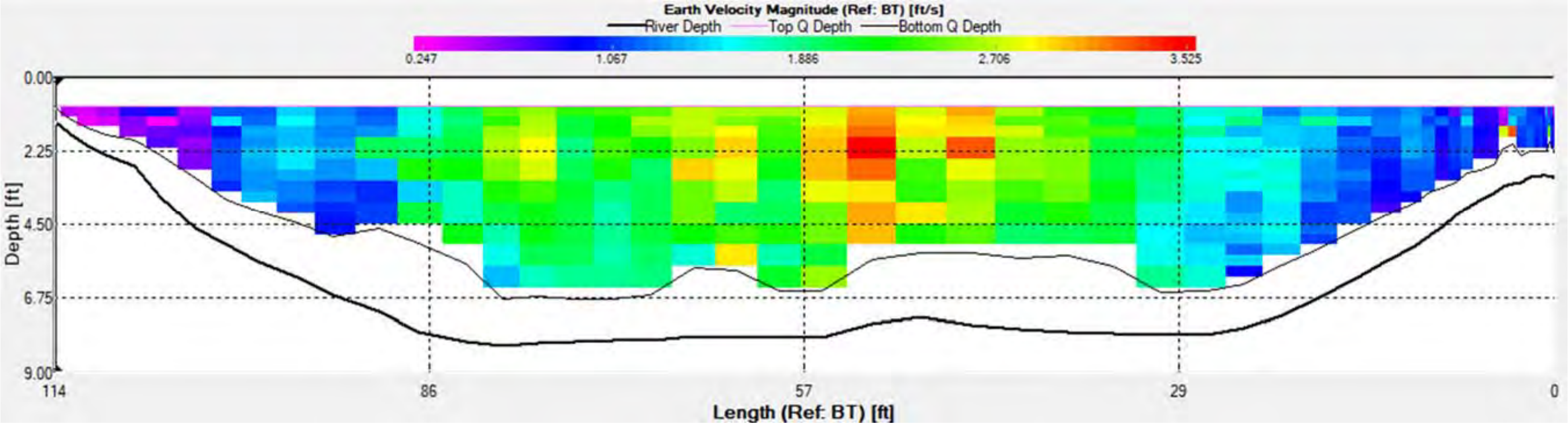
Cross-section 6



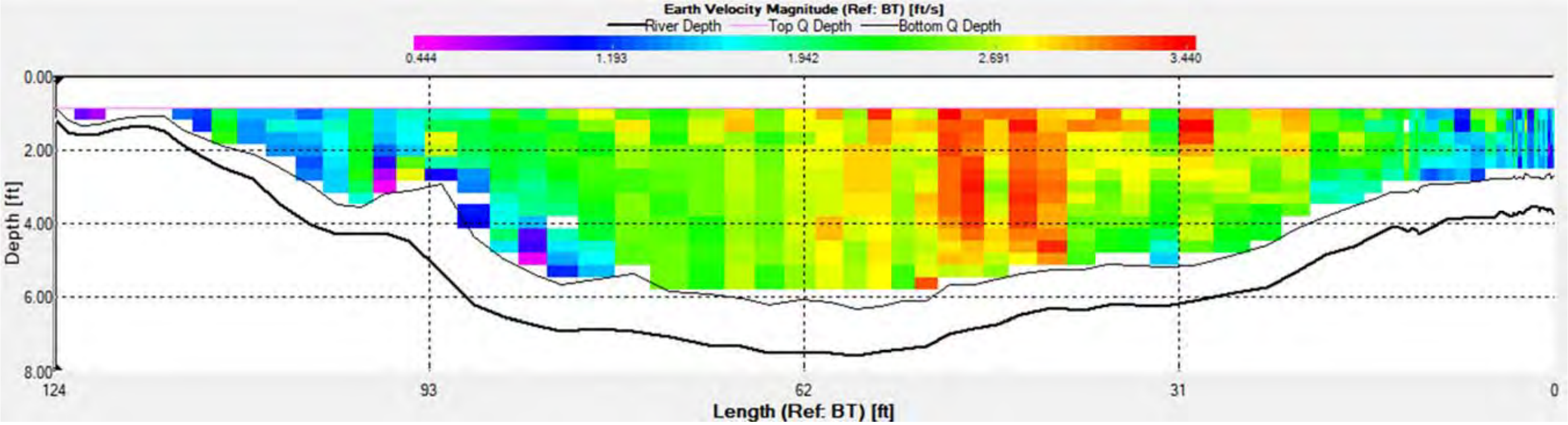
Cross-section 7



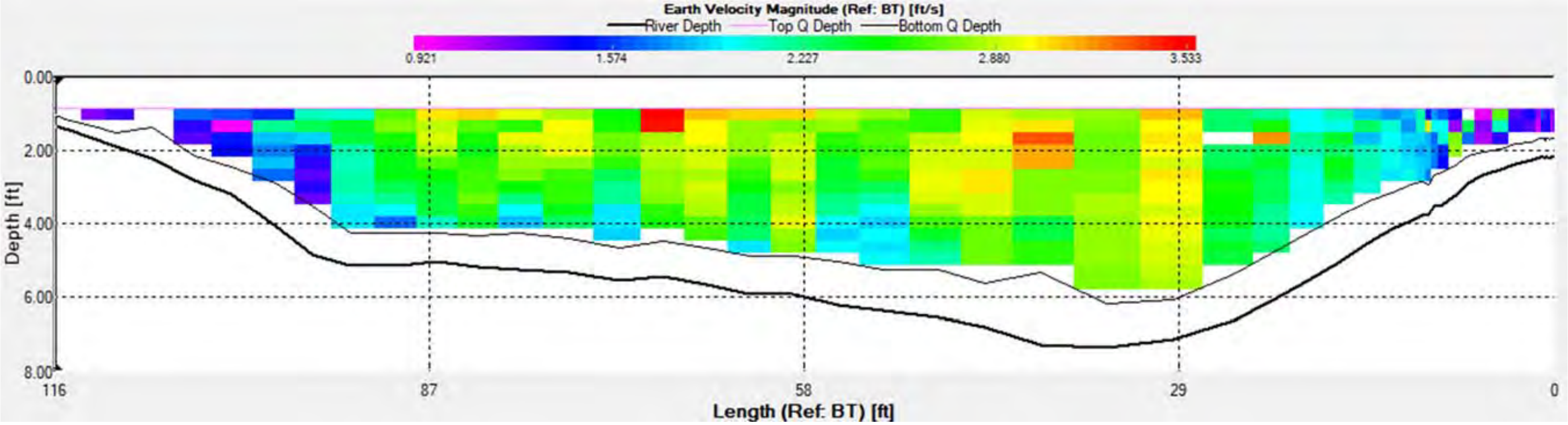
Cross-section 8



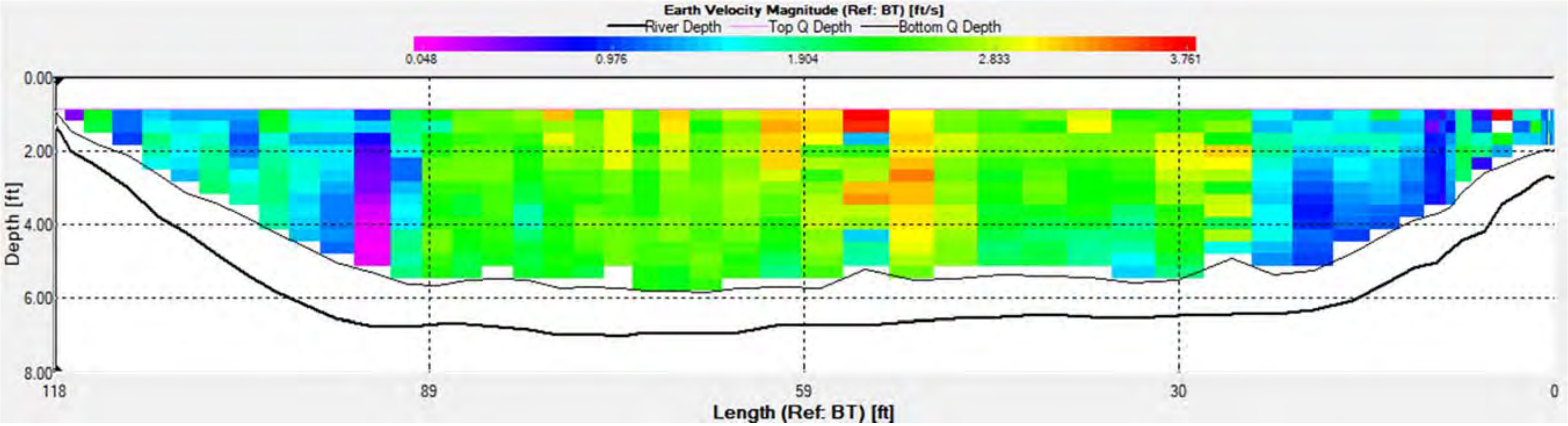
Cross-section 9



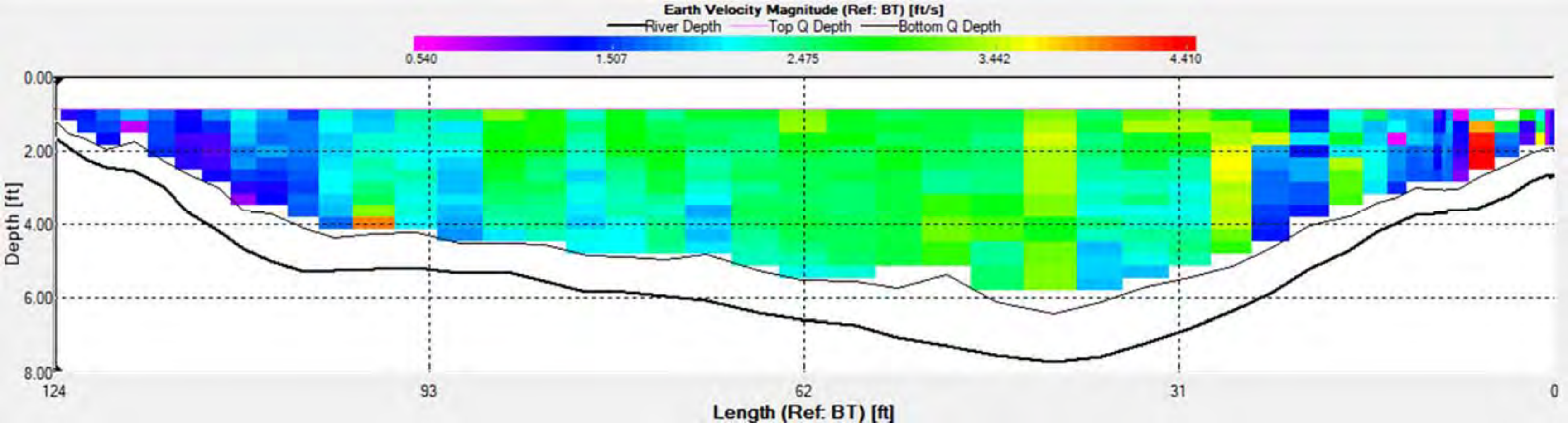
Cross-section 10



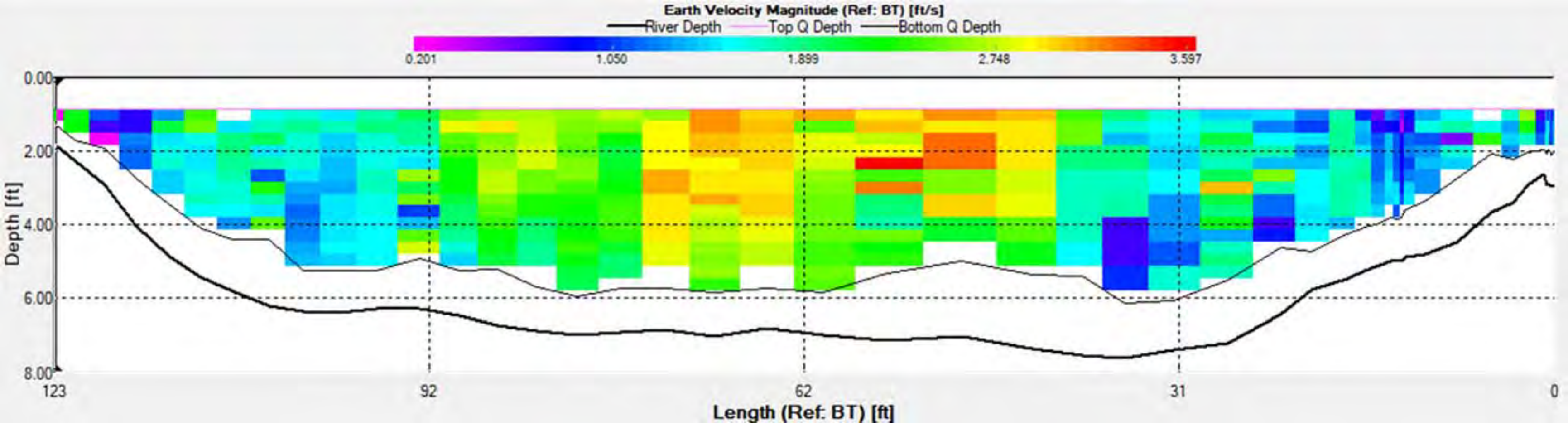
Cross-section 11



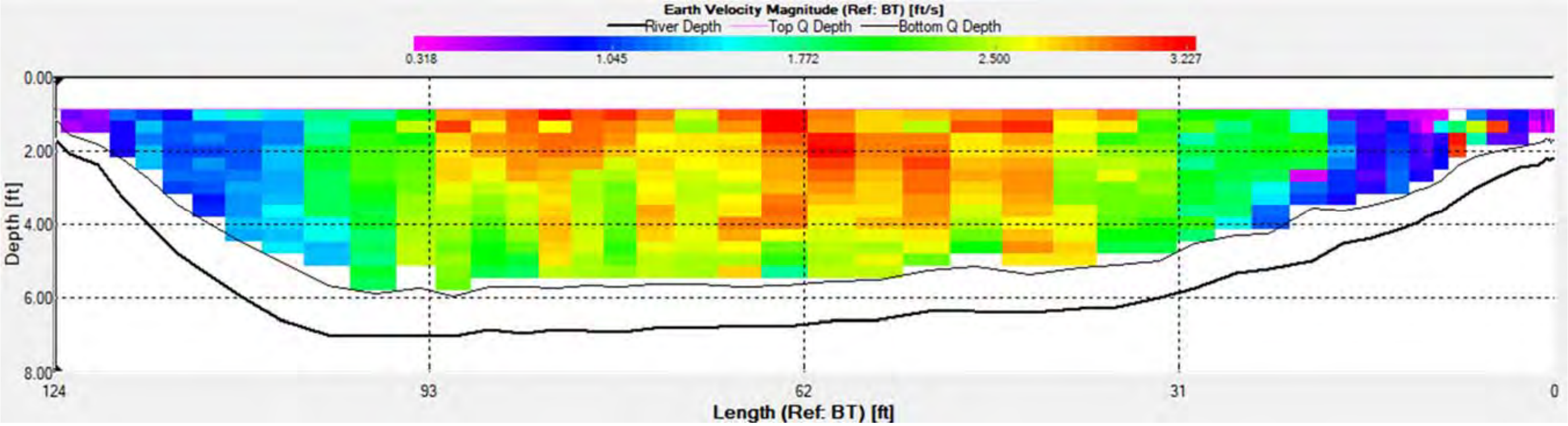
Cross-section 12



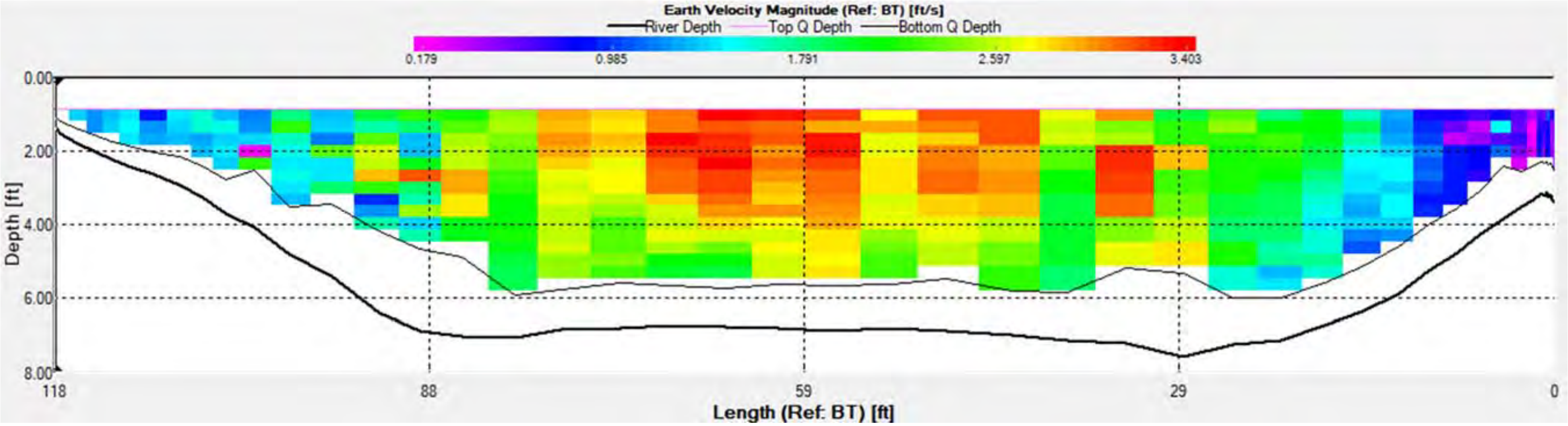
Cross-section 13



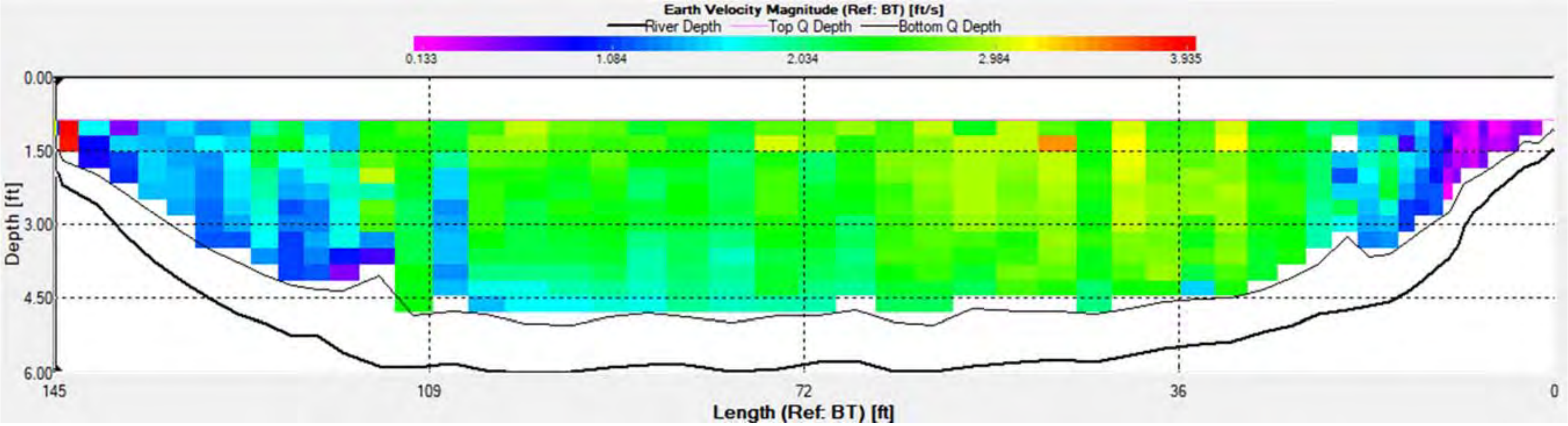
Cross-section 14



Cross-section 15



Cross-section 16



Bankfull Channel Dimension Comparison

Measurement Location (Stationing from Site Visit Map)	Drainage Area* (sq. mi.)	Approximate Bankfull Width** (ft)	Predicted Bankfull Width*** (ft)	Predicted Bankfull Depth*** (ft)	Predicted Bankfull Area*** (ft^2)	Departure from Expected (%)
Kankakee River at USGS Gage 05515000	174.0	55.0	69	3.2	219	-20%
River Mile 129.5	175.2	60.0	69	3.2	219	-13%
R.M. 129	176.4	65.0	69	3.2	220	-6%
R.M. 128.5	177.6	55.0	70	3.2	221	-21%
R.M. 128	178.8	100.0	70	3.2	221	43%
K.R. above Little K.R.	180.0	95.0	70	3.2	222	36%
K.R. incl. Little K.R.	233.0	75.0	76	3.4	253	-1%
K.R. above Pine Ck	234.0	85.0	76	3.4	253	12%
K.R. incl. Pine Ck	348.0	90.0	86	3.6	308	4%
R.M. 125.6	349.0	80.0	86	3.6	308	-7%
R.M. 125.1	350.0	85.0	86	3.6	309	-2%
R.M. 124.6	351.0	75.0	86	3.6	309	-13%
R.M. 124.1	352.0	75.0	86	3.6	310	-13%
R.M. 123.6	353.0	80.0	87	3.7	310	-8%
K.R. above Breckenridge Ditch	354.0	80.0	87	3.7	311	-8%
K.R. incl. Breckenridge Ditch	376.0	70.0	88	3.7	320	-21%
R.M. 122.2	378.0	85.0	88	3.7	321	-4%
R.M. 121.7	380.0	85.0	89	3.7	322	-4%
R.M. 121.2	382.0	85.0	89	3.7	323	-4%
R.M. 120.7	384.0	90.0	89	3.7	323	1%
R.M. 120.2	386.0	70.0	89	3.7	324	-21%
R.M. 119.7	388.0	80.0	89	3.7	325	-10%
K.R. above Jensen Ditch	390.0	75.0	89	3.7	326	-16%
K.R. incl. Jensen Ditch	400.0	80.0	90	3.7	330	-11%
R.M. 118.3	400.6	80.0	90	3.7	330	-11%
R.M. 117.8	401.2	85.0	90	3.7	330	-6%
R.M. 117.3	401.8	80.0	90	3.7	331	-11%
R.M. 116.8	402.4	75.0	90	3.7	331	-17%
K.R. above Long Ditch	403.0	95.0	90	3.7	331	5%
K.R. incl. Long Ditch	464.0	90.0	94	3.8	355	-5%
R.M. 115.4	468.0	80.0	95	3.8	357	-16%
K.R. above Salisbury Ditch	472.0	80.0	95	3.8	358	-16%
K.R. incl. Salisbury Ditch	492.0	85.0	96	3.9	366	-12%
K.R. above Waltham Ditch	493.0	80.0	96	3.9	366	-17%
K.R. at USGS Gage 05515500	537.0	100.0	99	3.9	382	1%
R.M. 113.0	537.8	80.0	99	3.9	382	-19%
R.M. 112.5	538.6	100.0	99	3.9	382	1%
R.M. 112.0	539.4	95.0	99	3.9	383	-4%
R.M. 111.5	540.2	85.0	99	3.9	383	-14%
K.R. above Marquart Ditch	541.0	85.0	99	3.9	383	-14%
K.R. incl. Marquart Ditch	551.0	95.0	100	3.9	387	-5%
K.R. incl. Robbins Ditch	637.0	110.0	104	4.1	415	5%
K.R. above Bailey Ditch	638.0	90.0	104	4.1	416	-14%
K.R. incl. Bailey Ditch	656.0	95.0	105	4.1	422	-10%
R.M. 108.7	657.0	90.0	105	4.1	422	-15%
R.M. 108.2	658.0	100.0	106	4.1	422	-5%
R.M. 107.7	659.0	105.0	106	4.1	422	-1%
R.M. 107.2	660.0	100.0	106	4.1	423	-5%
R.M. 106.7	661.0	95.0	106	4.1	423	-10%
R.M. 106.2	662.0	110.0	106	4.1	423	4%
R.M. 105.7	663.0	100.0	106	4.1	424	-5%
R.M. 105.2	664.0	100.0	106	4.1	424	-5%
R.M. 104.7	665.0	95.0	106	4.1	424	-10%
R.M. 104.3	666.0	100.0	106	4.1	425	-6%
R.M. 103.8	667.0	95.0	106	4.1	425	-10%
R.M. 103.3	668.0	90.0	106	4.1	425	-15%
R.M. 102.8	669.0	100.0	106	4.1	426	-6%
K.R. above Yellow River	670.0	95.0	106	4.1	426	-10%
K.R. incl. Yellow River	1248.0	130.0	129	4.6	580	1%
K.R. incl. Origer Ditch	1258.0	125.0	130	4.6	582	-4%
R.M. 99.3	1260.5	125.0	130	4.6	582	-4%
K.R. above Pitner Ditch	1263.0	125.0	130	4.6	583	-4%
K.R. incl. Payne Ditch	1334.0	140.0	132	4.6	599	6%
R.M. 96.3	1338.5	135.0	132	4.6	600	2%
R.M. 95.3	1343.0	135.0	132	4.6	601	2%
R.M. 94.3	1347.5	135.0	133	4.6	602	2%

Measurement Location (Stationing from Site Visit Map)	Drainage Area* (sq. mi.)	Approximate Bankfull Width** (ft)	Predicted Bankfull Width*** (ft)	Predicted Bankfull Depth*** (ft)	Predicted Bankfull Area*** (ft^2)	Departure from Expected (%)
K.R. USGS Gage 05517500	1352.0	115.0	133	4.6	603	-13%
R.M. 92.3	1355.0	135.0	133	4.6	604	2%
R.M. 91.3	1358.0	150.0	133	4.6	604	13%
K.R. above Davis Ditch	1361.0	145.0	133	4.6	605	9%
K.R. at USGS Gage 05517530	1376.0	140.0	133	4.6	608	5%
K.R. incl. Cook Ditch	1401.0	130.0	134	4.7	614	-3%
K.R. above Reeves Ditch	1403.0	145.0	134	4.7	614	8%
K.R. above Benkie Ditch	1537.0	145.0	138	4.7	642	5%
K.R. incl. Benkie Ditch	1549.0	150.0	139	4.7	645	8%
K.R. above Sandy Hook Ditch	1550.0	145.0	139	4.7	645	5%
K.R. incl. Phillips Ditch	1622.0	150.0	141	4.8	660	7%
R.M. 82.2	1622.3	160.0	141	4.8	660	14%
R.M. 81.2	1622.7	155.0	141	4.8	660	10%
K.R. above Breyfogel Ditch	1623.0	150.0	141	4.8	660	7%
K.R. incl. Breyfogel Ditch	1646.0	190.0	141	4.8	665	35%
R.M. 78.2	1646.0	175.0	141	4.8	665	24%
K.R. above Hodge Ditch	1646.0	170.0	141	4.8	665	20%
K.R. incl. Hodge Ditch	1731.0	175.0	144	4.8	681	22%
R.M. 75.2	1732.8	175.0	144	4.8	682	22%
R.M. 74.2	1734.6	165.0	144	4.8	682	15%
R.M. 73.2	1736.4	170.0	144	4.8	682	18%
R.M. 72.2	1738.2	185.0	144	4.8	683	29%
K.R. above Dehaan Ditch	1740.0	180.0	144	4.8	683	25%
K.R. incl. Dehaan Ditch	1777.0	155.0	145	4.9	690	7%
K.R. at USGS Gage 05518000	1779.0	160.0	145	4.9	691	11%
K.R. above tributary	1780.0	180.0	145	4.9	691	24%
K.R. incl. tributary	1789.0	175.0	145	4.9	693	21%
K.R. above Knight Ditch	1794.0	185.0	145	4.9	694	27%
K.R. incl. Knight Ditch	1840.0	195.0	146	4.9	702	33%
R.M. 64.2	1843.0	195.0	146	4.9	703	33%
K.R. above Beaver Lake Ditch	1846.0	200.0	146	4.9	703	37%
K.R. incl. Beaver Lake Ditch	1906.0	185.0	148	4.9	715	25%
R.M. 61.1	1909.0	180.0	148	4.9	715	22%
K.R. above Best Ditch	1912.0	185.0	148	4.9	716	25%
K.R. incl. Best Ditch (state line)	1920.0	195.0	148	4.9	717	31%
R.M. 57.4	1931.0	220.0	149	4.9	719	48%
R.M. 56.4	1931.2	220.0	149	4.9	719	48%
R.M. 55.3	1931.9	250.0	149	4.9	719	68%
R.M. 54.4	1934.9	230.0	149	4.9	720	55%
R.M. 53.4	1935.4	200.0	149	4.9	720	35%
K.R. above Singleton Ditch	1938.1	250.0	149	4.9	721	68%
K.R. incl. Singleton Ditch	2227.5	250.0	155	5.0	772	61%
K.R. incl. Trim Creek	2293.4	430.0	157	5.1	783	174%
R.M. 49.4	2294.0	520.0	157	5.1	783	231%
K.R. at USGS Gage 05520500	2297.0	430.0	157	5.1	784	174%
K.R. incl. Tower Creek	2318.4	380.0	157	5.1	787	141%
K.R. incl. Farr Creek	2338.3	490.0	158	5.1	791	210%
R.M. 42.2	2342.8	420.0	158	5.1	792	166%
R.M. 40.2	2351.1	645.0	158	5.1	793	308%
K.R. incl. Spring Creek	2381.2	670.0	159	5.1	798	322%
K.R. incl. Iroquois River	4521.1	740.0	195	5.7	1096	280%
K.R. incl. Gar Creek	4595.8	530.0	196	5.7	1105	171%
K.R. incl. Soldier Creek	4624.4	360.0	196	5.7	1108	84%
R.M. 30.0	4628.8	365.0	196	5.7	1109	86%
K.R. incl. Davis Creek	4638.3	530.0	196	5.7	1110	170%
K.R. incl. Wiley Creek	4649.2	630.0	196	5.7	1111	221%
R.M. 24.0	4654.5	580.0	197	5.7	1112	195%
K.R. incl. Rock Creek	4782.5	575.0	198	5.8	1127	190%

* Drainage areas at Indiana locations were estimated using IDNR's Drainage Areas of Indiana Streams. Drainage areas in Illinois were estimated using USGS's StreamStats tool.

** Approximate bankfull widths were determined by measuring the width of the channel defined by the most recent county DEMs at the prescribed bankfull depth above the lowest elevations. This method is expected to result in slightly overestimated bankfull widths.

*** Predicted bankfull width and depth determined using the Northern Moraine & Lake Region regression equations published by the USGS in Regional Bankfull-Channel Dimensions of Non-Urban Wadeable Streams in Indiana.

Measurement Location (Stationing from Site Visit Map)	Drainage Area* (sq. mi.)	Approximate Bankfull Width** (ft)	Predicted Bankfull Width*** (ft)	Predicted Bankfull Depth*** (ft)	Predicted Bankfull Area*** (ft^2)	Departure from Expected (%)
Iroquois River incl. Slough Ck	363.0	110.0	87	3.7	314	26%
IR near Foresman Gage 05524500	449.0	85.0	93	3.8	349	-9%
IR above Strole Ditch	479.0	110.0	95	3.9	361	15%
IR above Whaley Ditch	545.0	115.0	99	3.9	385	16%
IR near State Line	672.0	98.0	106	4.1	427	-8%
IR near Iroquois Gage 05525000	686.0	110.0	107	4.1	431	3%
IR incl. Eastburn Ditch	715.0	92.0	108	4.1	440	-15%
IR near Jefferson St, Watseka	740.0	100.0	110	4.2	447	-9%
IR incl. Sugar Ck	1300.0	156.0	131	4.6	591	19%
IR above Spring Ck	1316.0	168.0	132	4.6	595	28%
IR incl. Spring Ck	1588.0	246.0	140	4.8	653	76%
IR incl. Prairie Ck	1700.0	216.0	143	4.8	675	51%
IR incl. Pike Ck	1781.0	320.0	145	4.9	691	121%
IR incl. Langan Ck	1890.0	300.0	148	4.9	712	103%
IR incl. Beaver Ck	2076.0	370.0	152	5.0	746	143%
IR near Chebanse Gage 05526000	2090.0	332.0	152	5.0	748	118%
IR before KR confl.	2135.0	570.0	153	5.0	756	272%

* Drainage areas at Indiana locations were estimated using IDNR's Drainage Areas of Indiana Streams. Drainage areas at Illinois sites were estimated using USGS's StreamStats tool.

** Approximate bankfull widths were determined by measuring the width of the channel defined by county DEMs from 2013 or later at the prescribed bankfull depth above the lowest elevations. This method is expected to result in slightly overestimated bankfull widths. In cases of extremely low topographic relief, aerial imagery was

*** Predicted bankfull width and depth determined using the Northern Moraine & Lake Region regression equations published by the USGS in Regional Bankfull-Channel Dimensions of Non-Urban Wadeable Streams in Indiana.

Measurement Location (Stationing from Site Visit Map)	Drainage Area* (sq. mi.)	Approximate Bankfull Width** (ft)	Predicted Bankfull Width*** (ft)	Predicted Bankfull Depth*** (ft)	Predicted Bankfull Area*** (ft^2)	Departure from Expected (%)
Singleton Ditch at USGS Gage 05518500	34.2	30.0	41	2.4	98	-27%
Ditch Mile 21	38.6	30.0	43	2.5	104	-30%
D.M. 20	42.9	30.0	44	2.5	109	-32%
D.M. 19	47.3	30.0	46	2.6	115	-34%
S.D. incl. Bryant Ditch	51.6	45.0	47	2.6	120	-4%
D.M. 17	52.8	45.0	47	2.6	121	-5%
D.M. 16	54.0	50.0	48	2.6	122	5%
D.M. 15	55.3	45.0	48	2.6	124	-6%
D.M. 14	56.5	45.0	48	2.6	125	-7%
S.D. above Greisel Ditch	57.7	45.0	49	2.7	127	-8%
S.D. above Cedar Creek Ditch	87.7	50.0	56	2.9	156	-10%
D.M. 11	121.0	60.0	62	3.0	183	-3%
S.D. above Bruce Ditch	123.0	60.0	62	3.0	184	-3%
S.D. above Bailey Ditch	133.0	60.0	63	3.1	191	-5%
S.D. above West Creek	165.0	70.0	68	3.2	213	3%
S.D. incl. West Creek	220.0	85.0	74	3.4	245	14%
S.D. at state line	220.0	75.0	74	3.4	245	1%
S.D. above Bull Creek	228.1	90.0	75	3.4	250	19%
S.D. incl. Bull Creek	248.2	100.0	77	3.4	261	29%
D.M. 3	254.9	105.0	78	3.4	264	35%
D.M. 2	255.5	110.0	78	3.4	264	41%
D.M. 1	261.8	130.0	79	3.5	268	65%
S.D. at Kankakee R	262.0	140.0	79	3.5	268	78%

* Drainage areas were estimated using USGS's StreamStats tool.

** Approximate bankfull widths were determined by measuring the width of the channel defined by the most recent county DEMs at the prescribed bankfull depth above the lowest elevations. This method is expected to result in slightly overestimated bankfull widths.

*** Predicted bankfull width and depth determined using the Northern Moraine & Lake Region regression equations published by the USGS in Regional Bankfull-Channel Dimensions of Non-Urban Wadeable Streams in Indiana.

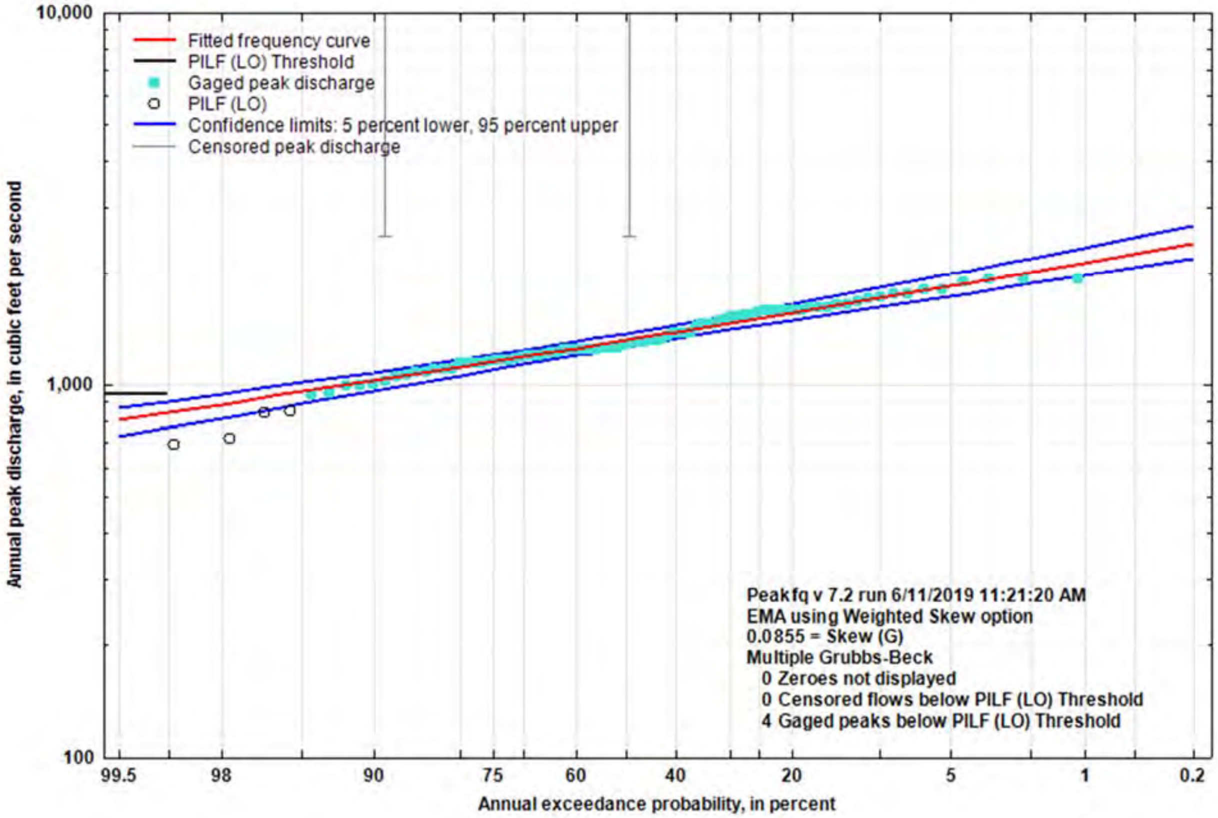
Appendix 2 – USGS Gage Analysis

B17C Gage Analysis

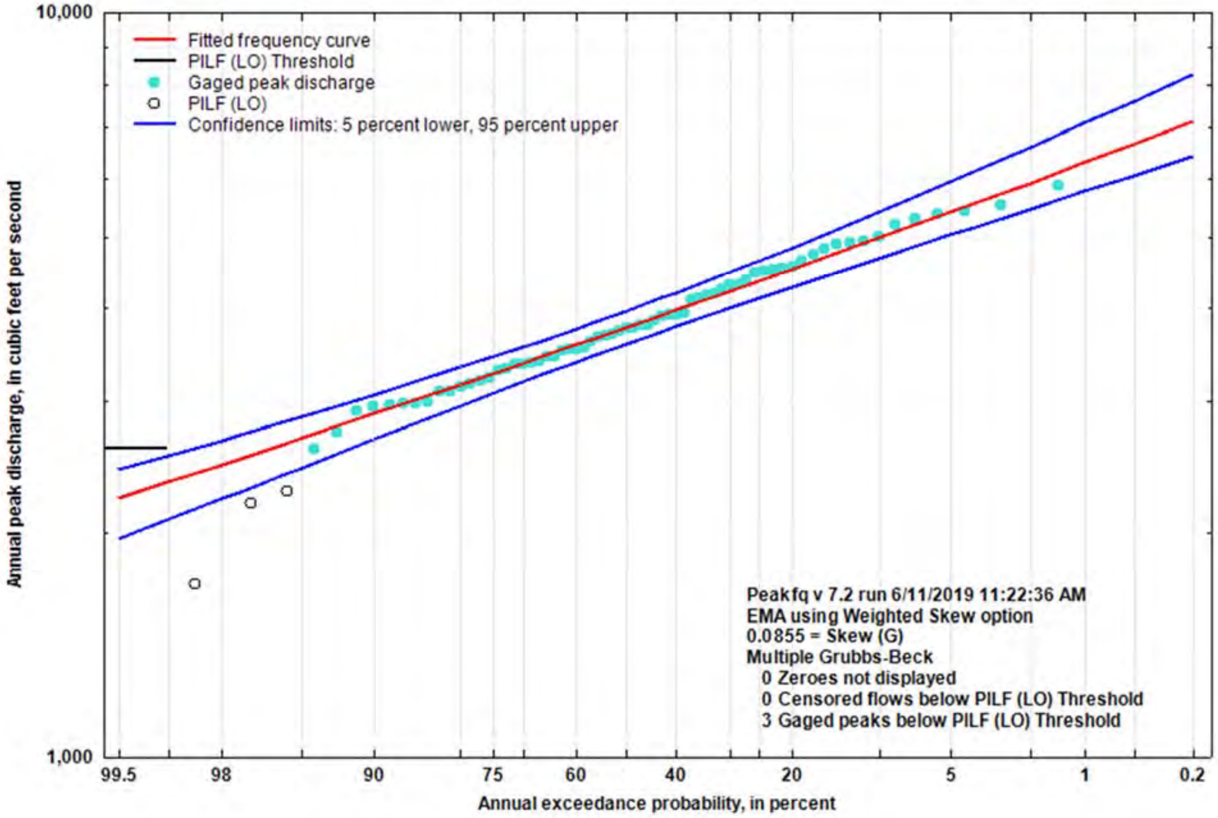
River System	Kankakee						Yellow		Iroquois				Sugar Creek
Gage	Davis	Dunns Bridge	Kouts	Shelby	Momence	Wilmington	Plymouth	Knox	Rensselaer	Foresman	Iroquois	Chebanse	Milford
Area (mi2)	542	1352	1376	1779	2294	5150	294	435	203	449	686	2091	446
80% AEP	1110	3160	3410	3710	5260	16700	1719	1770	1130	2120	2840	9540	3930
67% AEP	1210	3440	3690	4050	6000	20500	1951	2040	1280	2510	3400	11300	5090
50% AEP	1310	3770	4000	4440	6890	25400	2232	2360	1470	2990	4110	13500	6690
43% AEP	1360	3910	4140	4620	7300	27800	2361	2520	1550	3220	4450	14600	7500
20% AEP	1550	4510	4710	5340	9070	39100	2917	3190	1910	4240	5990	19300	11500
10% AEP	1700	4970	5130	5880	10500	49100	3364	3730	2200	5100	7320	23300	15400
4% AEP	1870	5510	5630	6540	12300	62800	3924	4430	2570	6230	9080	28500	21000
2% AEP	2000	5900	5990	7000	13600	73700	4339	4960	2840	7100	10500	32600	25800
1% AEP	2120	6270	6330	7450	15000	85200	4753	5490	3100	7990	11900	36800	31000
0.5% AEP	2230	6640	6660	7900	16300	97500	5170	6020	3370	8910	13400	41100	36700
0.2% AEP	2380	7110	7090	8470	18100	115000	5729	6750	3730	10200	15400	47000	45200
2018 Flood	2040	5840	5650	6380	12300	52300	5670	5900	3010	5140	9900	28900	19600

Highlighted cells denote B17C predicted events that most closely match the 2018 flood.

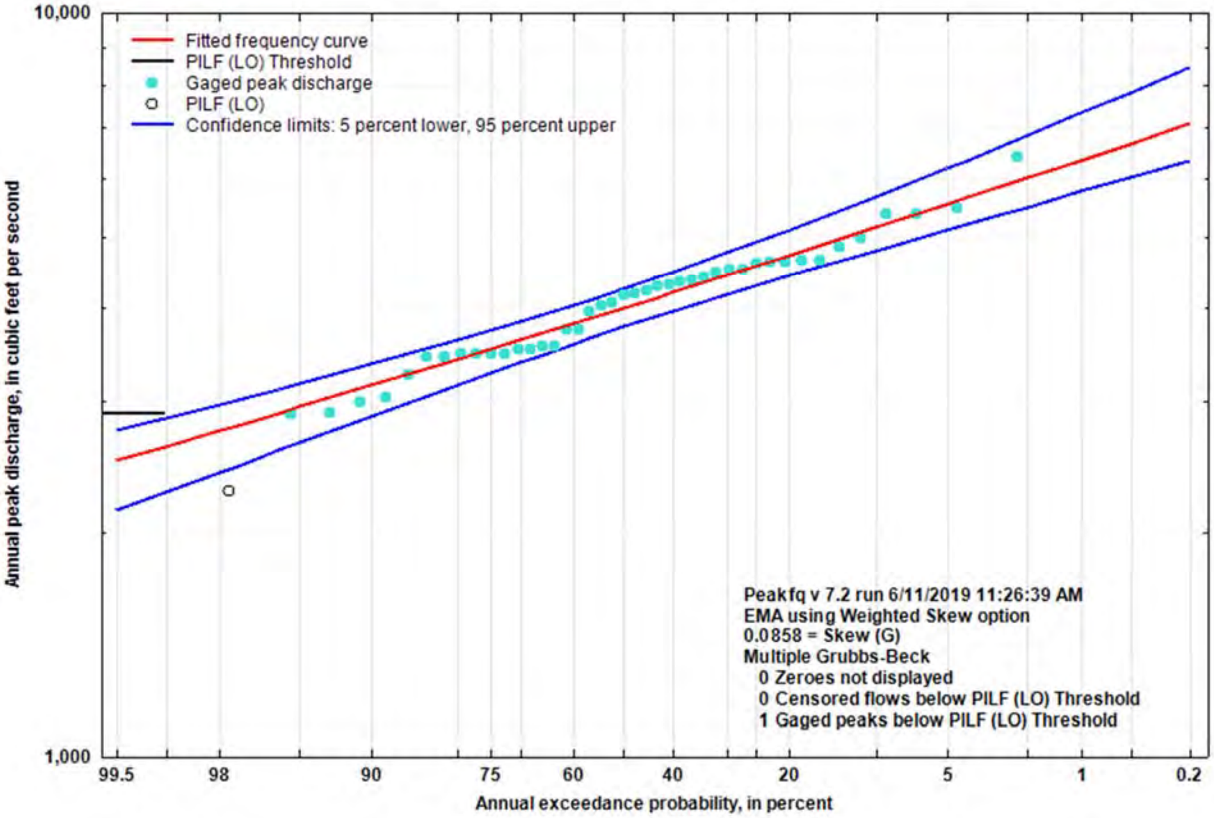
Kankakee River near Davis, IN (05515500)



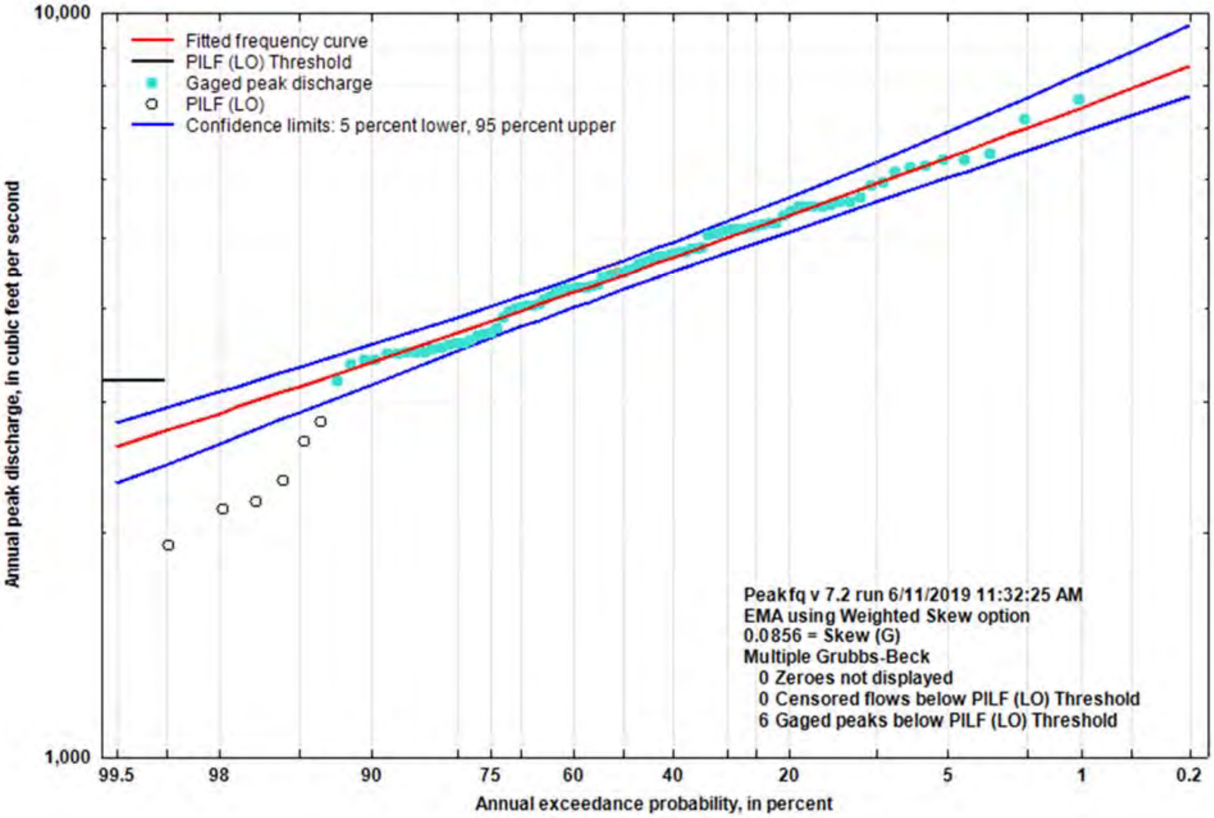
Kankakee River near Dunns Bridge, IN (05517500)



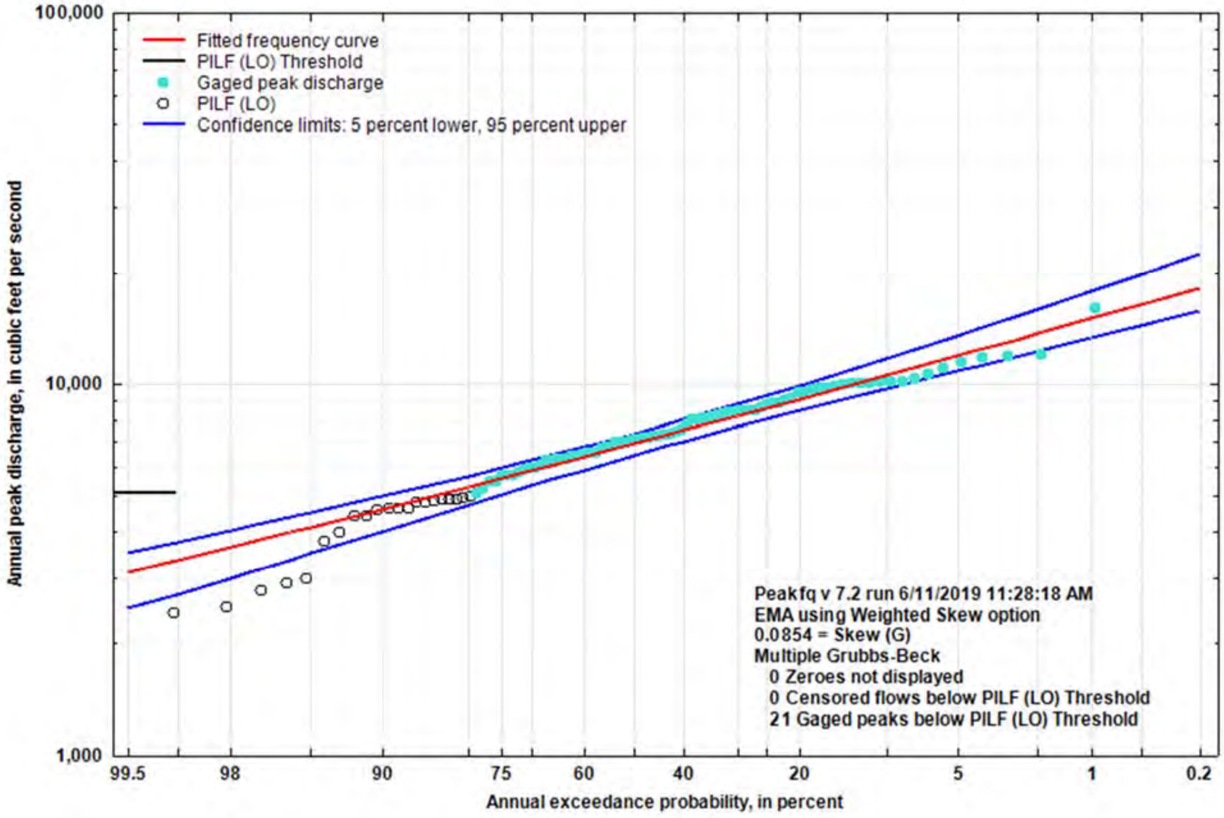
Kankakee River near Kouts, IN (05517530)



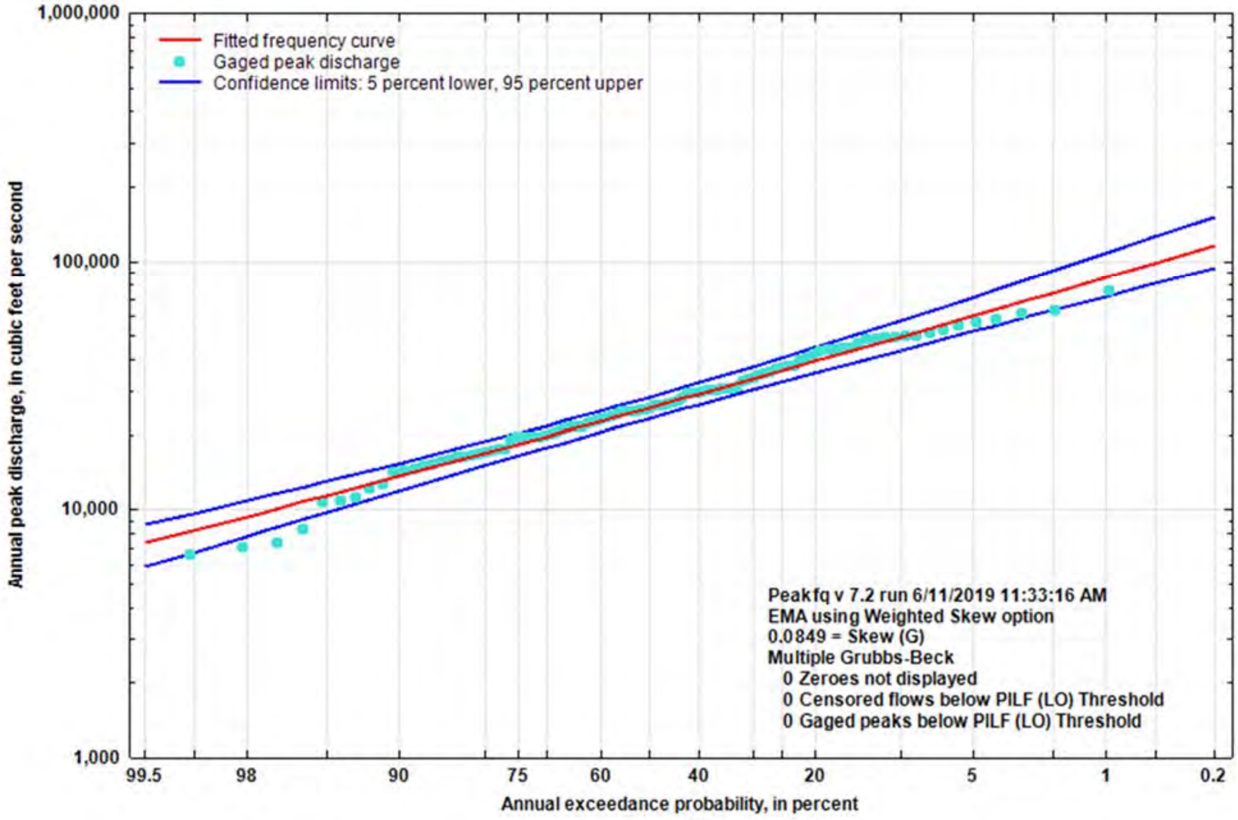
Kankakee River near Shelby, IN (05518000)



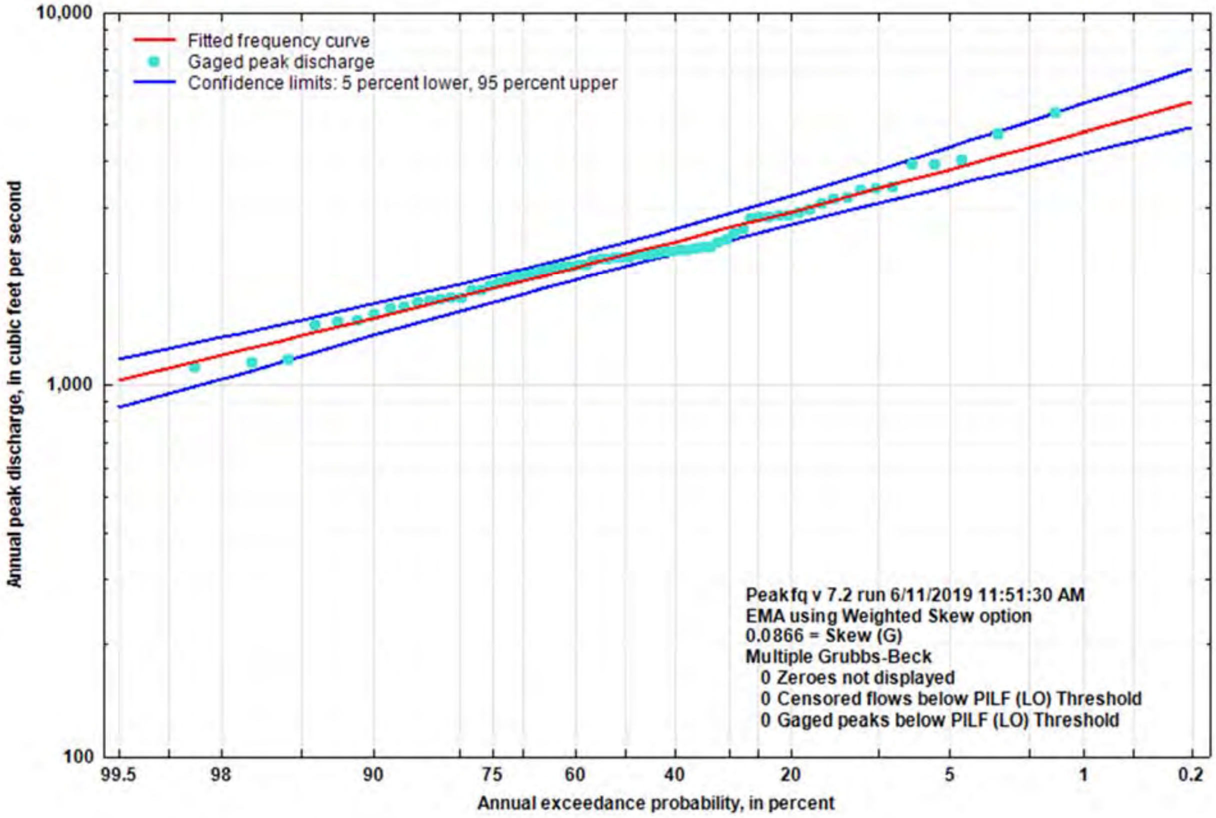
Kankakee River near Momence, IL (05510500)



Kankakee River near Wilmington, IL (05527500)

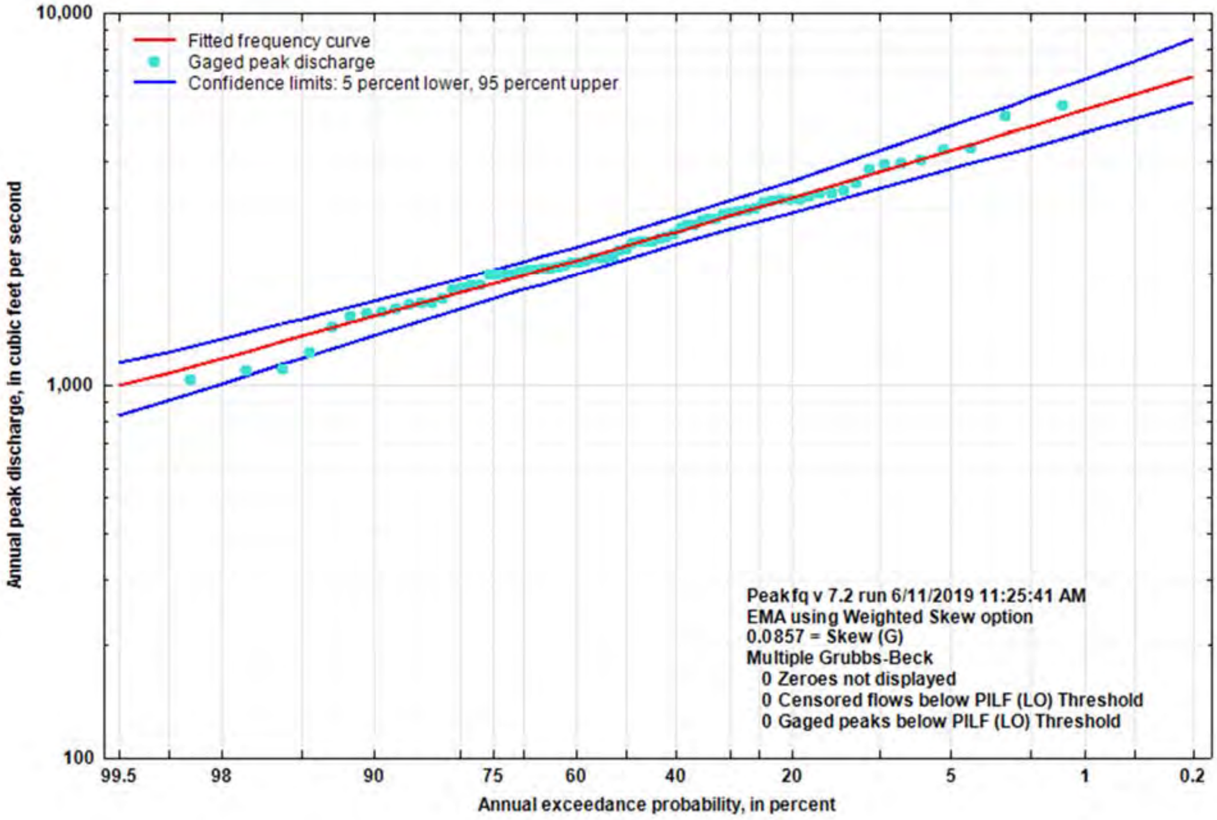


Yellow River near Plymouth, IN (05516500)



Peakfq v 7.2 run 6/11/2019 11:51:30 AM
EMA using Weighted Skew option
0.0866 = Skew (G)
Multiple Grubbs-Beck
0 Zeroes not displayed
0 Censored flows below PILF (LO) Threshold
0 Gaged peaks below PILF (LO) Threshold

Yellow River near Knox, IN (05517000)



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Multiple Grubbs-Beck
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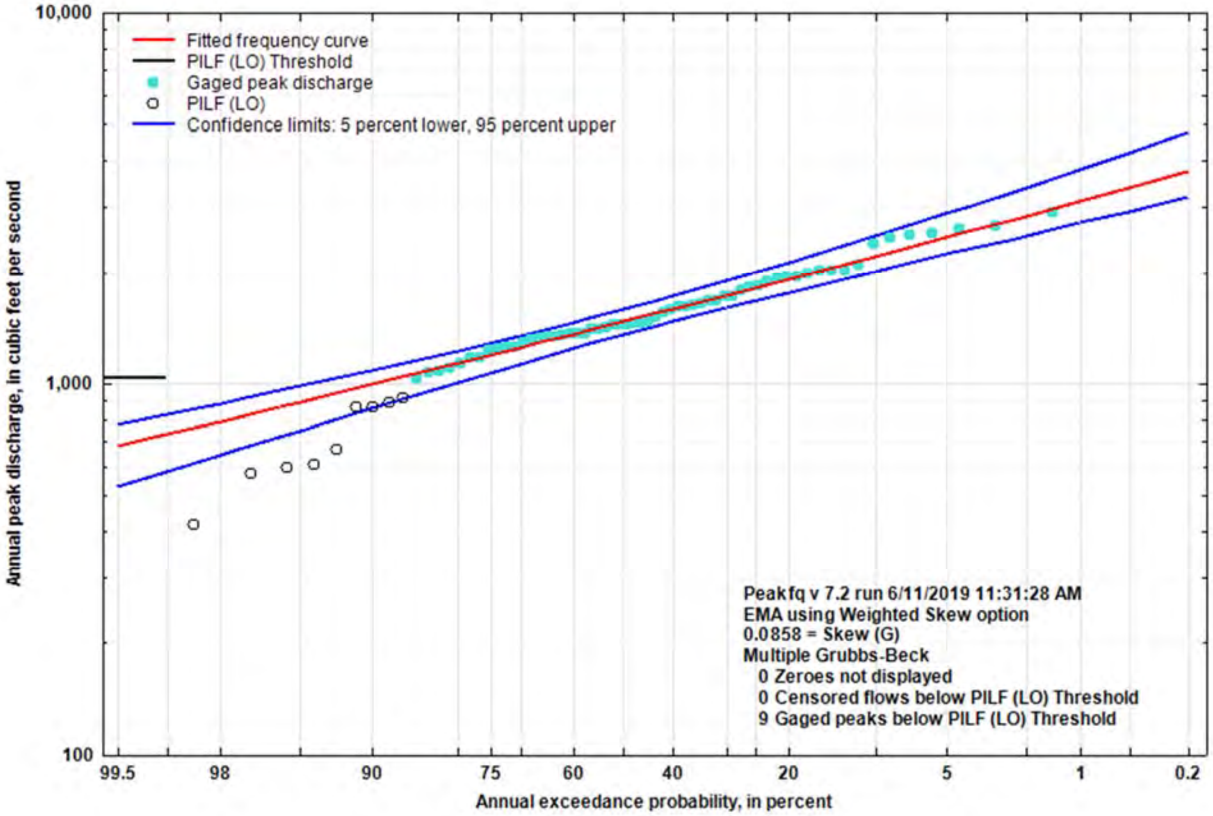
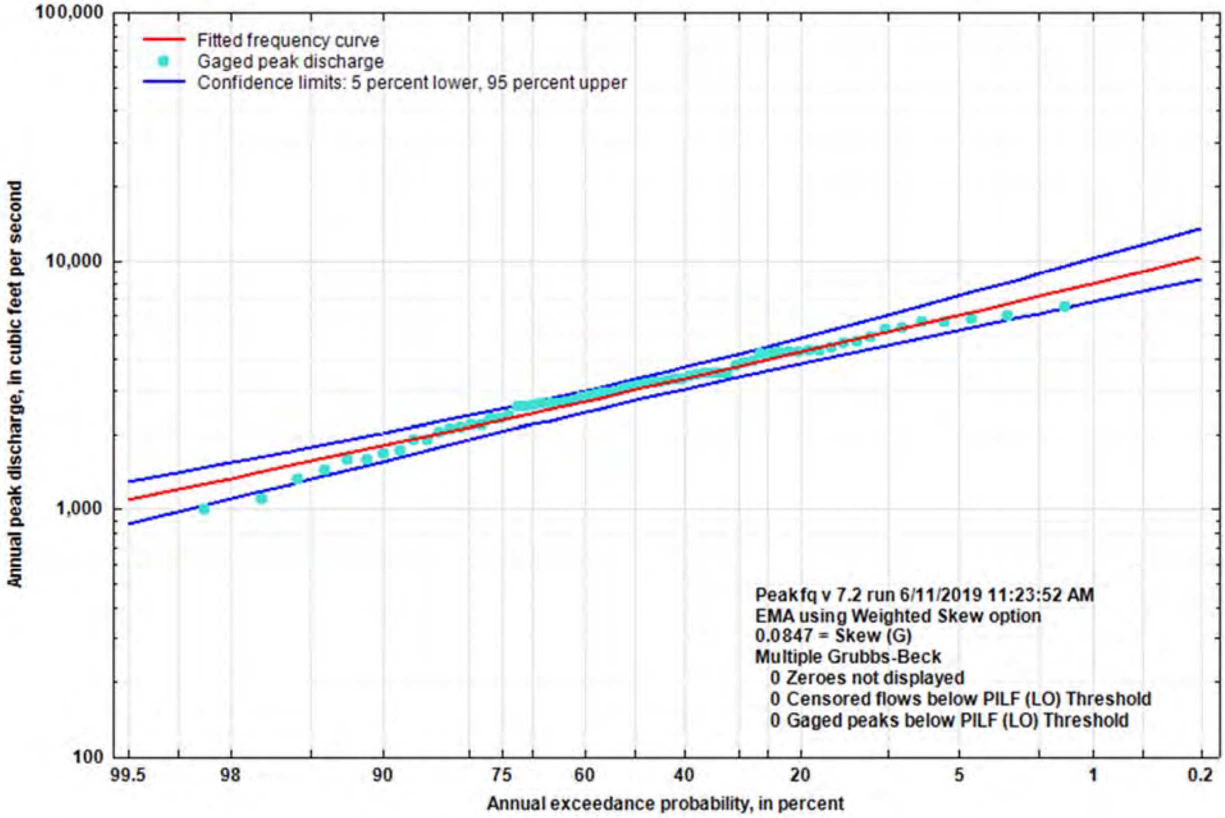
0 Gaged peaks below PILF (LO) Threshold

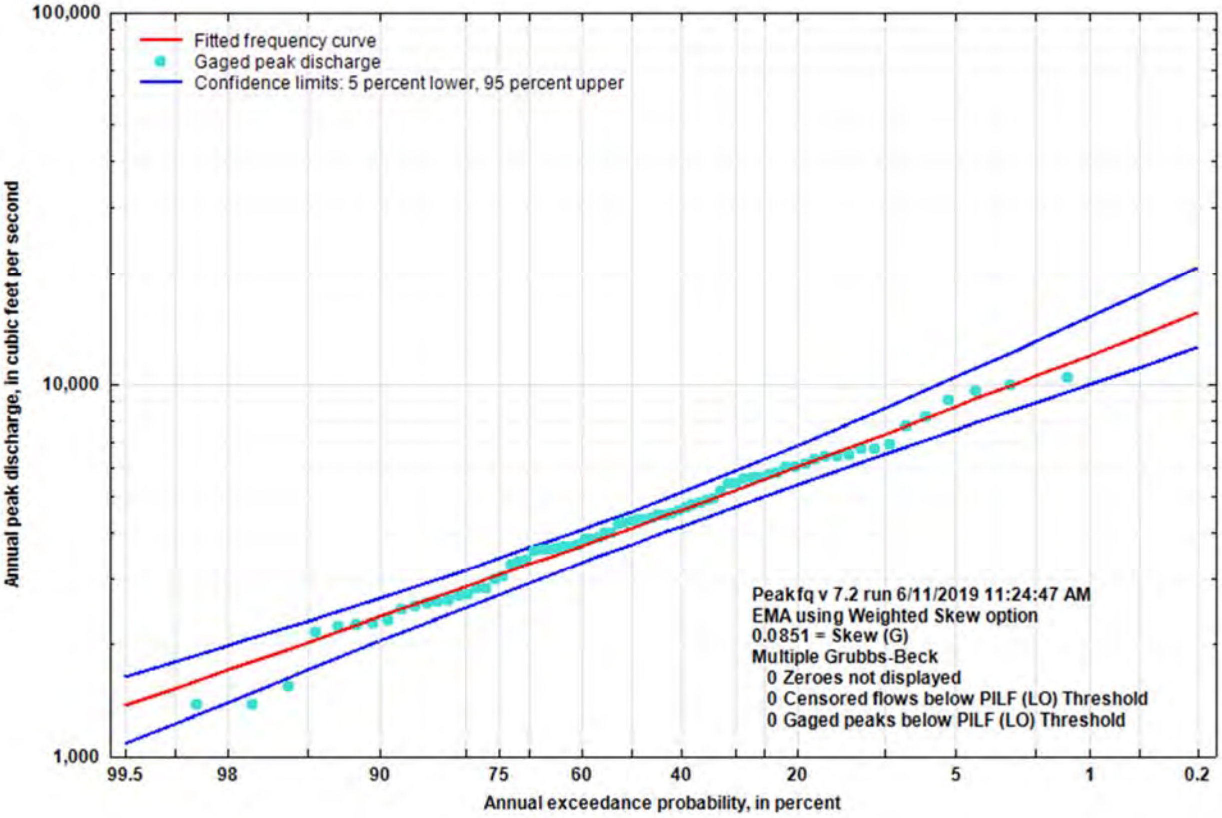
Iroquois River near Rensselaer, IN (05522500)



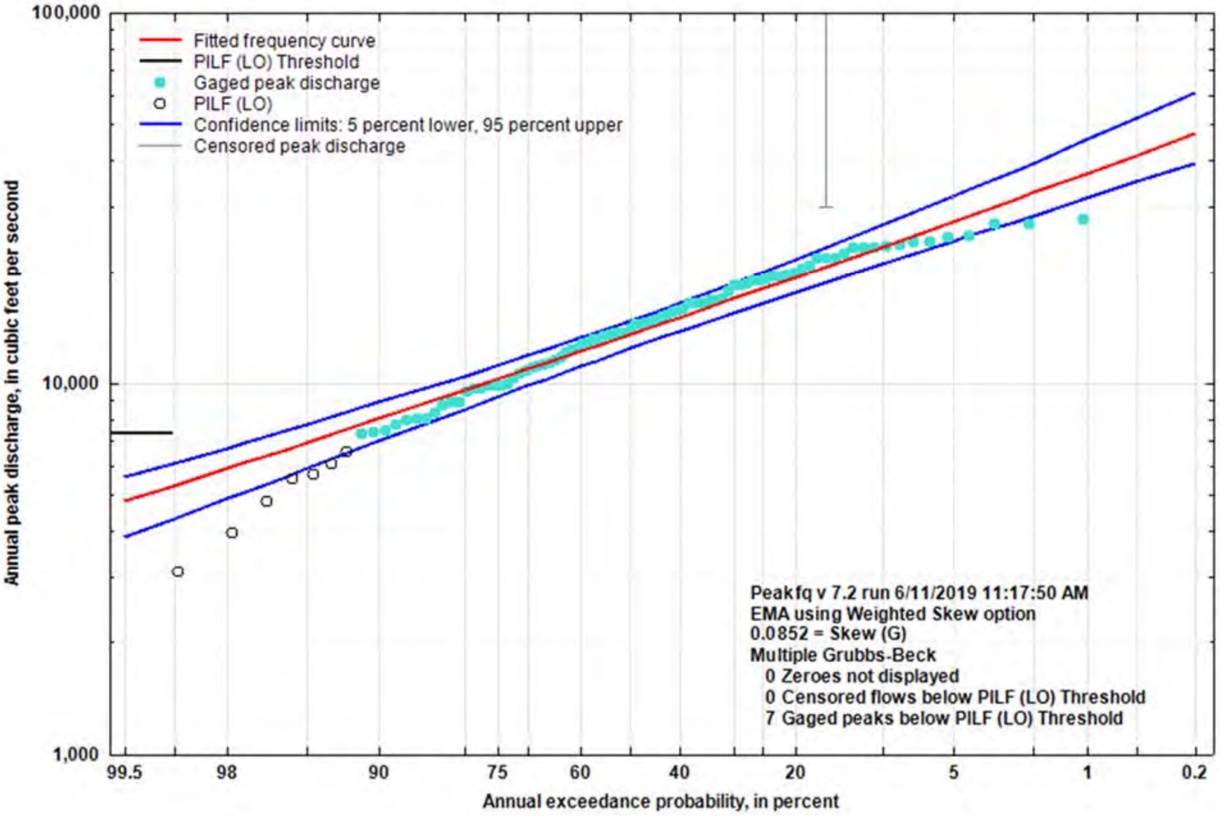
Iroquois River near Foresman, IN (05524500)



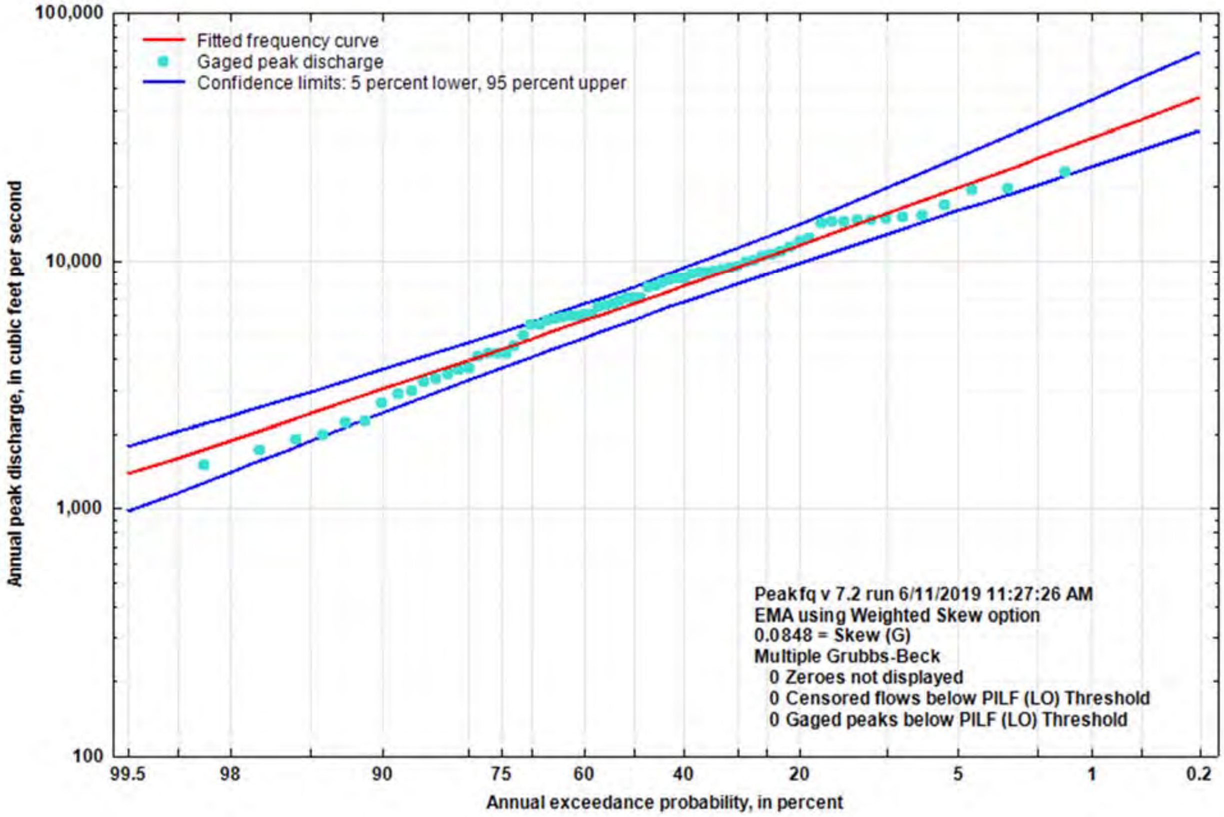
Iroquois River near Iroquois, IN (05525000)



Iroquois River near Chebanse, IN (05526000)

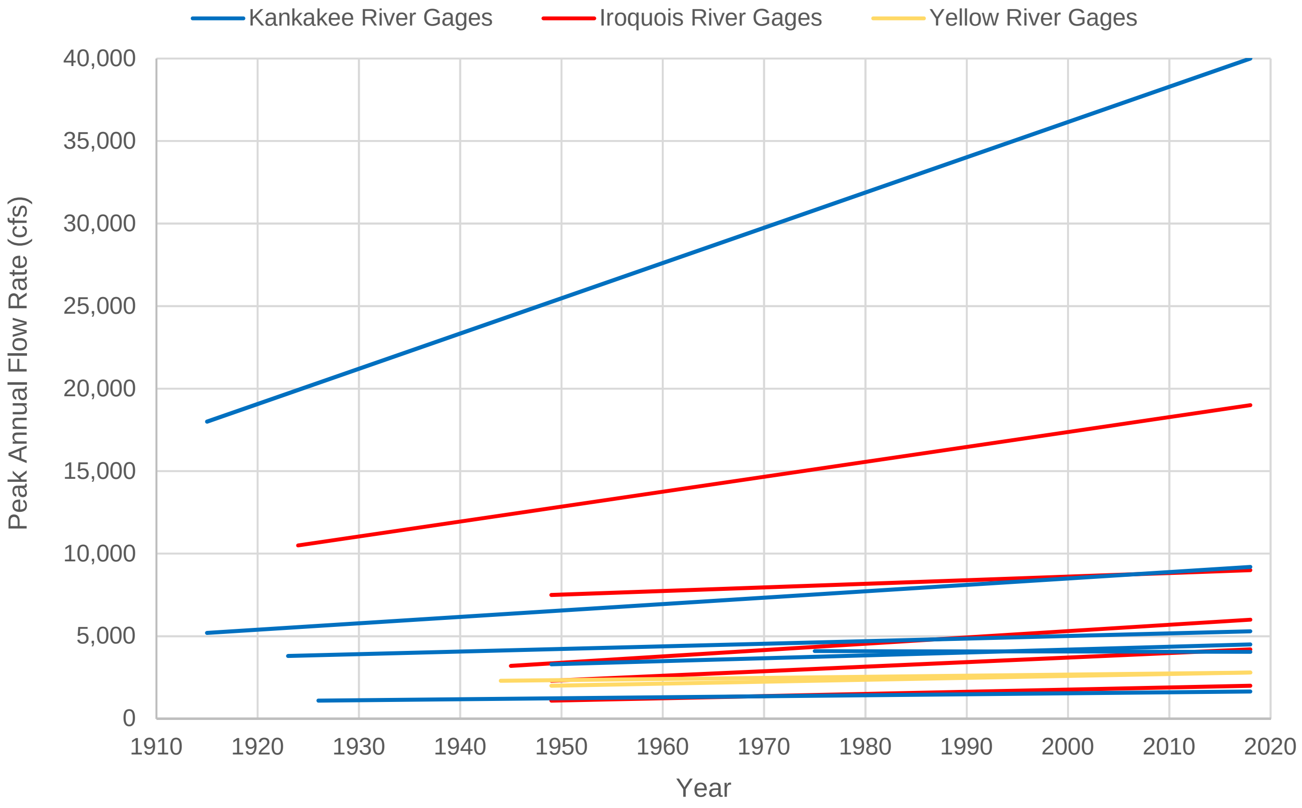


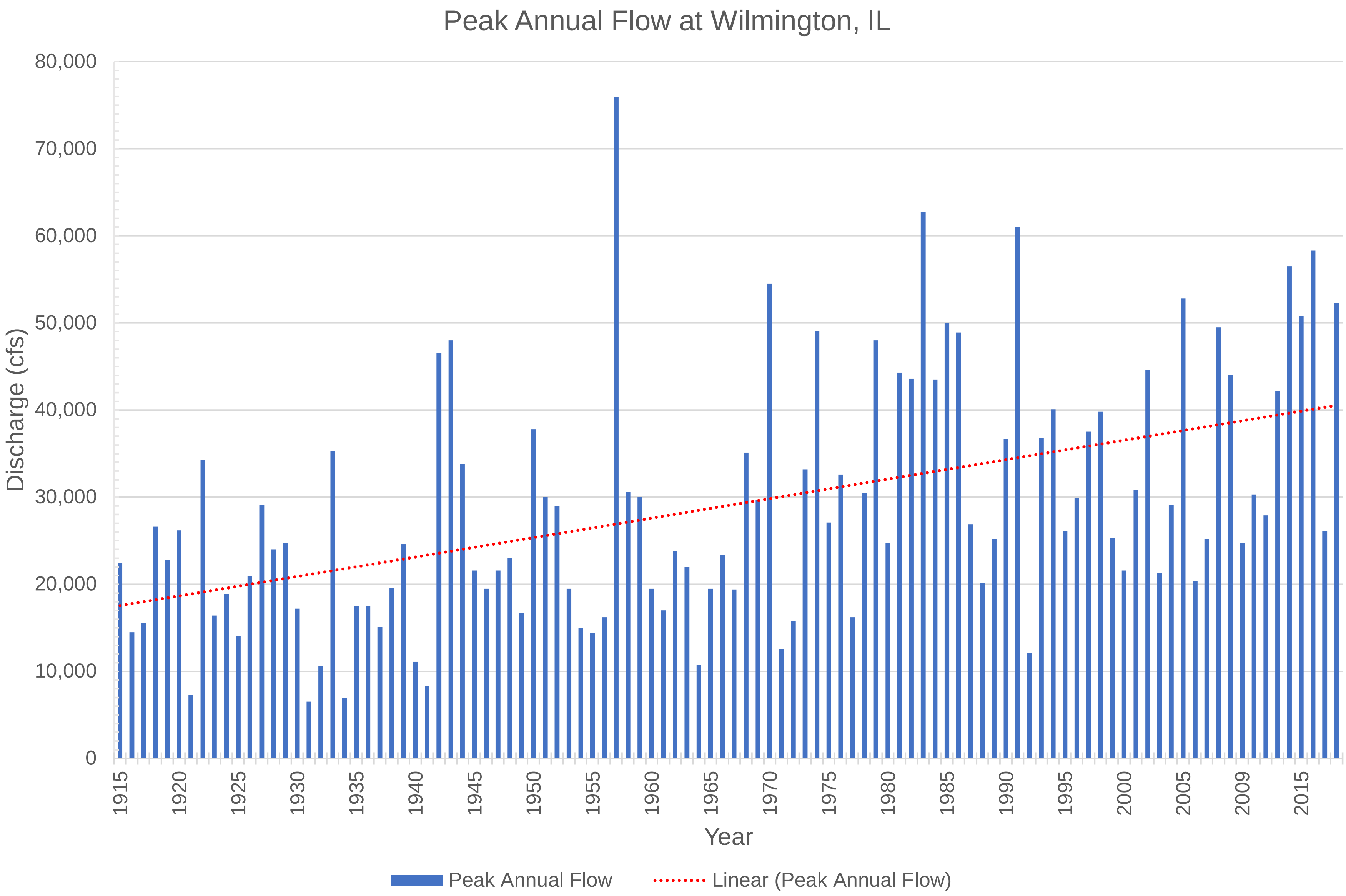
Sugar Creek near Milford, IL (05525500)

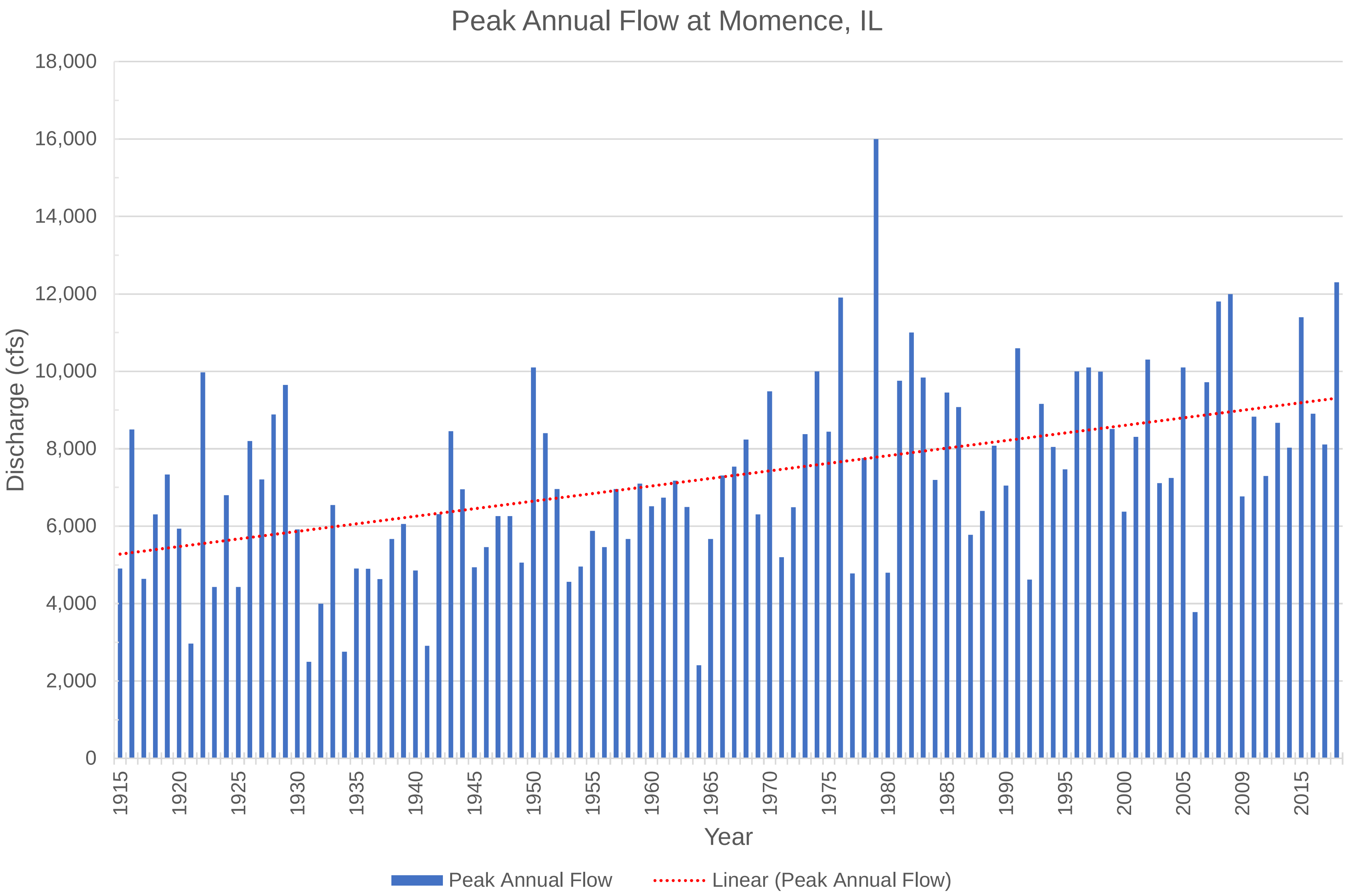


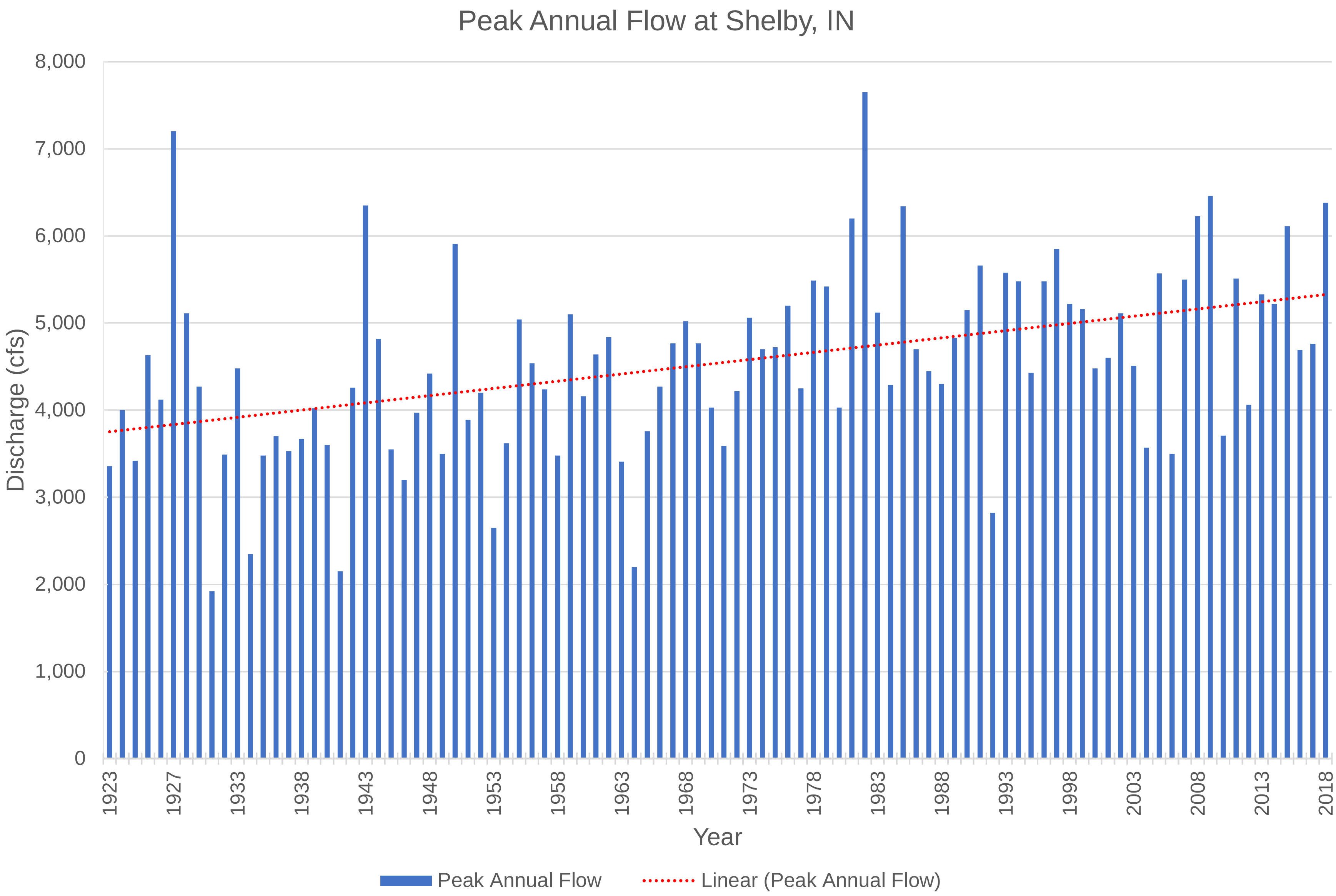
Flow Trend Analysis

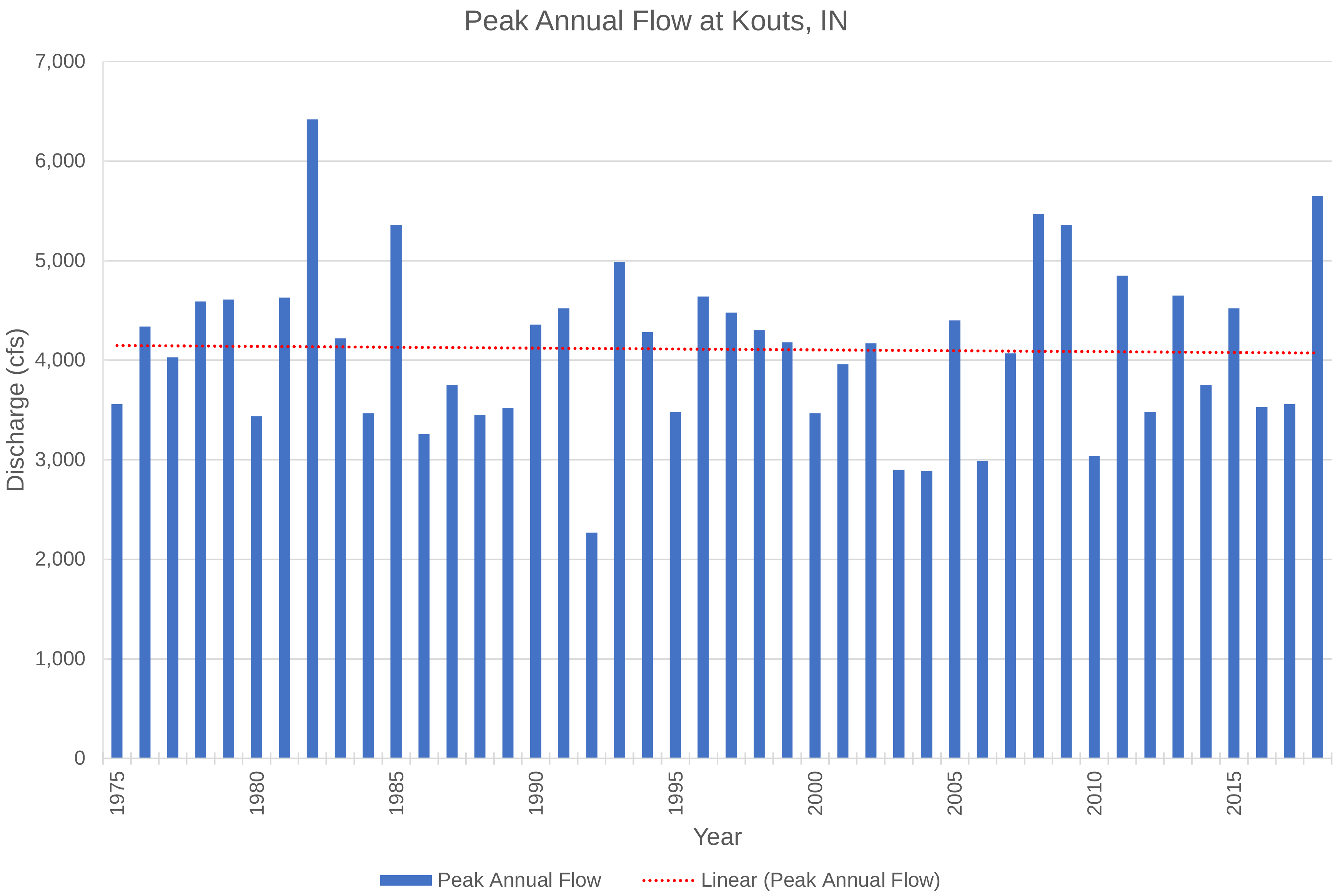
Stream	Gage	Year	Peak Annual Flow Rate (cfs)	% Increase over Gage Record
Kankakee River	Wilmington 05527500	1915	18,000	122%
		2018	40,000	
	Momence 05510500	1915	5,200	77%
		2018	9,200	
	Shelby 05518000	1923	3,800	39%
		2018	5,300	
	Kouts 05517530	1975	4,100	-1%
		2018	4,050	
	Dunns Bridge 05517500	1949	3,300	36%
		2018	4,500	
	Davis 05515500	1926	1,100	50%
		2018	1,650	
Yellow River	Knox 05517000	1944	2,300	22%
		2018	2,800	
	Plymouth 05516500	1949	2,000	40%
		2018	2,800	
Iroquois River	Chebanse 05526000	1924	10,500	81%
		2018	19,000	
	Iroquois 05525000	1945	3,200	88%
		2018	6,000	
	Foresman 05524500	1949	2,300	83%
		2018	4,200	
	Rensselaer 05522500	1949	1,100	82%
		2018	2,000	
Sugar Creek	Milford 05525500	1949	7,500	20%
		2018	9,000	

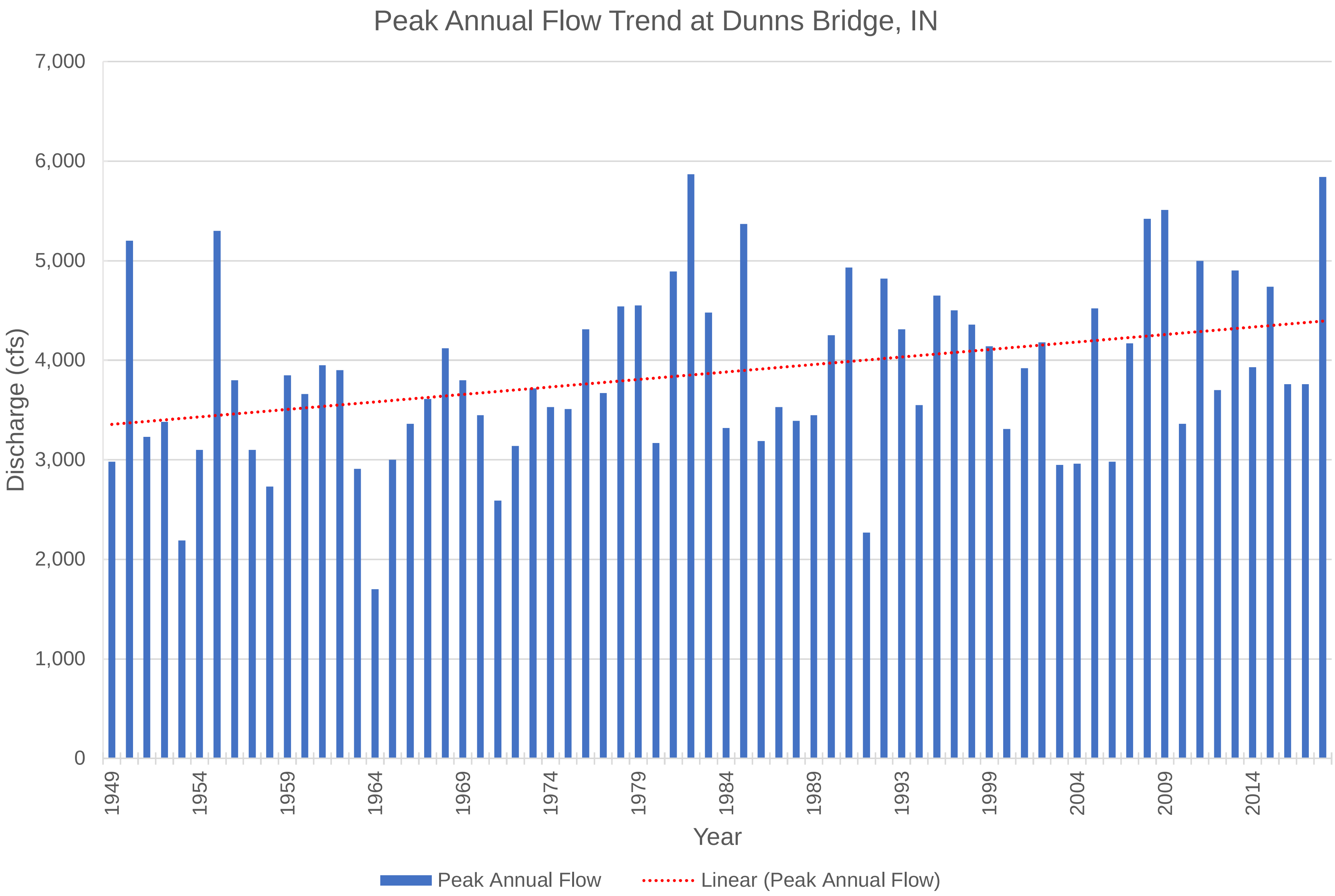


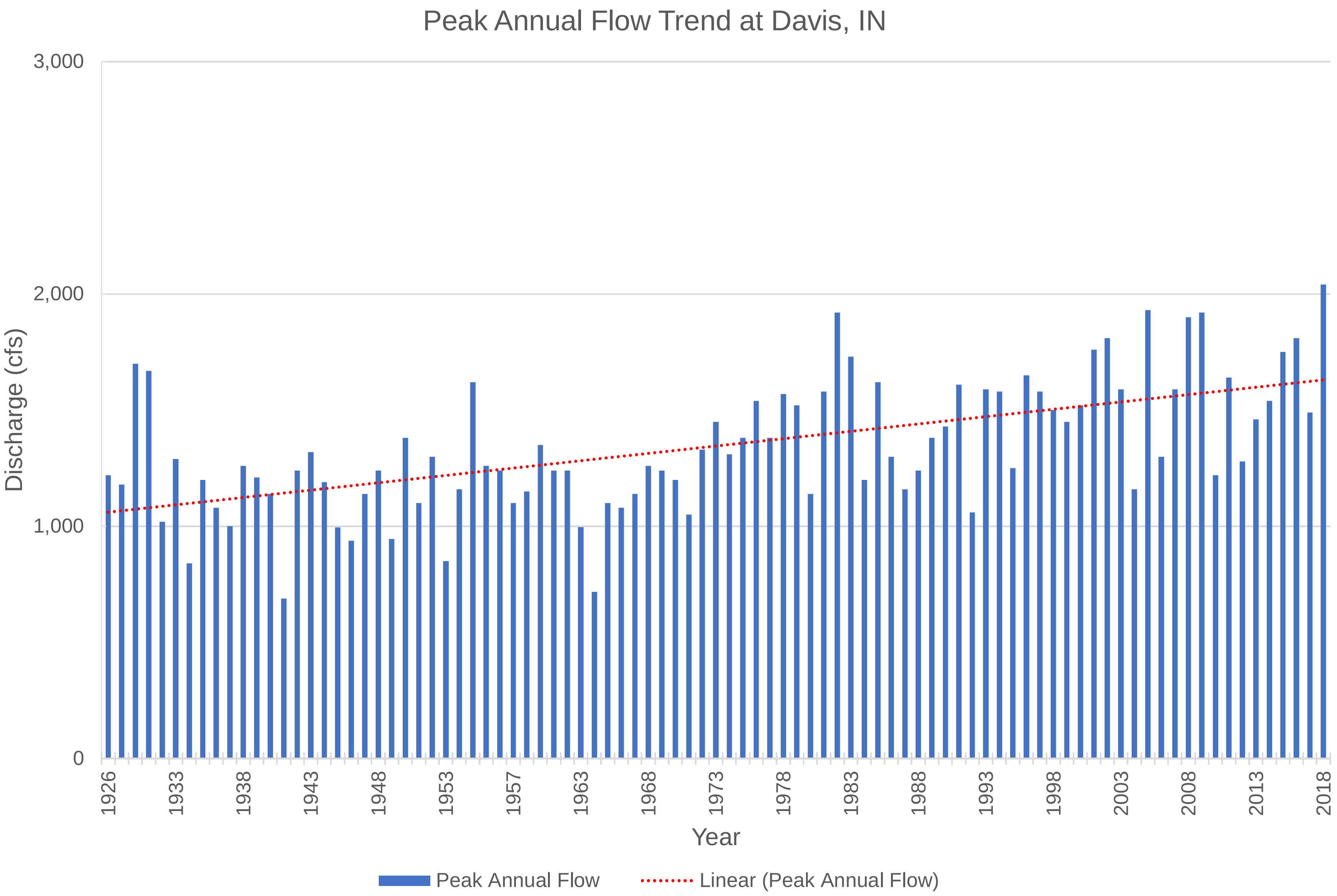

Peak Annual Flow at Wilmington, IL
Discharge (cfs)
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
1915
1920
1925
1930
1935
1940
1945
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2009
2015
Year
Peak Annual Flow
Linear (Peak Annual Flow)

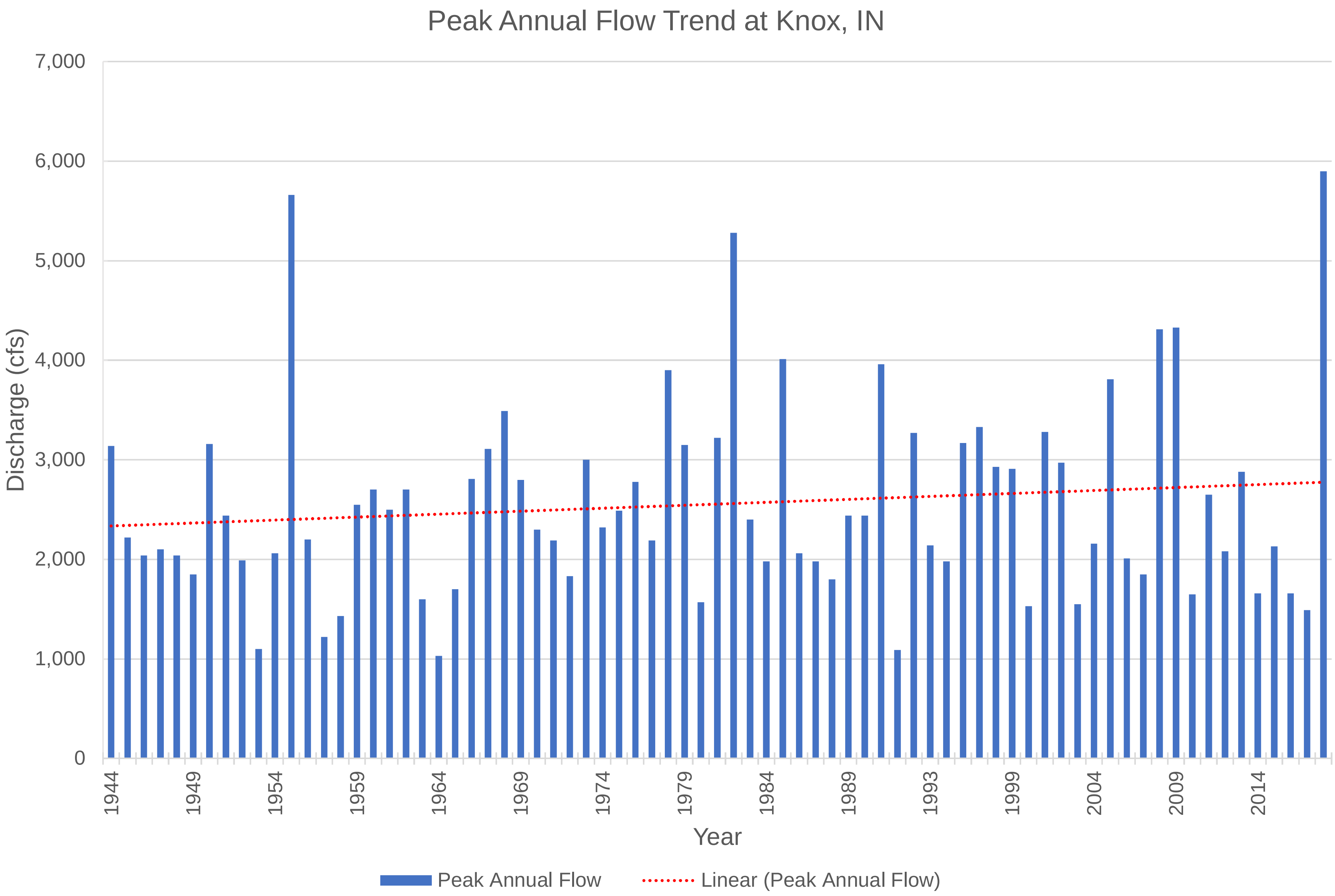

Peak Annual Flow at Momence, IL
Discharge (cfs)
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
1915
1920
1925
1930
1935
1940
1945
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2009
2015
Year
Peak Annual Flow
Linear (Peak Annual Flow)

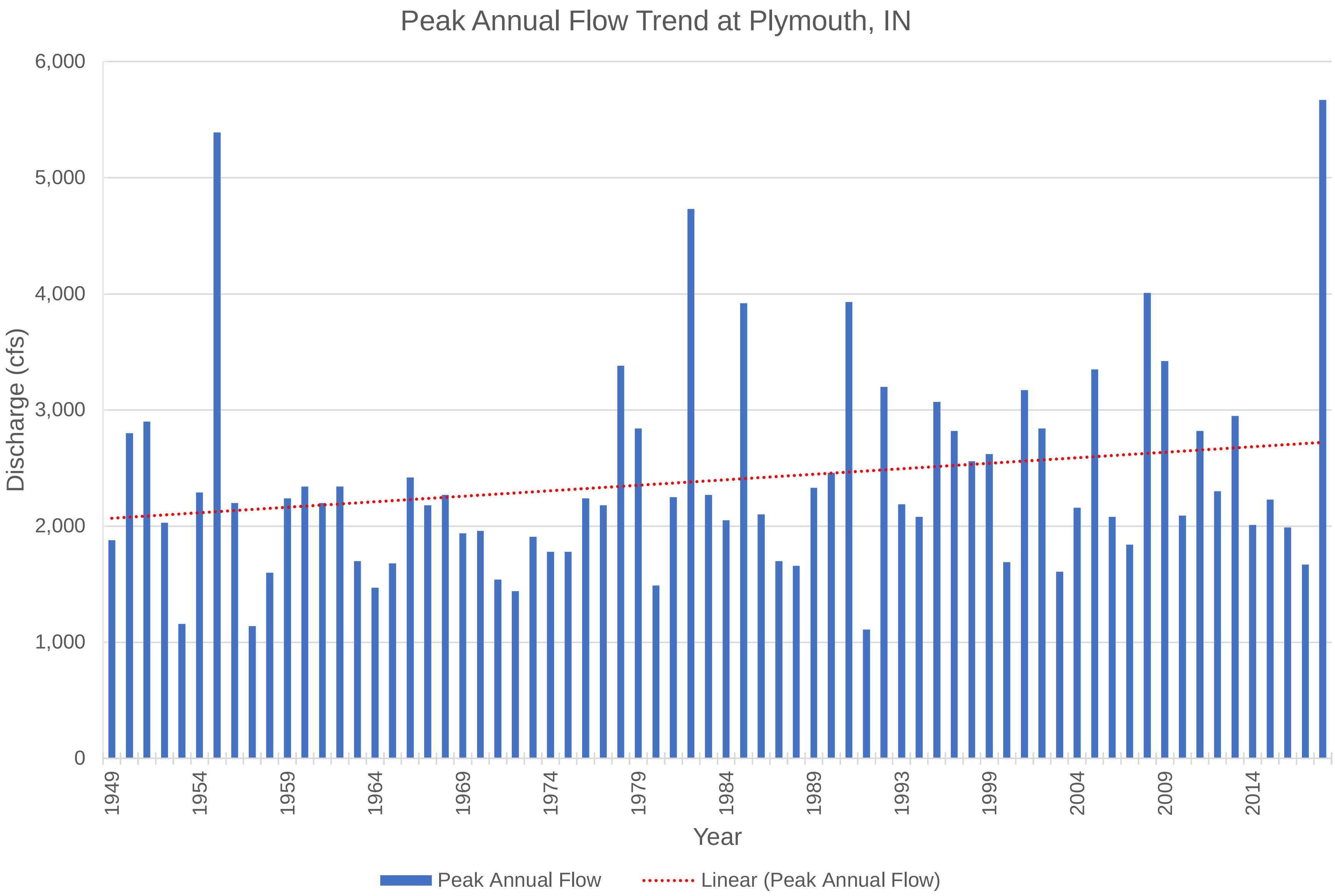

Peak Annual Flow at Shelby, IN
Discharge (cfs)
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
1923
1927
1933
1938
1943
1948
1953
1958
1963
1968
1973
1978
1983
1988
1993
1998
2003
2008
2013
2018
Year
Peak Annual Flow
Linear (Peak Annual Flow)

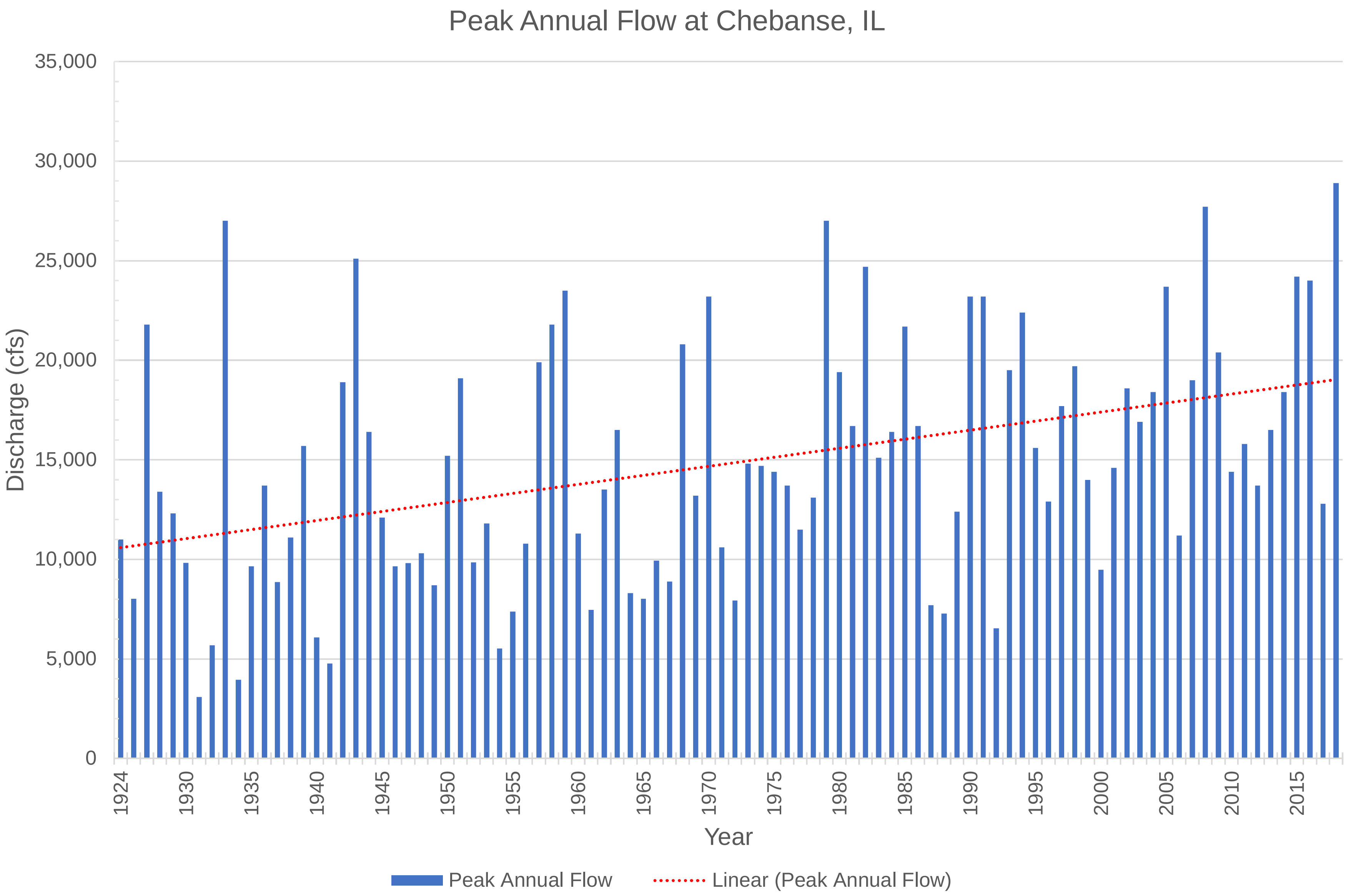

Peak Annual Flow at Kouts, IN
Discharge (cfs)
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
1975
1980
1985
1990
1995
2000
2005
2010
2015
Year
Peak Annual Flow
Linear (Peak Annual Flow)

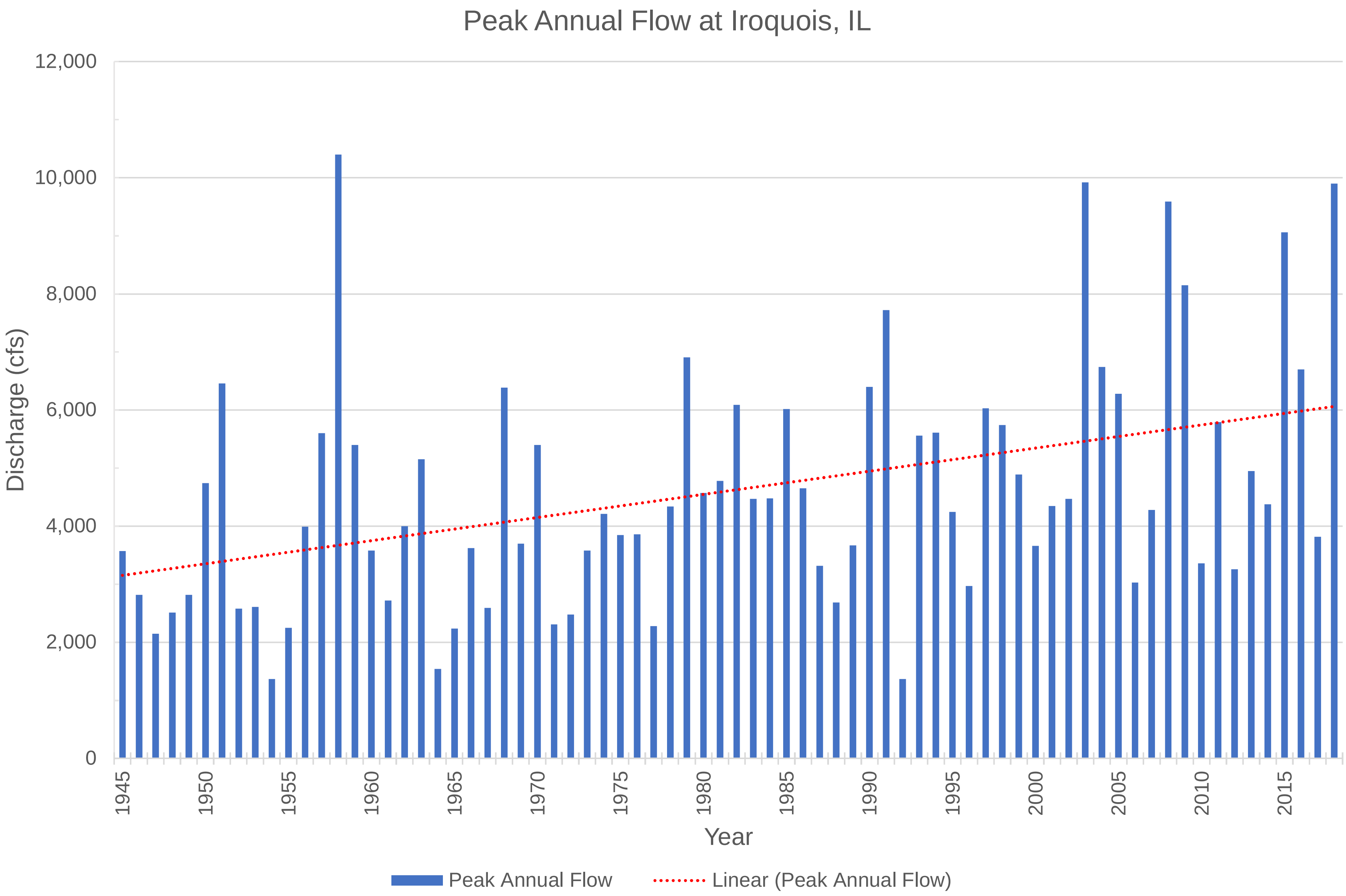

Peak Annual Flow Trend at Dunns Bridge, IN
Discharge (cfs)
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
1949
1954
1959
1964
1969
1974
1979
1984
1989
1993
1999
2004
2009
2014
Year
Peak Annual Flow
Linear (Peak Annual Flow)

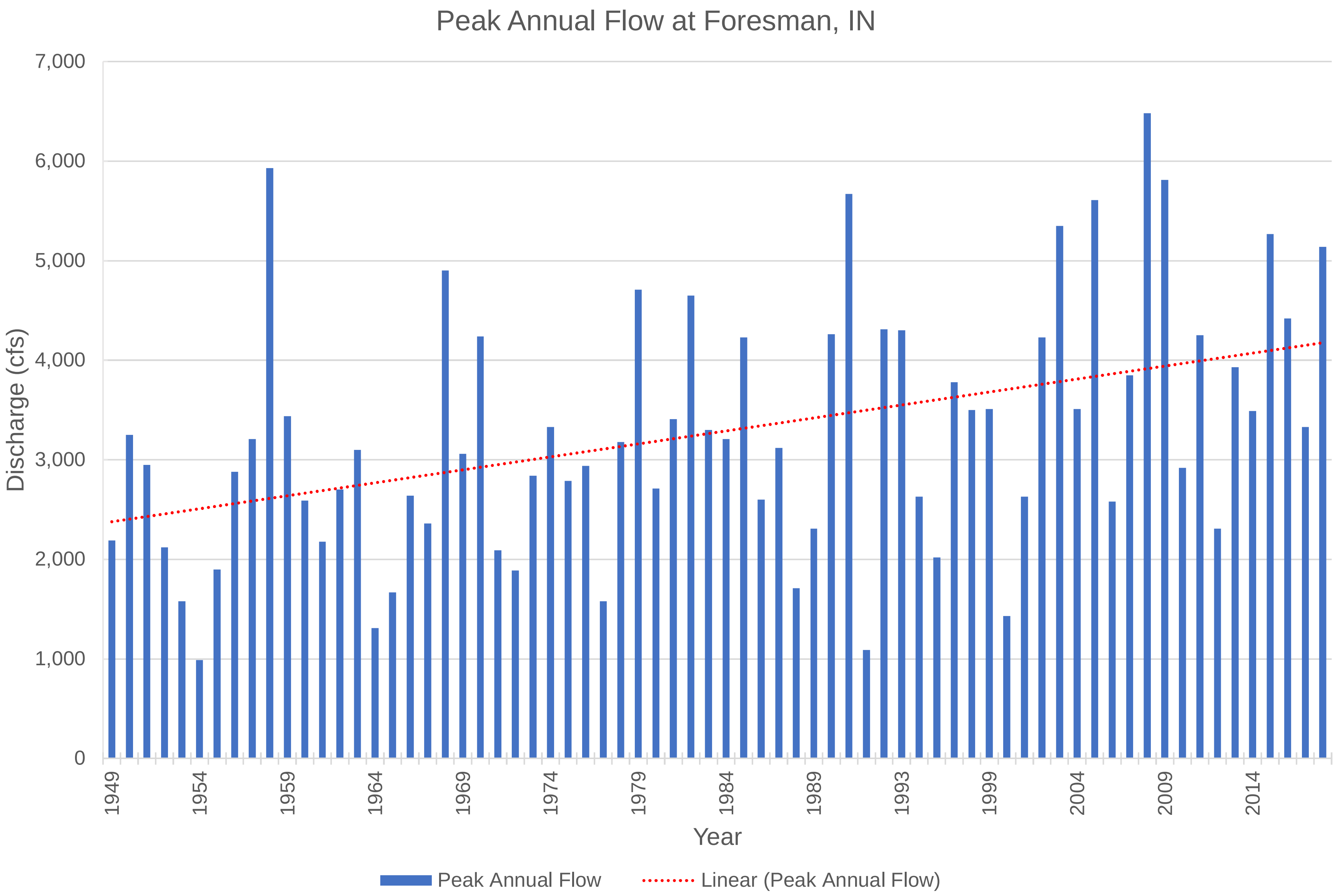

Peak Annual Flow Trend at Davis, IN
Discharge (cfs)
3,000
2,000
1,000
0
1926
1933
1938
1943
1948
1953
1957
1963
1968
1973
1978
1983
1988
1993
1998
2003
2008
2013
2018
Year
Peak Annual Flow
Linear (Peak Annual Flow)

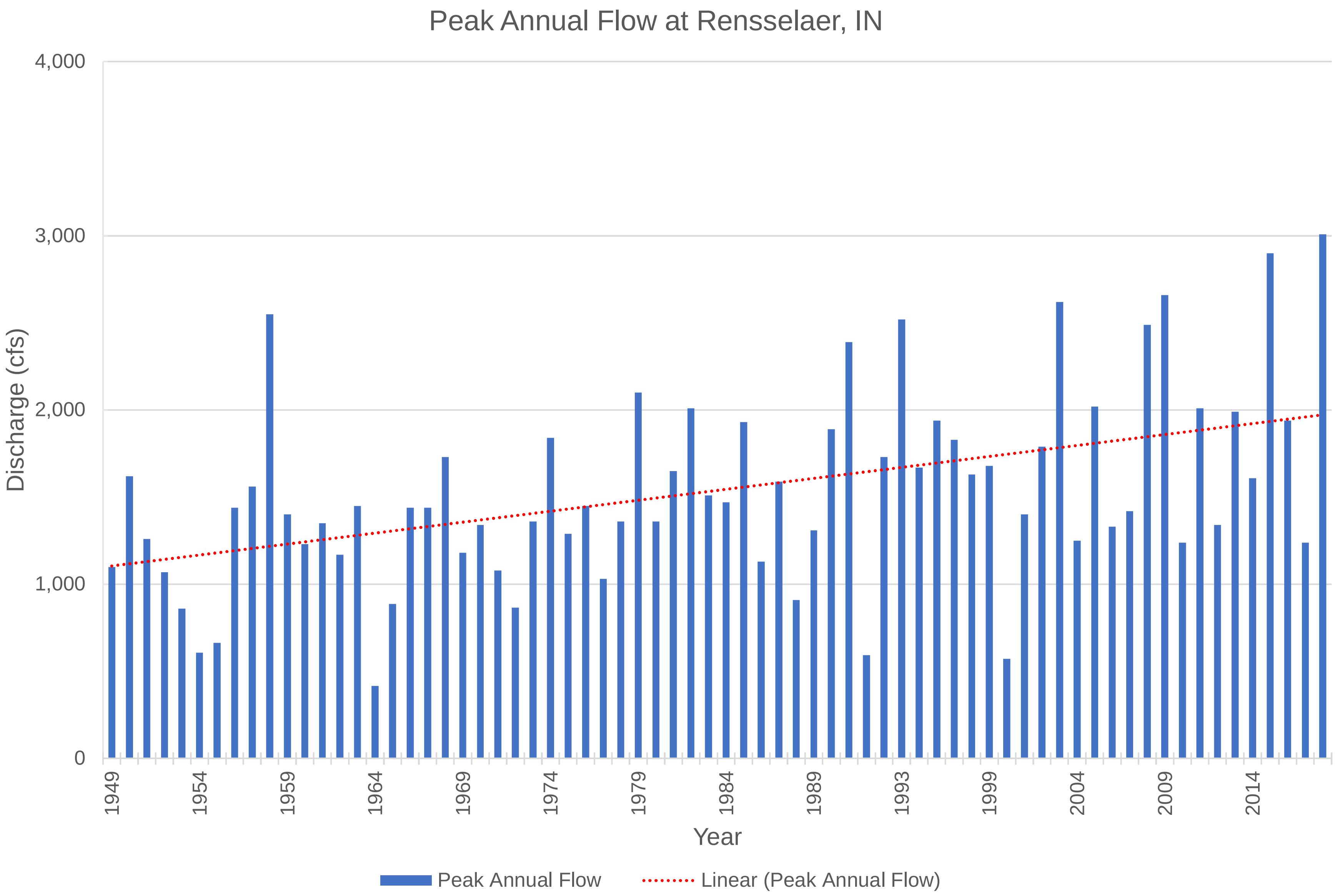

Peak Annual Flow Trend at Knox, IN
Discharge (cfs)
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
1944
1949
1954
1959
1964
1969
1974
1979
1984
1989
1993
1999
2004
2009
2014
Year
Peak Annual Flow
Linear (Peak Annual Flow)

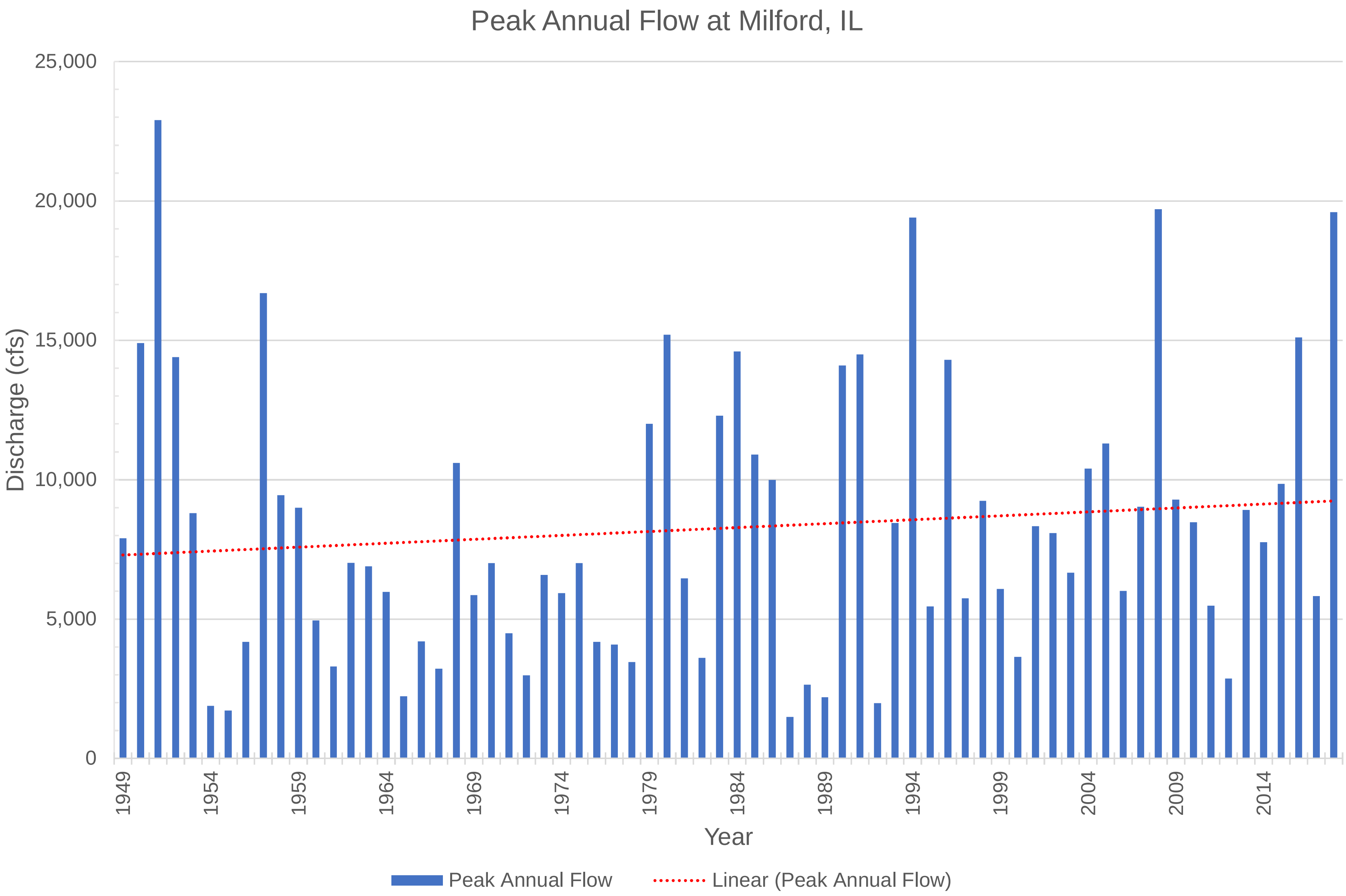

Peak Annual Flow Trend at Plymouth, IN
Discharge (cfs)
0
1,000
2,000
3,000
4,000
5,000
6,000
1949
1954
1959
1964
1969
1974
1979
1984
1989
1993
1999
2004
2009
2014
Year
Peak Annual Flow
Linear (Peak Annual Flow)


Peak Annual Flow at Chebanse, IL
Discharge (cfs)
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
1924
1930
1935
1940
1945
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
Year
Peak Annual Flow
Linear (Peak Annual Flow)


Peak Annual Flow at Iroquois, IL
Discharge (cfs)
12,000
10,000
8,000
6,000
4,000
2,000
0
1945
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
Year
Peak Annual Flow
Linear (Peak Annual Flow)


Peak Annual Flow at Foresman, IN
Discharge (cfs)
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
1949
1954
1959
1964
1969
1974
1979
1984
1989
1993
1999
2004
2009
2014
Year
Peak Annual Flow
Linear (Peak Annual Flow)


Peak Annual Flow at Rensselaer, IN
Discharge (cfs)
4,000
3,000
2,000
1,000
0
1949
1954
1959
1964
1969
1974
1979
1984
1989
1993
1999
2004
2009
2014
Year
Peak Annual Flow
Linear (Peak Annual Flow)



Peak Annual Flow at Milford, IL
Discharge (cfs)
25,000
20,000
15,000
10,000
5,000
0
1949
1954
1959
1964
1969
1974
1979
1984
1989
1994
1999
2004
2009
2014
Year
Peak Annual Flow
Linear (Peak Annual Flow)

Sediment Gage Data Analysis

Yearly Sediment Totals

Stream	Kankakee River			Yellow River				Iroquois River		
Gage	Davis	Shelby	Momence	Plymouth	Oak Grove	Knox	Brems	Foresman	Iroquois	Chebanse
1978										
1979			162,766						94,167	560,123
1980			119,912	15,107					89,984	363,861
1981			425,864	32,379						560,582
1993			223,056						57,149	429,419
1994			109,331						33,130	234,038
1995			157,080						31,476	198,564
2012										
2013					22,721	73,558	89,899			
2014	23,748				15,261	37,679	17,778			
2015	23,710	122,338			20,160	45,874	34,564	31,782		
2016	26,974	105,002			17,231	41,802	36,762	24,972		
2017	27,821	91,049			21,798	56,696	63,182	32,128		
2018	29,071	117,584			29,218	102,893	114,379	36,246		
Average	**26,265**	**108,993**	**199,668**	**23,743**	**21,065**	**59,750**	**59,427**	**31,282**	**61,181**	**391,098**
ERDC 2013	27,400		204,000				59,500			419,000

Appendix 3 – Hydrologic and Hydraulic Analysis

Hydrologic and Hydraulic Model Summary

FINAL

HYDROLOGIC AND HYDRAULIC ANALYSIS SUMMARY

FOR THE

KANKAKEE RIVER FLOOD & SEDIMENT MANAGEMENT WORK PLAN

June 2019

Prepared by:

Christopher B. Burke Engineering, LLC
115 West Washington Street, Suite 1368 South
Indianapolis, Indiana 46204

CBBEL Project No. 18-0290.00000

CHAPTER 1 INTRODUCTION

As described in Section 2.4 of the main Work Plan report, two modeling approaches – hydrologic and hydraulic – were used to analyze the Kankakee River system. These models differed in areal extent, intended use, data required, and software used. The hydrologic and hydraulic models were developed and calibrated to simulate the flooding event from February-March of 2018, as well as a number of hypothetical combinations of storm events and management strategies. Both models were developed using software created by the Hydrologic Engineering Center (HEC) of the U.S. Army Corps of Engineers (USACE). The hydrologic model was developed using HEC-HMS, while the hydraulic model was developed using HEC-RAS. The following paragraphs provide an overview of the hydrologic and hydraulic analyses.

CHAPTER 2 HYDROLOGIC MODEL METHODOLOGY

Hydrologic calculations were completed utilizing Natural Resource Conservation Service (formerly, Soil Conservation Service, or SCS) methodologies and publicly available data from state and federal agencies. The following paragraphs describe each component of the hydrologic analysis.

2.1 PRECIPITATION

Gridded, hourly precipitation totals from February 12 – March 26, 2018, were used in this analysis. The values were downloaded as point files from the National Science Foundation's Earth Observing Laboratory. These hourly point precipitation totals were averaged over each subbasin to create the precipitation timeseries for the simulation.

Three different hypothetical rainfall events were also considered by the analysis; the 50% annual exceedence probability (AEP), 10% AEP, and 1% AEP (also known as the 2-year, 10-year, and 100-year recurrence interval events) were considered for the 10-day storm events. The 10-day event duration was utilized because the resulting flow rates from the calibrated model most closely matched the results of the B17C analysis discussed in Section 2.4.1 of the main Work Plan report. The rainfall depth for each of the storm events are listed in Table 1. The rainfall was applied evenly over the contributing drainage area, using the corresponding NOAA Atlas 14 10-percent exceedance rainfall hyetograph to distribute the rain temporally.

Table 1: Rainfall Depths by Storm Event

	Rainfall Depth (in)		
Storm Duration	**50% AEP**	**10% AEP**	**1% AEP**
10-day	4.84	6.60	9.51

2.2 WATERSHED AND SUBBASIN DELINEATION

The overall model domain was defined by the drainage area contributing to flow at the Kankakee River gage near Wilmington, IL (05527500). This watershed was divided into 10 subbasins to account for spatial variability in rainfall patterns as well as basin characteristics such as topography, land use, and soil properties. These subbasins are outlined in Exhibit A2.1 and summarized in Table A1. The framework for these subbasins consisted of USGS HUC-10 watershed boundaries. Seven of the subbasins represented Kankakee River watersheds, including one for Singleton Ditch in Lake County, IN and Kankakee County, IL. The remaining three subbasins represented Iroquois River watersheds. The HUC-10 watersheds were sometimes combined to facilitate the calibration of modeled flow volumes to existing gage data. For example, two HUC-10 watersheds were combined into a single subbasin so that modeled outflow from that region could be directly compared to the Kankakee gage near Shelby, IN (05518000).

2.3 INFILTRATION

The SCS Curve Number method was used to calculate initial losses and rainfall infiltration. The default initial abstraction value, 0.2S, was utilized for all subbasins. The NRCS TR-55 publication was used to develop a single, composite curve number for each subbasin using hydrologic soil parameters from the Soil Survey Geographic (SSURGO) dataset and land cover data from the 2011 National Land Cover Dataset (NLCD). The NLCD polygons were compared to more recent aerial imagery to verify that land use classes were still accurate. If large tracts of land were converted from one land use to another in a way that would impact the runoff potential for the area (e.g. development of an agricultural field or converting forest to farmland), the land use classification was modified to reflect the change. Exhibits A2.2 and A2.3 summarize the soil and land use data, respectively, used in the analysis.

2.4 SNOWMELT PARAMETERS

Due to the timing of the spring 2018 flooding event, it was necessary to account for the initial presence and subsequent melting of snow across the watershed during the calibration event. Parameters such as snow depth, snow temperature, and snow water equivalent were averaged for each subbasin based on data from the Snow Data Assimilation System (SNODAS), which is maintained by the National Snow and Ice Data Center (NSIDC). Other parameters such as the snow melt rates and thermal conduction were estimated based on recommended ranges listed in the HEC-HMS user manual as well as results from a previous study of watersheds in northern Indiana and southern Michigan. Temperature data were gathered from weather stations throughout the Kankakee River basin and composited into a single timeseries.

2.5 RUNOFF TRANSFORM

The Clark Unit Hydrograph was used to transform the excess rainfall into runoff. TR-55 methodologies were used to calculate the time of concentration (Tc) for each subbasin that did not have an outlet corresponding to a USGS streamflow gage. The maximum length used for the sheet flow component was 100 feet based upon current NRCS guidelines. The locations of transitions from shallow concentrated flow to open channel flow were established when flowpaths entered a stream or large drainage ditch. The 2-year, 24-hour rainfall depth for the computations was derived from the NOAA Atlas 14 publication. For the subbasins that had an outlet corresponding with the location of a USGS gage, the Tc values were estimated based on drainage area, then adjusted during calibration. Initial Clark R values were calculated using the relationship R/(Tc+R) = 0.6, which is a commonly used value for northern Indiana watersheds. The outflow from each subbasin was routed downstream using reaches with assumed velocities of 3 ft/s. Initial values for these hydrologic parameters were adjusted to better align with observed data as described in Section 1.6. The delineations of reaches and Tc flow paths are shown in Exhibit A2.4.

2.6 HYDROLOGIC ROUTING

No hydrologic routing of runoff hydrographs was used in the analysis due to the use of an unsteady-state, 2-dimensional hydraulic model. Runoff hydrographs were applied to the hydraulic model at the end-point of the time of concentration flowpaths. The flow was routed hydraulically from the point where the water entered the Kankakee River near the mouth of the tributaries.

2.7 MODEL CALIBRATION

The HEC-HMS model was created by applying the rainfall timeseries and estimates of runoff potential described above to each subbasin. The model predictions of runoff volume and the timing and magnitude of the peak streamflow were compared to observed data from the USGS gages identified in Table 1. Adjustments were made to the CN, T_c, and R values of each subbasin to increase the accuracy with which the model predicted the response of streamflow to precipitation inputs. The hydrologic characteristics of each subbasin are summarized in Table 2.

Table 2: Hydrologic Parameters for Model Subbasins

Subbasin	Area (mi^2)	CN	T_c (hr)	Storage Coefficient (hr)
KR1	174	72.2	5.23	574
KR2	378	66.7	4.44	713
KR3	850	83.6	18.8	699
KR4	377	80.7	10.9	735
KR5	261	86.3	5.5	971
KR6	85	84.6	4.62	149
KR7	650	90.2	13.8	335
SD	255	87.5	4.6	200
IR1	686	72.3	5.93	173
IR2	447	72.3	3.9	380
IR3	1004	84.6	8.7	72

During hydrologic model calibration, the total runoff volume was the primary calibration target. Curve numbers for each of the subbasins were adjusted to match the observed flow volumes as well as possible. Because the hydrologic model does not explicitly account for flowpaths and storage during storm events, the T_c and storage coefficient parameters were adjusted to approximate the timing and value of the peak discharge at each observed flow location. In general, the runoff volumes were very close to observed values, while the modeled peaks were generally higher and later than those measured during the 2018 storm. Observed and modeled quantities are shown in Table 3.

Table 3: Observed and Modeled Flow Statistics

USGS Gage	Observed Peak (cfs)	Modeled Peak (cfs)	Peak Flow Error (%)	Volume Error (%)
Davis	2,040	2,220	8.7	-12.4
Kouts	5,650	6,690	18.3	-4.4
Shelby	6,380	8,360	31.0	-3.6
Momence	12,300	12,660	2.9	-3.9
Chebanse	28,900	33,810	17.0	0.2
Wilmington	52,300	50,380	-3.7	-1.8

CHAPTER 3 HYDRAULIC MODEL METHODOLOGY

The hydraulic analysis of the Kankakee River, Singleton Ditch, and adjacent overbank areas was completed using an unsteady-state 2-dimensional (2D) model in HEC-RAS. The use of a full 2D model allows for a more detailed and accurate representation of complicated overbank flow paths that exist in the flat, heavily ditched and bermed Kankakee watershed. Diffusion wave equations were used to solve the routing of water in-channel and in the overbanks. The following paragraphs provide an overview of the hydraulic analysis.

3.1 MODEL DOMAIN

The hydraulic model analyzed the Kankakee River from the western border of St. Joseph County, IN, to the northwest corner of Kankakee County, IL. The areal extent of the hydraulic model was determined by applying a 4,000-foot buffer around the Kankakee River's 100-year floodplain. This resulted in a model domain of approximately 560 square miles, including portions of eight counties: St. Joseph, La Porte, Starke, Porter, Jasper, Lake, and Newton Counties in Indiana, and Kankakee County, Illinois. This domain was divided into three sub-models to better manage model simulation time and computer memory allocation. The sub-models were split near USGS gages at embankments that were not expected to overtop during the 1% AEP flood. The first sub-model analyzed the reach from the western border of St. Joseph County to Highway 49 near the USGS gage near Kouts, IN (05517530). The second sub-model analyzed the reach from Kouts to the railroad embankment at Island Park just upstream of the Momence, IL gage (05510500). The third and final sub-model covered the reach from Momence to the point where the river exits Kankakee County near Wilmington, IL.

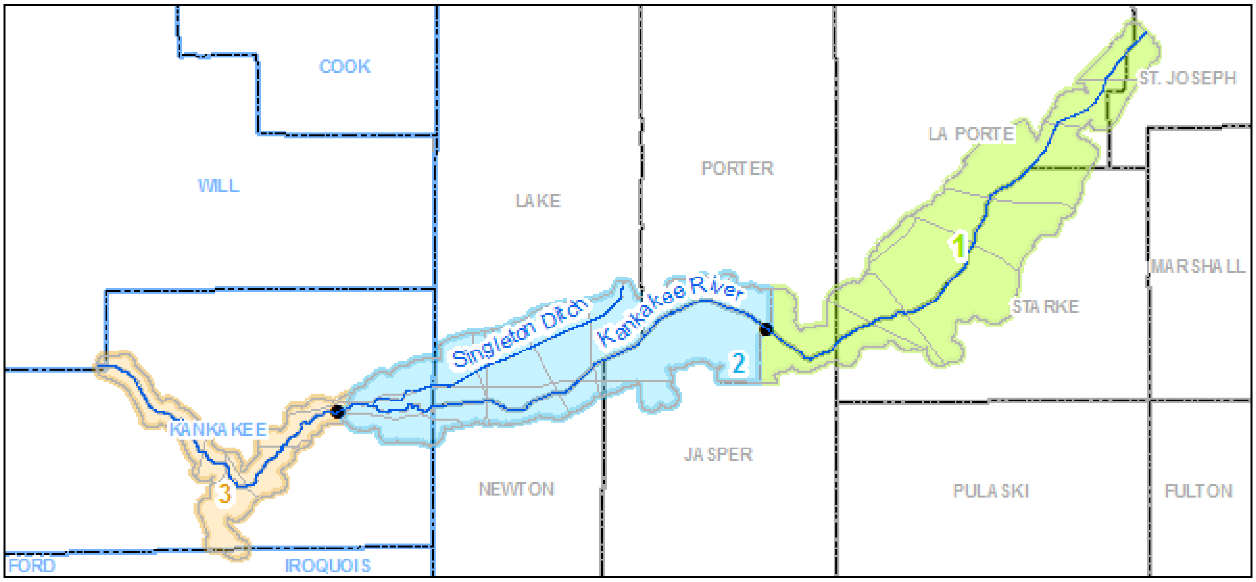


Figure 1: Model Domain

3.2 STORAGE AREA DISCRETIZATION

Each of the three sub-models was divided into several 2D flow areas: one for the Kankakee River and a variable number used to describe the overbank terrain. The flow areas describing the Kankakee River were discretized using a 20 ft square mesh. The cell size of 20 ft was selected to balance the need to provide sufficient characterization of the river geometry with the desire to keep the total number of cells within reasonable limits.

The overbank flow areas were delineated based on dividing features, such as major highways and railroad embankments, that were expected to act as dams or weirs during flooding events. A baseline cell size of 200 ft was used in the overbank flow areas. The cell size was decreased in certain locations, primarily along breaklines, to more accurately represent flow in the vicinity of berms, ditches, and roads.

The 2D flow areas were hydraulically connected to adjacent 2D areas by digitizing lateral flow structures to act as weirs along the dividing features. The weir coefficients for these structures were modified to reflect the nature of the surface feature as well as the orientation of the feature relative to flow.

3.3 BREAKLINES

Breaklines are used to adjust the orientation of cell faces so that they accurately represent barriers to flow. The use of a 200 ft mesh in the overbank areas without breaklines results in poor representation of some hydraulically relevant surface features, such as berms or roads. Breaklines allow the model to more realistically and accurately determine at what elevation the water would physically pass over the flow barrier; the absence of a breakline may allow the model to predict the presence of water on both sides of the dividing feature without the water surface elevation exceeding the crest of the dividing feature. This can lead to substantial errors in predicted river behavior and flooding extent, which is commonly referred to as "leakage". Leakage can be minimized by digitizing breaklines along the top of dividing features, which forces the cell faces to realign along the axis of the breaklines. The Polis Center at IUPUI has developed a detailed geospatial database of non-levee embankments which contains digitizations of a large number of berms, roads, and railroads along the Kankakee River in northwestern Indiana. This layer was supplemented by manually digitizing topographic features using terrain data.

3.4 TERRAIN DATA

County-wide Digital Elevation Models (DEMs) for each of the 8 counties within the domain served as the baseline for the hydraulic model simulations. Each of the DEMs had a 5-foot cell size, which was appropriate for capturing all relevant topographic features for a model of this scale.

Because the LiDAR data upon which the DEMs were based do not penetrate the water surface, it was necessary to manually "carve out" the river channel that exists below the water surface. The channel bathymetry was estimated based on channel bed profiles from previous FIS studies of the river. A trapezoidal geometry was assumed, using 2H:1V side slopes and a flat channel bed that matched the FIS profile at bridges and railroad crossings. This approach likely over-estimated the volume of the channel.

Modifications were made to the existing topographic data to create hypothetical terrains to simulate potential changes to the management of the Kankakee River. To simulate the effects of a comprehensive dredging scenario, the elevation of the bed of the Kankakee River was decreased by four feet for the ~43-mile reach from the mouth of Yellow River to the Indiana-Illinois State line. Channel side slopes from the current channel bed down to the dredged channel bed were maintained at 2H:1V.

Two alternative berm management scenarios were also represented by creating hypothetical terrain layers. The first of these alternatives involved the removal of all Kankakee River berms. This was simulated by replacing the ground surface elevations of the berms with the surface elevations of natural ground 50-100 feet behind the berms. All existing ditch berms and setback berms/levees were maintained. The second scenario preserved most of the riverine berms, but made strategic cuts in the berms to allow the river to access portions of the floodplain that are currently occupied by wetlands or sub-marginal farmland, as identified in Section 5.1.6. For each of the approximately 160 cuts, the ground surface elevation of the berm was replaced with the elevation of the natural ground directly behind it.

3.5 SURFACE ROUGHNESS

Surface roughness in the channel and overbank regions was determined based on the 2011 NLCD classifications. The NLCD raster has a 30-meter resolution. The data was adjusted to account for gridding errors or changes in land use. Gridding errors were typically a result of a misalignment between the Kankakee River and its representation on a fixed 30-meter grid. Changes based on land use were made using 2018 Indiana aerial photography, Google Earth, or the ESRI imagery basemap. The Manning's roughness values for each land cover type are shown in Table 4.

Table 4: Manning's n Value by Land Cover

NLCD Gridcode	Description	Manning's n Value
11	Open Water	0.035
21	Developed, Open Space	0.04
22	Developed, Low Intensity	0.08
23	Developed, Medium Intensity	0.12
24	Developed, High Intensity	0.20
31	Barren Land	0.03
41	Deciduous Forest	0.10
42	Evergreen Forest	0.10
43	Mixed Forest	0.10
52	Shrub / Scrub	0.12
71	Grasslands / Herbaceous	0.06
81	Pasture / Hay	0.05
82	Cultivated Crops	0.04
90	Woody Wetlands	0.08
95	Emergent Herbaceous Wetlands	0.06

3.6 STREAMFLOW INPUTS

The streamflow inputs for the hydraulic model were derived from the calibrated outputs of the hydrologic model. For each of the seven subbasins along the Kankakee River in the hydrologic model, the total predicted outflow for that basin was applied to the hydraulic model at discrete locations corresponding to major tributary inlets along the Kankakee. For example, if the hydrologic model predicted a subbasin outflow of 1,000 cubic feet per second (cfs) and that subbasin contained four major Kankakee River tributaries, then internal boundary conditions (BCs) placed in the Kankakee at the mouths of each of the tributaries would insert 250 cfs into the river each. In the case of the Yellow River, which accounts for ~50% of the drainage area of its subbasin, the tributaries were not all given equal weight; half of the total predicted subbasin outflow was inserted at the mouth of the Yellow River and the remaining half was distributed evenly among the lesser tributaries.

3.7 BOUNDARY CONDITIONS

In addition to the internal BCs that were used to insert flow along the run of the river, external upstream and downstream BCs were needed for each of the three hydraulic sub-models. Where possible, observed gage data were used as upstream BCs and USGS rating curves were used for downstream BCs. Table 5summarizes the BCs used for each sub-model.

A notable change was made to the Momence gage rating curve for use as the downstream boundary condition of the second sub-model. Because the hydrologic break (railroad embankment) was approximately 0.7 miles upstream of the Momence gage and five feet higher in elevation, the rating curve for the gage was adjusted to estimate the rating curve at the bridge embankment. According to FIS flood profiles, the water surface elevation was consistently 3.5 feet higher at the railroad than at the gage during storms ranging from 10% AEP to 0.2% AEP. Thus, a 3.5 ft offset was added to the USGS rating curve to create the downstream BC.

Table 5: Sub-Model External Boundary Conditions

Sub-Model	Upstream BC	Downstream BC
1	KR1 Outflow (HMS)	Gage 05517530 Rating Curve
2	Gage 05517530 Flow	Gage 05510500 Rating Curve
3	Gage 05510500 Flow	0.001 Energy Slope

3.8 MODEL CALIBRATION

The hydraulic model was calibrated primarily to flow and stage at USGS gaging stations during the 2018 event. Comparisons between model results and observed data at the Davis, Kouts, Shelby, and Momence gages are reported in Section 2.4.2 of the main body of this report. Flow was underpredicted at all reference gages, and there was a negative trend in the accuracy of flow predictions from upstream to downstream. At the Davis gage, predicted flows were within 5% of observed values, while flow was underpredicted by almost 25% at Momence. This trend may have worsened in the downstream direction due to cumulative effects of flow boundary condition approximations and the “leakage” due to the discretization of the 2-D model mesh. The predictions of stage were generally more accurate at gages near the downstream boundaries of the sub-models (Kouts, Momence) than at other gages.

3.9 SIMULATION RESULTS

Several storm events and hypothetical management scenarios were combined to predict how the system would behave under a variety of conditions. The 2018 storm as well as 50%, 10%, and 1% AEP storms were modeled to analyze watershed impacts over a range of flood events. The potential management scenarios included the existing condition (EX), a dredging scenario (DR), a no riverine berms scenario (NB), and the proposed constructed breaches and setback berms scenario (CB) described in Section 5.1 and shown in Exhibit 3.

3.9.1 Existing Condition Scenario

The modeled flood extent for the existing condition showed a combination of containment within the channel and significant riverine flooding (Exhibit A3.1). Minimal flooding was seen in the reach from St. Joseph County to the northern border of Starke County, and the Kankakee was largely contained within the channel in Jasper County from Kouts through the "Big North Bend" area near De Motte. The setback berm in Lake County also appeared to be very effective. Regions of notable flooding existed south of Davis, IN, on the Porter County side of the "Big North Bed", and in western Jasper County near Hodge Ditch. Significant flooding was seen in the Momence Wetland as well as along portions of Singleton Ditch in Indiana and Illinois. It should be noted that the modeled flood extents likely constituted underpredictions near major tributaries of the Kankakee because, with the exception of Singleton Ditch, flow from those tributaries was not explicitly modeled.

3.9.2 Dredging Scenario

The DR scenario included dredging the Kankakee entire width of the riverbed by four feet from the confluence of the Yellow River to the IN-IL state line. The DR simulations demonstrated consistent trends in water surface elevations (WSEs) and inundated areas. Dredging the channel reduced the WSE in the Indiana portion of the model in all modeled storm events. The 50% AEP event was almost entirely contained upstream of Shelby, IN. The increase in the amount of water inside the channel in Indiana led to increased flooding near Momence, IL, including increased backwater flooding along Singleton Ditch. A comparison between the existing condition and dredged scenario for the 2018 event is shown in Exhibit A3.2. Although the WSE was consistently reduced, the in-channel flow depth was increased as a result of the reduction in floodplain activation. The increases in flow depth and velocity in the channel would likely lead to increased erosion in Indiana and increased deposition near the state line and in the Momence wetlands.

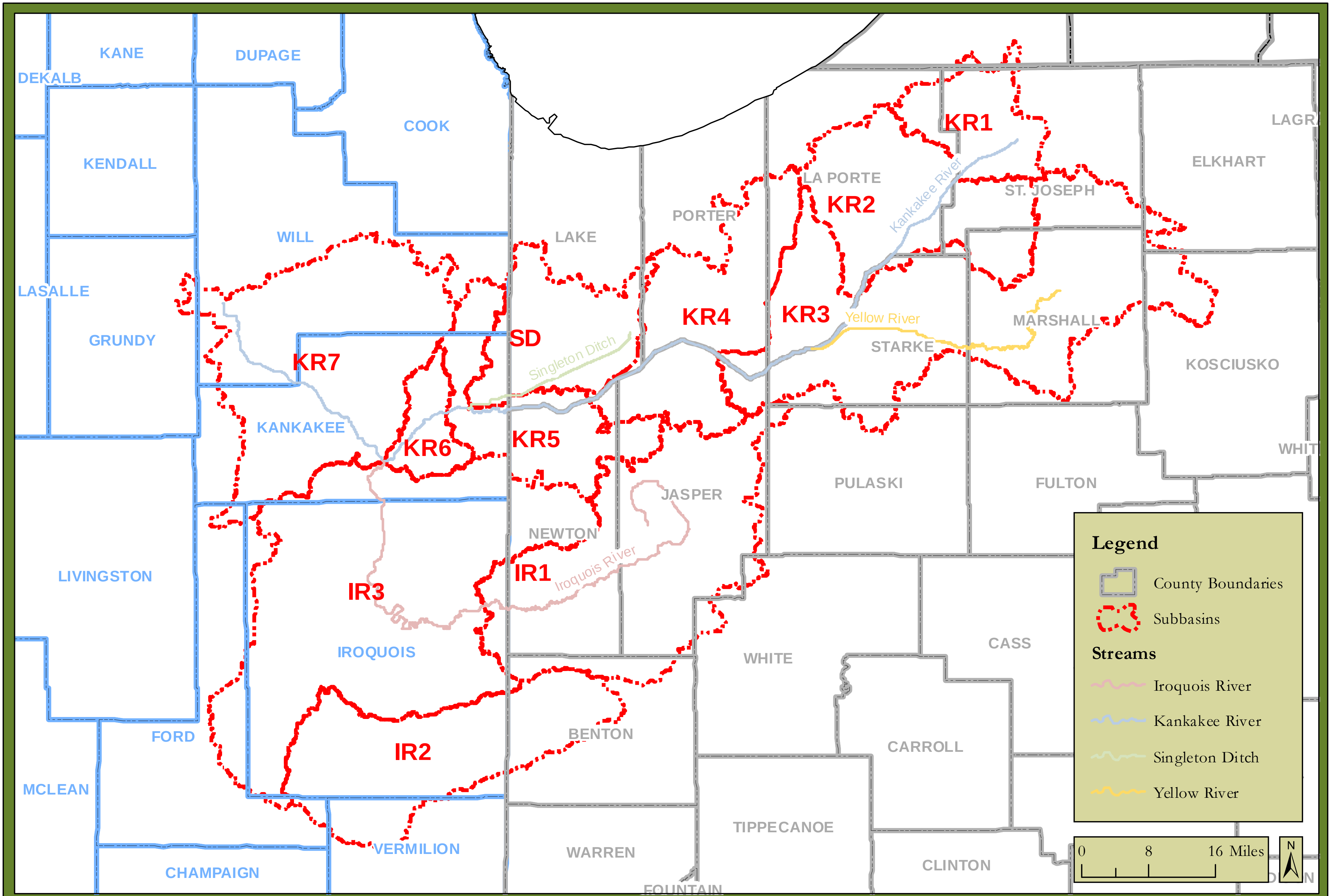
3.9.3 No Berm Scenario

The NB scenario did not consider the removal of all berms within the model domain. Rather, all of the berms along the Kankakee River banks themselves were removed. Setback berms, ditch berms, road embankments, etc. that were located away from the banks of the Kankakee were not modified. The NB scenario increased the overall size of inundated area in all simulated storms. However, the WSEs were slightly decreased due to the reduction in Kankakee River peak flow and a decrease in the restriction of flow into and out of the channel. In the 50% AEP event, the most prominent increases in inundated area were seen near English Lake and De Motte in Indiana. In the higher-flow events, increases in the size of the inundated area were widespread. The reductions in flow and WSE were more minor in Illinois as berms play a smaller role in river management in that portion of the river system. While the greatest reductions in channel flow rate were near 20% at locations in Indiana, the difference was on the order of 10% in Illinois. A comparison between the existing condition and no riverine berm scenario for the 2018 event is shown in Exhibit A3.3.

3.9.4 Strategic Constructed Breaches and Setback Berms Scenario

The CB scenario was only evaluated for the 50% AEP and 2018 storms. During the 50% AEP, the intended early floodplain activation occurred most noticeably west of De Motte, near Shelby, and in the LaSalle FWA in Indiana. In the 2018 simulation, the reduction in flow and WSE was approximately half that seen during the NB scenario. Although floodplain storage was more readily accessed in the CB scenario than in the existing condition, the revised berm alignments in the CB simulation prevented the increased flooding from being as widespread as in the NB scenario. Additionally, the Kankakee FWA near English Lake, IN was accessed in both the 50% AEP and 2018 events, unlike the NB scenario which did not include breaching the interior berms of the FWA.

Hydrologic Parameter Calculations



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PROJECT: Kankakee River Flood and Sediment Management Work Plan

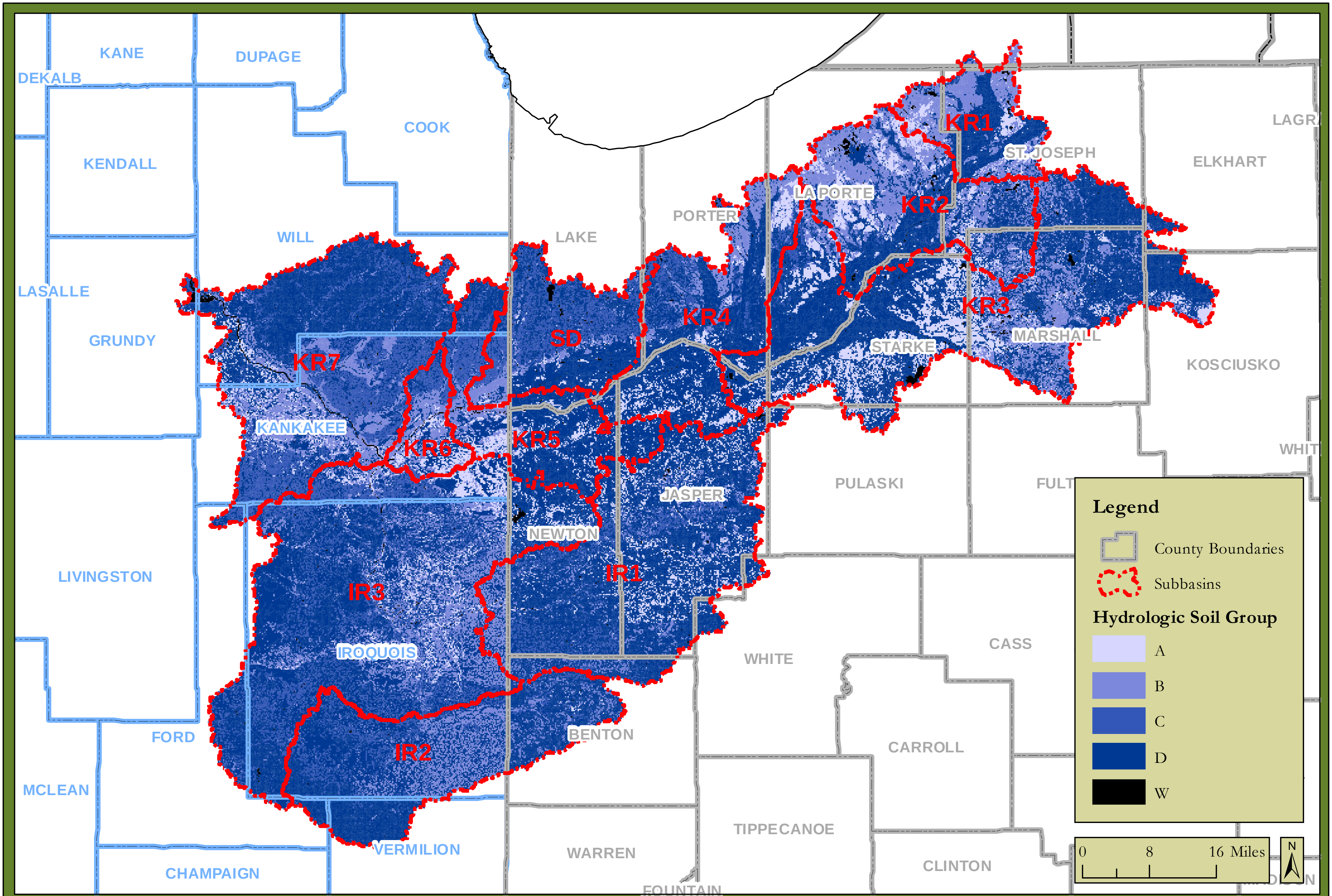
PROJECT NO. 18-0290

APPROX. SCALE 1 "=80,000 '

TITLE: Hydrologic Subbasins

DATE: 06/2019

EXHIBIT A2.1



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PROJECT: Kankakee River Flood and Sediment Management Work Plan

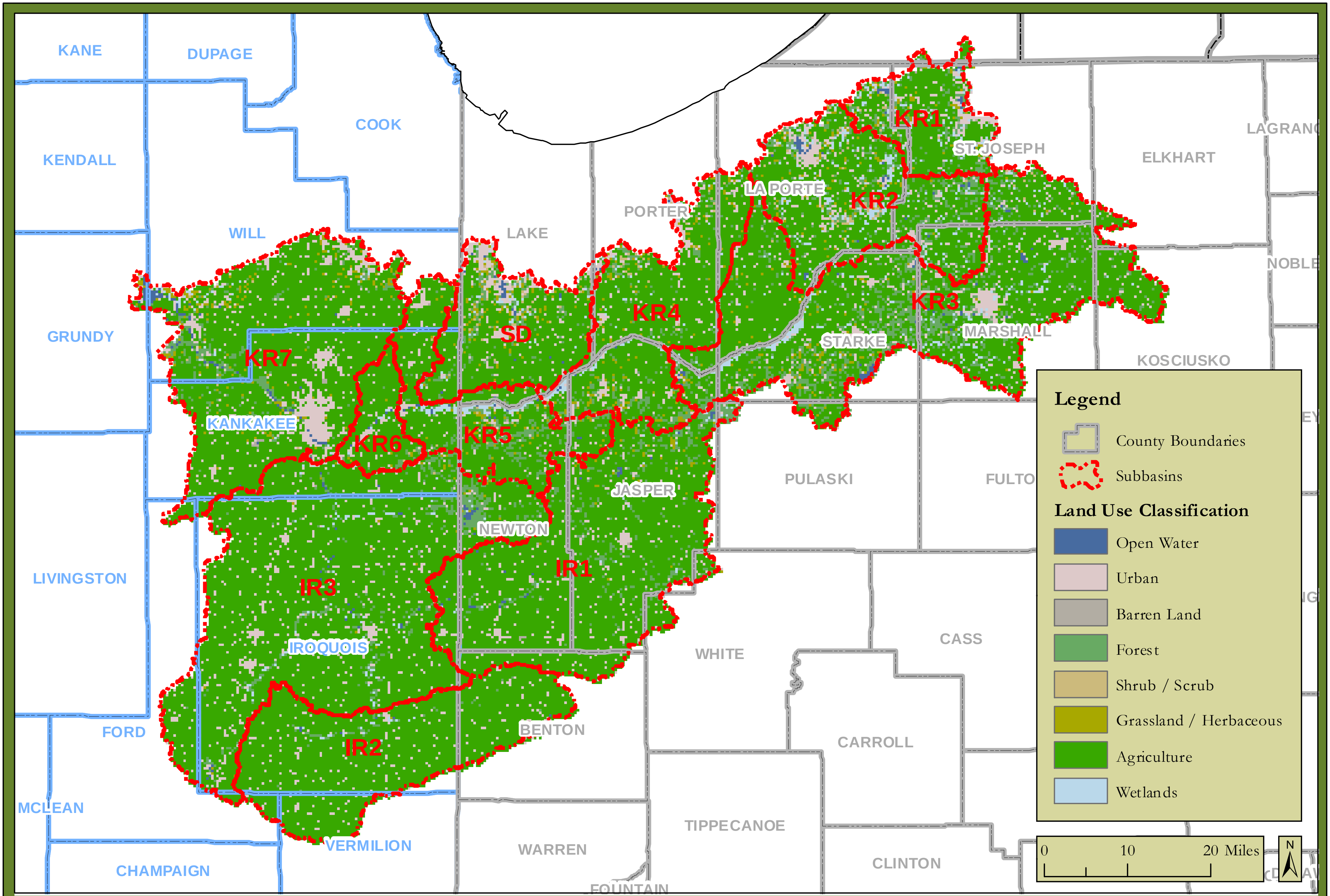
PROJECT NO. 18-0290

APPROX. SCALE 1 "=80,000 '

DATE: 06/2019

TITLE: Hydrologic Soil Data

EXHIBIT A2.2



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PROJECT:
Kankakee River Flood and
Sediment Management Work Plan

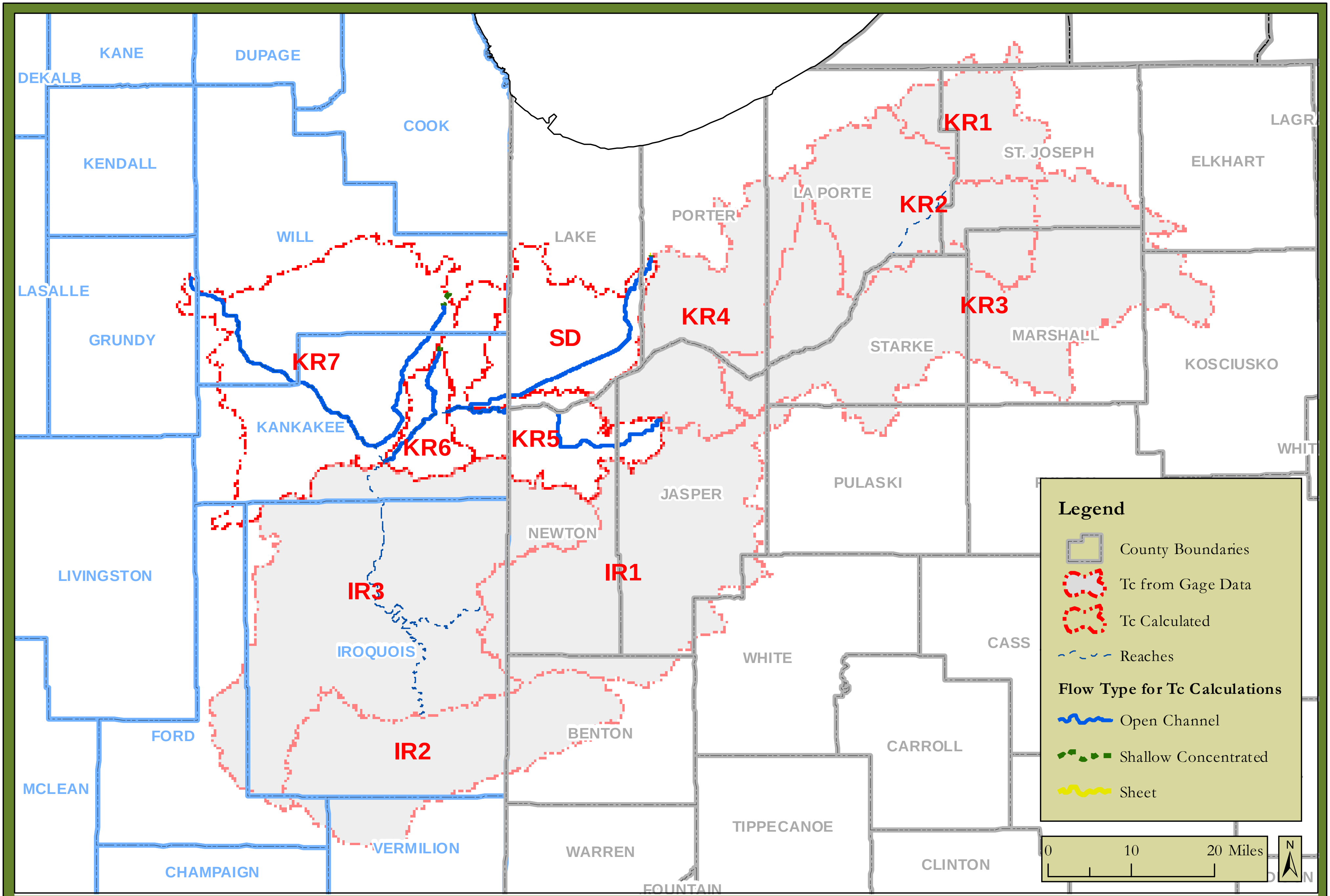
PROJECT NO.
18-0290

APPROX. SCALE
1 "=80,000 '

DATE: 06/2019

TITLE:
Land Use Classification

EXHIBIT A2.3



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PROJECT: Kankakee River Flood and Sediment Management Work Plan

PROJECT NO. 18-0290

APPROX. SCALE 1 "=80,000 '

TITLE: Hydrologic Flow Paths

DATE: 06/2019

EXHIBIT A2.4

Composite Curve Number Calculation Worksheet

CBBEL Project No.	18-0290.00000	Calcs. By	IKH	Date	10/16/2018
CBBEL Project Name	Kankakee River Flood and Sediment Management	Check By		Date	
Basin Name	**KR7**				

Soil Name and Hydrologic Group	% Area for Each Soil Type	Cover Description	CN	% Land Use Area per Soil Type	% Total Area	CN X % Total Area
A	5.3	Open Water	100	0	0.0	1.5
		Developed, Open Space	51	4	0.2	11.8
		Developed, Low Intensity	61	6	0.3	19.9
		Developed, Medium Intensity	75	1	0.0	3.1
		Developed, High Intensity	89	0	0.0	1.1
		Barren Land (Rock / Sand / Clay)	77	0	0.0	0.3
		Deciduous Forest	25	19	1.0	24.7
		Evergreen Forest	25	0	0.0	0.1
		Mixed Forest	25	0	0.0	0.2
		Shrub / Scrub	39	1	0.0	1.1
		Grasslands / Herbaceous	30	6	0.3	10.3
		Pasture / Hay	39	2	0.1	3.2
		Cultivated Crops	64	60	3.2	206.2
		Small Grains	39			
		Urban/Recreational Grasses	39			
		Woody Wetlands	30	1	0.0	0.9
		Emergent Herbaceous Wetlands	49	0	0.0	0.0
			Total =	100		
B	17.2	Open Water	100	0	0.0	4.3
		Developed, Open Space	68	4	0.6	43.9
		Developed, Low Intensity	75	9	1.5	111.4
		Developed, Medium Intensity	84	2	0.4	33.6
		Developed, High Intensity	92	1	0.2	16.6
		Barren Land (Rock / Sand / Clay)	86	0	0.0	2.0
		Deciduous Forest	55	4	0.7	37.7
		Evergreen Forest	55	0	0.0	0.2
		Mixed Forest	55	0	0.0	1.5
		Shrub / Scrub	61	0	0.0	2.0
		Grasslands / Herbaceous	58	3	0.5	27.0
		Pasture / Hay	61	4	0.7	40.9
		Cultivated Crops	75	72	12.4	929.1
		Small Grains	61			
		Urban/Recreational Grasses	61			
		Woody Wetlands	55	1	0.2	8.6
		Emergent Herbaceous Wetlands	69	0	0.0	0.2
			Total =	100		
C	23.1	Open Water	100	0	0.0	4.8
		Developed, Open Space	79	3	0.7	56.6
		Developed, Low Intensity	83	8	1.9	159.9
		Developed, Medium Intensity	89	3	0.6	53.3
		Developed, High Intensity	94	1	0.2	19.8
		Barren Land (Rock / Sand / Clay)	91	0	0.0	3.3
		Deciduous Forest	70	2	0.5	37.7
		Evergreen Forest	70	0	0.0	0.2
		Mixed Forest	70	0	0.1	3.8
		Shrub / Scrub	74	0	0.0	2.1
		Grasslands / Herbaceous	71	2	0.5	36.6
		Pasture / Hay	74	5	1.2	86.8
		Cultivated Crops	82	74	17.2	1412.4
		Small Grains	74			
		Urban/Recreational Grasses	74			
		Woody Wetlands	70	0	0.1	3.8
		Emergent Herbaceous Wetlands	79	0	0.0	0.1
			Total =	100		
D	53.0	Open Water	100	0	0.1	13.1
		Developed, Open Space	84	3	1.7	142.6
		Developed, Low Intensity	87	6	3.1	272.0
		Developed, Medium Intensity	91	1	0.7	60.7
		Developed, High Intensity	95	0	0.2	19.2
		Barren Land (Rock / Sand / Clay)	94	0	0.2	17.3
		Deciduous Forest	77	4	2.0	151.1
		Evergreen Forest	77	0	0.0	0.5
		Mixed Forest	77	0	0.1	9.8
		Shrub / Scrub	80	0	0.1	4.9
		Grasslands / Herbaceous	78	4	1.9	146.2
		Pasture / Hay	80	4	2.3	187.6
		Cultivated Crops	85	76	40.1	3411.5
		Small Grains	80			
		Urban/Recreational Grasses	80			
		Woody Wetlands	77	1	0.5	38.6
		Emergent Herbaceous Wetlands	84	0	0.0	1.9
			Total =	100		
Water	1.2757138	Open Water	100		1.3	127.6
Totals	100				100	8029.4
					CN =	80.3
					Use CN	**80**

Composite Curve Number Calculation Worksheet

CBBEL Project No.	18-0290.00000	Calcs. By	IKH	Date	10/16/2018
CBBEL Project Name	Kankakee River Flood and Sediment Management	Check By		Date	
Basin Name	**KR6**				

Soil Name and Hydrologic Group	% Area for Each Soil Type	Cover Description	CN	% Land Use Area per Soil Type	% Total Area	CN X % Total Area
A	19.4	Open Water	100	0	0.1	5.4
		Developed, Open Space	51	7	1.4	73.0
		Developed, Low Intensity	61	6	1.2	71.0
		Developed, Medium Intensity	75	0	0.1	3.9
		Developed, High Intensity	89	0	0.0	0.9
		Barren Land (Rock / Sand / Clay)	77	0	0.0	1.0
		Deciduous Forest	25	12	2.3	57.3
		Evergreen Forest	25	0	0.0	0.3
		Mixed Forest	25	1	0.1	3.2
		Shrub / Scrub	39	0	0.1	3.4
		Grasslands / Herbaceous	30	3	0.7	19.7
		Pasture / Hay	39	2	0.5	18.3
		Cultivated Crops	64	65	12.7	811.7
		Small Grains	39			
		Urban/Recreational Grasses	39			
		Woody Wetlands	30	2	0.3	10.0
		Emergent Herbaceous Wetlands	49	0	0.0	0.4
			Total =	100		
B	31.2	Open Water	100	1	0.2	20.5
		Developed, Open Space	68	5	1.5	104.9
		Developed, Low Intensity	75	5	1.6	121.9
		Developed, Medium Intensity	84	0	0.1	10.4
		Developed, High Intensity	92	0	0.0	4.4
		Barren Land (Rock / Sand / Clay)	86	0	0.0	0.5
		Deciduous Forest	55	2	0.6	32.3
		Evergreen Forest	55	0	0.0	0.4
		Mixed Forest	55	1	0.2	10.4
		Shrub / Scrub	61	0	0.0	1.3
		Grasslands / Herbaceous	58	1	0.3	18.2
		Pasture / Hay	61	2	0.7	41.2
		Cultivated Crops	75	81	25.4	1904.2
		Small Grains	61			
		Urban/Recreational Grasses	61			
		Woody Wetlands	55	2	0.5	26.5
		Emergent Herbaceous Wetlands	69	0	0.0	0.8
			Total =	100		
C	15.6	Open Water	100	0	0.0	1.0
		Developed, Open Space	79	1	0.1	10.9
		Developed, Low Intensity	83	4	0.5	45.2
		Developed, Medium Intensity	89	0	0.0	1.3
		Developed, High Intensity	94	0	0.0	0.4
		Barren Land (Rock / Sand / Clay)	91			
		Deciduous Forest	70	0	0.0	1.0
		Evergreen Forest	70			
		Mixed Forest	70	0	0.0	0.5
		Shrub / Scrub	74			
		Grasslands / Herbaceous	71	0	0.1	4.4
		Pasture / Hay	74	3	0.5	39.3
		Cultivated Crops	82	91	14.2	1166.5
		Small Grains	74			
		Urban/Recreational Grasses	74			
		Woody Wetlands	70	0	0.0	0.0
		Emergent Herbaceous Wetlands	79	0	0.0	0.2
			Total =	100		
D	32.9	Open Water	100	0	0.0	0.5
		Developed, Open Space	84	3	1.0	80.6
		Developed, Low Intensity	87	3	1.1	93.6
		Developed, Medium Intensity	91	0	0.0	2.9
		Developed, High Intensity	95	0	0.0	0.8
		Barren Land (Rock / Sand / Clay)	94	0	0.0	0.1
		Deciduous Forest	77	1	0.4	31.8
		Evergreen Forest	77	0	0.0	0.0
		Mixed Forest	77	0	0.0	3.7
		Shrub / Scrub	80	0	0.0	2.1
		Grasslands / Herbaceous	78	1	0.3	24.7
		Pasture / Hay	80	2	0.5	43.7
		Cultivated Crops	85	89	29.4	2497.5
		Small Grains	80			
		Urban/Recreational Grasses	80			
		Woody Wetlands	77	0	0.1	5.1
		Emergent Herbaceous Wetlands	84	0	0.0	0.2
			Total =	100		
Water	0.9367134	Open Water	100		0.9	93.7
Totals	100				100	7529.3
					CN =	75.3
					Use CN	**75**

Composite Curve Number Calculation Worksheet

CBBEL Project No. 18-0290.00000 Calcs. By IKH Date 10/16/2018
CBBEL Project Name Kankakee River Flood and Sediment Management Check By Date
Basin Name **KR5**

Soil Name and Hydrologic Group	**% Area for Each Soil Type**	**Cover Description**	**CN**	**% Land Use Area per Soil Type**	**% Total Area**	**CN X % Total Area**
A	14.5	Open Water	100	0	0.0	0.8
		Developed, Open Space	51	4	0.5	27.3
		Developed, Low Intensity	61	4	0.6	36.6
		Developed, Medium Intensity	75	1	0.1	6.1
		Developed, High Intensity	89	0	0.0	3.0
		Barren Land (Rock / Sand / Clay)	77	0	0.0	0.4
		Deciduous Forest	25	34	5.0	124.3
		Evergreen Forest	25	0	0.0	0.6
		Mixed Forest	25	0	0.0	0.6
		Shrub / Scrub	39	1	0.2	6.5
		Grasslands / Herbaceous	30	6	0.9	26.9
		Pasture / Hay	39	2	0.3	10.4
		Cultivated Crops	64	47	6.7	430.4
		Small Grains	39			
		Urban/Recreational Grasses	39			
		Woody Wetlands	30	1	0.1	3.5
		Emergent Herbaceous Wetlands	49	0	0.0	0.3
			Total =	100		
B	13.4	Open Water	100	0	0.1	6.2
		Developed, Open Space	68	3	0.4	24.4
		Developed, Low Intensity	75	5	0.6	46.1
		Developed, Medium Intensity	84	1	0.1	7.6
		Developed, High Intensity	92	0	0.0	3.9
		Barren Land (Rock / Sand / Clay)	86	0	0.0	0.3
		Deciduous Forest	55	5	0.6	33.2
		Evergreen Forest	55	0	0.0	0.7
		Mixed Forest	55	0	0.0	2.6
		Shrub / Scrub	61	0	0.0	2.8
		Grasslands / Herbaceous	58	2	0.2	12.2
		Pasture / Hay	61	4	0.6	36.3
		Cultivated Crops	75	66	8.8	662.1
		Small Grains	61			
		Urban/Recreational Grasses	61			
		Woody Wetlands	55	14	1.8	100.0
		Emergent Herbaceous Wetlands	69	0	0.0	2.6
			Total =	100		
C	10.7	Open Water	100	0	0.0	0.5
		Developed, Open Space	79	2	0.2	15.9
		Developed, Low Intensity	83	6	0.6	53.1
		Developed, Medium Intensity	89	1	0.1	8.8
		Developed, High Intensity	94	0	0.0	2.2
		Barren Land (Rock / Sand / Clay)	91	0	0.0	2.2
		Deciduous Forest	70	1	0.1	8.0
		Evergreen Forest	70	0	0.0	0.0
		Mixed Forest	70	0	0.0	3.0
		Shrub / Scrub	74	0	0.0	2.0
		Grasslands / Herbaceous	71	2	0.3	18.5
		Pasture / Hay	74	5	0.6	42.9
		Cultivated Crops	82	81	8.7	711.7
		Small Grains	74			
		Urban/Recreational Grasses	74			
		Woody Wetlands	70	0	0.0	1.6
		Emergent Herbaceous Wetlands	79			
			Total =	100		
D	60.8	Open Water	100	0	0.1	12.0
		Developed, Open Space	84	2	1.1	96.4
		Developed, Low Intensity	87	4	2.3	198.9
		Developed, Medium Intensity	91	1	0.4	31.9
		Developed, High Intensity	95	0	0.1	6.5
		Barren Land (Rock / Sand / Clay)	94	0	0.0	3.2
		Deciduous Forest	77	6	3.5	273.0
		Evergreen Forest	77	0	0.0	2.9
		Mixed Forest	77	0	0.1	5.9
		Shrub / Scrub	80	0	0.3	23.6
		Grasslands / Herbaceous	78	2	1.5	117.5
		Pasture / Hay	80	2	1.4	109.5
		Cultivated Crops	85	80	48.4	4116.7
		Small Grains	80			
		Urban/Recreational Grasses	80			
		Woody Wetlands	77	2	1.4	110.3
		Emergent Herbaceous Wetlands	84	0	0.1	7.8
			Total =	100		
Water	0.6546498	Open Water	100		0.7	65.5
Totals	100				100	7670.7
					CN =	76.7
					Use CN	**77**

Composite Curve Number Calculation Worksheet

CBBEL Project No.	18-0290.00000	Calcs. By	IKH	Date	10/16/2018
CBBEL Project Name	Kankakee River Flood and Sediment Management	Check By		Date	
Basin Name	**SD**				

Soil Name and Hydrologic Group	**% Area for Each Soil Type**	**Cover Description**	**CN**	**% Land Use Area per Soil Type**	**% Total Area**	**CN X % Total Area**
A	5.7	Open Water	100	0	0.0	2.5
		Developed, Open Space	51	2	0.1	6.3
		Developed, Low Intensity	61	3	0.2	10.8
		Developed, Medium Intensity	75	1	0.0	2.2
		Developed, High Intensity	89	0	0.0	0.3
		Barren Land (Rock / Sand / Clay)	77	0	0.0	0.2
		Deciduous Forest	25	6	0.3	7.8
		Evergreen Forest	25	0	0.0	0.1
		Mixed Forest	25	0	0.0	0.3
		Shrub / Scrub	39	1	0.0	1.8
		Grasslands / Herbaceous	30	3	0.2	5.4
		Pasture / Hay	39	3	0.2	6.1
		Cultivated Crops	64	71	4.0	256.0
		Small Grains	39			
		Urban/Recreational Grasses	39			
		Woody Wetlands	30	7	0.4	12.6
		Emergent Herbaceous Wetlands	49	3	0.2	8.3
			Total =	100		
B	36.3	Open Water	100	0	0.1	6.0
		Developed, Open Space	68	2	0.7	48.0
		Developed, Low Intensity	75	3	1.2	89.6
		Developed, Medium Intensity	84	1	0.2	16.0
		Developed, High Intensity	92	0	0.0	3.8
		Barren Land (Rock / Sand / Clay)	86	0	0.1	7.1
		Deciduous Forest	55	3	1.0	56.0
		Evergreen Forest	55	0	0.0	2.7
		Mixed Forest	55	0	0.1	3.8
		Shrub / Scrub	61	1	0.4	21.7
		Grasslands / Herbaceous	58	2	0.8	44.1
		Pasture / Hay	61	3	1.1	64.6
		Cultivated Crops	75	83	30.1	2256.9
		Small Grains	61			
		Urban/Recreational Grasses	61			
		Woody Wetlands	55	1	0.5	27.9
		Emergent Herbaceous Wetlands	69	0	0.1	8.1
			Total =	100		
C	51.4	Open Water	100	0	0.1	6.7
		Developed, Open Space	79	4	2.2	175.5
		Developed, Low Intensity	83	10	5.3	442.0
		Developed, Medium Intensity	89	2	1.1	97.4
		Developed, High Intensity	94	0	0.2	20.4
		Barren Land (Rock / Sand / Clay)	91	0	0.0	3.3
		Deciduous Forest	70	9	4.8	333.0
		Evergreen Forest	70	0	0.1	3.7
		Mixed Forest	70	0	0.1	6.9
		Shrub / Scrub	74	3	1.3	99.8
		Grasslands / Herbaceous	71	6	2.9	204.1
		Pasture / Hay	74	8	3.9	285.6
		Cultivated Crops	82	56	28.7	2350.6
		Small Grains	74			
		Urban/Recreational Grasses	74			
		Woody Wetlands	70	1	0.7	49.2
		Emergent Herbaceous Wetlands	79	0	0.1	6.4
			Total =	100		
D	5.2	Open Water	100	0	0.0	0.6
		Developed, Open Space	84	2	0.1	10.9
		Developed, Low Intensity	87	6	0.3	29.0
		Developed, Medium Intensity	91	1	0.0	4.1
		Developed, High Intensity	95	0	0.0	1.3
		Barren Land (Rock / Sand / Clay)	94	0	0.0	0.3
		Deciduous Forest	77	2	0.1	8.7
		Evergreen Forest	77	0	0.0	0.1
		Mixed Forest	77	0	0.0	0.7
		Shrub / Scrub	80	1	0.0	3.6
		Grasslands / Herbaceous	78	4	0.2	17.8
		Pasture / Hay	80	10	0.5	39.8
		Cultivated Crops	85	70	3.6	309.7
		Small Grains	80			
		Urban/Recreational Grasses	80			
		Woody Wetlands	77	2	0.1	9.5
		Emergent Herbaceous Wetlands	84	1	0.0	2.2
			Total =	100		
Water	1.4191589	Open Water	100		1.4	141.9
Totals	100				100	7641.5
					CN =	76.4
					Use CN	**76**

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Project No.: 18-0290.00000
Project Name: Kankakee River Work Plan
Calcs. By: IKH Date: 10/16/18
Check By: HLF Date: 10/16/18

Time of Concentration

Basin: KR5

SHEET FLOW

Tt(hr) = (0.007(n L)^0.8)/(P2^0.5 s^0.4)

(ft) Length	(ft) U/S Elev	(ft) D/S Elev	Slope	(in) P2	n
100	689.1	688.8	0.003	2.83	0.06

Surface Description	n-value
Smooth surfaces	0.011
Fallow (no residue)	0.05
Cultivated soils:	
Residue cover<20%	0.06
Residue cover>20%	0.17
Average	0.15
Grass:	
Short grass	0.15
Lawn grasses	0.24
Bermudagrass	0.41
Range (natural)	0.13
Woods:	
Light underbrush	0.4
Dense underbrush	0.8

Tt (hr)
0.18

TOTAL T_t (hr) **0.18**

SHALLOW CONCENTRATED FLOW

Tt(hr) = L/(3600 V)

V(paved) = 20.3282 S^0.5
V(unpaved) = 16.1345 S^0.5

(ft) Length	(ft) U/S Elev	(ft) D/S Elev	Slope	Pave(y/n)			Coef.	Velocity
1159.2	688.8	685.5	0.0028	N	y =	20.33	16.135	0.86
					n =	16.13		

Tt (hr)
0.37

TOTAL T_t (hr) **0.37**

OPEN CHANNEL/PIPE FLOW

(assuming a velocity)

Tt(hr) = L/(3600 V)

(ft) Length	(ft/s) Velocity
193605	3

Tt (hr)
17.93

TOTAL T_t (hr) **17.93**

(w/o assuming a velocity)

Tt(hr) = L/(3600 V)

V(ft/s) = (1.49 R^2/3 S^1/2)/n

					Open Channel		Pipe					
(ft) Length	(ft) U/S Elev	(ft) D/S Elev	Slope	n-value	(ft) Bottom	(ft) SS	(ft) DIA	(ft) Depth	Area	R	Velocity	Tt (hr)

TOTAL T_t (hr) **0.00**

Total T_c = 18.48 hours = 1109 minutes **T_{lag} = 11.09 hours = 665 minutes**

Adjusted Indiana-Specific T_c = 30.80 hours = 1848 minutes (If applicable)

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Calcs. By: IKH Date: 10/16/18
Check By: HLF Date: 10/16/18

Time of Concentration

Basin: KR6

SHEET FLOW

Tt(hr) = (0.007(n L)^0.8)/(P2^0.5 s^0.4)

Length (ft)	U/S Elev (ft)	D/S Elev (ft)	Slope	P2 (in)	n
100	710.7	710	0.007	2.83	0.06

Surface Description	**n-value**
Smooth surfaces	0.011
Fallow (no residue)	0.05
Cultivated soils:	
Residue cover<20%	0.06
Residue cover>20%	0.17
Average	0.15
Grass:	
Short grass	0.15
Lawn grasses	0.24
Bermudagrass	0.41
Range (natural)	0.13
Woods:	
Light underbrush	0.4
Dense underbrush	0.8

Tt (hr) 0.13

TOTAL T_t (hr) 0.13

SHALLOW CONCENTRATED FLOW

Tt(hr) = L/(3600 V)

V(paved) = 20.3282 S^0.5
V(unpaved) = 16.1345 S^0.5

Length (ft)	U/S Elev (ft)	D/S Elev (ft)	Slope	Pave(y/n)			Coef.	Velocity
3096.5	710	701.7	0.0027	N	y =	20.33	16.135	0.84
					n =	16.13		

Tt (hr) 1.03

TOTAL T_t (hr) 1.03

OPEN CHANNEL/PIPE FLOW

(assuming a velocity)

Tt(hr) = L/(3600 V)

Length (ft)	Velocity (ft/s)
102168	3

Tt (hr) 9.46

TOTAL T_t (hr) 9.46

(w/o assuming a velocity)

Tt(hr) = L/(3600 V)

V(ft/s) = (1.49 R^2/3 S^1/2)/n

Length (ft)	U/S Elev (ft)	D/S Elev (ft)	Slope	n-value	Open Channel Bottom (ft)	Open Channel SS (ft)	Pipe DIA (ft)	Depth (ft)	Area	R	Velocity	Tt (hr)

TOTAL T_t (hr) 0.00

Total T_c = 10.62 hours = 637 minutes

T_{lag} = 6.37 hours = 382 minutes

Adjusted Indiana-Specific T_c = 17.69 hours = 1062 minutes (If applicable)

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Check By: HLF Date: 10/16/18

Time of Concentration

Basin: KR7

SHEET FLOW

Tt(hr) = (0.007(n L)^0.8)/(P2^0.5 s^0.4)

(ft) Length	(ft) U/S Elev	(ft) D/S Elev	Slope	(in) P2	n
100	728.7	727.7	0.01	2.83	0.06

Surface Description	**n-value**
Smooth surfaces	0.011
Fallow (no residue)	0.05
Cultivated soils:	
Residue cover<20%	0.06
Residue cover>20%	0.17
Average	0.15
Grass:	
Short grass	0.15
Lawn grasses	0.24
Bermudagrass	0.41
Range (natural)	0.13
Woods:	
Light underbrush	0.4
Dense underbrush	0.8

Tt (hr)
0.11

TOTAL T_t (hr) **0.11**

SHALLOW CONCENTRATED FLOW

Tt(hr) = L/(3600 V)

V(paved) = 20.3282 S^0.5
V(unpaved) = 16.1345 S^0.5

(ft) Length	(ft) U/S Elev	(ft) D/S Elev	Slope	Pave(y/n)			Coef.	Velocity
10760	727.7	709	0.0017	N	y =	20.33	16.135	0.67
					n =	16.13		

Tt (hr)
4.44

TOTAL T_t (hr) **4.44**

OPEN CHANNEL/PIPE FLOW
(assuming a velocity)

Tt(hr) = L/(3600 V)

(ft) Length	(ft/s) Velocity
301201	3

Tt (hr)
27.89

TOTAL T_t (hr) **27.89**

(w/o assuming a velocity)

Tt(hr) = L/(3600 V)

V(ft/s) = (1.49 R^2/3 S^1/2)/n

(ft) Length	(ft) U/S Elev	(ft) D/S Elev	Slope	n-value	Open Channel (ft) Bottom	Open Channel (ft) SS	Pipe (ft) DIA	(ft) Depth	Area	R	Velocity	Tt (hr)

TOTAL T_t (hr) **0.00**

Total T_c = 32.44 hours = 1947 minutes **T_{lag} = 19.47 hours = 1168 minutes**

Adjusted Indiana-Specific T_c = 54.07 hours = 3244 minutes (If applicable)

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Project Name: Kankakee River Work Plan
Calcs. By: IKH Date: 10/16/18
Check By: HLF Date: 10/16/18

Time of Concentration

Basin: SD

SHEET FLOW

Tt(hr) = (0.007(n L)^0.8)/(P2^0.5 s^0.4)

(ft) Length	(ft) U/S Elev	(ft) D/S Elev	Slope	(in) P2	n
100	793.6	790.7	0.029	2.83	0.4

Surface Description	**n-value**
Smooth surfaces	0.011
Fallow (no residue)	0.05
Cultivated soils:	
Residue cover<20%	0.06
Residue cover>20%	0.17
Average	0.15
Grass:	
Short grass	0.15
Lawn grasses	0.24
Bermudagrass	0.41
Range (natural)	0.13
Woods:	
Light underbrush	0.4
Dense underbrush	0.8

Tt (hr) 0.33

TOTAL T_t (hr) 0.33

SHALLOW CONCENTRATED FLOW

Tt(hr) = L/(3600 V)

V(paved) = 20.3282 S^0.5
V(unpaved) = 16.1345 S^0.5

(ft) Length	(ft) U/S Elev	(ft) D/S Elev	Slope	Pave(y/n)			Coef.	Velocity
661.32	790.7	768.2	0.034	N	y =	20.33	16.135	2.98
					n =	16.13		

Tt (hr) 0.06

TOTAL T_t (hr) 0.06

OPEN CHANNEL/PIPE FLOW

(assuming a velocity)

Tt(hr) = L/(3600 V)

(ft) Length	(ft/s) Velocity
185591	3

Tt (hr) 17.18

TOTAL T_t (hr) 17.18

(w/o assuming a velocity)

Tt(hr) = L/(3600 V)

V(ft/s) = (1.49 R^2/3 S^1/2)/n

(ft) Length	(ft) U/S Elev	(ft) D/S Elev	Slope	n-value	Open Channel (ft) Bottom	Open Channel (ft) SS	Pipe (ft) DIA	(ft) Depth	Area	R	Velocity	Tt (hr)

TOTAL T_t (hr) 0.00

Total T_c = 17.57 hours = 1054 minutes **T_{lag} = 10.54 hours = 633 minutes**

Adjusted Indiana-Specific T_c = 29.29 hours = 1757 minutes (If applicable)

Hydraulic Model Results

Legend

- Indiana Counties
- Illinois Counties
- Municipal Boundaries
- ▨ 50% AEP Event
- 🟦 2018 Event
- ▨ 1% AEP Event
- Rivers / Streams / Ditches

Christopher B. Burke Engineering, LLC PNC Center, Suite 1368 South 115 West Washington Street Indianapolis, Indiana 46204 (t) 317.266.8000 (f) 317.632.3306	PROJECT: Kankakee River Flood and Sediment Management Work Plan	PROJECT NO. 18-0290	APPROX. SCALE 1"=1mile
	TITLE: Flood Extents for the Existing Condition (Sheet 1 of 3)		DATE: 06/2018 EXHIBIT A3.1

Legend

- Indiana Counties
- Illinois Counties
- Municipal Boundaries
- ▩ 50% AEP Event
- 🟦 2018 Event
- ▨ 1% AEP Event
- Rivers / Streams / Ditches

BURKE

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PROJECT:	Kankakee River Flood and Sediment Management Work Plan	PROJECT NO. 18-0290	APPROX. SCALE 1"=1mile
TITLE:	Flood Extents for the Existing Condition (Sheet 2 of 3)		DATE: 06/2018
			EXHIBIT A3.1

Legend

- ▭ Indiana Counties
- ▭ Illinois Counties
- ▭ Municipal Boundaries
- ▨ 50% AEP Event
- 🟦 2018 Event
- ▨ 1% AEP Event
- ∼ Rivers / Streams / Ditches

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PROJECT:	Kankakee River Flood and Sediment Management Work Plan	PROJECT NO. 18-0290	APPROX. SCALE 1"=1mile
TITLE:	Flood Extents for the Existing Condition (Sheet 3 of 3)		DATE: 06/2018
			EXHIBIT A3.1

Legend

▢ Indiana Counties
▢ Illinois Counties
▢ Municipal Boundaries
🟦 2018 Event, Existing Condition
▨ 2018 Event, Dredged Scenario

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PROJECT:	Kankakee River Flood and Sediment Management Work Plan
PROJECT NO.	18-0290
APPROX. SCALE	1"=1mile
TITLE:	Modeled Flood Extents (Sheet 1 of 3)
DATE:	06/2018
EXHIBIT	A3.2

Legend

- Indiana Counties
- Illinois Counties
- Municipal Boundaries
- 2018 Event, Existing Condition
- 2018 Event, Dredged Scenario

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PROJECT:	Kankakee River Flood and Sediment Management Work Plan	PROJECT NO. 18-0290	APPROX. SCALE 1"=1mile
			DATE: 06/2018
TITLE:	Modeled Flood Extents (Sheet 2 of 3)		EXHIBIT A3.2

Legend

- ▭ Indiana Counties
- ▭ Illinois Counties
- ▭ Municipal Boundaries
- 🟦 2018 Event, Existing Condition
- ▨ 2018 Event, Dredged Scenario

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	TITLE: Modeled Flood Extents (Sheet 3 of 3)		DATE: 06/2018 EXHIBIT A3.2

Legend

- Indiana Counties
- Illinois Counties
- Municipal Boundaries
- 🟦 2018 Event, Existing Condition
- ▨ 2018 Event, No Berms Scenario
- Rivers / Streams / Ditches

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PROJECT:	Kankakee River Flood and Sediment Management Work Plan	PROJECT NO. 18-0290	APPROX. SCALE 1"=1mile
TITLE:	Flood Extents for EX and NB Scenarios (Sheet 1 of 3)		DATE: 06/2018
			EXHIBIT A3.3

Legend

- Indiana Counties
- Illinois Counties
- Municipal Boundaries
- 2018 Event, Existing Condition
- ▨ 2018 Event, No Berms Scenario
- Rivers / Streams / Ditches

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PROJECT: Kankakee River Flood and Sediment Management Work Plan

PROJECT NO. 18-0290

APPROX. SCALE 1"=1mile

TITLE: Flood Extents for EX and NB Scenarios (Sheet 2 of 3)

DATE: 06/2018

EXHIBIT A3.3

Legend

- ▭ Indiana Counties
- ▭ Illinois Counties
- ▭ Municipal Boundaries
- ▨ 2018 Event, Existing Condition
- ▨ 2018 Event, No Berms Scenario
- ~ Rivers / Streams / Ditches

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PROJECT:	Kankakee River Flood and Sediment Management Work Plan	PROJECT NO. 18-0290	APPROX. SCALE 1"=1mile
TITLE:	Flood Extents for EX and NB Scenarios (Sheet 3 of 3)		DATE: 06/2018
			EXHIBIT A3.3

Legend

- ▭ Indiana Counties
- ▭ Illinois Counties
- ▭ Municipal Boundaries
- 🟦 2018 Event, Existing Condition
- ▨ 2018 Event, Constructed Breaches and Setback Berms Scenario
- ～ Rivers / Streams / Ditches

CBB BURKE
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PROJECT:	Kankakee River Flood and Sediment Management Work Plan	PROJECT NO. 18-0290	APPROX. SCALE 1"=1mile
TITLE:	Flood Extents for EX and CB Scenarios (Sheet 1 of 3)		DATE: 06/2018
			EXHIBIT A3.4

Legend

- ▢ Indiana Counties
- ▢ Illinois Counties
- ▢ Municipal Boundaries
- 🟦 2018 Event, Existing Condition
- ▨ 2018 Event, Constructed Breaches and Setback Berms Scenario
- ~ Rivers / Streams / Ditches

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PROJECT: Kankakee River Flood and Sediment Management Work Plan

PROJECT NO. 18-0290

APPROX. SCALE 1"=1mile

TITLE: Flood Extents for EX and CB Scenarios (Sheet 2 of 3)

DATE: 06/2018

EXHIBIT A3.4

Legend

- ▭ Indiana Counties
- ▭ Illinois Counties
- ▭ Municipal Boundaries
- 🟦 2018 Event, Existing Condition
- ▨ 2018 Event, Constructed Breaches and Setback Berms Scenario
- ~ Rivers / Streams / Ditches

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PROJECT:	Kankakee River Flood and Sediment Management Work Plan
PROJECT NO.	18-0290
APPROX. SCALE	1"=1mile
TITLE:	Flood Extents for EX and CB Scenarios (Sheet 3 of 3)
DATE:	06/2018
EXHIBIT	A3.4

Appendix 4 – Improvement Cost Estimates

Opinion of Probable Cost for Kankakee River Flood & Sediment Management Work Plan

Recommended Improvements

Line	Description	Estimated Quantities	Units	Unit Price	Estimated Cost (Rounded)
1	**Yellow River Upstream Improvements**				
1.1	Streambank Stabilization using Toe Wood (or similar)[1]	76,600	LF	$ 200	$ 15,320,000
1.2	Construction Contingency (Unforeseen Conditions - 25%)	76,600	LF	$ 50	$ 3,830,000
1.3	Topographic Survey	1	LS	$ 96,000	$ 96,000
1.4	Engineering Design & Permitting (8%)	1	LS	$ 1,532,000	$ 1,532,000
1.5	Construction Observation (4%)	1	LS	$ 766,000	$ 766,000
1.6	Post Construction Monitoring & Maintenance (10%)	76,600	LF	$ 20	$ 1,532,000
1.7	Estimated Yellow River Upstream Improvements Cost				$ 23,076,000
2	**Kankakee Bank Stabilization Improvements**				
2.1	Streambank Stabilization using Plantings (or similar)	123,200	LF	$ 25	$ 3,080,000
2.2	Construction Contingency (Unforeseen Conditions - 50%)	123,200	LF	$ 13	$ 1,540,000
2.3	Engineering Design & Permitting (8%)	1	LS	$ 370,000	$ 370,000
2.4	Construction Observation (4%)	1	LS	$ 185,000	$ 185,000
2.5	Estimated Kankakee Bank Stabilization Improvements Cost				$ 5,175,000
3	**Zone-Specific Access & Logjam Mgmt**				
3.1	Construct/Improve Bridge Access	25	EA	$ 30,000	$ 750,000
3.2	Maintenance of Access along Channel	37.6	MI	$ 20,000	$ 752,000
3.3	Construction Contingency (Unforeseen Conditions - 30%)	1	LS	$ 450,600	$ 451,000
3.4	Engineering Design & Permitting (8%)	1	LS	$ 157,000	$ 157,000
3.5	Construction Observation (4%)	1	LS	$ 79,000	$ 79,000
3.6	Estimated Zone-Specific Access & Logjam Mgmt Cost				$ 2,189,000
4	**Large Wood Removal along Yellow River at Fish and Wildlife Area**				
4.1	Large Wood Removal	5.2	MI	$ 15,000	$ 78,000
4.2	Construction Contingency (Unforeseen Conditions - 50%)	1	LS	$ 39,000	$ 39,000
4.3	Estimated Large Wood Removal along Yellow River at Fish and Wildlife Area Cost				$ 117,000
5	**Selective and Temporary Berm Maintenance**				
5.1	Bank Stabilization (As-needed; Assumed 10% of total length)	43,000	FT	$ 100	$ 4,300,000
5.2	Breach Repair (As-needed; Assumed 1/mile)	82	EA	$ 20,000	$ 1,640,000
5.3	Construction Contingency (Unforeseen Conditions - 40%)	1	LS	$ 2,376,000	$ 2,376,000
5.4	Engineering Design & Permitting (8%)	1	LS	$ 666,000	$ 666,000
5.5	Construction Observation (4%)	1	LS	$ 333,000	$ 333,000
5.6	Estimated Selective and Temporary Berm Maintenance Cost				$ 9,315,000
6	**Strategic Berm Removal & Setback Berm Construction**				
6.1	Construct Breach / Remove Berm (100 ft each)	149	EA	$ 20,000	$ 2,980,000
6.2	Construct / Improve Setback Berm	38.3	MI	$ 680,000	$ 26,044,000
6.3	Construction Contingency (Unforeseen Conditions - 50%)	1	LS	$ 14,512,000	$ 14,512,000
6.4	Engineering Design & Permitting (8%)	1	LS	$ 3,483,000	$ 3,483,000
6.5	Construction Observation (4%)	1	LS	$ 1,742,000	$ 1,742,000
6.6	Flooding & Access Easements[2]	1	LS	$ 10,000,000	$ 10,000,000
6.7	Estimated Strategic Berm Removal & Setback Berm Construction Cost				$ 58,761,000
7	**Yellow River Downstream Improvements**				
7.1	Streambank Stabilization using Toe Wood (or similar)[3]	46,000	LF	$ 200	$ 9,200,000
7.2	Construction Contingency (Unforeseen Conditions - 25%)	46,000	LF	$ 50	$ 2,300,000
7.3	Topographic Survey	1	LS	$ 58,000	$ 58,000
7.4	Engineering Design & Permitting (8%)	1	LS	$ 920,000	$ 920,000
7.5	Construction Observation (4%)	1	LS	$ 460,000	$ 460,000
7.6	Post Construction Monitoring & Maintenance (10%)	46,000	LF	$ 20	$ 920,000
7.7	Estimated Yellow River Downstream Improvements Cost				$ 13,858,000
8	**Bridge Removal / Replacement**				
8.1	Remove Existing Bridge	37,800	SF	$ 60	$ 2,268,000
8.2	Replace Existing Bridge	14,200	SF	$ 290	$ 4,118,000
8.3	Construction Contingency (Unforeseen Conditions - 50%)	37,800	SF	$ 30	$ 1,134,000
8.4	Topographic Survey	1	LS	$ 15,000	$ 15,000
8.5	Engineering Design & Permitting (8%)	1	LS	$ 602,000	$ 602,000
8.6	Construction Observation (4%)	1	LS	$ 301,000	$ 301,000
8.7	Estimated Bridge Removal / Replacement Cost				$ 8,438,000
9	**Storage Areas to Offset Increased Runoff**				
9.1	Construct Detention Basins	250.0	AC-FT	$ 30,000	$ 7,500,000
9.2	Construction Contingency (Unforeseen Conditions - 50%)	1	LS	$ 3,750,000	$ 3,750,000
9.3	Engineering Design & Permitting (8%)	1	LS	$ 900,000	$ 900,000
9.4	Construction Observation (4%)	1	LS	$ 450,000	$ 450,000
9.5	Estimated Storage Areas to Offset Increased Runoff Cost				$ 12,600,000
	Estimated Total Cost for Work Plan Implementation				**$ 133,529,000**
10	**Strategic Flood Protection Measures[8]**				
10.1	Construct Flood Protection Barrier (Levee or floodwall)	46,000	LF	$ 700	$ 32,200,000
10.2	Construct Interior Drainage System	4	EA	$ 250,000	$ 1,000,000
10.3	Construction Contingency (Unforeseen Conditions - 50%)	1	LS	$ 9,960,000	$ 9,960,000
10.4	Topographic Survey	1	LS	$ 50,000	$ 50,000
10.5	Engineering Design & Permitting (8%)	1	LS	$ 3,453,000	$ 3,453,000
10.6	Construction Observation (4%)	1	LS	$ 1,727,000	$ 1,727,000
10.7	Estimated Strategic Flood Protection Measures Cost				$ 48,390,000

Notes and Assumptions

1 Unit cost is based on the mitigated unstable bank length and observed cost from the Yellow River Pilot Project. Improvement length is based on the length of unstable banks in the improvement area shown in EX4.

2 Flooding easements provided to property owners subjected to more frequent flooding as a result of berm removal.

3 See Note 1. Length of improvements is based on the length of unstable banks in the improvement area shown in EX4.

4 All costs are estimates based on the engineer's knowledge of common construction methods and materials. Christopher B. Burke Engineering does not guarantee that the actual bid price will not vary from the costs used with this estimate.

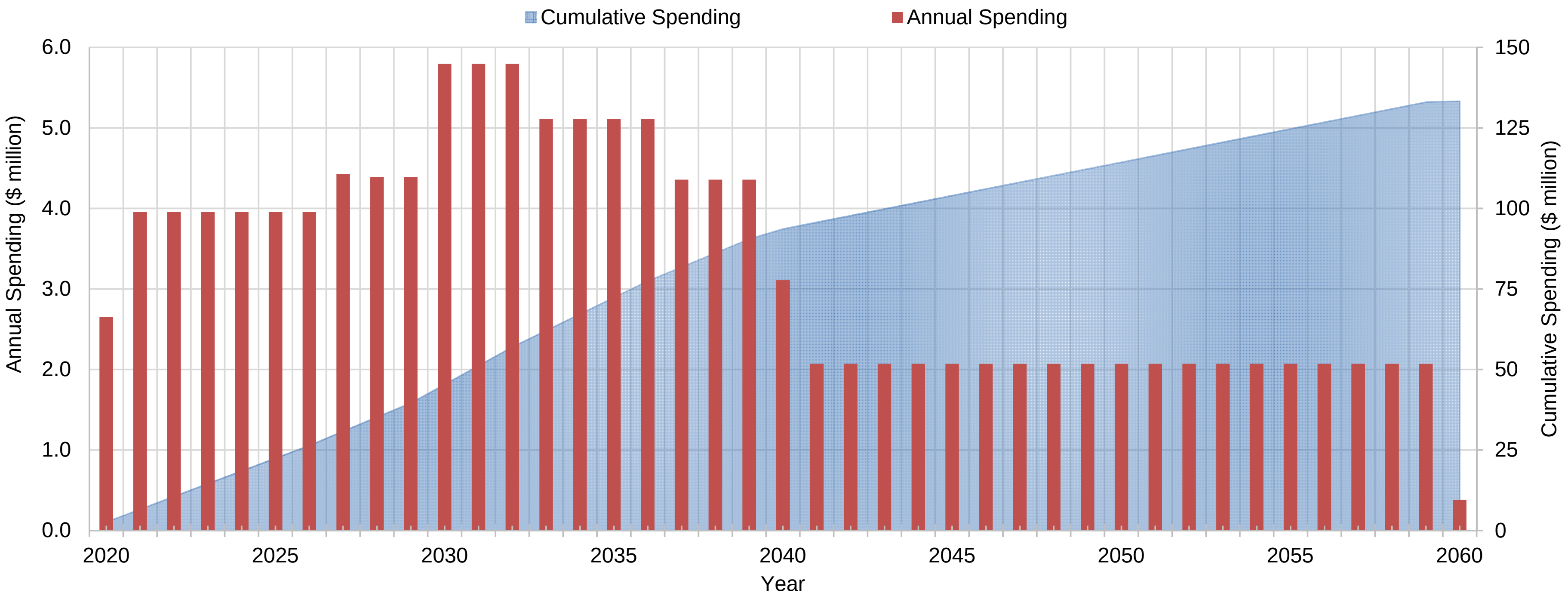
5 All costs are in 2018 dollars; Estimated costs have been rounded.

6 This estimate does not include unforeseen costs increases that may result from shortages in fuel / materials as a result of a natural or man-made disaster.

7 Costs have been estimated without the benefit of survey data, utility coordination, or design. This estimate is intended for planning level consideration, and should only be used for such purposes.

8 It is anticipated that the strategic flood protection measures will be cost-shared between several entities, as such, the cost of the improvements has not been included in the Estimated Total Cost for Work Plan Improvements.

No.	Active Management Recommendation	Design &Permitting Cost	Construction Cost	Easement Cost	Total Cost
1	Yellow River Upstream Improvements	$2,298,000	$20,778,000		$23,076,000
2	Kankakee Bank Stabilization Improvements	$555,000	$4,620,000		$5,175,000
3	Zone-Specific Access & Logjam Mgmt	$236,000	$1,953,000		$2,189,000
4	Large Wood Removal along Yellow River at Fish and Wildlife Area	$0	$117,000		$117,000
5	Selective and Temporary Berm Maintenance	$999,000	$8,316,000		$9,315,000
6	Strategic Berm Removal & Setback Berm Construction	$5,225,000	$43,536,000	$10,000,000	$58,761,000
7	Yellow River Downstream Improvements	$1,380,000	$12,478,000		$13,858,000
8	Bridge Removal / Replacement	$903,000	$7,535,000		$8,438,000
9	Storage Areas to Offset Increased Runoff	$1,350,000	$11,250,000		$12,600,000
	TOTAL COST	$12,946,000	$110,583,000	$10,000,000	$133,529,000



Year	Yellow River Upstream Improvements	Kankakee Bank Stabilization Improvements	Zone-Specific Access & Logjam Mgmt	Large Wood Removal along Yellow River at Fish and Wildlife Area	Selective and Temporary Berm Maintenance	Strategic Berm Removal & Setback Berm Construction	Yellow River Downstream Improvements	Bridge Removal / Replacement	Storage Areas to Offset Increased Runoff	Annual	Cumulative Spending
2019	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
2020	$328,286	$517,500	$54,725	$117,000	$232,875	$1,088,400	$0	$0	$315,000	$2,653,786	$2,653,786
2021	$1,367,186	$517,500	$54,725	$0	$232,875	$1,469,025	$0	$0	$315,000	$3,956,311	$6,610,096
2022	$1,367,186	$517,500	$54,725	$0	$232,875	$1,469,025	$0	$0	$315,000	$3,956,311	$10,566,407
2023	$1,367,186	$517,500	$54,725	$0	$232,875	$1,469,025	$0	$0	$315,000	$3,956,311	$14,522,718
2024	$1,367,186	$517,500	$54,725	$0	$232,875	$1,469,025	$0	$0	$315,000	$3,956,311	$18,479,029
2025	$1,367,186	$517,500	$54,725	$0	$232,875	$1,469,025	$0	$0	$315,000	$3,956,311	$22,435,339
2026	$1,367,186	$517,500	$54,725	$0	$232,875	$1,469,025	$0	$0	$315,000	$3,956,311	$26,391,650
2027	$1,038,900	$258,750	$54,725	$0	$232,875	$1,469,025	$0	$1,054,500	$315,000	$4,423,775	$30,815,425
2028	$1,038,900	$225,300	$54,725	$0	$232,875	$1,469,025	$0	$1,054,500	$315,000	$4,390,325	$35,205,750
2029	$1,038,900	$225,300	$54,725	$0	$232,875	$1,469,025	$0	$1,054,500	$315,000	$4,390,325	$39,596,075
2030	$1,038,900	$225,300	$54,725	$0	$232,875	$1,469,025	$1,707,800	$753,500	$315,000	$5,797,125	$45,393,200
2031	$1,038,900	$225,300	$54,725	$0	$232,875	$1,469,025	$1,707,800	$753,500	$315,000	$5,797,125	$51,190,325
2032	$1,038,900	$225,300	$54,725	$0	$232,875	$1,469,025	$1,707,800	$753,500	$315,000	$5,797,125	$56,987,450
2033	$1,038,900	$0	$54,725	$0	$232,875	$1,469,025	$1,247,800	$753,500	$315,000	$5,111,825	$62,099,275
2034	$1,038,900	$0	$54,725	$0	$232,875	$1,469,025	$1,247,800	$753,500	$315,000	$5,111,825	$67,211,100
2035	$1,038,900	$0	$54,725	$0	$232,875	$1,469,025	$1,247,800	$753,500	$315,000	$5,111,825	$72,322,925
2036	$1,038,900	$0	$54,725	$0	$232,875	$1,469,025	$1,247,800	$753,500	$315,000	$5,111,825	$77,434,750
2037	$1,038,900	$0	$54,725	$0	$232,875	$1,469,025	$1,247,800	$0	$315,000	$4,358,325	$81,793,075
2038	$1,038,900	$0	$54,725	$0	$232,875	$1,469,025	$1,247,800	$0	$315,000	$4,358,325	$86,151,400
2039	$1,038,900	$0	$54,725	$0	$232,875	$1,469,025	$1,247,800	$0	$315,000	$4,358,325	$90,509,725
2040	$1,038,900	$0	$54,725	$0	$232,875	$1,469,025	$0	$0	$315,000	$3,110,525	$93,620,250
2041	$0	$0	$54,725	$0	$232,875	$1,469,025	$0	$0	$315,000	$2,071,625	$95,691,875
2042	$0	$0	$54,725	$0	$232,875	$1,469,025	$0	$0	$315,000	$2,071,625	$97,763,500
2043	$0	$0	$54,725	$0	$232,875	$1,469,025	$0	$0	$315,000	$2,071,625	$99,835,125
2044	$0	$0	$54,725	$0	$232,875	$1,469,025	$0	$0	$315,000	$2,071,625	$101,906,750
2045	$0	$0	$54,725	$0	$232,875	$1,469,025	$0	$0	$315,000	$2,071,625	$103,978,375
2046	$0	$0	$54,725	$0	$232,875	$1,469,025	$0	$0	$315,000	$2,071,625	$106,050,000
2047	$0	$0	$54,725	$0	$232,875	$1,469,025	$0	$0	$315,000	$2,071,625	$108,121,625
2048	$0	$0	$54,725	$0	$232,875	$1,469,025	$0	$0	$315,000	$2,071,625	$110,193,250
2049	$0	$0	$54,725	$0	$232,875	$1,469,025	$0	$0	$315,000	$2,071,625	$112,264,875
2050	$0	$0	$54,725	$0	$232,875	$1,469,025	$0	$0	$315,000	$2,071,625	$114,336,500
2051	$0	$0	$54,725	$0	$232,875	$1,469,025	$0	$0	$315,000	$2,071,625	$116,408,125
2052	$0	$0	$54,725	$0	$232,875	$1,469,025	$0	$0	$315,000	$2,071,625	$118,479,750
2053	$0	$0	$54,725	$0	$232,875	$1,469,025	$0	$0	$315,000	$2,071,625	$120,551,375
2054	$0	$0	$54,725	$0	$232,875	$1,469,025	$0	$0	$315,000	$2,071,625	$122,623,000
2055	$0	$0	$54,725	$0	$232,875	$1,469,025	$0	$0	$315,000	$2,071,625	$124,694,625
2056	$0	$0	$54,725	$0	$232,875	$1,469,025	$0	$0	$315,000	$2,071,625	$126,766,250
2057	$0	$0	$54,725	$0	$232,875	$1,469,025	$0	$0	$315,000	$2,071,625	$128,837,875
2058	$0	$0	$54,725	$0	$232,875	$1,469,025	$0	$0	$315,000	$2,071,625	$130,909,500
2059	$0	$0	$54,725	$0	$232,875	$1,469,025	$0	$0	$315,000	$2,071,625	$132,981,125
2060	$0	$0	$0	$0	$0	$380,625	$0	$0	$0	$380,625	$133,361,750
TOTAL	**$23,076,000**	**$5,007,750**	**$2,189,000**	**$117,000**	**$9,315,000**	**$58,761,000**	**$13,858,000**	**$8,438,000**	**$12,600,000**	**$3,252,726**	**$133,361,750**

* Blue shading denotes the implementation period for the project, including both design and construction phases.

* Red text denotes project funding that requires bonding or funding partnerships as the funding requirement for the project cannot be reasonably funded in the conceptual implementation window for the work.

Option 1. Dredging and Clear-cutting

Kankakee River Dredging Proposal

Channel length to be dredged		
Project Length (mi)	90	miles
Average Cross section to be dredged		
Average channel bottom width (ft)	40	feet
Average channel depth of dredge (ft)	4	feet
Volume to be dredged	2,816,000	CY
Cost to dredge proposed length	$33,792,000	@ $12/CY
Mob/obstruction Demob every 5 miles	$1,425,000	
Clear-cutting of one-side levee	$1,440,000	
TOTAL	$36,657,000	
20 mile round trip hauling	$22,528,000	@ $8/CY
TOTAL w/HAULING	$59,185,000	
PER MILE COST	**$407,300**	
PER MILE COST w/HAULING	**$657,611**	

Yellow River Dredging Proposal

Channel length to be dredged		
Project Length (mi)	40	miles
Average Cross section to be dredged		
Average channel bottom width (ft)	40	feet
Average channel depth of dredge (ft)	4	feet
Volume to be dredged	1,251,556	CY
Cost to dredge proposed length	$15,018,667	@ $12/CY
Mob/obstruction Demob every 5 miles	$675,000	
Clear-cutting of one-side levee	$640,000	
TOTAL	$16,333,667	
20 mile round trip hauling	$10,012,444	@ $8/CY
TOTAL w/HAULING	$26,346,111	
PER MILE COST	**$408,342**	
PER MILE COST w/HAULING	**$658,653**	

- DISCLAIMERS
- **This price does not include many chargeable items.**
- Fees associated with design, bidding, inspection, construction auditing and observation have not been included.
- The cost estimate for hauling is a 2018 unit price. This is only for trucking and hauling. It does not include land acquisition for disposal, nor filling, nor any fees associated with private property disposal, nor double handling of material (only end-dumping).
- This project estimate includes only basic cost estimates of dredging material at $12/CY with side-casting and mob/demob every 5 miles at $75,000. This may not accurately reflect the number of actual mob/demob due to Federal, state, and local bridge heights may vary to allow passage. Hauling is estimated at $8/CY.
- This estimate does not include easements , access, environmental impacts and their associated costs.
- This estimate does not include any allowances for state or county road or bridge repairs, some of which have significant weight restrictions.
- The adjacent levees and embankments may be subject to seepage or slope instability. No allowances have been made for the cost of repair.
- This estimate does not include erosion control for disturbed ground surface.
- Clear-cutting assumes 8 large trees per river mile at a cost of $2000 per tree. One side of the river is assumed to be clear-cut.
- Tree and clear-cutting debris removal has not been included in the cost.