CITY OF BRAZIL WELLFIELD FEH MITIGATION ALONG BIG WALNUT CREEK

Prepared for:

Indiana University and the Indiana Office of Community and Rural Affairs (OCRA) in Support of the Development of the Indiana Fluvial Erosion Hazard Mitigation Manual, an Indiana Silver Jackets Initiative

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EXECUTIVE SUMMARY

This report documents the results and methodology used by Christopher B. Burke Engineering, LLC (CBBEL) to determine the root causes of and potential mitigation options for a fluvial erosion hazard (FEH) affecting a City of Brazil, Indiana wellfield along the Big Walnut Creek corridor. This assessment and preparation of this document was conducted in support of the development of the Indiana Fluvial Erosion Hazard Mitigation Manual, which was an initiative of the Indiana Silver Jackets, made possible through a grant from the Indiana Office of Community and Rural Affairs (OCRA). A FEH mitigation study was completed to identify the stressors leading to channel instability issues to develop conceptual mitigation solutions.

Big Walnut Creek is a major tributary to the Eel River; the watershed includes Bainbridge, Jamestown, Lizton, North Salem, and Greencastle. Channel instability and migration have been an issue for many years, most notably near the wellfield just south of Highway 40.

A system assessment of Big Walnut Creek was completed by CBBEL to identify the root causes of the erosion occurring near the at-risk wellhead. The system assessment included review of previous studies and analysis of available data that was focused primarily on the wellfield reach. The system assessment determined that five major factors are most responsible for the current channel instability and migration issues.

1. **Highly mobile channel material:** Observations made during site visits revealed a large amount of the channel material is highly erodible, fine-grained sand.
2. **Local hydrology:** An overflow path that begins at the wellfield site appears to have exacerbated the initial erosion at the site.
3. **Sediment ‘sinks’:** A large gravel pit just downstream of the wellfield may currently be contributing to channel instability and will likely cause more severe channel instability in the future.
4. **Channel incision and inadequate floodplain storage:** Confinement of the flow in the channel and the lost floodplain storage have resulted in significant erosion risk.
5. **Increased flow rates and flow volume:** Higher peak flow and more flow volume have resulted in longer-lasting and more erosive flows that destabilize the stream.

The observed bank migration rate at the FEH site and the distance from the stream to the wellhead suggest that improvements are not immediately necessary. A monitoring program should be established to evaluate the bank migration and level of instability in Big Walnut Creek near the gravel pit. If the migration rate increases, or a catastrophic failure of the bank occurs, consideration for a more proactive means of reducing the risk to the wellfield is warranted.

CBBEL evaluated strategies for mitigating the FEH at the wellhead and determined that the necessary improvements are relatively minor in the short-term. The improvements include toe protection, reducing the bank slope, and improving the erosion resistance in the overflow path and are expected to cost approximately $178,000 to implement. The long-term solution to preventing the instability in Big Walnut Creek from damaging the wellhead is more complicated due to the captured gravel pit downstream from the site. Additional evaluation is necessary to determine what measures would be necessary and to determine if it is practicable and more beneficial to correct the gravel pit rather than construct additional protective measures at the wellhead site.

CHAPTER 1 PROJECT OVERVIEW

1.1 INTRODUCTION

This report documents the results and methodology used by Christopher B. Burke Engineering, LLC (CBBEL) to determine the root causes of and potential mitigation options for a fluvial erosion hazard (FEH) affecting a City of Brazil, Indiana wellfield along the Big Walnut Creek corridor. This assessment and the preparation of this document was conducted in support of the development of the Indiana Fluvial Erosion Hazard Mitigation Manual. The development of the Manual was an initiative of the Indiana Silver Jackets, made possible through a grant from the Indiana Office of Community and Rural Affairs (OCRA). A FEH mitigation study approach was used to identify the stressors leading to channel instability issues near the Brazil wellfield and to aide in the development of conceptual mitigation solutions.

Figure 1: Stream Bank near Wellfield

1.2 PROJECT HISTORY

Big Walnut Creek is a major tributary to the Eel River, with a drainage area (DA) of 326 square-miles (mi^2). Big Walnut Creek begins in Boone County, and flows south through Putnam County where it joins Mill Creek just north of Poland, Indiana to create Eel River. The watershed primarily includes the main stem without significant upstream tributaries as the orientation of the watershed is long and narrow, with a length-to-width ratio of approximately 5:1. The Big Walnut Creek Watershed extends north to the Boone County Airport south of Lebanon, Indiana and includes Bainbridge, Jamestown, Lizton, North Salem, and the majority of Greencastle. A map of the study area is shown in **Exhibit 1**. Channel instability and migration have been an issue with Big Walnut Creek for many years, most notably near the wellfield just south of Highway 40.

1.3 PROJECT PURPOSE

The purpose of the study is to determine a means of reducing the risk of damage to the existing wellhead near Brazil, Indiana due to erosion in Big Walnut Creek. A better understanding of Big Walnut Creek is required to determine the current characteristics of the channel and watershed, to identify the root causes of the channel instability, and to determine what, if any, mitigation strategies are warranted, applicable, and able to be implemented without detrimental impact to adjacent stream reaches.

1.4 ANALYSIS PROCESS

The project was completed in several successive phases. Phase I of the project included a significant data gathering effort. The information acquired during the data collection phase included local testimony collected during an initial stakeholders' meetings on June 17, 2016 and February 3, 2017, previous studies, observations from site visits, historical aerial photography, streamflow data, rainfall data, soils information, and land use data.

The second phase of the project consisted of the assimilation and processing of the data collected during Phase I to determine the major themes of the current morphologic condition of the site and the river system. The processed data were then used to identify the watershed- and local-scale stressors acting on the river system.

Phase III involved the development of conceptual solutions for the stressors identified in Phase II of the project. An implementation sequence of the recommended strategies was also developed during this portion of the work.

CHAPTER 2 DATA GATHERING

Existing data and previous studies, where available, were used as supporting information for the FEH mitigation study. Additional data and observations were collected to provide a more comprehensive understanding of the physical processes at work near the site and within the river system. The following sections detail the origin and use of existing datasets and applicable previous studies, as well as the type and extent of additional information gathered.

2.1 SOURCES OF DATA

Topography Data

The analysis of the Big Walnut Creek corridor near the site and watershed required detailed topographic information for various calculations. The 2012IndianaMap Digital Elevation Model (DEM) was used as the source of topographic data for bankfull width approximation, floodplain connectivity considerations, and as the terrain source for a two-dimensional hydraulic model. The IndianaMap DEM covers the entire Big Walnut Creek Watershed and has a 5-foot cell resolution, which is sufficient for producing 1-foot contours.

A limited site survey was completed by CBBEL on April 14, 2017 to allow for channel classification and confirmation of the 2012 DEM accuracy.

A topographic map of the Big Walnut Creek Watershed is provided in **Exhibit 2**.

Soil & Land Use Data

Information concerning the properties of the soil as well as the types and extent of land use practices in the area were necessary for a portion of the analysis. Soil information was obtained from the National Resource Conservation Service's (NRCS) Soil Survey Geographic Database (SSURGO).

Land use information was gathered from the 2011 National Land Cover Dataset (NLCD). Aerial photography from the 2012 IndianaMap Framework Dataset was inspected to generally confirm the land uses shown in the NLCD data.

The characterization of channel bed and bank material was completed using visual observation and the Quaternary Map of Indiana (Gray, 1989).

Rainfall Data

Rainfall information was gathered from several weather stations from the National Climatic Data Center (NCDC). This information was used to examine the changes in storm frequency, duration, and intensity over time.

Streamflow Data

Streamflow information served as a critical component to the hydrologic analysis completed as a part of this study. All streamflow information was obtained from the United States Geological Survey's (USGS) online portal.

Aerial Photography

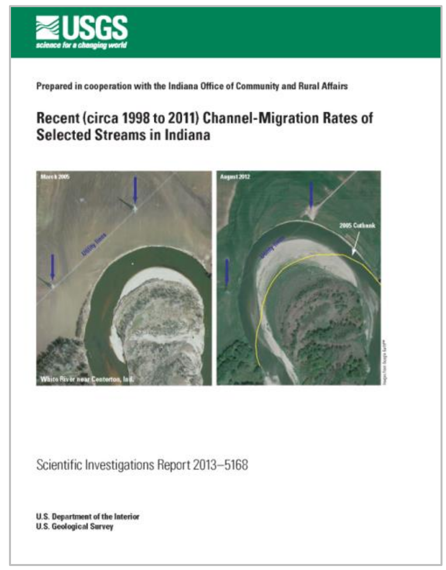
Aerial photography of the Big Walnut Creek Watershed was obtained from multiple sources. The primary source of aerial photography information was the 2012 IndianaMap Orthophotography. Historical aerial imagery was collected from Google Earth, as well as the Indiana Historical Society archives.

2.2 PREVIOUS STUDIES

The review of previous studies in the Big Walnut Creek Watershed was limited to hydrologic and hydraulic analyses, as well as a small number of other reports of significance to fluvial stability and flooding considerations.

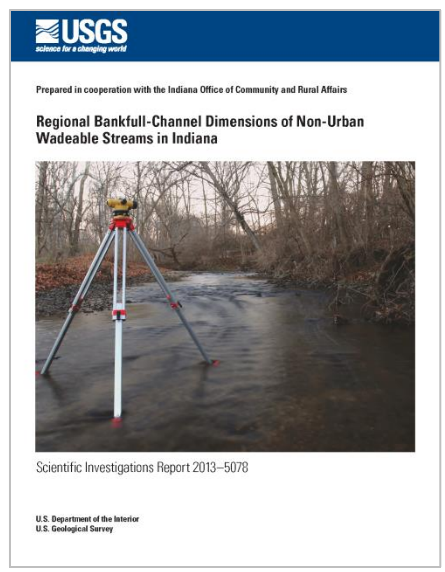
Recent (circa 1998 to 2011) Channel Migration Rates of Selected Streams in Indiana (USGS, 2013)

A total of 42 stream reaches in Indiana were measured to determine observed lateral migration rates of the streams, or how much a channel's banks shift relative to the surrounding land features. Lateral migration rates can be used as a surrogate for overall stream stability. The analysis completed by the USGS revealed that of the streams considered, Big Walnut Creek has the 5th highest lateral migration rate. The channel moves at a rate of almost 12 feet per year on average, with the maximum migration rate reaching a value of almost 23 feet per year.



Regional Bankfull Channel Dimensions of Non-Urban Wadeable Streams in Indiana (USGS, 2013)

Regionally-based relationships for channel dimensions were developed by analyzing data from streams throughout Indiana. The data was obtained from 81 streams that are non-urban, wadeable, and pristine or naturalized. The regional equations can be used to determine a channels departure from the expected dimensions as well as to aid in channel restoration design processes.



CHAPTER 3 FEH MITIGATION STUDY

The FEH mitigation study included consideration of the findings of previous studies, an extensive site investigation, and the contributing watershed area to the main stem of Big Walnut Creek. The FEH mitigation study was broken into three major categories of observations and analysis, including site assessment, watershed-scale assessment, and reach-scale assessment. The following paragraphs provide an overview of each component of the FEH mitigation study.

3.1 IDENTIFICATION OF ASSESSMENT REACH

The preliminary identification of an assessment reach is necessary to determine the extent of the stream that will be evaluated during the site assessment, to establish the portion of the overall watershed that should be considered during the watershed-scale assessment, and to provide an initial estimate of the extent of the reach-scale assessment.

A preliminary assessment reach is centered on the FEH location and extends a minimum of 12 bankfull widths in the upstream and downstream direction. The anticipated bankfull width of Big Walnut Creek at the location of the FEH was determined by applying the contributing drainage area at that point in the stream (316 mi^2) to the regional bankfull equations for the Central Till Plain in Indiana. An approximate bankfull width of 120 feet was determined. The preliminary assessment reach identified for the FEH site is shown in Figure 2.

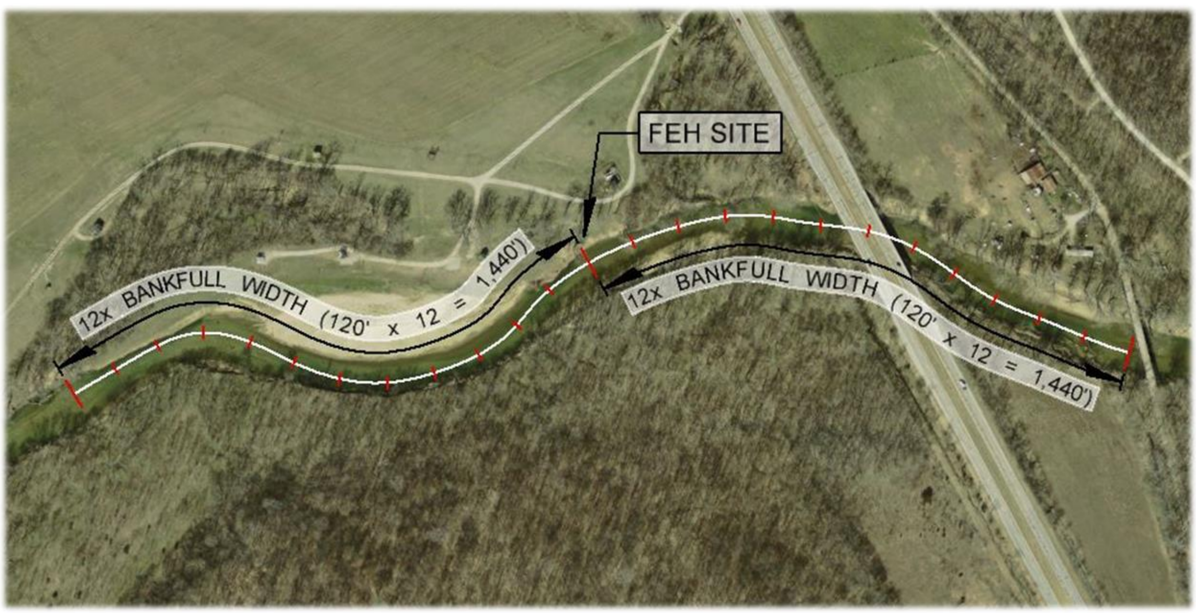


Figure 2: Preliminary Assessment Reach

3.2 SITE ASSESSMENT

Site visits were conducted on April 4 and 14, 2017 to observe the river corridor along the preliminary assessment reach to determine the characteristics of the channel, to help identify the physical processes occurring in the channel, and to assess the presence and condition of the habitat in the reach. Photographs from the site visit are provided in Appendix 1. The site observations focused on measuring key dimensions of the channel, evaluating the quality and availability of the in-stream and riparian habitat and locating signs of morphological change, or changes in the channel, such as scoured and/or failed streambanks, significant upland erosion, and sediment deposition.

3.2.1 Channel Properties and Level II Classification

Observations and representative measurements were made to allow for the assessment reach to be classified and to provide information that can be evaluated to determine if the channel should be expected to be relatively stable or unstable.

Big Walnut Creek is a C4/5 stream according to Rosgen Classification of Natural Rivers. A C4/5 stream is a slightly entrenched stream with moderate sinuosity, gentle slope, and gravel streambed. A copy of the field measurements and stream classification form is provided in Appendix 2.

The exposed soil profiles in the eroded streambanks through the assessment reach were observed to be primarily formed of sandy, mobile material, even at the toe of the slope. The lack of an erosion resistant material at the toe of the slope suggests that lateral migration and scour will continue.

3.2.2 Habitat Assessment

Aquatic and riparian resources were evaluated via habitat evaluation, fish sampling, aquatic macro-invertebrate evaluation, and wetland delineation.

The stream habitat quality was evaluated using the Qualitative Habitat Evaluation Index (QHEI), which uses channel substrate, instream cover, channel morphology, riparian zone and bank erosion, pool/glide and riffle/run quality, and stream gradient to characterize the diversity and robustness of the stream habitat. The QHEI score for the assessment reach was 77, indicating that the reach has habitat that is considered 'more diverse'.

Fish sampling and evaluation was completed by electrofishing and calculating an Index of Biotic Integrity (IBI). The resulting IBI score was 28, which is considered poor and is indicative of a stream that is dominated by a small number of species (8), with very few sensitive species (1) being observed.

Macro-invertebrate habitat was evaluated using the macro-invertebrate Index of Biotic Integrity (mIBI) which summarizes the macro-invertebrate community into a single pollution tolerance value. The mIBI score for the assessment reach was 32, which correlates to an impaired condition.

Figure 3: Wetland Area within Assessment Reach

The wooded riparian vegetation and mature physical structure of Big Walnut Creek helps to support habitat quality that is rated as good based on the QHEI protocol; however, macro-invertebrate and fish indices indicate impaired biological integrity. As a result, the overall quality habitat can be qualitatively described as Fair to Poor. Additional detail concerning the habitat assessment can be found in the water quality report in Appendix 2.

Wetland delineations were conducted using methods identified in the Regional Supplement to the Corps of Engineers Delineation Manual: Midwest Region (Version 2.0) (August 2010). Four wetlands and five streams were identified including Big Walnut Creek, a perennial stream under both state and federal jurisdiction. See Appendix 2 for the Big Walnut Creek Wetland Delineation Report. Forested wetlands provide high-value habitat; as a result, the wetland areas should be protected if the recommended improvements include adjacent work. The full wetland delineation report is provided in Appendix 2.

3.2.3 Channel Stability Assessment

An assessment of channel stability was completed using the Bank Erosion Hazard Index and the Phankuch-Rosgen Stability Rank to qualitatively define the level of instability present in Big Walnut Creek in the assessment reach. Evaluations using both methods were determined at 2 representative locations within the assessment reach, one on either side of the FEH site. Calculation sheets for each type of evaluation are provided in Appendix 2.

Bank Erosion Hazard Index

The Bank Erosion Hazard Index (BEHI) is used to assess the condition of channel banks and the potential for erosion by characterizing bank geometry and vegetation. The upstream and downstream BEHI scores were 37 and 59, respectively, indicating that while the downstream reach is far more prone to bank erosion, both areas have a significant risk of bank erosion.

Phankuch-Rosgen Stability Rank

The Phankuch-Rosgen stream channel stability ranking procedure uses detailed observations of the upper and lower banks, channel bottom, and stream classification to characterize a stream as stable, moderately unstable, or unstable. The upstream portion of the assessment reach was determined to be moderately unstable, while the downstream portion of the assessment reach was determined to be unstable.

Figure 4: Representative Locations
Upstream (above), Downstream (below)

3.3 WATERSHED-SCALE ASSESSMENT

An evaluation of the contributing watershed was completed to determine if there are systemic issues contributing to the instability noted at the FEH site. The watershed assessment was also used to determine the potential causes of observed changes at the site.

3.3.1 Rainfall Analysis

The average annual precipitation in the Big Walnut Creek Watershed is approximately 43 inches.The annual precipitation has an increasing trend over the last 45 years, increasing by approximately 8 inches, or approximately 0.2 inches per year, as shown in Figure 5.

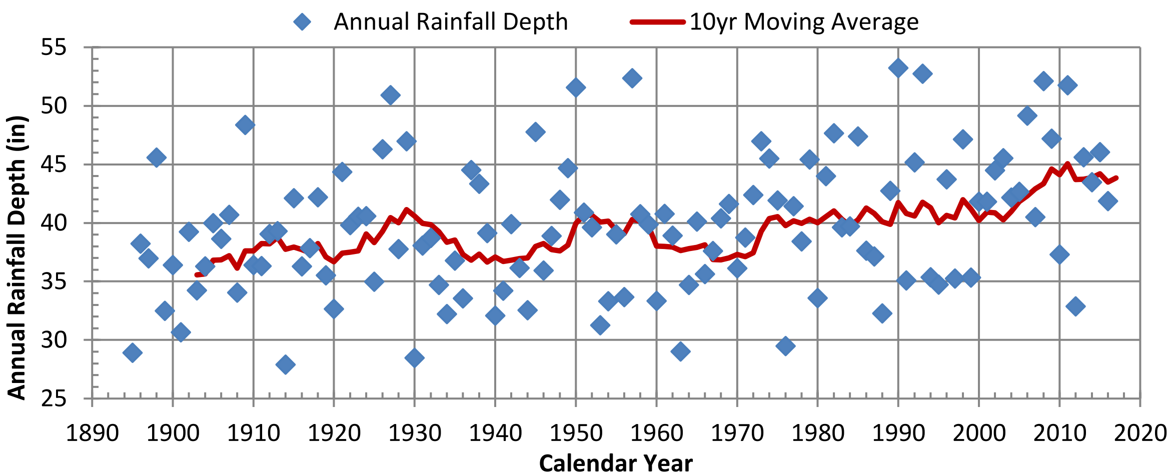


Figure 5: West Central Indiana Annual Rainfall Depth

More relevant with regards to erosion potential than annual average precipitation is the frequency of heavy rainfall events. Previous studies of National Weather Service data from 1958 to 2012 has shown that the Midwest has seen the amount of precipitation falling during the heaviest 1% of storms increase by 37%, as shown in Figure 6.

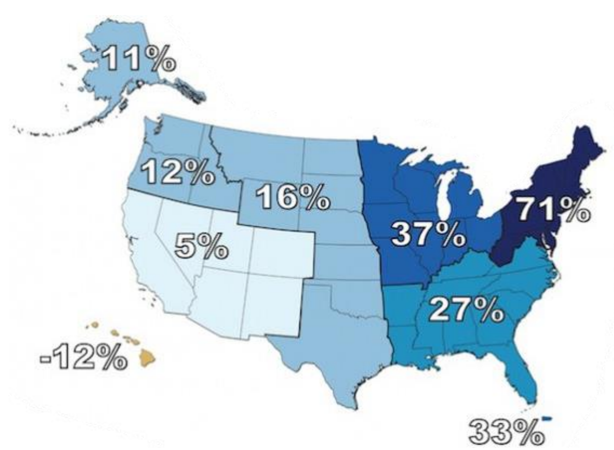


Figure 6: Change in Very Heavy Precipitation

Percent changes in the amount of rainfall falling in the heaviest 1% or rainfall events from 1958 – 2012, from the 2014 National Climate Assessment

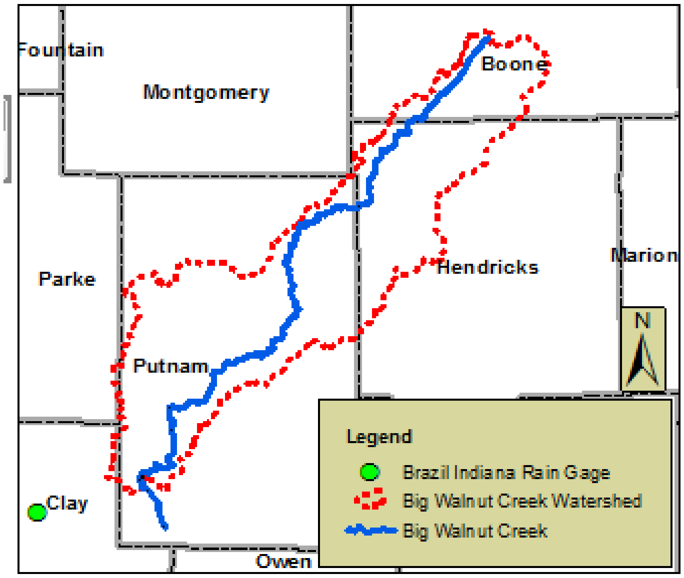


Figure 7: Brazil NCDC Rainfall Station Location

Analysis of local rainfall data (as measured at the Brazil gage) shows that the percentage of the annual rainfall depth that occurs during the heaviest 1% of rainfall events has remained relatively constant since the gage's installation in 1948.The percentage of rainfall falling during the heaviest events has ranged from 14% to 34%, with an average of approximately 23% per year.

Rainfall intensity can also be described by the depth of rainfall that occurs over a given duration. The rainfall depth for various event durations was analyzed for the Big Walnut Creek Watershed using the Brazil rain gage data. The analysis considered the depth of rainfall to occur in 5 given durations to determine how the intensity for the top 5% of the most severe events has changed over time. Figure 8 shows the 10-year moving average of the rainfall depth exceeded by only 5%- of events for each duration. The graphs show that in the vicinity of the rain gage, the rainfall intensities have been increasing in recent years.

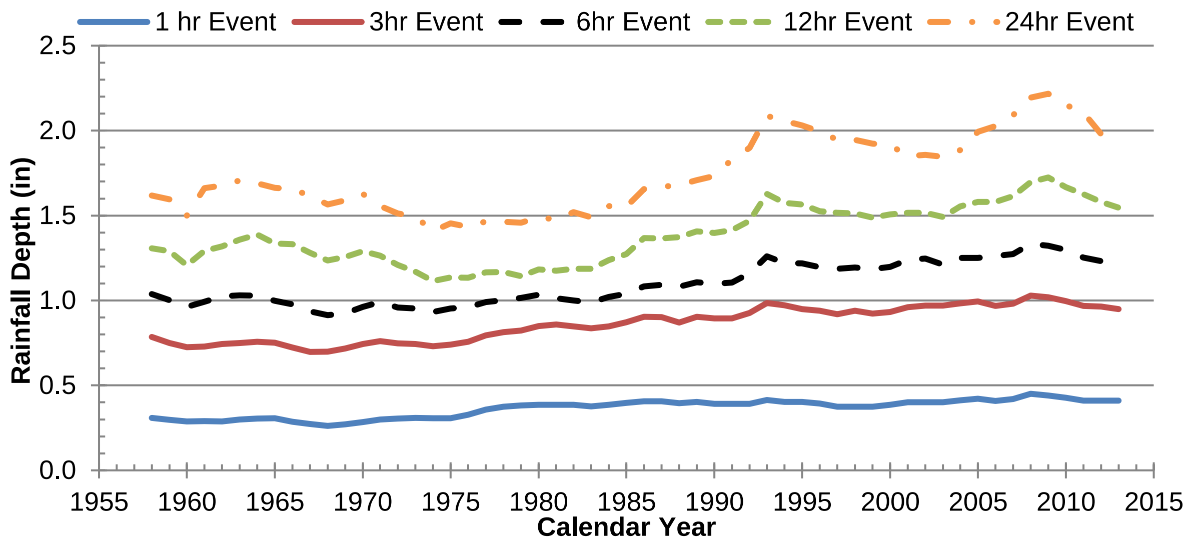


Figure 8: Rainfall Depth Exceeded by Top 5% of Events by Duration

(10-year Moving Average)

Though the analysis of the Brazil rain gage did identify a discernable trend in the frequency of heavy rainfall events, analysis of a single gaging station does not necessarily reflect climatic trends of an entire region, such as that noted in Figure 6.

3.3.2 Land Use Change

The current land use within the Big Walnut Creek Watershed is primarily a mix of agricultural and urban land. A summary of the different land use classifications in the watershed from 1992 to present day are provided in Table 1.

A slight shift in the proportion of agricultural, forested, and urban lands occurred between 1992 and 2001. There has been little change in the land use conditions in the watershed between 2001 and 2011.

Table 1: Land Use Summary

Watershed Land Use by Year (%)				
Land Use Description	**1992**	**2001**	**2006**	**2011**
Open Water	0.5%	0.5%	0.5%	0.5%
Urban	1.1%	3.5%	4.1%	3.7%
Barren / Rock	0.0%	0.0%	0.0%	0.0%
Forested	16.6%	23.0%	23.0%	23.1%
Shrub / Scrub	0.0%	0.0%	0.0%	0.0%
Grassland / Herbaceous	0.0%	0.6%	0.8%	0.6%
Agricultural	81.7%	72.3%	71.6%	72.1%
Wetland	0.1%	0.0%	0.0%	0.0%

Figure 9 shows a visual of the land use conversions that occurred between 1992 and 2011. The relatively small amount of change that has occurred to the land use intensity likely has no significant implications on the way that the watershed responds to rainfall, which is discussed more thoroughly in Section 3.3.1. A larger-scale image and data summary are provided in Appendix 3

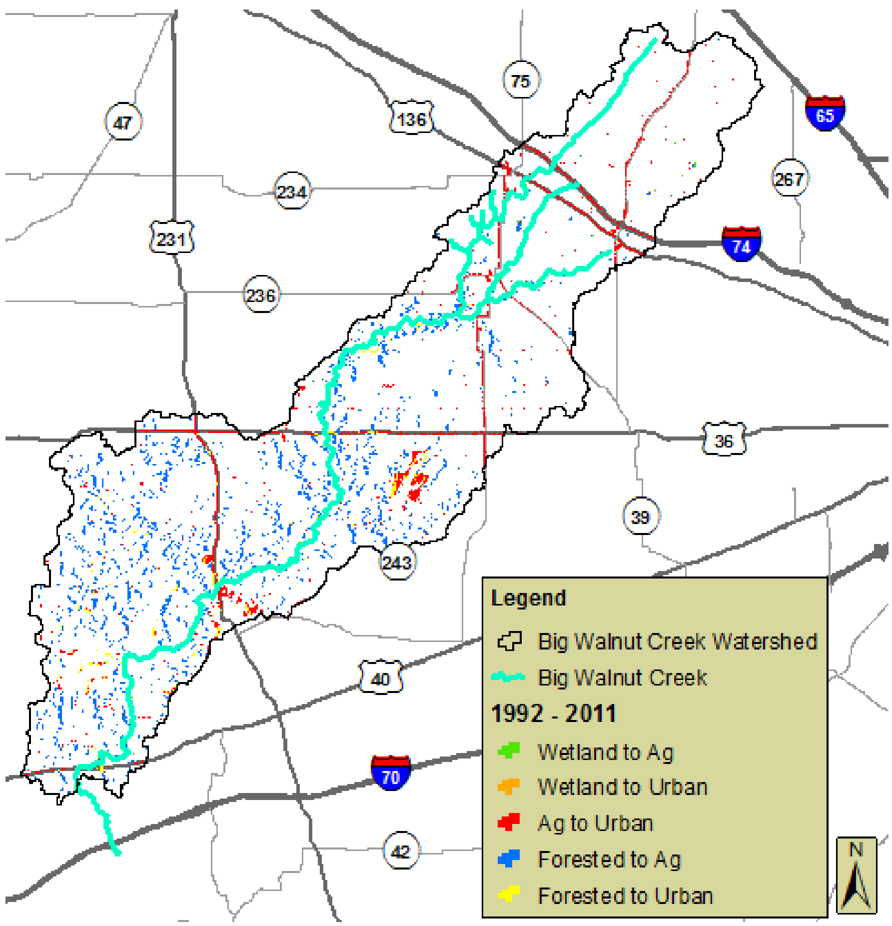


Figure 9: Land Use Conversion from 1992 - 2011

3.3.3 Watershed Hydrology

The response of a watershed to rainfall is a key factor in the amount of fluvial instability and flooding risk potential posed by a stream. The amount of runoff and the time required for the flow to reach the stream affect the erosive potential in the channel and determine how much flow must pass through the most restrictive sections of the channel, which may or may not result in significant flooding. Increased drainage efficiency in agricultural areas, urban development, and other intensive land uses frequently increase runoff and decrease infiltration. These changes often result in higher and more frequent peak flows, a larger volume of runoff, and a much faster response that can lead to flash floods.

Big Walnut Creek has two streamflow gages within the watershed, one near Reelsville and one near Roachdale. The Reelsville gage was in operation from 1949 to 2002 and is located near the downstream end of the project limits. The Roachdale gage is currently active and has been in service since 2001.The Roachdale gage is located upstream of the assessment reach. The gage data for both gages was analyzed to develop a relationship that correlates the flow from one gage to the other to allow the Reelsville gage record to be synthesized for the period from 2002 to the present; the relationship is shown in Figure 10.

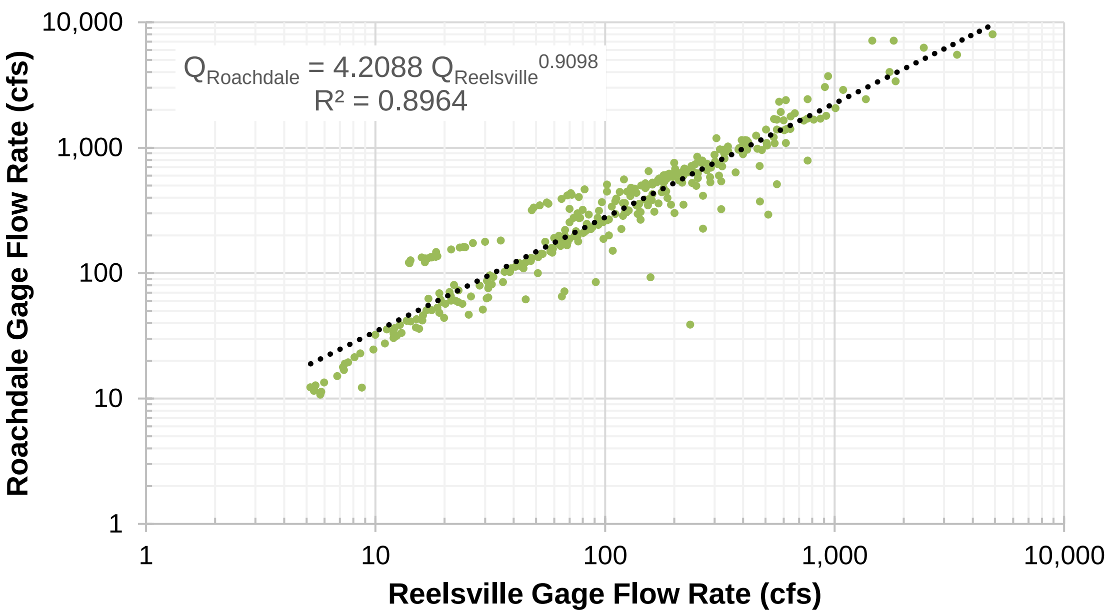


Figure 10: Correlation between Reelsville and Roachdale Gages

Figure 11 provides a plot of the peak annual flow rate for the Reelsville gage. The streamflow gage data shows the 10-year average peak annual flow rate has been increasing since 1985 and is slightly higher than the highest average in 1971.In 1985 the average peak annual flow was approximately 6,500 cubic-feet per second (cfs).By 2016 the average peak annual flow increased to approximately 13,100 cfs, more than double the 10-year average annual peak flow rate in 1985; this equates to an average of 2% increase each year for the past 31 years.

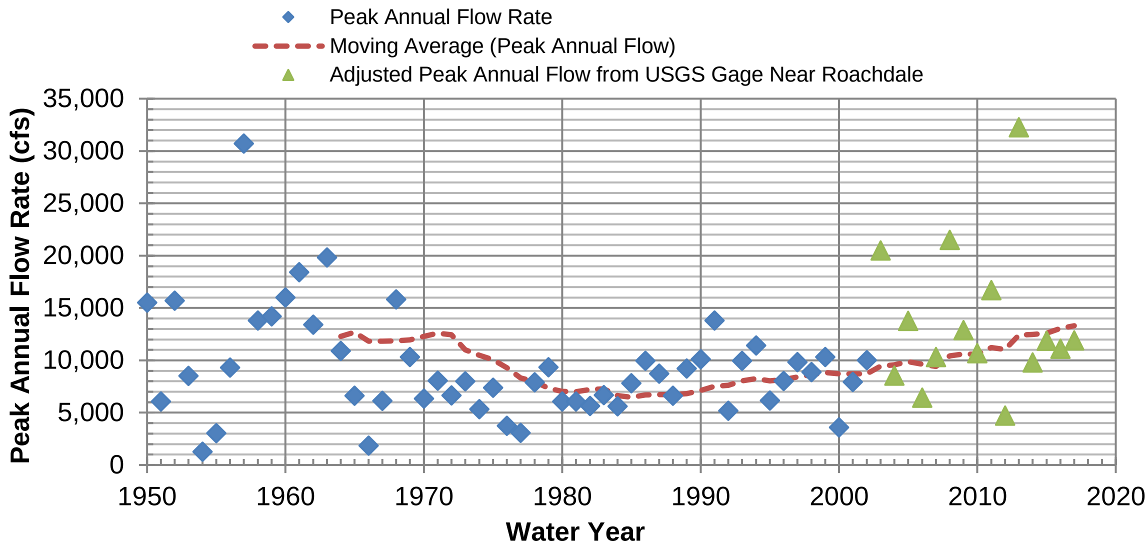


Figure 11: Peak Annual Flow Rate at USGS Gage in Reelsville, IN

It is important to remember that erosion can occur in streams at any flow rate. High flow rates obviously lead to high erosion rates; however, it is typically the 1.5-year flow rate (approximately bankfull) that statistically moves the most sediment over time and not the 100-year flow rate. This fact highlights the true nature of erosion in streams, a relatively slow and grinding process that is constantly reshaping the channel. A statistical analysis of the Big Walnut Creek gage data suggests that the 1.5-year flow rate is approximately 6,600 cfs. For a healthy stream, the 1.5-year flow rate will occur for a few hours every 18 months; in Big Walnut Creek, the 1.5-year flow rate has been occurring more frequently and for a longer duration since 1995 and now occurs [on average] for a full day each year, as shown in Figure 12.

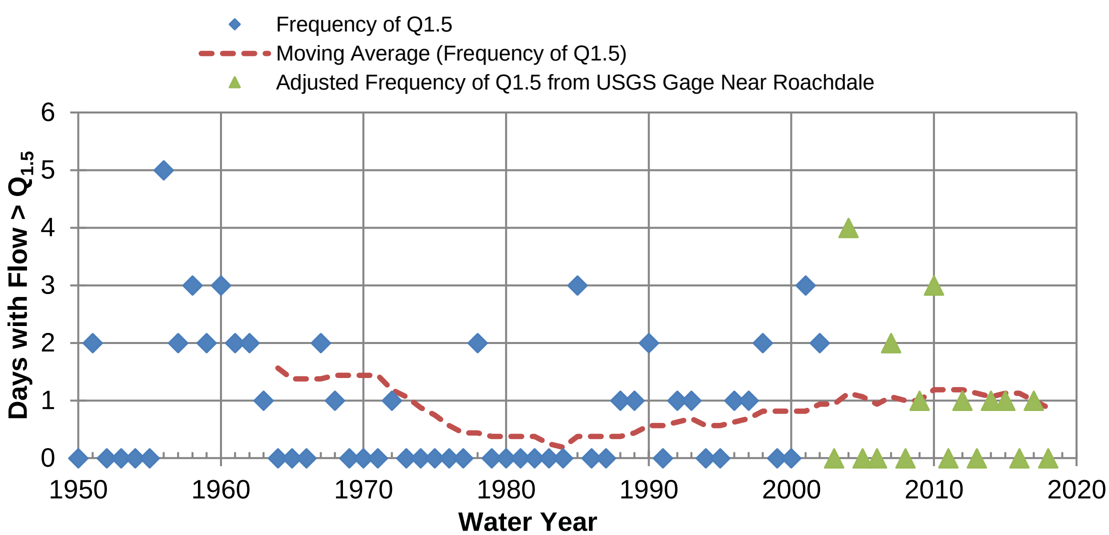


Figure 12: Frequency of 1.5-year Discharge at USGS Gage in Reelsville, IN

The increase in the amount of time when the channel is at bankfull conditions is partly due to the faster development of runoff in the watershed that results in increased peak flow rates, and it is also partly due to an increase in runoff volume.

The increase in annual rainfall and increased drainage efficiency of agricultural areas has caused a larger quantity of runoff volume during storm events. For reference, 1 acre-foot (ac-ft) of water is approximately equal to a full football field covered with 1 foot of water. Figure 13 shows the average daily flow volume for Big Walnut Creek, which has increased from 620 ac-ft in 1950 to 860 ac-ft in 2015; this equates to a 39% increase in flow volume. The rain-adjusted flow volume trend provides an indication of how much the increased rainfall depth may be affecting the flow volume; the rain-adjusted flow volume in 2015 was 770 ac-ft, or approximately 24% more than 1950, still a very significant increase.

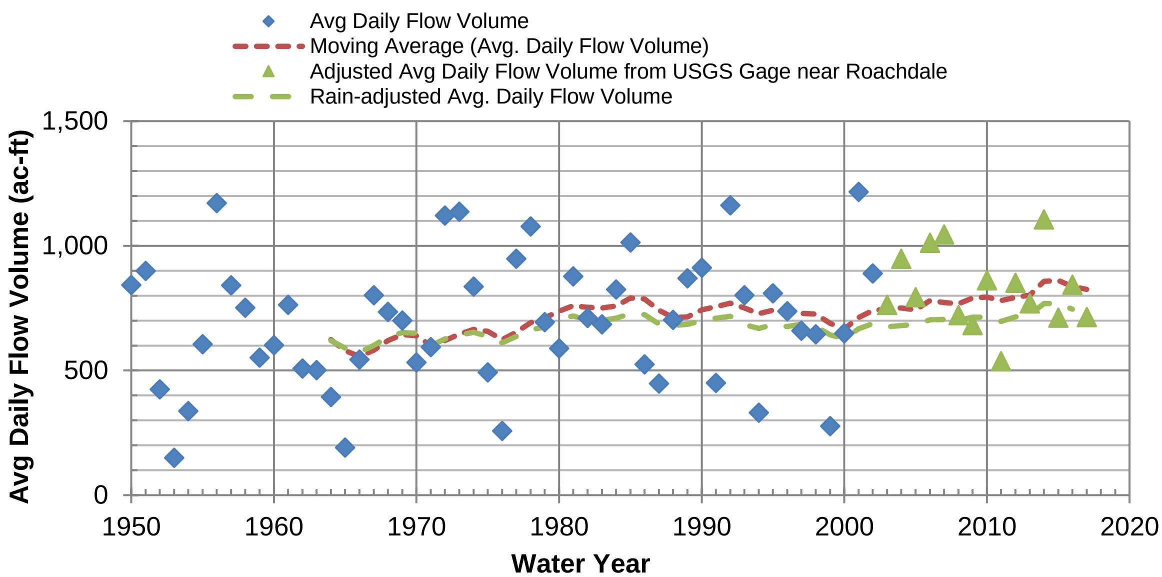


Figure 13: Average Daily Flow Volume at USGS Gage in Reelsville, IN

3.3.4 Comparison of Channel Dimensions to Regional Curves

The apparent bankfull width of the channel was determined at 13 locations along Big Walnut Creek. The measurements were made using the IndianaMap DEM to determine the channel geometry. The method used is expected to produce slightly wider bankfull widths than would likely be observed if field measurements were taken; despite this inherent exaggeration, the values shown in Table 2 can provide an understanding of the departure from bankfull widths calculated using regional curves. “Regional curves” are developed relationships between drainage area and bankfull channel dimensions. The Indiana regional curves were developed in 2013 by the USGS by measuring stream channel dimensions in some of the most natural or least disturbed stream reaches in Indiana and can be invaluable in understanding how modified a stream reach may be.

Moderate deviation from the expected value is evident through the area from upstream of US 40 continuing to location of the USGS gage near Reelsville. It should be noted that the channel passes through alluvium in all areas where the stream is significantly over-widened. A map of the measurement locations is provided in Appendix 3.

Table 2:Comparison of Observed Channel Properties with Regional Curves

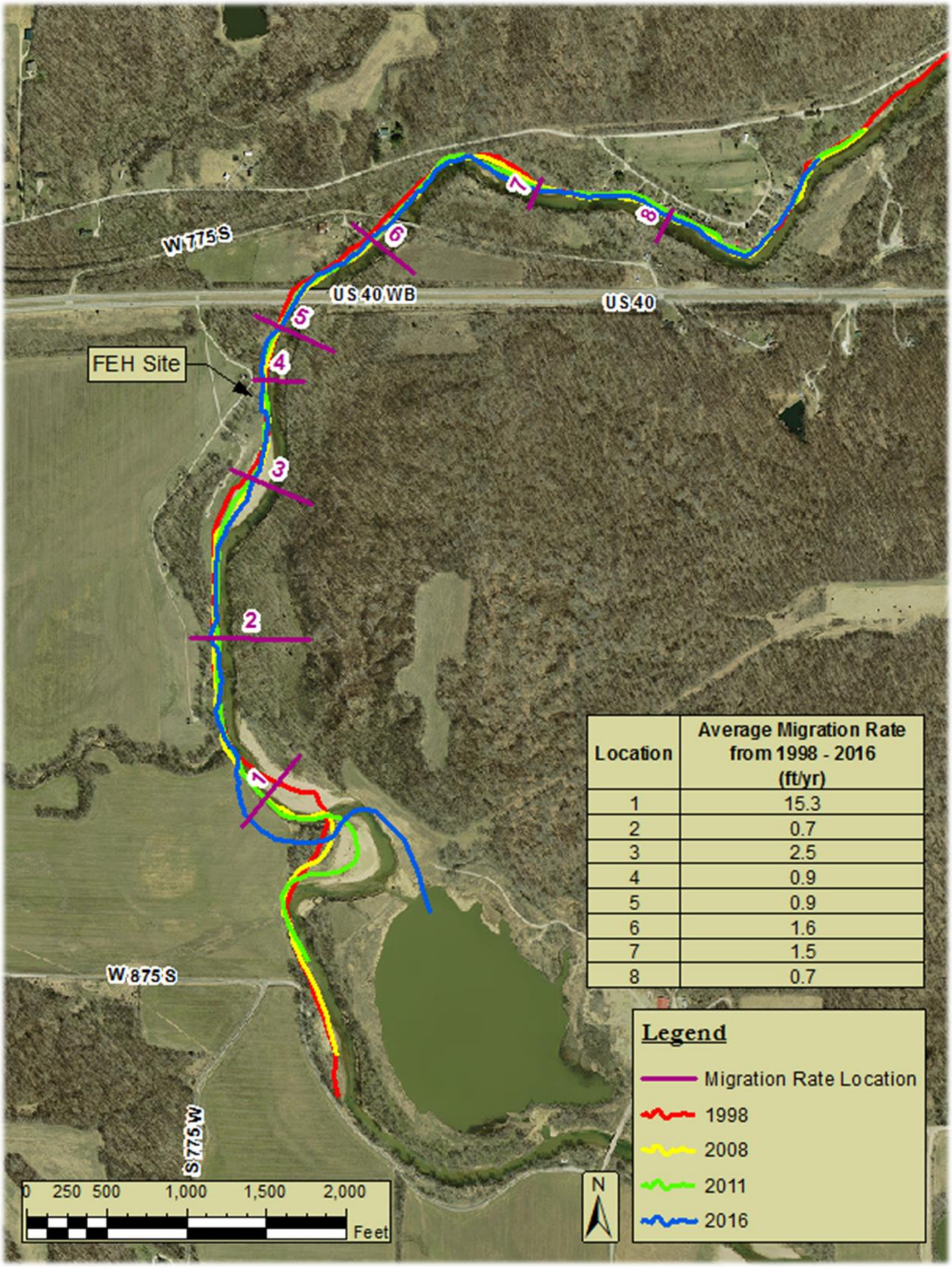
Measurement Location	Drainage Area (sq. mi.)	Approximate Bankfull Width* (ft)	Predicted Bankfull Width** (ft)	Departure from Expected Bankfull Width (ft [%])	Surficial Geology at Measurement Location
1	119.4	85	87	2 ft [-2%]	Siltstone and Shale
2	131.0	95	90	5 ft [6%]	Alluvium
3	154.6	105	95	10 ft [11%]	Alluvium
4	162.6	110	96	14 ft [14%]	Alluvium
5	194.4	120	102	18 ft [18%]	Alluvium
6	208.0	110	104	6 ft [6%]	Alluvium
7	215.5	110	105	5 ft [4%]	Alluvium
8	293.6	105	117	12 ft [-10%]	Alluvium
9	303.6	115	118	3 ft [-3%]	Alluvium
10	315.1	100	119	19 ft [-16%]	Sandstone, Shale, and
11	316.2	135	120	15 ft [13%]	Alluvium
12	326.0	145	121	24 ft [20%]	Alluvium
13	331.8	120	121	1 ft [-1%]	Alluvium

*Approximate bankfull width measured from cross-sections of the IndianaMap DEM channel width was measured at an elevation that was the predicted bankfull depth above the invert of the cross-section. This method is expected to produce bankfull widths that will be slightly wider than those that would be measured in the field (if bankfull indicators could be reasonably identified).
**Predicted bankfull width and depth determined using the Central Till Plain Region regression equations published by the USGS in Regional Bankfull-Channel Dimensions of Non-Urban Wadeable Streams in Indiana.

3.3.5 Lateral Migration Analysis

CBBEL completed a comparison of historical imagery for the assessment reach to determine the apparent migration rate of 11 locations over an 18-year period (1998 – 2016). The streambank was traced in each image to allow for a consistent means of measurement and to provide visualization of the lateral migration. Figure 14 and Figure 15 illustrate the channel migration over the 18-year period. The alignment of both banks were traced using aerials from 1998, 2008, 2011, and 2016.The migration rates for the assessment reach banks were similar to slightly higher than that of the neighboring sites on the Big Walnut Creek from the 2013 UGSG analysis of WC-4 and WC-5.The migration rate at WC-4 is higher than all but two of the USGS study locations along the Big Walnut Creek and is influenced by the instability caused by the gravel pit downstream of its location. The migration rate between Locations 1 and 3, shown in Figure 14, has increased between 2011 and 2016.

The highest lateral migration rate was observed at Location 1. Visual observation of the bank line tracings indicates that the lateral migration rate immediately downstream of the measurement location is even higher. The capture of the gravel pit appears to have a severe detrimental impact to the stability of the banks.



Location	Average Migration Rate from 1998 - 2016 (ft/yr)
1	15.3
2	0.7
3	2.5
4	0.9
5	0.9
6	1.6
7	1.5
8	0.7

Figure 14: Historical Lateral Migration along west bank of Big Walnut Creek

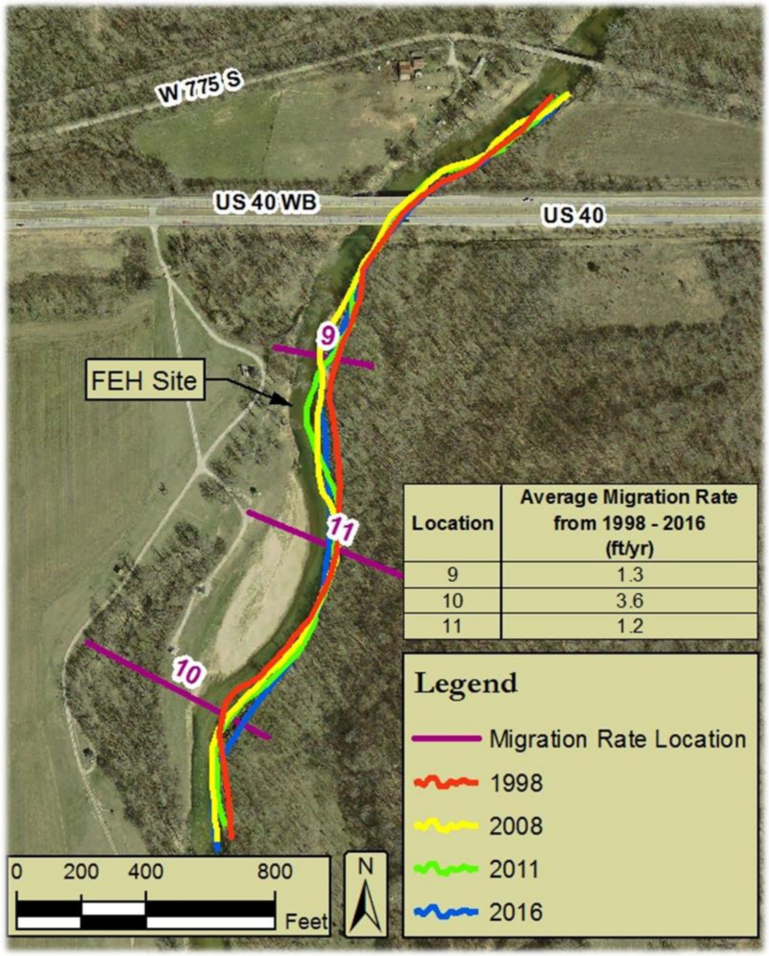


Figure 15: Historical Lateral Migration along east bank of Big Walnut Creek

3.3.6 Identification of At-Risk Infrastructure

The fluvial erosion hazard corridor for Putnam County was used to establish the at-risk area and which infrastructure would need to be evaluated. Each location within the assessment reach where significant infrastructure was located within the corridor was examined to determine the migration rate of the channel and the perceived risk level given the anticipated detrimental impact if the infrastructure was compromised. The risk level was determined according to the criteria in Table 3.

Table 4 provides a summary of all the at-risk infrastructure identified during the assessment, including the risk level and contributing factors. The table also includes the analysis locations from the 2013 USGS report.

Table 3: Risk Level Criteria

Risk Level	Stability Level	Impact to Public if Infrastructure is Compromised
High	Unstable	Minor Disruption → Severe risk to public health or loss of critical infrastructure
	Recently Stable / Transitional	Moderate Disruption → Severe risk to public health or loss of critical infrastructure
	Stable	Severe risk to public health or loss of critical infrastructure
Moderate	Unstable	Minor Disruption → Significant disturbance to daily commute/activities
	Recently Stable / Transitional	Moderate Disruption → Significant disturbance to daily commute/activities
	Stable	Significant disturbance to daily commute/activities
Low	Unstable	No disruption → Minor disruption to localized areas
	Recently Stable / Transitional	No disruption → Minor disruption to localized areas
	Stable	Minor disruption to localized areas

Table 4: Identification of Fluvial Erosion Hazards

Location	FEH Description	Impact of Compromised Infrastructure	Risk Level
CB-1	Road (CR 875 S)	Minor disruption to localized area	Low
CB-2	Gravel Pit	Potential destabilization of US & DS channel	Moderate
WC-4	WALNUT-4	-	-
CB-3	Refined Products Line	Potential disruption of utilities	Low
CB-4	Well	Severe risk to loss of critical infrastructure	High
CB-5	Well	Severe risk to loss of critical infrastructure	High
CB-6	Powerline	Potential disruption of power	Low
CB-7	Powerline	Potential disruption of power	Low
CB-8	Structure	Potential loss of life and homes	Low

3.4 REACH-SCALE ASSESSMENT

A more detailed evaluation of the assessment reach was completed to quantify the parameters needed to develop conceptual active management solutions. The analyses were also used to further improve the understanding of the local system. The following paragraphs summarize the additional analyses completed for the reach-scale assessment.

3.4.1 Refined Assessment Reach

The preliminary assessment reach extent was evaluated to determine if the detailed analyses should cover the entirety of the reach or if analysis and evaluation efforts could be limited to a smaller area. Figure 16 shows the extent of the preliminary assessment reach and the refined assessment reach.

Some of the analyses completed considered areas beyond the refined assessment reach but did so only to reduce the influence of assumptions and selected boundary conditions for the hydraulic model.

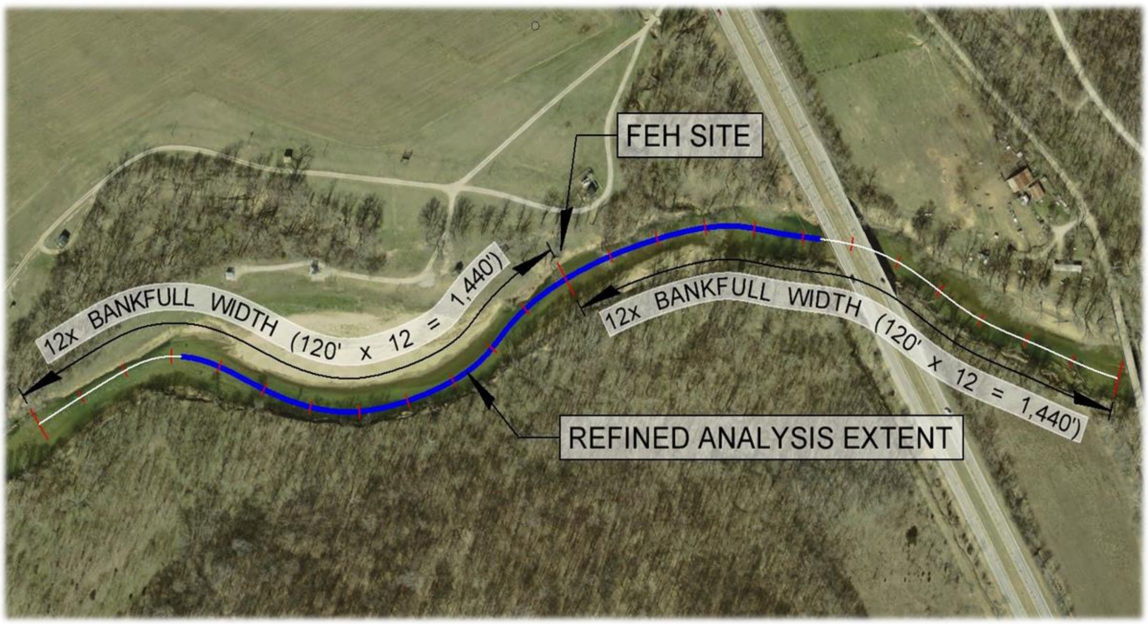


Figure 16: Preliminary Reach Limits vs. Refined Analysis Extent

3.4.2 Channel Forming Discharge Evaluation

The channel forming discharge was determined using two different methods: a gage analysis of the Reelsville USGS stream gage utilizing the Advisory Committee on Water Information (ACWI) B17C guidelines to determine the 1.5-year flow event (see Section 3.3.3), and a site assessment determination of bankfull discharge. The results of the B17C and bankfull discharge analysis are provided in Appendix 4. The channel forming discharge at the site was estimated to be 4,200 cfs, based on the results of the combined analyses, which roughly corresponds to the 1.3-year flow event.

The Big Walnut Creek has a sand and gravel streambed. Maintenance flows for a stream of this type should include the flow rate at which the larger particles on the bed is first mobilized, the bankfull or effective discharge, and the flow rate that activates and rejuvenates the floodplain. For a gravel-bed stream that has a large sand component, the corresponding maintenance flow rates are 0.6 Q_{BKF}, Q_{BKF}, and the 25-year flow event. These flow rates equate to 2,520 cfs, 4,200 cfs, and 16,200 cfs, respectively at the FEH site.

Maintenance flows are at greatest risk of being detrimentally affected in streams where the hydrology is being significantly altered by flow withdrawal or input. Big Walnut Creek largely functions in a natural hydrologic condition; however, modifications to the channel can alter the sediment transport in the stream, particularly bedload transport. It is important that any modifications made to the channel allow for the current channel maintenance flows to move sediment in the same fashion and at or near the same threshold values.

3.4.3 Hydraulic Analysis

A two-dimensional hydraulic model was developed for the refined assessment reach to determine the speed and direction of flow in the channel near the wellfield. The hydraulic model was configured to consider flows that ranged from baseflow conditions up to flows that overtop the channel banks. Additional information concerning the hydraulic model is provided in Appendix 4.

The results from the hydraulic model indicate that the maximum flow velocity in the refined assessment reach ranges from 1.6 to 5.0 feet per second (ft/s) for the flows considered. The anticipated velocities are sufficient to mobilize the soil forming the channel banks due to the small particle size and lack of sufficient cohesion. The outside bend is likely to continue experiencing erosion, causing continued migration of the meander bend.

During more severe flow events, the hydraulic model indicates that the flow leaves the channel just upstream of the at-risk wellhead location, where the streambank is currently eroded. The velocities where the flow leaves the channel range from 3.5 to 5.0 ft/s for events up to the 100-year flow. The velocities through the overflow path are 2 ft/s or less.

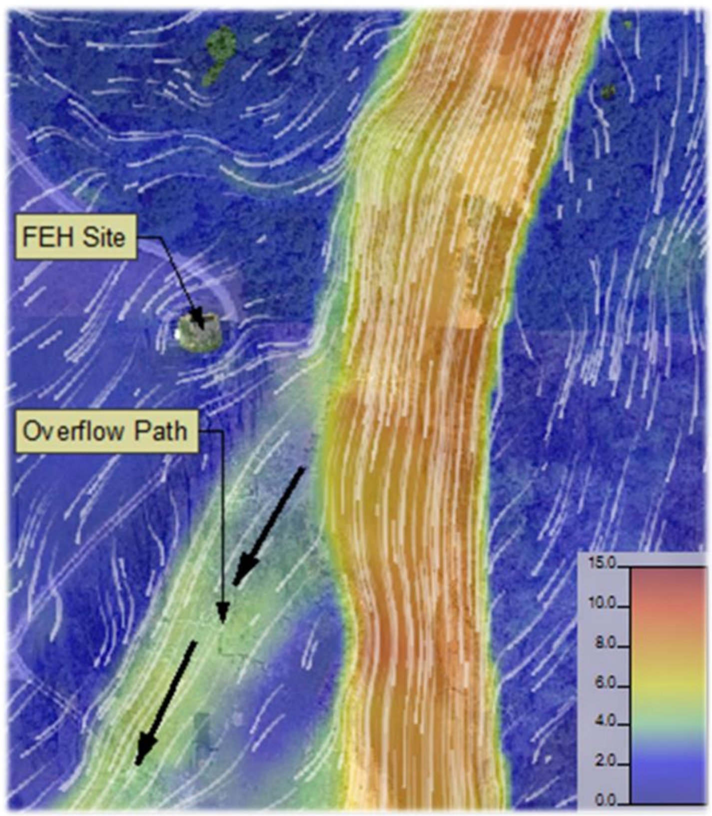


Figure 17: Overflow Path near FEH Site

The hydraulic model also included the area downstream of the assessment reach to reduce the impact of boundary condition assumptions, and to provide insights into the conveyance of flow through and around a gravel pit that has been captured by Big Walnut Creek. The high conveyance capacity of the large gravel pit causes the flow to accelerate through the upstream and downstream breaches in the gravel pit barrier. The increased velocities at the breaches have the potential to degrade the main channel bed and initiate [or continue] head-cutting in the upstream direction, potentially to, or beyond, the location of the at-risk wellhead. The diversion of flow through the gravel pit also produces a reduction of main channel velocity in the bypassed segment of the Big Walnut Creek. This reduction in velocity has the potential to increase sedimentation, which may lead to the abandonment of the reach over time.

3.4.4 Scour Evaluation & Sediment Competence

The results of the hydraulic model were used to compute general scour and bend scour the FEH site. The general scour calculations were completed using the Blodgett and Pemberton and Lara methods; bend scour was computed using the methodology outlined in the National Engineering Handbook Part 654 Chapter 9. The results of the analyses show that scour depth near the FEH site are expected to range from 3 to 6 feet for general scour, and from 3 to 8 feet for bend scour. Long-term channel degradation is not accounted for in the above-mentioned scour depths; however, it will likely be a significant factor due to the capture of the gravel pit, unless corrective actions are taken. Scour calculations are provided in Appendix 4.

An evaluation of long-term channel degradation was completed to evaluate the potential for the channel bed to be naturally armored by particles large enough that they are not mobilized and to determine the amount of degradation that is likely to occur should the capture of the gravel pit go uncorrected. The smallest armoring-particle size was determined using Borah's method from TS-14B of the Part 654 of the National Engineering Handbook, with the assumption that the 100-year event (about 20,800cfs) controlled the bed armoring process. Figure 198 shows the relationship between the flow rate in the channel and the largest mobile particle on the channel bed. Sediment competence calculations are provided in Appendix 4.

Due to the fact that over 60% of the channel materials are not of sufficient size to resist mobilization during the 1-year event (about 1,800 cfs), it does not appear likely that the channel will be naturally armored without considerable degradation, which will likely continue until the channel reaches the equilibrium slope. An equilibrium slope was not evaluated as the gravel pit causes any determination to be highly speculative.

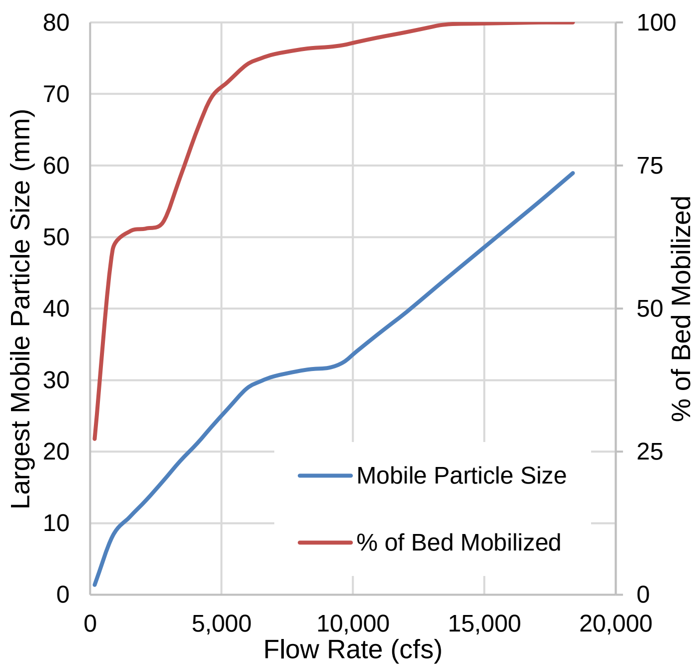


Figure 18: Sediment Competence Curve

3.5 KEY FINDINGS OF FEH MITIGATION STUDY

The most significant factors affecting the stability of the channel through the assessment reach identified during the FEH mitigation study are described in the following paragraphs. All the stressors identified are affected by at least one of the other stressors, creating a compounding effect that reduces the overall stability of the river.

Figure 19: FEH Site

Highly Mobile Channel Material

The material forming the bed and banks of the channel is primarily gravel-sized sediment with a significant amount of sand. Soil profiles in the banks and large gravel bars within the stream suggest that the material was previously and is currently highly-mobile, as confirmed by the sediment competence evaluation discussed in Section 3.4.4.The prevalence of erodible materials means that the stream will likely continue to be mobile for the foreseeable future due to the fact that it is infeasible to protect the entirety of the stream against erosion. The mobility of the channel sediments, given the inputs of water and sediment from the watershed, should be considered the primary cause of the stream's instability.

Figure 20: Erodible Channel Materials

Local Hydrology

The overflow path that begins at the FEH site appears to be exacerbating the initial erosion at the FEH site during relatively frequent events. The overflow path activates during events as low as the 2-year event, according the hydraulic model results. The increased flow velocity through the overflow can contribute to bank erosion, particularly because of the flow direction. Flow oriented toward the streambank imparts a significant amount of stress on the channel lining. Once the channel lining is disturbed, exposing the erodible bank materials, the erosion continues at a frequency that will effectively prevent the establishment of significant, erosion resistant vegetation that could stabilize the upper portion of the slope.

Sediment ‘Sinks’

Locations in a system that have essentially no capacity to carry sediment are referred to as sediment ‘sinks’. Sediment sinks can result in massive instabilities in streams with high sediment loads, such as Big Walnut Creek. The large gravel pit excavated near Big Walnut Creek, just downstream of the assessment reach serves as an enormous sediment sink when intercepted. Once the flow enters the gravel pit, the sediment transport capacity vanishes, allowing nearly all the sediment being carried to be deposited. Deposition will continue to occur until the gravel pit is filled to a level that is at or above the natural stream bed. This creates a tremendous imbalance in the sediment capacity and sediment supplied to the reach immediately downstream of the gravel pit. Once the flow re-enters the downstream channel the sediment capacity increases dramatically. The sediment supplied from the upstream reach (i.e. the gravel pit) is essentially non-existent leaving the sediment capacity to be harvested from the channel bed and banks. This is often referred to as the stream being ‘hungry’, as the bed and banks are rapidly eaten away. This type of stressor also leads to degradation of the channel bed upstream of the gravel pit, as described in Section 3.4.4.

Figure 21: Intercepted Gravel Pit near Reelsville, IN
(Google Earth, 2018)

Channel Incision & Inadequate Floodplain Storage

The long-term degradational trend for Big Walnut Creek has caused the channel to become incised and disconnected from the natural floodplain. The result of the channel incision and floodplain disconnection is that in many places the flow is confined to the channel and does not have the ability to be stored in a floodplain during a ‘bankfull’ event, or when the channel is flowing at the bankfull discharge. In healthy streams, the channel and floodplain are connected. This has significant benefit during flooding, as excess flow and sediment can exit the channel and be stored in the floodplain.

Figure 22: Incised Channel with Detached Floodplain
(Big Walnut Creek near Wellfield)

Increased Flow Rates and Flow Volume

The hydrologic analysis of the watershed discussed in Section 3.3 indicates that there is a significant amount of destabilizing activity in the watershed. The analysis of stream gage data shows a dramatic upward trend in the peak annual flow rate and indicates that a gradual climb in flow volume has occurred. Analysis of rainfall data shows that the rainfall depth and intensity have also increased, though not enough to completely explain the strong upward trend in flow rate and volume. There has been no significant land use change in the watershed to explain the remainder of the increases, which points to an increase in agricultural runoff production. Many agricultural areas in Indiana are making use of extensive tile drainage networks and surface draining to increase crop production; these systems also often lead to increases in runoff production.

The increased peak annual flow and flow volume may not be the primary factor affecting the stability of the assessment reach; however, longer-lasting and more erosive flows work to destabilize a stream. The magnitude and volume of the flow are detrimental in terms of increasing the sediment load of the stream, but the changing nature of those conditions often leads to instability, sometimes severe. Using Lane's Balance, shown in Figure 23, one can determine the effect of increased flow rates and flow volume. If the amount of water is increased on the right-hand side of the scale, it will tip, leading to degradation of the channel. Degradation should be expected to occur unless the channel boundary sediments coarsen, which the analysis of scour and bed armoring in Section 3.4.4 suggests is not likely.

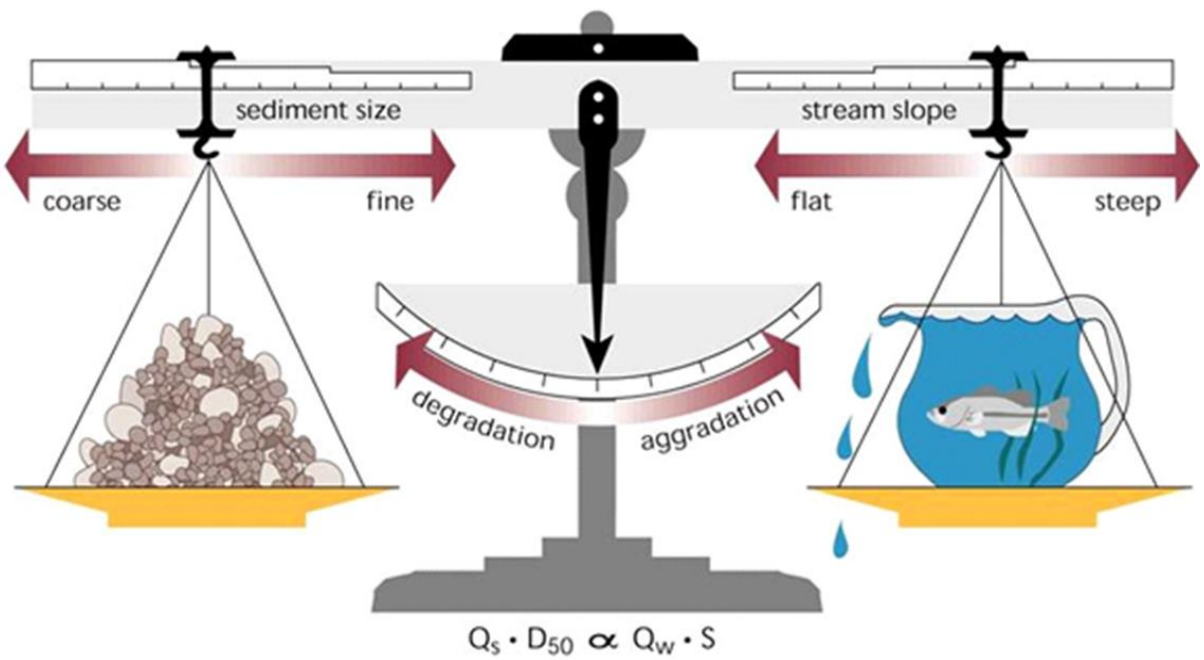


Figure 23:Lane's Balance
(USFWS, after Lane, 1955)

CHAPTER 4 STAKEHOLDER INPUT AND MITIGATION OBJECTIVES

The identification of the overall mitigation objectives is critical to the development of mitigation strategies and the success of the project. Establishing a clear decision-making process, evaluating the impairments to be addressed, and considering the potential improvements using a merit-based system is imperative to a prudent design. It is also important to identify what will constitute 'project success'. These factors should be considered by appropriate stakeholders.

4.1 DECISION MAKING PROCESS

The decision to proceed with a design of mitigation features will ultimately lie with the Brazil Water Utility. The conceptual improvements identified later in Chapters 5 and 6 were determined by the designer using the objectives noted below with consideration of the impairments to be mitigated and the likelihood of mitigation success.

4.2 MITIGATION OBJECTIVES

Conversations with Brazil Water Utility officials revealed concern over the long-term viability of the wellfield adjacent to Big Walnut Creek due to observations of severe streambank erosion. The following objectives were implied:

1. Prevent the stream from compromising the nearest wellhead [and all others]
2. Reduce the long-term FEH risk
3. Low maintenance need for improvements
4. Cost efficient construction

4.2.1 Impairments to be Mitigated

The FEH site has several impairments that must be considered to meet the mitigation objectives. The impairments are primarily local instabilities proximate to the FEH. The following issues must be addressed by the design:

1. Local flow acceleration through the overland flow path
2. General scour at the site, largely attributable to a highly erodible bed material
3. Peak annual flow rates that are on a significant increasing trend
4. Potential channel degradation due to the capture of the gravel pit downstream of the assessment reach

4.2.2 Functional Lift

The relatively small extent of the FEH of interest and the confining objectives for the project reduce the potential for providing function lift to the stream reach.

It may be possible to increase the stability of the immediately adjacent streambanks by better aligning flow during flooding events; however, unless the improvements extend well beyond the FEH site, negligible benefits should be expected elsewhere.

The amount of sediment load reduction or habitat construction possible for an FEH mitigation project in the assessment reach is not expected to provide significant benefit to the overall stream.

4.3 PRIORITIZED MITIGATION OBJECTIVES& PERFORMANCE METRICS

The mitigation objectives identified in Section 4.2 were provided in the order of priority that was understood from conversations with the Brazil Water Utility. The specific mitigation objectives have been expanded in the list below and are accompanied by designer-specified performance objectives intended to achieve the stated objectives:

1. **Prevent the stream from compromising the nearest wellhead [and all others]:**

   This mitigation objective will require active management strategies to effectively stop erosion in the vicinity of the at-risk wellhead. Prudent performance metrics for the improvements near the well include:

   A. Flow velocity during the 100-year event must be below the acceptable performance threshold of the surface cover/protection to prevent erosion during all but the most extreme of flow events.
   B. Flow vectors during the full range of flow events should be well aligned with the surface contouring inundated by and adjacent to the flow.

2. **Reduce the long-term FEH risk**

   This mitigation objective may include passive or active management strategies to reduce the risk of erosion near the at-risk wellhead or the likelihood that negative effects from the captured gravel pit would compromise the integrity of the implemented improvements at the FEH site. Specific performance metrics are as follows:

   A. Protect against long-term degradation, ideally by addressing the issue at the source (i.e. the gravel pit)
   B. Mitigation measures implemented in and adjacent to the stream should consider the potential for the peak annual flow rate to continue to rise for the engineering life-span of the project

3. **Low maintenance need for improvements**

   Low maintenance requirements hinge on the types of improvements designed and the types of materials selected. Maintenance need is heavily dependent on uncontrolled variables (e.g. severity and frequency of flooding, debris strikes, etc.). As a result, performance metrics are limited to anticipated outcomes rather than results of detailed analyses:

   A. Maintenance activities should be required no more frequently than once, annually.
   B. Material selections should have a long (20+ year) life-span to reduce or prevent the need to replace components of the project.

4. Cost efficient construction

Minimizing the project implementation cost requires evaluation of materials and active management stabilization methods used. Though the overall cost of the improvements cannot be accurately predicted or determined prior to the selection of active management treatments, generalized goals can be established:

A. The overall construction cost should be between $200 and $300 per foot of stabilized streambank.
B. The complexity of the design should be minimized to reduce installation costs and materials should be locally available and cost efficient.

CHAPTER 5 PASSIVE MANAGEMENT CONSIDERATIONS

Passive management strategies are most effective for addressing systemic issues that are watershed-based, or site-specific issues for a location that does not have a large contributing drainage area. As a result, the use of passive management strategies for mitigation of the FEH of interest is not a standalone solution to the problem; however, passive measures can often provide an increased benefit to the design of site-specific measures.

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.

The anticipated timeframe and likelihood of implementing passive management improvements does not match up well with the project objectives, particularly the interest in immediately protecting the closest wellhead. As a result, the implementation of passive measures would be required to occur under a parallel effort to the implementation of FEH mitigation measures.

CHAPTER 6 ACTIVE RIVER MANAGEMENT ANALYSIS

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. Active river management methods must address both vertical and lateral instability to be effective.

6.1 VERTICAL STABILITY CONSIDERATIONS

Improvements to the FEH mitigation site will need to address two potential sources of vertical instability: scour along the toe of the bank during significant flow events and the potential long-term degradation or head-cutting caused by the downstream gravel pit.

Toe protection measures are typically necessary for FEH mitigation sites that have vertical or horizontal stability issues due to the fact that a bank is not likely to remain stable if the toe is eroded. Toe protection usually comes in the form of large stone, concrete, or wooden revetment that is designed to be immobile, even during high flow events. For sandy stream beds, large, loosely-placed rock is not a suitable means of toe protection as the material can shift out of position when smaller materials are evacuated from around the unfiltered edges of the stone placement. If the revetment stone is effectively restrained, filtered, and installed to a sufficient depth, it can provide adequate toe protection. Toe wood is a bank stabilization technique suitable for sand bed streams that utilizes large woody materials (trees, branches, etc.) to protect the toe of a bank, while also providing redirection of the flow. An example of each type of toe protection measure is shown in Figure 24.

Grade control structures are often used to prevent the process of channel degradation, or the gradual lowering of the channel invert elevation due to erosion downstream propagating upstream. Grade control structures can be made of large, immobile stone, concrete, or sheet piling and span the width of the channel to stop the upstream migration of a headcut.

Figure 24: Toe Protection Measures
Riprap toe protection (top); soil lifts above toe wood (middle); toe wood (bottom)

6.2 LATERAL STABILITY CONSIDERATIONS

Failed, over-steepened, and undermined banks are unstable due to an inability to support the weight of the soil forming the bank. Where banks suffer from this type of geotechnical instability, a simple and cost-effective means of correcting the issue is to reduce the slope to a more stable angle, typically in the range of 3-feet horizontal to 1-foot vertical (3H:1V), or flatter.

Natural, healthy streams in Indiana typically meander and gradually move back and forth across their floodplain. In certain situations, such as this one, allowing the movement of the stream can endanger critical infrastructure. Utilizing an armoring system on the channel banks can help to prevent the natural erosion processes that allow the channel to move or change its shape in meaningful ways. Channel armoring is accomplished by installing a system that can withstand the flow velocity in the channel with negligible loss of bank and bed material over time; riprap, turf reinforcement mats, soil cement, etc. are examples of common armoring systems.

Figure 25: Armored Channel in Indianapolis, IN

Flow redirection includes altering the flow patterns that develop in a channel. The flow velocity through meander bends is typically higher around the outside of the bend along the bank. This creates a situation where weaker, unprotected bank materials can become significantly eroded and develop into what is known as a cut-bank. Cut-banks are areas along the outside of a meander bend that often suffer bank failures and are characterized by over-steepened or even vertical banks. The purpose of flow redirection is to realign flow that is directed toward the bank and to reduce the flow velocity along the bank. Flow redirection can be achieved by installing specialized structures, or by regrading the channel banks.

6.3 PROPOSED MITIGATION MEASURES

The type of mitigation techniques used to improve the stability of a stream is dependent on the type of instability present in the channel. The reach of Big Walnut Creek exhibits various forms of instability, including bank and overbank scour, potential vertical instability, and minor lateral migration. The proposed mitigation techniques considered and the portions of the stream to which the strategies are applicable are discussed below.

6.3.1 Evaluation of and Selection of Improvement Alternatives

There are different treatment methods available to address the different types of instability presented at the mitigation site. For vertical instability, treatments that provide toe protection are the most applicable. These treatments include toe wood, interlocking concrete jacks, and gabion baskets. For lateral instability, treatments that provide channel armoring are the most applicable. These treatments include gabion baskets, live stakes, and erosion control blanket systems. Each of the three types of toe protection were considered in conjunction with live stakes and erosion control blankets.

A triple bottom line comparison was completed for the three channel improvement alternatives to evaluate the economic costs, social benefits, and environmental benefits. A summary of the triple bottom line comparison is provided in Table 5. The complete triple bottom line decision matrix is included in Appendix 5.

Table 5: Triple Bottom Line Comparison of Improvement Alternatives

Improvement Alternative	Economic Score	Social Score	Environmental Score	Total Score
Toe Wood	2.6	1.3	3.2	**7.1**
Interlocking Concrete Jacks	2.2	1.0	2.8	**6.0**
Gabion Wall	1.8	1.0	2.5	**5.3**

Toe wood had the highest economic score because it was the least expensive and have low to moderate lifecycle cost. Gabion baskets were the most expensive and have moderate to high lifecycle cost. The interlocking concrete jacks have a low to moderate lifecycle cost but have a higher installation cost than toe wood.

Toe wood had the highest score for potential social benefits. All the protection types had a moderate to high benefit to public health and safety. Toe wood is expected to offer a limited benefit to quality to life due to the potential improvement for recreational use; the other two protection types provide no meaningful benefit beyond public health and safety. None of the protection types are expected to provide widespread benefit to properties or reduced flooding/drainage problems.

Toe wood had the highest environmental benefit score due to the potential for moderate to high improvement and/or protection to stream habitat; the other alternatives are not expected to meaningfully change the stream habitat. All the protection types provided a robust level of protection and did little to restore or protect the floodplain function of the stream. Gabion baskets could have some minor negative impacts to the adjacent stream reach due to a lack of energy dissipation.

6.3.2 Description of Improvements

The use of large woody debris (LWD), often referred to as ‘toe wood’, is a proven mitigation technique. It can be used to reinforce the toe of an over-steepened streambank or to protect the outside of a meander bank. The toe wood application can be made to adjust the bankfull dimensions of the channel, as well as to create floodplain benches. Erosion control blankets will be used to prevent erosion of the path near the wellfield. Toe wood had a triple bottom line score of 7.1, which was the highest of the treatments.

A schematic layout of the potential improvements is provided in **Exhibit 3**. As can be seen in the exhibit, significant impacts to the stream are required to install the treatments. It is anticipated that armoring the streambank would require the acquisition of the following environmental permits, at a minimum:

IDNR Construction in a Floodway

IDEM Section 401 Water Quality Certification

USACE Section 404 Dredge & Fill Permit

IDEM Rule 5 Permit

The recommended bank armoring detail, or any other stabilization method, should not be used indiscriminately along the channel to 'fix' the banks. The installation of bank armoring can result in increased erosion and instability downstream of the project that impacts adjacent properties. Strategic use with great attention to detail to integrate the improvements into the stream corridor is paramount to project success.

The cost of designing, permitting, and constructing these improvements is expected to be approximately $178,000. A detailed breakdown of the anticipated project cost is provided in Appendix 5.

6.3.3 Anticipated Performance

The improvements are expected to stabilize the streambank through the FEH site. Reinforcing the toe of the bank, adjusting the bank to provide a stable slope, and protecting the overflow path with erosion control blanket should provide sufficient resistance to erosion and prevent further migration. An evaluation of the mitigation objectives using the previously identified performance metrics is as follows:

1. **Prevent the stream from compromising the nearest wellhead [and all others]:**

   The anticipated maximum flow velocity during the 100-year event is 9.6 ft/s in the channel and 5.5 ft/s in the overflow path. Toe wood is a particularly robust system that is capable of withstanding velocities in excess of 8 ft/s. Most permanent erosion control blanket systems have a performance threshold of up to 9 ft/s in an unvegetated state. This performance metric is met, as both erosion prevention systems have adequate erosion resistance during the 100-year event.

   The adjustment of the western channel bank alignment and inclusion of a small shelf to improve the transition to the point bar cause the flow vectors to be much more well-aligned with the bank during the full range of flow events.

2. **Reduce the long-term FEH risk**

   The FEH site is protected against long-term degradation by using toe wood, which remains stable even when the structure is slightly undercut. Without acquiring the gravel pit property or establishing an agreement with the owner, designing significant improvements, and identifying a funding source for the remediation of the captured gravel pit, the problem cannot be addressed at the source. As a result, this performance metric is only partially met.

   The enlargement of the channel cross-section above the bankfull elevation increases the flow capacity in the immediate vicinity of the FEH site. As a result, the mitigation measures accommodate the potential for the peak annual flow rate to continue to rise to the greatest extent practicable given the improvements.

3. **Low maintenance need for improvements**

   The use of mitigation measures that are only vegetative on the surface reduces the difficulty of the required maintenance activities; in fact, the grass species used in conjunction with the erosion control blankets can be selected such that they do not need to be mowed to maintain a vigorous stand.

   When installed correctly, toe wood has an indefinite lifespan, as wood does not rot when continuously submerged in water. The use of non-degradable erosion control blankets and vegetation as reinforcement reduce the likelihood that the system would need to be augmented or replaced. Toe wood is also particularly tolerant of channel degradation and slight undermining of the structure. While this reduces the overall risk to the wellfield from the captured gravel pit downstream, it does not eliminate the issue.

4. Cost efficient construction

The overall construction cost for the improvements is anticipated to be approximately $178,000. The total length of stabilized streambank is 350 feet, resulting in a unit cost of $508 per foot. Typically, FEH mitigation measures only need to be installed along the streambank. The anticipated construction cost excluding the expense of reinforcing the overflow path is $345 per foot. The necessity to armor the overflow path should be further evaluated as the site ages. It may be possible to employ more effective vegetation management and forego the expense of armoring the overflow path.

The proposed methods are cost efficient and the materials should be locally available. Installing toe wood is an involved process that requires an experienced contractor to successfully implement; however, the overall goal is achieved.

CHAPTER 7 RECOMMENDATIONS

The results of the stream assessment described in Section 3.0 and the key factors influencing the stability of Big Walnut Creek described in Section 3.5 suggest that the issues are likely to persist and cannot be solved by correcting a problem in a specific location. However, the wellfield serves as critical infrastructure to Brazil, and should therefore be protected against damage from fluvial erosion. Monitoring the channel conditions at the FEH site and near the captured gravel pit will be a critical component to mitigating the fluvial erosion hazard at the wellfield.

7.1 MONITORING

The observed bank migration rate at the FEH site and the distance from the stream to the at-risk wellhead suggest that improvements are not immediately necessary, if the erosion continues to occur at the same rate. The location of the meander bend relative to the at-risk well should be monitored on an annual basis, and/or after significant flooding events. If the migration rate increases, or a catastrophic failure of the bank occurs, consideration for a more proactive means of reducing the risk to the wellhead is warranted.

The channel instability near the gravel pit downstream of the wellhead should also be monitored on a regular basis to identify the trend in the erosion and deposition, as well as the apparent impact to the upstream channel. Should conditions suggest that a wave of channel incision is occurring, additional analysis and evaluation of the instability should be completed, as discussed in Section 7.3.

7.2 IMPROVEMENT IMPLEMENTATION

Armoring approximately 350 feet of the bank at the FEH site is expected to prevent the lateral migration of the streambank. Reinforcing the toe of the bank, adjusting the upper portion of the bank to provide a stable slope, and protecting the upper slope and overflow path with erosion control blanket should provide sufficient resistance to erosion to prevent further migration. Exhibit 3 shows a typical section of the recommended method of bank armoring. Additional methods and treatments that are applicable for bank armoring exist; however, the recommended method was selected based on limiting the risk of failure while being sensitive to overall project cost.

7.3 GRAVEL PIT ANALYSIS

The potential impact of the main channel of Big Walnut Creek having captured the gravel pit downstream of the FEH site could be severe. Interception of the gravel pit will likely lead to potentially severe channel degradation that radiates in the upstream and downstream directions, further destabilizing the streambanks. It is recommended that a more detailed analysis of the gravel pit and proximate areas be conducted to determine what precautionary measures are warranted and would be sufficient to prevent further destabilization of Big Walnut Creek.

7.4 NEXT STEPS

The following steps are recommended to reduce the fluvial erosion hazard risk at the at-risk wellhead near Brazil:

1. Meet with CBBEL to discuss the findings and recommendations of this report.
2. Establish a monitoring plan that records the location of the streambank and other significant changes to the channel at the identified fluvial erosion hazard location, the gravel pit, and any additional FEH locations that may become a concern in the future.
3. Complete a master plan for the gravel pit to determine the precautionary measures necessary to prevent further destabilization of Big Walnut Creek.

CHAPTER 8 REFERENCES

Chow, V. T. (1959). Open-Channel Hydraulics. Caldwell: The Blackburn Press.

Leopold, L.B., Wolman, M.G., and Miller, J.P. (1964) Fluvial Processes in Geomorphology. Freeman, 522 p.

National Oceanic and Atmospheric Administration (NOAA). National Climatic Data Center (NCDC). *Hourly Rainfall Data for Indianapolis International Airport*. Available http://gis.ncdc.noaa.gov/map/viewer/.Accessed April 6, 2016.

Robinson, B.A., 2013, Recent (circa 1998 to 2011) channel-migration rates of selected streams in Indiana: U.S. Geological Survey, Scientific Investigations Report 2013–5168, 14 p. plus 1 app., http://pubs.usgs.gov/sir/2013/5168/.

Robinson, B.A., 2013, Regional bankfull-channel dimensions of non-urban wadeable streams in Indiana: U.S. Geological Survey, Scientific Investigations Report 2013-5078, 33 p.

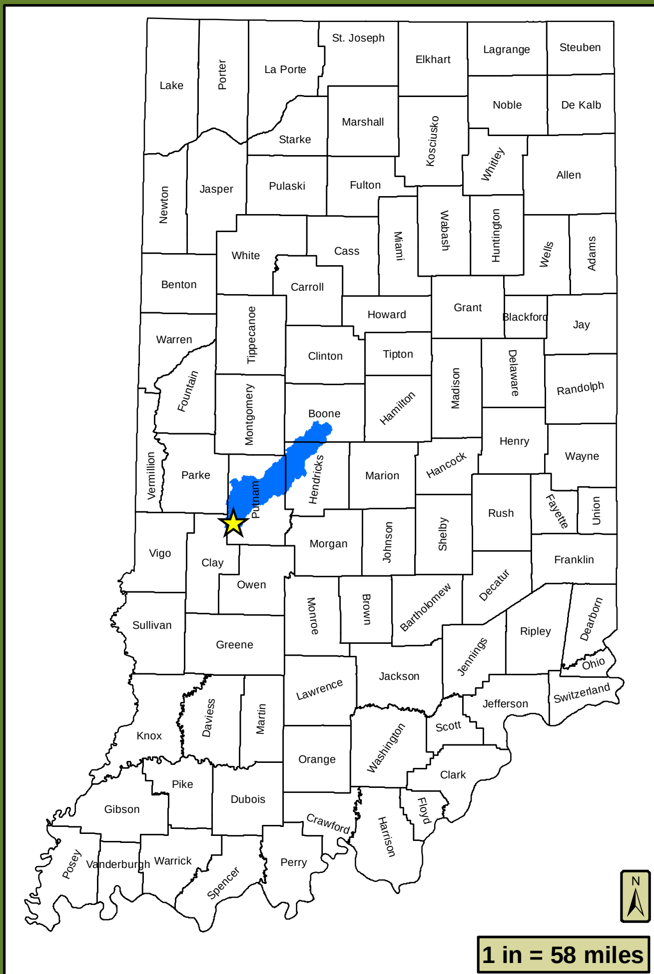
Rosgen, D, L. (1996) Applied River Morphology. Wildland Hydrology, variously paged.

United States Department of Agriculture. Natural Resources Conservation Service. Urban Hydrology for Small Watersheds (Technical Release 55). June 1986.

United States Geological Survey. Stream Gage Data for Station 03357500 Big Walnut Creek NEAR REELSVILLE, IN. Available http://maps.waterdata.usgs.gov/mapper. Accessed April 13, 2018.

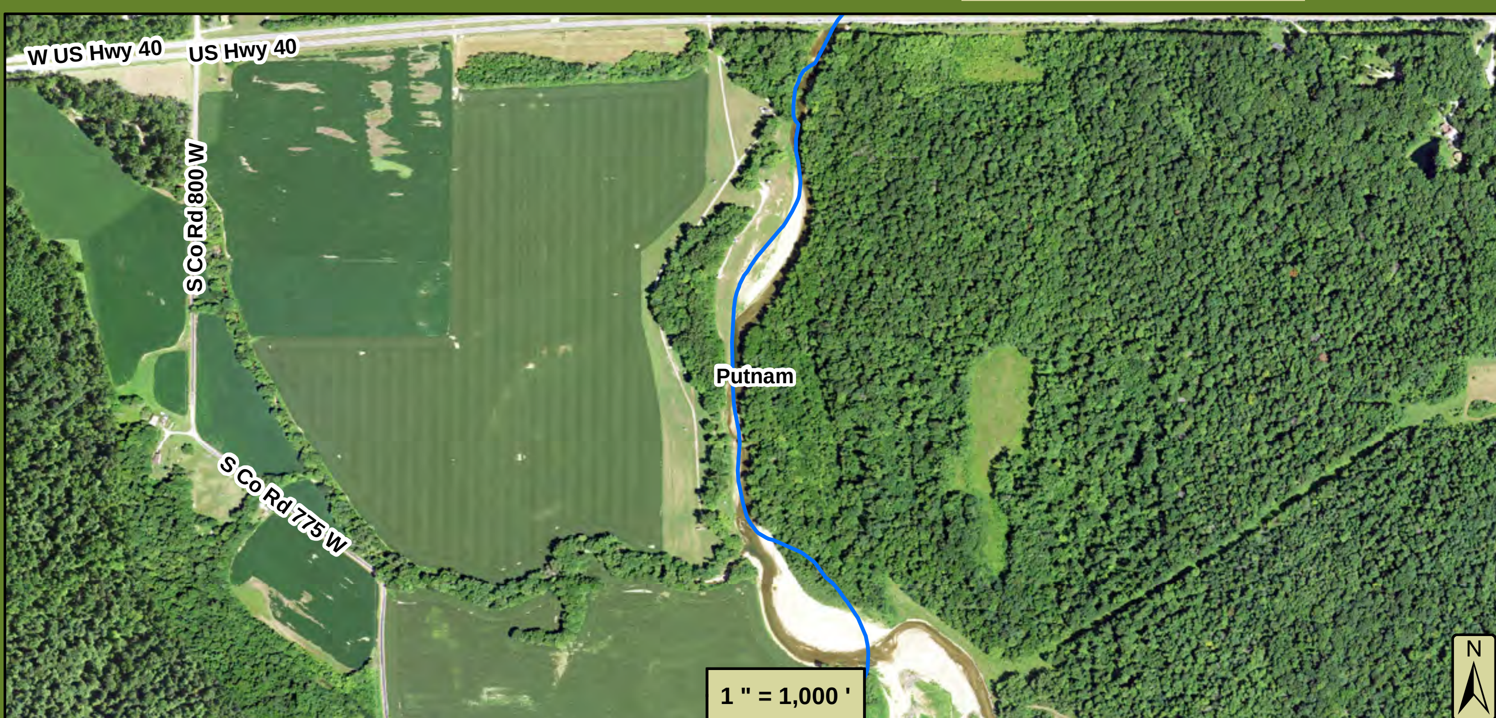
United States Geological Survey. Stream Gage Data for Station 03357330 Big Walnut Creek NEAR ROACHDALE, IN. Available http://maps.waterdata.usgs.gov/mapper. Accessed April 3, 2018.

Exhibits



STATE MAP

VICINITY MAP



STUDY AREA MAP

CB
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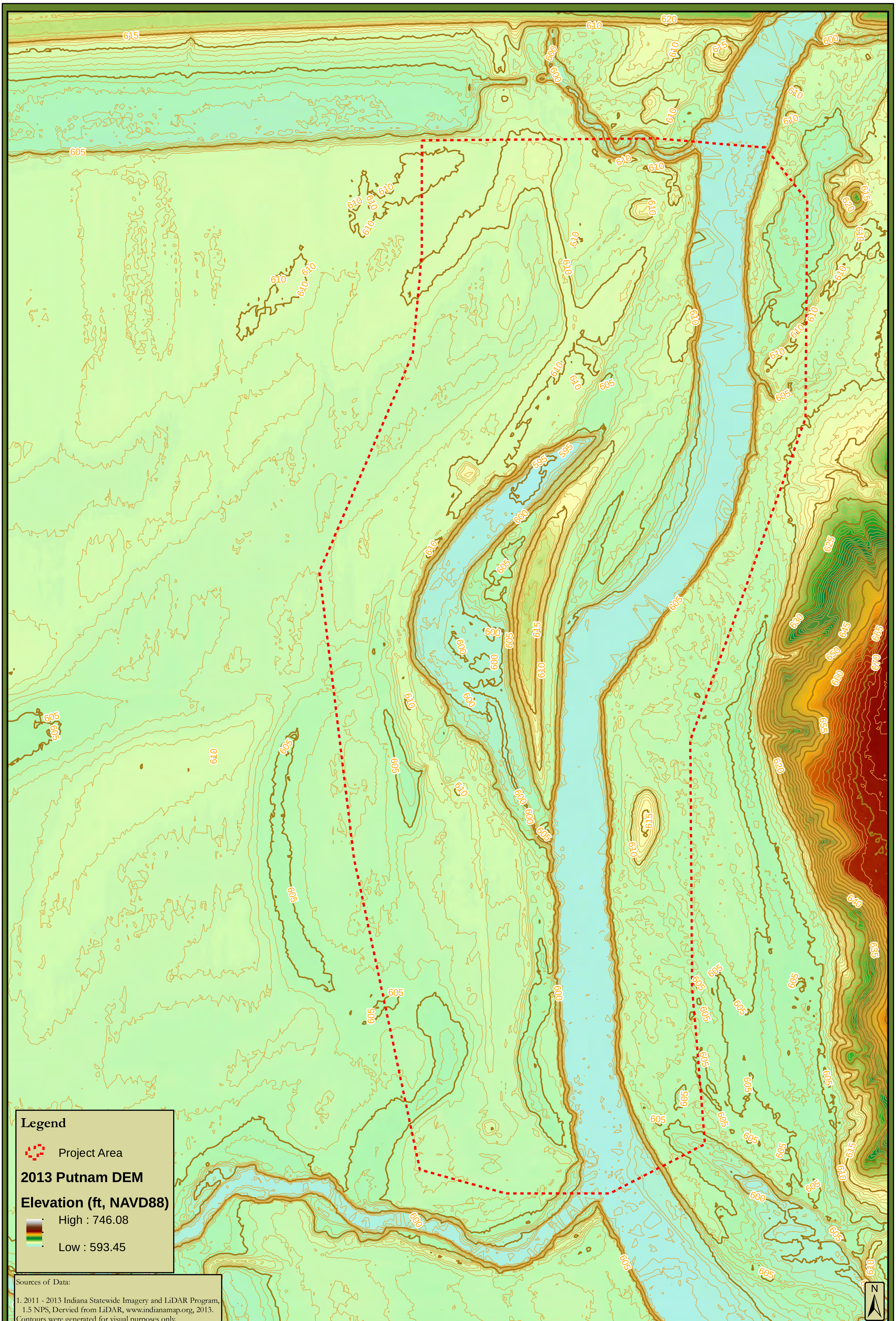
PROJECT: Big Walnut Creek FEH Mitigation Assessment	PROJECT NO. 14-0014	APPROX. SCALE As Shown
TITLE: Study Area Map		DATE: 10/2018
		EXHIBIT 1



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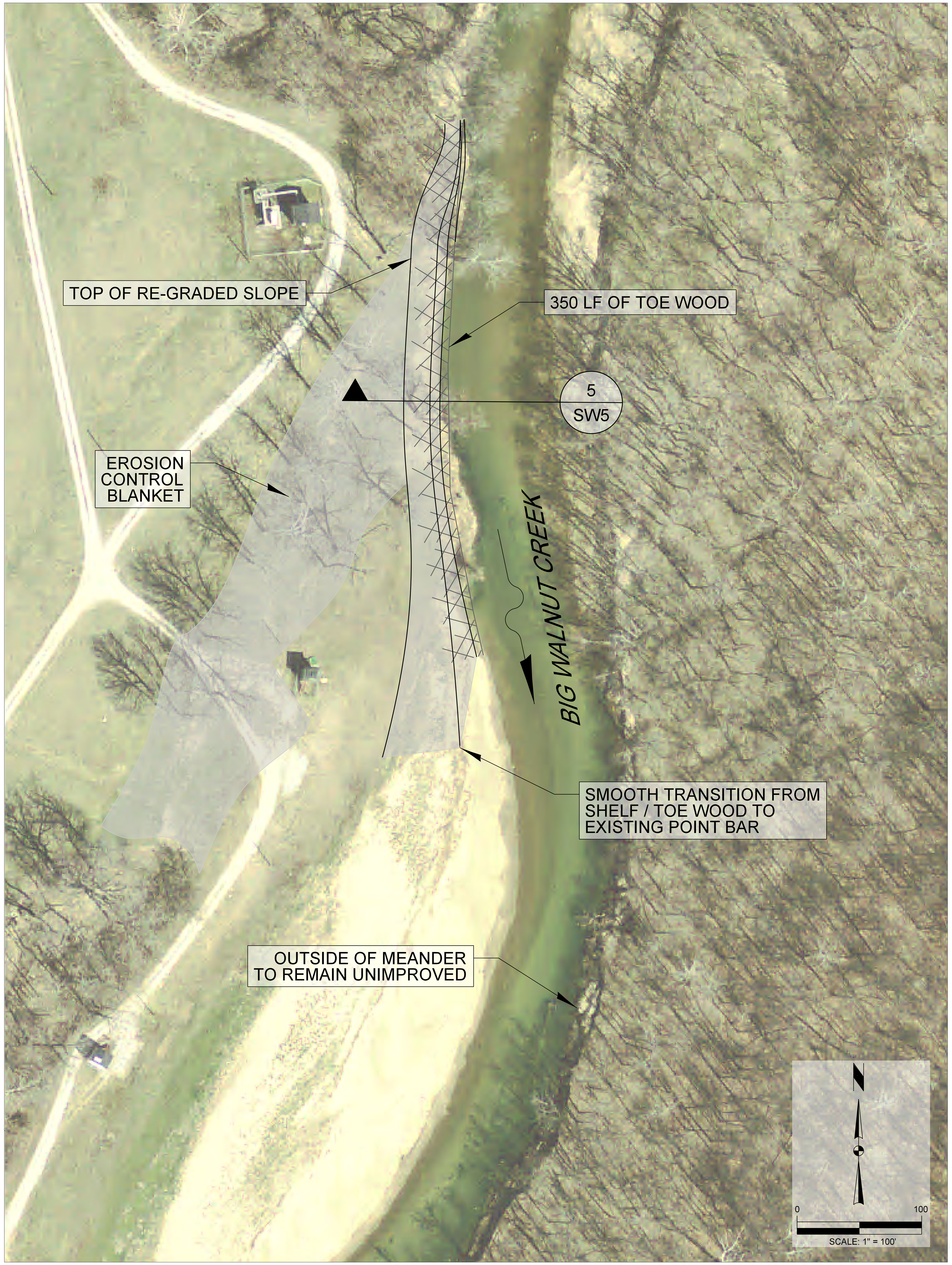
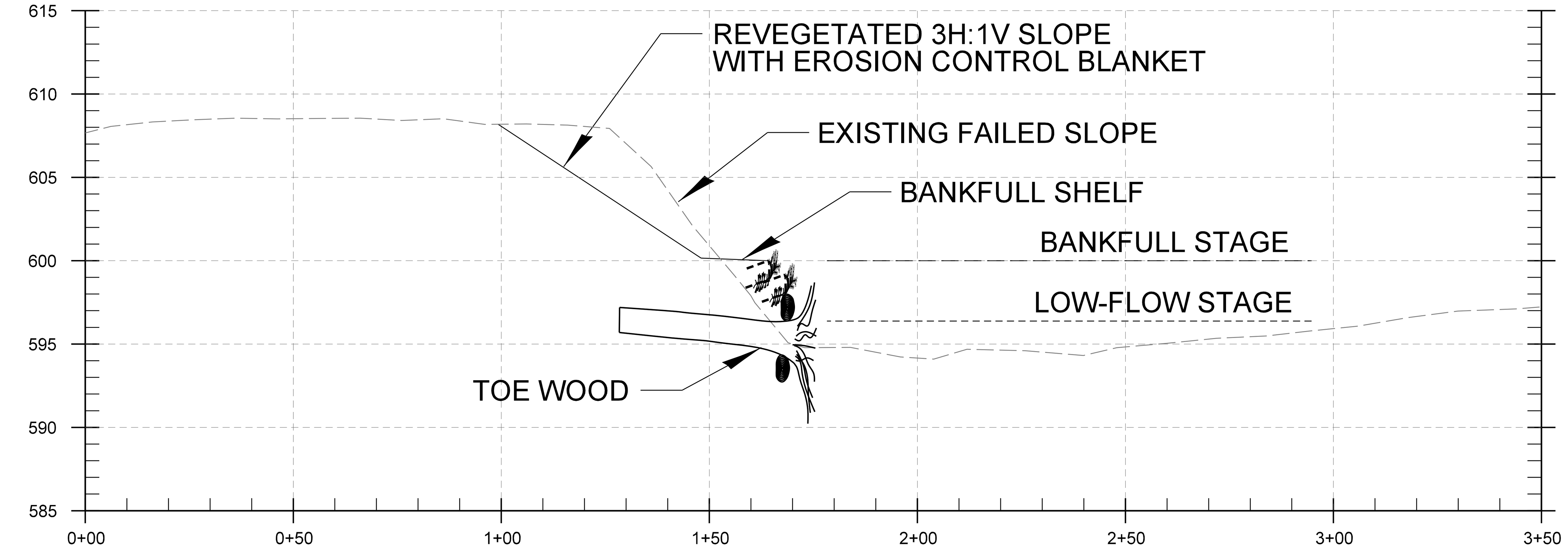
PROJECT:	Big Walnut Creek FEH Mitigation Assessment
PROJECT NO.	14-0014
APPROX. SCALE	1"=200'
TITLE:	Topographic Map of Big Walnut Creek Project Area
DATE:	10/2018
EXHIBIT	2





1 SECTION A - A

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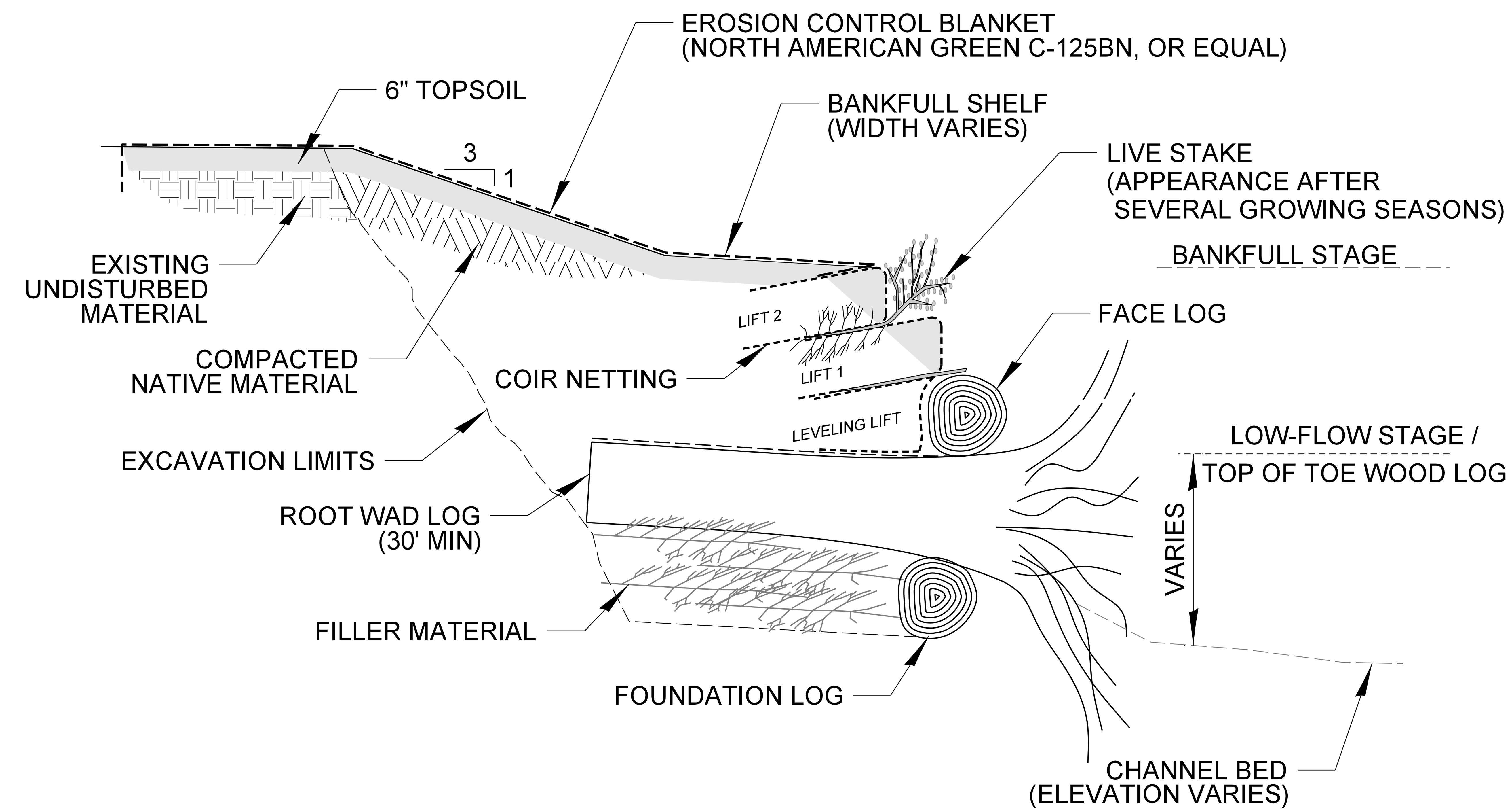

2 TYPICAL MITIGATION DETAIL

NOT TO SCALE

CBB

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CERTIFIED: PRELIMINARY NOT FOR CONSTRUCTION

TITLE: SCHEMATIC LAYOUT

PROJECT: BIG WALNUT CREEK FEH MITIGATION

PROJECT NO. 14-0014.00000

SHEET 1 OF 1

DRAWING NO. EX3

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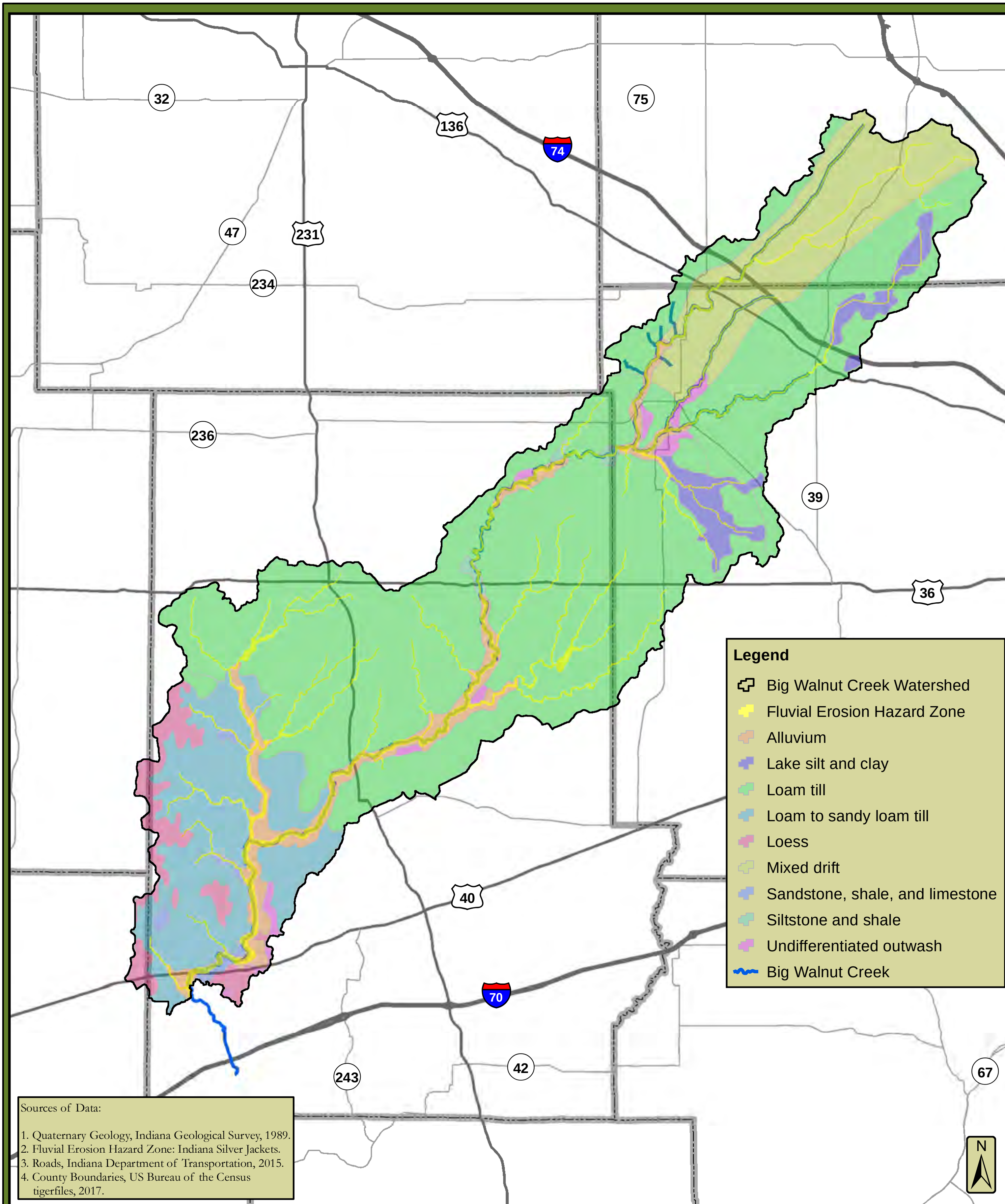
10/16/2018



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PROJECT: **Big Walnut Creek FEH Mitigation Assessment**

PROJECT NO. 14-0014

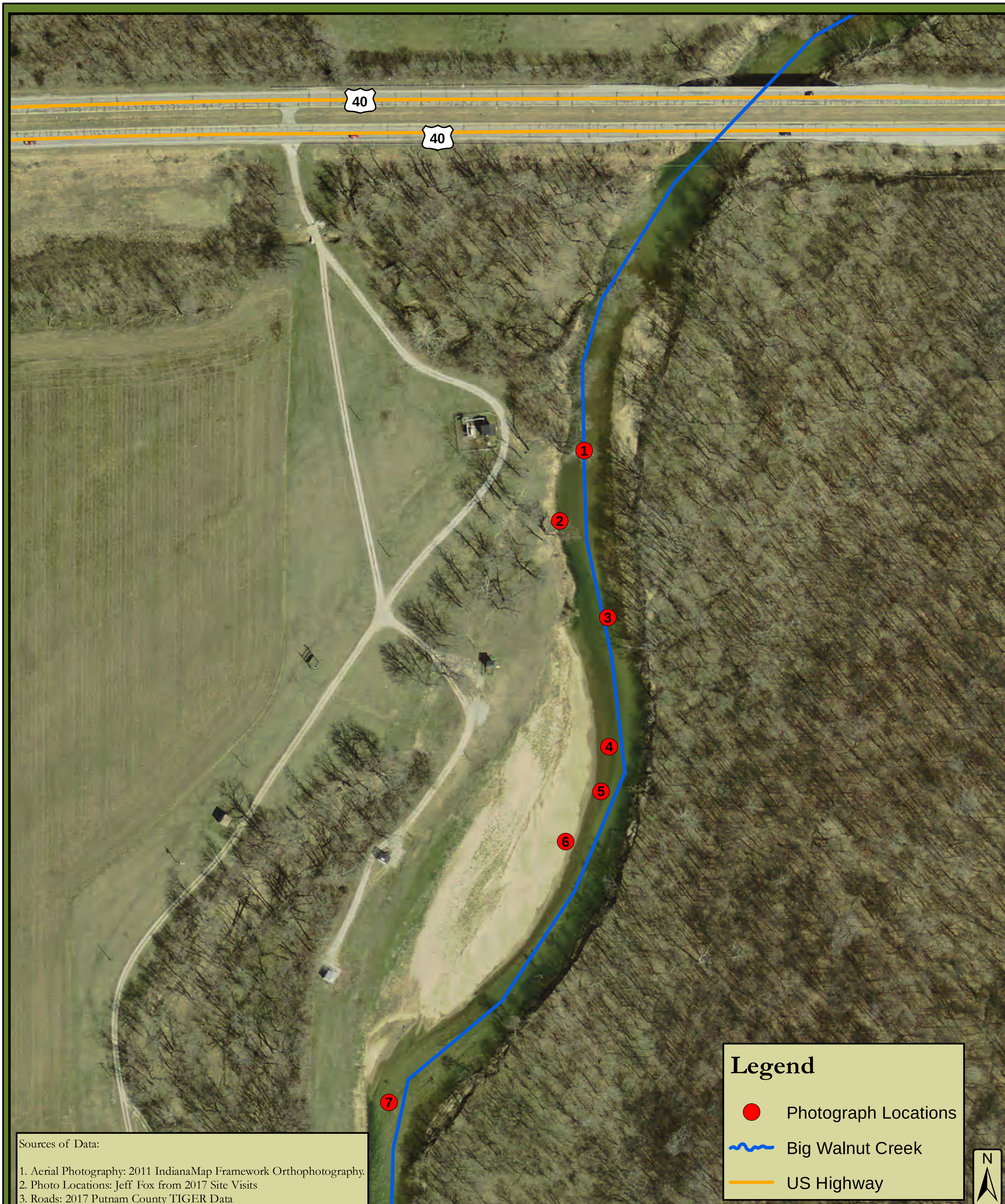
APPROX. SCALE 1"=25,000'

DATE: 10/2018

TITLE: **Quaternary Geology**

EXHIBIT 4

Appendix 1:Site Observation Photographs



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PROJECT:	PROJECT NO.	APPROX. SCALE
Big Walnut Creek FEH Mitigation Assessment	14-0014	1"=200'
TITLE: Photo Location Map		DATE: 10/2018
		EXHIBIT A1.1

Photo 1: Big Walnut Creek near Wellfield site (west bank)

Photo 2: Big Walnut Creek near Wellfield site (east bank)
(Note eroded slope and lack of vegetation)

Photo 3: Eroded Bank along Wellfield site

Photo 4: Eroded Bank opposite of Wellfield site

Photo 5: Sloughing Bank

(Note destabilizing erosion at the toe of the slope)

Photo 6: Big Walnut Creek at Wellfield Site

Photo 7: Big Walnut Creek looking downstream towards Wellfield site

Appendix 2:Site Assessment Data & Calculations

Water Quality Report

BIG WALNUT CREEK WATER QUALITY REPORT FOR 2017
BRAZIL, CLAY COUNTY, INDIANA
CHRISTOPHER B. BURKE ENGINEERING, LLC.
Project No. 140014

INTRODUCTION

Christopher B. Burke Engineering, LLC. (CBBEL-Indy) completed an aquatic resource assessment of Big Walnut Creek near Brazil, Clay County, Indiana. The project stream section is located south of State Route 40 and east of the Municipal Water Pumping Station (Exhibit 1). Big Walnut Creek is located in the Interior River Lowland (Ecoregion 72) and subregion 74b the Glaciated Wabash Lowlands. One stream section was sampled (Exhibit 1) due to above average water level. The aquatic resource assessment, which included fish sampling, aquatic macro-invertebrate habitat evaluation and water quality sampling, was completed as part of an overall watershed assessment. Representative stream photographs are included at Exhibit 2.

Big Walnut Creek is a 4^{th} order stream. The stream has characteristically well-developed deep pools and wide riffles. The substrate is sandy gravel and poorly embedded. The creek flows generally north to south through rural wooded riparian and park-like landscapes. The sampling area was chosen based on the shallowest access point in the creek at the time of the site visit (Exhibit 1).

This report summarizes the methods, results and discussion of data collected for stream habitat evaluations, aquatic macro-invertebrates, fish and water quality.

STREAM HABITAT EVALUATIONS

CBBEL completed the stream habitat evaluation using the Qualitative Habitat Evaluation Index (QHEI). Stream Habitat Results are presented in Table 1 and Water Quality Parameters are in Table 2. The QHEI data form is in Appendix A.

QHEI uses six evaluation metrics: substrate, instream cover, channel morphology, riparian zone and bank erosion, pool/glide and riffle/run quality, and stream gradient. The QHEI score is the sum total of all six metrics. A higher score represents more diverse and better quality habitat.

The QHEI scores are used to classify stream habitat as poor or more diverse, as follows (IDEM, 2012):

- Total QHEI scores <51 indicate poor habitat;
- Total QHEI scores ≥51 indicate a more diverse habitat for colonization of aquatic organisms.

Additional physical parameters were also recorded including substrate type, stream width, water depth, riparian vegetation, and water clarity.

As required by IDEM protocol, USGS realtime staff gage data for Clay County, Indiana was reviewed prior to sampling. However, none of the staff gages in Clay County were within the same drainage basin. The USGS stream gage (https://waterdata.usgs.gov/in/nwis/rt) to the west on the Wabash River near Terra Haute indicated higher than normal water levels, and to the south at Eel River near Bowling Green indicated higher than normal water level on the day of the sampling.

Results and Discussion

QHEI was completed after the fish sampling (Table 1). Big Walnut Creek was bordered by tree lined riparian woodland and open park habitats. Table 1 provides an overall summary of physical characteristics of the stream sampled. Big Walnut Creek has a drainage area approximately 316 mi^2 and is considered a 4^{th} order stream.

Big Walnut Creek

Big Walnut Creek is a natural stream with a wooded riparian corridor on the east bank and a mix of park like area woodlots within the project area (Table 2). This stream section exhibited slightly higher than average flow at the time of sampling. Based on data collected during the site visit Big Walnut Creek had a QHEI score of 77 which is considered to be more diverse (Table 1)(Appendix A).

Table 1. Summary of Stream Habitat Data for Big Walnut Creek 2017.

	Ave. Width (ft)	Ave Depth (ft)	QHEI	Riparian Corridor Composition	Surrounding Land Use	Drainage Area (mi^2)
Sampling Point	80	2	77	Tree, Shrub Turf	Woodland, Parkland	$\geq$316**

** Drainage area as determined by StreamStat for Indiana (https://water.usgs.gov/osw/streamstats/indiana.html)

Water Parameters

Water parameters such as water temperature, water clarity, dissolved oxygen, pH, and conductivity were taken during fish sampling with an YSI 556 MPS (Multiprobe System) (Table 2).

Table 2. Water Quality Parameters from Big Walnut Creek on June 19, 2017

Water Parameters	Result
Water Clarity	Fair Visibility
pH	7.8
Dissolved Oxygen (DO)	7.2 mg/L
Water Temperature (C)	24.6°
Conductivity	842 µs

BIOTIC EVALUATIONS

Aquatic life within Big Walnut Creek was collected under Indiana Scientific Purposes License #17-147. Mussels were not sampled instream due to deep water, however, shells observed on the shorelines were collected and identified (Table 6).

Aquatic Macro-invertebrates

Aquatic macro-invertebrates were sampled on June 19, 2017 by two staff at one centrally located sampling area associated with the large sand/gravel bar that also contained the most diverse habitats on Big Walnut Creek (Exhibit 1).

Methods

Aquatic macro-invertebrates were sampled a minimum of 15 meters upstream and downstream from a field identified point. CBBEL completed an IDEM Aquatic Macroinvertebrate Header form for the sampling (Appendix B). Water parameters were recorded including water temperature, dissolved oxygen, pH and specific conductivity. Representative site photos were taken (Exhibit 2). A combination of jab/sweep and kick samples were taken in representative shoreline and riffle habitats, respectively. In each sampling, large debris was removed and the sample was elutriated. The cleaned sample was picked and placed in a 250ml Nalgene container with 70% alcohol and a small amount of formalin. Sample labels were prepared for each site. Macro-invertebrates were preserved and brought back to the laboratory for identification to family, or the lowest reasonable taxonomic level.

Several indices were calculated including: cumulative EPT (Ephemeroptera, Plecoptera, and Trichoptera) richness, macro-invertebrate IBI, and mean taxa richness.

Identification and nomenclature followed Peckarsky et al. (1990). Vouchers of aquatic macroinvertebrate specimens collected and identified during this study were retained at CBBEL.

Results and Discussion

During this study, 84 macro-invertebrates were sorted and identified from 1 sampling area including specimens from 2 phyla, 4 classes, 10 orders, 17 families, and 16 genera (Table 3). Aquatic macro-invertebrates were identified to the lowest taxonomic classification practicable. In this project all invertebrates were identified to family or genus level. In general, the majority of species collected are relatively intolerant of pollution including the Ephemoptera (mayflies), Trichoptera (caddis flies) and Odonata (dragonfly and damselfly larvae).

Table 3. Aquatic Macro-invertebrates collected at Big Walnut Creek 2017 by CBBEL-Indy.

Phylum	**Class**	**Order**	**Family**	**Lowest Identified Taxa Name**	**Number**
Mollusca	Bivalvia	Veneroidea	Corbiculidae	*Corbicula fluminea*	6
	Gastropoda	Pulmonata	Physidae	Physidae	1
			Lymnaeidae	Lymnaeidae	1
Arthropoda	Malacostraca	Decapoda	Cambaridae	*Orconectes rusticus*	1
	Insecta	Hemiptera	Corixidae	*Trichocorixia* sp.	6
		-	Coenagrionidae	*Agria sp.*	1
		Odonata	Coenagrionidae	*Enallagma sp.*	1
			Calopterygidae	*Hetaerina sp.*	11
			Macromiidae	*Macromia sp.*	1
			Aeshnidae	*Boyeria sp.*	1
		Ephemeroptera	Oligoneuridae	*Isonychia sp.*	14
			Heptageniidae	*Stenonema sp.*	2
			Tricorythidae	*Tricorythodes sp.*	16
		Trichoptera	Hydropsychidae	*Macrostemum sp.*	1
			Hydropsychidae	*Cheumatopsyche sp.*	14
		Coleoptera	Haliplidae	*Peltodytes sp.*	1
			Dryopidae	*Helicus sp.*	2
		Diptera	Chironomidae	Chironomidae	1
		Plecoptera	Perlidae	*Neoperla sp.*	3
				TAXA: 18	84

Summary of Macroinvertebrate Indices

Aquatic habitat quality was based on the macro-invertebrate Index of Biotic Integrity (IDEM undated), which summarizes the aquatic macro-invertebrate community into a single pollution tolerance value. Scores less than 36 are considered impaired while those equal to or greater than 36 are considered unimpaired. Based on the data collected mIBI for the sampling location was 32, which indicates impaired aquatic habitat quality (Table 4). However, it is close to being unimpaired and perhaps additional monitoring at different times of the year may provide more insight into water quality.

Table 4.MIBI Table for Sampling Location at Big Walnut Creek, Brazil Indiana in 2017.

Metric	No.	Score
Number of Taxa	18	1
Number of Individuals	84	1
Number of EPT Taxa	6	3
Total Number of Diptera Taxa	1	1
% Orthocladiinae+Tanytarini	1	5
% Non-insects Minus Crayfish	9	5
% Intolerant	75	5
% Tolerant	5	5
% Predators	27	3
% Shredder + Scrapers	8	1
% Collector-Filterers	63	1
% Sprawlers	0	1
	Total	32
	Rank	Impaired

Cumulative EPT Richness is the total number of taxa of Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies). The EPT taxa are generally considered good indicators of water quality. EPT taxa richness will decrease with degrading water quality. Six EPT taxa were collected during sampling. EPT Richness range of "0-2", can indicate lower water quality (Table 4). However Big Walnut Creek has a watershed that drains 316 square miles and 6 EPT is a moderate value.

Taxa Richness can be used as an indicator of macroinvertebrate diversity. A greater number represents a more diverse community. Generally, the number of taxa decreases with increased degradation. Taxa Richness was 18 for Big Walnut Creek which is low (Table 4). Intolerant taxa were 75%. Mayflies, Caddisflies and damselflies were the most encountered aquatic macro-invertebrates in the sample (Table 5).

Index data for aquatic macro-invertebrates collected in 2017 including mIBI, EPT, Taxa Richness, dominants and percent intolerants is summarized in Table 5.

Table 5. Summary of Macro-invertebrate Data Collected in 2017 within Big Walnut Creek.

mIBI	Rank	EPT	Taxa Richness	Dominants	% Intolerants
32	Impaired	6	18	Mayflies, Caddis Flies, Damselflies	75%

Mussels

CBBEL-Indy completed a visual search for mussels within Big Walnut Creek, however, no live mussels were observed in the stream. However, dead shells were observed along the shoreline and deposition areas and they were collected for identification and shell condition was noted. Fresh shells indicate living species, worn shells indicate that there may or may not be a living species in the stream. Subfossil shells are long time dead shells that are pure white and the species likely is no longer present.

Following is a list of species observed and their relative condition. Identification based on Cummings and Mayer (1992)(Table 6).

Table 6. Mussels Species collected along Big Walnut Creek on June 19, 2017

Common Name	**Scientific Name**	**Number**	**Condition**
Pink heelsplitter	*Potamilus alatus*	5	Fresh to Worn
Washboard	*Megalonaias nervosa*	9	Worn
Asian clam	*Corbicula fluminea*	4	Fresh to Worn
Fatmucket	*Lampsilis siliquoidea*	14	Worn to Subfossil
Elktoe	*Alasmidonta marginata*	1	Subfossil
Three ridge	*Amblema plicata*	1	Worn
Creek heelsplitter	*Lasmigona compressa*	1	Worn
Plain pocketbook	*Lampsilis cardium*	12	Worn to Subfossil
Elephant ear	*Elliptio crassidens*	3	Worn to Subfossil

Fish

Fish were sampled on June 19, 2017 by two CBBEL staff at specific sampling locations within Big Walnut Creek (Exhibit 1).

Methods

Fish sampling was based on backpack electrofishing protocol (IDEM 2005). The stream sampling location was sampled once. A shallow representative stream reach within the wetted stream width within the project corridor was sampled utilizing a Smith-Root backpack electro-fishing unit set up with the following parameters: 300 volts at 60Hz. Fish were sorted by species, enumerated and external abnormalities were recorded. Non-vouchered individuals were returned to the stream. One to two individuals per species were vouchered, as well as any unidentified species, into a Nalgene bottle with 10% formalin. Photos of the sampling area and representative fish species were taken and electro-fishing time was also recorded. An Index of Biotic Integrity (IBI) score was calculated *the Interior River Lowland Calibration* (based on Simon and Dufour 2005). IBI scores that are in the range of 53-60 are excellent, 45-52 are good, 35-44 are fair, 23-34 are poor, 12-22 are very poor and <12 had no fish. Identification and nomenclature for fish followed Simon (2011). Vouchers of fish specimens collected and identified during this study were retained at CBBEL.

Results and Discussion

A total of 168 individuals of 8 species were collected during 3.2 minutes of electrofishing and several seine pulls (Table 10). Dominant species collected included River carpsucker (total = 74%) and common shiner (total = 20%) (Table 7). One intolerant species were observed the northern hogsucker. IBI was calculated for the sampling location as 28, respectively which is considered poor (integrity class) by IDEM (Table 7).

Table 7. Fish Species in Big Walnut Creek June 19, 2017.

Common Name	**Scientific Name**	**Number**
Creek chub	*Semotilus atromaculatus*	1
River carpsucker	*Carpoides carpio*	125
Common shiner	*Luxilus cornutus*	33
Silverjaw minnow	*Ericymba buccata*	3
Largemouth bass	*Micropterus salmoides*	2
Central stoneroller	*Campostoma anomalum*	2
Northern hogsucker	*Hypentelium nigricans*	1
Bluntnose minnow	*Pimephales notatus*	1
	Number Collected	168
	Number of Species	8
	Sensitive or Intolerant Species	1
	DELT (Abnormalities)	0
	IBI	28
Electro-fisher Parameters	Freq (Hz)	60
	Volts (v)	300
	Start	33655
	End	33848
	Total Time (seconds)	193

S =Sensitive species, SI = Sensitive and Intolerant and I = Intolerant

Conclusion

Big Walnut Creek is a 4th order stream with open parkland and wooded riparian vegetation with mature physical structure. Habitat quality is good based on the QHEI protocol. Macro-invertebrate and fish indices indicate impaired biological integrity. Overall quality is Fair to Poor. This baseline data can be compared over the timeframe of the project.

Table 8. Summary of Biotic Data for Streams in the Illiana Corridor B3 in Indiana in 2017.

Sampling Point	QHEI (Habitat)	mIBI (Invertebrates)	IBI (Fish)	Overall Quality
Sampling Point	77	32	28	Fair to Poor

Literature Cited

Cummings, K.S. and C.A. Mayer. 1992. *Field Guide to the Freshwater Mussels of the Midwest.* Illinois Natural History Survey Manual 5. 194 pp.

Indiana Department of Environmental Management (IDEM). 2005. *Fish Community Assessment (Sections 5.0. and 5.1). In: Summary Protocols, Probability Based Site Assessment. Revision #7. 32/03/002/1999.* July 28, 2005. 12 pp.

Peckarsky, B. L., P.R. Fraissinet, M.A. Penton, and D.J. Conklin, Jr. 1990. *Freshwater Macroinvertebrates of Northeastern North America.* Cornell University Press. 442 pp.

Simon, T.P. and Ronda L. Dufour. 2005. Guide to appropriate metric selection for calculating the Index of Biotic Integrity (IBI) for Indiana Large and Great Rivers, Inland Lakes, and Great Lakes nearshore. U.S. Department of the Interior, Fish and Wildlife Service, Bloomington Field Office, Bloomington, Indiana.

Simon, T.P. 2011 Fishes of Indiana: A Field Guide. Indiana University Press. Bloomington, IN 345 pp.

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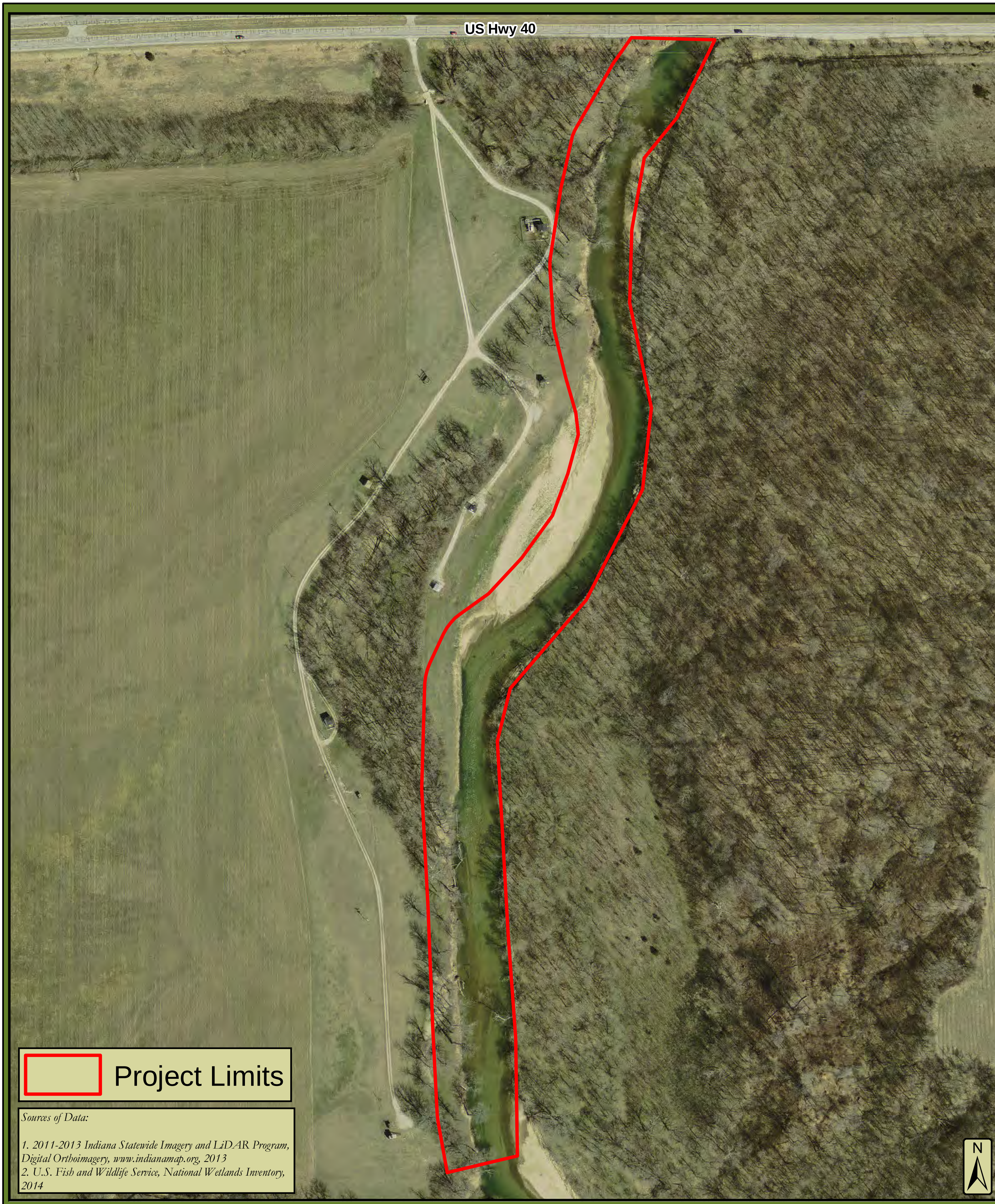

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PROJECT: **Big Walnut Creek**	PROJECT NO. **14-0014**	APPROX. SCALE **1"=300'**	
TITLE: **Aerial**		DATE: **04/2017**	EXHIBIT **1**

Photo 1: Upstream View of Big Walnut Creek Sampling Area

Photo 2: Downstream View of Walnut Creek

Photo 3: Pink Heelsplitter

Photo 4: Asian Clam

Photo 5: Washboard

Photo 6: Dragonfly Larvae

Photo 7: Mayfly larvae

Photo 8: Caddisfly Larvae

Photo 9: Damselfly Larvae

Photo 10: Common Shiner

Photo 11: Silverjaw Minnow

Photo 12: River Carpsucker

Christopher B. Burke Engineering, Ltd. **9575 W. Higgins Road, Suite 600** **Rosemont, Illinois 60018** **847-823-0500**	**CLIENT:**	**Project No. 140014**	**06/12/17**
	Big Walnut Creek Aquatic Fauna		**Exhibit 2**

Attachment 7. IDEM OWQ Biological Qualitative Habitat Evaluation Index (front).

OWQ Biological QHEI (Qualitative Habitat Evaluation Index)

Sample #	bioSample #	Stream Name	Location
1 of 1	1	BIG WALNUT CREEK	S. ROUTE 40

Surveyor	Sample Date	County	Macro Sample Type	☒ Habitat Complete	QHEI Score:
RPS	6/19/17	CLAY	KICK/SWEEP		77

1] SUBSTRATE Check ONLY Two predominant substrate TYPE BOXES; estimate % and check every type present

BEST TYPES (PREDOMINANT P/G R/R; PRESENT P/G R/R; TOTAL %)
- ☐☐ BLDR/SLABS[10] ☐☐ ___
- ☐☐ BOULDER[9] ☐☐ ___
- ☐☐ COBBLE[8] ☐☐ ___
- ☒☐ GRAVEL[7] ☐☐ 60
- ☒☐ SAND[6] ☐☐ 30
- ☐☐ BEDROCK[5] ☐☐ ___

NUMBER OF BEST TYPES: ☐ 4 or more [2] ☒ 3 or less [0]

OTHER TYPES (PREDOMINANT P/G R/R; PRESENT P/G R/R; TOTAL %)
- ☐☐ HARDPAN[4] ☐☐ ___
- ☐☐ DETRITUS[3] ☐☐ ___
- ☐☐ MUCK[2] ☐☐ ___
- ☐☐ SILT[2] ☒☐ 10
- ☐☐ ARTIFICIAL[0] ☐☐ ___

(Score natural substrates; ignore sludge from point-sources)

ORIGIN Check ONE (Or 2 & average)
- ☐ LIMESTONE[1]
- ☒ TILLS[1]
- ☐ WETLANDS[0]
- ☐ HARDPAN[0]
- ☒ SANDSTONE[0]
- ☐ RIP/RAP[0]
- ☐ LACUSTRINE[0]
- ☐ SHALE[-1]
- ☐ COAL FINES[-2]

QUALITY
- SILT: ☐ HEAVY[-2] ☐ MODERATE[-1] ☒ NORMAL[0] ☐ FREE[1]
- EMBEDDEDNESS: ☐ EXTENSIVE[-2] ☐ MODERATE[-1] ☐ NORMAL[0] ☒ NONE[1]

Substrate: 17 (Maximum 20)

Comments

2] INSTREAM COVER Indicate presence 0 to 3 and estimate percent: 0–Absent; 1–Very small amounts or if more common of marginal quality; 2-Moderate amounts, but not of highest quality or in small amounts of highest quality; 3-Highest quality in moderate or greater amounts (e.g., very large boulders in deep or fast water, large diameter log that is stable, well developed root wad in deep/fast water, or deep, well-defined, functional pools.)

%	Amount	Type	%	Amount	Type	%	Amount	Type
		UNDERCUT BANKS[1]	60	3	POOLS > 70cm[2]			OXBOWS, BACKWATERS[1]
5	1	OVERHANGING VEGETATION[1]			ROOTWADS[1]			AQUATIC MACROPHYTES[1]
10	2	SHALLOWS (IN SLOW WATER)[1]			BOULDERS[1]	10	2	LOGS OR WOODY DEBRIS[1]
		ROOTMATS[1]						

AMOUNT Check ONE (Or 2 & average)
- ☐ EXTENSIVE > 75%[11]
- ☒ MODERATE 25 - 75%[7]
- ☒ SPARSE 5 - < 25%[3]
- ☐ NEARLY ABSENT < 5%[1]

Cover: 12 (Maximum 20)

Comments

3] CHANNEL MORPHOLOGY Check ONE in each category (Or 2 & average)

SINUOSITY
- ☐ HIGH[4]
- ☒ MODERATE[3]
- ☐ LOW[2]
- ☐ NONE[1]

DEVELOPMENT
- ☐ EXCELLENT[7]
- ☒ GOOD[5]
- ☐ FAIR[3]
- ☐ POOR[1]

CHANNELIZATION
- ☒ NONE[6]
- ☐ RECOVERED[4]
- ☐ RECOVERING[3]
- ☐ RECENT OR NO RECOVERY[1]

STABILITY
- ☐ HIGH[3]
- ☒ MODERATE[2]
- ☐ LOW[1]

Channel: 16 (Maximum 20)

Comments

4] BANK EROSION AND RIPARIAN ZONE Check ONE in each category for EACH BANK (Or 2 per bank & average)

River right looking downstream

EROSION (L R)
- ☒☐ NONE/LITTLE[3]
- ☐☒ MODERATE[2]
- ☐☐ HEAVY/SEVERE[1]

RIPARIAN WIDTH (L R)
- ☐☐ WIDE > 50m[4]
- ☐☒ MODERATE 10-50m[3]
- ☒☐ NARROW 5-10m[2]
- ☐☐ VERY NARROW[1]
- ☐☐ NONE[0]

FLOOD PLAIN QUALITY (L R)
- ☐☒ FOREST, SWAMP[3]
- ☐☐ SHRUB OR OLD FIELD[2]
- ☒☐ RESIDENTIAL, PARK, NEW FIELD[1]
- ☐☐ FENCED PASTURE[1]
- ☐☐ OPEN PASTURE, ROWCROP[0]
- ☐☐ CONSERVATION TILLAGE[1]
- ☐☐ URBAN OR INDUSTRIAL[0]
- ☐☐ MINING/CONSTRUCTION[0]

Indicate predominant land use(s) past 100m riparian.

Riparian: ___ (Maximum 10) 14

Comments

5] POOL/GLIDE AND RIFFLE/RUN QUALITY

MAXIMUM DEPTH Check ONE (ONLY!)
- ☒ > 1m[6]
- ☐ 0.7-<1m[4]
- ☐ 0.4-<0.7m[2]
- ☐ 0.2-<0.4m[1]
- ☐ < 0.2m[0] [metric=0]

CHANNEL WIDTH Check ONE (Or 2 & average)
- ☐ POOL WIDTH > RIFFLE WIDTH[2]
- ☒ POOL WIDTH = RIFFLE WIDTH[1]
- ☐ POOL WIDTH < RIFFLE WIDTH[0]

CURRENT VELOCITY Check ALL that apply
- ☐ TORRENTIAL[-1]
- ☐ VERY FAST[1]
- ☐ FAST[1]
- ☒ MODERATE[1]
- ☒ SLOW[1]
- ☐ INTERSTITIAL[-1]
- ☐ INTERMITTENT[-2]
- ☐ EDDIES[1]

Indicate for reach – pools and riffles.

Recreation Potential (Circle one and comment on back)
- ☒ Primary Contact
- ☐ Secondary Contact

Pool/Current: 9 (Maximum 12)

Comments

Indicate for functional riffles; Best areas must be large enough to support a population of riffle-obligate species:

Check ONE (Or 2 & average) ☐ NO RIFFLE [metric=0]

RIFFLE DEPTH
- ☒ BEST AREAS > 10cm[2]
- ☐ BEST AREAS 5 - 10cm[1]
- ☐ BEST AREAS < 5cm [metric=0]

RUN DEPTH
- ☐ MAXIMUM > 50cm[2]
- ☒ MAXIMUM < 50cm[1]

RIFFLE/RUN SUBSTRATE
- ☐ STABLE (e.g., Cobble, Boulder)[2]
- ☐ MOD. STABLE (e.g., Large Gravel)[1]
- ☒ UNSTABLE (e.g., Fine Gravel, Sand)[0]

RIFFLE/RUN EMBEDDEDNESS
- ☒ NONE[2]
- ☐ LOW[1]
- ☐ MODERATE[0]
- ☐ EXTENSIVE[-1]

Riffle/Run: 5 (Maximum 8)

Comments

6] GRADIENT (ft/mi)
- ☐ VERY LOW - LOW[2-4]
- ☒ MODERATE[6-10]
- ☐ HIGH - VERY HIGH[10-6]

DRAINAGE AREA (316 mi²)

%POOL: 60 %GLIDE: 0
%RUN: 10 %RIFFLE: 30

Gradient: 8 (Maximum 10)

IDEM 11/15/12

Attachment 7 (continued). IDEM OWQ Biological QHEI (back).

IDEM

OWQ Biological QHEI (Qualitative Habitat Evaluation Index)

COMMENT ________________________________

A-CANOPY
- ☐ > 85% - Open
- ☒ 55% - < 85%
- ☐ 30% - < 55%
- ☐ 10% - < 30%
- ☐ < 10% - Closed

B-AESTHETICS
- ☐ Nuisance algae
- ☐ Invasive macrophytes
- ☐ Excess turbidity
- ☐ Discoloration
- ☐ Foam/Scum
- ☐ Oil sheen
- ☐ Trash/Litter
- ☐ Nuisance odor
- ☐ Sludge deposits
- ☐ CSOs/SSOs/Outfalls

C-RECREATION

Area / Depth

Pool: ☒ > 100ft² ☒ > 3ft

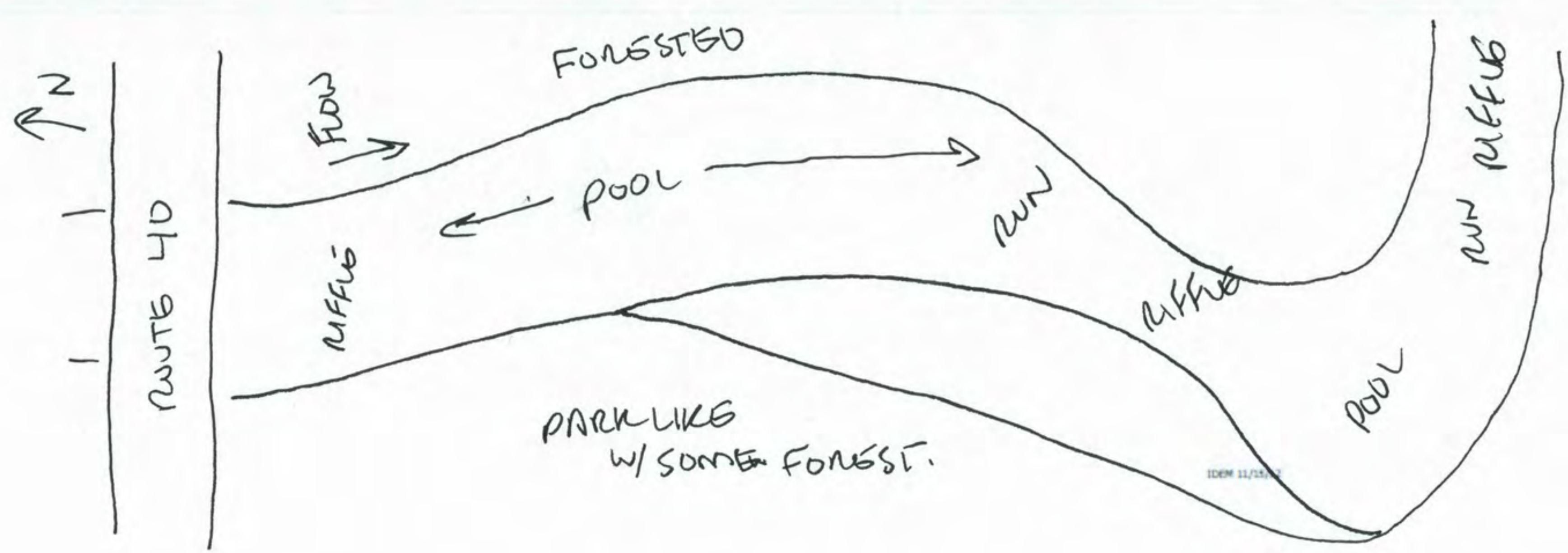
D-MAINTENANCE
- ☒ Public ☐ Private
- ☐ Active ☐ Historic
- Succession: ☐ Young ☐ Old
- ☐ Spray ☐ Islands ☐ Scoured
- Snag: ☐ Removed ☐ Modified
- Leveed: ☐ One sided ☐ Both banks
- ☐ Relocated ☐ Cutoffs
- Bedload: ☒ Moving ☐ Stable
- ☐ Armoured ☐ Slumps
- ☐ Impounded ☐ Desiccated
- ☐ Flood control ☒ Drainage

E-ISSUES
- ☐ WWTP ☐ CSO ☐ NPDES
- ☐ Industry ☐ Urban
- ☐ Hardened ☐ Dirt & Grime
- ☐ Contaminated ☐ Landfill
- BMPs: ☐ Construction ☐ Sediment
- ☐ Logging ☐ Irrigation ☐ Cooling
- Erosion: ☒ Bank ☐ Surface
- ☐ False bank ☐ Manure ☐ Lagoon
- ☐ Wash H_2O ☐ Tile ☐ H_2O Table
- Mine: ☐ Acid ☐ Quarry
- Flow: ☒ Natural ☐ Stagnant
- ☐ Wetland ☒ Park ☐ Golf
- ☐ Lawn ☐ Home
- ☐ Atmospheric deposition
- ☐ Agriculture ☐ Livestock

Looking upstream (> 10m, 3 readings; ≤ 10m, 1 reading in middle); Round to the nearest whole percent

	Right	Middle	Left	Total Average
% open	___ %	___ %	___ %	___ %
	X	X	X	

Stream Drawing:



Attachment 6. IDEM OWQ Macroinvertebrate Header Form.

IDEM

Office of Water Quality: Macroinvertebrate Header

L-Site #	Event ID	Stream Name	Location	County	Surveyor
		BIG WALNUT CR.	NEAR BRAZIL	CLAY	RPS HDB

Sample Date	Sample #	Macro#	# Containers
06/19/17			1

☐ Habitat Complete ☐ Sample Quality Rejected

Macro Sample Type: ☐ Black Light ☐ Kick ☐ CPOM ☒ MHAB ☐ Hester-Dendy ☐ Qualitative

☒ Normal ☐ Duplicate ☐ Replicate

Riparian Zone/Instream Features

Watershed Erosion: ☐ Heavy ☒ Moderate ☐ None

Watershed NPS Pollution: ☒ No Evidence ☐ Obvious Sources ☐ Some Potential Sources

Stream Depth Riffle (m):	Stream Depth Run (m):	Stream Depth Pool (m):	Distances Riffle-Riffle (m):	Distances Bend-Bend (m):
0.2	1.0	1.5	NA	NA

Stream Width (m):	High Water Mark (m):	Velocity (ft/s):
≈ 25	UNK	UNK

Stream Type: ☐ Cold ☒ Warm

Turbidity (Est): ☐ Clear ☒ Slightly Turbid ☐ Opaque ☐ Turbid

Salinity (mg/L): NA

ORP (mV): NA

☐ Channelization ☐ Dam Present

Predominant Surrounding Land Use: ☒ Forest ☒ Field/Pasture ☐ Agricultural ☐ Residential ☐ Commercial ☐ Industrial
Other

Sediment

Sediment Odors: ☒ Normal ☐ Sewage ☐ Petroleum ☐ Chemical ☐ Anaerobic ☐ None Other

Sediment Deposits: ☐ Sludge ☐ Sawdust ☐ Paper Fiber ☒ Sand ☐ Relic Shells Other

Sediment Oils: ☒ Absent ☐ Moderate ☐ Profuse ☐ Slight

☐ Are the undersides of stones, which are not deeply embedded, black?

Substrate Components

(Note: Select from 0%, 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90%, or 100% for each inorganic/ organic substrate component)

Inorganic Substrate Components (% Diameter)							Organic Substrate Components (% Type)			
Bedrock	Boulder (>10 in)	Cobble (2.5-10 in)	Gravel (0.1-2.5 in)	Sand (gritty)	Silt	Clay (slick)	Detritus (sticks, wood)	Detritus (CPOM)	Muck/Mud (black, fine FPOM)	Marl(gray w/ shell fragments)
0	0	0	60	30	10		0	0	0	0

Water Quality

Water Odors: ☒ Normal ☐ Sewage ☐ Petroleum ☐ Chemical ☐ None Other

Water Surface Oils: ☐ Slick ☐ Sheen ☐ Glob ☐ Flocks ☒ None

IDEM 03/14/13

Wetland Delineation Report

CHRISTOPHER B.
BURKE
ENGINEERING, LLC

Big Walnut Creek

Wetland Delineation Report

Putnam County, IN | April 2017

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JURISDICTIONAL WATERS AND WETLAND DELINEATION REPORT
BIG WALNUT CREEK SITE
PUTNAM COUNTY, INDIANA

EXECUTIVE SUMMARY

Christopher B. Burke Engineering, LLC (CBBEL) staff conducted an onsite field investigation of the Big Walnut Creek site in Putnam County, Indiana. Field work was conducted on April 4, 2017 during which time four (4) wetlands and four (4) streams were identified onsite. Wetland delineations were conducted using methods identified in the Regional Supplement to the Corps of Engineers Delineation Manual: Midwest Region (Version 2.0) (August 2010).

Table 1 is a summary of the "waters"/wetland sites identified, including acreage or linear footage and our opinion of federal regulatory jurisdiction.

Table 1: Summary of Waters/Wetlands in Project Area

Site	Wetland/Stream Type	Acreage/Liner Footage (within project limits)	Jurisdiction
Wetland 1	Forested (PFO)	1.88 Acre	State/Federal
Wetland 2	Forested (PFO)	0.35 Acre	State/Federal
Wetland 3	Forested (PFO)	0.003 Acre	State/Federal
Wetland 4	Forested (PFO)	0.07 Acre	State/Federal
UNT 1	Perennial	401 Linear Feet	State/Federal
UNT 2	Intermittent	144 Linear Feet	State/Federal
UNT 3	Ephemeral	211 Linear Feet	State/Federal
UNT 4	Ephemeral	132 Linear Feet	State/Federal
Big Walnut Creek	Perennial	2,700 Linear Feet	State/Federal

1.0 STUDY AREA

On April 4, 2017, Christopher B. Burke Engineering, LLC (CBBEL) completed a Wetland/"Waters" of the U.S field investigation of the Big Walnut Creek Site in Putnam County, Indiana (**Exhibit 1**). This report was prepared to document our findings and to determine if the on-site "waters"/wetland areas are jurisdictional under Sections 404/401 of the Clean Water Act (CWA) or under current Indiana Regulations. The project site includes both banks of an approximate 2,700-foot reach of Big Walnut Creek, downstream from the US Highway 40 bridge crossing east of Brazil, Indiana. Specifically, the project is located in Sections 20 and 29, of Township 13 North, Range 5 West on the Reelsville 7.5 Minute Quadrangle Map.

Wetland/"waters" boundaries were delineated in accordance with the Midwest Region methodology established by the USACE. The delineated wetlands/"waters" and data points are shown on **Exhibit 6**. Information collected on site is listed in the attached data forms (**Appendix 2**).

2.0 METHODOLOGY

2.1 WETLAND DETERMINATION METHODOLOGY

Wetland determinations were conducted using the methodology from the *Regional Supplement to the Corps of Engineers Delineation Manual: Midwest Region (Version 2.0),* dated August 2010. The Midwest Regional Supplement identifies the mandatory technical criteria for wetland identification. The three essential characteristics of a wetland are hydrophytic vegetation, hydric soils and wetland hydrology as described below:

Hydrophytic Vegetation: The hydrophytic vegetation criterion is based on a separation of plants into five basic groups:

(1) Obligate wetland plants (OBL) almost always occur (estimated probability >99%) in wetlands under natural conditions;

(2) Facultative wetland plants (FACW) usually occur in wetlands (estimated probability 67-99%), but occasionally are found in non-wetlands;

(3) Facultative plants (FAC) are equally likely to occur in wetlands or nonwetlands (estimated probability 34-66%);

(4) Facultative upland plants (FACU) usually occur in non-wetlands (estimated probability 67-99%), but occasionally are found in wetlands (estimated probability 1-33%); and

(5) Obligate upland plants (UPL) almost always occur (estimated probability >99%) in non-wetlands under natural conditions.

***Indicator 1 - Rapid Test for Hydrophytic Vegetation*:** The rapid test for hydrophytic vegetation is met if all dominant species across all strata are OBL or FACW, or a combination of the two, based on a visual assessment.

Indicator 2 - Dominance Test: If greater than 50% of the plants present are FAC, FACW, or OBL the subject area is considered to be wetland in terms of vegetation, and no further vegetation analysis is required.

Indicator 3 - Prevalence Index: This test is conducted if the plant community fails the Dominance Test, but indicators of hydric soil and wetland hydrology are both present. The Prevalence Index is a weighted-average (based on percent cover) wetland indicator status of all plant species in the sampling plot, where each indicator status category is given a numeric value (OBL=1, FACW=2, FAC=3, FACU=4, and UPL=5). If the Prevalence Index is less than or equal to 3.0, then the hydrophytic vegetation criteria has been met.

Indicator 4 - Morphological Adaptations: This test is conducted if the plant community fails the prevalence test, but indicators of morphological adaptations for life in wetlands, on otherwise upland plant species, are present. If more than 50 percent of FACU species have morphological adaptations for life in wetlands, this species is considered a hydrophyte and is re-assigned an indicator of FAC. The Dominance Test and Prevalence Test should be re-calculated, and the hydrophytic vegetation criteria is satisfied if either test is satisfied.

Hydric Soils: Hydric soils are defined in the Midwest Regional Supplement as "soils that have formed under conditions of saturation, flooding, or ponding long enough during the growing season to develop anaerobic conditions in the upper part." Field indicators include matrix color, redox depletions and concentrations, sulfate reduction and resultant odor, organic matter accumulation, gleying, and soil texture. Specific types of hydric soils in the Midwest Region include, Histosols, Sandy Soils, Muck or Peat, and Loam or Clay Soils. Within these soil groups, there are many indicators specific to each type of soil.

Wetland Hydrology: The wetland hydrology criterion is often the most difficult to determine. Typically, the presence of water for a week or more during the growing season creates anaerobic conditions. Anaerobic conditions lead to the prevalence of wetland plants and soils. In the Midwest Regional Supplement, hydrology indicators are divided into four groups; Group A. Observation of Surface Water or Saturated Soils, Group B. Evidence of Recent Inundation, Group C. Evidence of Current or Recent Soil Saturation, and Group D. Evidence from Other Site Conditions or Data. Within each group, indicators are divided into two categories, *Primary* and *Secondary*. In the absence of a primary indicator, two or more secondary indicators from any group are required to conclude that wetland hydrology is present. Some indicators of wetland hydrology are surface water, saturation, water marks, sediment deposits, water stained leaves, drainage patterns, sulfide odor, crayfish burrows, stunted or stressed plants, or geomorphic position.

2.2 STREAM METHODOLOGY

The location of potentially jurisdictional channels was determined using the Putnam County Soil Survey, the USGS Quadrangle Map, and aerial photography. An onsite evaluation determined if additional channels, not shown on any existing mapping, were present within the project limits. There were several jurisdictional streams documented.

3.0 RESULTS AND DISCUSSION

3.1 IDENTIFIED WETLAND AREAS

Wetland Site 1 (DP 2 & 3): Wetland Site 1 is a large concave bowl shaped area found along the western bank of Big Walnut Creek within the project limits. This forested wetland (PFO) is approximately 1.88 acre in size. Dominant vegetation consists of silver maple (*Acer saccharinum*, FACW, American sycamore (*Platanus occidentalis*, FACW, eastern cottonwood (*Populus deltoides*, FAC), garlic mustard (*Allaria petolata*, FAC), bluntleaf bedstraw (*Galium obtusum*, FACW), stinging nettle (*Urtica dioica*, FACW), and wingstem (*Verbesina alternifolia*, FACW). Hydrology for this wetland includes saturation at the surface, water marks, sparsely vegetated concave surface, water-stained leaves, drainage patterns, geomorphic position, and the FAC-neutral test.

Soil sampled for Wetland Site 1 is a clay loam with a matrix color of 10YR 4/2 and a redox concentration of 10YR 6/8. The soil mapped for this area is Stonelick Sandy Loam (Sw). The boundaries of Site 1 are defined by change in topography to the north, south, east, and west.

Wetland Site 1 is adjacent to and drains to Big Walnut Creek. This stream should be considered a "water of the U.S.", and it is our opinion that Wetland Site 1 would fall under the jurisdiction of the US Army Corps of Engineers (USACE), if impacted. Final jurisdictional determination must be made by the USACE. The State of Indiana retains jurisdiction over isolated wetlands and would need to be notified prior to any work in the wetland if it is determined to be outside of federal jurisdiction.

Wetland Site 2 (DP 3): Wetland Site 2 is a large saturated area found along the east bank within the northern portion of the project limits. This forested wetland (PFO) is approximately 0.35 acre in size. Dominant vegetation consists box elder (*Acer negundo*, FAC), silver maple (FACW), eastern cottonwood (FAC), riverbank wild-rye (*Elymus riparius*, FACW), and wingstem (FACW). Hydrology for this wetland includes up to 12-inches of standing water, saturation at the surface, water marks, geomorphic position, and the FAC-neutral test.

Soil sampled for Wetland Site 2 is a clay/sand loam mix with a matrix color of 10YR 4/1 from 0-3 inches and 10YR 4/4 from 3-20 inches. The soil mapped for this area is Shoals Silt Loam (Sh). The boundaries of Site 2 are defined by a change in topography to the north and a change in hydrology to the south, east, and west.

Wetland Site 2 is adjacent to Big Walnut Creek. This stream should be considered a "water of the U.S.", and it is our opinion that Wetland Site 2 would fall under the jurisdiction of the US Army Corps of Engineers (USACE), if impacted. Final jurisdictional determination must be made by the USACE. The State of Indiana retains jurisdiction over isolated wetlands and would need to be notified prior to any work in the wetland if it is determined to be outside of federal jurisdiction.

Wetland Site 3 (DP 7): Wetland Site 3 is a saturated area found south of Wetland Site 2. This forested wetland (PFO) is approximately 0.003 acre in size and extends east outside of the project limits. Dominant vegetation consists of American sycamore (FACW), American elm (*Ulmus Americana*, FACW), riverbank wild-rye (FACW), and bluntleaf bedstraw (FACW). Hydrology for this wetland includes up to 3-inches of standing water, saturation at the surface, water-stained leaves, geomorphic position, and the FAC-neutral test.

Soil sampled for Wetland Site 3 is a clay loam with a matrix color of 10YR 4/1 and a redox concentration of 7.5YR 5/8. The soil mapped for this area is Stonelick Sandy Loam (Sw). The boundaries of Site 3 are defined by change in hydrology to the north, south, east, and west.

Wetland Site 3 is adjacent to and connected via Unnamed Tributary (UNT) 3 to Big Walnut Creek. These streams should be considered "waters of the U.S.", and it is our opinion that Wetland Site 3 would fall under the jurisdiction of the US Army Corps of Engineers (USACE), if impacted. Final jurisdictional determination must be made by the USACE. The State of Indiana retains jurisdiction over isolated wetlands and would need to be notified prior to any work in the wetland if it is determined to be outside of federal jurisdiction.

Wetland Site 4 (DP 8): Wetland Site 4 is a saturated area located south of Wetland Site 3 within the project limits. This forested wetland (PFO) is approximately 0.07 acre in size. Dominant vegetation consists of box elder (FAC), sedge species (*Carex spp*., FACW), riverbank wild rye (FACW), and wingstem (FACW). Hydrology for this wetland includes up to 3-inches of standing water, saturation at the surface, drainage patterns, geomorphic position, and the FAC-neutral test

Soil sampled for Wetland Site 4 is a clay loam with a matrix color of 10YR 4/1 and a redox concentration of 7.5YR 5/8. The soil mapped for this area is

Stonelick Sandy Loam (Sw). The boundaries of Site 4 are defined by change in hydrology to the north, south, east, and west.

Wetland Site 4 is adjacent to and connected via UNT 4 to Big Walnut Creek. These streams should be considered "waters of the U.S.", and it is our opinion that Wetland Site 4 would fall under the jurisdiction of the US Army Corps of Engineers (USACE), if impacted. Final jurisdictional determination must be made by the USACE. The State of Indiana retains jurisdiction over isolated wetlands and would need to be notified prior to any work in the wetland if it is determined to be outside of federal jurisdiction.

3.2 NON-WETLAND DATA POINTS

Data Point 1: Data Point 1 is located within a forested area along the west bank of Big Walnut Creek north of UNT 1. Vegetation at this data point consists of box elder (FAC), Ohio Buckeye (*Aesculus glabra*, FAC), American sycamore (FACW), eastern cottonwood (FAC), riverbank wild-rye (FACW), bluntleaf bedstraw (FACW), stinging nettle (FACW), and wingstem (FACW). The soil at this site has a matrix color of 10YR 4/3 and did not exhibit any redox concentrations. This area exhibited one secondary indicator of wetland hydrology; therefore, this data point does not qualify as wetland.

Data Point 4: Data Point 4 is located along the west bank of Big Walnut Creek south of Wetland Site 1. Vegetation at this data point consists of silver maple (FACW), Kentucky blue grass (*Poa pratensis*, FAC), and meadow fescue (*Schedonorus pratensis*, FACU). The soil at this site has a matrix color of 10YR 4/3 and did not exhibit any redox concentrations. This area exhibited one secondary indicator of wetland hydrology; therefore, this data point does not qualify as wetland.

Data Point 5: Data Point 5 is located within a forested area along the east bank of Big Walnut Creek south of UNT 2. Vegetation at this data point consists of Ohio Buckeye (FAC), American sycamore (FACW), eastern cottonwood (FAC), stinging nettle (FACW), and wingstem (FACW). The soil at this site has a matrix color of 10YR 4/3 and did not exhibit any redox concentrations. This area exhibited one secondary indicator of wetland hydrology; therefore, this data point does not qualify as wetland.

Data Point 9: Data Point 9 is located within a forested area along the east bank of Big Walnut Creek south of Wetland Site 4. Vegetation at this data point consists of box elder (FAC), silver maple (FACW), eastern cottonwood (FAC), Virginia waterleaf (*Hydrophyllum virginianum*, FAC), and wingstem (FACW). The soil at this site has a matrix color of 10YR 4/3 and did not exhibit any redox concentrations. This area exhibited one secondary indicator of wetland hydrology; therefore, this data point does not qualify as wetland.

Data Point 10: Data Point 10 is located within a forested area along the east bank of Big Walnut Creek south of Data Point 9. Vegetation at this data point consists of box elder (FAC), Ohio buckeye (FAC), eastern cottonwood (FAC), roverbank wild rye (FACW), Virginia waterleaf (FAC), and wingstem (FACW). The soil at this site has a matrix color of 10YR 3/3 and did not exhibit any redox concentrations. This area exhibited one secondary indicator of wetland hydrology; therefore, this data point does not qualify as wetland.

3.3 OTHER JURISDICTIONAL WATERS

Big Walnut Creek….

UNT 1 is a perennial stream that flows east through the site. The Ordinary High Water Mark (OHWM) of the channel was measured at approximately 1.5-foot above the bed of the channel. The channel width was approximately 10 feet wide within the project limits. Dominant substrates include silt, gravel, artificial concrete, and brick.

UNT 2 is an intermittent stream that flows west along US Highway 40. The Ordinary High Water Mark (OHWM) of the channel was measured at approximately 12-inches above the bed of the channel. The channel width was approximately 2.5 feet wide within the project limits and the dominant substrate is mud, silt, and sand.

UNT 3 is an ephemeral tributary that flows west from Wetland Site 3. The Ordinary High Water Mark (OHWM) of the channel was measured at approximately 6-inches above the bed of the channel. The channel width was approximately 1.5 feet wide within the project limits and the dominant substrates consist of detritus, silt, and sand.

UNT 4 is an ephemeral tributary that flows west through Wetland Site 4. The Ordinary High Water Mark (OHWM) of the channel was measured at approximately 6-inches above the bed of the channel. The channel width was approximately 2 feet wide within the project limits and the dominant substrates consist of silt and sand.

UNT 1, 2, 3, and 4 flow into Big Walnut Creek within the project limits. It is our opinion that these streams should be considered "Waters of the U.S." and, therefore, under federal jurisdiction. Any work within the channel will require Clean Water Act approval from the USACE and the IDEM. Additionally, an IDNR Construction in a Floodway permit will be required if there is any work within regulatory floodway.

4.0 REFERENCE MATERIALS

4.1 EXHIBIT REFERENCES

The following reference materials were reviewed and used to assist in the "Waters"/Wetland field reconnaissance. They are included as Exhibits 1-6.

EXHIBIT 1 –Site Location Map
The project site includes both banks of an approximate 2,700-foot reach of Big Walnut Creek, downstream from the US Highway 40 bridge crossing east of Brazil, Indiana. Specifically, the project is located in Sections 20 and 29, of Township 13 North, Range 5 West on the Reelsville 7.5 Minute Quadrangle Map.

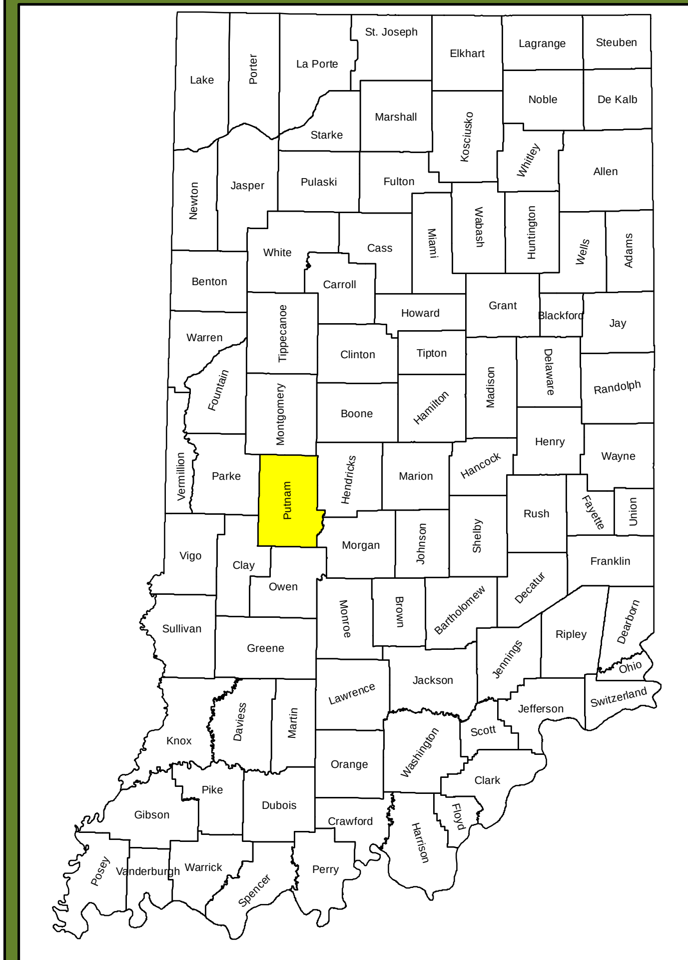
EXHIBIT 2- National Wetlands Inventory Map
The National Wetland Inventory (NWI) does indicate several wetlands within the project limits; however, the NWI serves only as a large-scale guide; actual wetland locations and types often vary from that mapped. The NWI map may also predate the development of the subject wetland.

EXHIBIT 3 – Soils Map
The Soil Survey of Putnam County, Indiana (1971) was reviewed to determine the location of hydric soils on site. Mapped hydric soil can be indicative of wetland conditions. Sholas Silt Loam (Sh) and Stonelick Sandy Loam (Sw) are mapped throughout the project limits and are not considered a hydric soils.

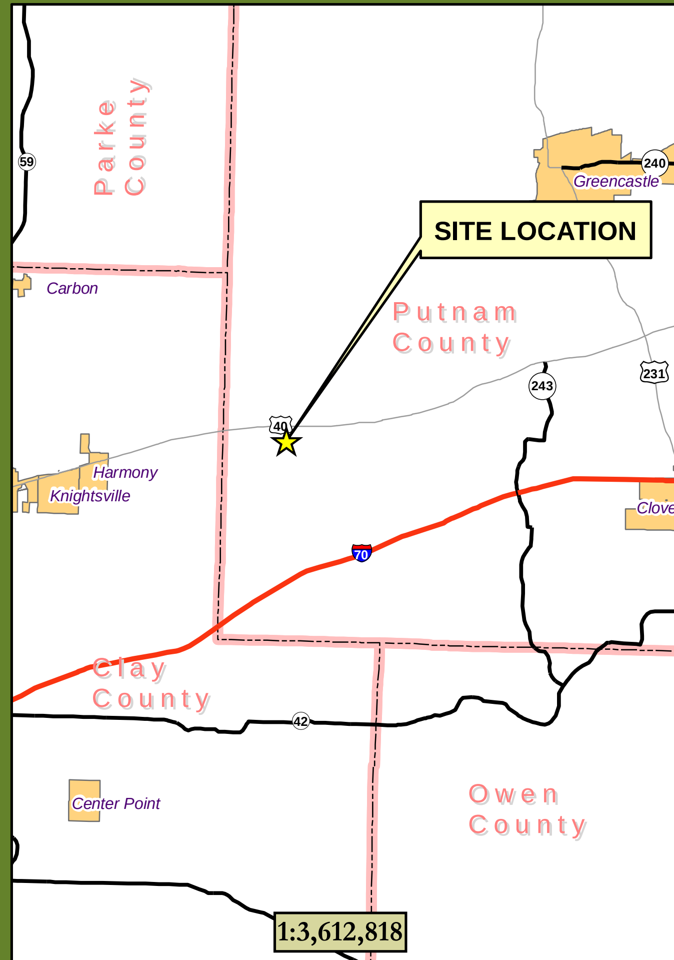
EXHIBIT 4 –Topography Map
U.S.G.S. 7.5-Minute Quadrangle Map, Reelsville, 1997 was reviewed to determine the local drainage pattern. The map indicates relatively flat throughout the majority of the project limits.

EXHIBIT 5 – DFIRM
The Digital Flood Insurance Rate Map (DFIRM), Effective, June 5, 2017, was reviewed to determine the location of floodplain or floodway within the study area. Mapped floodplains can be indicative of wetland hydrology. The FIRM indicates Unnumbered Zone A throughout the project limits.

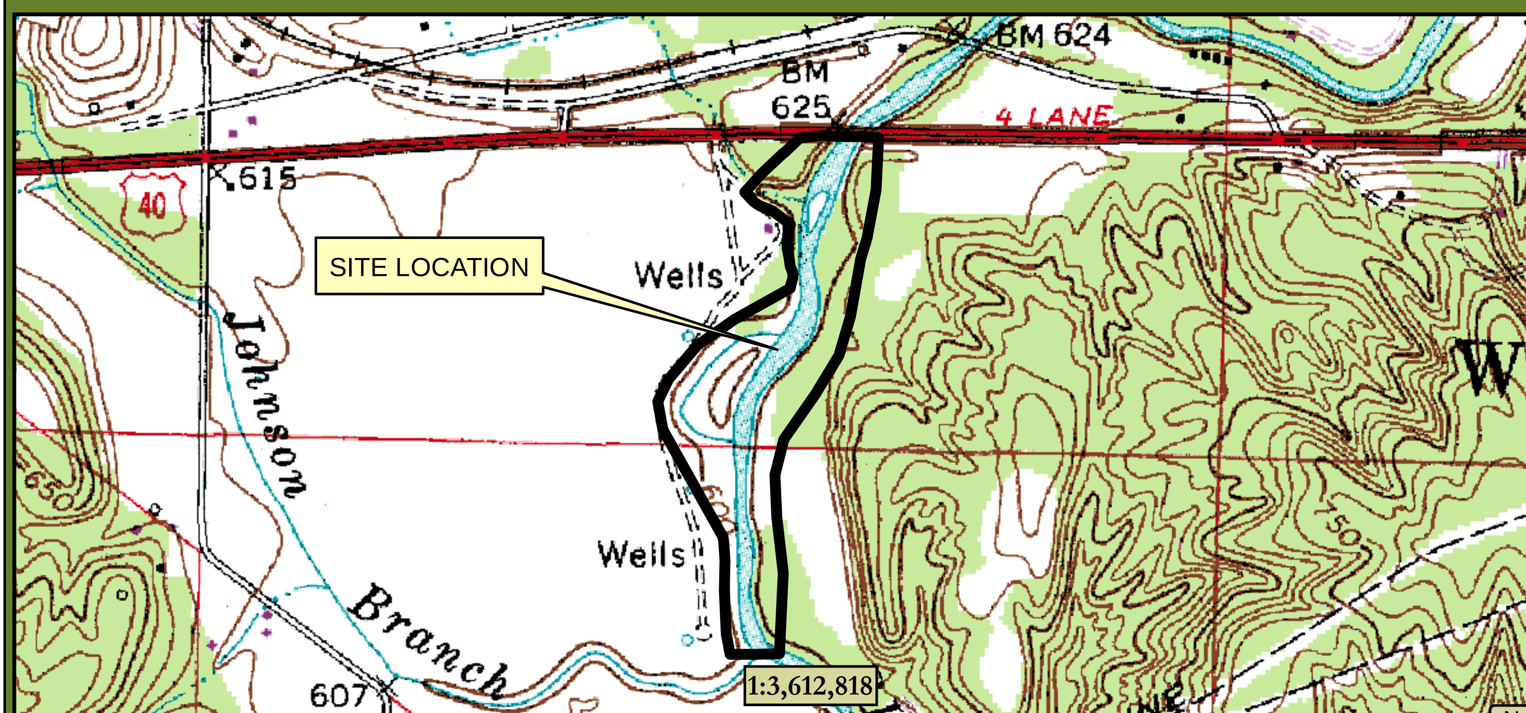
EXHIBIT 6 –Delineated Wetlands/"Waters", Data Points & Photo Stations
The aerial photograph of the site was reviewed to determine drainage patterns and identify poorly drained areas, or note changes in vegetation. The data points and photo stations are overlaid on the aerial photograph.



STATE MAP



VICINITY MAP



AREA MAP

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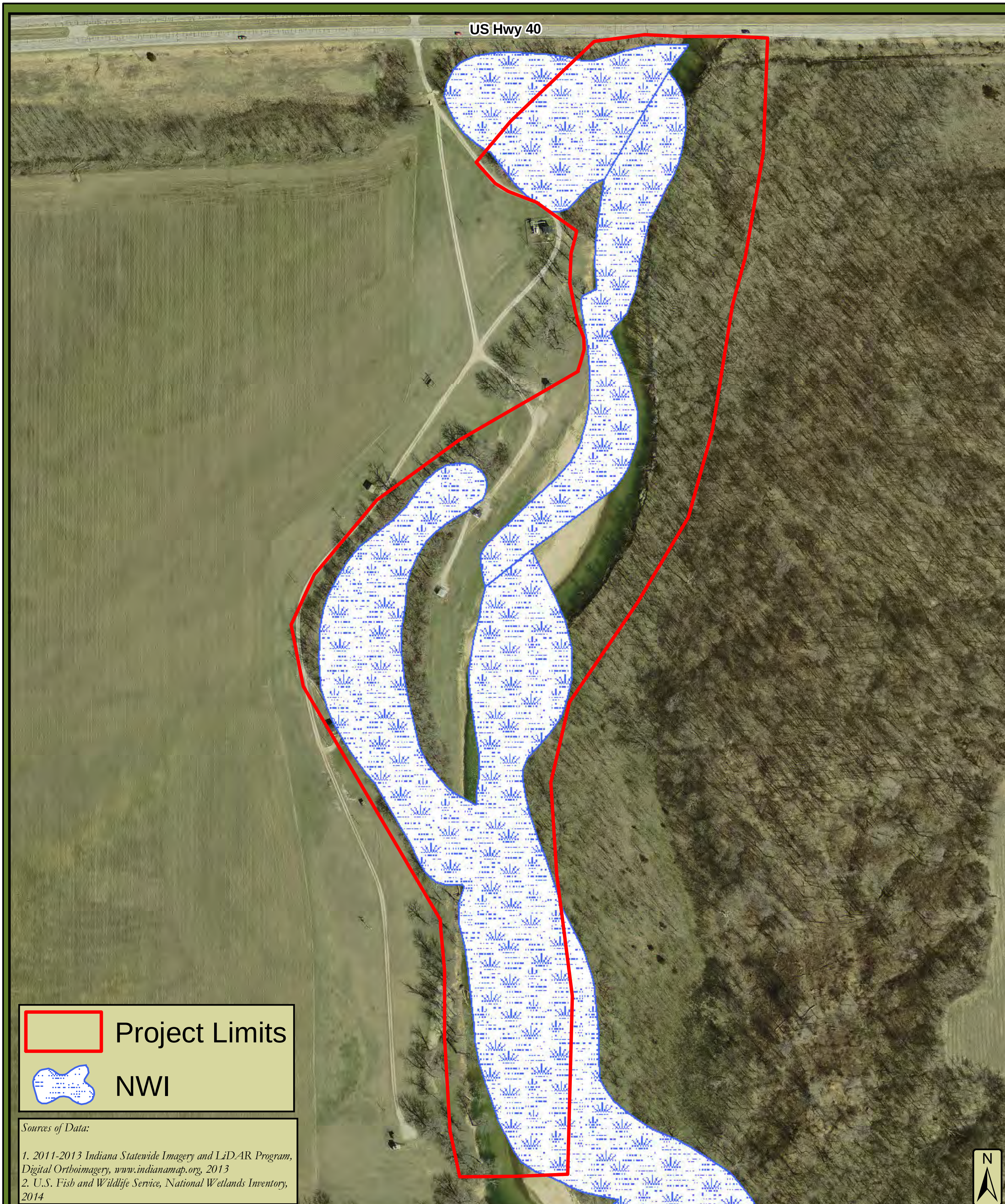
115 West Washington Street
Indianapolis, Indiana 46204
(t) 317.266.8000 (f) 317.632.3306

PROJECT: Big Walnut Creek	PROJECT NO. 14-0014	APPROX. SCALE as shown
TITLE: SITE LOCATION		DATE: 04/2017
		EXHIBIT 1



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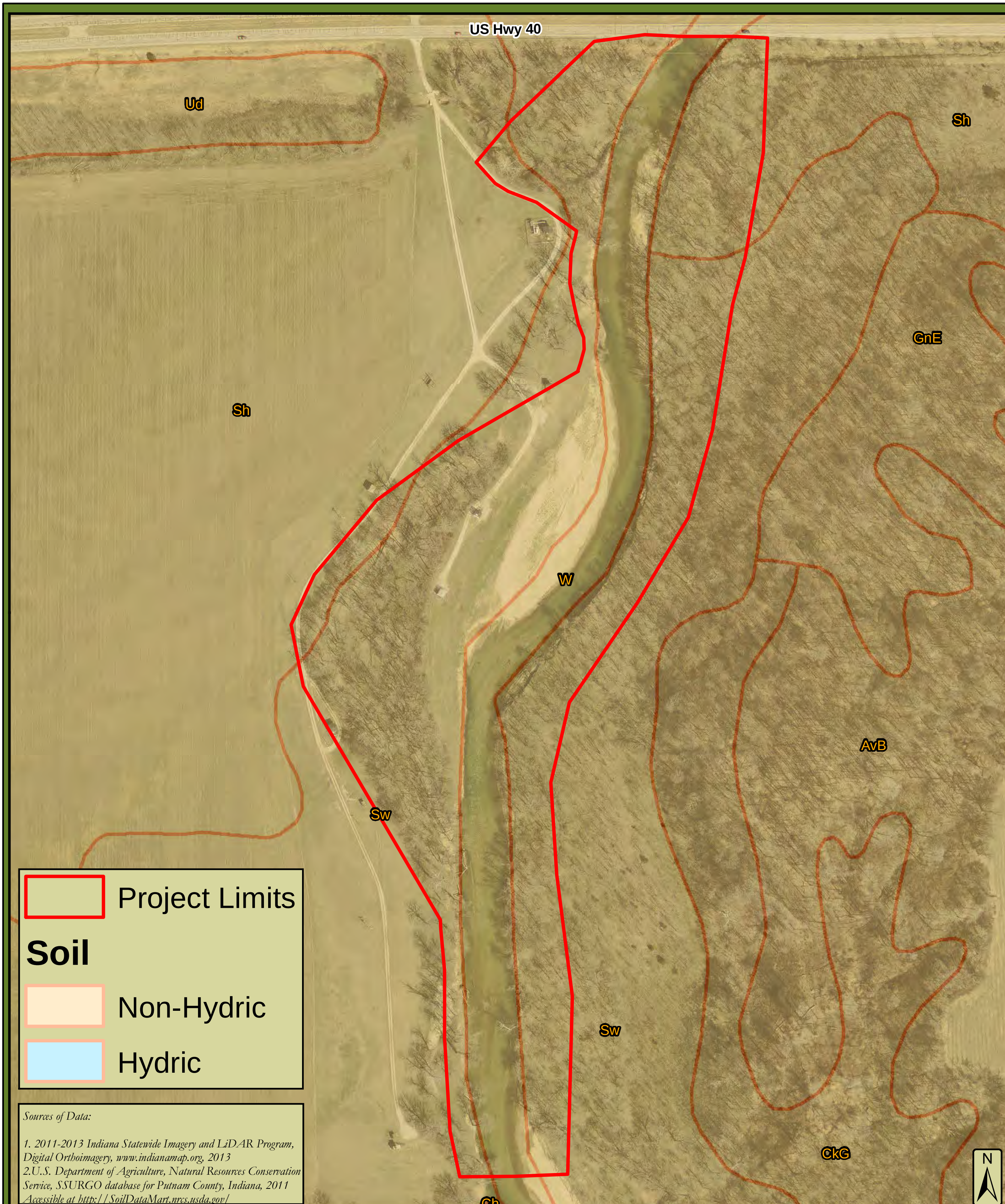
(t) 317.266.8000 (f) 317.632.3306

PROJECT: Big Walnut Creek		**PROJECT NO.** 14-0014	**APPROX. SCALE** 1"=300'
TITLE: NWI			**DATE:** 04/2017
			EXHIBIT 2



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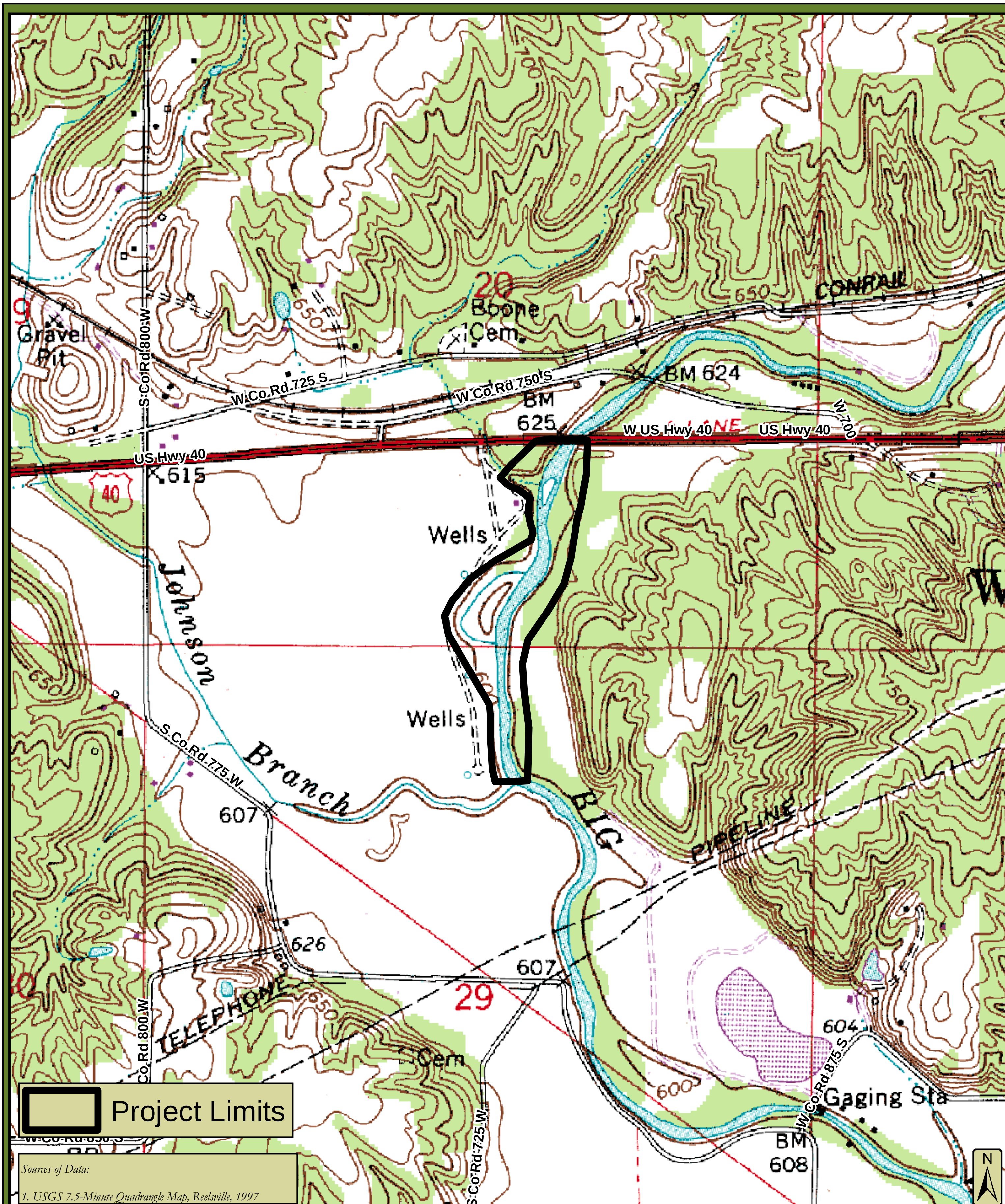
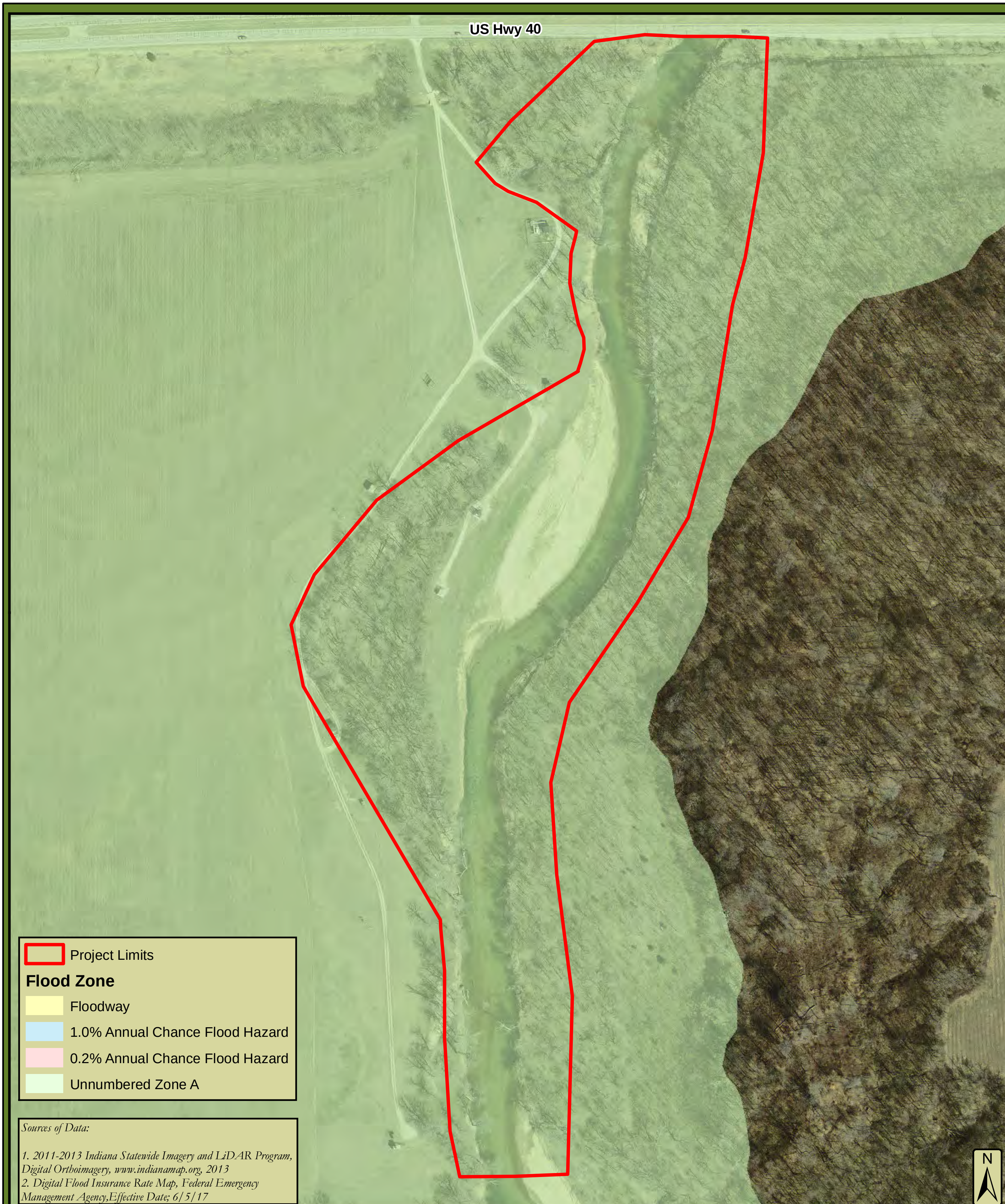
115 West Washington Street
Indianapolis, Indiana 46204
(t) 317.266.8000 (f) 317.632.3306

PROJECT:	PROJECT NO.	APPROX. SCALE
Big Walnut Creek	14-0014	1"=300'
TITLE: SOIL		DATE: 04/2017
		EXHIBIT 3



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: **Big Walnut Creek**	PROJECT NO. **14-0014**	APPROX. SCALE **1"=1,000'**
	TITLE: **TOPO**		DATE: **04/2017**
			EXHIBIT **4**



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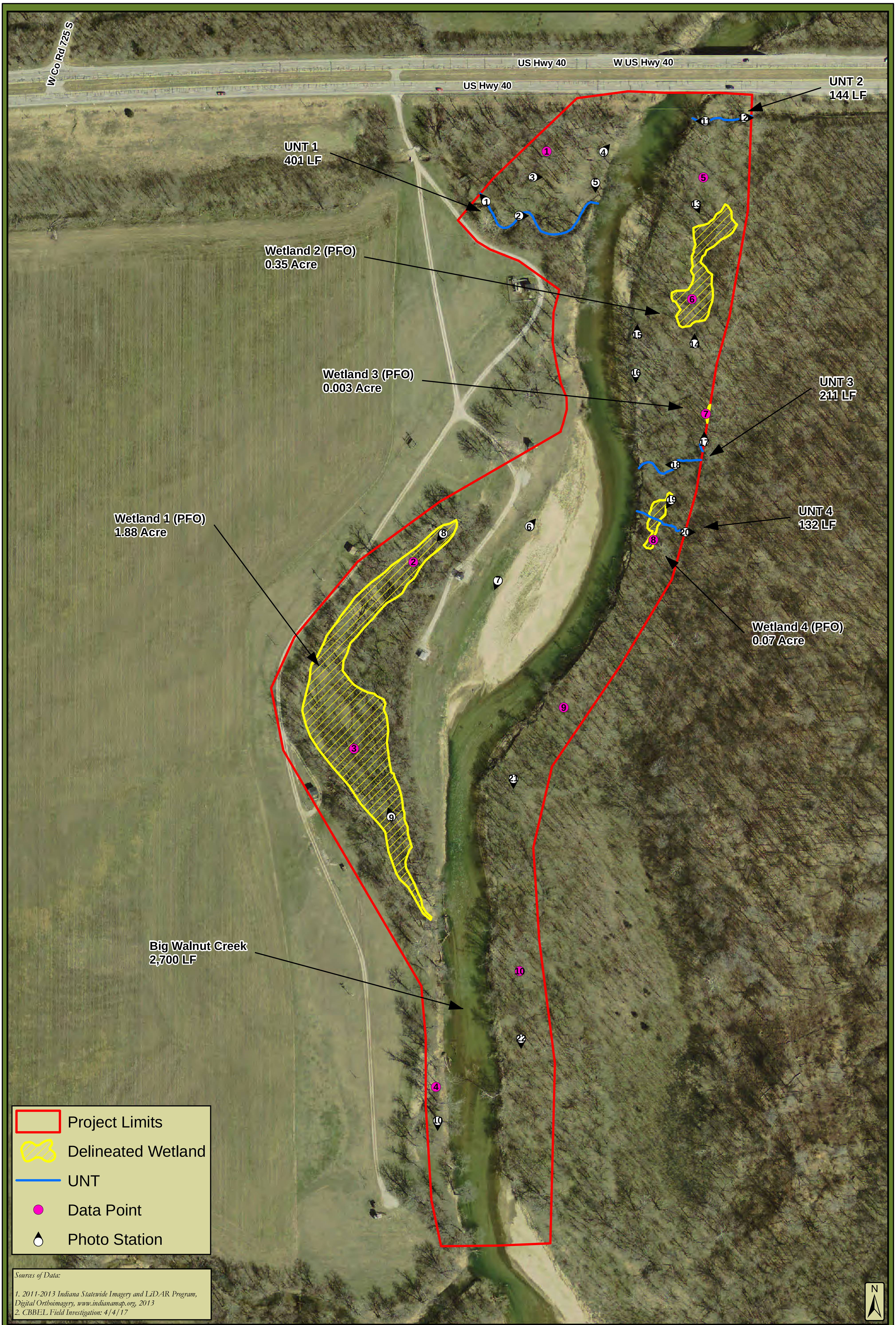
PROJECT:	PROJECT NO.	APPROX. SCALE
Big Walnut Creek	14-0014	1"=300'
TITLE: DFIRM		DATE: 04/2017
		EXHIBIT 5



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: Big Walnut Creek	PROJECT NO. 14-0014	APPROX. SCALE 1"=200' DATE: 04/2017
	TITLE: DELINEATED WETLANDS/"WATERS", DATA POINTS, & PHOTO STATIONS		EXHIBIT 6

WETLAND DETERMINATION DATA FORM – Midwest Region

Project/Site: Big Walnut Creek- Wetland Delineation City/County: Brazil/Putnam Sampling Date: 4/4/17

Applicant/Owner: IUPUI State: IN Sampling Point: DP1

Investigator(s): Sarah Wright; Jamie Furgason Section, Township, Range: Section 20, Township 13 North, Range 5 West

Landform (hillslope, terrace, etc.): ______ Local relief (concave, convex, none): none

Slope (%): ______ Lat: 39.5498 Long: -86.9848 Datum: NAD83

Soil Map Unit Name: Sw- Stonelick Sandy Loam NWI classification: PFO1A

Are climatic / hydrologic conditions on the site typical for this time of year? Yes ◉ No ○ (If no, explain in Remarks.)

Are Vegetation ☐, Soil ☐, or Hydrology ☐ significantly disturbed? Are "Normal Circumstances" present? Yes ◉ No ○

Are Vegetation ☐, Soil ☐, or Hydrology ☐ naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes ◉ No ○	Is the Sampled Area within a Wetland?	Yes ◉ No ○
Hydric Soil Present?	Yes ○ No ◉		
Wetland Hydrology Present?	Yes ○ No ◉		

Remarks:

VEGETATION – Use scientific names of plants.

Tree Stratum (Plot size: 30ft.)	Absolute % Cover	Dominant Species?	Indicator Status
1. Acer negundo	20	Yes	FAC
2. Aesculus glabra	20	Yes	FAC
3. Platanus occidentalis	30	Yes	FACW
4. Populus deltoides	30	Yes	FAC
5.			
	100	= Total Cover	
Sapling/Shrub Stratum (Plot size: 15ft.)			
1.			
2.			
3.			
4.			
5.			
	0	= Total Cover	
Herb Stratum (Plot size: 5ft.)			
1. Elymus riparius	5	No	FACW
2. Galium obtusum	10	No	FACW
3. Urtica dioica	30	Yes	FACW
4. Verbesina alternifolia	30	Yes	FACW
5.			
6.			
7.			
8.			
9.			
10.			
	75	= Total Cover	
Woody Vine Stratum (Plot size: 5ft.)			
1.			
2.			
	0	= Total Cover	

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 6 (A)

Total Number of Dominant Species Across All Strata: 6 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 100 (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:	
OBL species		x 1 =	
FACW species		x 2 =	
FAC species		x 3 =	
FACU species		x 4 =	
UPL species		x 5 =	
Column Totals:	0 (A)		(B)

Prevalence Index = B/A = ______

Hydrophytic Vegetation Indicators:

- ☐ 1 - Rapid Test for Hydrophytic Vegetation
- ☑ 2 - Dominance Test is >50%
- ☐ 3 - Prevalence Index is ≤3.0[1]
- ☐ 4 - Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
- ☐ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes ◉ No ○

Remarks: (Include photo numbers here or on a separate sheet.)

SOIL

Sampling Point: DP1

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox Features %	Type[1]	Loc[2]	Texture	Remarks
0-16	10YR 4/3	100					Sand	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, MS=Masked Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators:

- ☐ Histosol (A1)
- ☐ Histic Epipedon (A2)
- ☐ Black Histic (A3)
- ☐ Hydrogen Sulfide (A4)
- ☐ Stratified Layers (A5)
- ☐ 2 cm Muck (A10)
- ☐ Depleted Below Dark Surface (A11)
- ☐ Thick Dark Surface (A12)
- ☐ Sandy Mucky Mineral (S1)
- ☐ 5 cm Mucky Peat or Peat (S3)
- ☐ Sandy Gleyed Matrix (S4)
- ☐ Sandy Redox (S5)
- ☐ Stripped Matrix (S6)
- ☐ Loamy Mucky Mineral (F1)
- ☐ Loamy Gleyed Matrix (F2)
- ☐ Depleted Matrix (F3)
- ☐ Redox Dark Surface (F6)
- ☐ Depleted Dark Surface (F7)
- ☐ Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

- ☐ Coast Prairie Redox (A16)
- ☐ Dark Surface (S7)
- ☐ Iron-Manganese Masses (F12)
- ☐ Very Shallow Dark Surface (TF12)
- ☐ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type: ______

Depth (inches): ______

Hydric Soil Present? Yes ○ No ◉

Remarks:

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one is required; check all that apply)

- ☐ Surface Water (A1)
- ☐ High Water Table (A2)
- ☐ Saturation (A3)
- ☐ Water Marks (B1)
- ☐ Sediment Deposits (B2)
- ☐ Drift Deposits (B3)
- ☐ Algal Mat or Crust (B4)
- ☐ Iron Deposits (B5)
- ☐ Inundation Visible on Aerial Imagery (B7)
- ☐ Sparsely Vegetated Concave Surface (B8)
- ☐ Water-Stained Leaves (B9)
- ☐ Aquatic Fauna (B13)
- ☐ True Aquatic Plants (B14)
- ☐ Hydrogen Sulfide Odor (C1)
- ☐ Oxidized Rhizospheres on Living Roots (C3)
- ☐ Presence of Reduced Iron (C4)
- ☐ Recent Iron Reduction in Tilled Soils (C6)
- ☐ Thin Muck Surface (C7)
- ☐ Gauge or Well Data (D9)
- ☐ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

- ☐ Surface Soil Cracks (B6)
- ☐ Drainage Patterns (B10)
- ☐ Dry-Season Water Table (C2)
- ☐ Crayfish Burrows (C8)
- ☐ Saturation Visible on Aerial Imagery (C9)
- ☐ Stunted or Stressed Plants (D1)
- ☐ Geomorphic Position (D2)
- ☑ FAC-Neutral Test (D5)

Field Observations:

Surface Water Present? Yes ○ No ◉ Depth (inches): ______

Water Table Present? Yes ○ No ◉ Depth (inches): ______

Saturation Present? (includes capillary fringe) Yes ○ No ◉ Depth (inches): ______

Wetland Hydrology Present? Yes ○ No ◉

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

WETLAND DETERMINATION DATA FORM – Midwest Region

Project/Site: Big Walnut Creek- Wetland Delineation City/County: Brazil/Putnam Sampling Date: 4/4/17

Applicant/Owner: IUPUI State: IN Sampling Point: DP2

Investigator(s): Sarah Wright; Jamie Furgason Section, Township, Range: Section 20, Township 13 North, Range 5 West

Landform (hillslope, terrace, etc.): ______ Local relief (concave, convex, none): concave

Slope (%): ______ Lat: 39.5472 Long: -86.9856 Datum: NAD83

Soil Map Unit Name: Sw- Stonelick Sandy Loam NWI classification: PFO1A

Are climatic / hydrologic conditions on the site typical for this time of year? Yes (●) No ( ) (If no, explain in Remarks.)

Are Vegetation ☐, Soil ☐, or Hydrology ☐ significantly disturbed? Are "Normal Circumstances" present? Yes (●) No ( )

Are Vegetation ☐, Soil ☐, or Hydrology ☐ naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes (●)	No ( )	Is the Sampled Area within a Wetland? Yes (●) No ( )
Hydric Soil Present?	Yes (●)	No ( )	
Wetland Hydrology Present?	Yes (●)	No ( )	

Remarks:

VEGETATION – Use scientific names of plants.

Tree Stratum (Plot size: 30ft.)	Absolute % Cover	Dominant Species?	Indicator Status
1. Acer saccharinum	30	Yes	FACW
2. Platanus occidentalis	30	Yes	FACW
3. Populus deltoides	30	Yes	FAC
4.			
5.			
	90 = Total Cover		
Sapling/Shrub Stratum (Plot size: 15ft.)			
1.			
2.			
3.			
4.			
5.			
	0 = Total Cover		
Herb Stratum (Plot size: 5ft.)			
1. Alliaria petiolata	5	No	FAC
2. Galium obtusum	5	No	FACW
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
	10 = Total Cover		
Woody Vine Stratum (Plot size: 5ft.)			
1.			
2.			
	0 = Total Cover		

Remarks: (Include photo numbers here or on a separate sheet.)

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 3 (A)

Total Number of Dominant Species Across All Strata: 3 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 100 (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:	
OBL species		x 1 =	
FACW species		x 2 =	
FAC species		x 3 =	
FACU species		x 4 =	
UPL species		x 5 =	
Column Totals:	0 (A)		(B)

Prevalence Index = B/A = ______

Hydrophytic Vegetation Indicators:

- ☐ 1 - Rapid Test for Hydrophytic Vegetation
- ☑ 2 - Dominance Test is >50%
- ☐ 3 - Prevalence Index is ≤3.0[1]
- ☐ 4 - Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
- ☐ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes (●) No ( )

SOIL

Sampling Point: DP2

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox Features %	Type[1]	Loc[2]	Texture	Remarks
0-16	10YR 4/2	100	10YR 6/8	5	C	M	Clay	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, MS=Masked Sand Grains.
[2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators:

- ☐ Histosol (A1)
- ☐ Histic Epipedon (A2)
- ☐ Black Histic (A3)
- ☐ Hydrogen Sulfide (A4)
- ☐ Stratified Layers (A5)
- ☐ 2 cm Muck (A10)
- ☐ Depleted Below Dark Surface (A11)
- ☐ Thick Dark Surface (A12)
- ☐ Sandy Mucky Mineral (S1)
- ☐ 5 cm Mucky Peat or Peat (S3)
- ☐ Sandy Gleyed Matrix (S4)
- ☐ Sandy Redox (S5)
- ☐ Stripped Matrix (S6)
- ☐ Loamy Mucky Mineral (F1)
- ☐ Loamy Gleyed Matrix (F2)
- ☑ Depleted Matrix (F3)
- ☐ Redox Dark Surface (F6)
- ☐ Depleted Dark Surface (F7)
- ☐ Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

- ☐ Coast Prairie Redox (A16)
- ☐ Dark Surface (S7)
- ☐ Iron-Manganese Masses (F12)
- ☐ Very Shallow Dark Surface (TF12)
- ☐ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type: ______

Depth (inches): ______

Hydric Soil Present? Yes ◉ No ○

Remarks:

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one is required; check all that apply)

- ☐ Surface Water (A1)
- ☐ High Water Table (A2)
- ☑ Saturation (A3)
- ☑ Water Marks (B1)
- ☐ Sediment Deposits (B2)
- ☐ Drift Deposits (B3)
- ☐ Algal Mat or Crust (B4)
- ☐ Iron Deposits (B5)
- ☐ Inundation Visible on Aerial Imagery (B7)
- ☑ Sparsely Vegetated Concave Surface (B8)
- ☑ Water-Stained Leaves (B9)
- ☐ Aquatic Fauna (B13)
- ☐ True Aquatic Plants (B14)
- ☐ Hydrogen Sulfide Odor (C1)
- ☐ Oxidized Rhizospheres on Living Roots (C3)
- ☐ Presence of Reduced Iron (C4)
- ☐ Recent Iron Reduction in Tilled Soils (C6)
- ☐ Thin Muck Surface (C7)
- ☐ Gauge or Well Data (D9)
- ☐ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

- ☐ Surface Soil Cracks (B6)
- ☑ Drainage Patterns (B10)
- ☐ Dry-Season Water Table (C2)
- ☐ Crayfish Burrows (C8)
- ☐ Saturation Visible on Aerial Imagery (C9)
- ☐ Stunted or Stressed Plants (D1)
- ☑ Geomorphic Position (D2)
- ☑ FAC-Neutral Test (D5)

Field Observations:

Surface Water Present?	Yes ○	No ◉	Depth (inches): ______
Water Table Present?	Yes ○	No ◉	Depth (inches): ______
Saturation Present? (includes capillary fringe)	Yes ◉	No ○	Depth (inches): 0

Wetland Hydrology Present? Yes ◉ No ○

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

WETLAND DETERMINATION DATA FORM – Midwest Region

Project/Site: Big Walnut Creek- Wetland Delineation City/County: Brazil/Putnam Sampling Date: 4/4/17

Applicant/Owner: IUPUI State: IN Sampling Point: DP3

Investigator(s): Sarah Wright; Jamie Furgason Section, Township, Range: Section 20, Township 13 North, Range 5 West

Landform (hillslope, terrace, etc.): ______ Local relief (concave, convex, none): concave

Slope (%): ______ Lat: 39.5457 Long: -86.9858 Datum: NAD83

Soil Map Unit Name: Sw- Stonelick Sandy Loam NWI classification: PFO1A

Are climatic / hydrologic conditions on the site typical for this time of year? Yes ◉ No ○ (If no, explain in Remarks.)

Are Vegetation ☐, Soil ☐, or Hydrology ☐ significantly disturbed? Are "Normal Circumstances" present? Yes ◉ No ○

Are Vegetation ☐, Soil ☐, or Hydrology ☐ naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes ◉ No ○	Is the Sampled Area within a Wetland?	Yes ◉ No ○
Hydric Soil Present?	Yes ◉ No ○		
Wetland Hydrology Present?	Yes ◉ No ○		

Remarks:

VEGETATION – Use scientific names of plants.

Tree Stratum (Plot size: 30ft.)	Absolute % Cover	Dominant Species?	Indicator Status
1. Acer saccharinum	35	Yes	FACW
2. Platanus occidentalis	20	Yes	FACW
3. Populus deltoides	35	Yes	FAC
4.			
5.			
	90	= Total Cover	
Sapling/Shrub Stratum (Plot size: 15ft.)			
1.			
2.			
3.			
4.			
5.			
	0	= Total Cover	
Herb Stratum (Plot size: 5ft.)			
1. Galium obtusum	10	No	FACW
2. Urtica dioica	20	Yes	FACW
3. Verbesina alternifolia	20	Yes	FACW
4.			
5.			
6.			
7.			
8.			
9.			
10.			
	50	= Total Cover	
Woody Vine Stratum (Plot size: 5ft.)			
1.			
2.			
	0	= Total Cover	

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 5 (A)

Total Number of Dominant Species Across All Strata: 5 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 100 (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:
OBL species		x 1 =
FACW species		x 2 =
FAC species		x 3 =
FACU species		x 4 =
UPL species		x 5 =
Column Totals:	0 (A)	(B)

Prevalence Index = B/A = ______

Hydrophytic Vegetation Indicators:

- ☐ 1 - Rapid Test for Hydrophytic Vegetation
- ☑ 2 - Dominance Test is >50%
- ☐ 3 - Prevalence Index is ≤3.0[1]
- ☐ 4 - Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
- ☐ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes ◉ No ○

Remarks: (Include photo numbers here or on a separate sheet.)

SOIL

Sampling Point: DP3

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0-16	10YR 4/2	100	10YR 6/8	10	C	M	Clay	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, MS=Masked Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators:

- ☐ Histosol (A1)
- ☐ Histic Epipedon (A2)
- ☐ Black Histic (A3)
- ☐ Hydrogen Sulfide (A4)
- ☐ Stratified Layers (A5)
- ☐ 2 cm Muck (A10)
- ☐ Depleted Below Dark Surface (A11)
- ☐ Thick Dark Surface (A12)
- ☐ Sandy Mucky Mineral (S1)
- ☐ 5 cm Mucky Peat or Peat (S3)
- ☐ Sandy Gleyed Matrix (S4)
- ☐ Sandy Redox (S5)
- ☐ Stripped Matrix (S6)
- ☐ Loamy Mucky Mineral (F1)
- ☐ Loamy Gleyed Matrix (F2)
- ☑ Depleted Matrix (F3)
- ☐ Redox Dark Surface (F6)
- ☐ Depleted Dark Surface (F7)
- ☐ Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

- ☐ Coast Prairie Redox (A16)
- ☐ Dark Surface (S7)
- ☐ Iron-Manganese Masses (F12)
- ☐ Very Shallow Dark Surface (TF12)
- ☐ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type: ____________

Depth (inches): ____________

Hydric Soil Present? Yes ◉ No ○

Remarks:

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one is required; check all that apply)

- ☐ Surface Water (A1)
- ☐ High Water Table (A2)
- ☑ Saturation (A3)
- ☑ Water Marks (B1)
- ☐ Sediment Deposits (B2)
- ☐ Drift Deposits (B3)
- ☐ Algal Mat or Crust (B4)
- ☐ Iron Deposits (B5)
- ☐ Inundation Visible on Aerial Imagery (B7)
- ☐ Sparsely Vegetated Concave Surface (B8)
- ☐ Water-Stained Leaves (B9)
- ☐ Aquatic Fauna (B13)
- ☐ True Aquatic Plants (B14)
- ☐ Hydrogen Sulfide Odor (C1)
- ☐ Oxidized Rhizospheres on Living Roots (C3)
- ☐ Presence of Reduced Iron (C4)
- ☐ Recent Iron Reduction in Tilled Soils (C6)
- ☐ Thin Muck Surface (C7)
- ☐ Gauge or Well Data (D9)
- ☐ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

- ☐ Surface Soil Cracks (B6)
- ☑ Drainage Patterns (B10)
- ☐ Dry-Season Water Table (C2)
- ☐ Crayfish Burrows (C8)
- ☐ Saturation Visible on Aerial Imagery (C9)
- ☐ Stunted or Stressed Plants (D1)
- ☑ Geomorphic Position (D2)
- ☑ FAC-Neutral Test (D5)

Field Observations:

Surface Water Present? Yes ○ No ◉ Depth (inches): ____________

Water Table Present? Yes ○ No ◉ Depth (inches): ____________

Saturation Present? (includes capillary fringe) Yes ◉ No ○ Depth (inches): 0

Wetland Hydrology Present? Yes ◉ No ○

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

WETLAND DETERMINATION DATA FORM – Midwest Region

Project/Site: Big Walnut Creek- Wetland Delineation City/County: Brazil/Putnam Sampling Date: 4/4/17

Applicant/Owner: IUPUI State: IN Sampling Point: DP4

Investigator(s): Sarah Wright; Jamie Furgason Section, Township, Range: Section 29, Township 13 North, Range 5 West

Landform (hillslope, terrace, etc.): ____ Local relief (concave, convex, none): none

Slope (%): ____ Lat: 39.5442 Long: -86.9853 Datum: NAD83

Soil Map Unit Name: Sw- Stonelick Sandy Loam NWI classification: None

Are climatic / hydrologic conditions on the site typical for this time of year? Yes ◉ No ○ (If no, explain in Remarks.)

Are Vegetation ☐, Soil ☐, or Hydrology ☐ significantly disturbed? Are "Normal Circumstances" present? Yes ◉ No ○

Are Vegetation ☐, Soil ☐, or Hydrology ☐ naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

	Yes	No
Hydrophytic Vegetation Present?	◉	○
Hydric Soil Present?	○	◉
Wetland Hydrology Present?	○	◉

Is the Sampled Area within a Wetland? Yes ◉ No ○

Remarks:

VEGETATION – Use scientific names of plants.

Tree Stratum (Plot size: 30ft.)	Absolute % Cover	Dominant Species?	Indicator Status
1. Acer saccharinum	30	Yes	FACW
2.			
3.			
4.			
5.			
	30 = Total Cover		
Sapling/Shrub Stratum (Plot size: 15ft.)			
1.			
2.			
3.			
4.			
5.			
	0 = Total Cover		
Herb Stratum (Plot size: 5ft.)			
1. Poa pratensis	50	Yes	FAC
2. Schedonorus pratensis	45	Yes	FACU
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
	95 = Total Cover		
Woody Vine Stratum (Plot size: 5ft.)			
1.			
2.			
	0 = Total Cover		

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 2 (A)

Total Number of Dominant Species Across All Strata: 3 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 66 (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:	
OBL species		x 1 =	
FACW species		x 2 =	
FAC species		x 3 =	
FACU species		x 4 =	
UPL species		x 5 =	
Column Totals:	0 (A)		(B)

Prevalence Index = B/A = ____

Hydrophytic Vegetation Indicators:

- ☐ 1 - Rapid Test for Hydrophytic Vegetation
- ☑ 2 - Dominance Test is >50%
- ☐ 3 - Prevalence Index is ≤3.0[1]
- ☐ 4 - Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
- ☐ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes ◉ No ○

Remarks: (Include photo numbers here or on a separate sheet.)

SOIL

Sampling Point: DP4

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox Features %	Type[1]	Loc[2]	Texture	Remarks
0-16	10YR 4/3	100					Clay	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, MS=Masked Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators:

- ☐ Histosol (A1)
- ☐ Histic Epipedon (A2)
- ☐ Black Histic (A3)
- ☐ Hydrogen Sulfide (A4)
- ☐ Stratified Layers (A5)
- ☐ 2 cm Muck (A10)
- ☐ Depleted Below Dark Surface (A11)
- ☐ Thick Dark Surface (A12)
- ☐ Sandy Mucky Mineral (S1)
- ☐ 5 cm Mucky Peat or Peat (S3)
- ☐ Sandy Gleyed Matrix (S4)
- ☐ Sandy Redox (S5)
- ☐ Stripped Matrix (S6)
- ☐ Loamy Mucky Mineral (F1)
- ☐ Loamy Gleyed Matrix (F2)
- ☐ Depleted Matrix (F3)
- ☐ Redox Dark Surface (F6)
- ☐ Depleted Dark Surface (F7)
- ☐ Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

- ☐ Coast Prairie Redox (A16)
- ☐ Dark Surface (S7)
- ☐ Iron-Manganese Masses (F12)
- ☐ Very Shallow Dark Surface (TF12)
- ☐ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type: ______

Depth (inches): ______

Hydric Soil Present? Yes ○ No ◉

Remarks:

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one is required; check all that apply)

- ☐ Surface Water (A1)
- ☐ High Water Table (A2)
- ☐ Saturation (A3)
- ☐ Water Marks (B1)
- ☐ Sediment Deposits (B2)
- ☐ Drift Deposits (B3)
- ☐ Algal Mat or Crust (B4)
- ☐ Iron Deposits (B5)
- ☐ Inundation Visible on Aerial Imagery (B7)
- ☐ Sparsely Vegetated Concave Surface (B8)
- ☐ Water-Stained Leaves (B9)
- ☐ Aquatic Fauna (B13)
- ☐ True Aquatic Plants (B14)
- ☐ Hydrogen Sulfide Odor (C1)
- ☐ Oxidized Rhizospheres on Living Roots (C3)
- ☐ Presence of Reduced Iron (C4)
- ☐ Recent Iron Reduction in Tilled Soils (C6)
- ☐ Thin Muck Surface (C7)
- ☐ Gauge or Well Data (D9)
- ☐ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

- ☐ Surface Soil Cracks (B6)
- ☐ Drainage Patterns (B10)
- ☐ Dry-Season Water Table (C2)
- ☐ Crayfish Burrows (C8)
- ☐ Saturation Visible on Aerial Imagery (C9)
- ☐ Stunted or Stressed Plants (D1)
- ☐ Geomorphic Position (D2)
- ☑ FAC-Neutral Test (D5)

Field Observations:

Surface Water Present?	Yes ○	No ◉	Depth (inches): ______
Water Table Present?	Yes ○	No ◉	Depth (inches): ______
Saturation Present? (includes capillary fringe)	Yes ○	No ◉	Depth (inches): ______

Wetland Hydrology Present? Yes ○ No ◉

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

WETLAND DETERMINATION DATA FORM – Midwest Region

Project/Site: Big Walnut Creek- Wetland Delineation City/County: Brazil/Putnam Sampling Date: 4/4/17

Applicant/Owner: IUPUI State: IN Sampling Point: DP5

Investigator(s): Sarah Wright; Jamie Furgason Section, Township, Range: Section 20, Township 13 North, Range 5 West

Landform (hillslope, terrace, etc.): ______ Local relief (concave, convex, none): none

Slope (%): ______ Lat: 39.5498 Long: -86.9830 Datum: NAD83

Soil Map Unit Name: Sh- Shoals Silt Loam NWI classification: None

Are climatic / hydrologic conditions on the site typical for this time of year? Yes (●) No ( ) (If no, explain in Remarks.)

Are Vegetation ☐, Soil ☐, or Hydrology ☐ significantly disturbed? Are "Normal Circumstances" present? Yes (●) No ( )

Are Vegetation ☐, Soil ☐, or Hydrology ☐ naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes (●)	No ( )
Hydric Soil Present?	Yes ( )	No (●)
Wetland Hydrology Present?	Yes ( )	No (●)

Is the Sampled Area within a Wetland? Yes (●) No ( )

Remarks:

VEGETATION – Use scientific names of plants.

	Absolute % Cover	Dominant Species?	Indicator Status
Tree Stratum (Plot size: 30ft.)			
1. Aesculus glabra	20	Yes	FAC
2. Platanus occidentalis	20	Yes	FACW
3. Populus deltoides	40	Yes	FAC
4.			
5.			
	80 = Total Cover		
Sapling/Shrub Stratum (Plot size: 15ft.)			
1.			
2.			
3.			
4.			
5.			
	0 = Total Cover		
Herb Stratum (Plot size: 5ft.)			
1. Urtica dioica	20	Yes	FACW
2. Verbesina alternifolia	50	Yes	FACW
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
	70 = Total Cover		
Woody Vine Stratum (Plot size: 5ft.)			
1.			
2.			
	0 = Total Cover		

Remarks: (Include photo numbers here or on a separate sheet.)

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 5 (A)

Total Number of Dominant Species Across All Strata: 5 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 100 (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:	
OBL species		x 1 =	
FACW species		x 2 =	
FAC species		x 3 =	
FACU species		x 4 =	
UPL species		x 5 =	
Column Totals:	0 (A)		(B)

Prevalence Index = B/A = ______

Hydrophytic Vegetation Indicators:

- ☐ 1 - Rapid Test for Hydrophytic Vegetation
- ☑ 2 - Dominance Test is >50%
- ☐ 3 - Prevalence Index is ≤3.0[1]
- ☐ 4 - Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
- ☐ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes (●) No ( )

SOIL

Sampling Point: DP5

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox %	Type[1]	Loc[2]	Texture	Remarks
0-16	10YR 4/3	100					Clay	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, MS=Masked Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators:

- ☐ Histosol (A1)
- ☐ Histic Epipedon (A2)
- ☐ Black Histic (A3)
- ☐ Hydrogen Sulfide (A4)
- ☐ Stratified Layers (A5)
- ☐ 2 cm Muck (A10)
- ☐ Depleted Below Dark Surface (A11)
- ☐ Thick Dark Surface (A12)
- ☐ Sandy Mucky Mineral (S1)
- ☐ 5 cm Mucky Peat or Peat (S3)
- ☐ Sandy Gleyed Matrix (S4)
- ☐ Sandy Redox (S5)
- ☐ Stripped Matrix (S6)
- ☐ Loamy Mucky Mineral (F1)
- ☐ Loamy Gleyed Matrix (F2)
- ☐ Depleted Matrix (F3)
- ☐ Redox Dark Surface (F6)
- ☐ Depleted Dark Surface (F7)
- ☐ Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

- ☐ Coast Prairie Redox (A16)
- ☐ Dark Surface (S7)
- ☐ Iron-Manganese Masses (F12)
- ☐ Very Shallow Dark Surface (TF12)
- ☐ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type: ____________

Depth (inches): ____________

Hydric Soil Present? Yes ○ No ◉

Remarks:

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one is required; check all that apply)

- ☐ Surface Water (A1)
- ☐ High Water Table (A2)
- ☐ Saturation (A3)
- ☐ Water Marks (B1)
- ☐ Sediment Deposits (B2)
- ☐ Drift Deposits (B3)
- ☐ Algal Mat or Crust (B4)
- ☐ Iron Deposits (B5)
- ☐ Inundation Visible on Aerial Imagery (B7)
- ☐ Sparsely Vegetated Concave Surface (B8)
- ☐ Water-Stained Leaves (B9)
- ☐ Aquatic Fauna (B13)
- ☐ True Aquatic Plants (B14)
- ☐ Hydrogen Sulfide Odor (C1)
- ☐ Oxidized Rhizospheres on Living Roots (C3)
- ☐ Presence of Reduced Iron (C4)
- ☐ Recent Iron Reduction in Tilled Soils (C6)
- ☐ Thin Muck Surface (C7)
- ☐ Gauge or Well Data (D9)
- ☐ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

- ☐ Surface Soil Cracks (B6)
- ☐ Drainage Patterns (B10)
- ☐ Dry-Season Water Table (C2)
- ☐ Crayfish Burrows (C8)
- ☐ Saturation Visible on Aerial Imagery (C9)
- ☐ Stunted or Stressed Plants (D1)
- ☐ Geomorphic Position (D2)
- ☑ FAC-Neutral Test (D5)

Field Observations:

Surface Water Present? Yes ○ No ◉ Depth (inches): ______

Water Table Present? Yes ○ No ◉ Depth (inches): ______

Saturation Present? (includes capillary fringe) Yes ○ No ◉ Depth (inches): ______

Wetland Hydrology Present? Yes ○ No ◉

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

WETLAND DETERMINATION DATA FORM – Midwest Region

Project/Site: Big Walnut Creek- Wetland Delineation City/County: Brazil/Putnam Sampling Date: 4/4/17

Applicant/Owner: IUPUI State: IN Sampling Point: DP6

Investigator(s): Sarah Wright; Jamie Furgason Section, Township, Range: Section 20, Township 13 North, Range 5 West

Landform (hillslope, terrace, etc.): ______ Local relief (concave, convex, none): none

Slope (%): ______ Lat: 39.5493 Long: -86.9829 Datum: NAD83

Soil Map Unit Name: Sh- Shoals Silt Loam NWI classification: None

Are climatic / hydrologic conditions on the site typical for this time of year? Yes (●) No ( ) (If no, explain in Remarks.)

Are Vegetation ☐, Soil ☐, or Hydrology ☐ significantly disturbed? Are "Normal Circumstances" present? Yes (●) No ( )

Are Vegetation ☐, Soil ☐, or Hydrology ☐ naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes (●)	No ( )
Hydric Soil Present?	Yes (●)	No ( )
Wetland Hydrology Present?	Yes (●)	No ( )

Is the Sampled Area within a Wetland? **Yes** (●) **No** ( )

Remarks:

VEGETATION – Use scientific names of plants.

Tree Stratum (Plot size: 30ft.)	Absolute % Cover	Dominant Species?	Indicator Status
1. Acer negundo	25	Yes	FAC
2. Acer saccharinum	35	Yes	FACW
3. Populus deltoides	35	Yes	FAC
4.			
5.			
	95 = Total Cover		
Sapling/Shrub Stratum (Plot size: 15ft.)			
1.			
2.			
3.			
4.			
5.			
	0 = Total Cover		
Herb Stratum (Plot size: 5ft.)			
1. Elymus riparius	20	Yes	FACW
2. Verbesina alternifolia	20	Yes	FACW
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
	40 = Total Cover		
Woody Vine Stratum (Plot size: 5ft.)			
1.			
2.			
	0 = Total Cover		

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 5 (A)

Total Number of Dominant Species Across All Strata: 5 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 100 (A/B)

Prevalence Index worksheet:

Total % Cover of:	Multiply by:
OBL species ______	x 1 = ______
FACW species ______	x 2 = ______
FAC species ______	x 3 = ______
FACU species ______	x 4 = ______
UPL species ______	x 5 = ______
Column Totals: 0 (A)	______ (B)

Prevalence Index = B/A = ______

Hydrophytic Vegetation Indicators:

- ☐ 1 - Rapid Test for Hydrophytic Vegetation
- ☑ 2 - Dominance Test is >50%
- ☐ 3 - Prevalence Index is ≤3.0[1]
- ☐ 4 - Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
- ☐ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? **Yes** (●) **No** ( )

Remarks: (Include photo numbers here or on a separate sheet.)

SOIL

Sampling Point: DP6

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox Features %	Type[1]	Loc[2]	Texture	Remarks
0-3	10YR 4/1	100					Clay	
3-20	10YR 4/4	100					Sand	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, MS=Masked Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators:

- ☐ Histosol (A1)
- ☐ Histic Epipedon (A2)
- ☐ Black Histic (A3)
- ☐ Hydrogen Sulfide (A4)
- ☐ Stratified Layers (A5)
- ☐ 2 cm Muck (A10)
- ☐ Depleted Below Dark Surface (A11)
- ☐ Thick Dark Surface (A12)
- ☐ Sandy Mucky Mineral (S1)
- ☐ 5 cm Mucky Peat or Peat (S3)
- ☐ Sandy Gleyed Matrix (S4)
- ☐ Sandy Redox (S5)
- ☐ Stripped Matrix (S6)
- ☐ Loamy Mucky Mineral (F1)
- ☐ Loamy Gleyed Matrix (F2)
- ☐ Depleted Matrix (F3)
- ☐ Redox Dark Surface (F6)
- ☐ Depleted Dark Surface (F7)
- ☐ Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

- ☐ Coast Prairie Redox (A16)
- ☐ Dark Surface (S7)
- ☐ Iron-Manganese Masses (F12)
- ☐ Very Shallow Dark Surface (TF12)
- ☐ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type: ______

Depth (inches): ______

Hydric Soil Present? Yes ◉ No ○

Remarks:

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one is required; check all that apply)

- ☑ Surface Water (A1)
- ☐ High Water Table (A2)
- ☑ Saturation (A3)
- ☑ Water Marks (B1)
- ☐ Sediment Deposits (B2)
- ☐ Drift Deposits (B3)
- ☐ Algal Mat or Crust (B4)
- ☐ Iron Deposits (B5)
- ☐ Inundation Visible on Aerial Imagery (B7)
- ☐ Sparsely Vegetated Concave Surface (B8)
- ☐ Water-Stained Leaves (B9)
- ☐ Aquatic Fauna (B13)
- ☐ True Aquatic Plants (B14)
- ☐ Hydrogen Sulfide Odor (C1)
- ☐ Oxidized Rhizospheres on Living Roots (C3)
- ☐ Presence of Reduced Iron (C4)
- ☐ Recent Iron Reduction in Tilled Soils (C6)
- ☐ Thin Muck Surface (C7)
- ☐ Gauge or Well Data (D9)
- ☐ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

- ☐ Surface Soil Cracks (B6)
- ☐ Drainage Patterns (B10)
- ☐ Dry-Season Water Table (C2)
- ☐ Crayfish Burrows (C8)
- ☐ Saturation Visible on Aerial Imagery (C9)
- ☐ Stunted or Stressed Plants (D1)
- ☑ Geomorphic Position (D2)
- ☑ FAC-Neutral Test (D5)

Field Observations:

Surface Water Present? Yes ◉ No ○ Depth (inches): 12

Water Table Present? Yes ○ No ◉ Depth (inches): ______

Saturation Present? (includes capillary fringe) Yes ◉ No ○ Depth (inches): 0

Wetland Hydrology Present? Yes ◉ No ○

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

WETLAND DETERMINATION DATA FORM – Midwest Region

Project/Site: Big Walnut Creek- Wetland Delineation City/County: Brazil/Putnam Sampling Date: 4/4/17

Applicant/Owner: IUPUI State: IN Sampling Point: DP7

Investigator(s): Sarah Wright; Jamie Furgason Section, Township, Range: Section 20, Township 13 North, Range 5 West

Landform (hillslope, terrace, etc.): ______ Local relief (concave, convex, none): none

Slope (%): ______ Lat: 39.5485 Long: -86.9831 Datum: NAD83

Soil Map Unit Name: Sw- Stonelick Sandy Loam NWI classification: None

Are climatic / hydrologic conditions on the site typical for this time of year? Yes ◉ No ○ (If no, explain in Remarks.)

Are Vegetation ☐, Soil ☐, or Hydrology ☐ significantly disturbed? Are "Normal Circumstances" present? Yes ◉ No ○

Are Vegetation ☐, Soil ☐, or Hydrology ☐ naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes ◉ No ○	Is the Sampled Area within a Wetland?	Yes ◉ No ○
Hydric Soil Present?	Yes ◉ No ○		
Wetland Hydrology Present?	Yes ◉ No ○		

Remarks:

VEGETATION – Use scientific names of plants.

	Absolute % Cover	Dominant Species?	Indicator Status
Tree Stratum (Plot size: 30ft.)			
1. Platanus occidentalis	35	Yes	FACW
2. Ulmus americana	35	Yes	FACW
3.			
4.			
5.			
	70 = Total Cover		
Sapling/Shrub Stratum (Plot size: 15ft.)			
1.			
2.			
3.			
4.			
5.			
	0 = Total Cover		
Herb Stratum (Plot size: 5ft.)			
1. Elymus riparius	20	Yes	FACW
2. Galium obtusum	10	No	FACW
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
	30 = Total Cover		
Woody Vine Stratum (Plot size: 5ft.)			
1.			
2.			
	0 = Total Cover		

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: ______ (A)

Total Number of Dominant Species Across All Strata: ______ (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: ______ (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:	
OBL species		x 1 =	
FACW species		x 2 =	
FAC species		x 3 =	
FACU species		x 4 =	
UPL species		x 5 =	
Column Totals:	0 (A)		(B)

Prevalence Index = B/A = ______

Hydrophytic Vegetation Indicators:

- ☑ 1 - Rapid Test for Hydrophytic Vegetation
- ☐ 2 - Dominance Test is >50%
- ☐ 3 - Prevalence Index is ≤3.0[1]
- ☐ 4 - Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
- ☐ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes ◉ No ○

Remarks: (Include photo numbers here or on a separate sheet.)

SOIL

Sampling Point: DP7

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox Features %	Type[1]	Loc[2]	Texture	Remarks
0-16	10YR 4/1	100	7.5YR 5/8	5			Clay	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, MS=Masked Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators:

- ☐ Histosol (A1)
- ☐ Histic Epipedon (A2)
- ☐ Black Histic (A3)
- ☐ Hydrogen Sulfide (A4)
- ☐ Stratified Layers (A5)
- ☐ 2 cm Muck (A10)
- ☐ Depleted Below Dark Surface (A11)
- ☐ Thick Dark Surface (A12)
- ☐ Sandy Mucky Mineral (S1)
- ☐ 5 cm Mucky Peat or Peat (S3)
- ☐ Sandy Gleyed Matrix (S4)
- ☐ Sandy Redox (S5)
- ☐ Stripped Matrix (S6)
- ☐ Loamy Mucky Mineral (F1)
- ☐ Loamy Gleyed Matrix (F2)
- ☑ Depleted Matrix (F3)
- ☐ Redox Dark Surface (F6)
- ☐ Depleted Dark Surface (F7)
- ☐ Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

- ☐ Coast Prairie Redox (A16)
- ☐ Dark Surface (S7)
- ☐ Iron-Manganese Masses (F12)
- ☐ Very Shallow Dark Surface (TF12)
- ☐ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type: ______

Depth (inches): ______

Hydric Soil Present? Yes ◉ No ○

Remarks:

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one is required; check all that apply)

- ☑ Surface Water (A1)
- ☐ High Water Table (A2)
- ☑ Saturation (A3)
- ☐ Water Marks (B1)
- ☐ Sediment Deposits (B2)
- ☐ Drift Deposits (B3)
- ☐ Algal Mat or Crust (B4)
- ☐ Iron Deposits (B5)
- ☐ Inundation Visible on Aerial Imagery (B7)
- ☐ Sparsely Vegetated Concave Surface (B8)
- ☑ Water-Stained Leaves (B9)
- ☐ Aquatic Fauna (B13)
- ☐ True Aquatic Plants (B14)
- ☐ Hydrogen Sulfide Odor (C1)
- ☐ Oxidized Rhizospheres on Living Roots (C3)
- ☐ Presence of Reduced Iron (C4)
- ☐ Recent Iron Reduction in Tilled Soils (C6)
- ☐ Thin Muck Surface (C7)
- ☐ Gauge or Well Data (D9)
- ☐ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

- ☐ Surface Soil Cracks (B6)
- ☐ Drainage Patterns (B10)
- ☐ Dry-Season Water Table (C2)
- ☐ Crayfish Burrows (C8)
- ☐ Saturation Visible on Aerial Imagery (C9)
- ☐ Stunted or Stressed Plants (D1)
- ☑ Geomorphic Position (D2)
- ☑ FAC-Neutral Test (D5)

Field Observations:

Surface Water Present? Yes ◉ No ○ Depth (inches): 3

Water Table Present? Yes ○ No ◉ Depth (inches): ______

Saturation Present? (includes capillary fringe) Yes ◉ No ○ Depth (inches): 0

Wetland Hydrology Present? Yes ◉ No ○

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

WETLAND DETERMINATION DATA FORM – Midwest Region

Project/Site: Big Walnut Creek- Wetland Delineation City/County: Brazil/Putnam Sampling Date: 4/4/17

Applicant/Owner: IUPUI State: IN Sampling Point: DP8

Investigator(s): Sarah Wright; Jamie Furgason Section, Township, Range: Section 20, Township 13 North, Range 5 West

Landform (hillslope, terrace, etc.): ______ Local relief (concave, convex, none): none

Slope (%): ______ Lat: 39.5478 Long: -86.9834 Datum: NAD83

Soil Map Unit Name: Sw- Stonelick Sandy Loam NWI classification: None

Are climatic / hydrologic conditions on the site typical for this time of year? Yes (X) No ( ) (If no, explain in Remarks.)

Are Vegetation ☐, Soil ☐, or Hydrology ☐ significantly disturbed? Are "Normal Circumstances" present? Yes (X) No ( )

Are Vegetation ☐, Soil ☐, or Hydrology ☐ naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes (X)	No ( )
Hydric Soil Present?	Yes (X)	No ( )
Wetland Hydrology Present?	Yes (X)	No ( )

Is the Sampled Area within a Wetland? Yes (X) No ( )

Remarks:

VEGETATION – Use scientific names of plants.

Tree Stratum (Plot size: 30ft.)	Absolute % Cover	Dominant Species?	Indicator Status
1. Acer negundo	50	Yes	FAC
2.			
3.			
4.			
5.			
	50 = Total Cover		

Sapling/Shrub Stratum (Plot size: 15ft.)	Absolute % Cover	Dominant Species?	Indicator Status
1.			
2.			
3.			
4.			
5.			
	0 = Total Cover		

Herb Stratum (Plot size: 5ft.)	Absolute % Cover	Dominant Species?	Indicator Status
1. Carex spp.	10	No	FACW
2. Elymus riparius	20	Yes	FACW
3. Verbesina alternifolia	20	Yes	FACW
4.			
5.			
6.			
7.			
8.			
9.			
10.			
	50 = Total Cover		

Woody Vine Stratum (Plot size: 5ft.)	Absolute % Cover	Dominant Species?	Indicator Status
1.			
2.			
	0 = Total Cover		

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 3 (A)

Total Number of Dominant Species Across All Strata: 3 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 100 (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:	
OBL species		x 1 =	
FACW species		x 2 =	
FAC species		x 3 =	
FACU species		x 4 =	
UPL species		x 5 =	
Column Totals:	0 (A)		(B)

Prevalence Index = B/A = ______

Hydrophytic Vegetation Indicators:

- ☐ 1 - Rapid Test for Hydrophytic Vegetation
- ☑ 2 - Dominance Test is >50%
- ☐ 3 - Prevalence Index is ≤3.0[1]
- ☐ 4 - Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
- ☐ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes (X) No ( )

Remarks: (Include photo numbers here or on a separate sheet.)

SOIL

Sampling Point: DP8

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox Features %	Type[1]	Loc[2]	Texture	Remarks
0-16	10YR 4/1	100	7.5YR 5/8	10			Clay	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, MS=Masked Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators:

- [ ] Histosol (A1)
- [ ] Histic Epipedon (A2)
- [ ] Black Histic (A3)
- [ ] Hydrogen Sulfide (A4)
- [ ] Stratified Layers (A5)
- [ ] 2 cm Muck (A10)
- [ ] Depleted Below Dark Surface (A11)
- [ ] Thick Dark Surface (A12)
- [ ] Sandy Mucky Mineral (S1)
- [ ] 5 cm Mucky Peat or Peat (S3)
- [ ] Sandy Gleyed Matrix (S4)
- [ ] Sandy Redox (S5)
- [ ] Stripped Matrix (S6)
- [ ] Loamy Mucky Mineral (F1)
- [ ] Loamy Gleyed Matrix (F2)
- [x] Depleted Matrix (F3)
- [ ] Redox Dark Surface (F6)
- [ ] Depleted Dark Surface (F7)
- [ ] Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

- [ ] Coast Prairie Redox (A16)
- [ ] Dark Surface (S7)
- [ ] Iron-Manganese Masses (F12)
- [ ] Very Shallow Dark Surface (TF12)
- [ ] Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type: ______

Depth (inches): ______

Hydric Soil Present? Yes **(•)** No ( )

Remarks:

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one is required; check all that apply)

- [x] Surface Water (A1)
- [ ] High Water Table (A2)
- [x] Saturation (A3)
- [ ] Water Marks (B1)
- [ ] Sediment Deposits (B2)
- [ ] Drift Deposits (B3)
- [ ] Algal Mat or Crust (B4)
- [ ] Iron Deposits (B5)
- [ ] Inundation Visible on Aerial Imagery (B7)
- [ ] Sparsely Vegetated Concave Surface (B8)
- [ ] Water-Stained Leaves (B9)
- [ ] Aquatic Fauna (B13)
- [ ] True Aquatic Plants (B14)
- [ ] Hydrogen Sulfide Odor (C1)
- [ ] Oxidized Rhizospheres on Living Roots (C3)
- [ ] Presence of Reduced Iron (C4)
- [ ] Recent Iron Reduction in Tilled Soils (C6)
- [ ] Thin Muck Surface (C7)
- [ ] Gauge or Well Data (D9)
- [ ] Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

- [ ] Surface Soil Cracks (B6)
- [x] Drainage Patterns (B10)
- [ ] Dry-Season Water Table (C2)
- [ ] Crayfish Burrows (C8)
- [ ] Saturation Visible on Aerial Imagery (C9)
- [ ] Stunted or Stressed Plants (D1)
- [x] Geomorphic Position (D2)
- [x] FAC-Neutral Test (D5)

Field Observations:

Surface Water Present? Yes **(•)** No ( ) Depth (inches): 3

Water Table Present? Yes ( ) No **(•)** Depth (inches): ______

Saturation Present? (includes capillary fringe) Yes **(•)** No ( ) Depth (inches): 0

Wetland Hydrology Present? Yes **(•)** No ( )

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

WETLAND DETERMINATION DATA FORM – Midwest Region

Project/Site: Big Walnut Creek- Wetland Delineation City/County: Brazil/Putnam Sampling Date: 4/4/17

Applicant/Owner: IUPUI State: IN Sampling Point: DP9

Investigator(s): Sarah Wright; Jamie Furgason Section, Township, Range: Section 20, Township 13 North, Range 5 West

Landform (hillslope, terrace, etc.): ______ Local relief (concave, convex, none): none

Slope (%): ______ Lat: 39.5459 Long: -86.9843 Datum: NAD83

Soil Map Unit Name: Sw- Stonelick Sandy Loam NWI classification: None

Are climatic / hydrologic conditions on the site typical for this time of year? Yes (●) No ( ) (If no, explain in Remarks.)

Are Vegetation ☐, Soil ☐, or Hydrology ☐ significantly disturbed? Are "Normal Circumstances" present? Yes (●) No ( )

Are Vegetation ☐, Soil ☐, or Hydrology ☐ naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes (●)	No ( )
Hydric Soil Present?	Yes ( )	No (●)
Wetland Hydrology Present?	Yes ( )	No (●)

Is the Sampled Area within a Wetland? Yes (●) No ( )

Remarks:

VEGETATION – Use scientific names of plants.

	Absolute % Cover	Dominant Species?	Indicator Status
Tree Stratum (Plot size: 30ft.)			
1. Acer negundo	25	Yes	FAC
2. Acer saccharinum	35	Yes	FACW
3. Populus deltoides	35	Yes	FAC
4.			
5.			
	95 = Total Cover		
Sapling/Shrub Stratum (Plot size: 15ft.)			
1.			
2.			
3.			
4.			
5.			
	0 = Total Cover		
Herb Stratum (Plot size: 5ft.)			
1. Hydrophyllum virginianum	20	Yes	FAC
2. Verbesina alternifolia	20	Yes	FACW
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
	40 = Total Cover		
Woody Vine Stratum (Plot size: 5ft.)			
1.			
2.			
	0 = Total Cover		

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 5 (A)

Total Number of Dominant Species Across All Strata: 5 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 100 (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:
OBL species		x 1 =
FACW species		x 2 =
FAC species		x 3 =
FACU species		x 4 =
UPL species		x 5 =
Column Totals:	0 (A)	(B)

Prevalence Index = B/A = ______

Hydrophytic Vegetation Indicators:

- ☐ 1 - Rapid Test for Hydrophytic Vegetation
- ☑ 2 - Dominance Test is >50%
- ☐ 3 - Prevalence Index is ≤3.0[1]
- ☐ 4 - Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
- ☐ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes (●) No ( )

Remarks: (Include photo numbers here or on a separate sheet.)

SOIL

Sampling Point: DP9

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox Features %	Type[1]	Loc[2]	Texture	Remarks
0-16	10YR 4/3	100					Clay	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, MS=Masked Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators:

- [ ] Histosol (A1)
- [ ] Histic Epipedon (A2)
- [ ] Black Histic (A3)
- [ ] Hydrogen Sulfide (A4)
- [ ] Stratified Layers (A5)
- [ ] 2 cm Muck (A10)
- [ ] Depleted Below Dark Surface (A11)
- [ ] Thick Dark Surface (A12)
- [ ] Sandy Mucky Mineral (S1)
- [ ] 5 cm Mucky Peat or Peat (S3)
- [ ] Sandy Gleyed Matrix (S4)
- [ ] Sandy Redox (S5)
- [ ] Stripped Matrix (S6)
- [ ] Loamy Mucky Mineral (F1)
- [ ] Loamy Gleyed Matrix (F2)
- [ ] Depleted Matrix (F3)
- [ ] Redox Dark Surface (F6)
- [ ] Depleted Dark Surface (F7)
- [ ] Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

- [ ] Coast Prairie Redox (A16)
- [ ] Dark Surface (S7)
- [ ] Iron-Manganese Masses (F12)
- [ ] Very Shallow Dark Surface (TF12)
- [ ] Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type: ______

Depth (inches): ______

Hydric Soil Present? Yes ○ No ◉

Remarks:

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one is required; check all that apply)

- [ ] Surface Water (A1)
- [ ] High Water Table (A2)
- [ ] Saturation (A3)
- [ ] Water Marks (B1)
- [ ] Sediment Deposits (B2)
- [ ] Drift Deposits (B3)
- [ ] Algal Mat or Crust (B4)
- [ ] Iron Deposits (B5)
- [ ] Inundation Visible on Aerial Imagery (B7)
- [ ] Sparsely Vegetated Concave Surface (B8)
- [ ] Water-Stained Leaves (B9)
- [ ] Aquatic Fauna (B13)
- [ ] True Aquatic Plants (B14)
- [ ] Hydrogen Sulfide Odor (C1)
- [ ] Oxidized Rhizospheres on Living Roots (C3)
- [ ] Presence of Reduced Iron (C4)
- [ ] Recent Iron Reduction in Tilled Soils (C6)
- [ ] Thin Muck Surface (C7)
- [ ] Gauge or Well Data (D9)
- [ ] Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

- [ ] Surface Soil Cracks (B6)
- [ ] Drainage Patterns (B10)
- [ ] Dry-Season Water Table (C2)
- [ ] Crayfish Burrows (C8)
- [ ] Saturation Visible on Aerial Imagery (C9)
- [ ] Stunted or Stressed Plants (D1)
- [ ] Geomorphic Position (D2)
- [x] FAC-Neutral Test (D5)

Field Observations:

Surface Water Present? Yes ○ No ◉ Depth (inches): ______

Water Table Present? Yes ○ No ◉ Depth (inches): ______

Saturation Present? (includes capillary fringe) Yes ○ No ◉ Depth (inches): ______

Wetland Hydrology Present? Yes ○ No ◉

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

WETLAND DETERMINATION DATA FORM – Midwest Region

Project/Site: Big Walnut Creek- Wetland Delineation City/County: Brazil/Putnam Sampling Date: 4/4/17

Applicant/Owner: IUPUI State: IN Sampling Point: DP10

Investigator(s): Sarah Wright; Jamie Furgason Section, Township, Range: Section 29, Township 13 North, Range 5 West

Landform (hillslope, terrace, etc.): ______ Local relief (concave, convex, none): none

Slope (%): ______ Lat: 39.5442 Long: -86.9846 Datum: NAD83

Soil Map Unit Name: Sw- Stonelick Sandy Loam NWI classification: PFO1A

Are climatic / hydrologic conditions on the site typical for this time of year? Yes ◉ No ○ (If no, explain in Remarks.)

Are Vegetation ☐, Soil ☐, or Hydrology ☐ significantly disturbed? Are "Normal Circumstances" present? Yes ◉ No ○

Are Vegetation ☐, Soil ☐, or Hydrology ☐ naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes ◉	No ○	Is the Sampled Area within a Wetland? Yes ◉ No ○
Hydric Soil Present?	Yes ○	No ◉	
Wetland Hydrology Present?	Yes ○	No ◉	

Remarks:

VEGETATION – Use scientific names of plants.

Tree Stratum (Plot size: 30ft.)	Absolute % Cover	Dominant Species?	Indicator Status
1. Acer negundo	20	Yes	FAC
2. Aesculus glabra	20	Yes	FAC
3. Populus deltoides	30	Yes	FAC
4.			
5.			
	70 = Total Cover		
Sapling/Shrub Stratum (Plot size: 15ft.)			
1.			
2.			
3.			
4.			
5.			
	0 = Total Cover		
Herb Stratum (Plot size: 5ft.)			
1. Elymus riparius	10	No	FAC
2. Hydrophyllum virginianum	15	No	FAC
3. Verbesina alternifolia	20	Yes	FACW
4.			
5.			
6.			
7.			
8.			
9.			
10.			
	45 = Total Cover		
Woody Vine Stratum (Plot size: 5ft.)			
1.			
2.			
	0 = Total Cover		

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 4 (A)

Total Number of Dominant Species Across All Strata: 4 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 100 (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:
OBL species		x 1 =
FACW species		x 2 =
FAC species		x 3 =
FACU species		x 4 =
UPL species		x 5 =
Column Totals:	0 (A)	(B)

Prevalence Index = B/A = ______

Hydrophytic Vegetation Indicators:

- ☐ 1 - Rapid Test for Hydrophytic Vegetation
- ☑ 2 - Dominance Test is >50%
- ☐ 3 - Prevalence Index is ≤3.0[1]
- ☐ 4 - Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
- ☐ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes ◉ No ○

Remarks: (Include photo numbers here or on a separate sheet.)

SOIL

Sampling Point: DP10

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox Features %	Type[1]	Loc[2]	Texture	Remarks
0-16	10YR 3/3	100					Clay	

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, MS=Masked Sand Grains. [2]Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators:

- ☐ Histosol (A1)
- ☐ Histic Epipedon (A2)
- ☐ Black Histic (A3)
- ☐ Hydrogen Sulfide (A4)
- ☐ Stratified Layers (A5)
- ☐ 2 cm Muck (A10)
- ☐ Depleted Below Dark Surface (A11)
- ☐ Thick Dark Surface (A12)
- ☐ Sandy Mucky Mineral (S1)
- ☐ 5 cm Mucky Peat or Peat (S3)
- ☐ Sandy Gleyed Matrix (S4)
- ☐ Sandy Redox (S5)
- ☐ Stripped Matrix (S6)
- ☐ Loamy Mucky Mineral (F1)
- ☐ Loamy Gleyed Matrix (F2)
- ☐ Depleted Matrix (F3)
- ☐ Redox Dark Surface (F6)
- ☐ Depleted Dark Surface (F7)
- ☐ Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

- ☐ Coast Prairie Redox (A16)
- ☐ Dark Surface (S7)
- ☐ Iron-Manganese Masses (F12)
- ☐ Very Shallow Dark Surface (TF12)
- ☐ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type: ______

Depth (inches): ______

Hydric Soil Present? Yes ○ No ◉

Remarks:

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one is required; check all that apply)

- ☐ Surface Water (A1)
- ☐ High Water Table (A2)
- ☐ Saturation (A3)
- ☐ Water Marks (B1)
- ☐ Sediment Deposits (B2)
- ☐ Drift Deposits (B3)
- ☐ Algal Mat or Crust (B4)
- ☐ Iron Deposits (B5)
- ☐ Inundation Visible on Aerial Imagery (B7)
- ☐ Sparsely Vegetated Concave Surface (B8)
- ☐ Water-Stained Leaves (B9)
- ☐ Aquatic Fauna (B13)
- ☐ True Aquatic Plants (B14)
- ☐ Hydrogen Sulfide Odor (C1)
- ☐ Oxidized Rhizospheres on Living Roots (C3)
- ☐ Presence of Reduced Iron (C4)
- ☐ Recent Iron Reduction in Tilled Soils (C6)
- ☐ Thin Muck Surface (C7)
- ☐ Gauge or Well Data (D9)
- ☐ Other (Explain in Remarks)

Secondary Indicators (minimum of two required)

- ☐ Surface Soil Cracks (B6)
- ☐ Drainage Patterns (B10)
- ☐ Dry-Season Water Table (C2)
- ☐ Crayfish Burrows (C8)
- ☐ Saturation Visible on Aerial Imagery (C9)
- ☐ Stunted or Stressed Plants (D1)
- ☐ Geomorphic Position (D2)
- ☑ FAC-Neutral Test (D5)

Field Observations:

Surface Water Present? Yes ○ No ◉ Depth (inches): ______

Water Table Present? Yes ○ No ◉ Depth (inches): ______

Saturation Present? (includes capillary fringe) Yes ○ No ◉ Depth (inches): ______

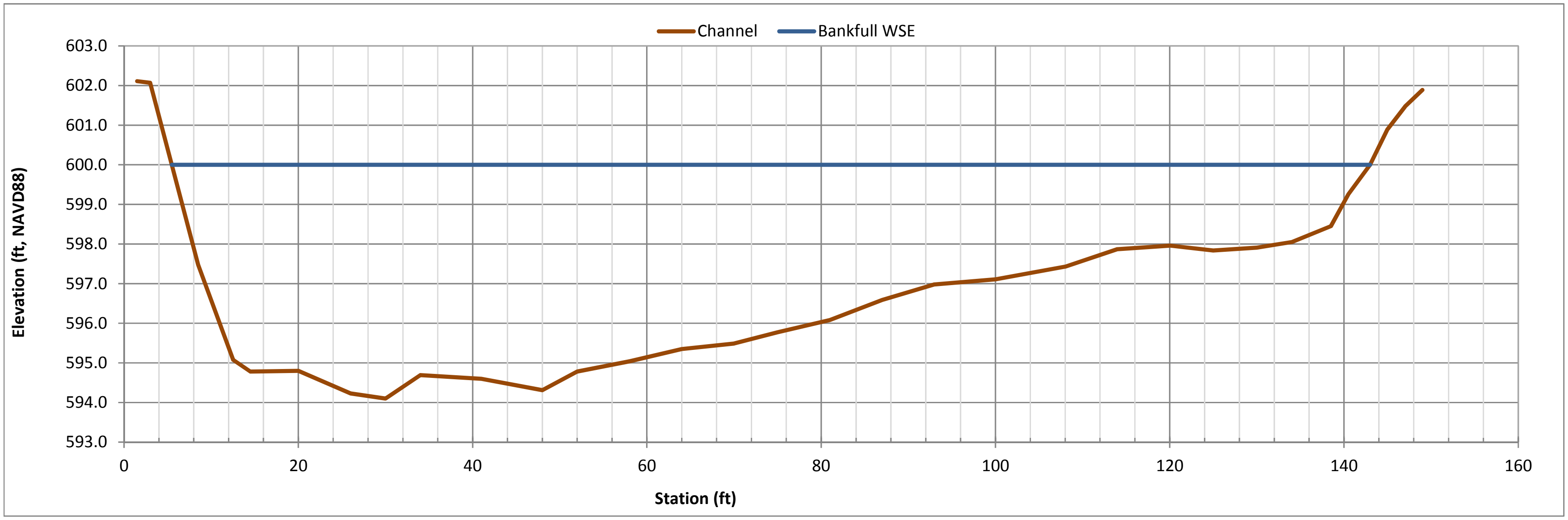
Wetland Hydrology Present? Yes ○ No ◉

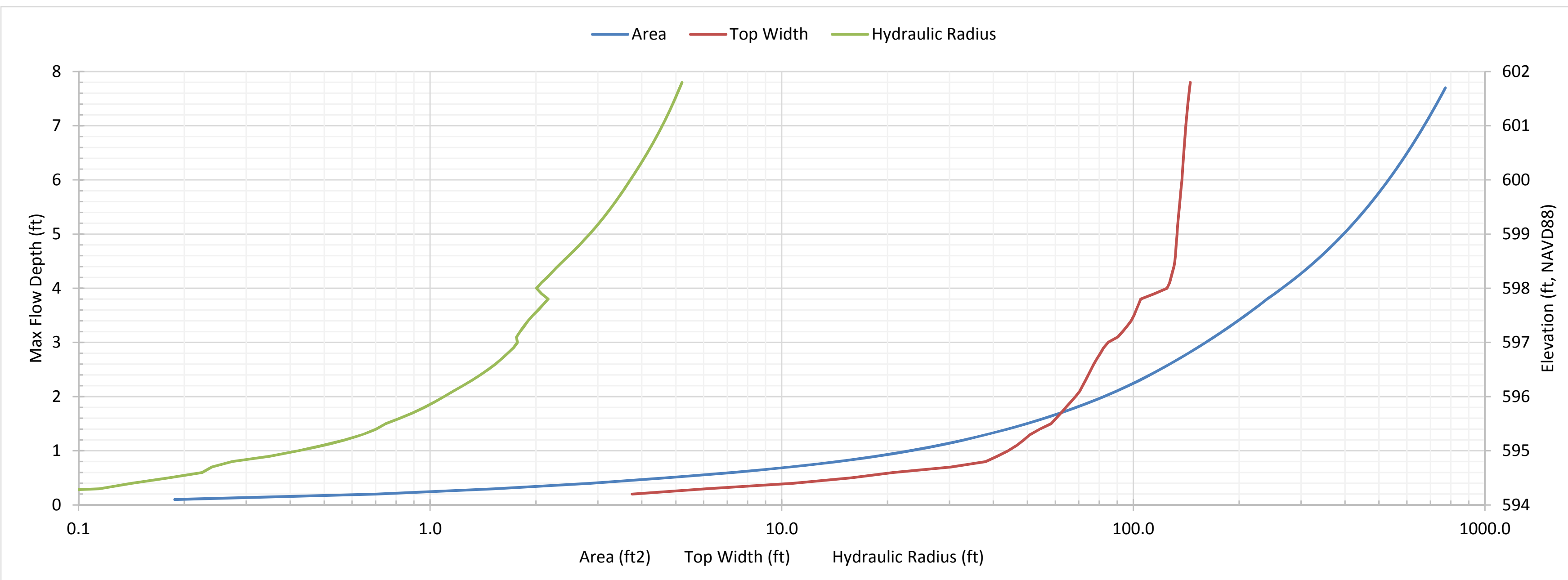
Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks:

Bankfull Cross Section Plot

Channel Classification





Stream Classification Sheet

Worksheet 2-3. Field form for Level II stream classification (Rosgen, 1996; Rosgen and Silvey, 2005).

Stream:	**Big Walnut Creek**				
Basin:	**Big Walnut Creek**	Drainage Area:	**202,496** acres	**316.4**	mi^2
Location:	**Brazil, IN**				
Twp.&Rge:		Sec.&Qtr.:			
Cross-Section Monuments (Lat./Long.):				Date:	**4/14/17**
Observers:	**BJM, JDF, BWM, DRH**			Valley Type:	**U-GL-TP**

Bankfull WIDTH (W_{bkf}) WIDTH of the stream channel at bankfull stage elevation, in a riffle section.	**138.5**	ft
Bankfull DEPTH (d_{bkf}) Mean DEPTH of the stream channel cross-section, at bankfull stage elevation, in a riffle section ($d_{bkf} = A / W_{bkf}$).	**4.04**	ft
Bankfull X-Section AREA (A_{bkf}) AREA of the stream channel cross-section, at bankfull stage elevation, in a riffle section.	**559.5**	ft^2
Width/Depth Ratio (W_{bkf} / d_{bkf}) Bankfull WIDTH divided by bankfull mean DEPTH, in a riffle section.	**34.3**	ft/ft
Maximum DEPTH (d_{mbkf}) Maximum depth of the bankfull channel cross-section, or distance between the bankfull stage and Thalweg elevations, in a riffle section.	**6.24**	ft
WIDTH of Flood-Prone Area (W_{fpa}) Twice maximum DEPTH, or ($2 \times d_{mbkf}$) = the stage/elevation at which flood-prone area WIDTH is determined in a riffle section.	**415**	ft
Entrenchment Ratio (ER) The ratio of flood-prone area WIDTH divided by bankfull channel WIDTH (W_{fpa} / W_{bkf}) (riffle section).	**3.0**	ft/ft
Channel Materials (Particle Size Index) D_{50} The D_{50} particle size index represents the mean diameter of channel materials, as sampled from the channel surface, between the bankfull stage and Thalweg elevations.	**4**	mm
Water Surface SLOPE (S) Channel slope = "rise over run" for a reach approximately 20–30 bankfull channel widths in length, with the "riffle-to-riffle" water surface slope representing the gradient at bankfull stage.	**0.00063**	ft/ft
Channel SINUOSITY (k) Sinuosity is an index of channel pattern, determined from a ratio of stream length divided by valley length (SL / VL); or estimated from a ratio of valley slope divided by channel slope (VS / S).	**1.03**	

Stream Type **C4/5** (See **Figure 2-14**)

BEHI Calculations

Worksheet 5-8. Form to calculate Bank Erosion Hazard Index (BEHI) variables and an overall BEHI rating (Rosgen, 1996, 2001a). Use **Figure 5-19** with BEHI variables to determine BEHI score.

Stream:	**Big Walnut Creek**	Location:	**Brazil, IN**
Station:		Observers:	**BJM**
Date: **4/14/17**	Stream Type: **C4/5**	Valley Type:	**U-GL-TP**

BEHI Score (Fig. 5-19)

Study Bank Height / Bankfull Height (C)

Study Bank Height (ft) =	11.8 (A)	Bankfull Height (ft) =	4.0 (B)	(A) / (B) =	3.0 (C)	10.0

Root Depth / Study Bank Height (E)

Root Depth (ft) =	4 (D)	Study Bank Height (ft) =	11.8 (A)	(D) / (A) =	0.3 (E)	5.5

Weighted Root Density (G)

Root Density as % =	80% (F)	(F) x (E) =	27.1 (G)	6.3

Bank Angle (H)

Bank Angle as *Degrees* =	60 (H)	4.0

Surface Protection (I)

Surface Protection as % =	90% (I)	1.5

Bank Material Adjustment:

Bedrock (Overall Very Low BEHI)
Boulders (Overall Low BEHI)
Cobble (Subtract 10 points if uniform medium to large cobble)

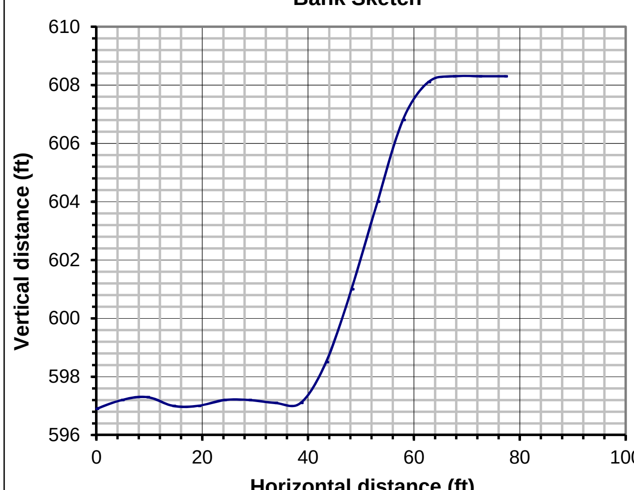
Gravel or Composite Matrix (Add 5–10 points depending on percentage of bank material that is composed of sand)
Sand (Add 10 points)
Silt/Clay (no adjustment)

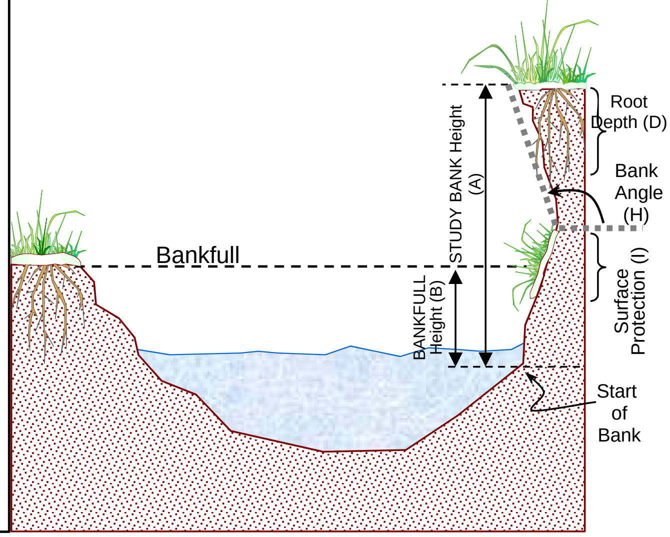
Bank Material Adjustment 5.0

Stratification Adjustment
Add 5–10 points, depending on position of unstable layers in relation to bankfull stage 5.0

Very Low	Low	Moderate	High	Very High	Extreme	Adjective Rating	**High**
5 – 9.5	10 – 19.5	20 – 29.5	30 – 39.5	40 – 45	46 – 50	and Total Score	**37.2**

Bank Sketch





Phankuch-Rosgen Stability Calculations

Worksheet 5-7. Pfankuch (1975) stream channel stability rating procedure, as modified by Rosgen (1996, 2001b).

Stream: | Location: | Valley Type: | Observers: | Date:

Location	Key	Category	Excellent: Description	Rating	Good: Description	Rating	Fair: Description	Rating	Poor: Description	Rating
Upper banks	1	Landform slope	Bank slope gradient <30%.	2	Bank slope gradient 30–40%.	4	Bank slope gradient 40–60%.	6	Bank slope gradient > 60%.	8
Upper banks	2	Mass erosion	No evidence of past or future mass erosion.	3	Infrequent. Mostly healed over. Low future potential.	6	Frequent or large, causing sediment nearly yearlong.	9	Frequent or large, causing sediment nearly yearlong OR imminent danger of same.	12
Upper banks	3	Debris jam potential	Essentially absent from immediate channel area.	2	Present, but mostly small twigs and limbs.	4	Moderate to heavy amounts, mostly larger sizes.	6	Moderate to heavy amounts, predominantly larger sizes.	8
Upper banks	4	Vegetative bank protection	> 90% plant density. Vigor and variety suggest a deep, dense soil-binding root mass.	3	70–90% density. Fewer species or less vigor suggest less dense or deep root mass.	6	50–70% density. Lower vigor and fewer species from a shallow, discontinuous root mass.	9	<50% density plus fewer species & less vigor indicating poor, discontinuous and shallow root mass.	12
Lower banks	5	Channel capacity	Bank heights sufficient to contain the bankfull stage. Width/depth ratio departure from reference width/depth ratio = 1.0. Bank-Height Ratio (BHR) = 1.0.	1	Bankfull stage is contained within banks. Width/depth ratio departure from reference width/depth ratio = 1.0–1.2. Bank-Height Ratio (BHR) = 1.0–1.1.	2	Bankfull stage is not contained. Width/depth ratio departure from reference width/depth ratio = 1.2–1.4. Bank-Height Ratio (BHR) = 1.1–1.3.	3	Bankfull stage is not contained; over-bank flows are common with flows less than bankfull. Width/depth ratio departure from reference width/depth ratio > 1.4. Bank-Height Ratio (BHR) > 1.3.	4
Lower banks	6	Bank rock content	> 65% with large angular boulders. 12"+ common.	2	40–65%. Mostly boulders and small cobbles 6–12".	4	20–40%. Most in the 3–6" diameter class.	6	<20% rock fragments of gravel sizes, 1–3" or less.	8
Lower banks	7	Obstructions to flow	Rocks and logs firmly imbedded. Flow pattern w/o cutting or deposition. Stable bed.	2	Some present causing erosive cross currents and minor pool filling. Obstructions fewer and less firm.	4	Moderately frequent, unstable obstructions move with high flows causing bank cutting and pool filling.	6	Frequent obstructions and deflectors cause bank erosion yearlong. Sediment traps full, channel migration occurring.	8
Lower banks	8	Cutting	Little or none. Infrequent raw banks <6".	4	Some, intermittently at outcurves and constrictions. Raw banks may be up to 12".	6	Significant. Cuts 12–24" high. Root mat overhangs and sloughing evident.	12	Almost continuous cuts, some over 24" high. Failure of overhangs frequent.	16
Lower banks	9	Deposition	Little or no enlargement of channel or point bars.	4	Some new bar increase, mostly from coarse gravel.	8	Moderate depostion of new gravel and coarse sand on old and some new bars.	12	Extensive deposit of predominantly fine particles. Accelerated bar development.	16
Bottom	10	Rock angularity	Sharp edges and corners. Plane surfaces rough.	1	Rounded corners and edges. Surfaces smooth and flat.	2	Corners and edges well rounded in 2 dimensions.	3	Well rounded in all dimensions, surfaces smooth.	4
Bottom	11	Brightness	Surfaces dull, dark or stained. Generally not bright.	1	Mostly dull, but may have <35% bright surfaces.	2	Mixture dull and bright, i.e., 35–65% mixture range.	3	Predominantly bright, > 65%, exposed or scoured surfaces.	4
Bottom	12	Consolidation of particles	Assorted sizes tightly packed or overlapping.	2	Moderately packed with some overlapping.	4	Mostly loose assortment with no apparent overlap.	6	No packing evident. Loose assortment, easily moved.	8
Bottom	13	Bottom size distribution	No size change evident. Stable material 80–100%.	4	Distribution shift light. Stable material 50–80%.	8	Moderate change in sizes. Stable materials 20–50%.	12	Marked distribution change. Stable materials 0–20%.	16
Bottom	14	Scouring and deposition	<5% of bottom affected by scour or deposition.	6	5–30% affected. Scour at constrictions and where grades steepen. Some deposition in pools.	12	30–50% affected. Deposits and scour at obstructions, constrictions and bends. Some filling of pools.	18	More than 50% of the bottom in a state of flux or change nearly yearlong.	24
Bottom	15	Aquatic vegetation	Abundant growth moss-like, dark green perennial. In swift water, too.	1	Common. Algae forms in low velocity and pool areas. Moss here, too.	2	Present but spotty, mostly in backwater. Seasonal algae growth makes rocks slick.	3	Perennial types scarce or absent. Yellow-green, short-term bloom may be present.	4
			Excellent total =	0	Good total =	2	Fair total =	39	Poor total =	96

Stream type	A1	A2	A3	A4	A5	A6	B1	B2	B3	B4	B5	B6	C1	C2	C3	C4	C5	C6	D3	D4	D5	D6
Good (Stable)	38-43	38-43	54-90	60-95	60-95	50-80	38-45	38-45	40-60	40-64	48-68	40-60	38-50	38-50	60-85	70-90	70-90	60-85	85-107	85-107	85-107	67-98
Fair (Mod. unstable)	44-47	44-47	91-129	96-132	96-142	81-110	46-58	46-58	61-78	65-84	69-88	61-78	51-61	51-61	86-105	91-110	91-110	86-105	108-132	108-132	108-132	99-125
Poor (Unstable)	48+	48+	130+	133+	143+	111+	59+	59+	79+	85+	89+	79+	62+	62+	106+	111+	111+	106+	133+	133+	133+	126+

Stream type	DA3	DA4	DA5	DA6	E3	E4	E5	E6	F1	F2	F3	F4	F5	F6	G1	G2	G3	G4	G5	G6
Good (Stable)	40-63	40-63	40-63	40-63	40-63	50-75	50-75	40-63	60-85	60-85	85-110	85-110	90-115	80-95	40-60	40-60	85-107	85-107	90-112	85-107
Fair (Mod. unstable)	64-86	64-86	64-86	64-86	64-86	76-96	76-96	64-86	86-105	86-105	111-125	111-125	116-130	96-110	61-78	61-78	108-120	108-120	113-125	108-120
Poor (Unstable)	87+	87+	87+	87+	87+	97+	97+	87+	106+	106+	126+	126+	131+	111+	79+	79+	121+	121+	126+	121+

Grand total =	137
Existing stream type =	C4
*Potential stream type =	C4
Modified channel stability rating =	Poor (Unstable)

*Rating should be adjusted to potential stream type, not existing.

Worksheet 5-7. Pfankuch (1975) stream channel stability rating procedure, as modified by Rosgen (1996, 2001b).

Stream: Location: Valley Type: Observers: Date:

Location	Key	Category	Excellent Description	Excellent Rating	Good Description	Good Rating	Fair Description	Fair Rating	Poor Description	Poor Rating
Upper banks	1	Landform slope	Bank slope gradient <30%.	2	Bank slope gradient 30–40%.	4	Bank slope gradient 40–60%.	6	Bank slope gradient > 60%.	8
Upper banks	2	Mass erosion	No evidence of past or future mass erosion.	3	Infrequent. Mostly healed over. Low future potential.	6	Frequent or large, causing sediment nearly yearlong.	9	Frequent or large, causing sediment nearly yearlong OR imminent danger of same.	12
Upper banks	3	Debris jam potential	Essentially absent from immediate channel area.	2	Present, but mostly small twigs and limbs.	4	Moderate to heavy amounts, mostly larger sizes.	6	Moderate to heavy amounts, predominantly larger sizes.	8
Upper banks	4	Vegetative bank protection	> 90% plant density. Vigor and variety suggest a deep, dense soil-binding root mass.	3	70–90% density. Fewer species or less vigor suggest less dense or deep root mass.	6	50–70% density. Lower vigor and fewer species from a shallow, discontinuous root mass.	9	<50% density plus fewer species & less vigor indicating poor, discontinuous and shallow root mass.	12
Lower banks	5	Channel capacity	Bank heights sufficient to contain the bankfull stage. Width/depth ratio departure from reference width/depth ratio = 1.0. Bank-Height Ratio (BHR) = 1.0.	1	Bankfull stage is contained within banks. Width/depth ratio departure from reference width/depth ratio = 1.0–1.2. Bank-Height Ratio (BHR) = 1.0–1.1.	2	Bankfull stage is not contained. Width/depth ratio departure from reference width/depth ratio = 1.2–1.4. Bank-Height Ratio (BHR) = 1.1–1.3.	3	Bankfull stage is not contained; over-bank flows are common with flows less than bankfull. Width/depth ratio departure from reference width/depth ratio > 1.4. Bank-Height Ratio (BHR) > 1.3.	4
Lower banks	6	Bank rock content	> 65% with large angular boulders. 12"+ common.	2	40–65%. Mostly boulders and small cobbles 6–12".	4	20–40%. Most in the 3–6" diameter class.	6	<20% rock fragments of gravel sizes, 1–3" or less.	8
Lower banks	7	Obstructions to flow	Rocks and logs firmly imbedded. Flow pattern w/o cutting or deposition. Stable bed.	2	Some present causing erosive cross currents and minor pool filling. Obstructions fewer and less firm.	4	Moderately frequent, unstable obstructions move with high flows causing bank cutting and pool filling.	6	Frequent obstructions and deflectors cause bank erosion yearlong. Sediment traps full, channel migration occurring.	8
Lower banks	8	Cutting	Little or none. Infrequent raw banks <6".	4	Some, intermittently at outcurves and constrictions. Raw banks may be up to 12".	6	Significant. Cuts 12–24" high. Root mat overhangs and sloughing evident.	12	Almost continuous cuts, some over 24" high. Failure of overhangs frequent.	16
Lower banks	9	Deposition	Little or no enlargement of channel or point bars.	4	Some new bar increase, mostly from coarse gravel.	8	Moderate depostion of new gravel and coarse sand on old and some new bars.	12	Extensive deposit of predominantly fine particles. Accelerated bar development.	16
Bottom	10	Rock angularity	Sharp edges and corners. Plane surfaces rough.	1	Rounded corners and edges. Surfaces smooth and flat.	2	Corners and edges well rounded in 2 dimensions.	3	Well rounded in all dimensions, surfaces smooth.	4
Bottom	11	Brightness	Surfaces dull, dark or stained. Generally not bright.	1	Mostly dull, but may have <35% bright surfaces.	2	Mixture dull and bright, i.e., 35–65% mixture range.	3	Predominantly bright, > 65%, exposed or scoured surfaces.	4
Bottom	12	Consolidation of particles	Assorted sizes tightly packed or overlapping.	2	Moderately packed with some overlapping.	4	Mostly loose assortment with no apparent overlap.	6	No packing evident. Loose assortment, easily moved.	8
Bottom	13	Bottom size distribution	No size change evident. Stable material 80–100%.	4	Distribution shift light. Stable material 50–80%.	8	Moderate change in sizes. Stable materials 20–50%.	12	Marked distribution change. Stable materials 0–20%.	16
Bottom	14	Scouring and deposition	<5% of bottom affected by scour or deposition.	6	5–30% affected. Scour at constrictions and where grades steepen. Some deposition in pools.	12	30–50% affected. Deposits and scour at obstructions, constrictions and bends. Some filling of pools.	18	More than 50% of the bottom in a state of flux or change nearly yearlong.	24
Bottom	15	Aquatic vegetation	Abundant growth moss-like, dark green perennial. In swift water, too.	1	Common. Algae forms in low velocity and pool areas. Moss here, too.	2	Present but spotty, mostly in backwater. Seasonal algae growth makes rocks slick.	3	Perennial types scarce or absent. Yellow-green, short-term bloom may be present.	4
			Excellent total =	4	Good total =	24	Fair total =	33	Poor total =	40

Stream type	A1	A2	A3	A4	A5	A6	B1	B2	B3	B4	B5	B6	C1	C2	C3	C4	C5	C6	D3	D4	D5	D6
Good (Stable)	38-43	38-43	54-90	60-95	60-95	50-80	38-45	38-45	40-60	40-64	48-68	40-60	38-50	38-50	60-85	70-90	70-90	60-85	85-107	85-107	85-107	67-98
Fair (Mod. unstable)	44-47	44-47	91-129	96-132	96-142	81-110	46-58	46-58	61-78	65-84	69-88	61-78	51-61	51-61	86-105	91-110	91-110	86-105	108-132	108-132	108-132	99-125
Poor (Unstable)	48+	48+	130+	133+	143+	111+	59+	59+	79+	85+	89+	79+	62+	62+	106+	111+	111+	106+	133+	133+	133+	126+

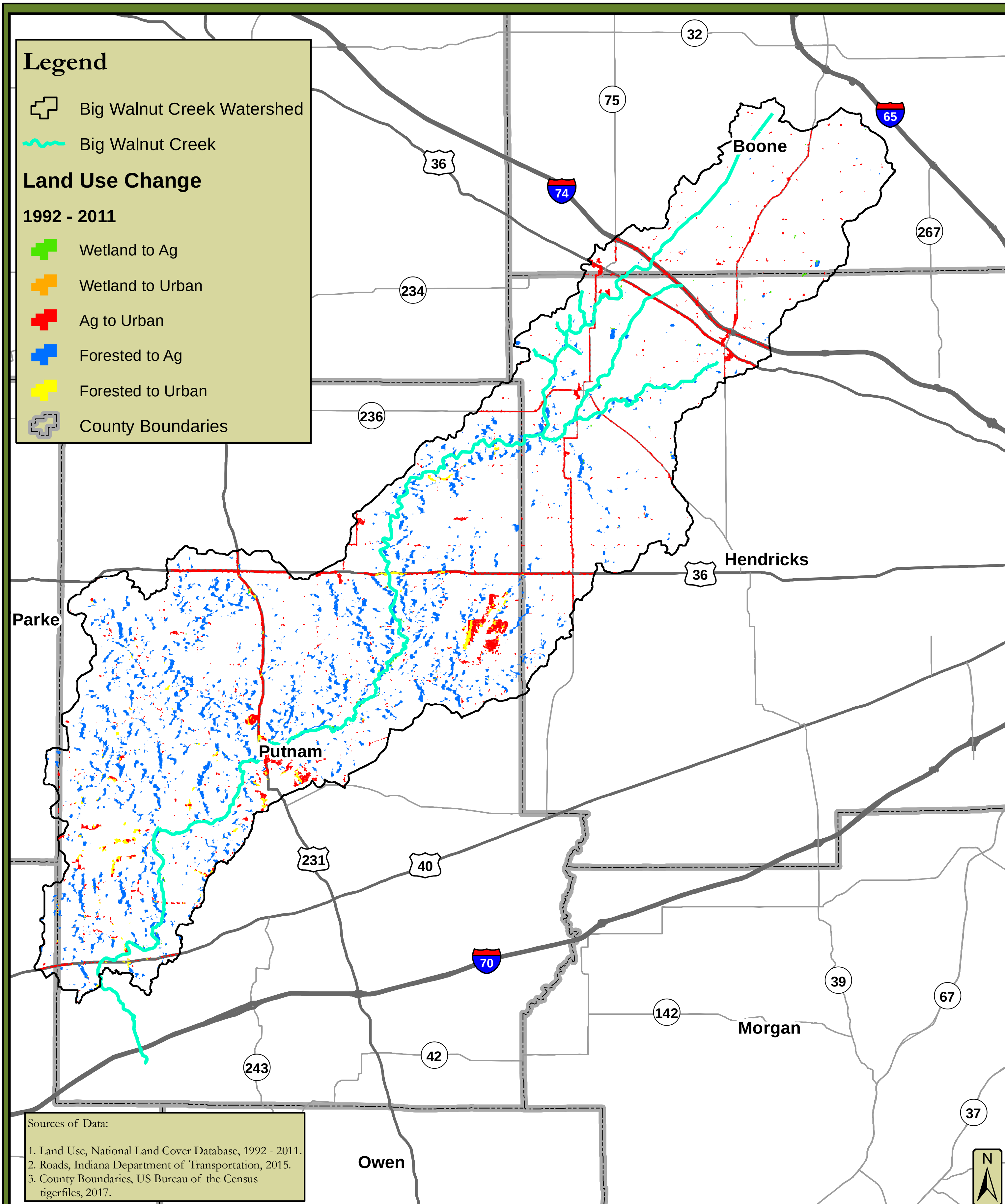
Stream type	DA3	DA4	DA5	DA6	E3	E4	E5	E6	F1	F2	F3	F4	F5	F6	G1	G2	G3	G4	G5	G6
Good (Stable)	40-63	40-63	40-63	40-63	40-63	50-75	50-75	40-63	60-85	60-85	85-110	85-110	90-115	80-95	40-60	40-60	85-107	85-107	90-112	85-107
Fair (Mod. unstable)	64-86	64-86	64-86	64-86	64-86	76-96	76-96	64-86	86-105	86-105	111-125	111-125	116-130	96-110	61-78	61-78	108-120	108-120	113-125	108-120
Poor (Unstable)	87+	87+	87+	87+	87+	97+	97+	87+	106+	106+	126+	126+	131+	111+	79+	79+	121+	121+	126+	121+

Grand total =	101
Existing stream type =	C4
*Potential stream type =	C4
Modified channel stability rating =	Fair (Mod. Unstable)

*Rating should be adjusted to potential stream type, not existing.

Appendix 3:Watershed-scale Assessment Data & Calculations

Land Use Change Map and Tabular Summary



Sources of Data:

1. Land Use, National Land Cover Database, 1992 - 2011.
2. Roads, Indiana Department of Transportation, 2015.
3. County Boundaries, US Bureau of the Census tigerfiles, 2017.

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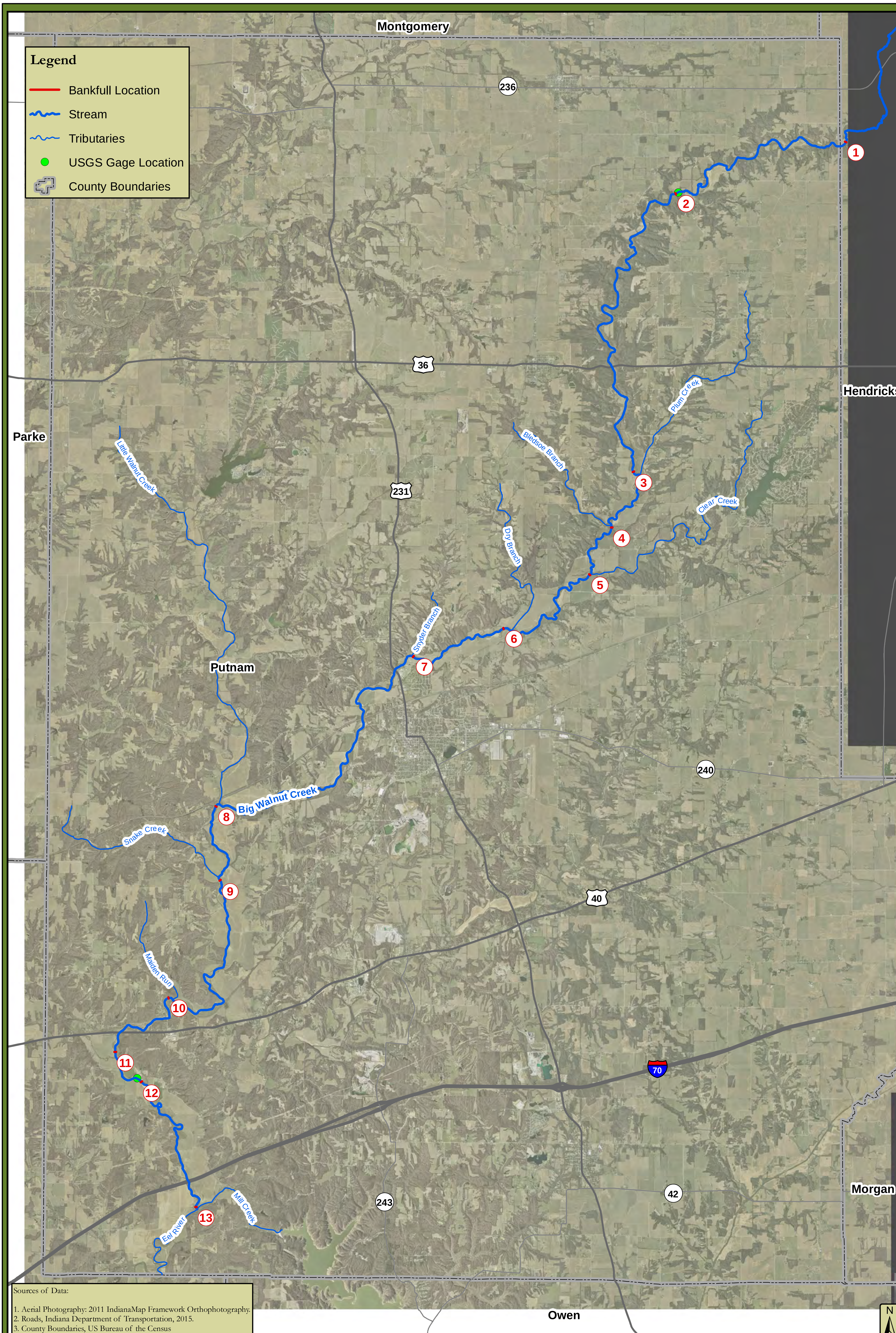
PNC Center, Suite 1368 South
115 West Washington Street
Indianapolis, Indiana 46204
(t) 317.266.8000 (f) 317.632.3306

PROJECT: Big Walnut Creek FEH Mitigation Assessment	PROJECT NO. 14-0014	APPROX. SCALE 1"=25,000'
TITLE: Land Use Change Map		DATE: 10/2018
		EXHIBIT A3.1

Watershed Land Use by Year (%)				
Land Use Description	**1992**	**2001**	**2006**	**2011**
Open Water	0.5%	0.5%	0.5%	0.5%
Urban	1.1%	3.5%	4.1%	3.7%
Barren / Rock	0.0%	0.0%	0.0%	0.0%
Forested	16.6%	23.0%	23.0%	23.1%
Shrub / Scrub	0.0%	0.0%	0.0%	0.0%
Grassland / Herbaceous	0.0%	0.6%	0.7%	0.6%
Agricultural	81.7%	72.3%	71.6%	72.1%
Wetland	0.1%	0.0%	0.0%	0.0%
	100.00%	100.00%	100.00%	100.00%

Approximate Bankfull Location Map and Bankfull Dimension Comparison



Sources of Data:

1. Aerial Photography: 2011 IndianaMap Framework Orthophotography.
2. Roads, Indiana Department of Transportation, 2015.
3. County Boundaries, US Bureau of the Census tigerfiles, 2017.

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PROJECT: Big Walnut Creek FEH Mitigation Assessment	PROJECT NO. 14-0014	APPROX. SCALE 1"=10,000'	DATE: 10/2018
TITLE: Approximate Bankfull Location Map		EXHIBIT A3.2	

Bankfull 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 (%)
Big Walnut Creek @ County Boundary	119.4	85.0	87	3.4	296	-2%
Big Walnut Creek at USGS Gage 03357330 (CR 550 East)	131.0	95.0	90	3.5	309	6%
Big Walnut Creek at Plum Creek	154.6	105.0	95	3.6	335	11%
Big Walnut Creek at Bledsoe Branch	162.6	110.0	96	3.6	344	14%
Big Walnut Creek at Clear Creek	194.4	120.0	102	3.7	375	18%
Big Walnut Creek at Dry Branch	208.0	110.0	104	3.7	388	6%
Big Walnut Creek at Snyder Branch	215.5	110.0	105	3.8	394	4%
Big Walnut Creek at Little Walnut Creek	293.6	105.0	117	3.9	458	-10%
Big Walnut Creek at Snake Creek	303.6	115.0	118	4.0	466	-3%
Big Walnut Creek at Maiden Run	315.1	100.0	119	4.0	474	-16%
Big Walnut Creek at US 40	316.2	135.0	120	4.0	475	13%
Big Walnut Creek at USGS Gage 03357500 (CR 875 South)	326.0	145.0	121	4.0	482	20%
Big Walnut Creek @ Confluence with Eel River	331.8	120.0	121	4.0	486	-1%

* Drainage areas at the upstream and downstream extent of the study area were determine using USGS's StreamStats tool. The intermediate locations' drainage areas were determined by linear interpolation.

** Approximate bankfull widths were determined by measuring the width of the channel defined by the 2012 IndianaMap DEM 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 Central Till Plain Region regression equations published by the USGS in Regional Bankfull-Channel Dimensions of Non-Urban Wadeable Streams in Indiana.

Appendix 4:Reach-scale Assessment Data & Calculations

Stream Gage Analysis

PEAK_03357500

```
1
  Program PeakFq           U. S. GEOLOGICAL SURVEY            Seq.002.000
  Version 7.2         Annual peak flow frequency analysis      Run Date / Time
  3/28/2018                                                     07/26/2018 15:47

                               --- PROCESSING OPTIONS ---

                      Plot option         = Graphics device
                      Basin char output   = None
                      Print option        = Yes
                      Debug print         = No
                      Input peaks listing = Long
                      Input peaks format  = WATSTORE peak file

                      Input files used:
                         peaks (ascii)  - R:\2014\14-0014.00000\Worksheets\Big
Walnut Creek\PEAK_03357500.TXT
                         specifications - R:\2014\14-0014.00000\Worksheets\Big
Walnut Creek\PKFQWPSF.TMP
                      Output file(s):
                         main - R:\2014\14-0014.00000\Worksheets\Big Walnut
Creek\PEAK_03357500.PRT


  ***  User responsible for assessment and interpretation of the following analysis
***

1


  Program PeakFq           U. S. GEOLOGICAL SURVEY            Seq.001.001
  Version 7.2         Annual peak flow frequency analysis      Run Date / Time
  3/28/2018                                                     07/26/2018 15:47

            Station - 03357500  BIG WALNUT CREEK NEAR REELSVILLE, IN


                  TABLE 1 - INPUT DATA SUMMARY

                Number of peaks in record            =       53
                Peaks not used in analysis           =        0
                Gaged peaks in analysis              =       53
                Historic peaks in analysis           =        0
                Beginning Year                       =     1950
                Ending Year                          =     2002
                Historical Period Length             =       53
                Skew option                          =   WEIGHTED
                Regional skew                        =   -0.400
                     Standard error                  =    0.550
                     Mean Square error               =    0.303
                Gage base discharge                  =      0.0
                User supplied high outlier threshold =   --
                User supplied PILF (LO) criterion    =   --
                Plotting position parameter          =     0.00
                Type of analysis                              EMA
                PILF (LO) Test Method                        MGBT
                Perceptible Ranges:
                    Start Year  End Year  Lower Bound  Upper Bound
                          1950      2002          0.0          INF    DEFAULT

                Interval Data                    =   None Specified
```

TABLE 2 - DIAGNOSTIC MESSAGE AND PILF RESULTS

WCF002J-CALCS COMPLETED. RETURN CODE = 2
EMA002W-CONFIDENCE INTERVALS ARE NOT EXACT IF HISTORIC PERIOD > 0

MULTIPLE GRUBBS-BECK TEST RESULTS

```
MULTIPLE GRUBBS-BECK PILF THRESHOLD  3030.0
NUMBER OF PILFS IDENTIFIED              2
    CLASSIFICATION OF PILFS:
        NUMBER OF ZERO FLOWS            0
        NUMBER OF CENSORED FLOWS        0
        NUMBER OF GAGED PEAKS           2
            GAGED PEAKS AND CORRESPONDING P-VALUES
                  1250.0    (0.0162)
                  1820.0    (0.0042)
```

Kendall's Tau Parameters

	TAU	P-VALUE	MEDIAN SLOPE	No. of PEAKS
GAGED PEAKS	-0.084	0.378	-35.208	53

1

Program PeakFq   U. S. GEOLOGICAL SURVEY   Seq.001.002
Version 7.2   Annual peak flow frequency analysis   Run Date / Time
3/28/2018   07/26/2018 15:47

Station - 03357500 BIG WALNUT CREEK NEAR REELSVILLE, IN

TABLE 3 - ANNUAL FREQUENCY CURVE PARAMETERS -- LOG-PEARSON TYPE III

	LOGARITHMIC		
	MEAN	STANDARD DEVIATION	SKEW
EMA WITHOUT REG SKEW	3.9109	0.2279	-0.266
EMA WITH REG SKEW	3.9108	0.2283	-0.312

EMA ESTIMATE OF MSE OF SKEW WITHOUT REG SKEW   0.1150
EMA ESTIMATE OF MSE OF SKEW W/GAGED PEAKS ONLY (AT-SITE) 0.1150

TABLE 4 - ANNUAL FREQUENCY CURVE -- DISCHARGES AT SELECTED EXCEEDANCE PROBABILITIES

ANNUAL EXCEEDANCE PROBABILITY	<- EMA ESTIMATE -> WITH REG SKEW	WITHOUT REG SKEW	<- FOR EMA ESTIMATE WITH REG SKEW -> LOG VARIANCE OF EST.	<-CONFIDENCE LIMITS-> 5% LOWER	95% UPPER
0.9950	1804.	1850.	0.0129	672.9	2560.0

0.9900	2129.	2171.	0.0095	927.0	2886.0
0.9500	3282.	3309.	0.0040	2030.0	4061.0
0.9000	4090.	4104.	0.0025	2905.0	4915.0
0.8000	5284.	5281.	0.0016	4195.0	6224.0
0.6667	6646.	6627.	0.0013	5560.0	7753.0
0.5000	8369.	8338.	0.0011	7157.0	9723.0
0.4292	9179.	9146.	0.0011	7883.0	10670.0
0.2000	12750.	12740.	0.0011	10990.0	15040.0
0.1000	15660.	15690.	0.0014	13410.0	19150.0
0.0400	19270.	19420.	0.0021	16190.0	25360.0
0.0200	21910.	22170.	0.0029	18000.0	30730.0
0.0100	24500.	24900.	0.0040	19570.0	36770.0
0.0050	27040.	27600.	0.0053	20950.0	43580.0
0.0020	30360.	31170.	0.0075	22510.0	53980.0

*Note: If Station Skew option is selected then EMA ESTIMATE WITH REG SKEW will display values for and be equal to EMA ESTIMATE WITHOUT REG SKEW.

1

Program PeakFq U. S. GEOLOGICAL SURVEY Seq.001.003
Version 7.2 Annual peak flow frequency analysis Run Date / Time
3/28/2018 07/26/2018 15:47

Station - 03357500 BIG WALNUT CREEK NEAR REELSVILLE, IN

TABLE 5 - INPUT DATA LISTING

WATER YEAR	PEAK VALUE	PEAKFQ CODES	FLOW INTERVALS (WHERE LOWER BOUND NOT = UPPER BOUND) LOWER BOUND	UPPER BOUND	REMARKS
1950	15500.0				
1951	6040.0				
1952	15700.0				
1953	8500.0				
1954	1250.0				
1955	3030.0				
1956	9300.0				
1957	30700.0				
1958	13800.0				
1959	14200.0				
1960	16000.0				
1961	18400.0				
1962	13400.0				
1963	19800.0				
1964	10900.0				
1965	6600.0				
1966	1820.0				
1967	6120.0				
1968	15800.0				
1969	10300.0				
1970	6340.0				
1971	8050.0				
1972	6650.0				
1973	7970.0				
1974	5320.0				
1975	7360.0				
1976	3730.0				
1977	3070.0				
1978	7890.0				
1979	9340.0				
1980	6050.0				

1981	6060.0
1982	5640.0
1983	6670.0
1984	5610.0
1985	7800.0
1986	9940.0
1987	8710.0
1988	6610.0
1989	9190.0
1990	10100.0
1991	13800.0
1992	5160.0
1993	9930.0
1994	11400.0
1995	6150.0
1996	8020.0
1997	9830.0
1998	8860.0
1999	10300.0
2000	3570.0
2001	7910.0
2002	10000.0

Explanation of peak discharge qualification codes

PeakFQ CODE	NWIS CODE	DEFINITION
D	3	Dam failure, non-recurrent flow anomaly
G	8	Discharge greater than stated value
X	3+8	Both of the above
L	4	Discharge less than stated value
K	6 OR C	Known effect of regulation or urbanization
H	7	Historic peak

- Minus-flagged discharge -- Not used in computation
  -8888.0 -- No discharge value given
- Minus-flagged water year -- Historic peak used in computation

1

Program PeakFq　　U. S. GEOLOGICAL SURVEY　　Seq.001.004
Version 7.2　　Annual peak flow frequency analysis　　Run Date / Time
3/28/2018　　07/26/2018 15:47

Station - 03357500 BIG WALNUT CREEK NEAR REELSVILLE, IN

TABLE 6 - EMPIRICAL FREQUENCY CURVES -- HIRSCH-STEDINGER PLOTTING POSITIONS

WATER YEAR	RANKED DISCHARGE	EMA ESTIMATE	FLOW INTERVALS (WHERE LOWER BOUND NOT = UPPER BOUND) LOWER BOUND	UPPER BOUND
1957	30700.0	0.0184		
1963	19800.0	0.0370		
1961	18400.0	0.0555		
1960	16000.0	0.0740		
1968	15800.0	0.0925		
1952	15700.0	0.1110		

1950	15500.0	0.1296
1959	14200.0	0.1481
1958	13800.0	0.1851
1991	13800.0	0.1666
1962	13400.0	0.2037
1994	11400.0	0.2222
1964	10900.0	0.2407
1969	10300.0	0.2777
1999	10300.0	0.2592
1990	10100.0	0.2963
2002	10000.0	0.3148
1986	9940.0	0.3333
1993	9930.0	0.3518
1997	9830.0	0.3703
1979	9340.0	0.3889
1956	9300.0	0.4074
1989	9190.0	0.4259
1998	8860.0	0.4444
1987	8710.0	0.4630
1953	8500.0	0.4815
1971	8050.0	0.5000
1996	8020.0	0.5185
1973	7970.0	0.5370
2001	7910.0	0.5556
1978	7890.0	0.5741
1985	7800.0	0.5926
1975	7360.0	0.6111
1983	6670.0	0.6297
1972	6650.0	0.6482
1988	6610.0	0.6667
1965	6600.0	0.6852
1970	6340.0	0.7037
1995	6150.0	0.7223
1967	6120.0	0.7408
1981	6060.0	0.7593
1980	6050.0	0.7778
1951	6040.0	0.7963
1982	5640.0	0.8149
1984	5610.0	0.8334
1974	5320.0	0.8519
1992	5160.0	0.8704
1976	3730.0	0.8890
2000	3570.0	0.9075
1977	3070.0	0.9260
1955	3030.0	0.9445
* 1966	1820.0	0.9630
* 1954	1250.0	0.9816

* DENOTES PILF (LO)

1

Program PeakFq U. S. GEOLOGICAL SURVEY Seq.001.005
Version 7.2 Annual peak flow frequency analysis Run Date / Time
3/28/2018 07/26/2018 15:47

Station - 03357500 BIG WALNUT CREEK NEAR REELSVILLE, IN

TABLE 7 - EMA REPRESENTATION OF DATA

<---- USER-ENTERED ----><--------

WATER YEAR	OBSERVED Q_LOWER	OBSERVED Q_UPPER	EMA Q_LOWER	EMA Q_UPPER	PERCEPTIBLE RANGES LOWER	PERCEPTIBLE RANGES UPPER	FINAL PERCEPTIBLE RANGES LOWER	FINAL PERCEPTIBLE RANGES UPPER
1950	15500.0	15500.0	15500.0	15500.0	0.0	INF	3030.0	INF
1951	6040.0	6040.0	6040.0	6040.0	0.0	INF	3030.0	INF
1952	15700.0	15700.0	15700.0	15700.0	0.0	INF	3030.0	INF
1953	8500.0	8500.0	8500.0	8500.0	0.0	INF	3030.0	INF
1954	1250.0	1250.0	0.0	3030.0	0.0	INF	3030.0	INF
1955	3030.0	3030.0	3030.0	3030.0	0.0	INF	3030.0	INF
1956	9300.0	9300.0	9300.0	9300.0	0.0	INF	3030.0	INF
1957	30700.0	30700.0	30700.0	30700.0	0.0	INF	3030.0	INF
1958	13800.0	13800.0	13800.0	13800.0	0.0	INF	3030.0	INF
1959	14200.0	14200.0	14200.0	14200.0	0.0	INF	3030.0	INF
1960	16000.0	16000.0	16000.0	16000.0	0.0	INF	3030.0	INF
1961	18400.0	18400.0	18400.0	18400.0	0.0	INF	3030.0	INF
1962	13400.0	13400.0	13400.0	13400.0	0.0	INF	3030.0	INF
1963	19800.0	19800.0	19800.0	19800.0	0.0	INF	3030.0	INF
1964	10900.0	10900.0	10900.0	10900.0	0.0	INF	3030.0	INF
1965	6600.0	6600.0	6600.0	6600.0	0.0	INF	3030.0	INF
1966	1820.0	1820.0	0.0	3030.0	0.0	INF	3030.0	INF
1967	6120.0	6120.0	6120.0	6120.0	0.0	INF	3030.0	INF
1968	15800.0	15800.0	15800.0	15800.0	0.0	INF	3030.0	INF
1969	10300.0	10300.0	10300.0	10300.0	0.0	INF	3030.0	INF
1970	6340.0	6340.0	6340.0	6340.0	0.0	INF	3030.0	INF
1971	8050.0	8050.0	8050.0	8050.0	0.0	INF	3030.0	INF
1972	6650.0	6650.0	6650.0	6650.0	0.0	INF	3030.0	INF
1973	7970.0	7970.0	7970.0	7970.0	0.0	INF	3030.0	INF
1974	5320.0	5320.0	5320.0	5320.0	0.0	INF	3030.0	INF
1975	7360.0	7360.0	7360.0	7360.0	0.0	INF	3030.0	INF
1976	3730.0	3730.0	3730.0	3730.0	0.0	INF	3030.0	INF
1977	3070.0	3070.0	3070.0	3070.0	0.0	INF	3030.0	INF
1978	7890.0	7890.0	7890.0	7890.0	0.0	INF	3030.0	INF

```
   1979     9340.0     9340.0     9340.0     9340.0          0.0          INF
3030.0          INF
   1980     6050.0     6050.0     6050.0     6050.0          0.0          INF
3030.0          INF
   1981     6060.0     6060.0     6060.0     6060.0          0.0          INF
3030.0          INF
   1982     5640.0     5640.0     5640.0     5640.0          0.0          INF
3030.0          INF
   1983     6670.0     6670.0     6670.0     6670.0          0.0          INF
3030.0          INF
   1984     5610.0     5610.0     5610.0     5610.0          0.0          INF
3030.0          INF
   1985     7800.0     7800.0     7800.0     7800.0          0.0          INF
3030.0          INF
   1986     9940.0     9940.0     9940.0     9940.0          0.0          INF
3030.0          INF
   1987     8710.0     8710.0     8710.0     8710.0          0.0          INF
3030.0          INF
   1988     6610.0     6610.0     6610.0     6610.0          0.0          INF
3030.0          INF
   1989     9190.0     9190.0     9190.0     9190.0          0.0          INF
3030.0          INF
   1990    10100.0    10100.0    10100.0    10100.0          0.0          INF
3030.0          INF
   1991    13800.0    13800.0    13800.0    13800.0          0.0          INF
3030.0          INF
   1992     5160.0     5160.0     5160.0     5160.0          0.0          INF
3030.0          INF
   1993     9930.0     9930.0     9930.0     9930.0          0.0          INF
3030.0          INF
   1994    11400.0    11400.0    11400.0    11400.0          0.0          INF
3030.0          INF
   1995     6150.0     6150.0     6150.0     6150.0          0.0          INF
3030.0          INF
   1996     8020.0     8020.0     8020.0     8020.0          0.0          INF
3030.0          INF
   1997     9830.0     9830.0     9830.0     9830.0          0.0          INF
3030.0          INF
   1998     8860.0     8860.0     8860.0     8860.0          0.0          INF
3030.0          INF
   1999    10300.0    10300.0    10300.0    10300.0          0.0          INF
3030.0          INF
   2000     3570.0     3570.0     3570.0     3570.0          0.0          INF
3030.0          INF
   2001     7910.0     7910.0     7910.0     7910.0          0.0          INF
3030.0          INF
   2002    10000.0    10000.0    10000.0    10000.0          0.0          INF
3030.0          INF
1


 End PeakFQ analysis.
   Stations processed :       1
   Number of errors   :       0
   Stations skipped   :       0
   Station years      :      53


Data records may have been ignored for the stations listed below.
(Card type must be Y, Z, N, H, I, 2, 3, 4,  or *.)
(2, 4, and * records are ignored.)
```

For the station below, the following records were ignored:

FINISHED PROCESSING STATION: 03357500   USGS BIG WALNUT CREEK NEAR REELSVI

For the station below, the following records were ignored:

FINISHED PROCESSING STATION:

Bankfull Discharge Calculations

Worksheet 5-2. Computations of velocity and bankfull discharge using various methods (Rosgen and Silvey, 2005).

Bankfull VELOCITY / DISCHARGE Estimates

Site	Big Walnut Creek		Location	Brazil, IN	
Date	4/14/17	Stream Type	C4/5	Valley Type	U-GL-TP
Observers	BJM, JDF		HUC	__ __ __ __ __ __ __ __ __ __ __ __	

INPUT VARIABLES			OUTPUT VARIABLES		
Bankfull Cross-section AREA	531.9	A_{bkf} (SqFt)	Bankfull Mean DEPTH	3.87	D_{bkf} (Ft)
Bankfull WIDTH	137.5	W_{bkf} (Ft)	Wetted PERIMETER $\sim 2 * d_{bkf} + W_{bkf}$	140.00	W_{Pbkf} (Ft)
D84 @ Riffle	22.6	Dia. (mm)	D84 mm / 304.8 =	0.07	D84 (Ft)
Bankfull SLOPE	0.00063	S (Ft / Ft)	Hydraulic RADIUS A_{bkf} / W_{Pbkf}	3.80	R (Ft)
Gravitational Acceleration	32.2	g (Ft /Sec²)	Relative Roughness R (ft) / D84 (ft)	51.240	
Drainage AREA	316.4	DA (SqMi)	Shear Velocity $u^* = \sqrt{gRS}$	0.2776	u* (Ft / Sec)

ESTIMATION METHODS	Bankfull VELOCITY		Bankfull DISCHARGE	
1. Friction Factor / Relative Roughness $u = [2.83 + 5.66 \text{Log}\{R / D84\}] u^*$	3.5	Ft / Sec	1847	CFS
2. Roughness Coefficient: a) Manning's 'n' from friction factor / relative roughness. (Figs. 5-6, 5-7) $u = 1.4895 * R^{2/3} * S^{1/2} / n$ n = 0.025	7.8	Ft / Sec	4160	CFS
2. Roughness Coefficient: $u = 1.4895 * R^{2/3} * S^{1/2} / n$ b) Manning's 'n' from Jarrett (USGS): $n = 0.39 S^{.38} R^{-.16}$ n = Note: This equation is for applications involving **steep, step-pool, high boundary roughness, cobble-boulder-dominated stream systems**; i.e., for stream types A1, A2, A3, B1, B2, B3, C2 and E3.		Ft / Sec		CFS
2. Roughness Coefficient: $u = 1.4895 * R^{2/3} * S^{1/2} / n$ c) Manning's 'n' from Stream Type n = 0.025	7.8	Ft / Sec	4160	CFS
3. Other Methods, ie. Hydraulic Geometry (Hey, Darcy-Weisbach, Chezy C, etc.)		Ft / Sec		CFS
3. Other Methods, ie. Hydraulic Geometry (Hey, Darcy-Weisbach, Chezy C, etc.)		Ft / Sec		CFS
4. Continuity Equations: a) USGS Gage: u = Q / A Return Period for Bankfull Discharge (Yr.) Q = 1.3		Ft / Sec	4200	CFS
4. Continuity Equations: b) Regional Curves u = Q / A		Ft / Sec		CFS

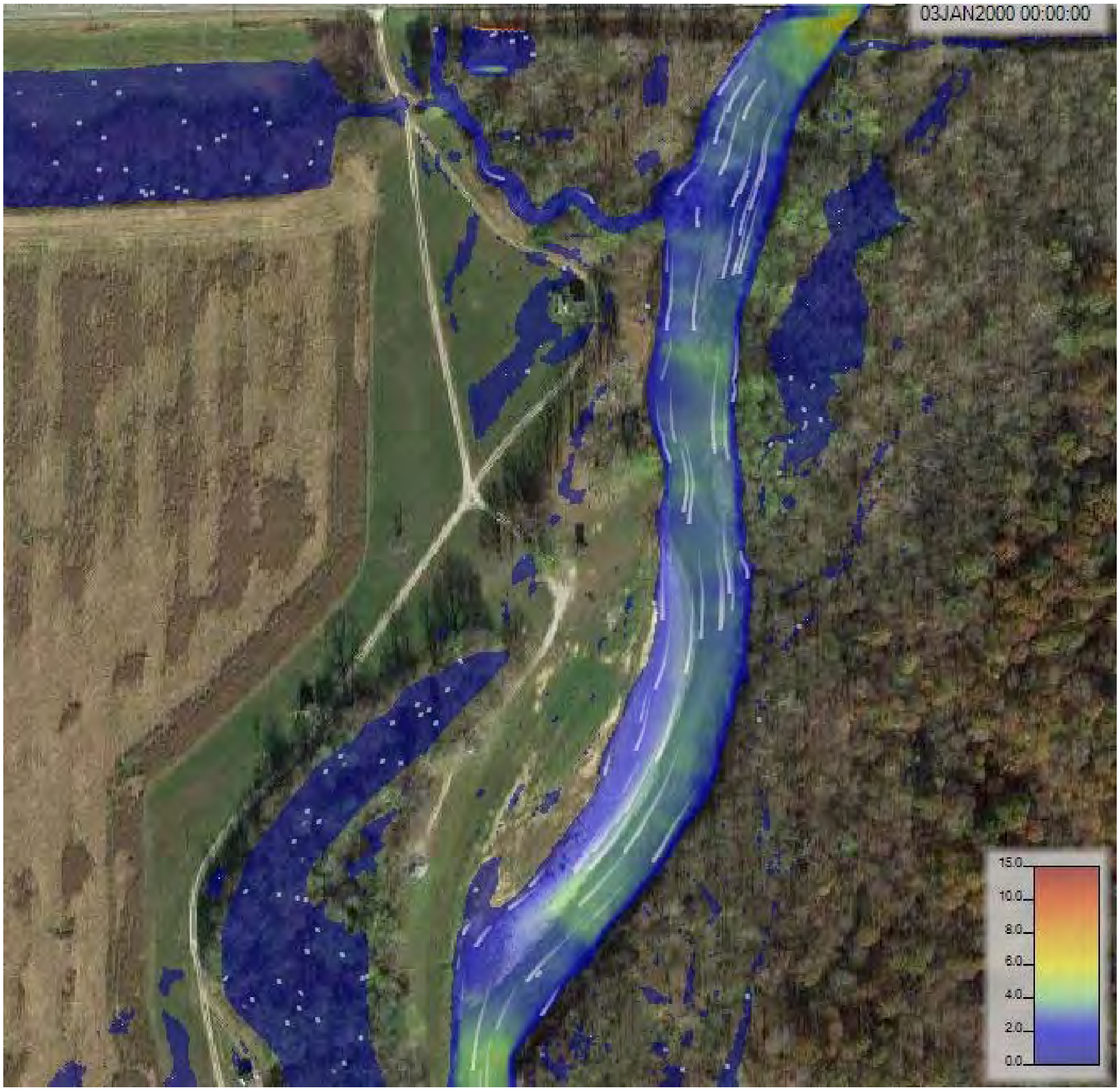
Options for using the D84 term in the **relative roughness relation** (R/D84), when using estimation method 1.

Option 1. For **sand-bed** channels: measure the **"protrusion height"** (h_{sd}) of sand dunes above channel bed elevations. Substitute an average sand dune protrusion height (h_{sd} in feet) for the D84 term in estimation method 1.

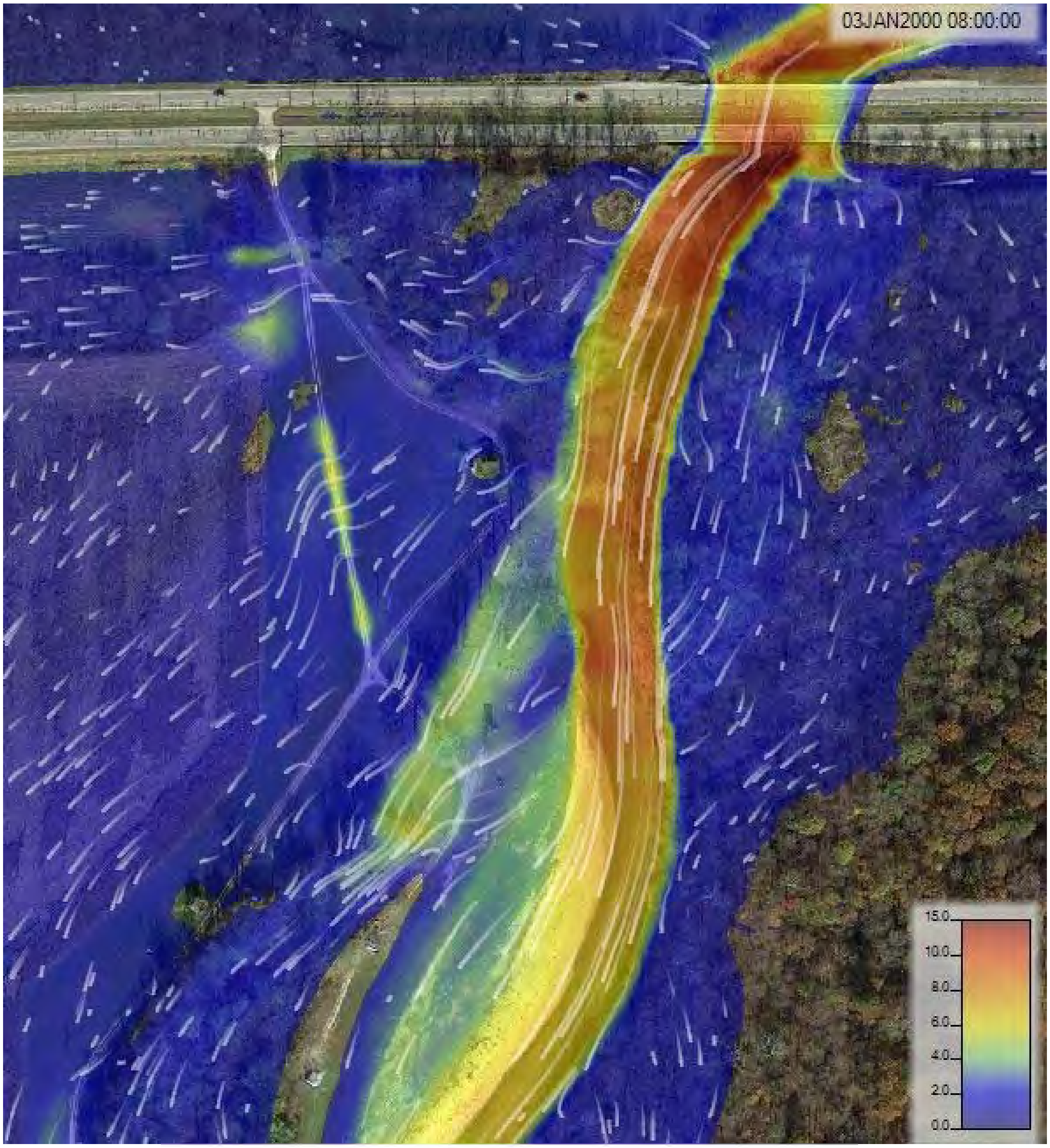
Option 2. For **boulder-dominated** channels: measure several **"protrusion heights"** (h_{bo}) of boulders above channel bed elevations. Substitute an average boulder protrusion height (h_{bo} in feet) for the D84 term in estimation method 1.

Option 3. For **bedrock-dominated** channels: measure several **"protrusion heights"** (h_{br}) of rock separations/steps/joints/ uplifted surfaces above channel bed elevations. Substitute an average bedrock protrusion height (h_{br} in feet) for the D84 term in estimation method 1.

Flow Velocity Grids



Bankfull Velocity Grid w/flowlines



100-Year Velocity Grid w/flowlines

Scour and Sediment Competence Calculations

Scour and Sediment Competence Evaluation for Big Walnut Creek

Date: 10/16/2018
Project No.: 14-0014

General Scour:

Blodgett Method:

z_t (mean) = $KD^{-0.115}$ D = D_{50}

z_t (max) = $KD^{-0.115}$

where:
z_t (mean) = best fit curve, ft

z_t (max) = enveloping curve, ft

D_{50} = median size of bed material, ft

K = 1.42 for z_t mean
K = 6.5 for z_t max

D_{50} (from site visit) = 4 mm
D_{50} (from site visit) = 0.013 ft

z_t (mean) = 2.34 ft

z_t (max) = 10.70 ft

Pemberton and Lara Method (Using Blench and Lacey Constants)

$z_t = KQ^aW^bD^c$

$Q = Q_d$
$W = W_f$
$D = D_{50}$

where:

z_t = maximum scour depth, ft
K = coefficient (see table below)
Q_d = design discharge, ft^3/s
W_f = flow widt at design discharge, ft

D_{50} = median size of bed material, mm
a, b, c = exponents (see table below)

Q_d = 6,800 cfs
W_f = 144.63 ft
D_{50} = 4 mm

Condition	Lacey				Blench			
	K	a	b	c	K	a	b	c
Moderate bend	0.195	1/3	0	- 1/6	0.530	2/3	- 2/3	-0.1092
Severe bend	0.292	1/3	0	- 1/6	0.530	2/3	- 2/3	-0.1092

Moderate bend, Lacey:

z_t = 2.93 ft

Severe bend, Lacey:

z_t = 4.39 ft

Moderate bend, Blench:

z_t = 5.93 ft

Severe bend, Blench:

z_t = 5.93 ft

Bend Scour:

NEH654.09 Method:

$z_b = y\ (y_{max}/y - 1)$

where:
y = average flow depth in the bend (ft)
y_{max} = maximum flow depth in the bend (ft)

y = 5.06 ft
$y_{max}/y = 1.5 + 4.5\ (W_i/Rc)$

where:
W_i = channel width at bend inflection point, ft
Rc = bend radius of curvature, ft

W_i = 154.8 from aerial photograph
Rc = 680 from aerial photograph

y_{max}/y = 2.52 ft

z_b = 7.69 ft

Flow Probability						Sediment Competence		Degradation Prior to Channel Armoring		
Bin Number	Min Flow Rate (cfs)	Max Flow Rate (cfs)	Frequency	Probability of Occurrence (%)	Average Flow Rate (cfs)	Mobile Sediment Size (mm)	% of Riffle Mobile (%)	Armor Particle Size (mm)	Degradation to Armor (ft)	% of Riffle Mobile (%)
1	0	621	21587	86.29	172	1.377	27.22	1.50	0.01	29.83
2	620	1240	2084	8.33	856	8.203	60.25	5.84	0.05	60.00
3	1240	1860	588	2.35	1508	10.873	63.48	7.23	0.07	60.00
4	1860	2480	276	1.10	2134	13.229	64.00	8.39	0.08	60.49
5	2480	3100	140	0.56	2774	15.880	65.08	9.63	0.10	61.98
6	3100	3720	84	0.34	3420	18.663	72.88	10.89	0.11	63.50
7	3720	4340	63	0.25	4078	21.174	81.25	11.98	0.13	64.00
8	4340	4960	47	0.19	4625	23.492	86.95	15.92	0.17	64.07
9	4960	5580	42	0.17	5241	26.001	89.62	17.54	0.23	69.15
10	5580	6200	22	0.09	5952	28.806	92.60	19.36	0.33	75.18
11	6200	6820	22	0.09	6500	29.861	93.72	20.03	0.38	77.45
12	6820	7440	14	0.06	7023	30.560	94.47	20.48	0.42	78.95
13	7440	8060	7	0.03	7864	31.220	95.17	20.91	0.47	80.37
14	8060	8680	7	0.03	8414	31.537	95.51	21.11	0.49	81.04
15	8680	9300	12	0.05	9088	31.735	95.72	21.24	0.51	81.47
16	9300	9920	4	0.02	9634	32.496	96.04	21.73	0.58	82.67
17	9920	10540	3	0.01	10144	34.033	96.57	22.71	0.72	84.97
18	10540	11160	2	0.01	10900	36.265	97.31	24.14	0.92	87.64
19	11160	11780	2	0.01	11511	38.010	97.85	25.25	1.08	88.82
20	11780	12400	5	0.02	12051	39.553	98.32	26.24	1.22	89.87
21	12400	13020	1	0.00	13000	42.484	99.23	28.10	1.71	91.85
22	13020	13640	1	0.00	13300	43.412	99.51	28.69	1.87	92.48
23	13640	14260	1	0.00	13772	44.859	99.72	29.61	2.31	93.22
24	14260	14880	1	0.00	14500	47.069	99.78	31.00	3.21	94.10
25	14880	15500	0	0.00	15190	49.164	99.84	32.32	4.06	94.93
26	15500	16120	1	0.00	16000	51.625	99.91	33.88	5.06	95.90
27	16120	16740	0	0.00	16430	52.931	99.94	34.70	5.59	96.42
28	16740	17360	0	0.00	17050	54.814	100.00	35.89	6.36	97.17
29	17360	17980	0	0.00	17670	56.752	100.00	37.10	8.23	97.57
30	17980	18600	2	0.01	18369	58.943	100.00	38.48	10.44	97.99

Worksheet 5-15. Sediment competence calculation form to assess bed stability.

Stream:	**Big Walnut Creek**		Stream Type:		
Location:	**Brazil, IN**		Valley Type:		
Observers:	**BJM, JDF**		Date: **4/17/17**		
Enter required information					
4.00	D_{50}	Riffle bed material D_{50} (mm)			
1.25	$\hat{D}_{50}$	Bar sample D_{50} (mm)			
0.15	D_{max}	Largest particle from bar sample (ft)	45.0	(mm)	304.8 mm/ft
0.00063	S	Existing bankfull water surface slope (ft/ft)			
4.04	d	Existing bankfull mean depth (ft)			
1.65	γ_s	Submerged specific weight of sediment			
Select the appropriate equation and calculate critical dimensionless shear stress					
0.030	$D_{50}/\hat{D}_{50}$	Range: 3 – 7	Use EQUATION 1: $\tau^* = 0.0834\ (D_{50}/\hat{D}_{50})^{-0.872}$		
	D_{max}/D_{50}	Range: 1.3 – 3.0	Use EQUATION 2: $\tau^* = 0.0384\ (D_{max}/D_{50})^{-0.887}$		
0.030	τ^*	Bankfull Dimensionless Shear Stress	EQUATION USED:		Eq. 1
Calculate bankfull mean depth required for entrainment of largest particle in bar sample					
11.7	d	Required bankfull mean depth (ft)	$d = \dfrac{\tau^* \gamma_s D_{max}}{S}$		
		Check: ☐ Stable ☐ Aggrading ☐ Degrading			
Calculate bankfull water surface slope required for entrainment of largest particle in bar sample					
0.00182	S	Required bankfull water surface slope (ft/ft)	$S = \dfrac{\tau^* \gamma_s D_{max}}{d}$		
		Check: ☐ Stable ☐ Aggrading ☐ Degrading			
Sediment competence using dimensional shear stress					
0.2	Bankfull shear stress $\tau = \gamma d S$ (lbs/ft^2) (substitute hydraulic radius, R, with mean depth, d)				
39.3	Moveable particle size (mm) at bankfull shear stress **(Figure 5-54)**				
2.4	Predicted shear stress required to initiate movement of D_{max} (mm) **(Figure 5-54)**				
7.7	Predicted mean depth required to initiate movement of D_{max} (mm) $d = \dfrac{\tau}{\gamma S}$				
0.00508	Predicted slope required to initiate movement of D_{max} (mm) $S = \dfrac{\tau}{\gamma d}$				

Appendix 5: Triple Bottom Line & Cost Estimate Calculations

Alternative Name, Treatment Type, or Other Project Metric	**Cummulative Score (15)**	ECONOMIC				SOCIAL					ENVIRONMENTAL				
		Capital Cost	**Lifecycle O&M Cost**	**Shared Funding**	Score (5)	**Widespread Benefit (# of properties)**	**Reduce Flooding Drainage Problems**	**Benefit to Public Health & Safety**	**Benefit to Quality of Life**	Score (5)	**Level of Protection for Threatened Features**	**Impact to Adjacent Stream Reaches**	**Restore/ Protect Floodplain Function**	**Improve/ Protect Stream Habitat**	Score (5)
	Weighting Factor=	*0.45*	*0.20*	*0.35*	*1.00*	*0.25*	*0.25*	*0.25*	*0.25*	*1.00*	*0.40*	*0.30*	*0.20*	*0.10*	*1.00*
	0=	*> $1000/ft*	*very high*	*none*		*0*	*none*	*none*	*none*		*added risk*	*significant (-)*	*no change*	*no change*	
	1=	*>$750/ft <$1000/ft*	*high*	*100% Owner*		*1-10*	*limited*	*limited*	*limited*		*no change*	*minor (-)*	*limited*	*limited*	
	2=	*>$500/ft <$750/ft*	*mod-high*	*75% Owner*		*11-30*	*limited-mod*	*limited-mod*	*limited-mod*		*minimal*	*no change*	*limited-mod*	*limited-mod*	
	3=	*>$250/ft <$500/ft*	*moderate*	*50% Owner*		*31-100*	*moderate*	*moderate*	*moderate*		*moderate*	*minor (+)*	*moderate*	*moderate*	
	4=	*>$100/ft <$250/ft*	*low-mod*	*75% Other*		*101-300*	*mod-high*	*mod-high*	*mod-high*		*high*	*moderate (+)*	*mod-high*	*mod-high*	
	5=	*<$100/ft*	*low*	*100% Other*		*300+*	*high*	*high*	*high*		*robust*	*significant (+)*	*high*	*high*	
Toe Wood	**7.1**	4	4	0	2.6	0	0	4	1	1.3	5	2	1	4	3.2
A-Jacks	**6.0**	3	4	0	2.2	0	0	4	0	1.0	5	2	1	0	2.8
Gabion Wall	**5.3**	3	2	0	1.8	0	0	4	0	1.0	5	1	1	0	2.5

Opinion of Probably Cost for Big Walnut Creek FEH Mitigation Project

Toe Wood & Overflow Improvements

Line	Description	Estimated Quantities	Units	Unit Price	Estimated Cost (Rounded)
1	**Demolition**				
2	Strip & Stockpile Topsoil	200	CY	$ 7	$ 1,000
3	Selective Tree Clearing, Grubbing, & Hauling	1	LS	$ 5,000	$ 5,000
4				Estimated Demolition Cost	$ 6,000
5	**Channel Improvements**				
6	Mass Excavation	1,100	CY	$ 7	$ 8,000
7	Place & Compact Fill Material	1,100	CY	$ 7	$ 8,000
8	Install Toe Wood	350	LF	$ 76	$ 27,000
9	Install Soil Lifts	700	SF	$ 19	$ 14,000
10	Install Live Willow Stakes	700	EA	$ 3	$ 2,000
11	Topsoil Placement	2,000	SY	$ 2	$ 5,000
12	Finish Grading	2,200	SY	$ 1	$ 2,000
13	Seeding	2,200	SY	$ 2	$ 4,000
14	Install Erosion Control Blankets	2,000	SY	$ 3	$ 6,000
15				Estimated Channel Improvements Cost	$ 76,000
16	**Overflow Improvements**				
17	Finish Grading	5,000	SY	$ 1	$ 5,000
18	Seeding	5,000	SY	$ 2	$ 10,000
19	Install Erosion Control Blankets	4,500	SY	$ 3	$ 14,000
20				Estimated Overflow Improvements Cost	$ 29,000
21	**Miscellaneous**				
22	Dewatering	1	LS	$ 1,000	$ 1,000
23	Erosion and Sediment Control	1	LS	$ 1,000	$ 1,000
24	Construction Surveying	1	LS	$ 2,000	$ 2,000
25	Construction Mobilization/Demobilization	1	LS	$ 7,000	$ 7,000
26	Project Administration & Unforeseen Additional Costs (50%)	1	LS	$ 56,000	$ 56,000
27				Estimated Miscellaneous Cost	$ 67,000
28					
29				**Total Construction Cost**	**$ 178,000**
30					
31	**Professional Services**				
32	Topographic Site Survey	1	LS	$ 4,000	$ 4,000
33	Geotechnical Engineering Investigation	1	LS	$ 4,000	$ 4,000
34	Engineering Design	1	LS	$ 54,000	$ 54,000
35	Construction Observation	1	LS	$ 15,000	$ 15,000
36				Estimated Professional Services Cost	$ 77,000
31					
32				**Estimated Total Cost for Project**	**$ 255,000**

Notes and Assumptions

1. 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.
2. All costs are in 2018 dollars.
3. Estimated costs have been rounded.
4. This estimate does not include unforeseen costs increases that may result from shortages in fuel and materials as a result of a natural or man-made disaster.
5. 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.
6. This estimate does not include easement, right-of-way, or land acquisition costs that may be necessary to construct the proposed alternative.
7. This estimate does not include the cost of environmental mitigation, which may be necessary as a result of project impacts