

LAFAYETTE, CENTRAL WABASH, TIPPECANOE COUNTY, INDIANA
SECTION 905(b) (WRDA 86) ANALYSIS

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Executive Summary

A Section 905(b) Analysis was prepared for the Wabash River in Tippecanoe County, Indiana as an initial response to the Omnibus Appropriations Act, 2009, Division C - Energy and Water Development and Related Agencies. The purpose of the reconnaissance phase study is to determine if there is a Federal (Corps) interest in providing flood damage reduction and ecosystem restoration solutions to the various water resource problems and needs along 29 miles of the Wabash River in Tippecanoe County, Indiana.

The Wabash River is the largest inland commercial fishery in Indiana and is a globally significant ecosystem known for species diversity and richness and for the presence of many endangered, threatened, and rare species. It is socially and economically important as a source of drinking water, a commercial fishery, and an outstanding recreational resource. Further, the recreational uses associated with parks and associated amenities that currently exist and are proposed in the Master Plan for the Wabash Greenway (see Attachment 1) and other projects contribute to the economy of the area.

The ecosystem restoration approaches identified through this project are anticipated to further this economic development by improving riparian habitats through stream bank stabilization and riparian plantings, restore and enhance wetlands and through in-stream aquatic habitat improvements.

Public concerns associated with the study area include water quality, bank erosion, flooding and flow flashiness, wildlife habitat, historic and cultural resource preservation, recreation, economics and property rights.

While episodic flooding does occur in the study area as a result of extreme or unusual precipitation events, there is no evidence suggesting that recurrent or frequent flooding or flood damage to structures was an issue. There were anecdotal reports of flooding of historical developments in the Tippecanoe River floodway and in Indian Creek.

Potential projects that address the public concerns and are consistent other planning efforts including the Master Plan for the Wabash Greenway were identified. Projects included stabilization of approximately 35,000 linear feet (6.5 miles) of stream and enhancements to approximately 37 acres of riparian vegetation. Wetland function was evaluated on portions of 430 acres of wetlands and enhancements to hydrology and plant communities were identified. Cost estimates for stream stabilization projects ranged from \$6.9 million to \$17.3 million; cost estimates for riparian enhancements were approximately \$0.75 million. Additional assessment is needed to refine these cost estimates and develop cost estimates for wetland enhancements.

Ecosystem restoration is an output with a high budget priority. Coordination with other resource agencies (i.e., the Indiana Department of Natural Resources, Planning with POWER, the Tippecanoe Soil and Water Conservation District) occurred throughout development of the Wabash River Corridor Master Plan. However, the scope and scale of the potential project eligible for the Corps' consideration at this location does not warrant a General Investigations feasibility study, nor follow on project authorization from Congress.

However, there are some aquatic ecosystem features that would justify consideration under Section 206 of the Continuing Authorities Program (CAP). Consideration should be given for evaluating the implementability of an Aquatic Ecosystem Restoration project under Section 206 of the Continuing Authorities Program. Wabash River Enhancement Corporation would be a local sponsor for the program.

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1. STUDY AUTHORITY

This Section 905(b) Analysis was prepared as an initial response to the Omnibus Appropriations Act, 2009, Division C - Energy and Water Development and Related Agencies, which reads, in part, as follows:

Agency	Account	Title	Amount	Requestor (House only)
US Army Corps of Engineers (Corps)	Investigations	Central Wabash River, IN	\$96,000	Buyer, Steve

There are over 30 separate Congressional Resolutions outstanding which request study of portions or all of the Wabash River Basin. The resolution quoted below constitutes the comprehensive authority under which this study has been conducted:

“RESOLVED BY THE COMMITTEE ON PUBLIC WORKS OF THE UNITED STATES SENATE. That the Board of Engineers for Rivers and Harbors, created under Section 3 of the River and Harbor Act, approved June 13, 1902, be, and is hereby requested to review the reports of Chief of Engineers on the Wabash River and tributaries, Illinois and Indiana, submitted as House Document Numbered 100, Seventy-third Congress, First Session and other reports, with a view to determine whether any modifications of the recommendations contained therein are advisable at this time in the interest of flood control and the development and conservation of the water and related resources of the basin.” (Adopted: 06 May 1958)”

Funds in the amount of \$96,000 were appropriated to conduct the reconnaissance phase of the study.

2. STUDY PURPOSE

The purpose of the reconnaissance phase study is to determine if there is a Federal (Corps) interest in providing flood damage reduction and ecosystem restoration solutions to the various water resource problems and needs along the Wabash River in Tippecanoe County, Indiana. In response to the study authority, the reconnaissance study was initiated on 20 April 2010. The Wabash River is a globally significant ecosystem known for species diversity and richness and for the presence of many endangered, threatened, and rare species. It is socially and economically important as a source of drinking water, a commercial fishery, and an outstanding recreational resource.

3. LOCATION OF STUDY, NON-FEDERAL SPONSOR AND CONGRESSIONAL DISTRICTS

a. The study area is located in the Wabash River Corridor in Tippecanoe County, Indiana including the waterfronts of the cities of Lafayette and West Lafayette. The extent of the study area is shown below in Figure 1. The study area extends from River Mile 318.5 at the Tippecanoe – Carroll County line to River Mile 289.5 at the Tippecanoe County line between Warren and Fountain Counties.

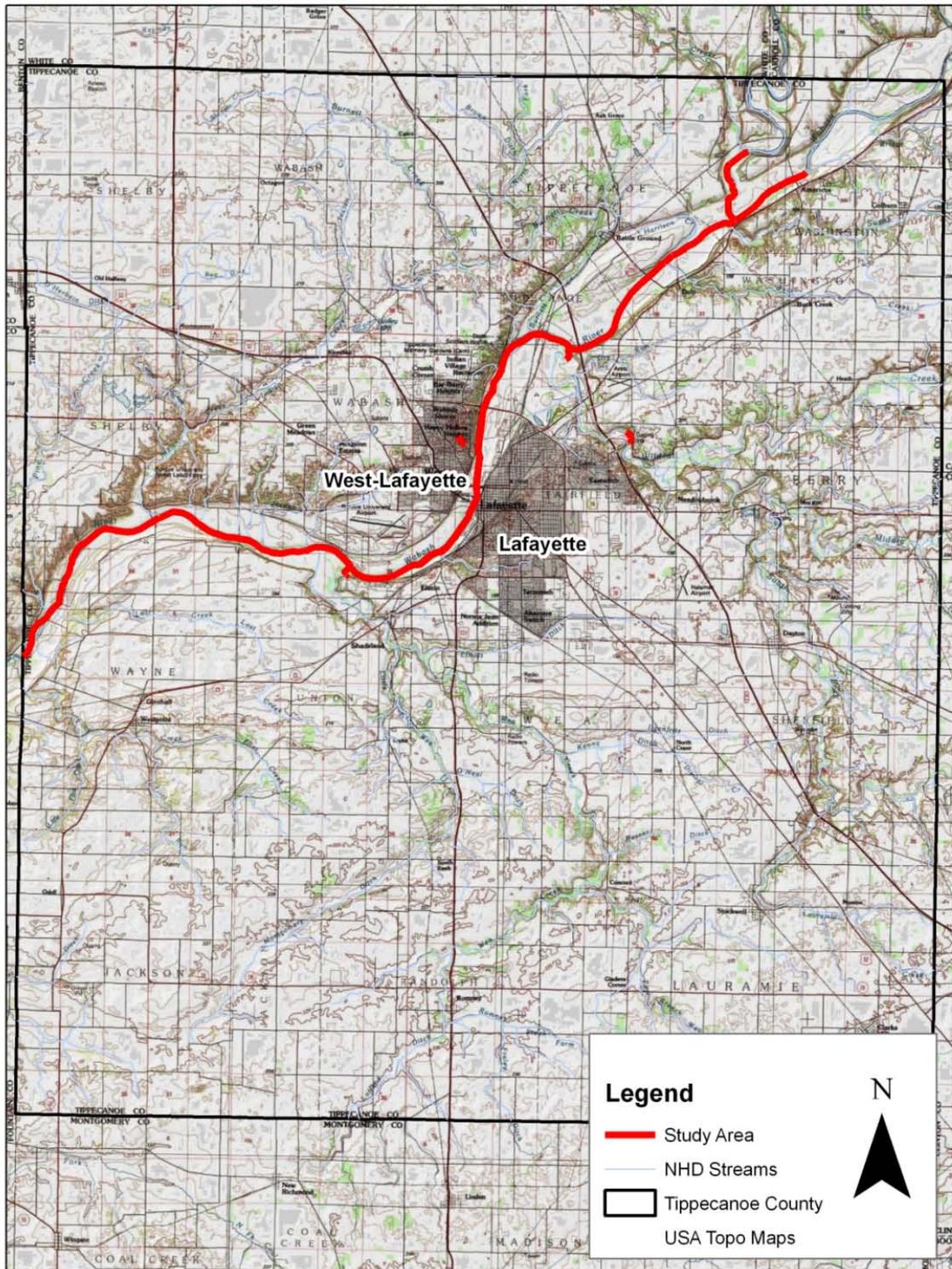


Figure 1. Study Area Location Map

The study area also includes the mouths of major tributaries to the Wabash River in Tippecanoe County including the Tippecanoe River and Wildcat Creek. An unnamed tributary that flows through Happy Hollow Park in Lafayette was identified as a significant sediment load and was included in the study. The study area includes Tippecanoe County, the cities of Lafayette and West Lafayette, Indiana and other communities in the county for the purpose of establishing the economic benefits of the project.

b. The potential non-Federal sponsor for a feasibility phase of study is the Wabash River Enhancement Corporation (WREC). Potential supporting sponsors include the Cities of Lafayette and West Lafayette, Indiana, Tippecanoe County, Indiana; the State of Indiana; North Central Health Services (NCHS) and various non-governmental agencies with interests in restoration, conservation and preservation of natural and cultural resources along the Wabash River.

The study area lies within the 4th Congressional District, Indiana - Representative Todd Rokita.

4. PRIOR REPORTS AND EXISTING PROJECTS

a. Reports related to flow regime, ecosystem integrity, water quality, and Wabash River projects and plans are summarized in Sections 1 through 4 below.

1) Reports Related to Flow Regime

Federal Emergency Management Agency. 2009. *Flood Insurance Study Tippecanoe County, Indiana, and Incorporated Areas. Flood Insurance Study Number 18157CV000A.*

The initial hydrologic and hydraulic analysis was completed in January 1979 for the May 1980 Flood Insurance Study (FIS) reports for the City of Lafayette, City of West Lafayette, Town of Battleground and the September 1980 FIS report for unincorporated areas of Tippecanoe County.

The hydrologic and hydraulic analyses for Cole Ditch, Cole Ditch Unnamed tributary 1, Cole Ditch Unnamed tributary 2, Cuppy Ditch, East Branch Wea Creek, Indian Creek, and Tippecanoe River were completed in September 2005. The IDNR orthographic photo images were produced at a scale of 1:800. The aerial photography is dated March 2002.

The study describes the location, population, weather (including annual rainfall), terrain, vegetation, soil type, drainage density, land use, gage station locations with elevation and peak discharge and principal flood problems for each of the communities studied.

Indiana Division of Water. 1980. *Coordinated Discharge Graph of the Wabash River (modified).* Indiana Department of Natural Resources, Division of Water. April 1980.

The following statistics were given for the Wabash River. The Wabash River at Lafayette drains 7,267 square miles and discharges for selected flood frequencies for this area are shown on the table below.

Table 1. Flood Frequency for the Wabash River at Lafayette

Flood Frequency	Discharge (cfs) (1)
10-Year	62,000
25-Year	76,000
50-Year	85,000
100-Year	94,000
Note: 1. cfs – cubic feet per second	

Burke, D.B., R.P. Richards, T.T. Loftus and J.W. Kramer. 2004. *A New Flashiness Index: Characteristics and Applications to Midwestern Rivers and Streams*. Journal of the American Water Resources Association. (JAWRA 40(2):503-522.

Flashiness reflects the frequency and rapidity of short term changes in stream flow, especially during runoff events, and is an important component of the hydrologic regime of a stream. Changes in land use and management may increase or decrease flashiness, which is often detrimental to aquatic life. Flashiness may be increased by activities such as increases in the amount of impervious surfaces in a basin, increases in the amount of drained agricultural land, and conversion of forests and wetlands to other uses. Large flood control reservoirs typically decrease flashiness through controlled releases of flood flows. The authors examined stream flow data from USGS gauging stations around the Midwestern United States. Two of the gauges were located in the area currently under consideration. The authors found no significant increase in flashiness at one location in the study area and an increase at another area that was not significant at the 0.05 level.

Zucker, L.A. and L.C. Brown (Eds.). 1998. *Agricultural Drainage: Water Quality Impacts and Subsurface Drainage Studies in the Midwest*. Ohio State University Extension Bulletin 871. The Ohio State University.

The bulletin reviews the status and importance of drainage for agricultural production in the North Central Region, identifies the positive and negative effects of agricultural drainage, and summarizes new drainage methods which work to increase productivity, enhance the positive effects of agricultural drainage, and mitigate the adverse effects of agricultural drainage on the environment. More than half the natural wetlands in the United States have been lost to drainage practices with much of it related to agricultural drainage. Loss of wetlands is associated with declines in wildlife habitat and adverse effects on water quality. Wetland loss and the corresponding loss of wetland functions that sustain healthy ecosystems are one of the most important environmental issues facing agriculture.

In the North Central Region, the Great Lakes and Corn Belt states (Illinois, Indiana, Iowa, Michigan, Minnesota, Missouri, Ohio and Wisconsin) are some of the most highly drained states in the U.S. Illinois, Indiana and Ohio are ranked first, second and fourth, respectively among all states in land area that is artificially drained. Over eight million (8.1 million) acres are drained in Indiana. Eighty-five percent (85%) of drained land in Indiana is cropland. Fifty percent (50%) of Indiana's cropland is artificially drained.

2) Reports on Ecosystem Integrity

Gammon, J.R. 1998. *The Wabash River Ecosystem*. Published by Cinergy Corporation, Plainfield, Indiana, Eli Lilly and Company, Indianapolis, Indiana, and DePauw University, Greencastle, Indiana. Distributed by Indiana University Press, Bloomington, Indiana.

This book is a summary of a long-term research program focused on the Wabash River Ecosystem beginning in 1968 and concluding in 1997. In general, most fish species populations improved over the course of the study with several species expanding their ranges into previously unoccupied areas. This fish population and community response is probably associated with the 50% reduction in biochemical oxygen demand (BOD) loading that occurred in the mid 1980's.

The fisheries resource of the Wabash River main stem is of global significance and is comprised of more than 150 species, including rare species such as shovelnose sturgeon, paddlefish, black redhorse, spotted gar, and blue sucker. Economically significant sport fish populations occur in the study area including smallmouth bass, largemouth bass, sauger, white bass, flathead catfish, channel catfish, and various sunfish species. Reproductive success for nearly all of the fish species was extremely low following the prolonged elevated flows of 1993, although populations appeared to achieve modest rebounds near the conclusion of the study. Fish species that are intolerant to degraded water quality or habitat are most often found in the upper reaches of the main stem Wabash within the area presently under study.

The condition of riparian forests is highly variable throughout the 518 km Wabash River corridor. In total, more than 27 km along the river banks were observed to have sparsely forested riparian zones consisting of one to two trees. The Wabash River between Delphi and Attica accounted for 7.7 km of the riparian forests observed in this condition. The absence of riparian forests along the main stem apparently contributed to the presence of bare banks along nearly 29 of the 518 km comprising nearly 3% of the total length within the study area.

Wamsley, K. 2010. *Water over white stone*. The Nature Conservancy's Wabash River Initiative. E-mail correspondence and white paper provided by Kent Wamsley of The Nature Conservancy on March 5, 2010 at 9:05 a.m.

The Wabash River is the longest free-flowing river east of the Mississippi. Nearly 400 rare species inhabit the system, including 151 species of fish and 75 species of freshwater mussels. The middle reach of the Wabash River, which includes the area currently under study, contains nearly 120 species of plants and animals that are rare, threatened or endangered. The Nature Conservancy (TNC) has ranked the Tippecanoe River, a large tributary at the upstream end of the study area, as the 8th most important freshwater system in North America for the conservation of imperiled species. Federally listed species such as *Pleurobema clava* (clubshell) and *Cyprogenia stegaria*

(fanshell) are known to occur in this river as are other rare species including sheepsnose (mussel), rayed bean (mussel), and rabbitsfoot (mussel), the Tippecanoe darter, Eastern sand darter, Western sand darter, Mimic shiner, paddlefish, and Shovelnose sturgeon.

TNC has identified the following ecological processes that sustain rare, threatened, and endangered species in the study area:

- Hydrologic fluctuations within natural bounds
- High water quality from headwaters and groundwater
- Clean river substrates for habitat
- Channel formation connectivity (riffle, run, pool)
- Connectivity to backwaters and floodplain

TNC identified the following stressors that threaten the continued existence of these species in the study area:

- Increased flooding due to loss of upstream wetlands and agricultural drainage
- Nutrient and toxin loading from agriculture and urban activities
- Increased sedimentation from agricultural, drainage ditch, bank erosion, and urban activities
- Loss of connectivity due to dams on tributaries, levees and agriculture limit access to natural floodplain communities (the Huntington dam is the only main-stem dam)

TNC goals for the Wabash River ecosystem that are relevant to this study include:

- Restoring forested floodplains and reconnecting adjacent oxbows and backwaters
- Reforesting 20,000 acres in the Wabash River floodplain by 2016
- Acquire and restore floodplain lands

Fisher, B.E. 2006. *Current status of freshwater mussels (Order Unionoida) in the Wabash River Drainage of Indiana. Proceedings of the Indiana Academy of Science. 115(2):103-109.*

This study is the synthesis of data from prior studies of the distribution and population status of freshwater mussels in the Wabash River basin and tributaries. The following conclusions were drawn from the study:

- Reproductive populations for 30 species exist in the main stem Wabash River and its tributaries;
- Reproductive populations for 18 species historically found in the main stem Wabash River are now restricted to its tributaries;

- Nine (9) species had populations that were always restricted to the tributaries; and
- 18 species have been extirpated from the entire Wabash River drainage.
- The federally endangered *Pleurobema clava* (clubshell) is still found in the upper Wabash River and the Tippecanoe River. Another federally endangered species, *Cyprogenia stegaria* (fanshell), is found in the Tippecanoe River below Lake Freeman and occasionally in the Wabash main stem.

Cummings, K.S., C.A. Mayer, and L.M. Page. 1988. *Survey of the Freshwater Mussels (Mollusca: Unionidae) of the Wabash River Drainage. Phase II: Upper and Middle Wabash River. Prepared for Indiana Department of Natural Resources Division of Fish and Wildlife.*

The Illinois Natural History Survey searched for freshwater mussels at 31 locations along the Wabash River from Huntington Reservoir to Francisville in Knox County. Two study sites were located in Tippecanoe County and a third was located in Carroll County southwest of Delphi near the Tippecanoe County line.

Weathered dead and sub-fossil specimens of the federally endangered *Cyprogenia stegaria* were found at the Tippecanoe County sites. The abundance of shells on exposed bars suggests that this species was once very common. Sub-fossil shells of the federally endangered *Pleurobema plenum* were found at the furthest downstream Tippecanoe County site. Weathered dead *Pleurobema clava* shells and sub-fossil *Epioblasma torulosa rangiana* shells were found at the upstream site. Both of these species are federally endangered.

One live specimen of the federal candidate species *Quadrula cylindrica* (rabbitsfoot) was found at Colliers Island downstream of the Granville Bridge. Six live *Plethobasus cyphus* (sheepnose) mussels were found upstream of Lafayette near the County line. Sub-fossil valves for the federal candidate species *Villosa fabalis* were found in Tippecanoe County one-mile southeast of Battle Ground. Many of the species represented by only weathered or sub-fossil valves are believed extirpated from the Wabash River.

Stefanavage, T.C. 2009. *Summary of Harvest Estimates and License Sales for Indiana's Inland River Commercial Fisheries, 2007. Fish Management Report. Fisheries Management Section, Indiana Department of Natural Resources, Division of Fish and Wildlife. 13 pp.*

The Wabash River accounted for approximately half of the total inland river commercial harvest in Indiana for 2006. Inland commercial sales for 2007 were 335 licenses and 1,268 net tags. Reported total inland harvest for 2007 was 76,828 lbs down from the 2006 harvest of 94,218 lbs. Fluctuations in the total harvest from year to year are due to a number of variables.

The greatest influence appears to be major water level fluctuations. Inland catfish harvest for 2007 was 59,216 lbs (29,944 lbs channel catfish, 22,160 lbs flathead catfish, 7,112 lbs blue catfish). Catfish harvest comprised 77% of

the total catch. The estimated monetary value of the 2007 inland commercial harvest was \$216,042.

B.J. Armitage and E.T. Rankin. 2009. *An Assessment of Threats to the Biological Condition of the Wabash River Aquatic Ecosystem of Indiana*. Prepared for The Nature Conservancy, Indiana Chapter. 1505 N. Delaware Street, Suite 200. Indianapolis, IN 46202.

Armitage and Rankin reviewed fish assemblage, habitat, and water quality data collected in 1999 and from 2004 to 2006 in the Wabash River main stem. They grouped and analyzed the data by watersheds at the eight digit Hydrologic Unit Code (HUC-8). Two of these HUC-8 watersheds (i.e., 05120105 and 05120108) coincide with the Tippecanoe County study area. The upstream extent of HUC 05120105 resides within Cass County and terminates in Tippecanoe County upstream of the confluence with the Tippecanoe River.

Index of Biotic Integrity (IBI) scores in Carroll County immediately upstream of the Tippecanoe County line were classified as “good” or “excellent”. Five of the ten most common fish species in this reach of the Wabash River are considered “intolerant” or “sensitive” to habitat or water quality degradation. Live mussel species ranged between 20 and 23 species and with live and dead valves included, richness ranges between 30 and 36 species.

Four sample sites were located within Tippecanoe County and all were classified as “good”. Most water quality parameters in the main stem did not deviate substantially from “reference background” conditions. Exceptions included nitrate and total suspended solids, which were deemed to exhibit a high degree of deviation. Total phosphorous concentrations in this watershed frequently exceeded targets established by Ohio EPA for large rivers. Nutrient sources were thought to originate in upstream watersheds.

IBI scores in Tippecanoe County ranged from “very good” (n = 1) to “fair” (n = 3) with the remainder classified as “good”. Nitrate, total suspended solids, and zinc (one HUC 11 watershed only) were deemed to exhibit a “high” deviation from reference background concentrations. “High”, “Very High”, and “Extreme” deviations were far more frequently observed in the tributaries than in the main stem. Fewer intolerant and sensitive species were observed in the fish assemblage and one of the ten dominant fishes was the common carp, a non-native species.

The authors examined potential enhancement options for the Wabash River identified three classes of actions. The first class concerns habitat loss and degradation on the main stem Wabash River. Major stressors in the main stem may be addressed by:

- Restoring bottomland forests which in turn resist bank erosion and provide habitat structure when recruited to the river and
- Restoring oxbow and other wetland types.

3) Reports on Water Quality

Christensen, C.C. 1998. *Indiana fixed station statistical analysis 1997*. Indiana Department of Environmental Management, Office of Water Management, Assessment Branch, Surveys Section, Indianapolis, Indiana. IDEM 32/02/005/1998.

This report, produced by the Indiana Department of Environmental Management (IDEM), Office of Water Management, analyzed fixed station monitoring data from 1991 to 1997 throughout the State of Indiana, including Wabash River. Physical, chemical, bacteriological, and radiological parameters were collected monthly at fixed stations along the river, and trends in mean, median and standard deviation of those parameters were examined. Three fixed stations occur within Tippecanoe County, Indiana. Water quality results at these locations portrayed statistical or probable decreases in parameters such as Biological Oxygen Demand (BOD), chemical oxygen demand (COD), chloride, copper, iron, ammonia, Total Kjeldhal Nitrogen (TKN), total phosphorus, total residue, sulfate, and zinc. Statistical or probable increases were found in parameters such as alkalinity, pH, and E. coli bacteria.

Holdeman, M.A.; Gibson, S.C.; Christensen, C.C. 1998. *Trend Analysis of Fixed Station Water Quality Monitoring Data in the Upper Wabash River Basin 1998*. Indiana Department of Environmental Management, Office of Water Management, Assessment Branch, Indianapolis, Indiana. 23p. IDEM 32/02/023/2003.

This report produced by the Assessment Branch of the IDEM Office of Water Management, analyzed data from 372 water samples collected at fixed station monitoring sites throughout the upper Wabash River basin in 1998. Samples were analyzed for nine recoverable metals and nutrient levels. Overall, 100 samples exceeded Chronic Aquatic Criteria standards for metals. Levels of lead and mercury exceeding the standards were found in the Wabash River and Wildcat Creek in Tippecanoe County. Upper basin nutrient analysis results showed increased median values for Phosphorus, Total Kjeldahl Nitrogen (TKN), and Total Organic Carbon; while lower reaches of the basin had higher nitrate levels.

McFall, L.; Martin, S.; Christensen, C. 2000. *1998 Upper Wabash River basin sampling sites and stream standard violations, report for the 305(b) Coordinator, compiled by Arthur C. Garceau*. Indiana Department of Environmental Management, Office of Water Management, Assessment Branch, Indianapolis, Indiana. 25p. IDEM 32/02/022/2000

This report, produced by the IDEM Office of Water Management, summarized water quality sampling results, highlighting regulatory violations. Sampling programs acted upon in 1998 included Watershed Monitoring, Fixed Station, E. coli, and Total Maximum Daily Load (TMDL).

Results of the Watershed Monitoring probabilistic program did not observe any stream standard violations that pertain to aquatic life uses; however, other sampling programs did observe violations at specific sites. Within Tippecanoe County, Indiana, violations included cyanide, lead, mercury, and E. coli levels near Battle Ground, Indiana.

Tetra Tech, Inc. 2006. *Wabash River Nutrient and Pathogen TMDL Development. Report for Illinois Environmental Protection Agency and Indiana Department of Environmental Management, Indianapolis.*

This report, a collective effort by the States of Indiana and Illinois, summarized comprehensive water quality results throughout the Wabash River, identified impairments, pollution sources, and needs for Total Maximum Daily Load (TMDL), and identified possible Implementation Plans.

Within the study area for this report, the TMDL included E. coli bacteria, nutrients, pH and dissolved oxygen. In the Wabash River above Lafayette, the TMDL included 87% to 88% reductions in E. coli bacteria from nonpoint sources. For phosphorus, the TMDL included 46% and 70% reductions from point sources (i.e., wasteload allocations) and 4% and 6% reductions from nonpoint sources (i.e., load allocations). No reductions were included in this segment for nitrate.

US Geological Survey. *Water Quality Samples for Indiana. USGS 03335500 Wabash River at Lafayette, Indiana*

The US Geological Survey National Water Information System (NWIS) database included the following data from 59 suspended sediment samples for the Wabash River at Lafayette, Indiana (Site # 03335500), collected between 1964 and 1981.

Table 2. Suspended Sediment in the Wabash River

Statistic	Suspended Sediment (mg/L)	Suspended Sediment Discharge (tons/day)	Flow (cfs) (1)
Min	6	13	575
Avg	93	3,282	6,826
Max	980	81,500	58,100

Note: 1. cfs – cubic feet per second

McDuffee R. 2002. *An Assessment of Pesticides in the Lower Wabash River Basin and Kankakee River Basin. Indiana Department of Environmental Management, Office of Water Quality, Assessment Branch, Surveys Section, Indianapolis, Indiana. IDEM 032/02/028/2002.*

The Wabash River at Lafayette drains 7,267 square miles. A total of 6,563 square miles (90%) of the drainage basin is planted in corn and soybeans. Annually, 2.4 million pounds of atrazine are applied to corn and 1.7 million pounds of glyphosate (Roundup©) are applied to soybeans in the Wabash River watershed above Lafayette.

Atrazine is suspected as an endocrine disrupter and has a potential to produce tumors in a long term setting. IDEM's Office of Drinking Water has recently implemented a Source Water Protection Program for human health and safety.

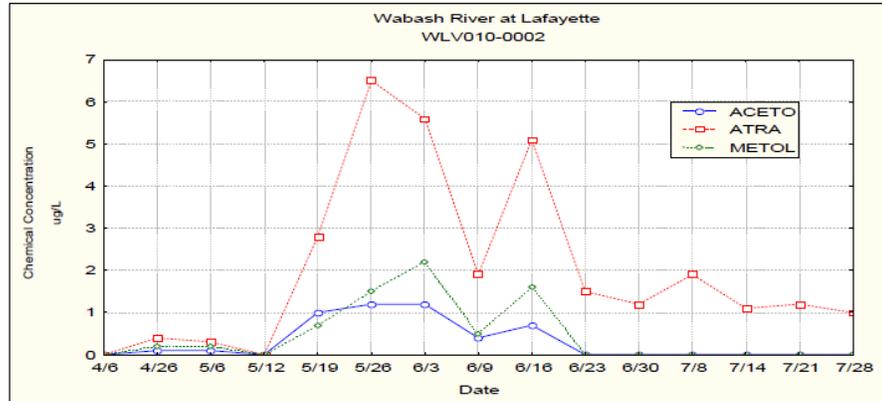


Figure 2. Concentrations over time of Selected Pesticides Acetochlor (ACETO), Atrazine (ATRA), and Metolachlor (METOL) at Site WL010-0002 (Wabash River at Lafayette, Indiana).

4) Reports on Wabash River Projects and Plans

US Army Corps of Engineers 1938. *Flood Control Plan Wabash River and Tributaries Basin Study.*

This report was prepared in response to the flooding in the basin that occurred as a part of the massive flooding in the Ohio River basin in 1937. The report discussed and/or recommended 70 levee or channel improvement projects and nine large reservoir projects. This report was revised in 1940 and updated in 1944. Follow up basin comprehensive studies were later conducted in 1963, 1968, and 1971. Of the original nine reservoir projects, a total of three were constructed at or near the originally proposed sites: CM Hardin; Monroe; and Cagles Mill. Four other large multipurpose reservoir projects were constructed at other locations in the basin: Roush; Salamonie; Mississinewa; and Patoka. Of the 70 originally proposed levee/channel projects: 36 were ultimately implemented under various types of construction authorizations; 13 were authorized for construction by Congress but never funded; and one is currently scheduled for construction under a recently executed cost sharing agreement. One additional levee at Mt. Carmel was added to the original project list and constructed. While no levee project was proposed or constructed at Lafayette, flow in the river at the community is affected by three of the multipurpose reservoir projects located 40 to 50 miles upstream of Lafayette.

US Army Corps of Engineers, 1977. *Wabash River Comprehensive Navigation Study.*

This study looked at the possibility of constructing a series of locks and dams on the Wabash River for the purpose of establishing commercial navigation in the basin. The report concluded that the proposal was economically unjustified by a wide margin. A 1989 review of the findings reached the same conclusion.

US Army Corps of Engineers. 2007. *Wabash River Analysis – Phase I Tippecanoe County, Indiana. Planning Assistance to States Study Final Report.*

The purpose of the Planning Assistance to States (PAS) study is to complete a Hydrologic and Hydraulic (H&H) study of issues pertaining to the development of a Conceptual Master Plan (CMP) by the Wabash River Enhancement Corporation (WREC) for Riverfront Development along the Wabash River in Lafayette-West Lafayette, Indiana.

The HEC-RAS model was developed for the Wabash River from Mile 307 upstream to Mile 321. The model was calibrated using data obtained from IDNR for the July 6-11, 2003 flood event. The report recommended that the model be expanded to the Tippecanoe County limits for future planning purposes. Results of the model were calculated for the 1-, 2-, 5-, 10-, 25-, 50-, 100-, and 500- year events and are presented in tables and graphs.

In addition to development of the HEC-RAS model, the report also analyzed an eroding bank located on the left bank of the Wabash River at river mile 313.3. A 400-foot bank is being undercut during high flows and is encroaching on the Lafayette Greenwood Riverwalk. The report estimates that without any countermeasures taken, the bank will reach the trail within five years. Several options, including stabilization of the bank and the relocation of the trail were presented. Bank profile graphs and photographs are included as part of the report.

Wallace, Roberts and Todd. 2010. *Master Plan for the Wabash River Greenway.*

The Wabash River Enhancement Corporation funded the development of a master plan for a greenway along the Wabash River. The greenway study area consisted of the 100-year Wabash River floodplain from Delphi in Carroll County through Lafayette and West Lafayette to Independence in Fountain / Warren County. This area was divided into six (6) segments, and for each segment the master plan identified recreational opportunities such as driving and bicycle routes, camping, boating as well as cultural features. To the extent feasible, the master plan integrated and leveraged other planned improvements such as planned trails. Within the rural sections of the greenway, potential improvements were focused primarily on enhancements to existing parks. Within the urban section of the greenway (i.e., within Lafayette and West Lafayette), the plan identified twenty-one (21) projects, including the development of several new parks, two new pedestrian / bicycle bridges and significant enhancements and improvements to existing parks and bridges. The plan outlined the addition of new land to the greenway through conservation easements and acquisitions for parks and preserves. The plan outlined conservation development approaches that retain natural lands in new subdivisions. The plan recommended a review of codes and regulations, incentives and potential formation of a greenway partnership to foster and encourage implementation of the greenway master plan. This plan is provided as Attachment 1.

Wabash River Corridor Master Plan, Urban Sections (Phase 1), Lafayette, Tippecanoe County, Indiana.

This planning effort includes the development of a plan of action for a downtown river reach. The plan is comprised of a series of implementable strategies and projects for both short and long term planning horizons. The downtown river segment is defined as the areas between the Route 52 Bridge to the north, the Route 231 Bridge to the south, primarily River Road to the west, and the Ninth Street corridor leading down to the rail corridor (south of Columbia) to the east. The aerial photograph of existing conditions and renderings of concepts for the proposed Master Plan in the Urban Sections or “Core Area” are provided in Attachment 1. The plan includes recreational trails, pedestrian crossings, development of access sites for paddling and fishing, riparian forest and wetland restoration.

Two public meetings were held to determine community goals for the corridor and to present the first round of ideas developed from community goals. Future meetings will present the final selected alternatives and detail the associated costs to achieve these goals. Over two hundred community members attended and participated in the first meeting and more than one hundred attended the second meeting to provide input during the planning process.

Wabash River Heritage Corridor Commission. 2004. Wabash River Heritage Corridor Management Plan. Lafayette, Indiana.

The plan identifies significant resources within the corridor, defines strategies that could be implemented to conserve and enhance those resources and identifies key resources and tools that can be used by local governments and organizations to implement strategies.

The plan identified the following actions related to natural resources:

- Stabilization of the riverbank.
- Re-establish riparian forests and wetlands along the river.
- Develop and implement setback programs to reduce surface runoff and non-point source pollution.
- Enforce existing regulations regarding point source pollution related to treatment plants and septic systems; explore the need for new regulations.
- Promote monitoring of water quality and public education about water quality.
- Preservation of large regional natural areas.
- Fish stocking and wildlife re-introduction in and along the Wabash River.

The plan identified 59 projects valued at over \$13 million conducted between 1990 and 2000. In Tippecanoe County, 16 projects have been implemented, valued at \$1.9 million. Projects include land acquisition, trail construction, reforestation, interpretive signage and other improvements.

Purdue University. 2007. *River Vision: Community Forum on the Future of the Wabash River Corridor in Tippecanoe County.* Department of Forestry and Natural Resources & Living Laboratories on the Wabash (LLOW)

Purdue University facilitated a forum on the Wabash River in Tippecanoe County in November 2006. The forum was attended by over one hundred community members and other interested stakeholders. The focus of River Vision was to develop a preliminary list of values, ideas and visions for the future of the Wabash River in Tippecanoe County.

The goal of the day was to gather community input about the future of the Wabash River to inform the master planning process for the corridor. Among other findings, approximately 50% of the key values were associated with improving the natural systems, ecology, and recreational opportunities along the Wabash River. Recognizing the need to preserve the area's heritage and explore educational opportunities along the corridor was also important to participants.

Eco Logic, LLC. *J. Frederick Hoffman Memorial Nature Area Ecological Assessment and Reforestation Plan.* Prepared for: Tippecanoe County Parks Foundation.

The Hoffman Memorial Nature Area is a 420-acre property that contains a large agricultural field in the central, upland area of the property, as well as two smaller agricultural areas adjacent to the Wabash. The goals of the reforestation plan are to increase habitat critical to many species of birds, manage and minimize the detrimental effects of invasive plant species, and control onsite erosion during the transition from open areas to forest communities.

A total of seventeen acres of floodplain forest will be established, as well as 127 acres of upland forest. Implementation of the plan is tentatively scheduled to start in the spring of 2011.

City of West Lafayette. Undated. *Happy Hollow Park Erosion Control Fact Sheet. Wet Weather Program.*

The fact sheet describes the ravine system in Happy Hollow Park, outlines causes of accelerated erosion, and presents plans for a project to stabilize the ravine. The use of gabions, turf blankets, terracing and specialized vegetation were under consideration for stabilizing slopes and stream banks in the park. The cost of the proposed project is \$4,450,000.

Based on personal communication from Mr. Joe Payne of the West Lafayette Parks Department and Mr. Ted Bumbleburg of the Lafayette Parks Department, there currently aren't any projects for Mascouten Park. Happy Hollow Park has erosion problems with erosion on steep slopes, erodible soils, and effects of urbanization on stormwater runoff. West Lafayette is trying to establish an MS4 utility and some funds generated by a proposed stormwater fee could be used to address some of these issues along with other drainage and erosion issues in the community.

Happy Hollow Park has been targeted for the implementation and demonstration of erosion control best management practices (BMPs) in the future. A transportation enhancement plan for the park addresses some of the bank stabilization issues. Outwash from Happy Hollow has formed a gravel bar in the Wabash River. The community would like to remove the gravel bar but the Indiana Department of Natural Resources (IDNR) is hesitant because they are concerned about the potential for destruction of mussel habitat.

City of West Lafayette. 2010. *Wabash Heritage Trail Extension Phase I and II Plans*. Project No. 0710997 (Constr.). H. Stewart Kline and Associates, Consulting Engineers and Architects. March 25, 2010.

These construction plans provide detailed descriptions of the Wabash Heritage Trail Extension Phase I, which consists of 1.05 miles and Phase II, which consists of 0.22 miles along the river in West Lafayette.

Christopher B. Burke Engineering, Ltd. 2007. *Wildcat Creek Stahl Ditch – Kitty Run Watershed Management Plan*. Indianapolis, Indiana.

The Wildcat Creek Stahl Ditch-Kitty Run watershed (HUC-14: 05120107010100 and 05120107020010) includes the City of Kokomo, Indiana, which discharges untreated stormwater to Wildcat Creek, as well as untreated combined sewage discharge from eighteen combined sewer overflows (CSOs). There is considerable development on the outskirts of the City, although 65% of the watershed remains in agricultural use.

Baseline characterizations of the watershed identified water quality problems related to elevated levels of toxicants (PCBs and pesticides), bacteria, nutrients, total suspended solids, degraded habitats and stressed biological communities. Potential sources of these pollutants include point source NPDES facilities, agricultural practices, and urban land uses (failing septic systems, pet and wildlife waste, and industrial waste, erosion from construction sites and runoff from impervious surfaces).

Targeted management measures to improve water quality include:

- Addressing failing septic systems;
- Establishing streamside buffers;
- Implementing conservation tillage practices on highly erodible lands;
- Restoring areas with stream bank erosion;
- Developing parks and trails along waterways; and
- Complying with the requirements of the Phase II MS4 program.

Wildcat Creek Watershed Alliance, Inc. 2003. *Little Wildcat Creek Watershed Management Plan*. Prepared by Goode and Associates, Inc. for the Wildcat Creek Watershed Alliance. IDEM 319 Project ARN #00-199. July 2001-June 2003.

The Little Wildcat Creek Watershed is a HUC-14 watershed (HUC 05120107020020) within the Wildcat Creek Watershed. It drains 12,054

acres within Howard and Tipton County, Indiana. The dominant land use is agriculture with 76% of the watershed is in agricultural production, 16% of the watershed is low density urban development.

The Howard County portion of the watershed is near the City of Kokomo and is rapidly urbanizing. Baseline characterizations of the watershed identified water quality problems related to elevated levels of oxygen consuming wastes, nutrients and bacteria. Potential sources of these pollutants include agricultural practices and urban land uses and development, as well as point sources from NPDES-permitted facilities. Both Gord Ditch and the East Fork of Little Wildcat Creek were listed on IDEM's 2002 303(d) list of impaired streams for E. coli.

Wildcat Creek Watershed Alliance. 2003. *Spring Creek-Lick Run Watershed Management Plan*. Prepared by Goode and Associates, Inc. for the Wildcat Creek Watershed Alliance. IDEM 319 Project ARN#00-199. July 2001–June 2003.

The Spring Creek-Lick Run Watershed is a HUC-14 watershed (HUC 05120107040100) within the Wildcat Creek Watershed that drains 10,842 acres within Clinton County, Indiana. 94% of the watershed is in agricultural production. Baseline characterizations of the watershed identified water quality problems related to elevated levels of nutrients, pesticides, sediment and bacteria. Potential sources of these pollutants include agricultural practices and urban land uses and development, as well as point sources from NPDES-permitted facilities. Heavilon Ditch and the South Fork of Wildcat Creek are both listed on IDEM's 303(d) list of impaired streams. Heavilon Ditch is listed for ammonia, dissolved oxygen, E. coli, and organic enrichment, while South Fork Wildcat Creek is listed for cyanide and E. coli. A TMDL for Heavilon Ditch is under development.

Tippecanoe County Soil & Water Conservation District. 2005-2010 *Long Range Plan*.

This Long-Range Plan is a roadmap for conserving soil and resources. The plan is intended to advance comprehensive conservation programs and innovative approaches to put "conservation on the ground". The plan includes measurable goals for the natural resources for Tippecanoe County related to:

- Stable Soils
- Healthy Forests and Riparian Buffers
- Clean Streams and Water Resources
- Productive Farms
- Sustainable Communities
- River Corridor Enhancement

5. PLAN FORMULATION

a. National Objectives

1) National Economic Development

The national or Federal objective of water and related land resources planning is to contribute to national economic development consistent with protecting the nation's environment pursuant to national environmental statutes, applicable executive orders and other Federal planning requirements. Contributions to national economic development are increases in the net value of the national output of goods and services, expressed in monetary units.

The Wabash River is the largest inland commercial fishery in Indiana. Further, the recreational uses associated with parks and other amenities that currently exist and are proposed in the Master Plan for the Wabash Greenway (see Attachment 1) and other projects contribute to the economy of the area.

The ecosystem restoration approaches identified through this project are anticipated to further this economic development by improving riparian habitats through stream bank stabilization and riparian plantings, restore and enhance wetlands and through in-stream aquatic habitat improvements. These projects are anticipated to improve water quality, in-stream habitat and enhance river access, thereby benefitting commercial fisheries and recreational uses of the river.

2) Ecosystem Restoration

The Corps has added a second national objective in response to legislation and administration policy. This objective is to contribute to the nation's ecosystems through ecosystem restoration with contributions measured by changes in the amounts and values of habitats.

The Wabash River is a globally significant ecosystem known for species diversity and richness and for the presence of many endangered, threatened, and rare species. It is socially and economically important as a source of drinking water, a commercial fishery, and an outstanding recreational resource. Anthropogenic stressors that affect so many other large river ecosystems such as large scale mines, dams, levees, and navigation infrastructure only marginally influence conditions in the study area. Nonetheless, the Wabash River is not without challenges.

As described in prior sections of this document, water quality remains a challenge despite tremendous improvements that occurred as a result of the Clean Water Act. Floodplain forests are but a fraction of their pre-settlement extent. Many of its aquatic species continue to slip toward extinction. However, because of the quality and integrity of the Wabash River

ecosystem, these challenges also represent opportunities for real and meaningful improvements.

If the plan presented herein were fully implemented, the potential magnitude and types of benefits from the proposed actions would reduce bank erosion along 34,500 linear feet (6.5 miles); result in revegetation of 37 acres of riparian buffer and restoration or enhancement of up to 440 acres of wetlands. To the extent feasible, these project areas would be protected and managed through conservation easements.

b. Public Concerns

A number of public concerns were identified during the course of the reconnaissance study. The Wabash River Enhancement Corporation (WREC) conducted a survey of 850 residents of Tippecanoe County in 2009 with 313 responses. Additional input was received through coordination with WREC and other potential sponsors, and some initial coordination with other agencies. The public concerns that are related to the establishment of planning objectives and planning constraints are:

- **Water Quality.** The WREC survey found that half the respondents have the perception that their contact with waters of the Wabash River is unsafe and that pollution of the river is getting worse. Over 90% believe there is potential to make the river cleaner and healthier.
- **Bank Erosion.** Bank erosion is a concern for several reasons, including: loss of fertile farmland and park land; threatened structures; and degradation of aquatic habitat and water quality.
- **Flooding and Flow Flashiness.** Flooding is a concern for residential, commercial, industrial, agricultural and municipal property owners along the Wabash River and its tributaries. There is a perception that flow in the river is flashier with flood peaks that rise higher and faster and recede more quickly compared to natural conditions. Flashiness has consequences for flooding, bank erosion and habitat degradation issues along the river and its tributaries.
- **Wildlife Habitat.** In the 2009 WREC survey, over 90% of respondents believe the river provides important habitat for birds and other wildlife.
- **Historic and Cultural Resource Preservation.** The river corridor in Tippecanoe County has a rich history of native nations and European settlement. Over 67% of survey respondents cited the river as an important link to the story of interactions between the native nations and settlers.
- **Recreation.** Over 2/3 of the respondents to the survey agree that trails along the river provide an excellent site for hiking or biking; parks along the river provide opportunities for children to play and interact with nature; and would enjoy places to eat outside along the river.
- **Economics.** Respondents to the WREC survey believe the river is important because it supports farming, industrial and municipal operations (66% of respondents) and that local funding to revitalize the river is a great investment for the future (over 69%).

- **Property Rights.** Agriculture is the predominant land use along the river in Tippecanoe County. The property owners value their land as an asset on which they and their families rely for their livelihood and are protective of their rights of ownership.

c. **Problems and Opportunities**

Problems and opportunities were evaluated for the following general categories:

- Bank stability and erosion;
- Riparian corridors;
- Wetland ecosystems;
- Aquatic ecosystems; and
- Flooding.

Bank stability and erosion, wetland ecosystems, and aquatic ecosystems were evaluated in the field during reconnaissance level surveys conducted from April 13 to 16, 2010. Surveyed areas included the Wabash River, the mouth of the Tippecanoe River and the mouth of Wildcat Creek in the study area. Field methods relied on standard visual assessment protocols (e.g., Rapid Bioassessment Protocols) and were designed to document existing conditions and to identify opportunities for ecosystem restoration, stream bank stabilization, sediment load reduction and water quality improvements. The reconnaissance study concentrated on publicly owned parcels, and parcels owned by non-profit entities and non-government organizations along the banks of the Wabash River in Tippecanoe County. These parcels were selected based on prior experience of the sponsor in acquiring rights of entry on privately owned property in the corridor and cooperation of public agencies and non-government organizations along the river. Riparian corridors were assessed by measuring the width of the forested riparian areas on aerial photographs. Widths were measured on each side of the river along 108 transects spaced at regular intervals. Potential for flooding was primarily based on review of available information and stakeholder interviews.

1) **Bank Stability and Erosion**

The Bank Erosion Hazard Index (BEHI) was used to evaluate bank stability and to predict bank erosion rates. BEHI values are determined by quantifying the bank height ratio, bank angle, rooting depth, root density, bank protection and bank material. BEHI ratings and estimates of the near-bank shear stress can be used to estimate annual bank erosion rates. BEHI scores (indices) range from 5 to 50. Narrative bank erosion hazard or risk rating categories are presented in the table below.

Table 3. Bank Erosion Hazard Results

Narrative Hazard or Risk Rating Category	BEHI Index	Number of Sites
Very low	5 to 9.5	6
Low	10 to 19.5	27
Moderate	20 to 29.5	47
High	30 to 39.5	16
Very high	40 to 45	5
Extreme	46 to 50	1
Total		102

BEHIs were estimated at 102 sites along the study reach. Narrative hazard ratings ranged from very low to extreme. Most banks in the study area have a low to moderate erosion hazard based on bank geometry, vegetative cover, root depth and density and bank materials. Estimates of near bank stress ranged from very low to very high. Erosion rates were calculated by using measured sediment rating curves for North Carolina, which are the closest available published curves. The table below summarizes the results of the BEHI study. Erosion rates presented in the table are relative, as regional sediment curves for the Wabash River watershed were not available. Hillslope erosion in Happy Hollow Park was calculated using the USDA's Universal Soil Loss Equation (USLE). Assumptions used in the calculation include that the soil type is sandy loam, the average slope is 26%, and the land type is forested with 40% groundcover.

Table 4. Estimated Erosion Rates in the Study Area.

Greenway Area (3)	Study Area	Tons/yr (1)	Tons/yr/ft	Study Bank Length	Length of Mod-High Bank Erosion
WABASH RIVER					
1	Hoffman Memorial Nature Area	194	0.034	5,687	4,187
2/3	Prophetstown State Park (Wabash)	3,487	0.176	19,837	6,252
3	Davis Ferry Park/Heron Island	71	0.012	5,710	870
3	Amphitheatre/Tecumseh Trails Park	14	0.003	4,675	1,596
4	Downtown Area	889	0.018	50,320	31,736
5	Ft. Ouiantenon	30	0.017	1,744	1,744
6	Colliers Island	103	0.039	2,665	1,058
6	Wabash Bottoms	65	0.020	3,225	1,634
6	Ross Hills Camp/Goose Island	161	0.028	8,032	3,654
6	Granville Bridge Park/Indian Creek Basin	53	0.022	2,390	2,082
5	Historic Ft. Ouiantenon	389	0.283	1,376	1,376
WILDCAT CREEK					
3	Wildcat Creek Mouth	1,413	0.844	1,674	1674
3	Wildcat Creek (Clegg Gardens)	negligible	negligible	1,736	0
TIPPECANOE RIVER					
2	Prophetstown State Park (Tippecanoe)	440	0.041	10,612	6,113

Greenway Area (3)	Study Area	Tons/yr (1)	Tons/yr/ft	Study Bank Length	Length of Mod-High Bank Erosion
WEA CREEK					
5	Wea Creek Mouth	348	0.246	1,414	922
HAPPY HOLLOW					
4	Happy Hollow Stream Erosion	78	0.062	1,253.00	662
4	Happy Hollow Hillside Erosion	4,464	56 ton/yr/ac (2)	NA	NA
Notes: 1. Erosion rates were calculated using the North Carolina Sediment Rating Curves 2. Calculated using Universal Soil Loss Equation (USLE) 3. Greenway areas are shown in Attachment 1. 4. Areas in bold contribute significant sediment within the study area.					

Vegetative cover, bank height, bank angle and root depths and densities all play a role in increasing bank erosion hazards in the study reach. Revegetation of stream banks along with reshaping of banks where necessary to achieve stable bank heights and angles are important factors in reducing bank erosion potential in the study reach. Observations of BEHI indices along the study reach indicate that restoration of riparian zones with native trees and vegetation will improve both stream habitat and bank stability.

Three areas were estimated to contribute significant sediment to the Wabash River within the study area: Prophetstown State Park, Wildcat Creek and Happy Hollow. Projects in these areas to stabilize stream banks and reduce erosion would reduce sediment inputs to the Wabash River.

Aerial photographs of Tippecanoe County dated 1929 (Purdue University, 1929) were obtained and included in the GIS data base from Tippecanoe County. Comparisons of the 1929 photography with 2009 aerial photography were used to estimate average annual erosion rates along the study reach for the last 80 years. Assuming an eroded bank height of 6 feet, the gross estimated bank erosion in the study reach since 1929 is 1,400,000 tons or an average of 15,000 tons per year. This equates to a loss of an average of 0.3 feet of bank per year or 25 feet of bank over 80 years within the study area.

2) Riparian Corridors

The following figure depicts the width of the forested riparian area within the study area. The average width of the riparian area on the left bank of the Wabash River was 170 feet and the average width of the riparian area on the right bank was 185 feet. However, nearly one-third of transects were observed to have riparian forest widths of 20 feet or less. Approximately 40% of transects were observed to have widths less than 40 feet.

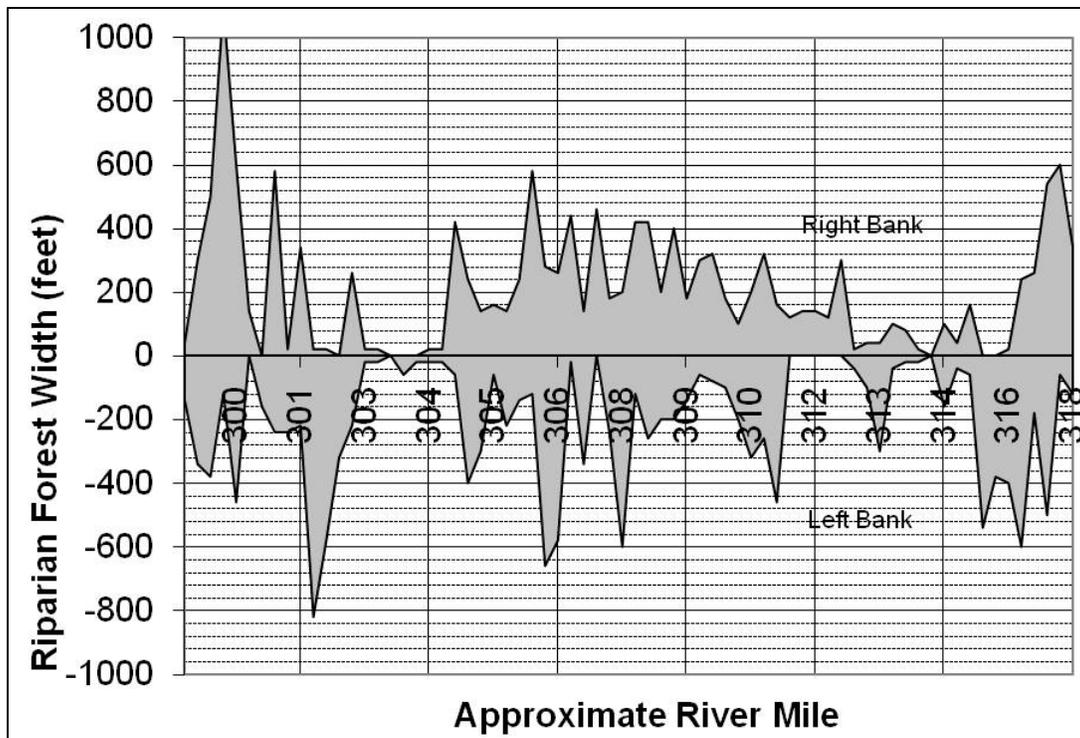


Figure 3. Riparian Corridor Width in Study Area

3) Wetland Evaluations

The condition of existing wetlands in the study area was evaluated in terms of functionality, quality, and restoration potential. The Ohio Rapid Assessment Method for Wetlands (Version 5) (ORAM) was used for this purpose. Six metrics are used to quantify the quality of wetlands using ORAM: (1) wetland size; (2) upland buffers and upland land use; (3) hydrology; (4) habitat alteration and development; (5) special wetland communities; and (6) vegetation, interspersions, and microtopography. Wetlands are placed in three quality categories based on their total metric scores: Category 1, Category 2 and Category 3.

ORAM defines Category 1 wetlands as "limited quality waters". Wetlands in this category have the lowest quality. They are either severely degraded, have limited potential for restoration, or have low functionality.

Category 2 wetlands support moderate wildlife habitat, hydrological or recreational functions. They are dominated by native species but typically do not support or have adequate habitat for rare, threatened or endangered species. These wetlands are degraded but have potential for the restoration of lost wetland functions. They can be considered as functioning, diverse, healthy water resources that have ecological integrity and value.

Category 3 wetlands have superior habitat, superior hydrological functions, or superior recreational value. They typically have high levels of diversity, high proportions of native species, and/or high functional value. They include wetlands which contain or provide habitat for threatened or

endangered species, are high quality mature forested wetlands, vernal pools, bogs, fens, or which are scarce on a regional or statewide basis. Category 3 wetlands can possess one or all of the above characteristics. For example, forested wetlands located in a flood plain may exhibit “superior” hydrologic functions (e.g., flood retention, nutrient removal), but not contain mature trees or high levels of plant species diversity and still be considered a Category 3 wetland.

Potential wetlands were mapped prior to the field reconnaissance study based on the extent of hydric soils in the study area. Five of the six primary ORAM metrics were used to evaluate twenty-eight (28) wetland sites. Special wetland communities were not apparent, are not critical to this study and the detail necessary for their evaluation is beyond the scope of a reconnaissance study. Where a site received a score in between two categories, the higher of the two categories was assigned, as described in the ORAM User’s Manual. Nine (9) high quality Category 3 wetlands were identified, seventeen (17) are Category 2 wetlands that have the most restoration potential, and two (2) are low quality Category 1 wetlands (see Table below). Three (3) additional potential wetland restoration areas were identified from digital aerial photographs. Based on National Wetland Inventory (NWI) data, there approximately 440 acres of wetlands in the study area. Most are Category 2 wetlands with good potential for restoration of wetland ecosystems.

Table 5. Summary of ORAM Data

ORAM Category	ORAM Score Range	Number of Sites
Category 1	0 to 29.5	2
Category 2	30 to 59.5	17
Category 3	60 to 100	9
Total		28

A summary of the potential wetland enhancement sites is shown in the table below. Three (3) sites were identified from aerial photographs; ORAM assessments were not completed at these locations. National Wetland Inventory (NWI) data were used to approximate the potential size of wetland that could be restored. The actual size of the wetland enhancement projects at each site may differ from the NWI area listed in the table below.

An initial project priority designation of high, medium or low is assigned to each potential wetland enhancement project, based on ORAM score, potential project size, land ownership and other factors.

There were two (2) limited quality waters (i.e., ORAM Category 1) wetlands. One of these was given a low priority due to the significant effort needed for restoration. The other Category 1 wetland was located north of the Lafayette Memorial Golf Course (W-16). This wetland was given a high priority because plans for wetland restoration efforts have already been discussed for this area as part of potential modifications to golf course.

Initial project priority for wetlands classified as moderate quality (i.e., ORAM Category 2) ranged from low to high. Generally, potential projects

in Category 2 wetlands with an ORAM score under 40 were given a low priority, and potential projects in wetlands with an ORAM score above 40 were given a medium to high priority. There were a few exceptions, which are explained below.

- An area near Granville Bridge Park (W-25) received an ORAM score of 38 but was given a high priority due to the presence of wetland hydrology and potential for educational opportunities for the public, as the potential wetland is adjacent to the Granville Bridge and parking area.
- An area within the Hoffman Memorial Nature Area (W-1) received an ORAM score of 57 but was given a low priority due to the area being located adjacent to a campground, where mosquitoes from a restored wetland could be detrimental to the camping experience.
- An island adjacent to Prophetstown State Park on the Tippecanoe River (W-4) received an ORAM score of 54 but was given a low priority due to the uncertainty of ownership of the island.

Wetlands classified as high quality (i.e., ORAM Category 3) projects were given a medium or high priority, based on their ability to be restored. Potential projects on publicly-owned lands or owned by non-profit entities or non-government organizations were given a higher priority than projects on privately-owned lands. Projects that could be coordinated with other efforts, such as the Wabash River Greenway Master Plan, were given higher priority. Additional site-specific information and constraints were also considered when assigning project priority (as noted in the examples above).

Table 6. Summary of Wetland Quality Data for Wetland Sites

Greenway Area	Study Area	Wetland ID	ORAM Score	ORAM Category	Project Priority	NWI Area (acres)
WABASH RIVER						
2	Hoffman Memorial Nature Area	W-1	57	2	L	7.8
		W-2	56.5	2	H	4.9
2	Prophetstown State Park (Wabash River)	W-6	62	3	M	1.9
2		W-7	68	3	H	12.0
3		W-8	51	2	H	4.2
3		W-9	44	2	M	3.1
3		Davis Ferry Park	W-13	37.5	2	L
3	Heron Wildlife Preserve	W-14	58.5	2	M	9.5
3	Across Wabash River from Future Wetland Restoration Area	W-15	47.5	2	M	11.0
3	Future Wetland Restoration Area (North of Lafayette Memorial Golf Course)	W-16	29	1	H	15.2
4	Mascouten Community Park	W-17	55.5	2	H	4.3
4	Forested Area on Opposite Bank of Shamrock Park	W-18	69.5	3	H	37.9
4	Island near Shamrock Park	W-19	4	1	L	2.0

Greenway Area	Study Area	Wetland ID	ORAM Score	ORAM Category	Project Priority	NWI Area (acres)
4	South bank of the Wabash River near Highway 231 Bridge	W-20	49.5	2	M	32.9
5	Right Bank between Granville Bridge and Historic Ouiantenon Property	W-23	NA	NA	M	NA
5	Left Bank upstream of Granville Bridge	W-24	NA	NA	M	6.5
5	Granville Bridge Park	W-25	38	2	H	8.8
		W-26	58	2	M	6.7
6	Goose Island Nature Preserve	W-27	67	3	M	NA
6	Ross Hills Park	W-28	73	3	H	59.6
6	Lost Creek	W-29	NA	NA	M	NA
6	Wabash Bottoms Trail	W-30	60	3	H	12.5
6	Colliers Island	W-31	76	3	H	5.3
MOOTS CREEK						
2	Prophetstown State Park (Moots Creek)	W-3	54	2	H	9.7
TIPPECANOE RIVER						
2	Prophetstown State Park (Tippecanoe River)	W-4	54	2	L	4.0
		W-5	62	3	H	6.8
WILDCAT CREEK						
3	Wildcat Creek confluence with the Wabash River	W-10	39	2	L	2.0
		W-11	54	2	M	1.5
		W-12	55	2	M	< 1
WEA CREEK						
5	Wea Creek confluence with the Wabash River	W-21	59	2	M	28.7
		W-22	60	3	M	135.0
Note: 1. Greenway areas are shown in Attachment 1.						

4) Aquatic Ecosystems

The existing condition of the aquatic ecosystem was evaluated at forty one (41) sites along the study reach. The habitat parameters for the Rapid Bioassessment Protocols (Barbour, et. al., 1999) were used to evaluate the quality of aquatic habitat. The protocol scores habitat by quantifying the integrity of habitat features including epifaunal substrate and cover, sediment deposition, channel flow characteristics, presence of channel alteration, channel sinuosity, frequency of riffles, bank stability, vegetative protection on banks, and the width of riparian zones. RBP habitat parameter scores along the study reach ranged from 37 to 133. The maximum score for habitat parameters is 200. Limiting factors for the sites evaluated in the study are riparian zone width, vegetative protection, bank stability, epifaunal substrate and cover, and sediment deposition. The restoration of riparian zones with native trees, shrubs, grasses and forbs will improve each of these factors and habitat quality.

5) Flooding

While episodic flooding does occur in the study area as a result of extreme or unusual precipitation events, there is no evidence suggesting that recurrent or frequent flooding or flood damage to structures was an issue. There were anecdotal reports of flooding of historical developments in the Tippecanoe River floodway and in Indian Creek. Information supporting these reports was not available at the time this report was prepared.

d. Planning Objectives

The national objectives of National Economic Development and National Ecosystem Restoration are general statements and not specific enough for direct use in plan formulation. The water and related land resource problems and opportunities identified in this study are stated as specific planning objectives to provide focus for the formulation of alternatives. These planning objectives reflect the problems and opportunities and represent desired positive changes in the without project conditions. The planning objectives are specified as follows:

- To reduce stream bank erosion and the associated impacts of water quality and ecosystem restoration in the study area.
- To restore riparian, aquatic and wetland ecosystems in the study area.
- To improve aquatic and riparian habitats for sport, endangered and threatened species along the river corridor.
- To improve land use and management practices in the study area that will enhance water resources.
- To improve recreational opportunities that will foster economic growth and support for ecosystem restoration, conservation and preservation activities.
- To provide alternatives for improved access to natural and historic attractions along the river that will contribute to the economic growth of the study area.

e. Planning Constraints

The planning constraints identified in this study are as follows:

1) Compliance with local land use plans

- Wabash River Enhancement Corporation
- Area Plan Commission of Tippecanoe County
- Indiana State Park Plans and Policies
- Tippecanoe County Soil & Water Conservation District. 2005-2010 Long Range Plan
- State Scenic By-Ways (Division Road and River Road)
- Hazard Mitigation Plan
- Wabash Heritage Trail
- Wabash River Heritage Corridor Commission
- Route 52 Corridor Planning Study

- Tippecanoe County Parks and Recreation Board
- City of Lafayette Parks and Recreation
- City of West Lafayette Parks and Recreation Department
- Tippecanoe County Highway Department
- Purdue University
- Historic Prophetstown Farm
- Prophetstown State Park
- Wabash Valley Trust for Historic Preservation
- NICHES (Northern Indiana Citizens Helping Ecosystems Survive) Land Trust

2) Applicable Executive Orders, Statutes and Regulations

- Water Resources Development Acts
- Section 404 of the Clean Water Act
- Section 401 of the Clean Water Act
- National Environmental Policy Act
- Endangered Species Act
- Section 106 of the National Historic Preservation Act
- Comprehensive Environmental Response, Compensation and Liability Act, 42 U.S.C. 9601 et. seq. (CERCLA). (See 42 U.S.C. 9601(14).)
- Sec. 3001 of the Resource Conservation and Recovery Act, 42 U.S.C. 6921 et. seq.
- Section 311 of the Clean Air Act, 33 U.S.C. 1321
- Section 307 of the Clean Water Act, 33 U.S.C. 1317
- Section 112 of the Clean Air Act, 42 U.S.C. 7412
- Section 7 of the Toxic Substance Control Act, 15 U.S.C. 2606
- Indiana Code 4-21.5-3-5 of Indiana Orders and Procedures Act
- 327 IAC 15-5, Rule 5 (Construction /Land Disturbance Storm Water Permitting)
- 327 IAC 15-13, Rule 13 (Municipal Separate Storm Sewer System)
- Other legal constraints

3) Infrastructure Constraints

- The proposed plan must not have a negative impact on flood levels of the Wabash River or its tributaries.
- The proposed plan must be designed to withstand high flow events.
- The proposed plan must be designed to minimize and facilitate maintenance requirements.

- The proposed plan must not cause damage to existing infrastructure, such as bridges, outfalls, utilities, etc.

This project identified planning constraints; if this project continues to the feasibility phase, a more detailed analysis of overlapping or conflicting constraints should be conducted.

It should be noted that this plan is conceptually consistent with the Master Plan for the Wabash River Greenway (WRT, 2010); Prophetstown State Park planned floodplain reforestation project, the Tippecanoe County Soil and Water Conservation District's goal of riparian corridor enhancements and wetlands enhancements adjacent to the golf course.

f. Measures to Address Identified Planning Objectives

A management measure is a feature or activity at a site, which address one or more of the planning objectives. A wide variety of measures was considered. Each measure was assessed and a determination made regarding whether it should be retained in the formulation of alternative plans.

1) No Action

Agencies are required to consider the option of "No Action" as one of the alternatives in order to comply with the requirements of the National Environmental Policy Act (NEPA). No Action assumes that no project would be implemented by the Federal Government or by local interests to achieve the planning objectives. No Action, which is synonymous with the Without Project Condition, forms the basis from which all other alternative plans are measured.

For this project under the No Action alternative, stream banks would continue to erode, contributing sediment to the Wabash River, which degrades water quality and covers in-stream habitats that are important for spawning fish and aquatic insects upon which the fish feed. Degraded riparian corridors would continue not to protect stream banks from erosion, and would continue not to provide habitats for aquatic species. Degraded wetlands would continue to provide some runoff storage and habitats, but would not reach their full potential as an integral component of a healthy Wabash River ecosystem.

2) Structural and Non-Structural Ecosystem Enhancements

This section provides an overview of possible structural and non-structural ecosystem restoration approaches that could be implemented to benefit ecosystem function and recreational value of the Wabash River in Tippecanoe County. While these projects do not specifically address flooding, implementation of projects associated with stream stability, wetland restoration and enhancement are anticipated to provide temporary storage for elevated flows thereby reducing flashiness. Additional study would be needed to quantify benefits for flooding and flashiness reduction.

i. Stream Stability and Riparian Restoration Approaches

Natural Channel Design - Natural Channel Design is a process by which new or reconstructed stream channels and their associated floodplain riparian systems are designed to be naturally functional, stable, healthy, productive, and sustainable.

Bankfull Bench – Bankfull Bench excavation is a technique used to decrease bank erosion. The term bankfull refers to the insipient point of flooding of the channel and usually corresponds to a storm event with a 1.2 to 1.6 year return interval. Construction of a bankfull bench (see Figure 4) in incised channels can be a beneficial way to reduce bank erosion by decreasing shear stress, alleviate flooding and flashiness within the watershed, restore hydrology to former floodplain wetlands, and, in turn, increase the ecological value of the river corridor. In addition, the implementation of a bankfull bench within public lands provides recreational value, as it improves access to the river and increases public safety within the park. Although the construction of a bankfull bench is recommended several times in the preliminary plan, more data collection will be necessary to ultimately determine the feasibility of this reconnaissance level recommendation.

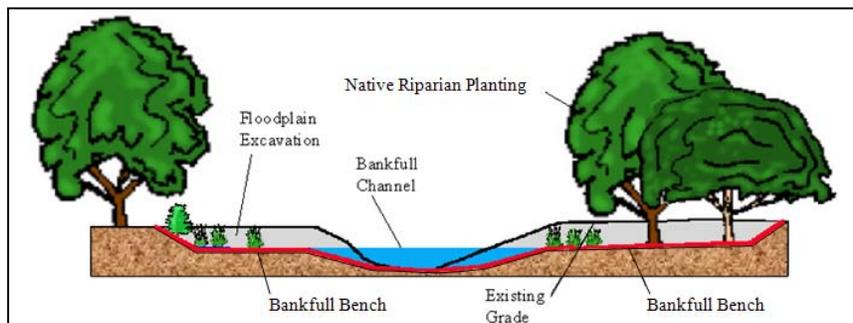


Figure 4. Bankfull Bench

Wood Toe Sod Mat – Wood Toe Sod Mat is a restoration strategy that involves the layering of sod over woody debris keyed into and along the bank to armor the bank. Live stakes are driven into the bank to anchor sod. This technique provides instant vegetative protection and acts as an undercut bank feature which provides excellent habitat for aquatic species.



Figure 5. Wood Toe Sod Mat

Native Riparian Plantings – Native Riparian Plantings increases the stream stability by providing root mass and bank protection to hold otherwise loose soil into the banks. In addition, vegetative cover reduces velocities of surface runoff, preventing erosion by overland flow. As part of the planting effort, it is important to manage invasive species so that native planted species are given optimum conditions for survival. Native riparian plantings also increase the available habitat for aquatic, terrestrial and avian species. Plantings are recommended in areas with existing sparse vegetation or narrow riparian corridor.

ii. Wetland Enhancement

Wetland restoration and enhancement projects aim to restore the critical ecosystem functions provided by wetlands, in addition to providing other benefits important to humans. Ecosystem functions provided by wetlands include sediment and nutrient retention, which increases water quality and reduces erosion, and habitat creation for many types of wildlife, including fish, resident and migratory birds and aquatic macroinvertebrates. In addition, wetlands can reduce flood damage in an area by providing temporary storage of flood waters. Wetland restoration projects should be coordinated with other enhancement efforts to provide recreational, educational, cultural and aesthetic benefits to residents and visitors. Strategies used to implement these wetland restoration and enhancement projects include restoring or enhancing the hydrology of historic

river channels, planting native wetland vegetation and controlling invasive species.

iii. **In-stream Habitat**

The objective of in-stream habitat restoration strategies is to alter physical environment such that aquatic organisms can better complete phases of their life history (e.g., reproduction, incubation, growth). Target organisms considered in this study were fish (e.g., shovelnose sturgeon, walleye) and freshwater mussels but other organisms (e.g., migratory birds) would certainly benefit from the restoration strategies presented below.

Lateral margin enhancements - As a result of human activities in the floodplain, riparian forests have altered the structural and functional characteristics of in-stream ecosystems. Lateral margin enhancements will focus on increasing the structural complexity of shallow shoreline habitats that are important nursery areas for larval and juvenile fish. Examples of enhancement projects would include placement of wood structures, construction of undercut banks through the use of wood toe sod mats, and modification of tributary confluences and alcove habitat.

Spawning Substrates - Large flood storage reservoirs have interrupted the transport of coarse-grained substrates and widespread bank erosion in the study area has increased the delivery of fine-grained sediments. Consequently, stream bed substrates in the study area are highly embedded (i.e., partially or fully covered with sediment) and the grain sizes are likely smaller than pre-settlement conditions. These habitats are important for fish spawning and provide habitat for aquatic insects, an important food source. Therefore, improving these habitats provides additional opportunities for fish spawning over the long term. Examples of potential projects targeting spawning substrates would include gravel augmentation and modification of channel geometry to alter sediment transport competence and capacity.

Island creation / side channel restoration - Island habitats and their associated side channels are ecologically important features for a number of reasons. They maximize the zone of interface between strictly aquatic habitats and those that are more terrestrial in nature. The energy budget for aquatic food webs is subsidized by organic material of terrestrial origin (e.g., leaf litter, sticks, etc.). Stream channel width to depth ratios are typically higher in areas with islands and consequently near bed shear stresses are lower during high flows (important for mussels) and velocity profiles are stable (important for fish). The increased roughness of vegetation on the islands can serve as a velocity refuge for fish during high flow events. This restoration strategy will rely on two different approaches for creating these habitats.

Channel restoration - The channel restoration strategy is intended to eliminate disequilibrium conditions by restoring a stream to a stable dimension, pattern, and profile. As part of a stream restoration project, channel relocation could be appropriate to address bank erosion and sediment loading from smaller tributaries (e.g., Wildcat Creek, Moots Creek).

iv. Conservation Easements

Conservation easements are recommended as a strategy to protect project areas on public or non-profit owned lands to preclude or control potential future disturbance of riparian corridors, wetlands or other projects established as part of this plan. Conservation easements can also be used to preclude or control disturbance of important habitat features on privately owned lands. For example, conservation easements could be established on agricultural lands to conserve riparian buffers and wetlands.

v. Recreational Opportunities

The Master Plan for the Wabash River Greenway (WRT, 2010) addresses public interaction with the river corridor by the development of trails and addition of public access facilities. Ecological and stream stability enhancements to the watershed will increase public access to the river, promote larger biomass of sport fish, encourage the habitation of wildlife, provide educational opportunities, and improve aesthetic value of the corridor.

g. Preliminary Plan

1) Preliminary Plans Eliminated from Further Considerations

None of the preliminary plans was eliminated from further consideration during this initial planning phase. It is possible that some plans included in this study could be eliminated at a future time pending the results of more detailed analysis.

2) Preliminary Plans for Further Considerations

The preliminary plan components are summarized on the table below and on maps provided in Attachment 2. Narrative descriptions of the preliminary plan follow the table.

Table 7. Preliminary Plan Summary

Map # (1)	Property	STREAM STABILITY			WETLAND ENHANCEMENT				IN-STREAM HABITAT			WRT Section (3)
		Preliminary Plan	Priority	Linear Feet of Mod-High Erosion	Preliminary Plan	Wetland ID	Priority	Wetlands area (acres) (2)	Preliminary Plan	Priority	Size of Conceptual Restoration	
1	Hoffman Memorial Nature Area	Construct bankfull bench, and/or install wood toe sod mat, and/or plant native vegetation on banks	M	4,187	Restore/enhance hydrology and restore wetland plant community. Wetland adjacent to campground, which may prohibit restoration.	W-1	L	7.8				2
					Restore/enhance hydrology and restore wetland plant community.	W-2	H	4.9				
2	Prophetstown State Park (Moots Creek)	Address channel instability at the confluence of Moots Creek and the Tippecanoe River	M	961	East edge of Prophetstown State Park. Restore hydrology of historic channel. Restore/enhance wetland plant community	W-3	H	9.7				2
2	Prophetstown State Park (Tippecanoe River)	Construct bankfull bench and/or wood toe sod mat and/or plant native vegetation on banks of Tippecanoe River	H	6,113	Restore/enhance hydrology on island by reducing elevation	W-4	L	4.0				2
2	Prophetstown State Park (Wabash River)	Construct bankfull bench, and/or install wood toe sod mat, and/or plant native vegetation on Wabash River	H	6,252	Restore hydrology of old channel and wetland plant community.	W-6	M	1.9	Construct in-channel wood jam to restore degraded island and side habitat	H	N/A	2
2					Restore/enhance hydrology and restore wetland plant community.	W-7	H	12.0				2
3					West end of Prophetstown State Park. Restore hydrology of old channel and wetland plant community.	W-8	H	4.2				3
3					West end of Prophetstown State Park. Restore hydrology of old channel and wetland plant community. Adjacent to I-65 bridge crossing.	W-9	M	3.1				3

Map # (1)	Property	STREAM STABILITY			WETLAND ENHANCEMENT				IN-STREAM HABITAT			WRT Section (3)
		Preliminary Plan	Priority	Linear Feet of Mod-High Erosion	Preliminary Plan	Wetland ID	Priority	Wetlands area (acres) (2)	Preliminary Plan	Priority	Size of Conceptual Restoration	
3	Wildcat Creek	Address channel instability at the confluence of Wildcat Creek and the Wabash River-potential restoration area	H	450	Confluence of Wildcat Creek and Wabash River. Restore/enhance wetland plant community.	W-10	L	2.0				3
3					Restore/enhance wetland plant community. Potential to restore hydrology to historic channel.	W-11	M	1.5				
3					Restore/enhance wetland plant community. Potential to restore hydrology to historic channel.	W-12	M	< 1				
3	Davis Ferry Park				Restore hydrology of old channel and wetland plant community. Adjacent field at a lower elevation.	W-13	L	10.1				3
3	Heron Wildlife Preserve				Island and depressional areas give potential to restore/enhance hydrology. Nesting geese present. Potential for wildlife habitat.	W-14	M	9.5				3
3	Across Wabash River from Future Wetland Restoration Area				Depressional areas within forest. Potential to restore hydrology to historic channel.	W-15	M	11.0				3
3	Future Wetland Restoration Area	Construct bankfull bench, install wood toe sod mat as part of future wetland restoration activities	H	2,296	Area north of Lafayette Memorial Golf Course. Potential to establish wetland plant community/native species on bank to reduce erosion.	W-16	H	15.2				3
3	Lafayette Memorial Golf Course	Construct bankfull bench and/or wood toe sod mat and/or plant native vegetation	H	1,905								3
4	Happy Hollow Park	Stabilize tributary to Wabash utilizing natural channel design techniques	M	662								4
4	McAllister Park, Lybault Field, Digby Park	Construct bankfull bench and/or wood toe sod mat and/or plant native vegetation	M	5,774								3/4

Map # (1)	Property	STREAM STABILITY			WETLAND ENHANCEMENT				IN-STREAM HABITAT			WRT Section (3)
		Preliminary Plan	Priority	Linear Feet of Mod-High Erosion	Preliminary Plan	Wetland ID	Priority	Wetlands area (acres) (2)	Preliminary Plan	Priority	Size of Conceptual Restoration	
4	Mascouten Community Park				Restore hydrology to depressional areas and restore wetland plant community.	W-17	H	4.3				4
4	Forested Area on Opposite Bank of Shamrock Park				High quality habitat. Restore herbaceous wetland plant community and possibly hydrology of old channel.	W-18	H	37.9				4
4	Island near Shamrock Park				Potential to create backwater area between island and near bank.	W-19	L	2.0				4
4	South bank of the Wabash River near Highway 231 Bridge				0.25 miles downstream of WWTP discharge. Potential to restore hydrology to depressional area and restore wetland plant community.	W-20	M	32.9				4
4	Island downstream of Highway 231 Bridge								Construct in-channel wood jam to restore degraded island and side habitat	H	N/A	
5	Wea Creek	Perform additional study to determine source and potential solutions of erosion at confluence with Wabash River	H	922	Confluence of Wea Creek and Wabash River. Restore hydrology to historic channel and wetland plant community.	W-21	M	28.7				5
					Confluence of Wea Creek and Wabash River. Restore hydrology to historic channel and wetland plant community.	W-22	M	135.0				
5	Historical Fort Ouiantenon	Construct bankfull bench and/or wood toe sod mat and/or plant native vegetation	H	1,376								5
5	Right Bank between Granville Bridge and Historic Ouiantenon Property				Restore hydrology to historic channel and wetland plant community.	W-23	M	N/A				5
5	Left Bank upstream of Granville Bridge				Restore wetland plant community.	W-24	M	6.5				5

Map # (1)	Property	STREAM STABILITY			WETLAND ENHANCEMENT			IN-STREAM HABITAT			WRT Section (3)	
		Preliminary Plan	Priority	Linear Feet of Mod-High Erosion	Preliminary Plan	Wetland ID	Priority	Wetlands area (acres) (2)	Preliminary Plan	Priority		Size of Conceptual Restoration
6	Granville Bridge Park				Within Granville Bridge Park on either side of bridge. Historic channel holding water. Potential to restore wetland plant community. Boat ramp intersects wetland.	W-25	H	8.8				5
					Downstream of Granville Bridge Park. Historic channel holding water. Potential to restore wetland plant community. Adjacent to agricultural area.	W-26	M	6.7				
6	Indian Creek Basin	Construct bankfull bench and/or wood toe sod mat and/or plant native vegetation	M	837							6	
6	Goose Island Nature Preserve				Restore hydrology of historic channel and wetland plant community.	W-27	M	N/A				6
6	Ross Hills Park				Restore wetland plant community.	W-28	H	59.6				6
6	Lost Creek				Restore hydrology of historic channel and wetland plant community near Lost Creek.	W-29	M	N/A				6
6	Wabash Bottoms Trail	Construct bankfull bench and/or wood toe sod mat and/or plant native vegetation	M	1,634	Forested riparian area with historic channels. Restore hydrology to channels and restore wetland plant community.	W-30	H	12.5				6
6	Colliers Island	Address bank erosion on upstream side of island as part of establishment of wetland hydrology	M	1,058	Establish hydrology in depressional areas. Establish wetland plant community. Bald eagle nest present on island; potential for other wildlife habitat.	W-31	H	5.3				6

Notes:

1. Map # - See Attachment 2.
2. Wetlands Area – from National Wetland Inventory
3. Cross reference to trail sections in the Master Plan for the Wabash River Greenway, provided as Attachment 1.

1. Area 1

Area 1 of the Wabash River Greenway Plan consists of the northern portion of the study area. This area starts near Delphi in Carroll County and continues downstream on the Wabash River to Americus (Tippecanoe County). Historic prairie soils are conducive to the predominantly agricultural land use of this portion of the river corridor.

The J. Frederick Hoffman Memorial Nature Area is a 434-acre park located along the Wabash River. The Master Plan for the Wabash River Greenway indicates that the following developments may be constructed within the park:

- Parking Area
- Restrooms
- Spur Trail
- Boat Ramp
- Camping
- Picnic Facilities
- Playground

This plan identified several ecosystem restoration opportunities within this property:

- Stabilize approximately 4,187 feet of eroding stream bank
- Restore / enhance about degraded wetlands (2 areas)
- Plant native vegetation to improve riparian conditions



Figure 6. Eroding Bank at J. Frederick Hoffman Memorial Nature Area

2. Area 2

Area 2 is rural in nature and encompasses a large portion of Prophetstown State Park, a 3,020 acre park dedicated to returning the landscape to pre-European settlement conditions. In addition, travelers of the Greenway can observe historic agricultural practices at the early 20th century farm operated in Historic Prophetstown.

The proposed Greenway Trail will parallel the existing Highway 225 within Prophetstown State Park. A canoe launch/landing area may be constructed upstream of the park on the Tippecanoe River off of Pretty Prairie Road.

The Plan recommends the following bank stability and ecosystem enhancements within Area 2:

- Address channel instability at the Moots Creek Confluence with the Tippecanoe River.
- Restore wetlands in the vicinity of the Moots Creek/Tippecanoe River confluence.
- Stabilize approximately 6,100 ft of bank on the Tippecanoe River through Prophetstown State Park.
- Bank stabilization of 5,469 ft of eroding bank on the Wabash River through Prophetstown State Park.
- Restore wetlands adjacent to the Wabash River.
- Connect Tippecanoe River to abandoned side channel to extend length of high quality riverine habitat.
- Construct in-channel wood jam to restore degraded island and side habitat on Wabash River adjacent to Prophetstown State Park.



Figure 7. Unstable channel in Moots Creek near the confluence with the Tippecanoe River



Figure 8. Bare Banks within Prophetstown State Park on the Wabash River

3. Area 3

This section of the Greenway includes the downstream portion of Prophetstown State Park. The river corridor begins to transition to a more urban land use through Area 3 as the Wabash River enters the cities of Lafayette and West-Lafayette. Additional public lands in this area include Davis Ferry Park, Tippecanoe Amphitheater, and the Future Wetland Restoration Area. The Wildcat Creek confluence with the Wabash River is also located within this section of the proposed Greenway.

Greenway Trail is proposed to be constructed within the Davis Ferry Park. An additional trail will be constructed along the south edge of the future wetland restoration area, adjacent to Route 52.

Components of the ecosystem enhancement portion of preliminary plan are as follows:

- Address channel instability at the confluence of Wildcat Creek and the Wabash River.
- Restore wetland habitat at Davis Ferry Park, Heron Wildlife Preserve, Wildcat Creek, and the Future Wetland Restoration Area.
- Stabilize 2,296 feet of eroding bank along the Future Wetland Restoration Area.



Figure 9. Eroded banks on Wildcat Creek

4. Area 4

This section of the Greenway traverses the downtown areas of Lafayette and West-Lafayette and continues downstream to the low density suburban and rural land uses. There are several public lands within the downtown area that currently provide recreation and access to the Wabash River. The Greenway plan would focus on the enhancement of these areas, as well as the addition of new public access opportunities.

As part of the preliminary plan, the following ecosystem enhancements are recommended for Area 4:

- Remove existing gabion baskets from the Happy Hollow Park. Stabilize Happy Hollow Park hillslope and stream erosion by planting native vegetation on the slopes and utilizing natural channel design techniques to reduce erosion on the tributary to Wabash River.
- Stabilize 5,774 feet of moderate to highly eroding bank through McAllister Park, Lybault Field, and Digby Park areas.
- Wetland restoration/enhancement opportunities exist at Mascouten Community Park, in the vicinity of Shamrock Park, and near the highway



Figure 10. Eroding gabion baskets on Happy Hollow Creek



Figure 11. Eroding hillslope in Happy Hollow Park

5. Area 5

This section of the Greenway is characterized by agricultural and forested land uses. Several educational opportunities exist in this portion of the Greenway, as it will traverse the Tippecanoe Wildlife Habitat Area, NICHE's Wea Creek Gravel Hill Prairie, Granville Bridge Park and Fort Ouiantenon Park. As part of the proposed Greenway activities, a trail will be constructed to connect Fort Ouiantenon Park to Granville Bridge Park. A restroom facility is also proposed at the Granville Bridge Park. In addition, the preliminary plan recommends the following stream and wetland enhancements.

- Perform additional study to determine source and potential solutions of erosion at the Wea Creek confluence with the Wabash River.

- Restore hydrology to historic channels adjacent to Wea Creek to create high quality wetland habitat.
- Stabilize 1,209 feet of eroding bank at the Historic Fort Ouiantenon property.
- Restore remnant channels near Granville Bridge Park to create wetland habitat.
- Restore historic channels to create wetland habitat near Granville Bridge Park (private property).



Figure 12. Bank Erosion at Historic Fort Ouiantenon Property

6. Area 6

The southern portion of the proposed Greenway will continue south from Granville Bridge Park in Tippecanoe County to Cicott Park in Fountain County. Users of the Greenway will experience wildlife and nature in this rural area of the Wabash River corridor. In addition, several educational opportunities exist, as the proposed trail will parallel the historic canal structure and pass early European settlements. A new boat ramp is proposed at Cicott Park to increase recreational access to the river in this portion of the Greenway. Additional public lands in Area 6 include Indian Creek Basin, Ross Hills Park, Wabash Bottoms, Colliers Island, and the Roy Whistler Wildlife Area. Ecosystem enhancements in the preliminary plan include:

- Stabilize 837 feet of eroding bank at the Indian Creek Basin Property.
- Restore backwater hydrology and wetland plant community at Goose Island Nature Preserve.
- Stabilize 1,634 feet of eroding bank at the Wabash Bottoms Trail property.
- Address 1,058 feet of bank erosion on the upstream side of Colliers Island.

- Restore additional wetlands at Ross Hills Park, Wabash Bottoms Trail, Lost Creek, and Colliers Island.



Figure 13. Eroding Bank at Colliers Island

3) Alternative Implementation Authorities

As much as 90% of the land in rural sections of the study area is in agricultural production. The Natural Resources Conservation Service (NRCS), Cooperative Extension Service (CES) and other agencies of the US Department of Agriculture (USDA) are potential alternative implementation authorities for components of the project. Existing programs such as the Conservation Reserve Program (CRP) may be viable alternatives for facilitating restoration of riparian, wetland and floodplain areas in the project area.

h. Conclusions from the Preliminary Screening

This project required an engineering and environmental evaluation of the anticipated impacts of the plans. The preliminary screening indicates that alternatives stream bank stabilization, riparian corridor revegetation, wetlands restoration and enhancements have the greatest potential for implementation. If this plan were fully implemented, the potential magnitude and types of benefits from the proposed actions would reduce bank erosion along 34,500 linear feet (6.5 miles), result in revegetation of 37 acres of riparian buffer and restoration or enhancement of 440 acres of wetlands. These projects are anticipated to reduce flooding and flashiness by providing temporary storage of runoff via bankfull benches, restoration and enhancement of wetlands. Recreational benefits include improved stream access via bank full benches, and enhancements to the recreational experience value due to improved ecosystem conditions and improved water quality. To the extent feasible, these project areas would be protected and managed through conservation easements.

The environmental effects of these improvements include reduced inputs of sediment and associated pollutants such as nutrients and pesticides into the Wabash River. Bankfull benches, restored and enhanced wetlands provide opportunities to implement mitigation projects within the watershed to address needs generated as a result of some components of the Master Plan for the

Wabash River Greenway. For example, three new bridges were included in the greenway plan, along with numerous enhancements to area parks, some of which may be constructed in the floodplain. The projects proposed in this study could be used as local mitigation for greenway projects, and other projects that impact streams, floodplains and wetlands in the Wabash River floodplain area.

Estimated Preliminary Plan Costs:

Assumptions: Cost estimate is based on the following unit prices:

- Bank Stabilization: \$500/LF
- Riparian Plantings: \$20,000/ac
- Wetland Restoration Plantings: \$18,000/ac
- Wetland Invasive Species Control: \$9,000/ac
- Restoration of Wetland Hydrology: \$10,000/ac

60% of wetlands identified in the preliminary plan will require restoration

- 50% of these wetlands will require invasive species management
- 10% will require restoration of hydrology

Estimated Ecosystem Enhancements		
Construction Cost	\$	25,098,000 (Note 1)
Contingency	\$	5,019,600
Total Construction Costs	\$	30,117,600
Non-Construction Costs		
Construction Management (7%)	\$	1,756,860
Design (15%)	\$	3,764,700
Permits/As-Built/Monitoring (5%)	\$	1,254,900
 Total Construction Phase Cost	 \$	 36,894,060

Note 1: Breakdown of Ecosystem Enhancement Tasks:

<u>Item:</u>		
Mobilization	\$	30,000
Stream Stabilization	\$	17,275,000
Stream Riparian Plantings	\$	743,000
Wetland Restoration Plantings	\$	5,400,000
Wetland Invasive Species Control	\$	1,350,000
Wetland Hydrology Restoration	\$	300,000
 Total	 \$	 25,098,000

Preliminary costs to perform bank stabilization projects are provided below. Note that these costs do not include engineering services, such as design, construction observation, or permitting. Table 8 contains low and high estimates per foot for stabilization of the bank using more invasive techniques including wood toe sod mat or bankfull bench. Table 9 summarizes the estimated cost to stabilize moderate to high erosion streambanks by only planting riparian vegetation.

Table 8. Preliminary Conceptual Cost Estimate for Bank Stabilization

Greenway Area	Property	Potential Project Area (Linear Feet)	Estimated Cost (Low Range)	Estimated Cost (High Range)
1	Hoffman Memorial Nature Area	4,200	\$840,000	\$2,100,000
2	Prophetstown State Park (Moots Creek)	1,000	\$200,000	\$500,000
2	Prophetstown State Park (Tippecanoe River)	6,100	\$1,220,000	\$3,050,000
2/3	Prophetstown State Park (Wabash River)	6,300	\$1,260,000	\$3,150,000
3	Wildcat Creek	450	\$90,000	\$225,000
3	Future Wetland Restoration Area	2,300	\$460,000	\$1,150,000
3	Lafayette Memorial Golf Course	1,900	\$380,000	\$950,000
4	Happy Hollow Park	700	\$140,000	\$350,000
4	McAllister Park, Lybault Field, Digby Park	5,800	\$1,160,000	\$2,900,000
5	Wea Creek	900	\$180,000	\$450,000
5	Historical Fort Ouiantenon	1,400	\$280,000	\$700,000
6	Indiana Creek Basin	800	\$160,000	\$400,000
6	Wabash Bottoms Trail	1,600	\$320,000	\$800,000
6	Colliers Island	1,100	\$220,000	\$550,000
	Total	34,550	\$6,910,000	\$17,275,000

Note: Low range estimate based on \$200 per linear foot; high range estimate based on \$500 per linear foot

Table 9. Riparian Plantings Cost Estimate

Greenway Area	Property	Potential Project Area (Linear Feet)	Potential Riparian Project Area (Acres) (1)	Estimated Cost (2)
1	Hoffman Memorial Nature Area	4,200	2.4	\$48,000
2	Prophetstown State Park (Moots Creek)	1,000	0.6	\$12,000
2	Prophetstown State Park (Tippecanoe River)	6,100	3.5	\$70,000
3	Prophetstown State Park (Wabash River)	6,300	3.6	\$72,000
3	Wildcat Creek	450	0.3	\$5,000
3	Tippecanoe Amphitheater	1,600	0.9	\$18,000
3	Heron Island	870	0.5	\$10,000
4	Downtown Area	31,700	18.2	\$365,000
5	Wea Creek	900	0.5	\$10,000
5	Fort Ouiantenon	1,700	1	\$20,000
5	Historical Fort Ouiantenon	1,400	0.8	\$16,000
6	Granville Bridge Park/Indian Creek Basin	2,100	1.2	\$24,000
6	Ross Hills Camp/Goose Island	3,700	2.1	\$42,000
6	Wabash Bottoms Trail	1,600	0.9	\$18,000
6	Colliers Island	1,100	0.6	\$13,000
	Total	64,720	37	\$743,000
Notes: 1. Assumes 25 foot buffer width 2. Assumes \$20,000 per acre for native riparian plantings				

The wetland restoration and enhancement projects discussed in this report will be implemented by restoring or enhancing the hydrology of historic river channels, planting native wetland vegetation and/or controlling invasive species. These projects require each wetland restoration site to be assessed individually to identify the current and desired ecological functions in order to determine the type and amount of restoration needed. Revegetating an area with native wetland tree and shrub seedlings typically costs \$16,000 to \$18,000 per acre. Controlling invasive species commonly found in wetland areas typically will cost \$8,000 to \$9,000 per acre.

Restoring or enhancing the hydrology of an historic channel to provide various ecosystem functions is a very site-specific process, and further assessments would be needed before a discussion of costs would be possible.

i. Establishment of a Plan Formulation Rationale

The conclusions from the preliminary screening form the basis for the next iteration of the planning steps that would be conducted in supplemental studies. The likely array of alternatives that will be considered in the next iteration includes stream bank stabilization, riparian reforestation, and wetland restoration and enhancements on public lands or lands owned by non-profit entities. To the extent feasible, as per results of subsequent studies, in-stream habitat enhancements could also be constructed. To the extent feasible, project areas on public lands, non-profit lands and private lands should be protected by conservation easements. Future screening and reformulation will be based on the following factors: mitigation needed within the study area, recreational benefits of improved stream access through construction of bankfull benches, recreational and educational benefits of public access to restored and enhanced wetlands.

6. FEDERAL INTEREST

Ecosystem restoration is an output with a high budget priority and ecosystem restoration through stream bank stabilization, riparian buffer restoration, wetlands restoration and enhancement and in-stream aquatic habitat improvements is the primary output of the alternatives to be evaluated in the feasibility phase. These projects are anticipated to mitigate stream flashiness by providing temporary runoff storage in wetlands and bankfull benches and reduced overland flow through reforested riparian buffers. However, the scope and scale of the potential project eligible for the Corps' consideration at this location does not warrant a General Investigations feasibility study, nor follow on project authorization from Congress.

There is also potential Federal interest in other related outputs of the alternatives including recreation, water quality improvements, stream bank stabilization, alternative transportation, historic preservation and cultural resource preservation and development that could be developed, but most likely in concert with other Federal agencies besides the Corps. Given this scenario there does not appear to be a project of significant magnitude to carry into a General Investigation feasibility study by the Corps. However, there are some aquatic ecosystem features that would justify consideration under Section 206 of the Continuing Authorities Program (CAP).

7. PRELIMINARY FINANCIAL ANALYSIS

Not Applicable – no General Investigation feasibility effort is recommended.

8. ASSUMPTIONS AND EXCEPTIONS

Not Applicable – no General Investigation feasibility effort is recommended.

9. FEASIBILITY PHASE MILESTONES

Not Applicable – no General Investigation feasibility effort is recommended.

10. FEASIBILITY PHASE COST ESTIMATE

Not Applicable – no General Investigation feasibility effort is recommended.

11. VIEWS OF OTHER RESOURCE AGENCIES

Coordination with other resource agencies such as the Indiana Department of Natural Resources (IDNR), the Planning with POWER (Protecting Our Water and Environmental Resources) Project (Planning with POWER), and the Tippecanoe County Soil and Water Conservation District (SWCD) has occurred throughout Phase 1 and 2 of the Wabash River Corridor Master Plan. In general these agencies are interested in projects that will lead to streambank stabilization, increasing the width of riparian buffers, and increasing public access points to the Wabash River within the study area. Individual agency plans are detailed below.

IDNR is interested in stream bank stabilization projects, especially in agricultural areas where banks have been cleared. They could also support river access points for boating activities. IDNR has expressed interest in pursuing agreements where they would construct and maintain boat access sites, in addition to creating buffers between the river and adjacent agricultural, industrial and municipal lands.

Planning with POWER is supported by Purdue Cooperative Extension Service and the Indiana-Illinois SEA Grant program. Planning with POWER aims to protect water resources through land use planning initiatives. Within the study area, it has been determined that additional public access areas would lead to increased use of the Wabash River as a resource. Potential activities of the project include providing river access at fluctuating stages, as well as providing paved trails that can be utilized by bikers.

The Tippecanoe County SWCD aims to install riparian buffers along the Wabash River and its tributaries in order to separate the water body from agricultural activity. Buffer width is intended to be 600 feet along the Wabash River and 300 feet along its tributaries. The Tippecanoe County SWCD is also currently working with landowners in floodplains to adopt practices that will increase the sustainability of their property.

All potential projects should be compatible with Wetland Reserve and Floodplain Protection Programs. Access to state parks should comply with policies limiting entrances and exits within state park areas. Projects should also consider park master plans.

12. POTENTIAL ISSUES AFFECTING INITIATION OF FEASIBILITY PHASE

Not Applicable – no General Investigation feasibility effort is recommended.

13. PROJECT AREA MAP

A map of the study area is provided as Attachment No. 2.

14. RECOMMENDATIONS

I find insufficient basis for proceeding into a cost shared General Investigation feasibility study at Lafayette, Central Wabash, Tippecanoe County, Indiana. However, consideration should be given for evaluating the implementability of an Aquatic Ecosystem Restoration project under Section 206 of the Continuing Authorities Program. Wabash River Enhancement Corporation would be a local sponsor for the program.

Date: _____

KEITH A. LANDRY
COLONEL, CORPS OF ENGINEERS
DISTRICT COMMANDER